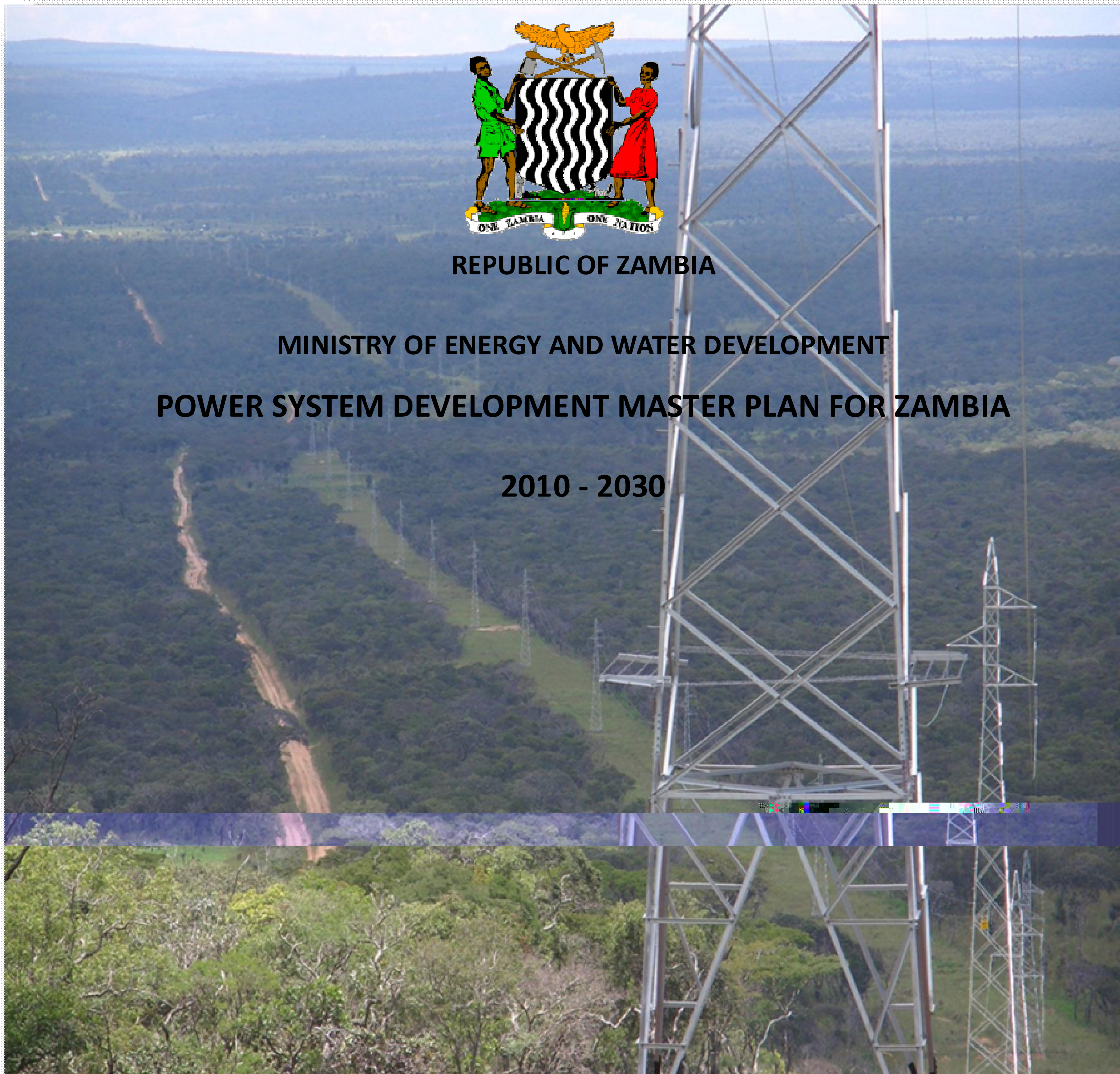
REPUBLIC OF ZAMBIA

MINISTRY OF ENERGY AND WATER DEVELOPMENT

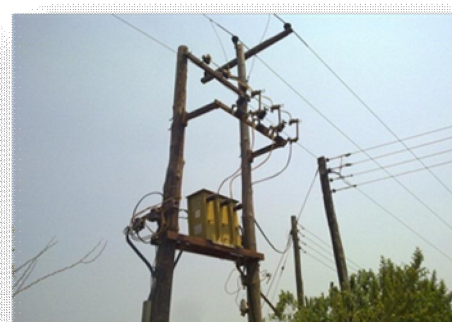
POWER SYSTEM DEVELOPMENT MASTER PLAN FOR ZAMBIA

2010 - 2030



"A long term plan for least cost development of Generation, Transmission and Distribution plans for socio-economic development of the country"

February 2010



FUNDED BY THE GOVERNMENT OF JAPAN THROUGH THE JAPAN INTERNATIONAL COOPERATION AGENCY

Foreword

In 2008, the Government through the Ministry of Energy and Water Development adopted a new National Energy Policy (NEP) which took into account the changes in the energy sector at national, regional and international levels. The objective of the new policy is to create conditions that will ensure the availability of adequate supply of energy from various sources, which are dependable, at the lowest economic, financial, social and environmental cost consistent with national development goals.
As part of the implementation of the new National Energy Policy, the Government decided to develop the Power System Development Master Plan (PSDMP) whose objective is to provide a blueprint for Power System Development in the country up to the year 2030. The plan highlights least cost expansion options for Generation, Transmission and Distribution in the country.

The PSDMP has prioritized power generation projects which when developed would add a total of 4,337 megawatts to the National Electricity Grid. The estimated cost of implementing the plan is US$9.5 billion for generation projects, US$2.3Billion for transmission projects and US$179.7 Million for distribution projects. The total estimated cost is therefore US$12.1 Billion by the year 2030.

The Ministry would like to pay tribute to the Government of Japan for providing the financing that made it possible to develop this plan. The Ministry also extends a special word of thanks to Chubu Electric Power Company of Japan, the consultants who prepared the master plan, other Government Ministries, ZESCO Limited, the Private Sector and other stakeholders who provided information that made it possible to prepare this plan. At a personal level I would also like to thank officials from my Ministry who worked tirelessly to ensure that this plan is prepared as envisaged by the Government.

MINISTER FOR ENERGY AND WATER DEVELOPMENT

LUSAKA
June 2011

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Acronyms

ABWR	Advanced Boiling Water Reactor
AfDB	African Development Board
AfDF	African Development Fund
AGR	Advanced Gas Cooled Reactor
AIDS	Acquired Immune Deficiency Syndrome
AU	Africa Union
B/D	Basic Design (Study)
BIS	Business Information System
BOO	Build-Own-Operate
BOOT	Build-Own-Operate-Transfer
BOT	Build-Operate-Transfer
BPC	Botswana Power Corporation
BWR	Boiling Water Reactor
BSAC	British South African Company
BTU	British Thermal Unit
CAPCO	Central African Power Corporation
CEC	Copperbelt Energy Corporation
CEPCO	Chubu Electric Power Company, Inc.
CF	Capacity Factor
CFRD	Concrete Facing Rockfill Dam
CHP	Combined Heat and Power (Plant)
CIA	Central Intelligence Agency
C/P	Cooperation Partner(s)
C/P	Counterpart
CPC	Copperbelt Power Corporation
CPI	Consumer Price Index
CSO	Central Statistical Office
DBSA	Development Bank of South Africa
DD, D/D	Detailed Design (Study)
DfID	Department for International Development, UK
DOE	Department of Energy
DOPI	Department of Planning and Information
DRC	Democratic Republic of the Congo
DSM	Demand Side Management
EAPP	Eastern African Power Pool
ECZ	Environmental Council of Zambia
EIA	Environmental Impact Assessment

EIB	European Investment Bank
EIS	Environmental Impact Statement
EDM	Electricidade de Mocambique
ENE	Empresa Nacional de Electricidade
EPPCA	Environment Protection and Pollution Control Act
ERB	Energy Regulation Board
ESCOM	Electricity Supply Corporation of Malawi
ESKOM	ESKOM Enterprises
FPB	Federal Power Board
FNDP	Fifth National Development Plan
FPI	Framework and Package of Incentives (for Hydropower Generation and Transmission Development)
FS, F/S	Feasibility Study
FY	Fiscal Year
GCR	Gas Cooled Reactor
GDP	Gross Domestic Product
GIS	Geographic Information System
GNI	Gross National Income
GNP	Gross National Product
GRZ	Government of the Republic of Zambia
GSD	Geological Survey Department
GSJ	Geological Survey of Japan
GWh	Gigawatt hour
HFO	Heavy Fuel Oil
HIPC	Heavily Indebted Poor Country
HIV	Human Immunodeficiency Virus
HP	Heritage Party
HTGR	High Temperature Gas Cooled Reactor
HWR	Heavy Water Reactor
IAEA	International Atomic Energy Agency
ICB	International Competitive Bid
ICOMOS	International Council on Monuments and Sites
IDA	International Development Association
IAEA	International Atomic Energy Agency
IEA	International Energy Agency
IEE	Initial Environmental Examination
IFC	International Finance Corporation
IFS	International Financial Statistics

IMF	International Monetary Fund
IPP	Independent Power Producer
ITT	Itezhi-Tezhi
ITTPS	Itezhi-Tezhi Power Station
J	Joule
JBIC	Japan Bank for International Cooperation
JICA	Japan International Cooperation Agency
JV	Joint Venture
LCU	Local Currency Unit
LHPC	Lunsemfwa Hydropower Company
LWGR	Light Water cooled Graphite moderated Reactor
K	(Zambian) Kwacha
KCM	Konkola Copper Mines plc.
KGL	Kafue Gorge Lower (project)
KGPS	Kafue Gorge Power Station
KNBE	Kariba North Bank Extension (project)
KNBPS	Kariba North Bank Power Station
KPI	Key Performance Indicator
kWh	Kilowatt-hour
LEC	Lesotho Electricity Corporation
LFO	Light Fuel Oil
m.a.s.l	meter above sea level
MBO	Management Buy Out
MCL	Maamba Collieries Limited
MDG	Millennium Development Goals
MEWD	Ministry of Energy and Water Development
MFNP	Ministry of Finance and National Planning
MIGA	Multilateral Investment Guarantee Agency
MLGH	Ministry of Local Government and Housing
M/M	Minutes of Meeting
MMD	Movement for Multiparty Democracy
MMMD	Ministry of Mines and Minerals Development
MOTRACO	Mozambique Transmission Company
MP	Member of Parliament
MTENR	Ministry of Tourism, Environment and Natural Resources
MW	Megawatt
NEP	National Energy Policy
NES	National Energy Strategy

NCC	National Control Centre
NGO	Non Governmental Organization
NISIR	National Institute for Scientific and Industrial Research
ODA	Official Development Assistance
OPPPI	Office for Promoting Private Power Investment
p.a.	per annum
PAPs	Project Affected Persons
PB	Project Brief
PF	Patriotic Front
PLC	Public Limited Company
PPA	Power Purchase Agreement
PPP	Public-Private Partnership
PPP	Purchasing Power Parity
PRSP	Poverty Reduction Strategy Paper
PS, P/S	Power Station
PSRP	Public Service Reform Programme
PSS/E	Power System Simulator for Engineering
PV	Photovoltaic
PWR	Pressurized Water Reactor
RCC	Regional Control Centre
RCC	Roller Compacted Concrete (Dam)
RE	Renewable Energy
REA	Rural Electrification Authority
REF	Rural Electrification Fund
REMP	Rural Electrification Master Plan
SADC	Southern African Development Community
SAPP	Southern African Power Pool
SCADA	Supervisory Control and Data Acquisition System
SEA	Strategic Environmental Assessment
SEB	Swaziland Electricity Board
SIDA	Swedish International Development Cooperation Agency
SNEL	Societe Nationale dôElectricite
SPC	Special Purpose Company
SS, S/S	Substation
TANESCO	Tanzania Electricity Supply Company Ltd
TOE	Tonnes of Oil Equivalent
TWh	Terawatt-hour
UDA	United Democratic Alliance

UDI	Unilateral Declaration of Independence
ULP	United Liberal Party
UNDP	United Nations Development Program
UNIP	United National Independence Party
UNZA	University of Zambia
UPND	United Party for National Development
VAT	Value Added Tax
VFPS	Victoria Falls Power Station
WASP	Wien Automatic System Planning
WB	The World Bank
WEC	World Energy Council
WESTCOR	Western Power Corridor Company
Zam-En	Zambian Energy Corporation (Netherland) BV
ZCCM	Zambia Consolidated Copper Mines Limited
ZCCM-IH	ZCCM Investments Holdings plc
ZAWA	Zambia Wildlife Authority
ZDA	Zambia Development Agency
ZESA	Zimbabwe Electricity Supply Authority
ZESCO	ZESCO Limited
ZIC	Zambia Investment Centre
ZIMCO	Zambia Industrial and Mining Corporation Limited
ZMK	Zambia Kwacha
ZPA	Zambia Privatisation Agency
ZRA	Zambezi River Authority

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Introduction

Introduction

Due to the favorable tone of its economic development, the demand for electricity in the Republic of Zambia has been increasing at annual rates on the order of 3 - 4 percent in recent years. Toward the end of mitigating poverty, the Zambian government has posted the national targets of increasing the rural electrification rate, which is currently on the level of 2 percent, to 50 percent, and the urban electrification rate from a corresponding 48 to 90 percent, by 2030. It consequently faces the urgent task of further developing power sources to meet the growing demand for power and conditioning the transmission and distribution networks to raise the electrification rate nationwide.

Hydropower accounts for about 94 percent of Zambia's existing power source mix, and only about 30 percent of the estimated hydropower potential has been developed. For this reason, it would be advisable to formulate optimal generation plans that are centered around hydropower as the key national energy.

Zambia is located in the southern part of Africa, and is a major member of the Southern African Power Pool (SAPP), which is advocating the formation of a power pool that would enable power supply through intraregional interchange. It has already begun power interchange with neighboring countries, but a plan has not yet been determined for interchange with neighbors based on long-term demand forecasting and centered around Zambia. There is a need for the preparation of a more effective international power interchange plan grounded in the needs in neighboring countries.

To help stabilize the supply of power over the medium and long terms against this background, the government of Zambia requested the Japanese government to carry out a development study for preparation of a comprehensive master plan for power development.

In response to this request, the Japan International Cooperation Agency (JICA) executed a project formation study (i.e., "Project Formation Study for Power Development Planning in Zambia") in February and March 2008 in order to ascertain the detailed items involved in the request and confirm the appropriateness of master plan preparation. Through consultations with the concerned parties in Zambia and a field survey of the major hydropower facilities, the JICA confirmed the need for preparation of a master plan and concluded a Minutes of Meeting on the scope of the study proper with the Zambian side. Finally, it reached an agreement with the Zambian side with respect to the undertaking of ñthe Study for Power System Development Master Plan in Zambiaò on the substance of a Scope of Work (attached in Annexure) in September 2008.

Objective

(a) The main objective of the Study is to formulate a blue print for the Power System Development Master Plan up to 2030 which shall be practical and comprehensive. The master plan will coordinate generation, transmission, and distribution expansion to ensure with confidence that all proposed capital investments are not ad hoc and are instead part of a long-term structured plan. It will ensure that network expansion is economically efficient and will provide a realistic framework for loss reduction. The study shall use the least cost analysis to compare various options available for the development of generation, transmission and distribution systems.

(b) The second objective of the Study is to conduct technical transfer through seminar and technical workshop for MEWD staff in modern power system planning techniques and tools.

Area Covered

The Study will cover the entire area of Zambia and its neighboring countries and take into account the demand and expansion programs in Southern African Power Pool (SAPP) and Eastern African Power Pool (EAPP).

Expected Key Outputs of Study

The expected key outputs of the Study shall include but not limited to the following:

(i) A detailed long-term demand forecast for Zambia at the power substation level with demand disaggregated between main consumer/customer groups;

(ii) A series of realistic least-cost long-term generation capacity expansion scenarios

(iii) A series of least-cost transmission expansion plans, matched to the generation expansion scenarios developed;

(iv) An assessment of the amount and timing of generation and transmission investments for each system development scenario;

(v) An estimate of distribution investment costs to meet demand growth;

(vi) A program of distribution loss reduction initiatives;

(vii) Institutional reform recommendations for MEWD / Electricity Industry to develop capacity to implement and revise the power system master plan as and when necessary;

The above outputs shall be achieved by using the least-cost analysis to compare various options for generation, transmission, and distribution through the following key activities to include;

(i) Assessing existing electricity demand and prepare a demand forecast, using both bottom-up (location-specific) data and top-down (macroeconomic) parameters;

(ii) Developing demand-side management options;

(iii) Assessing potential energy sources for generation development, and compare the likely development costs ;

(iv) Developing a series of least cost staged generation expansion plans

(v) Undertaking computer modeling of the country's current existing power system down to the power substation level, and analyze constraints;

(vi) Developing and conducting computer modeling of network expansion options to match the various generation expansion plans, and forecast demand growth;

(vii) Calculate annual investment requirements and investment net present values under each of the expansion plans and for a reasonable set of input cost assumptions;

(viii) Identify, analyze, and prepare cost estimates for options and opportunities for loss reduction, including projects forming part of the overall master plan and stand-alone projects;

(ix) Prepare a detailed transmission and distribution capital works program for the first 5 years of the master plan, including loss reduction subprojects;

Counterpart Team and Study Team

The counterpart organization of the Study shall be the Ministry of Energy and Water Development (MEWD) on behalf of the Government of Zambia.

The counterpart team and the study team are shown in Table 0.1.

Table 0.1 Counterpart Team and Study Team

No.	Assignment	Name	C/P	Title
1	Team Leader/ Power system development and Policy	Keiji SHIRAKI	Mr. Oscar S. Kalumiana	Director
2	Demand Forecast	Masayasu ISHIGURO	Mr. Alex Matale	Advisor
3	Sub Leader / Generation Development Planning / GIS Database	Hirokazu NAKANISHI	Mr. Arnold M. Simwaba Mr. Aggrey Siuluta	Sr. Electrification Officer Energy Informatics Officer
4	Hydro Power Planning 1 Hydro Power Planning 2	Yasuhiro KAWAKAMI Takashi AOKI	Mr. Patrick Mubanga	Sr. Power Sys. Dev. Officer
5	Interconnection Planning / Transmission Planning 1	Kazunori OHARA	Mr. William Sinkala	Electrification Officer
6	Interconnection Planning / Transmission Planning 2	Atsushi SUZUKI	Mr. Arnold M. Simwaba	Sr. Electrification Officer
7	Power System Planning	Yoshihide TAKEYAMA	Mr. Nkunsuwila Silomba	Electrification Officer
8	Environmental and Social Considerations	Kenzo IKEDA	Mrs. Langiwe Chandi	Sr. Energy Officer (Renewable Energy)
9	Economic and Financial Analysis / Private Investment Promotion Analysis	Takeshi KIKUKAWA	Mr. Lufunda Muzeya	Energy Economist
10	Distribution Planning	Tatsumi FUKUNAGA	Mr. Alex Matale	Advisor
11	Coordinator	Hiroyuki KONDO	Mr. Patrick Mubanga	Sr. Power Sys. Dev. Officer

Flow of Overall Study

The study will consist of five stages, as follows.

Stage 1 (Kick-off and basic study stage)

Key points

- Explanation and discussion of the inception report at the 1st seminar meeting
- Explanation and discussion of the inception report at the donor meeting
- Collection of basic information

Stage 2 (Power system development formulation I and neighboring country survey stage)

Key points

- Demand forecasting
- Preparation of the optimal generation plan
- Interviews with neighboring countries about power supply and demand, preparing the interconnecting plan (draft)

Stage 3 (Power system development formulation II and technology transfer stage)

Key points

- Explanation of the interim report at the 2nd seminar meeting
- Preparation of the transmission/ distribution plan (draft)
- Technology transfer by the workshop
- Case study
- Re-commissioning

Stage 4 (Power system development plan formulation III stage)

Key points

- Explanation and discussion of the power system development
- Counterpart training in Japan

Stage 5 (Master plan authorization stage)

Key points

- Explanation and discussion of the draft final report at the 3rd seminar meeting
- Explanation and discussion of the draft final report at the donor meeting

The study flow is shown, as follows.

Table 0.2 Study flow

Year	2008						2009									
Month	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1

Stage – Field survey: 1st Field Survey (December); 2nd Field Survey (February); 3rd Field Survey (first half) (May); 3rd Field Survey (second half) (July); 4th Field Survey (October–November)

Stage – Task in Japan: Preliminary Work in Japan (November); 1st Task in Japan (December–January); 2nd Task in Japan (March); 3rd Task in Japan (April–June); 4th Task in Japan (August–October); 5th Task in Japan (December)

First Stage

Task in Japan

(1) Preliminary Work in Japan
1)Preparation and submission of inception report
2)Preparation of 1st field survey
3)Preparation of 1st seminar

Field Survey

(2)1st Field Survey
1)Support and holding the 1st seminar
2)Holding the donor meeting
3)Collection and analysis of basic information
- National development plans
- Information for demand forecast
- Power development plan
- State of water resource development
- Transmission system plan
- Tariff system
- Law and institution related to socioenvironmental considerations
- State of hydropower and water resources development in neighboring countries
- Power generation potential for types other than hydropower
- Power import and export charge
- SAPP organization and operating status

Second Stage

Task in Japan

(3)1st task in Japan
1)Analysis of collected materials
2)Preparation for the study of in neighboring countries
3)Environmental and social considerations

(5)2nd task in Japan
1)Preparation of a draft short list for potential hydropower development site
2)Compilation and analysis of the result of the survey in neighboring countries
3)Simulation of power development plan
4)Analysis of the current status of the domestic system
5) Analysis of environmental and social considerations

Field Survey

(4)2nd field survey
1)Estimate of the power demand
2)Implementation of the study in neighboring countries
3)Confirmation and examination of the hydropower development potential
- Additional collection of data and cross-checking with socioenvironmental data
- Simple on-site study
-Reconsultation with concerned institution
-Preparation of a draft matrix of hydropower projects
4)Environmental and social considerations
5)Measures to promote private-sector investment
6)Measures for more efficient management of power business

Third Stage

Task in Japan

(6)3rd task in Japan
1)Preparation of interim report
2)Preparation of draft guidelines for the case study
3)Preparation of recommissioning
4)Preparation for the case study
5)Preparation for construction of the GIS database
6)Environmental and social considerations
7)Preparation for the technology transfer workshop
8)Formulation of the draft international power interchange plan

Field Survey

(7)3rd field survey (first half)
1)Second seminar
2)Technology transfer workshop
3)Start of preparation of the domestic transmission system plan
4)Implementation of the case study
5)Environmental and social considerations
6)Recommissioning of environmental and social survey
7)Construction of the GIS database

Fourth Stage

Task in Japan

(8)Task in Japan
1)Formulation of draft transmission plan
2)Revision of the draft generation plan
3)Formulation of the draft power system development plan

Field Survey

(9)3rd field survey (Second half)
1)Economic and financial analysis
2)Presentation and discussion of the draft power development plan
3)Inspection of the recommissioned survey

Fifth Stage

Task in Japan

(10)4th task in Japan
1)Revision of the draft power development plan
2)Preparation of the draft final report

(12)Fifth task in Japan
1)Preparation of the final report

Field Survey

(11)4th field survey
1)Third seminar
2)Donor meeting

Stage – Field survey: 1st Field Survey (December); 2nd Field Survey (February); 3rd Field Survey (first half) (May); 3rd Field Survey (second half) (July); 4th Field Survey (October–November)

Stage – Task in Japan: Preliminary Works in Japan (November); 1st Task in Japan (December–January); 2nd Task in Japan (March); 3rd Task in Japan (April–June); 4th Task in Japan (August–October); 5th Task in Japan (December)

Month	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1
Workshop, Seminar			1st Seminar			Annual Report		2nd Seminar, Workshop					3rd Seminar			
Report			*Inception Report*								*Interim Report*		*Draft Final Report*			*Final Report*

General Information of Zambia

In this chapter, general information of Zambia such as history, geography, society, politics, economy etc. was described in Japanese edition, which was informative for strangers to Zambia and should be included in the final report of JICA study. However, most of the information here was unnecessary for Zambian people and has less importance to formulate the power system master plan. For this reason, the contents of this chapter were transferred to Appendix A by request from Zambian side.

Sections in this chapter show below for someoneֳs reference.

- History
- Geography
  - Land Area
  - Climate
- Society
  - Population
  - Ethnicity, Languages and Religions
- Economy
- Surrounding countries

Energy Policies and Primary Energy Resources

In this chapter, energy policies and primary energy resources were described in Japanese edition, which should be included in the final report of JICA study. However, most of the information here was unnecessary for Zambian people and has less importance to formulate the power system master plan. For this reason, the contents of this chapter were transferred to Appendix B by request from Zambian side.

Sections in this chapter show below for someoneœs reference.

Current status of power sector[1]

Power demand and supply

Existing generation facilities

The installed capacity of power generation facilities in Zambia totals about 1,860 MW. ZESCO owns the lion's share of this total at 1,744 MW, followed by the CEC at 90 MW and other private producers at 38 MW. The list of on-grid sources, i.e., sources connected to the "national grid", is confined to the three major ZESCO hydropower stations (Kariba North, Kafue Gorge, and Victoria Falls) and the Mulungushi and Lunsemfwa power stations owned and operated by the Lunsemfwa Hydropower Company (LHPC). All other power stations transmit and distribute power to specified areas through micro- or mini-grids**.**

Table 0.1 Principal Generation Facilities in Zambia

(Unit: kW)

Station	Installed Capacity	Available Capacity	Remarks
ZESCO			
Main Hydros	1,713,000	1,233,000	
Kariba North	660,000	510,000	
Kafue Gorge	945,000	615,000	
Victoria Falls	108,000	108,000	
Mini Hydros	23,750	19,750	
Lusiwasi	12,000	9,000	
Musonda Falls	5,000	5,000	
Chishimba Falls	6,000	5,000	
Lunzua River	750	750	
Diesel	7,285	6,545	
Mwinilunga	1,360	1,360	
Kabompo	1,160	1,160	
Zambezi	960	960	
Mufumbwe	400	400	
Luangwa	1,280	732	
Lukulu	512	320	
Chama	263	263	
Kaputa	550	550	
Chavuma	800	800	
Total ZESCO	1,744,035	1,259,295	
CEC	80,000	80,000	
Bancroft	20,000	20,000	Gas Turbine
Luano	40,000	40,000	Gas Turbine
Luanshya	10,000	10,000	Gas Turbine
Mufulira	10,000	10,000	Gas Turbine
Lunsemfwa	38,000	38,000	
Lunsemfwa	18,000	18,000	Hydro
Mulungushi	20,000	20,000	Hydro
Total	1,862,035	1,377,295	

(Source) Statistics Yearbook of Electric Energy 2007/08, ZESCO

[1] The history and organization of power industry in Zambia included in Japanese edition are transferred to Appendix C by request from Zambian side.

ZESCO

i) Hydropower facilities

The major hydropower stations managed by ZESCO are Kariba North Bank (KNBPS), Kafue Gorge (KGPS), and Victoria Falls (VFPS). Taken together, these three sources account for about 98 percent of Zambia's entire installed generation capacity. Table 0.2 shows the hydropower facilities managed by ZESCO.

Table 0.2 Hydropower facilities managed by ZESCO (as of March 2008)

Power Station	Installed Capacity (MW)	Location
Kariba North Bank	660 (720)*	Zambezi River
Kafue Gorge	945 (990)*	Kafue River
Victoria Falls	108	Zambezi River
Sub Total	1,723	
Mini Hydropower Station		
Lusiwasi	12	Northern Province
Musonda Fall	5	Northern Province/ Luapula Province
Chishimba Fall	6	Northern Province
Lunzua River	0.75	Northern Province
Sub Total	23.75	
Total	1,746.75	

* Values after rehabilitation.

(Source) ZESCO, Statistics Year Book of Electric Energy 2007/2008

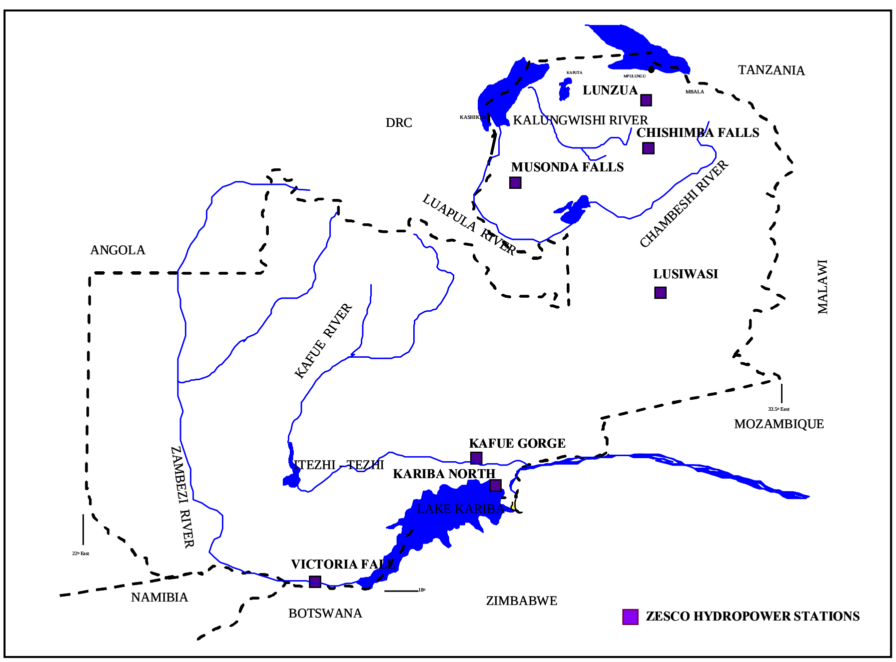


Figure 0.1 Location of the hydropower facilities managed by ZESCO

The generated output of the three major stations (KNBPS, KGPS, and VFPS) declined owing to the drought that lasted from 1995 to 1996, fire at the KGPS in 1989, and work for rehabilitation projects at these stations. Over fiscal years 1977 - 2007, it averaged about 8,400 GWh annually. Over fiscal years 1998 - 2001, before the start of rehabilitation projects, the output stayed on virtually the same level each year.

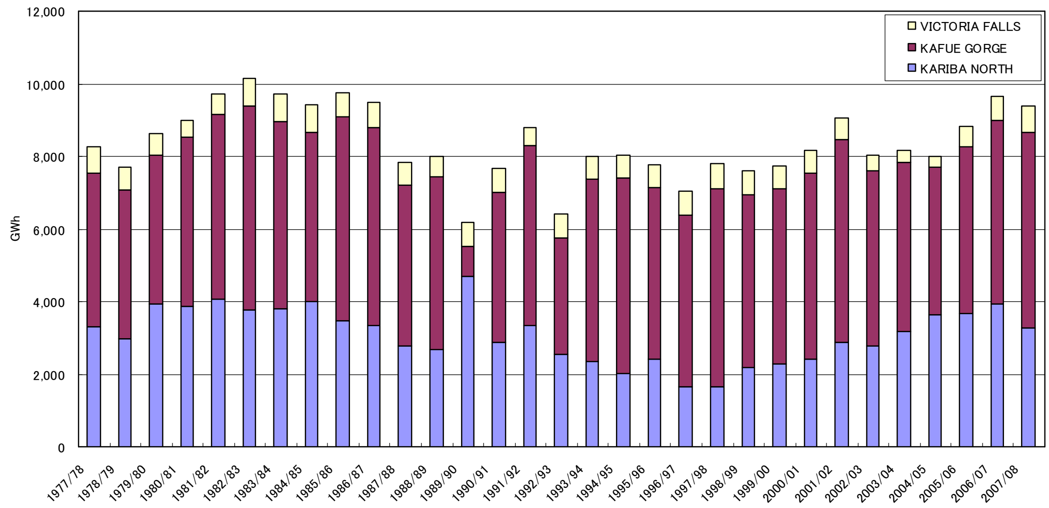


Figure 0.2 Yearly trend of generated output at the KNBPS, KGPS, and VFPS

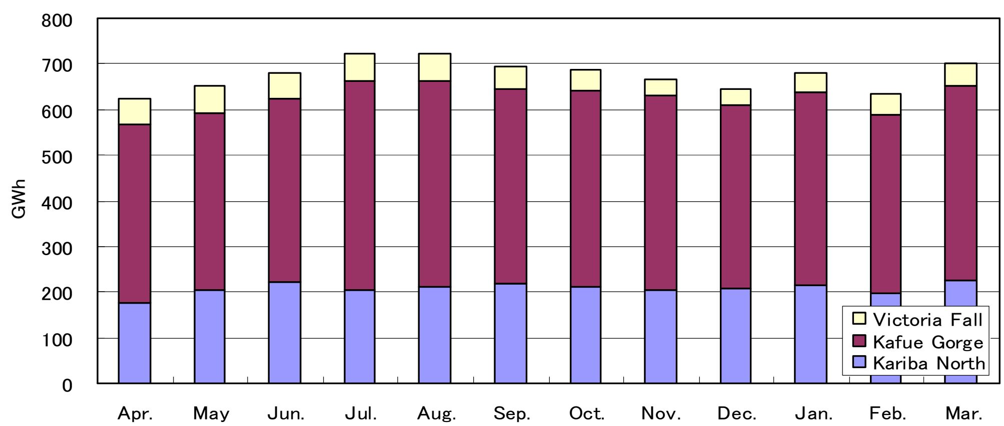


Figure 0.3 Monthly trend of generated output at the KNBPS, KGPS, and VFPS

(a) Kariba North Bank Power Station (KNBPS)

The KNBPS dam was constructed in the 1950s, in Kariba Gorge on the Zambezi River. It has a height of 128 meters and crest length of 617 meters, and forms a reservoir with a storage capacity of 185 billion cubic meters, making it one of the world's largest artificial lakes. The reservoir has an extended length of 280 kilometers and width of 32 kilometers at its widest point. The KNBPS was placed into operation in 1976. At that time, it was equipped with four units, each with an output of 150 MW, for a total capacity of 600 MW.

The Zambezi River flows over the national border with Zimbabwe, and an institution was therefore established to coordinate the interests of concerned countries in its development.

With the enactment of the Zambezi River Authority Act in 1987, the Zambezi River Authority (ZRA) began to exercise jurisdiction over development of the river. It is engaged in dam management and maintenance, compilation of hydrological data, and survey of water quality and various other items. The ZRA also controls the amount of water use for power generation. Each year, it makes water allocations for such use and determines the allocations for the following year based on the results of analysis of hydrological data etc. Although ZESCO operates the power stations, the output is under the ceiling of water allocation by the ZRA.

The yearly trend shows that the generated output of the KNBPS was low in the 1990s. The operation has run-of-river control, and output basically depends on the dam water level. A look at the yearly trend of this level reveals that it was low in the 1990s. There were similarly many years in that decade when the flow of water from the Zambezi into Lake Kariba was low. Due to the large size of the reservoir, the station is not seriously affected by droughts in a single year, but continuation for several years has the effect of decreasing generated output unless the dam water level recovers.

As for the yearly operation pattern, the trend for the years 1998 - 2003, which were selected to exclude the influence of rehabilitation projects, indicates output on approximately the same level from year to year. The reservoir formed by the Kariba dam is operated in a manner to attain full supply level in July for use of the stored amount during the dry season. The water level declines until January, when storage starts again and continues until July. The operation may also be affected by factors such as facility deterioration since the start of operation in 1976. For this reason, a rehabilitation project was implemented from 2004 to 2009 in order to extend facility service life and increase capacity. This project expanded the capacity of each unit from 150 to 180 MW, and the combined capacity from 600 to 720 MW, for a total increase of 120 MW.

Figure 0.4 Kariba Dam (photo)

Table 0.3 Outline of the KNBPS

Name of the HP	Kariba North Bank
General information	
Installed capacity (MW)	720 (180 × 4 units)
Rated Discharge (m^3/s)	186.79
Rated head (m)	92
Plant factor (%) (in 2007/08)	73.5 (available capacity 510 MW)
Annual generation (GWh) (in 2007/08)	3,282
Technical information	
Dam type	Double Curvature Concrete Arch
Dam height and crest length (m)	Height 128 m, crest length 617 m
Dam Construction (year)	1958
Catchment area (km^2)	663,000
Area of the reservoir (km^2)	5,180
Total storage capacity (m^3)	185,000 million
Effective storage capacity (m^3)	64,740 million
Maximum supply level (m.a.s.l)	487.8
Minimum operating level (m.a.s.l)	474.8
Spillway Gate, discharge capacity	6 sluice gates, 9.14 x 8.84 6 × 1,574 m^3/s
Power house	L 130m,W 24m, H 45m
Type of turbine	Vertical Francis
Commercial operation date	#1: 5th May 1977 #2: 13th December 1976 #3: 24th August 1976 #4: 24th May 1976

(Source) ZESCO

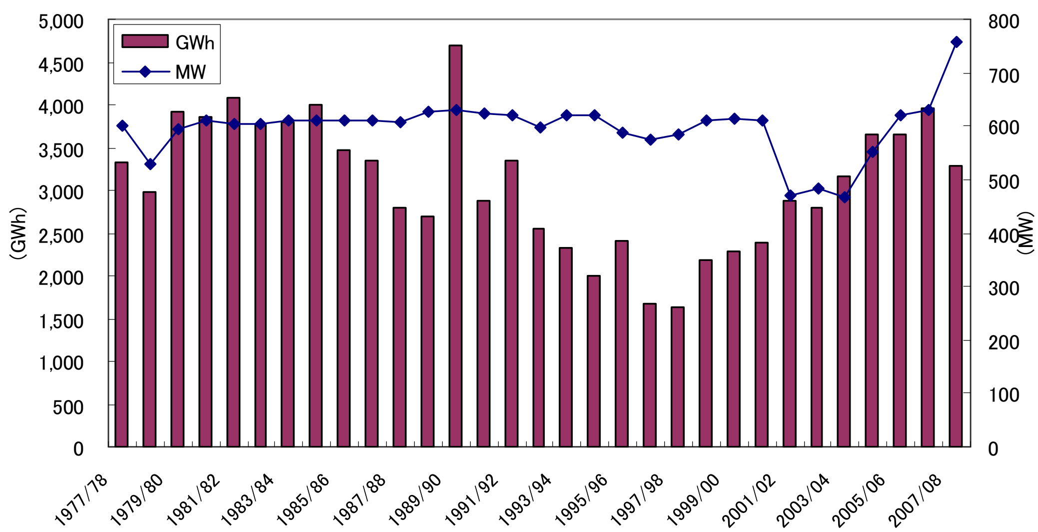


Figure 0.5 Yearly power generation at the KNBPS (actual, FY1977 - 2007)

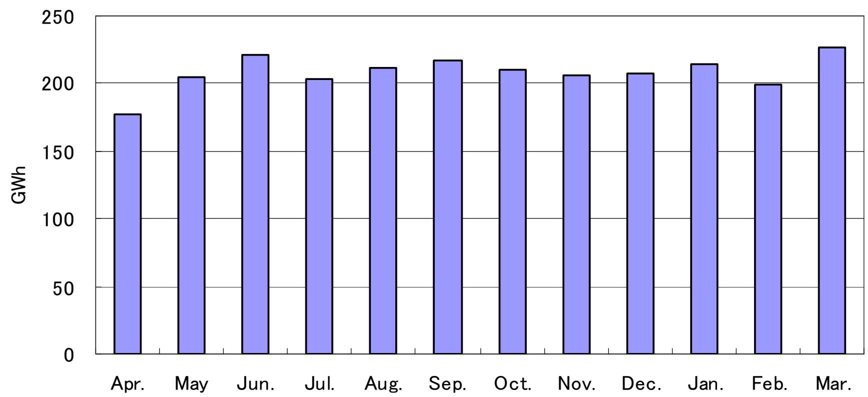


Figure 0.6 Monthly power generation at the KNBPS (1998 – 2002 average)

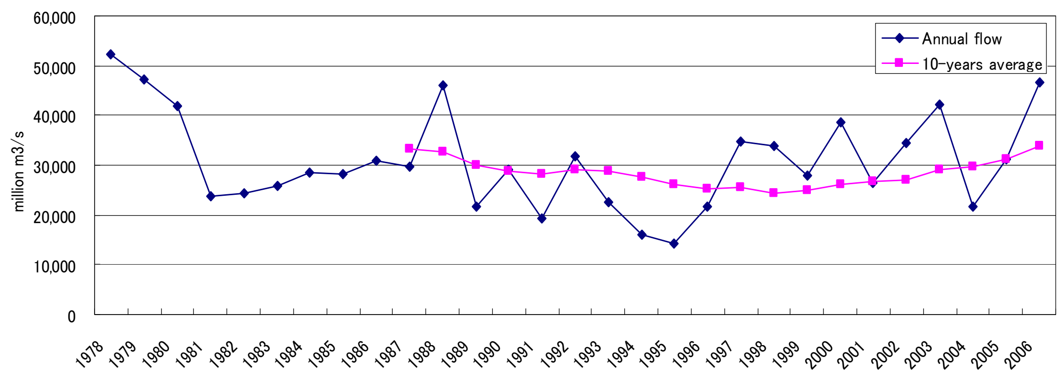


Figure 0.7 Annual flow of the Zambezi upstream
(Victoria Falls water measurement station)

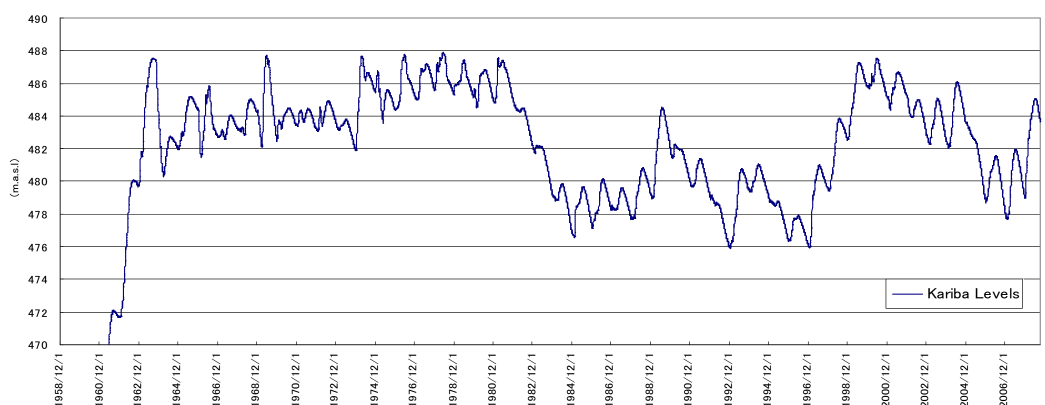


Figure 0.8 Yearly trend of dam water level in Kariba Dam

(b) Kafue Gorge Power Station (KGPS)

The KGPS lies on the Kafue River, which is a tributary of the Zambezi and the biggest river in Zambia after it. The Kafue is characterized by flat terrain upstream from the KGPS; the average grade is 0.0025 percent. The difference of elevation to the reservoir of the Itezhi Tezhi upstream is in the range of only 5 - 6 meters. For this reason, it takes about 90 days for discharge from the ITT reservoir to reach the Kafue Gorge reservoir. The ITT reservoir was constructed in 1978 and has a storage capacity of about 6 billion cubic meters. It levels the Kafue flow disparity between the rainy and dry seasons, and plays the role of supplying the KGPS. The flow-adjusting function of the ITT reservoir contributes to the supply of water for irrigation and drinking in the surrounding area as well as the KGPS operation.

Operation was commenced by KGPS Unit No.1 in 1971 and by three other units in 1972. As this was before development of the ITT reservoir, the station initially had four units with a capacity of 150 MW each, for a combined 600 MW. In 1978, upon the completion of the ITT reservoir, the remaining two units were placed into operation, and made the KGPS the biggest power station in Zambia. At this time, it was installed with six 150-MW units, for a combined capacity of 900 MW, and had an effective head of 387 meters, headrace tunnel length of 10 kilometers, and underground power house.

The trend of generated output reveals a substantial drop in 1989/90. This drop was caused by the outbreak of fire within the station. From actual data for the KNBPS in these years, it can be seen that the generated output is higher than in normal years and that the KNBPS compensated for the reduction at the KGPS. The figures for monthly average generated output also indicate coordination between the KNBPS and the KGPS to assure a certain combined output.

As the station has been operating since 1972, there have also been apprehensions about facility superannuation. In response, a rehabilitation project was implemented from 2004 to 2009 in order to lengthen facility service life and increase capacity. The project expanded the capacity of each unit from 150 MW to 165 MW and the total from 900 to 990 MW, up 90 MW.

Another notable facility feature is the shape of the water intake screen. The KGPS reservoir is sometimes covered with aquatic plants, depending on the season. The station is therefore installed with a flat screen in front of the intake as shown in Figure 0.9 to prevent the plants from coming near the intake aperture.

Figure 0.9 KGPS water intake screen (photo)

Figure 0.10 Kafue Gorge Dam (photo)

Table 0.4 Outline of the KGPS

Name of HP	Kafue Gorge
General information	
Installed capacity (MW)	990 (165 x 6 units)
Rated Discharge (m^3/s)	46
Net head (m)	387
Plant factor (%) (in 2006/7)	76.6 (available capacity 750 MW)
Annual generation (GWh) (in 2006/7)	5,034
Technical information	
Dam type	Earth and Rock Fill
Dam height and crest length (m)	Height 50 m, crest length 375m
Dam Construction (year)	1968
Effective storage capacity (m^3)	800 million
Maximum supply level (m.a.s.l)	977.2
Minimum operating level (m.a.s.l)	975.4
Spillway Gate, discharge capacity	4 radial gates, 14 x 12 4,250 m^3/s
Headrace tunnel length (km)	10
Penstock	6 vertical penstocks Concrete lined in the upper 200m part, dia 3.3m Steal lining in the lower 170m part, dia 2.75m
Power house	Underground
Type of turbine	Vertical Francis
Tailrace tunnel (km)	1.4
Commercial operation date	#1: 1971 #2,3,4: 1972 #5,6: 1978

(Source) ZESCO

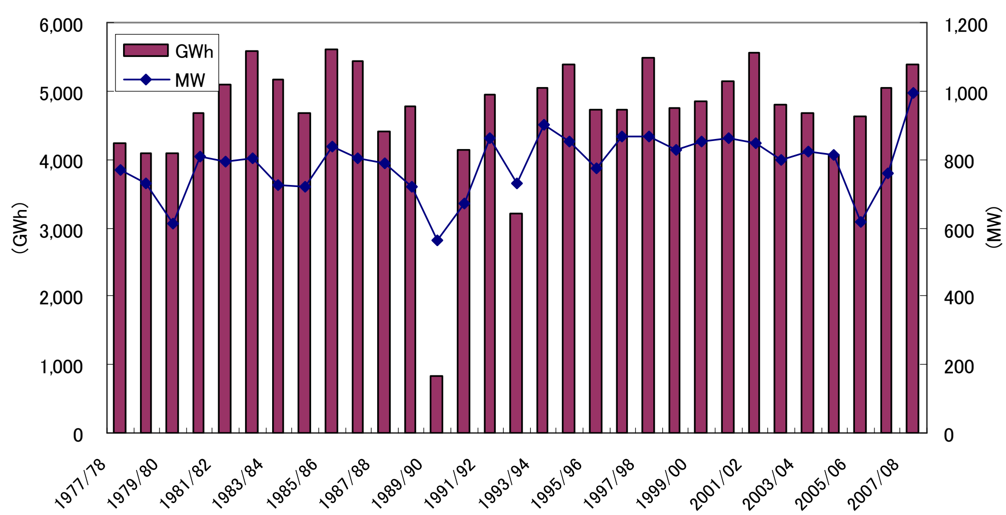


Figure 0.11 Yearly power generation at the KGPS (actual, FY1977 - 2007)

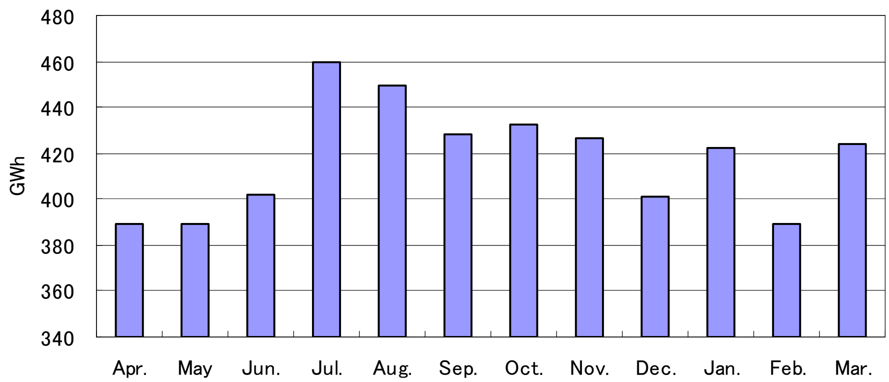


Figure 0.12 Monthly power generation at the KGPS (1998 – 2002 average)

(c) Victoria Falls Power Station (VFPS)

The VFPS lies on the main channel of the Zambezi on the border with Zimbabwe, in Livingstone, the former national capital. It is a run-of-river type of hydropower plant with a total capacity of 108 MW. It does not have a weir, and its intake is directly above Victoria Falls, a World Heritage site.

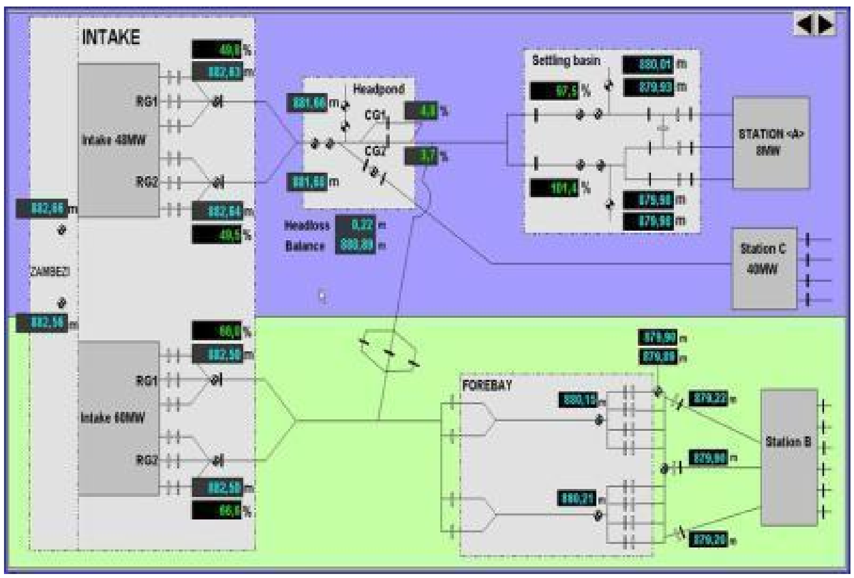
Development of Victoria Falls began in 1938, and the station had two units with a capacity of 1 MW each, for a total of 2 MW, when it went into operation. In 1956, the addition of two units with a capacity of 3 MW each raised the total to 8 MW. At this stage, the facility was known as Station A. There followed the development of Station B, which was installed with six 10-MW units for a total capacity of 60 MW, in 1968, and of Station C, which was installed with four 10-MW units for a total capacity of 40 MW, in 1972. Taken together, the three stations (A, B, and C) had a capacity of 108 MW.

Actual figures for the operation indicate that the generated output depends on the river flow because the station is of the run-of-river type. In fiscal 2007, the facility working rate was 77.5 percent as calculated on the basis of actual ZESCO statistics. Victoria Falls is a World Heritage site, and operation of the VFPS is under restrictions when the Zambezi flow rate is less than 400 cubic meters per second. Analysis of the duration curves obtained from flow data over the 30-year period 1978 - 2007 compiled by the Big Tree (Victoria Falls) observation station reveals that rates falling into this category 70 percent flow, that is 255 day flow (see Figure 0.17). In the months September - December, which correspond with the dry season, the flow rate falls below 400 cubic meters per second. The maximum rate of intake for generation is 117.2 cubic meters per second, and corresponding analysis of the duration curves yields a figure close to the minimum flow. While this would appear to show that the power station could constantly obtain the maximum intake throughout the year, there is no weir, and water can consequently only be taken from the flow along the left bank, where the intake is located.

As the operation dates from 1938, there have been apprehensions about superannuation. In response, a rehabilitation project aimed at renovating facilities and lengthening the service life was implemented from 2003 to 2005.

Table 0.5 Outline of the VFPS

	Station A	Station B	Station C
Year of Commission	1938: 2 MW (1×2 MW) 1956: 6 MW (2×3 MW)	1968	1972
Installed Capacity (MW)	8 MW	60 MW (6 × 10 MW)	40 MW (4 × 10 MW)
Intake	No intake weir Left bank just upstream of the Victoria Falls		
Maximum Water discharge (m^3/s)	10.5	106.7	
Gross head (m)	105.77	112.77	
Power Station	Surface	Underground	Surface



(Source) ZESCO

Figure 0.13 Overall VFPS system

(Source) ZESCO

Figure 0.14 VFPS area (photo)

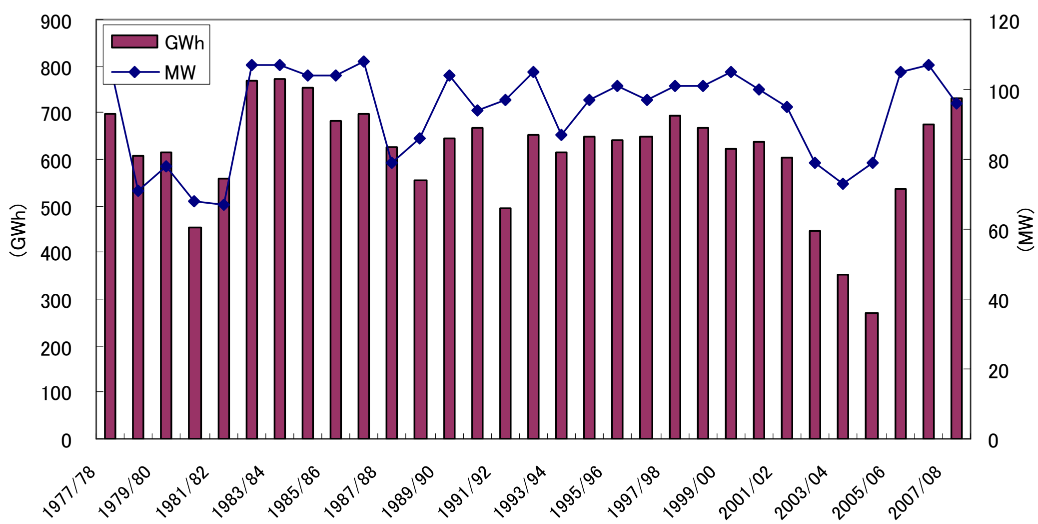


Figure 0.15 Yearly power generation at the VFPS (actual, FY1977 - 2007)

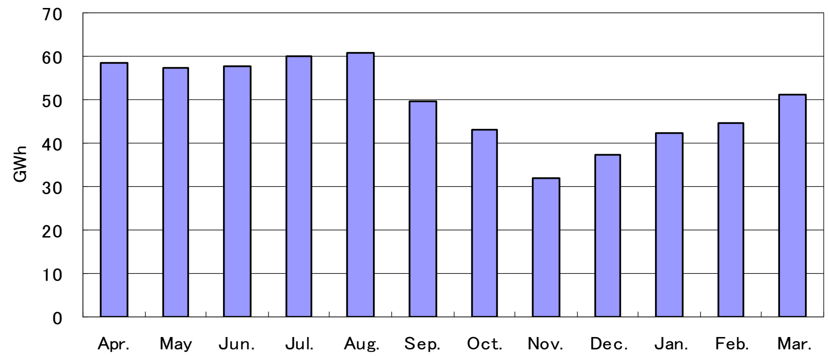


Figure 0.16 Monthly power generation at the VFPS (actual average, 1998 - 2002)

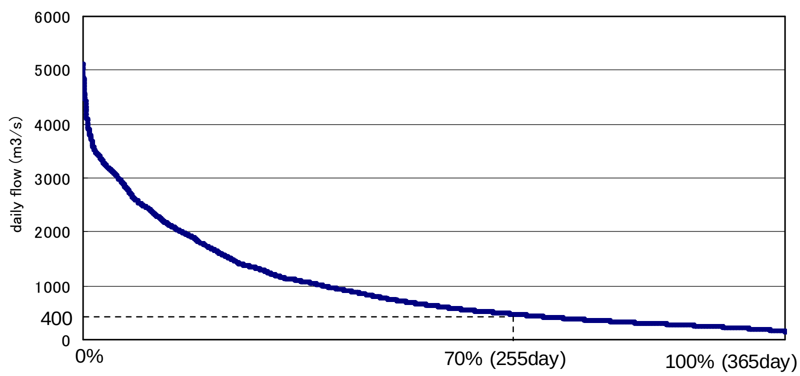


Figure 0.17 Duration curve at the VFPS site

Table 0.6 River flow at the VFPS site (Big Tree observation station)

	Oct.	Nov.	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	max	min	ave
1978/79	550.55	601.71	835.10	1,071.70	1,523.85	2,469.46	4,132.12	3,885.23	2,252.68	1,246.49	763.81	568.30	4,132.12	550.55	1,658.42
1979/80	428.20	488.02	795.29	1,224.13	2,426.83	2,615.39	3,077.00	2,754.82	1,959.41	1,037.46	668.43	502.17	3,077.00	428.20	1,498.09
1980/81	384.68	423.44	591.86	843.60	1,176.43	1,902.23	3,100.19	3,210.79	2,093.58	1,055.32	651.66	479.81	3,210.79	384.68	1,326.13
1981/82	348.11	319.59	423.80	558.29	765.51	957.71	1,423.79	1,579.44	1,157.10	659.54	482.13	373.16	1,579.44	319.59	754.01
1982/83	317.29	364.57	598.32	842.39	1,033.94	1,227.45	1,381.16	1,331.15	902.59	549.26	420.28	331.49	1,381.16	317.29	774.99
1983/84	260.64	297.19	422.29	633.04	867.75	1,273.47	2,049.55	1,766.23	1,033.37	514.53	377.52	293.56	2,049.55	260.64	815.76
1984/85	241.84	279.17	405.63	619.52	962.58	1,170.32	1,762.20	2,153.66	1,660.37	757.19	467.10	339.63	2,153.66	241.84	901.60
1985/86	256.29	247.49	314.31	489.27	698.90	1,018.57	1,760.80	2,683.44	1,691.02	768.08	471.81	353.27	2,683.44	247.49	896.11
1986/87	317.15	446.56	684.45	876.82	1,054.90	1,472.11	2,235.42	1,965.80	1,278.23	643.88	467.22	354.36	2,235.42	317.15	983.08
1987/88	290.29	270.33	404.14	531.66	835.09	1,311.90	1,940.60	2,388.34	1,675.52	795.70	479.74	360.48	2,388.34	270.33	940.32
1988/89	283.98	300.50	454.62	672.60	1,108.78	2,795.89	3,272.67	3,590.39	2,571.99	1,379.35	650.46	432.24	3,590.39	283.98	1,459.46
1989/90	332.24	298.66	302.04	538.97	864.49	1,003.67	1,164.17	1,194.06	1,167.40	615.55	415.72	300.94	1,194.06	298.66	683.16
1990/91	253.35	236.56	324.11	553.36	930.41	2,065.06	2,295.37	2,003.50	1,231.50	539.36	379.09	288.35	2,295.37	236.56	925.00
1991/92	224.56	276.81	466.02	652.77	814.71	1,014.49	1,101.69	1,048.19	712.93	444.47	332.67	251.84	1,101.69	224.56	611.76
1992/93	184.93	213.17	292.84	461.99	741.87	1,236.97	2,411.44	3,122.88	1,886.87	801.13	420.11	287.78	3,122.88	184.93	1,005.16
1993/94	219.92	211.79	350.82	538.85	926.21	1,540.15	2,040.09	1,299.46	542.09	361.64	291.19	220.17	2,040.09	211.79	711.86
1994/95	163.96	164.36	230.16	361.88	507.94	773.39	1,408.22	1,253.30	508.10	317.45	245.27	178.11	1,408.22	163.96	509.35
1995/96	126.09	133.47	239.80	387.79	536.49	695.12	913.75	1,013.22	547.12	335.81	256.26	186.08	1,013.22	126.09	447.58
1996/97	130.39	132.84	223.35	420.59	767.71	1,012.81	1,456.18	1,723.84	1,266.26	528.11	326.79	233.47	1,723.84	130.39	685.20
1997/98	168.03	159.74	239.33	516.49	857.17	2,110.46	3,170.68	2,826.72	1,690.58	727.00	438.12	304.08	3,170.68	159.74	1,100.70
1998/99	212.35	181.03	295.68	540.88	854.75	1,867.01	2,644.55	3,024.32	1,815.93	736.02	421.25	282.70	3,024.32	181.03	1,073.04
1999/00	203.14	196.34	276.44	456.28	638.48	974.19	2,665.20	2,431.60	1,513.26	638.63	368.68	261.12	2,665.20	196.34	885.28
2000/01	171.67	145.21	278.23	569.54	919.29	2,325.08	3,074.11	3,287.84	2,112.01	974.83	507.49	351.52	3,287.84	145.21	1,226.40
2001/02	239.08	246.13	424.22	561.34	717.83	1,053.96	1,706.71	1,940.91	1,634.16	812.40	431.95	296.61	1,940.91	239.08	838.77
2002/03	226.86	202.70	282.83	501.87	831.01	1,300.96	2,226.46	3,422.10	2,211.60	1,092.60	521.07	337.67	3,422.10	202.70	1,096.48
2003/04	230.41	208.74	298.55	558.43	908.48	2,107.00	4,051.29	3,535.83	2,227.32	1,080.18	522.95	343.84	4,051.29	208.74	1,339.42
2004/05	241.84	216.41	334.51	502.47	775.33	1,142.96	1,378.68	1,384.15	1,122.58	558.89	371.63	275.59	1,384.15	216.41	692.09
2005/06	177.66	165.59	308.93	560.82	921.02	1,327.20	2,375.63	2,482.70	1,898.12	903.61	449.66	295.84	2,482.70	165.59	988.90
2006/07	228.05	248.17	395.75	702.00	2,016.28	4,279.80	3,360.58	2,761.50	1,829.41	946.07	549.76	385.14	4,279.80	228.05	1,475.21
ave.	255.64	264.70	396.32	612.05	964.97	1,587.75	2,261.39	2,312.60	1,523.90	752.43	453.44	326.53	2,312.60	255.64	975.98

(d) Mini-hydropower stations

In addition to the large-scale stations KNBPS, KGPS, and VFPS, ZESCO manages mini-hydropower stations at four locations, i.e., Lunzua, Chishimba Falls, Musonda Falls, and Lusiwasi, with respective capacities of 0.75, 6, 5, and 12 MW. Taken together, the four generated about 60 GWh in the year 2007/08. This total was less than 1 percent as high as that of 9,403 GWh for the three stations KNBPS, KGPS, and VFPS in the same year. As shown in Figure 0.18, because the stations are of the run-of-river type, the generated output tends to be lower in the third quarter, which corresponds with the dry season.

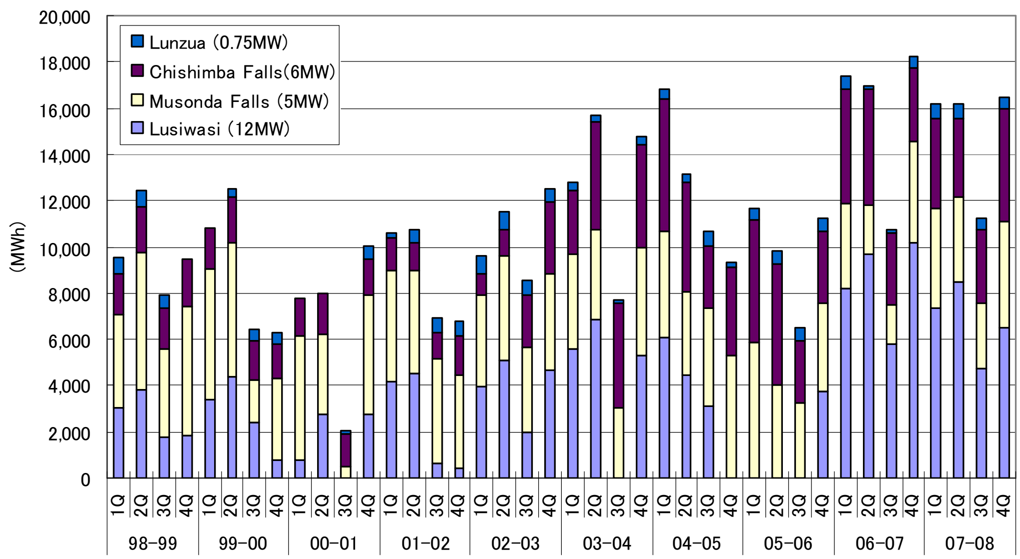


Figure 0.18 Actual generated output at the mini-hydropower stations

ii) Other generation facilities

As shown in Table 0.1, ZESCO has some diesel generation sets to supply off-grid area, besides the hydropower facilities mentioned above. These diesel generators are set mainly in the North-Western Province where the national grid is not expanded. While some diesel generators were abolished with the expansion of transmission lines, others were replaced in the area where grid expansion was not planned. Table 0.7 shows the operational status of these diesel generation facilities.

Table 0.7 Operational Status of Diesel Generation Facilities

Station		Province	Capacity (kW)	Generation 2006 (MWh)	Generation 2006 CF	Generation 2007 (MWh)	Generation 2007 CF
1	Kaputa	Northern	550	1,167	24.2%	1,007	20.9%
2	Chama	Eastern	263	836	36.3%	840	36.5%
3	Luangwa	Lusaka	1,280	783	7.0%	1,128	10.1%
4	Mwinilunga	North-western	1,360	2,469	20.7%	2,169	18.2%
5	Kabompo	North-western	1,160	2,759	27.2%	2,078	20.4%
6	Zambezi	North-western	960	2,201	26.2%	2,159	25.7%
7	Chavuma	North-western	800	701	10.0%	597	8.5%
8	Mufumbwe	North-western	400	1,036	29.6%	705	20.1%
9	Lukulu	Western	512	1,109	24.7%	1,050	23.4%
Total			7,285	13,061	20.5%	11,733	18.4%

(Source) ZESCO annual report

Private sector

i) Hydropower facilities

As of March 31, 2008, Zambia had one private hydropower company: Lunsemfwa Hydropower Company (LHPC). LHPC owned two hydropower stations and was selling power to ZESCO. Located at Lunsemfwa and Mulungushi, the two stations had respective capacities of 18 and 20 MW, for a total of 38 MW. LHPC stated that it had plans to increase these capacities by 6 and 8.5 MW, respectively.

In fiscal 2007/08, the generated output of these stations came to a combined 286 GWh, or only about 3 percent as high as the corresponding output of 9,403 GWh for the KNBPS, KGPS, and VFPS. The monthly trend indicates a lower output in the third quarter under the influence of the dry season as the stations are of the run-of-river type. The output tended to be lowest in November.

LHPC is also planning to develop additional hydropower sources in the vicinity of existing ones (see Clause 0).

Table 0.8 Private hydropower facilities (as of 31 March 2008)

Power Station	Installed Capacity (MW)	Location	Ownership
Lunsemfwa	18	Central Province	LHPC
Mulungushi	20	Central Province	LHPC
Total	38		

(Source) ZESCO, Statistics Year Book of Electric Energy 2007/2008

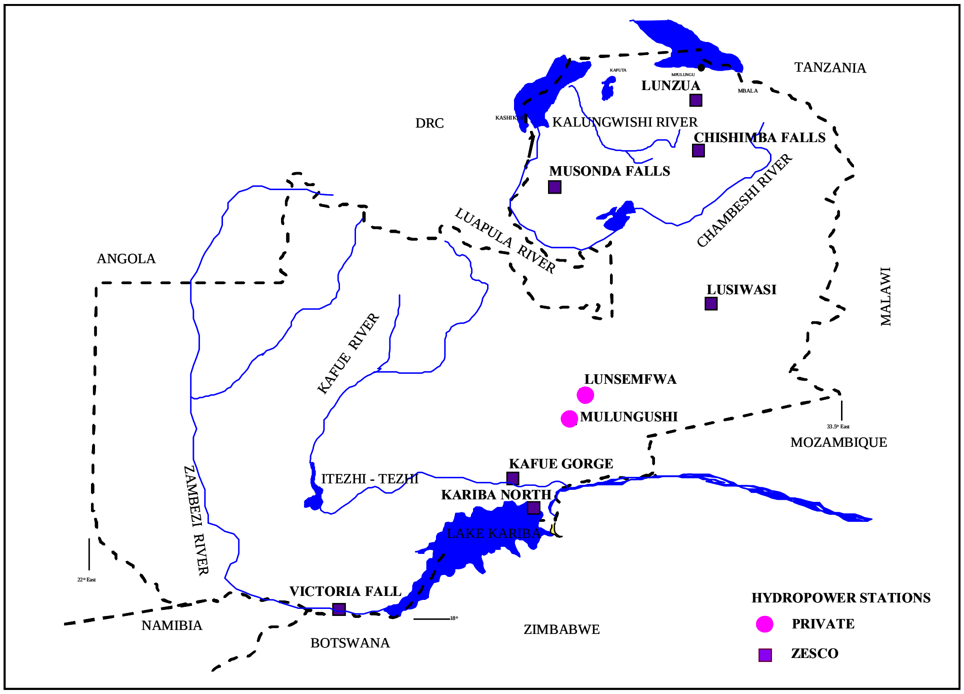


Figure 0.19 Map of private hydropower facility sites

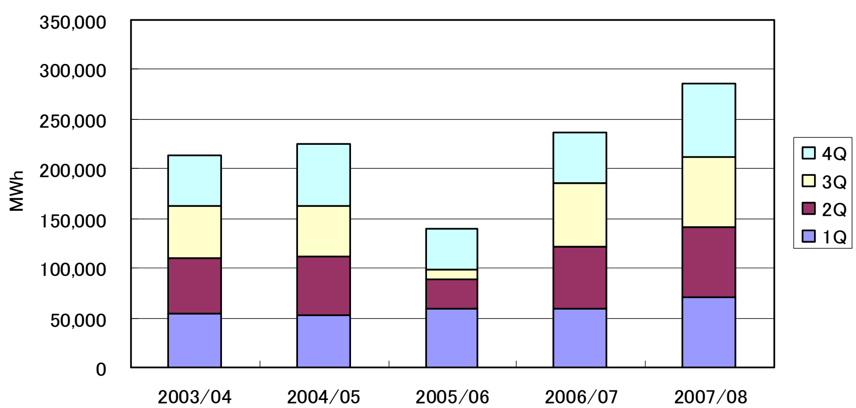


Figure 0.20 Generated output of private hydropower facilities (FY2003 - 2007)

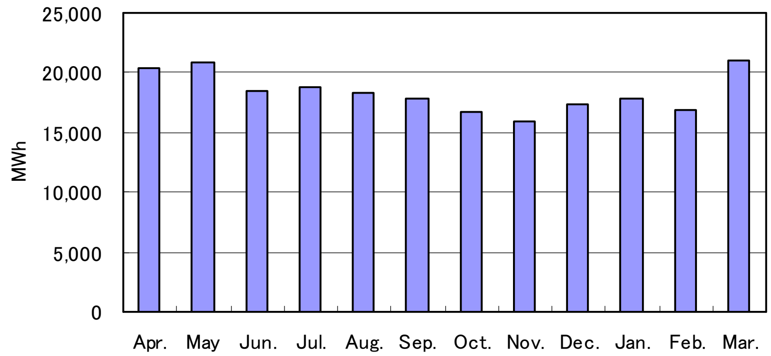


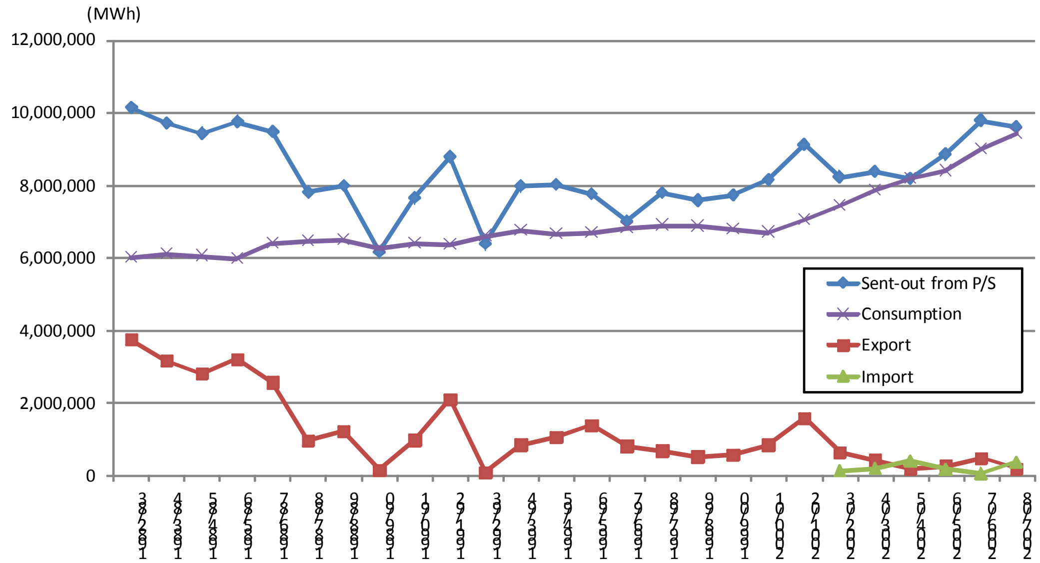
Figure 0.21 Monthly output of private hydropower facilities(average, 2003 - 2007)

ii) Other Generation Facilities

CEC has four gas turbine generators with total capacity of 80 MW. However, CECôs main business is to sell electricity purchased from ZESCO under long-term Bulk Supply Agreement to mining companies by using its own transmission and distribution facilities, so that these generation facilities are recognized as emergency generators when power supply from ZESCO is disrupted.

Demand and supply situation

As seen in the previous section, installation of new generation facilities has long been stagnant, so that energy export is decreasing due to growth of domestic power demand. Additionally, drought and rehabilitation of existing facilities are making matters even worse to import energy in recent years. Figure 0.22 indicates the trend of power balance for 25 years between FY 1983/84 and FY 2007/08. Power consumption has been steadily increasing, especially after 2000 while power generation by hydropower ranges approximately from 6 to 10 TWh p.a. despite the fluctuation induced by river flow or rehabilitation of facilities. As a result, power import started from FY 2002 and import exceeded export in FY 2004 and 2007 as around 4 tera-watt-hour of energy was exported a quarterly century before.



Note) Fiscal Year (FY): April to March

Figure 0.22 Trend of power demand and Supply (FY 1982 – 2007)

Sector-wise demand structure

Electricity demand in Zambia has been increasing at the annual rate of 3 ï 4 %, mainly owing to mining sector and agricultural sector.

The largest power purchaser in the whole sale level is Copperbelt Energy Corporation supplying energy to the mines in Copperbelt, whose share (44 %) is larger than any distribution divisions of ZESCO. Power demand in Zambia heavily depends on demand of mining industry and is subject to be affected by fluctuation of their consumption.

Among distribution of ZESCO, the Lusaka distribution division is the largest. In terms of end use, residential use (service) accounts for the lionǒs share while the manufacturing sector share is just 17 %.

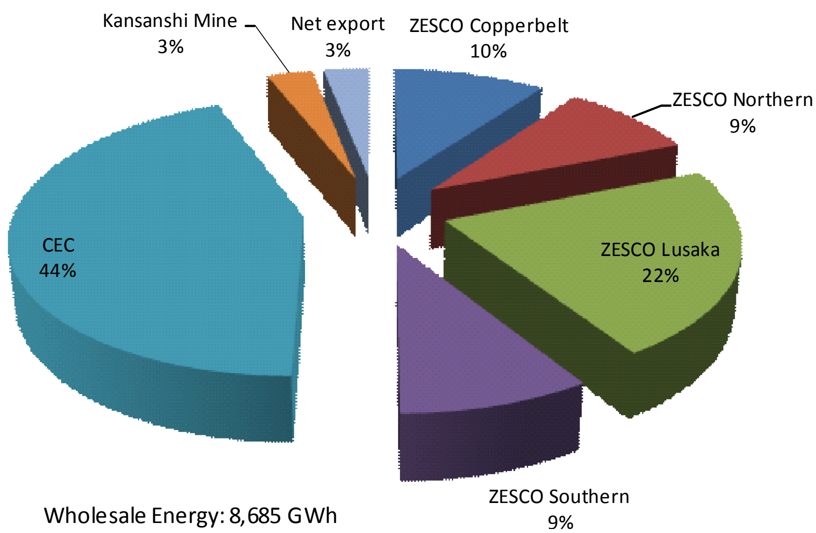


Figure 0.23 Power wholesale of ZESCO

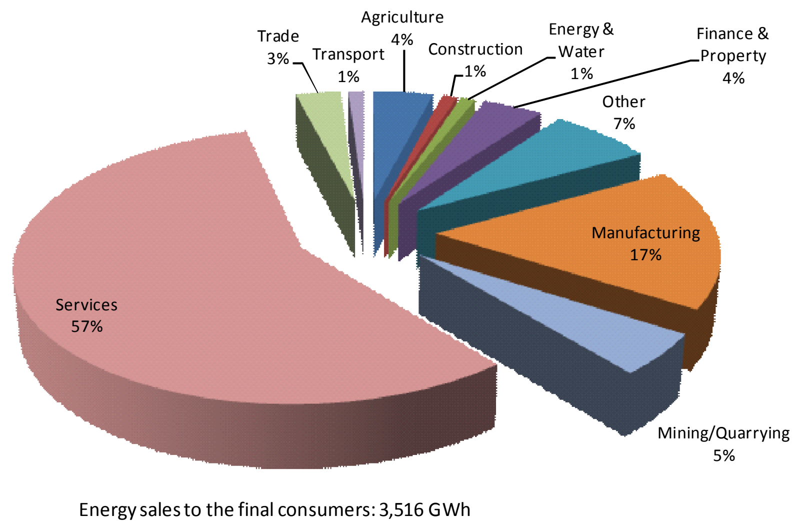


Figure 0.24 Final power consumption of ZESCO

Structurally, future demand growth will depend on mining company demand. Copper ore production may be affected by international market conditions. If the market price declines, Zambia could lose its competitive edge. Power demand could then also decline, a trend which has historical precedence. Thus, power demand in the mining sector is strongly affected by copper price on the international market and by price volatility.

Future increases in electrification ratios also are important factors. By 2030, the Zambian government plans to increase the electrification ratio from the current 3.1% to 50% in rural areas, 48% to 90% in urban areas, and to reach the nationwide target ratio of 60% by 2030. These increases will be additionally piled up in future demand; but the increases will be determined by restriction in actual supply rather than by potential demand.

Recent power demand from SCADA data

The National Control Centre of ZESCO has a SCADA system that monitors and controls the Zambian domestic supply-demand balance and can operate interconnections. The SCADA system stores various data series for about two years. Then, we looked these data to see the trend of Zambian demand.

Load duration curve

The important records named óSystem Total Load[2]ô represent to be deducted sum of the value of interconnections from total gross output are stocked by SCADA. These records represent gross total demand including losses (transmission and distribution losses) from another point of view.

Figure 0.25 shows the load duration curves in CY2007 and 2008.

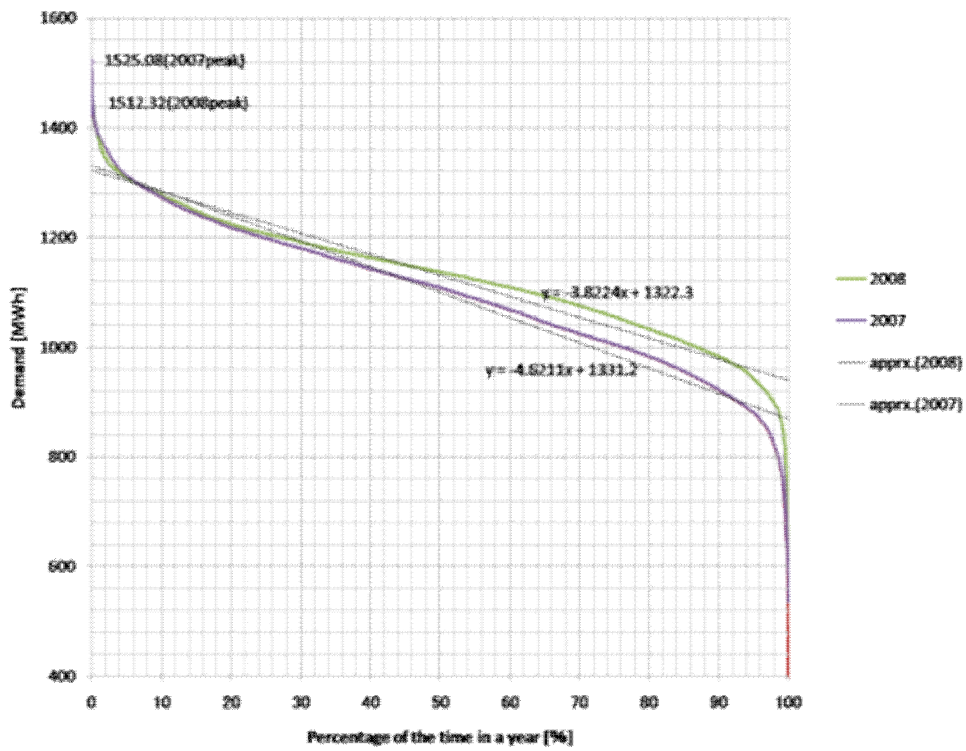


Figure 0.25 Load duration curves in 2007, 2008

Comparing 2007ös and 2008ös, it is clear that conditions around the peak points are similar but those of other points, especially in the light load period, is increased. This shows that an original power demand in Zambia has been activated, and it is surmisable that there was a bottom raising of the power consumption atmosphere in Zambia overall, and that there was the

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2 This value can be given by following equation;
óSystem Total Loadô= óVicrtia Falls PS Total GenP(MWh) ô+óKafue Gorge PS Total GenP(MWh) ô+
óKariba North Bank PS Total GenP(MWh) ô+óLusiwasi PS Total GenP(MWh) ô+
óIntetrchange toward Zimbabweô+óIntetrchange toward DRCô+óIntetrchange toward Namibiaô+
óIntetrchange toward Botsuwanaô

continuation of a steady power demand by Zambian copper industry influenced with the price of international copper that is growing up of a right shoulder until July, 2008.

Thus, the overall rising of the running electric energy as for year with load factor improvement is a desirable tendency on electrical power supplier's financial affairs.

Daily load curve

Following figure shows daily load curves. These show the date and value of peak power demand in 2007 and 2008, off-peak demand (Sunday) in 2007 and 2008, Easter Sunday in 2007 and 2008 respectively[3].

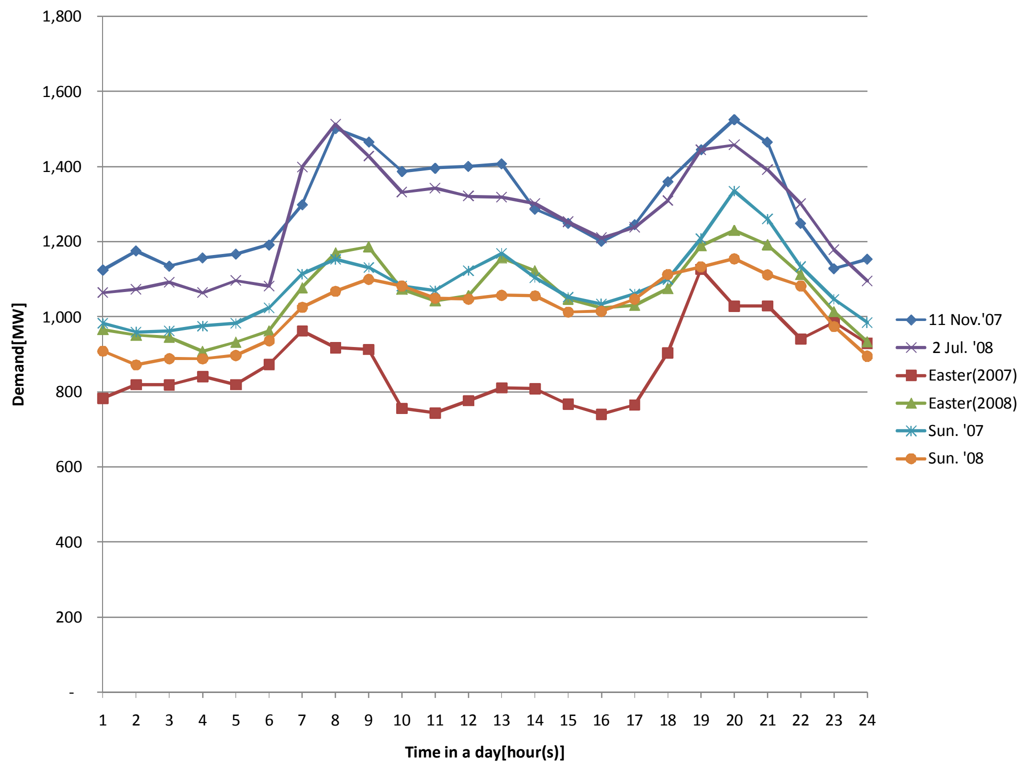

Figure 0.26 Daily load curves

This shows that the power demand has two peaks (morning and evening) and those of normal Sunday and Easter Sunday have three summits (morning, evening and afternoon). Thus, it is clear that residential consumption is the main determinant of the occurrence of peak demand.

Weekly averaged demand

Following figure shows transition of weekly averaged demand in 2007 and 2008.

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[3] Frequently we compare the several daily curves in order to confirm characteristic between nationalitiy and the shape of demands.

Major curve,

Minor curve-1 : We select Sunday when the people donâ work on.

Minor curve-2 : We select the day of holiday when the people tend to take rests whole day on.

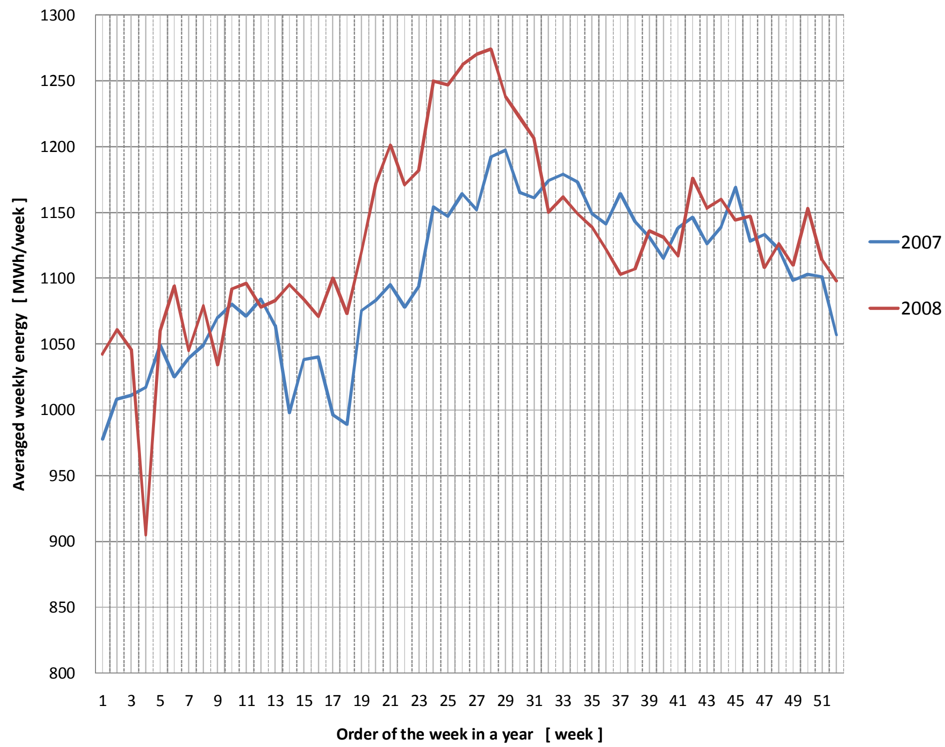


Figure 0.27 Transition of weekly averaged demand in 2007 and 2008

Recent power demand in Zambia tended to rise gradually until July (27th-31st week) when the peak power was generated, getting depressed was not shown afterwards, and to be going to connect the power next year. As a result, the tendency is seen from 2007 to 2008 In this case, however, after July, 2008, the tendency in recent years cannot be found. It is guessed that this is because industrial demand for the electric power is controlled by the production adjustment of copper by dramatic slowdown of copper price since July, 2008.

Quarterly load duration curves

Figure 0.28 shows the load duration curve for each quarter of calendar 2007, and Figure 0.29, that for each quarter of calendar 2008.

The quarterly load duration curves trace the same line. The differences of the maximum and minimum levels in each time period in each quarter are also of a similar magnitude. These results indicate that power consumption in Zambia does not vary greatly across the seasons (rainy and dry) seasons. The cause may be due to the following factors:

A. The residential power demand tends to remain basically constant regardless of the change of seasons (rainy versus dry).

B. The electrification rate is low, and seasonal demand fluctuation has little influence on demand.

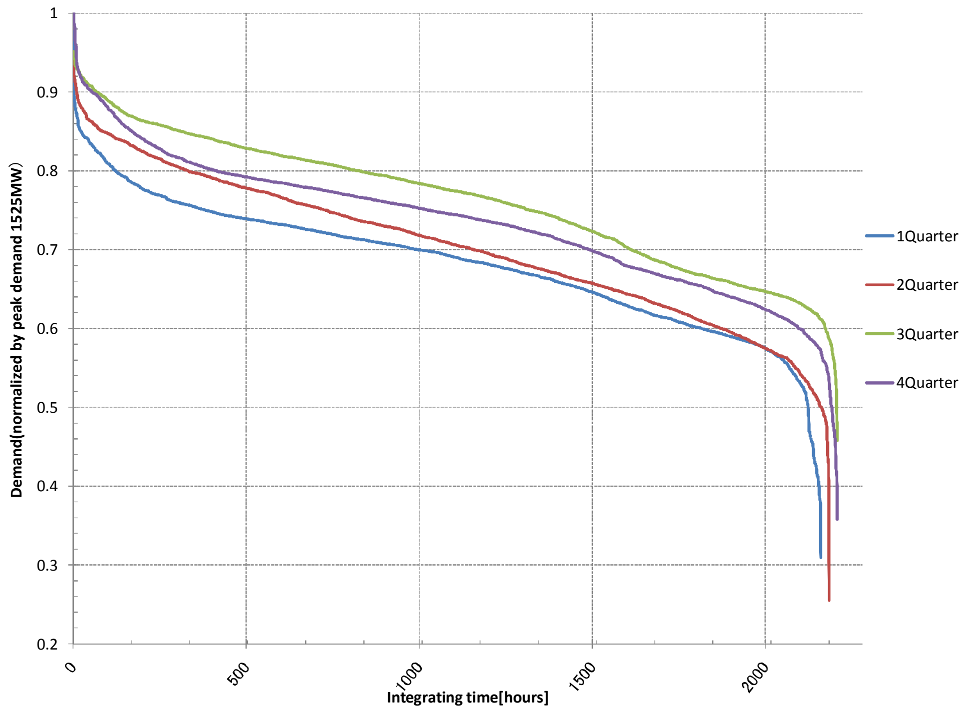


Figure 0.28 Quarterly load duration curves in 2007

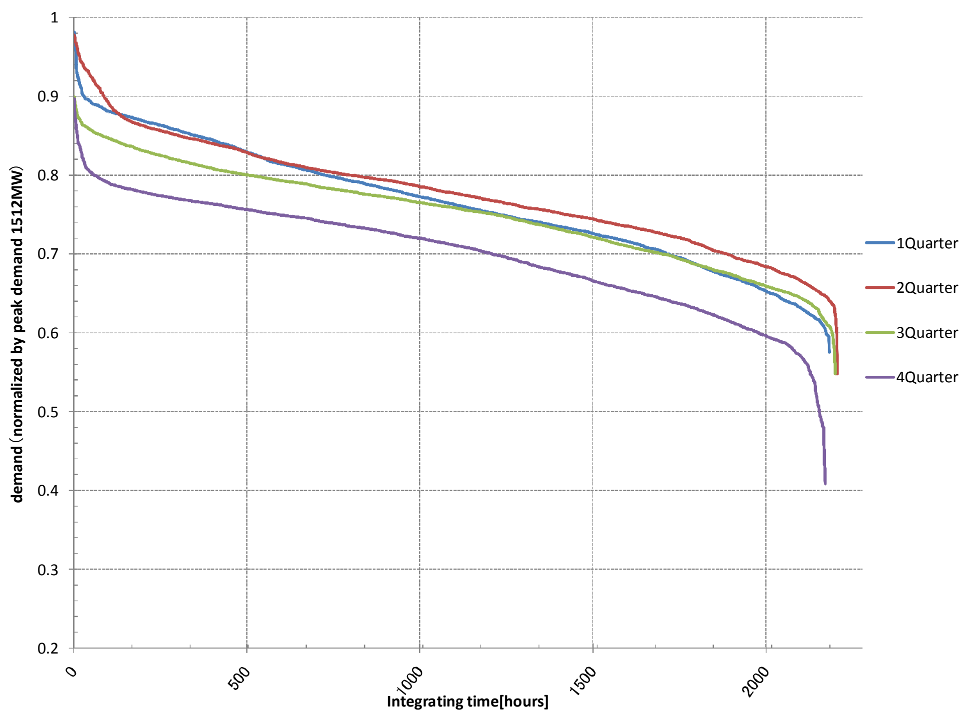


Figure 0.29 Quarterly load duration curves in 2008

Time-period loads in load duration curves

Application of three time periods (peak, daytime, and nighttime, the latter two being off-peak periods) to the daily load curves shown in Figure 0.26 yields the following data.

A. Peak load time period: 6 - 9 AM and 7 - 10 PM, six hours total

B. Daytime load time period: 9 AM - 7 PM, ten hours total

C. Nighttime load time period: 11 PM - 6 AM, eight hours total

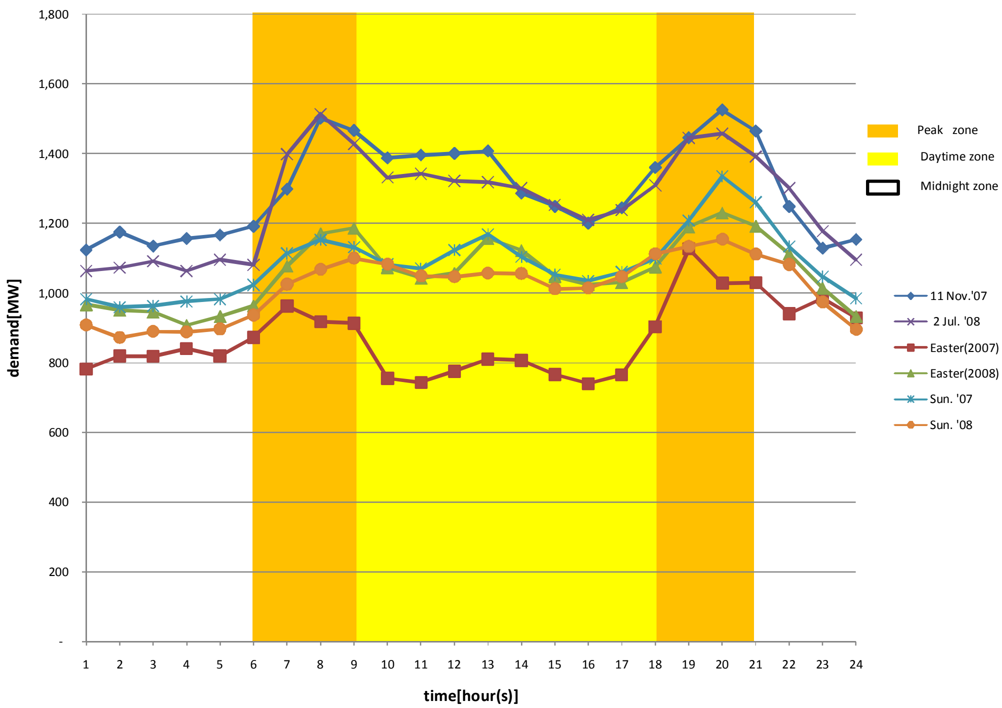


Figure 0.30 Definition of peak, daytime, and nighttime load time periods

This sheds certain light on the position occupied by each time period in the load duration curve. The degree of clarity regarding this position is also a barometer of the electrification rate and extent of economic activities. The position of each time period should become even clearer along with future demand increase.

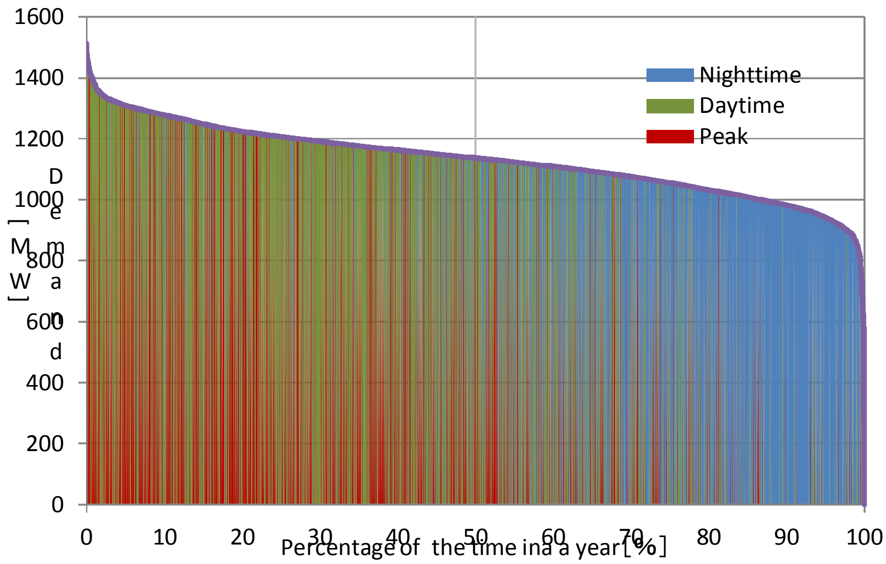


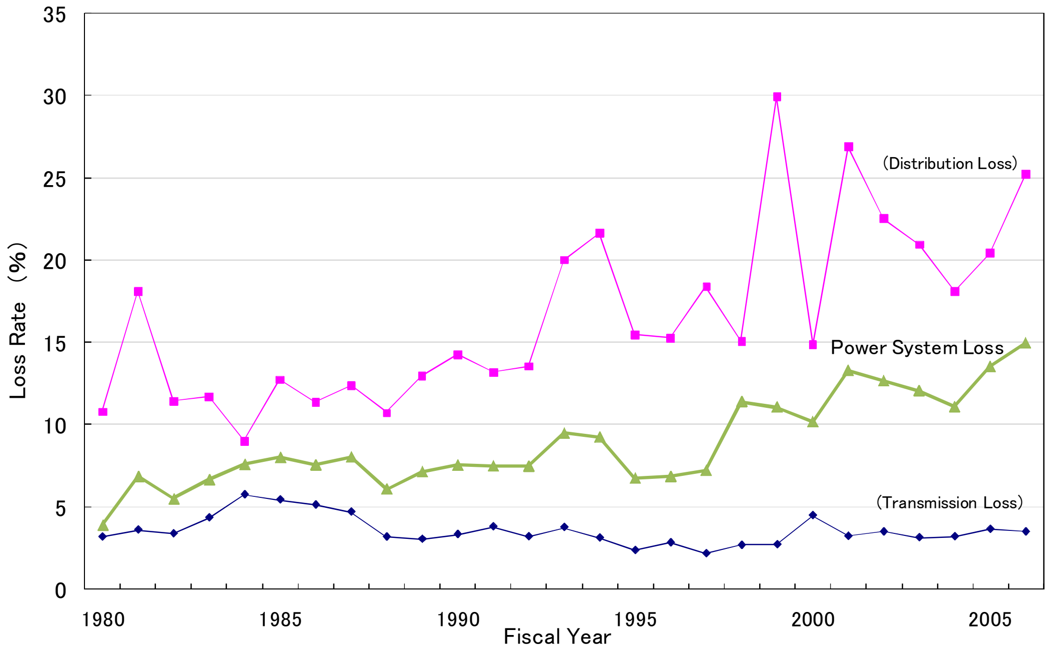
Figure 0.31 Duration curve identified each load time period

Power system loss

Power system loss consists of transmission loss and distribution loss. Transmission loss is the difference between the sending end electrical energy and the distribution end electrical energy (the electrical energy received at distribution substations plus the electrical energy involved in power wholesales and export). Division of this difference by the sending end electrical energy yields the transmission loss rate. Distribution loss is the difference between the electrical energy received at distribution substations and terminal power consumption. Division of this difference by the electrical energy received at distribution substations yields the distribution loss rate.

Figure 0.32 shows the trend of system loss at ZESCO since fiscal 1980, based on data in "ZESCO Statistics Yearbook of Electric Energy".

The transmission loss rate was 3.5 percent in fiscal 2006, and did not change greatly over the period in question. The distribution loss rate, on the other hand, varied significantly from year to year, and rose over the last three years. It reached 25.2 percent in fiscal 2006. The total system loss rate was 14.9 percent in fiscal 2006.



(Source) ZESCO Statistics Yearbook of Electric Energy

Figure 0.32 Trend of the system loss rate

Power import and export

Figure 0.33 presents actual data for power import and export over fiscal years 2002 - 2008.

With its wealth of hydropower resources, Zambia was once a net exporter[4] of electrical power. In fiscal 2002, however, it began to import power due to generation failures and outages for construction as part of power rehabilitation projects. In fiscal 2004 and 2007, it imported more power than it exported. The major factors behind the increased import were the long-term shutdown of generators for rehabilitation at the KNBPS and output decrease due to low inflow into KNBPS and VFPS in fiscal 2004, and demand increase and output decrease due to rehabilitation at the KNBPS in fiscal 2007.

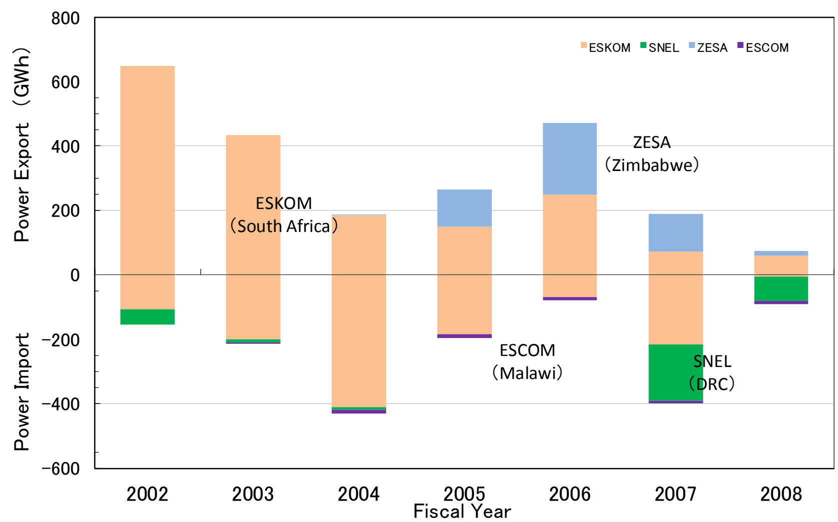
As for the trend in recent years, Zambia's biggest partner in power transactions has been South Africa (ESKOM). In fiscal 2007, ESKOM accounted for 38 percent of Zambia's total power export and 54 percent of its total power import. The tight supply of power in Zimbabwe explains the increased export to that country. The reason for the decline in this export in fiscal 2008 was the long-duration opening of the international interconnection due to apprehensions about system instability in Zimbabwe. This interconnection is also the only interconnection for power transactions with South Africa (ESKOM), and its opening consequently also meant absence of an interconnection with South Africa. This combined with the decrease in capacity for power exports because of the rise in domestic demand slackened the overall power import and export activity in fiscal 2008.

[4] Over the 20-year period of fiscal 1982 - 2001, Zambia exported an average of 1,470 GWh of power per year. It exported the most power in 1982, when its export to ZESA alone came to 3,756 GWh

A notable trend in more recent years is the sharp increase in power imports from the DRC. The DRC (SNEL) is anticipated to emerge as a new player to resolve difficulties (and particularly the power import shortage) in power transactions with South Africa (ESKOM) and Zimbabwe (ZESA). A provisional agreement for resolution of the supply capability shortage in Zambia had not yet been concluded at the time of writing.

As shown in Table 0.9, Zambia has power transaction agreements with Namibia, South Africa, and Zimbabwe.

Zambia's distribution system is interconnected with those of Botswana, Namibia, Zimbabwe, Tanzania, and the DRC. Zambia exports power to these countries. In fiscal 2007, it exported 25 GWh to Botswana, 26 GWh to Namibia, 3 GWh to Zimbabwe, 14 GWh to Tanzania, and 9 GWh to the DRC, for a total of 77 GWh. (Over the 20-year period from fiscal 1982 to 2001, Zambia exported an average of 1,470 GWh per year. Export was highest in 1982, when that to ZESA alone came to 3,756 GWh.)



(Source) ZESCO Statistics

Figure 0.33 Actual ZESCO power import and export (FY 2002 – FY 2008)

Table 0.9 Mutual agreements for power transactions

Countries	Utilities	Agreement
Namibia	NamPower	Firm agreement[5] for supply of 5 MW
South Africa	ESKOM	Non-firm agreement[6] for supply of up to 300 MW
Zimbabwe	ZESA	Non-firm agreement for supply of up to 150 MW

(Source) ZESCO

Table 0.10 shows the progress of construction on transmission ties for interconnection

[5] An agreement for assurance of priority use of power transmission for a reserved capacity.

[6] An agreement for assurance of use of power transmission after determination of transmitted power use based on the firm agreement. However, use of the power transmission for the reserved capacity can be canceled for adjustment in times of transmission line congestion and response in times of unexpected contingency.

between Zambia and neighboring countries. These ties will assist to resolve the existing bottlenecks in the SAPP system and in executing new power transactions.

Table 0.10 Progress of construction of transmission inter-connection ties

Interconnection point and other country	Interconnection point in Zambia	Specifications	Progress of construction
DRC Kolwezi	Lumwana	330kV transmission line extension	Construction in Zambia has been completed for a distance of 268 km from the Luano substation to the Lumwana substation. There remains the leg of about 60 km from the Lumwana substation to the border with the DRC. The transmission line in the DRC is in the stage of detailed design; construction has not yet begun (the requisite distance is 100 km). The authorities are awaiting funding from the World Bank. The line is scheduled for completion in 2011.
	Luano	220kV transmission line reinforcement	Scheduled for completion in 2010
Namibia Katima Mulilo	Katima Mulilo	220kV transmission line extension	Construction has been completed between Livingstone in Zambia and the Katima-Mulilo leg in Namibia. The further leg extending into central Namibia is now under construction with HVDC cable. The Phase 1 construction with HVDC cable is scheduled for completion at a capacity of 300 MW before the end of fiscal 2010. The capacity is to be increased eventually to 600 MW, but the schedule for this construction has not yet been determined.
Tanzania Mbeya	Pensulo	330kV transmission line extension	The feasibility study and the EIA study have already been completed. Work is awaiting approval by the Tanzanian authorities.
Malawi Lilongwe		330kV transmission line extension	The feasibility study was finished in 1992, but another one should be implemented to reflect the latest situation.
Zimbabwe Hwange	Livingstone	330kV transmission line extension	Construction of this interconnection is scheduled for completion in mid 2010. The line is part of the ZIZABONA Interconnector Project for linkage of the four countries Zambia, Zimbabwe, Botswana, and Namibia. Technical and economic analyses have already been executed. More detailed studies are now being implemented jointly by ZESA and ZESCO.

Electricity tariff

The current average prices are calculated by ERB as follows.

Table 0.11 Average Electricity Price

Customer Category	Average Prices (US cents/kWh: 2006/07)
Mining	2.34
Residential	3.05
Large Power	2.07
Small Power	3.14
Commercial	5.87
Services	3.97
Exports	2.87
Total	2.66

The overall average electricity price is 2.66 USc/kWh whereas the residential price is 3.05 USc/kWh. On the other hand, the average prices for the mining customers and large customers show the lowest in the categories with 2.34 USc/kWh and 2.07 USc/kWh, respectively. The discrepancy of the cost-reflective matters among the customers has been identified and discussed. This aspect has led to the tariff adjustment of the recent couple of years.

The electricity tariff in Zambia has been revised on January 1st, 2008. The selected tariff schedule is as given below including the fixed, demand and energy charges. The above tariffs are exclusive of 3% government exercise duty and 17.5% Value Added Tax (VAT).

Table 0.12 Electricity Tariff Schedule (2008)

Category	Unit	Approved Tariff 2008 (ZMK)	Approved Tariff 2008 in US cents
Residential <R2- Consumption 101 to 400kWh>	Energy Charge/kWh	127.00	3.27
Commercial <C1-Consumption up to 700kWh>	Energy Charge/kWh	165.00	4.25
	Fixed Monthly Charge	29,972.00	772.87
Social Services <School, Hospital, Street Lighting, etc>	Energy Charge/kWh	144.00	3.71
	Fixed Monthly Charge	24,972.00	643.94
Small Power <MD-1 Capacity between 16-300kVA>	Max Demand Charge/kVA	15,094.00	389.22
	Energy Charge/kWh	99.00	2.55
	Fixed Monthly Charge	158,035.00	4075.17
Large Power <MD-3 Capacity between 2001-7500kVA>	Max Demand Charge/kVA	24,973.00	643.97
	Energy Charge/kWh	80.00	2.06
	Fixed Monthly Charge	346,808.00	8942.96

(Source) ZESCO Tariff Data in Web Site (2008)

The electricity price in Zambia is one of the lowest in the region. The following table shows the sales and revenues of power utilities in the region. The unit price of Zambia is 2.55 UScents/kWh.

Table 0.13 Comparison of Electricity Price

			2006-07		
			Sales (GWh)	Revenue (US$ mil.)	Unit Price (Cents/kWh)
1	Angola	ENE	2,006.0	184.30	9.19
2	Botswana	BPC	2,626.0	111.40	4.24
3	DR Congo	SNEL	5,697.0	180.00	3.16
4	Lesotho	LEC	420.0	34.20	8.14
5	Malawi	ESCOM	970.0	5.00	0.52
6	Mozambique	EDM	1,380.0	126.00	9.13
7	Namibia	NamPower	3,199.0	193.00	6.03
8	South Africa	ESKOM	208,316.0	5,926.00	2.84
9	Swaziland	SEB	855.8	55.50	6.49
10	Tanzania	TANESCO	2,549.0	188.00	7.38
11	Zambia	ZESCO	8,116.0	207.00	2.55
12	Zimbabwe	ZESA	10,293.0	130.00	1.26

(Source) JEPIC Data (2007)

The last tariff adjustment for ZESCO was in 2005 when the actual increase was only 11%. Thus ZESCO did not realize the tariff adjustment for the last three years. Before the 2005 increase, the adjustment was in 2003 when approximately 5% increase was realized. Given that the increase of the consumer prices in Zambia has been more than 15% p.a. for the last several years on average, the power tariff did not reflect the economic situation. ERB however approved the tariff adjustment for the next three years.

The approved tariff is a multi-year tariff to meet a number of conditions and requirements that spreads over three years of 2008-2010. The indicative increases for each year are as shown in the following table.

Table 0.14 Tariff Adjustment Schedule (Annual Increase Rate)

Customer Category	2008	2009	2010
Residential	26.8%	16.6%	11.9%
Commercial	1.3%	0.3%	0.3%
Social Services	6.8%	1.9%	1.9%
Small Power (MD1 & MD2)	16.2%	5.5%	4.5%
Large Power (MD3 & MD4)	27.5%	16.6%	2.2%

(Source) ERB Data in Web Site (2008)

Even though the multi-year tariff intends to fix the tariff schedule for the next three years, the tariff level will be reviewed by ERB at the end of each year based on the actual situation. Therefore it is critical to closely monitor the financial position of ZESCO in order to sustain the service delivery. The tariff increase scenario originally intends to enhance the performance and efficiency of ZESCO thereby motivating ZESCO to improve the operations and service delivery to end consumers.

The investment program for the next five years (2010-2014) is currently being examined by

ZESCO in consideration of the ERB-approved multi-year tariff increase. Even though ERB is not in a position to directly review and approve the investment program, the financial condition of ZESCO needs to meet the several financial targets agreed upon. It is necessary on the other hand for ZESCO to meet the technical and commercial benchmarks as well. Therefore the investment program will be critical for ZESCO to achieve both of the financial and technical benchmarks.

Financial situation

Key Performance Indicators (KPIs) for ZESCO

The financial position of ZESCO is monitored and evaluated by the Key Performance Indicators (KPIs) by ERB. The KPIs covers wide-ranging areas including (i) customer metering, (ii) cash management, (iii) staff productivity, and (iv) quality of services, (v) system loss. The salient features of the indicators can be summarized as follows.

i) Customer Metering

- All new customers are metered upon connection.
- All new residential connections should be done within 30 days after customer pays for connection.
- All un-metered customers are metered by March 2010. The milestone for this KPI is that one-third (1/3) of the backlog is metered every year till 2010.

ii) Cash Management

- All customers are billed timely and on a regular basis by December 2007.
- Reduce debtor days from current 180 days to not more than 60days by March 2010. The milestone for this KPI is that one-third (1/3) of the target is reduced every year till 2010.
- Total trade receivables do not exceed 17% of turnover by March 2010.
- Total receivables do not exceed 17% of total income by March 2010.

iii) Staff Productivity

- Increase number of customers per employee to 100 customers per employee by March 2010.
- Reduce staff costs from current level of 49% of operating budget to about 30% of operating budget by 2010.

iv) Quality of Service Supply

- Reduce annual unplanned outage to 5 hours per customers by March 2010.

v) System Loss

- Maintain transmission losses at 3% or less.
- Reduce distribution losses to 14% by March 2010.

The performance of the above-mentioned indicators is reviewed in the following section.

ZESCO Performance as of January 2009

The performance of ZESCO as of January 2009 can be summarized as follows.

Table 0.15 ZESCO KPI Summary as of third quarter of 2008

Indicator	Target	Actual	Difference
Customer Metering			
	95,039	132,143	(37,104)
Metering New Customers	6,115	766	(5,349)
s)	68	82	(14)
Cash Management			
(1) Total Receivables	38.47%	61.29%	(22.72%)
(2) Trade Receivables	36.19%	34.95%	2.14%
(3) Debtor Days	130.94	127.57	3.37
Staff Productivity			
(1) Customer-Employee Ratio	72	74	2
Quality of Service			
(1) Unplanned Outage	41	15	26
System Loss			
(1) Transmission Loss (%)	3.00	(3.56)	6.56
(2) Distribution Loss (%)	17.75	19.00	(1.25)

(i) Metering

Unmetered customer issue remains a challenge for ZESCO. Out of a total of 11,545 customers connected between April and September 2008, only 1,440 customers were metered. The number of new connection with meters is far below the total number of new connection made. Thus the number of the unmetered customers is increasing instead of decreasing.

The connection time for the new residential customers has not been improved during the year 2008. It takes still more than eighty two days for ZESCO to connect the new customers as of the third quarter of 2008. Therefore, it is considered that ZESCO needs to accelerate the efforts to improve the operational efficiency.

(ii) Cash Management

The target of the total and trade receivables is less than 17% of turnover by 2010. The total receivables as of the third quarter of 2008 were 61% which is far above the target whereas the trade receivables met the target. In fact, while the receivables are expected to reduce about 4.6% every six months, ZESCO needs to accelerate the improvement more than the originally intended pace.

(iii) Staff Productivity

The actual customer-employee ratio met the target as of the third quarter of 2008. ZESCO recorded a total reduction of 532 in the number of staff in the 2nd and 3rd quarters.

This could contribute the improvement of performance. ZESCO could be on the track to achieve the KPI target if the performance of the staff reduction in the 3rd quarter continues.

(iv) Quality of Service Supply

The distinction between planned and unplanned outages was made. Unplanned outage is broken down into óunplanned outagesò and ñload sheddingò. The KPI of unplanned outage refers to the unplanned outage excluding the load shedding. The actual performance of the unplanned outages stood 15 hours for the 3rd quarter of 2008, which met the target

(v) System Loss

The transmission losses are to be maintained at 3% or less. The performance of the 3rd quarter was a negative value due to the flaw in data previously submitted to ERB. However the trend of the transmission losses in 2008 has been promising.

The target of the distribution losses is to reduce the losses to 14% by 2010. This can be translated to be approximately 2% reduction annually.

Financial Position of ZESCO

The past financial performance of ZESCO can be highlighted in the following table.

The financial performance of ZESCO for 2006-2008 was volatile mainly because of the exchange rate fluctuation. In 2006 ZESCO had a loss in operation due to the appreciation of Kwacha. On the other hand, in 2007 when the Kwacha was appreciated, while ZESCO had a operating profit, the fluctuation of foreign exchange gave a significant negative impact on the resulted loss for the year of K156 billion after the consideration of taxation. Therefore the exchange rate has been a significant factor for ZESCO finance particularly the liability management. This is increasingly a critical factor because the borrowings of ZESCO have been more than doubled for the last four years from 2004 to 2008. Therefore, the asset and liability management will continue to be a critical factor for the management of the capital expenditure for ZESCO.

Table 0.16 Five-Year Financial Record of ZESCO (2004-2008)

(Unit: Kwacha mil.)

Item	2008	2007	2006	2005	2004
P/L Account					
Revenue	94,2621	868,725	768,915	782,641	717,373
(Loss)/Profit before taxation	(13,271)	(218,212)	(76,812)	(71)	(34,828)
Taxation	48,629	62,117	(76,812)	(71)	(34,828)
Profit/(Loss) for the Year	35,358	(156,095)	42,339	35,633	41,676
B/S Account					
Property, Plant and Equipment	3,340,420	3,121,712	2,915,555	2,670,342	1,972,692
Investment in Joint Venture	3,115	-	-	-	-
Net Current (Liabilities)/Assets	(179,340)	(27,859)	51,394	100,654	134,894
Deferred Liabilities	(382,747)	(364,806)	(334,174)	(290,038)	(242,531)
Borrowings	(800,481)	(693,294)	(528,561)	(674,572)	(373,218)
Capital Grants and Contributions	(455,447)	(405,987)	(254,065)	(175,639)	(144,980)
Deferred Income Tax	(5,627)	(55,231)	(119,519)	(43,456)	(43,646)
Net Assets	1,609,893	1,574,535	1,730,630	1,688,291	1,303,211
Financed by					
Shares Capital	215	215	215	215	215
Reserves	1,609,678	1,574,320	1,730,415	1,688,076	1,302,996
Shareholdersô Funds	1,609,893	1,574,535	1,730,630	1,688,291	1,303,211

(Source) ZESCO Annual Report (2008)

Table 0.17 Financial Performance Ratio

(Unit: Kwacha mil.)

Item	2008	2007	2006	2005	2004
Net Profit Margin	4%	(18%)	6%	5%	6%
Return on Capital Employed	0%	(10%)	2%	2%	3%
Current Ratio	0.82	0.97	1.07	1.14	1.26
Quick Ratio	0.79	0.92	0.98	1.06	1.16
Interest Coverage	(0.41)	0.85	11.76	3.32	7.34
Debt/Equity Ratio	74%	71%	65%	62%	58%
Gearing Ratio	33%	31%	23%	25%	22%
Debtor Days	147	176	168	189	172
Turnover per Employee (ZMK mil)	242	240	202	210	199
Deferred Liabilities per Employee (ZMK mil)	98	101	88	78	67
Asset Turnover	0.29	0.28	0.26	0.28	0.34

(Source) ZESCO Annual Report (2008)

The net profit margin has been decreased from 2006 to 2008 from 6% to 4%. ZESCOôs net income showed a negative K156 billion in 2007, which resulted in the negative profit margin of 17%. Several reasons can be identified for the financial performance. One of the reasons is the low tariff level in consideration of the cost. The power tariff in Zambia has been one of the lowest in the region. The cost of power import is also a critical factor for the ZESCO finance. Due to the increasing domestic demand in Zambia and the limited generation capacity due to the rehabilitation projects, Zambia is now a net importer of energy from the SAPP. Given the high import tariff from the neighboring countries, ZESCO has experienced a net loss from the power trade. At the same time, ZESCO carried out the power shedding and has not met the increasing demand in 2008. These situations could lead the power supply services to a negative spiral of poorer performance.

Financial Support by Government

The current on-lending balance of the ZESCO debt that is guaranteed by GRZ is as summarized in the following.

Table 0.18 ZESCO On-lending Status

Donor	Tranche & Currency	Name of Project	Loan Amount (Kwacha mil.)
African Dev. Fund	1. AFU	Kafue Gorge Restoration	6,592
	1. JPY	Victoria Falls Katima Mulilo	4,850
	2. USD		4,850
	3. EUR		4,850
	1. EUR	Victoria Falls Katima Trans.	3,795
	2. JPY		3,795
	3. USD		3,795
	4. AFU		3,795
EIB	1. EUR	ZESCO Kariba North Bank Project	21,000
	2. EUR	Victoria Falls Project	20,500
	3. EUR	Power Rehabilitation Study	170
IDA	1. SDR	Power Rehabilitation Project	55,100
Belgium Gov.	1. EUR	Mapepe Substation	820
NDF	1. SDR	Power Rehabilitation Project	5,000
		Power Rehabilitation Project	6,082
		Total	144,994

Source) Ministry of Finance and Planning (2009)

The largest donor is IDA followed by EIB. The African Development Fund is also a large contributor. These three donors are the majority lenders to ZESCO.

The sovereign guarantees for the power sector were suspended due to one of the conditions of the debt relief under the HIPC initiatives. However, the Ministry of Finance and Planning states that s substantial funds guaranteed by the government is now ready to be provided to ZESCO in any forms of guarantees. The funds however are subject to review and approval by the government. The government guarantee would be expected to contribute to stabilize the ZESCO finance as well provide a comfort to private investment projects.

Power Situation of the surrounding countries

Table 4.19 shows the balance of power supply and demand in fiscal 2007 in countries that are SAPP members. As is clear from this table, at 9 percent, the supply reserve margin in SAPP as a whole was below the 10-percent target. At present, it is slightly lower at about 8 percent with the exclusion of Malawi, Angola, and Tanzania, which lack system interconnections with other SAPP members. According to the SAPP annual report (2007/2008), the tightness in the power supply is projected to continue until 2013, when new power stations are scheduled to commence operation.

The installed capacity is lower than the peak demand in Botswana, Mozambique, Lesotho, Namibia, and Swaziland, which depend heavily on power import. In South Africa, Malawi, Tanzania, and Zimbabwe as well, the supply reserve margin is less than 5 percent and the supply is therefore tight. The main power exporters are South Africa, Mozambique, and the DRC. The main power importers are South Africa, Botswana, Mozambique, Namibia, Swaziland, and Zimbabwe.

Table 0.19 Power supply-demand balance in SAPP member countries (FY2007)

Country	Utility	Capacity (MW)			Energy (GWh)			
		Generation (Available)	Peak Load	Reserve Margin (%)	Generation Sent out	Sales	Import	Export
Botswana	BPC	120	493	-	657	2,815	2,572	0
Mozambique	EdM	174	365	-	222	1,380	1,352	309
	HCB	2,075	-	-	15,847	-	-	15,847
Angola	ENE	870	535	63%	3,293	2,362	21	0
Malawi	ESCOM	246	240	3%	1,447	1,166	0	0
South Africa	ESKOM	38,384	36,513	5%	239,108	224,367	10,998	11,368
Lesotho	LEC	70	109	-	486	478	49	7
Namibia	Nampower	360	449	-	1,576	3,259	2,045	0
Swaziland	SEB	50	196	-	126	856	993	0
DRC	SNEL	1,170	1,050	11%	7,581	6,100	78	1,014
Tanzania	TANESCO	680	653	4%	4,141	3,225	57	0
Zimbabwe	ZESA	1,825	1,758	4%	7,781	10,293	2,367	30
Zambia	ZESCO	1,630	1,468	11%	9,677	8,285	199	0
SAPP Total		47,654	43,829	9%	291,941	264,586	20,731	28,575
SAPP Interconnected Total		45,858	42,401	8%	283,060	257,833	20,653	28,575

Source: SAPP Annual Report 2007/2008

Power Demand Forecast

Data used for forecast

Electricity statistics

The ZESCO statistics available in annual reports and the ZESCO billing data were used for the demand forecast analysis.

Data on final energy consumption in the ZESCO statistics have been revised twice. These data were disaggregated by tariff category up to fiscal 2000, but by industrial classification beginning in fiscal 2001. Furthermore, items of the industrial classification were revised again in fiscal 2005. For this reason, when time-series data by customer category are selected, they cannot retain continuity in tree periods, i.e., before fiscal 2001, between fiscal 2001 and 2004, and after fiscal 2004. Needless to say, this inconsistency is only observed in energy consumption by customer category; the figures for total energy consumption retain a continuity.

The billing data are disaggregated by tariff category. However, these data were revised in fiscal 2004 due to a change of the computer system, used for data processing. Data downloaded from the old system have substantial discrepancy with those in the ZESCO statistics and show figures that are 20 - 30% lower. Although the reason for this discrepancy is not clear, ZESCO explained that billing data had omissions and some of the billing data might not be reflected in the computer system.

Energy sales data downloaded from the new system, i.e., the Business Information System (BIS), is consistent with those of the ZESCO statistics. However, a comparison cannot be made in respect of energy consumption by consumer category between the billing system and the ZESCO statistical data because they use different customer categories.

On the question of which data reflect the actual final energy consumption more faithfully, the ZESCO statistics are the most reliable data in the view of ZESCO. In addition, other data on power generation capacity, generated energy, and electricity import and export are available in the ZESCO statistics, and relations among those data are also reliable.

Macro-economic indicators

The analysis used macro-economic data for items including GDP released by the Central Statistical Office (CSO). Although some data are also quoted from the database of the International Monetary Fund (IMF), the original data source is the Government of Zambia, and there is no discrepancy with those of the CSO.

Method of forecast

Two methods were used: one based on an econometric model, and the other, on an end-use model for which estimates for the future energy demand from large customers were added up. More specifically, the power demand in the retail division in four ZESCO franchises was forecasted using the econometric model, and the bulk power demand in the mining sector, for which power is supplied by CEC and ZESCO using transmission lines, by added up mining-project plans in the future.

Structure of final demand

To predict the future power demand, the structure of the final consumption was split into the following three sectors:

- the residential and the commercial sectors in the retail division;
- the industrial sector excluding the mining sector in the retail division; and
- the mining sector receiving bulk power supply.

The reason for simplifying the demand structure is that statistical errors and omissions cannot be ignored due to the discontinuity of demand data by either industrial classification or tariff category if the demand structure is broken into small sub-sectors. Actually, there are many discrepancies in the past demand data, and categories for disaggregating demand structure were changed twice (i.e., in fiscal 2001 and 2005) in the ZESCO statistics.

The residential and the commercial sectors were not split but aggregated. This is because small shops often operate their business in houses and it is therefore difficult to distinguish residential and commercial power consumption. Even though their profile may be commercial, customers often make a residential power supply contract.

Figure 0.1 shows a comparison of energy consumption among metered customers by tariff category. In fiscal 2007, customers in the most low-volume category of industrial use, i.e., Maximum Demand Tariff 1[7], consumed an annual average of more than 100GWh per contract. However, the corresponding averages were only 6GWh in the residential sector and 10GWh in the commercial sector. As this indicates, levels of power consumption in the residential and the commercial sectors are much lower than those in the industrial sector, and on roughly the same order.

There is another reason for aggregating the residential and the commercial sectors. Although the data for final energy consumption in the ZESCO statistics are disaggregated by industrial classification, it is not certain whether individual enterprises are categorized in the same classification in both the CSO GDP data and the ZESCO statistical data. For example, if we compare power consumption by industrial classification as reported in the ZESCO statistics, the figures changed significantly between fiscal 2004 and 2005. This means that some customers were categorized in ñIndustry Aò in fiscal 2004 but ñIndustry Bò in fiscal 2005. Furthermore, in fiscal 2005, customers categorized in ñOthersò increased sharply, perhaps because of difficulties encountered in customer classification.

[7] Consisting of customers whose capacity is in the range of 16 - 300kVA. ñMaximum Demand Tariff 2ò consists of customers whose capacity is in the range of 301 - 2,000kWA, ñMaximum Demand Tariff 3,ò those whose capacity is in the range of 2,001 - 7,500kWA, and ñMaximum Demand Tariff 4,ò those whose capacity is over 7,500kWA.

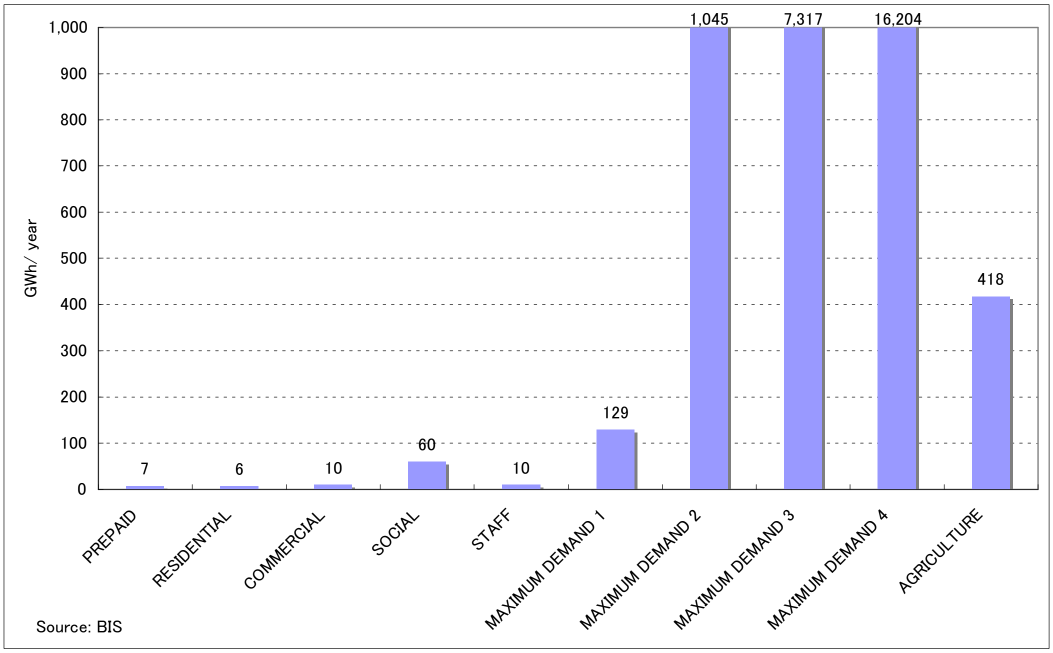


Figure 0.1 Annual Energy Consumption per Contract (Fiscal 2007)

Final energy consumption in the past

The data for fiscal 1999 - 2006 in the ZESCO statistics were used to estimate the GDP elasticity of energy consumption. As shown in Figure 0.2, final energy consumption exhibits a certain irregularity. Retail power sales in fiscal 2000 increased significantly compared to the previous and following years. Further, those in fiscal 2006 decreased as compared to the previous year.

It is not clear if this irregularity was caused by statistical error or actually occurred. In light of macro-economic conditions in Zambia, at least, this sort of significant change is unlikely. One possibility is that demand was curbed by limited power supply capacity and dropped below latent demand in some years.

In this connection, when analyzing and discussing past statistical data, it must be borne in mind that data contain irregular figures in some years.[8]

[8] Data themselves have errors and omissions, and they do not present a completely accurate picture of the customer situation. In addition, the ZESCO staff in charge of statistics said that the handling of data changed in some years. For these reasons, we had to accept a degree of data uncertainly.

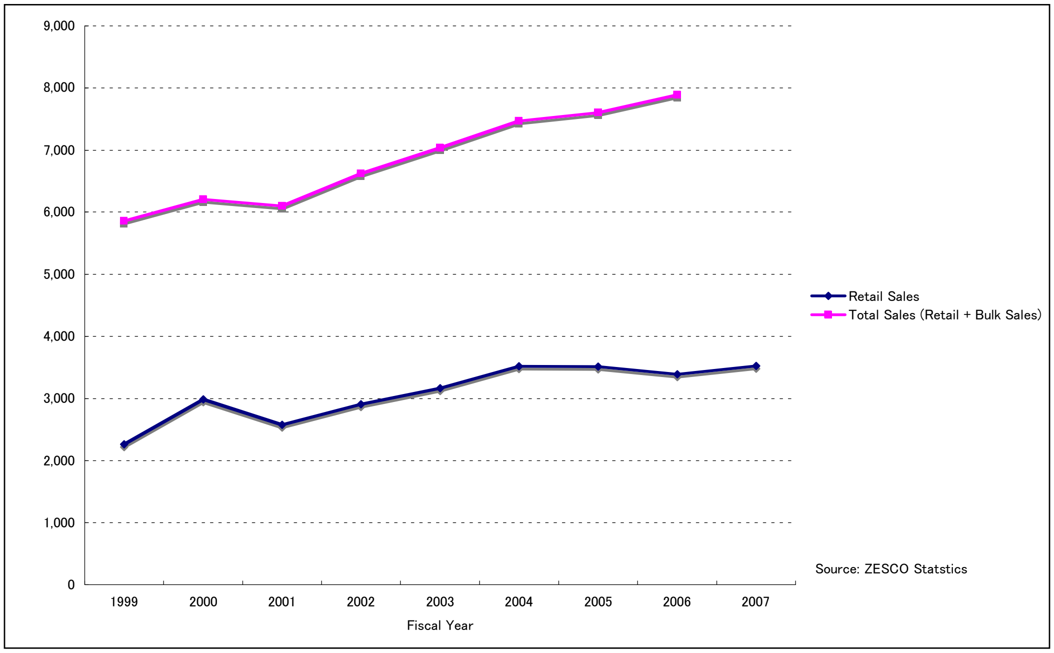


Figure 0.2 Final Energy Consumption in the Past (fiscal 1999 – 2007)

Power demand forecast for the retail division using an econometric model

As noted above, the retail division was divided into two sectors: the residential-and-commercial sector and the industrial sector excluding mining. We used statistical data for the years fiscal 1999 - 2006 for multivariate analysis, but data on energy consumption for these two sectors were not available in the ZESCO statistics.

Due to this restriction, we estimated energy consumption in the two sectors using the billing system data. The billing system data and the ZESCO statistical data are consistent with each other for total energy consumption in fiscal 2005 and 2006, and we therefore did not have any problems in handling data for this period. Because the billing system data up to fiscal 2004 do not include all energy consumption, however, we cannot directly use these data. On the premise that the actual ratio of energy consumptions in two sectors was the same as that derived from the billing system data, which apprehended a only limited number of customers, we distributed the total energy consumption in the ZESCO statistical data between the two sectors using said ration in order to obtain estimates for energy consumption in each.

The residential-and-commercial sector

Energy consumption in the residential-and-commercial sector is strongly affected by increase in household income and electrification ratio. We applied the following equation to estimate energy demand in this sector using the number of customers and per-capita GDP data as explanatory variables. Here, per-capita GDP represents household income, and the number of customers, the electrification ratio. Future demand is estimated using the elasticity of each explanatory variable derived from the past data.

$\log D_e = a + b_1 * \log GDP_{pc} + b_2 * \log N$

D_e: Energy demand (kWh)

GDP_{pc}: Per-capita GDP (1994 kwacha)

N: Number of customers in the residential-and-commercial sector

a: Constant

b_1: Elasticity of per-capita GDP

b_2: Elasticity of the number of customers in the residential-and-commercial sector

The results of regression using the past data between fiscal 1999 and 2007 is shown in Table 0.1. The original data themselves have errors and monitions, as mentioned above. Therefore, the coefficient of determination (i.e., R^2) of 0.836 is assumed to be showing good correlation. The normalized values of line-slopeð b_1 and b_2ð are 0.41 and 0.51, and the effect of increase in the number of customers against increase in energy demand is slightly stronger than that in per-capita GDP (household income).

Table 0.1 Coefficients of Regression Line
(the Residential-and-Commercial Sector)

a	b_1	b_2	Coefficient of determination, R^2
2.40241	0.566434	0.943780	0.835706

(Source) JICA Study Team.

The industrial sector excluding mining

In the equation for estimating the demand in the industrial sector excluding mining, the value-added product of industry (i.e., GDP by sector) was used as an explanatory variable to obtain GDP elasticity in the sector.

$\log D_e = a + b * \log GDP_{ind}$

D_e: Energy demand (kWh)

GDP_{ind}: Added value of the industrial sector (1994 kwacha)

a: Constant

b: Elasticity of GDP_{ind}

As in the case of the residential-and-commercial sector, a regression analysis was performed using data for the past nine years (fiscal 1999 ï 2007). The results are shown in Table 0.2. Although the value of the coefficient of determination (i.e., R^2) is not so good as that in the residential-and-commercial sector analysis, correlation is observed. Assuming that there is much irregularity (including inconsistency) in the past nine-year data and that considerable error is to be expected, this result is on an acceptable level.

Table 0.2 Coefficients of the Regression Line (the Industrial Scoter Excluding Mining)

a	b	Coefficient of determination, R^2
14.1978	0.874445	0.550992

(Source) JICA Study Team

Power demand forecast for the mining sector using the end-use model based on mining project integration

Table 0.3 and Table 5.4 show the result of integration of data for new mining projects in CEC and ZESCO franchises. Although individual project lists are the latest ones updated by both companies, we must understand that the schedule of each project may change depending on economic conditions.

From the viewpoint of an investor, projects scheduled over the short and medium terms have a fairly high probability of execution, but those scheduled over the long term (more than 10 years in the future) will be occasionally revised in accordance with the economic conditions, and consequently are more uncertain.

Table 0.3 Forecast for New Mining Projects by the CEC

Low scenario

Cnages in peak demand (MW)

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Luanshaya Copper Mines		−17	−17	−17	−17	−17	−17	−17	−17	−17	−17	−17
Chambishi Metals, Cobalt Smelter		−51	−51									
Chambishi Metals, SX		−23	−23									
Konkola Copper Mines, Nchanga Smelter Ramp-up Pjhase 1		35	35	35	35	35	35	35	35	35	35	35
Konkola Copper, Mines Nchanga Smelter Ramp-up Pjhase 2							25	25	25	25	25	25
Konkola Copper, Mines New Konkola Concentrator		20	20	20	20	20	20	20	20	20	20	20
Konkala Copper Mines, New Shaft				15	15	15	15	15	15	15	15	15
Konkola Copper Mines, Dewatering increases at New Shaft							25	25	25	25	25	25
Mopani Copper Mines, Nkana Mine		−60	−60									
Mopani Copper Mines, Muflira Mine		−47	−47	−47	−47	−47	−47	−47	−47	−47	−47	−47
NFM Africa Mining			4	4	4	4	4	4	4	4	4	4
Total	528	385	389	538	538	538	588	588	588	588	588	588
Energy demand (MWh)												
CEC	4,023,994	2,934,162	2,964,647	4,100,206	4,100,206	4,100,206	4,481,266	4,481,266	4,481,266	4,481,266	4,481,266	4,481,266

High scenario

Cnages in peak demand (MW)

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Luanshaya Copper Mines		−17	−17									
Chambishi Metals, Cobalt Smelter		−51										
Chambishi Metals, SX		−23										
Konkola Copper Mines, Nchanga Smelter Ramp-up Pjhase 1		45	45	45	45	45	45	45	45	45	45	45
Konkola Copper Mines, Nchanga Smelter Ramp-up Pjhase 2					40	40	40	40	40	40	40	40
Konkola Copper Mines, New Konkola Concentrator		20	20	20	20	20	20	20	20	20	20	20
Konkola Copper Mines, Processing of Chingola Refractory							55	55	55	55	55	55
Konkala Copper Mines, New Shaft				15	15	15	15	15	15	15	15	15
Konkola Copper Mines, Dewatering increases at New Shaft							25	25	25	25	25	25
Mopani Copper Mines, Nkana Mine												
Mopani Copper Mines, Muflira Mine		−47	−47									
NFM Africa Mining			4	4	4	4	4	4	4	4	4	4
Tea Mining, Konkola North				20	20	20	20	20	20	20	20	20
Mulianshi Project					35	35	35	35	35	35	35	35
Caledonis Nama Mine						50	50	50	50	50	50	50
Total	528	455	533	632	707	757	837	837	837	837	837	837
Energy demand (MWh)												
CEC	4,023,994	3,467,646	4,062,100	4,816,598	5,388,188	5,769,248	6,378,944	6,378,944	6,378,944	6,378,944	6,378,944	6,378,944

Note: Load factor = 87%

Source: CEC

Table 0.4 Outlook for New Contracts with Mining Companies by ZESCO

Projected Demand (MW)

	MW	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Mining	495	0	132.3	235.3	343	435	515	535	560	565	565	590
Lumwana (Equinox)	160		73.3	73.3	90	90	90	90	90	90	90	90
Kansanshi Increment	60		12	12	12	12	32	52	72	72	72	72
Nodola Lime Uprating	10		10	10	10	10	10	10	10	10	10	10
Mkushi North Mine	40			20	40	40	40	40	40	40	40	40
Mazabuka Nikel Mine	7		7	7	7	7	7	7	7	7	7	7
Kabompo Copper & Gold Mine	60				30	60	100	100	100	100	100	100
Omega Mine	5			8	8	8	8	8	8	8	8	8
Chambishi Copper Smelter			30	40	50	60	80	80	80	85	85	110
Kafue Smelter	48			33	33	43	43	43	48	48	48	48
Kabwe Smelter	105			32	63	105	105	105	105	105	105	105
Energy demand (MWh)												
Mining	LF=87%	0	985,106	1,752,044	2,553,978	3,239,010	3,834,690	3,983,610	4,169,760	4,206,990	4,206,990	4,393,140

Source: ZESCO

Premises of the forecast

Macro-economic growth

Zambia has enjoyed steady economic growth since 1999 and maintained a growth rate of around 6% per annum from 2006 to 2008 (see Figure 5.3). In the fifth National Development Plan, the Government of Zambia also set a target of at least 7% per annum for economic growth over the years 2006 - 2010. While actual figures did not reach the target, the country has continued to achieve sustainable economic growth.

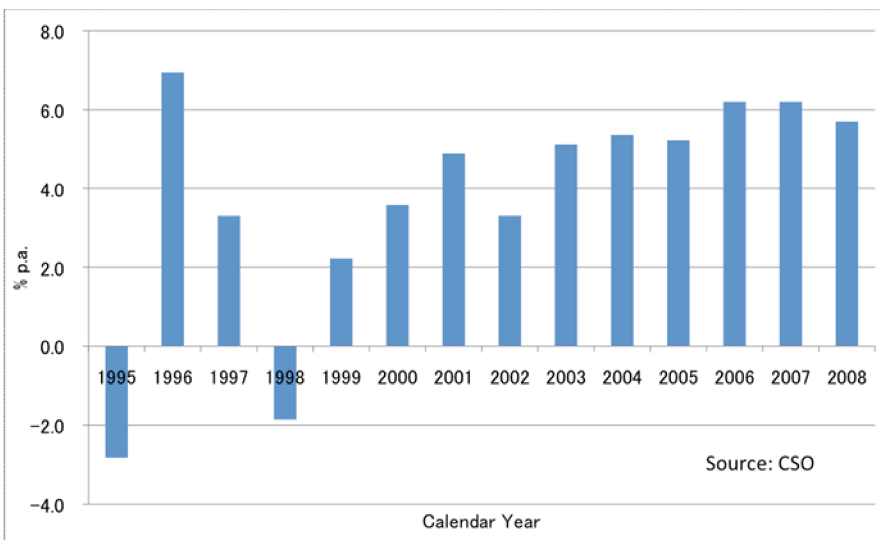


Figure 0.3 Trend of GDP Growth (1995 – 2008)

The question is how the global recession triggered by financial crisis in autumn of 2008 will affect Zambiaȇs economy. Although it is very difficult to say at present, one indicator of the future course is the Global Economic Prospect released annually by the World Bank. In the 2009 Prospect, economic growth in the year 2009 is expected to decline to 4.6% per annum [9](see Table 0.5).

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[9] The World Economic Outlook 2009 released by IMF in October 2009 foresaw GDP growth of 4.537% from 2008. Coincidentgally, the CSO of the GOZ announced its estimate of the GDP growth in 2009, i.e., 6.3% p.a. There is a big difference between the World Bnak/IMF and the CSO estimates. The CSO commented that fundamental difference is the methodology used for constant price estimates of taxes less subsidies on subsidies.

Table 0.5 Prospect for Zamia's Economic Growth

Calendar Year					Prediction		
	1991-2000	2005	2006	2007	2008	2009	2010
GDP at market prices (2000 US$), % p.a.	0.7	5.2	6.2	6.2	6.1	4.6	6.0

(Source) The World Bank

Population growth

The population of Zambia was 9.78 million in 1997, 10.8 million in 2002, and 12.16 million in 2007 (see Figure 0.4). During this period, the average growth rate was 2.2 % per annum over the past ten years and 2.4% per annum over the past five years.

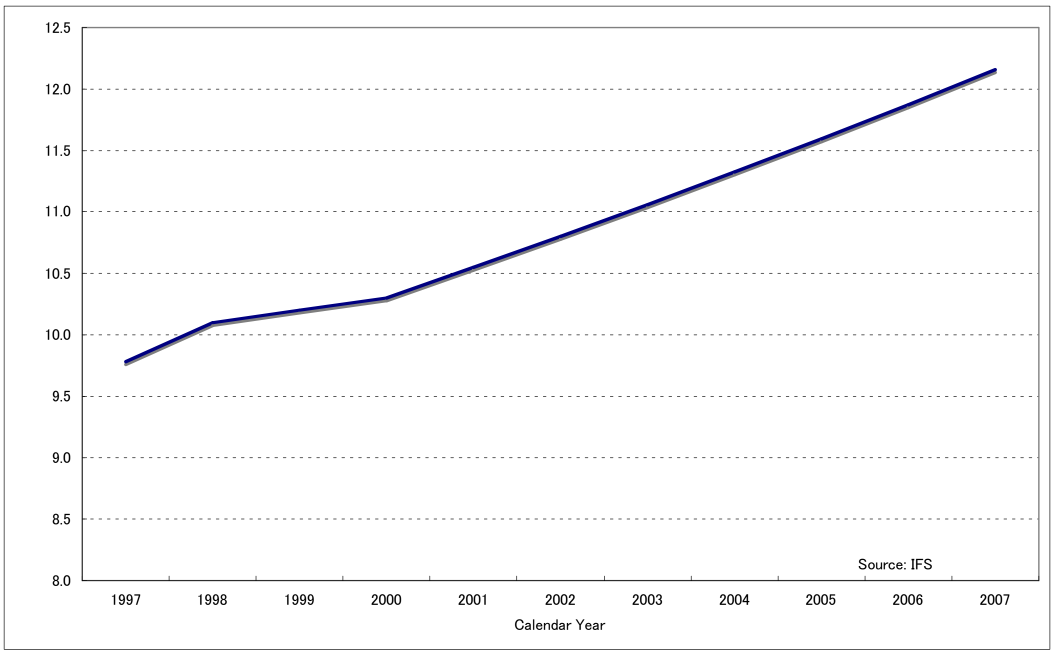

Figure 0.4 Trend of Population Growth (1997 – 2007)

Electrification ratio

The overwhelming majority of the customers are in the residential-and-commercial sector. In fiscal 2005, the customers in this sector accounted for 93% of total number of contracts (see Figure 0.5).

An increase in the electrification ratio translates into one in the number of customers. The rate of increase in the number of customers reached more than 10% per annum in the second half of the 1990s, but has slowed since 2000. The rate of increase in the number of customers in the residential and commercial sector, which is the major target of electrification, averaged around 4% per annum between fiscal 2003 and 2007, when macroeconomic conditions stabilized (see Figure 5.6).

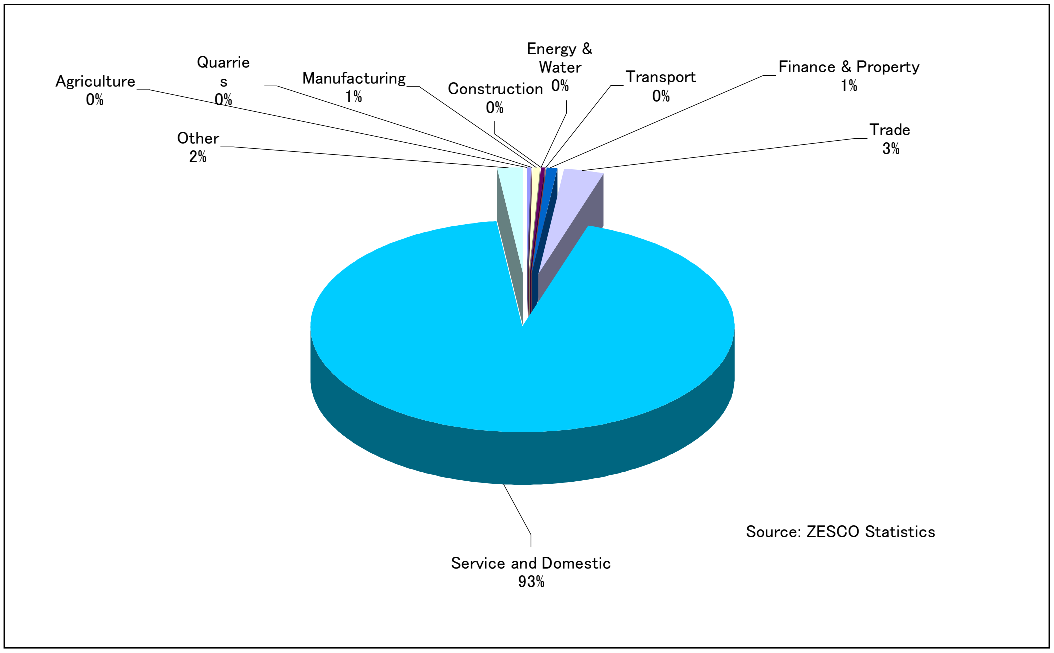

Figure 0.5 Breakdown of the Number of Customers (Fiscal 2005)

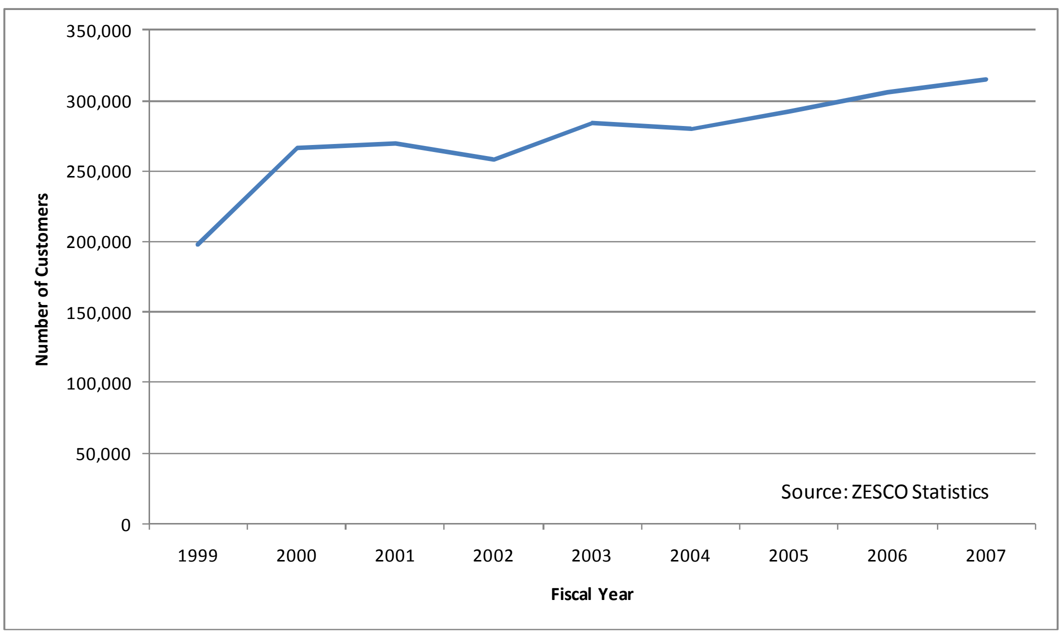

Figure 0.6 Trend of the Number of Customers (Fiscal 1999 – 2007)

Forecast scenarios

Based on differences in respect of macro-economic conditions, population growth, and customer increase rate, we drafted three scenarios: base, high, and low cases (see Table 0.6).

Table 0.6 Forecast Scenarios

Base case	● The prevailing resection will continue until the end of fiscal 2011, but economy will recover beginning in fiscal 2012 and grow at a rate of 6% per annum, on a per with that achieved in the first half of the 2000s. ● The number of customers will increase at a rate of 4% per annum.
High case	● The economy will recover in fiscal 2011, i.e., one year earlier than in the base case, and continue to grow at a rate of 7% per annum. ● The number of customers will increase at a rate of 6% per annum.
Low case	● The economy will recover in fiscal 2013, i.e., one year later than in the base case, and continue to grow at a rate of 5% per annum. ● The number of customers will increase at a rate of 3.5% per annum.

(Source) JICA Study Team.

Premises are detailed in Table 5.7**.** With regard to the future macroeconomic outlook, for another one or two years, GDP growth in Zambia will probably decline due to the effects of the international financial crisis. During this period of economic downturn, we put the growth rate at 4.5% p.a. quoting forecasts of international institutions. After recovery from the global recession, GDP growth is assumed to be 6% p.a., which is equivalent to the actual growth rate from the mid 2000s to just before the financial crisis, in the base-case scenario, and 7% p.a.ð i.e., the target figure in the governmentõs economic development planð in the high-case scenario. The 5 % p.a. rate in the low-case scenario is the same level of economic growth, which the country experienced during the early 2000s.

Population growth is forecast at 2.3% p.a. following the historical trend. The electrification rate is forecast to increase at the rate of 4% p.a. equivalent to that of increase in the number of customers in the residential and commercial sector for the past five years, in the base-case scenario, 6% p.a. in the high-case scenario, and 3.5% p.a. in the low-case scenario.

Table 0.7 Premises of Each Scenario

	Base case	High case	Low case
Economic growth (GDP)	Fiscal 2008-11: 4.5% p.a. Beginning in fiscal 2012: 6% p.a.	Fiscal 2008-10: 4.5% p.a. Beginning in fiscal 2011: 7% p.a.	Fiscal 2008-12: 4.5% p.a. Beginning in fiscal 2013: 5% p.a.
Population growth	2.3% p.a.	2.3% p.a.	2.3% p.a.
Growth of electrification ratio	4% p.a.	6% p.a.	3.5% p.a.

(Source) JICA Study Team.

Forecast Results

Fiscal year basis

In the base case, the energy demand of 8.1 billion kWh (8.1TWh) in fiscal 2007 will increase to 16.6 billion kWh (16.6TWh) in fiscal 2020 and 21.6 billion kWh (21.6TWh) in fiscal 2030 (see Figure 0.7).

The average growth rates in this case are 5.7% per annum for the thirteen years between fiscal 2007 and 2020, and 4.4% per annum for the twenty-three years up to fiscal 2030. It may be noted that the growth rate during the fiscal 1999 - 2007 period was 4.1% per annum.

In the high case, energy demand will amounted to 19.9 billion kWh (19.9TWh) in fiscal 2020 and 28.5 billion kWh (28.5TWh) in fiscal 2030 (see Figure 0.8). The average growth rates are 7.1% per annum for the thirteen years between fiscal 2007 and 2020 , and 5.6% per annum for the twenty-three years up to fiscal 2030.

In the low case, energy demand will amount to 15.9 billion kWh (15.9TWh) in fiscal 2020 and 19.4 billion kWh (19.4TWh) in fiscal 2030 (see Figure5.8). The average growth rates are 5.3% per annum for the thirteen years between fiscal 2007 and 2020, and 3.9% per annum for the twenty-three years up to fiscal 2030.

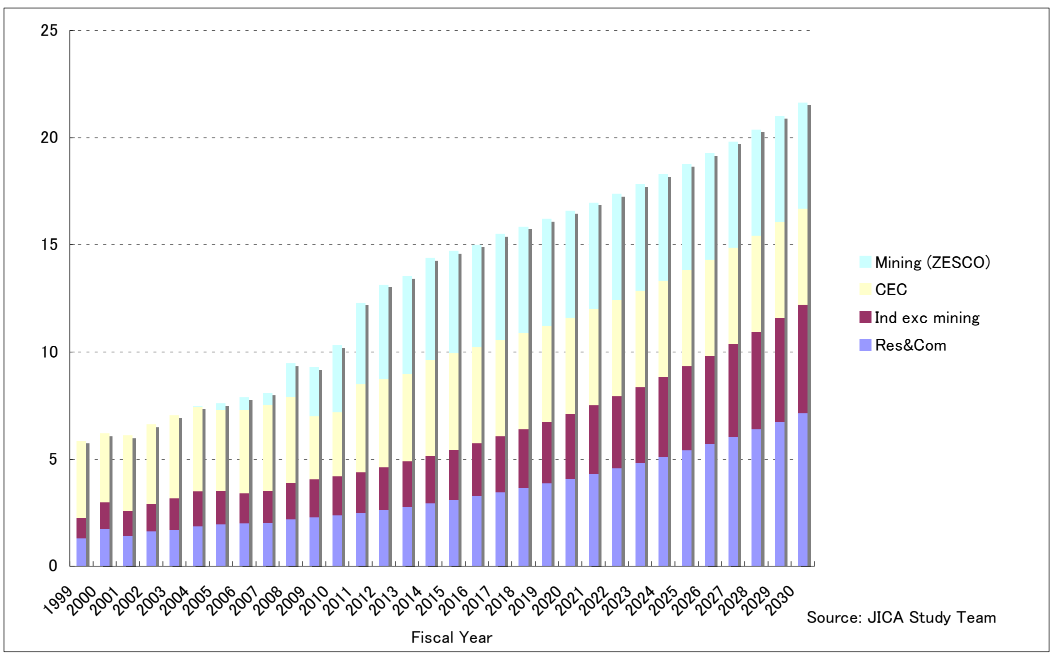

Figure 0.7 Energy Demand Forecast (Base case)

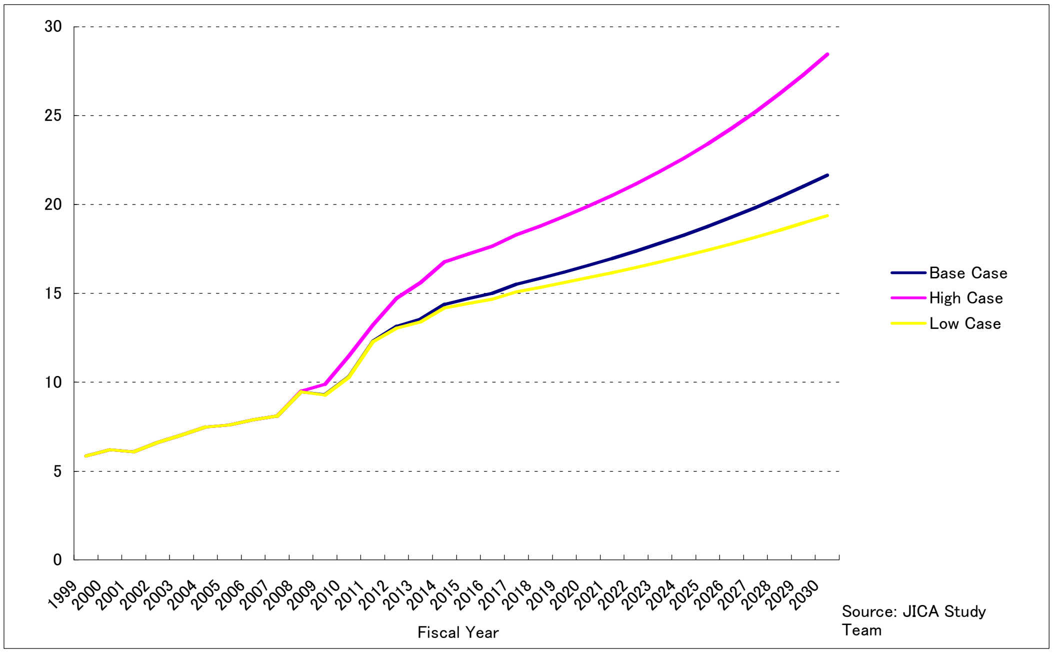

Figure 0.8 Comparison of Demand in Different Scenarios

Calendar year basis

The forecast presented above is based on fiscal year used for the ZESCO accenting system, which starts on April 1 and ends on March 31 of the following year. Table 5.8 shows the energy demand forecast upon conversion to the calendar year. In making the conversion, we estimated the calendar-year figure by adding one quarter of the forecast for the previous fiscal year to the three quarters of the forecast for the current fiscal year.

Table 0.8 Energy Demand Forecast (Converted to Calendar Year Basis)

Base case (Unit: kWh)

CY	Res&Com	Ind exc mining	Total of retail	CEC	Mining (ZESCO)	Total
2000	1,629,072,929	1,175,852,048	2,804,924,977	3,312,212,000		6,117,136,977
2001	1,507,322,656	1,172,260,123	2,679,582,779	3,443,413,500		6,122,996,279
2002	1,579,610,076	1,246,875,567	2,826,485,643	3,660,052,250		6,486,537,893
2003	1,688,147,151	1,415,512,198	3,103,659,350	3,829,437,000		6,933,096,350
2004	1,813,022,270	1,619,230,907	3,432,253,177	3,916,487,750	14,747,696	7,363,488,623
2005	1,926,903,679	1,589,973,480	3,516,877,159	3,840,055,750	216,134,408	7,573,067,316
2006	1,993,688,478	1,427,315,925	3,421,004,403	3,905,190,000	491,533,721	7,817,728,124
2007	2,018,606,842	1,470,686,530	3,489,293,373	4,002,272,450	561,503,402	8,053,069,225
2008	2,144,524,320	1,656,848,994	3,801,373,314	4,023,993,600	1,300,332,752	9,125,699,666
2009	2,256,037,522	1,759,372,643	4,015,410,165	3,206,619,900	2,121,812,702	9,343,842,767
2010	2,353,508,331	1,828,411,616	4,181,919,947	2,957,025,600	2,914,997,852	10,053,943,399
2011	2,455,190,310	1,900,159,725	4,355,350,035	3,816,315,900	3,629,255,402	11,800,921,337
2012	2,587,550,366	1,993,473,416	4,581,023,782	4,100,205,600	4,247,273,402	12,928,502,784
2013	2,735,897,564	2,097,678,977	4,833,576,541	4,100,205,600	4,507,883,402	13,441,665,543
2014	2,892,749,675	2,207,331,714	5,100,081,389	4,386,000,600	4,684,725,902	14,170,807,891
2015	3,058,594,295	2,322,716,368	5,381,310,664	4,481,265,600	4,759,185,902	14,621,762,166
2016	3,233,946,976	2,444,132,567	5,678,079,542	4,481,265,600	4,768,493,402	14,927,838,544
2017	3,419,352,825	2,571,895,598	5,991,248,423	4,481,265,600	4,908,105,902	15,380,619,925
2018	3,615,388,201	2,706,337,233	6,321,725,434	4,481,265,600	4,954,643,402	15,757,634,436
2019	3,822,662,508	2,847,806,584	6,670,469,092	4,481,265,600	4,954,643,402	16,106,378,094
2020	4,041,820,086	2,996,671,014	7,038,491,100	4,481,265,600	4,954,643,402	16,474,400,102
2021	4,273,542,217	3,153,317,089	7,426,859,306	4,481,265,600	4,954,643,402	16,862,768,308
2022	4,518,549,241	3,318,151,581	7,836,700,821	4,481,265,600	4,954,643,402	17,272,609,823
2023	4,777,602,794	3,491,602,526	8,269,205,320	4,481,265,600	4,954,643,402	17,705,114,322
2024	5,051,508,183	3,674,120,336	8,725,628,518	4,481,265,600	4,954,643,402	18,161,537,520
2025	5,341,116,877	3,866,178,965	9,207,295,843	4,481,265,600	4,954,643,402	18,643,204,845
2026	5,647,329,167	4,068,277,146	9,715,606,313	4,481,265,600	4,954,643,402	19,151,515,315
2027	5,971,096,955	4,280,939,678	10,252,036,632	4,481,265,600	4,954,643,402	19,687,945,634
2028	6,313,426,717	4,504,718,796	10,818,145,512	4,481,265,600	4,954,643,402	20,254,054,514
2029	6,675,382,633	4,740,195,601	11,415,578,234	4,481,265,600	4,954,643,402	20,851,487,236
2030	7,058,089,892	4,987,981,571	12,046,071,463	4,481,265,600	4,954,643,402	21,481,980,465

High Case

CY	Res&Com	Ind exc mining	Total of retail	CEC	Mining (ZESCO)	Total
2000	1,629,072,929	1,175,852,048	2,804,924,977	3,312,212,000		6,117,136,977
2001	1,507,322,656	1,172,260,123	2,679,582,779	3,443,413,500		6,122,996,279
2002	1,579,610,076	1,246,875,567	2,826,485,643	3,660,052,250		6,486,537,893
2003	1,688,147,151	1,415,512,198	3,103,659,350	3,829,437,000		6,933,096,350
2004	1,813,022,270	1,619,230,907	3,432,253,177	3,916,487,750	14,747,696	7,363,488,623
2005	1,926,903,679	1,589,973,480	3,516,877,159	3,840,055,750	216,134,408	7,573,067,316
2006	1,993,688,478	1,427,315,925	3,421,004,403	3,905,190,000	491,533,721	7,817,728,124
2007	2,018,606,842	1,470,686,530	3,489,293,373	4,002,272,450	561,503,402	8,053,069,225
2008	2,162,303,296	1,656,848,994	3,819,152,290	4,023,993,600	1,300,332,752	9,143,478,642
2009	2,299,259,258	1,759,372,643	4,058,631,901	3,606,732,900	2,121,812,702	9,787,177,503
2010	2,424,617,355	1,828,411,616	4,253,028,972	3,913,486,200	2,914,997,852	11,081,513,024
2011	2,600,644,481	1,930,212,152	4,530,856,633	4,627,973,700	3,629,255,402	12,788,085,735
2012	2,804,313,127	2,047,856,549	4,852,169,676	5,245,290,900	4,247,273,402	14,344,733,978
2013	3,023,932,019	2,172,671,248	5,196,603,266	5,673,983,400	4,507,883,402	15,378,470,068
2014	3,260,750,294	2,305,093,271	5,565,843,565	6,226,520,400	4,684,725,902	16,477,089,867
2015	3,516,114,917	2,445,586,277	5,961,701,194	6,378,944,400	4,759,185,902	17,099,831,496
2016	3,791,478,339	2,594,642,184	6,386,120,523	6,378,944,400	4,768,493,402	17,533,558,325
2017	4,088,406,760	2,752,782,891	6,841,189,651	6,378,944,400	4,908,105,902	18,128,239,953
2018	4,408,589,036	2,920,562,108	7,329,151,144	6,378,944,400	4,954,643,402	18,662,738,946
2019	4,753,846,286	3,098,567,291	7,852,413,577	6,378,944,400	4,954,643,402	19,186,001,379
2020	5,126,142,247	3,287,421,703	8,413,563,950	6,378,944,400	4,954,643,402	19,747,151,752
2021	5,527,594,448	3,487,786,592	9,015,381,040	6,378,944,400	4,954,643,402	20,348,968,842
2022	5,960,486,251	3,700,363,509	9,660,849,760	6,378,944,400	4,954,643,402	20,994,437,562
2023	6,427,279,837	3,925,896,766	10,353,176,604	6,378,944,400	4,954,643,402	21,686,764,406
2024	6,930,630,215	4,165,176,038	11,095,806,253	6,378,944,400	4,954,643,402	22,429,394,055
2025	7,473,400,318	4,419,039,129	11,892,439,447	6,378,944,400	4,954,643,402	23,226,027,249
2026	8,058,677,289	4,688,374,907	12,747,052,196	6,378,944,400	4,954,643,402	24,080,639,998
2027	8,689,790,040	4,974,126,418	13,663,916,458	6,378,944,400	4,954,643,402	24,997,504,260
2028	9,370,328,186	5,277,294,182	14,647,622,368	6,378,944,400	4,954,643,402	25,981,210,170
2029	10,104,162,460	5,598,939,702	15,703,102,162	6,378,944,400	4,954,643,402	27,036,689,964
2030	10,895,466,732	5,940,189,177	16,835,655,909	6,378,944,400	4,954,643,402	28,169,243,711

Low Case

CY	Res&Com	Ind exc mining	Total of retail	CEC	Mining (ZESCO)	Total
2000	1,629,072,929	1,175,852,048	2,804,924,977	3,312,212,000		6,117,136,977
2001	1,507,322,656	1,172,260,123	2,679,582,779	3,443,413,500		6,122,996,279
2002	1,579,610,076	1,246,875,567	2,826,485,643	3,660,052,250		6,486,537,893
2003	1,688,147,151	1,415,512,198	3,103,659,350	3,829,437,000		6,933,096,350
2004	1,813,022,270	1,619,230,907	3,432,253,177	3,916,487,750	14,747,696	7,363,488,623
2005	1,926,903,679	1,589,973,480	3,516,877,159	3,840,055,750	216,134,408	7,573,067,316
2006	1,993,688,478	1,427,315,925	3,421,004,403	3,905,190,000	491,533,721	7,817,728,124
2007	2,018,606,842	1,470,686,530	3,489,293,373	4,002,272,450	561,503,402	8,053,069,225
2008	2,140,056,477	1,656,848,994	3,796,905,470	4,023,993,600	1,300,332,752	9,121,231,822
2009	2,245,239,197	1,759,372,643	4,004,611,840	3,206,619,900	2,121,812,702	9,333,044,442
2010	2,335,858,310	1,828,411,616	4,164,269,926	2,957,025,600	2,914,997,852	10,036,293,378
2011	2,430,134,861	1,900,159,725	4,330,294,586	3,816,315,900	3,629,255,402	11,775,865,888
2012	2,528,216,466	1,974,723,279	4,502,939,745	4,100,205,600	4,247,273,402	12,850,418,747
2013	2,639,250,814	2,058,711,936	4,697,962,750	4,100,205,600	4,507,883,402	13,306,051,752
2014	2,758,169,865	2,148,446,041	4,906,615,906	4,386,000,600	4,684,725,902	13,977,342,408
2015	2,882,447,156	2,242,091,431	5,124,538,587	4,481,265,600	4,759,185,902	14,364,990,089
2016	3,012,324,118	2,339,818,590	5,352,142,708	4,481,265,600	4,768,493,402	14,601,901,710
2017	3,148,053,061	2,441,805,431	5,589,858,492	4,481,265,600	4,908,105,902	14,979,229,994
2018	3,289,897,662	2,548,237,624	5,838,135,286	4,481,265,600	4,954,643,402	15,274,044,288
2019	3,438,133,481	2,659,308,929	6,097,442,410	4,481,265,600	4,954,643,402	15,533,351,412
2020	3,593,048,492	2,775,221,555	6,368,270,047	4,481,265,600	4,954,643,402	15,804,179,049
2021	3,754,943,645	2,896,186,523	6,651,130,168	4,481,265,600	4,954,643,402	16,087,039,170
2022	3,924,133,450	3,022,424,051	6,946,557,501	4,481,265,600	4,954,643,402	16,382,466,503
2023	4,100,946,590	3,154,163,957	7,255,110,547	4,481,265,600	4,954,643,402	16,691,019,549
2024	4,285,726,555	3,291,646,076	7,577,372,632	4,481,265,600	4,954,643,402	17,013,281,634
2025	4,478,832,314	3,435,120,697	7,913,953,012	4,481,265,600	4,954,643,402	17,349,862,014
2026	4,680,639,010	3,584,849,018	8,265,488,028	4,481,265,600	4,954,643,402	17,701,397,030
2027	4,891,538,687	3,741,103,622	8,632,642,310	4,481,265,600	4,954,643,402	18,068,551,312
2028	5,111,941,057	3,904,168,974	9,016,110,031	4,481,265,600	4,954,643,402	18,452,019,033
2029	5,342,274,291	4,074,341,936	9,416,616,228	4,481,265,600	4,954,643,402	18,852,525,230
2030	5,582,985,853	4,251,932,313	9,834,918,166	4,481,265,600	4,954,643,402	19,270,827,168

Source: JICA Study Team.

Peak Demand Forecast Result

Forecast of the peak demand(MW) up to 2030 requires an estimate of the current peak demand to serve as the standard. The peak demand in 2008-09 (including system loss) was sought by the following equation.

$$P_{peak} = (P_{SCADA} + P_{u.d..} + P_{s.d})_t$$

Here, Pscada = the maximum total system load recorded by SCADA

Pud = unmeasured demand

Psd = surprise demand.

(1) Maximum total system load

In examination of the peak demand based on SCADA data, the Pscada was determined with attention to the following points.

- The peak demand in Zambia tends to occur in July.
- The peak demand occurs between 7:00 and 10:00 AM, and 4:00 - 9:00 PM, as shown in the aforementioned daily load curve.

(2) Unmeasured demand

The unmeasured demand is defined as the demand that physically cannot be measured by SCADA. In the case of SCADA, the items falling under this definition are private power generation within the system and the off-grid demand in the northeastern and northern provinces.

A. Private power generation within the system

As shown in ZESCO statistics, the Copperbelt Energy Corporation PLC (CEC) has gas-fired power generation facilities with a combined capacity of 80 MW. The chief purpose of these facilities is to assure the minimum requisite power in times of emergency. CEC also frequently starts up the generatorsfor peak lopping.

In addition, Konkola Copper Mines (KCM) owns gas-fired generation facilities with a combined capacity of 20 MW at Nkana. As in the case of CEC, the purpose is to assure the minimum requisite power in times of emergency.

In light of this situation, the demand met by private generation facilities was estimated at 40 MW[10].

Table 0.9 Private generation facilities in Zambia

Station	Machine type	Installed capacity[MW]	Available capacity[MW]	Owner
Bancroft	Gas turbine	20	20	CEC
Luano	Gas turbine	40	40	CEC
Luanshya	Gas turbine	10	10	CEC
Mufulila	Gas turbine	10	10	CEC
Nkana	Gas turbine	20	20	KCM
Total		100	100	

(Source) Prepared by the Study Team based on ZESCO annual statistics

B. Off-grid demand

In Zambia, the transmission system does not yet cover all of the country, and there are some off-grid systems (also termed independent systems) not connected to the transmission system. The main power sources in these systems are diesel generators and mini hydropower plants.

10 This assumption dose not have precise evidence but we decide to estimate the value equal to the maximum available capacity among the plants because we have to ready for the serious situation.

The diesel power generation facilities are installed mainly in North-West Province and supply power to small-scale local systems.

Table 0.10 shows actual data for their operation over the period in question.

Mini-hydropower facilities consist of the facilities owned by ZESCO in Northern Province (shown in Table 0.11). In an interview, ZESCO stated that, due to problems with them, these facilities cannot be connected to the transmission system and instead supply power to a small-scale local system

In addition, there are some mini hydropower generation facilities owned by private enterprises, such as that at Zengamina (700 kW).

The off-grid demand was estimated to total 10 MW.

Table 0.10 Actual data for operation of diesel generation facilities

Plant Name	Location	Available Capacity [MW]	Demand record（Jul.-Sep.'08）	
			MWh	MW
KABOMPO	North-Western	1.160	437	0.5
ZAMBEZI	North-Western	0.960	419	0.6
MWINILUNGA	North-Western	1.360	564	0.8
CHAVUMA	North-Western	0.800	146	0.2
LUKULU	Western	0.320	371	0.3
LWANGWA	Lusaka	0.732	391	0.3
KAPUTA	Northern	0.550	254	0.3
MUFUMBWE	North-Western	0.400	112	0.3
CHAMA	Eastern	0.263	N/A	0.3
		Total	2694	3.6

(Source)ZESCO annual statistic

Table 0.11 Actual data for operation of mini hydropower generation facilities

Plant Name	Location	Available Capacity [MW]	Demand record（Jul.-Sep.'08）	
			MWh	MW
KABOMPO	North-Western	1.160	437	0.5
ZAMBEZI	North-Western	0.960	419	0.6
MWINILUNGA	North-Western	1.360	564	0.8
CHAVUMA	North-Western	0.800	146	0.2
LUKULU	Western	0.320	371	0.3
LWANGWA	Lusaka	0.732	391	0.3
KAPUTA	Northern	0.550	254	0.3
MUFUMBWE	North-Western	0.400	112	0.3
CHAMA	Eastern	0.263	N/A	0.3
		Total	2694	3.6

(Source)ZESCO annual statistic

(3) Surprise demand

The term "surprise demand" refers to demand that cannot be recorded due to external factors, even though it should be recordable by SCADA. The external factors are planned and unplanned outages.

A. Planned outages (rolling blackout or load shedding)

In the distribution system in Zambia, power is supplied by ZESCO. Planned outages are implemented in order to curtail overload operation of distribution facilities. ZESCO has established a total of four divisions (Lusaka, Southern, Northern, and Copperbelt) for operation and management of the distribution system. The Study Team surveyed the situation as regards planned outages at each division.

a. ZESCO Lusaka Division

The Lusaka Division has a power demand that is from two to three times as high as those in other divisions. It includes supply to Lusaka towns in its vicinity (such as Kafue and Mazabuka), and the area extending to Kabwe in Central Province. The division compiles daily data.

Table 5.12 presents data on planned outages in the area under the jurisdiction of the ZESCO Lusaka Division.

Table 0.12 Data on planned outages in the distribution system in 2008 in the Lusaka Division area

Month	Load Shedding (MWh)	Ref.:' Total System Load' given by SCADA(MWh)
Jan.	5168.8	756826.9
Feb.	9244.3	733901.4
Mar.	8748.1	803343
Apr.	11834.8	782262.8
May	8216.2	858510.9
Jun.	7868.4	884268
Jul.	12048.4	929060.7
Aug.	10878.2	859046
Sep.	10298.3	805556.7
Oct.	5803.5	853900.5
Nov.	2819.2	816993.9
Dec.	1128.9	832338.7

b. ZESCO Southern Division

The Southern Division is in charge of the area centered around Livingstone, Sesheke and Kasane, which are points of interconnection with Namibia and Botswana; and the vicinity of

Muzuma. Table 0.13 and Table 0.14 show these schedules for planned outages for the Southern Division.

Table 0.13 Schedule for planned distribution system outages in the Livingstone area

Day of the week	Term	Max demand [MW]
Monday	5:30-9:00	1.2
	17:00-21:00	5.0
Tuesday	5:30-9:00	0.0
	17:00-21:00	5.0
Wednesday	5:30-9:00	0.5
	17:00-21:00	3.0
Thursday	5:30-9:00	1.2
	17:00-21:00	6.5
Friday	5:30-9:00	0.5
	17:00-21:00	5.0
Saturday	5:30-9:00	0.0
	17:00-21:00	5.0
Sunday	5:30-9:00	1.7
	17:00-21:00	3.0

Table 0.14 Schedule for planned distribution system outages in the Choma area

Day of the week	Term	Max demand [MW]
Monday	5:30-9:00	5.0
	18:00-21:00	4.0
Tuesday	5:30-9:00	3.0
	18:00-21:00	4.0
Wednesday	5:30-9:00	4.0
	18:00-21:00	8.0
Thursday	5:30-9:00	4.0
	18:00-21:00	5.0
Friday	5:30-9:00	5.0
	18:00-21:00	5.0
Saturday	5:30-9:00	2.0
	18:00-21:00	4.0
Sunday	5:30-9:00	2.0
	17:00-21:00	5.0

c. ZESCO Copperbelt and Northern divisions

The ZESCO Copperbelt Division is based in Kitwe, the hub of the copper mining industry, and covers Kalulushi, Mufulira, Chingola, and Chililabombwe.

The information from the Copperbelt Division is a list of load shedding due to frequency fluctuation, not actual data on planned outages as received from the other divisions. Because planned outages are made in the major cities of Lusaka and Livingstone, it is thought that the Copperbelt Division also makes them.

Table 0.15 List of load shedding at the Copperbelt Division

Frequency threshold	Amount of Load shedding(MW)
48.75Hz -	5
48.50Hz -	7.5
48.00Hz -	5.0
47.75Hz -	7.5
Total	25.0

(Source) Prepared by the Study Team based on information obtained from ZESCO

The ZESCO Northern Division, which is based in Ndola, a major city alongside Kitwe, also disclosed its schedule for planned outages. However, there were no details of the demand volume, and the Division is planning a series of rotating outages in the northern and southern areas under its jurisdiction between 18:30 and 20:30. The amount of outage during the week is estimated at 25 MW.

The combined amount of planned outage in these divisions is estimated at 60 MW.In sum, the peak demand in fiscal 2008-09 (including system loss) was put at 1,600 MW.

Table 0.16 Calculation of peak demand to serve as the standard

Attribute	Load (MW)
P_{SCADA}	1512
$P_{u.d..}$	50
$P_{s.d}$	60
P_{peak}	1600

The Study Team made forecasts for the peak demand(MW) in each of three cases: base case, high case, and low case. The results are shown in tables Table 0.17 -Table 0.19 and Figure 0.9**.**

In the base case, the peak demand in fiscal 2030 is forecast at 4,066 MW, about 2.5 times as high as that of 1,600 MW in fiscal 2008 (for an average increase rate of 4.3 percent). Similarly, it was forecast at 5,406 MW, about 3.4 times as high (for an average increase rate of 5.7 percent) in the high case and 3,544 MW, about 2.2 times as high (for an average increase rate of 3.7 percent) in the low case.

Table 0.17 Peak Demand Forecast Result (Base Case Scenario)

(Base Case Senario)

Term	Total Consumption at Customers (GWh)	Peak Demand (MW)														
		CEC				Mining(Zesco)				Retail				Coincident Factor	Total (MW)	Load Factor
		GWh	Loss	LF	MW	GWh	Loss	LF	MW	GWh	Loss	LF	MW			
2008-09	9,242	4,024	3.2%	0.91	521	1,323	3.2%	0.61	256	3,894	24.4%	0.55	1,000	0.90	1,600	0.74
2009-10	9,006	2,934	3.2%	0.91	380	2,016	3.2%	0.61	390	4,056	24.4%	0.55	1,041	0.90	1,631	0.71
2010-11	9,932	2,965	3.2%	0.91	384	2,743	3.2%	0.61	531	4,224	24.4%	0.55	1,084	0.90	1,801	0.71
2011-12	11,853	4,100	3.2%	0.91	531	3,354	3.2%	0.61	649	4,399	24.4%	0.55	1,129	0.90	2,080	0.72
2012-13	12,542	4,100	3.2%	0.91	531	3,801	3.2%	0.61	735	4,642	24.4%	0.55	1,191	0.90	2,214	0.72
2013-14	12,947	4,100	3.2%	0.91	531	3,949	3.2%	0.61	764	4,898	24.4%	0.55	1,257	0.90	2,299	0.72
2014-15	13,784	4,481	3.2%	0.91	580	4,136	3.2%	0.61	800	5,168	24.4%	0.55	1,326	0.90	2,438	0.72
2015-16	14,069	4,481	3.2%	0.91	580	4,136	3.2%	0.61	800	5,453	24.4%	0.55	1,399	0.90	2,504	0.71
2016-17	14,370	4,481	3.2%	0.91	580	4,136	3.2%	0.61	800	5,753	24.4%	0.55	1,477	0.90	2,574	0.71
2017-18	14,687	4,481	3.2%	0.91	580	4,136	3.2%	0.61	800	6,071	24.4%	0.55	1,558	0.90	2,647	0.71
2018-19	15,022	4,481	3.2%	0.91	580	4,136	3.2%	0.61	800	6,405	24.4%	0.55	1,644	0.90	2,725	0.71
2019-20	15,376	4,481	3.2%	0.91	580	4,136	3.2%	0.61	800	6,759	24.4%	0.55	1,735	0.90	2,806	0.70
2020-21	15,749	4,481	3.2%	0.91	580	4,136	3.2%	0.61	800	7,132	24.4%	0.55	1,830	0.90	2,893	0.70
2021-22	16,142	4,481	3.2%	0.91	580	4,136	3.2%	0.61	800	7,525	24.4%	0.55	1,931	0.90	2,984	0.70
2022-23	16,557	4,481	3.2%	0.91	580	4,136	3.2%	0.61	800	7,941	24.4%	0.55	2,038	0.90	3,080	0.70
2023-24	16,996	4,481	3.2%	0.91	580	4,136	3.2%	0.61	800	8,379	24.4%	0.55	2,151	0.90	3,181	0.69
2024-25	17,458	4,481	3.2%	0.91	580	4,136	3.2%	0.61	800	8,841	24.4%	0.55	2,269	0.90	3,288	0.69
2025-26	17,946	4,481	3.2%	0.91	580	4,136	3.2%	0.61	800	9,329	24.4%	0.55	2,394	0.90	3,401	0.69
2026-27	18,461	4,481	3.2%	0.91	580	4,136	3.2%	0.61	800	9,844	24.4%	0.55	2,527	0.90	3,520	0.69
2027-28	19,005	4,481	3.2%	0.91	580	4,136	3.2%	0.61	800	10,388	24.4%	0.55	2,666	0.90	3,646	0.68
2028-29	19,578	4,481	3.2%	0.91	580	4,136	3.2%	0.61	800	10,962	24.4%	0.55	2,813	0.90	3,778	0.68
2029-30	20,184	4,481	3.2%	0.91	580	4,136	3.2%	0.61	800	11,567	24.4%	0.55	2,969	0.90	3,918	0.68
2030-31	20,823	4,481	3.2%	0.91	580	4,136	3.2%	0.61	800	12,206	24.4%	0.55	3,133	0.90	4,066	0.68

Table 0.18 Peak Demand Forecast (High Case Scenario)

(High Case Senario)

Term	Total Consumption at Customers (GWh)	Peak Demand (MW)														
		CEC				Mining(Zesco)				Retail				Coincident Factor	Total (MW)	Load Factor
		GWh	Loss	LF	MW	GWh	Loss	LF	MW	GWh	Loss	LF	MW			
2008-09	9,265	4,024	3.2%	0.91	521	1,323	3.2%	0.61	256	3,918	24.4%	0.55	1,006	0.90	1,600	0.74
2009-10	9,589	3,468	3.2%	0.91	449	2,016	3.2%	0.61	390	4,106	24.4%	0.55	1,054	0.90	1,699	0.72
2010-11	11,107	4,062	3.2%	0.91	526	2,743	3.2%	0.61	531	4,302	24.4%	0.55	1,104	0.90	1,940	0.73
2011-12	12,777	4,817	3.2%	0.91	623	3,354	3.2%	0.61	649	4,607	24.4%	0.55	1,182	0.90	2,204	0.73
2012-13	14,123	5,388	3.2%	0.91	697	3,801	3.2%	0.61	735	4,934	24.4%	0.55	1,266	0.90	2,423	0.74
2013-14	15,003	5,769	3.2%	0.91	747	3,949	3.2%	0.61	764	5,284	24.4%	0.55	1,356	0.90	2,574	0.74
2014-15	16,174	6,379	3.2%	0.91	826	4,136	3.2%	0.61	800	5,660	24.4%	0.55	1,453	0.90	2,764	0.74
2015-16	16,577	6,379	3.2%	0.91	826	4,136	3.2%	0.61	800	6,062	24.4%	0.55	1,556	0.90	2,857	0.74
2016-17	17,009	6,379	3.2%	0.91	826	4,136	3.2%	0.61	800	6,494	24.4%	0.55	1,667	0.90	2,956	0.73
2017-18	17,471	6,379	3.2%	0.91	826	4,136	3.2%	0.61	800	6,957	24.4%	0.55	1,786	0.90	3,063	0.73
2018-19	17,968	6,379	3.2%	0.91	826	4,136	3.2%	0.61	800	7,453	24.4%	0.55	1,913	0.90	3,177	0.72
2019-20	18,500	6,379	3.2%	0.91	826	4,136	3.2%	0.61	800	7,985	24.4%	0.55	2,050	0.90	3,300	0.72
2020-21	19,071	6,379	3.2%	0.91	826	4,136	3.2%	0.61	800	8,556	24.4%	0.55	2,196	0.90	3,432	0.72
2021-22	19,683	6,379	3.2%	0.91	826	4,136	3.2%	0.61	800	9,168	24.4%	0.55	2,353	0.90	3,573	0.71
2022-23	20,340	6,379	3.2%	0.91	826	4,136	3.2%	0.61	800	9,825	24.4%	0.55	2,522	0.90	3,724	0.71
2023-24	21,044	6,379	3.2%	0.91	826	4,136	3.2%	0.61	800	10,529	24.4%	0.55	2,702	0.90	3,886	0.70
2024-25	21,799	6,379	3.2%	0.91	826	4,136	3.2%	0.61	800	11,285	24.4%	0.55	2,896	0.90	4,060	0.70
2025-26	22,610	6,379	3.2%	0.91	826	4,136	3.2%	0.61	800	12,095	24.4%	0.55	3,104	0.90	4,247	0.70
2026-27	23,479	6,379	3.2%	0.91	826	4,136	3.2%	0.61	800	12,964	24.4%	0.55	3,327	0.90	4,447	0.69
2027-28	24,412	6,379	3.2%	0.91	826	4,136	3.2%	0.61	800	13,897	24.4%	0.55	3,567	0.90	4,662	0.69
2028-29	25,412	6,379	3.2%	0.91	826	4,136	3.2%	0.61	800	14,898	24.4%	0.55	3,824	0.90	4,893	0.69
2029-30	26,486	6,379	3.2%	0.91	826	4,136	3.2%	0.61	800	15,972	24.4%	0.55	4,099	0.90	5,140	0.68
2030-31	27,638	6,379	3.2%	0.91	826	4,136	3.2%	0.61	800	17,124	24.4%	0.55	4,395	0.90	5,406	0.68

Table 0.19 Peak Demand Forecast (Low Case Scenario)

(LowCase Senario)

Term	Total Consumption at Customers (GWh)	Peak Demand (MW)														
		CEC				Mining(Zesco)				Retail				Coincident Factor	Total (MW)	Load Factor
		GWh	Loss	LF	MW	GWh	Loss	LF	MW	GWh	Loss	LF	MW			
2008-09	9,236	4,024	3.2%	0.91	521	1,323	3.2%	0.61	256	3,888	24.4%	0.55	998	0.90	1,600	0.74
2009-10	8,993	2,934	3.2%	0.91	380	2,016	3.2%	0.61	390	4,043	24.4%	0.55	1,038	0.90	1,629	0.71
2010-11	9,912	2,965	3.2%	0.91	384	2,743	3.2%	0.61	531	4,205	24.4%	0.55	1,079	0.90	1,797	0.71
2011-12	11,826	4,100	3.2%	0.91	531	3,354	3.2%	0.61	649	4,372	24.4%	0.55	1,122	0.90	2,075	0.72
2012-13	12,447	4,100	3.2%	0.91	531	3,801	3.2%	0.61	735	4,547	24.4%	0.55	1,167	0.90	2,193	0.72
2013-14	12,798	4,100	3.2%	0.91	531	3,949	3.2%	0.61	764	4,748	24.4%	0.55	1,219	0.90	2,266	0.72
2014-15	13,576	4,481	3.2%	0.91	580	4,136	3.2%	0.61	800	4,959	24.4%	0.55	1,273	0.90	2,392	0.72
2015-16	13,796	4,481	3.2%	0.91	580	4,136	3.2%	0.61	800	5,180	24.4%	0.55	1,329	0.90	2,443	0.72
2016-17	14,027	4,481	3.2%	0.91	580	4,136	3.2%	0.61	800	5,410	24.4%	0.55	1,388	0.90	2,496	0.71
2017-18	14,267	4,481	3.2%	0.91	580	4,136	3.2%	0.61	800	5,650	24.4%	0.55	1,450	0.90	2,551	0.71
2018-19	14,518	4,481	3.2%	0.91	580	4,136	3.2%	0.61	800	5,901	24.4%	0.55	1,515	0.90	2,609	0.71
2019-20	14,780	4,481	3.2%	0.91	580	4,136	3.2%	0.61	800	6,163	24.4%	0.55	1,582	0.90	2,670	0.71
2020-21	15,054	4,481	3.2%	0.91	580	4,136	3.2%	0.61	800	6,437	24.4%	0.55	1,652	0.90	2,733	0.71
2021-22	15,339	4,481	3.2%	0.91	580	4,136	3.2%	0.61	800	6,723	24.4%	0.55	1,725	0.90	2,800	0.70
2022-23	15,638	4,481	3.2%	0.91	580	4,136	3.2%	0.61	800	7,021	24.4%	0.55	1,802	0.90	2,869	0.70
2023-24	15,950	4,481	3.2%	0.91	580	4,136	3.2%	0.61	800	7,333	24.4%	0.55	1,882	0.90	2,941	0.70
2024-25	16,276	4,481	3.2%	0.91	580	4,136	3.2%	0.61	800	7,659	24.4%	0.55	1,966	0.90	3,016	0.70
2025-26	16,616	4,481	3.2%	0.91	580	4,136	3.2%	0.61	800	7,999	24.4%	0.55	2,053	0.90	3,095	0.70
2026-27	16,971	4,481	3.2%	0.91	580	4,136	3.2%	0.61	800	8,354	24.4%	0.55	2,144	0.90	3,177	0.69
2027-28	17,342	4,481	3.2%	0.91	580	4,136	3.2%	0.61	800	8,725	24.4%	0.55	2,239	0.90	3,263	0.69
2028-29	17,730	4,481	3.2%	0.91	580	4,136	3.2%	0.61	800	9,113	24.4%	0.55	2,339	0.90	3,353	0.69
2029-30	18,135	4,481	3.2%	0.91	580	4,136	3.2%	0.61	800	9,518	24.4%	0.55	2,443	0.90	3,446	0.69
2030-31	18,557	4,481	3.2%	0.91	580	4,136	3.2%	0.61	800	9,941	24.4%	0.55	2,551	0.90	3,544	0.68

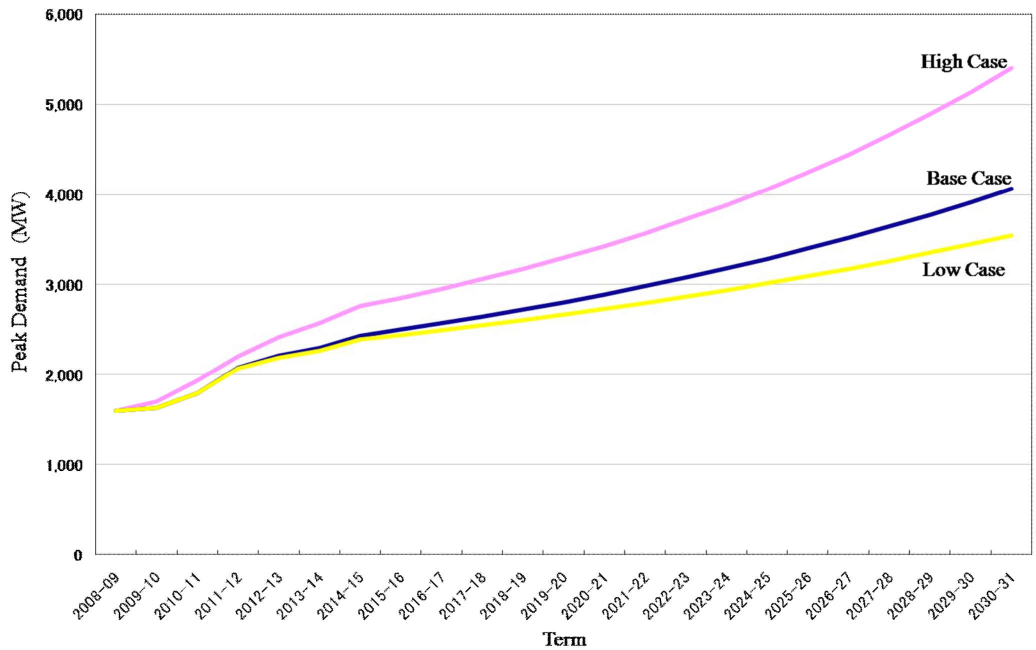

Figure 0.9 Peak Demand Forecast

Reference

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Generation Development Planning

Generation Development Situation

Existing power development plan

There has been no additional generation development in Zambia since 1970s when the construction of the existing hydropower plants was completed. In recent years, however, there have finally emerged practical signs of development to meet the demand growth.

According to the government office OPPPI to promote private power investment, projects shown in Table 0.1 are listed as candidates in Zambia.

13 projects except Maamba coal thermal are hydropower development, and have about 5,360 MW capacity in total.

Table 0.1 Generation Projects List by OPPPI

No.	Project	Capacity (MW)	Project sponsor	Current status (as of Dec '08)
1	Kariba North extension	360	ZESCO	Under construction
2	Batoka Gorge	800	n/a	Pre-F/S completed
3	Devilôs Gorge	800	n/a	n/a
4	Mpata Gorge	600	n/a	n/a
5	Kafue Gorge Lower	750	n/a	Under F/S
6	Itezhi Tezhi	120	ZESCO/TATA	Under D/D
7	Mumbotuta Falls	301	n/a	n/a
8	Mambilima Falls (5 PSôs)	1,100	n/a	n/a
9	Kalungwishi	218	Lunzua Power Authority	Under negotiation on I/A
10	Kabompo Gorge	34	CEC/TATA	Under F/S
11	Lusiwasi extension	62	ZESCO or Private	Under F/S
12	Mutinondo/ Luchenene	40 30	Power Min	Under negotiation on I/A
13	Lunsemfwa/ Mkushi Rivers	147	Lunsemfwa Hydro	Under F/S
14	Maamba coal	n/a	n/a	n/a
Total		**5,362**		

(Source) Assembled by the Study Team hearing from OPPPI

The SAPP generation development plan supported by the World Bank, listed six generation projects with the total capacity 2,390 MW up to 2030 in Zambia, indicated in Table 0.2. Among them, Kariba North and Kafue Gorge projects are planned to raise their capacities as a part of ongoing power rehabilitation projects, and expected to complete in 2009. Therefore, additional power capacity after 2010 comes to 2,030 MW, which may meet the base case power demand, but miss the high case one by 1,000 MW, indicated in Section 5.4.

Table 0.2 Generation Projects List by SAPP

	Project Name	Type	Capacity Added (MW)	Operating Year
1	Kariba North Refurbishment	Hydro	210	2008-2009
2	Kafue Gorge Upper Refurbishment	Hydro	150	2009
3	Kariba North Extension	Hydro	360	2012
4	Itezhi-Tezhi	Hydro	120	2013
5	Kafue Gorge Lower	Hydro	750	2017
6	Batoka Gorge	Hydro	800	2017
Total			**2,390**	

(Source) SAPP Regional Generation and Transmission Expansion Plan Study (Draft Final Report (interim), May 2008) and Interview by JICA Study Team

In addition, five projects shown in Table 0.3 are nominated as immediate future projects in the latest annual report (2008) of ZESCO. Among them, ZESCO is the developer of the rehabilitation of the existing power stations; Kafue Gorge and Kariba North. However, as for Kafue Gorge Lower and Maamba, the developers are not yet decided and, the developer of Kabompo is the joint venture of private CEC and TATA, according to Table 0.1.

Table 0.3 Generation Projects List by ZESCO

	Project	Type	Capacity (MW)	Expected date	Expected project cost (US$ million)
1	Kafue Gorge Rehabilitation	Hydro	60	2008	
2	Kariba North Rehabilitation	Hydro	30	2008	
3	Kafue Gorge Lower	Hydro	750	2012	600
4	Kabompo	Hydro	34	2012	--
5	Maamba	Coal Thermal	500	2014	192
Total			**1,374**		

(Source) ZESCO Annual Report, 2008

As mentioned above, there are some project lists gathered by different organizations, which enough covers the power demand up to 2030. On the other hand, project details such as commercial operation years and installed capacities are not consistent with each other. Therefore, the Study Team summarized the latest progress and specification of the projects listed in Table 0.1, Table 0.2 and Table 0.3 in the following part, scanning the existing information such as the F/S reports and hearing from the relevant government organizations and developers.

Current status of generation projects

Rehabilitation of existing power stations

The existing three major power stations (Victorial Falls, Kariba North Bank and Kafue Gorge) were built before the 1970s. At all of the existing power stations, facility reliability has degraded substantially due to aging. In response, power rehabilitation projects (PRPs) has been executed with aid from the World Bank to extend facility life at existing stations and assure supply over the short term to meet the demand, which has been tightening the supply in recent years. Taken together, PRPs increased output by 210 MW. Although PRPs cover not only generation facilities but also transmission and distribution facilities, this account concerns mainly the increase in generation facility output.

i) Victoria Falls Hydropower Station

The Victoria Falls Hydropower Station consists of three stations (A, B, and C) with respective outputs of 8, 60, and 40 MW, for a total of 108 MW. While it did not expand the capacity, the PRP lengthened the service life and increased reliability. The station personnel indicated that the PRP work began in 2003 and was finished in 2006.

ii) Kariba North Bank Hydropower Station

The Kariba North Bank Hydropower Station is installed with four 150 MW generators and has a total output of 600 MW. The PRP is to raise the capacity per generator to 180 MW and the total output to 720 MW, for an increase of 120 MW from before.

According to personnel at the station, the PRP began in 2002, and work on the first three units has already been completed. The work on the fourth is scheduled for completion in 2010. There are reports to the effect that the turbines were not replaced for the first two units, which consequently cannot operate at full output if the water level is too low.

iii) Kafue Gorge Hydropower Station

The Kafue Gorge Hydropower Station is equipped with six generators, each with a capacity of 150 MW, for a total output of 900 MW. The PRP is aimed at raising the output of each unit from 150 to 165 MW, for a total output of 990 MW, or 90 MW more than before the rehabilitation.

According to the station personnel, the PRP work began in 2001 and proceeded for two units at a time. Work on units 3 - 6 has already been completed, and that on units 1 and 2 is scheduled for completion in February 2009.

Table 0.4 Output increases in power rehabilitation projects (PRP)

Power Station	Capacity (MW)		Increase (MW)
	Before PRP	After PRP	
Victoria Falls	108	108	--
Kariba North Bank	600 (150 x 4 units)	720 (180 x 4 units)	120
Kafue Gorge	900 (150 x 6 units)	990 (165 x 6 units)	90

New hydropower development projects

The progress of the new waterpower project is summarized in Table 0.5 and speak below the summary of each project.

Table 0.5 State of progress of new hydropower development projects

No.	Project	Capacity (MW)	Developer	Progress Pre-FS	Progress FS	Related documents
1	Kariba North Bank Extension	360	ZESCO	✓✓	✓✓	> 2x180 Kariba North Bank Extension Hydropower Station Basic Design Report, 2008 > Kariba North Bank Power Station Extension Final Feasibility Study Report, 2005
2 3 4	Mpata Gorge Devilõs Gorge Batoka Gorge	543 500 800	ZRA	✓✓		> Batoka Gorge Hydro Electric Scheme Feasibility Report, 1993
5	Itezhi Tezhi	120	ZESCO /TATA	✓✓	✓✓	> Feasibility Study for Itezhi Tezhi Hydro Electric Project (2x60MW), 2007
6	Kafue Gorge Lower	750	N.Y	✓✓	✓	> FS under Preparation by IFC > Site Selection Report for the Kafue Gorge Lower Hydroelectric Project,2006
7	Lusiwasi Extension	50	ZESCO or Private	✓✓	✓	> FS under preparation by ZESCO > Small Hydropower Stations Rehabilitation and Upgrading Study, 1997
8	Mumbotuta Falls - Site CX	 301	n/a	✓✓		> Development of Hydroelectric Power in the Luapula and Northern Areas of Zambia, 2001
9	Mambilima Falls - Site II - Site I	 202 124	n/a	✓✓		
10	Kabwelume Falls	62	Lunzua Power Authority (Private)	✓✓		> Under negotiation of Implementation Agreement
11	Kundabwika Falls	101				
12	Mutinondo	40	Power Min (Private)			> Implementation Agreement to be designed in 2009
13	Luchenene	30				
14	Lunsemfwa	55	LHPC (Private)		✓	> FS to be completed by 2010
15	Mkushi	65			✓	
16	Kabompo	34	CEC/TATA	✓✓	✓	> FS ongoing by private > Small Hydropower Pre-Investment Study North-Western Province, 2000

✓✓ Completed
✓: Ongoing or prepared

i) Kariba North Bank Extension Project

This project is aimed at extension of the capacity of the Kariba North Bank Hydropower Station (720 MW) by 360 MW (through installation of two 180 MW generators). A Chinese firm (Sinohydro Corporation Ltd.) commenced construction with the Chinese governmentõs assistance in fiscal 2008, and plans to install the new units into operation in 2013.

Table 0.6　　　Outline of the Kariba North Bank Extension Project

Item	Description
Dam & Reservoir	Kariba dam (Existing) Construction of new intake at the upstream of the existing one
Installed Capacity (MW)	360 (180MW x 2units)
Turbine & Generator	Francis, Vertical shaft
Rated power (MW)	183.7 (1unit)
Rated discharge (m^3/s)	227.6 (1unit)
Rated water head (m)	89
Intake	2 intake chamber Invert elevation: 458m
Headrace Tunnel	Diameter: 7.8m
Powerhouse	Underground Length: 51m, Width: 24m Elevation of generator floor: 385.5m Installation elevation:372.5m
Tailrace Tunnel	Horseshoe type Maximum height: 9.8m

Source: 2 x 180MW Kariba North Bank Extension Hydropower Station Basic Design Report (2008)

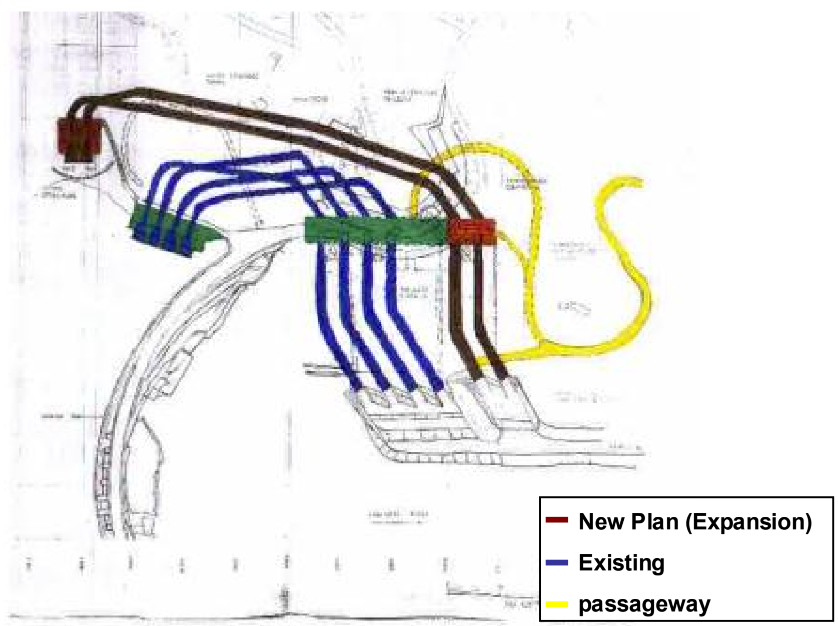


Figure 0.1　　　Layout of the Kariba North Bank Extension Project

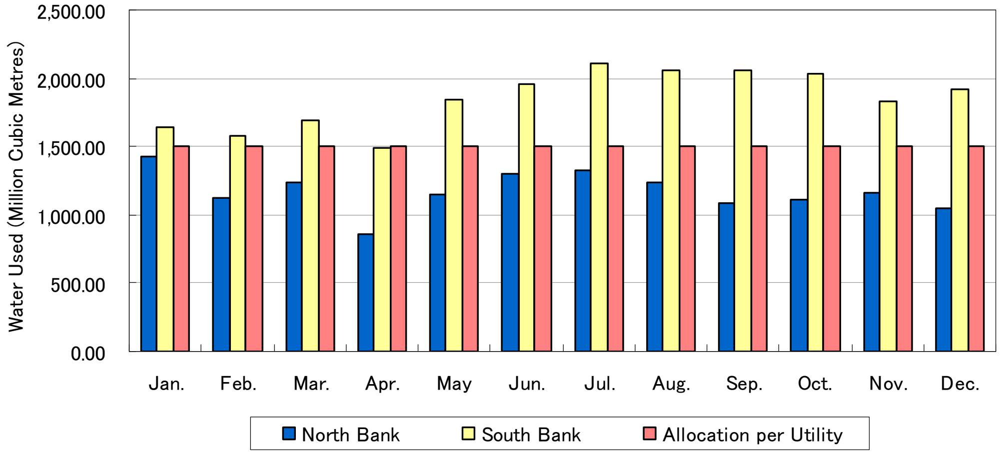
The Kariba North Bank Hydropower Station lies on the main Zambezi channel, and the amount of water it may use to generate power is determined by the ZRA. Basically, the yearly amount of water allocated for power generation is evenly split with the South Bank Hydropower Station in Zimbabwe. According to the Kariba North Bank Power Station Extension Final Feasibility Study Report 2005, the increase brought by the Kariba North Expansion Project is calculated at 380 gigawatt-hours (GWh) per year. A look at the procedure reveals that this calculation was made by extrapolating the amount of generated power from the amount of water discharged from the floodgate in the past instead of the yearly amount of water allocated to Zambia. The discharge from the floodgate is surplus water, and its diversion for power generation would result in a commensurate increase in output. Interviews with station personnel, however, indicated a lack of clarity about handling of the discharge when it became necessary to discharge water from the floodgate. In actual operation, the station must effectively operate in overall terms, i.e., with both the preexisting and additional capacity, within the yearly water allocation determined in advance by the ZRA. This, in turn, requires full operation during peak periods and reduction of the amount of water use during low-load periods to adjust the balance of water inflow and outflow. The Kariba North Bank Project is for generation using a reduced flow of water during low-load periods, and therefore may be regarded as a facility with a low plant factor, developed for peak application, as opposed to a base source.

In 2007, the Kariba North Bank Hydropower Station utilized 14.1 billion cubic meters of water for power generation. This figure was less than the allocation of 18 billion cubic meters (see Table 0.7 and Figure 0.2). The gap was presumably due to the decrease in water use for power generation because operation of one unit was suspended for the rehabilitation work. In ZESCO's annual report as well, the possible generated output in this year was put at 510 MW. Because the post-rehabilitation output is supposed to be 660 MW, calculation of the yearly water use at 660 MW applying the output ratio as is yields a figure of 18.2 billion cubic meters, or about the same as the annual allocation. Unless the allocation is increased, the amount of water use for the increase of 360 MW will have to be derived within the allocation limit. Without a change in the conventional pattern of operation of the existing facilities, it will not be possible to acquire the extra amount of water required for use of the additional capacity. There is a need for effective operation together with the existing capacity (660 MW).

Table 0.7 Amount of water use for power generation at KNBPS & KSBPS

month	Kariba North Bank			Kariba South Bank			Cumulative	Cumulative	
	Water Allocated (MCM)	Water Used (MCM)	Allocation rate (%)	Water Allocated (MCM)	Water Used (MCM)	Allocation rate (%)	Allocation for Kariba Complex (MCM)	Water Used at Kariba Complex (MCM)	Allocation Rate (%)
Jan.	1,500.00	1,421.04	95%	1,500.00	1,641.83	109%	3,000.00	3,062.87	102%
Feb.	1,500.00	1,127.95	75%	1,500.00	1,583.46	106%	6,000.00	5,774.28	96%
Mar.	1,500.00	1,236.68	82%	1,500.00	1,685.99	112%	9,000.00	8,696.95	97%
Apr.	1,500.00	854.87	57%	1,500.00	1,487.98	99%	12,000.00	11,039.80	92%
May	1,500.00	1,143.39	76%	1,500.00	1,849.42	123%	15,000.00	14,032.61	94%
Jun.	1,500.00	1,304.83	87%	1,500.00	1,953.67	130%	18,000.00	17,291.11	96%
Jul.	1,500.00	1,322.11	88%	1,500.00	2,103.31	140%	21,000.00	20,716.53	99%
Aug.	1,500.00	1,237.51	83%	1,500.00	2,055.01	137%	24,000.00	24,009.05	100%
Sep.	1,500.00	1,091.42	73%	1,500.00	2,054.10	137%	27,000.00	27,154.57	101%
Oct.	1,500.00	1,106.09	74%	1,500.00	2,032.57	136%	30,000.00	30,293.23	101%
Nov.	1,500.00	1,158.02	77%	1,500.00	1,830.89	122%	33,000.00	33,282.14	101%
Dec.	1,500.00	1,050.77	70%	1,500.00	1,922.12	128%	36,000.00	36,255.03	101%
Total	18,000.00	14,054.68	78%	18,000.00	22,200.35	123%	36,000.00	36,255.03	101%

(Source) Zambezi River Authority, Annual Report and Accounts for the year ended 31st December 2007



(Source) Zambezi River Authority, Annual Report and Accounts for the year ended 31st December 2007

Figure 0.2 Amount of water use for power generation at the KNBPS & KSBPS

ii) Itezhi Tezhi Project

The Itezhi Tezhi (ITT) Project is sited on the Kafue River, a tributary of the Zambezi. The reservoir already built was constructed in 1978 and has a capacity of 6 billion cubic meters. It acts to level the flow disparity between the wet and dry seasons, and supplies water to the Kafue Gorge (KG) Hydropower Station. The area extending downstream from the ITT reservoir on the Kafue River has an extremely flat topography. More specifically, it is characterized by an average grade to the KG reservoir (also downstream) of 0.0025 percent, a corresponding horizontal distance of about 230 kilometers, and a vertical disparity of 5 - 6 meters. For these reasons, it takes water discharged from the ITT reservoir about 90 days to reach the KG reservoir serving the KG Hydropower Station downstream. Nevertheless, the flow-adjusting function of the ITT reservoir makes a positive contribution to operation of the KG Hydropower Station and to other water use (for agriculture and drinking).

The ITT Project was studied in 1977 ("Itezhi Tezhi Power Station Preinvestment Study", SWECO), and there were plans for construction of a generation facility with a capacity of 80 MW downstream of the existing dam. In a feasibility study executed in 1999 ("Feasibility Study of the Itezhi Tezhi Hydroelectric Project", Harza), however, the capacity was revised upward to 120 MW. In a subsequent study ("Itezhi Tezhi Hydro Electric Project", Tata Consulting Engineers Limited (TCE), 2007), the plan was revised again on the grounds that an aboveground station was more economical than the underground one which had been planned. The plan for the underground station had already been authorized by the EIA in 2006, and the EIA again authorized the aboveground type in January 2009. This paved the way for further preparations for development.

The plans call for use of one of the two existing discharge pipes as a raceway and expansion of the station capacity, without modification of the existing structures (i.e., the reservoir and dam).

Because the reservoir operation will not change upon plant construction, the discharge pattern will probably remain basically the same. As a result, there should be no impact on operation of the Kafue Gorge Hydropower Station.

As its operators are ZESCO and Tata, a foreign-affiliated private company, the ITT Project is one of development based on public-private partnership. The two have already established the Itezhi Tezhi Power Corporation (ITTPC), which has an SPC status.

Table 0.8 Outline of the Itezhi Tezhi Project

Name of the HP	Itezhi Tezhi
General information	
Region, District	Itezhi-Tezhi District, Southern Province of Zambia
Special Purpose Company (SPC)	Itezhi Tezhi Power Corporation (ITTPC) Limited
Shareholders	ZESCO Limited and TATA Africa Holdings (SA) (PTY) Limited
Installed capacity (MW)	120 MW (2 x 60 MW)
Type of generation	Base load (24 hours generation)
Catchment area (km^2)	Kafue basin - 150,000 Km^2
Maximum Generation Discharge (m^3/s)	306 m^3/s
Net head (m)	40 m
Plant factor (%)	95%
Annual generation (GWh)	611
Project framework	
Current status	Bidding governed by the World Bank eligibility rules and procedures EPC Bid Documents issued on 8 December 2008 on ICB basis Site Visit & Pre Bid Meeting held from 20 to 23 January 2009, Tender Opening to be held on 20 March 2009
Expected start month/year of construction	EPC Contract Award ï June 2009 Contractor Mobilization ï August 2009 Project Completion ï 2013 (December 2012*)
Construction period	46 months (42months*)
Total project cost (US$)	Estimated total project cost ï 164.95million (2007 price level), (US$200million*)
Technical information	
Dam type	Existing, Rock-fill dam
Dam height and crest length (m)	Existing, Maximum height is 51m and crest length is 1,400 m
Type and number of spillway gate	Existing, Three radial spillway gates
Area of the reservoir (m^2)	390 km^2 at Full Supply Level
Total storage capacity (m^3)	6,000 million m^3
Effective storage capacity (m^3)	5,300 million m^3

Name of the HP	Itezhi Tezhi
Type, size and length (m) of headrace	i) Indicative dimensions only. Bidders to optimize the design ii) Existing tunnel, 15m diameter & 410m length from intake iii) Horseshoe concrete lined tunnel, 9m diameter & 145m length iv) Concrete lined surge shaft with diameters 10m riser & 30m upper v) Concrete or steel lined tunnel, 9m diameter & 50m length
Type , size and length (m) of penstock	Circular steel lined tunnel, 6m diameter and 5m length from bifurcation
Type and size (m) of power house	Surface Power House constructed of RCC Machine hall size: 87 m long x 23.2 m wide x 49 m high Transformer hall size: 52m long x 15m wide x 21 m high Tail race channel of trapezoidal section, 20m width & 150m long
Type of turbine	Vertical shaft Kaplan
Environmental impact	According to hearing from the ITTPC, Environmental and Socio-economic impact to be mitigate according to the Environmental Impact Management Plan No resettlements (Project site has been a restricted area) There are no known archaeological/heritage sites within the project area

(*) Hearing base
(Source) TCE Consultation Engineers Ltd. Feasibility Report for Itezhi Tezhi Hydro Electric Project (2 x 60MW)
JICA Study Team, Hearing from Itezhi Thezhi Power Corporation (ITTPC)

The ITT Project is characterized by public-private partnership, as noted above. For this reason, an interview was held with the ITTPC, the concerned SPC, in February 2009. The following information was obtained from this interview.

- The ITT Project offtaker is ZESCO, which is also, however, one of the SPC investors. In the interest of fair contracting under this circumstance, the SPC has hired advisors in the areas of commercial transactions and financing as well as a technical consultant, and is conducting deliberations on the details of the power purchasing agreement (PPA).
- Construction of transmission lines is the responsibility of ZESCO. An agreement has been reached to incorporate a provision for generation compensation in the event of delay in construction of transmission lines.
- Operation and maintenance are scheduled to be outsourced, but the details have not yet been determined. The basic outline must be firmed up by the time of PPA conclusion.
- In spite of the outlays by ZESCO, the project is for an independent power producer (IPP). In the ITTPC's interpretation, this means that it is outside the application scope for governmental procurement rules. The ITTPC intends to promote the project while

conferring with government-related agencies on this interpretation.

As this indicates, procedures are moving ahead in consultation with concerned agencies because there is no precedent for development based on public-private partnership. Incentives under consideration for the project include a tax holiday for five years, exemption from import duties, and exemption from the value-added tax (VAT). The detailed determinations require discussion with the government, and there are apprehensions that this will take considerable time.

iii) Kafue Gorge Lower Project

The Kafue Gorge Lower (KGL) Project is planned for a site about 200 meters downstream of the Kafue Gorge (KG) Hydropower Station. Preparations are being made for a feasibility study for it. It would be the most downstream project on the Kafue River; the ITT Hydropower Project utilizing the ITT reservoir is moving ahead upstream of it. Together with the KG Hydropower Station directly upstream, it will form part of the river system development on the Kafue.

According to information obtained from the IFC in February 2009, the feasibility study was then being implemented. However, there are problems including the lack of an access road to the candidate site and of a boring exploration, and three sites are still under study for the dam. In spite of this, the detailed specifications of the plan were to be determined in the early part of fiscal 2009. The KGL Project is located directly downstream of the KG Hydropower Station and would construct a reservoir with a certain storage capacity. As a result, it would enable variation in the operating pattern of the existing KG Hydropower Station. For example, it would be effective to operate the KG Hydropower Station in peak periods because its capacity of 990 MW is the largest in Zambia. By having re-regulation apply to the KGL Hydropower Station, this would enable peak operation that takes account of change in the flow duration downstream. It would also make it possible to place the KGL Hydropower Station itself in peaktime operation using its effective reservoir capacity. Another prospect under study is the installation of facilities to moderate changes in the downstream flow situation, such as a weir with a height of about 10 meters. Coordination with upstream facilities is indispensable for efficient operation and peak accommodation. In any case, the KGL Project may be regarded as one that will have a big influence on plans for power plants on the Kafue River system.

Table 0.9 Outline of the Kafue Gorge Lower Project

Name of the HP	Kafue Gorge Lower
General information	
Region, District	Kafue Gorge, Kafue
Installed capacity (MW)	750 (187.5 x 4 units)
Type of generation	Peaking station, Storage dam
Catchment area (km^2)	815
Maximum Generation Discharge (m^3/s)	434 (108.5 m^3 x 4)
Net head (m)	186 (approx. yet to be designed)
Plant factor (%)	32 (at 750MW)
Annual generation (GWh)	2,400
Project framework	
Current status	Feasibility Study to be completed by May 2009
Expected start month/year of construction	2011
Construction period	55 months
Total project cost (US$)	738 million (2005 price level)
Technical information	
Dam type	RCC dam
Dam height and crest length (m)	120 (approx.)
Area of the reservoir (km^2)	2.14 at 610 m elevation
Type of turbine	Francis Turbine
Environmental impact	According to hearing from the IFC, an update of EIA yet to be finalized soon. (So far the project has minimal impact with regards to resettlement.

Source: MWH, Site Selection Report for the Kafue Gorge Lower Hydroelectric Project (2006)
JICA Study Team, Hearing from IFC

In 2008, the IFC concluded an advisory agreement with the Zambian government related to KGL hydropower development, for work in areas such as feasibility studies and arrangements for investors.

The following outline derives from a presentation of the project by the IFC. Although the peak accommodation and other aspects of the operating pattern have not yet been fixed, the reservoir is expected to have an effective capacity sufficient for about two days' worth of operation. The main specifications are a dam height of 120 meters, headrace tunnel length of 8 kilometers, vertical shaft length of 200 meters, and aboveground construction. Although the project will not entail relocation of any residents, it is likely to have an economic impact on 12,000 (in 2,000 households), mainly in connection with fishing. A trial calculation yielded a project cost of 1,874 million dollars. As for technical considerations, the geology of the tunnel area and parts traversed by waterways has not yet been sufficiently determined because an additional boring exploration has not been made. There are anticipated to be additional problems such as difficult conditions for engineering and construction in zoning for dams and headrace, as the work must be executed in a narrow valley.

iv) Lusiwasi Expansion Project

The Lusiwasi Expansion Project is aimed at adding 50 MW to the capacity of the existing Lusiwasi Hydropower Station (run-of-river type, output of 12 MW) owned by ZESCO. The station lies on the Lusiwasi River, which is a tributary of the Luangwa River running through South Luangwa National Park. On the western side of this park is a hilly region with elevation differences of about 500 meters. Other hydropower plants to be described below are planned for rivers running through this hilly region, and all of these plans are being promoted under private initiative.

The plan for expansion consists of two stages. The first stage is an upstream plan for installation of a new weir between the existing intake and the Lusiwasi reservoir to create a reservoir, and construction of a run-of-river type hydropower station with an output of 10 MW. In the second stage, a capacity of 40 MW is to be added to the existing Lusiwasi Hydropower Station.

The feasibility study is scheduled to be finished by 2010.

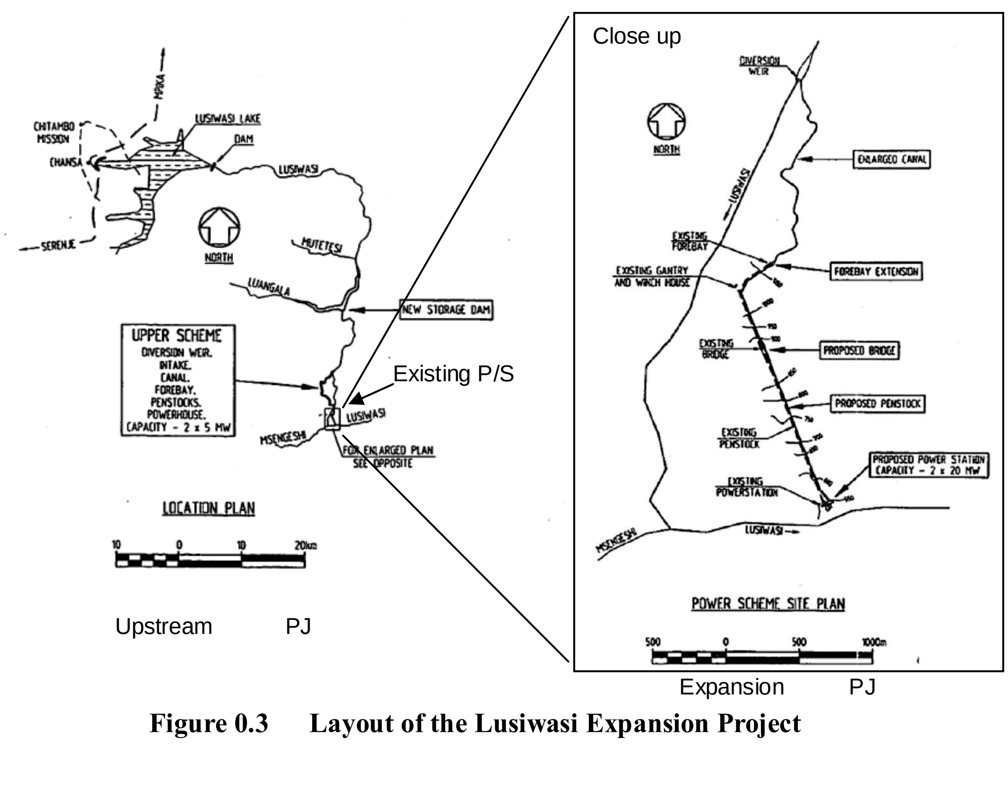


Figure 0.3 Layout of the Lusiwasi Expansion Project

Table 0.10 Outline of the Lusiwasi Expansion Project

	Upper scheme	Expansion	Existing
Capacity (MW)	10 (5 x 2units)	40 (20 x 2units)	12 (3 x 4units)
Design discharge (m^3/s)	13.3	9.6	2.9
Gross Head (m)	95	522.6	522.6
Net Head (m)	90	500	509.2
Turbine	Francis, Horizontal	Pelton, Horizontal	Pelton, Horizontal
Generation (GWh)	40.3	160.1	48.8
Plant Factor (%)	46.0	45.7	46.4
Project Cost (million US$) (1997 price level)	19.52	60.53	-
Construction Period	14 months	28 months	-

(Source) Knight Piesold Limited, Small Hydropower Stations Rehabilitation and Upgrading Study Final Report (1997)

v) Kabompo Gorge Project

Led by the private sector, the Kabompo Gorge Project is aimed at development of a hydropower station with an output of 34 MW in the Kabompo Gorge on the Kabompo river, which flows through North-Western Province. At present (2009), the CEC and the Indian capital TATA are collaborating in preparations for a feasibility study.

Table 0.11 Outline of the Kabompo Project

Name of the HP	Kabompo
General information	
Region, District	Northwestern Province, Mwinilunga District
Installed capacity (MW)	34 (17 x 2 units)
Catchment area (km^2)	2,300
Maximum Generation Discharge (m^3/s)	24
Net head (m)	160
Plant factor (%)	59
Annual generation (GWh)	176
Project framework	
Current status	Evaluation of RFP for Consulting Services for bankable feasibility study
Expected start month/year of construction	2010
Construction period	42 months
Total project cost (US$)	65.9 million (2000 price level) (US$ 77.3 million include the Transmission line)
Technical information	
Dam type	Concrete Arch (under review)
Dam height and crest length (m)	68
Area of the reservoir (km^2)	28.1
Total storage capacity (m^3)	289 million
Effective storage capacity (m^3)	274 million
Type of turbine and generator	Vertical Francis
Environmental impact	According to the TATA Zambia Ltd., preliminary EIA indicated a moderate impact on the human settlements and medium to high impact on fauna and flora due to undisturbed nature of the project site

Source: NORPLAN A.S, Small Hydropower Pre-Investment Study North-Western Province, Zambia (2000)
JICA Study Team, Hearing from TATA Zambia Ltd

vi) Mutinondo/ Luchenene Projects

The Mutinondo and Luchenene projects are to take shape on the Munyamadzi River and its tributary, respectively. The Munyamadzi flows through the Muchinaga Escarpment, which makes for an elevation difference of about 500 meters, to the west of South Luangwa National Park. Both rivers flow into the Luangwa, which flows through the middle area of South Luangwa National Park.

These projects are for the development of two hydropower stations in the hilly region spreading out on the western side of South Luangwa National Park, at a site about 100 kilometers northwest of the existing Lusiwasi Hydropower Station. It envisions construction of one station on the Munyumadzi River with a capacity of 40 MW, and the other on a tributary of the Munyumadzi with a capacity of 30 MW. For both, the plans are being promoted with a Zambian private company (Power Min) serving as the developer.

Table 0.12 Outline of the Mutinondo Project

Name of the HP	Mutinondo
General information	
Region, District	Northern Province, Mpika
Installed capacity (MW)	40 (1 unit)
Type of Generation	Run of river
Catchment area (km^2)	841
Maximum Generation Discharge (m^3/s)	9.96
Net head (m)	460
Plant factor (%)	53.7
Annual generation (GWh)	188
Project framework	
Current status	Pre-feasibility study
Expected start month/year of construction	After 2010
Construction period	36 months
Total project cost (US$)	67 million (2008 price level)
Technical information	
Dam type	Concrete weir
Dam height and crest length (m)	7m, 20m crest length
Type, size and length(m) of headrace	Low pressure steel conduit, 1.5m diameter, 1,000m
Type, size and length(m) of penstock	Steel, 1.5m diameter, 1,080m
Type, size (m) of Power house	Surface, 27m x 30m
Type of turbine	Vertical axis Pelton
Environmental impact	According to the PowerMin, little flow in by-passed channel and visual impact due to civil work and access road

(Source) JICA Study Team, Hearing from PowerMin

Table 0.13 Outline of the Luchenene Project

Name of the HP	Luchenene
General information	
Region, District	Northern Province, Mpika
Installed capacity (MW)	30 (1 unit)
Type of Generation	Run of river
Catchment area (km^2)	813
Maximum Generation Discharge (m^3/s)	9.08
Net head (m)	380
Plant factor (%)	52.9
Annual generation (GWh)	139
Project framework	
Current status	Pre-feasibility study
Expected start month/year of construction	After 2010
Construction period	36 months
Total project cost (US$)	65 million (2008 price level)
Technical information	
Dam type	Concrete weir
Dam height and crest length (m)	7 m, 20 m crest length
Type, size and length(m) of headrace	Low pressure steel conduit, 1.5m diameter, 1,480m
Type, size and length(m) of penstock	Steel, 1.5 m diameter, 870m
Type, size (m) of Power house	Surface, 26 m x 28 m
Type of turbine and generator	Vertical axis pelton
Environmental impact	According to the PowerMin, little flow in by-passed channel and visual impact due to civil work and access road

Source: JICA Study Team, Hearing from PowerMin

vii) Lunsemfwa/Mkushi Projects

Lunsemfwa and Mkushi projects are planned by Lusemfwa Hydropower Company, a private power producer which sells to ZESCO. It is for construction of a new hydropower station with an output of 55 MW downstream of the existing Lunsemfwa Hydropower Station. The company also has plans to increase the capacity of the existing 18 MW station by 6 MW along with this downstream development. It is also making plans for construction of a 65 MW Hydropower Station on the Mkushi River adjacent to Lunsemfwa.

Table 0.14 Outline of the Lunsemfwa Project

Name of the HP	Lunsemfwa
General information	
Region, District	Central Province, Kabwe
Installed capacity (MW)	55
Catchment area (km^2)	3,600
Maximum Generation Discharge (m^3/s)	19
Net head (m)	330.5
Plant factor (%)	95.9
Annual generation (GWh)	462
Project framework	
Current status	Conceptual study
Expected start month/year of construction	2011 if feasibility viable
Construction period	48 months
Total project cost (US$)	138 million (2008 price level)
Technical information	
Dam type	Earth fill dam
Dam height and crest length (m)	48.8 m, 366 m crest length
Type and number of spillway gate	Radial Mechanical spill gates, 2 gates
Total storage capacity (m^3)	695 million
Effective storage capacity (m^3)	670 million
Type, size and length(m) of headrace	4.0 m diameter, 13,000 m
Type, size and length(m) of penstock	Concrete/Steel lined 2.75/2.3dia., 359m
Type, size (m) of Power house	Underground, 12m x 55m
Type of turbine	Francis
Environmental impact	According to the Lunsemfwa hydropower company, no resettlement, Area not inhabited. Result in Mining and agricultural in the area. No precious animals, area is in a gorge.

(Source) JICA Study Team, Hearing from Lunsemfwa Hydropower Company

Table 0.15 Outline of the Mkushi Project

Name of the HP	Mkushi
General information	
Region, District	Central Province, Kabwe
Installed capacity (MW)	65
Catchment area (km^2)	8,440
Maximum Generation Discharge (m^3/s)	21
Net head (m)	357.5
Plant factor (%)	39.2
Annual generation (GWh)	223
Project framework	
Current status	Conceptual study
Expected start month/year of construction	2011 if feasibility viable
Construction period	48 months
Total project cost (US$)	163 million (2008 price level)
Technical information	
Dam type	Earth fill dam
Dam height and crest length (m)	48.8m, 366m crest length
Type and number of spillway gate	Radial Mechanical spill gates, 2 gates
Total storage capacity (m^3)	260 million
Effective storage capacity (m^3)	245 million
Type, size and length(m) of headrace	4.0m diameter, 3,000m
Type, size and length(m) of penstock	Concrete/ Steel lined 2.75/2.3dia., 388m
Type, size (m) of Power house	12m x 48m
Type of turbine	Francis
Environmental impact	According to the Lunsemfwa hydropower company, no resettlement, Area not inhabited. Result in Mining and agricultural in the area. No precious animals, area is in a gorge.

(Source) JICA Study Team, Hearing from Lunsemfwa Hydropower Company

viii) Kalungwisi River Kabwelme Falls/ Kundabwika Falls Project

The Kalungwisi River forms the border between Luapula and Northern provinces, which are both situated in northern Zambia. A study[11] was made of hydropower development in this region in 2001. An assessment of the development prospects concluded that plants could possibly be constructed near Kabwelme Falls and Kundabwika Falls on the Kalungwisi River.

At present (2009), the Lunzua Power Authority, a private capital, is making preparations for development at both sites.

[11] Harza, Development of Hydroelectric Power in the Luapula and Northern Areas of Zambia (2001)

Table 0.16 Outline of the Kabwelume Falls Project

Name of the HP	Kabwelume Fall
General information	
Region, District	Luapula & Northern Province
Installed capacity (MW)	62
Catchment area (km^2)	10,868
Maximum Generation Discharge (m^3/s)	127.6
Net head (m)	54.9
Plant factor (%)	59.7
Annual generation (GWh)	324 (with 6 m^3release for the fall)
Project framework	
Current status	Implementation Agreement negotiation as of Dec 2008
Expected start month/year of construction	2016
Construction period	43 months
Total project cost (US$)	126.89 million (2000 price level)
Technical information	
Dam type	RCC Gravity dam
Dam height and crest length (m)	Maximum height 14m, and 1,400m crest length
Type and number of spillway gate	Free flow spillway
Area of the reservoir (km^2)	2.53
Total storage capacity (m^3)	15.22 million
Effective storage capacity (m^3)	2.44 million
Type, size and length (m) of headrace	i) Fully concrete lined, 8 m wide invert side slopes of 3H to 1V ii) Longitudinal average slope of 0.11%, 1,400m length
Type, size and length (m) of penstock	5 m dia, surface steel
Type, size (m) of Power house	Surface 2.5km downstream of the fall, on the right bank
Type of turbine	Vertical Francis
Environmental impact	Few or No resettlements

(Source) Harza, Development of Hydroelectric Power in the Luapula and Northern Areas of Zambia (2001)

Table 0.17 Outline of the Kundabwika Falls Project

Name of the HP	Kundabwika Fall
General information	
Region, District	Luapula & Northern Province
Installed capacity (MW)	101
Catchment area (km^2)	12,602
Maximum Generation Discharge (m^3/s)	148.8
Net head (m)	76.7
Plant factor (%)	60.3
Annual generation (GWh)	533 (with 6 m^3release for the fall)
Project framework	
Current status	Implementation Agreement negotiation as of Dec 2008
Expected start month/year of construction	2016
Construction period	39 months
Total project cost (US$)	211.42 million (2000 price level)
Technical information	
Dam type	RCC Gravity dam
Dam height and crest length (m)	Maximum height 27.5m, and 211m crest length
Type and number of spillway gate	4 radial gates (12m x14m)
Area of the reservoir (km^2)	12.6
Total storage capacity (m^3)	111.8 million
Effective storage capacity (m^3)	11.8 million
Type, size and length(m) of headrace	i) Fully concrete lined, 8 m wide invert side slopes of 3H to 1V ii) Longitudinal average slope of 0.11%, 1,550m length
Type, size and length(m) of penstock	5.5 m diameter, surface steel
Type, size (m) of Power house	Surface 3.4 km downstream of the fall, on the left bank
Type of turbine	Vertical Francis
Environmental impact	Estimated number of persons to be relocated is 60 persons.

(Source) Harza, Development of Hydroelectric Power in the Luapula and Northern Areas of Zambia (2001)

ix) Luapula River Mumbotuta Falls Site CX/Mambilima Falls Site II, Site I Project

The Luapula River forms the border between Luapula Province and the DRC. In 2001, a study[12] was made on hydropower development in northern Zambia, in Luapula and Northern provinces. The assessment of the prospects for hydropower development on the Luapula River concluded that stations could possibly be constructed at Site CX near the Mumbotuta Falls and sites II and I near the Mambilima Falls.

[12] Harza, Development of Hydroelectric Power in the Luapula and Northern Areas of Zambia (2001)

The Luapula River forms an international border, but there are no rules or other procedure for development on such rivers with the DRC, and also no organ that could discharge a role like that of the ZRA for the Zambezi. This situation points to the need for consultation between the two countries and preparation of rules for coordination on matters such as development on the Luapula and water rights.

There has also not been any actual progress in the Mumbotuta Falls and Mambilia Falls projects since the study in 2001.

Table 0.18 Outline of the Mumbotuta Falls Site CX Project

Name of the HP	Mumbotuta Falls Site CX
General information	
Region, District	Luapula Province
Installed capacity (MW)	301
Catchment area (km^2)	115, 400
Maximum Generation Discharge (m^3/s)	520
Net head (m)	65.4
Plant factor (%)	55.0
Annual generation (GWh)	1,449
Project framework	
Construction period	49 months
Total project cost (US$)	482.91 million (2000 price level)
Technical information	
Dam type	Concrete Facing Rock Fill Dam (CFRD)
Dam height and crest length (m)	Maximum height 75.5m, and 600m crest length
Type and number of spillway gate	Free Overflow, 400m ï long
Type, size (m) of Power house	Surface Right bank downstream of the dam
Type of turbine and generator	Vertical Francis

(Source) Harza, Development of Hydroelectric Power in the Luapula and Northern Areas of Zambia (2001)

Table 0.19 Outline of the Mambilima Falls Site II Project

Name of the HP	Mambilima Falls Site II
General information	
Region, District	Luapula Province
Installed capacity (MW)	202
Catchment area (km^2)	155,527
Maximum Generation Discharge (m^3/s)	701.1
Net head (m)	32.6
Plant factor (%)	56.7
Annual generation (GWh)	1003
Project framework	
Construction period	56 months
Total project cost (US$)	637.88 million (2000 price level)
Technical information	
Dam type	Concrete Facing Rock Fill Dam (CFRD)
Dam height and crest length (m)	Maximum height 49.0m, and 3,400m crest length
Type and number of spillway gate	Free Overflow, 150m ï long
Type, size (m) of Power house	Surface Right bank downstream of the dam
Type of turbine and generator	Vertical Kaplan

(Source) Harza, Development of Hydroelectric Power in the Luapula and Northern Areas of Zambia (2001)

Table 0.20 Outline of the Mambilima Falls Site I Project

Name of the HP	Mambilima Falls Site I
General information	
Region, District	Luapula Province
Installed capacity (MW)	124
Catchment area (km^2)	155,527
Maximum Generation Discharge (m^3/s)	704.0
Net head (m)	19.9
Plant factor (%)	56.1
Annual generation (GWh)	609
Project framework	
Construction period	48 months
Total project cost (US$)	460.06 million (2000 price level)
Technical information	
Dam type	Concrete Facing Rock Fill Dam (CFRD)
Dam height and crest length (m)	Maximum height 34.0 m, and 1,600 m crest length
Type and number of spillway gate	Free Overflow, 260m ï long
Type, size (m) of Power house	Surface Right bank downstream of the dam
Type of turbine and generator	Vertical Kaplan

(Source) Harza, Development of Hydroelectric Power in the Luapula and Northern Areas of Zambia (2001)

x) Batoka Gorge, Devil's Gorge, and Mpata Gorge Project

These projects are for development on the main channel of the Zambezi River. As such, the development rights are basically held by the ZRA, which is executing the feasibility studies and making preparations required for the development. A study[13] concerning the Batoka Gorge Project was made in 1993, but there has been no concrete progress since then. There have not been any detailed studies concerning the Devil's Gorge and Mpata Gorge projects, and no detailed information is available about them.

In addition to coordination with Zimbabwe, promotion of the Batoka Gorge Project requires consideration of Victoria Falls, which is a World Heritage site, and the existence of many stakeholders in connection with irrigation and other items upstream. The district is also one of the major sightseeing spots in Zambia, and coordination with stakeholders in the tourism industry is therefore also essential. The current plans envision a maximum water level of 762 meters. The upstream edge of the reservoir at this level would extend about 10 kilometers downstream of Victoria Falls at the grade indicated on a 1/250,000-scale topographical map.

Table 0.21 Outline of Batoka Gorge, Devil's Gorge, and Mpata Gorge projects

Name of the HP	Batoka Gorge	Devilǒs Gorge	Mpata Gorge
General Information			
Region, Disistrict	Kazungula	kazungula	Luangwa
Installed capacity	1,600 MW (800MW)	1,000 MW(500MW)	1,085 MW(543MW)
Catchment area (km^2)	508,000	-	-
Rated net head (m)	166.55	-	-
Plant factor (%)	62.4	40.0	79.6
Annual generation (GWh)*	8,745	5,604	7,570
Project framework			
Construction period	7 years	-	-
Total project cost (million US$)	1,681 (1993 price level)	1,072 (1993 price level)	1,516 (1993 price level)
Technical information			
Dam type	RCC Gravity Arch	Double Curvature Concrete Arch	Double Curvature Concrete Arch abutting onto a concrete gravity wing on the right bank
Dam height & crest length (m)	Maximum height 181 m	Maximum height 181 m, and 695 m crest length	Maximum height 78 m, and 480 m crest length
Area of the reservoir (km^2)	25.6	780	1,230
Type of power house	Underground	Underground	surface
Type of turbine	Francis	Francis	Francis

Source: ZRA, Batoka Gorge hydro electric scheme feasibility report (1993)
ZRA Home page

Other Generation Development Plan

Thermal power, renewable energy generation will be considerable as domestic generation sources other than hydropower. Small generation facilities less than 30 MW will be out of

[13] ZRA, Batoka Gorge Hydro Electric Scheme Feasibility Report (1993)

scope since this study is in kind a master plan.

As seen in Appendix, domestic primary energy resource which can be developed up to 2030 is limited to coal from Maamba Collieries.

As for the Maamba project, ZCCM-Investment Holdings (ZCCM-IH), the owner of Maamba Collieries Limited, has been negotiating a contract on resuscitation of coal productivity and construction of a thermal power plant, with a foreign investor. ZCCM-IH keeps fully confidential in this regard since it is still under negotiation, while Singaporeôs Nava Bharat is nominated as the preferred bidder and the capacity of mine-mouth power station is 350 MW, according to some newspaper reports.

Power Development Situation of the Adjacent Countries

Table 0.22 and Table 0.23 show the power development plan for the adjacent countries described in the draft final report (interim, May 2008) of SAPP Regional Generation and Transmission Expansion Plan Study by the World Bank. With regard to the expansion plan for Namibia (NamPower) and Tanzania (TANESCO), the information has been updated by the interview result with the relevant staff in the 2nd field study. In the future expansion plans, the generating capacity of 61,642MW will be added except for Zambia. About 75 % of 61,642 MW is the installing generating capacity for the development plan of South Africa. The available generating capacity of total SAPP is 47,654MW in the end of the fiscal year of 2007.

Table 0.22 Power Development Plan for the Adjacent Countries (1) (BPC, EdM, ESCOM, ESKOM, LEC, NamPower, SNEL)

Utility	Project name	Type	Capacity Added (MW)	Operating Year
BPC	Morupule B	Thermal	1,200	2012 - 2015
EdM	Mavuzi & Chicamba - Refurbishment	Hydro	35	2008 - 2009
	Mphanda Nkuwa	Hydro	1,300	2020
	Sub-Total		1,335	
ENE	Gas Turbine - Rehabilitation	Thermal	107	2008 - 2013
	TG-12.5	Thermal	13	2008
	ENE Diesels	Thermal	2	2008
	Benguela	Thermal	83	2008
	Capanda 2	Hydro	260	2008
	TG-20	Thermal	20	2008
	TG-40	Thermal	80	2009 - 2010
	TG-60	Thermal	60	2009
	Gove - Refurbishment	Hydro	60	2010
	Cambambe 2	Hydro	260	2013
	ENE Combined Cycle Plants	Thermal	1,200	2014 - 2023
	ENE Gas Turbine Plants	Thermal	300	2017 - 2025
	Sub-Total		2,445	
ESCOM	Tedzani 1 & 2 - Refurbishment	Hydro	40	2008
	Kaphichira 2	Hydro	64	2010
	Songwe	Hydro	340	2014 - 2016
	Sub-Total		444	
ESKOM	Camden DE-mothball	Thermal	190	2008
	Arnot Upgrade2	Thermal	200	2008 - 2011
	Grootvlei DE-mothball	Thermal	940	2008 - 2009
	Cape OCGT Phase2	Thermal	1,200	2008
	Komati De-mothball	Thermal	909	2008 - 2011
	DME OCGT	Thermal	1,050	2010
	Maedupi Coal	Thermal	4,230	2012 - 2015
	Braamhoek Pumped Strage	Hydro	1,332	2012 - 2013
	Bravo Coal	Thermal	4,800	2013 - 2016
	Generic Coal	Thermal	11,610	2014 - 2025
	Steelpoort Pumped Storage	Hydro	1,484	2015 - 2016
	Generic Pumped Storage	Hydro	2,968	2016 - 2024
	Generic Nuclear	Nuclear	18,702	2017 - 2025
	Hendrina Retirement	Thermal	-1,895	2022
	Arnot Retirement	Thermal	-2,280	2024
	Sub-Total		45,440	
LEC	Muela 2	Hydro	110	2012
	Oxbow	Hydro	80	2017
	Sub-Total		190	
NamPower	Van ECK Retirement	Thermal	-108	2011
	Luderitz	Wind	42	2011
	Ruacana 4th Unit	Hydro	92	2012
	Paratus Retirement	Thermal	-24	2012
	Kudu	Thermal	800	2013
	Baynes	Hydro	500	2016
	Walvis Bay	Thermal	400	-
	Sub-Total		1,702	
SNEL	Zongo - Refurbishment	Hydro	60	2008 - 2011
	Koni - Refurbishment	Hydro	42	2008
	Mwadingusha - Refurbishment	Hydro	36	2008 - 2010
	Sanga - Refurbishment	Hydro	8	2008 - 2011
	Nseke - Refurbishment	Hydro	62	2009
	Nzilo - Refurbishment	Hydro	27	2009
	Inga 2 - Refurbishment	Hydro	640	2010 - 2014
	Inga 1 - Refurbishment	Hydro	120	2012 - 2013
	Busaga	Hydro	240	2019 - 2022
	Zongo 2	Hydro	120	2021
	Nzilo 2	Hydro	120	2023
	Sub-Total		1,475	

Source: SAPP Regional Generation and Transmission Expansion Plan Study (Draft Final Report (Interim), May 2008) and Interview by JICA study team

Table 0.23 Power Development Plan for the Adjacent Countries (2)

(TANESCO, ZESA)

Utility	Project name	Type	Capacity Added (MW)	Operating Year
TANESCO	Aggreko, Alstom, Dowans1,2 Retirement	Thermal	-183	2008
	Tegata	Thermal	41	2009
	Small Diesel, Ubungo Retirement	Thermal	-55	2009
	Kinyerezi1	Thermal	100	2009
	Kinyerezi2	Thermal	100	2010
	Kiwira1	Thermal	200	2010
	Kiwira2	Thermal	200	2012
	Ruhudji	Hydro	358	2014
	Wind	Wind	50	2015
	Rusumo Falls	Hydro	21	2015
	Kakono	Hydro	53	2017
	Mpanga	Hydro	144	2018
	Wind	Wind	50	2018
	Mchuchuma1	Thermal	200	2019
	Rumakali	Hydro	222	2021
	Masigira	Hydro	118	2022
	Songas1 Retirement	Thermal	-40	2023
	Mnazi Gas	Thermal	150	2023
	Songas2 Retirement	Thermal	-110	2024
	Mnazi Gas	Thermal	150	2024
	Mchuchuma2	Thermal	200	2024
	Songas3 Retirement	Thermal	-37	2025
	Stiegler's Gorge1	Hydro	300	2025
	Mchuchuma3	Thermal	200	2026
	Local Gas	Thermal	150	2027
	Stiegler's Gorge2	Hydro	600	2027
	Tegata IPTL, GT Retirement	Thermal	-141	2027
	Coastal GT CNG	Thermal	300	2028
	Stiegler's Gorge3	Hydro	300	2029
	Coastal CC LNG1	Thermal	174	2029
	Kenyerezi1 Retirement	Thermal	-100	2029
	Local Coal	Thermal	200	2030
	Kenyerezi2 Retirement	Thermal	-100	2030
	Coastal CC LNG2	Thermal	174	2030
	Sub-Total		3,989	
ZESA	Hwange - Refurbishment	Thermal	480	2008 - 2009
	Kariba South Extension	Hydro	300	2014
	Hwange Extension	Thermal	600	2015
	Lupane	Thermal	300	2015
	Gokwa North	Thermal	1,050	2015 - 2023
	Batoka Gorge	Hydro	800	2017
	Sub-Total		3,530	
Total			61,642	

(Reference)

Utility	Project name	Type	Capacity Added (MW)	Operating Year
ZESCO	Kariba North Refurbishment	Hydro	210	2008 - 2009
	Kafue Gorge Upper Refurbishment	Hydro	150	2009
	Kariba North Extension	Hydro	360	2012
	Itezhi-Tezhi	Hydro	120	2013
	Kafue Gorge Lower	Hydro	750	2017
	Batoka Gorge	Hydro	800	2017
	Sub-Total		2,390	

Source: SAPP Regional Generation and Transmission Expansion Plan Study (Draft Final Report (Interim), May 2008) and Interview by JICA study team

Generation Development Scenarios

Taking the Southern Africa Power Pool (SAPP) into consideration, the following two generation development scenarios will be nominated;

i) Domestic power supply will fully cover the domestic power demand to enhance the national energy security (Scenario 1), and

ii) Domestic generation development will be set back expecting power import from SAPP, from the view point of economical efficiency and feasibility (Scenario 2).

The Scenario 2 includes the scenario in an extreme case which contains no generation development but transmission system to import power. Generally for most hydropower generations in Zambia, coal thermal power generations in the coal-borne South Africa, Botswana etc. become economically dominant. However, it is high-risk causing an irreparable situation to expect for electricity import in this master plan excessively, due to the following reasons;

- Currently, SAPP has no extra capacity as a whole and the power demand-supply situation in each member country is tight,
- There is no guarantee that the generation development plan of each SAPP member countries progresses on schedule,
- It may not become always advantageous to Zambia in the case of pricing by the relative contract without SAPP having no price transparent market.

As a matter of course, wide area power trade may bring merits such as reduction of generation development (investment cost) by improving the system reliability, reduction of operation and maintenance cost, fuel costs reduction by economical system operation etc, so that such reliable interconnection plan should be reflected in the master plan if exists. Consequently, Scenario 1 was selected as the base generation development scenario in this study in which only domestic power supply is available for domestic power demand, while domestic transmission system was planned corresponding to the international power interconnection lines which has already been specifically planned.

In this case, when power trade plan including price negotiation is clarified in the future, the generation development plan can be easily adjusted just by delaying the future plan.

Additionally, Scenario 1 will be classified as the following two sub-scenarios;

1) Primary energy basis self-supply,
2) Electricity basis self-supply.

Specifically, in the first scenario, hydropower and domestic coal are considered as primary energy source usable for power generation, and in the second one, imported coal from neighboring coal producing countries like the South Africa, Zimbabwe, Mozambique etc. is additionally available. In the case of Japan, electric power supply is 100 % secured by domestic generation due to its geographical reason of insularity, but self-sufficiency of total primary energy remains around 4 % (19 % even if considering nuclear energy).

The primary energy basis self-supply scenario (Scenario 1-1) has advantage of independence of primary energy from other countries from the viewpoint of energy security, but supply reliability in the dry year/season will be low reviewing the past record of power supply because most of power is supplied by hydropower power stations including the existing ones. Electricity basis self-supply scenario (Scenario 1-2) has realistic alternative to import coal from neighboring coal producing countries. As stated, coal thermal generation generally has advantage in generation cost comparing with hydropower generation, and is suitable to introduce private investment thanks to its low initial investment requirement. Moreover, it has merit of diversification of generation and securing the power supply free from the natural conditions such as drought.

In this manner, both scenarios were investigated in this study as they had good and bad points.

Generation Development Plan

Nominated Generation Development Projects

Hydropower projects

The specifications of hydropower development projects considered in the generation development planning are shown in Table 0.24 on the basis of the generation development situation noted in 0.

Table 0.24 Hydropower development projects list (as of March 2009)

River	Province	Project	Capacity (MW)	Developer	Status of Progress	Project Cost (Million US$)	Environmental & Social consideration
Zambezi	Southern	Kariba North Extension	360	ZESCO	Construction	318.65 (2005 price)	No significant impacts (Using existing dam and reservoir. Additional installation of water intake gate.)
	Lusaka	Mpata Gorge	543 (1,085)	ZRA	n/a	758.00 (1993 price)	Coordination with Zimbabwe Impacts on ecosystem (located within Luano GMA and adjacent to Lower Zambezi NP)
	Southern	Devilôs Gorge	500 (1,000)	ZRA	n/a	536.00 (1993 price)	Coordination with Zimbabwe. Certain impacts on river ecosystem
	Southern	Batoka Gorge	800 (1,600)	ZRA	Pre-FS completed (1993)	855.80 (1993 price)	Coordination with Zimbabwe Certain impacts on river ecosystem
Kafue	Southern	Itezhi Tezhi	120	ZESCO /TATA	FS completed (2007) D/D ongoing	164.95 (2007 price)	Impacts on ecosystem (Using existing dam and reservoir, but located within Namwala GMA, adjacent to Kafue NP, and upstream of Kafue flats Ramsar site). No resettlement anticipated
	Lusaka	Kafue Gorge Lower	750	N.Y.	Under preparation of FS by IFC	738.35 (2005 price)	No resettlement anticipated Impacts on ecosystem (located within Chiawa GMA)
Luapula	Luapula	Mumbotuta Fall - Site CX	301	N.Y.	Pre-FS completed (2001)	482.91 (2000 price)	Coordination with DRC Impacts on ecosystem (located within Mansa GMA)
	Luapula	Mambilima Fall - Site II - Site I	202 124	N.Y.	Pre-FS completed (2001)	637.88 460.06 (2000 price)	Coordination with DRC Certain impacts on river ecosystem
Kalungwishi	Luapula &Northern	Kabwelume Falls Kundabwika Falls	62 101	Lunzua Power Authority	Pre-FS completed (2001) I/A under negotiation	126.89 211.42 (2000 price)	Impacts on ecosystem (located within /adjacent to Lusenga Plains NP, and upstream of Lake Mweru wa Ntipa Ramsar site)
Others	Central	Lusiwasi Extension	50	ZESCO	FS ongoing	80.05 (1997 price)	Impacts on ecosystem (located adjacent to South Luangwa NP) No or little resettlement anticipated
	Northern	Mutinondo	40	Power Min	I/A under negotiation	67.00 (2008 price)	Impacts on ecosystem (located adjacent to South Luangwa NP, North Luangwa NP and Munyamadzi GMA) No or little resettlement anticipated
	Northern	Luchenene	30	Power Min	I/A under negotiation	65.00 (2008 price)	
	Central	Lunsemfwa	55	Lunsemfwa	Under preparation of FS	138.00 (2008 price)	Impacts on ecosystem (located adjacent to / within Luano GMA) No or little resettlement anticipated
	Central	Mkushi	65	Lunsemfwa	Under preparation of FS	163.00 (2008 price)	
	North Western	Kabompo	34	CEC/TATA	Under preparation of FS	65.90 (2000 price)	Impacts on ecosystem (located adjacent to Masele-Matebo NP)
Total			4,137				

Other generation development projects

i) Domestic coal thermal (Maamba mine-mouth coal thermal)

The rated output of Maamba mine-mouth coal thermal was described as 500 MW in the generation list of ZESCO (Table 0.3) and 350 MW in the newspaper reports[14] issued in the current year.

On the other hand, productivity of Maamba coal mines is 1 million tonnes per year at full capacity. Considering the domestic industrial use of 200,000 tonnes per year, 700,000 to 800,000 tonnes of coal can be used for power generation at most. Zambian coals are classified in bituminous to subbituminous with low volatile matter which is suitable for stoker boilers with lower thermal efficiency, not for PC[15] boilers with higher thermal efficiency. Relation between annual coal supply and expected generation output is shown in Table 0.25. Assuming 30 percent of thermal efficiency and 700,000 tonnes of annual coal supply conservatively, expected generation output will be less than 200 MWe. Therefore, the study took the installed capacity of the domestic coal power generation (Maamba mine-mouth coal thermal) as 200 MWe class.

Table 0.25 Relation between coal supply and generation output

Thermal efficiency	Annual coal supply (metric ton/ year)		
	700,000	750,000	800,000
30 %	196 MWe	210 MWe	224 MWe
35 %	229 MWe	245 MWe	262 MWe
40 %	262 MWe	280 MWe	299 MWe

(Source) Study Team

ii) Imported coal thermal generation

There is no plan of importing coal so far in the national policy documents such as NEP. However, even though production capacity of domestic coal is recovered, annual production will remain approximately 1 million tonnes annually, corresponding to 200 MW class power generation. Considering the required additional power supply is 4,000 MW up to 2030, including reserve, approximately 15 % of coal generation facility as a drought countermeasure can make the reserve margin less compared with hydropower generation only. It is about 1,000 MW that should be introduced by 2030 when total generation capacity comes to 6,000 MW. In this case, 260,000 to 360,000 tonnes of coal are required annually from the calculation shown in Table 0.25. At present, domestic productivity of coal is short, so that coal import was considered.

Moreover, compared with hydropower generation, coal thermal generation has the following benefit;

- Easy to invite private investment: less initial investment and smaller natural climate

[14] For example, see http://www.domain-b.com, January 10, 2009
[15] Pulverized Coal

risks,

- Shorter construction period: advantageous to overcome the immediate future demand-supply gap,
- Small geographical limitation: site selection close to demand centres.

As might be expected, when domestic coal productivity is enhanced in the future, some imported coal thermal projects may be simply converted into domestic coal thermal projects.

Estimation of unit generation cost of projects

Reevaluation of project costs

Preceding the estimation of economical efficiency of each generation project, reevaluation of each project cost was conducted. It is necessary to bring the construction costs of each project into conformance with each other, as far as possible. Table 0.26 shows the results of a compilation of construction costs based on the limited information in terms of the net construction cost, consisting of the costs for civil and mechanical work, contingency and engineering.

Table 0.26 Estimation of net construction cost

No.	Project	Price level at the study conducted time								Ref.
		Civil Work (A)	Electoro Mechanical Work (B)	Contingency (C)	C/(A+B) (%)	Engineering & Administration (D)	D/(A+B+C) (%)	Net Construction Cost (million US$) (E)	Price Level (year)	
1	Kariba North Expansion	94.4	87.9	23.0	12.6%	48.8	23.8%	254.1	2005	[1]
2	Itezhi Tezhi	63.9	41.4	13.7	13.0%	17.0	14.3%	136.0	2007	[2]
3	Kafue Gorge Lower	507.0	533.0	109.7	10.6%	230.0	20.0%	1,379.7	2008	[3]
4	Lusiwasi Expansion	37.7	31.8	4.7	6.7%	5.9	8.0%	80.0	1997	[4]
5	Batoka Gorge	606.0	449.5	118.4	11.2%	98.7	8.4%	1,272.7	1993	[5]
6	Devil's Gorge	374.8	278.0	73.2	11.2%	61.1	8.4%	787.0	1993	[5]
7	Mpata Gorge	506.2	375.4	98.9	11.2%	82.5	8.4%	1,063.0	1993	[5]
8	Mumbotuta Fall, CiteCX	164.2	47.1	43.6	20.6%	26.8	10.5%	281.6	2000	[6]
9	Mambilia Fall site2	244.0	43.7	60.9	21.2%	34.9	10.0%	383.3	2000	[6]
10	Mambilia Fall site1	165.1	39.9	42.3	20.6%	24.7	10.0%	272.0	2000	[6]
11	Kabompo Gorge	30.8	23.3	5.7	10.5%	6.0	10.1%	65.9	2000	[7]
12	Kalungwishi Kabwelume Falls	43.8	16.9	10.9	18.0%	7.2	10.0%	78.8	2000	[6]
13	Kalungwishi Kundabwika Falls	74.1	27.4	16.8	16.5%	11.8	10.0%	130.1	2000	[6]
14	Mutinondo	30.0	24.5	5.6	10.3%	6.1	10.1%	66.2	2008	[8]
15	Luchenene	31.0	21.7	5.7	10.8%	5.9	10.1%	64.3	2008	[8]
16	Lunsemfwa	106.0	83.0	19.0	10.1%	21.0	10.1%	229.0	2009	[9]
17	Mkushi	60.0	38.0	10.0	10.2%	11.0	10.2%	119.0	2009	[9]

[1] ZESCO,Kariba North Bank Power Station Extension Final Feasibility Study Report (2005)
[2] ITPC, Feasibility Study Report for Itezhi Tezhi Hydro Electric Project (2x60MW) (2007)
[3] Interim Summary Report, Kafue Gorge Lower Hydroelectric Power Project (2009)
[4] ZESCO, Small hydropower stations, Rehabilitation and Upgrading Study Final Report (1997)
[5] ZRA,Batoka Gorge Hydropower Scheme-Feasibility Study Final report (1993)
[6] ZESCO,Feasibility Study of the Development Hydroelectric Power in the Luapula and Northern Areas of Zambia (2001)
[7] Hearing from the developer, TATA Zambia limited
[8] Hearing from the developer,PowerMin
[9] Hearing from the developer,Lunsemfwa Company

Next, an estimate was made of the project cost in 2009. The figure for the civil work cost assumes an escalation at the rate of 4.5 percent annually. For the mechanical cost, the plan cost index (PCI) was utilized to obtain the 2008 prices as the latest figure, and these were applied as the 2009 prices. Figures for the contingency and engineering cost were calculated on the basis of the respective rates shown in Table 0.27. The addition of interest during construction to the net construction cost obtained in this manner was taken as the project cost as of 2009. The interest during construction was arrived at by application of a discount rate of 10 percent.

Table 0.27 Estimate of project cost (as of 2009)

No.	Project	Price Level (year)	Plant Cost Index at price level year	Plant Cost Index ratio (2008/price level year)	Price level at 2009					Construction period (year)	Interest during construction (%)	Construction cost (million US$)
					Civil Work (A')	Electoro Mechanical Work (B')	Contingency (C')	Engineering & Administration (D')	Net Construction Cost (million US$) (E')			
1	Kariba North Expansion	2005	128.7	1.18	112.6	104.0	27.3	58.0	302.0	4.0	18.53	357.9
2	Itezhi Tezhi	2007	153.7	0.99	69.8	41.0	14.4	17.9	143.1	4.0	18.53	169.6
3	Kafue Gorge Lower	2008	152.4	1.00	529.9	533.0	112.1	235.0	1,410.0	5.0	23.78	1,745.3
4	Lusiwasi Expansion	1997	118.9	1.28	63.9	40.7	7.0	8.9	120.6	2.5	11.13	134.0
5	Batoka Gorge	1993	120.4	1.27	1,225.6	569.0	201.3	167.9	2,163.7	7.0	35.14	2,924.1
6	Devil's Gorge	1993	120.4	1.27	757.9	351.8	124.5	103.8	1,338.0	7.0	35.14	1,808.2
7	Mpata Gorge	1993	120.4	1.27	1,023.7	475.2	168.1	140.2	1,807.3	7.0	35.14	2,442.4
8	Mumbotuta Fall, CiteCX	2000	100.0	1.52	244.0	71.7	65.2	40.0	420.9	4.5	21.12	509.8
9	Mambilia Fall site2	2000	100.0	1.52	362.6	66.5	90.8	52.0	571.9	5.0	23.78	707.8
10	Mambilia Fall site1	2000	100.0	1.52	245.3	60.8	63.2	36.9	406.2	4.0	18.53	481.5
11	Kabompo Gorge	2000	100.0	1.52	45.8	35.5	8.6	9.1	99.0	3.5	16.00	114.9
12	Kalungwishi Kabwelume Falls	2000	100.0	1.52	65.1	25.8	16.3	10.7	117.9	4.0	18.53	139.7
13	Kalungwishi Kundabwika Falls	2000	100.0	1.52	110.2	41.7	25.1	17.7	194.7	3.5	16.00	225.8
14	Mutinondo	2008	152.4	1.00	31.4	24.5	5.7	6.2	67.8	3.0	13.53	77.0
15	Luchenene	2008	152.4	1.00	32.4	21.7	5.9	6.0	66.0	3.0	13.53	74.9
16	Lunsemfwa	2009	-	1.00	106.0	83.0	19.0	21.0	229.0	4.0	18.53	271.4
17	Mkushi	2009	-	1.00	60.0	38.0	10.0	11.0	119.0	4.0	18.53	141.1

Escalation	4.5%
Interest during construction is the value at the 10% discountrate.	
Plant Cost Index: Japan Machinery Center for Trade and Investment,JMC, 2008 PCI / LF (Plant cost index / Location factor)	

Computation of unit generation cost

Based on the project cost indicated in Table 0.27, the unit construction cost and unit generation cost were calculated. The premises of calculation of unit generation cost is shown in Table 0.28.

Table 0.28 Premise on computation of unit generation cost

Item	Unit	Hydropower	Coal Thermal
Annual hours	hrs	8,765.8	
Development cost	US$/kW	each project cost	1,200
Discount rate	%	10%	
Life Time	Years	50	30
Capital Recovery Factor	--	0.1009	0.1061
Fixed O&M cost	US$/MW-Yr	1%	8,040
Variable O&M cost	US¢/kWh		0.142
Heat rate	kcal/kWh	--	2,473
[Fuel: Coal]			
Price	US$/ton	--	70
	US¢/Gcal	--	1,167
Heat content	Kcal/kg	--	6,000
	GJ/ton	--	25.01

Table 0.29 shows the results of calculation of unit construction costs and unit generation costs. Figure 0.4 and Figure 0.5 also shows the relation between installed capacity and unit generation cost, and between capacity factor and unit generation cost, respectively.

Table 0.29 Unit construction cost and unit generation cost of generation projects

	Project	Capacity (MW)	Annual Energy (GWh)	Capacity Factor (%)	Project Cost (million $)	Unit capital cost ($/kW)	Levelized capital cost (¢/kWh)	O&M cost (¢/kWh) Fixed	O&M cost (¢/kWh) Variable	Fule cost (¢/kWh)	Unit generation cost (¢/kWh)
1	Kariba North Extension	360	380	12.0%	358	994	9.50	0.94		--	10.44
2	Itezhi Tezhi	120	611	58.1%	170	1,417	2.81	0.28		--	3.08
3	Lusiwasi Extension	80	200	28.6%	134	1,675	6.74	0.67		--	7.41
4	Mutinondo	40	188	53.6%	77	1,925	4.13	0.41		--	4.54
5	Luchenene	30	139	52.9%	75	2,500	5.44	0.54		--	5.98
6	Lunsemfwa	55	462	95.8%	271	4,927	5.92	0.59		--	6.50
7	Mkushi	65	223	39.1%	141	2,169	6.38	0.63		--	7.01
8	Kabompo Gorge	34	176	59.1%	115	3,382	6.59	0.65		--	7.24
9	Kabwelume Falls	62	324	59.6%	140	2,258	4.36	0.43		--	4.79
10	Kundabwika Falls	101	533	60.2%	226	2,238	4.28	0.42		--	4.70
11	Kafue Gorge Lower	750	2,400	36.5%	1,745	2,327	7.33	0.73		--	8.06
12	Mambilima Falls SiteI	124	609	56.0%	481	3,879	7.97	0.79		--	8.76
13	Mambilima Falls SiteII	202	1,003	56.6%	708	3,505	7.12	0.71		--	7.83
14	Mumbotuta Falls	301	1,449	54.9%	510	1,694	3.55	0.35		--	3.90
15	Batoka Gorge	800	4,372	62.3%	1,462	1,828	3.37	0.33		--	3.71
16	Devil's Gorge	500	2,802	63.9%	904	1,808	3.25	0.32		--	3.58
17	Mpata Gorge	543	3,785	79.5%	1,221	2,249	3.25	0.32		--	3.58
	Total Hydro	**4,167**	**19,656**	**53.8%**	**8,738**	**2,097**	**4.484**	**0.445**		**--**	**4.928**
	Coal Thermal Power	200	1,459	83.2%	240	1,200	1.74	0.110	0.142	2.885	4.88

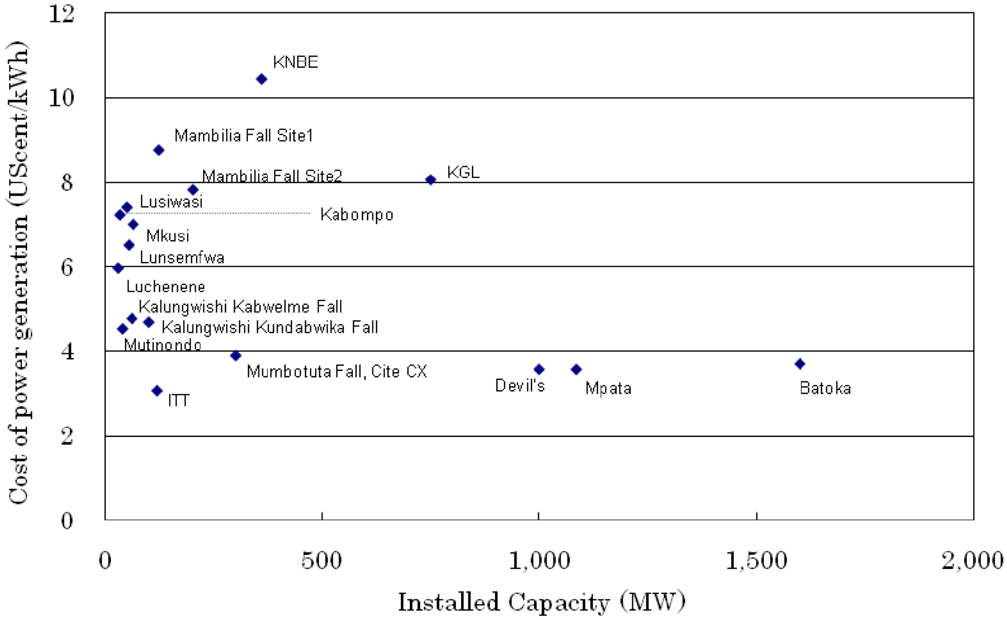


Figure 0.4 Relation between installed capacity and unit generation cost

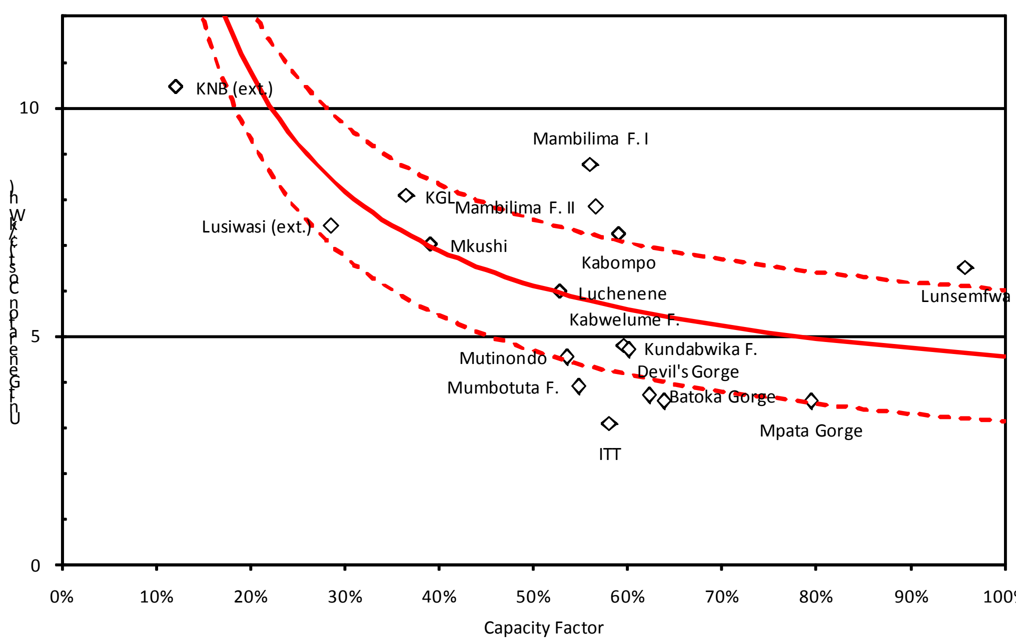


Figure 0.5 Relation between capacity factor and unit generation cost

As shown in Table 0.29, the average unit construction of 17 hydropower projects was US$ 2,097/kW, and the average unit generation cost of hydropower projects was US¢4.928/kWh, almost equivalent to that of coal thermal generation. The unit generation costs of Itezhi-Tezhi project which needs power station installation only by utilizing the exiting reservoir, and the large scale Zambezi River three projects (Batoka Gorge, Devil's Gorge and

Mpata Gorge) with high capacity factor, were relatively low. On the other hand, the unit generation costs of peaking power project; Kariba North extension and Kafue Gorge Lower, were high.

It should be noticed that unit generation costs of three projects along Zambezi River may increase by reevaluation of project costs in the future which were originally estimated in 1993 and which no detailed study was conducted on DevilôGorge and Mpata Gorge projects so far.

It is desirable that further study should be conducted to elaborate the project design and estimate the project cost, as the unit generation cost will affect the future electricity tariff setting.

Sensitivity of unit generation cost of coal thermal generation

The details of Maamba project is still unrevealed as the feasibility study has not been conducted. As for imported coal thermal generation projects, capital investment in coal transportation should be considered adding power plant investment. As internationally unit generation cost of coal thermal power is commonly around US¢5/kWh, the big deviation hardly happen. Here sensitivity analysis regarding plant costs and (coal) fuel costs to figure out the fluctuation band width of unit generation cost of thermal power generation, was conducted for confirmation since there were so many unknown factors at present. Additionally, capital investment on coal transportation should be included in the fuel price.

Calculating six patterns of unit generation costs with assumption of US$ 1,200/ 1,500/kW of unit construction cost and US$ 35/ 70/ 105/ton of coal price, unit generation cost varies between US¢3.44/kWh and US¢6.76/kWh as indicated in Table 0.30, which are almost on the same level with hydropower project cost in Table 0.29 while hydropower project costs need further investigation as stated before. Taking added value in light of energy diversification ready for drought into consideration, coal thermal projects should be taken in generation development plan.

Table 0.30 Sensitivity of unit generation cost of coal thermal generation

Fuel price (US$/ton)	Unit capital cost (US$/kW)	Levelized capital cost (US¢/kWh)	O&M cost (US¢/kWh) Fixed	O&M cost (US¢/kWh) Variable	Fuel cost (US¢/kWh)	Total (US¢/kWh)
35	1,200	1.745	0.110	0.142	1.443	3.44
	1,500	2.181				3.88
70	1,200	1.745			2.885	4.88
	1,500	2.181				5.32
105	1,200	1.745			4.328	6.33
	1,500	2.181				6.76

(Source) JICA Study Team

Hydropower development project matrix

Evaluating the hydropower projects indicated in Table 0.24 from the viewpoint of economic efficiency, project progress, social and environmental consideration aspects and system requirement, hydropower development project matrix was formulated as shown in Table 0.31.

As unit generation costs were taken as the indicator of economic efficiency, it is unfair to simply compare peak generation projects with lower capacity factor with base generation projects with higher capacity factor, so that unit generation costs of hydropower projects were compared with those of coal thermal generation projects with the same capacity factor (see red lines in Figure 0.5. As for project progress, many projects are still in the stage of Pre F/S or conceptual design, so that the projects which F/Sõs were completed, and/or the project sponsors were decided, were given higher priority. From the social and environmental aspects, there found no serious concern detected due to no detailed investigation like F/Sõs in many projects, which were given lower priority. Amidst of tight power demand-supply situation, every project has significant importance, but the projects located in the northern region of the country where the existing generation facilities are less, were given higher priority.

Evaluating these four indicators, 17 projects were prioritized and generation development plan was formulated along with the ranking. However, in most of the projects there were no feasibility studies conducted so far, the ranking in Table 0.31 will be subject to change due to the further study results. For instance, the project cost of Kafue Gorge Lower project were estimated as US$ 800 million less than half of current figure before the current feasibility study was conducted supported by IFC. It is noted that such modification should happen in the future.

Table 0.31 Hydropower development project matrix

	Project	Type	Developer	Capacity (MW)	Annual Energy (GWh)	Stage	Unit gen. cost (¢/kWh)		Implement-ation	Social & environ. Consideration	Site location (system requirement)	Rank
1	Kariba North (ext)	RES	ZESCO	360	380	Construction	10.44	ʓ	ʓ	ʓ	ʓ	1
2	Itezhi Tezhi	RES	ZESCO/TATA	120	611	DD	3.08	ʓ	ʓ	ʓ	△	2
3	Lusiwasi (ext)	ROR	ZESCO	10	40	FS	7.41	△	△	△	ʓ	3
				40	160							
4	Kafue Gorge Lower	RES	n/a	750	2,400		8.06	△	△	△	△	10
5	Mutinondo	ROR	Power Min	40	188	Pre FS/ concept	4.54	△	△	△	ʓ	4
6	Luchenene	ROR	Power Min	30	139		5.97	△	△	△	ʓ	5
7	Kabwelume Falls	RES	LPA	62	324		4.78	ʓ	△	×	ʓ	7
8	Kumdabwika Falls	RES	LPA	101	533		4.70	ʓ	△	×	ʓ	6
9	Kabompo Gorge	RES	CEC/TATA	34	176		7.23	×	△	×	ʓ	11
10	Mambilima Falls I	RES	n/a	124	609		8.76	×	×	×	ʓ	17
11	Mumbotuta Falls	RES	n/a	301	1,449		3.90	ʓ	×	×	ʓ	13
12	Mambilima Falls II	RES	n/a	202	1,003		7.82	×	×	×	ʓ	15
13	Batoka Gorge	RES	ZMB-ZWE govt.	800	4,373		3.71	ʓ	△	×	△	16
14	Lunsemfwa	RES	LHPC	55	462		6.51	×	△	×	ʓ	8
15	Mkushi	RES	LHPC	65	223		7.01	△	△	×	ʓ	9
16	Devil's Gorge	RES	ZMB-ZWE govt.	500	2,802	n/a	3.58	ʓ	×	△	△	12
17	Mpata Gorge	RES	ZMB-ZWE govt.	543	3,785		3.58	ʓ	×	△	△	14
Total				**4,137**	**19,657**		**4.928**					

(Legend) ʓ : Good, △: Fair, ×: Poor or No information

Target Supply Reliability

Reserve margin and/or LOLP (Loss of Load Probability) are generally used as target supply reliability.

Reserve margin was selected as the target for generation development planning and the following margins were considered;

i)	Dry year reserve:	16%	(based on the latest 30 years statistics),
ii)	Planned maintenance:	13%	(45 days per year),
iii)	Degradation:	5%,	
iv)	Forced outage:	5%,	and
v)	Others:	11%.	

Total reserve margin came to 50 percent[16] for installed capacity in total.

Table 0.32 Target supply reliability

Items	Targets	Remarks
Target demand	Base case	
Reserve margin	50% for installed capacity	For Maintenance work, drought reserve
Drought reserve	20% margin in energy balance	Statistically 16% less generation in drought years

The target reserve margin set here can be diminished by considering the international power trade. However, no specific trade plan is presented, and SAPP has only 6 percent of reserve margin as a whole. Therefore, conservative target was established.

Generation Development Planning

Primary energy basis self-supply scenario (Scenario 1-1)

Considering the primary energy self-supply, power generation other than hydropower is Maamba mine-mouth coal thermal station (200 MW) only, and all the hydropower projects in Table 0.31 should be realized to secure the supply reliability set in Table 0.32. Generation projects list for Scenario 1-1 is shown in Table 0.33.

[16] Definition of Reserve Margin is various by a country. In case of taking total installed capacity as denominator, many developing countries set the target of 30 to 40 percent. However, higher value were set here since Zambia was subject to suffer drought influence due to high hydropower proportion.

Table 0.33 **Generation projects list for Scenario 1-1**

	Project	Province	Type	Developer	Capacity (MW)	Annual Energy (GWh)	Project cost (m US$)
2013	Kariba North (ext)	Southern	RES	ZESCO	360	380	358
	Itezhi Tezhi	Southern	RES	ZESCO/TATA	120	611	170
2014	Lusiwasi (ext)	Central	ROR	ZESCO	10	40	134
		Central	ROR	ZESCO	40	160	
	Maamba coal	Southern	Thermal	Nava Bharat	200	1,459	240
2015	Mutinondo	Northern	ROR	Power Min	40	188	77
	Luchenene	Northern	ROR	Power Min	30	139	75
2016	Kabwelume Falls	Luapula & Northern	RES	LPA	62	324	140
	Kumdabwika Falls		RES	LPA	101	533	226
	Lunsemfwa	Central	RES	LHPC	55	462	271
	Mkushi	Central	RES	LHPC	65	223	141
2017	Kafue Gorge Lower	Lusaka	RES	n/a	750	2,400	1,745
2018	Kabompo Gorge	North Western	RES	CEC/TATA	34	176	115
2019	Devil's Gorge	Southern	RES	ZMB-ZWE gvt	500	2,802	1,808
2021	Mumbotuta Falls	Luapula	RES	n/a	301	1,449	510
2023	Mpata Gorge	Lusaka	RES	ZMB-ZWE gvt	543	3,785	2,442
2025	Mambilima Falls (site II)	Luapula	RES	n/a	202	1,003	708
2027	Batoka Gorge	Southern	RES	ZMB-ZWE gvt	800	4,373	1,828
2029	Mambilima Falls (site I)	Luapula	RES	n/a	124	609	481
Total scenario 1-1					**4,337**	**21,116**	**11,469**

The capacity balance in Scenario 1-1 is shown in Figure 0.6. As Kariba North extension and Itezhi Tezhi in 2013 and Maamba coal thermal in 2014 will be added in the power system, slight reserve for capacity will be expected in 2014. It is after 2017 that the power system may has substantial reserve, when Kafue Gorge Lower starts operation. These four projects are quite important to overcome the demand-supply gap for the time being. Finally, the power system will keep 40 to 60 percent of reserve margin after Devil's Gorge operation in 2019.

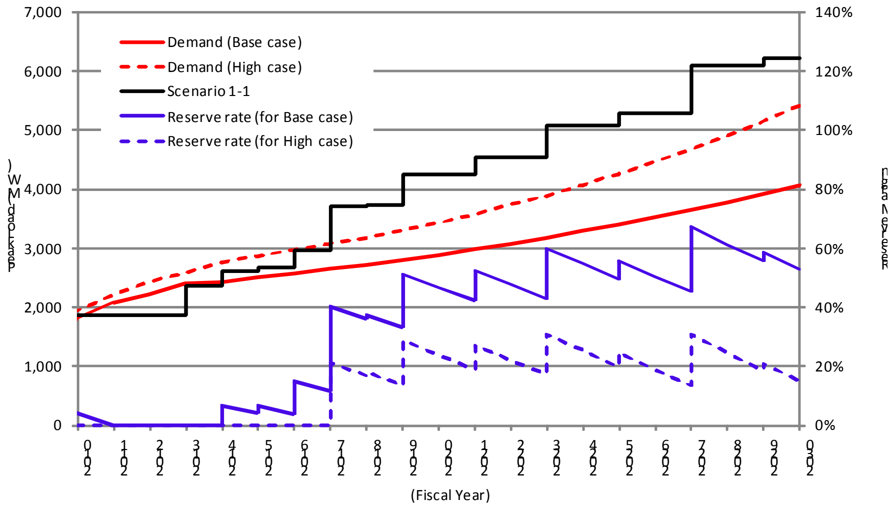


Figure 0.6 Capacity balance in Scenario 1-1

On the other hand, from the viewpoint of annual energy, power supply will be insufficient until 2019 as indicated in Figure 0.7. That is to say, as hydropower plants with lower capacity factor are the primary generation sources in this scenario, annual energy will be short while capacity balance is sufficient. As a countermeasure, electricity import in the low load period can be taken if peak supply is enough by operating hydropower stations. On the other hand, by modifying some projects to have more capacity factor with decreasing their peak power, other alternative which can reduce the initial investment costs will be suggested

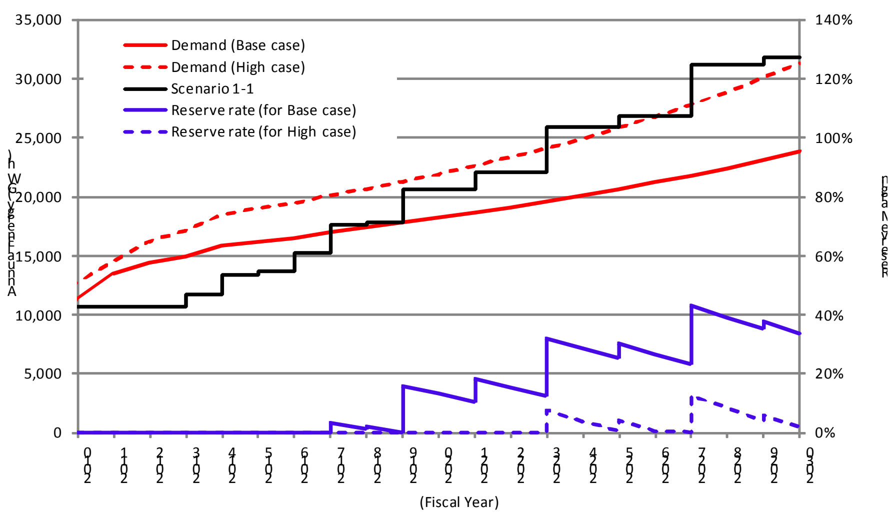


Figure 0.7 Energy balance in Scenario 1-1

Electricity basis self-supply scenario (Scenario 1-2)

Formulating generation development with one-fourth of total capacity of coal thermal generation including import coal thermal, 14 hydropower projects excluding lower priority projects in Table 0.31; Batoka Gorge and Mambilima Falls (site I & II), should be developed.

Table 0.34 Generation projects list for Scenario 1-2

	Project	Province	Type	Developer	Capacity (MW)	Annual Energy (GWh)	Project cost (m US$)
2013	Kariba North (ext)	Southern	RES	ZESCO	360	380	358
	Itezhi Tezhi	Southern	RES	ZESCO/TATA	120	611	170
2014	Lusiwasi (ext)	Central	ROR	ZESCO	10	40	134
		Central	ROR	ZESCO	40	160	
	Maamba coal	Southern	Thermal	Nava Bharat	200	1,459	240
2015	Mutinondo	Northern	ROR	Power Min	40	188	77
	Luchenene	Northern	ROR	Power Min	30	139	75
2016	Kabwelume Falls	Luapula & Northern	RES	LPA	62	324	140
	Kumdabwika Falls		RES	LPA	101	533	226
	Generic coal 1	n/a	Thermal	Private	300	2,189	360
2017	Kafue Gorge Lower	Lusaka	RES	n.y.	750	2,400	1,745
2018	Lunsemfwa	Central	RES	LHPC	55	462	271
	Generic coal 2	n/a	Thermal	Private	300	2,189	360
2020	Mkushi	Central	RES	LHPC	65	223	141
	Kabompo Gorge	North Western	RES	CEC/TATA	34	176	115
2021	Generic coal 3	n/a	Thermal	Private	300	2,189	360
2024	Devil's Gorge	Southern	RES	ZMB-ZWE gvt	500	2,802	1,808
2026	Mumbotuta Falls	Luapula	RES	n/a	301	1,449	510
2029	Mpata Gorge	Lusaka	RES	ZMB-ZWE gvt	543	3,785	2,442
Total Scenario 1-2					**4,111**	**21,698**	**9,532**

Scenario 1-2 can realize earlier elimination of demand-supply gap as indicated in Figure 0.8 by introducing 500 MW coal thermal generation by 2016. After 2017, the power system will secure the sufficient supply reserve.

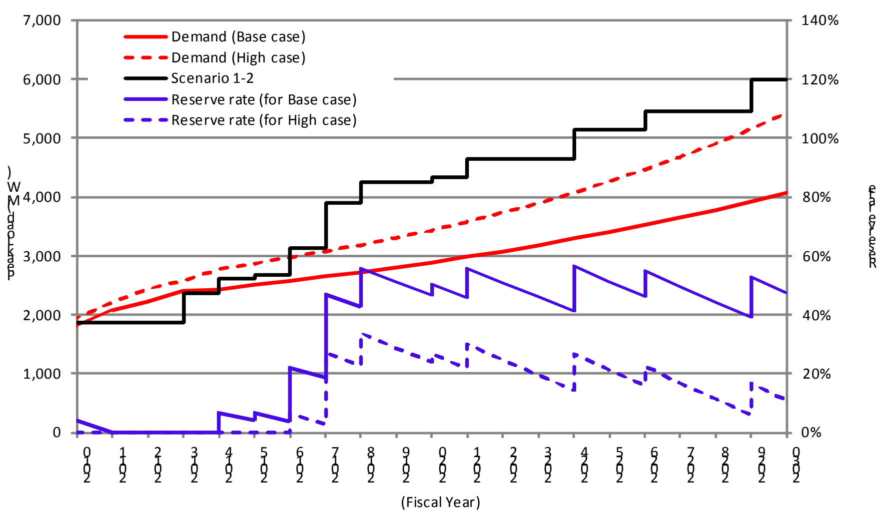


Figure 0.8 Capacity balance in Scenario 1-2

As for energy balance, Scenario 1-2 can secure supply reserve earlier[17] by introducing higher capacity coal thermal generation regularly in 2014, 2016 and 2018.

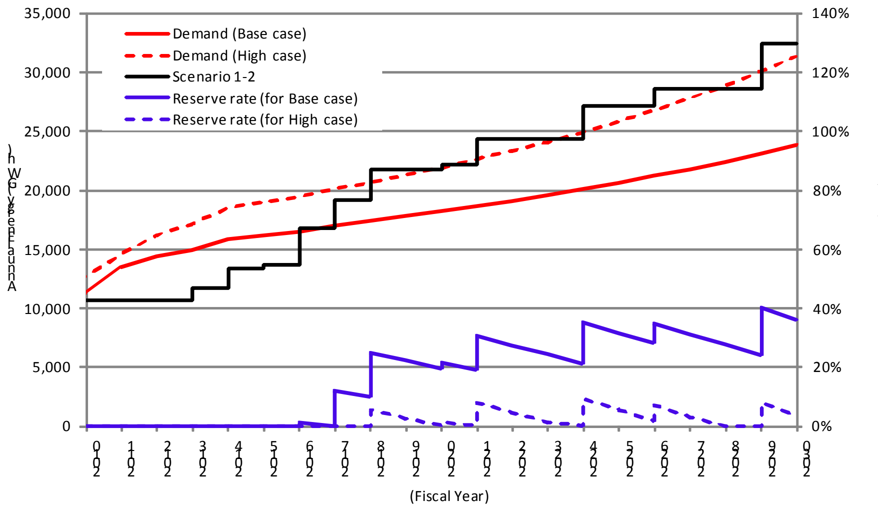


Figure 0.9 Energy balance in Scenario 1-2

[17] Actually Scenario 1-2 needs lower reserve margin as it introduces more coal thermal generation, free from drought influence.

Summary of generation development plan

Table 0.35 summarizes the two generation development scenarios above mentioned. As planned with the same target supply reliability, both scenarios need almost same amount of installed capacity and annual energy generation. The initial investment of Scenario 1-2 is lower which includes more coal thermal generation with lower initial investment. However, the difference between both scenarios is US$ 1,937 million, and divided by the difference of coal thermal generation energy; 2,189 GWh×38 years = 83,182 GWh, it comes to US¢ 2.33/kWh, which is almost the same as the fuel cost of coal thermal generation indicated in Table 0.29. Therefore, both scenarios have almost the same economic efficiency.

Table 0.35 Summary of generation development planning

		Scenario 1-1			Scenario 1-2		
		Installed capacity (MW)	Annual energy (GWh)	Investment (m US$)	Installed capacity (MW)	Annual energy (GWh)	Investment (m US$)
-2015	Total	800	3,054	1,054	800	2,978	1,054
	Hydro	600	1,518	814	600	1,442	814
	Coal	200	1,459	240	200	1,459	240
2016-2020	Total	1,567	6,920	4,446	1,667	8,496	3,358
	Hydro	1,567	6,920	4,446	1,067	3,888	2,638
	Coal	0	0	0	600	4,378	720
2021-2025	Total	1,046	6,237	3,660	800	4,991	2,168
	Hydro	1,046	6,237	3,660	500	2,687	1,808
	Coal	0	0	0	300	2,189	360
2026-2030	Total	924	4,982	2,309	844	5,234	2,952
	Hydro	924	4,982	2,309	844	5,234	2,952
	Coal	0	0	0	0	0	0
Total	**Total**	**4,337**	**21,193**	**11,469**	**4,111**	**21,698**	**9,532**
	Hydro	**4,137**	**19,734**	**11,229**	**3,011**	**13,672**	**8,212**
	Coal	**200**	**1,459**	**240**	**1,100**	**8,026**	**1,320**

Interconnection Plan

Formulation policy

Power interchange through international interconnections is important from the perspective of energy security, that is, assuring an efficient supply of energy. It is also vital for stimulation of the power market economy through import of power with a unit generation cost lower than that of domestically generated power and sale of surplus power to other countries, as well as the accompanying stimulation of the regional economy.

However as noted in connection with the Generation Development Planning in the previous chapter, Zambiaös supply and demand balance will not significantly depend on power interchange through international interconnections. This is because positioning of power supplied through international interconnections (mainly imported power) as a major component of the supply-demand balance would make Zambia's energy security dependent on power sources in other countries, that is, their energy security. As such, it would negate the meaning of the master plan in Zambia, which operates and maintains large-scale hydropower sources and is eager for continued introduction of hydropower and various other power sources. Considering Zambiaös vision to join the group of middle-income countries, its objective would be to satisfy the majority of demand with power generated within its borders and to supply any deficit of reserve power (here referring mainly to the spinning margin and part of the standby reserve power) from other countries through international interchange. Zambia will also participate in strategic power sales and in the regional power market economy when there is surplus power.

Geographically, Zambia is situated in the center of SAPP. In the SAPP, it has exports and wheels power mainly to South Africa, which is the biggest power consumer in SAPP. Zambia also wheels power generated in the southern SAPP countries to northern ones such as Tanzania, which has an adverse supply-demand balance. Therefore Zambia must be a strong backbone for SAPP, through its possession and continued reinforcement of trunk transmission lines linking the northern and southern halves of SAPP.

Zambia's investment in transmission has the addede benefit of supporting rural electrification by extending the grid and reinforcing capacity.

The treatment of the interconnection plan in this chapter will not go into the details of contracts (partner countries, contract schemes, etc.) but instead discuss power import required by Zambia and its possible power export. This is because SAPP is yet to develop into fully fledged competitive market.

Formulation method

Figure 7.1 shows the flow of formulation of the study. The power demand forecast and generaton development plan presented in the preceding chapters provided the basis for calculation of the possible power export and requisite power import by Zambia.

Another major factor here alongside the amount of electrical energy (in terms of GWh) is the amount power (in terms of MW), meaning the amount of peak demand that cannot be supplied, i.e., the facility surplus shortage in the time period when the peak demand occurs. Naturally, load curtailment (through means such as load shedding) must be performed for that portion of the peak demand which cannot be met. Therefore, the Study Team made calculations for imported power in addition to the amount of electrical energy import and export.

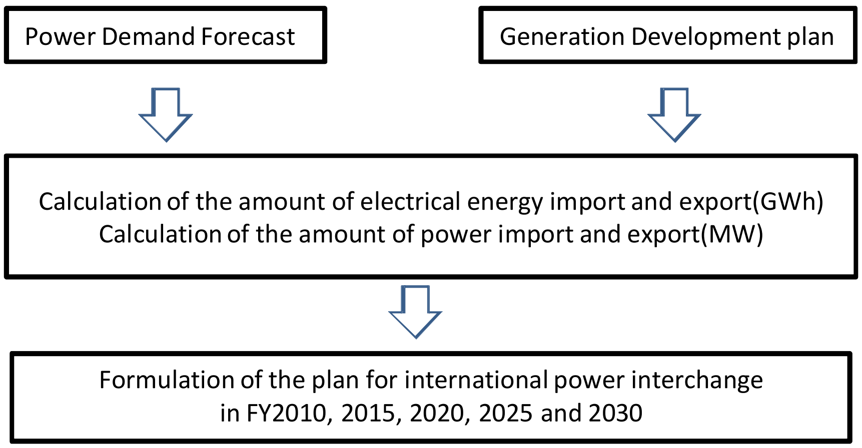


Figure 0.1 Flow of formulation of the international power interchange plan

Results of calculation of the amount of electrical energy import and export

The following discusses the amount of electrical energy import and export in Scenario 1-1

Figure 7.2 shows the results of the rough calculation in the case of ordinary water level years for hydropower generation in Scenario 1-1 of the generation development plan, in the base case of the power demand forecast. In this case, the generated output would continue to be short, and require import of 4,650 GWh in fiscal 2012. The requisite import would decline with the startup of the Maamba coal-fired power station (200 MW) and Kariba North Extension power station (360 MW) in fiscal 2014. In fiscal 2019, the supply and demand would be balanced with the startup of the Kafue Gorge Lower power station (750 MW). With the startup of large-scale hydropower stations at Devil's Gorge (500 MW) and other locations along the Zambezi in succeeding years, Zambia would become capable of exporting power in amounts up to 8,255 GWh.

Figure 7.3 shows the results of calculations made for the cases of wet and dry years in Scenario 1-1 in the base demand forecast case, in addition to those for ordinary water years. Even in the case of continued wet levels, Zambia would have to import power over fiscal years 2011 - 2016. In that of continued dry levels, the supply-demand balance would greatly worsen and necessitate import almost every year. The startup of the large-scale hydropower plants on the Zambezi at Mpata Gorge (543 MW) and Devil's Gorge (500 MW) is vital for development of an export capability.

Figures 7.4 - 7.6 show the calculation results in each of the three demand forecast cases (high, low, and base) and each water level case (ordinary - Figure 7.4, wet - Figure 7.5, and dry

- Figure 7.6).

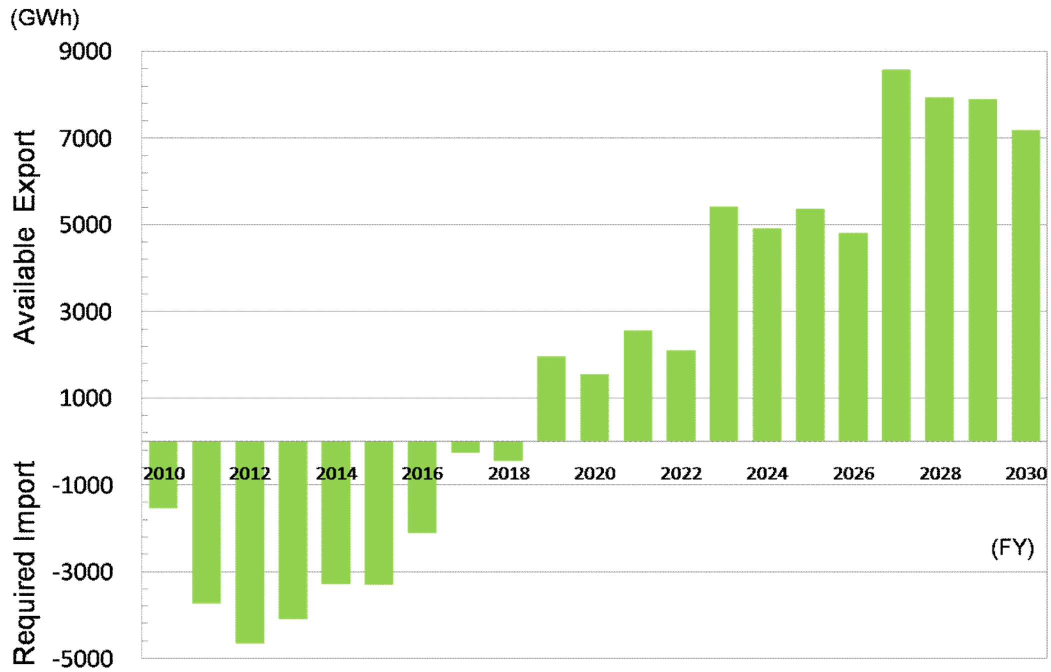


Figure 0.2 Approximate amount of electrical energy import and export in ordinary years (Base case, Scenario 1-1)

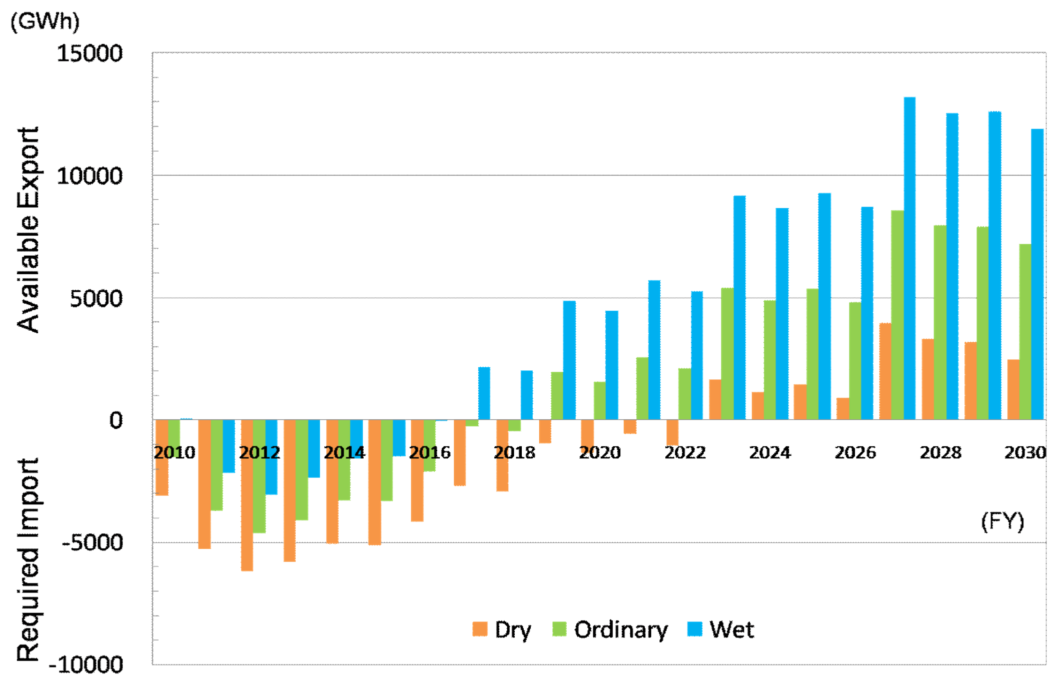


Figure 0.3 Comparison of amounts of electrical energy import and export at wet, ordinary, and dry levels (Scenario 1-1)

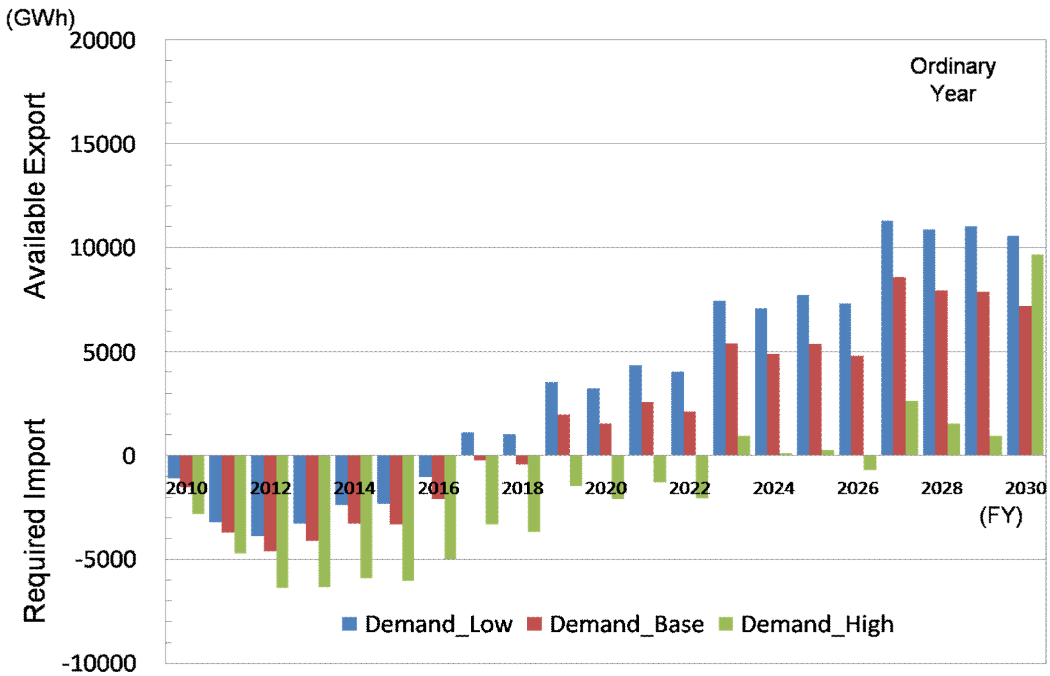


Figure 0.4 **Comparison of amounts of electrical energy import and export based on the power demand forecast (Ordinary level, Scenario 1-1)**

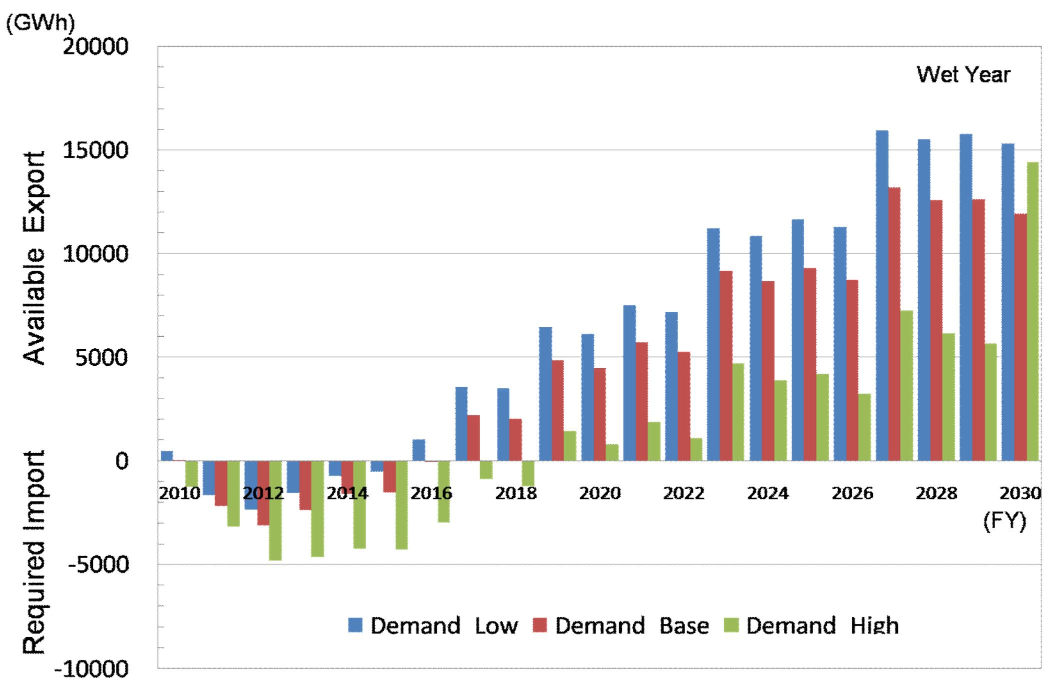


Figure 0.5 **Comparison of amounts of electrical energy import and export based on the power demand forecast (Wet level, Scenario 1-1)**

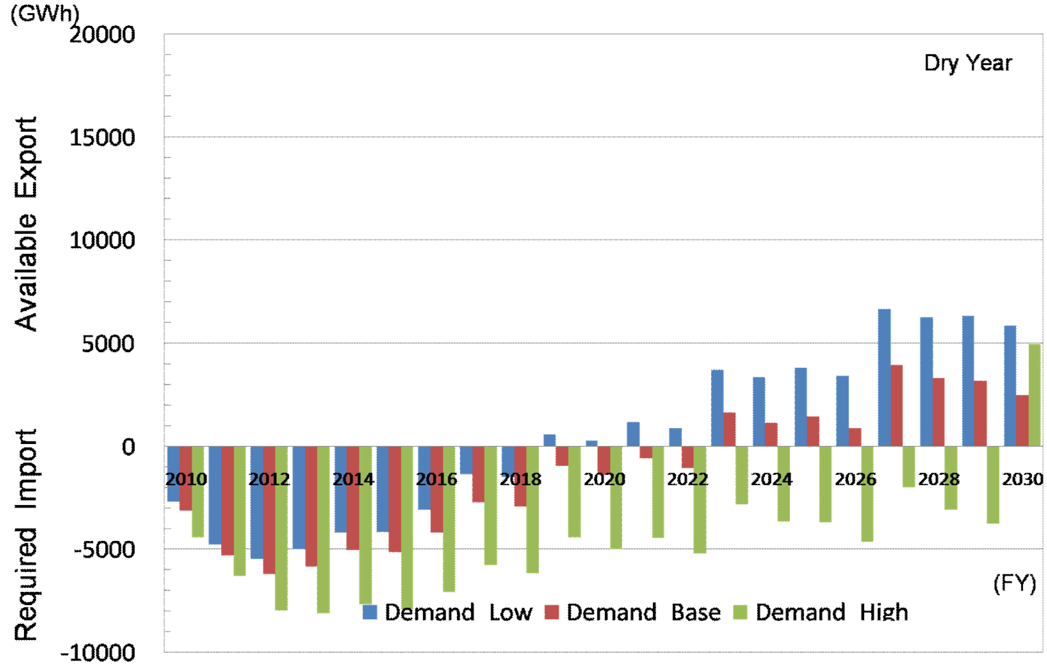


Figure 0.6 Comparison of amounts of electrical energy import and export based on the power demand forecast (Dry level, Scenario 1-1)

The following discusses the amount of electrical energy import and export in development Scenario 1-2

Figure 7.7 shows the results of the rough calculation of the amount of electrical energy import and export in ordinary years for hydropower generation in the base demand forecast case in Scenario 1-2 of the generation development plan. As in the case of Scenario 1-1, the supply would be insufficient in the immediately succeeding years, but the input of a coal-fired power station in fiscal 2016 would support the base power and dramatically reduce the extent of supply shortage. Thereafter, a supply surplus could be steadily maintained through effective supply of base power by successive input of coal-fired power stations.

Figure 7.8 shows the calculation results for wet and dry levels in addition to ordinary ones in the base demand forecast case in Scenario 1-2. It best manifests the effects of thermal power station introduction, and indicates that there would be no supply shortage beginning in fiscal 2016.

Figures 7.9 - 7.11 show the calculation results in each of the three demand forecast cases (high, low, and base) and each water level case (ordinary - Figure 7.9, wet - Figure 7.10, and dry - Figure 7.11). It should be noted that, beginning in fiscal 2016, there would constantly be a surplus of about 2,000 GWh in the base case even in years with dry levels. This figure is equivalent to the yearly amount of power generated by one of the candidate coal-fired power stations, and would constitute a sufficient level of reserve power.

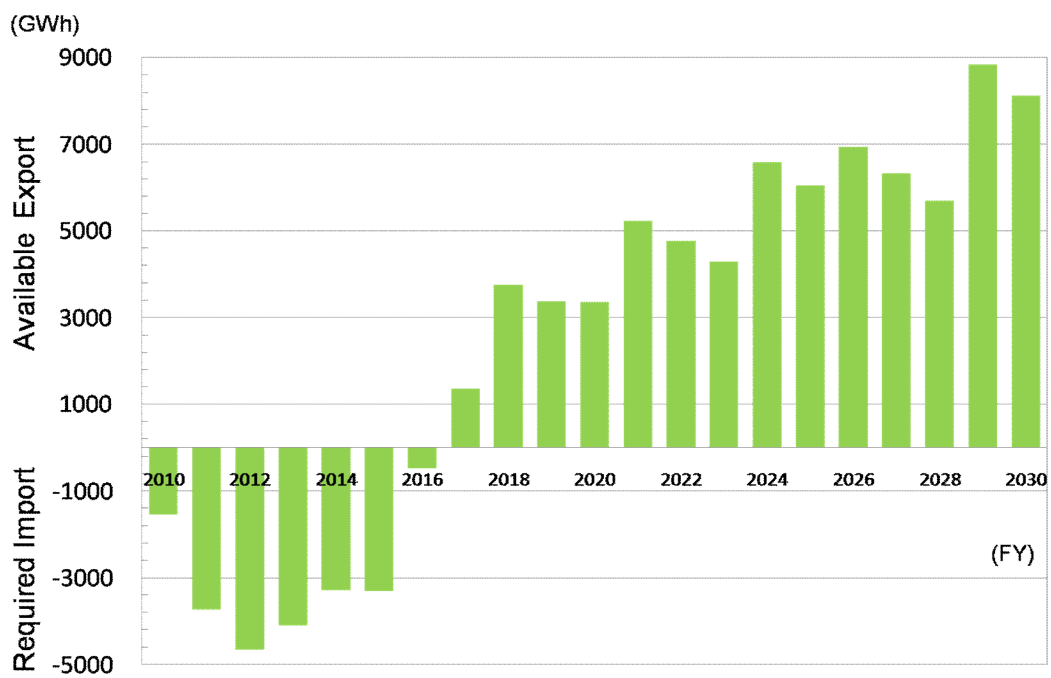


Figure 0.7 Approximate amount of electrical import and export in ordinary years (Base case, Scenario 1-2)

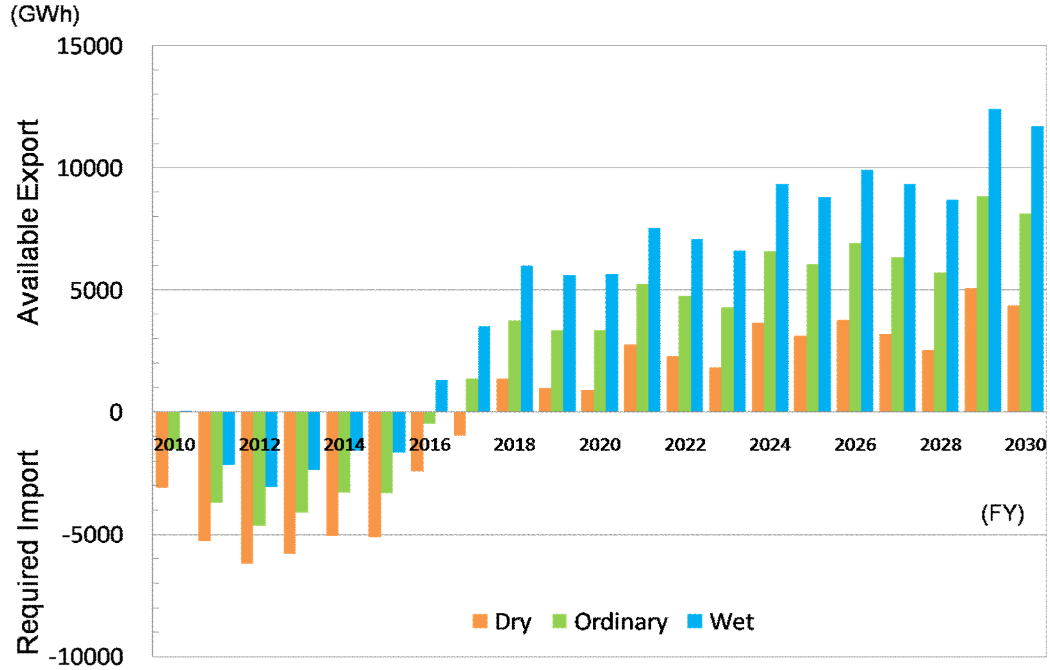


Figure 0.8 Comparison of amounts of electrical energy import and export at wet, ordinary, and dry levels (Scenario 1-2)

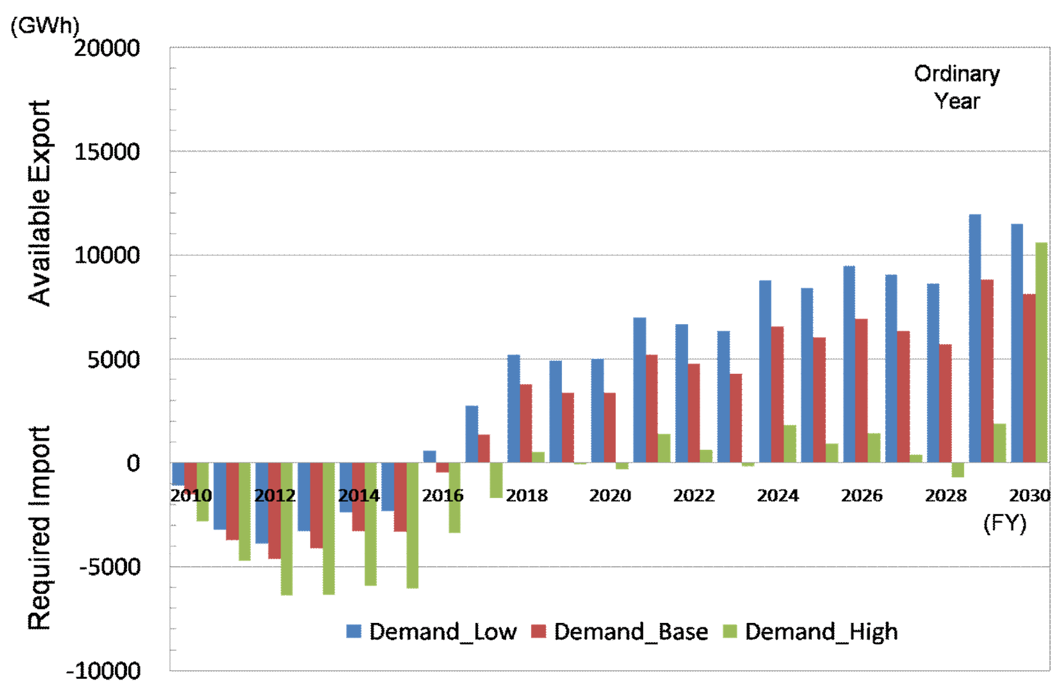


Figure 0.9 Comparison of amounts of electrical energy import and export based on the power demand forecast (Ordinary level, Scenario 1-2)

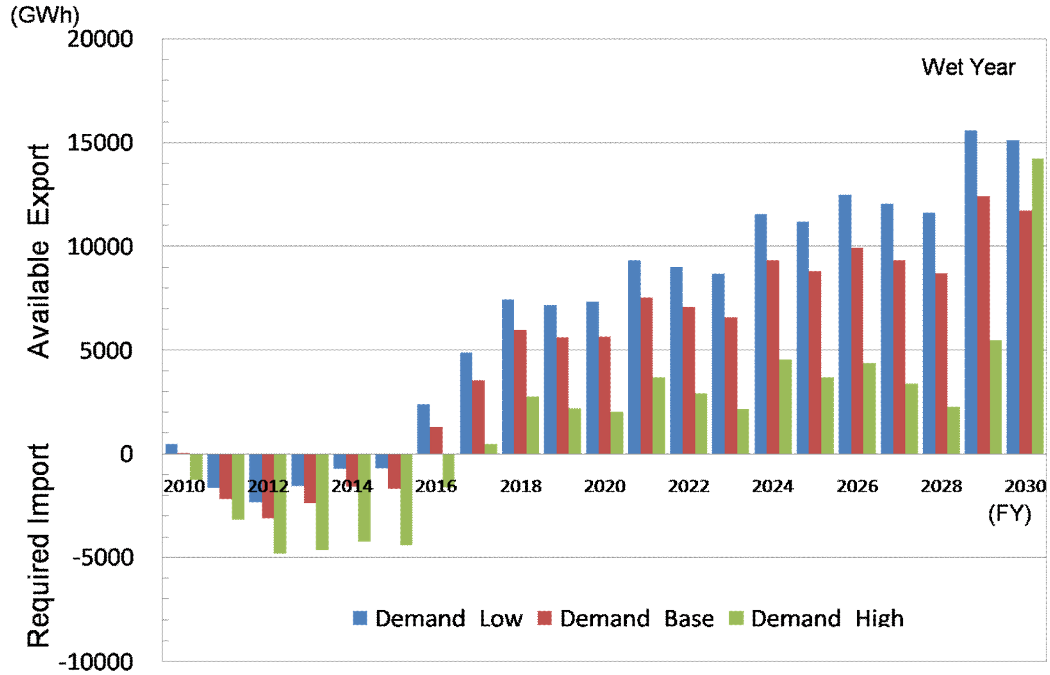


Figure 0.10 Comparison of amounts of electrical energy import and export based on the power demand forecast (Wet level, Scenario 1-2)

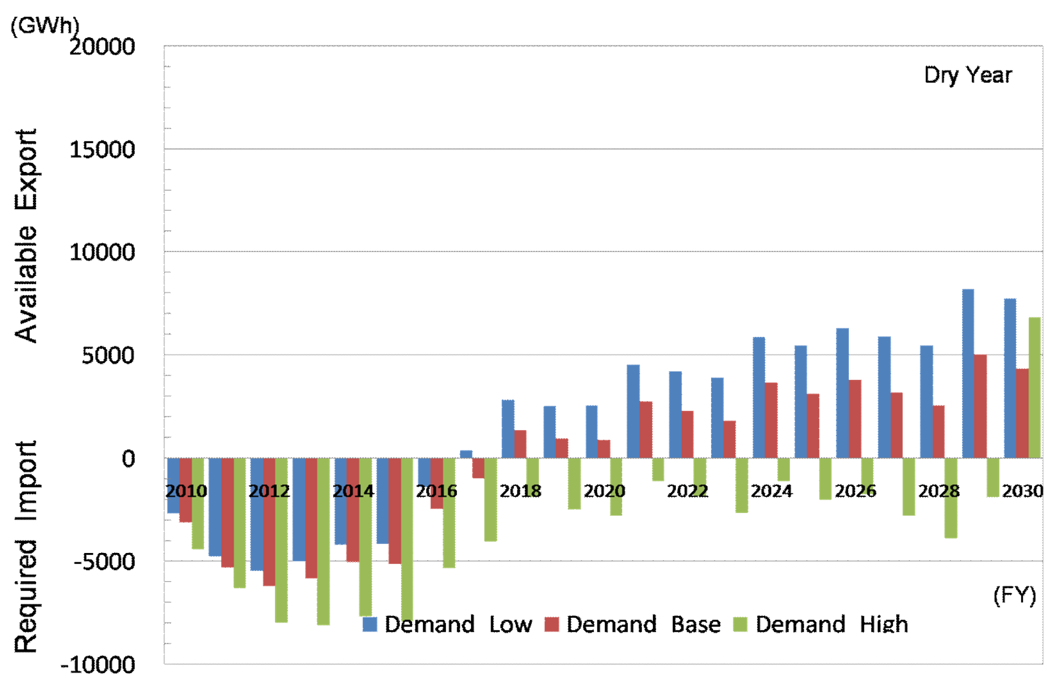


Figure 0.11 Comparison of amounts of electrical energy import and export based on the power demand forecast (Dry level, Scenario 1-2)

Results of calculation of power import and export (MW)

To estimate the need for power import, the Study Team made a comparison of the forecast peak demand and the available generation capacity. The results are shown in Figure 7.12.

The available generation capacity was calculated in accordance with the following assumptions.

* Coal-fired thermal power units will each operate with 80 percent of capacity factor..
* The reservoir -type hydropower units will each operate with 100 percent of capacity factor.
* The run-of-river hydropower units will each operate with 60 percent of capacity factor due to their dependence on the prevailing water level.

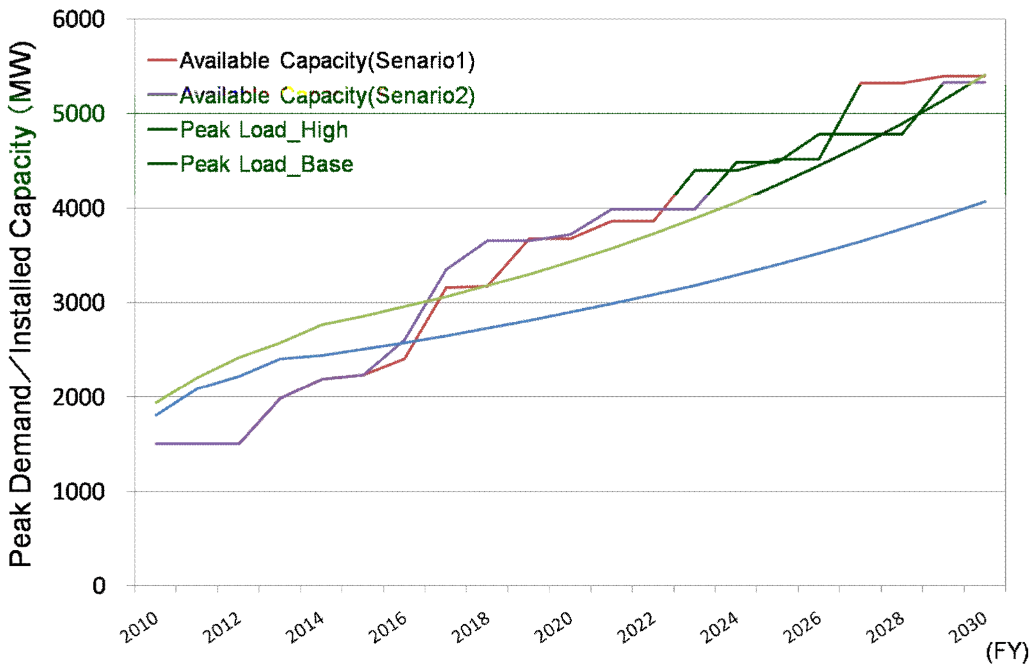


Figure 0.12 Correlation between forecast peak demand(MW) and available generation capacity

This figure shows the following observations can be made about the period beginning in fiscal 2017.

* In the base case, Zambia could retain a margin in the range of 800 - 1,300 MW in both generation development plan scenarios. This range amounts to possession of a power reserve of over 20 percent every fiscal year, and indicates a high level of system stability.
* In the high case demand forecast scenario, the reserve capability would be extremely slim in certain fiscal years, but would generally remain in the range of 5 - 8 percent.

In other words, beginning in fiscal 2017, Zambia would probably be fully capable of exporting power for response to peak demand.

International power interchange in the future

Tables 7.1 - 7.3 summarize the results of the rough calculation of electrical energy and power import and export (MW and TWh) described in the preceding sections.

Table 0.1 Results of calculation of power and electrical energy import and export (Demand forecast : Base case)

Import and Export			2010	2015	2020	2025	2030
Export	Power(MW)				700	1000	1300
	Electrical Energy (TWh)	Wet			4.4/5.6	9.2/8.8	11.9/11.7
		Ordinary			1.5/3.3	5.3/6.0	7.2/8.1
		Dry			-/0.9	1.4/3.1	2.4/4.3
Import	Power(MW)		300	300			
	Electrical Energy (TWh)	Wet	0.2/0.2	1.5/1.6			
		Ordinary	1.5/1.5	3.3/3.3			
		Dry	3.1/3.1	5.1/5.1	1.3/-		

Note: Figures to the left of the / slashes are for Scenario 1-1, and those to the right, for Scenario 1-2.

Table 0.2 Results of calculation of power and electrical energy import and export (Demand forecast : High case)

Import and Export			2010	2015	2020	2025	2030
Export	Power(MW)				700	1000	1300
	Electrical Energy (TWh)	Wet			4.4/5.6	9.2/8.8	11.9/11.7
		Ordinary			1.5/3.3	5.3/6.0	7.2/8.1
		Dry			-/0.9	1.4/3.1	2.4/4.3
Import	Power(MW)		300	300			
	Electrical Energy (TWh)	Wet	0.2/0.2	1.5/1.6			
		Ordinary	1.5/1.5	3.3/3.3			
		Dry	3.1/3.1	5.1/5.1	1.3/-		

Note: Figures to the left of the / slashes are for Scenario 1-1, and those to the right, for Scenario 1-2.

In light of the figures in these tables, the matter which must be accorded top priority in studies by Zambia is the identity of a source for procurement of the shortage of power and electrical energy over the immediately following years

The study of imported power on the assumption that there will be ordinary levels in fiscal 2010 as shown in Table 7.1 found a requisite power of 300 MW and requisite energy of 1.5 TWh. Division of the latter figure by the number of hours per year yields a figure of 171 MW (1.5 TWh / 8,760 h). As this is lower than 300 MW, Zambia would have to consider the option of importing power to meet the peak in addition to the import contracted for base power. The same calculation on the assumption that the fiscal 2010 water level would be dry yields a figure of 353 MW (3.1 TWh / 8,760 h). This would raise the possibility of response to peak demand within the context of contracts for power import for base demand. Table 7.3 shows the results of the examinations concerning shortage of power and electrical energy.

Table 0.3 Study of shortage of imported power and electrical energy

Required Volume			2010	2015	2020	2025	2030
Base Case	Requisite peak capacity (MW)		300	300			
	Requisite power	Wet	Base(100) Peak(200)	Base(200) Peak(100)			
		Ordinary	Base(200) Peak(100)	Base(300)			
		Dry	Base(400)	Base(600)	Base(300)		
High Case	Requisite peak capacity (MW)		300	300			
	Requisite power	Wet	Base(200) Peak(100)	Base(600)			
		Ordinary	Base(400)	Base(700)	Base(300)		
		Dry	Base(600)	Base(900)	Base(600)	Base(300)	

Note: "Base" refers to contracts for base power, and "Peak", to contracts for peak power. Figures in parentheses indicate the amounts of power to be contracted in MW.

Because the shortage would come in the immediately succeeding years, it would presumably be difficult for Zambia to develop new partners for supply of the shortages of power and electrical energy. Therefore, the study here was restricted to South Africa and the Democratic Republic of the Congo (DRC), with which Zambia currently has transactions.

For the routes for power reception, the Study Team selected the interconnection with the DRC (interconnection capacity of 600 MW[18]) and the interconnection with South Africa via Zimbabwe (Kariba South Route, interconnection capacity of 300 MW[19]).

The figures for interconnection line capacity noted above were obtained by multiplying the result of calculation using PSS/E, the system analysis simulation tool, by a fixed safety coefficient.

A study must be made to determine whether or not the DRC (SNEL) and South Africa (ESKOM) are actually capable of supplying the amounts of power. In this connection, Table 7.4 shows related figures taken from a project report that was supported by the World Bank.

[18] This figure indicates the capacity of supply through a double-circuit 220kV transmission line and single-circuit 330kV transmission line.

[19] This figure indicates the capacity of supply through a double-circuit 330kV transmission line. The capacity appears to be heading for increase along with construction of the central corridor, but the feasibility of this project is still uncertain, and this prospective increase was consequently excluded from consideration. There is also a reception route via Namibia (the ZIZABONA Project), but this was also excluded from consideration due to uncertainty about its operation.

Table 0.4 P rospects for power import from the DRC and South Africa

Country	Interconnection Capaciry (MW)	Exportable power (MW)		
		2010	2015	2020
DRC	600	179	326～3740	55～3620
South Africa	300	Impossible	Impossible	Impossible or up to 1215
Ref.:Zimbabwe	(300)	Impossible	Impossible or up to 648	Impossible or up to 826

(Source) Prepared by the Study Team with data taken from the interim draft final report of the SAPP Regional Generation and Transmission Plan Study, 2008

It would be impossible to import the requisite power from South Africa. The Study Team considered the prospect of supply from Zimbabwe (ZESA) using the same interconnection, but the power exports by that country show great fluctuation. The DRC is consequently the only possible supplier. Although it would be unable to export the entire requisite amount in fiscal 2010, it would be able to do so in fiscal 2015. Therefore, the conclusion of a firm-type long-term transaction contract with the DRC should enable Zambia to build a more advantageous relationship.

Regarding exported power, the Study Team did not select a certain form of contract or transaction-partner country. The reason is that the present plans for development of power sources and transmission lines among SAPP countries may not be implemented on schedule due to factors such as shortage of funds and stagnation of private-sector investment. It may also be noted that, for extensive power interchange, the level of transaction prices ranks alongside infrastructural conditioning as an item of the greatest concern. This level depends largely on the future course of power tariffs in the related countries. The Study Team therefore advises Zambia to monitor the future situation in SAPP countries and engage in power transactions when the time is right. For the time being, Zambia could retain exported power as power reserve (standby reserve) to heighten the reliability of its own supply or have it make a contribution through power sales.

Transmission Development Plan

Current state of the transmission system in Zambia

Figure 0.1 presents a chart of the transmission system in Zambia. This system is marked by the following characteristics.

Trunk transmission lines

These consist mainly of 330kV lines. The power flows from the large-scale hydropower stations in the south (such as Kariba North and Kafue Gorge) toward the Copperbelt area, and the voltage tends to fall as the flow proceeds north. SCADA data for the Luano substation in 2008 show that the 330kV bus voltage was not up to the standard (330kV plus or minus 5 percent) in about 40 percent of the time periods per year.

Load transmission lines

These consist mainly of 66kV lines. In the northeastern and western areas, most are long-distance single-circuit lines, and do not meet the N-1 rule in many locations. Because power is transmitted over distances in excess of 100 km by 66kV lines, voltage drops greatly at the line ends. According to 2008 SCADA data for the Kasama substation, the 66kV bus voltage did not meet the standard (66kV plus or minus 5 percent) in more than one-third of the time periods per year.

For these reasons, it is consequently vital to find measures to keep voltage stability in the Zambian transmission system. In response, the formulation of the transmission plan emphasized this point.

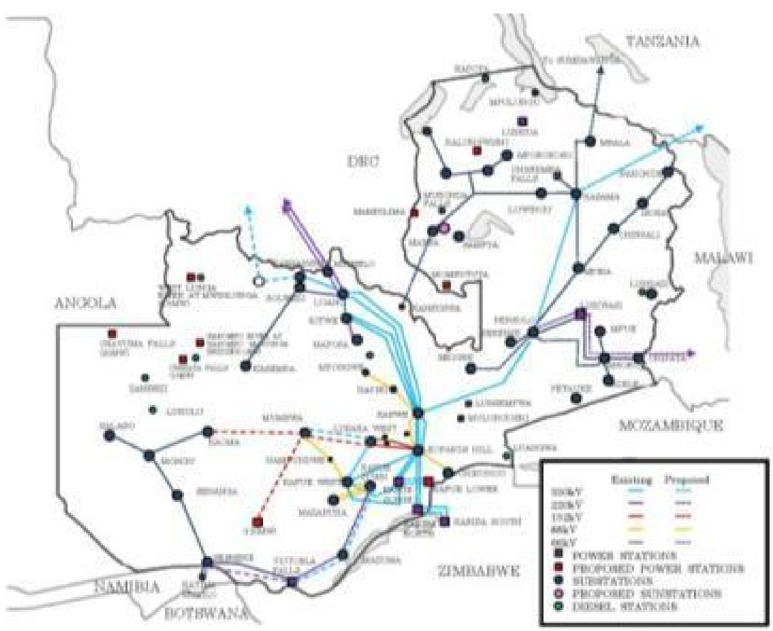


Figure 0.1 Transmission system in Zambia

Criteria applied in formulation of the transmission development plan

Table 0.1 shows the criteria applied in formulation of plans for transmission development in Zambia. It may be added that the standard formulated by the power transmission and development authority in Zambia follow the Grid Code determined by the ERB. It was decided to follow this standard in the preparation of this plan as well. The N-1 rule, which is used as the standard criteria around the world, and is also applied in Zambia. In areas with a low demand density such as the northeastern and western ones, however, this criterion cannot be met because the transmission lines have only one circuit. Although this situation is unavoidable when there are only limited finances available for promoting rural electrification (RE), areas covered only by single-circuit transmission lines should be reduced as far as possible into the future. For this purpose, the Study Team formulated the plan with a view to a phased shrinkage of areas not up to the N-1 rule.

Table 0.1 Criteria applied in formulation of the transmission development plan

Item	Criteria
Station Bus Voltages	Steady state: +/-5% of the nominal value
	Contingency conditions: +/-10% of nominal value
Equipment Loading	Steady state: Within Rated Current of equipment
	Short time overload: 20% above Rated Current for 20 minutes maximum
System Operation Security	System should stand a single contingency
System Stability	System stability (voltage and angle) is to be maintained following a single contingency outage after a permanent line to ground fault on any transmission line or transformer. For single circuit supply arrangements, the criterion will be relaxed.
Power Factor	0.95 (for transmission planning)
Frequency	With SAPP Interconnection: 49.95 - 50.05 Hz range 90% of the time
	Isolated Case: above 49 Hz

In formulation of the transmission plan, the Study Team also made demand forecast at each substation based on the demand forecast presented in Chapter 5 and the current level of demand at each substation. The results are shown in Table 0.2 and this methodology is represented in Appendix.

Table 0.2 Results of the demand forecast at substations

Peak Demand (MW)

Substation	2008	2010	2015	2020	2025	2030
Kalabo	1	1.1	1.6	1.8	2.4	3.1
Mongu	3	3.4	4.7	5.4	7.2	9.4
Senanga	1	1.1	1.6	1.8	2.4	3.1
Sesheke	1	1.1	1.6	1.8	2.4	3.1
Zambezi	5	5.6	7.8	9	12	15.7
Kazunlula	4	4.5	6.3	7.2	9.6	12.5
Vincria Falls	15	16.9	23.5	27.1	35.9	47
Maamba	5	5.6	7.8	9	12	15.7
Muzuma	10	11.3	15.6	18.1	23.9	31.3
Nampundwe	12	13.5	18.8	21.7	28.7	37.6
Mazabuka	38	42.8	59.4	68.7	91	106.6
Monze	4					12.5
Kafue Town	30	33.8	46.9	54.2	71.8	94
Mapepe	14	15.8	21.9	25.3	33.5	43.9
Water Works1	30	33.8	46.9	54.2	71.8	94
Water Works2	40	45	62.6	72.3	95.8	125.3
Coventry Street	15	16.9	23.5	27.1	35.9	47
Coventry Street	80	90	125.1	144.6	191.5	250.6
Coventry Street	25	28.1	39.1	45.2	59.9	78.3
Lusaka West	70	78.8	109.5	126.5	167.6	219.3
Roma	100	112.5	156.4	180.7	239.4	313.3
Chirundu	1	1.1	1.6	1.8	2.4	3.1
Chongwe	7	7.9	10.9	12.6	16.8	21.9
Fig Tree	6	6.8	9.4	10.8	14.4	18.8
Kabwe	27	30.4	42.2	48.8	64.6	84.6
Kapiri Muposi	12	13.5	18.8	21.7	28.7	37.6
Mpongwe	6	6.8	9.4	10.8	14.4	18.8
BRKHL	13	14.6	20.3	23.5	31.1	40.7
Cosak	50	3	78.2	81.9	87.8	96.7
Chisenga	24	31	41.5	43.4	46.6	51.3
Chambishi	25	3	39.1	40.9	43.9	48.3
Solwezi	10	11.3	15.6	16.3	17.5	19.3
Kabundi	16	18	25	26.2	28.1	30.9
Stadium	70	78.8	109.5	114.6	123	135.4
Avenue	53	94.6	117.9	123.4	132.4	145.8
Bancroft	77	106.6	180.4	188.9	202.6	223.1
Bancroft North	20	22.5	31.3	32.8	35.2	38.7
Kansanshi	90	101.3	140.8	147.4	158.2	174.1
Lumwana1	30	33.8	46.9	49.1	52.7	58
Lumwana2	15	16.9	23.5	24.6	26.4	29.1
Chambishi	10	11.3	15.6	16.3	17.5	19.3
Kansuswa	12	13.5	18.8	19.7	21.1	23.2
Mufulira	57	64.1	89.2	93.4	100.2	110.3
Kankoyo	34	2	2	2.1	2.2	2.5
Mufulira West	6	6.8	9.4	9.8	10.6	11.6
C.S.S.(Kitwe)	24	27	37.5	39.3	42.1	46.4
Turf	14	15.8	21.9	22.9	24.6	27.1

Substation	2008	2010	2015	2020	2025	2030
Kitwe	35	39.4	54.7	57.3	61.4	67.6
Mill	32	36	50.1	52.4	56.3	61.9
Nkana	26	29.3	40.7	42.6	45.7	50.3
Mindola	35	2	54.7	57.3	61.4	67.6
Fikondi	5	5.6	7.8	8.2	8.8	9.6
Chibulma	8	9	12.5	13.1	14	15.5
Maposa	1	1.1	1.6	1.7	1.8	2
Pamodzi	28	31.5	43.8	45.9	49.2	54.2
Depot Road	18	20.3	28.2	29.5	31.7	34.9
Skyways	43	48.4	67.3	70.5	75.6	83.2
Ndola Refinery	2	2.3	3.1	3.2	3.5	3.8
Mushili	5	5.6	7.8	8.2	8.8	9.6
Bwana Mukubwa	11	12.4	17.2	18	19.3	21.3
Baluba	13	14.6	20.3	21.3	22.8	25.1
Maclaren	1	1.1	1.6	1.7	1.8	2
Irwin	1	1.1	1.6	1.7	1.8	2
Roan	10	11.3	15.6	16.3	17.5	19.3
Luanshya Minic	16	18	25	26.2	28.1	30.9
Stoke	1	1.1	1.6	1.7	1.8	2
Serenje	1	1.1	1.6	1.8	2.4	3.1
Mfuwe	5	5.6	7.8	9	12	15.7
Chipata	7	7.9	10.9	12.6	16.8	4.9
Azele	2	2.3	3.1	3.6	4.8	6.3
KANON	6	6.8	9.4	10.8	14.4	18.8
KAOMB	7	7.9	10.9	12.6	16.8	21.9
Mpika	3	3.4	4.7	5.4	7.2	9.4
Chinsali	1	1.1	1.6	1.8	2.4	3.1
Isoka	1	1.1	1.6	1.8	2.4	3.1
Nakonde	1	1.1	1.6	1.8	2.4	3.1
Mbala	4	4.5	6.3	7.2	9.6	12.5
Kasama	4	4.5	6.3	7.2	9.6	12.5
Luwingu	2	2.3	3.1	3.6	4.8	6.3
Mansa	2	2.3	3.1	3.6	4.8	6.3
Kawambwa Tea	2	2.3	3.1	3.6	4.8	6.3
Mporokoso	2	2.3	3.1	3.6	4.8	6.3
Frontier	26	29.3	40.7	40.7	40.7	40.7
Kaoma		3.8	5.4	7.0	9.2	12.0
Chavuma		0.3	0.4	0.6	0.8	1.0
Kabompo		2.2	3.1	4.1	5.3	7.0
Mufumbwe		1.3	1.8	2.3	3.1	4.0
Mwinilunga		1.9	2.7	3.5	4.6	6.0
Zambezi		2.2	3.1	4.1	5.3	7.0
Lukuku		2.2	3.1	4.1	5.3	7.0
Mbereshi		2.2	3.1	4.1	5.3	7.0
Nchelenge		2.6	3.6	4.7	6.1	8.0

The plan formulation also considered the influence of international power interchange. Because the transmission system must deliver a stable function even in the case of international interchange, the Study Team analyzed and studied each of two cases: a base case (without international interchange) and an interconnecting case (the condition thought to be the toughest for the Zambian system). Table 0.3 shows the cases analyzed.

Table 0.3 Conditions of international power interchange in transmission plan

Year	Base Case		Interconnecting Case	
	Import	Export	Import	Export
2015	0	0	-Sesheke 200MW	-Nakonde 200MW
2020			-Sesheke 200MW -Victoria Falls 200MW	-Nakonde 400MW
2025				
2030				

In Zambia, power sources are concentrated in the south, and power consequently always flows from the south to the north. As a result, a further magnification of this flow by import of power from Namibia and export of power to Tanzania would be the toughest condition for the Zambian system. The case of international interchange was therefore postulated as shown in Table 8.3. Power import from the DRC would supress the flow from south to north, and therefore alleviates the burden on the system in the aspects of both thermal capacity and voltage stability. Similarly, import from Kariba South would curb the flow between Victoria Falls and Lusaka, and therefore also be more advantageous than import from Namibia.

Transmission development plan in the scenario 1-1

The results of the demand forecast and power development plan served as the basis for formulation of the transmission plan in Zambia in the base scenario (Scenario 1-1). The formulation included a power flow analysis and study of N-1 rule.

In formulation of the transmission plan, the Zambian power system was divided into five regional areas, and the plan was prepared with consideration of the attributes of each area. Figure 8.2 shows this division. Furemore, stability analysis was studied in Zambian system and the result of this represented in Appendix.

To make the transmission development plan, the Zambian power system was divided into the following and considered the feature of each area.

- North-east area
- West area
- South area
- Lusaka area
- Copperbelt area

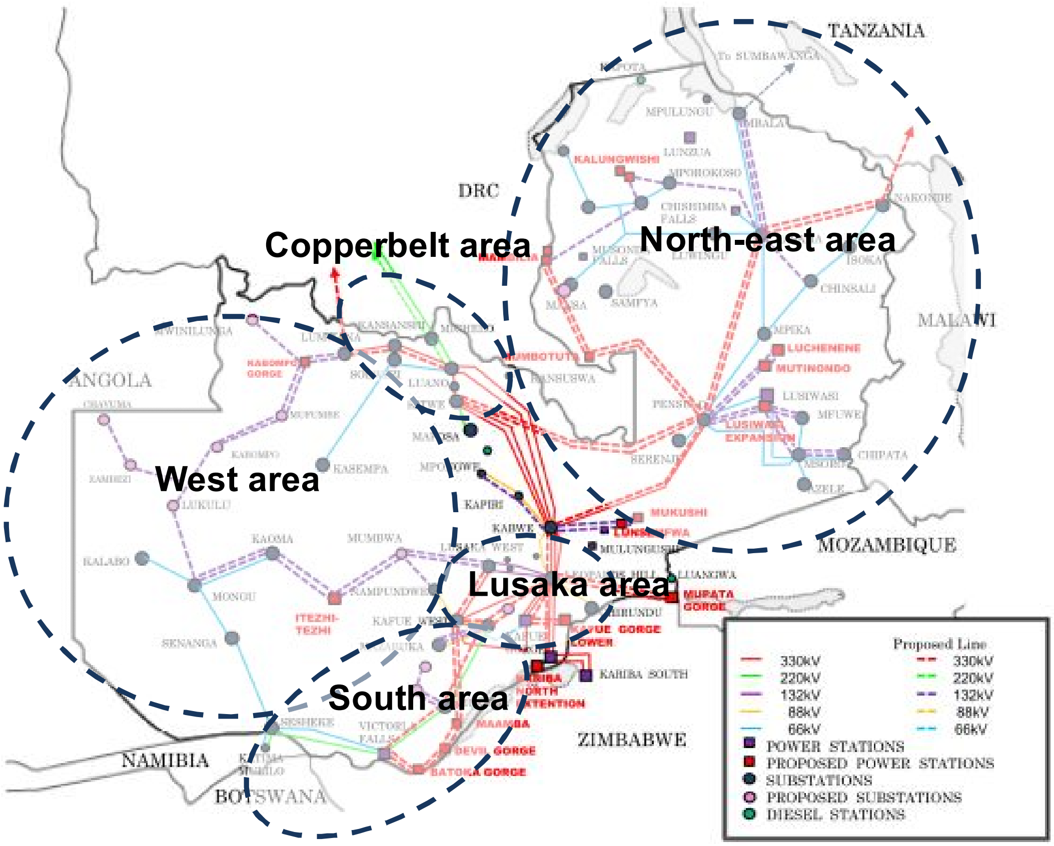


Figure 0.2 Division of regional areas applied in transmission plan formulation

The following sections present the attributes of each area and an outline of the development plan corresponding with them.

North-east area

In this area, there are plans for construction of a large-scale hydropower station near the border with the DRC, and for installation of international interconnection line with Tanzania and Malawi. The characteristics of the power system are as follows.

- The area is already covered by the 66kV transmission line.
- Most of the 66kV transmission lines run for a distance of more than 100 km, with a very steep voltage drop.
- The demand density is low, and the substation load is limited in size.
- At present, the system does not meet the N-1 rule.
- The candidate sites for large-scale hydropower stations are Mambilima, Mumbotuta, Kundbwika, and Kabwelume.

In this area, the major problem is the voltage stability on 66kV power lines. To resolve it, the Study Team decided to reinforcement of the system in this area through installation of 132kV and 330kV lines. In addition, 330kV transmission lines must be installed for supply of power from the large-scale hydropower stations (Mambilima and Mumbotuta) and for the interconnection with Tanzania. Effective use of these transmission lines would be vital for stabilizing the voltage in this area.

The formulation of the transmission development plan for this area took account of these factors. It may be outlined as follows.

(a) International interconnections

Two international interconnection lines are planned for this area. One is the interconnection line with Tanzania, and the other, with Malawi. The plans for each are described below.

・ Interconnection line with Tanzania (Pensulo-Kasama-Nakond-Tanzania)

There are currently plans for an interconnection with Tanzania in 2013 for eventual interchange of 400 MW of power with Tanzania and Kenya. Considering the transmission distance and the magnitude of the power flow, the interconnection line would have to be made with 330kV line. It would also function as the point of interconnection between EAPP and SAPP, and play a vital role in the SAPP system further in the future. As such, it must have a two-circuit structure to meet N-1 rule.

This area also has long 66kV transmission lines marked by a steep voltage drop. So, substations at Kasama and Nakande along the 330kV transmission line are necessary to keep the voltage stability in that part of the Northeast area centered on these locations. Voltage problems have already surfaced, and installation at an early date (between 2010 and 2015) with a two-circuit line is proposed.

・ Interconnection with Malawi (Pensulo-Lusiwasi-Msoro-Chipata-Malawi)

The Malawi system is on a limited scale. In 2008, its peak load came to 268 MW, and its maximum transmission voltage was 132kV. For this reason, the interconnection with this system will be based on use of a 132kV transmission line.

The area is installed with 66kV transmission lines, but the 132kV lines must be constructed at an early date (2010 - 2015), considering the need for increase in the capacity of the Lusiwasi power station and stabilization of voltage.

(b) Power lines

There are two important power lines in this area: one leading from the Mambilima and Mumbotuta power stations, and the other, from the Kundabwika and Kabwelume power stations. The plans for these transmission lines are as follows.

・ Mambilima and Mumbotuta power lines

These two power stations have a combined output of 326 MW, which is extremely large for the load in the vicinity[20]. Almost all of this output is transmitted to other areas (mainly Copperbelt). As a result, it was decided to link these stations with Copperbelt, the major demand site, by means of transmission lines. There are two candidate routes, as indicated below.

- Mambilina, Mumbotuta - Pensulo - Kitwe
- Mambilina, Mumbotuta - (DRC) - Kitwe

Of these two, that through the DRC is about 300 km shorter, and therefore would offer advantages in aspects such as construction costs (203 million US$) and transmission loss (4MW reduction at peak time of 2030). However, this route would be through another country, and therefore entail a high uncertainty as regards construction and operation. For this reason, the route through Pensulo is recommended here.

The phase for development of this power line would be 2020 - 2025, in step with the power station construction.

・ Kalungwishi power line

In the Kalungwishi district, there are plans for construction of two power stations at Kundabwika Falls and Kabwelume Falls. The two would have a combined output of 218 MW[21]. This output, too, is high for the load in the vicinity, and will be transmitted to other areas through Kasama. The distance from Kalungwishi to the Kasama substation is about 250 km, and installation with a single-circuit 132kV transmission line would present problems in the aspects of thermal capacity and transmission loss. These problems could be addressed by installing a two-circuit line with wider conductor (2 x Bison) than usual or a single-circuit 330kV line.

Table 0.4 shows the relative merits of these options.

Although there remains the problem of separating power system in the Northeast area in the event of transmission line failure, these results suggest that it would be better to adopt the 330kV transmission line, which offers benefits in the aspects of construction costs and transmission loss.

The area to be served by this transmission line is one of those with very poor voltage stability. For this reason, the construction of a substation at Mporokoso along this line to improve the voltage stability in this area is recommended.

Properly speaking, the construction of this transmission line should be timed to coincide with the phase of construction of the Kundabwika and Kabwelume substations (2015 - 2020). To

[20] The forecast for combined peak load in 2030 at Mporokoso, Kawambwa Tea, Mbereshi, Nchelenge, Luwing, Mansa, and Kasama is 52.7 MW

[21] In the generation development plan, this value is 163MW. But, there is some possibility to install 218MW on this area, and transmission expansion plan considered more sevire condition.

stabilize the voltage in this area, nevertheless, construction of part of the line (the Kasama-Mporokoso leg) in an earlier phase (preferably 2010 - 2015, when the Pensulo-Kasama 330kV transmission line is to be constructed) is recomended.

Table 0.4 Comparison of the Kalungwishi-Kasama transmission lines

Types of transmission line	132kV, two-circuit, Bison conductor x 2	330kV, single-circuit, Bison conductor x 2
Transmission loss (in transmission of 218 MW)	14.6MW	4.6MW
Construction cost	97 million USD	82 million USD
Other matters	This type of line would enable stable operation of the power system, including the power station vicinity, even in an N-1 condition	The system in the power station vicinity would be taken off the grid in the event of failure of one circuit on the Kundabwika, Kabwelume-Kasama transmission line.

(c) Other transmission lines

In addition to international interconnections and power lines, this area has a need for development of other transmission lines to maintain voltage. The major such lines are as follows.

Table 0.5 132kV transmission development plan in north-east area

Name	Voltage	Year	Remarks
Kasama ï Mbala	132kV	2010-2015	Installation at the time of construction of the Kasama-Pensulo 330kV transmission line
Kasama ï Chinsali		2010-2015	
Lusiwasi ï Mfue		2010-2015	Installation at the time of expanding capacity of Lusiwasi powerstation
Kalungwishi ï Nchelenge		2015-2020	Installation at the time of construction of the Kalungwishi substation
Kalungwishi ï Kawambwa Tea		2015-2020	

The major objective in the case of each of these transmission lines is stabilization of voltage in the area. Stable transmission over distances in excess of 100 km requires a 132kV system as opposed to the current 66kV system.

West area

Small-scale independent systems (diesel) are scattered in this area. Promotion of rural electrification requires interconnection of these systems. The characteristics of the transmission system in this area are as follows.

- Major planned power stations are Itezhi-tezhi (120 MW) and Kabompo Gorge (34 MW).
- Kaoma, Mongu, Senaga, Sesheke, and Kasempa are interconnected with 66kV transmission lines, but much of the area depends on independent systems.
- Most of the 66kV transmission lines are more than 100 km long.
- The demand density is low, and the load at each substation is light[22].
- The N-1 rule not met.

In this area, too, the biggest problem is voltage stability, particularly under the N-1 conditions. The plans for transmission development in this area are as follows.

A. Power lines

In this area, lines are needed from the Itezhi-tezhi and Kabompo Gorge power stations. The power line plans are as follows.

・Itezhi-tezhi line

Over the distance from Itezhi-tezhi to Lusaka West, the plan is to install a 220kV transmission line from Itezhi-tezhi to Mumbwa and a 330kV transmission line from Mumbwa to Lusaka West. Each line has planned as a single circuit. Up until 2017, when the Kafue Gorge Lower power station is placed into operation, there will be a shortage of sources in Zambia as a whole, and the trip of this line will naturally be linked to load shedding. For this reason, the installation of a double-circuit line for the Itezhi-tezhi line is recommended.

This line should be installed in the same period as when the power station is constructed (2010 - 2015 phase).

・Kabompo Gorge line

The Kabompo Gorge power station is to have an output of 34 MW, which is not so large. However, there are few power sources in the northwestern area, it will have an important role to improve voltage stability in this area. As such, the transmission line leading from it should ideally have a voltage of 132kV, the same as that of the system in the West area. It would be suitable for the line to be installed in the same phase as the power station input (2015 - 2020).

B. Western loop

Interconnection of the independent systems in the West area require the construction of a looped transmission line linking Itezhi-tezhi, Kaoma, Mougu, Lukulu, Kabompo, Mufumbe, and Kabompo Gorge. Due to the long transmission distance, it would be appropriate for this system to have a voltage of 132kV instead of the 66kV in use for some lines. In two legs (Itezhi-tezhi-Kaoma-Mongu and Kabompo Gorge-Mufumbe-Kabompo), it would be necessary to install double-circuit lines on later stage in order to assure the voltage stability needed to meet the N-1 rule.

As for the timing, it would be advisable to install the Itezhi-tezhi-Mongu leg in the same

[22] with the exception of Victoria Falls, the combined peak load at the ten other substations in the western area in 2030 is forecast at 59.6 MW

phase as construction of the Itezhi-tezhi power station (2010 - 2015), and to make extensions for the other legs, one after the other beginning with that linked to the power source, in the 2015 - 2020 phase.

South Area

In this area, there are plans for construction of large-scale power stations at Batoka Gorge and Devil Gorge as well as for international interconnections with Namibia, Botswana, and Zimbabwe. The area is also the subject of plans for construction of a coal-fired power station at Maamba. It is consequently of crucial importance for power trade (import and export) and supply to all parts of Zambia. The transmission plans in this area are as follows.

A. Trunk transmission line

In light not only of the plans for construction of large-scale power stations at Batoka Gorge, Devil Gorge, and Maamba but also the need for international power interchange with Namibia, this area will have a very large power flow. Because the future transmission capacity would be short with only a single route, it would be indispensable to develop the trunk transmission line network. It may also be noted that transmission line failure on this route could very well trigger outage throughout Zambia. Therefore, it must be given a structure to enable stable transmission of power under the N-1 rule at the minimum. The plan for development of trunk transmission lines in this area was formulated with consideration of these factors. Table 0.6 shows the results.

Table 0.6 Plan for development of trunk transmission lines in the South area

Name	Voltage	Year	Remarks
Victoria Falls ï Muzuma	330kV	2010-2015	Upgrade from 220kV to 330kV
Muzuma ï Kafue Town			
Sesheke - Victoria Falls 2^{nd}	220kV		Installation of 2^{nd} Circuit
Victoria Falls ï Maamba	330kV		New Circuit
Maamba ï Muzuma			
Maamba- Kafue West 1^{st}			New Circuit Double Circuit Tower
Maamba- Kafue West 2^{nd}			
Devil Gorge Power Station		2015-2020	Installation in Victoria Falls ï Maamba Line
Devil Gorge ï Maamba 2^{nd}			Installation of 2^{nd} Circuit
Muzuma ï Kafue Town 2^{nd}		2020-2025	Installation of 2^{nd} Circuit
Batoka Gorge Power Station		2025-2030	Installation in Victoria Falls ï Devil Gorge Line
Batoka Gorge ï Devil Gorge 2^{nd}			Installation of 2^{nd} Circuit

B. Others

Besides 330kV (and 220kV) transmission lines, this area contains 88kV systems at Muzuma and Mazabuka. In addition, it is installed with long-distance 33kV distribution lines. Substations such as Choma and Monze will not be able to cope with the future demand increase with their 33kV distribution lines.

The 88kV systems are in every case marked by a high degree of deterioration, and there are 66 and 132kV systems in the immediate vicinity in Zambia. Therefore, the plan on the premise of gradual abolition of the 88kV system along with facility expansion and of unification in the 132kV system is recommended. Table 0.7 shows the resulting plan.

Table 0.7 Plan for development of 132kV transmission lines in the South area

<table>
<tr><th>Name</th><th>Voltage</th><th>Year</th><th>Remarks</th></tr>
<tr><td>Muzuma ï Maamba</td><td rowspan="2">88kV</td><td rowspan="8">2010-2015</td><td rowspan="2">Disuse</td></tr>
<tr><td>Kafue Town ï Mazabuka</td></tr>
<tr><td>Muzuma ï Choma 1st</td><td rowspan="6">132kV</td><td rowspan="2">New Circuit
Double Circuit Tower</td></tr>
<tr><td>Muzuma ï Choma 2nd</td></tr>
<tr><td>Choma - Monze</td><td>New Circuit</td></tr>
<tr><td>Monze - Mazabuka</td><td>New Circuit (Cut off Operation)</td></tr>
<tr><td>Kafue Town ï Mazabuka 1st</td><td rowspan="2">New Circuit
Double Circuit Tower</td></tr>
<tr><td>Kafue Town ï Mazabuka 2nd</td></tr>
</table>

Among the transmission lines shown in Table 0.7, abolition of the Muzuma-Maamba 88kV line is recommended when the 220kV line from Victoria Falls to Kafue Town is replaced with a 330kV line. This is because the 220/88kV transformers in Muzuma will become incapable of use when the voltage is raised to 330kV.

Lusaka area

The Lusaka area is one of the load centers in Zambia, and its load is supplied through 88- and 132kV systems from Leopards Hill, Lusaka West, and Kafue West. The power flow through this system is close to the thermal capacity of the transmission lines. Load shedding is required on the N-1 conditions. In 2030, the area's load is forecast to be more than triple its current level, and the power flow will undergo a corresponding increase. The plan for transmission development in this area is as follows.

A. Expansion of 330kV transmission lines

As the demand in the Lusaka area is forecast to exceed 1 GW in 2030, a new 330kV system must be introduced to supply power for the load in the city. So the construction of a substation (330/132kV) at Lusaka South and concomitant installation of 330kV transmission lines are recommended.

At present, there is a 330kV transmission line linking Kafue West, Leopards Hill, and Kabwe as the route for transmission of power from large-scale power stations such as Maamba, Devil Gorge, and Batoka Gorge in the direction of Copperbelt. In the future, however, this route alone will not be sufficient to assure transmission capacity up to the N-1 rule. The situation demands augmentation of the Kafue West-Lusaka West-Kabwe route to strengthen the connection between the South Area and the Copperbelt Area. Table 0.8 shows the plan for development of 330kV transmission lines in this area.

Table 0.8 Plan for development of 330kV transmission lines in the Lusaka Area

Name	Voltage	Year	Remarks
Kafue West ï Lusaka West 2nd	330kV	2010-2015	
Lusaka West ï Kabwe 1st			New Circuit
Lusaka West ï Kabwe 2nd			
Lusaka South Substation			Installation in Kafue West ï Leopards Hill Line
Kafue West ï Lusaka West 3rd		2015-2020	
Kafue Gorge Lower ï Lusaka South 1st			New Circuit Double Circuit Tower
Kafue Gorge Lower ï Lusaka South 2nd			

B. Expansion of 132kV transmission lines

The transmission system in the city is currently a mixture of 88- and 132kV lines. The 88kV system will not have enough transmission capacity to cope with the future load increase, and its facilities are already in a deteriorated state. For these reasons, it is necessary to expand the 132kV system in Lusaka and phase out the 88kV system along with construction of the Lusaka South substation. Besides assuring the transmission capacity into the future, this will unify the voltage classes and enable more flexible operation of the system.

To this end, useage of a wider conductor (Zebra) is recommended than the conventional one (Wolf) for the 132kV transmission lines in this area. This is because most of the transmission lines here have a short distance (less than 30 km), and the available transmission capacity is determined by the thermal capacity of the line instead of voltage drop due to inductance. Under these circumstances, a switch to a wider line conductor is the most economical means of increasing capacity. Table 0.9 shows the plan for expansion of the 132kV transmission lines in this area.

Table 0.9 Plan for 132kV transmission line development in the Lusaka area

Name	Voltage	Year	Remarks
Leopards Hill ï Waterworks 1st	88kV	2010-2015	Disuse
Leopards Hill ï Waterworks 2nd			
Waterworks ï Coventry			
Leopards Hill ï Mapepe			
Mapepe ï Kafue West			
Lusaka West ï Roma 2nd	132kV	2010-2015	
Lusaka West ï Coventry 2nd			
Leopards Hill ï Coventry 2nd			
Lusaka South ï Mapepe 1st			New Circuit
Lusaka South ï Mapepe 2nd			Double Circuit Tower
Lusaka South ï Coventry 1st			New Circuit
Lusaka South ï Coventry 2nd			New Circuit
Lusaka South ï Waterworks 1st			New Circuit
Lusaka South ï Waterworks 2nd			Double Circuit Tower
Lusaka South ï Woodland 1st			New Circuit
Lusaka South ï Woodland 2nd			Double Circuit Tower
Leopards Hill ï Avondale 1st			New Circuit
Leopards Hill ï Avondale 2nd			Double Circuit Tower
Lusaka South ï Chawama 1st		2015-2020	New Circuit
Lusaka South ï Chawama 2nd			Double Circuit Tower
Avondale ï Chelston 1st			New Circuit
Avondale ï Chelston 2nd			Double Circuit Tower
Chelston ï University 1st			New Circuit
Chelston ï University 2nd			Double Circuit Tower
Lusaka West ï Matero 1st		2020-2025	New Circuit
Lusaka West ï Matero 2nd			Double Circuit Tower
Lusaka West ï Makeni 1st			New Circuit
Lusaka West ï Makeni 2nd			Double Circuit Tower
Lusaka South ï Coventry 3rd		2025-2030	New Circuit

Copperbelt area

The Copperbelt area is another load center in Zambia. Most of the transmission lines in this area have a voltage of 220kV or 66kV. The main part of the load is that of mining companies. Most of the transmission lines in this area have a length of less than 40 km, and this facilitates application of 66kV transmission lines. The plan for transmission system development in this area centers around 66- and 220kV transmission lines supplying power to large-volume customers.

There are few power stations in this area, which receives almost all of its supply from the South area through 330kV transmission lines. As a result, the voltage stability is low, and there is a need for measures to cope with the future demand increase. There are two types of prospective measures, as follows.

- Installation of an intermediate switching station and SVC
- Installation of new transmission lines

Each of these measures is outlined below.

A. Installation of an intermediate switching station and SVC

An intermediate switching station will be constructed on the transmission line between Kabwe-Kitwe and Luano to improve the voltage stability in the event of transmission line failure. This switching station may also be expected to level the power flow on the transmission line between Kabwe and the station and act to reduce transmission loss.

In addition, installation of an SVC with a regulating capability of ±100 MVar in the Kitwe substation will improve voltage stability in normal operation and in the event of transmission line failure. In this area, there is a high mining load and great voltage fluctuation along with fluctuation of this load. The SVC therefore may also be expected to have effects for improving voltage.

B. Installation of new transmission lines

On the Zambian side, studies are currently under way for construction of a 330kV transmission line between Mumbwa and Lumuwana to increase the reliability of the power supply in the Copperbelt area. The construction of this line would not only enhance the voltage stability in the Copperbelt area but also bring a great reduction in transmission loss. The installation of two transmission line routes from power sources to the Copperbelt area would also improve the system reliability. However, the transmission distance on this line would be very long (350km) and consequently entail a high construction cost.

Table 0.10 compares these two prospective measures.

Table 0.10 Comparison of voltage stabilization measures in the Copperbelt area

	Intermediate switching station plus SVC	New transmission line
Description	・Construction of an intermediate switching station between Kabwe-Kitwe and Luano (8 cct initially, with eventual increase to 12 cct) ・Installation of SVC with ±100 MVar in the Kitwe substation	Construction of a 2-cct 330kV transmission line between Mumbwa and Lumuwana
Cost	28 million USD	210 million USD
Reduction of transmission loss (2030 peak)	5.3MW	29.9MW
Other matters	Ability to curtail voltage fluctuation in normal operation	Ability to send some power to Copperbelt even in the event of failure on the route between Leopards Hill-Kabwe-Kitwe and Luano Facilitation of response to load increase in the Lumuwana direction

Based on the results of comparison, installation of the intermediate switching station and SVC is recommended, which has less effect for reducing transmission loss but costs much less. If the load in this area increases beyond the level forecast in this study, it would be necessary to reconsider the other option of constructing an additional transmission line.

Summary of plans for transmission development in scenario 1-1

Tables 8.11 and 8.12 present specific figures for the amount of transmission facilities earmarked for development in the plan for transmission development in the scenario 1-1. Figures 8.3 ï 8.12 present corresponding system diagrams for the years 2010, 2015, 2020, 2025, and 2030. It can be seen that the amount of transmission facilities to be developed would peak in a relatively early phase (2010 - 2015). This is because the problem of voltage stability, which is now very difficult to maintain, must be resolved early in order to cope with future power source development.

Table 0.11 Amount of transmission facility development (kms) in Scenario 1-1

Year	Voltage of Transmission Line (kV)			
	66	132	220	330
2010-2015	194	2,562	599	3,668
2015-2020	5	1,494	0	389
2020-2025	0	241	0	2,142
2025-2030	0	236	0	140

Table 0.12 Transmission development plan (Scenario 1-1)

Id	From	To	Install Year	Length (km)	Voltage (kV)	Conductor Type
3	Kariba North	Leopards Hill	2010-2015	123	330	2-Bison
2	Kabwe	Pensulo	2010-2015	298	330	2-Bison
1	Kabwe	Lusaka West	2010-2015	100	330	2-Bison
2	Luano	Kansanshi	2010-2015	197	330	2-Bison
1	Pensulo	Kasama	2010-2015	380	330	2-Bison
2	Pensulo	Kasama	2010-2015	380	330	2-Bison
1	Kafue West	Maamba	2010-2015	245	330	2-Bison
2	Kafue West	Maamba	2010-2015	245	330	2-Bison
2	Kafue West	Lsaka West	2010-2015	34	330	2-Bison
1	Kafue Town	Muzuma(UP Grade)	2010-2015	189	330	2-Bison
2	Kansanshi	Lumuwana	2010-2015	72	330	2-Bison
1	Kasama	Nakonde	2010-2015	210	330	2-Bison
2	Kasama	Nakonde	2010-2015	210	330	2-Bison
1	Kasama	Mporokoso	2010-2015	150	330	2-Bison
1	Victoria Falls	Muzuma(UP Grade)	2010-2015	159	330	2-Bison
1	Victoria Falls	Batoka Gorge	2010-2015	40	330	2-Bison
1	Victoria Falls	Muzuma	2010-2015	159	330	2-Bison
1	Batoka Gorge	Devil Gorge	2010-2015	70	330	2-Bison
1	Devil Gorge	Maamba	2010-2015	70	330	2-Bison
1	Maamba	Muzuma	2010-2015	55	330	2-Bison
2	Kansanshi	Lumuwana	2010-2015	72	330	2-Bison
1	Mumbwa	Lusaka West	2010-2015	105	330	2-Bison
2	Mumbwa	Lusaka West	2010-2015	105	330	2-Bison
2	Luano	Michelo	2010-2015	31.9	220	2-HD153
1	Luano	Stadium	2010-2015	16.4	220	2-Lion
2	Luano	Stadium	2010-2015	16.4	220	2-Lion
1	Michelo	Bankroft	2010-2015	10	220	2-HD153
2	Michelo	Bankroft	2010-2015	10	220	2-HD153

Id	From	To	Install Year	Length (km)	Voltage (kV)	Conductor Type
2	Victoria Falls	Sesheke	2010-2015	224	220	Bison
1	Mumbwa	Itezhi-Tezhi	2010-2015	145	220	Bison
2	Mumbwa	Itezhi-Tezhi	2010-2015	145	220	Bison
2	Coventry	Leopards Hill	2010-2015	28	132	Wolf
2	Coventry	Lusaka West	2010-2015	7	132	Wolf
2	Roma	Lusaka West	2010-2015	15	132	Wolf
1	Leopards Hill	Avondale	2010-2015	15	132	Zebra
2	Leopards Hill	Avondale	2010-2015	15	132	Zebra
1	Kasama	Mbala	2010-2015	161	132	Wolf
2	Kasama	Mbala	2010-2015	161	132	Wolf
1	Kasama	Chinsali	2010-2015	105	132	Wolf
1	Pensulo	Lusiwasi	2010-2015	90	132	Wolf
2	Pensulo	Lusiwasi	2010-2015	90	132	Wolf
1	Pensulo	Kanon	2010-2015	20	132	Wolf
2	Pensulo	Kanon	2010-2015	20	132	Wolf
1	Pensulo	Mutindo	2010-2015	110	132	Wolf
2	Pensulo	Mutindo	2010-2015	110	132	Wolf
1	Lusiwasi	Msoro	2010-2015	115	132	Wolf
2	Lusiwasi	Msoro	2010-2015	115	132	Wolf
1	Lusiwasi	Mfuwe	2010-2015	80	132	Wolf
2	Lusiwasi	Mfuwe	2010-2015	80	132	Wolf
1	Kabwe	Kapiri Mposhi	2010-2015	96	132	Wolf
1	Itezhi-Tezhi	Kaoma	2010-2015	180	132	Wolf
2	Itezhi-Tezhi	Kaoma	2010-2015	180	132	Wolf
1	Kaoma	Mongu	2010-2015	185	132	Wolf
1	Nampundwe	Lusaka West	2010-2015	60	132	Wolf
1	Kafue Town	Mazabuka	2010-2015	52	132	Zebra
2	Kafue Town	Mazabuka	2010-2015	52	132	Zebra
1	Mazabuka	Monze	2010-2015	60	132	Wolf
1	Mapepe	Lusaka South	2010-2015	20	132	Wolf
2	Mapepe	Lusaka South	2010-2015	20	132	Wolf
1	Lusaka South	Waterworks	2010-2015	14	132	Zebra
2	Lusaka South	Waterworks	2010-2015	14	132	Zebra
1	Lusaka South	Woodlands	2010-2015	13	132	Zebra
2	Lusaka South	Woodlands	2010-2015	13	132	Zebra
1	Lusaka South	Coventry A	2010-2015	21	132	Zebra

Id	From	To	Install Year	Length (km)	Voltage (kV)	Conductor Type
2	Lusaka South	Coventry A	2010-2015	21	132	Zebra
1	Coventry A	Coventry B	2010-2015	1	132	Zebra
2	Coventry A	Coventry B	2010-2015	1	132	Zebra
1	Muzuma	Choma	2010-2015	26	132	Wolf
2	Muzuma	Choma	2010-2015	26	132	Wolf
1	Choma	Monze	2010-2015	80	132	Wolf
1	Mutinond	Luchene	2010-2015	45	132	Wolf
2	Mutinond	Luchene	2010-2015	45	132	Wolf
2	Stadium	Avenue	2010-2015	1.27	66	2-HD124
3	Stadium	Avenue	2010-2015	1.27	66	2-HD124
2	Chisenga	Luano	2010-2015	11.4	66	Lynx
2	Mufulira	Kankoyo	2010-2015	0.4	66	2-HD124
2	Maposa	Dola Hill	2010-2015	21.3	66	Lynx
1	Maposa	Pamodzi	2010-2015	25	66	Lynx
2	Maposa	Pamodzi	2010-2015	25	66	Lynx
2	Ndola Refinery	Skyways	2010-2015	1.5	66	HD124
2	Pamodzi	Depot Road	2010-2015	6.3	66	Lynx
2	Kanon	Kaomb	2010-2015	21	66	Wolf
2	KZNGL	Victoria Falls	2010-2015	80	66	Wolf
	New SWS (Internal of Kabwe ï Kitwe, LuanoLine)		2010-2015			
	Lusaka South SS (Internal of Leopards Hill ï Kafue West Line)		2010-2015			
2	Kabwe	Lusaka West	2015-2020	100	330	2-Bison
3	Kafue West	Lsaka West	2015-2020	34	330	2-Bison
2	Devil Gorge	Maamba	2015-2020	70	330	2-Bison
1	Kundabwika	Mporokoso	2015-2020	95	330	2-Bison
1	Kafue Gorge Lower	Lusaka South	2015-2020	45	330	2-Bison
1	Kafue Gorge Lower	Lusaka South	2015-2020	45	330	2-Bison
1	Mukushi	Lunsemfwa	2015-2020	10	132	Wolf
2	Mukushi	Lunsemfwa	2015-2020	10	132	Wolf
1	Kundabwika	Kabwelume	2015-2020	25	132	Zebra
2	Kundabwika	Kabwelume	2015-2020	25	132	Zebra
1	Kundabwika	Nchelenge	2015-2020	75	132	Wolf
1	Kabwelume	Kawambwa Tea	2015-2020	30	132	Wolf

Id	From	To	Install Year	Length (km)	Voltage (kV)	Conductor Type
1	Msoro	Chipata	2015-2020	80	132	Wolf
2	Msoro	Chipata	2015-2020	80	132	Wolf
1	Kabwe	Lunsemfwa	2015-2020	65	132	Zebra
2	Kabwe	Lunsemfwa	2015-2020	65	132	Zebra
1	Kabwe	BRKHL	2015-2020	3	132	Wolf
2	Kabwe	BRKHL	2015-2020	3	132	Wolf
1	Kapiri Mposhi	Mpongwe	2015-2020	60	132	Wolf
1	Lumwana	Kabompo Gorge	2015-2020	70	132	Wolf
2	Lumwana	Kabompo Gorge	2015-2020	70	132	Wolf
1	Kabompo Gorge	Mwinilunga	2015-2020	100	132	Wolf
1	Kabompo Gorge	Mufumbwe	2015-2020	110	132	Wolf
1	Mufumbwe	Kabompo	2015-2020	105	132	Wolf
1	Kabompo	Mumbeji	2015-2020	80	132	Wolf
1	Mongu	Lukulu	2015-2020	160	132	Wolf
1	Lukulu	Mumbeji	2015-2020	80	132	Wolf
1	Mumbeji	Zambezi	2015-2020	75	132	Wolf
1	Zambezi	Chavuma	2015-2020	80	132	Wolf
1	Lusaka South	Chawama	2015-2020	6	132	Wolf
2	Lusaka South	Chawama	2015-2020	6	132	Wolf
1	University	Chelston	2015-2020	5	132	Zebra
2	University	Chelston	2015-2020	5	132	Zebra
1	Avondale	Chelston	2015-2020	5.7	132	Zebra
2	Avondale	Chelston	2015-2020	5.7	132	Zebra
3	Ndola Refinery	Skyways	2015-2020	1.5	66	HD124
2	Dola Hill	Pamodzi	2015-2020	3.7	66	Lynx
3	Kitwe	New SWS	2020-2025	91	330	2-Bison
4	Kitwe	New SWS	2020-2025	91	330	2-Bison
1	Leopards Hill	Mpata Gorge	2020-2025	255	330	2-Bison
2	Leopards Hill	Mpata Gorge	2020-2025	255	330	2-Bison
1	Pensulo	Mumbotuta	2020-2025	190	330	2-Bison
2	Pensulo	Mumbotuta	2020-2025	190	330	2-Bison
1	Pensulo	New SWS	2020-2025	219	330	2-Bison
2	Pensulo	New SWS	2020-2025	219	330	2-Bison
2	Kafue West	Kafue Town	2020-2025	3	330	2-Bison
2	Kafue Town	Muzuma	2020-2025	189	330	2-Bison
1	Mumbotuta	Mambilima	2020-2025	210	330	2-Bison

Id	From	To	Install Year	Length (km)	Voltage (kV)	Conductor Type
1	Mumbotuta	Mansa	2020-2025	130	330	2-Bison
1	Mambilima	Mambilima Site2	2020-2025	10	330	2-Bison
2	Mambilima	Mambilima Site2	2020-2025	10	330	2-Bison
1	Mambilima	Mansa	2020-2025	80	330	2-Bison
2	Kaoma	Mongu	2020-2025	185	132	Wolf
1	Makeni	Lusaka West	2020-2025	13	132	Zebra
2	Makeni	Lusaka West	2020-2025	13	132	Zebra
1	Matero	Lusaka West	2020-2025	15	132	Zebra
2	Matero	Lusaka West	2020-2025	15	132	Zebra
2	Batoka Gorge	Devil Gorge	2025-2030	70	330	2-Bison
3	Devil Gorge	Maamba	2025-2030	70	330	2-Bison
2	Kabompo Gorge	Mufumbwe	2025-2030	110	132	Wolf
2	Mufumbwe	Kabompo	2025-2030	105	132	Wolf
3	Lusaka South	Coventry A	2025-2030	21	132	Zebra

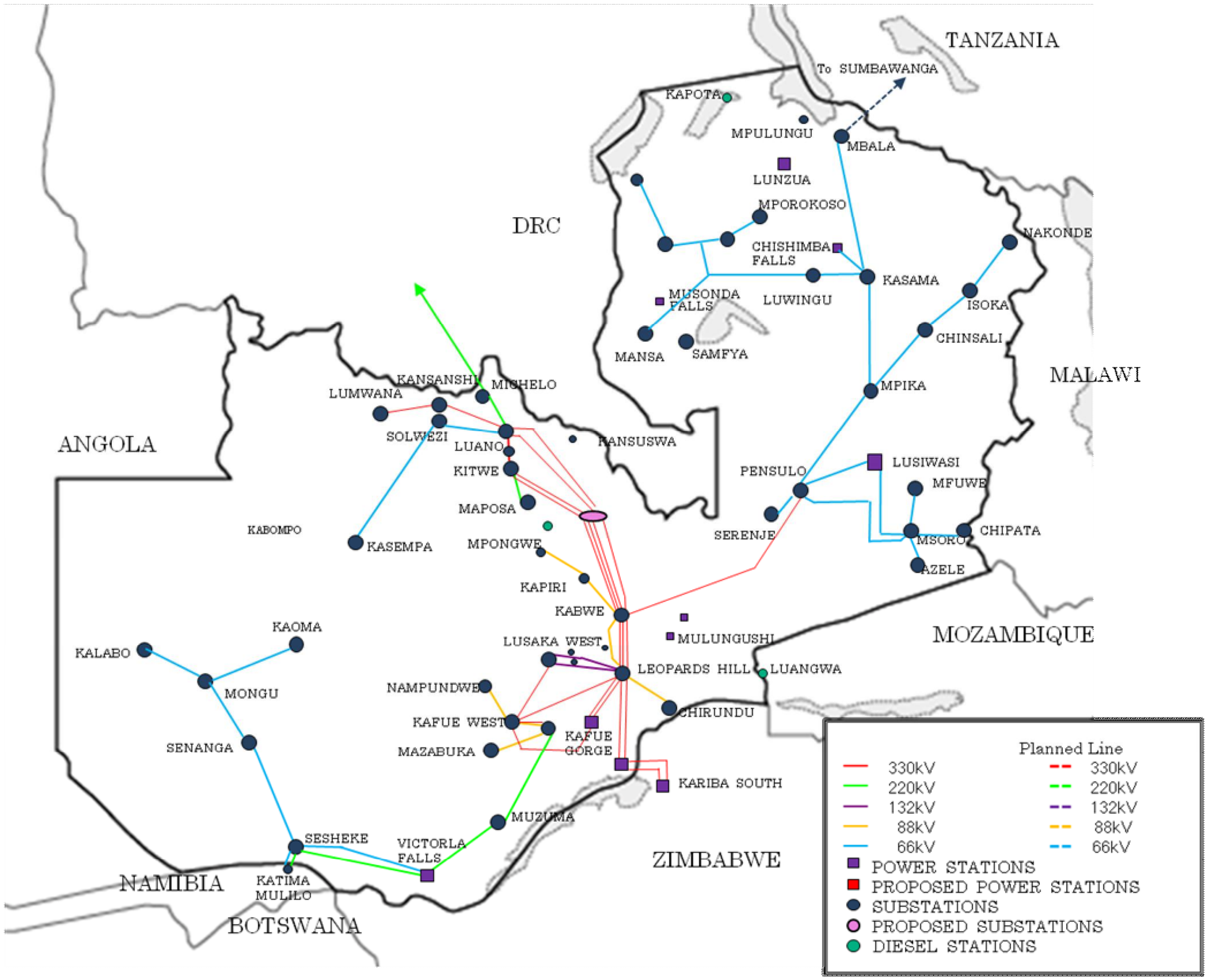


Figure 0.3 Zambian Power System on 2010

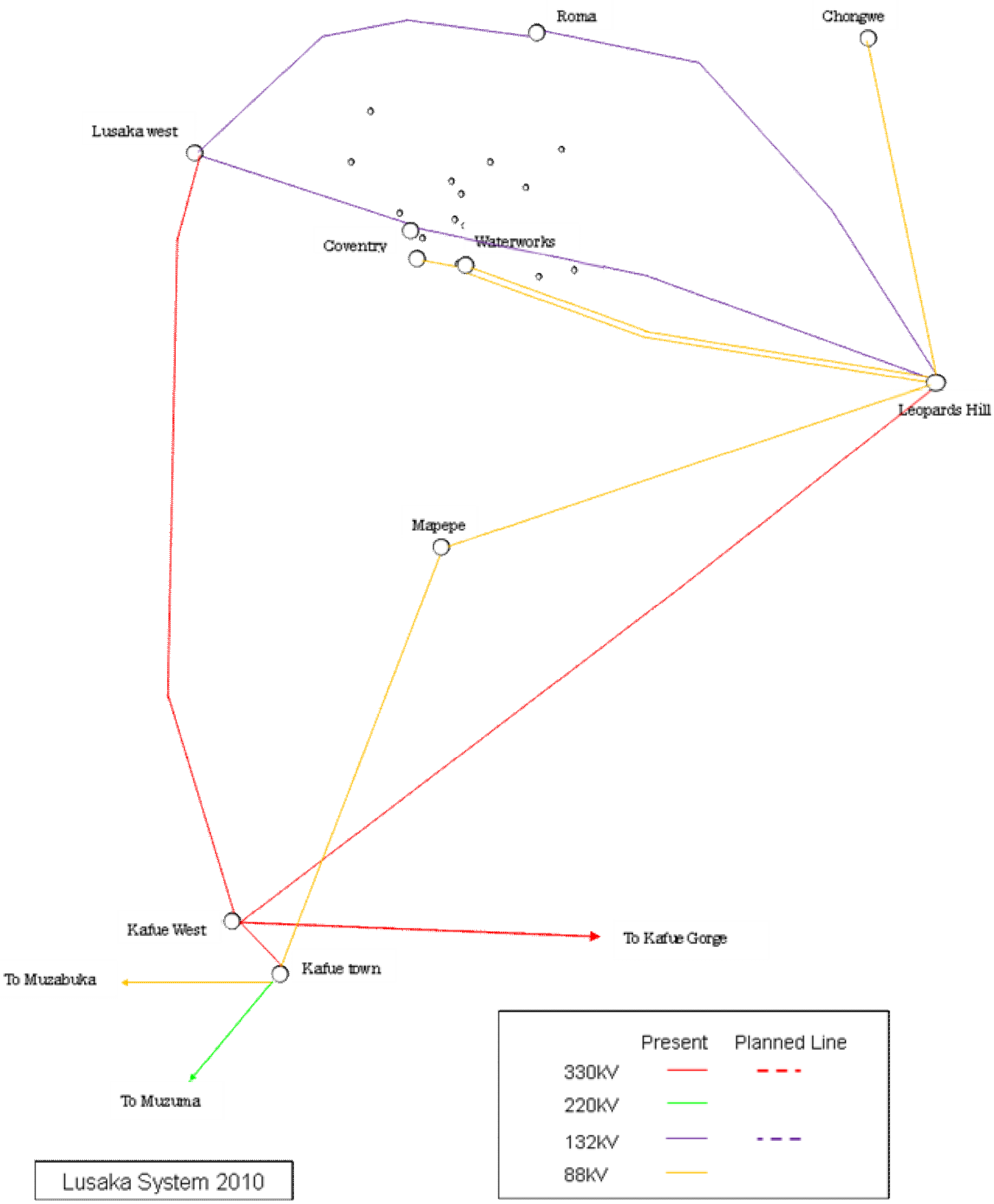


Figure 0.4 Lusaka Power System on 2010

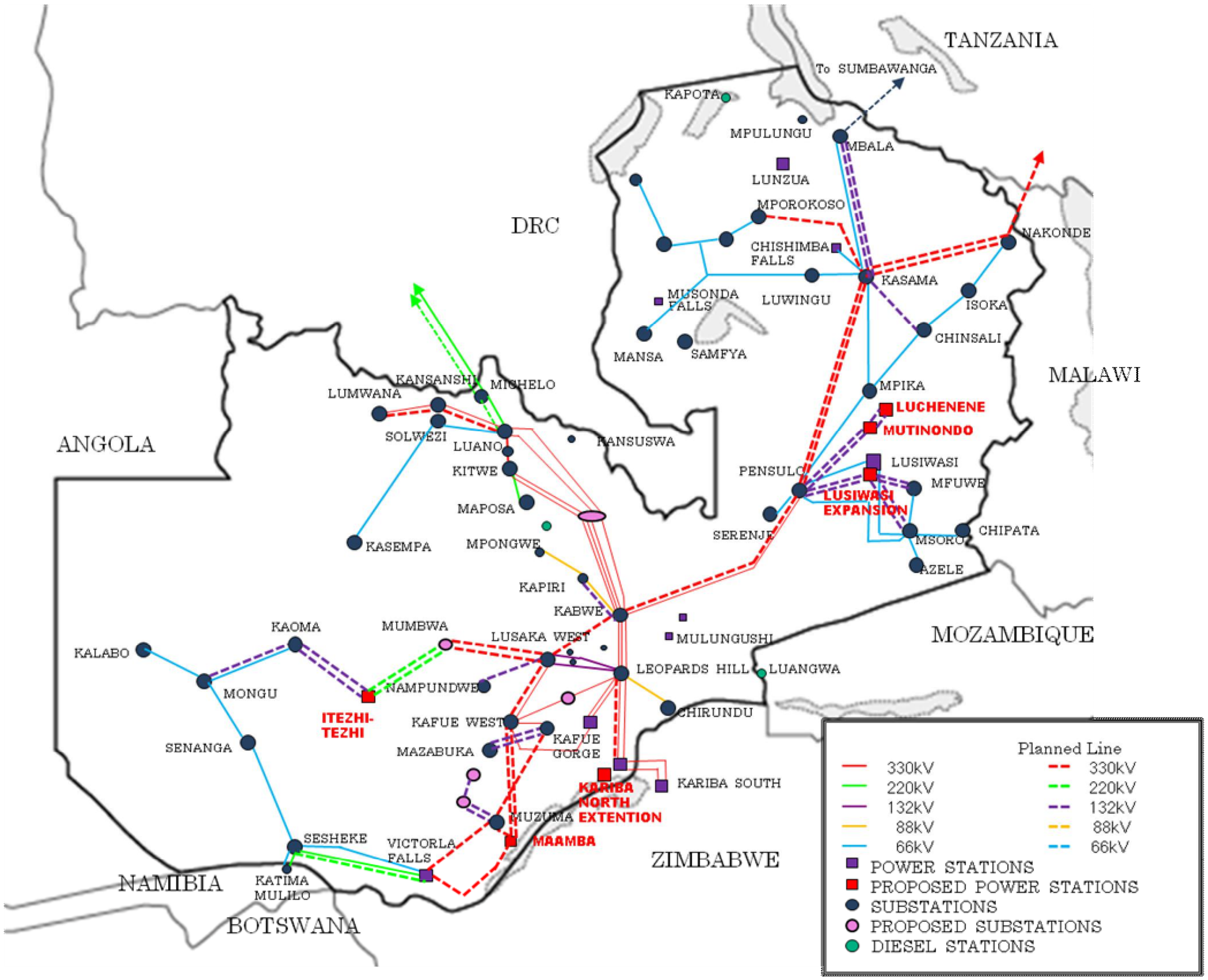


Figure 0.5 Zambian Power System on 2015 (Scenario1-1)

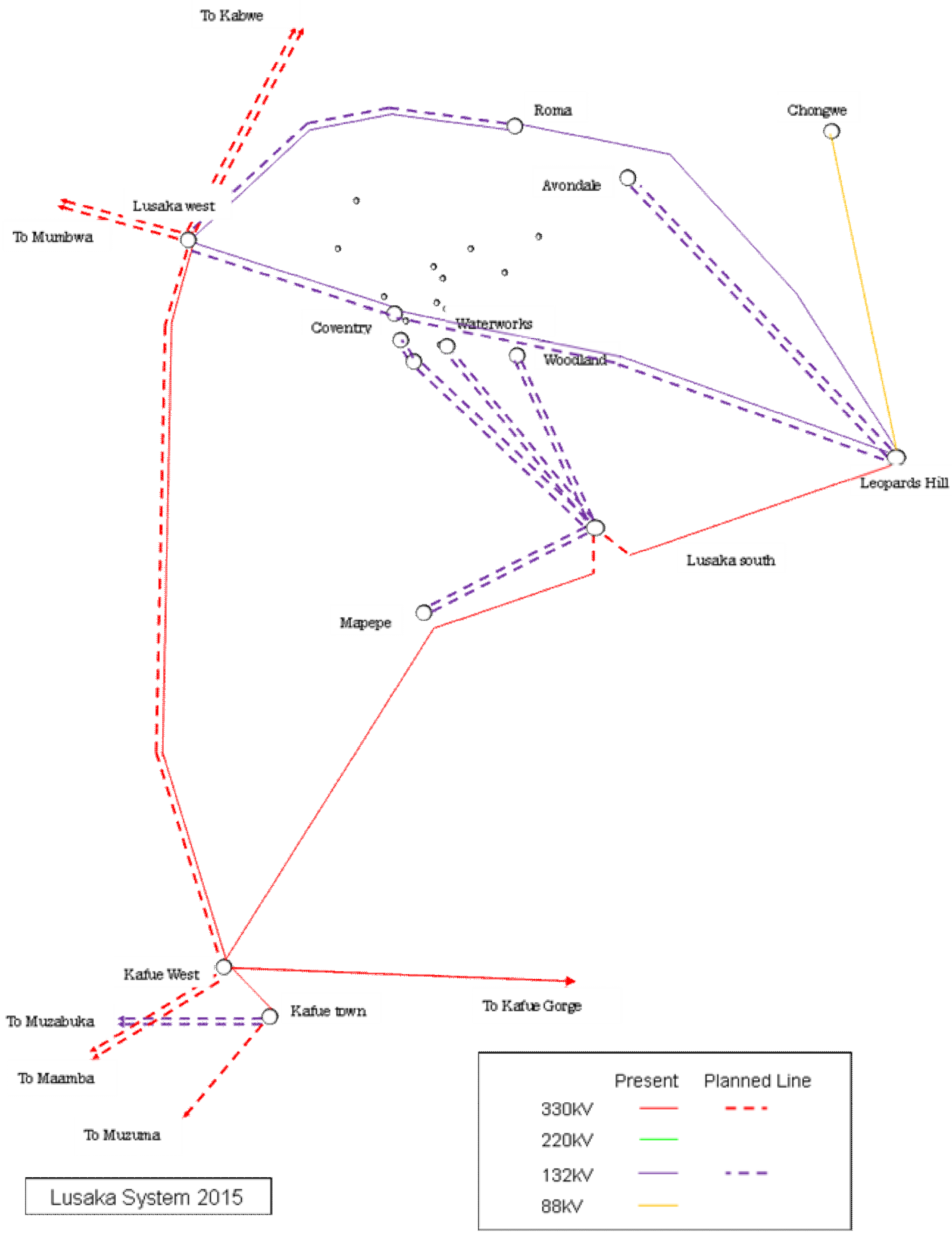


Figure 0.6 Lusaka Power System on 2015 (Scenario1-1)

Figure 0.7 Zambian Power System on 2020 (Scenario1-1)

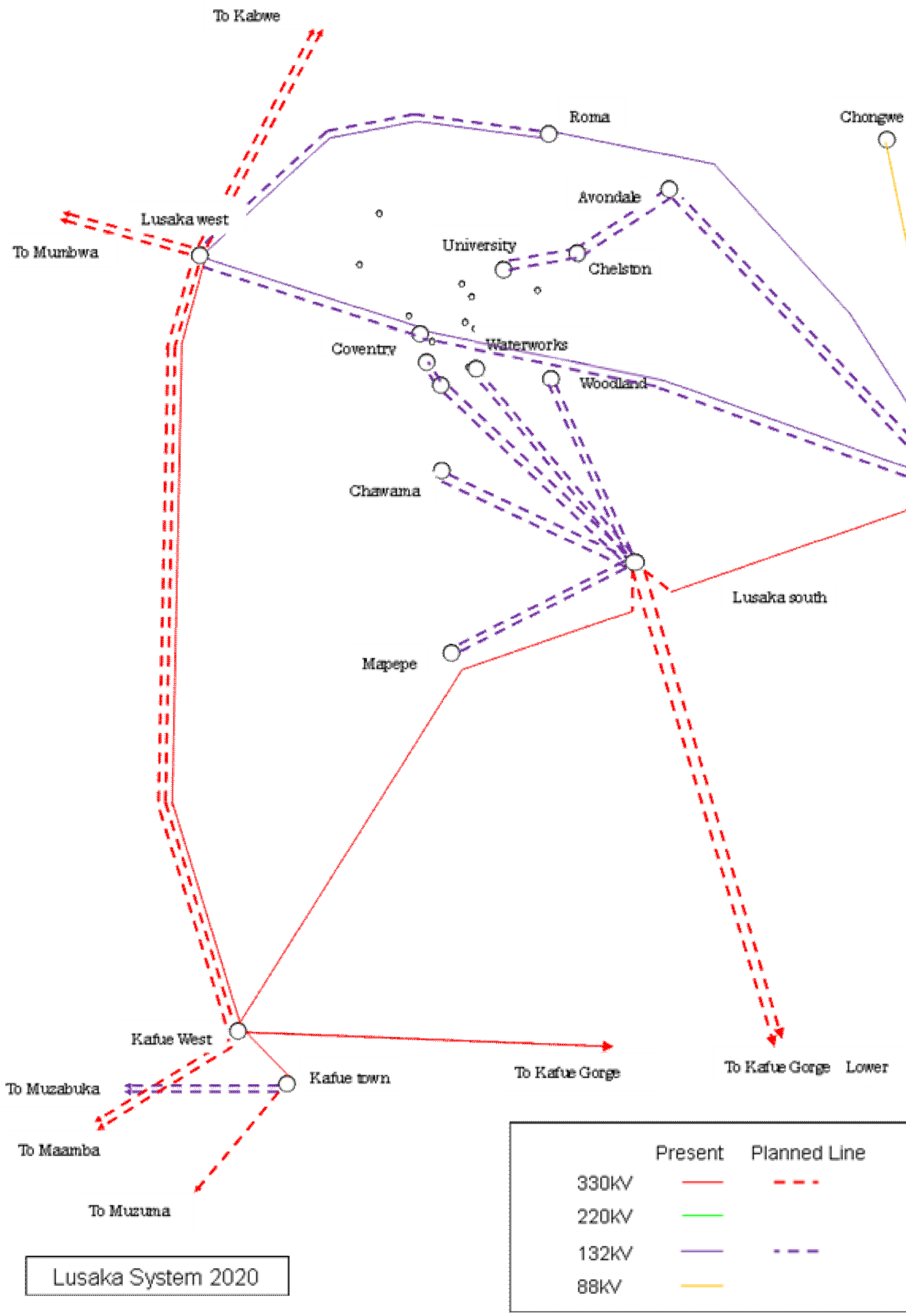


Figure 0.8 Lusaka Power System on 2020 (Scenario1-1)

Figure 0.9 Zambian Power System on 2025 (Scenario1-1)

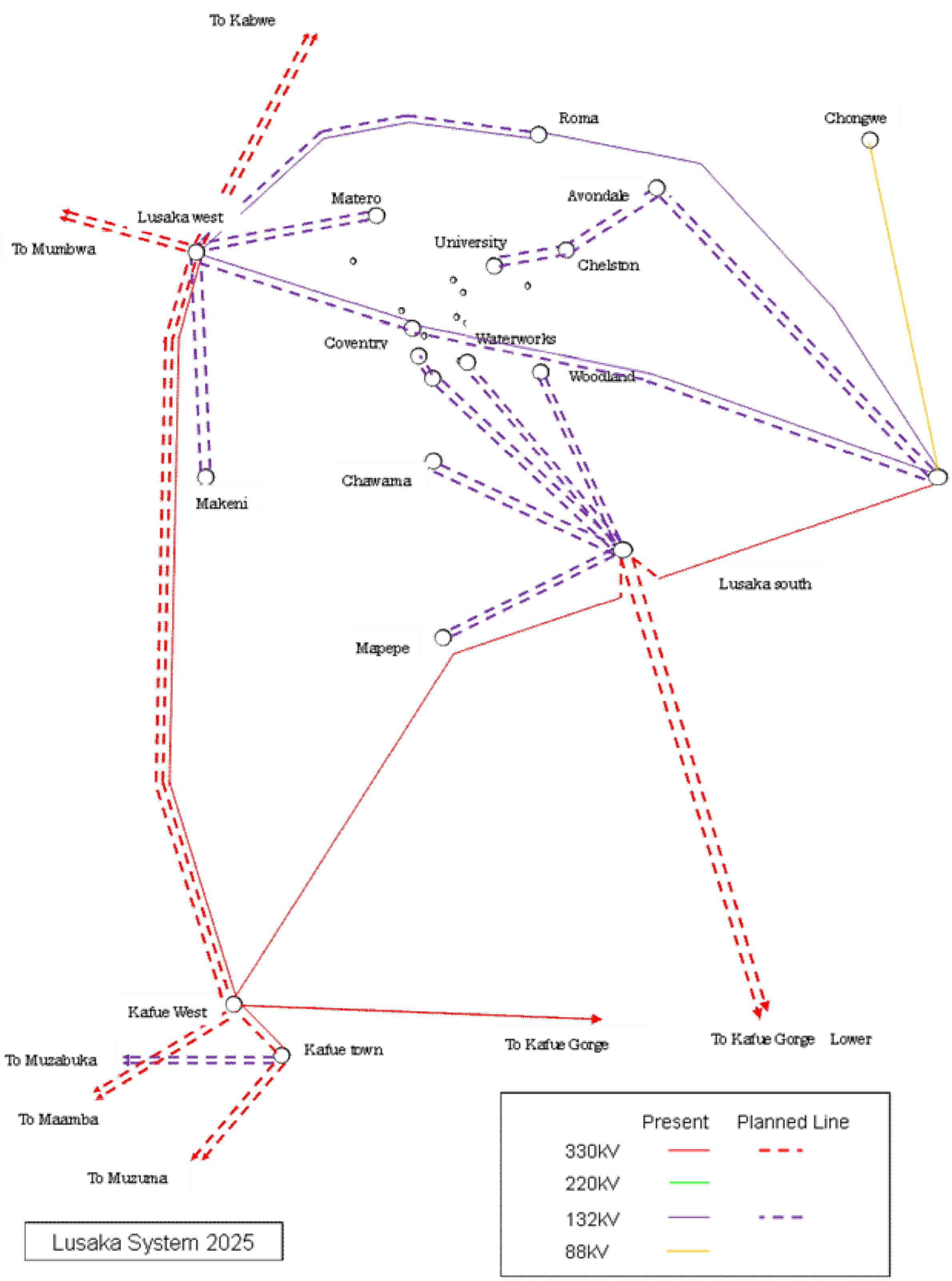


Figure 0.10 Lusaka Power System on 2025 (Scenario1-1)

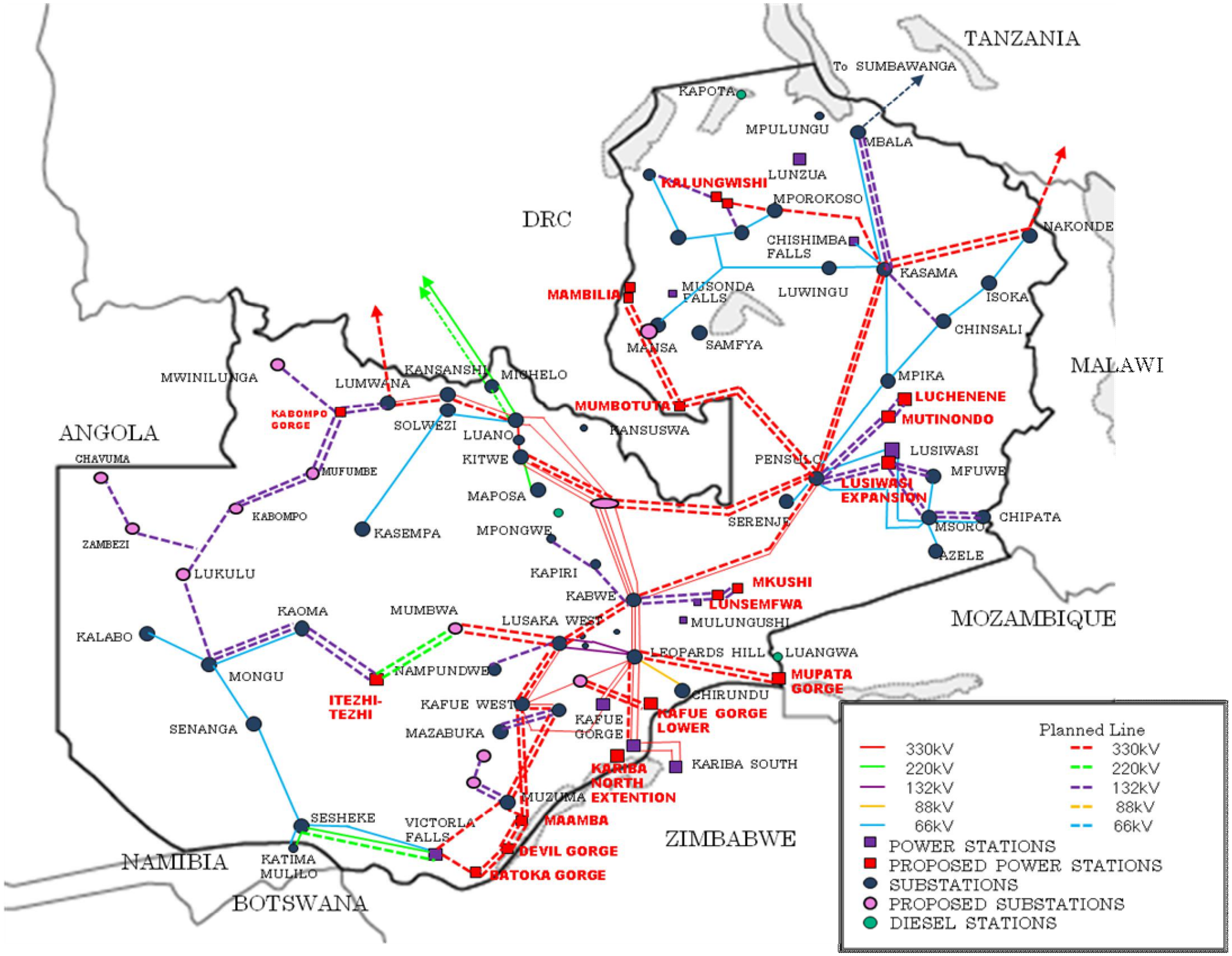


Figure 0.11 Zambian Power System on 2030 (Scenario1-1)

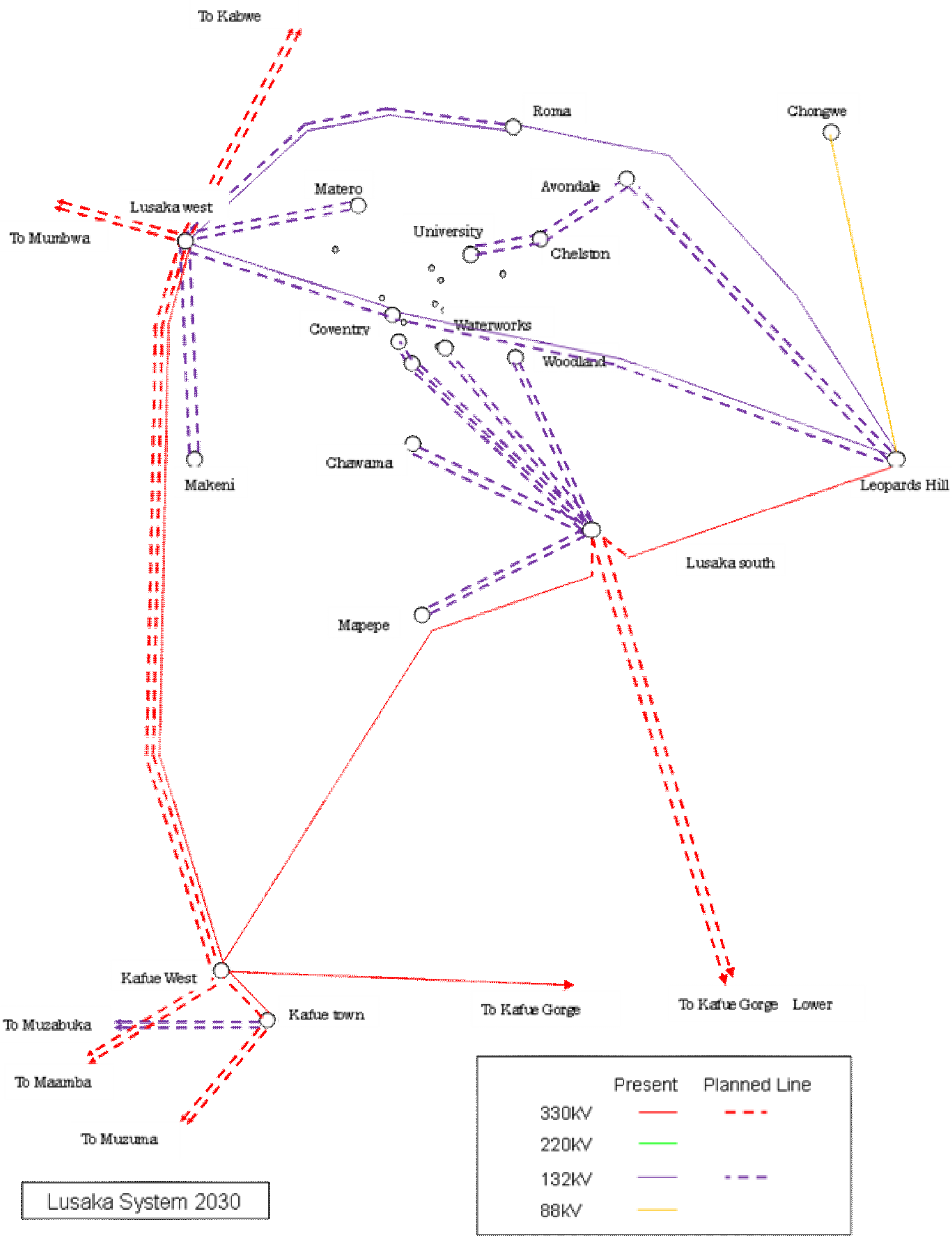


Figure 0.12 Lusaka Power System on 2030 (Scenario1-1)

Transmission development plan in the scenario 1-2

This transmission plan was formulated based on the results of the case of development of coal-fired thermal power sources (Scenario 1-2). The conditions as regards the demand forecast and international power interchange were the same as in Scenario 1-1. In this scenario, the siting of coal-fired power stations would have a great influence on transmission planning. The locations of the power station sites were taken as Table 0.13.

Table 0.13 Developing Plan of Coal Power Plant

Install year	Capacity (MW)	Location
2014	200	Maamba
2016	300	Maamba
2018	300	Kitwe
2021	300	Kitwe

Of these sites, plans are already moving ahead at that of Maamba, where a mine mouth coal power station is being constructed. The other candidate sites are another at Maamba, which is fairly close to Lusaka and equipped with a good transportation infrastructure, and Kitwe, which is located in the Copperbelt district (a load center) and equipped with a good railway infrastructure. Siting of all coal-fired power generation in Maamba would produce virtually the same transmission system composition as in Scenario 1-1, in which large-scale power sources are concentrated in the Zambezi basin. As such, examinations based on concentration of coal-fired sources in Kitwe was made, which constitutes a case different from that of Scenario 1-1.

The following sections present the transmission plan formulated in each regional area. The descriptions concern mainly the differences from Scenario 1-1.

Northeast area (Scenario 1-2)

In this area, the biggest difference from Scenario 1-1 would be the timing of the input of hydropower stations. In particular, the phase for development of the large-scale hydropower stations at Mambillima and Mumbotuta would be later than in Scenario 1-1, and this would push back the development of 330kV transmission lines to carry power from them. As a result, the development of the 330kV system in this area would also be later than in Scenario 1-1. Table 0.14 shows this difference.

Table 0.14 Plan for 330kV transmission development in the Northeast area

<table>
<tr><th rowspan="2">Name</th><th rowspan="2">Voltage</th><th colspan="2">Year</th><th rowspan="2">Remarks</th></tr>
<tr><th>Scenario1</th><th>Scenario2</th></tr>
<tr><td>Pensulo ï Kasama 1^{st}</td><td rowspan="14">330kV</td><td rowspan="6">2010-2015</td><td rowspan="6">2010-2015</td><td rowspan="2">New Circuit
Double Circuit Tower</td></tr>
<tr><td>Pensulo ï Kasama 2^{nd}</td></tr>
<tr><td>Pensulo ï Kabwe 2^{nd}</td><td>Installation of 2^{nd} circuit</td></tr>
<tr><td>Kasama ï Nakonde 1^{st}</td><td rowspan="2">New Circuit
Double Circuit Tower</td></tr>
<tr><td>Kasama ï Nakonde 2^{nd}</td></tr>
<tr><td>Kasama ï Mporokoso</td><td>New Circuit</td></tr>
<tr><td>Mporokoso - Kalungwishi</td><td>2015-2020</td><td>2015-2020</td><td>New Circuit</td></tr>
<tr><td>Pensulo ï Mumbotuta 1^{st}</td><td rowspan="7">2020-2025</td><td rowspan="3">2025-2030</td><td rowspan="2">New Circuit
Double Circuit Tower</td></tr>
<tr><td>Pensulo ï Mumbotuta 2^{nd}</td></tr>
<tr><td>Pensulo ï New SWS 1^{st}</td><td>New Circuit</td></tr>
<tr><td>Pensulo ï New SWS 2^{nd}</td><td rowspan="4">After
2030</td><td rowspan="4">New Circuit</td></tr>
<tr><td>Mumbotuta ï Mambilima</td></tr>
<tr><td>Mumbotuta ï Mansa</td></tr>
<tr><td>Mansa ï Mambilima</td></tr>
</table>

It may be noted that there is no significant difference between scenarios 1-1 and 1-2 in respect of the plan for development of transmission lines with a voltage of no more than 132kV. The delayed installation of the 330kV transmission line between Mumbotuta and Mansa, however, would make the voltage stability situation in the Mansa district harsher than in Scenario 1-1. If the demand in this district increases more rapidly than in the forecast, it would be necessary to take steps such as installing a 132kV transmssion line between Kalungwishi and Mansa.

West area (Scenario1-2)

There is no major difference between scenarios 1-1 and 1-2 as regards the plan for transmission development in this area. Development of the Kabompo Gorge power station would be later than in Scenario 1-1, and electrification of the western districts would require installation of a transmission line between Kabompo Gorge and Lumwana, regardless of whether or not the power source is finished.

South area (Scenario1-2)

In this area, power source development would be later than in Scenario 1-1, and the transmission power flow would be smaller. As compared to Scenario 1-1, the plan would therefore delay construction of trunk transmission lines. Table 0.15 shows the plan for development of trunk transmission lines in this area. For other systems, there would be no difference from Scenario 1-1.

Table 0.15 Plan for trunk transmission line development in the South area

Name	Voltage	Year		Remarks
		Scenario1	Scenario2	
Victoria Falls ï Muzuma	330kV	2010-2015	2010-2015	Upgrade from 220kV to 330kV
Muzuma ï Kafue Town				
Sesheke - Victoria Falls 2^{nd}	220kV			Installation of 2^{nd} Circuit
Victoria Falls ï Maamba	330kV			New Circuit
Maamba ï Muzuma				
Maamba- Kafue West 1^{st}				New Circuit Double Circuit Tower
Maamba- Kafue West 2^{nd}				
Devil Gorge Power Station		2015-2020	2020-2025	Installation in Victoria Falls ï Maamba Line
Devil Gorge ï Maamba 2^{nd}			2025	Installation of 2^{nd} Circuit
Muzuma ï Kafue Town 2^{nd}		2020-2025	After 2030	Installation of 2^{nd} Circuit
Batoka Gorge Power Station		2025-2030		Installation in Victoria Falls ï Devil Gorge Line
Batoka Gorge ï Devil Gorge 2^{nd}				Installation of 2^{nd} Circuit

Lusaka Area (Scenario1-2)

The plan for transmission development in this area in Scenario 1-2 would be almost the same as in Scenario 1-1, but the construction of the 330kV transmission line of Kafue West - Lusaka West - Kabwe would be later than in Scenario 1-1. This is because the input of coal-fired power in the north would reduce the flow of power from south to north by a commensurate amount. Table 0.16 shows the plan for development of 330kV transmission lines in this area.

Table 0.16 Plan for 330kV transmission line development in the Lusaka area

Name	Voltage	Year		Remarks
		Scenario1	Scenario2	
Kafue West ï Lusaka West 2^{nd}	330kV	2010-2015	2010-2015	
Lusaka West ï Kabwe 1^{st}				New Circuit
Lusaka West ï Kabwe 2^{nd}			After 2030	
Lusaka South Substation			2010-2015	Installation in Kafue West ï Leopards Hill Line
Kafue West ï Lusaka West 3^{rd}		2015-2020	2020-2025	
Kafue Gorge Lower ï Lusaka South 1^{st}			2015-2020	New Circuit Double Circuit Tower
Kafue Gorge Lower ï Lusaka South 2^{nd}				

Copperbelt (Scenario1-2)

In Scenario 1-2, the construction of coal-fired power stations in this area would greatly improve items such as voltage stability and power flow. There would consequently be no need for measures required to stabilize voltage in Scenario 1-1 (i.e., installation of SVC or a new transmission line), but installation of the intermediate switching station is recommended even in the case of Scenario 1-2, for the following reasons.

- Until construction of the coal-fired power station in Kitwe, the voltage stability would remain poor. This would require installation of the intermediate switching station to curb voltage fluctuation when the transmission line is tripped.
- The switching station would level the current flowing through the Kabwe-Kitwe and Kabwe-Luano transmission lines, and thereby bring a reduction in transmission loss.

Summary of the plan for transmission development in the scenario 1-2

Table 8.17 shows the amount of transmission facilities to be developed in the plan based on coal-fired thermal power development scenario (scenario 1-2), and Table 8-18, the related details. Figures 8.13 ï 8.16 present corresponding system diagrams for the years 2010, 2015, 2020, 2025, and 2030. It can be seen that the amount of transmission facilities to be developed would peak in a relatively early phase (2010 - 2015), but the degree of concentration would be lower than in Scenario 1-1. This is because the coal-fired power stations developed in the Kitwe district would reduce the flow of power through transmission lines to the north, and this reduction would relax conditions in respect of both thermal capacity and voltage stability relative to Scenario 1-1.

Table 0.17 Amount of transmission facility development (kms) in Scenario 1-2

Year	Voltage of Transmission Line (kV)			
	66	132	220	330
2010-2015	194	2,562	599	3,668
2015-2020	5	1,474	0	205
2020-2025	0	261	0	104
2025-2030	0	236	0	1,203

Table 0.18 Transmission development plan (Scenario 1-2)

Id	From	To	Install Year	Length (km)	Voltage (kV)	Conductor Type
3	Kariba North	Leopards Hill	2010-2015	123	330	2-Bison
2	Kabwe	Pensulo	2010-2015	298	330	2-Bison
1	Kabwe	Lusaka West	2010-2015	100	330	2-Bison
2	Luano	Kansanshi	2010-2015	197	330	2-Bison
1	Pensulo	Kasama	2010-2015	380	330	2-Bison
2	Pensulo	Kasama	2010-2015	380	330	2-Bison
1	Kafue West	Maamba	2010-2015	245	330	2-Bison
2	Kafue West	Maamba	2010-2015	245	330	2-Bison
2	Kafue West	Lsaka West	2010-2015	34	330	2-Bison
1	Kafue Town	Muzuma(UP Grade)	2010-2015	189	330	2-Bison
2	Kansanshi	Lumuwana	2010-2015	72	330	2-Bison
1	Kasama	Nakonde	2010-2015	210	330	2-Bison
2	Kasama	Nakonde	2010-2015	210	330	2-Bison
1	Kasama	Mporokoso	2010-2015	150	330	2-Bison
1	Victoria Falls	Muzuma(UP Grade)	2010-2015	159	330	2-Bison
1	Victoria Falls	Batoka Gorge	2010-2015	40	330	2-Bison
1	Victoria Falls	Muzuma	2010-2015	159	330	2-Bison
1	Batoka Gorge	Devil Gorge	2010-2015	70	330	2-Bison
1	Devil Gorge	Maamba	2010-2015	70	330	2-Bison
1	Maamba	Muzuma	2010-2015	55	330	2-Bison
2	Kansanshi	Lumuwana	2010-2015	72	330	2-Bison
1	Mumbwa	Lusaka West	2010-2015	105	330	2-Bison
2	Mumbwa	Lusaka West	2010-2015	105	330	2-Bison
2	Luano	Michelo	2010-2015	31.9	220	2-HD153
1	Luano	Stadium	2010-2015	16.4	220	2-Lion
2	Luano	Stadium	2010-2015	16.4	220	2-Lion
1	Michelo	Bankroft	2010-2015	10	220	2-HD153
2	Michelo	Bankroft	2010-2015	10	220	2-HD153
2	Victoria Falls	Sesheke	2010-2015	224	220	Bison
1	Mumbwa	Itezhi-Tezhi	2010-2015	145	220	Bison
2	Mumbwa	Itezhi-Tezhi	2010-2015	145	220	Bison
2	Coventry	Leopards Hill	2010-2015	28	132	Wolf
2	Coventry	Lusaka West	2010-2015	7	132	Wolf
2	Roma	Lusaka West	2010-2015	15	132	Wolf
1	Leopards Hill	Avondale	2010-2015	15	132	Zebra

Id	From	To	Install Year	Length (km)	Voltage (kV)	Conductor Type
2	Leopards Hill	Avondale	2010-2015	15	132	Zebra
1	Kasama	Mbala	2010-2015	161	132	Wolf
2	Kasama	Mbala	2010-2015	161	132	Wolf
1	Kasama	Chinsali	2010-2015	105	132	Wolf
1	Pensulo	Lusiwasi	2010-2015	90	132	Wolf
2	Pensulo	Lusiwasi	2010-2015	90	132	Wolf
1	Pensulo	Kanon	2010-2015	20	132	Wolf
2	Pensulo	Kanon	2010-2015	20	132	Wolf
1	Pensulo	Mutindo	2010-2015	110	132	Wolf
2	Pensulo	Mutindo	2010-2015	110	132	Wolf
1	Lusiwasi	Msoro	2010-2015	115	132	Wolf
2	Lusiwasi	Msoro	2010-2015	115	132	Wolf
1	Lusiwasi	Mfuwe	2010-2015	80	132	Wolf
2	Lusiwasi	Mfuwe	2010-2015	80	132	Wolf
1	Kabwe	Kapiri Mposhi	2010-2015	96	132	Wolf
1	Itezhi-Tezhi	Kaoma	2010-2015	180	132	Wolf
2	Itezhi-Tezhi	Kaoma	2010-2015	180	132	Wolf
1	Kaoma	Mongu	2010-2015	185	132	Wolf
1	Nampundwe	Lusaka West	2010-2015	60	132	Wolf
1	Kafue Town	Mazabuka	2010-2015	52	132	Zebra
2	Kafue Town	Mazabuka	2010-2015	52	132	Zebra
1	Mazabuka	Monze	2010-2015	60	132	Wolf
1	Mapepe	Lusaka South	2010-2015	20	132	Wolf
2	Mapepe	Lusaka South	2010-2015	20	132	Wolf
1	Lusaka South	Waterworks	2010-2015	14	132	Zebra
2	Lusaka South	Waterworks	2010-2015	14	132	Zebra
1	Lusaka South	Woodlands	2010-2015	13	132	Zebra
2	Lusaka South	Woodlands	2010-2015	13	132	Zebra
1	Lusaka South	Coventry A	2010-2015	21	132	Zebra
2	Lusaka South	Coventry A	2010-2015	21	132	Zebra
1	Coventry A	Coventry B	2010-2015	1	132	Zebra
2	Coventry A	Coventry B	2010-2015	1	132	Zebra
1	Muzuma	Choma	2010-2015	26	132	Wolf
2	Muzuma	Choma	2010-2015	26	132	Wolf
1	Choma	Monze	2010-2015	80	132	Wolf
1	Mutinond	Luchene	2010-2015	45	132	Wolf

Id	From	To	Install Year	Length (km)	Voltage (kV)	Conductor Type
2	Mutinond	Luchene	2010-2015	45	132	Wolf
2	Stadium	Avenue	2010-2015	1.27	66	2-HD124
3	Stadium	Avenue	2010-2015	1.27	66	2-HD124
2	Chisenga	Luano	2010-2015	11.4	66	Lynx
2	Mufulira	Kankoyo	2010-2015	0.4	66	2-HD124
2	Maposa	Dola Hill	2010-2015	21.3	66	Lynx
1	Maposa	Pamodzi	2010-2015	25	66	Lynx
2	Maposa	Pamodzi	2010-2015	25	66	Lynx
2	Ndola Refinery	Skyways	2010-2015	1.5	66	HD124
2	Pamodzi	Depot Road	2010-2015	6.3	66	Lynx
2	Kanon	Kaomb	2010-2015	21	66	Wolf
2	KZNGL	Victoria Falls	2010-2015	80	66	Wolf
	New SWS (Internal of Kabwe ï Kitwe, LuanoLine)		2010-2015			
	Lusaka South SS (Internal of Leopards Hill ï Kafue West Line)		2010-2015			
1	Kundabwika	Mporokoso	2015-2020	95	330	2-Bison
1	Kafue Gorge Lower	Lusaka South	2015-2020	45	330	2-Bison
1	Kafue Gorge Lower	Lusaka South	2015-2020	45	330	2-Bison
1	Kitwe	Kitwe Coal	2015-2020	10	330	2-Bison
2	Kitwe	Kitwe Coal	2015-2020	10	330	2-Bison
1	Kundabwika	Kabwelume	2015-2020	25	132	Zebra
2	Kundabwika	Kabwelume	2015-2020	25	132	Zebra
1	Kundabwika	Nchelenge	2015-2020	75	132	Wolf
1	Kabwelume	Kawambwa Tea	2015-2020	30	132	Wolf
1	Msoro	Chipata	2015-2020	80	132	Wolf
2	Msoro	Chipata	2015-2020	80	132	Wolf
1	Kabwe	Lunsemfwa	2015-2020	65	132	Zebra
2	Kabwe	Lunsemfwa	2015-2020	65	132	Zebra
1	Kabwe	BRKHL	2015-2020	3	132	Wolf
2	Kabwe	BRKHL	2015-2020	3	132	Wolf
1	Kapiri Mposhi	Mpongwe	2015-2020	60	132	Wolf
1	Lumwana	Kabompo Gorge	2015-2020	70	132	Wolf
2	Lumwana	Kabompo Gorge	2015-2020	70	132	Wolf
1	Kabompo Gorge	Mwinilunga	2015-2020	100	132	Wolf

Id	From	To	Install Year	Length (km)	Voltage (kV)	Conductor Type
1	Kabompo Gorge	Mufumbwe	2015-2020	110	132	Wolf
1	Mufumbwe	Kabompo	2015-2020	105	132	Wolf
1	Kabompo	Mumbeji	2015-2020	80	132	Wolf
1	Mongu	Lukulu	2015-2020	160	132	Wolf
1	Lukulu	Mumbeji	2015-2020	80	132	Wolf
1	Mumbeji	Zambezi	2015-2020	75	132	Wolf
1	Zambezi	Chavuma	2015-2020	80	132	Wolf
1	Lusaka South	Chawama	2015-2020	6	132	Wolf
2	Lusaka South	Chawama	2015-2020	6	132	Wolf
1	University	Chelston	2015-2020	5	132	Zebra
2	University	Chelston	2015-2020	5	132	Zebra
1	Avondale	Chelston	2015-2020	5.7	132	Zebra
2	Avondale	Chelston	2015-2020	5.7	132	Zebra
3	Ndola Refinery	Skyways	2015-2020	1.5	66	HD124
2	Dola Hill	Pamodzi	2015-2020	3.7	66	Lynx
3	Kafue West	Lsaka West	2020-2025	34	330	2-Bison
2	Devil Gorge	Maamba	2020-2025	70	330	2-Bison
1	Mukushi	Lunsemfwa	2020-2025	10	132	Wolf
2	Mukushi	Lunsemfwa	2020-2025	10	132	Wolf
2	Kaoma	Mongu	2020-2025	185	132	Wolf
1	Makeni	Lusaka West	2020-2025	13	132	Zebra
2	Makeni	Lusaka West	2020-2025	13	132	Zebra
1	Matero	Lusaka West	2020-2025	15	132	Zebra
2	Matero	Lusaka West	2020-2025	15	132	Zebra
3	Kitwe	New SWS	2025-2030	91	330	2-Bison
1	Leopards Hill	Mpata Gorge	2025-2030	255	330	2-Bison
2	Leopards Hill	Mpata Gorge	2025-2030	255	330	2-Bison
1	Pensulo	Mumbotuta	2025-2030	190	330	2-Bison
2	Pensulo	Mumbotuta	2025-2030	190	330	2-Bison
1	Pensulo	New SWS	2025-2030	219	330	2-Bison
2	Kafue West	Kafue Town	2025-2030	3	330	2-Bison
2	Kabompo Gorge	Mufumbwe	2025-2030	110	132	Wolf
2	Mufumbwe	Kabompo	2025-2030	105	132	Wolf
3	Lusaka South	Coventry A	2025-2030	21	132	Zebra

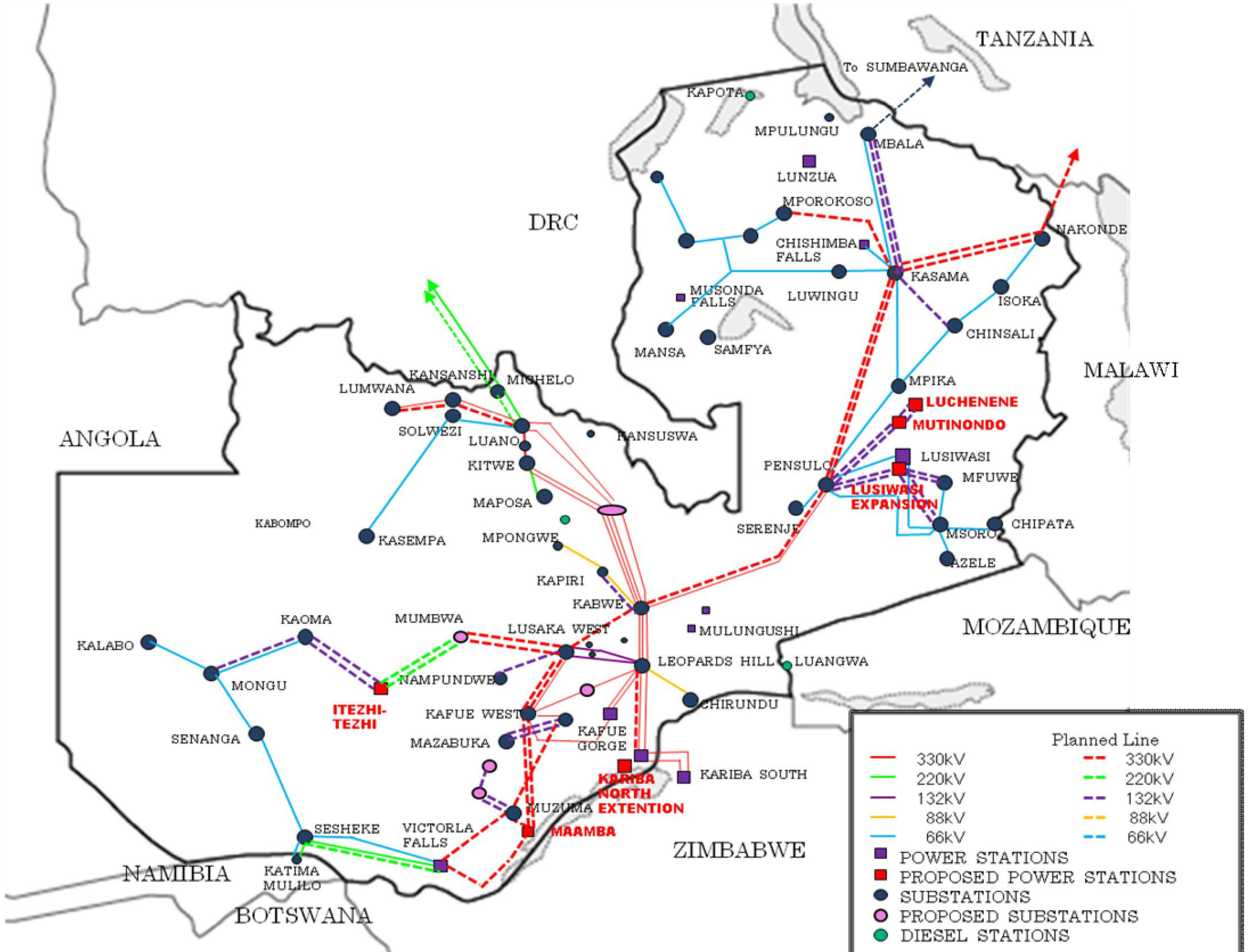


Figure 0.13 Zambian Power System on 2015 (Scenario 1-2)

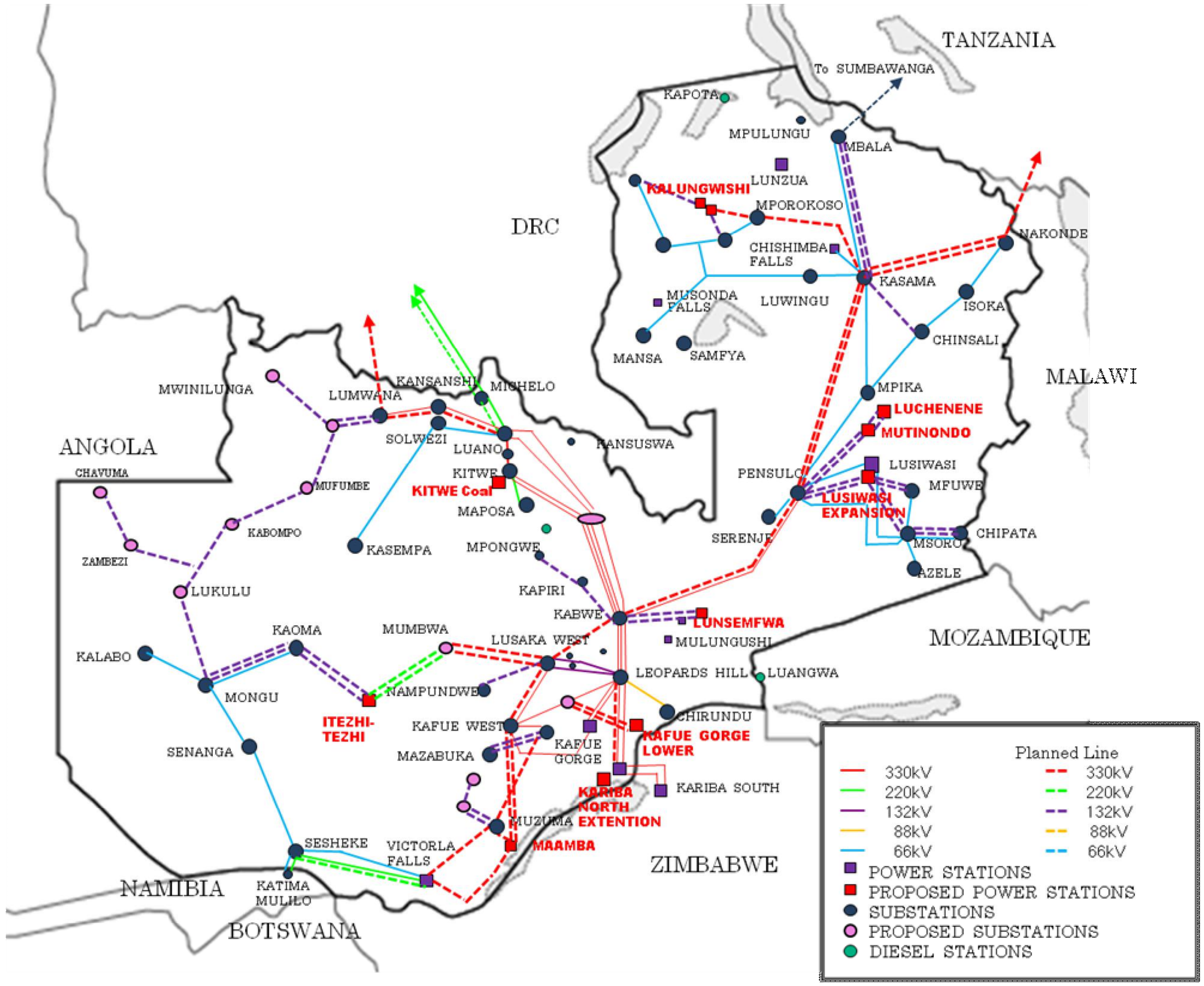


Figure 0.14 Zambian Power System on 2020 (Scenario 1-2)

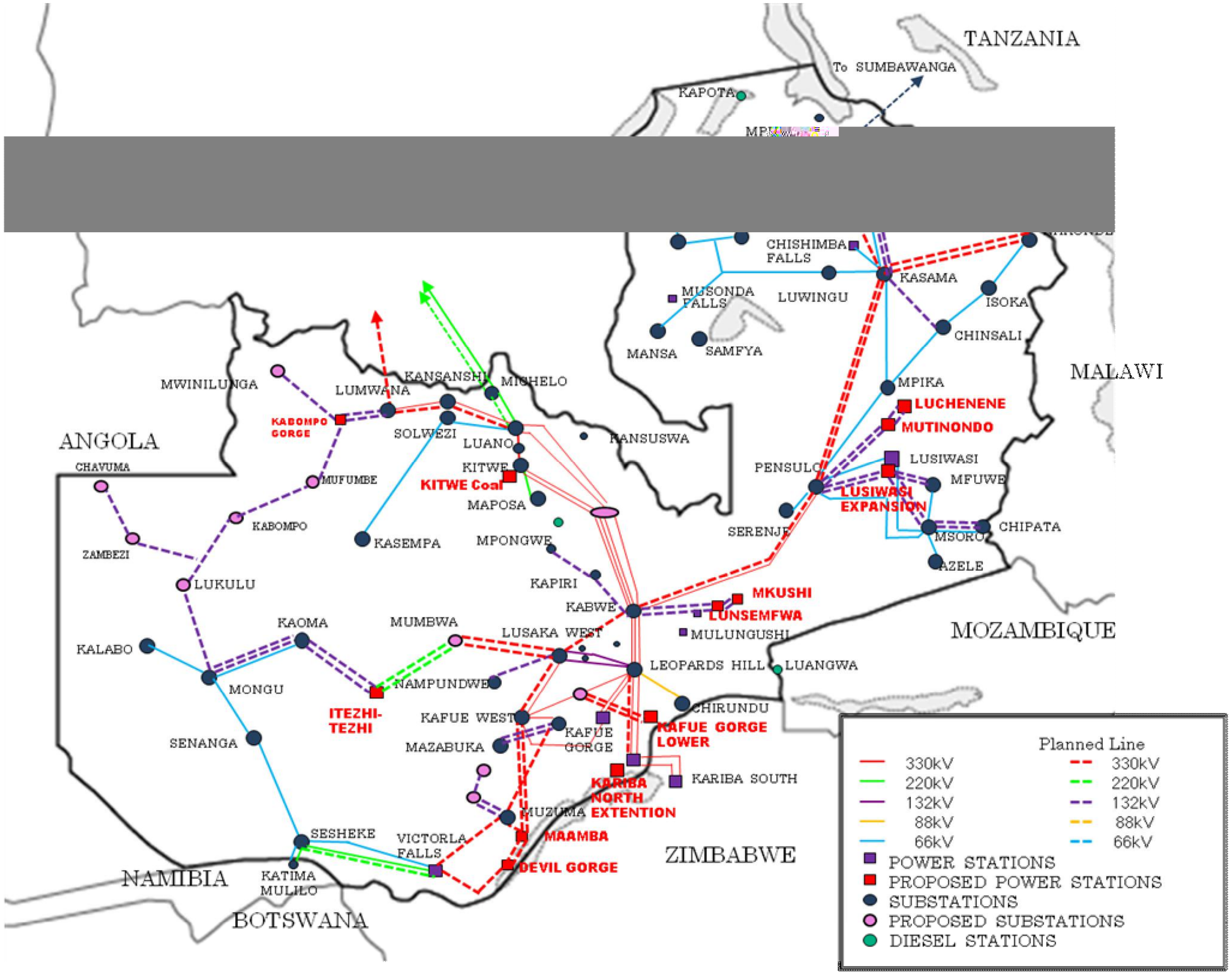


Figure 0.15 Zambian Power System on 2025 (Scenario 1-2)

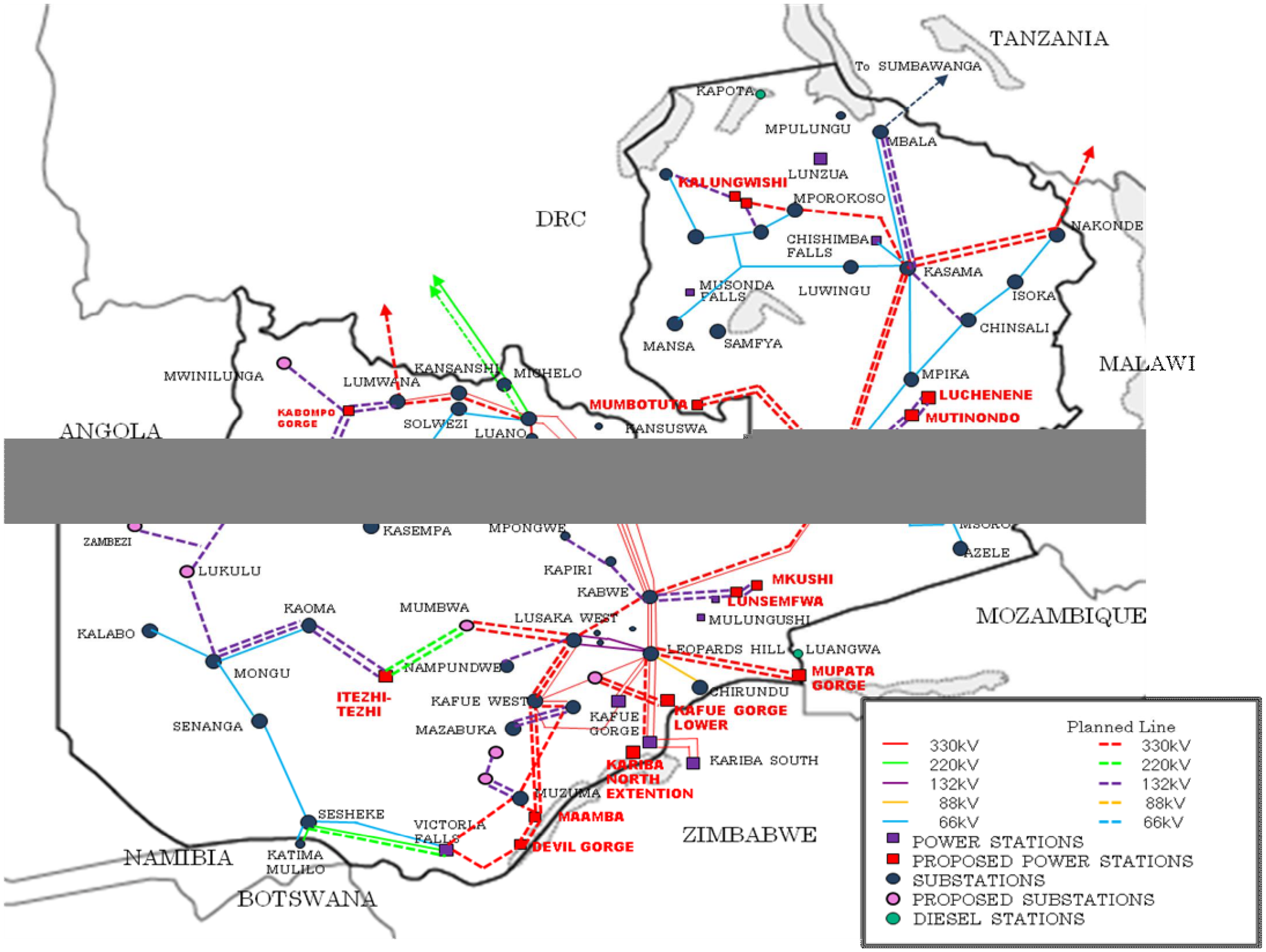


Figure 0.16 Zambian Power System on 2030 (Scenario 1-2)

Summary of transmission development plans

This section presents the cost of transmission development and transmission loss to summarize the plans prepared for transmission development. Table 0.19 shows the transmission development costs in Scenario 1-1, and Table 0.20, those in Scenario 1-2. These cost figures were calculated on the basis of equipment costs in 2008, and do not reflect factors such as future inflation rates.

Table 0.19 Transmission development cost in Scenario 1-1 (million USD)

Year	Transmisson Line	Switchgear	Transformer	Total
2010-2015	1,324	133	126	1,583
2015-2020	295	33	42	371
2020-2025	597	52	27	675
2020-2030	74	8	16	98
Total	2,290	226	211	2,728

Table 0.20 Transmission development cost in Scenario 1-2 (million USD)

Year	Transmisson Line	Switchgear	Transformer	Total
2010-2015	1,324	133	126	1,583
2015-2020	259	29	35	324
2020-2025	41	9	35	86
2020-2030	310	25	13	348
Total	1,934	197	210	2,341

From these tables, it can be seen that the cost of transmission development in Zambia would be very high and in 2030 reach a cumulative USD2.7 billion in Scenario 1-1 and USD2.3 billion in Scenario 1-2. The amounts required in the 2010 - 2015 phase would be particularly high, accounting for more than 50 percent of the total to 2030. The reason is that the transmission system in Zambia at present is operating under extremely tough conditions, and to meet any further demand increase will require a substantial increase in the trunk system and other component systems.

It also can be seen that Scenario 1-2 has generally lower development costs than Scenario 1-1 and would shift the development to a later phase (2025 - 2030). This is because the construction of coal-fired power stations at Kitwe would reduce the flow of power from south to north, and the development at Mambilima and Mumbotuta would be delayed.

Table 8.21 shows the transmission loss at peak time periods in 2010, 2015, 2020, 2025, and 2030.

Table 0.21 Transmission system loss at peak load in Zambia

Year	Peak Load (MW)	Scenario1-1				Scenario1-2			
		With IC*1		Without IC*2		With IC*1		Without IC*2	
		(MW)	(%)	(MW)	(%)	(MW)	(%)	(MW)	(%)
2010	1689.6	-	-	110.8	6.6	-	-	-	-
2015	2366.6	158.9	6.7	129.9	5.5	159.3	6.7	129.8	5.5
2020	2771.7	208.4	7.5	145.1	5.2	183.2	6.6	120.0	4.3
2025	3245.78	203.2	6.3	145.4	4.5	195.1	6.0	123.1	3.8
2030	3877.86	278.1	7.2	203.5	5.2	219.1	5.7	148.8	3.8

***1:** In the case of power import and export through international interconnections, under the conditions shown in Table 8-3.

***2:** In the case of no transmission or reception of power through international interconnections.

From this table, it can be seen that, with the transmission development, the loss rate would become somewhat lower relative to 2010 beginning in 2015. Due to the influence of the coal-fired power development in Kitwe, Scenario 1-2 would have less transmission loss than Scenario 1-1.

International interchange applying additional load on the Zambian system would entail higher loss. In certain cases, it would result in loss of more than 70 MW more than in the case of no international interchange in 2030. As this indicates, regular performance of power interchange requires consideration of transmission loss.

Distribution plan

Distribution plan subjects

Figure 0.1 and Table 0.1 show the power facilities that are subjects of the preparation of the distribution plan in this study, and definitions of the same, respectively. The specific distribution facilities[23] are as follows.

- 33 kV distribution lines from bulk supply points (BSPs[24]) to 33/11 kV substations.
- 33 kV distribution lines interconnecting 33/11 kV substations
- 33/11 kV substations

The subject areas in the study are Lusaka, Choma, Kafue, Livingstone, Mazabuka, Kapiri/Mkushi, Ndola, and Kitwe. The Kabwe, Chingola, and Luanshya areas, which were initially taken as subjects, were excluded from the subsequently planning because they do not contain any subject distribution facilities.

It was decided to prepare the plan for the period up to and including 2020. The 33/11 kV substations have a capacity of about 20 MVA at the most, and a planning period of about ten years was considered sufficient, as micro situational changes can have a substantial impact on the plan.

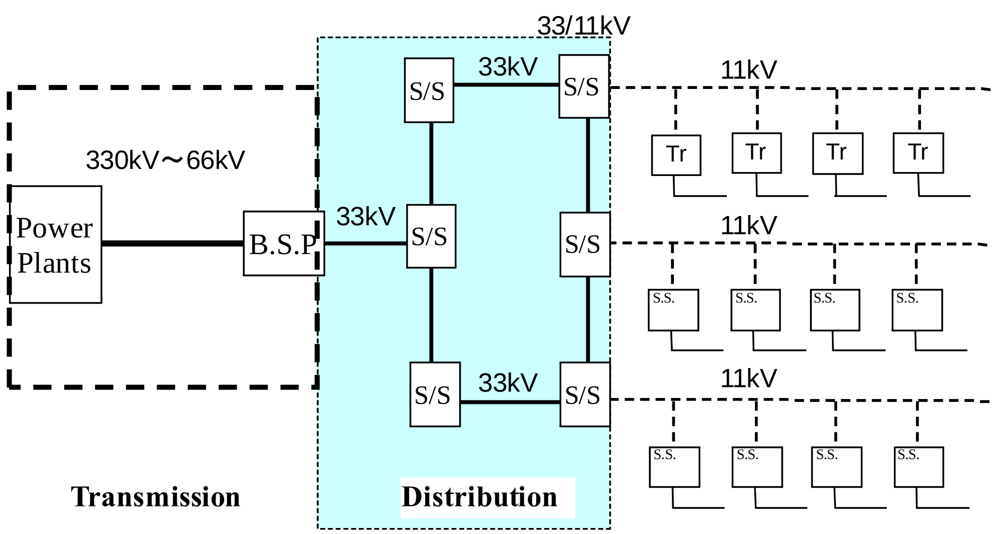


Figure 0.1 Subject power facilities in the distribution plan

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[23] The list of subjects does not include 33 kV distribution lines directly supplying 33 kV customers, 11 kV distribution lines, and low-voltage distribution lines.

[24] Distribution substations supplying power to 33 kV distribution lines, equivalent to what are called secondary substations in Japan.

Table 0.1 Definitions of subject power facilities in the distribution plan

Power facilities	Definitions
distribution line	- 33 kV lines from BSPs to 33/11 kV substations - 33 kV lines interconnecting 33/11 kV substations
substation	- 33/11 kV substations

Distribution plan standard

(1) System plan standard and analytical conditions

Table 0.2 shows the distribution plan standard in Zambia. The N-1 standard is in worldwide use, but is not applied in the distribution system in Zambia at present. The Study Team considered facility measures for satisfaction of the N-1 standard only in the case of the Lusaka area, which is important and has a large load. (The N-1 standard is grounded in the idea of preventing the failure of one of N number of facilities from disrupting the power supply from the remaining (N minus 1) facilities. The failure is assumed to be the failure of one distribution line or one transformer.)

Table 0.2 System plan standard and analytical conditions

		Description	
Thermal capacity	Normal times	No more than 100% of the normal power flow	
	Failure of one unit (N-1)	No more than 100% of the power flow in the event of a one-unit failure (applied only to the Lusaka area)	
Voltage		Drop of no more than 5% at the end of the 33 kV distribution line	
System analysis		System analysis program	PSS/E
		Years of analysis	2009 - 2020, except the study of single-unit failure (N-1), which will concern only 2020 and the Lusaka area
		Power demand	Assumption of the power demand studied in Chapter 5
		System plan	Study based on existing ZESCO plans

(2) Design standards

The study utilized the ZESCO design standards, as follows.

i) Power lines

(a) 33 kV overhead distribution lines

For overhead distribution lines, a selection is made from 50, 100, 150 mm^2 ACSR, in accordance with load capacity and the use of trunk and feeder line facilities. In heavy-load areas such as Lusaka, a selection is made of large-capacity conductors (e.g., 200, 300, or 350 mm^2 ACSR), in correspondence with the load capacity.

- Trunk lines: 100 or 150 mm^2 ACSR (350 mm^2 ACSR at maximum)
- Feeder(Branch) lines: 50 or 100 mm^2 ACSR

(b) 33 kV underground distribution lines

For underground distribution lines, a selection is made between 70, 120 mm^2 PICL, 185, or 240 mm2 XLPE, in accordance with the load capacity and the facility use of trunk and feeder lines. In heavy-load areas such as Lusaka, a selection is made of large-capacity conductors (e.g., 300 - 500 mm2 XLPE), in correspondence with the load capacity.

- Trunk lines: ordinarily 185 or 240 mm2 XLPE (500 mm2 XLPE at maximum)
- Feeder lines: ordinarily 70 or 120 mm2 PICL

ii) Supporting structures

The standard supporting structures in Zambia are wooden poles, which are used in light of their advantages in the aspects of procurement and cost. The standard length is 12 meters, but some poles with a length of more than 12 meters are used if the circumstances in the vicinity of distribution facilities demand it.

- Supporting structures: wooden poles, 12 m (16 m at maximum)

iii) Span distance

The span distances (between supporting structures) are as follows.

- Span distances: urban areas - 100 m, rural areas - 110 m (80 at minimum, 120 at maximum)

(3) Demand estimate results

Table 0.3 - Table 0.6 show the results of the demand estimates for each substation. The estimates of future demand for each substation were based on the demand estimates in Chapter 5. The table does not include an estimate for the demand iin the Lusaka South Multi-Facility Economic Zone (LS-MFEZ), which is slated for development in the

southern part of Lusaka, because it is not certain when this demand will emerge. However, facility formation was studied with consideration of a estimated demand equivalent to a final capacity of 14 MW beginning in 2015.

Table 0.3 Demand estimate results for each substation (Lusaka area)

Peak Demand (MW)

Substation	2008	2010	2015	2020
Shorthorn	13.8	15.0	19.4	25.3
Makeni	19.8	21.4	27.7	36.2
Chilanga	16.1	17.5	22.5	29.5
Barlaston	1.0	1.1	1.4	1.8
Liverpool	33.0	35.8	46.2	60.4
Chawama	16.3	17.7	22.9	29.9
Matero	41.7	45.2	58.4	76.4
Manda Hill	11.3	12.2	15.8	20.6
Bublin	10.5	11.4	14.7	19.2
Birdcage Walk	20.6	22.3	28.8	37.7
Kafe Road	46.0	49.9	64.4	84.2
University	25.1	27.2	35.1	45.9
Chelston	25.2	27.3	35.3	46.1
Kabulonga	19.5	21.1	27.3	35.7
Uth	4.1	4.5	5.8	7.5
Woodlands	27.1	29.4	38.0	49.7
Waterworks	18.1	19.6	25.3	33.1
Avondale	18.9	20.4	26.4	34.5
Ngwerere	1.6	1.8	2.3	3.0
Chongwe	4.0	4.3	5.6	7.3
Bauleni	9.6	10.4	13.4	17.6
Total	383.4	415.6	536.3	701.6

Table 0.4 Demand estimate results for each substation (Copperbelt region: Kitwe, Ndola)

Peak Demand (MW)

Substation	2008	2010	2015	2020
Kansuswa	2.7	2.9	3.8	4.9
Kafironda	2.2	2.4	3.1	4.0
Mwambashi	2.4	2.6	3.4	4.4
Chambishi	2.7	2.9	3.8	4.9
Chati	1.4	1.5	2.0	2.6
Katembula	1.2	1.3	1.7	2.2
Skyways	40.7	44.1	56.9	74.5
Zambezi Paper Mills	5.4	5.9	7.6	9.9
Kafubu dam	2.2	2.4	3.1	4.0
Chilanga	11.0	11.9	15.4	20.1
Zambezi Portland Cement	0.5	0.5	0.7	0.9
Swarp Spinning	0.5	0.5	0.7	0.9
Total	72.9	78.9	102.2	133.3

Table 0.5 Demand estimate results for each substation (southern region: Livingstone, Choma, Mazabuka, and Kafue)

Peak Demand (MW)

Substation	2008	2010	2015	2020
Kafue Town	12	13	16.8	22
Mazabuka	8	8.7	11.2	14.6
Magoye	0.9	1	1.3	1.6
Lochinvar	0.5	0.5	0.7	0.9
Monze	2	2.2	2.8	3.7
Chisekesi	2.1	2.3	2.9	3.8
Gwembe	0.5	0.5	0.7	0.9
Munyumbwe	0.4	0.4	0.6	0.7
Chipepo	0.2	0.2	0.3	0.4
Victoria Falls	28.0	30.4	39.2	51.2
Zimba	0.3	0.3	0.4	0.5
Kalomo	3.0	3.3	4.2	5.5
Choma	12	13	16.8	22
Itezhi-tezhi	0.3	0.3	0.4	0.5
Namwala	0.1	0.1	0.1	0.2
Maala	0.1	0.1	0.1	0.2
Maamba	2.5	2.7	3.5	4.6
Sinazongwe	6	6.5	8.4	11
Total	78.9	85.5	110.4	144.3

Table 0.6 Demand estimate results for each substation (central region: Kapiri/Mkushi)

Peak Demand (MW)

Substation	2008	2010	2015	2020
MTZ	9.1	9.9	12.7	16.7
Nkumbi Farmers	2.0	2.2	2.8	3.7
Amajuba Farmers	1.6	1.7	2.2	2.9
New Boma	2.1	2.3	2.9	3.8
North East	1.8	2.0	2.5	3.3
North West	2.5	2.5	2.5	2.5
Mkushi West	1.0	1.0	1.0	1.0
Mkushi Central	1.0	1.1	1.4	1.8
Kapiri Main	4.7	5.1	6.6	8.6
Total	22.3	24.2	31.2	40.8

(Note) For the Mkushi West and North West substations, the final capacity as of 2020 was used because of the existence of improvement plans.

(4) Construction cost integration unit costs

Table 0.7 and Table 0.8 show the unit cost figures were obtained by converting the figures in the 1995 table of unit construction costs prepared by ZESCO into current prices, with consideration of the rate of increase in the cost of commodities over the intervening years.

The tables for removal indicate only the cost of labor and other items directly related to the removal work; the calculation did not take into account profit on sale or reuse of the removed articles, or the cost of disposal accompanying scrapping, because the state of the removed articles is unclear.

Table 0.7 Unit construction costs for 33-kV distribution lines

Description			Unit Cost (1000US$)
Installation	Overhead line	350 mm^2 ACSR	41.8
		300 mm^2 ACSR	37.7
		200 mm^2 ACSR	33.8
		150 mm2 ACSR	30.6
		100 mm^2 ACSR	26.7
	Underground line	300 mm^2XLPE	200.6
		240 mm^2 XLPE	202.4
		95 mm^2 PILC	76.8
		95 mm^2 XLPE	92.9
Removal	Overhead line	200 mm^2 ACSR	11.8
		150 mm^2 ACSR	10.9
		100 mm^2 ACSR	9.7
		50 mm^2 ACSR	9.7
	Underground line	95 mm^2 PILC	27.6

Table 0.8 Unit construction costs for 33/11 kV transformers

Description		Unit Cost (1000US$)
Installation	2.5MVA	75.2
	5 MVA	133.9
	10 MVA	246.0
	15 MVA	375.9
	20 MVA	438.7
	25 MVA	503.0
	31.5 MVA	606.6
	40 MVA	731.2
	Primary and secondary point(entrance service and outlet of lines including bus-bar, CB, and so on)	163.6
Removal	1MVA	3.4
	2.5 MVA	3.4
	2.64MVA	3.4
	5 MVA	3.4
	7.5 MVA	3.4
	10 MVA	4.8
	11.8MVA	4.8
	15 MVA	4.8
	20 MVA	4.8

Distribution expansion plan (by 2020)

The Study Team prepared a plan for distribution system expansion by 2020 based on the results of the demand estimates and transmission plan formulation.

Lusaka area

The distribution lines in the Lusaka area are heavy-load lines with the highest demand density in Zambia. For the purpose of efficient maintenance and operation of the thermal capacity of distribution lines and substations as well as the distribution line voltage, the distribution system consists of a loop formed by interconnection of some BSPs (Lusaka West : 132/33 kV, Roma : 132/33 kV, Coventry : 132/33 kV, Mapepe : 88/33 kV, Waterworks : 88/33 kV, Chongwe : 88/33 kV) by means of the 33/11 kV substation bus and 33 kV distribution lines.

In 2008, several 33 kV distribution lines and 33/11 kV substations exceeded the tolerable limit of their thermal capacity. Other facilities as well are approaching their tolerable limit. Similarly, on some 33 kV distribution lines, the voltage drop exceeds the tolerable level. At present, the N-1 standard is not met. The results of the demand estimate for 2020 indicate an approximately 1.8-fold increase from 2008. The Study Team prepared a distribution expansion plan to meet this increase.

Figure 0.2 shows the distribution system expansion plan for the Lusaka area as of 2020. The following is an outline of the plan.

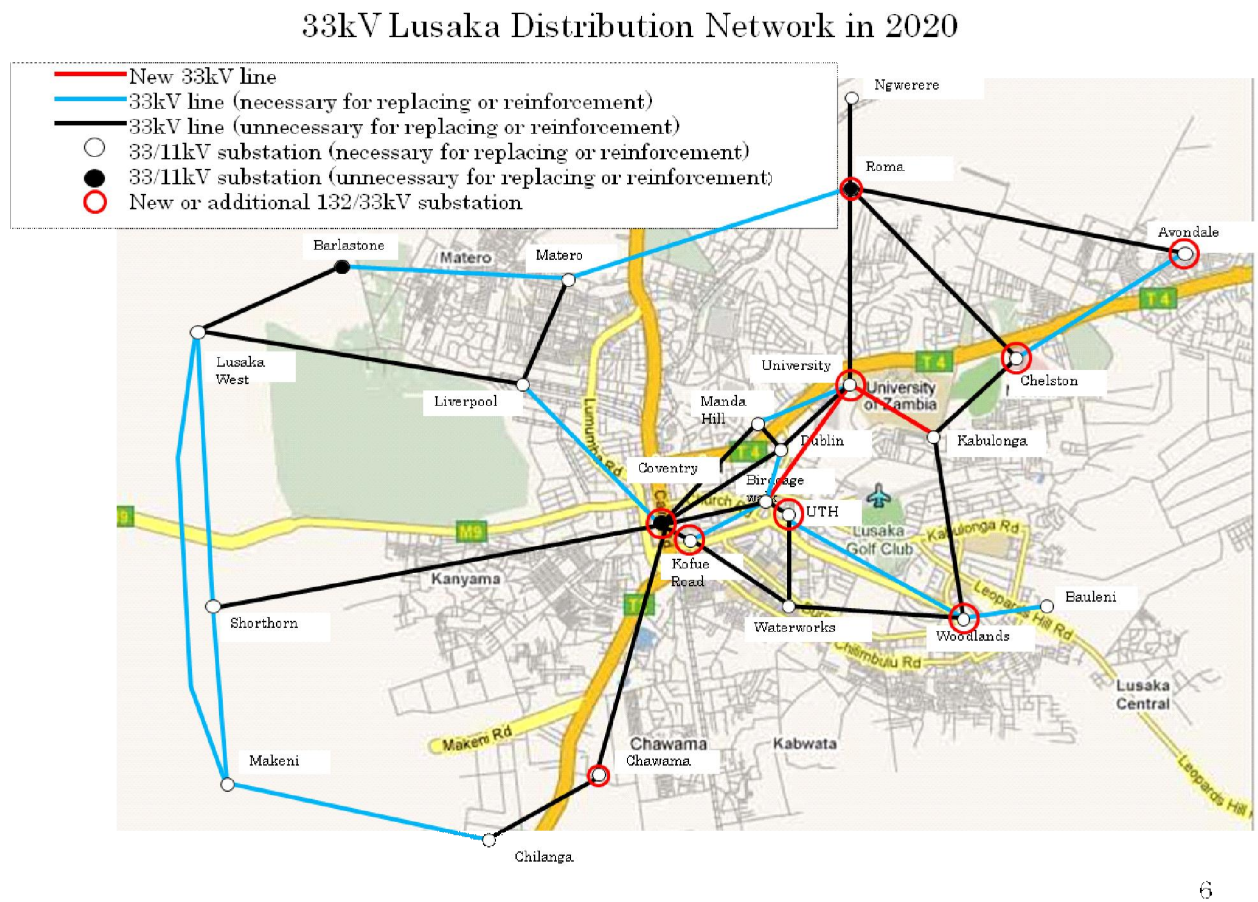


Figure 0.2 **Plan for expansion of the distribution system in the Lusaka area (by 2020)**

- Expansion of 33/11 kV substations and 33 kV distribution lines (by 2020)

  Almost all of the 33/11 kV substations will be in an overload status along with demand increase. This points to a need for replacement of existing transformers with large-capacity ones, installation of additional transformers, or construction of additional substations. Because almost all 33 kV distribution lines will become overloaded as well and have voltage drops beyond the standard, it is necessary to replace them with large-capacity lines or install additional lines. Because these measures of expansion were studied with a view to meeting the N-1 standard, the system composition as of 2020 would prevent supply interruption even with the failure of a single unit.

- Installation of additional 132 kV transmission lines and 132/33 kV BSPs (by 2020)

  Additional 132 kV transmission lines and 132/33 kV BSPs will be constructed as related in Chapter 8 in order to meet the demand in the Lusaka area.

Table 0.9 and Table 0.10 show the construction for expansion of distribution lines and substations, respectively, required by 2020. Figure9.3 shows the yearly cost of the expansion measures. Figure 0.4 presents the same information for 132 kV transmission lines and 132/33 kV BSPs.

Table 0.9 Distribution line expansion plan (Lusaka area)

From	To	No.	Length [km]	Type of countermeasure	New line	Before replacement	Cost [1000US$]	Year of implementation
Lusaka	Shorthorn	L1	2.72	Replacement	350ACSR	100ACSR	140.2	2010-2015
		L2	2.72	Additional line	350ACSR	-	113.8	
		L3	2.72	Additional line	350ACSR	-	113.8	
Lusaka	Makeni	L1	13.2	Replacement	300ACSR	100ACSR	626.1	2016-2020
Shorthorn	Makeni	L1	6	Replacement	300ACSR	150ACSR	292.0	2016-2020
		L2	6	Replacement	300ACSR	150ACSR	292.0	
Makeni	Chilanga	L1	16.3	Replacement	300ACSR	100ACSR	773.1	2016-2020
		L2	16.3	Replacement	300ACSR	100ACSR	773.1	
Barlaston	Matero	L2	5.6	Additional line	200ACSR	-	189.1	2016-2020
Liverpool	Coventry	L2	3.8	Additional line	350ACSR	-	158.9	2010-2015
		L3	3.8	Additional line	350ACSR	-	158.9	
Matero	Roma	L1	8.4	Replacement	240XLPECU	200ACSR	1799.1	2010-2015
		L2	8.4	Additional line	240XLPECU	-	1700.4	
		L3	8.4	Additional line	240XLPECU	-	1700.4	
		L4	8.4	Additional line	240XLPECU	-	1700.4	
Manda Hill	University	L2	2.2	Additional line	95PICLCU	-	169.0	2010-2015
Dublin	Birdcage Walk	L2	2.5	Additional line	95PICLCU	-	192.0	2016-2020
Dublin	University	L2	2.5	Additional line	95PICLCU	-	192.0	2016-2020
Birdcage Walk	Kafue Road	L2	3.7	Additional line	240XLPECU	-	749.0	2010-2015
		L3	3.7	Additional line	240XLPECU	-	749.0	
		L4	3.7	Additional line	240XLPECU	-	749.0	
Birdcage Walk	University	L1	2.5	Replacement	240XLPECU	95PICLCU	575.1	2010-2015
		L2	2.5	Additional line	240XLPECU	-	506.1	
		L3	2.5	Additional line	240XLPECU	-	506.1	
University	Kabulonga	L1	5	Additional line	300ACSR	-	0.0	2010-2015
		L2	5	Additional line	300ACSR	-	188.6	
Chelston	Avondale	L2	5.7	Additional line	100ACSR	-	151.9	2010-2015
Uth	Woodlands	L2	4.7	Additional line	240XLPECU	-	951.4	2010-2015
Woodlands	Bauleni	L3	2.8	Replacement	200ACSR	100ACSR	121.7	2010-2015
		L5	2.8	Replacement	200ACSR	100ACSR	121.7	
Total Construction Cost [1000US$]							**16,453.5**	

Table 0.10 **Substation expansion plan (Lusaka area)**

Substation		Type of countermeasure	New Transfomer [MVA]	Before replacement [MVA]	Cost [1000US$]	Year of implementation
Shorthorn	T1	Replacement	20	5	442.2	2010
	T2	Replacement	20	5	442.2	
	T3	Reinforcement	20	-	602.4	
Makeni	T1	Replacement	20	10	443.5	2010
	T2	Replacement	20	10	443.5	
	T3	Reinforcement	20	-	602.4	
Chilanga	T3	Reinforcement	20	-	602.4	2020
Liverpool	T3	Reinforcement	31.5	-	770.2	2020
Chawama	T1	Replacement	20	10	443.5	2013
	T2	Replacement	20	10	443.5	
	T3	Reinforcement	20	-	602.4	
Matero	T1	Replacement	31.5	20	611.4	2010
	T2	Replacement	31.5	20	611.4	
	T3	Reinforcement	31.5	-	770.2	
	T4	Reinforcement	31.5	-	770.2	
Manda Hill	T1	Replacement	31.5	20	611.4	2020
	T2	Replacement	31.5	20	611.4	
Dublin	T1	Replacement	20	7.5	442.2	2016
	T2	Replacement	20	7.5	442.2	
Birdcage Walk	T3	Reinforcement	20	-	602.4	2020
Kafue Road	T3	Reinforcement	25	-	666.6	2010
	T4	Reinforcement	25	-	666.6	
	T5	Reinforcement	25	-	666.6	
University	T3	Reinforcement	25	-	666.6	2020
Chelston	T1	Replacement	25	7.5	506.4	2010
	T2	Replacement	25	7.5	506.4	
	T3	Reinforcement	25	-	666.6	
Kbulonga	T1	Replacement	25	15	507.8	2017
	T2	Replacement	25	15	507.8	
	T3	Reinforcement	25	-	666.6	
Woodlands	T1	Replacement	31.5	20	611.4	2016
	T2	Replacement	31.5	20	611.4	
	T3	Reinforcement	31.5	-	770.2	

Waterworks	T3	Reinforcement	20	-	602.4	2016
Avondale	T3	Reinforcement	20	-	602.4	2020
Bauleni	T3	Reinforcement	10	-	409.6	2020
Total Construction Cost [1000US$]					**20945.9**	

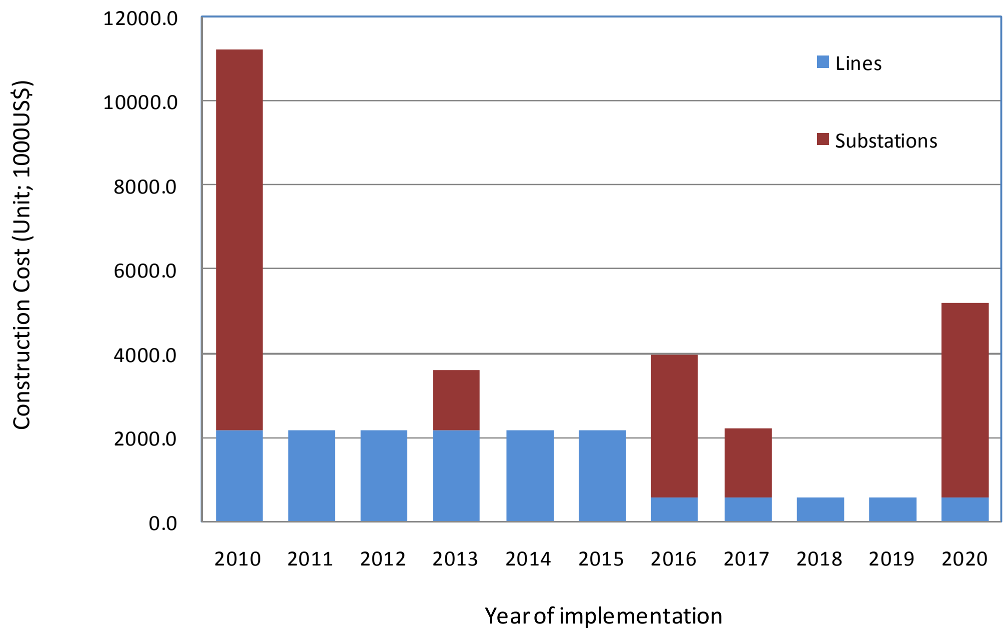


Figure 0.3 Construction cost (Lusaka area)

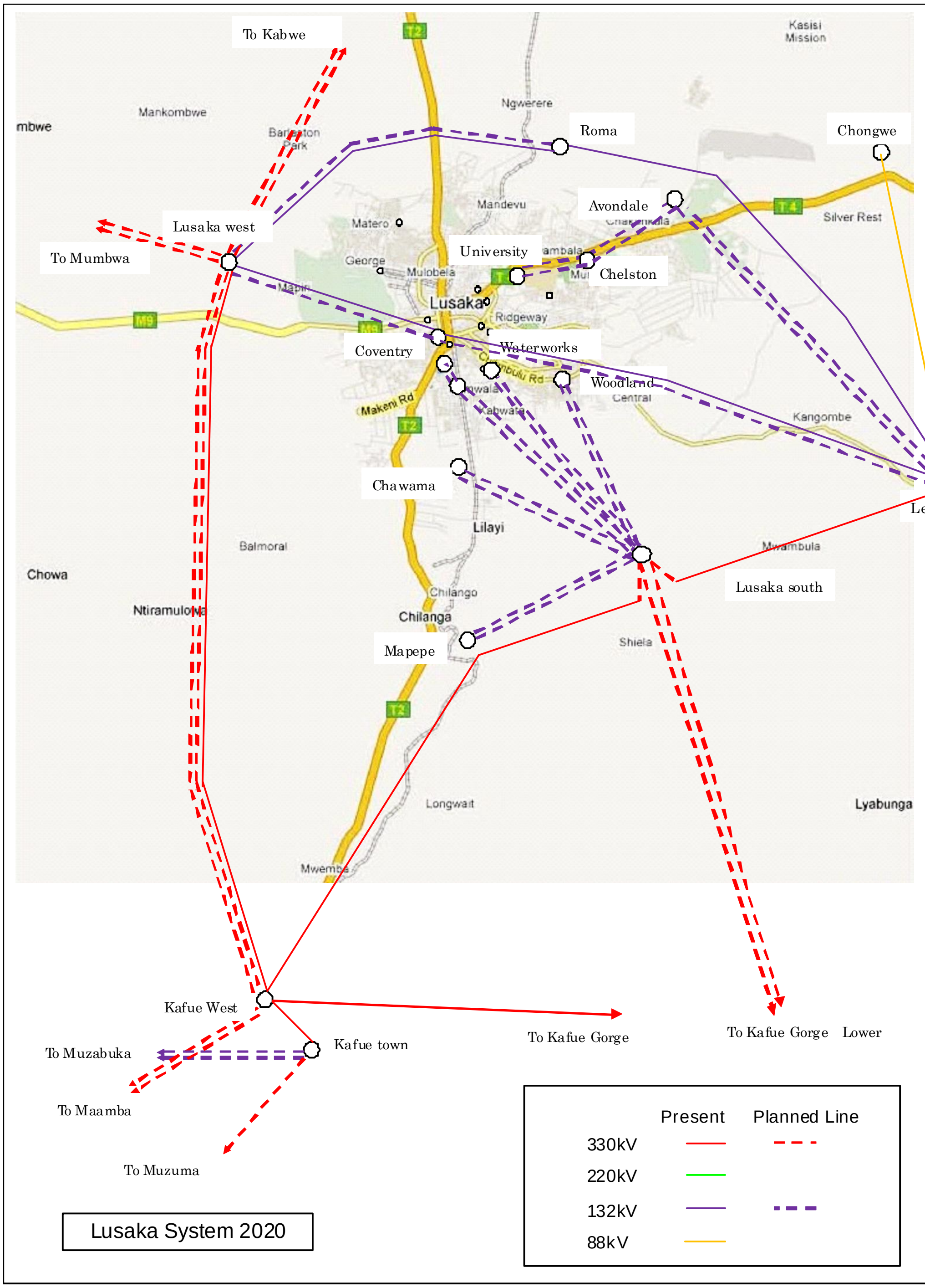


Figure 0.4 Plan for BSP development in the Lusaka area

Southern region : Livingstone, Choma, Mazabuka, and Kafue

In the southern region, which is characterized by low demand densities and long distribution line legs, measures to prevent excessive voltage drop on the lines are of vital importance. Figure 9.5 and Figure 9.6 shows the plan for expansion in the southern region. The plan is outlined below.

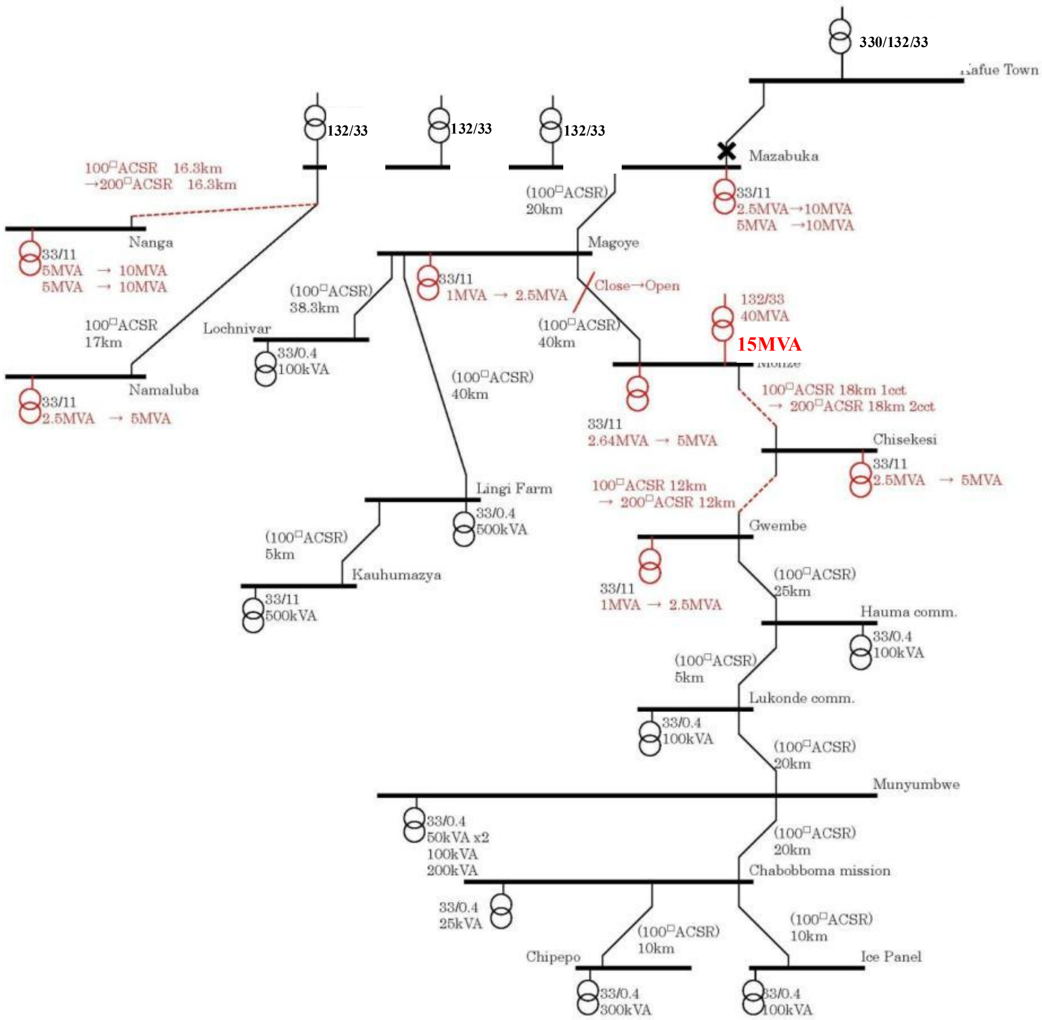


Figure 0.5 Plan for distribution expansion in the southern region (Mazabuka area)

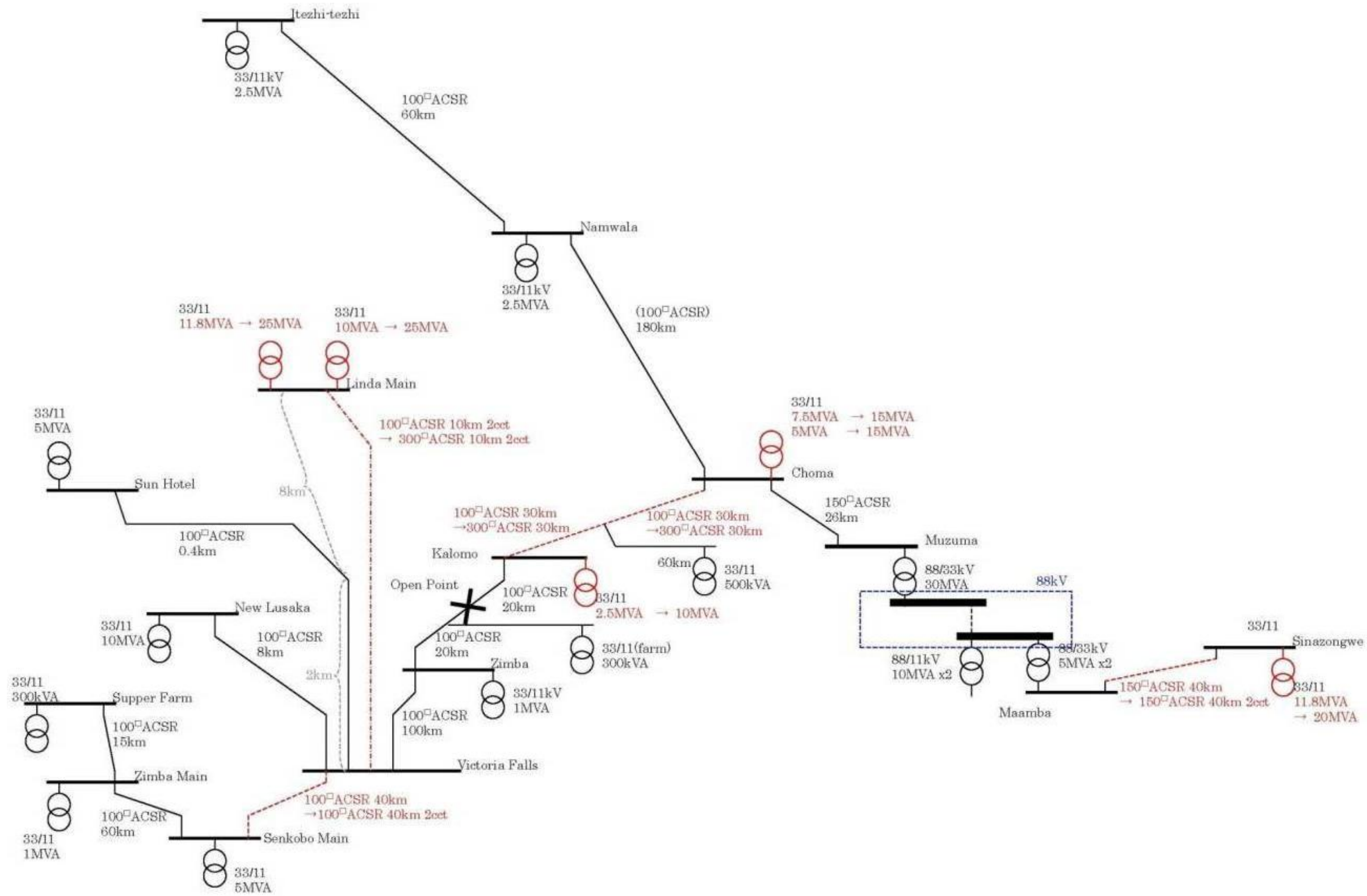


Figure 0.6 Plan for distribution expansion in the southern region (Livingstone area)

- Installation of additional 132 kV transmission lines and 132/33 kV BSPs (by 2020)

  In certain areas, the demand increase would make it difficult to supply load through distribution lines. For this reason, the plan calls for installation of additional 132 kV transmission lines and 132/33 kV BSPs, as described in Chapter 8.

- Expansion of 33 kV distribution lines (by 2020)

  Due to demand increase, the voltage drop would exceed the limit on several 33 kV distribution lines. As a result, it will be necessary to replace existing lines with large-capacity ones or install additional lines.

Table 0.11 and 9.12 show the construction for expansion of distribution lines and substations, respectively, required by 2020. Figure 0.7 shows the yearly cost of the expansion measures.

Table 0.11 Distribution line expansion plan (southern area)

<table>
<tr><th>From</th><th>To</th><th>No.</th><th>Length [km]</th><th>Type of countermeasure</th><th>New line</th><th>Before replacement</th><th>Cost [1000US$]</th><th>Year of implementation</th></tr>
<tr><td rowspan="2">Monze</td><td rowspan="2">Chisekesi</td><td>L1</td><td>18</td><td>Replacement</td><td>200ACSR</td><td>100ACSR</td><td>782.4</td><td rowspan="2">2010-2015</td></tr>
<tr><td>L2</td><td>18</td><td>Additional line</td><td>200ACSR</td><td>-</td><td>607.7</td></tr>
<tr><td>Chisekesi</td><td>Gwembe</td><td>L1</td><td>12</td><td>Replacement</td><td>200ACSR</td><td>100ACSR</td><td>521.6</td><td>2016-2020</td></tr>
<tr><td>Mazabuka</td><td>Nanga</td><td>L1</td><td>16.3</td><td>Replacement</td><td>200ACSR</td><td>100ACSR</td><td>708.5</td><td>2010-2015</td></tr>
<tr><td>Victoria Falls</td><td>Senkobo Main</td><td>L2</td><td>40</td><td>Additional line</td><td>100ACSR</td><td>-</td><td>1066.1</td><td>2010-2015</td></tr>
<tr><td rowspan="2">Victoria Falls</td><td rowspan="2">Linda Main</td><td>L1</td><td>10</td><td>Replacement</td><td>300ACSR</td><td>100ACSR</td><td>474.3</td><td rowspan="2">2010-2015</td></tr>
<tr><td>L2</td><td>10</td><td>Additional line</td><td>300ACSR</td><td>-</td><td>377.2</td></tr>
<tr><td>Maamba</td><td>Sinazongwe</td><td>L2</td><td>40</td><td>Additional line</td><td>150ACSR</td><td>-</td><td>1224.7</td><td>2010-2015</td></tr>
<tr><td rowspan="2">Choma</td><td rowspan="2">Kalomo</td><td>L1</td><td>60</td><td>Replacement</td><td>300ACSR</td><td>100ACSR</td><td>2845.7</td><td rowspan="2">2010-2015</td></tr>
<tr><td>L2</td><td>60</td><td>Additional line</td><td>300ACSR</td><td>-</td><td>2263.4</td></tr>
<tr><td colspan="7">Total Construction Cost [1000US$]</td><td>10871.6</td><td></td></tr>
</table>

Table 0.12 **Substations expansion plan (southern area)**

Substation		Type of countermeasure	New Transfomer [MVA]	Before replacement [MVA]	Cost [1000US$]	Year of implementation
Mazabuka	T1	Replacement	10	5	249.4	2010
	T2	Replacement	10	2.5	249.4	2010
Nanga	T1	Replacement	10	5	249.4	2020
	T2	Replacement	10	5	249.4	2020
Namaluba	T1	Replacement	5	2.5	137.4	2020
Magoye	T1	Replacement	2.5	1	78.6	2011
Monze	T1	Replacement	5	2.64	137.4	2012
Chisekesi	T1	Replacement	5	2.5	137.4	2011
Gwembe	T1	Replacement	2.5	1	78.6	2019
Choma	T1	Replacement	15	7.5	379.3	2010
	T2	Replacement	15	5	379.3	2010
Kalomo	T1	Replacement	10	2.5	249.4	2010
Linda Main	T1	Replacement	25	11.8	506.4	2011
	T2	Replacement	25	10	506.4	2011
Kansuswa	T1	Replacement	10	5	249.4	2018
Total Construction Cost [1000US$]					**3837.3**	

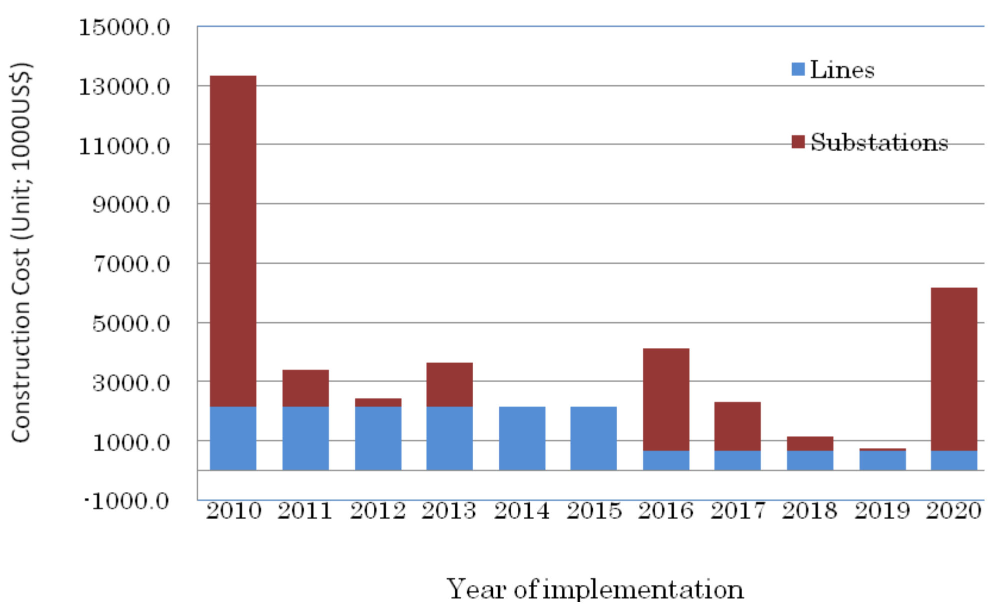


Figure 0.7 Construction cost (southern area)

Copperbelt region: Kitwe and Ndola

Figure 9.8 shows the plan for expansion in the Kitwe area. (There is no need for expansion in the Ndola area up to 2020.) The expansion is outlined below.

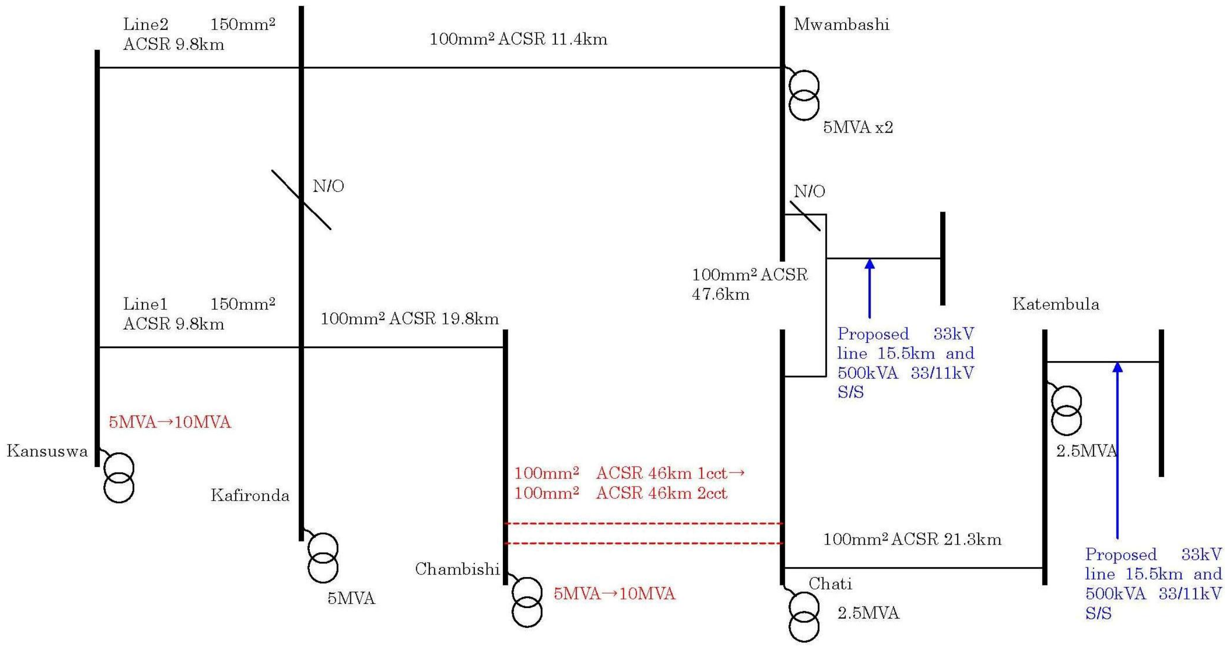


Figure 0.8 Plan for distribution system expansion in the Kitwe area

- Installation of additional 66 kV transmission lines and 66/33 kV BSPs (by 2020)

  Additional 66 kV transmission lines and 66/33 kV BSPs will be installed (at Chambishi, Chati, and Katembula) to meet the demand in the Kitwe area.

- Expansion of 33 kV distribution lines (by 2020)

  Due to demand increase, the voltage drop would exceed the limit on several 33 kV distribution lines. As a result, it will be necessary to replace existing lines with large-capacity ones or install additional lines. Table 9.13 and Table 9.14 show the plan for distribution line expansion by 2020, and Figure 9.9, the yearly construction cost.

  In the Ndola region, there is no need for expansion before 2020.

Table 0.13 Distribution line expansion plan (Kitwe area)

From	To	No.	Length [km]	Type of countermeasure	New line	Before replacement	Cost [1000US$]	Year of implementation
Chambishi	Katembula	L2	46	Additional line	100ACSR	-	1226.0	2010-2015
Total Construction Cost [1000US$]							**1226.0**	

Table 0.14 Substation expansion plan (Kitwe area)

Substation		Type of countermeasure	New Transfomer [MVA]	Before replacement [MVA]	Cost [1000US$]	Year of implementation
Kansuswa	T1	Replacement	10	5	249.4	2018
Chambishi	T1	Replacement	10	5	249.4	2018
Total Construction Cost [1000US$]					**498.8**	

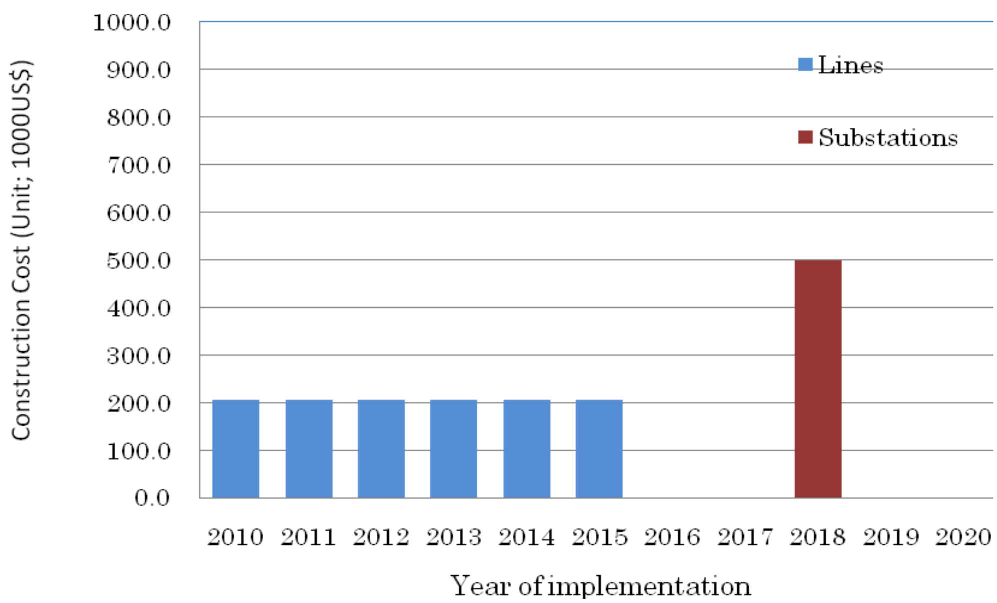


Figure 0.9 Construction Cost (Kitwe area)

Central region: Kapiri/Mkushi

Figure 9.10 shows the plan for expansion in the central region (Kapiri/Mkushi area).

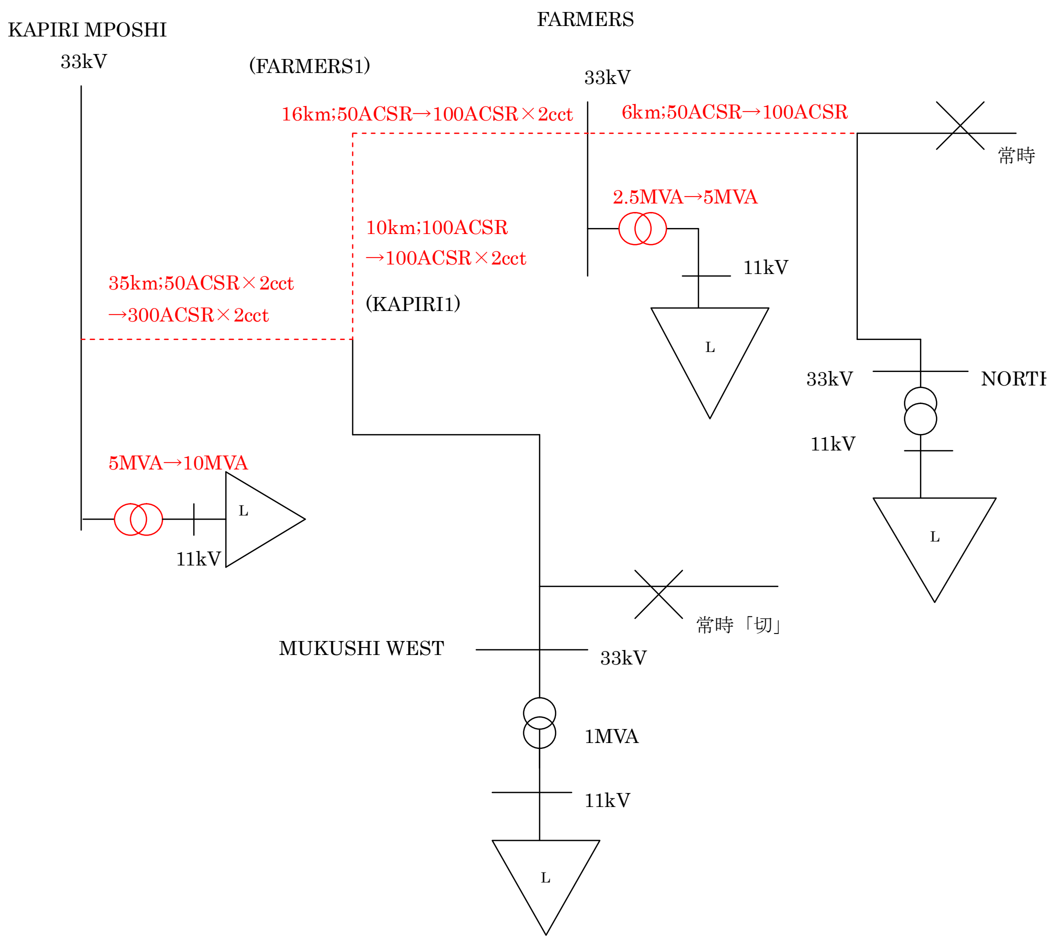


Figure 0.10 Plan for distribution expansion in the central region

- Expansion of 33 kV distribution lines (by 2020)

  Due to demand increase, the voltage drop would exceed the limit on several 33 kV distribution lines. As a result, it will be necessary to replace existing lines with large-capacity ones or install additional lines.

Table 0.15 and Table 0.16 show the plans for expansion of distribution lines and substations, respectively, by 2020. Figure 0.11 shows the yearly construction cost.

Table 0.15 Plan for distribution line expansion (central region)

From	To	No.	Length [km]	Type of countermeasure	New line	Before replacement	Cost [1000US$]	Year of implementation
Kapiri	Mkushi	L1	35	Replacement	300ACSR	50ACSR	1660.0	2010-2015
		L2	35	Replacement	300ACSR	50ACSR	1660.0	
Mkushi	Mkushi1	L2	10	Additional line	100ACSR	-	266.5	2010-2015
Mkushi1	Farmers	L1	16	Replacement	100ACSR	50ACSR	581.7	2010-2015
		L2	16	Additional line	100ACSR	-	426.4	
Farmers	North West	L1	6	Replacement	100ACSR	50ACSR	218.1	2010-2015
Total Construction Cost [1000US$]							**4812.8**	

Table 0.16 Plan for substation expansion (central region)

Substation		Type of countermeasure	New Transfomer [MVA]	Before replacement [MVA]	Cost [1000US$]	Year of implementation
Kapiri	T1	Replacement	10	5	249.4	2010
Farmers	T1	Replacement	5	2.5	137.4	2012
Total Construction Cost [1000US$]					**386.8**	

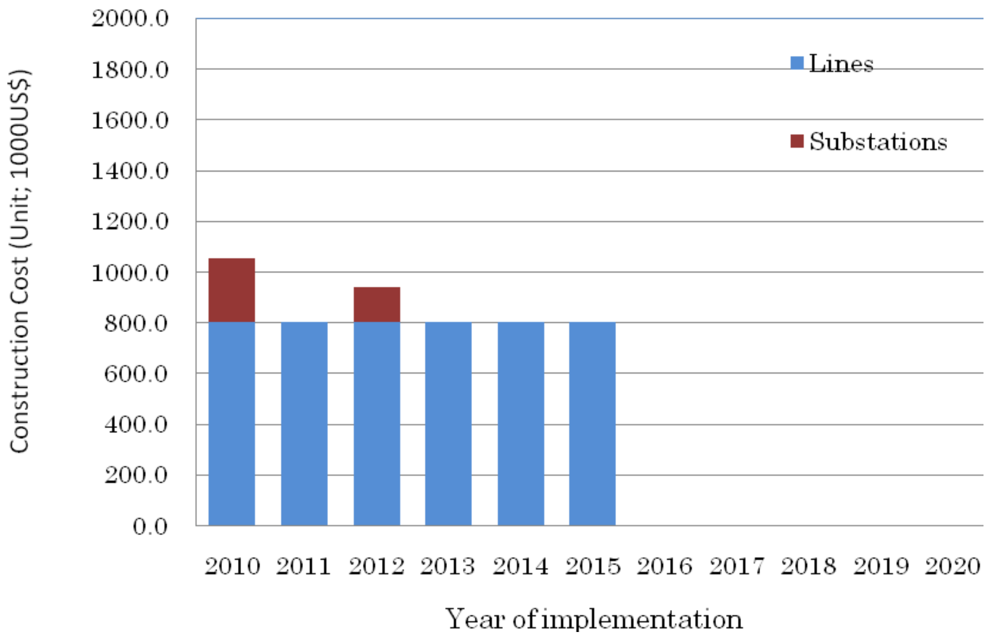


Figure 0.11 Construction cost (central region)

Opinions offered concerning reduction of system loss

Zambia government has the objective of reducing the system loss to less than 14% by March, 2010 base on the high system loss (i.e. 19% in 2007).

In this situation, reduction of system loss would appear to be helping to improve the financial dispostion of ZESCO, but the facts in this respect are not necessarily clear. Low-voltage distribution lines in Zambia are characterized by installation of large-capacity distribution transformers at the load center and extension of lines for long distances. This results in a load supply pattern marked by the typical low-load dispersion. Besides lowering the quality of the power supply due to the steep voltage drop, it is thought to be causing a lot of distribution loss. In addition, the use of cable that is of relatively small size for the load current is presumably another factor behind power loss.

Against this background, the Study Team advice the reduction of technical and non-technical loss as follows.

Outline of distribution loss and measures to reduce

(1) Classification of distribution lossDistribution loss may be classified as follows.

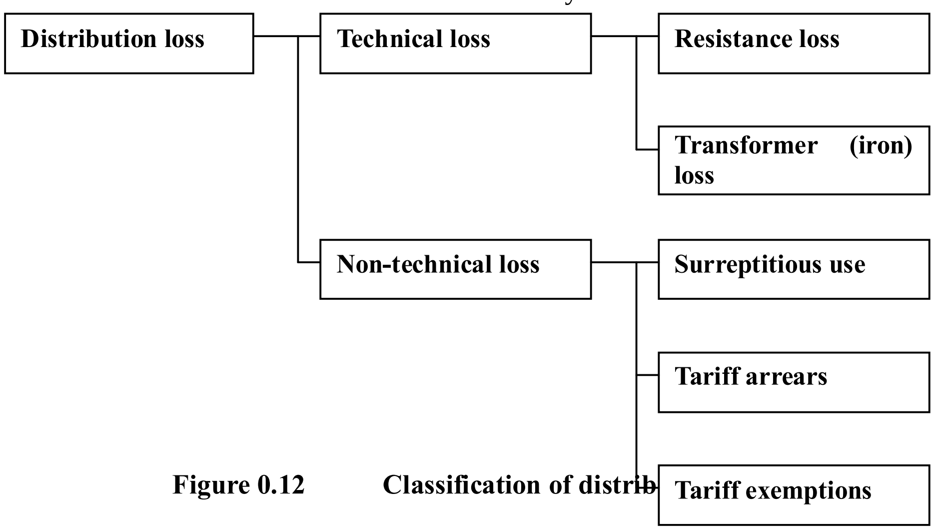


Figure 0.12 Classification of distrib

i) Technical loss

Resistance loss is caused by the electrical resistance of cable and varies in proportion with the square of current. In developing countries, it is thought to be on a generally high level. This is because, even if the demand increases, there is a tendency to refrain from increasing the capacity of transmission and distribution lines, and consequently to supply power in an overload status as well as to unreasonably extend distribution lines in order to curtail costs.

Transformer (iron) loss arises due to the iron cores of transformers. It varies in proportion with the transformer capacity, but is unrelated to the size of load. Even though they have the same capacity, transformers built in recent years have less iron loss than those built 30 or more years ago. There have also appeared low-loss models using an amorphous type of iron core.

ii) Non-technical loss

While the definition of non-technical loss varies with the country, the three basic types are surreptitious use, tariff arrears, and tariff exemptions. The term "surreptitious use" (power theft) refers to illegal use of power by a customer by means of supply that is not routed through the meter. As a result, this use is not included in the amount of power sales measured by the meter. There are two kinds of tariff arrears (non-collection): 1) that from cases in which the power utility cannot collect charges for the amount of power use measured by the meter (i.e., non-payment) and 2) that caused by mistaken measurement by defective meters. The term "tariff exemptions" refers to the practice of supplying power free of charge to governmental agencies as well as for street lights and other public facilities. In some countries, it is not counted as loss. As viewed from the standpoint of power utilities, however, it is equivalent to loss, because they cannot collect tariff charges, as in the case of other types. In some countries, it is even a factor putting a significant strain on utility management.

(2) Measures to reduce transmission and distribution loss

i) Technical loss

Table 0.17 outlines specific measures to reduce technical loss in distribution systems. Distribution loss requires an area-wise implementation of these measures, which can have an enormous effect for reducing loss. Considering the cost-benefit factor, it would therefore be uneconomical to undertake construction aimed solely at loss reduction; it is the normal practice to execute the measures along with other construction. For this reason, it would be more realistic to view measures for reduction of technical loss with a timeframe of about 10 years as opposed to the shorter term. Table 0.18 presents the findings of analysis and examination in this development study for distribution loss in Zambia. Due to the efficient distribution lines and substations expansion, the loss ratio was decreased.

Table 0.17 Classification of distribution loss

Classification		Causes	Problem points
Resistance loss	33- and 11 kV distribution lines	Low demand density	In rural areas, a low-capacity load is scattered over a wide area, and 33 kV distribution lines are extended for long distances (over 100 km) from BSPs. This invites an increase in resistance loss.
		Improper voltage	Distribution lines that ought to have a voltage of 33 kV considering the line span and amperage still have one of 11 kV, and measures have not been taken to increase it.
		Improper conductor size	Thin cables with a sectional area of 25- or 50-mm2 are used for the trunk parts of distribution lines. This is presumably causing a fair amount of resistance loss on trunk lines (in parts where the current is concentrated).
		Triphase imbalance	Considering the send-out current at primary substations, there are thought to be not a few feeders with a triphase imbalance rate of no more than 80 percent. It is estimated that current imbalance is increasing resistance loss.
	Low-voltage distribution lines	Long-distance, low-voltage systems	Even in villages with a fairly large number of customers, in some cases there is only one distribution-use substation (secondary transformer), to which are connected only low-voltage lines that extend for distances ranging from a few hundred meters to one kilometer. This is thought to be causing a lot of resistance loss.
Transformer (iron) loss	Transformers (secondary)	Large-capacity transformers	In areas electrified under RE programs, there are apparently many cases of installation of transformers with an extremely high capacity as compared to the total demand, even in districts that have a small demand at present and no firm prospects for a major increase in the future. (For example, transformers with a capacity in the range of 100 - 200 kVA are installed for low-voltage systems whose load will probably not exceed 20 or 30 kVA even in the future.)

Table 0.18 Results of reducting system loss (example; Lusaka area)

	2008 (before expansion)			2020 (after expansion)			Differece 2020 - 2008		
	P *	Q *	S *	P	Q	S	P	Q	S
Load Demand P_L	344.9	167.3	383.4	631.4	305.8	701.6	+ 286.46	+ 138.55	+ 318.20
Power Transmission P_S **	352.4	204.2	407.3	644.2	372.4	744.1	+ 291.80	+ 168.20	+ 336.81
Power loss P_S-P_L	7.5	36.9	23.9	12.8	66.6	42.5			
Loss ratio 1-P_L/P_S	2.11%	18.09%	5.88%	1.99%	17.88%	5.72%	-0.13%	-0.21%	-0.16%
Loss reduction ratio of 2020ôs loss ratio to 2008ôs				-6.06%	-1.16%	-2.71%			

* P: Effective power, Q: Reactive power, S: Apparent power

** Sending power at BSPs

ii) Non-technical loss

Non-technical loss requires specification of causes to determine countermeasures. Surreptitious use can be prevented by switching from bare to covered cable for low-voltage lines to make theft more difficult. It also demands steps in the institutional/systemic aspect, such as a reinforcement of confirmation (detection) by utilities and tougher official penalties for theft. The prospective measures for tariff arrears are a correction of measurement by replacement of defective meters and tighter regulations for collection (e.g., suspension of transmission to customers in arrears). Some African countries are introducing prepaid meters to combat non-payment, and this could help to reduce non-technical loss. In any case, the question of whether or not such measures take immediate effect depends largely on the national circumstances.

(Reference) Area Development Plans

There are five area-development (i.e., Multi-Facility Economic Zone) plans in Zambia.

- Chambishi Multi-Facility Economic Zone (MFEZ)
- Lusaka South MFEZ
- Lusaka East MFEZ
- Lumwana MFEZ
- Ndola MFEZ（Sub Saharan Gemstone Exchange）

In the JICA program of technical cooperation, a master plan study was conducted for the Lusaka South MFEZ, which is the only one of these projects that is promoted by the Government of Zambia (GOZ). The remaining four projects are implemented by the private sector, but Lumwana and Ndola MFEZs are still in planning stage.

As used here, the term ñMFEZò indicates a geographical economic area approved by the Minister of Commerce, Trade and Industry and aimed at attracting siting by high-tech manufacturing industries, in order to develop countryôs economy and increase its foreign exchange earnings. In return for investment in MFEZ, investors are to receive preferential treatment in taxation, such as tax exemptions.

Chambishi MFEZ

The Chambishi project was initiated as a program of governmental economic and trade cooperation between Zambia and China, and was the first MFEZ to be approved.

It is located in the Chambishi Copper Mine zone, which is 70 km from Ndola, the countryôs second-largest city, and 28 km from Kitwe. China Nonferrous Metal Company (CNMC) is to develop the area in Chambishi Town, on the outskirts of Kitwe (see Figure 0.13). CNMC has pledged to invest US$800 million in the MFEZ and create jobs for 6,000 people.

This area already has copper mines and smelteries. The main objective of the project is to develop industries in copper and, in addition, non-ferrous product (e.g., bars, wires and cables) using copper and cobalt. Furthermore, the project expects to produce chemicals and precious metals using by-products from smelteries.

The Cooperation Zone covers a planning area of 11.58 km^2, and consists of the existing mining and metallurgical industrial zone of 3.6 km^2 and a new expansion area of 7.98 km^2 (see Figure 0.14).

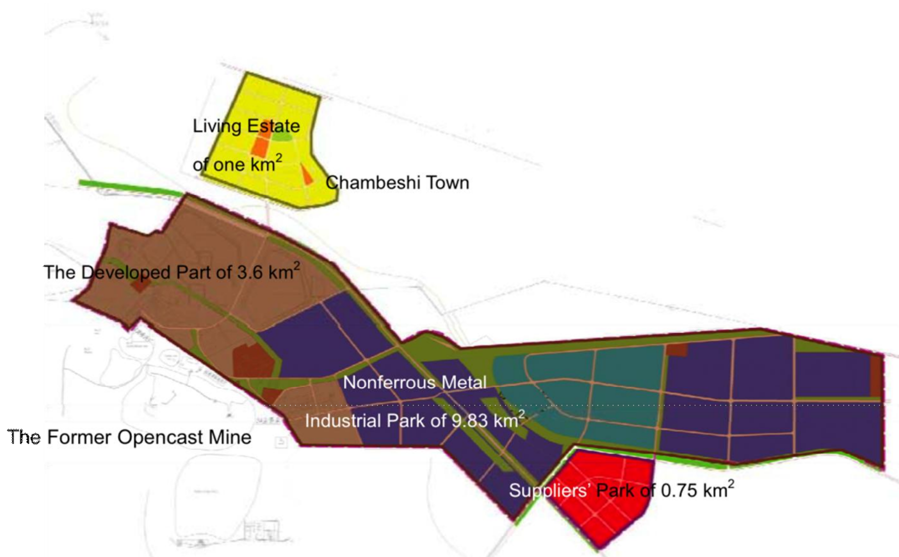
According to the plan, it will take five to eight years to attract siting by smelteries and related industries. Twelve companies have been nominated so far, five of them have already started construction. By the final stage of the project, 50 - 60 companies are expected to come.

Construction of sites by Chambishi Copper Smelter (including access road), Sino Metals Limited and Sino Acid Limited have already begun. A water-supply pipeline from Kafue

River to the MFEZ has already been installed, but the construction of power substation has just started.

(Source) China Nonferrous Metal Mining (Group) Co., Ltd., China Association of Development Zones, Master Plan for the Zambia-China Economic and Trade Cooperation Zone, June, 2007

Figure 0.13 Site of the Chambishi MFEZ



(Source) China Nonferrous Metal Mining (Group) Co., Ltd., China Association of Development Zones, Master Plan for the Zambia-China Economic and Trade Cooperation Zone, June 2007

Figure 0.14 Plot Plan of the Chambishi MFEZ

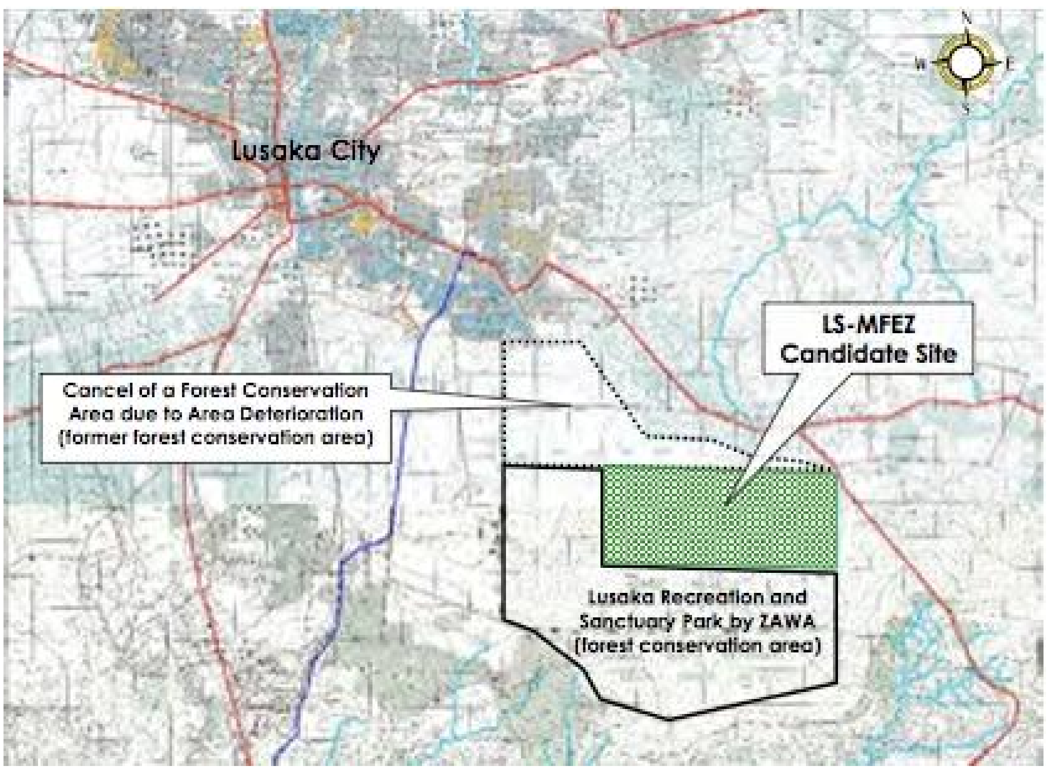
Lusaka South MFEZ (LS-MFEZ)

In the master plan, the development area will increase to 1,350ha (13.5km^2) by 2007 and 3,530ha (35.3 km^2) by 2030.

LS-MFEZ consists of seven zones, and five function modules, i.e., general industry, high-tech park, common service facility, central business district, and housing, are to be allocated.

Construction was started in July 2009, and infrastructural preparation is the first task. The power demand is expected to emerge in the forth quarter of 2010. The GOZ has already allocated 30 million kwacha to construct the access road.

However, it has not yet clarified what kind of industrial siting is targeted. In the Lusaka area, there is another economic cooperation project plan with China, i.e., Lusaka East MFEZ. The GOZ made a comment that it wanted to attract siting by industries of types different from those targeted in other projects.



(Source) JICA 2003

Figure 0.15 Site of LS MFEZ

Lusaka East MFEZ

As a sub-zone of the Zambia-China Economic Zone, which is developed to economic and trade cooperation between Zambia and China, plans call for development of the area near the

Lusaka International Airport, in the southern part of Lusaka. The Government of China has already allocated 120 million US dollar for the project.

It was announced that the project would soon be launched, but the construction work has not yet started.

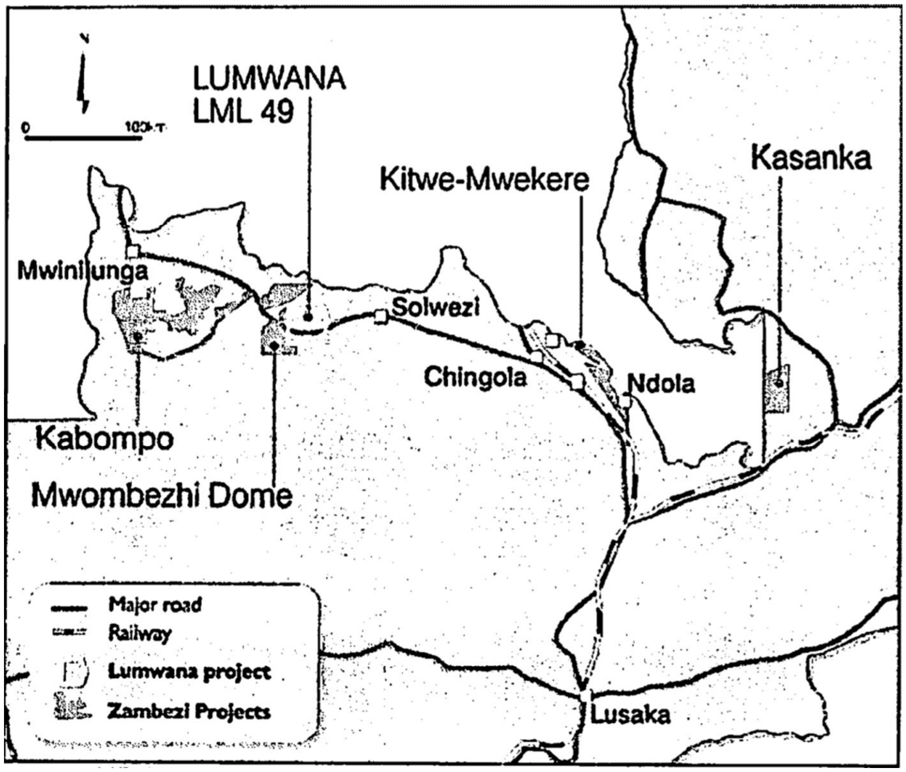
Lumwana MFEZ

Lumuwana Minig Company Limited, which is a subsidiary of Equinox Metals Limited (LMC) listed on the stock market in Canada and Australia, is to develop the Lumwana MFEZ in North West Province. It plans to invite participation by manufacturing industries based on a new mining project (i.e., Lumwana Copper Project), but the master plan has not yet been completed (see Figure 0.16).

The site area already contains open pit mining and related facilities and roads. It is equipped with systems for supply of water, including a reservoir with a capacity of 84 million m^3, and electrical power. In addtion, a high-voltage transmission line has been constructed between Solwezi and Lumwama. North-western Company, which was established as a regional power company, built a 7km line from ZESCOȇs 330/33 kV substation to Lumwan and a 33/11 kV substation in the town. LMCȇs consumption amounts to 50% of the line capacity.

The idea behind the MFEZ is to create a new manufacturing industry, which will surpass the existing Lumwana Copper Project. As an area development supporting the regionȇs economic development, the MFEZ encompasses of industrial, recreational, residential, commercial, agricultural, and fishery development zones. The phases of the development are as follows:

Phase 1 (2006-2009):	Development of open-pit mining and preparation of related infrastructure
Phase 2 (2010-2013):	Development of Lumwana Town, and education, commercial and medical facilities
Phase 3 (2014-2020):	Development and upgrading of road, railway and airport



Source: Lumwana Minig Company, Lumwana Mult-Facility Economic Zone Master Plan (2006-2020)

Figure 0.16 Access-road Network to Lumwana MFEZ

Ndola MFEZ (Sub-Saharan Gemstone Exchange)

Ndola MFEZ is a lapidary-based small-size industrial park planned in Cooperbelt. The aim of the project is to heighten the value-added level of the export of the locally mined gemstones by cutting and polishing them. This is the first Zambian-capital industrial park, and 20 companies are to be recruited. Five have already commenced operations and employ around 100 peoples.

Case Study

In this chapter, objectives that study team and counterpart accred in the site survey, Itezi tezhi project and Lusiwasi expansion one, were described in Japanese edition,which was informative for strangers to Zambia and should be included in the final report of JICA study. However, most of the information here has less importance to formulate the power system master plan. For this reason, the contents of this chapter were transferred to Appendix C by request from Zambian side.

Sections in this chapter show below for someone's reference.

Environmental and Social Consideration

Institutional Framework of Environmental and Social Considerations in Zambia

Laws and Regulations related to Environmental and Social Considerations

Legal and Policy Framework related to Environmental Conservation

In Zambia, the Environmental Protection and Pollution Control Act, 1990 (EPPCA) and the relevant regulations constitute the basic framework for environmental conservation. The Act establishes the Environmental Council of Zambia (ECZ) and determines its organizational structure and functions, provides regulatory framework for water and air pollution and waste management, and provides natural resource management system.

Acts and regulations to be taken into account in this Environmental and Social Considerations Study (ESC Study) are listed below.

- Environmental Protection and Pollution Control Act, 1990
- Environmental Protection and Pollution Control (Environmental Impact Assessment) Regulations, 1997
- Air Pollution Control (Licensing and Emissions Standards) Regulations, 1996
- Water Pollution Control (Effluent and Waste Water) Regulations, 1993
- Waste Management (Licensing of Transporters of Wastes and Waste Disposal Sites) Regulations, 1993
- Hazardous Waste Management Regulations, 2001
- Zambia Wildlife Act, 1998
- Forest Act, 1999, and Forest Act, 1973
- Natural Resource Conservation Act, 1970
- Land Act, 1995
- Electricity Act, 1995
- Land Acquisition Act, 1995
- Electricity Act, 1995
- Zambezi River Authority Act, 1987
- National Heritage Conservation Commission Act, 1989

Laws and Regulations regarding Environmental Impact Assessment

In Zambia, the Environmental Protection and Pollution Control (Environmental Impact Assessment) Regulations, 1997 stipulates the framework for Environmental Impact Assessment (EIA) including criteria for categorizing projects that require EIA, and the procedures of EIA. The Regulations require project proponents to produce either Project Brief (PB) or Environmental Impact Statement (EIS), depending on the significance of predicted impacts. PB or EIS is submitted to ECZ and assessed by ECZ. EIS is a report of EIA that is required when significant adverse impacts are predicted, while PB is a report of Initial Environmental

Examination (IEE) that is required when the potential adverse impacts are expected to remain low or medium. When significant impacts are identified as a result of the assessment of PB, ECZ may recommend a project proponent to elaborate EIS. Items to be clarified in EIS are presented below.

(c) a description of the project, reasonable alternatives, which may begin or increase operations to provide materials or services to the proposed project
(d) a description of the proposed site and reasons for rejecting alternative sites
(e) a brief description of the site and the surrounding environment including specifying any information necessary to identify and assess the environmental effects of the project
(f) a description of the raw material inputs into the project and their potential environmental effects
(g) a description of the technology and processes that shall be used
(h) a description of the products and by-products of the project
(i) the environmental effects of the project, and reasonable alternatives, including the direct, indirect cumulative, short-term and long-term effects
(j) the socio-economic impacts of the project such as resettlement of the affected people
(k) an impact management plan containing a description of measures proposed for preventing, minimising or compensating for any adverse impact, and enhancing beneficial effects, and measures to monitor effluent streams or important environmental features which may be affected by the project
(l) an indication of whether the environment of any neighbouring state is likely to be affected

Energy-sector-related projects that are required to produce PB or EIS are presented in the Table 0.1.

Table 0.1 Energy Sector Projects which Require PB or EIS

Projects which require PB	Projects which require EIS
- Hydropower schemes and electrification - Projects located in or near environmental sensitive areas	- Electricity generation station - Electrical transmission lines - 220kV and more than 1 km long - Surface roads for electrical and transmission lines for more than 1 km long - Dams and barrages: covering a total of 25 ha or more - All major roads outside urban areas, the construction of new roads and major improvements over 10 km in length or over 1 km in length if the road passes through a National Park, Game Management Area - Clearance of forestry in sensitive areas such as watershed areas or for industrial use 50 ha or more

(Source) Schedule 1 and 2 of Environmental Impact Assessment Regulations

Environmental Impact Assessment Regulations are basically applied to individual projects, and thus, a Master Plan is out of the scope of the regulations. EPPCA stipulates that ECZ ñmay identify é plans and policies for which environmental impact assessment are necessary and undertake or request others to undertake such assessments for considerationò. However, the detailed procedures for the assessment of such plans and policies are not established at present.

Environmental / emission standards

a) Emission standards for air pollutants

Table 0.2 indicates the emission standards for air pollutants related to power generation, which are specified by the Air Pollution Control (Licensing and Emission Standards) Regulations, 1996.

Table 0.2 Emission Standards related to Burning Facilities

Facility type	Parameter	Emission limits
Oil fired < 50MW	Dust	50 - 150 mg/Nm^3
	SO_2	850 mg/Nm^3
	CO	100 mg/Nm^3
Coal fired, <10 MW	Dust	150 mg/Nm^3
	SO_2	2000 mg/Nm^3
Coal Fired, 10<50 MW	Dust	50 mg/Nm^3
	SO_2	1000 mg/Nm^3
	CO	175 mg/Nm^3

(Source) Third Schedule of the Air Pollution Control (Licensing and Emission Standards) Regulations, 1996

b) Emission standards for effluent and waste water

Standards for effluent and waste water related to power generation, which are provided by the Water Pollution Control (Effluent and Waste Water) Regulations, 1993 are indicated in Table 0.3. In particular, coolant water from thermal power plants should be given due considerations.

Table 0.3 Relevant Standards for Effluent and Waste Water into Aquatic Environment

Parameters	**Emission Standards**
A. Physical	
Temperature (Thermometer)	40 degrees Celsius at point of entry
Colour (Hazen Units)	20 Hazen units
Odour and Taste (Threshold odour number)	Must not cause any deterioration in taste or odour as compared with natural state
Turbidity (NTU scale)	15 Nephelometer turbidity units
Total suspended solids (Gravimetric method)	100 mg/L must not cause formation of sludge or scum in receiving water
B. Bacteriological	
Algae /100 ml (Colony counter)	1000 cells
C. Chemical	
pH (0-14 scale) (Electro-metric method)	6.0 - 9.0
Chemical Oxygen Demand (COD) (Dichromat method)	COD based on the limiting values for organic carbon 90 mg O_2/L average for 24 hours
Biochemical Oxygen Demand (BOD) (Modified Winkler method and Membrane Electrode method)	50 mg O_2/L (mean value over 24 hours period) According to circumstances in relation to the self cleaning capacity of waters

(Source) Extracted from 3rd Schedule of the Water Pollution Control (Effluent and Waste Water) Regulations, 1993

c) Noise

Environmental standards for noise are not yet established in Zambia, thus, ECZ refers to international standards when it evaluates an Environmental Impact Statement. The Environmental Quality Standards for Noise in Japan are presented in Table 0.4 as reference. Category C may be appropriate for noise associated with the operation of thermal power plants.

Table 0.4 Environmental Quality Standards for Noise in Japan

Type of Area	Standard Value	
	Daytime	Nighttime
AA	50 dB or less	40 dB or less
A and B	55 dB or less	45 dB or less
C	60 dB or less	50 dB or less

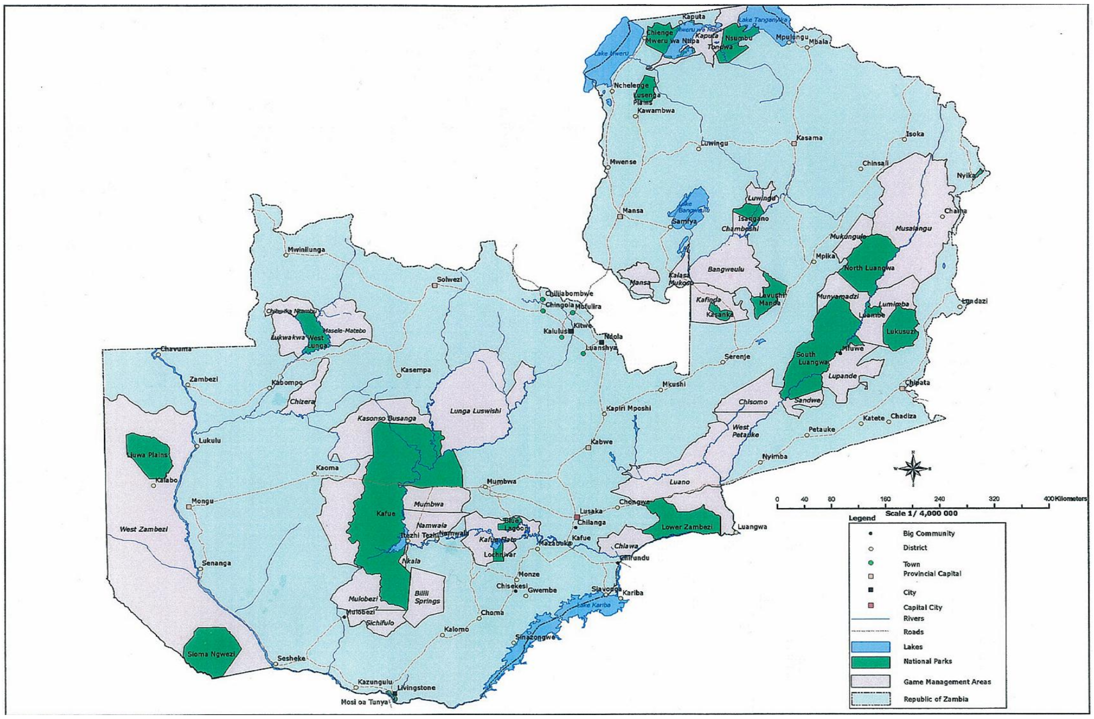
Notes:

1) In terms of the time category, daytime shall be the period from 6:00 a.m. to 10:00 p.m. and nighttime shall be the period from 10:00 p.m. to 6:00 a.m. of the following day.
2) Area category AA shall be applied to areas where quietness is specially required, such as those where convalescent facilities and welfare institutions are concentrated.
3) Area category A shall be applied to areas used exclusively for residences.
4) Area category B shall be applied to areas used mainly for residences.
5) Area category C shall be applied to areas used for commerce and industry as well as for a significant number of residences.

Legal framework for protected areas

The Zambia Wildlife Act, 1998 provides a legal framework for protected areas, such as National Parks and Game Management Areas. The Act stipulates the establishment of Zambia Wildlife Authority (ZAWA), regulations on National Parks and Game Management Areas, protection of wildlife and license for wildlife hunting, permission of sales, import and export of wildlife, and penalties and enforcement provisions. In National Parks and other protected areas, for instance, habitation, hunting of wildlife, and killing and wounding wildlife are prohibited.

There are 19 National Parks, which covers 63,820 km^2 or accounts for 8.5% of Zambia's land surface. In addition to the National Parks, 35 Game Management Areas are designated and they account for 22 % of the land surface of Zambia. Three (3) Wildlife Sanctuaries are also designated to protect wildlife. Figure 0.1 demonstrates the distribution of the protected areas.



(Source) Zambia Wildlife Authority

Figure 0.1 Distribution of the Protected Areas of Zambia

Zambia became a contracting party of the Ramsar Convention[25] in December 1991. There are eight (8) wetlands registered under the Ramsar Convention, covering 4,030,500 ha, as indicated in Table 0.5. Electronic maps showing the distribution of these wetlands were not available.

Table 0.5 List of Ramsar Sites in Zambia

Wetland	Area (ha)	Location	Description
Bangweulu Swamps	1,100,000	About 100 km east of Mansa, Northern Province	Bangweulu Swamps provides a breeding ground for birds, fish and wildlife (e.g., the African Elephant *Loxodonta africaca*, the buffalo *Syncerus caffer*, and Sitatunga *Tragelaphus spekei*, and Black Lechwe *Kobus leche*). It is home to the threatened Wattled Crane (*Grus carunculatus*), and the threatened Shoebill (*Balaeniceps rex*). The swamp is a natural flood controller and important for groundwater recharge.
Busanga Swamps	200,000	About 60 km south of Kasempa, Northwestern Province	A wide variety of ecosystem types such as swamps, lagoons, woodlands, rivers and large grassy plains are found. It hosts the vulnerable Wattled crane (*Grus carunculatus*), Cheetah (*Acinonyx jubatus*), and Lion (*Panthera leo*), and supports significant numbers of migratory birds and other fauna such as the Blue Duiker (*Cephalophus silvicultor*), Wildbeest (*Connochaetes gnou*) and Zebra (*Equus burchelli*).
Kafue Flats	600,500	About 60 km southwest of	A vast expanse of floodplains, grasslands, woodland zones and geothermal areas of high biodiversity in a complex patter of lagoons,

[25] The Convention on Wetlands of International Importance especially as Waterfowl Habitat

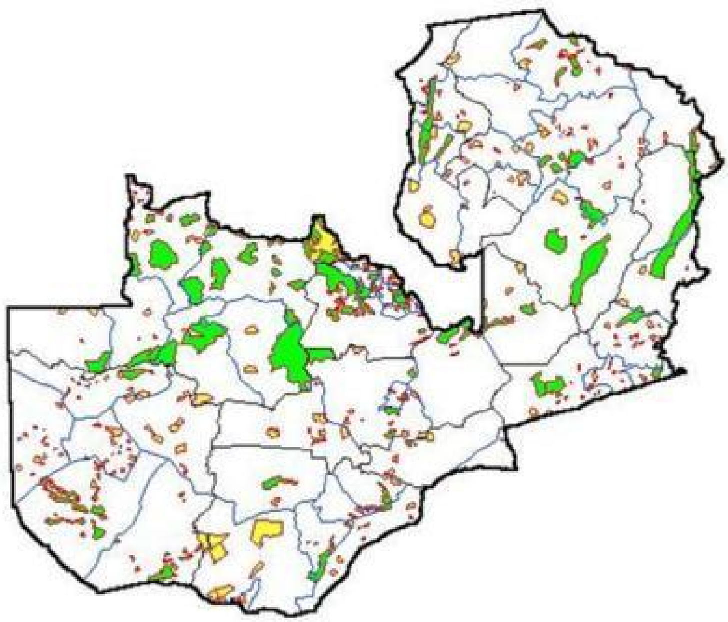
Wetland	Area (ha)	Location	Description
		Lusaka, and about 50 km south of Mumbwa, Southern & Central Provinces	oxbow lakes, and river channels. The site supports many endangered and endemic species such as the endemic Kafue lechwe (*Kobus leche kafuensis*), and Wattled crane (*Grus carunculatus*). It hosts migratory birds such as the White pelican (*Pelecanus onocrolatus*) and the Cattle Egret (*Bubulcus ibis*), as well as 67 fish species. The site provides clean and plentiful water and acting as a natural sink for nutrients and other micro-elements
Luangwa Flood Plains	250,000	About 100 km Northwest of Chipata, and about 90 km of southeast of Mpika, Eastern Province	Representative of the major wetland types of Southern Africa, the site is dominated by rivers that recharge many springs, freshwater lakes, lagoons, marshes and streams. The main habitats include evergreen miombo woodlands (with wild mango, African ebony, fig, and Natal mahogany) and the alluvial zone which sustains riverine vegetation. The plains host over 50 mammal species, including the African wild dog (*Lycaon pictus*) and the critically endangered Black Rhino (*Diceros bicornis*). It is an important breeding ground for birds like *Merops nubicoides, Merops bullockoides*, and *Hirundo paludicola*.
Lukanga Swamps	260,000	About 45 km West of Kabwe, Central Province	The largest permanent water body in the Kafue basin, comprising generally shallow swamps. They are a suitable habitat for birds and wildlife, hosting a number of threatened species such as the Wattled Crane, the Red Lechwe, African python, and the sitatunga. The area is also an important breeding ground for fish, the most abundant of which is Tilapia, with *T. rendalli* and *T. sparmani*.
Mweru wa Ntipa	490,000	About 70 km Northwest of Mporokosa, Northern Province	The main features are rivers, swamps, and the Lake Mweru wa Ntipa basin, which is surrounded by flat wetland plains with itigi thickets and miombo woodlands. Evergreen forests on the river and lake shores are a home to more than 390 bird species such as the Wattled crane, Shoebill, Black stork, and Goliath's Heron. Other species found here include the slender-snouted crocodile (*Crocodylus cataphractus*), wild dog (*Lycaon pictus*) and Elephant (*Loxodonta Africana*). The Mweru wa Ntipa lake records a number of indigenous fish species like the Green-Headed Bream (*Oreochromis macrochir*), Sharp Toothed Barbel (*Clarias mossambicus*), Cat Fish (*Auchenoglanis occidentalis*), and Mweru sardine (*Poecilothrissa moeruensis*).
Tanganyika	230,000	North of Mpulungu, Northern Province	Includes the Zambian part of Lake Tanganyika. The Zambian shoreline (about 238km) is steep and rocky, with some areas of shallow swampy land and limited stretches of sandy beaches. The site has a rich diversity of vegetation and hosts the African elephant, lion, and wild dog. It also hosts endemic reptiles like the Lake Tanganyika Water Snake (*Lycodonomorphus bicolor*) and Water Cobra (*Boulengerina annulata*). The Zambian part of the lake hosts over 252 fish species, 82 of which are endemic (e.g., *Neolamprologus brichardi* and *Altolamprologus compressicep*).
Zambezi Floodplains	900,000	West of Mongu, Western Province	The second largest wetland in Zambia, chiefly riverine wetland consisting of the Zambezi River and its naturally formed floodplains. There is sparse riparian vegetation, small stands of *Acacia albida* in the floodplains, *Syzygium guineens* along the main river channel and patches of *Diplorhynchus* scrub and *Borassus* forest in the northern areas. Semi-evergreen woodlands have economically important species like *Baikiaea plurijuga* and *Pterocarpus angolensis*. The site hosts the Lion (*Panthera leo*), several endemic reptiles, the Blue Wildebeest (*Connochaetes taurinus*), and many water birds. It is an important spawning ground for about 80 different fish species.

(Source) Website of the Ramsar Convention <http://www.ramsar.org/index.html#top>

Forest

Forests in Zambia are managed by the Forest Act. Although the Forest Act 1999 was already approved by the Parliament, the Act 1999 is not yet in force since relevant regulations and guidelines are still in preparation. The Act 1973 is currently used for the forest administration. The Act 1973 consists of several provisions such as the establishment of the National and Local Forests, regulations in the National and Local Forests, licenses for tree-cutting, management of forest produces, and relevant regulations.

There are two categories of forests, namely the National Forest and the Local Forest. One hundred eighty (180) National Forests are currently designated covering 5,145,162 hectares or 6.8 % of the total land surface, and there are 307 Local Forests covering 2,076,062 hectares or 2.8 %.



[Legend] : National Forest : Local Forest

(Source) Forestry Department

Figure 0.2 Distribution of Forest Reserves in Zambia

Legal framework for land tenure

Land in Zambia can largely fall into state land or customary land. The customary land constitutes more than 90 % of the total land of Zambia. The rights over the customary land are governed by the respective customary laws that can vary from region to region. The rights over the customary land are protected by the Land Act. It is, therefore, important to pay due attention to the customary laws governing a region where land acquisition for an undertaking will take place.

In terms of electricity projects, it is necessary to follow the provisions of the Electricity Act as well as those of the Land Acquisition Act. The Land Acquisition Act stipulates the procedures for land acquisition in general, including preliminary investigation, notice of intention to acquire property, principles for assessment of compensation, establishment of the Compensation Advisory Board. The Electricity Act provides the land acquisition procedures of electricity-related project. In particular, the Act stipulates detailed provisions for transmission projects, including compensation for land and properties beneath transmission lines, right of entry into land beneath the lines, and removal of trees and buildings interfering with transmission lines.

Legal and Policy Framework regarding Cultural Heritages

The National Heritage Conservation Commission Act provides the functions of National Heritage Conservation Commission (NHCC), and its organizational structure. In addition, the Act stipulates the declaration of national monuments, prohibition of alterations, removal and destruction, and protection measures for discovered ancient heritages and relics. The national heritages include both cultural and natural heritages, and they are officially designated by the recommendation of NHCC.

International Council on Monuments and Sites (ICOMOS), an international NGO engaging in the protection of cultural heritages, reported in 2001 that NHCC listed about 3,000 heritage sites such as archaeological and anthropological sites, historic and architectural buildings, engineering industrial structures, geomorphological, geophysical and ecology sites.

Zambia ratified the Convention concerning the Protection of the World Cultural and Natural Heritage in June 1984. ñMosi-oa-Tunya / Victoria Fallsò is currently registered under the Convention, and four (4) properties are included in the tentative list (Table 0.6).

Table 0.6 List of World Heritages of Zambia

Property Name	Status	Adjacent District, city
Mosi-oa-Tunya / Victoria Falls	Inscribed	In the vicinity of Livingstone, Southern Province
Mwela and adjacent areas rock art site (rock paintings)	Tentative List	7 km east of Kasama, Northern Province
Dag Hammarskjoeld Memorial (crash site)	Tentative List	10 km south-west of Ndola, Copperbelt Province
Kalambo falls archaeological site (prehistoric settlement site)	Tentative List	30 km north-west of Mbala, Northern Province
The Barotse Cultural Landscape and Kuomboka Ceremony	Tentative List	In the vicinity of Mongu, Western Province

(Source) UNESCO World Heritage Website <http://whc.unesco.org/>

Overview of Relevant Organizations

Environmental Council of Zambia (ECZ)

ECZ was established based on the Environmental Protection and Pollution Control Act, 1990. The major functions of ECZ are the following:

- Identify projects or types of projects, plans and policies for which environmental impact assessment are necessary and undertake or request others to undertake such assessments for consideration by ECZ;
- Advise the Government on the formulation of policies relating to sustainable management of natural resources and environment;
- Conduct studies and make recommendations on standards relating to the improvement

of the environment and the maintenance of a sound ecological system; and

- Consider and advise on all major development projects at an initial state and for that purpose ECZ may request information on the major development projects.

The Environmental Protection and Pollution Control Act, 1990 stipulates the organizational structure of ECZ and the council members. The Council consists of relevant ministries and government agencies, university researchers, representatives of the industrial sector and NGOs, and the chairman of the Council, who is appointed by the Minister, is responsible for the management of the Council. ECZ has four sections dealing with practical affairs, i.e., Pollution Control Inspectorate, Planning Environmental and Management, Human Resources, and Accounts and Finance. In addition, there are three regional offices at Ndola, Livingstone, and Chirundu Border.

ZESCO

ZESCO has its own environmental policy (ZESCO Environmental Policy) comprising of the following five statements.

- ZESCOôs ambition is to satisfy customersô 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 endeavor to create and enjoy the confidence of our customers and other stakeholders in our actions and operations.

ZESCO established the Environmental and Social Affairs Unit (ESU) under the Engineering Development Directorate in 1996, aiming at effectively handling environmental and socio-economic issues related to the operations of ZESCO. ESU consists of fifteen (15) staff members, including the Manager, Environmental Information Specialist, Social Scientist, Environmental Scientist, Soil Scientist, Ecologist, Hydrologist and other technological and assistant staff. Thirteen (13) staff members are assigned as of February 2009. The main functions of ESU are described below.

- Ensuring that ZESCO operates in accordance with Zambian environmental regulations
- Developing environmental guidelines and environmental operational plans for ZESCO on various aspects
- Advising engineering and other ZESCO staff on environmental and social issues
- Training ZESCO staff in environmental and social issues
- Developing baseline environmental and socio-economic database for catchment areas where ZESCO operates

- Conducting environmental impact assessments for ZESCO projects to identify the impacts, recommend mitigation measures and monitoring implementation of recommended mitigation measures
- Supervising consultants hired to do environmental work for ZESCO projects pertaining to power generation, transmission and distribution
- Managing land acquisition, resettlement programmes and compensation related to implementation of ZESCO projects
- Conducting public meetings in project areas to ensure that the public understands the project being undertaken by ZESCO and to get their input on various aspects of the project.

Zambia Wildlife Authority (ZAWA)

ZAWA was established by the Zambia Wildlife Act No.12 of 1998. ZAWA is responsible for controlling, managing and protecting protected areas, National Parks, Game Management Areas and Wildlife Sanctuary, designated based on the Act. It is also in charge of issuing all licenses and permits regarding the capture, hunting, import and export of wildlife. ZAWA consists of five major departments: Finance and Administration; Commercial; Operations; Research and Planning; and Game Management Areas.

Principles and Methodology for Environmental and Social Considerations

Basic Principles

This study formulates a master plan for power development extending to the year 2030. Although the formulation of the master plan does not directly cause any adverse environmental and social impacts, sub-projects included in the plan will cause such impacts. This study, therefore, conducted environmental and social consideration (ESC) study in accordance with the JICA Guidelines for Environmental and Social Considerations.

The objectives of ESC study at the master plan stage are to identify potential impacts at an earlier stage, and to mitigate or avoid serious adverse impacts by taking necessary measures against the impacts when determining detailed locations and specifications of facilities. Identifying environmental and social impacts prior to the determination of the details of sub-projects will make it possible to take appropriate measures at an earlier stage. In addition, clarifying points to consider at the master plan stage will contribute to the smooth implementation of EIA at the subsequent stages, i.e. a feasibility study (F/S) stage or a detailed design study (D/D) stage.

This ESC Study, based on the above views, conducts an Initial Environmental Examination (IEE) on environmental and social impacts anticipated at the master plan stage. It is at the F/S or D/D stage that environmental and social impacts can be appropriately assessed taking into account the site-specific conditions and detailed specifications.

The study pays due attentions to the following points.

1) Implementation of the ESC study incorporating the perspective of Strategic

Environmental Assessment (SEA)

This ESC study identifies points to be noted prior to the determination of detailed locations and sub-project components by predicting potential environmental and social impacts and considering necessary measures. The result of the ESC study is incorporated into the master plan.

2) Clarification of points to consider at the F/S stage

This ESC study clarifies points to consider and necessary procedure in an environmental and social assessment at the F/S stage. It is also expected to be utilized as a preliminary assessment in the F/S.

Methodology for Environmental and Social Considerations Study

This ESC study carries out the IEE on impacts predicted at the master plan stage. Potential impacts and necessary mitigation measures were examined based on literature reviews, surveys on sampled power facilities, and interviews to stakeholders. The sample facilities are presented in Table 0.7.

Table 0.7 List of Sampled Power Facilities

Facility Type	Location/ Name
Hydropower Plant	- Kafue, Lusaka Province: Kafue Gorge - Kariba, Southern Province: Kariba North - Livingstone, Southern Province: Victoria Falls - Central Province: Lusiwasi
Substation	- Chongwe, Lusaka Province: Leopards Hill - Mazabuka, Southern Province: Mazabuka - Choma, Southern Province: Choma
Transmission	- Transmission lines around Lusaka - Transmission lines around Kafue - Transmission lines around Kariba

(Source) JICA Study Team

The Study Team, in collaboration with officials of DOE and ZESCO, conducts the scoping of potential environmental and social impacts of sub-projects, and elaborates mitigation measures. The scoping result was then consulted with ECZ and other related institutions, and finalized.

Environmental and Social Impacts

Components of Master Plan

This study aims at formulating the master plan extending to the year 2030, which covers the following three (3) components.

1) A plan for optimal generation

An optimal generation plan for hydropower development and coal-fired thermal power development

2) A plan for the transmission and distribution system

   An optimal transmission and distribution plan with the view of the conformity with the optimal generation plan and consideration for voltage grades

3) A plan for international power interchange

   An international power interchange plan based on the rough calculation of power export and import, and verification of the interconnection capacity

In terms of the plan for power development, seventeen (17) hydropower projects were identified in the Study as presented in Table 6.31. Of these, Ten (10) projects are shortlisted since their feasibilities are considered higher.

Examination of Alternatives

Possible alternatives to be examined in this ESC study are the following.

1) Comparison of power development scenario
2) Site selection for hydropower development
3) Zero-option scenario

The basic stance on the examination of the above three (3) alternatives in this ESC study is presented below.

1) Comparison of power development scenario

   The master plan study proposes two scenarios, 1) a base case or Scenario 1-1; and 2) a scenario to encourage private investment in coal thermal power plants or Scenario 1-2. Sub-projects included in the respective scenarios are described in Chapter 8. The main differences between the two are the following: 1) Scenario 1-1 includes only one coal thermal power plant, i.e., the Maamba power plant, while Scenario 1-2 proposes additional three coal thermal plants; and 2) Scenario 1-2 does not refer to two hydropower plants included in Scenario 1-1, i.e., the Batoka Gorge and Mambilima Falls I, though the scenario includes a total of four coal thermal power plants. In terms of the three coal thermal plants proposed in Scenario 1-2, the detailed locations are not yet determined.

   Table 0.8 compares major potential impacts of the two scenarios.

Table 0.8 Comparison of Power Development Scenarios: Environmental and Social Impacts

Impacts	Scenario 1-1	Scenario 1-2
Involuntary Resettlement	Significant (Creation of a Reservoir)	Minor
Local Economy and Land Use	Significant (Creation of a Reservoir)	Minor
Infectious Diseases (HIV/AIDS)	be in the same range	be in the same range
Hydrology	Significant (Creation of a Reservoir, Water Intake from Rivers)	Minor
Biodiversity	Significant (Creation of a Reservoir)	Minor
Air Pollution	Minor	Significant (SO_2, NO_2, SPM, etc.)
Soil Contamination	Minor	Significant (Fly Ash, Coal Ash)
Waste	Minor	Significant (Fly Ash, Coal Ash)

Note 1: "Significant" and "Minor" indicates relative significance between the two scenarios.
Note 2: Items in brackets are main cause of adverse impacts
(Source) JICA Study

Comparison of Scenario 1-1 and 1-2 demonstrates that Scenario 1-1 involves impacts whose extent depends largely on the location of a project site, while Scenario 1-2 involves impacts related to pollution. The former includes involuntary resettlement and biodiversity, and the latter includes air pollution and wastes.

2) Site selection for hydropower development

The main component of the master plan is hydropower development. Hydropower development projects, in general, involve impacts whose extent greatly varies according to their location such as impacts on ecosystem and involuntary resettlement. Such impacts may cause significant adverse and irreversible impacts, and thus it is critical to consider alternatives when selecting the sites.

This master plan study will roughly indicates locations of new hydropower development projects, though the locations will not be determined in detail. The details of many projects are not determined yet, but will be determined in or prior to the F/S stage. This study therefore tries to confirm the distribution of protected areas, densely populated areas and cultural heritages, adjacent to the project sites based on available map information and other sources. The study then clarifies points to consider when selecting respective project sites.

3) Zero-option scenario

A zero-option scenario means a case without the power system development master plan. In considering the zero-option scenario, the environmental and social impacts of the zero-option scenario are compared with those caused by sub-projects included in the master plan.

Even in the zero-option scenario, power system development is expected to be carried out to meet the increasing power demand. However, the development will not be conducted in a planned manner without the plan, and as a result, serious impacts on peoplesôlives and economic activities will be unavoidable such as frequent power cuts and increase in electricity tariff. In addition, it will become hard to achieve the national targets for poverty reduction, i.e., increasing the rural electrification rate from 2 percent to 50 percent, and the urban electrification rate from 48 percent to 90 percent by 2030.

The case where power development is conducted in a planned manner is deemed more desirable than the case where power development is unplanned in order to avoid or mitigate potential environmental and social impacts. This is because the former case will enable project proponents and other stakeholders to predict potential impacts, and to prepare and take necessary measures. The former therefore will cause less significant impacts than the latter.

Based on the above considerations, an alternative pursuing the zero-option scenario is not considered in this ESC study.

Scoping Result

Formulation of the master plan per se does not cause any environmental and social impacts. Sub-projects included in the master plan, however, are expected to cause certain adverse impacts. This ESC study therefore identifies potential adverse impacts in general, but it does not refer to detailed or site-specific impacts since the master plan does not determine the candidate sites or project components in detail. Impacts may vary from sub-project to sub-project, and thus, the sub-projects with more significant impacts are featured during the scoping of potential impacts. Points to consider in conducting the scoping at the F/S phase are also described. Table 0.9 demonstrates the scoping result of the sub-projects included in the master plan.

Table 0.9 Scoping table for potential impacts of sub-projects

Impacts	Hydro		Thermal		Transmis-sion	
	Construc-tion	Operation	Construc-tion	Operation	Construc-tion	Operation
Involuntary Resettlement	A	A	B	B	B	B
Impacts on Local Economy (employment and livelihood) and Land Use	A	A	B	B	B	B
Impacts on Local Social Institutions such as Decision-making Institutions	B	B	C	C	C	C
Impacts on the Livelihoods of Indigenous Peoples and Ethnic Minorities	C	C	C	C	C	C
Local Conflict of Interests and Inequality	C	C	C	C		
Water Usage and Water Rights	B	B		C		
Sanitation and Infectious Diseases such as HIV / AIDS	B	B	B	C	B	C
Cultural Heritage	C	C	C	C	C	C
Topography and Geological Features	C		C		C	
Soil Erosion	C	B	C	C	C	C
Local Hydrology and Groundwater	C	A		C		
Flora and Fauna, and Biodiversity	A	A	C	C	B	C
Landscape	B	B	C	C	B	B
Global Warming				C		
Air Pollution				B		
Water Pollution	C	C		C		
Soil Contamination				C		
Waste	B	B	B	A	B	
Noise and Vibration	C		C	C	C	C
Ground Subsidence		C		C		
Offensive Odor						
Bottom Sediment		B		C		
Accident and Safety	B	C	B	C	B	C

[Legend] A: Significant impacts expected B: Certain impacts expected
C: Impacts unknown D: Negligible impacts

The current environmental and socio-economic conditions of Zambia and the detailed anticipated impacts are described in the following sections.

Involuntary Resettlement

[Hydropower] The master plan recommends the construction of hydropower stations. If villages are found in the vicinity of a proposed dam site, large-scale involuntary resettlement will take place. In terms of hydropower development projects, possibility to cause involuntary resettlement is considered high because many of them involve the construction of new dams except for projects using existing dams such as Kariba-North Extension and Itezhi-Tezhi. In particular, reservoir-type projects which require large reservoirs, such as the

Batoka Gorge and Mpata Gorge, will cause large-scale involuntary resettlement. On the other hand, run-off-river type projects, which require relatively small reservoirs, may cause certain impacts depending on the scale of planned facilities. The scale of involuntary resettlement will also vary depending on the distribution of villages. For instance, the Kafue Gorge Lower Project will not cause involuntary resettlement or will cause minor scale of involuntary resettlement since there are few villages in the sites to be submerged. Impacts of involuntary resettlement on local residentsôlivelihoods will continue after the operation of the facilities starts.

At the F/S phase of individual projects, it is necessary to conduct surveys on the distribution of villages around the proposed project sites and the areas to be submerged, and to identify the scale of the impacts.

[Thermal Power] A plan for the construction of a coal-fired thermal power plant in Maamba of Sinazongwe District is currently under consideration. Maamba Ward is a relatively large ward in the District with the population of approximately 10,000[26]. In addition to the Maamba project, three (3) coal thermal projects are proposed in Scenario 1-2. Sites around Kitwe and Kapiri Mposhi are tentatively proposed as the candidate sites for these projects. Although the possibility that the thermal power plant is constructed in the densely populated area is low, small-scale involuntary resettlement may be required if some households are found in the vicinity of the planned construction site. Impacts of involuntary resettlement on local residentsôlivelihoods will continue after the operation of the power stations starts.

[Transmission] The master plan will recommend the construction of transmission and sub-transmission lines. A way-leave size of a transmission line is 25m wide from the centre of the line on either side, and trees in this area will be regularly cut for maintenance. Although densely populated areas are in general to be avoided when determining the route of transmission and sub-transmission lines, small-scale involuntary resettlement may be required depending on the selected routes. Impacts of involuntary resettlement on local residentsôlivelihoods will continue after the completion of the civil works.

Impacts on Local Economy (employment and livelihood) and Land Use

[Hydropower] The construction of a hydropower station with a reservoir may cause changes in land use pattern due to the submersion of agricultural and forestry land, and other types of land. It may also cause the relocation of the whole of or part of villages, the acquisition of land, and the loss of livelihood means due to the submersion of land and buildings. Impacts on local residentsôlivelihoods will continue after the operation of the facilities starts.

[Thermal Power] The construction of thermal power stations may cause the relocation of households and commercial buildings, and the restriction of agricultural land use, and the acquisition of land. This may have certain adverse impacts on local economy. Impacts on local residentsôlivelihoods will continue after the operation of the power plants starts.

[26] Central Statistical Office. (2003) *Census of Population and Housing*

[Transmission] The construction of transmission and sub-transmission lines may cause land acquisition, the temporary restriction of land use, and the relocation or closing of stores. Entry into the land beneath transmission lines is restricted because the areas of either side of power lines are set as ñRight of Wayò for the purpose of maintenance and safety. Impacts on local residentsôlivelihoods will continue after the completion of civil works.

Impacts on Local Social Institutions such as Decision-making Institutions

[Hydropower] If the whole or considerable part of villages is submerged as a result of the construction of hydropower stations, some impacts such as loss or malfunction of local institutions may be predicted. Reservoirs to be constructed may cause separation in local society due to the creation of barriers for passage.

[Thermal Power] It is prohibited for local residents to enter into the site of power stations, thus social separation might be caused due to the passage obstruction depending on the layouts of power stations. Occurrence/ nonoccurrence of such impacts is unclear at present since it relies heavily on the contents of individual project plans.

[Transmission] Passage under transmission / sub-transmission lines may be restricted due to the Right of Way for maintenance and safety, thus social separation might be caused depending on the routes of the lines. Occurrence/ nonoccurrence of such impacts is unclear at present since it relies heavily on the contents of individual project plans.

At the F/S phase of individual projects, it is necessary to consult with chiefs and local residents around proposed project sites to identify social institutions to be given due considerations, and impacts to be caused by the proposed projects.

Impacts on the Livelihoods of Indigenous Peoples and Ethnic Minorities

[Hydropower, Thermal, Transmission] Designated habitats for indigenous peoples and ethnic minorities were not identified in this master plan study. However, if such habitats are found in the vicinity of generation facilities, reservoirs and the routes of transmission lines to be constructed, certain impacts may be predicted such as the relocation of houses and the loss of livelihood means. Existence/ nonexistence of habitats of indigenous peoples and ethnic minorities should be investigated at the F/S phase.

Local Conflict of Interests and Inequality

[Hydropower] In terms of damages such as the submersion or relocation of houses and other adverse impacts, the specific groups of local residents may suffer more than others depending on the location of reservoirs and facilities. This may cause a sense of inequality among the local residents.

[Thermal Power] Misdistribution and inequality such as concentration of pollution on a particular area may take place depending on the location or specification of planned power stations.

Occurrence/ nonoccurrence of the above impacts is unclear at present since it relies heavily on the contents of individual project plans. At the F/S phase of individual projects, it is necessary to pay due attention to whether proposed projects cause local conflicts of interests and inequality.

Water Usage and Water Rights

[Hydropower] Water resources of rivers to be developed for hydropower generation are already developed for other uses than power generation, such as irrigation. Water intake for power generation may cause conflicts with water intake for irrigation and other usage. In particular, international river basins such as the Zambezi basin require due coordination, otherwise conflicts over water may take place.

[Thermal Power] Thermal power stations require the considerable amount of coolant water, and thus the intake of the coolant water may affect local water usage and water rights. It is therefore necessary to confirm the required amount of coolant water, and to conduct surveys on local water usage and water rights related to water bodies where coolant water is taken.

Sanitation and Infectious Diseases such as HIV/ AIDS

HIV-infection rate in Zambia is estimated 15.2 % of the adult population according to the report of UNAIDS[27].

[Hydropower] HIV/ AIDS could spread as a result of the long-term inflow of construction workers into construction sites. Risk of malaria, chistosomiasis and other water-borne diseases may increase as a result of the creation of reservoirs. If a project causes large scale involuntary resettlement, problems of sanitation and infectious disease may be caused in relocation destinations.

[Thermal Power] The risk of HIV/ AIDS spread may increase due to the inflow of construction workers into construction sites. Problems of sanitation and infectious diseases might be caused in relocation destinations since involuntary resettlement may take place even though the resettlement will be small scale. Occurrence/nonoccurrence of such impacts in relocation destinations is unclear at present.

[Transmission] The construction of transmission/ sub-transmission lines will not require large-scale civil engineering works compared with power generation development, and the number of construction workers will smaller in many cases, but the possibility of HIV/ AIDS spread is undeniable. Problems of sanitation and infectious diseases might be caused in relocation destinations since involuntary resettlement may take place even though the resettlement will be small scale. Occurrence/nonoccurrence of such impacts in relocation destinations is unclear at present.

Cultural Heritage

As described in **Table 0.6**, one heritage is registered with the World Heritage Convention, and four are submitted on the tentative list. Furthermore, the National Heritage Conservation Commission listed about 3,000 cultural and natural heritages. When planning power development projects, due considerations should be given to such heritages, though all of them are not designated as national cultural heritages.

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27 UNAIDS. (2008) *Report on the Global HIV/ AIDS Epidemic 2008.*

[Hydropower] If the whole or part of villages is submerged as a result of hydropower development, the loss of local heritages such as cultural and religious facilities, cemeteries and traditional buildings is inevitable.

[Thermal Power and Transmission] If local heritages such as cultural and religious facilities are found in the vicinity of the planned construction sites and routes of transmission/ sub-transmission lines, certain impacts on the local heritages may be caused including the loss or relocation of the heritages, and impacts on the local landscape.

Occurrence/nonoccurrence of the above impacts is unclear at present since it relies heavily on the contents of individual project plans. At the F/S phase of individual projects, it is necessary to confirm existence/ nonexistence of cultural heritages around project sites, and to predict impacts caused by proposed projects.

Topography and Geological Features

[Hydropower, Thermal Power and Transmission] Submersion of land caused by the creation of reservoirs and land formation for the construction of power facilities and transmission lines may cause loss or damage of valuable topography and geological features. Although such topography and geological features are not identified in this master plan study and occurrence/nonoccurrence of such impacts is unclear, it is necessary to conduct surveys on such features around project sites at the F/S phase.

Soil Erosion

[Hydropower] Soil erosion may occur due to the construction of power facilities and dams. Soils around reservoirs may be eroded.

[Thermal Power] Soil erosion may occur during construction works, depending on the site selection of power plants.

[Transmission] If the routes of transmission/ sub-transmission lines are set on hilly lands, soil erosion may occur during civil works.

Although occurrence/nonoccurrence of the above impacts is unclear at present except soil erosion at newly created reservoirs, it is necessary to predict the possibility of soil erosion and the extent by surveying the topographic and geological conditions of project sites at the F/S phase of individual projects.

Local Hydrology and Groundwater

[Hydropower] Water intake from rivers and the creation of reservoirs or low-water section will affect the hydrology of the rivers to be developed. Such impacts on local hydrology will also affect the distribution and amount of nearby groundwater.

[Thermal Power] The intake of coolant water for the operation of thermal power plants may have some adverse impacts on local hydrology. Although occurrence/nonoccurrence of such impacts is unclear at present since it depends heavily on individual project plans, it is necessary to predict impacts of coolant water intake on local hydrology and groundwater at the F/S phase of individual projects, based on the characteristics of water bodies from which coolant water is taken and the amount of water to be taken.

Flora and Fauna, and Biodiversity

The distribution of protected areas and reserved forests are indicated in Figure 0.1 and Figure 0.2 respectively. If power development projects are planned in the vicinity of these protected areas and forests, impacts on flora and fauna are of concern.

[Hydropower] Hydropower development will have adverse impacts on floras and faunas such as the habitat loss of wildlife by reservoir creation, impacts on water creatures caused by changes in river flow, and clearance of trees for land formation. Many hydropower development projects included in the master plan are planned within or in the vicinity of National Parks and Game Management Areas. In particular, most of the shortlisted projects are planned in or around protected areas, namely Itezhi-Tezhi, Lusiwasi Expansion, Mutinondo, Luchenene, Lunsemfwa, Mkushi, Kabompo Gorge, Kabwleume Falls, Kundabwika Falls, and Kafue Gorge Lower. These projects may cause significant impacts on local ecosystems by the creation of reservoirs or extraction from nearby rivers.

[Thermal Power] There are no protected areas and forest reserves around Maamba where a coal-fired thermal generation station is planned to be constructed. Land formation for the construction of thermal power stations, however, might cause certain ecological impacts by the clearance of forests and loss of wildlife habitats. The other coal thermal plants are proposed to be constructed in the vicinity of Kitwe and Kapiri Mposhi. No protected areas are found around these sties, but certain ecological impacts such as vegetation clearance might also be anticipated like the Maamba project. Although occurrence/nonoccurrence of the above impacts is unclear at present since it relies on the contents of individual project plans, it is necessary to conduct surveys on the possibility of vegetation clearance and its extent at the F/S phase.

[Transmission] Forest clearance will be necessary for the construction of transmission/ sub-transmission lines. If the lines pass through protected areas and forest reserves, some impacts on flora and fauna are anticipated. Certain areas of either side of the lines are ñRight of Wayò where trees are regularly cleared for maintenance. Of the urgently needed projects proposed in the master plan, Improvement of Transmission System in North-East Area may pass through areas dotted with many protected areas, such as Lavushi-Manda National Park and Kasanka National Park located several tens of kilometers north of Serenje and Isangano National Park located in 100 km south of Kasama. Development of Transmission Line from Itezhi-Tezhi Power Station to Lusaka is expected to go through Kafue Flats and nearby protected areas. It is therefore required to carefully survey impacts on vegetation and wildlife animals of protected areas, when selecting the routes of these transmission lines.

Landscape

[Hydropower] Local landscape may be significantly changed due to the construction of hydropower stations and creation of reservoir. At the F/S phase of individual projects, it is necessary to identify the extent of impacts on local landscape based on opinions of local stakeholders.

[Thermal Power] Buildings and high stacks may affect local landscape depending on the location of a power plant. At the F/S phase, it is necessary to conduct surveys on existence/ nonexistence of the impacts, taking into account the topography of project sites and opinions of local stakeholders.

[Transmission] In Zambia, towers of transmission lines are about 20 m high for 132kV lines, while more than 20 m for 330kV lines, hence local landscape may be affected. At the F/S phase, it is necessary to identify the extent of impacts on local landscape based on opinions of local stakeholders.

Global Warming

[Hydropower and Transmission] Small amount of greenhouse gases (GHG) will be emitted from heavy machinery and construction vehicles for civil-engineering works, forest clearance for construction works, and submersion of forest by reservoir creation. However the impacts on climate change are negligible.

[Thermal Power] Heavy machinery and construction vehicles emit small amount of GHG, but the contribution of the GHG to global warming is negligible. Combustion of coal for power generation will continuously emit a certain amount of GHG. The degree of the impacts is unclear at present, thus it is necessary to predict the emission amount of greenhouse gases at the F/S phase based on the capacities and specifications of power plants, and the qualities of fuels.

Air Pollution

[Hydropower and Transmission] Negligible amount of air pollutants will be emitted from heavy machinery and construction vehicles.

[Thermal Power] Heavy machinery and construction vehicles emit negligible amount of air pollutants. Combustion of coal for power generation will emit some amount of air pollutants such as sulfur dioxide and nitrogen dioxide.

Water Pollution

[Hydropower] Construction works may cause the inflow of muddy water into rivers to be developed, and the creation of reservoirs may deteriorate the water quality of the rivers. Occurrence/nonoccurrence of water pollution is unclear at present since it depends heavily on the components of individual projects and the locations of related facilities. At the F/S phase of individual projects, it is necessary to predict the level of water pollution by surveys on water flows and volume of nearby water bodies and pollution sources around project sites.

[Thermal Power] Coolant water discharged from a thermal power plant may affect the water quality of a nearby water body depending on its quality and temperature. If chemicals are used to prevent water creatures from adherence to the inside of coolant pipes, such chemicals may cause water pollution. Occurrence/nonoccurrence of water pollution is unclear at present since it depends heavily on the components of individual projects and the locations of related facilities. At the F/S phase of individual projects, it is necessary to confirm the disposal process of coolant water, and to predict occurrence/ nonoccurrence of water pollution and its level.

Soil Contamination

[Thermal Power] There is a slight concern about soil contamination associated with the inappropriate disposal of coal ash and fly ash. Although the occurrence/nonoccurrence and its degree of soil contamination are unclear at present, it is necessary to confirm the disposal process of coal ash and fly ash when determining the detailed specifications of facilities.

Waste

[Hydropower and Transmission] The construction of hydropower facilities, transmission/ sub-transmission lines and substations will generate waste soil and construction wastes. The operation of thermal power plants and transmission lines will also generate wastes. In terms of transmission projects, waste transformer oils contaminated by Polychlorinated Biphenyl (PCB) may be discharged associated with the replacement of old transformers.

[Thermal Power] Construction of power stations will generate wastes such as waste soils and construction wastes. Coal ash and fly ash will be continuously generated during the operation of coal thermal power stations. Coal ash and fly ash are strong alkaline materials and may contain heavy metals depending on the quality of coal fuels, thus, if improperly disposed of, they may cause soil contamination and groundwater pollution.

Noise and Vibration

[Hydropower, Thermal Power and Transmission] The construction of hydropower facilities, transmission/ sub-transmission lines and substations will cause a certain level of noise and vibration. In particular, if there are villages in the vicinity of construction sites, a certain level of noise impacts on local residentsôlivelihoods is anticipated. Operation of a thermal plant will cause a certain level of noise. Transformers with high capacity will discharge low-frequency noise that can reach tens of meters. Whether a project causes noise impacts on neighboring communities is unclear since it relies heavily on the layout plans of individual projects. At the F/S phase of individual projects, it is necessary to predict the level and extent of noise and vibration based on the distribution of villages around project sites and layout plans of individual facilities.

Ground Subsidence

[Hydropower] Ground subsidence may occur depending on the ground stability of the construction sites for dam of sub-projects. Occurrence/nonoccurrence of ground subsidence is unclear at present, but it is necessary to conduct a geologic survey, when the detailed plan is determined, to identify possibility of ground subsidence and the degree.

[Thermal Power] If coolant water is taken from groundwater, operation of thermal power stations might cause ground subsidence. Occurrence/nonoccurrence of ground subsidence is unclear at present since it depends on individual project plans. For projects that plan to extract coolant water from groundwater sources, it is necessary to predict the possibility of ground subsidence by surveying the quantity of groundwater at the F/S phase.

Bottom Sediment

[Hydropower] Deposited materials may flow into reservoirs. At the F/S phase of individual projects, it is necessary to predict the level of bottom sediment by surveying expected amount of the inflow of deposited materials.

[Thermal Power] Coolant water discharge might cause adverse impacts on the bottom sediments of nearby water bodies. The occurrence/nonoccurrence of the impact is unclear at present since it depends on individual project plans. At the F/S phase of individual projects, it is necessary to survey on quality of discharged water based on the planned disposal system for coolant water.

Accident and Safety

[Hydropower] Accidents during construction works may take place. Water discharge from dams might cause damages of local residents.

[Thermal Power] Accidents during construction works and unintended leaks of hazardous coal ash may take place.

[Transmission] In addition to accidents during construction works, transmission/ sub-transmission lines may be broken down or hang down to the ground by disasters.

Occurrence/nonoccurrence of impacts related to the operation of power facilities is unclear since it relies on the components and locations of individual projects. At the F/S phase of individual projects, it is necessary to confirm the safety measures based on the topography and geology of project sites, the distribution of nearby villages, and planned civil works and construction schedule.

Mitigation Measures for the Potential Impacts

Considerations at the master plan stage

The basic policy of the environmental and social considerations at the master plan stage is to identify sub-projects with potential significant impacts, and then to avoid such impacts in planning sub-projects or to elaborate necessary mitigation measures at earlier phases. In particular, impacts whose significance depends on the location such as involuntary resettlement and impacts on the protected areas and wildlife need to be taken into consideration when selecting sub-project site.

The Study team tried to identify areas with potential significant impacts based on map information and other available information, in consultation with relevant institutions, and then tried to avoid the areas in elaborating the master plan.

Mitigation measures at project implementation stage

Project implementation stage can be divided into a feasibility study (F/S) phase, a basic design study (B/D) phase or a detail design study (D/D) phase, and a construction phase. Environmental Impact Assessment (EIA) is in general carried out at the F/S phase, and mitigation measures identified in the EIA are further elaborated at the B/D or D/D phases, then the measures are put into practice at the construction phase. This section aims to clarify points to consider for the convenience of the future preparation of EIA at the F/S phase.

1) Involuntary resettlement

When selecting sub-project sites, it is necessary to consider the possibility of alternatives to avoid involuntary resettlement as much as possible. Project proponents need to ascertain the physical and social conditions of candidate sites through field investigations and consultations with local representatives, such as chiefs, opinion leaders and district council members. Based on the information, sites with the high possibility of involuntary resettlement should be avoided. If involuntary resettlement is unavoidable, it is important to hold sufficient consultations with affected people and local representatives to obtain their agreement. A sub-project-specific resettlement plan, including the amount of compensation, support for restoring income and livelihoods, system for accepting and processing complaints and monitoring mechanism of the livelihoods of relocated households, shall be formulated and implemented. It should be noted that the monitoring needs to be continued, as appropriate, after the completion of construction works. The following items should be included the sub-project-specific resettlement plan at least.

1. Scope of land acquisition and resettlement
   - Scope of land acquisition and resettlement and the necessity
   - Alternative options to minimize land acquisition and resettlement
   - Key effects in terms of land acquired, assets lost, and people displaced from homes

2. Socioeconomic information
   - Definition and number of people to be affected
   - Impacts on people to be affected, taking into account social, cultural and economic parameters
   - Identification of all losses for people to be affected
   - Impacts on the poor, indigenous peoples, ethnic minorities, and other vulnerable groups and any special measures needed to restore/ enhance their economic and social base

3. Objectives, policy framework, and entitlements
   - Objectives of land acquisition and resettlement
   - Key national and local land, compensation and resettlement policies, laws, and guidelines
   - Eligibility of people who receive compensation and other supports

4. Consultation, and grievance redress participation
   - Identification of stakeholders
   - Mechanisms for stakeholder participation in planning, management, monitoring, and evaluation.
   - Identification of local institutions or organizations to support people affected, and potential role of NGOs
   - Procedures for redress of grievance by people affected

5. Relocation of housing and settlements
   - Options for relocation of housing and other structures, including replacement housing, replacement cash compensation, and self selection
   - Measures to assist with transfer and establishment at new sites
   - Options for developing relocation sites
   - Plan for layout, design, and social infrastructure for each site

- Means for safeguarding income and livelihoods, and measures for planned integration with host communities
- Special measures for addressing gender issues and those related to vulnerable groups

6. Income restoration strategy
   - Income restoration strategy
   - Job opportunities, including provisions for income substitution, retraining, and self-employment
   - Plan to relocate and restore businesses, including income substitution

7. Institutional framework
   - Tasks and responsibilities in planning, negotiating, consulting, approving, coordinating, implementing, financing, monitoring and evaluating land acquisition and resettlement
   - Review of the mandate of the land acquisition and resettlement agencies
   - Provision of capacity building, including technical assistance

8. Resettlement budget and financing
   - Identification of land acquisition and resettlement cost
   - Preparation of an annual budget and a plan of timing for release of funds

9. Implementation schedule
   - Time schedule showing start and finish dates for major resettlement task
   - Specification of timing for support prior to demolition of housing and other structures

10. Monitoring and evaluation
    - Plan for internal monitoring, key indicators of progress, mechanisms for reporting
    - Evaluation plan with provision for external and independent evaluation
    - Participation of people affected in monitoring and evaluation

(Source) Modified from *ADB Handbook on Resettlement: A Guide to Good Practice* and ZESCO Draft Resettlement Policy for Transmission and Distribution Projects

During local stakeholder meetings held in this study, participants stated that compensations were not sufficient under the projects implemented in the 1970ʼs. Although legal and policy frameworks and their execution status in the 1970ʼs are unclear, any projects to be implemented in the future shall provide project-affected-persons (PAPs) with sufficient compensations and supports for the restoration of their livelihoods.

The ESU of ZESCO formulated a Draft Resettlement Policy for Transmission and Distribution Projects in January 2003. Although the draft policy is not formally authorized, the recent project-specific resettlement plans for transmission and distribution projects were formulated in accordance with the policy. The policy covers almost all items listed above, and provides basic principles of each item, and thus satisfies the requirements of the JICA Guidelines for Environmental and Social Considerations. When implementing individual projects, a project-specific plan should be formulated, in accordance with the basic principles indicated in the draft policy, according to the natural and socio-economic characteristics of project sites.

ZESCO has several experiences in formulating project-specific resettlement plans for transmission projects, based on the draft policy. In the plans, the following costs were budgeted, and they are considered to pay due attention to the restoration of relocated peopleʼs livelihoods.

- Cost for building a new house that is slightly better than the current one
- Relocation cost, including transportation cost
- Funds to acquire land and buy inputs for the first agricultural season

In addition, costs to construct social facilities including schools and clinics are also budgeted where it is considered necessary. Such plans are deemed to take into account the restoration of livelihoods in relocation destination. These precedents can be referred to as good practices in formulating a resettlement plan.

2) Impacts on Local Economy (employment and livelihood) and Land Use

It is necessary to explain the content of a sub-project to local residents at the F/S stage or earlier stage. If a project may affect the livelihood means of local residents, the plan should be explained well in advance so that they have enough time to find alternative income generating means. In addition, a land acquisition plan including an income restoration program needs to be formulated, in case impacts of land acquisition on the economic bases of affected persons are unavoidable. The plan should be based on sufficient consultations with local people to be affected, and it is critical to reach an agreement with the people. The framework of the plan should cover items specified in section 1). It is also necessary to monitor their livelihoods and income restoration, as appropriate, even after the operation starts.

3) Impacts on Local Social Institutions such as Decision-Making Institutions

It is necessary to explain the content of a sub-project at the initial phase of the F/S stage, and confirm whether there are formal or informal decision-making institutions and other social institutions in the sub-project site. Informal decision-making institutions here include a local meeting held based on a traditional custom. If such institutions are identified, agreement with the institutions on the project implementation, and mitigations measures of potential impacts, and support for reorganizing the institutions needs to be obtained.

4) Impacts on the Livelihoods of Indigenous Peoples and Ethnic Minorities

It is necessary to consult with local governments and local representatives to confirm whether there are habitats of indigenous peoples and ethnic minorities. In case such habitats are identified, it is critical to hold a consultation with them, and make careful considerations to ensure that they will not experience unfair treatment.

5) Local Conflict of Interests and Inequality

It is necessary to consult with local governments, local representatives, and other stakeholders to confirm whether there are any concerns that may cause the local conflict of interests in the vicinity of sub-project sites. Specifically, it shall be highlighted whether adverse impacts concentrate on particular groups of local people, or whether there were troubles in the past in the vicinity of the sub-project site. If some impacts are anticipated, it is necessary to hold sufficient consultations with stakeholders, and to reach an agreement.

6) Water Usage and Water Rights

It is necessary to coordinate with water right holders at the planning stage of sub-projects, and to reach an agreement with them on the amount of water intake and its pattern. In case of international rivers, negotiations with relevant nations on water rights shall be highlighted.

7) Sanitation and Infectious Diseases such as HIV/ AIDS

Construction workers and local people should be provided with basic information on infectious diseases including HIV/ AIDS to prevent the spread of such diseases due to the inflow of construction workers. Mitigation measures such as the distribution of condoms shall be undertaken. ZESCO has collaborated with the Ministry of Health to conduct activities to prevent infectious diseases. It is effective and efficient to seek for the collaboration with outside resources such as the Ministry of Health and NGOs.

It is also necessary to undertake necessary measures, including the construction of drainage and information provision, to prevent sanitation and infectious disease-related problems in relocation destinations.

8) Cultural Heritage

It is necessary to explain the content of a sub-project, at the initial phase of F/S stage, to local governments, local representatives and local residents, and National Heritage Conservation Commission (NHCC) to confirm existence or non-existence of cultural heritages to be considered. If cultural heritages to be affected are identified, it is critical to hold consultations with local representatives, NHCC and other stakeholders, and elaborate mitigation measures including the modification of part of the sub-project plan and relocation of the heritages.

9) Topography and Geological Features

It is necessary to explain the content of a sub-project, at the initial phase of F/S stage, to local governments, local representatives and local residents, NHCC, and academic expert to confirm existence or non-existence of valuable topography and geological features. In case some valuable topography and geological features are identified, sufficient consultations with the stakeholders should be made, and necessary mitigation measures, including the modification of part of the sub-project plan, shall be elaborated.

10) Soil Erosion

Measures against soil erosion, including the construction of drainages, and avoidance of construction works during the high water and rainy season, shall be effectively implemented. With respect to hydropower development, the conservation of vegetation around reservoir and the minimization of the adverse effects of soil erosion should be given high priority. If transmission lines are constructed on hilly areas, soil conservation measures such as the conservation of vegetations and re-vegetations shall be undertaken.

11) Local Hydrology and Groundwater

The amount and pattern of water intake from rivers should be based on the results of surveys on river flows and local hydrology to avoid significant impacts on local hydrology. It is necessary to monitor the water amount and quality of nearby water bodies and wells, and to adjust the amount to be taken in case some impacts are observed such as the depletion of groundwater.

12) Flora and Fauna, and Biodiversity

It is necessary to conduct a detailed survey on flora and fauna in a sub-project site, and the distribution of their habitats, protected areas and forest reserves. Endangered or valuable species should particularly be detailed. The surveys, which should cover both the rainy and dry seasons, will require long time, and the surveys, therefore, should be conducted at the earlier stage of the F/S. More specifically, the surveys should follow the steps below.

- At the earlier stage of the F/S, it is necessary to confirm the existence/nonexistence of ecological survey data conducted in the vicinity of project sites, which can be a baseline data of the projects. Institutions which implement the ecological surveys or manage the survey data should also be confirmed.

- If ecological data is not available, it is necessary to consult with ZAWA and ECZ about the necessity and contents, including survey items, survey duration, frequency, etc.) of the ecological survey, and to conduct necessary surveys.

- If the project site is located around the border, it is also necessary to confirm the existence/nonexistence of agreements on wildlife protection with neighboring countries.

The environmental conservation measures should be considered, based on the above ecological survey results and agreements with neighboring countries, in line with the following priority.

- At first, it is necessary to avoid the alteration of valuable speciesô habitats and the clearance of forests as much as possible, based on the ecological survey results, when determining the facility layout and the route of access road.
- If some impacts are unavoidable, it is necessary to minimize the impacts by adjusting construction schedule and method such as the suspension of civil works during breeding period, the adjustment of working hours and construction schedule, and the setting of velocity limits of construction vehicles.
- If significant impacts are still predicted, environmental compensation measures should be undertaken. The compensation measures should be appropriately determined as per the degree and nature of potential impacts. They include the establishment of new protected area to create alternative habitats for wildlife, reforestation in the neighboring areas, and the installment of fish-way.

It is also necessary to elaborate effective mitigation measures for wildlife protection, referring to the precedents of infrastructure development projects.

13) Landscape

It is necessary to explain the content of a sub-project, at the initial phase of F/S stage, to local governments, local representatives and local residents to confirm whether impacts on local landscape can be significant. In case some impacts are predicted, it may be necessary to modify the sub-project plan including the route change of transmission lines, and to develop mitigation measures such as reforestation after the completion of civil works and coating with landscape-conscious colors.

14) Global Warming

Greenhouse gas emissions should be reduced by installing energy-efficient facilities in the thermal power plant to be constructed.

15) Air Pollution

It is necessary to ensure compliance with the Emission Standards specified by the Air Pollution Control (Licensing and Emission Standards) Regulations, 1996. The thermal power plant should be designed to reduce air pollutants by the reduction of sulfur concentration through coal pretreatment, or the installment of devices for flue desulfurization and denitration, and electrostatic precipitator.

16) Water Pollution

To prevent muddy water from flowing into rivers, it is necessary to make considerations such as the construction of temporary dams and the suspension of civil works during high water or rainy season.

Discharge of coolant water from the thermal power plant shall be in accordance with the Emission Standards specified by the Water Pollution Control (Effluent and Waste Water) Regulations, 1993. In particular, temperature shall be less than 40 degrees Celsius at point of discharge. In addition, it is crucial to reduce difference in temperature between the intake and outflow. In Japan, for instance, the difference in temperature is controlled within seven (7) degrees Celsius in general.

17) Soil Contamination

Coal ash from the thermal power plant should be appropriately disposed of to prevent the leakage into soil.

18) Waste

Waste soil and construction waste, coal ash from the thermal power plant, and other wastes discharged during the operation of facilities shall be disposed of in compliance with the Waste Management (Licensing of Transporters of Wastes and Waste Disposal Sites) Regulations, 1993. In the contract with sub-contractor, it is necessary to incorporate an article regarding the appropriate disposal of wastes into the contract with sub-contractors.

In Zambia, a system for properly disposal of PCB wastes is not established. It is therefore crucial to properly store PCB wastes oil to prevent the leakage into the environment. The followings are the standards to store PCB wastes specified by Japanese Waste Management Law.

ZESCO needs to properly store PCB waste in reference to the standards.

1) Take necessary measures to prevent the volatilization of PCB such as putting PCB oil into sealed containers, and to prevent exposure of PCB oil to high temperature. 2) Take necessary measures to prevent the decay of containers of PCB waste. 3) Set fences around storage sites. 4) Put a board indicating the followings in a prominent part of storage sites. a) That PCB waste is stored here b) Name of personnel or organization responsible for the storage and its contact information 5) Take necessary measures to prevent splash, leakage, and infiltration into the ground of PCB waste, and emission of offensive odors from PCB waste. 6) Take necessary measures to prevent rats, mosquitoes, flies and other harmful insects.

19) Noise and vibration

In case there are villages in the vicinity of the planned sites, prior notification of civil work hours and duration is necessary to reduce the impacts of noise and vibration.

It is necessary to make considerations on the layout and design of power facilities, referring to the international standards described in 11. 1.1 (3) c, to prevent noise and vibration.

20) Ground Subsidence

It is necessary to monitor groundwater level at the site where coolant water can be extracted by the thermal power generation plant. If some impacts are identified, the amount and pattern of the water intake should be adjusted.

21) Bottom Sediment

It is necessary to conduct regular dredging activities and the construction of sediment pool dam to prevent sedimentation within reservoirs.

22) Accident and Safety

Safety education to prevent accidents should be provided to construction workers, facility operators, maintenance and management staff and other relevant persons. It is necessary to inform local residents of the schedule of dam water discharge well in advance to ensure safety of downstream livelihoods. Regular patrols on the conditions of transmission lines are also necessary to prevent accidents.

Environmental Management Plan and Monitoring Activities

Environmental Management Plan

In the Environmental Impact Statement of sub-projects, an Environmental Management Plan to ensure the smooth implementation of proposed mitigation measures is required. The Environmental Protection and Pollution Control (Environmental Impact Assessment) Regulations, 1997 requires project proponents to formulate an Impact Management Plan including environmental conservation measures against adverse impacts and indicators for environmental monitoring (Regulation 11). Although the regulations do not specify the detailed contents of the plan, the Environmental Management Plan should cover the following items at least.

1) Mitigation measures against potential adverse impacts
   - Clarification of necessary mitigation measures
   - Implementation mechanism and responsibility of mitigation measures

2) Monitoring of adverse impacts
   - Monitoring of the implementation status of mitigation measures, and their effectiveness (monitoring items and methodology)
   - Monitoring of environmental quality such as air, water, and noise (monitoring items and methodology)
   - Monitoring of unexpected impacts (monitoring items and methodology)
   - Measures to be taken based on the monitoring results

3) Implementation mechanism of the Environmental Management Plan
   - Appointment of staff in charge of environmental management, and clarification of his/her responsibilities
   - Training for staff and contractors

4) Disclosure and public participation
   - Disclosure of the progress of projects
   - Disclosure of the implementation status of mitigation measures and monitoring results
   - Setting of stakeholder meetings
   - Procedures for processing complaints

5) Implementation schedule
   - Implementation schedule by individual task

The monitoring of adverse impacts is in particular important in the Environmental Management Plan. Through the monitoring activities, it can be confirmed whether mitigation measures proposed in EIA are appropriately implemented, and whether adverse impacts unexpected by EIA are observed. In addition, it is critical to increase the effectiveness of mitigation measures by reflecting the monitoring results to the contents of Environmental Management Plan.

Main monitoring items for sub-projects included in the master plan are identified in Table 0.10, based on the scoping results and considerations of mitigation measures.

Table 0.10 Major Environmental Monitoring Items

Project type	Key impacts	Monitoring items
Hydropower Development	Involuntary Resettlement/ Land Acquisition	- Occurrence/ nonoccurrence of involuntary resettlement and land acquisition - Appropriateness of process to reach agreements with people affected - Appropriateness of property value assessment and compensation - Appropriateness of resettlement process - Progress of resettlement and land acquisition - Progress of support for the rebuilding of livelihood of relocated people
	Local Economy/ Land Use	- Occurrence/nonoccurrence of impacts on local peopleȇs livelihood means
	Water Usage/ Water Rights	- Occurrence/ nonoccurrence of any impacts on local water usage and water rights
	Sanitation/ Infectious Diseases	- Progress of the proposed mitigation measures such as the distribution of condoms - Understandings of construction workers about infectious diseases
	Soil Erosion	- Status of soil erosion around construction sites - Progress of mitigation measures to prevent soil erosion such as re-vegetation
	Local Hydrology/ Groundwater	- Transition of water flows of nearby rivers and wetlands - Water levels of adjacent wells
	Flora and Fauna, and Biodiversity	- Existence/nonexistence of impacts on protected areas and valuable ecosystem (changes in number of indicator species, etc.) - Appropriateness and sufficiency of mitigation measures
	Cultural Heritage, Local Landscape	- Existence/nonexistence of impacts on cultural heritages and local landscapes - Appropriateness and sufficiency of mitigation measures
	Waste	- Appropriateness of the disposal of construction wastes
	Ground Subsidence	- Status of ground subsidence of a proposed new dam
	Bottom Sediment	- Status of sediment in a new reservoir
	Safety Measures	- Implementation of safety measures during civil works - Maintenance and inspection of facilities, and prevention of fire breaking
Thermal Power Development	Involuntary Resettlement/ Land Acquisition	Same as ñHydropower developmentò
	Local Economy/ Land Use	Same as ñHydropower developmentò
	Sanitation/ Infectious Diseases	Same as ñHydropower developmentò
	Flora and Fauna, and Biodiversity	Same as ñHydropower developmentò
	Cultural Heritage, Local Landscape	Same as ñHydropower developmentò
	Water Pollution	- Temperature and quality of discharged coolant water
	Air Pollution	- Quality of emission gas
	Waste	- Appropriateness of the disposal of construction wastes - Appropriateness of disposal of coal ash and fly ash
	Noise	- Noise level at site boundary

Project type	Key impacts	Monitoring items
	Safety Measures	Same as ñHydropower developmentò
Transmission Development	Involuntary Resettlement/ Land Acquisition	Same as ñHydropower developmentò
	Local Economy/ Land Use	Same as ñHydropower developmentò
	Sanitation/ Infectious Diseases	Same as ñHydropower developmentò
	Flora and Fauna, and Biodiversity	Same as ñHydropower developmentò
	Cultural Heritage, Local Landscape	Same as ñHydropower developmentò
	Waste	- Appropriateness of the disposal of construction wastes - Status of disposal and/or storage of PCB waste oil
	Noise	Same as ñHydropower developmentò
	Safety Measures	- Implementation of safety measures during civil works - Maintenance and inspection of facilities, and prevention of fire breaking - Prevention of electric shock
Common Issues	Mitigation Measures	- Implementation status of proposed mitigation measures and their appropriateness
	Unexpected Impacts	- Existence/nonexistence of unexpected impacts
	Complaints	- Establishment of system for accepting complaints and records of complaints - Appropriateness of processing complaints

(Source) JICA Study

The monitoring items of individual sub-projects can vary depending on the location and other conditions. For instance, if a sub-project is planned around the Ramsar sites, it is necessary to monitor impacts on waterfowls inhabiting in the sites. In addition, monitoring methodologies such as monitoring sites, frequency and duration, and indicator species shall be determined according to the characteristics of projects. Detailed monitoring methodologies and items should be adjusted, in consultation with relevant institutions including ECZ and ZAWA, as per potential environmental and social impacts of individual sub-projects.

Implementation Mechanism of Environmental Management Plan

The Environmental Management Plan should be appropriately implemented. It is therefore critical to secure human resources and budget needed to implement the plan, and to establish an implementation mechanism.

Project proponents are responsible for the implementation of the Environmental Management Plan. Proponents of power development projects to be developed in Zambia include private companies as well as ZESCO.

In terms of ZESCO projects, the Environmental and Social Affairs Unit (ESU) will implement the plan in collaboration with relevant department. In the ESU, experts are appointed who cover broad environmental and social issues such as environmental management, ecosystem, involuntary resettlement and land acquisition. The ESU has practical experiences in the Environmental Impact Assessment, thus, it can be concluded that the ESU has already developed basic capacity to implement the Environmental Management Plan effectively.

With respect to private projects, the developers should appoint personnel in charge of the implementation of the Environmental Management Plan. They also need to establish a mechanism to supervise consultants dealing with environmental and social issues.

Environmental and Social Considerations in Case Study

Stakeholder meetings conducted in this study are largely categorized into two types: 1) local stakeholder consultation meetings including local interviews at case study sites; and 2) a stakeholder meeting at Lusaka. The former aims to identify potential environmental and social impacts and understand local residentsô perceptions on the ground. It also contributes to the extraction of points to consider in environmental impact assessments at subsequent phases. The latter consulted with relevant government agencies, NGOs, and academe. It aims to learn the lessons of past projects, and to clarify points to consider at planning level.

Local Stakeholder Meeting at Case Study Sites

In this master plan study, PAPs cannot be identified since the master plan will not specify the exact locations of individual sub-project. This ESC study, therefore, holds a series of alternative meetings with stakeholders including local farmers, traditional chiefs and district assembly members at the two case study sites. The meetings aim to identify potential impacts of sub-projects in advance, and to clarify points to consider at the F/S stage.

The perceptions of local governments, local representatives and traditional chiefs on the environmental and social impacts associated with the hydropower development projects were investigated through the alternative stakeholder meetings.

Table 0.11 Stakeholder Meetings at Case Study Sites

Date	Location	Participants
5 June 2009	Serenje District, Central Province	Serenje District Development Coordination Council: Extension offices of government agencies, district officers, police, representatives of farmers, representatives of commercial and industrial sector, NGOs, etc.
3 June 2009	Mailou Community, Central Province	Chief Mailou who governs the area where the Lusiwasi Extension Project is proposed
9 June 2009	Itezhi-Tezhi District, Southern Province	Itezhi-Tezhi District Development Coordination Council: Extension offices of government agencies, district officers, police, representatives of farmers, representatives of commercial and industrial sector, NGOs, etc.
10 June 2009	Kaingu Community, Southern Province	Chief Kaingu who governs the area where the Itezhi-Tezhi Dam is located

(Source) JICA Study

The major points that were clarified through the stakeholder consultation meetings are presented below.

1) Consultation with District Development and Coordination Committees

[Positive Impacts]

- Hydropower development projects will create job opportunities associated with the construction and operation of a power station.
- Infrastructures such as roads are developed and improved, and local communities can

enjoy many benefits through improved infrastructures.

- Hydropower projects will increase income generation due to the enhancement of local economic activities.
- Rural electrification will be promoted. This will contribute to the improvement of living standards, and reduction in the use of wood fuels and thereby conservation of forest resources.
- Other multiple positive economic impacts are anticipated due to the enhancement of economic activities.
- Revenue increase of local governments and associated improvement of government service delivery are also expected

[Negative Impacts]

- Hydropower development projects may cause the submersion of land, which will reduce the availability of agricultural and other use of land. The anticipated influx of new settlers will increase the competition over land.
- Involuntary resettlement may occur. Loss of livelihood sources may affect persons to be affected.
- The influx of new settlers may inhibit timely delivery of social services such as education and health.
- Risks of infectious diseases may increase due to the influx of new settlers. Hydropower development projects may also cause the increase of mosquitoes due to the creation of a dam lake and hygienic related diseases such as diarrhea and cholera due to poor sanitation.
- The influx of people may lead to increase in deforestation, loss of wildlife habitats, and resultant conflicts between humans and animals.
- Valuable natural and cultural heritages may be affected.
- Change in river flow regimes due to the creation of a dam, water intakes from rivers, and controlled releases of water may affect water usage of local communities.

[Involuntary Resettlement and Land Acquisition]

- Involuntary resettlement and land acquisition will be inevitable, but they are only acceptable where sufficient consultations are held, and resettlement and acquisition conditions, including the amount of compensation, are agreeable with affected parties.
- All the concerned people should be involved in the process of consultations. Various facets of society including chiefs and other related residents should also be consulted.
- Compensation should be based on the appropriate evaluation on the properties and assets to be affected. Psychological compensation will be necessary when relocation of houses is required. In addition, project-affected people should be given new skills in case they are forced to change their livelihood means.
- The amount of compensation should be determined so that affected people can lead the same life as or slightly better life than before.

[Points to Consider]

- It is necessary to learn from what has been done in the past development project in or in the vicinity of the proposed sites.

2) Interviews with Chiefs

[Impacts of Power Development Projects]

- Many people affected by the construction of the existing Itezhi-Tezhi Dam in the 1970ös or the Lusiwasi Power Station in the 1960ös to 1970ös could not obtain proper compensation. With respect to future projects, proper compensation should be given to the affected people.
- Lifestyle of local residents may change drastically after the completion of a power development project, since such a project will bring about economic development.

[Points to Consider]

- The necessity of power development project is understandable, so the chiefs will not oppose the projects in principle. However, it is necessary to have sufficient consultations in advance.
- Consultation with local residents should avoid harvesting time when farmers are busy working.
- When constructing power stations, villages around the construction sites should be given high priority for electrification. There are un-electrified villages where transmission lines pass through, but such situation is not acceptable.
- Sufficient consultations will be necessary to avoid significant impacts on traditional and cultural sites, such as graves, shrines, and sites for rain-making rituals.

Stakeholder Meetings at Lusaka

A stakeholder meeting on environmental and social considerations for power development projects was held in Lusaka, inviting concerned government agencies, NGOs, and academe.

Table 0.12 Stakeholder Meeting at Lusaka

Date	Location	Participants
18 June 2009	Conference room of Department of Energy (DOE)	DOE, ZESCO, Forestry Department (FD), Zambia Wildlife Authority (ZAWA), National Heritage Conservation Commission (NHCC), Integrated Water Resources Management Center of the University of Zambia, WWF, Wildlife and Environment Conservation Society of Zambia (WECSZ)

(Source) JICA Study

The brief outline of the consultation meeting is indicated below.

[Potential Impacts]

- ZESCO developed the draft resettlement policy since there is no national resettlement framework program so far. Sufficient compensation should be provided to people affected in a timely manner.
- For the mitigation measures against involuntary resettlement, re-establishment of livelihoods of resettled persons in the new settlements and support to the

re-establishment should be given high priority.

- Construction of sanitation and health facilities and schools should be completed prior to the resettlement of people affected.
- It is necessary to avoid fragile and/or sensitive ecosystem when selecting the location of power development projects.
- Studies on dam construction impacts tend to focus much on flood related issues by newly created reservoir, but downstream ecosystem is also equally important.
- How to determine an environmental flow is critical when constructing a dam. In general the flow will be determined based on surveys on river flows and key species, however, consultations with broad range of stakeholders are necessary in the process of the determination.
- Cultural heritages tend to be given less considerations. It is necessary to consult with local residents to identify cultural heritages that should be given due attention.
- There should be mechanisms to minimize the loss of tourist attractions such as the beauty of nature.

[Points to Consider]

- Strategic Environmental Assessment (SEA) should be given due attention to have a bigger picture of the project. It is necessary to ensure the consistency with government policies and programs of various sectors by reviewing them.
- It is necessary to consider the alternatives to the proposed development projects.
- In terms of consultations, it is necessary to identify with whom, when and how to consult. In particular, prior consultations with relevant chiefs are critical.
- When consulting with local residents, it is important to facilitate income generating activities by referring to likely positive impacts as well as negative ones.
- Stakeholder consultations should be regularly held after the process of Environmental Impact Assessment, and this should be required for a project developer.

Stakeholder Meetings at Subsequent Phases

Sub-projects in the master plan will be further elaborated and the locations and specifications will be determined in the subsequent F/S, B/D, and D/D phases. Although an environmental impact assessment is in general conducted at the F/S stage, however, regardless of the study name, local stakeholder consultations shall be held prior to the determination of project sites and specifications, and the developer shall obtain agreement from the stakeholders.

The following points shall be noted for the local stakeholder consultations.

1) Stakeholders to be Consulted

The following stakeholders should be consulted at least.

- Local residents whose lands and other properties are acquired, and/or those who are forced to be relocated, including those without land title
- Local residents affected by projects

- Chiefs
- District Council and other local government institutions, in particular those in which a variety of stakeholders participate, such as District Development and Coordination Committee
- Extension or regional offices of ZAWA, ECZ, and Forestry Department and other central government agencies

In particular, agreements from chiefs as traditional authorities as well as PAPs are critical to initiate projects. In addition, a District Development Coordination Committee is institutionalized in each district in Zambia. A variety of stakeholders take part in the committee, including local officers of central government agencies, district government officers, NGOs, representatives of farmers and private businesses. In selecting a project site, it is effective for developers to consult with the committee members. In addition, consultations with regional offices of ZAWA, Forestry Department, and ECZ are expected to be effective to ascertain the distribution of protected areas and natural ecosystem.

2) Topics of Stakeholder Meeting

The following impacts should be taken into account in the stakeholder meetings at the F/S stage since the impacts can be significant.

- Involuntary resettlement
- Impacts on agricultural activities and other economic activities due to land acquisition
- Infectious diseases such as HIV/AIDS
- Impacts on cultural heritages
- Hydrological conditions and groundwater
- Flora and fauna, and biodiversity
- Impacts on local landscapes
- Noise and vibration
- Air pollution

It should be noted that local residents tend to focus on issues directly related to their livelihoods, such as involuntary resettlement and land acquisition. Biodiversity and landscape may not be given enough attentions. It is therefore necessary to hold individual meetings with local officials of ZAWA and Forestry Department.

Points to Consider at Project Implementation Stage

The master plan aims to identify potential projects, including power development projects, transmission projects and distribution projects, for the next 20 years. The master plan does not specify the exact locations of individual projects, and thus, ESC studies for the projects should be carried out when the locations are determined at the project implementation stage. This section presents points to consider in conducting ESC study at the project implementation stage.

Execution of Necessary Procedures

Environmental Impact Assessment Regulation, 1997 requires certain categories of power sector projects to formulate and submit PB and EIS, as indicated in Table 0.1. It is, therefore, critical for developers to take necessary procedures for the projects in consultation with ECZ.

Environmental and Social Consideration Study according to Project Locations

When ESC Study is conducted at the F/S stage, it is necessary to re-consider the scoping presented in 0 according to the individual conditions of project sites and the specifications. When carrying out the scoping, environmental and social impacts should be thoroughly examined in reference to the conditions of proposed locations and the specifications. In particular, if sites for dams and reservoirs and transmission line routes are specified, developers will be able to conduct detailed investigations on involuntary resettlement and land acquisition, and impacts on protected areas and biodiversity.

In the ESC study at the F/S phase, it is necessary to reconsider mitigation measures taking into account the local characteristics, in reference to mitigation measures described in 0. If impacts related to land acquisition and involuntary resettlement are predicted, stakeholder meetings should be properly carried out, properly taking into account the stakeholders and points to consider indicated in 0. Developers shall also give due considerations to consultations with traditional authorities such as chiefs, and obtain their agreement.

Considerations for alternative locations

In elaborating mitigation measures, the first priority should be put on seeking the alternative locations to avoid potential impacts. In case of unavoidable impacts, measures to minimize the impacts, or mitigation measures such as compensations should be taken into account. With respect to projects included in the master plan, it is essential to avoid locations where serious impacts are predicted, such as areas with high population density, protected areas and valuable landscapes. F/S should prepare more than one option regarding location selection, and determine the final location taking into account environmental and social impacts of respective options.

Environmental Management System

If projects included in the master plan are expected to have certain impacts, it is necessary to establish an Environmental Management Plan that addresses environmental measures and monitoring at the operational and maintenance phase as well as environmental measures at the construction phase. In terms of hydropower development projects, monitoring activities on involuntary resettlement process and unexpected impacts on ecosystem are critical. In particular, monitoring on ecosystem is critical since impacts on ecosystem cannot be thoroughly assessed in advance.

The reinforcement of the environmental management system of project developers can be considered important. ZESCO has the Environmental and Social Affairs Unit, which is deemed to have basic capacity of environmental management. On the other hand, private developersô environmental management system cannot be judged in this study in which the development plans are not yet detailed. It is essential for such developers to establish an effective environmental management mechanism that can handle the whole environmental management cycle, including the formulation, implementation and evaluation of environmental management plans. Furthermore, providing training courses of environmental and social considerations to individual engineers and technical staff is also critical.

Economic & Financial Analysis

Economic Analysis

The economic analysis looks at the economic situation of the government as well as the financing needs for the power sector, rather than the macro economic analysis because the sustainability to finance the power sector development will be increasingly important. Therefore, the section will examine the government budget finance first of all.

(1) Government Revenue Situation

The total government revenues and grant in 2008 was K12008.2 billion, excluding the collections from the new mining tax regimes. This can account for 22.0% of GDP. The total domestic revenues amounted to K9918.1 billion representing 82.6% of the total revenues and 18.7% of GDP. The grants accounted for 17.4% of the total revenue on the other hand.

The tax revenues collected in 2008 amounted to K9350.7 billion. The performance by items is as shown in the below table. The income taxes amounted to K4379.3 billion, which accounts for 46.8% of the total revenue. The VAT and customs amounted to K2210.0 billion and K2761.4 billion, respectively. The collection of the domestic VAT was below the expectation due to the administrative issues.

Table 0.1 Tax Revenue Performance in 2008 (without Additional Mining Revenue)

	2008 Performance (K billion)	Percentage(%)
Tax Revenue	**9,350.7**	**100.0**
A. Income Taxes	**4,379.3**	**46.8**
1. Company Tax	1,330.5	14.2
2. Paye	2,531.2	27.1
3. Withholding Tax	450.7	4.8
4. Mineral Royalty	66.9	0.7
B Value Added Tax	**2,210.0**	**23.6**
1. Domestic VAT	(430.7)	(4.6)
2. Import VAT	2,640.7	28.2
C. Customs & Exercise Duties	**2,761.4**	**29.5**
1. Customs Duty	1,202.6	12.9
2. Export Duty	190.4	2.0
3. Exercise Duty	1,368.4	14.6

(Source) Ministry of Finance and National Planning

Other revenues can be summarized in the following, which include additional mining revenue, non-tax revenue, and foreign support.

Table 0.2 Other Revenue in 2008

	2008 Performance (K billion)	Percentage(%)
Total of Other Revenues	**2,977.0**	**-**
Additional Mining Revenue	**319.5**	**100.0**
1. Company Tax	22.2	6.9
2. Windfall Tax	126.1	39.5
3. Mineral Royalty	171.2	53.6
Non-Tax Revenue	**567.4**	**100.0**
1. User Fee and Charges	388.9	68.5
2. Dividends	21.1	3.7
3. Medical Levy	12.6	2.2
4. Exceptional Revenues	144.8	25.5
Foreign Support	**2,090.1**	**100.0**
1. Grant Program	660.4	31.6
2. SWAPS	429.4	20.5
3. Grant Project	1,000.3	47.9

(Source) Ministry of Finance and National Planning

The total of other revenues in 2008 were K2977.0 billion. The revenues from the foreign resources amounted to K2090.1 billion in 2008. The additional mining revenue and non-tax revenue were K319.5 billion and K567.4 billion, respectively. The fiscal results in 2008 were less than the original expectation due to the poor performance of the tax collections from the mining, particularly the company tax and windfall tax.

(2) Government Expenditure Situation

The breakdown of the government expenditures in 2008 is as shown in the below table.

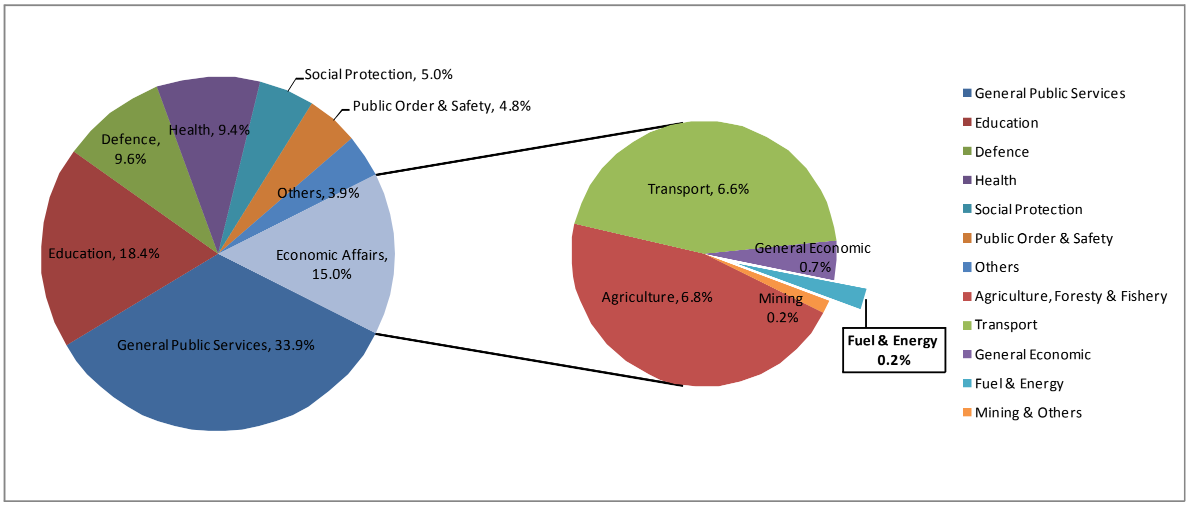
Table 0.3 Summary of Central Government Expenditure in 2008 (K billion)

	2008 Performance	Percentage (%)	Remarks
Total Expenditure	**13,410.7**	**100.0**	
I. Current Expenditure	**11,313.1**	**84.4**	
Personal Emoluments	4,435.1	33.1	
Public Service Retrenchment Program	30.0	0.2	
Use of Goods and Services	2,464.8	18.4	
Interest Payment	1,101.8	8.2	Domestic;879.8, External; 204.0
Subsidies	525.0	3.9	
Grants and Other Payments	1,676.0	12.5	
Social Benefits	168.7	1.3	
Other Expenses	911.7	6.8	incl. ZESCO financial restructuring
II. Capital Expenditure	**2,097.6**	**15.6**	
Non Financial Assets	2,050.0	15.3	
Financial Assets	47.6	0.4	

(Source) Ministry of Finance and National Planning

The total expenditure in 2008 was K13410.7 billion, which is approximately 24.2 percentage of GDP in 2008. The current and capital expenditures are K11313.1 billion and K2097.6 billion, respectively. As a percentage of the total, the current and capital expenditures are 84.4% and 15.6%, respectively. The interest payment for the domestic debts and external debts are K879.8 billion and K204.0 billion, respectively. The other expenses include K 98.5 billion that was spent on the ZESCO financial restructuring, which was not originally budgeted. The capital expenditure in 2008 was below the projected level because the government constrained expenditures in the second half of the year to accommodate unanticipated expenditures.

The expenditure by functional classification in 2008 can be also shown in the following chart. The emphasis on the expenditure was on the general public services, education, and health. While the expenditure on economic affairs accounted for 15.0% of the total, the expenditure on fuel and energy was only 0.2% of the total 2008 release.



Source) Ministry of Finance and National Planning (2008)

Figure 0.1 2008 Expenditure by Functional Classification

(3) Government Debt Situation

The domestic and external debts of the government can be summarized in the below tables. The domestic and external debts as of 2008 are K8541.9 billion and K2267.2 billion. The total debts are K10809.1 billion. Approximately 80% of the total debts are domestic and the rest of 20% is external.

Table 0.4 Domestic Debt Stock (K billion) 2006-2008

Debt Category	2006	2007	2008	% Change 07/08
Treasury Bills	3,262.0	3,416.4	3,280.8	(4.0)
GRZ Bonds	3,444.5	4,196.2	4,746.4	13.1
Domestic Arrears	513.0	233.4	197.9	(15.2)
Capital	333.6	90.3	23.9	(73.5)
Pension Arrears	386.5	302.7	149.6	(50.6)
Others	175.5	223.9	143.3	(36.0)
Total	8,115.1	8,462.9	8,541.9	0.9

(Source) Ministry of Finance and National Planning (2008)

Table 0.5 External Debt Stock (US million) 2007-2008

Creditor	2006	2007	2008	%Change 07/08
Total Gov External Debt	**1,019.0**	**1,106.2**	**1,218.7**	**10.2**
ADB/ADF	72.3	94.0	126.0	**34.0**
World Bank	257.3	315.5	365.0	**15.7**
IMF	32.5	85.9	96.6	**12.5**
Others	200.3	212.4	193.8	**(8.8)**
Bilateral	395.0	287.0	295.2	**2.9**
Suppliers Credit	61.6	111.4	142.1	**27.6**
Private& Parastatal	**840.3**	**980.7**	**1,048.5**	**6.9**
Total External Debt	**1,859.3**	**2,086.9**	**2,267.2**	**8.6**

(Source) Ministry of Finance and National Planning (2008)

The government has the debt management policy to maintain the overall debt stock within sustainable levels. The domestic debt has increased only 0.9% from 2007 to 2008 whereas the external debt has increased 8.6% during the same period. The increase of the external debt is due to the borrowing from ADB and World Bank as well as the rise in the private and parastatal debt.

In 2008 the government procured the new loan for ZESCO from the World Bank for the increased access to electricity. The loan amount is US$33.0 million. ZESCO also has the outstanding debt guaranteed by the government of K144944 million as of the end of 2008. This amount can be translated to approximately 5% of the total external debt of the government.

(4) Future Prospect

The government has established the macroeconomic targets for the period of 2008-2010 that include;

(i) Achieve real GDP growth of at least 7 percent a year

(ii) Bring down end-year inflation to no more than 5 percent by 2009

(iii) Limit domestic borrowing to 1.2 percent of GDP in 2008 and 1.0 percent of GDP in 2009 and 2010, and

(iv) Increase the coverage of gross international reserves to at least 2.4 months of import cover in 2008, 2.8 months of import cover in 2009 and 3.2 months of import cover in 2010.

The external debt strategy will remain to focus on sustaining a viable current account balance and debt position. While the government budget will rely on highly concessional loans, the external borrowing on commercial terms will be undertaken on a limited basis.

The government budget projection based on the Mid-Term Expenditure Framework (MTEF) for 2008-2010 can be summarized in the following table.

Table 0.6 Government Budget Projection (2008-2010)

		2008		2009		2010	
		Nominal Figure	% of GDP	Nominal Figure	% of GDP	Nominal Figure	% of GDP
GDP nominal (K billion)	(a)	51,559.0		56,670.0		61,475.0	
Total Revenue & Grants	(b)	11,728.5	22.7	12,794.3	22.6	13,757.0	22.4
Total Expenditure	(c)	12,680.4	24.6	13,759.7	24.3	14,803.0	24.1
Budget Deficit	**(d)=(b)-(c)**	**(951.9)**	**(1.8)**	**(965.4)**	**(1.7)**	**(1,046.0)**	**(1.7)**
Financing for Budget Deficit							
Domestic Financing	(e)	618.7	1.2	566.7	1.0	614.7	1.0
External Financing	(f)	333.2	0.6	398.7	0.7	431.3	0.7
Total	**(g)=(e)+(f)**	**951.9**	**1.8**	**965.4**	**1.7**	**1,046.0**	**1.7**
Total Balance	**(h)=(d)+(g)**	**0**		**0**		**0**	

Source) Consultant compilation based on Ministry of Finance and National Planning

The projection of the government budget from 2008 to 2010 remains tight given the difficult economic situation of the country and the world, and the tight borrowing ceiling policy. The domestic borrowing will be limited to 1.2% of GDP in 2008 and 1.0% of GDP in 2009 and 2010. The net external borrowing will be projected less than 0.6% of GDP in 2008 and 0.7% of GDP in 2009 and 2010.

The expenditure on the energy sector will also remain limited based on the MTEF. The below table summarized the expenditure budget projection by functional classification.

Table 0.7 Expenditure by Functional Classification (K billion)

Function	2008 METF	2009 MTEF	2010 MTEF
General Public Services	**4,164.9**	**4,334.3**	**4,167.5**
Executive	338.4	356.6	375.7
Legislation	444.2	670.8	340.7
General Government Services	2,649.0	2,558.0	2,552.0
Centralized Administrative Services	733.3	748.9	899.1
Defence	**822.0**	**898.4**	**978.4**
Public Order and Safety	**542.6**	**602.4**	**647.6**
Economic Affairs	**2,245.4**	**2,651.6**	**2,848.2**
General Economic	185.3	204.9	213.8
Agriculture	868.5	1,060.0	1,182.0
Fuel and Energy	48.3	66.5	69.6
Mining	43.2	36.9	38.7
Transport	1,085.8	1,267.6	1,327.0
Communication	14.3	15.7	17.1
Environmental Protection	**106.5**	**116.7**	**127.4**
Housing & Community Amenities	**829.7**	**904.5**	**979.4**
Health	**1,466.5**	**1,606.6**	**1,781.2**
Recreation, Culture & Religion	**143.3**	**244.5**	**232.5**
Education	**1,865.2**	**2,076.7**	**2,283.9**

The expenditure for the economic affairs will increase from K2245.4 billion in 2008 to K2848.2 billion in 2010 when the total expenditure will increase from K12675.9 billion in 2008 to K14291.6 billion in 2010. The increase rates for the economic affairs and the total expenditure during the period will be approximately 26.9% and 12.7%, respectively. Therefore the economic affairs would be one of the focuses of the budget allocation for the period. The allocation for fuel and energy will also increase.

(5) Investment Plan for Power Sector

ZESCO is currently preparing the next five-year corporate plan (2010-2014). The plan includes the investment program based on the demand forecast and the financing plan to implement the investment program. It was expected that the plan would be out by the final field survey in October, 2009 but to no avail. Therefore it is anticipated that the JICA Study would provide information on the system development program and investment plan.

(6) Private Financing Needs for Power Sector

The government recognizes the importance of developing the power system in the country by both of public and private sectors. The needs for rural electrification in the future are also well understood. On the other hand the financing needs for the future power development are beyond the government budget allocation to the energy sector.

The JICA Study estimates that the future financing needs for the power system development would be more than US$ 14 billion for the next twenty-one years including the financing from the private sector. On the other hand, the current budget allocation level for the economic affairs including other infrastructure is approximately K3,000 billion, which can be converted to US$ 600 million. Therefore it is unlikely for the government budget to finance the substantial portion of the development.

Given the government budget constraints, ZESCO would need to strengthen the partnership with private sector in the generation projects such as Kariba North Bank Extension and Itezhi-Tezhi Hydro Project. Kafue Gorge Lower is expected to mobilize the private financing for development. Maamba Thermal Power Project is also being planned by the private initiatives. There would also be additional thermal power development by private sector in the future. Therefore, the public private partnership (PPP) would be one of the critical keys for mobilizing the financial resources and the development in the future.

(7) Input-Output Economic Model

The investment and improvements in the capacity of the power system in Zambia will help catch up with the growing demand for the consumers and to meet the expanding the needs in the nation. The investment will also improve the reliability of the supply and the diversity of the energy mix by developing the thermal power plant. The development will also facilitate further regional cooperation in the power pool and help achieve the efficiency arrangement of the power development in the region.

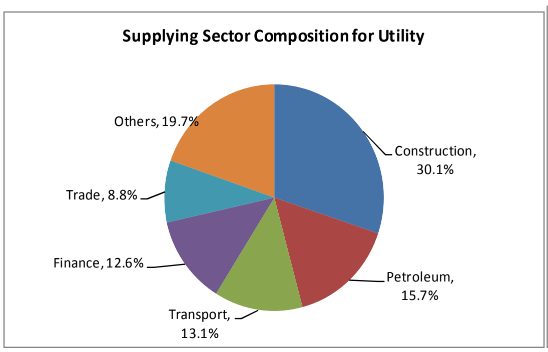
In the domestic context, the implementation of the development program will provide positive economic impacts by mobilizing the domestic resources for investment as well as attracting the foreign direct investment. The development program will enable the expansion of approximately 6,000MW additional generation capacity, the expansion of the new transmission line, and the upgrading of the distribution system. The investment will also serve as an important source of economic stimulus in many industries and areas.

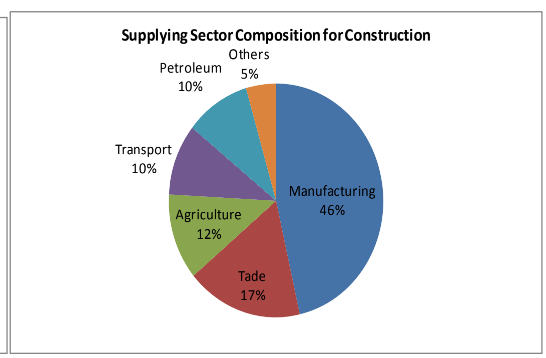
The economic impacts of the investment program for the power system can be classified into the two; the impact during the project implementation, the flow effect, and the impact after the completion of the project, the stock effect. The flow effect gives the demand effects on the related industry through the procurement associated with the project construction such as labor, materials and other services on the investment. The direct demand increase then develops further impacts on the economy through the cyclic activities from production, income generation, and consumption. Thus the flow has the two sub-components of the direct effect as well as the indirect and induces effects.

On the other hand, the stock effect is the impact that can be produces after the commissioning of the power system and by the provision of the power supply services. The power supply is expected to sustain the industry production and to develop another economic activity for example. The stock effect will continue throughout the life time of the facilities developed by the investment program. The Study focuses on the flow stock of the investment program due to the fact that the projection of the stock flow entails the assumptions of the various factors for the long-term period.

The Study uses the input-output economic analysis based on the information that was analyzed in 1995 by the Central Statistical Office of Zambia. The information is the latest input-output table in the nation. The original table classified the industries in the seventeen types such as agriculture, forestry & livestock, mining, food, textile, petroleum, manufacturing, utility, construction, trade, hotels& restaurants, transport, real estate, finance, community services, education, and public administration. The following table was adjusted by the Study to simplify the category into the fourteen (14) industries.

The utility industry is supplied by the construction and petroleum approximately 30% and 15%, respectively. The petroleum, transport and finance industries have also more than 10% shares for supplying the utility business. The construction industry is supplied by manufacturing industry for 46%. Therefore the investment in the utility affects wide-ranging industries in the nation.





Source) Compiled from input-output table (1995)

Figure 0.2 Supplying Sectors for Utility and Construction

Table 0.8 Input-Output Table for Zambia

Zambia Input-Output Table (ZMK billions in 1995 prices)

Supply of Commodities/ /Demand	01 Agric. Forestry	02 Mining	03 Food	04 Textile	05 Petroleun	06 Manifact.	07 Utility	08 Construction	09 Trade	10 Hotels	11 Transport	12 Real Estate	13 Finance	14 Education Public	Total of Intermediate Sectors	Final Demand: Consumption	Final Demand: Exports, etc	Final Demand: Total	Total Demand	(less) Total Imports etc	Domestic Production
01 Agric. Forestry	4.5	0.0	181.5	9.5	0.0	11.1	0.0	7.7	0.0	0.0	0.0	0.0	0.0	0.0	214.3	511.4	48.2	559.6	773.9	(21.2)	752.7
02 Mining	0	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	0.0	826.2	826.2	830.2	(210.1)	620.1
03 Food	3.5	0.0	26.3	0.0	0.0	0.0	0.0	0.0	0.0	23.1	0.0	0.0	0.0	0.9	53.8	479.0	36.7	515.7	569.5	(56.6)	512.9
04 Textile	0	0.0	0.0	27.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	28.0	50.6	42.7	93.3	121.3	(26.5)	94.8
05 Petroleum	2.4	42.1	1.9	0.8	9.9	26.1	7.1	6.3	13.9	2.3	46.5	3.5	0.9	24.9	188.6	65.4	1.5	66.9	255.5	(149.7)	105.8
06 Manifacturing	2.5	15.6	13.8	0.5	10.1	15.5	4.1	29.9	11.0	1.8	3.4	4.4	1.5	19.4	133.5	46.8	35.1	81.9	215.4	(73.9)	141.5
07 Utility	0	25.0	6.2	3.5	7.0	9.1	1.4	0.8	2.8	2.6	4.0	1.0	0.6	8.0	72.0	63.4	21.9	85.3	157.3	(25.5)	131.8
08 Construction	0	1.0	1.3	1.0	2.3	5.3	13.6	0.0	4.2	1.0	8.9	2.7	2.3	7.2	50.8	0.0	119.6	119.6	170.4	(44.6)	125.8
09 Trade	5.6	26.1	39.2	7.4	18.9	19.3	4.0	11.3	3.1	9.2	20.2	2.3	0.2	20.0	186.8	490.5	48.5	539.0	725.8	(62.0)	663.8
10 Hotels	0	0.0	0.0	0.9	1.1	1.8	0.0	0.0	0.0	0.0	3.1	2.9	0.0	8.6	18.4	71.1	0.0	71.1	89.5	(13.0)	76.5
11 Transport	5.3	7.9	7.1	6.0	5.7	8.6	5.9	6.4	131.3	3.9	79.6	8.6	9.6	17.3	303.2	63.1	59.4	122.5	425.7	(82.8)	342.9
12 Real Estate	6.3	1.8	5.3	1.0	3.4	2.6	0.4	1.1	15.5	2.7	2.7	3.7	1.8	17.2	65.5	127.7	38.1	165.8	231.3	(15.1)	216.2
13 Finance	0	4.8	1.1	1.8	1.4	1.8	5.7	1.0	10.6	2.1	5.5	1.7	63.5	5.0	106.0	38.9	0.0	38.9	144.9	(20.9)	124.0
14 Education Public	0	3.2	0.0	1.2	3.0	2.4	3.0	0.0	9.0	1.2	4.5	1.7	4.4	10.7	44.3	720.2	0.0	720.2	764.5	(133.6)	630.9
Total of Intermediate Sectors	30.1	131.5	283.7	60.8	62.8	103.6	45.2	64.5	201.4	49.9	178.4	32.5	84.8	140.0	1,469.2	2,728.1	1,277.9	4,006.0	5,475.2	(935.5)	4,539.7
Compensation	50.5	241.5	58.9	13.3	28.6	44.2	40.8	28.9	111.8	105.7	66.6	21.4	49.8	359.9	1,221.9						
Net Operating Surplus	671.2	24.6	165.0	14.2	9.6	(14.3)	42.3	31.7	328.6	(90.5)	79.7	154.3	(14.9)	2.4	1,403.9						
Consumption of Fixed capital	0	204.0	5.3	6.0	4.8	7.0	2.5	0.0	20.3	6.0	18.1	7.4	4.2	129.2	414.8						
Others	0.9	18.5	0.0	0.5	0.0	1.0	0.0	0.7	1.7	5.4	0.1	0.6	0.1	0.4	29.9						
Total of Value Added	722.6	488.6	229.2	34.0	43.0	37.9	85.6	61.3	462.4	26.6	164.5	183.7	39.2	491.9	3,070.5						
Domestic Production	752.7	620.1	512.9	94.8	105.8	141.5	130.8	125.8	663.8	76.5	342.9	216.2	124.0	631.9	4,539.7						

Source) Adjusted from data of Central Statistical Office of Zambia (2009)

a. Direct Spending

The investment program will make payments to many entities such as vendors and contractors from which the services and materials are procured. The payments can be classified into material& equipment, construction and others. Others include the government agencies that collect duties and fees. The expenditures to each vendor can be summarized in the categories listed in the below table.

Table 0.9 Direct Spending Amount

	Amount (US$ million)	Percentage (%)
Material & Equipment	7,944	55.8
Construction	6,286	44.2
Total	14,230	100.0

Source) Estimates by JICA Study Team (2009)

b. Indirect and Induced Effects

The direct spending will also give the indirect and induced effects as the capital continue to flow through the national economy. These indirect and induced impacts are determined by analyzing the relations among the industries by applying the input-output information by the Central Statistical Office. The analysis assumes that the composition and relations among the industries remain the same as 1995. The below table shows the result of the analysis assuming that ZMK 100 million investment is made in the power sector in Zambia.

Table 0.10 Indirect and Induced Economic Effects

Classification		Domestic Consumption	Primary Impact		Secondary Impact	
			Production Induced	Compensation Induced	Production Induced	Compensation Induced
01	Agric. Forestry	0.00	0.00	0.00	0.00	0.00
02	Mining	0.00	0.00	0.00	0.00	0.00
03	Food	0.00	0.00	0.00	0.02	0.00
04	Textile	0.00	0.13	0.02	0.00	0.00
05	Petroleum	0.00	0.59	0.16	0.09	0.02
06	Manifacturing	0.00	13.64	4.26	0.00	0.00
07	Utility	81.20	0.00	0.00	0.15	0.05
08	Construction	0.00	0.00	0.00	0.03	0.01
09	Trade	0.00	3.01	0.51	0.01	0.00
10	Hotels	0.00	1.35	1.87	0.05	0.06
11	Transport	0.00	0.00	0.00	0.03	0.01
12	Real Estate	0.00	10.86	1.08	0.00	0.00
13	Finance	0.00	0.00	0.00	0.00	0.00
14	Education Public	0.00	0.00	0.00	0.23	0.13
	Total	81.20	29.58	7.89	0.61	0.28

Source) Compiled by JICA Study (2009)

The investment of ZMK 100 million would have approximately 81.2% affects in the national economy in Zambia. The primary impacts on the production and the compensation would be around 29.6 and 7.9 million, respectively. On the other hand the secondary is the impacts on the economy that would be induced by the primary affects. The analysis has given the rather small impacts on the production and compensation of approximately 0.6 and 0.3 million, respectively.

(8) Macro-economic Analysis

The JICA Study Team recognized that the Ministry of Finance and National Planning has a macro-economic analysis model to analyze the economic activities including the impact of a large infrastructure investment. Since the model is confidential to other parties, it was not materialized to use the model for the macro-economic analysis during the study period. However the JICA Study Team had a few meetings with the concerned officers in the government and recommended to use the model to assess the economic impacts of the master plan. Therefore, it is expected that the government will carry out the macro-economic analysis after the acceptance of the final report based on the data and information handed over to the Department of Energy.

Financial Analysis

It is critical for the timely implementation of the investment plan to confirm the scenarios for financial resources that guarantee the future investment plan. Since the large size of the investment naturally requires the significant amount of the borrowings, the capital injection by the government and/or the private capital. Therefore, it is very important to confirm the forecast of the financial plan that includes the payment for the purchase of the private power and the repayment of the debt guaranteed by the government. The investment plan was discussed with the various stakeholders in Zambia, and the future projection of the financial position of ZESCO was carried in order to assess the future outlook of the finances of the power sector.

The major objectives for the financial analysis in the JICA Study are to (i) highlight the long-term financing needs for ZESCO in comparison with the scenarios that ZESCO initially planned and (ii) confirm the tariff adjustment possibility to finance the ZESCO's operation. In particular, since ZESCO filed the tariff adjustment to ERB in February, 2009, the JICA Study tried to compare with the ZESCO's original plan on the same ground and to highlight the difference. Therefore the Study basically used the ZESCO financial model and share most assumptions with the ZESCO original analysis. This will also benefit ERB and other decision makers to refer the results to the ZESCO analysis and compare the consequences of the study outputs.

The report basically discuss the result of the financial analysis based on the scenario 1-1 even though the analyses were made for both the scenario 1-1 and 1-2 because the scenario 1-1 imposes more severe conditions for ZESCO finance. The difference in the both results were also very marginal.

(1) Assumptions for Analysis

The study period is from Year 2009/10 to 2030/31.

a. Assumptions for Revenue

(i) Macroeconomics

The exchange rate is assumed to be US$1 = ZMK4700. The inflation rate in Zambia is assumed to be 15% in 2008, 12% in 2009 and 10% in 2010 and thereafter. The producer price inflation is assumed to be 3.5% in 2008 and 2009, and 2.5% in 2010 and thereafter.

(ii) Demand and Annual Sales

The electricity sales for the base case is expected to follow the below table.

Table 0.11 Projected Demand Growth and Annual Sales (GWh)

Year	2009	2019	2011	2012	2013
Energy Sent Out	11,022	12,477	14,566	15,299	15,736
Distribution Loss	1,508	1,529	1,561	1,325	1,378
Transmission Loss	331	374	437	459	472
Projected Sales	9,184	10,574	12,567	13,516	13,885
Year	**2014**	**2015**	**2016**	**2017**	**2018**
Energy Sent Out	16,542	16,855	17,188	17,539	17,908
Distribution Loss	1,433	1,472	1,512	1,554	1,599
Transmission Loss	496	506	516	526	537
Projected Sales	14,613	14,878	15,160	15,458	15,771
Year	**2019**	**2020**	**2021**	**2022**	**2023**
Energy Sent Out	18,297	18,754	19,238	19,751	20,293
Distribution Loss	1,646	1,702	1,761	1,823	1,888
Transmission Loss	549	563	577	593	609
Projected Sales	16,101	16,490	16,901	17,336	17,796
Year	**2024**	**2025**	**2026**	**2027**	**2028**
Energy Sent Out	20,867	21,474	22,117	22,797	23,517
Distribution Loss	1,958	2,032	2,110	2,192	2,279
Transmission Loss	626	644	664	684	706
Projected Sales	18,283	18,798	19,344	19,921	20,532
Year	**2029**	**2030**			
Energy Sent Out	24,279	25,086			
Distribution Loss	2,372	2,470			
Transmission Loss	728	753			
Projected Sales	21,179	21,864			

(Source) Compilation by JICA Study

The above figures are the projected supply data, which are calculated by the demand forecast and the supply capacity based on the development plan.

(iii) Power Tariff

ERB made the decision on the tariff adjustment for 2009 and 2010 on July 20th, 2009. The ERB board decision allows that with effect from 1st August, 2009, the average tariffs for the 2009/10 and 2010/11 have been increased by 35% and 26% respectively. The revised tariffs are as follows.

Table 0.12 Revised Electricity Tariffs

Customer Category	2009 to 2010	2010 to 2011
Residential	Increase: 40% New Tariff: K170.97/kWh	Increase: 33% New Tariff: K264/kWh
Large Power (MD3 & MD4)	Increase: 42% New Tariff: K110.19/kWh	Increase: 33% New Tariff: K264/kWh
Small Power (MD1 & MD2)	Increase: 40% New Tariff: K170.97/kWh	Increase: 33% New Tariff: K264/kWh
Commercial	Increase: 40% New Tariff: K170.97/kWh	Increase: 33% New Tariff: K264/kWh
Services	Increase: 40% New Tariff: K170.97/kWh	Increase: 33% New Tariff: K264/kWh
Average	Increase: 40% New Tariff: K170.97/kWh	Increase: 33% New Tariff: K264/kWh

(Source) Board Decision, Energy Regulatory Board (2009)

ERB states that the tariff revision falls within the current three-year multi-year tariff framework from 2008 to 2011. Thus the tariff revision in 2009 runs up to March 2011. Then after that a new tariff framework will be considered.

While the current tariffs are still below cost, ERB finds that ZESCO's service quality has generally deteriorated and that ZESCO needs to increase the budget allocation for maintenance costs. It has also been identified that ZESCO needs a recapitalization in strengthen the financial basis. The efforts for improving management performance needs to be continued such as the high staff costs, trade receivables, and billing/collection. The discussions on the restructuring issue of ZESCO have also been recommended to the government by ERB.

Based on the ERB decision, ZESCO announced the detailed tariff adjustment on July 20th 2009 as follows.

Table 0.13 ZESCO Revision of Electricity Tariffs

		Current Tariffs	Approved Tariffs
1. METERED RESIDENTIAL TARIFFS	(Capacity 15kVA)		
R1-Consumption up to 100kWh	Energy Charge/kWh	K77.00	K107.80
R2-Consumption above 101 to 400kWh	Energy Charge/kWh	K127.00	K177.80
R3-Consumption above 401kWh	Energy Charge/kWh	K207.00	K289.80
	Fixed Monthly Charge	K7, 411.00	K10, 375.40
Pre-paid	Energy Charge/kWh	K141.00	K197.40
2. COMMERCIAL TARIFFS	(Capacity 15kVA)		
C1-Consumption up to 700kWh	Energy Charge/kWh	K165.00	K209.55
	Fixed Monthly Charge	K29, 607.00	K37, 600.89
3. SOCIAL SERVICES TARIFFS			
Schools, Hospitals, Orphanages,	Energy Charge/kWh	K144.00	K180.00
Churches, Water pumping, Street Lighting	Fixed Monthly Charge	K24, 972.00	K31, 215.00
4. MAXIMUM DEMAND TARIFFS			
MD1-Capacity between 16 - 300kVA	MD Charge/kVA/Month	K8, 068.00	K10, 165.68
	Energy Charge/kWh	K116.00	K146.16
	Fixed Monthly Charge	K79, 018.00	K99, 562.68
MD2-Capacity between 301-2000kVA			
	MD Charge/kVA/Month	K15, 094.00	K19, 018.44
	Energy Charge/kWh	K99.00	K124.74
	Fixed Monthly Charge	K158, 035.00	K199, 124.10
MD3-Capacity between 2001-7500kVA			
	MD Charge/kVA/Month	K24, 973.00	K35, 461.66
	Energy Charge/kWh	K80.00	K113.60
	Fixed Monthly Charge	K346, 808.00	K492, 467.36
MD4-Capacity above 7500kVA	MD Charge/kVA/Month	K25, 112.00	K35, 659.04
	Energy Charge/kWh	K66.00	K93.72
	Fixed Monthly Charge	K693, 615.00	K984, 933.30

NOTE:
The above tariffs are:
(a) Exclusive of 3% Government excise duty
(b) Exclusive of 16% Value Added Tax (VAT)

Notice is hereby given that the Energy Regulation Board has approved revised electricity tariffs from

1st August 2009. This notice is being given in accordance with the requirements of section 8 subsection 2 of the Electricity Act CAP 433 of the Laws of Zambia. The fixed, energy, and demand charges will be as given below. Electricity bills based on the new charges should therefore, be received by our customers in August 2009.

(Source) ZESCO (2009)

The above tariff increase would allow ZESCO to proceed to the cost reflective tariffs towards the year 2011. The JICA Study analysis took the announced new tariffs in the financial analysis.

The power tariff was set each year to accommodate the revenue requirements to sustain the power sector business including (a) operating expenses, (b) depreciation, (c) financial costs, (d) taxation, and (e) return on net fixed assets. The allocation by business unit and by customer group is also considered. It is also assumed that the power tariff will be adjusted at the beginning of ZESCO fiscal year to reflect the full cost of services.

The analysis model for JICA Study is modified from the ZESCO model. The basic assumptions are also shared in the Study. ZESCO and ERB can benchmark the outputs with the existing tariff study.

b. Assumptions for Cost

(i) Depreciation

The ZESCO's financial accounting estimates of asset life as follows.

- Generation civil works and all the buildings: 50 years
- Generation plant and machinery: 30 years
- Transmission system: 25 years
- Distribution system: 20 years
- Others: 5 years

(ii) New Generation Plants

The development schedule for major generation plants is as shown in the following table that has been discussed in the previous section of the report.

Table 0.14 New Generation Plants

COD	Project	Province	Type	Developer	Capacity (MW)	Annual Energy (GWh)	Project cost (m US$)
2013	Kariba North (ext)	Southern	RES	ZESCO	360	380	358
	Itezhi Tezhi	Southern	RES	ZESCO/TATA	120	611	170
2014	Lusiwasi (ext)	Central	ROR	ZESCO	10 40	40 160	134
	Maamba Coal	Southern	Thermal	Private	200	1,536	240
2015	Mutinondo	Northern	ROR	Power Min	40	188	77
	Luchenene	Northern	ROR	Power Min	30	139	75
2016	Kabwelume Falls	Luapula & Northern	RES	LPA	62	324	140
	Kumdabwika Falls		RES	LPA	101	533	226
	Lunsemfwa	Central	RES	LHPC	55	462	271
	Mkushi	Central	RES	LHPC	65	223	141
2017	Kafue Gorge Lower	Lusaka	RES	n.y.	750	2,400	1,745
2018	Kabompo Gorge	North Western	RES	CEC/TATA	34	176	115
2019	Devil's Gorge	Southern	RES	ZRA-ZESCO	500	2,802	1,808
2021	Mumbotuta Falls	Luapula	RES	n.y.	301	1,449	510
2023	Mpata Gorge	Lusaka	RES	ZRA-ZESCO	543	3,785	2,442
2025	Mambilima Falls II	Luapula	RES	n.y.	202	1,003	708
2027	Batoka Gorge	Southern	RES	ZRA-ZESCO	800	4,373	1,828
2029	Mambilima Falls I	Luapula	RES	n.y.	124	609	481
					4,337	**21,116**	**11,469**

(Source) Compilation by JICA Study

(iii) Key Performance Improvement

The efficiency improvement and cost reduction projections are assumed to achieve in accordance with the performance agreement with ERB. These would include (a) customer metering, (b) cash management, (c) staff productivity, (d) quality of services, and (e) system loss.

Particularly the number of the employees will be reduced to achieve the ratio of customers per employee. After the confirmation of the achievement, the employees in generation, transmission and distribution can be allowed to increase based on the business base expansion such as the ZESCO installed capacity, the energy sent out in GWh and the distribution system expansion. Other operating expenses are assumed to increase reflecting the general inflation. The costs of fuel, lubricants and water charges are linked to the energy generated in GWh and escalated for Zambian inflation.

(iv) Taxation

The taxation rate is 35% for ZESCO. Available tax losses from previous periods are considered for the subsequent years.

(v) Power Purchase Tariff

The major power purchase tariffs are based on the cost estimation of the generation plants that are going to provide energy to ZESCO. The import power tariffs are also based on the current trade arrangement with the related organizations and the engineersôestimates of the JICA Study. The current power purchase price is estimated at 7.00 US cents /kWh, and will be adjusted in the subsequent years based on the price escalation projection.

c. Assumptions for Cash Flow

(i) Investment Needs

The assumed investment amounts are based on the least cost power system planning and transmission line system analysis by the JICA Study.

Table 0.15 Power Sector Investment Program Overview

		Scenario1-1			**Scenario1-2**		
		Installed capacity (MW)	Energy (GWh)	Investment (MUSD)	Installed capacity (MW)	Energy (GWh)	Investment (MUSD)
-2015	**Total**	**800**	**3,054**	**1,054**	**800**	**3,054**	**1,054**
	Hydro	600	1,518	814	600	1,518	814
	Coal	200	1,536	240	200	1,536	240
2016-2020	**Total**	**1,567**	**6,920**	**4,446**	**1,667**	**8,726**	**3,358**
	Hydro	1,567	6,920	4,446	1,067	4,118	2,638
	Coal	0	0	0	600	4,608	720
2021-2025	**Total**	**1,046**	**6,237**	**3,660**	**800**	**4,991**	**2,168**
	Hydro	1,046	6,237	3,660	500	2,687	1,808
	Coal	0	0	0	300	2,304	360
2026-2030	**Total**	**924**	**4,982**	**2,309**	**844**	**5,234**	**2,952**
	Hydro	924	4,982	2,309	844	5,234	2,952
	Coal	0	0	0	0	0	0
Total	**Total**	**4,337**	**21,193**	**11,469**	**4,111**	**73,059**	**9,532**
	Hydro	4,137	19,657	11,229	3,011		8,212
	Coal	200	1,536	240	1,100	8,448	1,320

(Source) JICA Study

(ii) Borrowing

90% of the future capital expenditure is assumed to be financed by debt and the rest of 10%

will be by equity. The assumption on the debt financing is that 85% is in US dollars and 15% is in Zambian Kwacha. The interest rates for US dollars and Zambian Kwacha are assumed to be 12% and 25%, respectively. These conditions are the same of those ZESCO applied in the financial projections.

(2) Findings from Financial Analysis

(i) Overall Financial Performance

The salient features for the ZESCO financial performances are as indicated in the following table.

Table 0.16 ZESCO Financial Performance

Year	2009	2010	2011	2012	2013
Operating Margin (%)	34.5%	38.8%	34.2%	32.1%	35.9%
Margin after Dividends (%)	15.8%	16.8%	11.2%	10.0%	12.3%
Retained Profit (K mil.)	307,594	404,753	395,933	494,245	690,204
Return on Fixed Assets (%)	15.9%	13.4%	12.6%	14.4%	16.4%
Year	**2014**	**2015**	**2016**	**2017**	**2018**
Operating Margin (%)	34.8%	34.5%	34.5%	31.4%	29.5%
Margin after Dividends (%)	12.2%	12.3%	12.6%	11.7%	11.5%
Retained Profit (K mil.)	778,594	857,987	956,356	919,553	950,246
Return on Fixed Assets (%)	16.5%	16.4%	17.6%	16.4%	16.0%
Year	**2019**	**2020**	**2021**	**2022**	**2023**
Operating Margin (%)	26.6%	23.7%	21.2%	21.6%	19.6%
Margin after Dividends (%)	10.5%	9.5%	8.6%	6.8%	8.1%
Retained Profit (K mil.)	897,562	853,834	819,779	694,908	887,765
Return on Fixed Assets (%)	14.7%	13.6%	12.4%	13.1%	12.1%
Year	**2024**	**2025**	**2026**	**2027**	**2028**
Operating Margin (%)	18.8%	17.6%	17.3%	16.5%	15.5%
Margin after Dividends (%)	6.6%	7.0%	6.8%	6.7%	6.3%
Retained Profit (K mil.)	771,725	874,063	921,366	970,132	970,900
Return on Fixed Assets (%)	11.9%	11.5%	12.1%	12.3%	12.2%
Year	**2029**	**2030**			
Operating Margin (%)	14.1%	12.8%			
Margin after Dividends (%)	6.7%	6.3%			
Retained Profit (K mil.)	946,611	921,629			
Return on Fixed Assets (%)	11.7%	11.3%			

(Source) Compilation by JICA Study

The analysis results of the margin show the sound financial performance. The asset return is also generally more than the expected level of eight percent.

(ii) Operating Costs

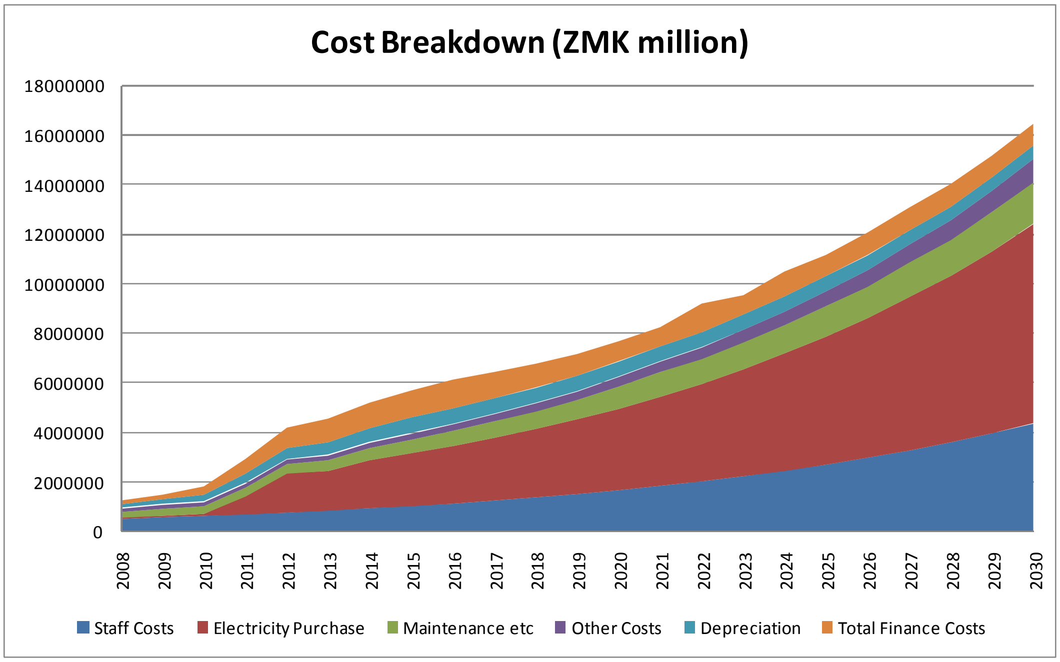
The operating costs of ZESCO for each customer group will change over the next twenty years as follows.

Table 0.17 Breakdown of Operating Costs 2009-2030 (% of total)

Year	2009	2010	2011	2012	2013
Power Purchase	5.0%	4.1%	24.8%	37.7%	34.9%
Payroll	40.3%	36.6%	24.6%	18.9%	19.2%
Fuel & Maintenance	19.3%	17.6%	11.7%	8.9%	9.7%
Depreciation	11.9%	15.3%	12.5%	10.3%	10.9%
Financing	13.6%	17.6%	20.5%	19.8%	20.9%
Others	9.8%	8.8%	5.8%	4.4%	4.5%
Total	100.0%	100.0%	100.0%	100.0%	100.0%
Year	**2014**	**2015**	**2016**	**2017**	**2018**
Power Purchase	37.5%	37.5%	38.0%	39.3%	40.8%
Payroll	18.5%	18.6%	18.9%	19.7%	20.6%
Fuel & Maintenance	9.3%	9.5%	10.0%	10.5%	10.5%
Depreciation	10.7%	10.9%	10.1%	9.6%	9.1%
Financing	19.8%	19.2%	18.7%	16.4%	14.3%
Others	4.3%	4.3%	4.3%	4.5%	4.7%
Total	100.0%	100.0%	100.0%	100.0%	100.0%
Year	**2019**	**2020**	**2021**	**2022**	**2023**
Power Purchase	41.9%	42.6%	43.7%	42.7%	45.1%
Payroll	21.4%	22.0%	22.6%	22.2%	23.6%
Fuel & Maintenance	10.9%	11.9%	12.1%	11.0%	11.7%
Depreciation	8.5%	7.9%	7.4%	6.6%	6.4%
Financing	12.4%	10.6%	9.2%	12.5%	8.1%
Others	4.8%	4.9%	5.0%	4.9%	5.2%
Total	100.0%	100.0%	100.0%	100.0%	100.0%
Year	**2024**	**2025**	**2026**	**2027**	**2028**
Power Purchase	45.0%	46.0%	46.5%	47.2%	47.7%
Payroll	23.5%	24.3%	24.8%	25.2%	25.8%
Fuel & Maintenance	10.8%	11.2%	10.6%	10.8%	10.5%
Depreciation	5.8%	5.4%	5.0%	4.3%	3.9%
Financing	9.6%	7.7%	7.6%	7.0%	6.5%
Others	5.2%	5.4%	5.4%	5.5%	5.6%
Total	100.0%	100.0%	100.0%	100.0%	100.0%
Year	**2029**	**2030**			
Power Purchase	48.1%	48.8%			
Payroll	26.2%	26.6%			
Fuel & Maintenance	10.6%	10.2%			
Depreciation	3.6%	3.3%			
Financing	5.8%	5.3%			
Others	5.7%	5.8%			
Total	100.0%	100.0%			

(Source) JICA Study Team (2009)

The actual cost breakdown is also shown in the below figure.



(Source) JICA Study (2009)

Figure 0.3 Cost Breakdown

The staff costs show a moderate increase compared with the total cost but a slightly higher than other costs such as maintenance and depreciation. On the other hand, the electricity purchase is expected to increase substantially over the period due to the increase of the purchase from IPPs.

(iii) Cost of Service

The projected cost of services for each category can be summarized in the following.

Table 0.18 ZESCO Cost of Services (in ZMK/kWh)

Year	2009	2010	2011	2012	2013
Mining	151	205	284	324	332
Residential	358	451	549	598	629
Large Power	172	224	304	360	380
Small Power	178	228	317	382	407
Commercial	313	393	490	544	576
Overall Ave.	207	266	344	388	407
Year	**2014**	**2015**	**2016**	**2017**	**2018**
Mining	360	384	399	406	416
Residential	678	723	752	765	780
Large Power	414	447	467	474	483
Small Power	444	480	501	505	512
Commercial	623	670	702	718	737
Overall Ave.	440	472	494	505	518
Year	**2019**	**2020**	**2021**	**2022**	**2023**
Mining	424	436	451	479	489
Residential	795	817	842	894	904
Large Power	491	505	521	560	563
Small Power	518	531	546	589	587
Commercial	757	780	806	859	870
Overall Ave.	531	549	570	610	621
Year	**2024**	**2025**	**2026**	**2027**	**2028**
Mining	513	531	552	575	592
Residential	948	975	1,009	1,045	1,074
Large Power	595	612	634	658	675
Small Power	621	636	658	682	698
Commercial	916	944	981	1,019	1,050
Overall Ave.	657	680	709	740	765
Year	**2029**	**2030**			
Mining	615	640			
Residential	1,111	1,149			
Large Power	699	724			
Small Power	721	745			
Commercial	1,090	1,131			
Overall Ave.	797	830			

(Source) Compilation by JICA Study

The supply costs of services of ZESCO will increase for all the customer categories. The residential customer will have a large increase until 2012. The increase after 2012 however is a moderate because the tariff will achieve the cost-reflective level by the time. The overall average cost shows the increase from 207 ZMK/kWh in 2009 to 830 ZMK/kWh in 2030. The increase can be translated to approximately seven percent per year. The increase would be a little lower than the assumed average domestic inflation rate which is ten percent per year.

(iv) Cash Position

The projections for the cash flow statements are as shown in the below.

Table 0.19 Cash Flow Statements (in ZMK million)

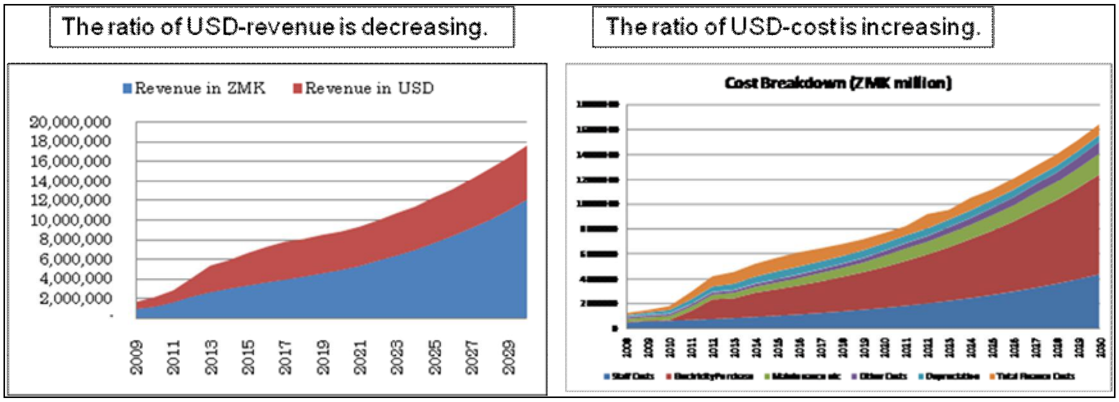
Year	2009	2010	2011	2012	2013
Cash Flow from Operation	649,700	897,527	975,238	1,190,880	1,554,744
Net Cash Outflow from Financial Services	(160,729)	(271,095)	(551,092)	(778,242)	(892,192)
Net Cash Flow from Capital Expenditure	(390,190)	(634,891)	(879,941)	(969,825)	(1,142,049)
Adjust. Income Tax Paid	(165,627)	(217,944)	(213,195)	(266,132)	(371,648)
Increase(Decrease) in Cash	(66,846)	(226,402)	(668,990)	(823,320)	(851,145)
Accumulated	246,482	455,968	213,368	(77,689)	(185,537)
Year	**2014**	**2015**	**2016**	**2017**	**2018**
Cash Flow from Operation	1,754,516	1,941,708	2,090,446	2,031,269	2,075,971
Net Cash Outflow from Financial Services	(965,753)	(1,023,689)	(1,068,511)	(970,043)	(880,164)
Net Cash Flow from Capital Expenditure	(1,290,891)	(1,439,710)	(1,453,013)	(1,464,084)	(1,478,018)
Adjust. Income Tax Paid	(419,243)	(461,993)	(514,961)	(495,144)	(511,671)
Increase(Decrease) in Cash	(921,371)	(983,684)	(946,038)	(898,002)	(793,882)
Accumulated	(268,423)	(328,121)	(244,237)	(151,952)	77,508
Year	**2019**	**2020**	**2021**	**2022**	**2023**
Cash Flow from Operation	1,992,404	1,922,582	1,869,175	1,677,077	1,973,790
Net Cash Outflow from Financial Services	(789,786)	(705,627)	(632,151)	(1,018,650)	(625,083)
Net Cash Flow from Capital Expenditure	(1,471,492)	(1,407,336)	(1,285,530)	(1,185,413)	(1,149,665)
Adjust. Income Tax Paid	(483,303)	(459,757)	(441,420)	(374,181)	(478,028)
Increase(Decrease) in Cash	(752,177)	(650,138)	(489,925)	(901,168)	(278,985)
Accumulated	291,937	561,312	954,226	801,421	1,478,491
Year	**2024**	**2025**	**2026**	**2027**	**2028**
Cash Flow from Operation	1,795,229	1,952,661	2,025,445	2,055,417	2,038,614
Net Cash Outflow from Financial Services	(852,181)	(686,609)	(726,866)	(700,117)	(675,073)
Net Cash Flow from Capital Expenditure	(1,136,734)	(1,123,938)	(1,033,843)	(1,045,385)	(1,057,935)
Adjust. Income Tax Paid	(415,544)	(470,649)	(496,120)	(522,379)	(522,792)
Increase(Decrease) in Cash	221,859	612,764	760,855	832,293	828,399
Accumulated	1,700,349	2,313,113	3,073,968	3,906,261	4,734,660
Year	**2029**	**2030**			
Cash Flow from Operation	1,997,072	1,958,650			
Net Cash Outflow from Financial Services	(624,929)	(583,437)			
Net Cash Flow from Capital Expenditure	(1,043,864)	(1,030,404)			
Adjust. Income Tax Paid	(509,713)	(496,262)			
Increase(Decrease) in Cash	837,993	841,071			
Accumulated	5,572,652	6,413,724			

(Source) Compilation by JICA Study

The cash arrangement for ZESCO would be an issue during the period when the large amount of investment would be made, particularly from 2012 to 2017. The cash requirement will be mostly due to the projected expansion of the transmission network. After the year 2018, ZESCO will have a sound cash position.

(v) Tariff Adjustment Framework

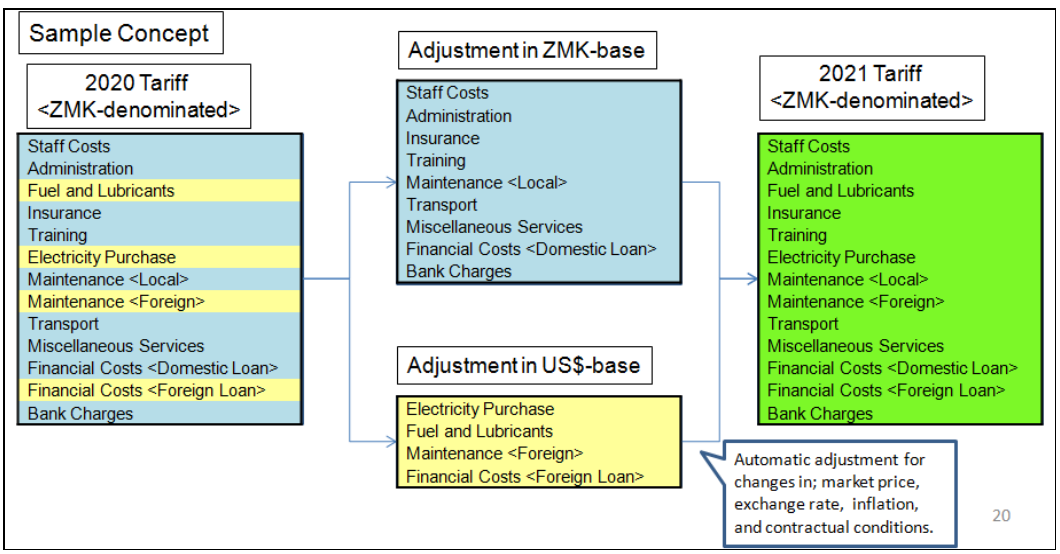
Due to the investment needs in the future, the cost denominated in US dollars will increase over the next twenty years. On the other hand, the revenue in US dollars, which is currently paid by the mining customers, may not increase as much as the revenue increases in US dollars. Therefore there is a concern that the gap may take place in the foreign-currency accounts.



(Source) JICA Study (2009)

Figure 0.4 Revenue and Cost in USD

The sample concept for disintegration of the cost items is shown in the following chart.

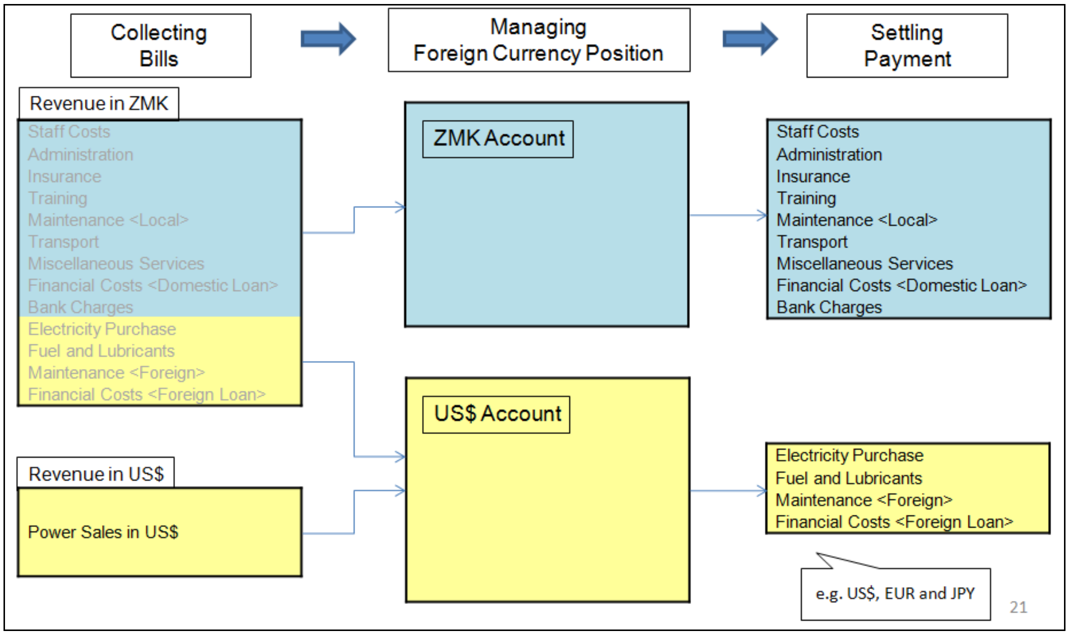


(Source) JICA Study (2009)

Figure 0.5 Disintegration of Tariff Structure

Most of the cost items are based on the Kwacha whereas some items are foreign currency based such as fuel, electricity purchase, maintenance cost for imported equipment and financial expenses for foreign loans. Therefore it is preferable to disintegrate the two portions of Kwacha and foreign currency for tariff adjustment. The two portions will have different ratios and increase rates in the cost breakdown and hence the different needs for tariff adjustment. An automatic adjustment scheme would also benefit the timely cost recovery and adjustment.

Once the two-part tariff adjustment is introduced, it would be easy to manage the foreign currency accounts to settle the payments. The flow diagram is as illustrated in the following.



(Source) JICA Study (2009)

Figure 0.6 Foreign Currency Management

The revenue of the foreign currency denominated portion, which is still paid in Kwacha by the retail customers, can be exchanged to the foreign currencies depending on the payment needs such as USD, EUR an JPY. The bank account of foreign currency base can be managed separately from the domestic currency account.

Recommendation on Economic and Financial Issues

ZESCO aims to continue the improvement of management including the reduction of personnel costs. The Study has found some important factors and future perspectives on the management of power sector. The following items are critical for the economic and financial matters on the power sector master plan.

(1) Future Perspectives for Capital Expenditure

The development plan shows the optimum scenario for future capital expenditure. The study expects that the sequential development will be conducted according to the proposed schedule. However if the development plan faces any slippage in the schedule, ZESCO would need to procure power from neighboring countries and may need additional funds for the purchase. The delay in the project schedule would therefore cause another increase of the power tariff.

The study proposed an alternative measure to address the issue by considering the coal-fired thermal power plants by imported coals. Although the additional study needs to be carried out to assess the feasibility and bankability, it is recommended to look into the alternative scenarios at an early stage in order to prepare for the unexpected situations.

(2) Financing for Future Investment

As the investment plan shows, the large amount cash expenditure projects are planned in the coming years, particularly from around 2012 to 2016. While the power tariff is expected to achieve the economic tariff that reflect the cost of power services, the funds to invest in the additional infrastructure still remains an issue to ZESCO. The study assumed that ninety percent of the fund would be contributed by the debt financing that would presumably guaranteed by the government. However the discussion on the financial issue needs to be carried out with the Ministry of Finance and National Planning.

(3) Cost of Services

The cost of services will increase due to the factors such as the inflation, the additional development requirements, the investment to improve the efficiency and reliability of power supply, and the payment obligation to IPPs. On the other hand the efficiency gain is also expected including the system loss reduction, the operation cost reduction in real term, and the overall cost saving from the scale of economy. The supply costs could also be further reduced by the utilization of the SAPP interconnection. It is recommended that ZESCO would take various initiatives to improve the management performance in a proactive manner and demonstrate the achievements to the concerned parties including ERB.

Moreover, it is expected that ZESCO would improve the service efficiency and performance in terms of the services from metering, billing, and collection. These would include the overall service level improvement for customers as well as the reduction of the receivables.

(4) Foreign Currency Position

ZESCO has basically two currencies for revenue such as Zambian Kwacha and US Dollars because the payment from mining customers is made in the foreign currency and the retail customers pay in the local currency. ZESCO then utilize the revenue in foreign currency to settle the payment for the debt services in foreign currency, the import equipment, the power purchase, and goods, and others. Currently ZESCO has s surplus in the foreign currency account balance due to the revenue from the power sales in foreign currency. However it is expected that the payment in foreign currency will increase over the period due to the increase of the power purchase from the private power producers. Therefore given the potential depreciation of the local currency against the foreign currency, the foreign currency management is increasingly important and critical for ZESCO. Even at this point, the exchange fluctuation causes the impact on the profit of ZESCO. In terms of the management of the foreign currencies, ZESCO's account will face the cash shortage in the future due to the increase of the foreign cash payment to the IPPs. Therefore the asset and liability management will be important to ZESCO.

(5) Power Tariff Adjustment

As shown in the financial analysis, the regular tariff adjustment will be inevitable even if the performance of ZESCO will improve due to the power supply cost increase. Therefore ERB should adjust the power tariff in a continuous and timely manner based on the ZESCOøs performance and the economic and business situations. The consideration on the power tariff continues to be critical because it would have a significant impact on the ZESCO finance. In addition, the foreign currency portion in the power tariff should also be adjusted in a timely manner to reflect the changes in foreign exchange to address the settlement needs for foreign currencies.

Current Status and Issues

The private investment will be an important vehicle for the power sector development in Zambia because the public funding would not be sufficient to sustain the continued and increasing needs for investment. However the current framework and environment for private investment are not always attractive for private investors even though some legal bases have been established. This section will review the current status and issues on the private investment promotion.

(1) National Public Private Partnership (PPP) Policy

National Public Private Partnership (PPP) Policy has been formulated in November, 2008 by the Ministry of Works and Supply. The objectives of the policy are to facilitate the PPP development to ensure the economic growth through enhanced productivity, improved competitiveness and wealth creation. The aims will also be applicable to the power sector for maximizing the benefits of private sector participation such as (i) Accelerated implementation of infrastructure projects, (ii) Efficient services to the public, (iii) Opportunities for business for local entrepreneurs, (iv) Access to infrastructure and services by the public, (v) Positive impact on social and economic welfare. The power sector has already identified some specific projects for private participation. All the private investment projects are expected to produce the above-mentioned benefits.

The PPP policy stipulates the guiding principles for undertaking the PPP projects including (i)Feasibility, (ii)Affordability, (iii) Bankability of Projects for Financiers and Developers, (iv)Value for Money, (v)Appropriate Risk Allocation, (vi)Economic and Social Benefits, (vii)Citizens Empowerment, (viii)Decentralization and (ix)Corporate Social Responsibility.

The PPP Policy has also identified wide-ranging arrangements for PPP such as service contract, management contract, lease, concession, build operate transfer (BOT)/ build own operate transfer (BOOT), and divestiture (privatization). Thus it is expected that the Government would seek appropriate form of contract and encourage innovation in project formulation.

The PPP policy will be implemented by a PPP Unit to be established in the Ministry of

Finance and National Planning as an Independent Statutory Body. The unit is expected to coordinate, administer and monitor PPP in Zambia. The contracting ministries and local authorities will play a lead role in project implementation with the assistance of the PPP unit. It is not however clear how the PPP unit will work with OPPPI in the case of power sector. Therefore it is strongly encouraged that the clear legal and regulatory framework is put in place by a new PPP legislation that will cover all the relevant sectors and organizations.

(2) The Framework and Package of Incentives for Private Participation in Hydropower Generation and Transmission Development (FPI)

The Framework and Package of Incentives for Private Participation in Hydropower Generation and Transmission Development (FPI) was published by the Government. The framework has not been revised for the last ten years, and would need to be updated based on the current economic and technical development.

(a)Finance

The financial resources are expected to be mobilized in the development concept of FPI. Thus project sponsors need to secure the sufficient revenue from the power sales in order to serve loans. Nevertheless the power tariff level appears to be low to achieve the sector goals of private sector participation. It is also noted that GRZ was not in a position to provide any types of government guarantees on the power sector projects including the partial guarantees due to the conditions of the debt relief package under the Highly Indebted Poor Countries (HIPC) Initiative. However the Study Team was notified that GRZ is now in a position to provide the government guarantees on power sector. Therefore sovereign guarantees can be considered to future projects in consultation with the Ministry of Finance and Planning.

The corporate tax may be exempted on incomes from sales or transmission of power according to FPI. The custom duties, value-added tax and other charges may be exempted. In addition, the provision states free repatriation of dividends and equity for private power projects. These tax and fiscal incentives should be aligned to prevailing laws and regulations.

(b)Power Tariff

Power tariff is administered by ERB including generation and transmission prices. The procedure to determine and approve the tariff for private power projects would follow the current methodology as far as the tariff would have significant impacts on ZESCO and hence public. The electricity costs for large consumers would be much lower than other consumers such as domestic and small commercial uses. However ERB would consider the social impacts on the private investment projects and may intervene in the tariff approval even in the case of power purchase agreements between private companies.

The procedure for application of bulk power tariff will be reviewed by ERB based on the application by project sponsors that need to provide a year-wise tariff profile for the first 30 years of the project. However except the four major tariff components, detail procedure and data requirements are not provided. ERB therefore need to provide a guidance and sample applications for project sponsors to clarify the basis for the regulation.

The transmission service charge is also described in FPI. The framework states that the sponsors will be paid service charges covering capital and maintenance cost including return on equity. ERB needs to develop and provide a detail methodology to estimate the charges. The Study Team identified a potential for international and domestic transmission line development by private sector particularly when ZESCO may not have a sufficient credit to mobilize the capital for long-distance transmission line development.

(c)Water Rights

Water rights are another issue for hydro project development. First, there is a mismatch between the duration of the water right approval of five years and the project life of hydropower, which is usually more than 30-50 years. Second, the hydropower use is not prioritized in the law. The draft water resources development act prioritizes the domestic use, environmental purposes, and agricultural purposes more than industrial use including hydropower. Therefore, there is always a risk not to have the water rights renewed if other prioritized needs emerge after the commissioning of hydro projects since the water rights for hydropower generation is not guaranteed by the relevant law. FPI provide a misleading message in this aspect.

(d)Institutional Framework

Office for Promoting Private Power Investment (OPPPI), which is established in MEWD is mandated to coordinate and lead the private investment in the power sector and the implementation of FPI. OPPPI needs to coordinate with various organizations to achieve the tasks such as ZDA, Ministry of Finance and Planning, Treasury Office, Ministry of Justice, and ERB in addition to private sector.

PPP Policy also aims to establish a PPP unit. Since the future private investment will have various modalities such as PPP, concessions and service contract, the coordination would be critical. Therefore the coordination by OPPPI will be increasingly important.

According to FPI, Government will support sponsors in the following actions for large hydropower projects including (i) appointment of an independent panel of experts from the start, (ii)extensive evaluation of site alternatives, and (iii)resolution of upstream and downstream issues. GRZ needs to specify and distinguish what would be regulatory and approval aspects to secure the environmental matters and what would be supporting aspects for project sponsors that may not have expertise on the matters. The conditions for development imposed by GRZ should be articulately provided to project sponsors. Otherwise the government interventions could be used for political measures.

(e)Open Access

While the grid code has been established in Zambia, it is not yet put into operation because of no or limited transactions in the country. However the demand for open access will be larger in the near future due to the increasing demand for diversified, cheaper and more reliable electricity. An independent system operator has not yet been put in place. Thus the regulator has not established an effective monitoring and regulatory system to ensure the efficient and fair trade of electricity.

The Study Team also learned that the revision of the grid code is being discussed by a committee led by ERB. The members of the committee include ERB, MEWD, CEC, other private firms and other stakeholders in the power sector. The discussion at the committee would lead to a possible structural reform of the power sector because the issues include the roles and responsibilities as well as the organizational setup for the system operator.

The current FPI assumes that ZESCO is to identify, describe and recommend the least-cost blocks of capacity and related infrastructure services required for the national grid. The function involves the forecasting of the future demand scenario and the planning of infrastructure investment. However the future role of ZESCO on the future planning will be changing because the independent system operator, if once established, may take over the function and ZESCO would be one of the power utility companies in addition to other generation and transmission utilities. ZESCO will however remain a major vertically integrated power company in Zambia, and need to plan its power system development.

(3) Key Issues

This section aims at identifying and analyzing the current status and issues for private investment. The major issues related with the private investment in the power sector in Zambia can be analyzed from the following viewpoints such as (i) finance, (ii) generation tariff, (iii) water rights, (iv) institutional framework, and (v) open access.

Finance

Some of the articles in FPI are not supported by legislations. Good samples of these issues are the corporate tax and custom duties. Even though the concept has been included in the policy paper, no clear legal documents appear to be provided. Thus private investors are not really sure how to proceed. These conditions should be put into statutory orders.

The funding for private projects will also be an issue for some project sponsors. Even though FPI proposes the establishment of Private Sector Infrastructure Development Fund and Hydro Planning Fund, no successful actions appear to be taken to materialize the funds. With the global financial crisis in 2008, the fund mobilization will be increasingly difficult for any private companies to develop hydropower in particular. Thus the public funding can be revisited to facilitate the timely development.

Power Tariff

The current power tariff level in Zambia is still less attractive to project sponsors if the current tariff level is applied to their generation project. In addition, ERB will need to take into considerations the financial and social impacts on the domestic consumers if the off-taker of the power is not a private firm but ZESCO.

ERB will need to establish a methodology for determining a tariff profile for project life in consideration of the profitability of the project and the economic and financial impacts on the current stakeholders including the domestic, commercial and industrial consumers as well as the power utilities.

Water Rights

The water rights have been a big concern and issue for hydropower project sponsors. In the Draft Water Resources Development Act, the priority for hydropower use is lower than the domestic purposes, the environmental purposes, and the agricultural use. The actual application of the law to the hydropower projects would not be clear for the long-term project life of hydropower in particular. Since OPPPI cannot make decisions on the water rights issue, OPPPI will need to closely coordinate with other organizations.

Institutional Framework

Even though OPPPI has a mandate to coordinate the private sector participation, the legal instruments have been weak to support the articles in FPI and the activities of OPPPI. The specific incentives for example should be entrenched in the specific law in order to protect the rights and profits of project sponsors. Therefore the FPI should be strengthened to increase the credibility and the instruments for administrative directions should be institutionalized in OPPPI.

The several initiatives and activities in government organizations need to be streamlined and strengthened. The private investment in the power sector entails comprehensive approach on cross-cutting matters in order to assist in investment. For instance while ZDA is supposed to be a one-stop office for investment projects, OPPPI will need to exchange information and coordinate the advisory and administrative services with ZDA. The tax issue can also be clearly explained and instructed by OPPPI on behalf of other government offices.

The Public Private Partnership (PPP) unit has been established in the Ministry of Finance and National Planning (MOFNP). The detailed inter-ministry arrangement for coordinating the PPP projects is not however still yet established, particularly on the coordination on financing and incentives issues. As discussed the private investors are sensitive to the financial an fiscal conditions associated with the investment such as the corporate income tax, import duty, and VAT. The future prospects and directions on the provision of the government guarantee are not under the discussion in the government departments including the guarantee for debt financing and power purchase agreement.

(e)Open Access

Open access has not been secured yet in Zambia even though the grid code has been established. GRZ will need to establish a appropriate legal and regulatory structure to implement open access, and develop/secure adequate capacity to plan and regulate the transmission line services. ERB's capacity to upgrade the grid code and enforce the regulation will need to be improved in order to achieve the efficient system development.

The discussions on open access will touch on a possible restructuring of the power industry. In fact international practices imply that the transparent and efficient operation of power system should be secured by an independent system operator. Since the function is currently undertaken by ZESCO, the introduction of system operator would result in the organizational restructuring of the incumbent power utility. The Study however does not originally intend to examine the sector reform methodology but aims to study the measures to successfully promote the private investment projects. Therefore the discussion would focus on the effective measures to introduce and expedite private investment projects.

Private Investment Promotion Plan

Needs Assessment and Financial Capacity

The Study conducted a series of interviews with the possible private investors in Zambia. The interviewee companies included the following.

Table 0.20 Possible Investors in Power Sector in Zambia

No.	Name of Company	Name of Project	Method of Selection	Capacity (MW)	Status of Project
1	Lusemfwa Company	Lusemfwa/ Mkushi River	Negotiation	147	F/S to be completed by June 2010
2	Mwinilunga Power Co.	West Lunga	Negotiation	3 + 3	PPA under negotiation with ZESCO
3	CEC/TATA	Kabompo Gorge	Bidding	34	F/S ongoing. PPA negotiation will be started in 2009.
4	Lunzua Power Authority (Olympic Milling)	Kalungwishi	Bidding	62 + 101	I/A under negotiation
5	Power Min Co.	Mutinondo/ Luchenene	Negotiation	40 + 30	No F/S has been completed.
6	TATA	Itezhi Tezhi	Negotiation	120	D/D ongoing.

Even though the other promising generation projects will also be undertaken by private firm, those projects have not identified and/or selected project sponsors. It is also not easy to discuss those projects when the project formulation and arrangement are ongoing. Therefore the Study will eliminate those projects from the examination such as Kafue Gorge[28], Lusiwasi Expansion, and Maamba Project.

Lusemfwa Company

Lusemfwa Company is currently the only independent power producers in Zambia that has a 18MW capacity. The majority shareholder is Eskom, the South African power utility. Lusemfawa intends to develop Lusemfwa/ Mkushi River Project.

[28] Kafue Gorge Project is currently being studied and prepared by IFC. The pre-qualification of the project sponsor will be completed by 2009, and the construction is planned to be started in 2011.

The proposed project has three power plants with the capacity of 55MW, 60MW and 32MW. The generated power is expected to be sold primarily to ZESCO. The feasibility study is going to be completed by 2010 including geological survey. The information memorandum is also expected to be finalized by the end of 2009. At the moment Lusemfwa is negotiating with financial institutions on funds. Information has also been sent to ERB for review on the license application and environmental clearance.

Lusemfwa identified a few viewpoints for GRZ to improve the environment for private investment in the power sector.

- A guideline by GRZ can be easy to understand for private investors including FPI.
- Water Act should be aligned with other laws such as Electricity Act and Energy Policy
- ERB should be operationalized on the open access issue.

The company anticipates necessary funding for the project from the corporate bond and financial institutions such as DBSA and IFC. Even the project requires a transmission line of 15km, the company intends to upgrade the existing substation of ZESCO and to construct the transmission line on behalf of ZESCO in order to accelerate the project implementation.

Mwinilunga Power Co.

Mwinilunga Power Co. runs a small hydropower plant (1MW) in the isolated area of the northwest region of Zambia. The company intends to develop West Lunga Project in Mwinilunga district with the capacity of 6MW in total. The two sites include Kakokakaw and Kanyikomboshi.

The feasibility study has been completed and the letter of intension for development has been sent to OPPPI. The environmental brief has also been sent to the environmental council. The negotiation with ZESCO is ongoing on the PPA. Since the project area is in the rural area, the project may be able to tap the subsidy fund from REA. Given the power cost for the area is about 41 US cents/kWh due to the high cost of diesel generation, the project will be a economical solution for the region.

The company is expected to sell the generated power to ZESCO and the region will be provided the power. A concession contract is also another option for the project whereby the Mwinilunga Power Co. will generate the power and operate the isolated distribution system on behalf of ZESCO. If the concession is materialized and successful, the regional investors and local government can demonstrate a proven business model and increase the confidence in rural development by a private company.

CEC/TATA

Kabompo Gorge Project is currently being developed by the joint venture of CEC and TATA. The project was advertised for public bidding and three bids were submitted approximately two years ago. The joint venture of CEC and TATA was selected in October 2008 as a successful bidder. The feasibility study will take twelve months and the application of license will be submitted after the feasibility study is completed.

The project sponsor identified a few issues on the project and the private development in general.

- The cost of F/S is borne by private sector, which may be a bottleneck for some investors.
- The project needs an access road including the 34km government road that needs a repair and upgrade. Since the road is managed by the road development agency, the timely construction with sufficient budget is extremely important to the project.
- The hydrological data is critical for improving the estimates of energy generation and the project viability. The government and the water board can assist in the data acquisition.
- The government process for the project application should be shortened, simplified and streamlined. It takes too much time.
- Tax benefits have not been adequately spelt out in the laws.
- The tariff regulation by ERB[29] should not be applicable to a direct PPA agreement with industrial consumers. The cap regulation on the project return does not make sense to private projects.
- GRZ can consider financing for the infrastructure necessary for the implementation of private projects such as access roads.

Lunzua Power Authority

Luzua Power Authority is a subsidiary company of Olympic Milling Company. Luzua Power Authority is a project sponsor for the Kalungwishi Project (173MW). The company was selected by an open bidding in 2007. The company and GRZ are currently negotiating the implementation agreement. The feasibility study was carried out by Harza in 2000.

Since the project requires a 510km transmission line to evacuate the generated power, the total project cost would exceed US $600 million. While the primary off-taker of the power is expected to be ZESCO, there is a possibility to supply the power to the other private companies in Zambia as well as other countries.

Luzua Power Authority has pointed out issues associated with the private power development in Zambia.[30]

- Water right issue remains a large concern for private investors.
- Hydrological risk is also a big concern due to the limited, reliable data available for estimating the energy production.
- The environmental issues are also getting more and more critical in addition to relocation due to the project. GRZ states that these risks should be borne by private project sponsors by

[29] ERB mentioned that Electricity Act is also applicable to private investment projects. ERB would also review the import tariff by private companies.
[30] Luzua Power Authority did not raise the mobilization of funds for project implementation as an issue for the project.

nature.

- The incentive programs by the government should also be strengthened such as fiscal incentives.

Power Min Co.

Power Min Company identified the Mutinondo/ Luchenene Project themselves on an unsolicited basis unlike many other private investment projects in Zambia. The feasibility study is being considered and the company is looking for financial sources for the F/S. The implementation agreement is also under preparation. The discussion on the off-taking arrangements and PPA is also a future task as well.

The company has identified the following issues on the private investment projects.

- Funding is an issue for Power Min even for the feasibility study cost. The mobilization of funds for implementation will also be an issue.
- The assistance by OPPPI is expected in terms of project formulation and implementation. Especially the water right and environmental clearance can be facilitated by OPPPI.
- The pricing conditions on the project implementation are not clear to the company.

Since the company has just started the preparation for the necessary study for the project, it is suggested that the company get in touch with OPPPI and obtain necessary information.

TATA

In addition to Kabompo Gorge Project, TATA is participating in the hydropower development for Itezhi Tezhi Project (120MW). The joint venture of ZESCO and TATA[31] is currently finalizing the formulation of the project implementation arrangement. The project cost is estimated to be US$150 million.

The feasibility study has been completed and approved. The project sponsor has already forwarded the PPA proposal to ZESCO. At the same time, the proposals for EPC contract are expected to be submitted in 2009. Currently the project sponsor is supported by the transaction adviser in the discussion on PPA.

Debt financing for the project may be provided by the international financial institutions such as EIB, DBSA and AfDB. The government guarantee for the debt finance has not been discussed yet. The issues on the project may be the operation of the three power plants including Itezhi Tezhi Plant, where the dispatch function would be managed by a system operator. The company wishes to have a concession agreement with the government that would include the financial conditions such as tax benefit, holding tax, import duty, VAT and others.

Since the project is expected to be one of the most promising projects in the near future, GRZ should demonstrate a showcase to other private investors by the successful

[31] The participation rates for the joint venture are ZESCO (50%) and TATA (50%).

implementation of Itezhi Tezhi Project. In particular, since the project sponsor is the joint venture of ZESCO and TATA, this is the first major initiative for the public private partnership. The financial institutions are also reported to show interests to support the project implementation by a concessional financing.

Recommendation on Private Investment Promotion

The environment for private investment promotion can be improved and enhanced from the viewpoints that are already identified as bottlenecks for development.

To provide clear framework and system for encouraging private investment

The framework should be updated and strengthened by necessary statutory instruments on the issues such as incentives for tax/duty, grid code/open access, environmental matters, and other legislations and regulations.

Many investorsôconcerns do not rest in the profitability and the technical risks of the specific projects but in the unclear legal situations and surrounding regulatory circumstances. If the conditions for the investment such as various taxes and import duties are certain to the investors, the investors will be more confident on the project implementation.

To accelerate processes for the review and approval of private investment project

There are already some projects in the pipeline that are waiting for administrative guidance and clearance. The instruction and support by GRZ are critical for implementation of projects because the advices of the government would drive the directions of the projects. The critical aspects on the projects include (i)environmental issues, (ii)licensing for project development, (iii)power tariff and PPA negotiation, (iv)design and construction, and (v)water rights matters.

The process should also be simplified and clearly understood by private investors. Some private investors also complain the slow processing by the government organizations and the complexity of clearance procedures. Since some of the investors could be new to the power market in Zambia, the facilitation by the government experts would lower the barriers to enter the market.

To enhance the capacity for coordination and review of the applications of the private power development

ERB appears to be occupied with the burning issues at hand such as the tariff issues, the monitoring of the performance agreement with ZESCO, and the revision of the grid code. ERB can take the lead in establishing the standard and good practice for regulating the private investment projects. FPI can also be upgraded to reflect the recent changes in the power sector and articulate the scope of works and the methodology for the regulation of the private power development by ERB. The tariff negotiation will be increasingly important when dealing with the diverse needs of different private investors and projects.

OPPPI will continue to be a focus and critical point for private sector participation in the power sector. It is significant for OPPPI to establish a credible position in coordinating the power projects. In addition to establishing a clear legal framework for the activities by OPPPI, the capacity and human resources need to be mobilized and developed in terms of the contract matters, project planning and coordination with various stakeholders both within and outside of GRZ.

To increase the government support to fund the project preparation and implementation by the private sector

Funds to support the private sector initiatives need to be revisited. There would be certainly needs and benefits for the intervention by the government for instance to mobilize the domestic capitals by local investors even though the number of the domestic investors would be less than the international players.

GRZ has already prepared several financial and fiscal incentives for the implementation of the private investment. These benefits should be realized and enjoyed automatically upon initiating the project implementation so that they can contribute to attracting more succeeding investment projects.

The hydrological data can also be collected and accumulated by public institutions such as the water board in order to use for future projects. The reliability of information will reduce the investment risks and hence increase the welfare of the consumers.

The government funds for infrastructure development that are related with the power projects also play a significant role in the project implementation. These would include the access road construction, the substation and other facilities for evacuating power, the information and communication facilities, and the other social services. These public facilities and services should not be a bottleneck for the implementation of private investment projects. The coordination by OPPPI is also critical in this aspect. The proposed PPP unit in the Ministry of Finance and Planning should also work with OPPPI to resolve the budget issues.

GIS Database

GIS introduction

Geographic information systems (GIS) perform comprehensive management, processing, and visual display of data with position-related information (spatial data) based on geographical location, to facilitate sophisticated analysis and prompt decision-making. The construction of a GIS database from the results of the master plan study for power development in Zambia will not only facilitate confirmation of results but also be of extensive use in future studies.

In the master plan study for rural electrification in Zambia implemented from May 2006 to January 2008, data for the medium-voltage distribution system and rural growth centres (RGC) were added to the existing GIS data in such forms as geographical information in the possession of Zambian administrative institutions.

This study will add data collected through the Study Team activities to the existing GIS data upon a review of the latter and consultation with the C/P.

GIS utilization and existing databases

GIS utilization

Although there is no GIS in the DOE, the counterpart institution in this study, there is one in the Department of Planning and Information (DOPI), which is also attached to the Ministry of Energy and Water Development (MEWD). In addition the Rural Electrification Agency (REA), the counterpart institution in the aforementioned RE master plan study, has Arc View and employs a GIS expert (a GIS officer engaged in management of design and construction for the medium-voltage distribution system). Similarly, DOE staff received training in Arc View and therefore basically know how to operate it.

Outside the power sector as well, GIS are in extensive use. Table 13.1 lists cases of GIS utilization in JICA schemes.

Effective use of combinations of these GIS databases (baseline information) could make possible various planning applying GIS.

Table 0.1 Examples of JICA schemes related to GIS databases in Zambia

Name of scheme	C/P	Productive of the scheme
Study for compilation of information on geology and mineral resources to promote investment in the mining sector	-Ministry of Mines and Minerals Development	-Map of mineral resource distribution -Geological map
Lusaka primary health care project	-Ministry of Health -Lusaka department of health (LDHMT)	-Map of health facilities -Places of residence of people with cholera
Capacity-building program for decentralization of power	-Cabinet Office -Ministry of Finance and National Planning -Ministry of Local Government and Housing	-Urban planning maps

(Source) JICA Study team

* GIS utilization in the REA

The work of RE promotion in the REA provides good examples of effective use of GIS databases. This use is outlined below because it is thought to furnish useful information for the transition to actual implementation of the master plan.

* Examples of RE promotion work

(1) Work flow

1) On-site visits to areas slated for RE

2) Use of GPS to plot routes for extension from power supply points (ends of existing distribution lines or substations if the lines are newly installed) on electrification routes

The GPS plot points are as follows.

-- Power supply points

-- High-voltage (HV; 33- or 11kV) feeders and line ends to be extended

-- Locations of pole transformers

-- Medium-voltage (MV; 400 V) feeders and line ends

-- Bridges on extension routes (for determination of river crossing locations)

-- Receiving customers

-- Locations of other items (route curves and other items whose location must be determined for route planning)

3) Preparation of GIS data

Use of GIS to map extension routes based on the plot points noted in section 2) above. Plots are not made for the points slated for pole erection (these points are generally determined from the prepared maps, on the basis of a 50-m span as the standard)

4) Preparation of design drawings

Charts are prepared by CAD based on the GIS data noted in Item 3).

5) Preparation of integration (addition) tables for materials used

Preparation of a bill of quantity (BOQ) required for extension work based on the design drawings noted in Item 4), and calculation of the requisite number of poles by dividing the route distance by the standard span

6) Determination of contractors

a. Submission of design drawings and BOQs to the Zambia Public Power Authority (ZPPA)

b. Announcement of the construction work to construction companies upon ZPPA approval of the drawings etc.

c. Determination of the construction company through performance of tenders or other procedures

7) Execution of the construction

Execution of the construction upon conclusion of the contracting agreement

8) Hand-over to ZESCO

Inspection of the facilities by the REA upon completion of the construction and hand-over to ZESCO

(2) Tool software used in this work

- GIS: Arc GIS Ver.9 (Arc View)
- GPS: eTrex Venture HC manufactured by Garmin (incorporated into the Arc GIS using the GPS interface)
- CAD: AutoCAD Ver.7

(3) Requisite manpower for the work

Ordinarily, one REA staff member visits each site to perform the work noted in items (1)-1) and -2) (employment of up to 8). This work can be completed within a period of 0.5 - 1.0 days per site.

The GIS officer prepares the GIS database and performs other work involving slips (work for 25 sites within 3 - 4 weeks)

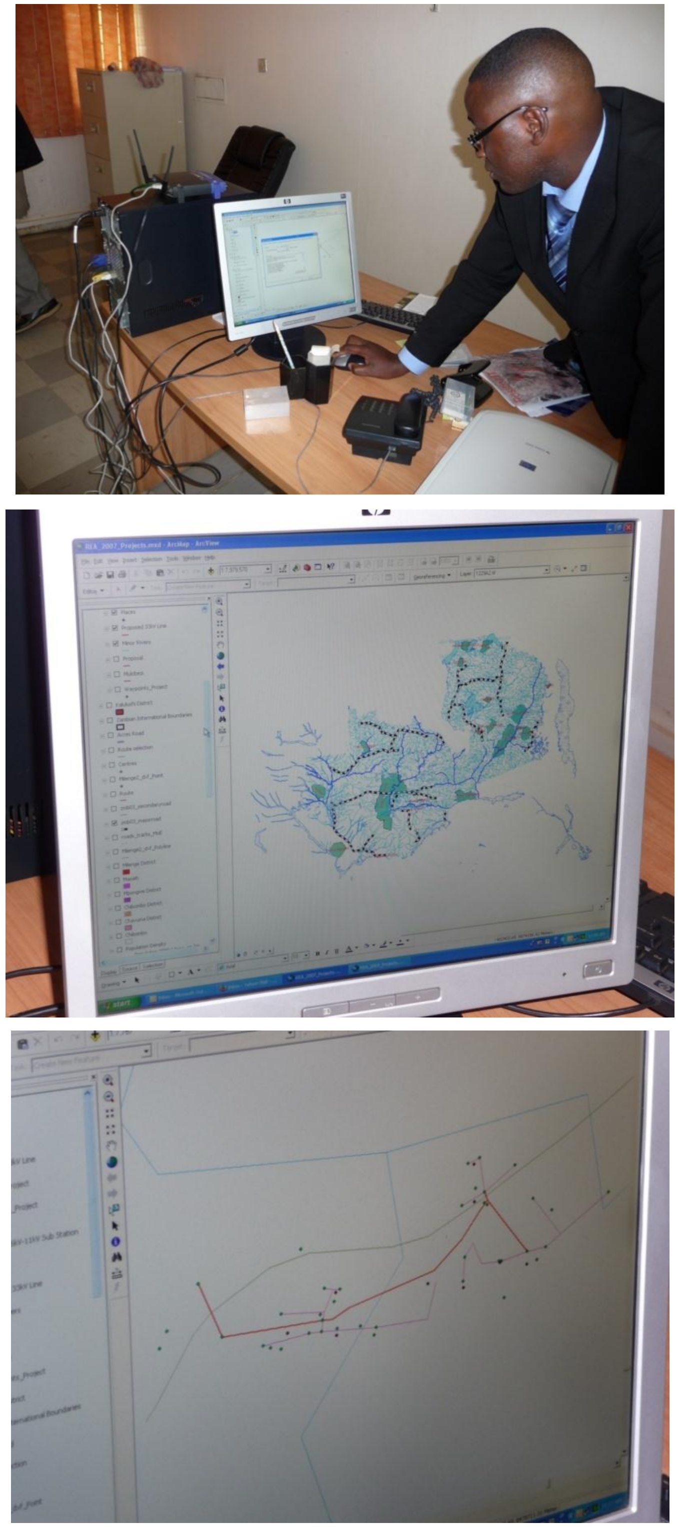


Figure 0.1 GIS environment in REA (photo)

Existing GIS databases

Table 13.2 shows the GIS databases based on information obtained from the concerned institutions through the field survey. These databases were built with data collected from the RE master plan study. They are managed in units of administrative institutions, and contains information on major infrastructure and other elements in Zambia.

However, they contain some information that uses different coordinates and consequently lacks a conformance of scale as well as other information not particularly needed for this study. In addition, they lack some requisite information, such as topographical data.

Therefore, it is necessary to compile requisite information through further study work (including re-collection and in-depth study).

Table 0.2 GIS databases at present

Administrative institutions	Databases
—	Map of Africa, national borders in Africa, provincial and county borders in Zambia
Ministry of Agriculture and Cooperatives	Farming districts, farms
Ministry of Education	Primary schools (electrified/unelectrified/without water), junior high schools, village centers, trunk roads, ordinary roads, national parks, railways, rivers, wetlands, dams, drainage conduits
Ministry of Energy and Water Resources	Transmission line routes, hydropower stations, diesel power stations, substations
Ministry of Environment, National Resources, and Tourism	Forests, grasslands, roads, railways, rivers
Department of National Statistics	Electoral districts, roads
Ministry of Health	Medical facilities, primary schools
REA	RGC, distribution line routes

(Source) Prepared by the Study Team based on information from the RE master plan

Construction of the GIS database

Selection of GIS applications

Of the GIS application software currently available in the market, the Study Team selected Arc View for the GIS in this study. Arc View has one of the major shares of the GIS market, and has also been adopted for the RE master plan in Zambia. In addition, it has many users who are oriented toward studies of expansibility through data exchange with other GIS software, and is steadily evolving as a result.

Furthermore, DOE staff were trained in Arc View in connection with the RE master plan study.

Guidelines in conditioning of the GIS environment

Efforts were made to prepare the survey results into a GIS database that would match the needs of the C/P and concerned institutions.

More specifically, the prerequisites included avoidance of a situation in which the database could not be easily updated and go out of use if the product exceeded the skills of users, and the need for sure database management (swift data revision, smooth data provision, and management of amplified versions) into the future.

The Study Team ascertained the needs among the C/P and other concerned institutions, and made judgments on the types of role that could be played by each.

In consideration of the above, the following is a proposal of the type of involvement with the GIS database on the part of the concerned institutions.

* DOE:

The DOE is the central organization charged with directing the master plan, and in a position to exercise leadership for the power system development in this study. It must interlink the GIS databases that are at the concerned institutions and specialized for their work, and direct the power system development in multiple aspects, including environmental considerations, locations of mineral resources, and city planning. Because the collection of information related to power systems spans a wide range, it would be unreasonable to expect the DOE to perform all the collection and database construction itself. Therefore, the DOE should seek provision of information from the concerned institutions, check the content, and perform the conversion processing for input into the GIS database (the specific procedure for this processing is contained in the related manual).

* REA:

As the administrative institution promoting rural electrification, the REA desires to be constantly supplied with the latest information on the progress and orientation of power system development. It is presumably most interested in the location and demand situation at bulk supply points involved in the extension of medium-voltage distribution lines, and supply points, whose installation expands from bulk supply points. A check with the REA revealed that, at present, it does not make proposals on matters such as the establishment of supply points and is engaged solely in design for extension from the existing points. However, the projection of a change of demand in the retail division as suggested by plans for development of provincial cities indicates a need for coordination of views with the Ministry of Local Government and Housing, ZESCO, and other concerned entities. Knowledge of micro-grid system demand represented by solar home systems (SHS), micro hydropower, and other such sources constituting potential demand as viewed from the perspective of the on-grid system would also be important for dealing with future demand increase and system planning. The REA would be suitable for leading collection of information on such items.

* ZESCO:

ZESCO is on the front lines of power system development and management, and the primary principal for technical promotion of the master plan. It has the most information on plans and actual data regarding the power system. As such, ZESCO would, properly speaking, be best qualified to act as administrator in connection with this environment. Nevertheless, this would pose the risk of detraction from information accuracy, as ZESCO also performs the development design and management itself. For this reason, it would be advisable for ZESCO to perform design and production of related GIS databases on its own initiative, and to construct an operational routine for periodic inspection by the DOE as the administrative body. (As used here, the term "production" does not refer to the production of run-format files for GIS software; details of such production are contained in the related manual.)

* CEC

The CEC ranks alongside ZESCO as an enterprise supporting the power system in Zambia. It possesses information on the mining sector, which largely determines the trend of power demand. In addition, in formation of its own system facilities, it must pay attention to changes in the demand of the distribution system of ZESCO, which supplies power through its own facilities. As a result, like ZESCO, it must be a GIS database builder. GIS database design (framework design), however, should be unified, and ought to be led by ZESCO. In other words, the CEC would be a database builder and party that refers to data. Other private enterprises (Lunsemfwa etc.) may be treated in the same way as the CEC.

Augmentation of GIS databases by the approach outlined above would enable more in-depth and progressive power development. As a secondary benefit, it would also refine the GIS databases of other concerned governmental institutions and thereby contribute to Zambia's advancement.

Deliverables

Following figure shows the deliverable of this study regarding GIS database. We would aspire to accept it and revising, managing and growing it by each ministry.

Table 0.3 Configlation of GIS database

Super Class	Sub Class	GIS data	Attribute
Root	0_World landscape	Operational Navigation tool	Layer
		World Shade relief	Map Document
	1_Zambia landscape	Zambia map UTM35	Shape file
		Zambia photo map UTM35	Raster data set
	2_Recent data	330kV transmission	Shape file
		220kV transmission	Shape file
		132kV transmission	Shape file
		88kV transmission	Shape file
		66kV transmission	Shape file
		Hydro power stations	Shape file
		Substations	Shape file
		Diesel stations	Shape file
		Proposed hydro power stations	Shape file
		Proposed thermal power station	Shape file
		Network facilities	Map Document
		Point facilities	Map Document
	3_Recommendation	Plan in 2015	Map Document
	for Scenario 1-1	Plan in 2020	Map Document
		Plan in 2025	Map Document
		Plan in 2030	Map Document
		Related data	Shape file
	4_Rcommendation	Plan in 2015	Map document
	For Scenario 1-2	Plan in 2020	Map document
		Plan in 2025	Map document
		Plan in 2030	Map document
		Rlated data	Shape file
	5_Reference 1		
	(PEMP data)		
	6_Reference 2		
	(misc. in PMP)		

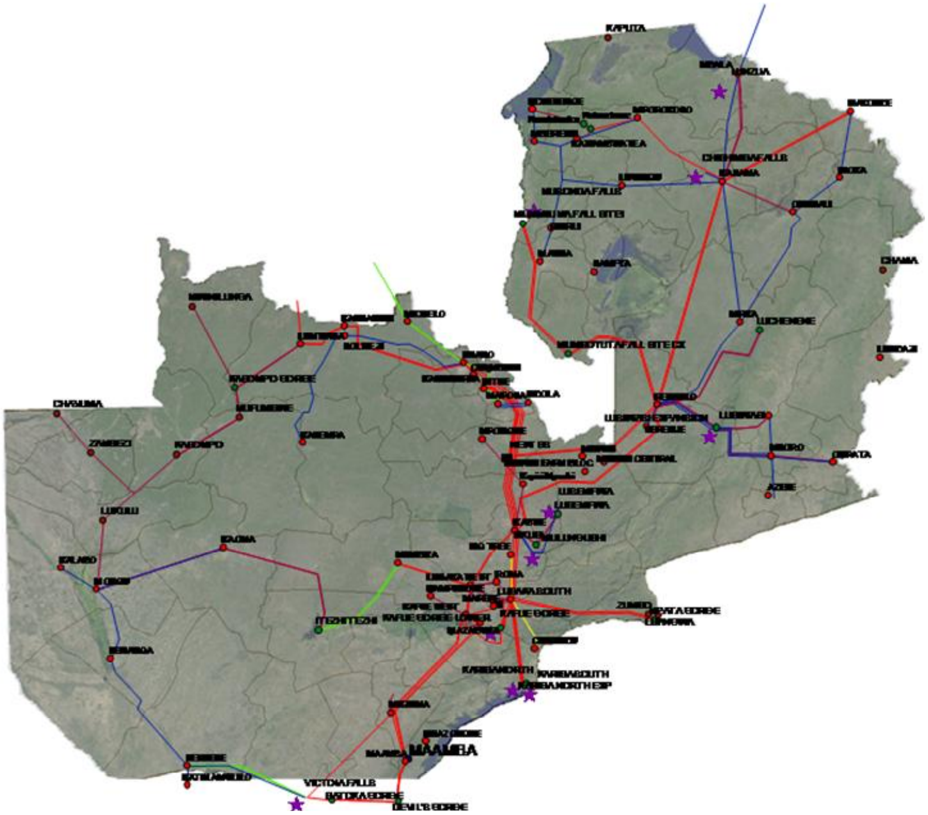


Figure 0.2 Example of the objective regarding GIS