Data Collection Survey on Southern African Power Pool Final Report

June 2017

Japan International Cooperation Agency (JICA)

JERA Co., Inc.

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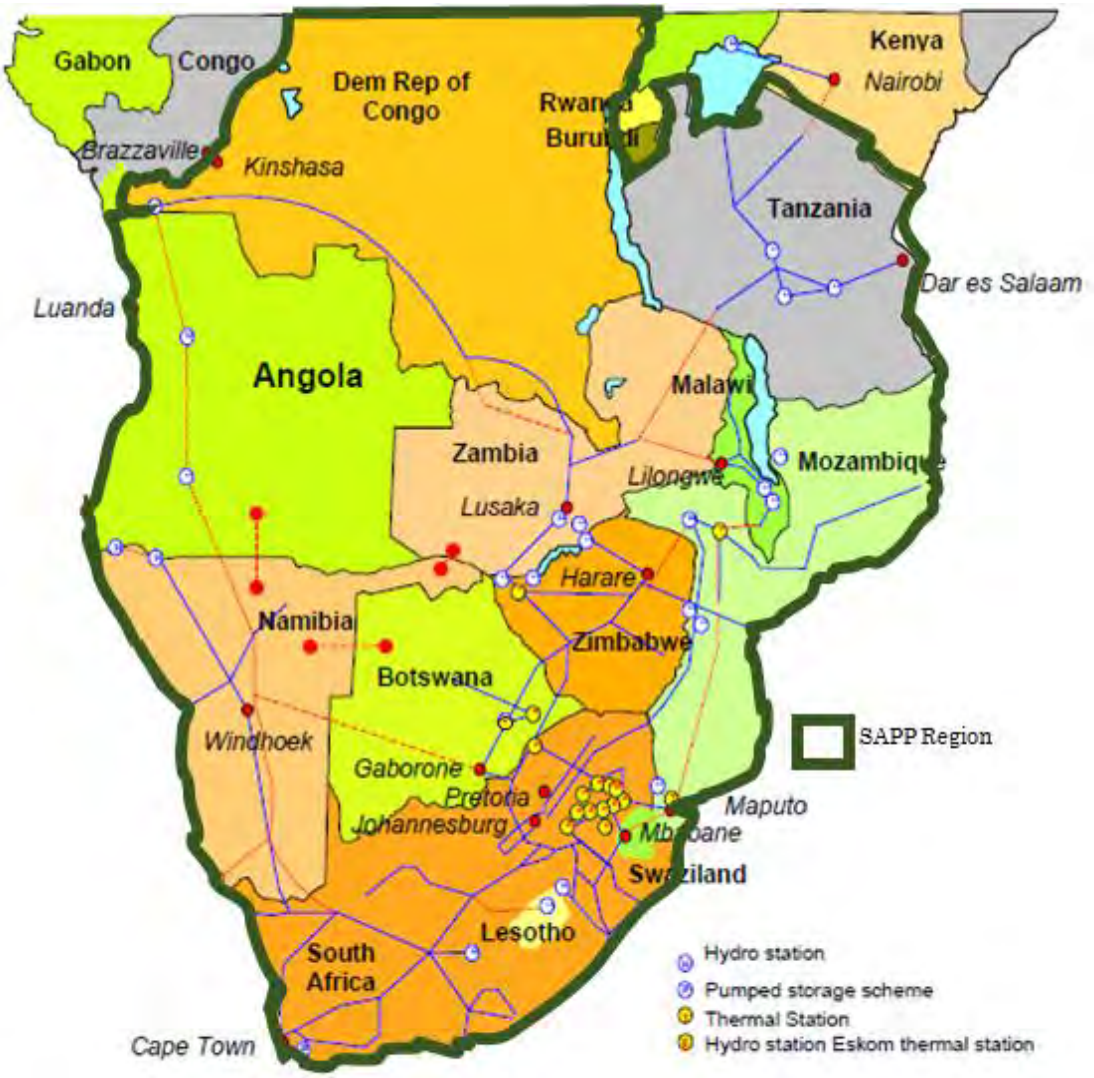
Member countries of South African Power Pool



Source: JICA Survey Team using SAPP Web Site (2016)

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Anonym and abbreviation

AC	Alternating Current
ACSR	Aluminum Cable Steel Reinforced
ADF	African Development Foundation
AfDB	African Development Bank
AnNa	Angola – Namibia
ATAS	Automatic Tariff Adjustment System
AU	African Union
AUC	African Union Commission
A-USC	Advanced - Ultra Super Critical
BADEA	Arab Bank for Economic Development in Africa
BEE	Black Economic Empowerment
BEWRA	Botswana Energy and Water Regulatory Agency, Botswana
BoSa	Botswana - South Africa
BPC	Botswana Power Corporation, BPC
BTB	Back to Back
CAPP/PEAC	Central African Power Pool / Pool Energetique de I'Afrique Centrale
CATE	Cellule d'Appui Technique au Ministère de l'Energie, DRC
CBM	Coal Bed Methane
CCGT	Combined Cycle Gas Turbine
CCS	Carbon dioxide Capture and Storage
CEC	Copperbelt Energy Corporation, Zambia
CGI3	Cellule Technique Inga 3, MRHE, DRC
CNELEC	Conselho Nacional da Electricidade, Mozambique
COD	Commercial Operation Date
COMESA	Common Market for Eastern and Southern Africa
CSP	Concentrated Solar Power
CTC	Central Transmission Corridor
DAM	Day Ahead Market
DC	Direct Current
DNEE	The National Directorate for Electrical Energy
DRC, DR Congo	Democratic Republic of the Congo
EAC	East African Community
EAD	Department of Energy Affairs, Botswana
EAPP	Eastern African Power Pool
ECB	Electricity Control Board, Namibia
ECCAS	Economic Community of Central African States
EDEL	Empresa de Distribuicao de Electricidade, Angola
EDM	Electricidade de Moçambique, Mozambique
EDEL	Empresa de Distribuicao de Electricidade, Angola
EIA	Environmental Impact Assessment
EIB	European Investment Bank
ENDE	Empresa Nacional de Distribuição de Electricidade, Angola
ENE	Empresa Nacional de Electricidade de Angola, Angola

EPC	Engineering, Procurement and Construction
ERB	Electricity Regulation Board, Zambia
ESCOM	Electricity Supply Corporation of Malawi Limited
ESIA	Environment Social Impact Assessment
EWURA	Energy and Water Utilities Regulatory Authority, Tanzania
FS	Feasibility Study
FUNAE	Fundo de Energia, Mozambique
GAMEK	Gabinete de Aproveitamento do Médio Kwanza, Angola
HCB	Hidroeléctrica de Cahora Bassa, Mozambique
HVAC	High Voltage Alternating Current
HVDC	High Voltage Direct Current
IDM	Intra day Market
IEP	Integrated Energy Plan
IGAD	Inter-Governmental Authority on Development
IGMoU	Inter Governmental Memorandom of Understanding
IoT	Internet of Things
IPP	Independent Power Producer
IRSE	Institute for Electricity Sector Regulation, Angola
ITC	Independent Transmission Company
IUMoU	Inter Utility Memorandom of Understanding
IPP	Independent Power Producer
IRENA	International Renewable Energy Agency
IRP	Integrated Resource Plan, RSA
IRSE	Instituto Regulator do Sector Eléctrico de Angola, Angola
JICA	Japan International Cooperation Agency
JETRO	Japan External Trade Organization
KEXIM	Export-Import Bank of Korea
LEC	Lesotho Electricity Company, Lesotho
LEWA	Lesotho Electricity and Water Authority, Lesotho
LHDA	Lesotho Highlands Development Authority, Lesotho
LHPC	Lunsemfwa Hydropower Company, Zambia
MCC	Millennium Challenge Corporation
MEM	Ministry of Energy and Minerals, Tanzania
MERA	Malawi Energy Regulation Authority, Malawi
MEWD	Ministry of Energy and Water Development, Zambia
MIREME	Ministry of Mineral Resources and Energy, Mozambique
MMEWR	Ministry of Minerals, Energy and Water Resources, Botswana
MNREM	Ministry of Natural Resources, Energy and Mining, Malawi
MINEA	Ministério da Energia e Águas, Angola
MOTRACO	Mozambique Transmission Company
MOU	Memorandum of Understanding
MOZAL	MOZAL, Mozambique
MoZiSa	Mozambique – Zimbabwe - South Africa
MRHE	Ministry of Hydraulic Resources and Electricity, DRC

MUSD	Million US Dollar(s)
N/A, n/a	Not Applicable
NBI	Nile Basin Initiative
NELSAP	Nile Equatorial Lake Subsidiary Action Program
NEPAD	New Partnership for Africa's Development
NEPAD IPPF	NEPAD Infrastructure Project Preparation Facility
NERSA	National Energy Regulator of South Africa
NDP	National Development Plan, Botswana
NP	Non Operating Member
OCGT	Open Cycle Gas Turbine
OP	Operating member
Opex	Operating expense
OPPPI	Office for Promoting Private Power Investment, Zambia
PDAM	Post Day Ahead Marker
PIDA	Programme for Infrastructure Development in Africa
PIDA PAP	Programme for Infrastructure Development in Africa, the Priority Action Plan
PPP	Public Private Partnership
Pre-FS	Pre-Feasibility Study
PRODEL	Pública de Produção de Electricidade, Angola
PTA	Preferential Trade Area for Eastern and Southern African States
PV	Photovoltaics
RE	Renewable Energy
REA	Rural Energy Agency, Tanzania
REDZ	Renewable Energy Development Zones, RSA
REIPP	Renewable Energy Independent Power Producer
REIPPPP	Renewable Energy Independent Power Producer Procurement Programme
RERA	Regional Electricity Regulatory Association
REU	Rural Electrification Unit, Lesotho
RFP	Request for Proposal
RIDMP	Regional Infrastructure Development Master Plan
RNT	Rede Nacional de Transporte de Electricidade, Angola
RSA	Republic of South Africa
SADC	Southern African Development Community
SADC-DIS	SADC-Directrate of Infrastructure and Services
SAPP	Southern African Power Pool
SAPP C.C.	SAPP Coordination Centre
SAPP PAU	Southern African Power Pool Project Advisory Unit
SCADA	Supervisory Control and Data Acquisition
SEC	Swaziland Electricity Company
SERA	Swaziland Energy Regulatory Authority
SGP	Strategic Grid Plan, RSA
SNEL	Societe Nationale d'Electricite, DRC
SPV	Special Purpose Vehicle
STATCOM	Static synchronous Compensator

STE	Sistema Nacional de Transporte de Energia (Mozambique Regional Transmission Backbone Project), Mozambique
A-SubC	Advanced Sub Critical
Tanesco	Tanzania Electric Power Supply Corporation
TDP	Transmission Development Plan, RSA
TICAD	Tokyo International Conference on African Development
TOU	Time of Use
UNDP	United Nations Development Programme
USAID	United States Agency for International Development
USC	Ultra Super Critical
USEA	United States Energy Association
USD	US Dollar(s)
UTIP	Unidade Técnica de Implementação dos Projectos Hidroelétricos (Technical Unit for the Implementation of Hydroelectric Projects), Mozambique
WASP	Wien Automatic System Planning Package
WB	World Bank
WF	Wind Farm
ZECO	Zanzibar Electricity Company, Tanzania
ZERA	Zimbabwe Energy Regulatory Authority, Zimbabwe
ZESA	ZESA Holdings Private Limited （Zimbabwe Electricity Supply Authority）, Zimbabwe
ZESCO	ZESCO Limited（Zambia Electricity Supply Corporation）, Zambia
ZETDC	Zimbabwe Electricity Transmission and Distribution Company, Zimbabwe
ZiZaBoNa	Zimbabwe・Zambia・Botswana・Namibia
ZPC	Zimbabwe Power Company, Zimbabwe
ZRA	Zambezi River Authority, Zambia-Zimbabwe
ZTK	Zambia - Tanzania - Kenya

Unit

Length, distance	mm	Millimeters
	cm	Centimeters (10.0mm)
	m	Meters (100.0cm)
	km	Kilometers (1,000.0m)
Dimension	mm^2	Square-millimeters (1.0mm x 1.0mm)
	cm^2	Square-centimeters (1.0cm x 1.0cm)
	m^2	Square-meters (1.0m x 1.0m)
	km^2	Square-kilometers (1.0km x 1.0km)
Volume	cm^3	Cubic-centimeters (1.0cm x 1.0cm x 1.0cm)
	m^3	Cubic-meters (1.0m x 1.0m x 1.0m)
Weight	g	gram (s)
	kg	kilogram (s) (1,000 g)
	ton	metric ton (1,000 kg)
Time	sec.	second (s)
	min.	Minute (s) (60 sec.)
	hr.	hour (s) (60 min.)
Currency	US Cents	United State Cents (1/1000 United State Dollar)
	USD	United State Dollars
	MUSD	Million United State Dollars (1,000 United State Dollars)
	AOA	Angolan Kwanza
	BWP	Botswana Pura
	LSL	Lesotho Loti (Maloti)
	CDF	Congolese Franc
	MWK	Malawian Kwacha
	MZN	Mozambican Metical
	NAc	Namibian cents
	NAD	Namibian Dollar（100 Namibian cents）
	ZAc	Southern African cents
	ZAR	South African Rand（100 Southern African cents）
	SZL	Swaziland Lilangeni
	TZS	Tanzanian Shilling
	ZMW	Zambian Kwacha
	ZWD	Zimbabwean Dollar
Electricity	V	Volts (Joule / Coulomb)
	kV	Kilo Volts (1,000V)
	A	Amperes (Coulomb/second)
	kA	Kilo amperes (1,000A)
	W	Watts (active power) (J/s: Joule/second)
	kW	Kilo Watts (10^3 W)

	MW	Mega Watts (10^6 W)
	GW	Giga Watts (10^9 W)
	Wh	Watt-hours
	kWh	Kilo Watt-hours (10^3 Wh)
	MWh	Mega Watt-hours (10^6 Wh)
	GWh	Giga Watt-hours (10^9 Wh)
	TWh	Tera Watt-hours (10^{12} Wh)
	VA	Volt-amperes (apparent power)
	kVA	Kilo Volt-amperes (10^3 VA)
	MVA	Mega Volt-amperes (10^6 VA)
	Var, VAr	Volt-amperes reactive (reactive power)
	kVar, kVAr	Kilo Volt-amperes (10^3 Var)
	MVar, MVAr	Mega Volt-amperes (10^6 Var)

Chapter 1 Introduction

1.1 Background of the Survey

Southern African counties, which have rich energy resources, have not been fully utilized in current situation. On the other hand, rolling black outs carried out in even the Republic of South Africa, which is well developed and consumes a majority of power demand with her own generation fleets. These implicit many challenges to be solved on the point of operation and cooperation across an expansive region.

Further, many Sub Saharan African countries face serious decisions to hike up electrification rate.

In response to these issues, various organizations such as the African Development Bank (AfDB), the Southern African Development Community (SADC) and the Southern African Power Pool (SAPP) have formulated a master plan in energy sector and in order to promote this master plan, many donors such as the World Bank (WB) and the United States Agency for International Development (USAID) have provided cooperation. However, in fact, projects are being delayed due to several constraints.

In order to improve the aforementioned situation, expectations for Japan and for Japanese technologies are rising.

In the meanwhile, Japanese companies have established production bases in RSA and are pursuing oil and natural gas businesses in the Republic of Mozambique and the Republic of Angola which enjoy remarkable economic growth. Japanese companies therefore have a keen interest in Southern African countries.

1.2 Purpose of the Survey

The Survey will be conducted for the purpose of following-up the 5th Tokyo International Conference on African Development (TICAD V) and reviewing power system development plans such as the existing master plans and relevant information, finding and prioritizing issues and projects comprehensively for realization of power pool as a part of strategic master plan formation for Southern African region, which is the goal of the Survey.

Further, the Survey will find out the possible cooperation for SAPP and SAPP member counties, considering the effect of project(s), with utilization of Japanese technology, if any.

1.3 Survey Plan and its activities

Table 1.3-1 shows the overview of the Survey.

Table 1.3-1 Overview of the Survey

FY	2015							2016											2017		
Month	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
Work Process Field Survey Domestic Work	1st Work; 1st Survey		2nd Work					2nd Survey; 3rd Work		4th Work			3rd Survey; 5th Work		6th Work		4th Survey; 7th Work					

Domestic Work Remarks / Field Survey Remarks

Phase 1

1st Work
1) Advance collection/analysis of power system related information of respective SAPP member countries
2) Collecting detailed information of Japanese technologies
3) Preparing/submittin g an Inception Repor

2nd Work
1) Interviewing Japanese corporations to evaluate the application of Japanese technologies
2) Holding (the first) seminar for Japanese corporations
3) Evaluation of the appropriateness of respective projects, summarizing "Project Lists" and preparing a "Shortlist of Expected Projects"
4) Preparation and decision of invitation program to Japan

1st Survey
1) Explanation/consultation of the inception report/advance survey results
2) Collection of information on the power system related plans of SAPP and SAPP member countries states
3) Interviewing Japanese corporations for applying Japanese technologies
4) Consultation on the invitation program to Japan

Phase 2

3rd Work
1) Coordin ation of the site seminar

4th Work
1) Submitting a progress report
2) Preparing a detailed plan of the invitation program to Japan

5th Work
1) Re-evaluation and modification by site-check surveys
2) Executing the invitation program to Japan, namely "Power Engineering Program"

2nd Survey
1) Review and consultation for investment plan
2) Conducting a site-check survey of expected projects (1)
3) Consultation concerning the site seminar(s)
4) Preparation of the invitation program to Japan

3rd Survey
1) Conducting a site survey (2) for expected project
2) Reviewing and consultation on investment plans
3) Holding the site seminar(s)

Phase 3

6th Work
1) Preparing a draft final report
2) Study for future cooperation

7th Work
1) Preparing and submitting the final report
2) Holding (the second) seminar for Japanese corporations

4th Survey
1) Consulting on the draft of the final report

Work Process Field Survey Domestic Work	1st Survey (Sep–Oct 2015); 1st Work (Sep 2015); 2nd Work (Nov 2015–Mar 2016)	2nd Survey (Apr–May 2016); 3rd Work (Jun 2016); 4th Work (Jul–Aug 2016)	3rd Survey (Oct 2016); 5th Work (Nov 2016); 6th Work (Nov–Dec 2016)	4th Survey (Dec 2016); 7th Work (Jan–May 2017)

Month	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
Seminar			△ Seminar for Japanese corporations										Seminar in Zimbabwe/South Africa ○		Invitation Program						△ Seminar for Japanese corporations	
Reports							△ Submission of Progress Report								△ Submission of Draft Final		△ Submission of Final (1st edition); Submission of Final (2nd edition) △					△ Submission of Final Report

(1) Counterpart

SAPP Coordination Centre[1]

(2) JICA Survey Team

Table 1.3-2 JICA Survey Team

No.	Profile	Portion
1	Yoshihide TAKEYAMA	Team Leader / Power system Planning
2	Yoshitaka SAITO	Generation development Planning
3	Toshitaka YOSHIDA	System Planning / Environmental and Social Consideration (Transmission system)
4	Takashi AOKI	Hydropower Equipment / Environmental and Social Consideration (Hydropower)
5	Mitsuhiro WATANABE	Thermal Power Equipment / Environmental and Social Consideration (Thermal Power)
6	Takeshi KIKUKAWA	Optimal Investment Planning / Economic and Financial Analysis
7	Tomohide KATO	Seminar Planning

Hereinafter, the name of SAPP member countries are represented following short form in this report.

Angola	The Republic of Angola (República de Angola)
Botswana	The Republic of Botswana
DR Congo	The Democratic Republic of Congo (République Démocratique du Congo)
Lesotho	The Kingdom of Lesotho
Malawi	The Republic of Malawi
Mozambique	The Republic of Mozambique (República de Moçambique)
Namibia	The Republic of Namibia
RSA, South Africa	The Republic of South Africa
Swaziland	The Kingdom of Swaziland (Umbuso weSwatini)
Tanzania	The United Republic of Tanzania
Zambia	The Republic of Zambia
Zimbabwe	The Republic of Zimbabwe

[1] SAPP member states can be convened by SAPP coordination center.

Chapter 2 Current Condition and issues of Southern African Power Pool

2.1 Southern African Power Pool (SAPP)

(1) Current Condition

Southern African Power Pool (SAPP) was chartered in August 1995, and SAPP Coordination Centre set up as a permanent organization in Harare, Zimbabwe officially launched in Harare in 2000.

Power utilities of twelve (12) member states excluding Mauritius and Madagascar have joined SAPP, of the fourteen (14) member states of the SADC[2].

Table 2.1-1 SAPP members

Full Name of Utility	Status	Abbreviation	Country
Botswana Power Corporation	OP	BPC	Botswana
Electricidade de Mocambique	OP	EDM	Mozambique
Electricity Supply Corporation of Malawi	NP	ESCOM	Malawi
Empresa Nacional de Electricidade	NP	ENE	Angola
Eskom	OP	Eskom	South Africa
Lesotho Electricity Corporation	OP	LEC	Lesotho
NamPower	OP	Nam Power	Namibia
Societe Nationale d'Electricite	OP	SNEL	DRC
Swaziland Electricity Company	OP	SEC	Swaziland
Tanzania Electricity Supply Company Ltd	NP	TANESCO	Tanzania
ZESCO Limited	OP	ZESCO	Zambia
Copperbelt Energy Cooperation	ITC	CEC	Zambia
Lunsemfwa Hydro Power Company	IPP	LHPC	Zambia
Zimbabwe Electricity Supply Authority	OP	ZESA	Zimbabwe

OP : Operating member, NP : Non-operating member, ITC : Independent Transmission Company, IPP : Independent Power Producer

Source : SAPP Annual Report 2015

Visions (goals) advocated by SAPP[3] are

- Facilitate the development of a competitive electricity market in the Southern African region,
- Give the end use a choice of electricity supply,
- Ensure that the Southern African region is the region of choice for investments by energy intensive users, and
- Ensure sustainable energy developments though sound economic, environmental and social practices

And, SAPP Coordination Centre will control the following activities.

- Coordination of SAPP businesses,
- Establishment of power market operation,

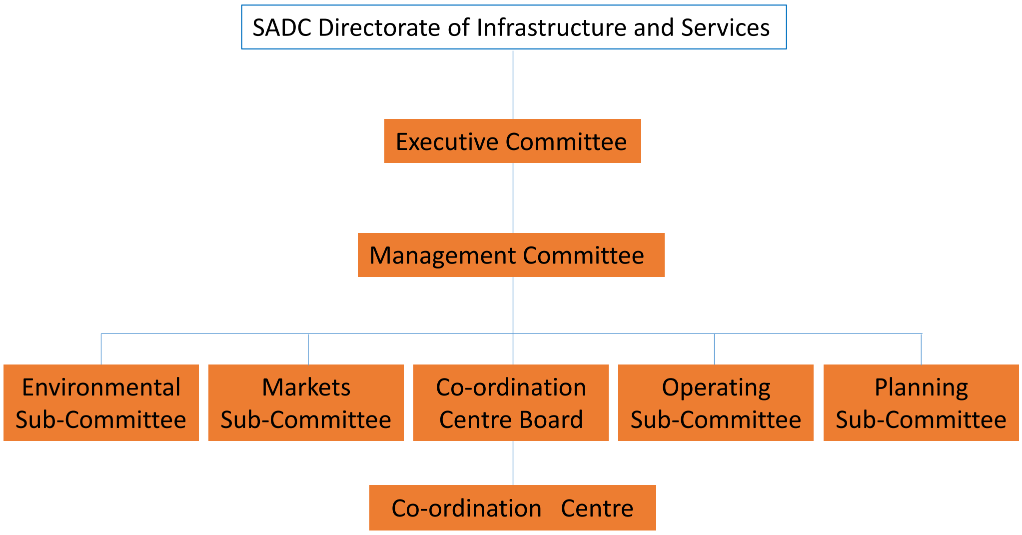
[2] In addition to the above-described members, the Hidroeletrica de Cahora Bassa (HCB) which is an independent power producer in the Republic of Mozambique and the MOTRACO which is an individual Transmission Company participating as observers.

[3] In the time of SAPP foundation, the SAPP vision was alliance of power supply utilizing abundant potential of hydropower in northern part and the coal resources in southern part for economic development of the whole inland SADC member states.

・Monitoring of SAPP-related businesses between the SAPP member states,
・Execution of technical survey for evaluating effects of planned projects,
・Technical training and education for operation members, and
・Accumulation of information and publication of statistics for power pool enhancement and system designing.

(2) Organization of SAPP

SAPP was founded as an organization for carrying out power infrastructure businesses activities under the SADC Directorate of Infrastructure and Services (SADC DIS). SAPP has four Sub Committees, each controlling activities under the Executive Committee and the Management Committee by representatives of SAPP member states. Also SAPP has the Coordination Centre as the main coordinator of all functions.[4]



Source : SAPP Annul Report 2014

Figure 2.1-1 SAPP organization

1) The Executive Committee

The Executive Committee is consisted by twelve (12) representative directors in power utility of the SAPP member states. This committee handles the board of directors of SAPP coordination center, controls the activity of SAPP Coordination Center and decides policy of SAP Coordination Center. This committee is held once in a half year.

Executive committee manages the following activities.

・Determination of responsibility, revision and approval of the right of the Management Committee
・Establishment and close, grant of responsibility, revision and approval of the right for each sub committee, working group, and task force.
・Approval of participation on SAPP member under approval of SADC energy minister meeting.
・Grant of observer qualification

[4] Dr. Lawarence Musaba who was a manager of SAPP Coordination Center died in December, 2015. The manager is not appointed now. So Mr Alison Chikova of chief engineer is as acting manager of SAPP Coordination Center. The manager is choosing by public advertisement now.

・Dispute resolution between members

2) Management Committee

The Management Committee is consisted by person who has the level of power system planning manager in power utility of the SAPP member states.This committee manages the activity of the standing Sub Committees,and the activity of working group and task force approved by Executive Committee. This committee is held once in a half year.

3) Sub Committee

Activities of each Sub Committees are as follows. Members of the individual Sub Committee are organized by working-level officials of member states and hold regular meetings to assess issues.

Table 2.1-2 SAPP Sub Committees and their tasks

Subcommittees	Main tasks
Planning Sub Committee	・Execution of SAPP system short-term demand forecast ・Review on system planning ・Progress management of interconnector project ・Analysis of operational capacity of interconnector
Operating Sub Committee	・Technical training and education of operators from each member state ・Statistics and analysis of disturbance in SAPP system
Markets Sub Committee	・Power market management ・Statistics and analysis of market performance
Environmental Sub Committee	・Development project's ESIA management ・Environmental study and measures in SAPP system

Source : JICA Survey Team

The chairperson of each Sub Committee is appointed by the committee member. SAPP Coordination Center manages each Sub Committee's operation.

SAPP Coordination Centre is operating various projects' activities and manages project promotion of interconnectors, large scale generation projects in cooperation with the countries concerned.

(3) Organization under SAPP Coordination Center

1) Organization in Harare, Zimbabwe

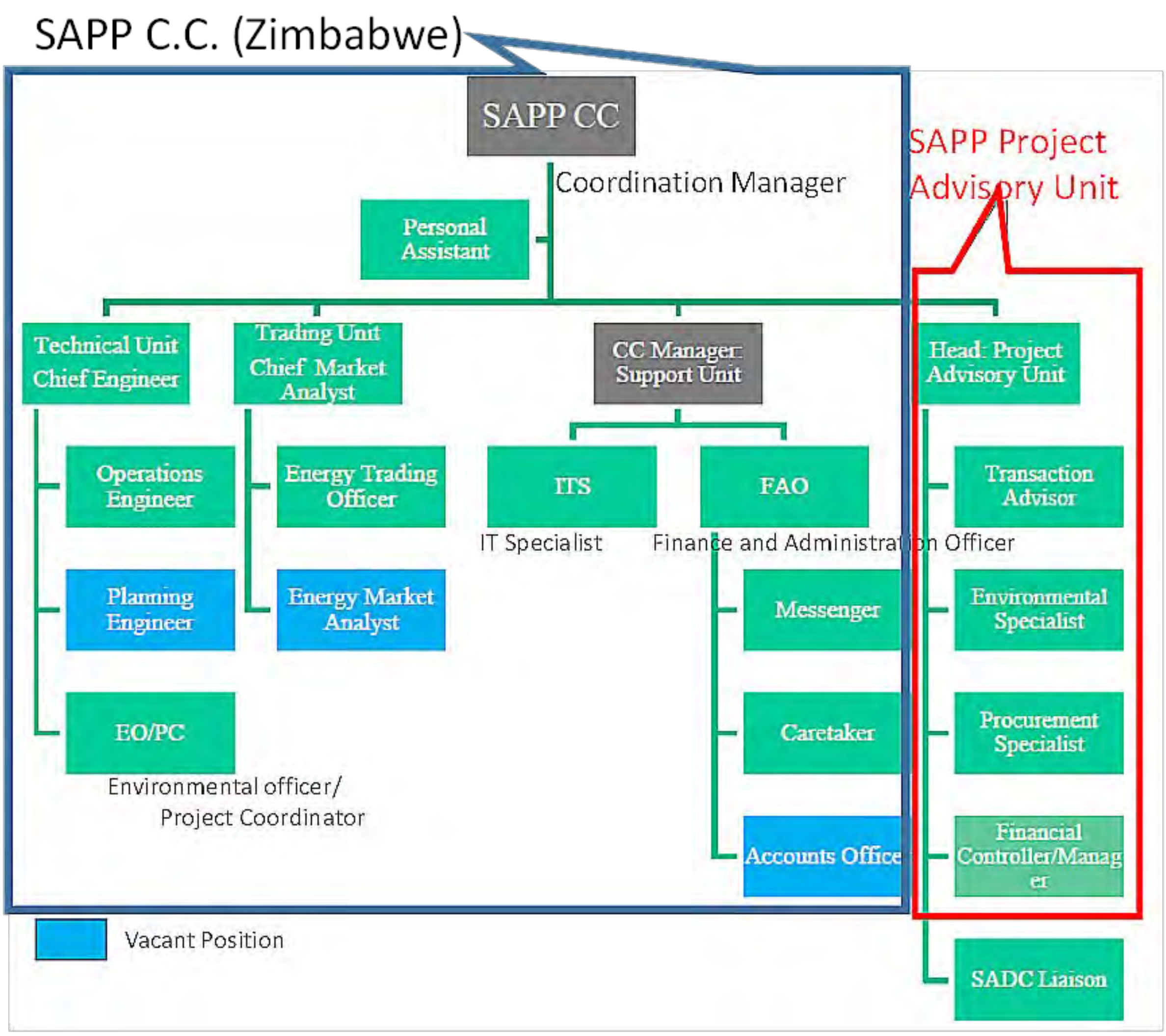
SAPP Coordination Center has technical unit and trading unit under the management of coordination manager. Technical unit manages planning sub committee and operating sub committee. Trading unit manages market sub committee.

2) SAPP Project Advisory Unit (SAPP PAU)

To accelerate and move forward the activities of SAPP coordination Coordination Center, such as coordination of SAPP businesses and execution of technical survey for evaluating effects of planned projects, especially interconnector project and large scale generation project, SAPP has established SAPP Project Advisory Unit by support of WB. That is why the number of projects and volume of their project to be studied are too much to do by the work force in SAPP coordination center. SAPP PAU was established in Santon, South Africa on December, 2015.

SAPP PAU has organized by five specialists under the management by Project manager. Further, this unit is managed by SAPP coordination manager. One of the specialists is from SADC-DIS to supervise the project progress directly.

SAPP PAU has to have an inspection by WB to confirm her activity every two years and have authentication of business continuation.



Source : SAPP PAU (2016)

Figure 2.1-2 Organization of SAPP coordination centre

Table 2.1-3 shows recent statistics of SAPP member states and Figure 2.1-3 shows tracks of capacity and peak demand in SAPP.

Table 2.1-3 SAPP statistics including the supply-demand balance

2014/2015

Country	Utility	Installed Capacity MW	Net Capacity MW	Maximum Demand MW	MD Growth %	Generation Sent Out GWh	Net Imports GWh	Net Exports GWh
Angola	ENE / PRODEL	2,210	1,805	1,599	49	5,613	0	0
Botswana	BPC	892	4,60	610	6	372	1207	0
DR Congo	SNEL	2,442	1,485	1,381	18	8,185.2	95	0
Lesotho	LEC	72	72	150	16	486	175	2.7
Malawi	ESCOM	351	351	326	17	1,809	0	0
Mozambique	EDM/HCB	2,308	2,279	830	18	390	1004	233
Namibia	Nampower	501	392	629	3	1,305	1337	37
South Africa	Eskom	46,963	41,074	36,170	1	237,430	542	4,909
Swaziland	SEC	70.6	70	221	8	288.1	889	0
Tanzania	Tanesco	1,380	1,143	935	5	3,034	0	0
Zambia	ZESCO	2,128	2,029	1,987	12	11,381	165	3,441
Zimbabwe	ZESA	2,045	1,600	1,671	8	6,951	979	1,231
SAPP Total		**61,362.6**	**52,760**	**46,509**		**269,059.1**		

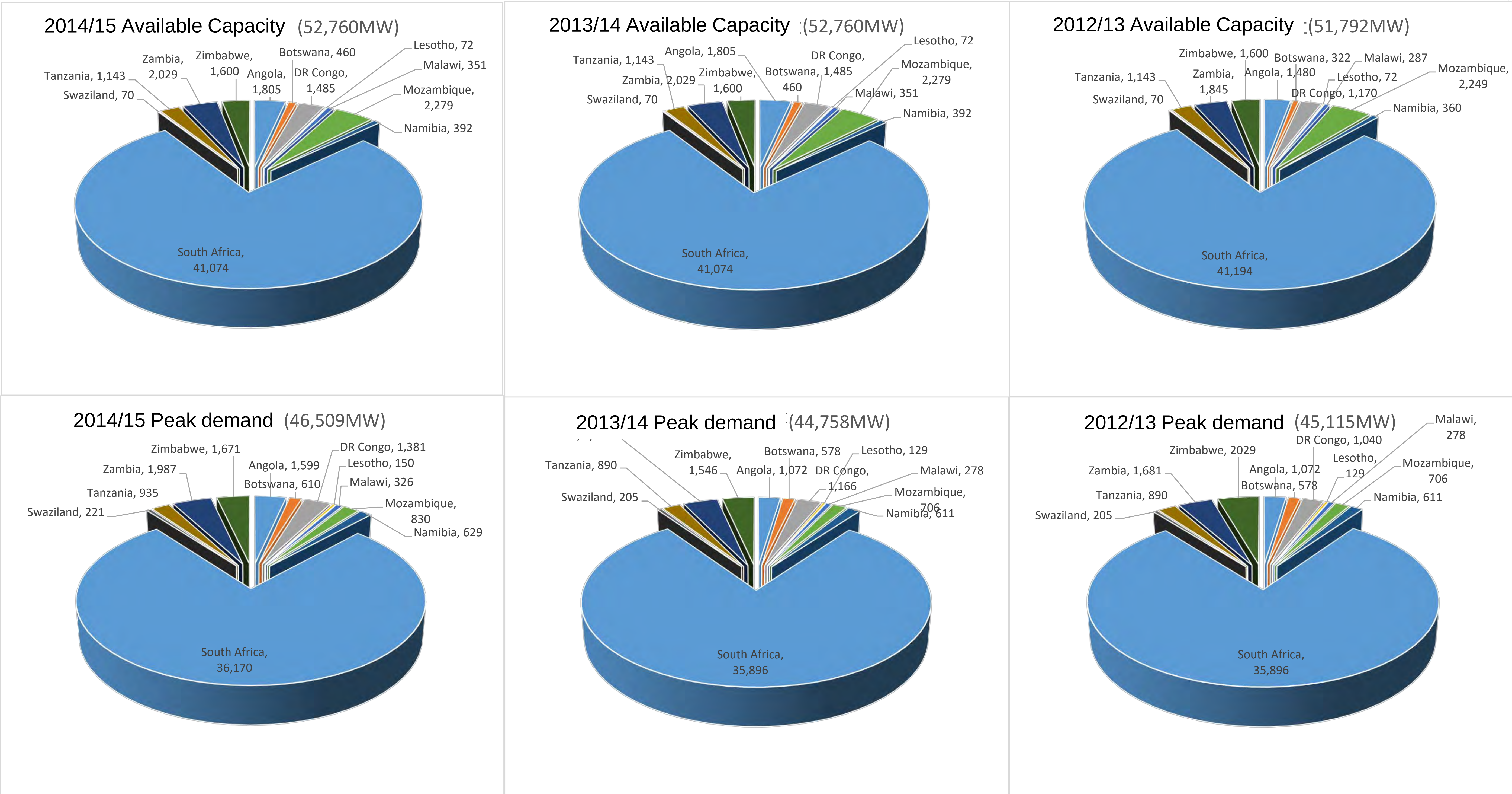
2013/2014

Country	Utility	Installed Capacity MW	Net Capacity MW	Maximum Demand MW	MD Growth %	Generation Sent Out GWh	Net Imports GWh	Net Exports GWh
Angola	ENE / PRODEL	2,028	1,805	1,072	9.30	5,613	49	0
Botswana	BPC	892	460	578	-2.0	372	3,017	0
DR Congo	SNEL	2,442	1,485	1,166	10.8	8,185.2	573.4	0
Lesotho	LEC	72	72	129	3.30	486	49	7.4
Malawi	ESCOM	351	351	278	1.10	1,809	0	19.1
Mozambique	EDM/HCB	2,308	2,279	706	12.20	390	89	330
Namibia	Nampower	501	392	611	8.30	1,305	1,591	36
South Africa	Eskom	44,170	41,074	35,896	1.90	237,430	413	4,089
Swaziland	SEC	70.6	70	205	-2.0	288.1	773	0
Tanzania	Tanesco	1,380	1,143	890	0.8	3,034	2,192	0
Zambia	ZESCO	2,128	2,029	1,681	5.3	11,381	164	65.6
Zimbabwe	ZESA	2,045	1,600	1,546	10.5	6,951	10.78	701
SAPP Total			**58,387.6**	**52,760**	**44,758**		**277,244.3**	

2012/2013

Country	Utility	Installed Capacity MW	Net Capacity MW	Maximum Demand MW	MD Growth %	Generation Sent Out GWh	Net Imports GWh	Net Exports GWh
Angola	ENE / PRODEL	1,793	1,480	1,072	9.3	5,613	49	0
Botswana	BPC	352	322	578	-2.0	372	3,017	0
DR Congo	SNEL	2,442	1,170	1,040	-2.9	7,641	562	69
Lesotho	LEC	72	72	129	3.3	486	49	7.4
Malawi	ESCOM	287	287	278	1.1	1,809	0	19.1
Mozambique	EDM/HCB	2,279	2,249	706	12.2	390	89	330
Namibia	Nampower	393	360	611	8.3	1,305	1,591	36
South Africa	Eskom	44,170	41,194	35,896	1.9	237,430	413	4,089
Swaziland	SEC	70.6	70	205	-2.0	288.1	773	0
Tanzania	Tanesco	1,380	1,143	890	0.8	3034	2,192	0
Zambia	ZESCO	1,870	1,845	1,681	0.3	11,381	164	65.6
Zimbabwe	ZESA	2,045	1,600	2,029	10.5	6,951	1,076	701
SAPP Total			**57153.6**	**51792**	**45155**		**27,6700.1**	

Source : JICA Sruvey Team using SAPP annual report 2013, 2014 and 2015



Source : JICA Sruvey Team using SAPP annual report 2013, 2014 and 2015

Figure 2.1-3 Trend of peak demand and available capacity in SAPP member states

(4) Performance of SAPP system operation

1) Supply capacity

Table 2.1-4 shows the demand and supply balance in SAPP as of 2015. Existing generation capacity is 61,859MW, whereas available capacity (send out) is 46,910MW. And total peak demand is 48,216MW, and peak demand including suppressed demand is 55,157MW. Therefore, net shortage of all SAPP members is 8,247MW, and 7,921MW is net deficit for SAPP operating members. Around 80% of total capacity and total demand is occupied by RSA.

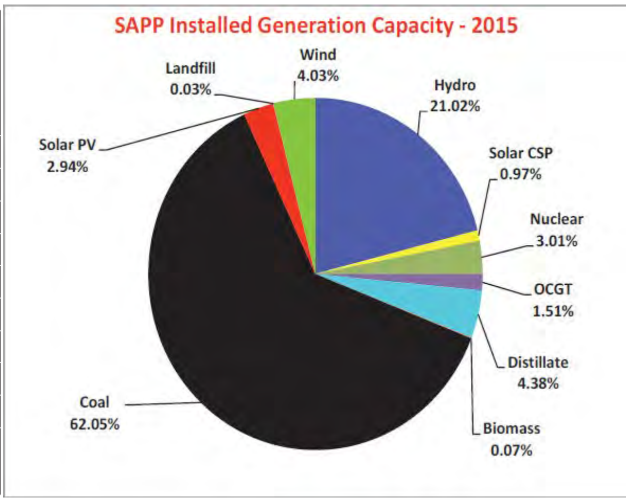
Table 2.1-4 Demand and supply balance in SAPP system in 2015- peak demand

Demand and Supply Balance with Current Peak Demand - 2015

No. Country	Utility	Installed capacity (MW)	Operating Capacity (MW)	Current Peak Demand (MW)	Peak Demand Plus Reserves	Capacity excess/ shortfall including Reserves
Angola	ENE	2,210	1,772	1,599	1,829	(57)
Botswana	BPC	892	410	610	698	(288)
DRC	SNEL	2,442	1,066	1,381	1,580	(514)
Lesotho	LEC	74	70	150	172	(102)
Malawi	ESCOM	352	351	326	373	(22)
Mozambique	EDM/HCB	2,724	2,279	830	949	1,330
Namibia	Nampower	501	354	629	720	(366)
South Africa	Eskom	46,963	36,000	37,661	43,080	(7,080)
Swaziland	SEC	70	55	219	251	(196)
Tanzania	TANESCO	1,380	823	935	1,070	(247)
Zambia	ZESCO/CEC/ LHPC	2,206	2,175	2,287	2,616	(441)
Zimbabwe	ZESA	2,045	1,555	1,589	1,818	(263)
TOTAL ALL		61,859	46,910	48,216	55,157	(8,247)
TOTAL Operating Members Only		57,917	43,964	45,356	51,885	(7,921)

Source : SAPP C.C. (2015)

Technology	Installed Generation Capacity, MW
Hydro	13,000
Coal	38,381
Nuclear	1,860
OCGT	936
Distillate	2,709
Wind	2,492
Solar CSP	600
Solar PV	1,821
Landfill	18
Biomass	42
Total	61,859

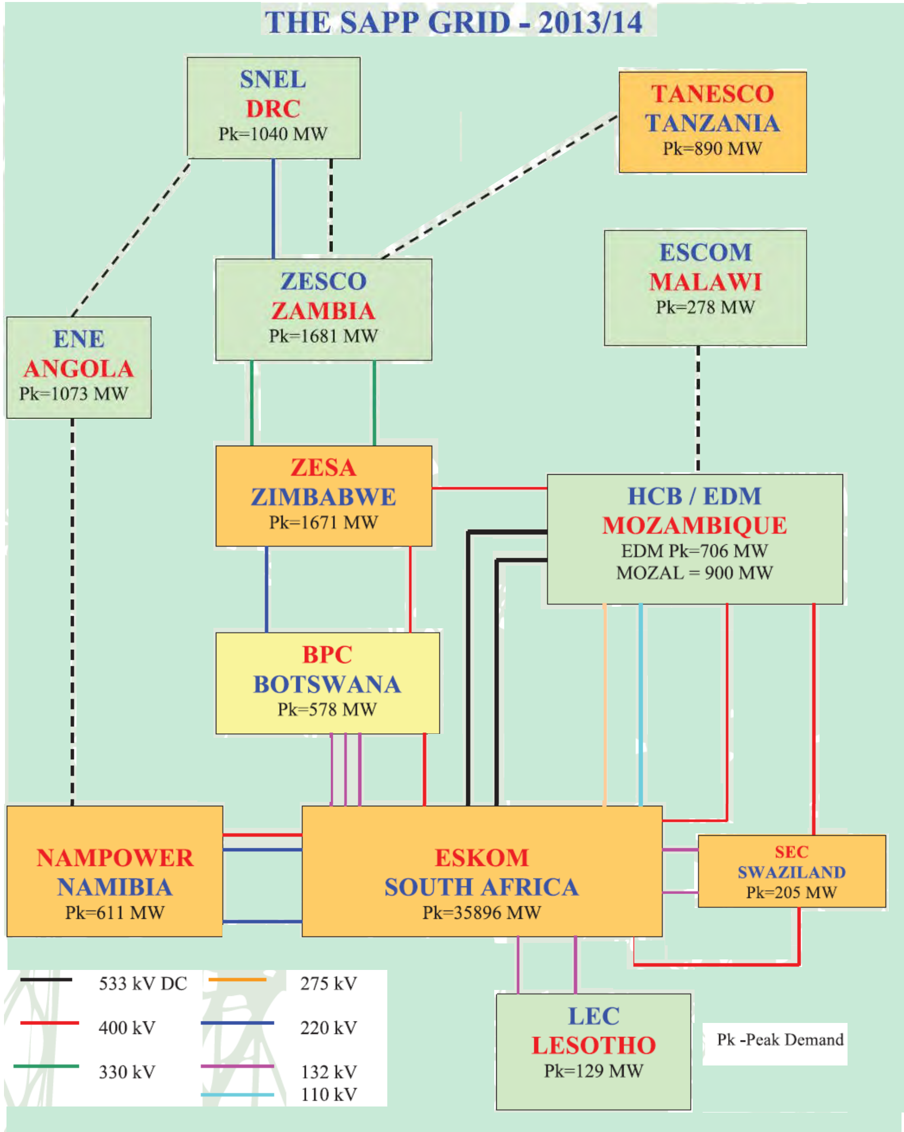


Source : SAPP Annual Report 2015

Figure 2.1-4 SAPP generation capacities by power source (2015)

Figure 2.1-4 shows the allocation of power source in SAPP as of 2015. SAPP has 61,589 MW capacity, and coal-fired generation : 62%, hydropower : 21%, nuclear power : 3% and gas-fired generation : 2% are its breakdown.

As for the distribution of primary energy, coal is found in southern area, especially RSA, Botswana, and water resource is found in northern area, such as the Zambezi River basin, the Congo River basin.Natural gas is found in Mozambique, especially in Temane and Ruvma area and east coastal area in Tanzamia, such as Songo-songo, Mnazi bay area.



Source : SAPP Annual Report 2015

Figure 2.1-5 SAPP system

Figure 2.1-5 shows the SAPP system as of December 2015, and apparently Angola, Tanzania and Malawi are not yet interconnected.

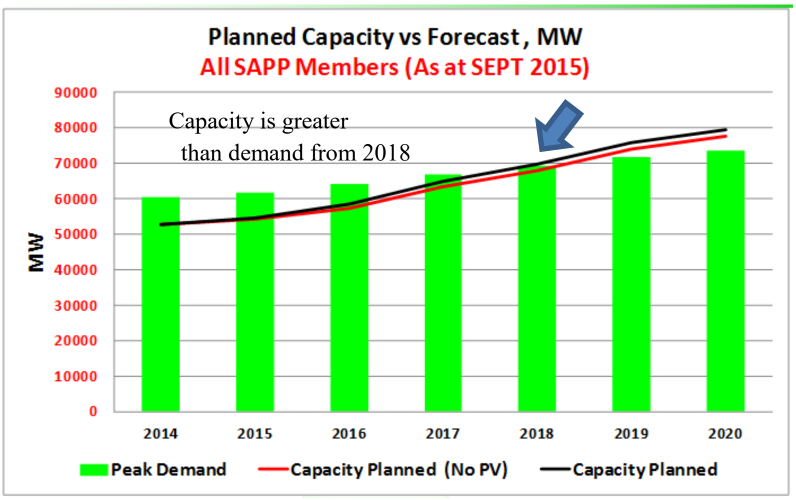
SAPP Coordination Center pointed out the importance of interconnector for all member states with the data in Figure 2.1-6.

The capacity meets demand in 2018 in case current generation development is expected to expand without interconnection to aforementioned three countries. But the capacity can meet demand in 2020 in same with interconnection to aforementioned three countries[5].

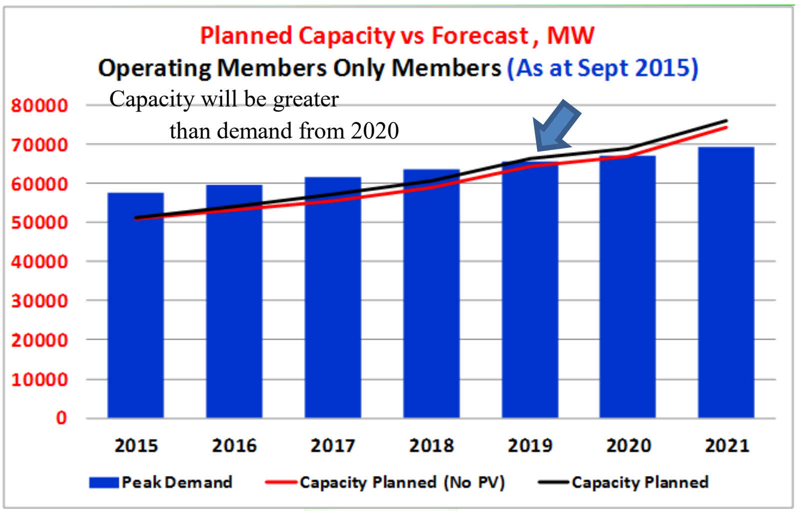
[5] Capacity Planned (No PV) means total capacity without PV. Demand in lighting period (19:00 -) is expected to be Peak

Thus, interconnection makes it possible to share one's surplus to others and operate all member's generation capacity for all benefits. Further interconnection can reduce the generation development by suitable utilization of existing generators for all members and create active power trade.

Prediction for total generation capacity in comparison to peak demand in all member



Prediction for total generation capacity in comparison to peak demand only in connected countries



Source：The Survey Team wrapped it up based on SAPP documents

Figure 2.1-6 Advantage of interconnection against increasing system capacity

2) Power trading

Table 2.1-5 shows negotiated bilateral contracts between SAPP members. And Table 2.1-6 shows same data on Table 2.1-5 with buyer oriented and seller oriented.

Main seller is Eskom, RSA and ZESO, Zambia. Buyer for them are mostly neighboring countries but some countries, which have to get the power via transferring countries, have a firm contract. These counties might not maintain their generation capacities.

Also, Table 2.1-6 shows that number of buyer is greater than that of seller. Thus most of member states need to import the power to secure their own supply conditions.

Further, Table 2.1-6 shows that the amount of import by Eskom is huge. The reason is that Eskom imports

demand, therefore PV is not the effective capacity for peak demand.

power from HCB, Mozambique and then feed the power to MOZAL (950MW), aluminum smelter, and EDM (300MW).

SAPP intends to create not only bilateral trade in mid-term to long-term, but competitive market. After 2014, SAPP Coordination Center established SAPP spot market to energize the power trade.

According to SAPP Annual Report 2015, the number of participant in the market was six per month in 2013 - 2014 period, but in 2014 – 2015 period, the number of that increased to eight. That implies that power market is energized.

However, selling bids were extremely less and and 38% of selling bids and 16% of buying bids were contracted. A total quantity of power transaction in 2014 – 2015 is 508,264 MWh. 88% of total transaction were dealed in Day Ahead Market (DAM), and 12% were in Post Day Ahead Market[6] (PDAM). Here, 12%[7] of total quantities in matching phase were failed (were not dealed) due to congestion, capacity shortage of the transmission line(s).

In January 2015, human interface of the power market was renewed to be easy to handle (Figure 2.1-9). To catch up with the power market integration, it is essential to develop transmission network and generation[8].

According to the announcement by Market Sub Committee in 2012, the next steps for power market integration will be introduction of ancillary service market and the balancing power supply market with market enlargement (Figure 2.1-10).

6 Intra day market (IDM) was opened on 1st December, 2015 instead of PDAM. IDM makes it possible to conduct real time trading.

7 In 2013-2014 period, around 70% of the total quantities in DAM were not contracted due to the transmission congestion.

8 The competitive market was introduced by support of Swedish government and Norwegian government. Their support was stated from 2007.

Table 2.1-5 Situation of negotiated bilateral contracts

Item	From	To	Supply Capacity MW	Start date	Expiry date	Utility Comments Updated, Keep or Delete Contract	Type (Firm or Non firm)
1	HCB	ESKOM	1150	1998	2030		Firm
2	ESKOM	SEC	250	1-Sep-00	1-Sep-25		Firm
3	ESKOM	LEC	24	1-Jun-05	Indefinite		Firm
4	ESKOM	BPC	150	1-Jan-08	31-Dec-12		Firm
5	HCB	ESKOM	250	31-Mar-08	14-Dec-14		Firm
6	HCB	EDM	300	2-May-84	31-Mar-30		Firm wheeling
7	ESKOM	NamPower	350	1-Jul-06	31-Mar-17		Non-Firm
8	HCB	ZESA	100	1997	2014		Firm
9	HCB	ZESA	As available	2008	2014		Non-Firm
10	HCB	EDM	200	2008	2030		Firm
11	EDM	SEC	50	2003	Renewed annually		Firm
12	EDM North	EDM South	300	1992	Indefinite		Firm
13	EDM South	EDM North	300	1992	Indefinite		Firm
14	EDM	NamPower	50	2008	Renewed annually		Firm
15	EDM	BPC	50	2007	Renewed annually		Firm
16	EDM	ZESA	50	2011	Continuous/Renewable		Non Firm
17	EDM	LEC	50	2008	Renewed annually		Firm
18	ZESCO	EDM	100	2009	Renewed annually	Keep	Firm
19	EDM	ZESCO	As required	2011	Continuous/Renewable	Keep	Non Firm
20	ZESCO	ZESA	200	2009	Renewed annually	Keep	Non Firm
21	ZESCO	ESKOM	300	2009	-	Keep/Not active	Non Firm
22	EDM	ESKOM	As available	1-Apr-10	31-Mar-12		Firm
23	EDM	ESKOM	100	1-Oct-09	Renewed every 2nd year		Firm wheeling
24	ZESA	NamPower	150	2008	2013		Firm
25	ZESCO	NamPower	50	Sep-09	Sep-19	Keep/Active	Firm
26	SNEL	BPC	50	2009	Continuous / Renewable		Firm
27	SNEL	ZESA	50	1992	2013		Firm
28	SNEL	ZESA	50	1992	2013		Non Firm
29	ESKOM	ZESCO	300	2009	-	Keep/Not very active	Non Firm
30	ESKOM	ZESA	as available	2009			Non-Firm
31	ZESA	ESKOM	As available	Jul-10	Renewed annually		Non Firm
32	ZESCO	BPC	100	Aug-14	Renewed annually	Keep/Active	Non-Firm
33	ZESCO	SNEL (KCC)	40	Nov-14	Renewed annually	Keep/Active	Firm
34	ZESCO	SNEL	100	1-Jul-12	Renewed annually		Non-Firm

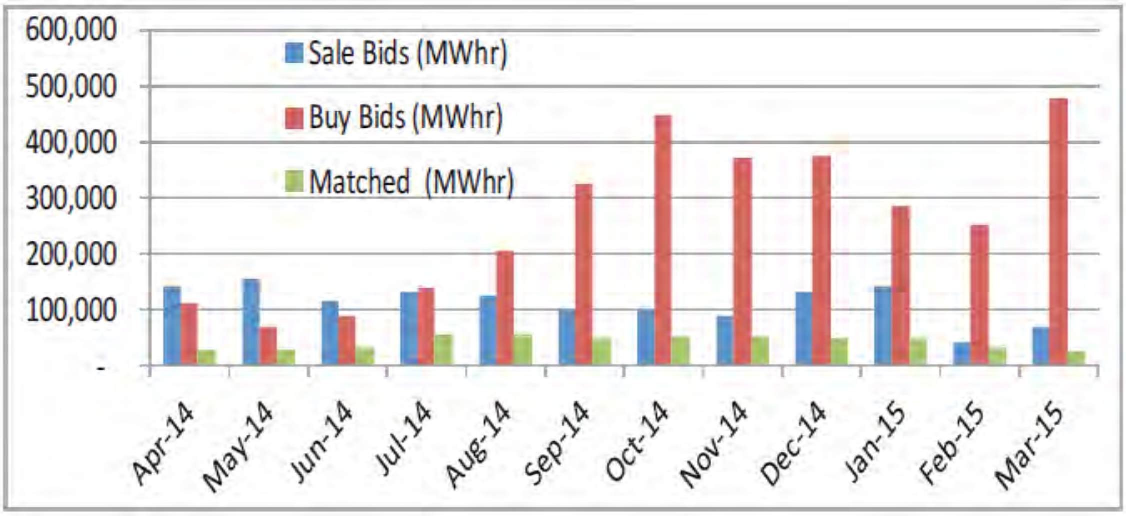
Source： SAPP C.C. (2016)

Table 2.1-6 Situation of negotiated bilateral contract (Seller/Buyer)

Seller	Buyer	Capacity[MW]		
ESKOM	SEC	250	424	Firm
	LEC	24		Firm
	BPC	150		Firm
	NamPower	350	650+Available	Non Firm
	ZESCO	300		Non Firm
	ZESA	As available		Non Firm
EDM	SEC	50	300+Available	Firm
	LEC	50		Firm
	BPC	50		Firm
	NamPower	50		Firm
	ESKOM	100		Firm
	ESKOM	As available		Firm
	ZESA	50	50+Required	Non Firm
	ZESCO	As required		Non Firm
EDM North	EDM South	300		
	EDM North	300		
HCB	EDM	300	2000	Firm
	EDM	200		Firm
	ESKOM	1150		Firm
	ESKOM	250		Firm
	ZESA	100		Firm
	ZESA	As available	Available	Non Firm
ZESCO	SNEL (KCC)	40	190	Firm
	EDM	100		Firm
	NamPower	50		Firm
	SNEL	100	700	Non Firm
	ESKOM	300		Non Firm
	BPC	100		Non Firm
	ZESA	200		Non Firm
ZESA	NamPower	150	150	Firm
	ESKOM	As available	Available	Non Firm
SNEL	BPC	50	100	Firm
	ZESA	50		Firm
	ZESA	50	50	Non Firm

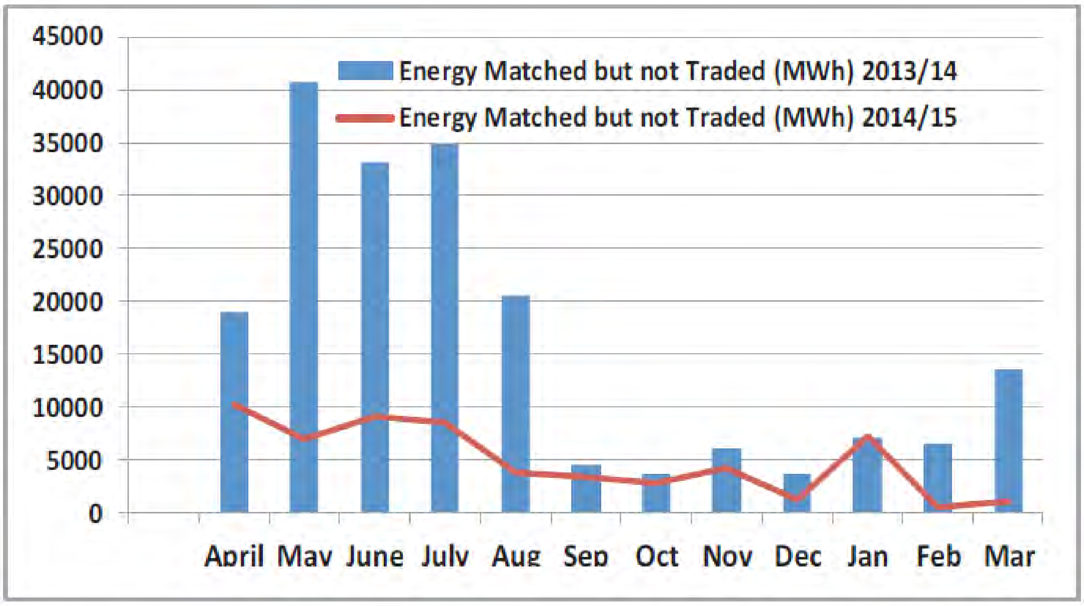
Seller	Buyer	Capacity[MW]		
ESKOM	SEC	250	300	Firm
EDM		50		Firm
ESKOM	LEC	24	74	Firm
EDM		50		Firm
ESKOM	BPC	150	250	Firm
EDM		50		Firm
SNEL		50		Firm
ZESCO		100	100	Non Firm
ZESCO	SNEL (KCC)	40	40	Firm
ZESCO	SNEL	100	100	Non Firm
ZESA	NamPower	150	250	Firm
ZESCO		50		Firm
EDM		50		Firm
ESKOM		350	350	Non Firm
HCB	EDM	300	600	Firm
HCB		200		Firm
ZESCO		100		Firm
EDM North	EDM South	300		
EDM South	EDM North	300		
HCB	ESKOM	1150	1500+Available	Firm
HCB		250		Firm
EDM		100		Firm
EDM		As available		Firm
ZESCO		300	300+Available	Non Firm
ZESA		As available		Non Firm
EDM	ZESCO	As required	300+Required	Non Firm
ESKOM		300		Non Firm
HCB	ZESA	100	200	Firm
SNEL		50		Firm
EDM		50	300+Available	Non Firm
ZESCO		200		Non Firm
SNEL		50		Non Firm
HCB		As available		Non Firm
ESKOM		As available		Non Firm

Source : JICA Survey Team using evidences from SAPP C.C. (2016)



Source : SAPP Annual Report 2015

Figure 2.1-7 Power market records (FY 2014/15)

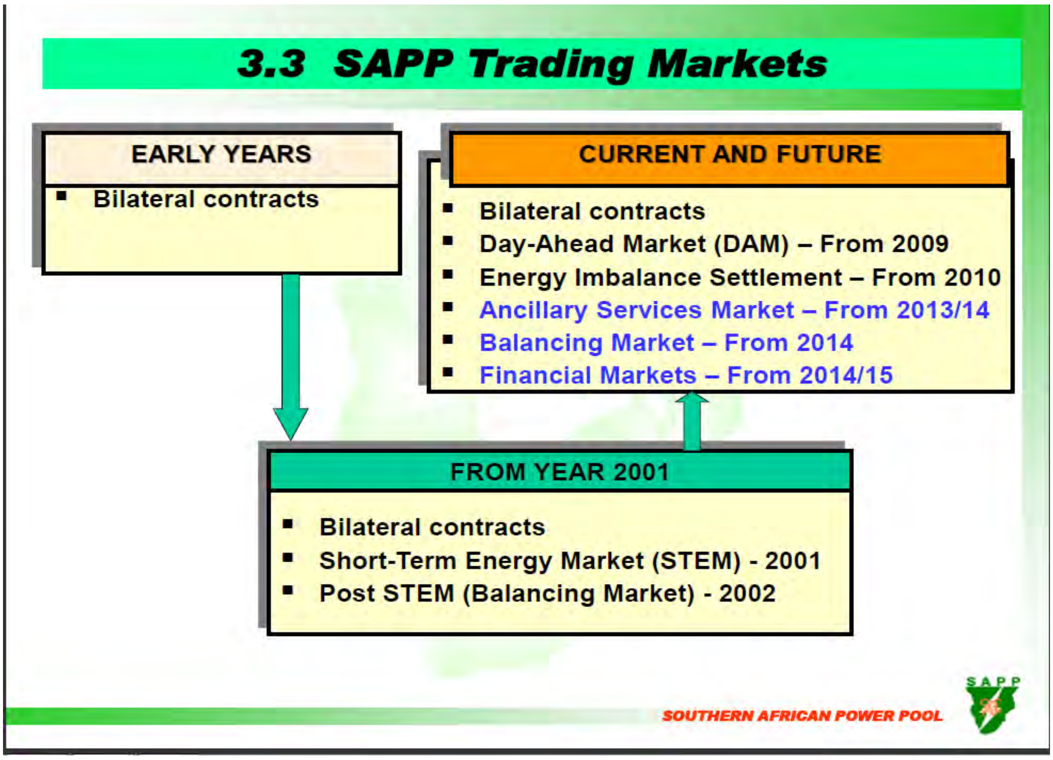


Source : SAPP Annual Report 2015

Figure 2.1-8 Failure results of power market due to transmission line congestion

Source : SAPP Annual Report 2015

Figure 2.1-9 SAPP power market web site



Source : The Southern African Power Pool - SAPP MANCO by Willem Theron (2012)[9]

Figure 2.1-10 SAPP market design concept

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[9] Energy imbalance settlement : Normally buyer and seller have to keep their trading volume which they negotiated. In case imbalance appeared they have to paid penalty charge as imbalance charge.
Ancillary service market : the market procuring the generators for spinning reserve, reserve margin and / or voltage stabilities, frequency stabilities for real time system control.
Balancing market : the market procuring the generators to stabilize the gross output of selling item (generator). This market is for sellers (power producer)
Financial market : Post-adjustment of the balance between bilateral trade and DAM trade in case that bilateral trade uses the framework of DAM.

3) Wheeling charge

Table 2.1-7 shows wheeling charges that obtained from SAPP Coordination Center. In this table, wheeling charges in 2011 and 2016 are set for comparison. The wheeling charge becomes slightly expensive in five years due to price escalation.

The wheeling charge is calculated by SAPP Coordination Center. Calculation mechanism is as follows.

- Available capacity calculation for power trade on all transmission system in SAPP,
- Usage charge calculation in each transmission facilities with their book values, and
- Summation of all route's usage charges on transmission facilities.

The reason of very small wheeling charge is because the book value of existing facilities are very low. In other words, transmission facilities are considerably old. The wheeling charge may sharply rise in the future as a new transmission lines are built.

It is noted that item 13 and item 38, in Table 2.1-7, is not same That is because power flow from south SAPP region to north SAPP region RSA is heavy and chronic. To reduce the power flow, item 38 is added the additional bias charge.

SAPP Coordination Center is currently studying the calculation method and the business transaction on the wheeling charge. It is expected to introduce the new wheeling charge system. The current and new policies of the wheeling charges can be summarized in Table 2.1-8.

The new pricing method intends to reflect the economic costs in the charges so as to expand the power trade market. It is necessary to watch the trend of the pricing system because the new system could also be applied for the existing transmission system.

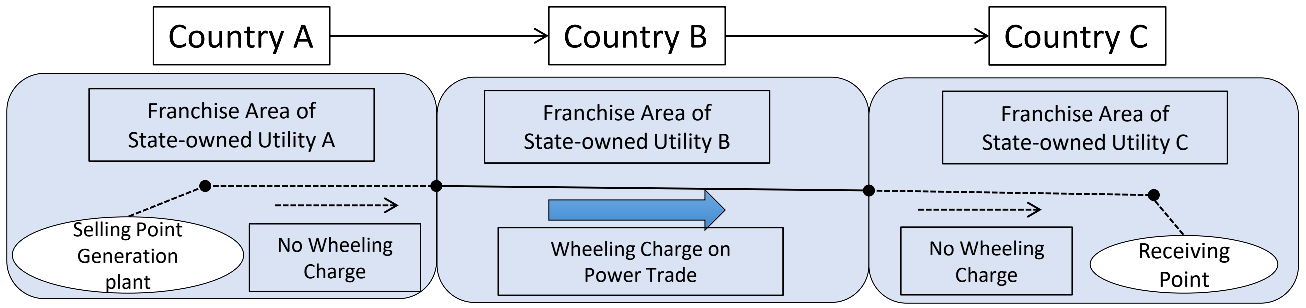
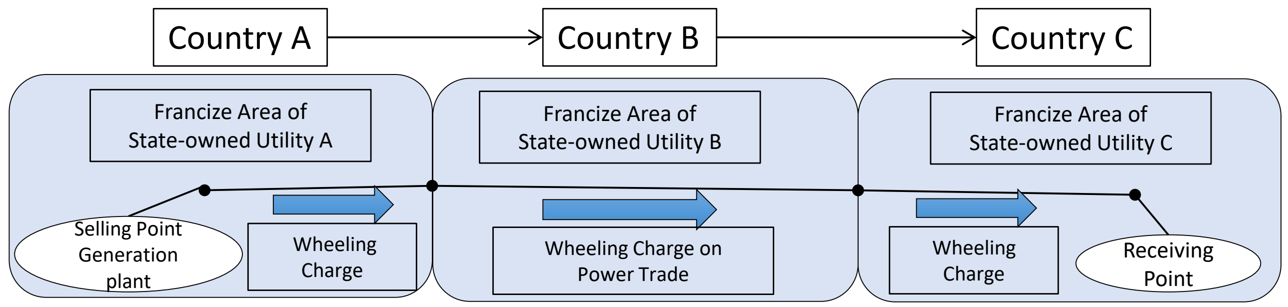
Table 2.1-7 List of wheeling charge (2011 and 2016)

Item	Transaction Seller to Buyer		WHEELERS, USc /kWh									Total
			BPC	ESKOM	EDM (S)	EDM (N)	SEC	ZESA	ZESCO	CEC	NAMPOWER	USc /kWh
1	SNEL - ZESCO	2016								0.042		0.042
		2011										-
2	SNEL - ZESA	2016							0.141	0.042		0.183
		2011							0.167			0.167
3	SNEL - BPC	2016						0.189	0.141	0.042		0.372
		2011						0.173	0.167			0.340
4	SNEL - ESKOM	2016	0.006					0.189	0.141	0.042		0.378
		2011	0.004					0.173	0.167			0.344
5	SNEL - NAMPOWER	2016	0.051	0.261				0.189	0.141	0.042		0.685
		2011	0.045	0.238				0.173	0.167			0.623
6	SNEL - SEC	2016	0.051	0.100				0.189	0.141	0.042		0.523
		2011	0.045	0.091				0.173	0.167			0.476
7	SNEL - LEC	2016	0.051	0.199				0.189	0.141	0.042		0.623
		2011	0.045	0.182				0.173	0.167			0.567
8	SNEL - HCB	2016				0.032		0.137	0.141	0.042		0.352
		2011						0.125	0.167			0.292
9	SNEL - EDM_S	2016	0.051	0.137			0.004	0.189	0.141	0.042		0.565
		2011	0.045	0.125			0.003	0.173	0.167			0.513
10	SNEL - NamPower (Zambezi)	2016							0.087	0.026		0.114
		2011							0.104			0.104
11	ZESCO - BPC	2016						0.189				0.189
		2011						0.173				0.173
12	ZESCO - BPC via 220 kV	2016						0.135				0.135
		2011										-
13	ZESCO - ESKOM	2016	0.006					0.189				0.195
		2011	0.004					0.173				0.177
14	ZESCO - NAMPOWER	2016	0.051	0.261				0.189				0.502
		2011	0.045	0.238				0.173				0.456
15	ZESCO - SEC	2016	0.051	0.100				0.189				0.340
		2011	0.045	0.091				0.173				0.309
16	ZESCO - LEC	2016	0.051	0.199				0.189				0.440
		2011	0.045	0.182				0.173				0.400
17	ZESCO - HCB / EDM_N	2016				0.032		0.138				0.170
		2011						0.126				0.126
18	ZESCO - EDM_S	2016	0.051	0.137			0.004	0.189				0.382
		2011	0.045	0.125			0.003	0.173				0.346
19	ZESCO - ESKOM via CAPRIVI	2016									0.351	0.351
		2011										-
20	ZESA - ESKOM	2016	0.006									0.006
		2011	0.004									0.004
21	ZESA - ESKOM(HVDC) via HCM	2016										-
		2011				(0.295)						0.295
22	ZESA - NAMPOWER	2016	0.051	0.261								0.313
		2011	0.045	0.238								0.283
23	ZESA - SEC	2016	0.051	0.100								0.151
		2011	0.045	0.091								0.136
24	ZESA - LEC	2016	0.051	0.199								0.251
		2011	0.045	0.182								0.227
25	ZESA - EDM_S	2016	0.051	0.137			0.004					0.193
		2011	0.045	0.125			0.003					0.173
26	ZESA - SNEL	2016							0.141	0.042		0.183
		2011							0.167			0.167
27	ZESA - NamPower (Zambezi)	2016							0.016			0.016
		2011							0.015			0.015
28	BPC - ZESCO	2016						0.189				0.189
		2011						0.173				0.173
29	BPC - SNEL	2016						0.189	0.141	0.042		0.372
		2011						0.173	0.167			0.340
30	BPC - NAMPOWER	2016		0.261								0.261
		2011		0.238								0.238
31	BPC - SEC	2016		0.100								0.100
		2011		0.091								0.091
32	BPC - LEC	2016		0.199								0.199
		2011		0.182								0.182
33	BPC - HCB	2016				0.032		0.222				0.254
		2011						0.201				0.201
34	BPC - HCB(HVDC)	2016										0.000
		2011		0.273								0.273
35	BPC - EDM_S	2016		0.137			0.004					0.141
		2011		0.125			0.003					0.128
36	ESKOM - ZESA	2016	0.006									0.006
		2011	0.004									0.004
37	ESKOM - ZESA(HVDC) via HCM	2016										-
		2011				(0.295)						0.295
38	ESKOM - ZESCO	2016	0.051					0.189				0.240
		2011	0.045					0.173				0.218
39	ESKOM - SNEL	2016	0.051					0.189	0.141	0.042		0.423
		2011	0.045					0.173	0.167			0.385
40	ESKOM - HCB	2016	0.051			0.032		0.222				0.305
		2011	0.045					0.201				0.246
41	ESKOM - SEC	2016			0.010							0.010
		2011			0.009							0.009
42	ESKOM - EDMS	2016					0.004					0.004
		2011					0.003					0.003
43	NAMPOWER - SNEL	2016	0.051	0.261				0.189	0.141	0.042		0.685
		2011	0.045	0.238				0.173	0.167			0.623
44	NAMPOWER - ZESCO	2016	0.051	0.261				0.189				0.502
		2011	0.045	0.238				0.173				0.456
45	NAMPOWER - ZESA	2016	0.006	0.261								0.267
		2011	0.004	0.238								0.242
46	NAMPOWER - BPC	2016		0.261								0.261
		2011		0.238								0.238

Item	Transaction Seller to Buyer		WHEELERS , USc /kWh									Total
			BPC	ESKOM	EDM (S)	EDM (N)	SEC	ZESA	ZESCO	CEC	NAMPOWER	USc /kWh
47	NAMPOWER - SEC	2016		0.204								0.204
		2011		0.186								0.186
48	NAMPOWER - LEC	2016		0.204								0.204
		2011		0.186								0.186
49	NAMPOWER - HCB	2016	0.051	0.261		0.032		0.222				0.566
		2011	0.045	0.238				0.202				0.485
50	NAMPOWER - HCB(HVDC)	2016										-
		2011		0.390								0.390
51	NAMPOWER - EDM_S	2016		0.246			0.004					0.250
		2011		0.225			0.003					0.228
52	NAMPOWER Zambezi - EDM_N	2016						0.127	0.016			0.143
		2011						0.116				0.116
53	HCB - SNEL	2016				0.032		0.138	0.141	0.042		0.353
		2011						0.126	0.168			0.294
54	HCB - ZESCO	2016				0.032		0.138				0.170
		2011						0.126				0.126
55	HCB - BPC	2016				0.032		0.222				0.254
		2011						0.202				0.202
56	HCB - BPC(HVDC)	2016										-
		2011		0.273								0.273
57	HCB - SEC	2016	0.051	0.100		0.032		0.222				0.404
		2011	0.045	0.091				0.202				0.338
58	HCB - LEC	2016	0.051	0.199		0.032		0.222				0.504
		2011	0.045	0.182				0.202				0.429
59	HCB - LEC(HVDC)	2016										-
		2011		0.329								0.329
60	HCB - EDM_S	2016	0.051	0.137		0.032	0.004	0.222				0.446
		2011	0.045	0.125			0.003	0.202				0.375
61	HCB - EDM_S(HVDC)	2016										-
		2011		0.309								0.309
62	HCB - ESKOM	2016	0.006			0.032		0.222				0.260
		2011	0.004					0.202				0.206
63	HCB - NAMPOWER	2016	0.051	0.261		0.032		0.222				0.566
		2011	0.045	0.238				0.202				0.485
64	HCB - NAMPOWER(HVDC)	2016										-
		2011		0.390								0.390
65	EDM_S - SNEL	2016	0.051	0.137			0.004	0.189	0.141	0.042		0.565
		2011	0.045	0.125			0.003	0.174	0.168			0.515
66	EDM_S - ZESCO	2016	0.051	0.137			0.004	0.189				0.382
		2011	0.045	0.125			0.003	0.174				0.347
67	EDM_S - ZESA	2016	0.006	0.137			0.004					0.147
		2011	0.004	0.125			0.003					0.132
68	EDM_S - BPC	2016		0.137			0.004					0.141
		2011		0.125			0.003					0.128
69	EDM_S - LEC	2016		0.211			0.004					0.215
		2011		0.193			0.003					0.196
70	EDM_S - HCB	2016	0.051	0.137		0.032	0.004	0.222				0.446
		2011	0.045	0.125			0.003	0.202				0.375
71	EDM_S - NAMPOWER	2016		0.246			0.004					0.250
		2011		0.225			0.003					0.228
72	EDM_S - ESKOM	2016					0.004					0.004
		2011					0.003					0.003
73	EDM_S - SEC	2016		0.082								0.082
		2011		0.075								0.075
74	SEC - SNEL	2016	0.051	0.100				0.189	0.141	0.042		0.523
		2011	0.045	0.091				0.174	0.168			0.478
75	SEC - ZESCO	2016	0.051	0.100				0.189				0.340
		2011	0.045	0.091				0.174				0.310
76	SEC - ZESA	2016	0.006	0.100								0.106
		2011	0.004	0.091								0.095
77	SEC - BPC	2016		0.100								0.100
		2011		0.091								0.091
78	SEC - NAMPOWER	2016		0.204								0.204
		2011		0.186								0.186
79	SEC - LEC	2016		0.144								0.144
		2011		0.132								0.132
80	SEC - HCB	2016	0.051	0.100		0.032		0.222				0.404
		2011	0.045	0.091				0.202				0.338
81	SEC - HCB(HVDC)	2016										0.000
		2011		0.245								0.245
82	SEC - ESKOM	2016			0.010							0.010
		2011			0.009							0.009
83	SEC - EDM_S	2016		0.082								0.082
		2011		0.075								0.075
84	LEC - SNEL	2016	0.051	0.199				0.189	0.141	0.042		0.623
		2011	0.045	0.182				0.174				0.401
85	LEC - ZESCO	2016	0.051	0.199				0.189				0.440
		2011	0.045	0.182				0.174				0.401
86	LEC - ZESA	2016	0.006	0.199								0.205
		2011	0.004	0.182								0.186
87	LEC - BPC	2016		0.199								0.199
		2011		0.182								0.182
88	LEC - NAMPOWER	2016		0.204								0.204
		2011		0.186								0.186
89	LEC - HCB	2016	0.051	0.199		0.032		0.222				0.504
		2011	0.045	0.182				0.202				0.429
90	LEC - HCB(HVDC)	2016										-
		2011		0.329								0.329
91	LEC - EDM_S	2016		0.211			0.004					0.215
		2011		0.193			0.003					0.196
92	LEC - SEB	2016		0.144								0.144
		2011		0.132								0.132

Source: JICA Survey Team using evidences from SAPP C.C. (2016)

Table 2.1-8　Methods to determine wheeling charges

Item		Current Method of SAPP	New Method under Examination
Basic Policy		(a) The power trades are made between the state-owned utilities only. There are no wheeling charges for the domestic segment in each country. (b) The wheeling charges in their own countries should be assumed by the internal costing of each utility of the seller and the buyer. (c) The method does not consider the case where a private company in one country would sell power to the other private company in other country. (The deals are only through the state-owned power utility based on the single-buyer, single-seller transaction.)	(a) All transmission lines are charged for power trade. (b) The power trades expect the cases where the trades are made between the companies other than the state-owned utilities and the deals are made in the power market. (c) The wheeling charges on the transmission consider the cost from the major sub-station in the selling country and the sub-station in the buyer country. (d) The model expects the multiple buyer - multiple sellers in the future.
Overview of Scheme			
Chara-cteristics	Pros	(a) The method is established as the calculation formula for the current power trade and widely accepted in the SAPP region. (b) It is a uniform methodology for the SAPP region. (There is the biased pricing consideration that restricts the northbound current and promotes the southbound current.) (c) The current pricing is based on the current transmission assets. Thus the wheeling charge is set lower than the actual cost.	(a) The pricing is based on the economic costs of the transmission assets. Thus it will allow rational development and utilization of the transmission system. (b) It will allow the equal charges to the users. (c) It may lead to the investment on the domestic transmission system in view of the international power trade. (d) The price setting is based on the market basis, which would promote the private sector participation.
	Cons	(a) The current system does not reflect the economic cost of the assets. This would provide limited incentives for investing on the new transmission lines and for the power trade by the private companies. (b) It is not expected that the generation projects that consider the international power trade could attract the private investors. (The trade needs to be made between state-owned utilities, not a direct agreement.) (c) The wheeling cost within the domestic country does not reflect on the costs.	(a) The wheeling charges are calculated at a higher price than the current method. (b) The transition to the new system would need to obtain the understanding on the establishment of the uniform method. The transmission assets need to be reevaluated in order to assess the pricing and examination of the assumptions. (c) It would take some more time to introduce the new system even though the SAPP office is currently studying the launch. (d) The technical issue would be the application to the network of the complicated currents. (e) The SAPP Coordination Center intends to prepare the proto-type model in 2017 and examine the model afterwards.
Policy in the Survey		The new system has not been established as of today. The evaluation of the model needs to be studied and tested. Therefore the Survey considers the following, (a) In the segment of the existing transmission lines, the pricing is determined by the current price setting method. The power trading cost will be calculated accordingly. (b) In the segment of the new transmission lines where the new development is made for the purpose of the international trade, the new system should be applied. (c) The total wheeling charge will be assessed by the summation of the above two segments.	

Source : JICA Survey Team

Box article : Power Trade and Operation in SAPP

Current wheeling charges

- The transmission capacity for the international trade would be allocated to the unused portion in the domestic market. (e.g. If the existing transmission is 70% utilized for the domestic use, the rest of 30% capacity can be allocated for the international trade.)
- The depreciation cost for the international transmission would be charged based on the 30% capacity portion to the users, in the case of the above.
- The transmission asset for pricing is on the historical cost basis and only the costs for international trade is considered. Thus the wheeling charge is lower than the actual costs.

Current power trade

(a) Market participants

The participants are the state-owned power utilities and CEC Company in Zambia only.

(b) Trading method

- The applicants for the power purchase place the amount and price for their requests of one-day, one-month in advance. The bidding prices include only the generation prices.
- The bid data are compared and evaluated at the SAPP Coordination Center. The highest bidder will win the tender.
- The SAPP Coordination Center takes care of paperwork such as disclosure of the bidding data, execution of the trade, preparation of the bills and the settlement. These transactions are handled by SAPP Coordination Center.

(c) Transaction price

- The payment for the power purchase would include the payment to the generation company (bid price), wheeling charge, technical loss and SAPP service charge (0.1 US cents/kWh from each of the seller and buyer). Thus the actual payment is higher than the bid price.
- The SAPP Coordination Center pays to the transmission company and the generation company for the payment received from the buyer.

(d) Others

- If there are several possible routes for transmission, all the possible routes are evaluated and reflected to the average costs for wheeling charge.
- The SAPP service charges are designed to recover all for the services by the SAPP Coordination Center.
- The SAPP Coordination Center accumulated the surplus of the transaction as a separate fund. The fund aims to provide the guarantee for the market participants and facilitate the trade. In the future, the fund may be utilized for the partial guarantee for the debt financing for the construction of new transmission lines.

Source : JICA Survey Team by the interview with SAPP C.C.

Figure 2.1-11 Procedure and mechanism of power trade in SAPP

2.2 SAPP priority project

(1) Definition of SAPP priority project

In 2011, SAPP Executive Committee gave priority to power generation projects and transmission projects including interconnectors as the priority project. The priority project means the project contributing to power pool integration. Further, the priority project has to be promoted and supervised in each stage by SAPP and SADC.

1) Generation priority project

Generation SAPP priority project were chosen by the evaluation with following eight keys.

① Generation capacity

② Levelized generation cost

③ Power supply transmission line(s) (power line(s))

④ Economic impact

⑤ Progress of project

⑥ Beneficiary ratio

⑦ Profit given to a region where project is in progress

⑧ The number of countries which participated in the project concerned

Table 2.2-1 shows the practical evaluation method with eight keys for generation selection.

Table 2.2-1 SAPP Priority project screening method – generatinon priority project

Item No	Key Aspects	Weight %	1 Weak	2 Below Standard	3 Standard	4 Above Standard	5 Best
1	Size of Project, MW	15	<50	50-200	200-500	500-1000	>1000
2	Levelised costs in Country (Including Transmission Lines), USD/MWh	25	>=131	101- 130	71 - 100	41 –70	<=40
3	Transmission integration aspects/stability/ technology	10	>750km	101-750km	50-100 km	<50km	Existing infrastructure, plug in
4	Economic impact	10	Little impact, limited to small area	National impact only -jobs, >GDP	Mainly national impact - jobs, >GDP and some	Balance between regional and national impact	Mainly regional impact - jobs, > GDP
5	Project Time domain (Commissioning date)	10	After 2019	2018	2017	2016	< 2015
6	Percentage off-take committed	10	<20	21 - 35	36 - 50	51 - 80	>80
7	Regional contribution as a % of project replacement)	15	<20	21 - 35	36 - 50	51 - 80	>80
8	participating member countries	5	1	2	3	4	>= 5

Source : SAPP Prioritization (2011)

Table 2.2-2, Table 2.2-3show the results of the selection. These were pubicated by SAPP to inform and push up the projects' progress. For reference, Table 2.2-4 shows the rest of the generation projects not to select as priority project, the score of which is below 50.

Table 2.2-2 SAPP priority project – generation priority project – capacity over 1,000MW

SAPP PRIORITY GENERATION PROJECTS (CAPACITY > 1000 MW)					
Priority Ranking	Country	Project Name	Capacity [MW]	Technology	Expected Commissioning Date
1	Mozambique	HCB North Bank	1245	Hydro	2022
2	Mozambique	Mphanda Nkuwa	1500	Hydro	2023
3	Zambia / Zimbabwe	Batoka	1600	Hydro	2022
4	DRC	Grand Inga Phase 1 (Inga 3 Low Head)	4800	Hydro	2022
5	Zimbabwe	Gokwe North	1400	Coal	2022
6	South Africa	New PF + FBC	6250	Coal	2026
7	South Africa	Nuclear	9600	Nuclear	2023
8	Lesotho	Kobong Pumped Storage	1200	Hydro	2020
	TOTAL		**27,595**		

Source : SAPP Prioritization (2011)

Table 2.2-3 SAPP priority project- generation priority project – capacity less than 1,000MW

SAPP PRIORITY GENERATION PROJECTS (CAPACITY < 1000 MW)					
Priority Ranking	Country	Project Name	Capacity [MW]	Technology	Expected Commissioning Date
1	Zimbabwe	Kariba South Extension	300	Hydro	2018
2	Namibia	Kudu	800	Gas	2019
3	Mozambique	Moatize	300	Coal	2019
4	Botswana	JMEP I	300	Coal	2020
5	Zambia	Kafue Gorge Lower	600	Hydro	2019
6	Namibia	Baynes	500	Hydro	2023
7	Mozambique	Benga	300	Coal	2019
8	Zimbabwe	Hwange 7 & 8	600	Coal	2019
9	Tanzania	Kinyerezi 2	240	Hydro	2015
10	Zambia	Mkushi	65	Hydro	2020
11	DRC	Busanga	240	Hydro	2020
12	Zambia	Kalungwishi	220	Hydro	2019
13	Zambia	Lunsemfwa	55	Hydro	2018
14	DRC	Zongo 2	150	Hydro	2017
15	Tanzania	Rumakali	520	Hydro	2020
16	Zambia	Mambilima Falls site 1&2	425	Hydro	2021
17	Zambia	Mpata Gorge	543	Hydro	2023
18	Tanzania	Ruhudji	480	Hydro	2020
19	Tanzania	Kiwira	200	Hydro	2020
	TOTAL		**6,838**		

Source : SAPP Prioritization (2011)

Table 2.2-4 SAPP project –reference - score less than 50

SAPP UTILITY INTEGRATED RESOURCE PLAN GENERATION PROJECTS				
Priority Ranking	**Country**	**Project Name**	**Capacity [MW]**	**Technology**
1	Lesotho	Monotsa Pump Storage	1000	Hydro
2	Zambia	Devils Gorge	500	Hydro
3	Malawi	Mpatamanga	260	Hydro
4	Malawi	Songwe	340	Hydro
5	Malawi	Kholombizo	240	Hydro
6	Zimbabwe	Lupane	300	Gas
7	South Africa	OCGT	2370	Gas
8	South Africa	CCGT Gas	3910	Gas
9	South Africa	New Wind	7200	Wind
10	South Africa	Solar PV	6900	Solar
11	Botswana	Solar CSTP	100	Solar
	TOTAL		**25,720**	

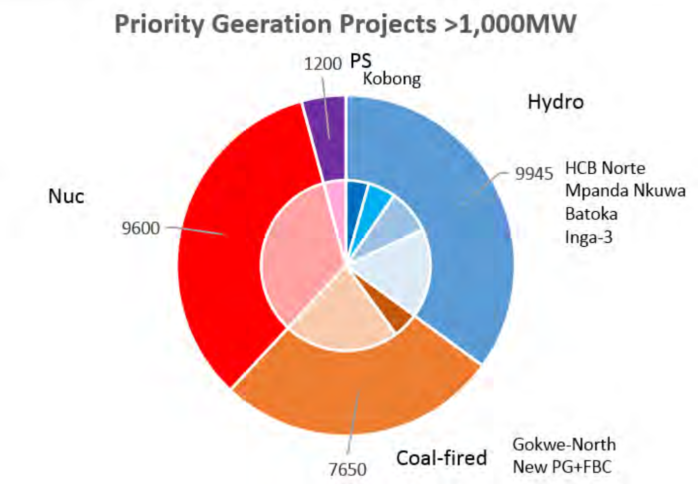
Source : SAPP Prioritization (2011)

Figure 2.2-1,Figure 2.2-2 and Figure 2.2-3 show the allocation of generation sources on the point of generation capacities.

It can be seen that hydropower development and coal-fired power development are the main body of the prioritized projects. Most of these projects are utilized as base load generators. By the way, hydropower development might be able to operate it as peak load generator, peaker, to benefit SAPP.

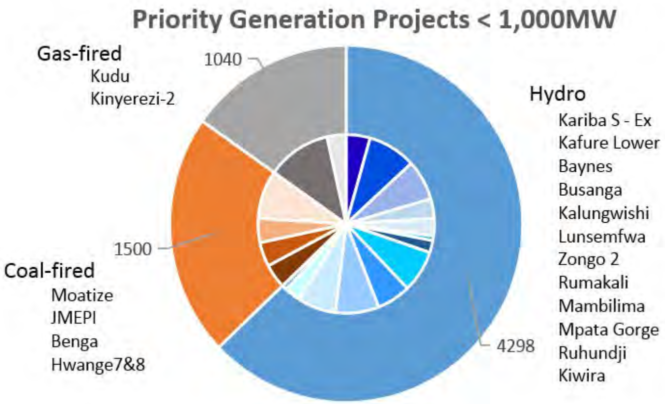
Figure 2.2-4 shows the eccentricity of SAPP priority projects. Most of hydropower projects are allocated on the Zambezi River basin (Zambia, Zimbabwe, and Mozambique). Therefore generation development area is divided into two, one is the northern area including DR Congo,Tanzania and the river basin aforementioned, and another is RSA.

Here, benefit from nuclear power development in RSA and pumped storage power in Lesotho to SAPP are not apparent.



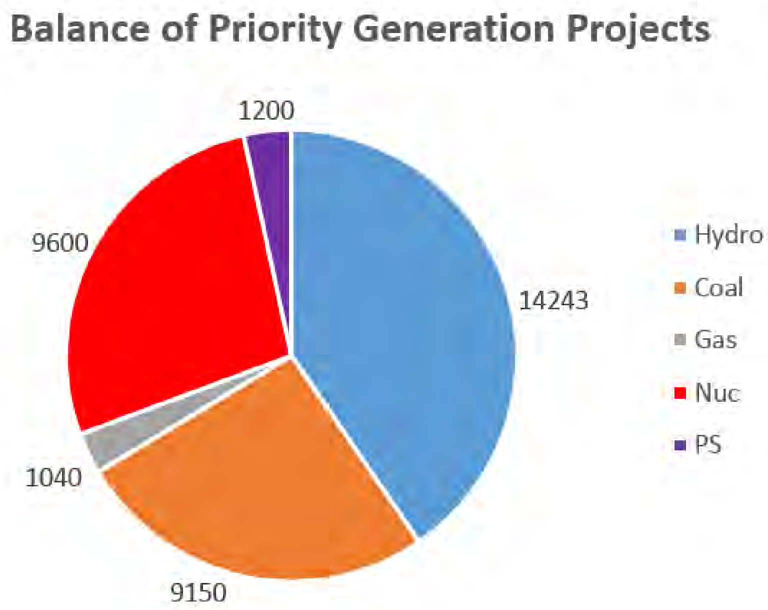
Source：JICA Survey Team

Figure 2.2-1　Capacity ratio of every power source in SAPP priority project (>1000MW)



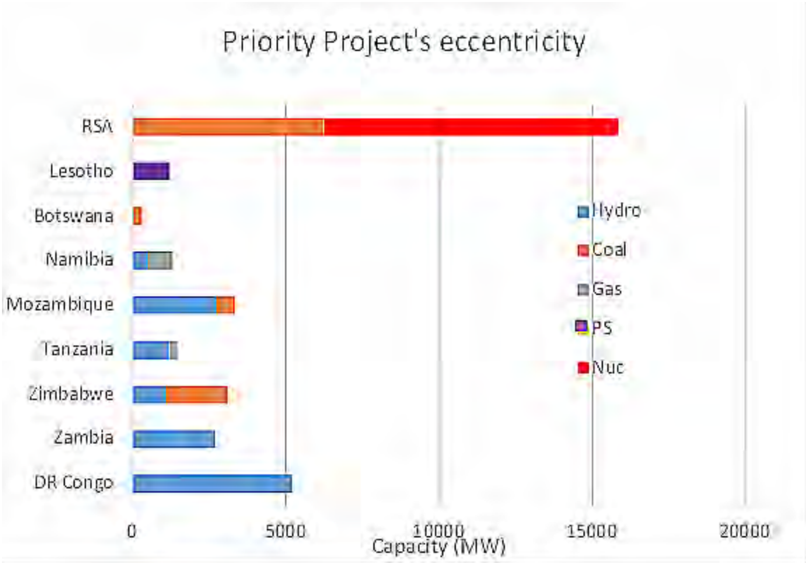
Source：JICA Survey Team

Figure 2.2-2　Capacity ratio of every power source in SAPP priority project (<1000MW)



Source：JICA Survey Team

Figure 2.2-3　Capacity ratio of every power source in SAPP priority project (Total)



Source : JICA Survey Team

Figure 2.2-4 Eccentricity of SAPP generation project allocation

2) Interconnector priority project

SAPP states that following three issues are important for grid integration.

- Trunk system construction for eliminating power trade congestions,
- Connection to non-interconnected SAPP member states, and
- Interconnector construction for realizing power transmission from new large-scale generator(s)

Table 2.2-5 shows the prioritized transmission project by SAPP in line with these concept in 2011.

Table 2.2-5 SAPP priority project - transmission project

Trunk system construction for eliminating power trade congestions				
No.	Project Name	Countries	Capacity [MW]	Expected Date
1	ZIZABONA	Zimbabwe, Zambia, Botswana, Namibia	600	2018
2	Central Transmission Corridor	Zimbabwe	300	2018
3	North West Upgrade	Botswana	600	2018
Connection to non-interconnected SAPP member states				
No.	Project Name	Countries	Capacity [MW]	Expected Date
1	Zambia-Tanzania	Zambia, Tanzania	400	2018
2	Mozambique-Malawi	Malawi, Mozambique	300	2019
3	Namibia-Angola	Angola, Namibia	400	2019
4	DRC-Angola	Angola, DRC	600	2019
Interconnector construction for realizing power transmission from new large-scale generator(s)				
No.	Project Name	Countries	Capacity [MW]	Expected Date
1	Mozambique Backbone (STE)	Mozambique	3,100	2022
2	2nd Mozambique-Zimbabwe	Mozambique, Zimbabwe	500	2018
3	2nd Zimbabwe-South Africa	South Africa, Zimbabwe	650	2018
4	2nd DRC-Zambia	DRC, Zambia	500	2017

Source: SAPP Prioritization (2011)

(2) Progress of interconnector priority project

SAPP Coordination Center is focusing on transmission development to energize power trade and issues a report of the development progress on each occasion. Progress of the interconnector SAPP priority projects are given below.

1) Interconnector project

(a) ZiZaBoNa Transmission Porject (Figure 2.2-6)

This is an interconnector project which borders on Zambia, Zimbabwe, Namibia and Botswana. The project is separated into two phases and phase 1 has been already accomplished.

This project makes it possible to connect not only to northern SAPP region and southern SAPP region at Victoria Falls substation, but to western SAPP region. Therefore this project has a benefit to feed power with high flexibility.

As of February 2016, an interim transaction report was submitted to SAPP C.C. and was reviewing by the countries concerned. Further, this project, especially phase 2 is now waiting the comment about financial condition from donors.

(b) Central Transmission Corridor Project (CTC) (Figure 2.2-7)

This project is a regional system project in Zimbabwe, but is important to feed power between northern SAPP region and southern SAPP region. It proposed by SAPP Pool Plan, established in 2009 to transfer bulk power from large-scale hydropower generations along the Zambezi River, such as Kariba North, Kariba South, Cahora Basssa and Mphanda Nkuwa project, to all SAPP area. Also this project is located next to ZiZaBoNa project. Therefore it can become hub system for SAPP grid in corroboration with ZiZaBoNa.

As of September 2016, EIA on segment, Bindura - Mutrashanga and on segment, Alaska -Sherwood B were being studied. Further procurement notice on FS on Alaska -Sherwood B segment were advertised.

(c) Botswana North-West Upgrade Project (Figure 2.2-8)

This project is also a regional system project in Botswana, but is important to connect northern SAPP region with southern SAPP region with ZiZaBoNa.

This project is separated into two phases. Phase 1 is to strengthen the northwestern part of Botswana, and phase 2 is for connection with ZiZaBoNa.

As of the end of 2016, an EPC contract for phase 1 was concluded, a detailed design was being carried out. Completion of the phase 1 construction will be in 2018. And now EPC for development of phase 2 is being selected. Completion of the phase 2 construction is set in 2019. In the meanwhile, this project is carried out by self-funding of BPC.

(d) Zambia - Tanzania - Kenya Interconnector Project (ZTK) (Figure 2.2-9)

This is a project for the purpose of connection with non-interconnected member state. Moreover this project is aiming to trade power to Eastern Power Pool (EAPP), while constructing regional trunk transmission line, as the national backbone.

Segment, Iringa - Shinyanga was being constructed by supports of JICA, WB, EIB and KEXIM.

Segment, Tanzania – Kenya is being coordinated for construction stage by supports of JICA and AfDB. On the other hand, progress of Zambian side is delayed.

The project in Zambia was revised because the project involved new transmission constructions, such as segment, Kabwe – Kasama, etc. In December 2016 conference was held in Lusaka to move forward anew project. The project in Zambia is separated into two phases, as shown in Figure 2.2-10. Phase 1 is the original concept to connect the each member state, and phase 2 is to secure the system reliability.

(e) Malawi - Mozambique Interconnector Project (Figure 2.2-11)

This is a project for the purpose of connection with non-interconnected member state, same as ZTK.

The interconnector will be used to feed power from Mozambique to Malawi during lighting period to meet peak demand.

(f) Angola – Namibia Interconnector Project (AnNa)

This is a project for the purpose of realizing power transmission from new large-scale generator. Baynes hydropower project, located in the Cunene River, between Angola and Namibia, and its power lines in Namibia and in Angola are the complete picture invites the procurement of transaction advisory services for this project.

(g) STE Backbone Project (Figure 2.2-12)

This project is a regional system project in Mozambique, and is important to connect northern Mozambique and southern Mozambique with both HVAC and HVDC transmission lines. HVAC transmission line is for integrating national system and HVDC transmission line is for supplying bulk power to meet demand in Maputo and RSA.

In 2011, many players had interests to develop the project[10]. However, stagnation of large-scale power generation[11] development influenced this project.

As of December 2016, it was during Diet approval about the demolition of the existing project consortium. After then, EDM and HCB will handle this project as main developers.

The government of Mozambique states this project and Mphanda Nkuwa hydropower project are jointly developed.

(h) Mozambique – Zimbabwe – South Africa Project (MoZiSa) (Figure 2.2-13)

This project is not SAPP priority project but this involves the 2nd Mozambique - Zimbabwe Interconnector and the 2nd Zimbabwe - South Africa Interconnector, shown in Table 2.2-5. Further, this involves a component of CTC project.

A point to be emphasized of this project is that this can implement two interconnectors with integrating Mozambican national grid. This project can bind northern Mozambique, rich coal and water resource area and RSA.

As of November 2015, a technical input report was submitted to the countries concerned and was reviewed. Further this project will be separated into two phases, namely Mozambique – Zimbabwe and Zimbabwe – South Africa.

[10] The consortium by Redes Energéticas Nacionais (Portuguese REN), Chinese company and EDM were established.
[11] The consortium by Brazilian Camargo Corrêa (40%), Mozambican Insitec (40%), EDM (20%) were established.

(i) BoSa Transmission Project (Figure 2.2-14)

This project is brand new project. And therefore this was not listed on SAPP priority project. This was formulated by the request to compensate transmission congestion and to be the entrance of trunk transmission for RSA.

Remarkable point is that this project is studied to apply 500kV design. Thus RSA is considering 500kV is the next generation's trunk system in SAPP. This will be operated with 400kV at the first and upgrade to 500kV in the future.

As of September 2016, FS was being reviewed.

2nd DR Congo - Zambia Interconnector, in Table 2.2-5 was accomplished in 2015[12]. But information of DR Congo - Angola Interconnector has not been provided from any other organizations.

In October 2016, SAPP Coordination Center announced that current status of interconnector projects are shown in Figure 2.2-5.

FS Stage , Project preparation
1. Malawi – Mozambique
2. ZTK (Zambia side)
3. BoSa
4. STE Backbone (HVDC, HVAC)
5. ZiZaBoNa
6. MoZiSa
7. Malawi – Tanzania
8. Angola - Namibia

Pre FS Stage
a. DRC - Angola
b. Zambia - Mozambique
c. Zambia - Malawi
d. Mozambique - Tanzania
e. Botswana - Namibia

Source : JICA Survey Team using evidence from SAPP C.C. (2016)

Figure 2.2-5 Current status of interconnector projects

[12] Constructed by CEC, Zambia

The projects which are not explained yet are below,

- Tanzania – Mozambique Interconnector
- Zambia – Mozambique Interconnector
- Malawi – Zambia Interconnector

Therefore these are explained briefly,

(j) Tanzania – Mozambique Interconnector

In March 2016, EDM, Mozambique and Tanesco, Tanzania signed Inter utility memorandum of understanding (IUMoU) to study the feasibility of this interconnector. With this interconnector, EDM will be keen to feed power generated at northern area to EAPP. And Tanesco is keen to send power generated at Mtwara area to Mozambique as one of the options.

As of December 2016, project teams are established in each utility, are preparing FS. Also each utility is preparing the inter-governmental negotiation.

(k) Zambia – Mozambique Interconnector

In March 2016, the government of Mozambique and the government of Zambia signed Inter Governmental memorandum of understanding (IGMoU) to study the feasibility of this interconnector with implementation of advanced ultra super critical coal-fired power plant, its capacity is 1,200MW.

As of December 2016, project teams are established in each utility, namely EDM and ZESCO.

SAPP Coordination Center provided the information of this project that NEPAD Infrastructure Project Preparation facility (NEPAD IPPF) funded the FS.

(l) Zambia – Malawi Interconnector

In August 2015, the government of Malawi and the government of Zambia signed IGMoU to study the feasibility of this interconnector. Project teams are established in each utility, namely ESCOM and ZESCO.

But IGMoU does not mentioned the power source to transfer by this interconnector. It assumed that Malawi is keen to diversify the power trade into several states.

Source： ZiZaBoNa Transmission Project Project Information (2013)

ZiZaBoNa Project

(Interconnector)

- Phase 1 - accomplished

<Zimbabwe side>

Hwange – Victoria Falls : existing route

<Zambia side>

Livingstone – Zambezi – Caprivi : existing route

<Interconnector>

Victoria Falls (Zim.) – Livingstone (Zam.) : existing route

<Power trade Contract>

Zimbabwe (Hwange coal-fired) →Namibia 80MW, 15years

- Phase 2

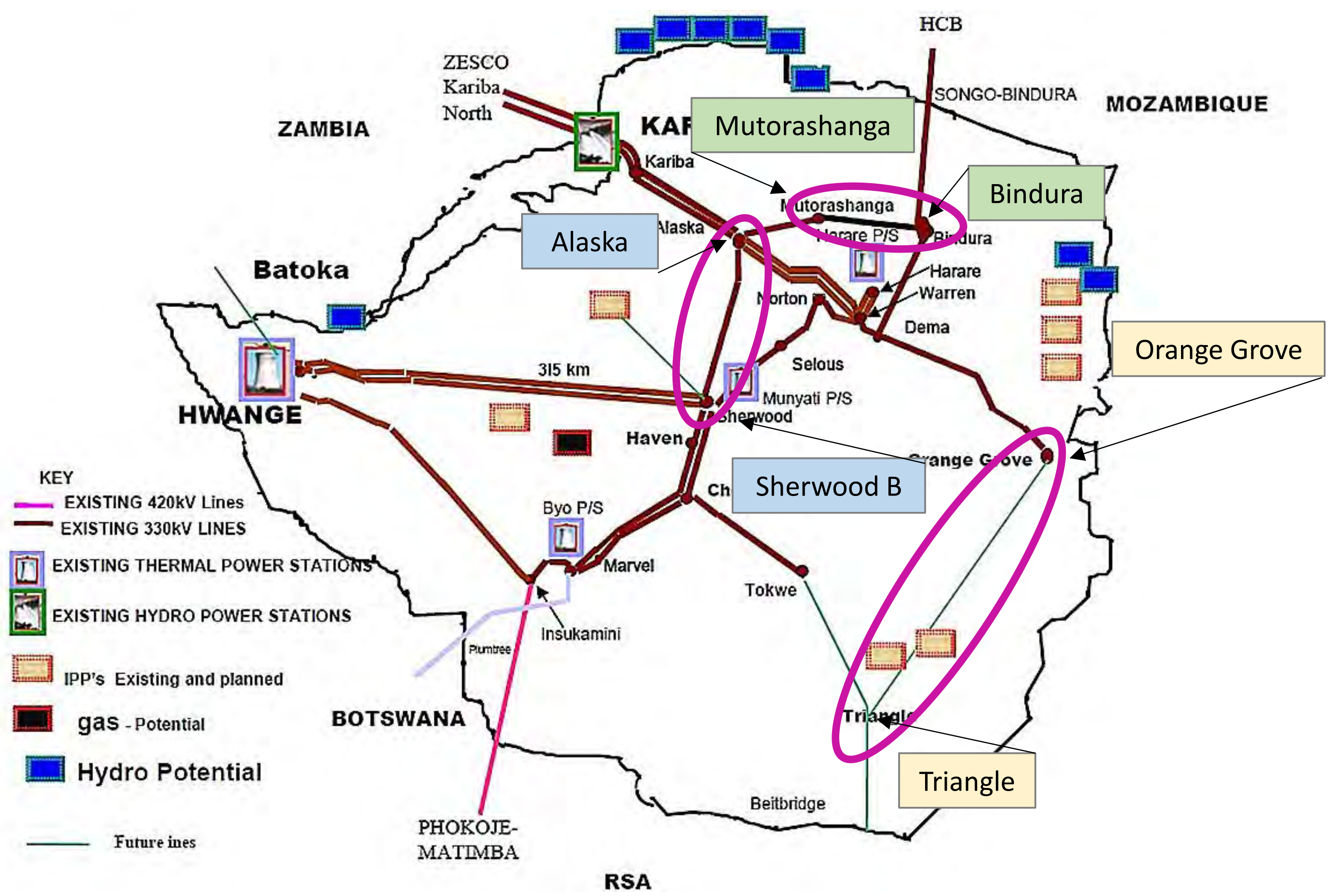
400kVtransmission line (initially 330kV operation)

Pandamatenga (Bots.) – Victoria Falls (Zim.)

Livingstone (Zam.) – Zambezi (Zam.)

Hwange (Zim.) – Victoria Falls (Zim.)

Figure 2.2-6　　ZiZaBoNa Project



Source：　Central Transmission Corridor – Zimbabwe Project Profile (2013)

CTC Project

Regional system (Zimbabwe)

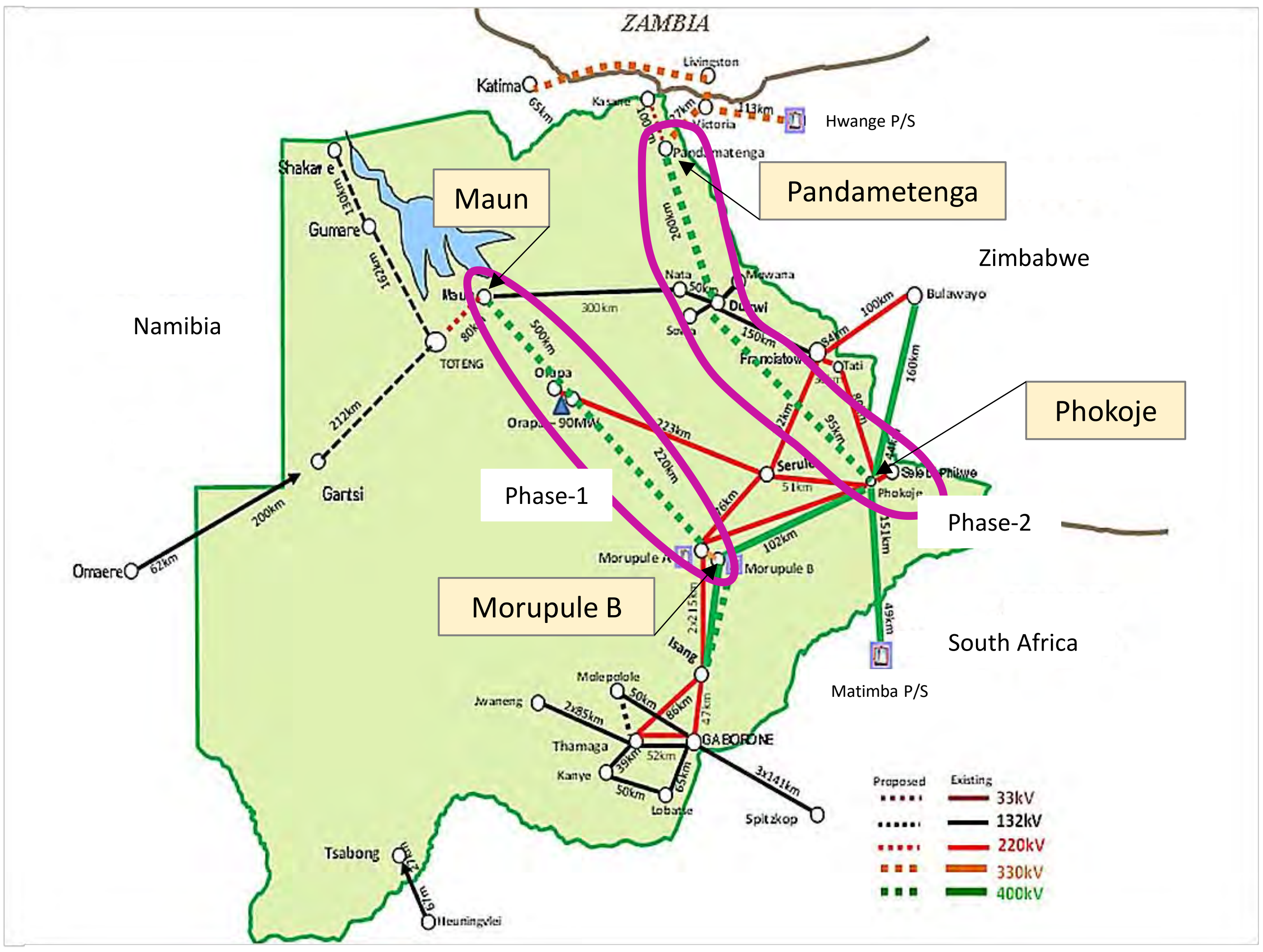
400kV transmission line

・Bindra – Mutrashanga

・Alaska－Sherwood B

・Orange Grove – Triangle

Figure 2.2-7　　CTC Project



Source : Public Notice North West Transmission Grid Project Update (2015)

North – West Project

Regional system (Botswana)

Phase 1

400kV transmission line

・Morupule B – Orapa-Maun

(incl. 220kV transmission lines)

Phase 2

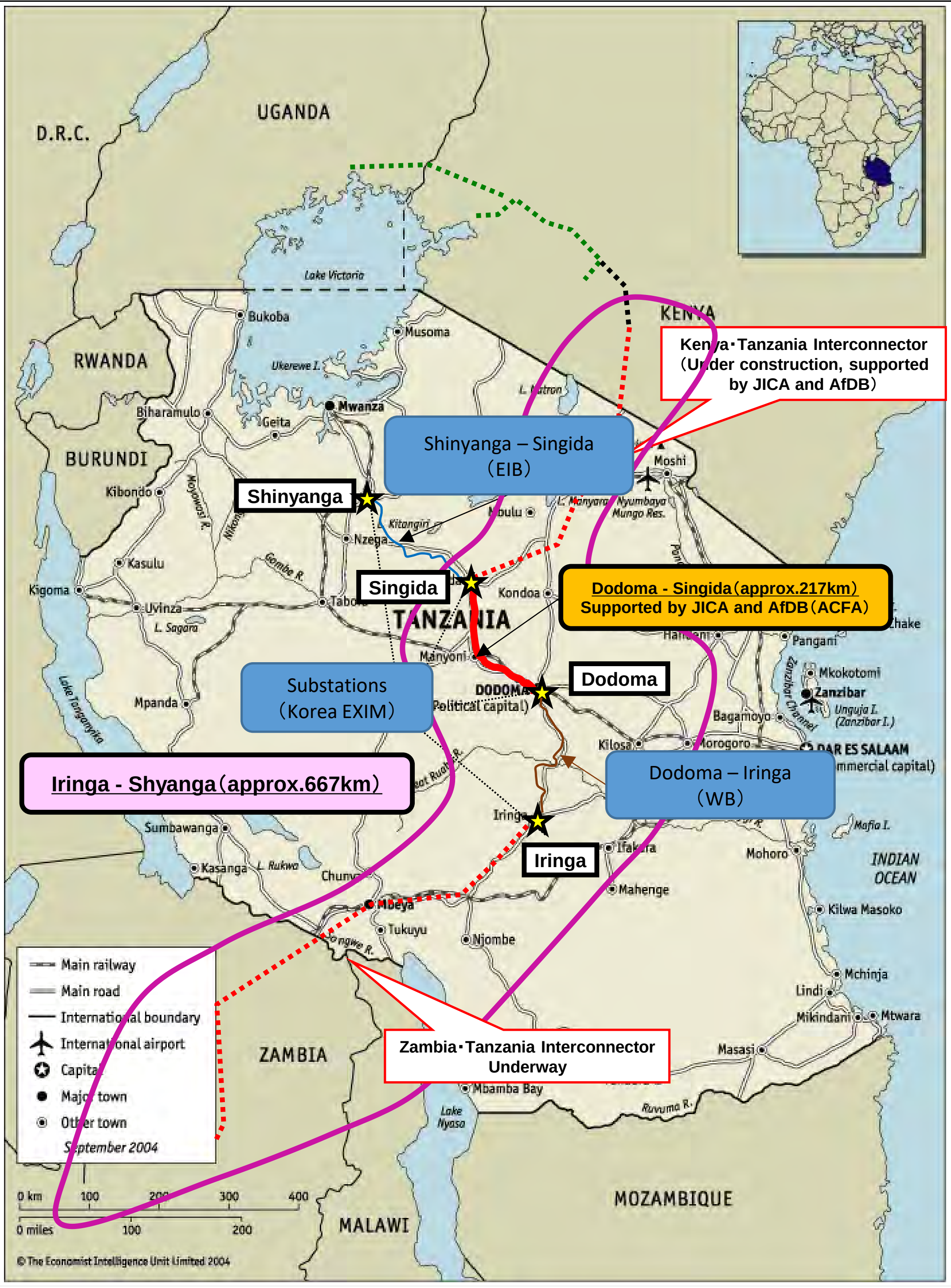
400kVtransmission line

・Phokoje－Dukwi

・Dukwi – Pnadamatenga

(incl. 220kV transmission lines)

Figure 2.2-8　North–West Project



ource – The Survey Team wrapped it up based on JICA Press release"Iringa-Sinyanga transmission project (2010)"

ZTK Project

(Interconnector)

400kVtransmission line

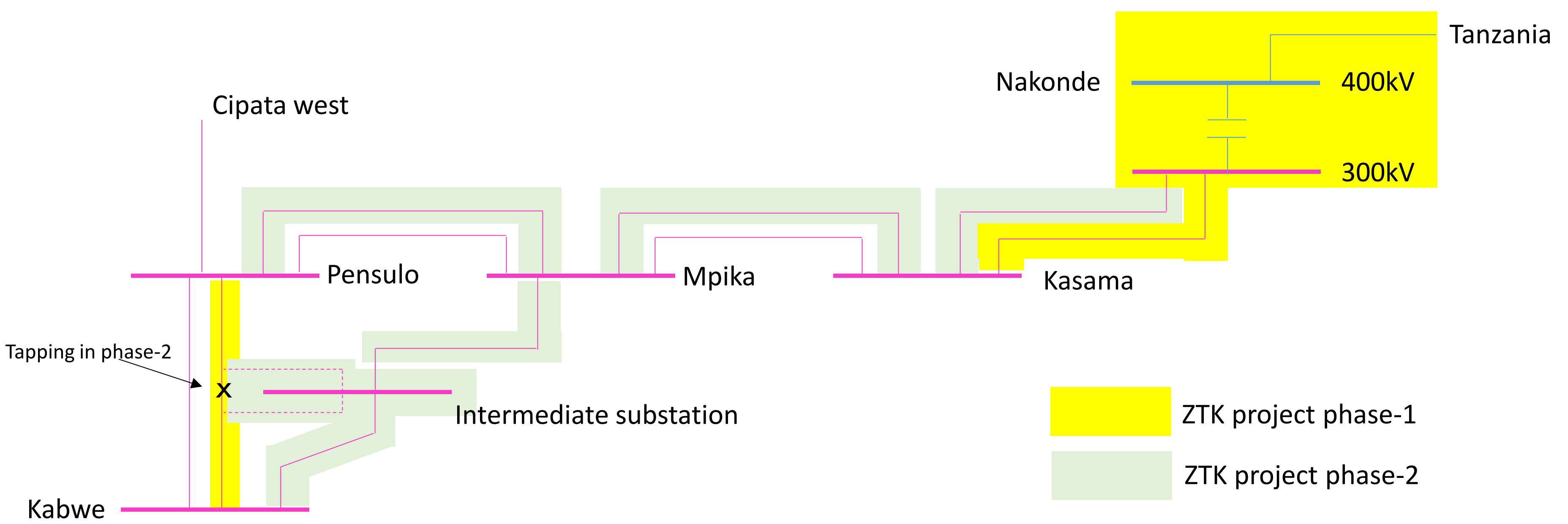
- Kenya – Singida (Tanzania)
- Mbeya (Tanzania) – Nakonde (Zamia)

(Regional system)

400kV transmission line

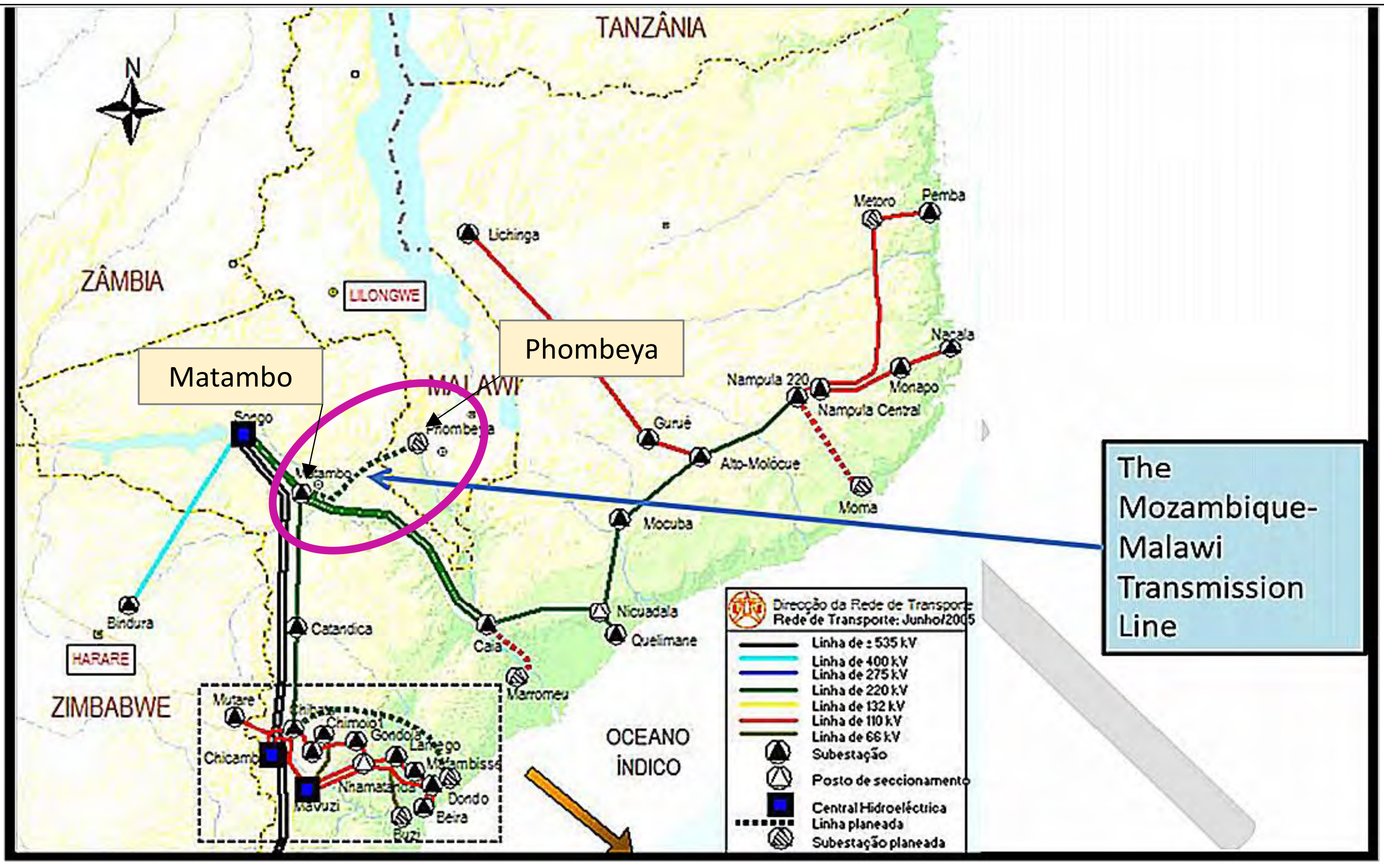
- Iringa - Shinanga
- Iringa - Mbeya

Figure 2.2-9 ZTK Project



Source : JICA Survey Team using evidence from ZESCO (2016)

Figure 2.2-10 ZTK Project – Zambian side



Source：Mozambique – Malawi Interconnector Project Brief (2013)

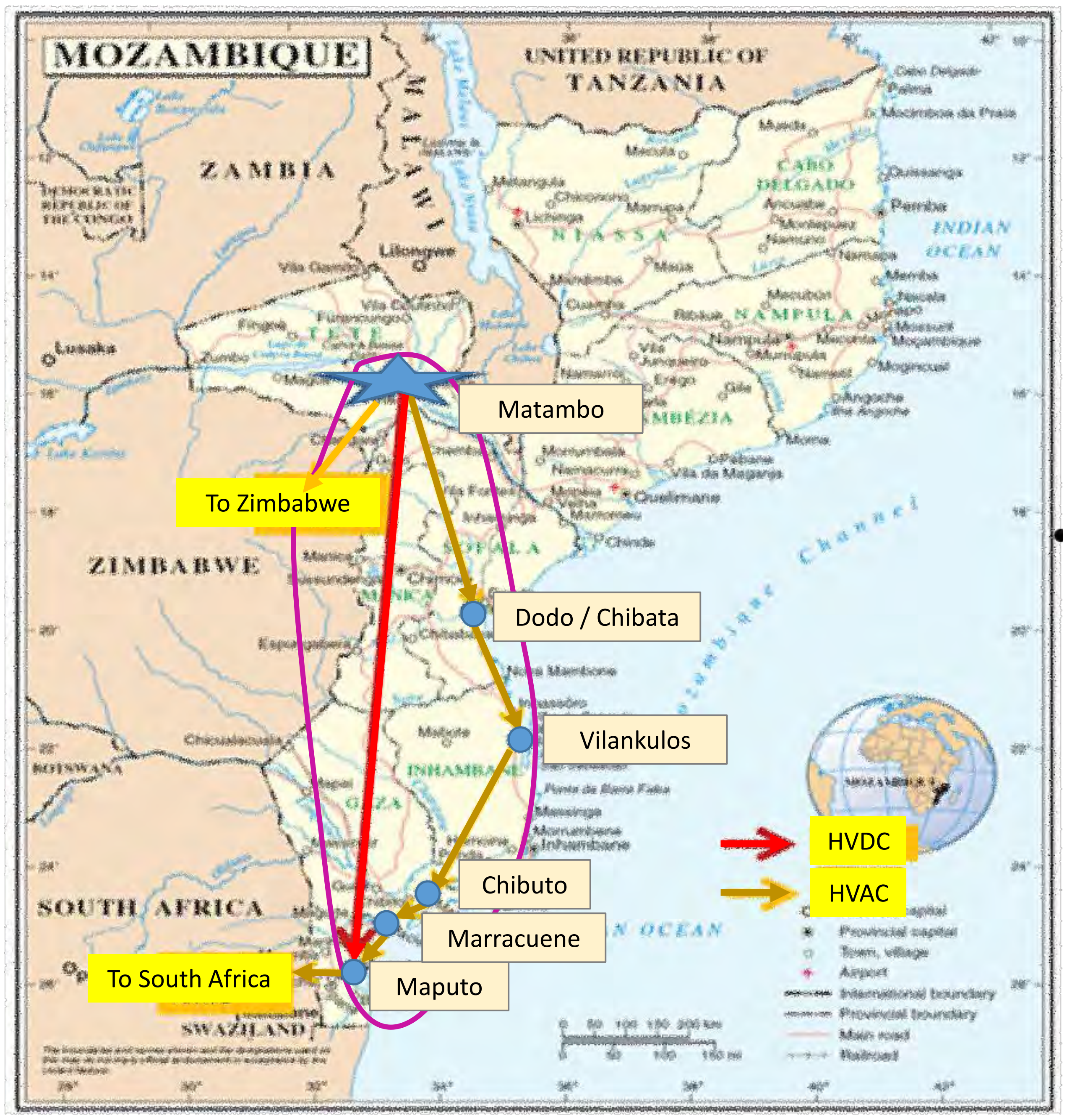
Mozambique – Malawi Interconnector Project

(Interconnector)

400kV transmission line

・Moz. Matambo – Malawi Phombeya

Figure 2.2-11　　Malawi - Mozambique Interconnector Project



Source：Mozambique trainmission backbone Project Brief (2013)

STE Backbone Project

Regional system (Mozambique)

Phase 1

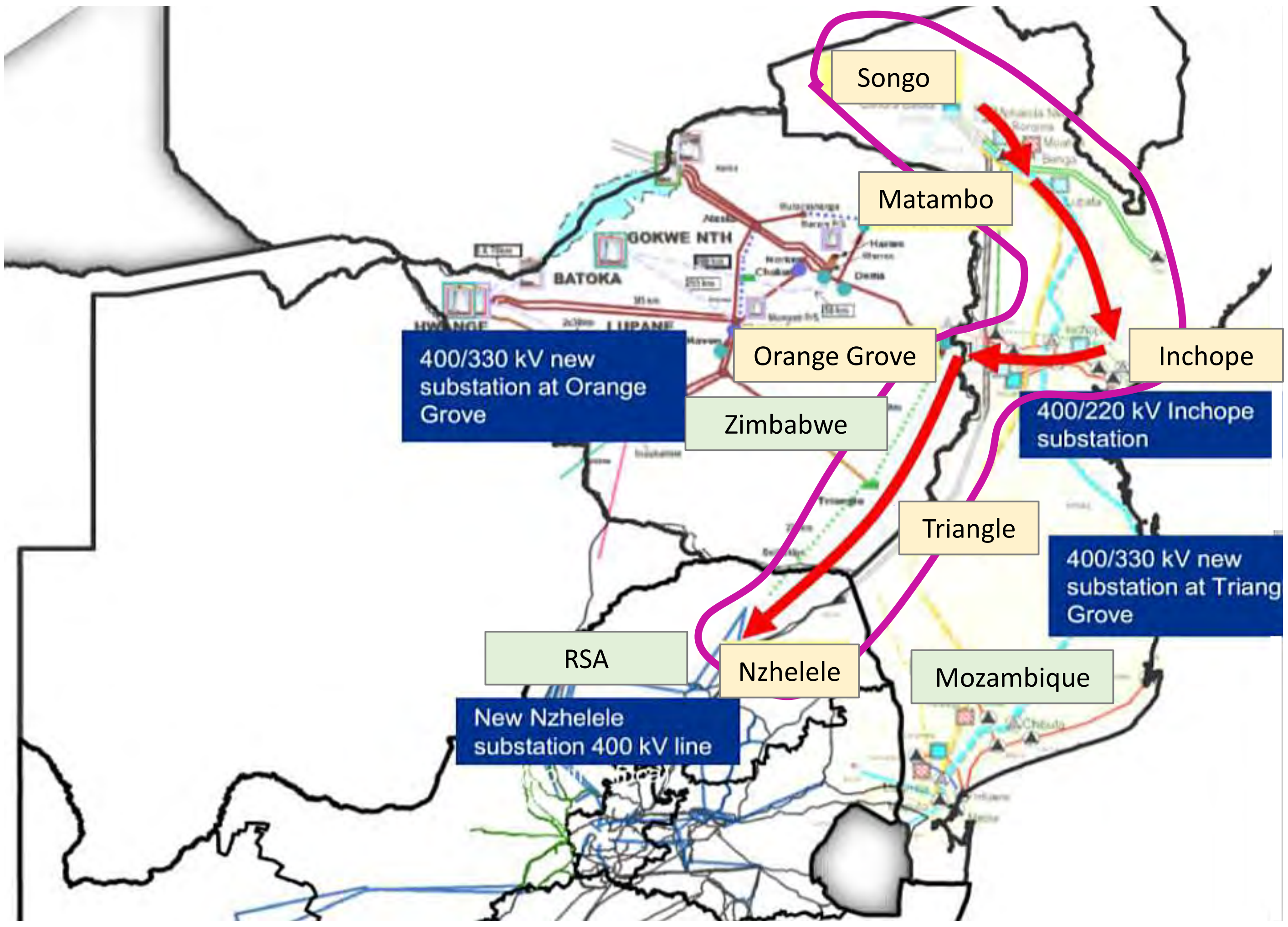
・Matambo - Maputo 500kV 1st HVDC

・Matambo - Maputo 400kVtransmission line

Phase 2

・Matambo - Maputo 500kV 2nd HVDC

Figure 2.2-12　　STE Backbone Project



MoZiSaProject

(Interconnector)

400kV transmission line

- Zim. Triangle – RSA Nzhelele
- Zim. Orange Grove – Moz. Inchope

(Regional system)

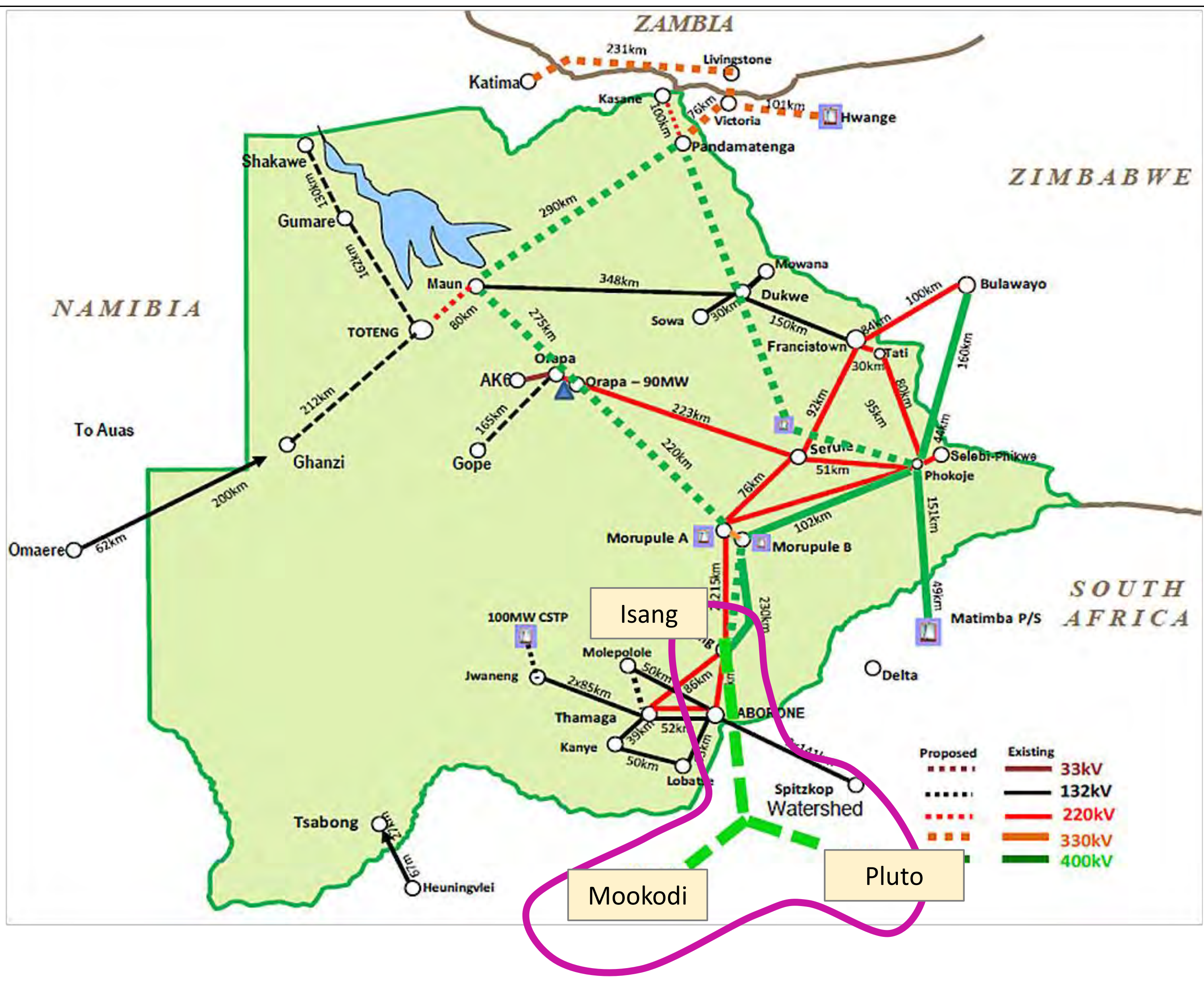
400kVtransmission line

・Inchope - Matambo

・Matambo - Songo

Source：Southern African Power Pool - MOZISA Transmission Project Draft Inception Report (2015)

Figure 2.2-13　　MoZiSa Project



BoSa Project

(Interconnector)

400kVtransmission line (500kVdesign)

・Botswana Isang – RSA Watershed B

Regional system (RSA)

400kVtransmission line (500kVdesign)

Existing TL (Watershed B-Pluto) reinforcement

Existing TL (Watershed B-Mookodi) reinforcement

Source： Transaction Advisory Services for the BOTSWANA-SOUTH AFRICA (BOSA) TRANSMISSION INTERCONNECTION PROJECT (2015)

Figure 2.2-14　　BoSa Project

2) Project scheme

Most of the interconnector projects including SAPP priority projects are planned that the project sponsors for these projects would be the state-owned power utilities.

Table 2.2-6 shows the policy of SAPP on the business arrangement of the transmission systems. The specific projects would be designed based on the actual conditions considering the various aspects.

Table 2.2-6 Business arrangement of transmission systems in SAPP

Ownership of Transmission lines	Owned by One Country	Owned by Multiple Countries
License	Single license License acquired by the utility of the country	Multiple license Each required acquired by each utility on the project
Off-taker	Single utility company (Owner and off-taker are the same in this case)	Multiple utilities The Special Purpose Vehicle may be dependent of the laws and regulations of the country
Risk Allocation	Owner assumes the operation risk, cash-low risk and others. Force Majeure and the clauses on the termination would need to be studied.	Each owner assumes the risks that correspond to the conditions of the licenses and off-take agreements.
Relations with Generation Sub-Sector	The risks on the generation capacity and the available capacity of generation would not be assumed by the transmission side.	
Financing Scheme	Case of project finance as a single transmission line project. Case of corporate finance based on the balance sheet of the utility company or the government Case of the combination of the above two. i.e. the utility company participates in the project as a shareholder.	
Wheeling Charge	Basic policy is by the capacity charge on the transmission in order to secure the loans from financial institutions. The energy charge on the wheeling would also be considered.	

Source : JICA Survey Team

(3) SAPP Pool Plan

In 2009, SAPP formulated SAPP Pool Plan 2009 by a support of WB. This plan is the power system master plan of SAPP system to consider smooth power trade and regional development to be done for the benefit to all member states.

Practically, all SAPP member states were studying jointly to wrap up the plan with their regional power system master plan.

A point to be noted in SAPP Pool Plan 2009 is that SAPP Pool Plan has two generation development plans, namely updated base case and updated alternative case (Table 2.2-7). Here, the meaning of updated is that original SAPP Pool Plan was revised to reflect the revised power system development plan of RSA published in study period. The main point of modification of revised power system development plan of RSA was downward revision of demand forecast and nuclear installation on generation development plan.

Therefore, the Updated Base Case was the plan that reflect these modifications. On the other hand, the Updated Alternative Case was a plan to be able to introduce power trade as much as possible in SAPP region. Practically, to energize the power trade on this case, nuclear installation in RSA was omitted on her generation development plan.

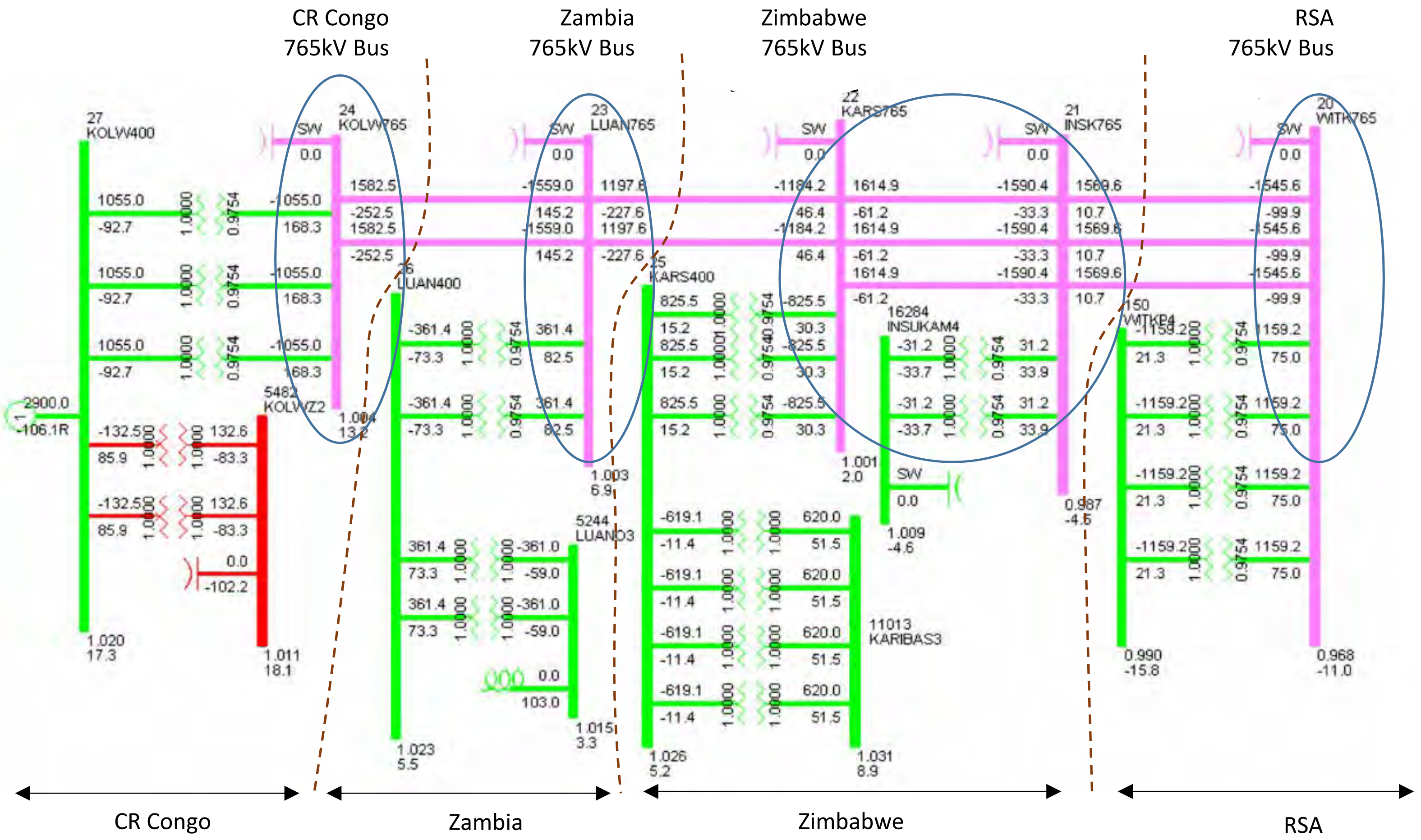
As for system planning, the 765 kV transmission system across SAPP was proposed (Figure 2.2-15). This proposal might be understandable to gather power in northern SAPP area and feed it to load center without any transmission loss. But current condition is not in line with this plan.

According to the information from WB, SAPP is now hiring consultants make new SAPP Pool Plan by a support of WB.

Table 2.2-7 Abstract of SAPP Pool Plan 2009 (Updated)

Generation development planning	
Updated Base Case	Surplus energy in a state should be transferred to any states which have deficit energy.
Updated Alternative Case	Vitalize the power trade without consideration of any restriction, such as transmission capacity.
System planning	
SAPP system was adjusted to the system standards of South Africa, a prioritizing a comb-shaped 765kV trunk system.	

Source : JICA Survey Team



Source : The Survey Team using SAPP Regional Generation Transmission Expansion Plan Study Final Report (2009)

Figure 2.2-15 SAPP power system model studied in SAPP Pool Plan

(4) Issues of SAPP

From the analysis aforementied, the Survey finds out them as issues of SAPP.

(Issue-1) Some power pool member states do not join the power pool operation without interconnectors.

(Issue-2) Power sources, e.g. generators are not sufficient for power trade in SAPP.

(Issue-3) Interconnector to energize the power trade is not sufficient.

(Issue-4) RSA has huge system capacity and other state are relatively small, therefore consensus building for all SAPP member states is difficult.

2.3 Southern African Development Community (SADC)

(1) General information

On April 1, 1980, for the purpose of being free from economic control by the old regime of South Africa under a policy of apartheid, Southern African countries formulated the Southern African Development Coordination Community (SADCC). In 1992, the name of the Community was changed to the Southern African Development Community (SADC) and South Africa which abolished the policy of apartheid also joined the Community in 1994. Since that time, the Community has advocated economic integration and a common market, and performs activities for settlement and prevention of disputes.

SADC is constituted of 15 countries in Southern African region, such as Tanzania, Zambia, Botswana, Mozambique, Angola, Zimbabwe, Lesotho, Swaziland, Malawi, Namibia, South Africa, Mauritius, Democratic Republic of Congo, Seychelles and Madagascar.

The purpose of SADC is to achieve promotion of economic growth, eradication of poverty, regional unification, maintenance and promotion of peace and safety, promotion of independent growth, formulation of nation-to-nation and intra-regional statistics and planning, protection of regional resources and effective use of them, and intensification of historical, social and cultural collaboration in the region. The Coordination Center is located in Gaborone, the capital of Botswana.

SADC Directrate of Infrastructure and Services (SADC-DIS) boosts the construction and enhancement of energy infrastructure in developing foundations for intra-regional economic growth, formulating a strategic facility planning for the execution of the Protocol on Energy which advocates the importance of energy for driving economic growth which is an important key for eradicating poverty. Specific planning is made public as the SADC Regional Development Master Plan, and each of the transmission projects and the power generation projects which have been described is shared with each of the member countries and SAPP.

Energy sector short-term action plan is shown in Table 2.3-1, and a water sector short-term action plan is shown in Table 2.3-1, respectively. These plans are the subsets of the SADC Regional Infrastructure Development Master Plan (RIDMP).

Table 2.3-1 hangs interconnector, domestic trunk system, large-scale hydropower generation and large-scale thermal power generation. These were given roles of driving subsequent infrastructure businesses as pilot projects in the SADC region. Further, some of the hydropower generation projects are organized within the water resource sector for utilizing water resources from various aspects (Table 2.3-2). The development projects described in the SADC short-term action plan are reflected in the SAPP priority project.

Moreover, these development projects are handled as priority development projects in not only SADC and SAPP but also public institution such as economic community in other area

A brief explanation will be given on COMESA, the EAC and the PIDA PAP, which appeared in Table 2.3-1.

Table 2.3-1 SADC short-term action plan - Energy Sector

Project	Benefiting countries/owners	Region	Project cost estimate US$ million	Expected completion year	Project status
Mozambique backbone transmission lines phase I and II	Mozambique, EDM	SADC	1 700	2016	Environmental Impact Assessments (EIAs) concluded and submitted to government
ZIZABONA – 400 kV transmission lines, 408 km	Zimbabwe, Zambia, Botswana and Namibia ZESA, ZESCO, BPC, NamPower	SADC	223	2015	Investors Round Table held in Namibia. IG MoU signed
ZTK interconnector – 400 HVAC transmission line, 700 km	Zambia, Tanzania and Kenya OPPPI, TANESCO, KPLC	SADC/COMESA/EAC/PIDA PAP	860	2016	Funding secured for Zambian portion and for feasibility studies in Tanzania
Central Transmission Corridor (CTC) network phase 2 – to strengthen power transmission capacity, particularly the 280 km Alaska–Sherwood line	Zimbabwe , ZESA and ATC	SADC/PIDA PAP	100	2016	Funding secured for project preparation
DRC–Zambia interconnector – 330 kV transmission line from Solwezi to Kolwezi	DRC and Zambia	SADC/PIDA PAP	94	2016	Funding secured from World Bank and Copperbelt Energy Corporation for the DRC and Zambian portions respectively
Namibia–Angola interconnector	Angola and Namibia ENE and NamPower	SADC/PIDA PAP	250	2016	Terms of Reference (ToRs) for technical studies have been prepared, awaiting approval
DRC–Angola interconnector	Angola	SADC/PIDA PAP	95	2016	Busy with feasibility study
2nd South Africa–Zimbabwe interconnector	South Africa and Zimbabwe	SADC/PIDA PAP	280	2017	To be anchored by power purchase agreement; still at feasibility study stage
2nd DRC–Zambia interconnector	DRC and Zambia	SADC/PIDA PAP	80	2017	To be anchored by power purchase agreement (PPA)
Mozambique–Malawi interconnector	Mozambique and Malawi	SADC/PIDA PAP	93	2015	Agreement reached between the two countries to move expeditiously
Cahora Bass North Bank Power Station	Mozambique	SADC	800	2017	To be anchored by PPAs
Mpanda Nkuwa hydropower station phase 1	Mozambique	SADC/PIDA PAP	2 000	2016	Ongoing
Hwange Power Station 7 and 8 expansion project	Zimbabwe	SADC	1 080	2017	Still at feasibility study stage
Gokwe North Power Station	Zimbabwe	SADC	2 240	2017	Updating feasibility studies
Inga III hydropower project	DRC	SADC	1 730	2018	Negotiating with financiers
Kudu Gas Power Station	Namibia	SADC	640	2016	Engineering and design studies under way
Total			**US$12.265 billion**		

Source : SADC Regional Instastructure Development Plan

2-39

Table 2.3-2 SADC short-term action plan - Water Sector

Project	Benefiting countries/owners	Region	Project cost estimate US$ billion	Expected completion year	Project status
Inga hydropower	DRC, shared regional electricity	SADC	8	2017	Pre-feasibility study completed in 2011. Feasibility study and design to follow
Lesotho Highlands phase II	Lesotho and South Africa	SADC	1	2017	Pre-feasibility study completed in 2011. Feasibility study and design to follow
Batoka Gorge hydropower	Zambia and Zimbabwe	SADC	3.5	2015	Feasibility studies completed, detailed design and tendering to follow (2012–2013)
Songwe River basin	Malawi and Tanzania	SADC	0.22	2017	Feasibility studies completed, detailed design and tendering to follow (2012–2013)

Source : SADC Regional Instastructure Development Plan

Common Market for Eastern and Southern Africa (COMESA)[13] :

COMESA was formally inaugurated in December 1994 as a succeeding organization of the Preferential Trade Area for Eastern and Southern African States (PTA) founded in 1981. Preferential goals of the COMESA are as follows:

① Creation of a completely free trade region which secures free movement of goods and services within the region and elimination of all tariffs.

② Establishment of common tariffs for imported goods and services from countries outside of the region.

③ Liberalization of investment and capital flow for the purpose of promoting improvement in intra-regional investment environment

④ Step-wise establishment of settlement alliance based on the COMESA Clearing House, introduction of intra-regional single currency and final establishment of intra-regional currency alliance

⑤ Application of intra-regional common visa system

COMESA selects infrastructure project including electricity project of member counties in accord with the purpose and supports development. COMESA Infrastructure Investment Conference was held on September 14, 2013. And the following electricity projects for SAPP member countries were introduced.

ZTK project forming one end of the north-south corridor[14] which is international interconnection is priority project in COMESA.

In addition, COMESA established COMESA Infrastructure Fund and finances investigations for the infrastructure formation in member countries.

Table 2.3-3 International interconnector project designated by COMESA

No	Project Title	Participating counries	Project Description	Status of implementation	Estimated cost in Mill US$ Dollars
1	Zambia-Tanzania-Kenya Power Interconnector	Zambia, Tanzania and Kenya	Construction of a power interconnector connecting the Eastern and Sourthern Africa power pools to facilitate trading in electricity; promote power systems stability and rural electrification.	A project implementation Unit (PIU) has already been established to coordinate fund mobilisation and project implementation	1,116.0
2	Zamiba-DRC Interconnector	DR Congo-Zambia	Construction of a power interconnector between Zambia and the DRC to facilitate trading in electricity and promote power systems stability	Funding for the line in Zambia (to link with World Bank funded section of the line on the DRC side) being cosidered by TTAIC. Alternative financing options are being reviewed	17.0

Source : COMESA Region Key Economic Infrastructure Projects – COMESA (2013)

[13] COMESA (2007) COMESA in Brief, 3rd Edition

[14] The Nile Equatorial Lake Subsidiary Action Program (NELSAP) of the Nile Basin Initiative (NBI). Especially it advocates mutual economic development and aggressive power trade between EAPP and SAPP.

Table 2.3-4 Generation projects designated by COMESA

No	Project Title	Participating Countries	Project Description	Status of Implementation	Estimated cost in Mill US$ Dollars
1	Kalungwishi Hydro project	Zambia	Construction of a 213MW power generation plant on the Lakungwishi river	Feasibility study completed. Lunzua Power Authority has been established to implement the project. The gearing structure is 20:80 equity to debt. IRR is 27.6%	641.0
4	Batoka Gorge Hydro-Power Station	Zambia and Zimbabwe	Construction of a dam and a 1,600MW hydro power plant on the Zambezi River	The detailed feasibility studies have been completed indicated that it is economically and technically feasible.	4,000
5	Ruzizi III Hydro Project	Burundi DRCongo, Rwanda	Construction of a 147MW hydropower plant on the Ruzizi River for supply of power to Rwanda, Burundi and the Democratic Republic of Congo.	The design and feasibility studies have been completed.	530.4 includeng the cost of transmission lines
6	Inga Power Project	DRC	Construction of a 3,500MW Inga 3 hydropower project on river Inga. The objective is to provide affordable, reliable and clean power DRC and neighboring states.	Awaiting results of a feasibility study complemented with studies on geology, hydropower production and the transmission system associated with the project	The feasibility study is estimated to cost USD 15 million. The estimated total cost of the project is USD 7,600

Source : COMESA Region Key Economic Infrastructure Projects – COMESA (2013)

East African Cooperation (EAC[15])

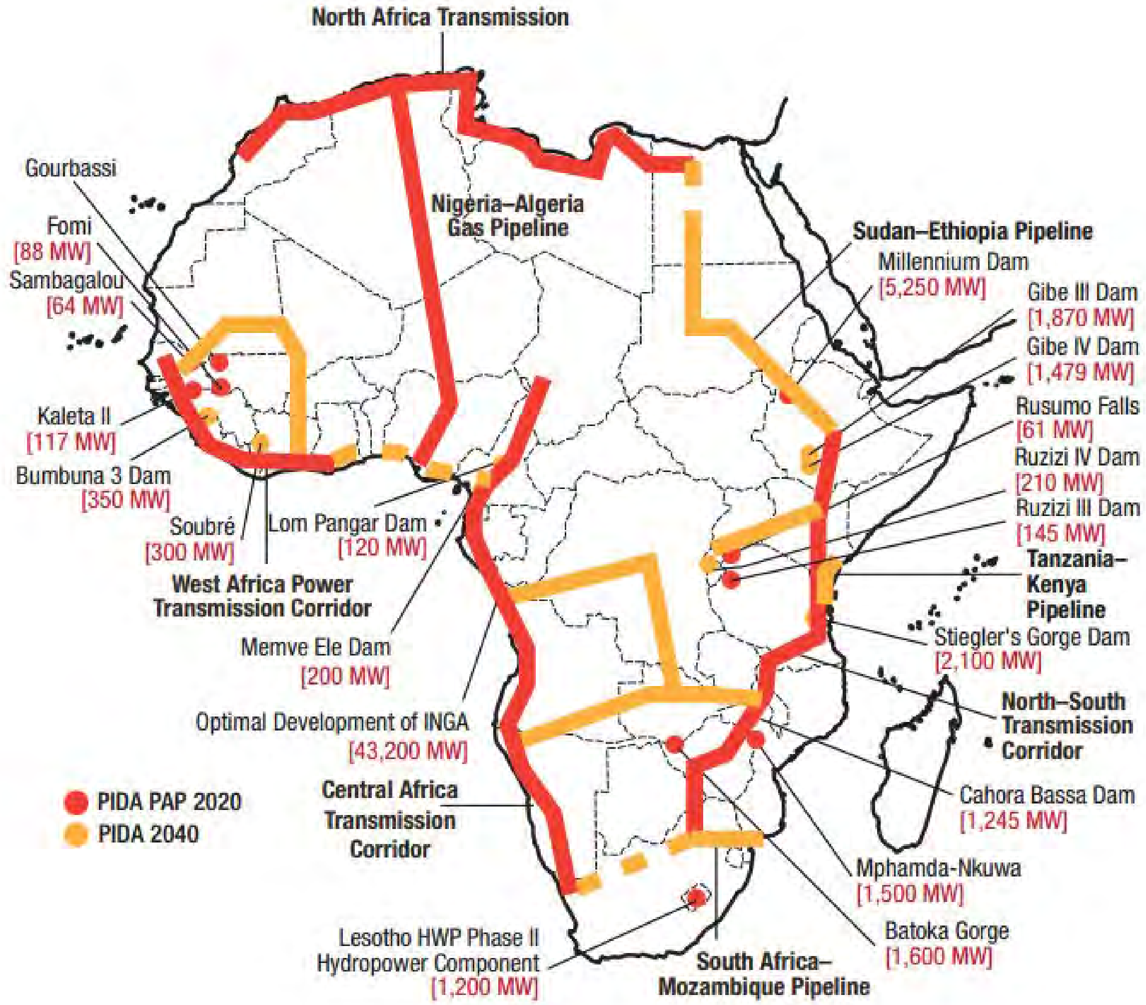
It was founded in 1917 to enact a tariffs association. The head office is located in Arusha, Tanzania. At the time, the member countries are Kenya, Uganda, Tanzania, Burundi, South Sudan and Rwanda. EAC has so far executed the following activities; prevention of double taxation between the member countries, simultaneous announcement of budget, currency exchange between the member countries without US dollar-based conversion and common passport.

EAC formulated EAC - EAPP Regional Power Plan (2013-2038) and international interconnector rules[16] with EAPP (Eastern African Power Pool). EAC corporates with EAPP about local grid development based on relationship with SADC and COMESA. ZTK Project is the concrete project.

The Programme for Infrastructure Development in Africa, the Priority Action Plan (PIDA PAP) :

It was inaugurated PIDA by the meeting of the heads of government of the 12th African Union Commission (AUC) held in Kampala, the capital of Uganda in July, 2010. Here, the importance of regional infrastructure development for realizing a goal of long-term growth in Africa until 2040 is expressed in terms of priority development projects. In particular, 51 projects have been selected as issues to be executed in the PIDA PAP, with the highest priority given, and strategic frameworks and execution programs are managed.

15 http://www.eac.int/history.htm
16 http://www.eac.int/energy/index.phpp?Itemid =84



Source : Programme for Infrastructure Development in Africa, Interconnecting integrating and transforming a continent – PIDA (2014)

Figure 2.3-1 Designated projects by PIDA and PIDA PAP

Table 2.3-5 Energy projects of PIDA PAP

Project	Description	Stage	Cost (US$ millions)	Countries	REC	Region
North–South Power Transmission Corridor	8,000 km line from Egypt through Sudan, South Sudan, Ethiopia, Kenya, Malawi, Mozambique, Zambia, Zimbabwe to South Africa	S2	6,000	Kenya, Ethiopia, Tanzania, Malawi, Mozambique, Zambia, Zimbabwe, South Africa	COMESA/EAC/ SADC/IGAD	Southern
Mphamda-Nkuwa	Hydroelectric power plant with a capacity of 1,500 MW for export on the SAPP market	S2	2,400	Mozambique, Zambezi basin	SADC	Southern
Lesotho HWP phase II hydropower component	Hydropower programme for power supply to Lesotho and power export to South Africa	S2	800	Orange-Senqu River Basin	SADC	Southern
Inga III Hydro	4,200 MW capacity run of river hydropower station on the Congo river with eight turbines	S2	6,000	DRC Congo River	ECCAS	Central
Central African Interconnection	3,800 km line from the DRC to South Africa through Angola, Gabon, Namibia and to the north to Equatorial Guinea, Cameroon and Chad	S1	10,500	South Africa, Angola, Gabon, Namibia, Ethiopia	ECCAS	Central
West Africa Power Transmission Corridor	2,000 km line along the coast connecting with the existing Ghana–Nigeria line with a capacity of 1,000 MW	S2	1,200	Guinea, Guinea Bissau, Gambia, Sierra Leone, Liberia, Côte d'Ivoire, Ghana	ECOWAS	Western
Batoka	Hydroelectric plant with a capacity of 1,600 MW to enable export of electricity	S3	2,800	Zambia/Zimbabwe Zambezi basin	COMESA/EAC	Eastern
Ruzizi III	Hydroelectric plant with a capacity of 145 MW to share power among Rwanda, Burundi and DRC promoted by CEPGL	S3	450	Rwanda/DRC	COMESA/EAC	Eastern
Rusumo Falls	Hydropower production of 61 MW for Burundi, Rwanda and Tanzania	S3	360	Nile River Basin	COMESA/EAC	Eastern

Source : Infrastructure Outlook 2040 – PIDA

Table 2.3-6 Transboundary water projects of PIDA PAP

Project	Description	Stage	Cost (US$ millions)	Countries	REC	Region
Multisectoral Investment Opportunity Studies	Identification and preparation of investment programmes in the basin	S1	1	Okavango River Basin	SADC	Southern
Lesotho HWP Phase II – water transfer component	Water transfer programme supplying water to Gauteng Province in South Africa	S3	1,100	Orange-Senqu River Basin	SADC	Southern

Source : Infrastructure Outlook 2040 – PIDA

(2) Issues of SADC

SADC-DIS is operated by only three staffs including officer. One program officer is in charge of overall energy sector, one staff is in charge of electric power and one staff is in charge of overall infrastructure. The staff in charge of electric power holds liaison of SAPP PAU, and is position to share the information, such as progress or issues of SAPP priority projects to SADC. In addition, a consultant from Austrian government's support is a resident in SADC DIS and is in charge of renewable energy introduction mainly.

As stated above, SADC DIS intervenes practical development work of SAPP PAU and organic work, such as policy making and promotion work. Therefore, SADC DIC seems to be understaffed.

2.4 Regional Electricity Regulatory Association (RERA)

RERA was founded as an association for integrally managing intra-regional regulation organizations for electric power supply in SADC regions at the SADC meeting in 2002.

This association boosts several activities, aiming promotion of the Protocol of Energy, SADC Energy Sector Action Plan (1997), SADC Energy Activity Plan (2000) as well as the realization of goals, namely development of power system infrastructure across African continent, advocated by NEPAD[17].

New Partnership for Africa's Development (NEPAD)

NEPAD is initiative of the AU for African development by oneself African. Former President of South Africa, Thabo Mbeki led the Millennium Partnership for the African Recovery Programme (MAP). In July 2001 it was approved at the organization of African Unity (OAU, now it changed to the African Union, AU).

This framework conducts comprehensive economic regeneration of Africa, such as not only hard portions (infrastructure, agriculture, environment etc.) but soft portions (capacity-developing, science etc.) with developing several programs and managing them. In particular, managing PIDA-PAP is one of main role of this framework.

A vision of RERA is to be a world organization for realizing a regulation building system which is firmly founded and well-balanced in SADC region. Specific duties of RERA are to provide and execute regulation policies between energy regulation managers within SADC regions, to develop the laws and regulations, and to coordinate and consult on specifications, and to secure cooperation and support systems between the regulation managers. The headquarters is located in Windhoek, the capital of Namibia.

Under the MoU between SADC and African Energy Commission (IRENA), which was advocated that IRENA provides the support for renewable-energy introduction in SADC region, RERA performs the practical works with IRENA for realization of African Clean Energy Corridor Initiative.

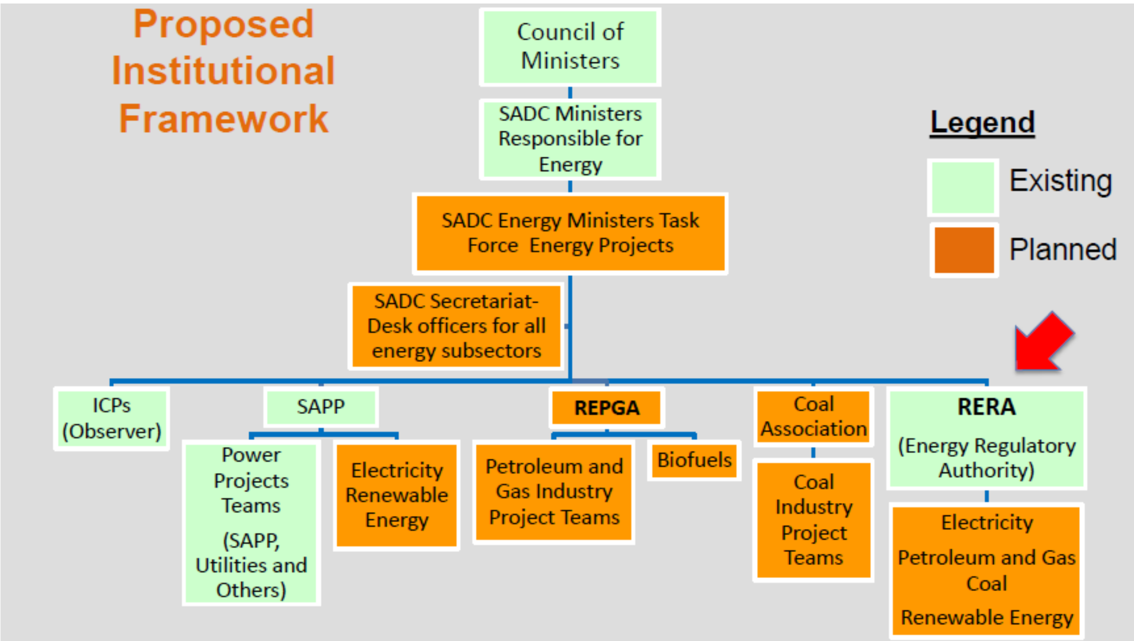
At present, regulatory organizations of 12 countries of SAPP among 15 SADC member countries have joined RERA. Of these organizations, four of them are power regulatory organizations, six of them are energy regulatory organizations and two of them are multi-sector (energy/water resources) regulatory organizations.

[17] New Partnership for Africa's Development; a development goal program for Africa set by the Organization of African Unity in 2001 (current African Union (AU))

Table 2.4-1 RERA members

Angola	Institute for Power sector Regulation (IRSE)
Botswana	(Nil)
DRC	(Nil)
Lesotho	Lesotho Electricity and Water Authority (LEWA)
Malawi	Malawi Energy Regulatory Authority (MERA)
Mozambique	National Electricity Advisory Council (CNELEC)
Namibia	Electricity Control Board (ECB)
RSA	National Energy Regulatory Authority (NERSA)
Swaziland	Swaziland Energy Regulatory Authority (SERA)
Tanzania	Energy & Water Utilities Regulatory Authority (EWURA)
Zambia	Energy Regulation Board (ERB)
Zimbabwe	Zimbabwe Energy Regulatory Authority (ZERA)

The organization map of RERA is shown in Fig. 2.4-1.



Source : RERA An Overview of Recent Southern Africa-the 3rd High Level Meeting of Regional Energy Regulatory Associations of Emerging Markets in Istanbul (2015)

Figure 2.4-1 RERA formation (including perspective)

Chapter 3　Current condition and issues of SAPP member countries

3.1　Angola

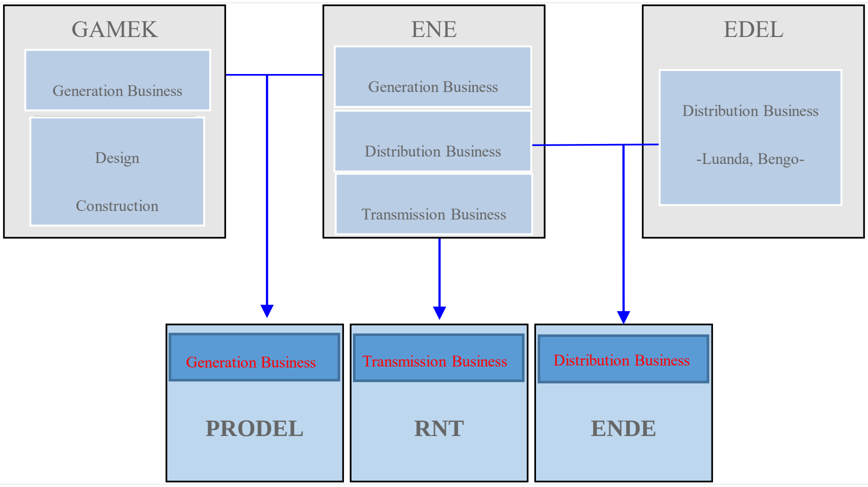
3.1.1　Power Sector

(1)　Overview of Power Sector

In Angola, planning and regulations were provided by the Ministerio da Energia under the General Electricity Act established in 1996. And the Cuanza River Development Public Company (GAMEK) managed development of the Kwanza River basin. The Empresa Nacional de Electricidade (ENE), the state-owned electric power company, managed generation and transmission. The Empresa de Distribuicao de Electriciade (EDEL), the state-owned distribution public company managed distribution. These were all in power sector.

Thereafter, Ministerio da Energia and the Ministry of Water Resources merged into the Ministerio da Energia e Aguas (MINEA) to supervise power sector and water sector.

In 2014, the General Electricity Act was amended and then power sector was reconstructed shown in Table 3.1-1. The purpose of the reconstruction was to pursue economic efficiency and sustainability of business in power sector.



Source : JICA Survey Team

Figure 3.1-1　Configuration of power sector (Angola)

Generation business was merged into Pública de Produção de Electricidade (PRODEL) from ENE and GAMEK. Total generation capacity owned by PRODEL is approximately 2,000 MW[18].

Transmission business was take over from ENE to Rede Nacional de Transporte de Electricidade (RNT). The most prioritized issue of RNT is establishing a stable nation-wide power system by connecting northern, central and southern transmission networks which are currently independent.

Before the reorganization, distribution business was being organized by ENE and Rede Nacional de Transporte de Electricidade (EDEL). EDEL maintained Luanda, capital of Angola, and ENE maintained nationwide except EDEL's area. And now distribution business is managed by Distribuição de Electricidade (ENDE).

[18] As of end of 2015

(2) Energy policy

Angola Energia 2025, established by MINEA, states target for power supply, and perspectives and effective plans to be done toward 2025. Following two issues are specific target on the publication.

- Electrification

The electrification rate of Angola is still 30% of the total population. However, since 70% of total domestic power consumption concentrated in Luanda. Therefore, rural electrification should be accelerated, and it should be aimed that national electrification rate in 2025 is 60%.

- Improvement of the power supply

Demand will skyrocket toward 2025, and to meet the demand generation development should be accelerated. Specifically, generation capacity should be 9,500 MW in 2025 which is more than four times greater than the present capacity. These development is composed by hydropower and gas-fired power.

(3) Regulatory body

In Angola, the regulatory authority is the Instituto Reulador Do Sector Eléctorico (IRSE). This firm is in charge of licensing of IPPs and determination of electricity tariff, etc.

(4) Electricity tariff

Electricity tariff table of Angola is shown in Table 3.1-1.

Table 3.1-1 Electricity tariff (Angola)

ElectricityTariff -Angola

Customer	Voltage	Unit	Tariff
Domestic	Low	Atz/kWh	3.50
Social Tariff	Low	Atz/kWh	1.20
Domestic Special	Low	Atz/kWh	4.60
Industry	Low	Atz/kWh	4.60
Trade & Services	Low	Atz/kWh	4.60
Industry	Medium	Atz/kWh	F=(2.4*P)+(2.0*W)
Trade & Services	Medium	Atz/kWh	Ditto

Note) F: monthly invoice
P: maximum peak in 15 minutes from the top of the last 12 months (kW)
W: monthly consumption of electricity (MWh)

Source : JICA Survey Team using evidence from IRSE Website

The electricity tariff varies depending on the customer category, amount of contracted electric power, amount of consumption, etc. Here, in order to work out typical tariff for each customer in SAPP member states, a demand pattern is assumed as shown in Table 3.1-2.

Table 3.1-2 Consumer model for trial in SAPP region

Customer Category	Voltage	Connected Capacity (kVA)	Consumption (kWh/month)
Domestic (Residential)	Low	n/a	Approx. 100
Small Commercial	Low	Around 3	Approx. 1,000
Large Commercial/Industry	Medium	Around 100	Approx. 10,000

Source : JICA Survey Team

Based on the profile shown in Table 3.1-2, electricity tariff of each customer in Angola is shown in Table 3.1-3.

It is noted that the electricity tariff shown below is net value and it excludes miscellaneous cost, such as an added value tax, an initial connection charge, an invalid electric power charge or a supplementary service charge.

Table 3.1-3 Trial calculation of electricity tariff (Angola)

Customer Category	Assumed consumption (kWh / month)	Electricity Tariff (US cents/kWh)
Domestic (Residential)	100	2.57
Small Commercial	1,000	3.38
Large Commercial/Industry	10,000	6.76

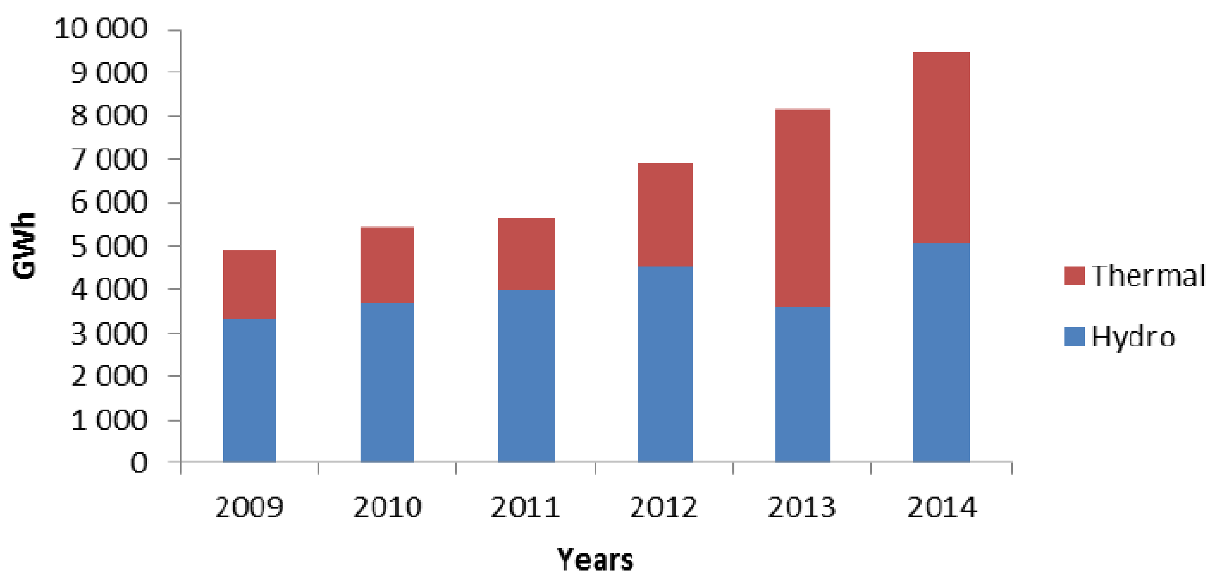
1 USD = 0.00600AOA, as of December, 2016
Source : JICA Survey Team

In Angola, charges for domestic (residential) customer use are set to be much lower than that for large-scale commercial use and industrial use. Further, the electricity tariff is characterized in that an additional charge is levied on peak electric power consumed by industries that receive medium–level electrical voltage, in addition to an electricity consumption specific charge.

3.1.2 **Power demand, existing facilities and development plan**

(1) Power Demand

The power demand Angola continues rising steadily as shown in Figure 3.1-2 and recently that reaches 9.5 TWh. As for transition of peak demand is not published.



Source : Sustainable Energy for All – Rapid Assessment and Gap Analysis:Angola

Figure 3.1-2 Electricity demand in Angola

(2) Existing facilities

1) Generation Facilities

Table 3.1-4 shows main generation fleets in Angola. And small scale diesel generators and small scale hydropowers spread nationwide.

Table 3.1-4 Existing power plants in Angola

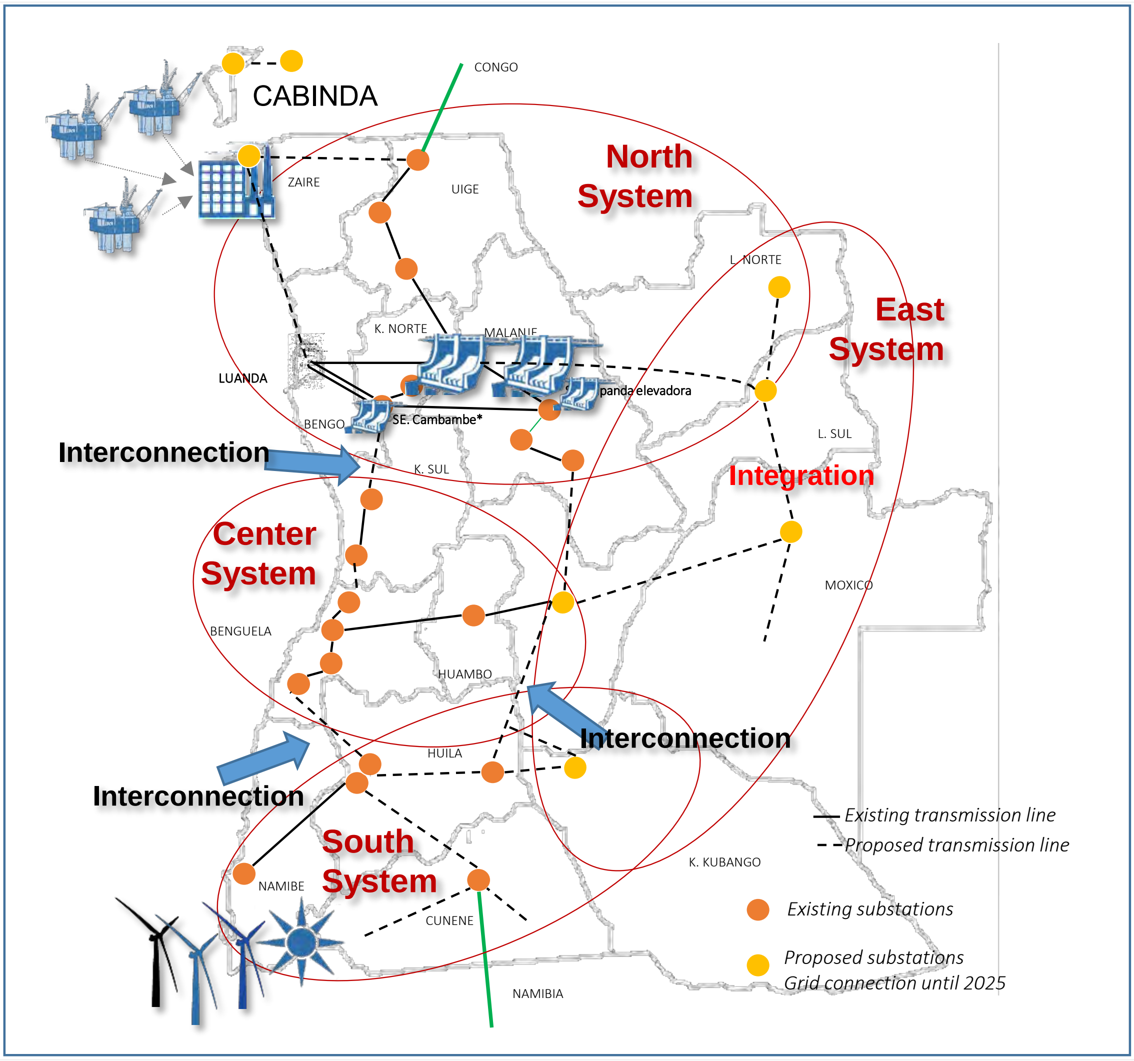
Power Plants	Type	Capacity (MW)
Capanda	Hydropower	520
Cambambe 1	Hydropower	180
Matala	Hydropower	40.8
Cazenga1~7	Thermal (OCGT:Diesel)	184.4
Boavista1~3	Thermal (OCGT:Diesel)	132.1

Source : JICA Survey Team using evidence from SAPP C.C. (2016)

2) Transmission facilities

➢ National power system

Current condition and development plan of national grid are shown in Figure 3.1-3. The grid is still isolated, and interconnection of all isolated systems is the main issue in Angola.



Source : Angola Energia 2025 – MINEA (2015)

Figure 3.1-3 Current condition of Angolan system and future development

➢ Interconnector

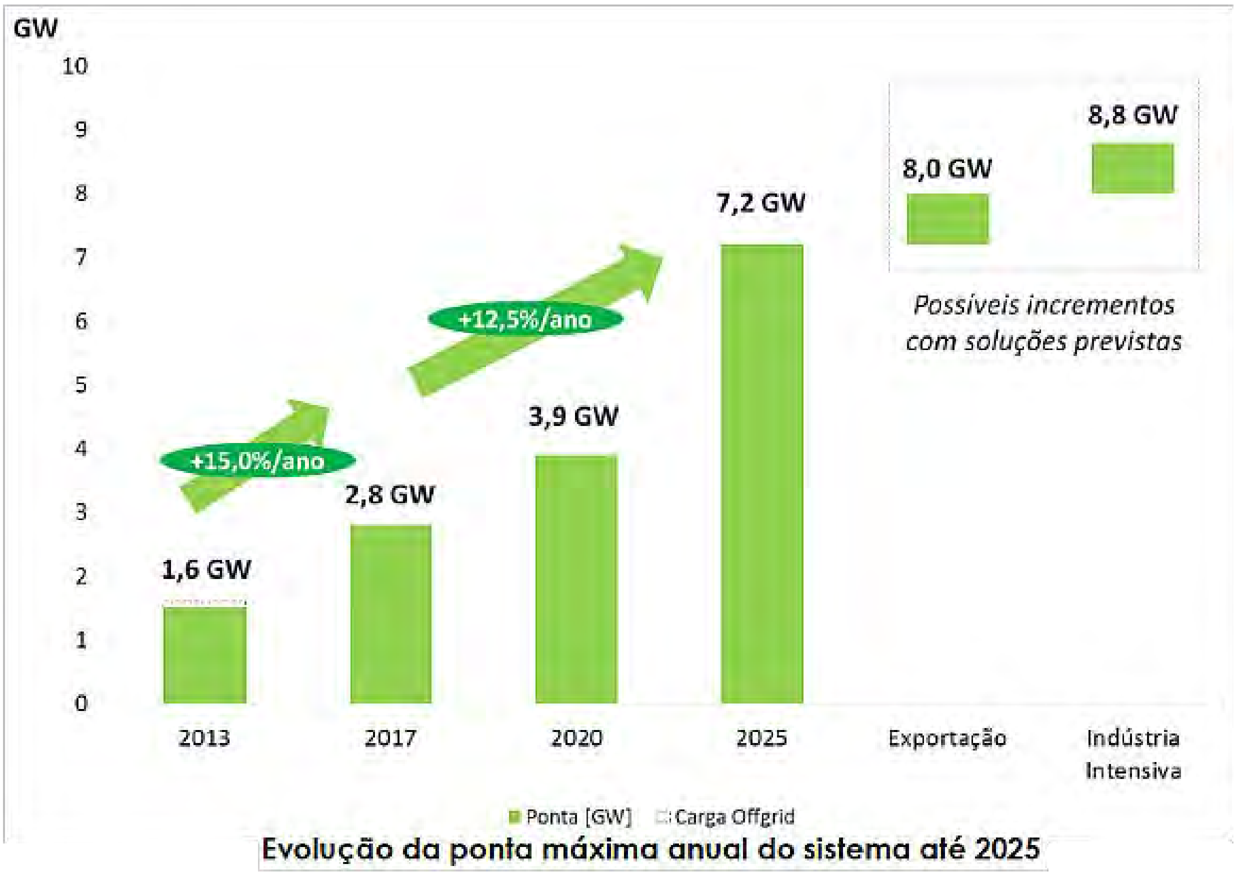
At present, no interconnector to link with SAPP member states exist.

(3) Power system development plan, power system master plan

In Angola, power system master plan has not been published. Instead, Angola Energia 2025, like a road map for power system development proposed by MINEA, mentions demand prediction, generation projects and grid enhancement toward 2025. Here, contents on this evidence would be explained briefly.

1) Demand forecast

Angola Energia 2025 mentions that electricity demand in 2025 is 7,200 MW and reaches 9,200 MW under favorable conditions. Demand will skyrocket from 1,600 MW in 2013 to 7,200 MW in 2025.



Source : Angola Energia 2025 –MINEA (2015)

Figure 3.1-4 Demand forecast in Angola up to 2025

2) Generation development plan

Information given by SAPP Coordination Centre represents that Angolan short term generation development is shown in Table 3.1-5.

Table 3.1-5 Planned generation projects in Angola

Projects	Type	Commercial operation year	Capacity (MW)
Cambambe 2	Hydropower	2016	780
Lauca	Hydropower	2017	2,060
Cauclo Cabaca	Hydropower	2022	2,050
Soyo 1	Gas (CCGT)	2017	750
Soyo 2	Gas (CCGT)	N/A	750

Source : JICA Survey Team using evidence from SAPP C.C. (2016)

On the other hand, Angola Energia 2025mentions that Angola pursues generation mix with utilization of domestic resources toward 2025. Especially hydropower candidates has huge capacity, around 4 GW to be developed. Table 3.1-6 shows the hydropower development candidates on the evidence[19].

3) System planning

Angola Energia 2025 prints the plan provided by RNT. It shows that interconnection among isolated grids is the prioritized project.

Further, priority issue for system planning are grid enhancement in line with rural electrification.

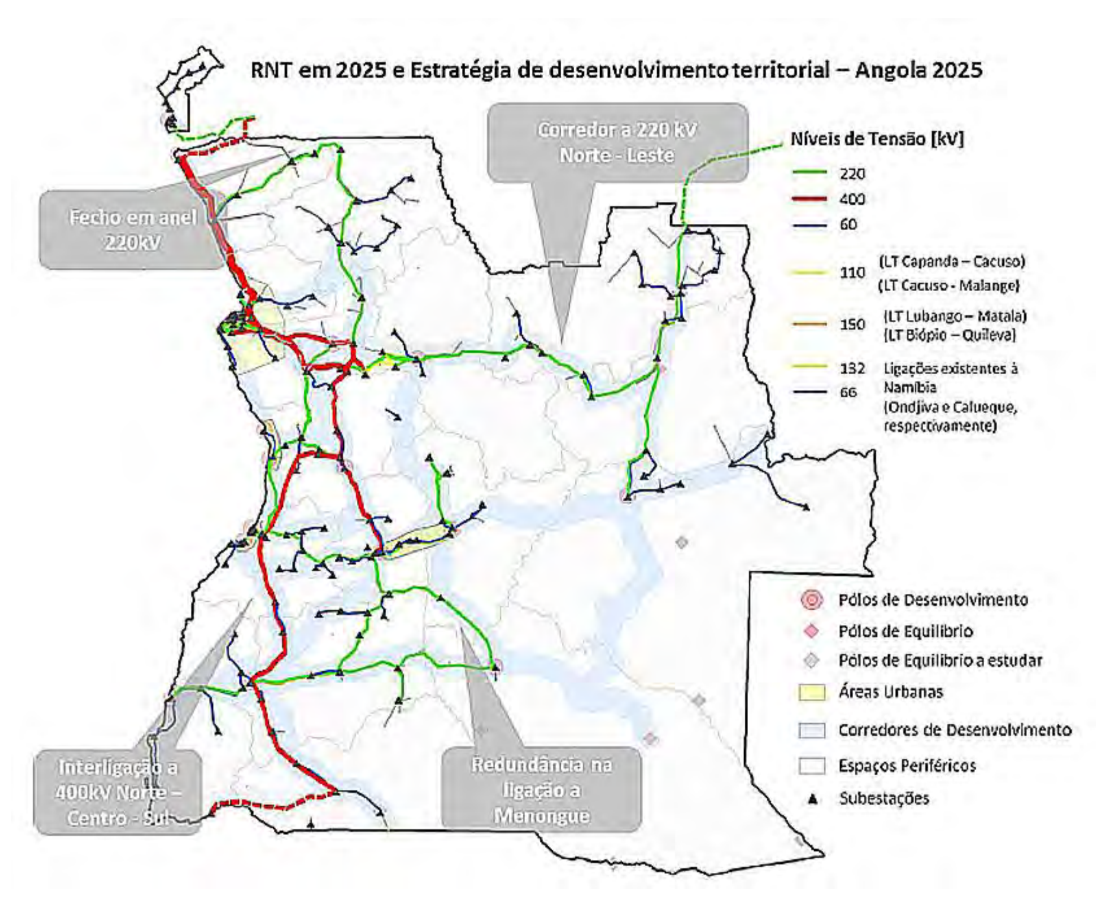
As for interconnection, Angola Energia 2025 studies the possibilities of power trade with national surplus energy and cheaper power in neighboring counties. Result is power export to DR Congo, its amount is 300MW, with interconnectors to Namibia and to DR Congo.

[19] Cauclo Cabaca's capacity on Table 3.1-6 is not same as that on Table 3.1-5. Therefore, capacities on Table 3.1-6 should be confirmed.

Table 3.1-6 Generation development list (Angola)

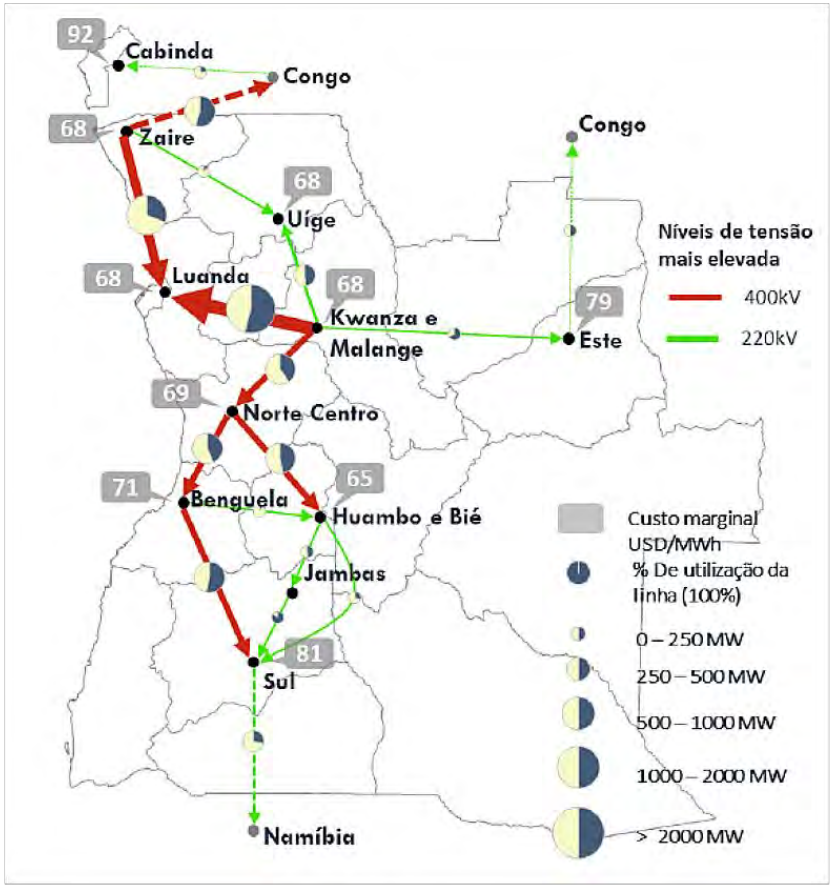
Name	Type	Owner	Capacity (MW)
CH Caculo Cabaça (Kwanza)	Hydro	PRODEL	1,000
CH Cafula (Queve)	Hydro	PRODEL	403
CH Baynes (50% Angola)	Hydro	PRODEL	200
CH Túmulo do Caçador (Condicional)	Hydro	PRODEL	453
CH Zenzo 1 (Condicional)	Hydro	PRODEL	460
CH Jamba Ya Mina	Hydro	IPP	180
CH Jamba Ya Oma	Hydro	IPP	75
CH Cacombo (Catumbela)	Hydro	IPP	29
CH Calengue (Catumbela)	Hydro	IPP	190
CH Quilengue (Queve)	Hydro	IPP	217
CH Cutato 1 (Hidrotérmico)	Hydro	IPP	157
CH Cutato 2 (Hidrotérmico)	Hydro	IPP	86
CH Cutato 3 (Hidrotérmico)	Hydro	IPP	57
CH Lomaum 2	Hydro	IPP	160
CH Luapasso (S.H.Luapasso)	Hydro	IPP	25
CH Camanengue (S.H.Luapasso)	Hydro	IPP	29
CH Samuela (S.H.Luapasso)	Hydro	IPP	15
CH Cambolo (Cuango - AO 2025)	Hydro	IPP	30
CH Cune 1 (Hidrotérmico)	Hydro	IPP	24
CH Cune 2 (Hidrotérmico)	Hydro	IPP	19
CH Cune 3 (Hidrotérmico)	Hydro	IPP	15
CH Cunhinga 1 (Hidrotérmico)	Hydro	IPP	29
CH Cunhinga 2 (Hidrotérmico)	Hydro	IPP	22
CH Cunhinga 3 (Hidrotérmico)	Hydro	IPP	22
CH Cunhinga 5 (Hidrotérmico)	Hydro	IPP	17
CH Chiumbe Dala (em curso)	Hydro	IPP	12
CH Cunje (em curso)	Hydro	IPP	8
CH Luquixe 2 (em curso)	Hydro	IPP	2
CH Andulo (Concurso M.H.)	Hydro	IPP	1
CH Kuito 2 (Concurso M.H.)	Hydro	IPP	1
CH Kuando (Concurso M.H.)	Hydro	IPP	2
CH Liapeca (Concurso M.H.)	Hydro	IPP	4
CH M'Bridge (Concurso M.H.) off-grid	Hydro	IPP	5
CH Cuemba (Concurso M.H.) off-grid	Hydro	IPP	1
Mini-hidricas várias on-grid (AO2025)	Hydro	IPP	47
Mini-hidricas várias off-grid (AO2025) off-grid	Hydro	IPP	28
Hydropower			4,024
CCGT Soyo 2A	CCGT	IPP	360
CCGT Soyo 2B	CCGT	IPP	360
Central térmica em Luena	Termal	PRODEL	80
CCGT Fútila II	CCGT	IPP	100
Thermal			900
Vários Parques eólicos (Estratégia Novas Renováveis)	Wind	IPP	100
Várias Centrais solares (Estratégia Novas Renováveis)	PV	IPP	100
Biocom	Biomass	IPP	100
Dombe Grande	Biomass	IPP	10
Projecto hidrotérmico	Biomass	IPP	300
Centrais de biomassa no Leste	Biomass	IPP	40
Residuos sólidos urbanos - Luanda	Biomass	IPP	30
Residuos sólidos urbanos - Benguela	Biomass	IPP	20
Renewables			700
Total	5,624		

Source : JICA Survey Team using Angola Energia 2025



Source : Angola Energia 2025 – MINEA (2015)

Figure 3.1-5 System planning in Angola



Source : Angola Energia 2025 – MINEA (2015)

Figure 3.1-6 Power interconnector plan in Angola

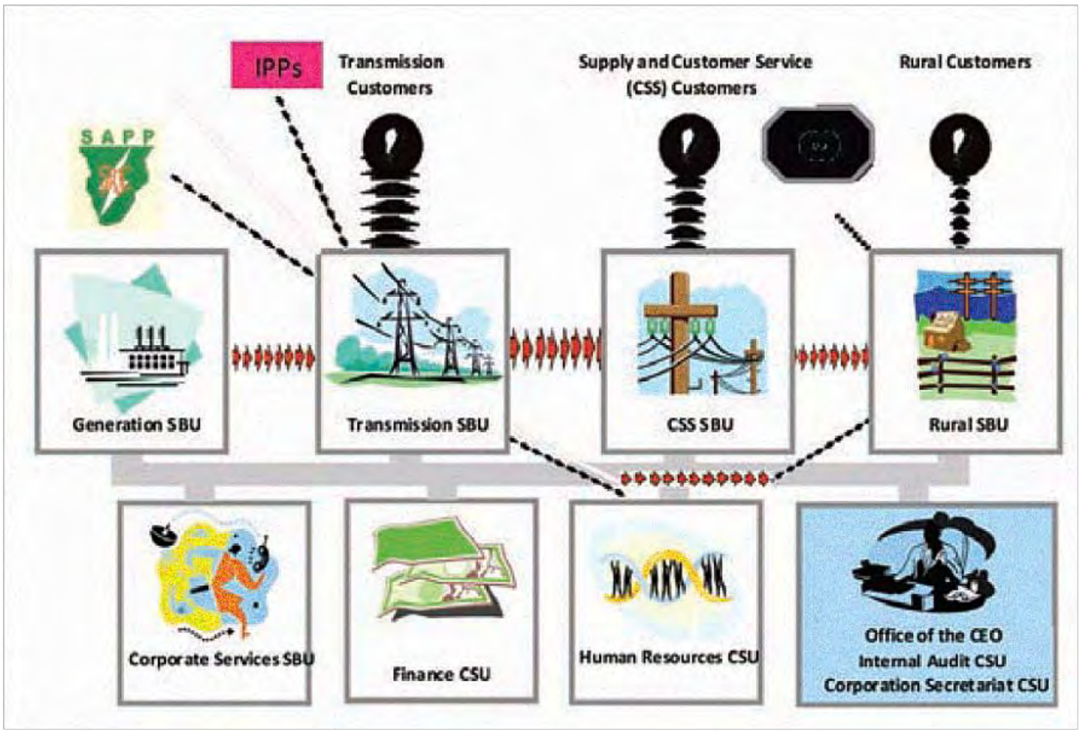
3.2 Botswana

3.2.1 Power Sector

(1) Overview of Power Sector

1) Botswana Power Corporation (BPC)

In Botswana, supply of electric power is controlled by the Department of Energy Affairs (EAD) under the Ministry of Minerals, Energy and Water Resources (MMEWR). Under the Botswana Power Corporation Act enacted in 1970, BPC which is state owned company was established. BPC is a vertically-integrated public company which deals with generation, transmission, distribution and power sales in a consistent manner.



Source：BPC Annual Report (2014)

Figure 3.2-1 BPC organization structure

2) IPP

IPP participation to power sector was permitted by Electricity Supply Act revised in 2007. In 2012, Karoo Sustainable Energy (KSE) [20] expressed an interest of participation, but there are no company which participates afterward. Although some IPP expressed intention to participate.

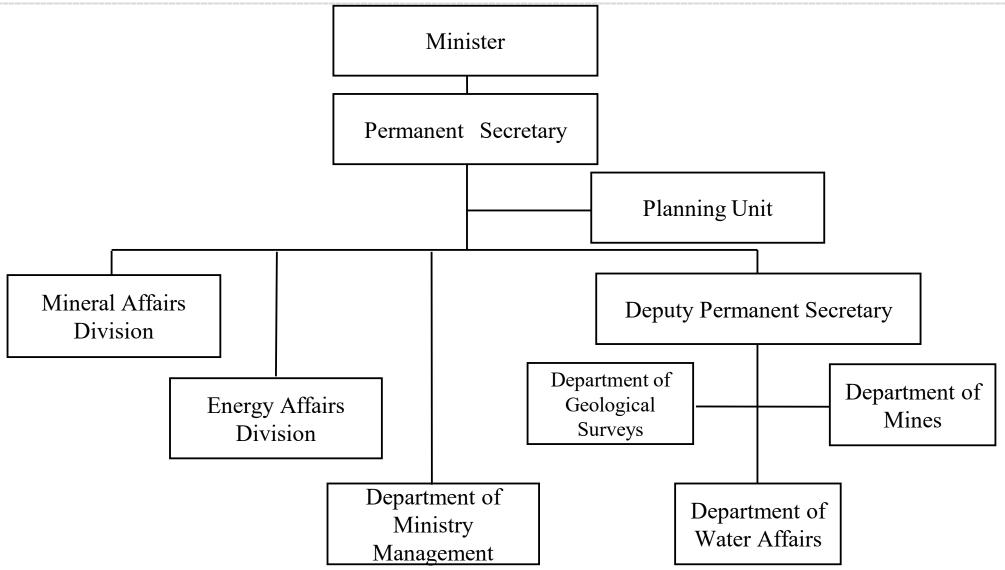
[20] Construction of power plant that use CBM at Opara

(2) Administrative body

1) Government

MMEWR controls power sector. At the present, no electricity regulation organization establishes in Botswana, and MMEWR carries out the regulatory duties such as electricity tariff calculation, electrical code provisionally. In the meanwhile, Botswana Energy and Water Regulatory Agency (BEWRA) will be planned to establish in near future.

The electricity business in Botswana is operated under the Energy Supply Act enacted in 1973.

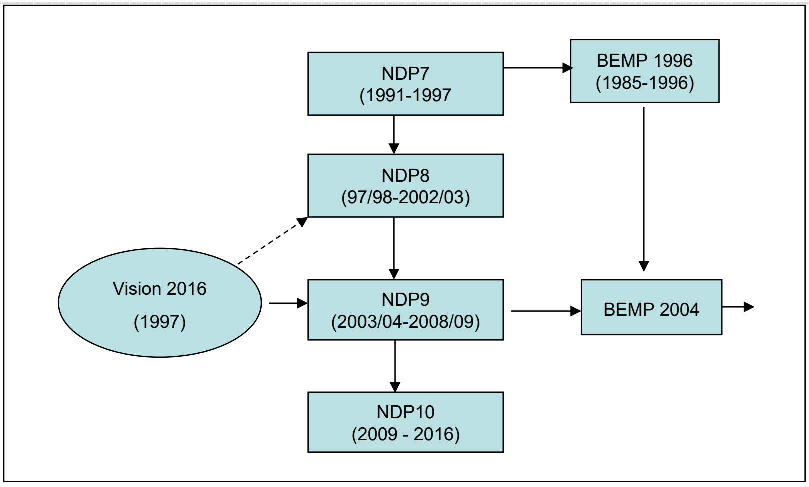


Source : JICA Survey Team

Figure 3.2-2 Formation of MMEWR

2) Energy policies

Figure 3.2-3 shows energy policies in Botswana.



Source : JCA Survey Team

Figure 3.2-3 Correlation of power sector politics

(a) Vision 2016

The following are strategies in the power sector advocated in the "National Development Vision, Vision 2016" established in 1996.

・In order to attain successful industrialization, cost-advantageous energy resources should be applied, and the merit of scale should be emphasized in the field of generation and power supply. To meet this, aggressive cooperation with neighboring counties is the key issue.

・Aggressive utilization of solar power since Botswana is rich in solar resources, for isolated area from the national power grid. The nation intends to develop solar technologies, thereby using solar as an energy source for schools.

(b) 10th National Development Plan 2009-2016 (NDP 10)

In accordance with Vision 2016, National Development Plan could set the reasonable directions with apparent target. Goals advocated in the NDP 10 are shown in Table 3.2-1.

Table 3.2-1 Goals and index values of energy sector in NDP 10

Goal of NDP 10	Index	Baseline as of 2008	Target as of 2016	Content of main efforts
Establishment of qualitative and quantitative generation capacity (fulfillment of national generation capacity improves energy security and suppress of drain foreign currency)	Regional capacity against peak demand	20%	100%	✓ Active generation development by IPP ✓ Grid expansion for IPP ✓ Usage of other resources (solar, biogas, diesel oil, CBM[21], etc.)
Uplift of electrification ratio	Electrification rate on grid	50%	80%	Effective and economical technology for electrification promotion
Usage of domestic coal	Access ratio to local energy	24%	30%	Investment promotion from private sector to utilize abundant domestic coal resource (mining, distribution)
Improvement of fuel supply security	Number of fuel storage days	23 days	90 days	Fuel procurement route, availability of various options, government-led fuel storage program
Environmental conservation	Rate of introduction of environmentally-conscious energy technology	0.3%	23%	CBM, coal liquefaction, coal gasification, etc.

Source : JICA Survey Team using NDP 10

(c) Botswana Energy Master Plan (BEMP)

BEMP is specific development plan in power sector in accordance with NDP's target. Latest BEMP was established in 2004. Since then no official BEMP exists.

[21] Coal Bed Methane

(3) Electricity tariff

The electricity tariff table of BPC is shown in Table 3.2-2. In Botswana, Tariff is classified to domestic (residential) customer use, small-scale business customers, medium-scale business customers, large-scale business customer, government and water pump respectively, and each category has three types of charge, such as fixed charge, energy charge and demand charge.

Table 3.2-2 Electricity tariff (Botswana)

Tariff Rates (12% VAT inclusive) -Botswana Effective 1st April 2014

Category		Fixed Charge (BWP)	Energy Charge		Demand Charge (BWP)	Tariff Category
Domestic Customers	TOU1	21.98	up to 200 kWh 0.6195	More than 200 kWh 0.8139	Nil	Doestic purposes; 230 volts single phase or 400 volts three-
Small Business	TOU6	66.53	up to 500 kWh 0.7092	More than 500 kWh 0.9534	Nil	Business customers; not exceeding 400 volts, load not
Medium Business	TOU7	66.53	0.4824		235.0389	Business customers; not exceeding 400 volts, load exceeding 35 kilowatts
Large Business	TOU8	66.53	0.434		127.1110	Business customers; not exceeding 11,000 volts
Government	TOU2	73.183	1.34816		Nil	All government, street lights
Water Pumping	TOU1	73.183	0.97207		Nil	Water pumping purposes

Source : BPC Website

Trial calculation of electricity tariffs is made for typical customers, the results of which are shown in the following table.

Table 3.2-3 Trial calculation of electricity tariff (Botswana)

Customer Category	Assumed consumption (kWh / month)	Electricity Tariff (US cents/kWh)
Domestic (Residential)	100	7.46
Small Commercial	1,000	7.56
Large Commercial/Industry	10,000	3.62

1USD = 0.09198BWP, as of December, 2016

Source : JICA Survey Team

3.2.2 **Power demand, existing facilities and development plan**

(1) Power demand

The following shows demand tracks in Botswana. An average increase rate of peak demand is 3.4%. Electricity sales tend to increase, with an average increase rate 3.0%.

Table 3.2-4 Peak demand and power generation in Botswana

FY	2007	2008	2009	2010	2011	2012	2013
Peak Demand [MW]	473	493	503	553	553	542	578
Electricity sales [GWh]	2,777	2,889	2,917	3,151	3,118	3,197	3,310
Generation send out [GWh] (incl. imports)	3,120	3,210	3,369	3,414	3,551	3,591	3,650

Source : BPC Annual Report 2013

As shown below, electricity sales for mining industry is the greatest, but recent years commercial sector has recorded remarkable increase.

Table 3.2-5 Power demand allocation in each sector in Botswana

FY	2007	2008	2009	2010	2011	2012	2013
Mining [GWh]	1,199	1,186	1,123	1,141	1,117	1,086	1,128
Commercial [GWh]	634	684	735	831	820	910	982
Domestic [GWh]	682	745	769	829	873	879	918
Government [GWh]	262	274	290	308	308	323	282

Source : BPC Annual Report 2013

(2) Existing facilities

1) Generation facilities

The following shows the power generation facilities in Botswana as of the end in 2015.

Table 3.2-6 Existing generation facilities (Botswana)

Plants	Type	Capacity(MW)	Remarks
Morupule A	Coal-fired	132 (4×33 MW)	Owned by BPC, and requires rehabilitation
Morupule B	Coal-fired	600 (4×150 MW)	Owned by BPC, and returned to operate in 2013
Orapa	Diesel	90	Owned by BPC, and plan to CBM (OCGT) from diesel
Matshelagabedi	Diesel	70	Owned by BPC

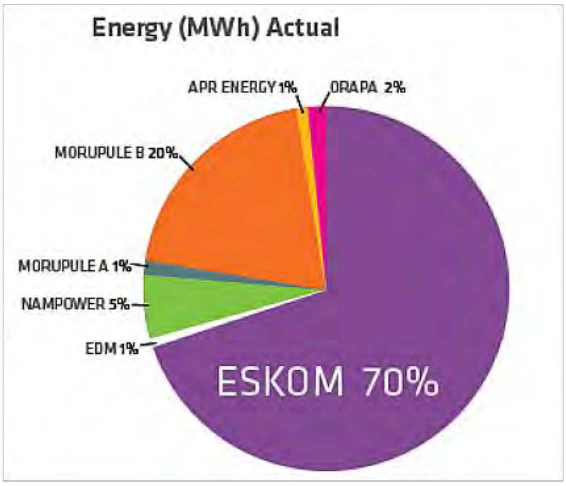
Source : JICA Survey Team wrapped it up based on BPC Annual Report 2013 etc.

2) Transmission facilities

Figure 3.2-5 shows existing power system in Botswana. The interconnectors that connect South Africa and Zimbabwe through Gaborone. But regional grid is not yet completed, especially northern and north western area.

3) Interconnector

In Botswana, five routes of interconnector bind Botswana and neighboring counties. Botswana is the key state to bind Southern SAPP states and northern SAPP states with interconnectors.



Source : BPC Annual Report 2013

Figure 3.2-4 Composition of generation in Botswana

Table 3.2-7 Interconnector (Botswana)

RSA	Phokoje – Matimba 400kV, 1 line
	Gaborone – Spitskop 132kV, 3 lines
	Tsabong – Heuningvei 132kV, 1 line
Zimbabwe	Francistown – Bulawayo 220kV, 1 line
Namibia	Gantsi – Omaere 132kV, 1 line

Source : JICA Survey Team

(3) Power system development plan

1) Generation development plan

(Hydropower)

In 2012, the Dikgatlhong Dam which is the largest dam in Botswana with effective storage capacity, 4,000 million cubic meters, was completed. However, no hydropower generation project is being planned.

(Thermal power)

Table 3.2-7 shows new thermal power generation project which is considered to promise installation.

Table 3.2-8 Thermal power project (Botswana)

Sites	Type	Capacity (MW)	Estimated Construction Cost (M USD)	Expected Commissioning year	Developer
Sese	Coal	600 (150MW×4)	1,500	2018	African Energy

Source : African Energy Web site

(Renewable energy)

In Botswana, solar radiation intensity is preferable and several sites are suitable for PV generation. Selebi-Phikwe (200 MW, 4 × 50MW) and Jwaneng (100 MW) is studying to come to installation.

As for wind power, wind farm, its capacity is 100 MW (50 MW × 2) and assumption of annual energy is 210 GWh, is planned in Kweneng District.

2) System planning

A component of ZiZaBoNa Project, from Pandamatenga to Victoria Falls, Zambia, 76km with 400kV is planned to construct.

Table 3.2-9 shows other projects for transmission lines to be implemented in Botswana.

Table 3.2-9 Regional transmission projects in Botswana

Projects	Current status of each project (As of Sep. 2015)
400kV transmission line (Morupule - Orapa) , and Orapa Substation (400/220kV)	Preparation and final confirmation of bid documents for procurement
400kV transmission line (Opara - Maun), and Maun Substation (400/220/132kV)	Preparation and final confirmation of bid documents for procurement
220kV transmission line (Maun - Toteng), and Toteng Substation (220/132kV)	Preparation and final confirmation of bid documents for procurement
132kV transmission line (Toteng –Gansl – Gumare – Shakawe), and Gumare / Shakawe Substation (132/33kV)	Preparation and final confirmation of bid documents for procurement
400kV transmission line (Orapa –Dukwi) and Dukwi Substation (400/132kV) 400kV transmission line (Dukwi - Pandamatenga) and Pandamatenga Substation (400/220kV)	Consultation for construction
220kV transmission lines extension, Pandamatenga - Kazungula, Pandamatenga – Lesoma, agricultural development area, and 220/33kV substations	Preparation of inception report
132kV transmission lines extension, Dukwi – Nata, Dukwi - Mosetse, and construction of 132/33kV substations	Preparation of request for proposal on outsourcing of consulting services

Source : PUBLIC NOTICE ”North West Transmission Grid Project Update” (2015)

3) Power system master plan

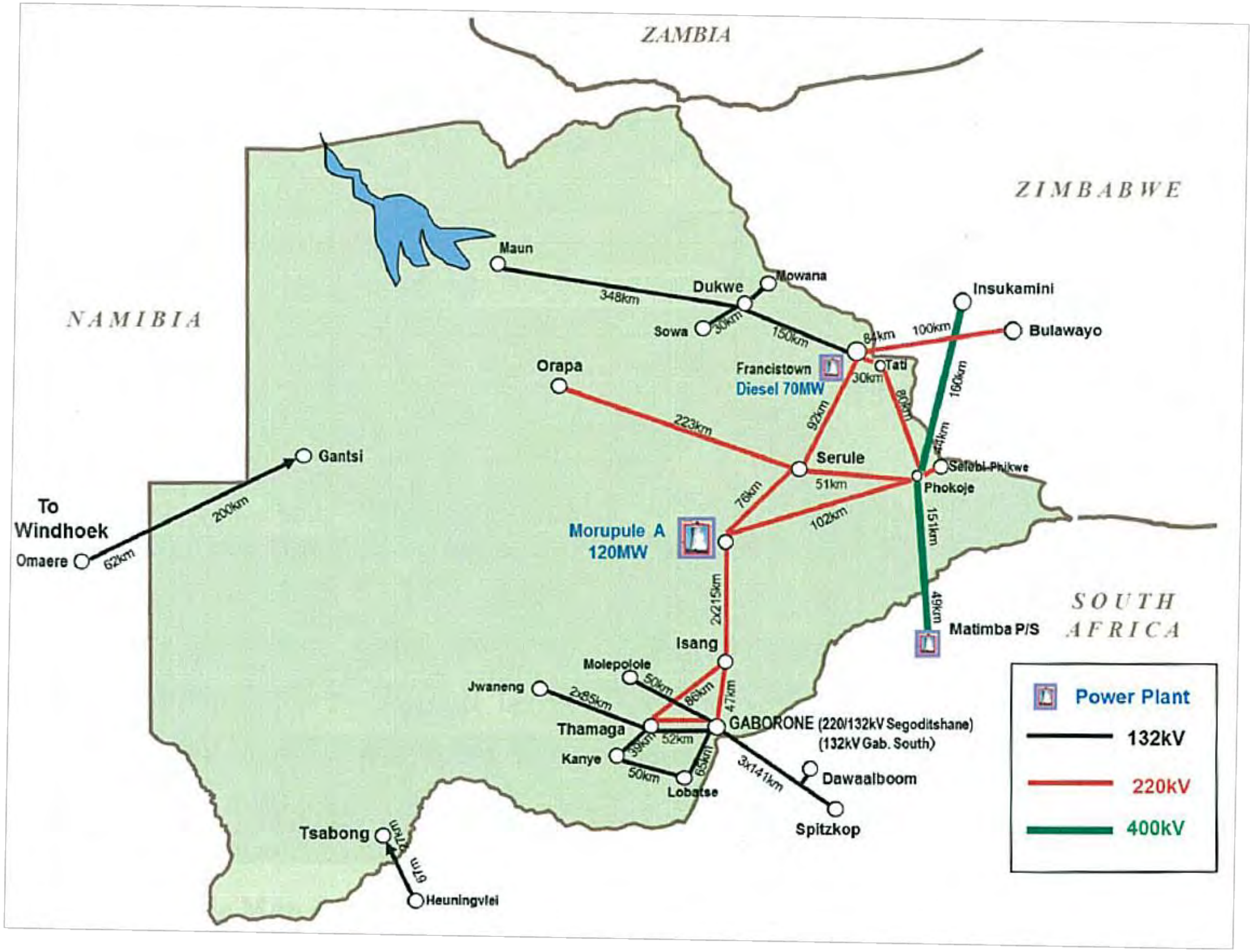
As shown in Table 3.2-2, power system master plan has not published lately. In the meanwhile, complementary information was in USEA archive. That is a document which was used by introduction of BPC’s activities with demand forecast and generation development plan, and was provided in 2013. It can be used as the master plan data as BPC guaranteed it to be reliable.

➢ Demand forecast

Figure 3.2-6 shows demand forecast toward 2031.

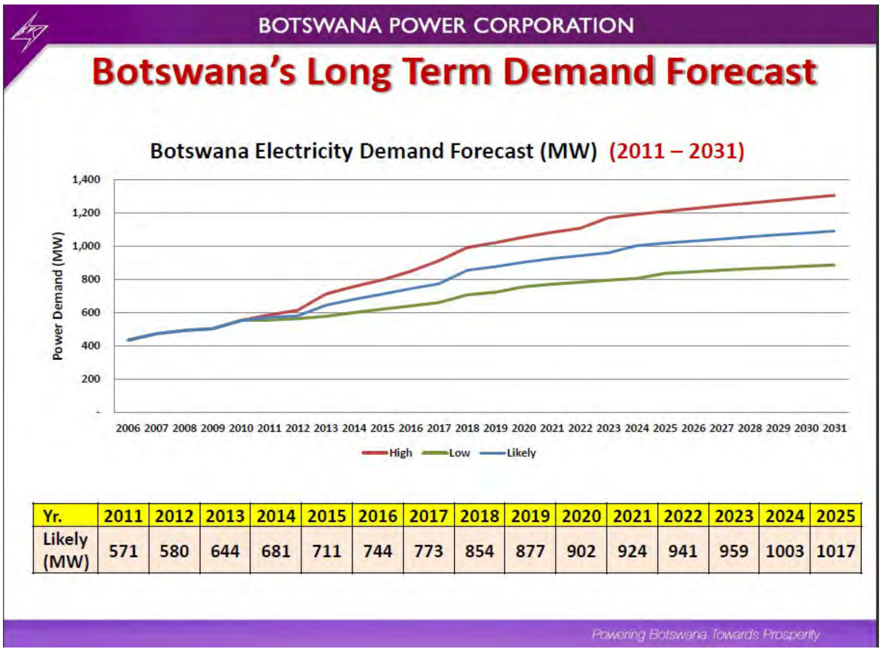
➢ Generation development plan, System planning

Main issue for generation development plan is rehabilitation of Morupule-A and development of Morupule-B in short and mid-term, and introduction of renewable, such as PV and wind farms and coal-fired power development is expectation in long-term.



Source : BPC (2016)

Figure 3.2-5 Power system diagram (Botswana)

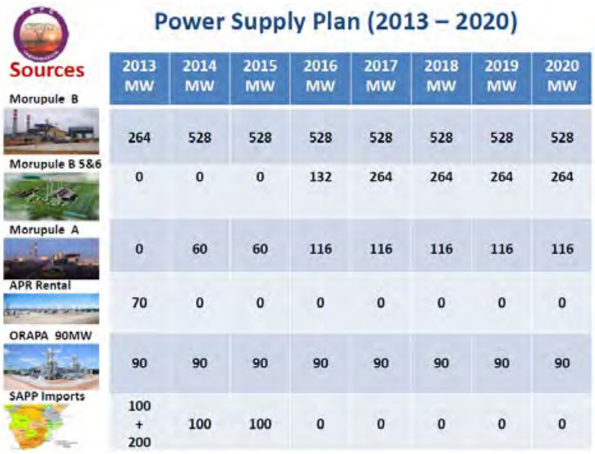


Yr.	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Likely (MW)	571	580	644	681	711	744	773	854	877	902	924	941	959	1003	1017

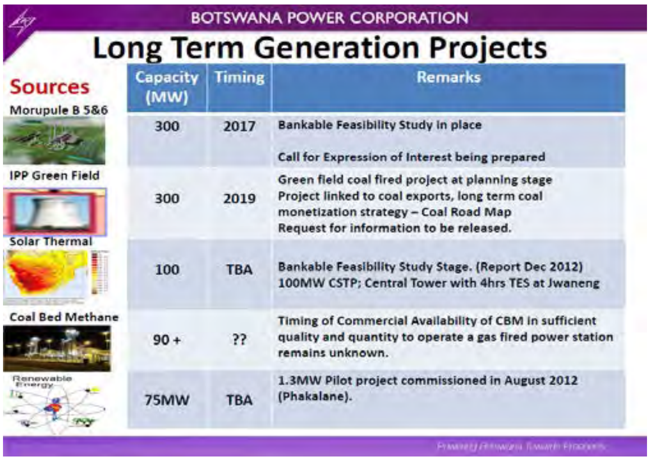
Source : ELECTRICITY SUPPLY INDUSTRY IN BOTSWANA,
POWER SUPPLY AND DEMAND IN SOUTHERN AFRICA (2013)

Figure 3.2-6 Demand forecast (Botswana)

➢ Generation development plan



Sources	2013 MW	2014 MW	2015 MW	2016 MW	2017 MW	2018 MW	2019 MW	2020 MW
Morupule B	264	528	528	528	528	528	528	528
Morupule B 5&6	0	0	0	132	264	264	264	264
Morupule A	0	60	60	116	116	116	116	116
APR Rental	70	0	0	0	0	0	0	0
ORAPA 90MW	90	90	90	90	90	90	90	90
SAPP Imports	100 + 200	100	100	0	0	0	0	0



Sources	Capacity (MW)	Timing	Remarks
Morupule B 5&6	300	2017	Bankable Feasibility Study in place Call for Expression of Interest being prepared
IPP Green Field	300	2019	Green field coal fired project at planning stage Project linked to coal exports, long term coal monetization strategy – Coal Road Map Request for information to be released.
Solar Thermal	100	TBA	Bankable Feasibility Study Stage. (Report Dec 2012) 100MW CSTP; Central Tower with 4hrs TES at Jwaneng
Coal Bed Methane	90 +	??	Timing of Commercial Availability of CBM in sufficient quality and quantity to operate a gas fired power station remains unknown.
Renewable Energy	75MW	TBA	1.3MW Pilot project commissioned in August 2012 (Phakalane).

Source : BPC presents Energy Sector (2013)

Figure 3.2-7 Power Development Plan (Botswana)

4) Feasibility of cross border projects for coal baseload IPP procurement programme in RSA

Definitely Botswana has rich coal resources. But it is difficult that export coal to other countries because transportations, such as rail road and tunk road to deliver it are fragile. Thus, it is expected to convert coal into electric power by coal-fired power at coal mines.

Coal baseload IPP procurement programme by the government of RSA admits the participation of external player to feed power to RSA with interconnector(s), namely cross-border project.

Recently Botswanan IPP companies submitted the request of cross-border IPP certification to participate the programme. Also this is welcome project on Integrated Resource Plan, South African power system master plan.

3.3 The Democratic Republic of Congo (DR Congo)

3.3.1 Power Sector

(1) Overview of Power Sector

Societe Nationale d'Electricite (SNEL)

A public enterprise company, Resideso was in charge of supplying electric power from 1960. Besides Resideso, private companies such as Comectrick, Forces du L'est, Forces du Bas-Congo, Sogefor, Sogelec and Cogelin handled the electricity business from power generation to power distribution.

SNEL, a state-owned electricity utility company founded for Inga hydropower development in 1970. SNEL conducted electricity business, such as generation, transmission and distribution in a consistent manner, therefore SNEL took over the business at above-described private companies in 1974. As a result, SNEL is organizing so as to handle the entire electricity business, generation, transmission, distribution[22] so far.

Thereafter, in 1994, the electricity business was opened to private sector. In 2003, reform of the system commenced in all fields including electric power. In 2009, privatization of SNEL was moved to action, and then. In 2011, SNEL restarted as a private company. So far SNEL is not subsidized by the government.

(2) Administrative body

1) Government

- Department of Electricity and Water Affairs

Department of Electricity and Water Affairs in the Ministry of Energy and Hydraulics is in charge of calculating electricity tariffs, extension planning of transmission systems, management of joint business among donors and a private sector, etc. Because there is no regulatory body in DR Congo.

- Cellule d' Appui Technique a l' Energie (CATE)

CATE is technical supportive section in the Ministry of Energy and Hydraulics. She would study demand forecast of DR Congo after the evaluation of previous demand forecast[23].

2) Electricity laws and regulations

As of 2015, the Electricity Act is in the process of revising work. The work will be orientating the promotion of new developer and formulation of competitive condition including rural electrification in power sector.

The Inga Law, related to Inga hydropower development is in a stage of obtaining legislative

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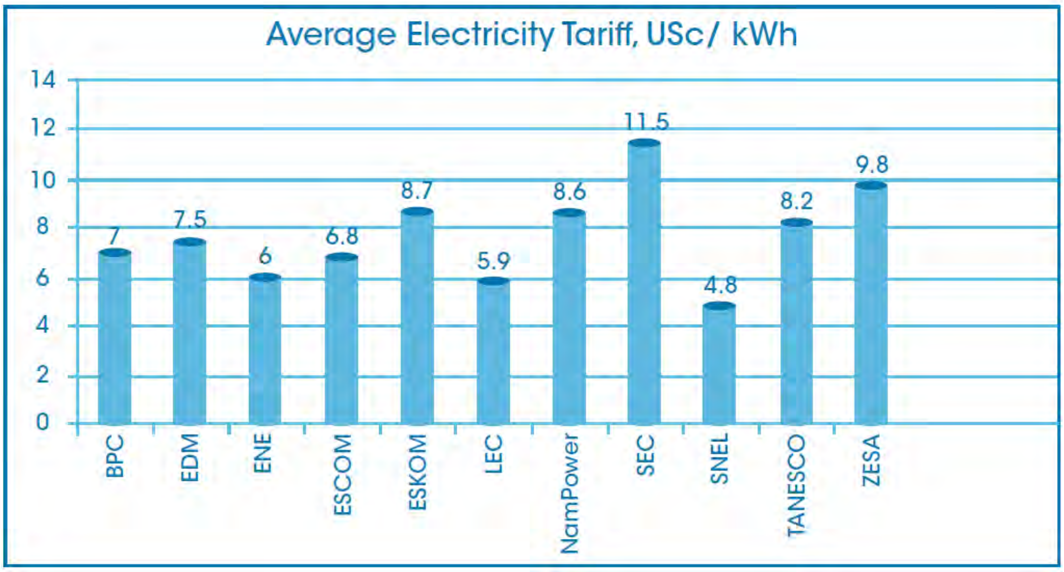
[22] Journal of Energy in Southern Africa Vol 17 No.3 August 2006

[23] Based on the interview on 1st site survey

approval[24].

(3) Electricity tariff

Precise information of electricity tariff cannot be obtained. However, information from International Renewable Energy Agency (IRENA) shows that electricity tariff in DR Congo is the cheapest in all SAPP member states.



Source：IRENA 2014, Analysis Infrastructure for Renewable Power in Southern Africa / SAPP Annual Report 2013

Figure 3.3-1 Electricity tariff comparison in FY 2012/13（SADC）

3.3.2 Power demand, existing facilities and development plan

(1) Power Demand

Precise power demand record could not been obtained from SNEL, therefore record represented in Table 2.1-3 is applied as the true value.

(2) Existing facilities

1) Generation Facilities

In DR Congo, generation facilities are mostly hydropower. The generation facilities owned by SNEL and mining companies are shown in Table 3.3-1.

[24] CATE, as of September, 2015

Table 3.3-1 Existing generation facilities (DR Congo)

Power plant	Commissioning year	Owner	Capacity (MW)
Bas Congo			
Inga 1	1972-74	SNEL	351
Inga 2	1981-82	SNEL	1,424
Zongo	1955-65	SNEL	75
Sanga	1932-49	SNEL	12
Mpozo	1934	SNEL	2.21
Katanga			
Mwadingusha	1929-54	SNEL	68
Koni	1950	SNEL	42.12
Nseke & Nzilo	1953-57	SNEL	356.40
Kyimbi	1959	SNEL	17.20
Kilubi	1954	SNEL	9.9
Kivu			
Ruzizi 1	1958-1972	SNEL	28.2
Ruzizi 2	1989	SNEL	26.6
Kasai occidental			
Lungudi	1949	SNEL	1.6
Province Oriental			
Tshopo Thermal	1955-1974	SNEL	18.8
Equateur			
Mobayi	1988-1989	SNEL	11.40
Budana		Kilomoto	13.8
Nzoro		Kilomoto	1.4
Soleniama1		Kilomoto	13.5
Soleniama2		Kilomoto	1.6
Ambwe/Kailo		Sominki	2.2
Belia		Sominki	2.2
Mangembe		Sominki	1.8
Lulingu		Sominki	0.7
Lutshurukuru		Sominki	5.1
Moga		Sominki	0.4
Tshala&Lubilanji1		Miba	8.6
Piana Mwanga		Congo Etain	29
Total			2,524.13

Source : Journal of Energy in Southern Africa • Vol 17 No 3 • August 2006, SNEL Annual Report 2000

2) Transmission facilities

Existing system capacities are shown in Table 3.3-2.

Table 3.3-2 Existing transmission line (DR Congo)

Location	500kV	220kV	132kV	120kV	70kV	55/50kV	Total (km)
Bas-Congo		216.6	185.3		164.5		611.4
Kinshasa		123.6			80.0		203.6
Bandundu		264.0					264.0
Equateur			22.5				22.5
Kivu					260.0		260.0
Katanga		834.1	120.0	1,198.8	70.0	188.8	2411.7
Inga-Kolwezi	1,774.0						1774.0
Total (km)	1,774.0	1,483.3	327.8	1,198.8	547.5	188.8	5,547.2

Source : Journal of Energy in Southern Africa • Vol 17 No 3 • August 2006, SNEL Annual Report 2000

3) Interconnector

±500kV HVDC transmission line from Inga site to Kolwezi is the gateway to interconnector between Zambia and DR Congo. The interconnector has been duplicated.

Table 3.3-3 Interconnector (CR Congo)

Zambia	Kolwezi – Luano (Zambia) 220kV, 2 lines

Source : JICA Survey Team

DR Congo joins SAPP and Eastern African Power Pool (EAPP) , and further Central African Power Pool / Pool Energetique de I'Afriuque Centrale (CAPP/PEAC). For EAPP, Rwanda, Brundi and DR Congo interconnects at Ruzizi-2 hydropower. And for CAPP/PEAC, Brazzaville, Republic of Congo and Kinshasa, DR Congo interconnects to feed the power from Inga[25].

(3) Power system development plan

1) Generation development plan

The hydro potential in DR Congo is estimated around 100,000 MW, 44% of which, 44,000 MW is concentrated on Inga area, 150km upstream from the mouth of the Congo River. Development of this site is called the Grand Inga Concept, and development of Inga 3 has commenced as phase 1.

In addition, performance of existing hydropower at Inga 1 and Inga 2 decreases drastically due to their deterioration and breakdown. In reality, power generated was less than a half of rated capacity. Therefore, donors such as WB, JICA etc. are planning to implement a rehabilitation project for existing power generation facilities in a coordinated manner.

Another aspect is that China is supporting generation development for mining companies. Since

[25] Every organization expect the benefit of Inga development.

DR Congo is rich in mineral resources, the mining industry is a major industry. On the other hand, due to insufficient supply of electric power from power grid, mining companies individually construct the generation facilities as captive power. Specifically, they are constructing hydropower plant for their own use. This tendency is supported by China, and Chinese companies exploit mineral resources jointly with local companies.

Generation development plans other than the Inga 3 are shown below.

Table 3.3-4　Status of hydropower development

水力案件	Status
Zongo 2　（150MW）	Sinohydro, with support of China
Katende（63MW）	Support if India
Nseke rehabilitation	PPP/ Tenke Fungurume Mining（TFM）
Zongo・Koni・Mwadingusha Rehabilitation	PPP/ Enterprise General Malta Forrest（EGMF）
Inga 2 Rehabilitation	Joint work of PPP/ Kamoto Copper Company SARL (KCC) andWB
Inga1 Rehabilitation	WB

Source：SNEL Overview of the Electricity Sector in the DRC（2013）

Other projects, not shown in Table 3.3-5, are being planned as PPP projects or joint business between private companies and donor organizations such as WB. Table 3.3-6 shows a list of hydropower development candidates in DR Congo which has rich hydro potentials[26] on the African continent.

[26] Precise status of each project is not seen.

Table 3.3-5 Hydropower candidates (DR Congo)

	Site	Potential(MW)			Site	Potential(MW)
01	Grand Inga	43,800		31	Kamanyola	240-390
02	Inga IX	1,500		32	Kiliba	15
03	Matadi	12,000		33	Ulindi	30
04	Pioka	22,000		34	Mwenga	9.5
05	Zongo II	150		35	Kamimbi	14
06	Kitona	12		36	Kibombo	13
07	Bamba	12		37	Kitete	21
08	Kakobola	10.5		38	Mwanangoye	46
09	Ruki	5.3		39	Portes d'Enfer	36
10	Mobayi II	17.5		40	Kyimbi II	25.8
11	Lepudungu	3		41	Piana Mwanga II	8.4
12	Nepoko	134		42	Sombwe	186
13	Bengamisa	15		43	Kiubo	66
14	Babeba	20-50		44	Mambilima I	124
15	Tshopo II	17		45	Mambilima II	201
16	Kisangani	460		46	Mambilima V	418
17	Wagenia	20-50		47	Mumbotuta M	210
18	Wanie Rukula	530-688		48	Mumbotuta CX	300
19	Semliki	28		49	Nzilo II	120
20	Ruwenzori I	6		50	Busanga	240
21	Ruwenzori II	6		51	Kalengwe	204
22	Kisalala	7.5		52	Kimimbi/Fuka	153
23	Muhuma	25		53	Delporte	5
24	Mugomba	40		54	Tshilomba	3
25	Rutshuru	4		55	Libilanji II bis	4.2
26	Ngingwe	3		56	Tshala II	12
27	Binza	5		57	Gd Katende	64
28	Osso	3		58	Katende/Bombo	10
29	Panzi	42		59	Tshikapa	64-128
30	Sisi	205		60	Lukenie	3

Source : SNEL WEB Site

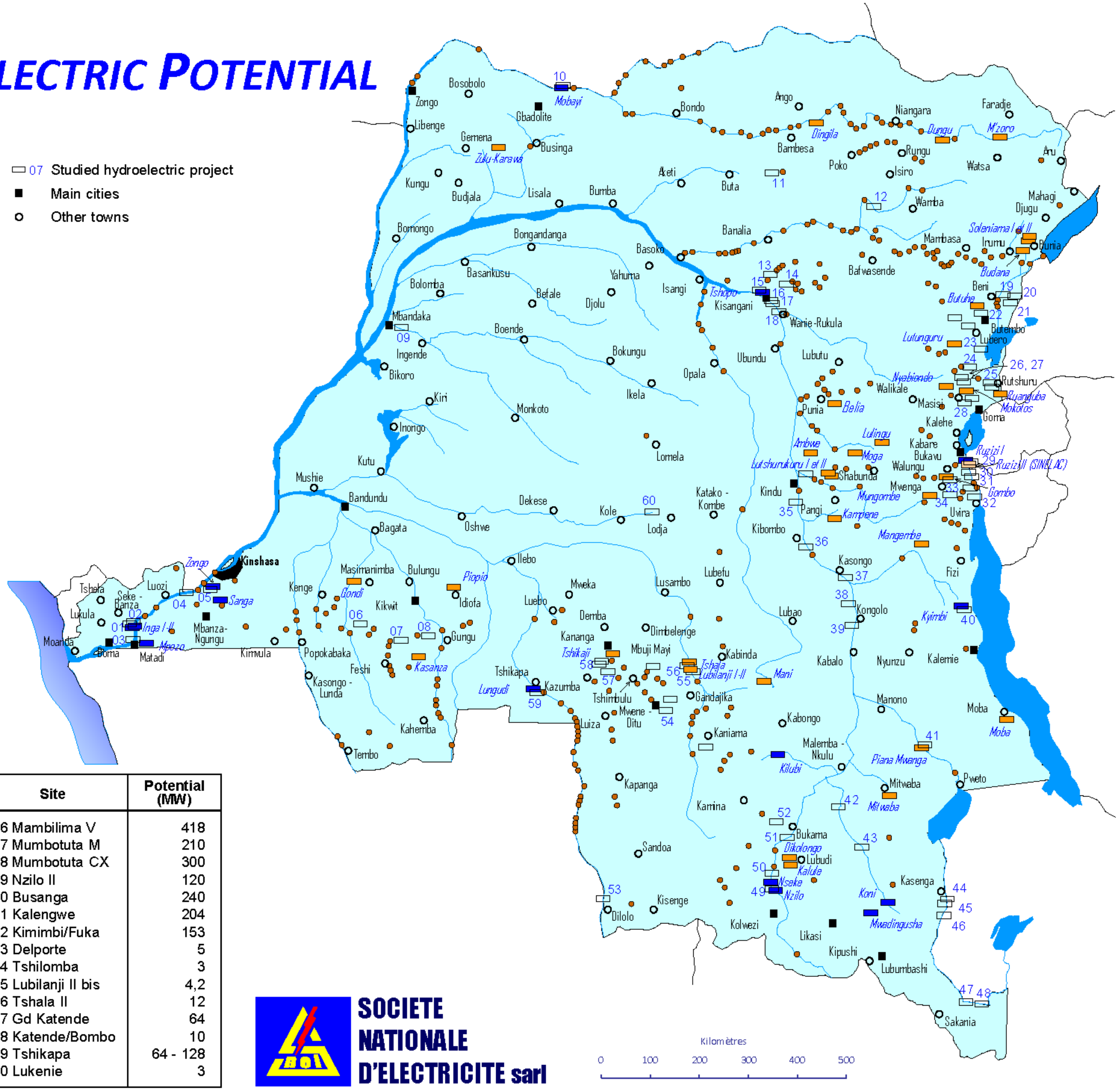
HYDROELECTRIC POTENTIAL

Legend

- Water falls or rapids
- Existing SNEL power plants
- Existing private power plants
- 07 Studied hydroelectric project
- Main cities
- Other towns

Site	Potential (MW)
01 Grand Inga	43.800
02 Inga IX	1.500
03 Matadi	12.000
04 Pioka	22.000
05 Zongo II	150
06 Kitona	12
07 Bamba	12
08 Kakobola	10,5
09 Ruki	5,3
10 Mobayi II	17,5
11 Lepudungu	3
12 Nepoko	134
13 Bengamisa	15
14 Babeba	20 - 50
15 Tshopo II	17
16 Kisangani	460
17 Wagenia	20 - 50
18 Wanie Rukula	530 - 688
19 Semliki	28
20 Ruwenzori I	6
21 Ruwenzori II	6
22 Kisalala	7,5
23 Muhuma	25
24 Mugomba	40
25 Rutshuru	4
26 Ngingwe	3
27 Binza	5
28 Osso	3
29 Panzi	42
30 Sisi	205
31 Kamanyola	240 - 390
32 Kiliba	15
33 Ulindi	30
34 Mwenga	9,5
35 Kamimbi	14
36 Kibombo	13
37 Kitete	21
38 Mwanangoye	46
39 Portes d'Enfer	36
40 Kyimbi II	25,8
41 Piana Mwanga II	8,4
42 Sombwe	186
43 Kiubo	66
44 Mambilima I	124
45 Mambilima II	201

Site	Potential (MW)
46 Mambilima V	418
47 Mumbotuta M	210
48 Mumbotuta CX	300
49 Nzilo II	120
50 Busanga	240
51 Kalengwe	204
52 Kimimbi/Fuka	153
53 Delporte	5
54 Tshilomba	3
55 Lubilanji II bis	4,2
56 Tshala II	12
57 Gd Katende	64
58 Katende/Bombo	10
59 Tshikapa	64 - 128
60 Lukenie	3



SOCIETE NATIONALE D'ELECTRICITE sarl

Source : SNEL WEB Site

Figure 3.3-2 Hydropower candidates (DR Congo)

Source : SNEL WEB Site

Figure 3.3-3 Transmission plan by SNEL (DR Congo)

2) System planning

Accoring to the report from SNEL[27], the system expansion plan of SNEL is shown below.

- 400kV second circuit between Inga and Kinshasa: by WB and the European Investment Bank (EIB)
- 220kV second circuit connecting to SAPP system by way of Zambia: by WB[28]
- Distribution network expansion in the capital, Kinshasa, and rehabilitation: by WB
- Transmission network integration for rural electrification: by AfDB

3) Power system master plan

WB supported the publication for the first power system master plan in DR Congo in 1988. The only information is available that the latest plan was enacted in 2001[29]. However, no information equivalent to a master plan has been found[30] so far.Further, CATE is going to study the demand forecast after evaluation of demand forecast established in 2005.

4) Cooperation by the donor organizations

Status of support to individual projects for system development is shown below.

Table 3.3-6 Support detail by donors in DR Congo

Donors	Type	Projects	Remarks
WB	Generation	Inga 3 hydropower (4,800 MW)	Construction CGI3 established by the support of WB
China	Generation	Zongo 2 hydropower (120 MW)	Construction
China	Generation	Busanga hydropower (240 MW)	Construction
India	Generation	Katende hydropower (64 MW)	Construction
AfDB	Generation	Ruzizi 3 hydropower (49 MW)	Construction (PPP project)
AfDB	Transmission	Inga 3 – Kolwezi 500kV HVDC for Inga 3	Construction (specification is not apparent yet)

Source : JICA Survey Team

5) The Inga 3 project

WB started the Inga 3 Project Promotion Office (Cellule Technique Inga 3 ; CGI3) which is a local branch in the capital, Kinshasa, with the objective of promoting the Inga 3 project and commenced activities toward realization of the project.

The Inga 3 project is positioned as a first phase of the Grand Inga concept (development of power generation of 44,000 MW including the existing Inga 1, Inga 2 and proposed Inga 3). After the

27 SNEL, Overview of the Electricity Sector in the DR Congo (2013)
28 By CEC
29 Interview to CATE, in September 2015
30 Interview to WB DR Congo Office, in September 2015

accomplishment of Inga 3, subsequent development needs construction of a dam on main stream of the Congo River, to allocate hydropower projects, namely Inga 4 to Inga 8. These are the overview of the Grand Inga concept.

Output of Inga 3, 4,800 MW will be distributed to several usage. 1,000 MW is for local consumption such as residential and officials, 1,300 MW is for local mining industries, and 2,500 MW is for Eskom, South Africa. A contract feeding 2,500 MW from Inga 3 to RSA has already been concluded between the government of RSA and the government of the DR Congo. Further, the contract also includes a provision for RSA taking 30% of developed output by the following Inga projects.

Inga 3 is to be conducted by joint financing of WB and AfDB and examined on the basis of the WB standards.

- Information on bid for Inga 3 project

An international competitive bid was made to provide a full turn-key specification including presentation of electricity selling price (generation unit cost). The bid invitation ended in December 2015. Three groups, namely, (1) China-based consortium, (2) Spain-based consortium and (3) Canada/South Korea based consortium had applied for a bid invitation. It was planned that examination (due diligence) was made during the period of January to June 2016, by all stakeholders (16 mining companies, besides related countries including South Africa) and a business developer was to be selected in September 2016. Thereafter, financial close was to be concluded during a period of September 2017 to December 2017, with forecasted six – year construction period. Construction work are roughly categorized into two, civil work, electric facilities work[31].

However, this bid disqualified, and now re-bid process and arrangement are still deliberating.

- Transmission development plan for Inga 3 project

AfDB is in charge of the development of power transmission lines for Inga 3 project.

The specification of transmission line is decided to apply HVDC, and the route is from the site border between Zambia and DR Congo. But the route from the border to RSA is not decided yet, and so is transmission specification.

[31] Installation of direct-current high-voltage (HVDC) transmission lines to the border of Zambia will supported by AfDB as another project package.

3.4 Lesotho

3.4.1 Power Sector

(1) Overview of power sector, administrative body, and regulatory body

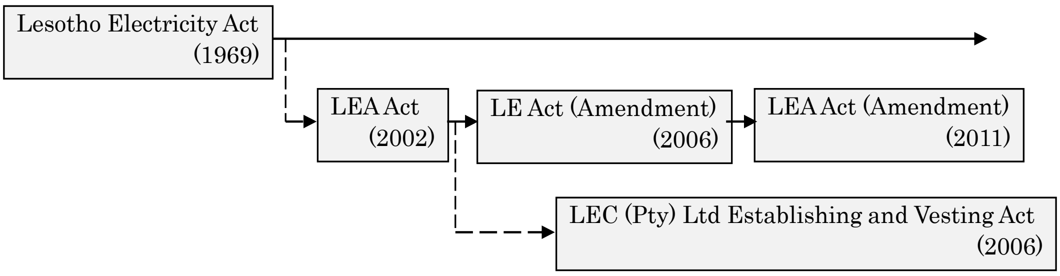
In Lesotho, electric power was supplied by Lesotho Electricity Company (LEC) founded in 1969 as a semi-governmental company in charge of generation, transmission and distribution. Under the Lesotho Electricity Authority Act (LEA Act) established in 2002, the Lesotho Electricity Authority (LEA) was founded. In 2006, a business license for transmission, distribution and sales was issued to LEC from LEA, and a license for generation business was issued to LEC and the Lesotho Highlands Development Authority (LHDA). In 2013, LEA was integrated into water business and organized as the Lesotho Electricity and Water Authority (LEWA), that is, a regulatory organization in charge of electricity and water utility business.

The generation business is charged by LEC and LHDA. Electric power generated by LEC is 0.1% which is only a very small amount, 64% is purchased from LHDA and deficit is covered by EDM, Mozambique and Eskom, RSA.

The transmission and distribution business is essentially operated by LEC. However, as aforementioned, electric power is dependent on import. Electric power is being fed by three substations, namely Mabote, Peka and Hendriks Drift. Further, at districts outside of supply area by LEC, electric power is supplied only to the district under assistance of the Government by the Rural Electrification Unit (REU) of the Department of Energy (DOE).

1) Electricity-related laws and regulations

Electricity-related laws and regulations in Lesotho are in Figure 3.4-1.



Source : JICA Survey Team

Figure 3.4-1 Electricity laws and regulations (Lesotho)

2) Energy policy

In Lesotho, the Lesotho Energy Policy 2015 advocates the following goals in power sector.

(a) Promotion of electrification

The goal of ordinary household electrification rates was 35% by 2015, and this goal was achieved at the beginning of 2015. The rate will be further increased, and all nation can access to the electric power system in near future.

(b) Reinforcement of generation facilities and introduction of renewable energy

In recent years, a domestic self-sufficiency rate of electric power has varied at around 50%, and the electricity demand is in reality dependent on import. Under these circumstances, aiming at improving the self-sufficiency rate by reinforcing power generation facilities, hydropower plants and wind power plants using local resources will be built.

(c) Improvement in electric power quality

In association with promotion of electrification and reinforcement of power generation facilities, the number of substations should be increased and transmission lines are being built. Further, electric power has been raised in quality.

(2) Electricity tariff

In Lesotho, the regulatory organization is LEWA and power utility is LEC, state-owned company. Electricity tariff is revised by LEWA annually. It would be set in several categories. Further, the electricity tariff table is provided for each customer as shown in Table 3.4-1.

Table 3.4-1 Electricity tariff (Lesotho)

APPROVED LEC ENERGY CHARGES 2015/16 (Effective from 01 April, 2015) - Lesotho

Customer Category	Industrial HV	Industrial LV	Commercial HV	Commercial LV	General Purpose	Domestic	Street Lighting
Approved Energy Charges Including *Customer and Electrification Levies (M/kWh)	0.2155	0.2326	0.2155	0.2326	1.3753	1.2249	0.726

*Customer Levy=LSL 0.0360 / kWh ; Electrification Levy for both Industrial HV/LV and Commercial HV/LV = LSL0.02 / kWh ; Electrification Levy for General Purpose, Domestic and Street Lighting= LSL 0.035 / kWh

APPROVED LEC MAXIMUM DEMAND CHARGES (Effective from 01 April, 2015)

Customer Category	Industrial HV	Industrial LV	Commercial HV	Commercial LV
Approved Maximum Demand Charges (LSL / kVA)	224.704	262.4547	224.704	262.4547

M : Maloti Source : LEWA Web Site (2016)

Trial calculation of electricity tariffs is made for typical customers, the results of which are shown in Table 3.4-2.

Table 3.4-2 Trial calculation of electricity tariff (Lesotho)

Customer Category	Assumed consumption (kWh / month)	Electricity Tariff (US cents/kWh)
Domestic (Residential)	100	8.76
Small Commercial	1,000	3.54
Large Commercial/Industry	10,000	1.85

1 USD = 0.07149 LSL, as of December, 2016

Source : JICA Survey Team

3.4.2 **Power demand, existing facilities and development plan**

(1) Power demand

Following is recent electricity sales, maximum demand, etc., in LEC.

Table 3.4-3 Electricity sales (LEC)

Items \ FY	2012/13	2013/14
Demand (GWh)	771.6	801.44
(Domestic production)	(461.5)	(516.44)
(Buying from Eskom, EDM)	(310.1)	(285)
Domestic production ratio (%)	60	64
Electricity sales (GWh)	685	705
Loss (%)	11.7	12.1

Source : LEWA Annual report 2013-2014

Table 3.4-4 Peak demand (LEC)

FY	Peak demand (MW)	Domestic production (MW)	Import (MW)	Deficit (%)
2009/10	133.4	72	61.4	46
2010/11	138	72	66	48
2011/12	141.69	72	66.69	49
2012/13	147.63	72	75.63	51
2013/14	143	72	71	50

Source : LEWA Annual report 2013-2014

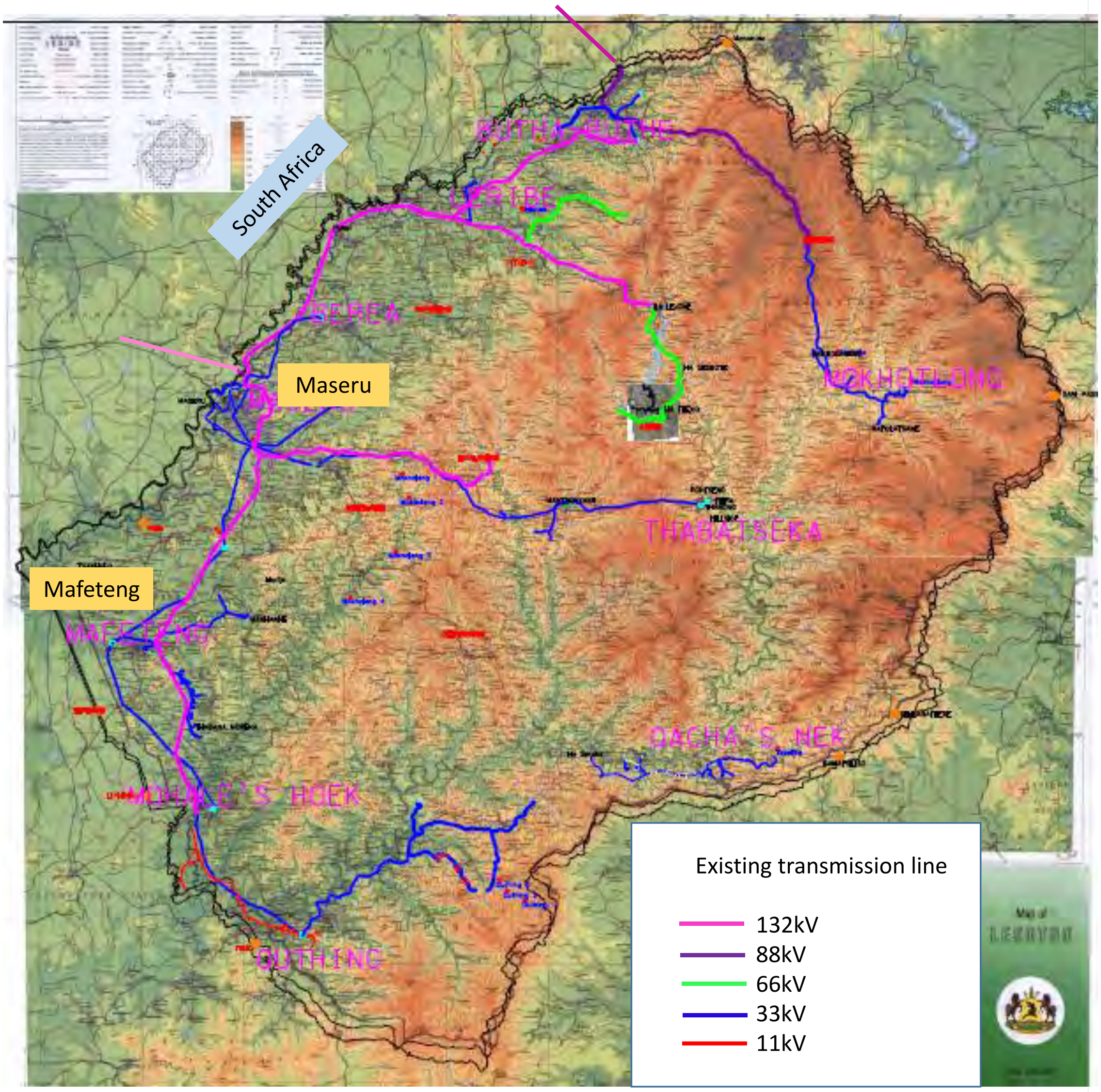
(2) Existing facilities

1) Generation facilities

Generation facilities in Lesotho are Muela hydropower (24 MW x 3) and mini-hydropower (Mant-Sonyane). Muela hydropower is owned by Lesotho Highland Water Project and the rest of hydropower is owned by LEC.

2) Transmission facilities

Transmission facilities of LEC is shown in Figure 3.4-2. LEC has only load system, which voltage is below 132kV, and interconnecting Free State, RSA.



Source : JICA Survey Team using evidence from LEC (2016)

Figure 3.4-2 Power system diagram (Lesotho)

(3) Development plan

1) Generation development plan

In electric energy policy circles, there is advocated a goal of developing a wind power generation plant at Let'seng in view of generation mix. At the present time, however, there is no plan of wind power generation plant.

2) System planning

In Lesotho, only system planning on a load system, with no information available for trunk system with interconnector.

3.5 Malawi

3.5.1 **Power Sector**

(1) Overview of Power Sector

ESCOM

As a state-owned electricity supplier, the Electricity Supply Corporation of Malawi (ESCOM) was in charge of generation, transmission and distribution consistently. However, in 1988, the corporation was restructured as a stock company under the Company Act. In 2004, the Electricity Act was revised to allow private sector participation in power generation business, and ESCOM itself was deregulated three business units, namely generation, transmission and distribution companies.

By the support of Millennium Challenge Corporation (MCC), ESCOM was applying reorganization. In June 2016, amendment of Electricity Act 2016 was approved, and brand-new utility, Electricity Generation Company Co. (EGENCO), which is responsible for generation, and anew ESCOM, the Electricity Supply Corporation of Malawi Limited which is still responsible for transmission and distribution.

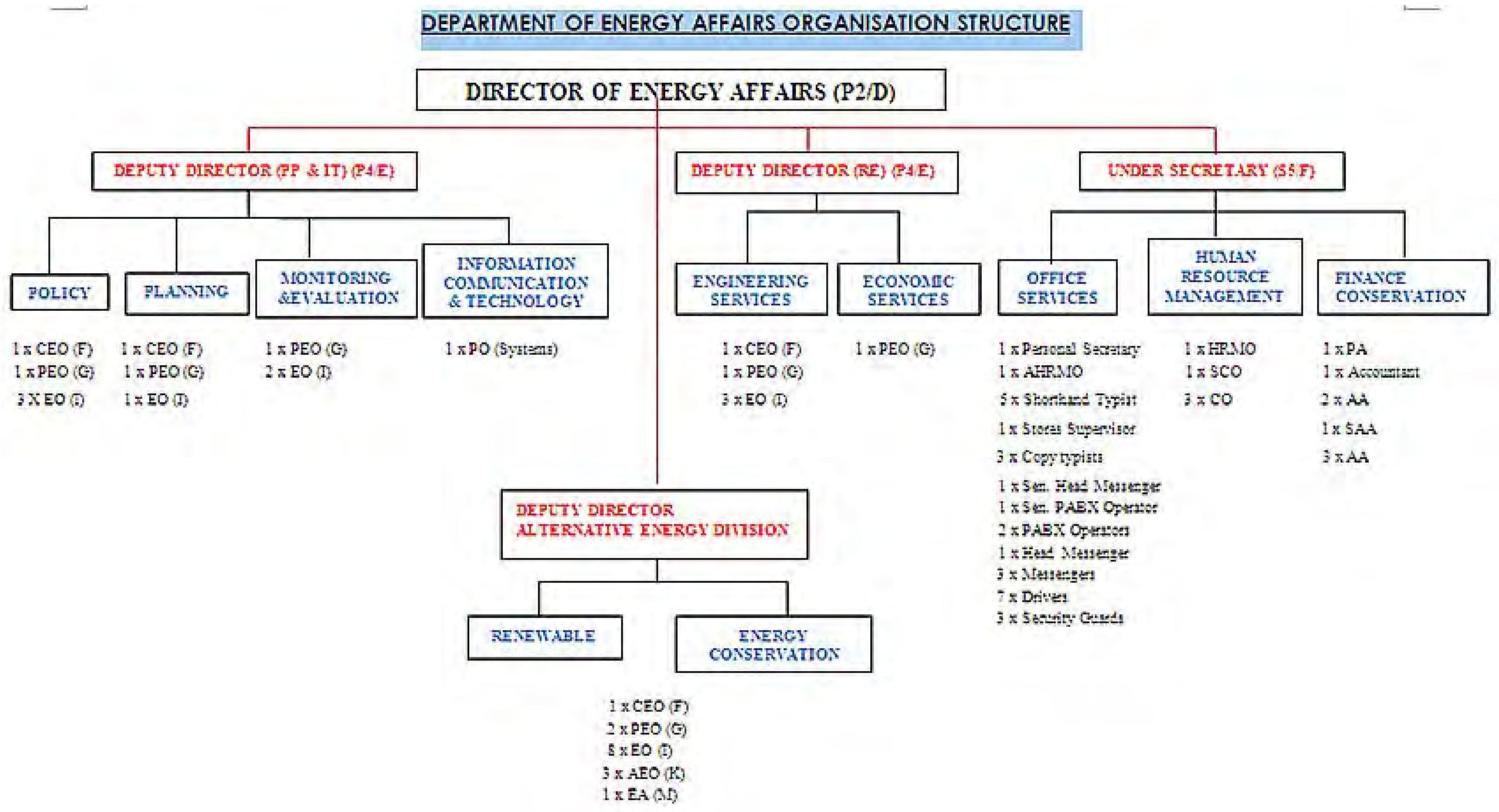
As of November 2016, rearrangement of the properties, such as worker and assets etc., for EGENCO and anew ESCOM was working. Therefore, new shape of power sector started in 2017. Here, both utilities, ESCOM and EGENCO are state owned companies.

Further, ESCOM owns three subsidiaries for operation, maintenance and management of power distribution facilities, that is, Northern Electricity Supply (NES), Central Electricity Supply (CES) and Southern Electricity Supply (SES).

(2) Administrative body

Ministry of Natural Resources, Energy and Mining is responsible for planning the energy policies, strategies and operations and supervision of energy sector. And Department of Energy Affairs, one of the functions in Ministry of Natural Resources, Energy and Mining, is the supervising organization of ESCOM.

Government of Malawi is now promoting IPP, especially PV. Details of power purchase agreement (PPA) for PV IPPs, and the number of players are not well-known, but around 70 MW of PV will be introduced.



Note ; ESCOM. eGenco is now structuring the organization
Source : JICA Malawi Office (2016)

Figure 3.5-1 Formation of Department of Energy Affairs

(3) Electricity laws and regulations

Laws and regulations on electric power are as follows:

- The Energy Regulation Act 2004
- The Electricity Act 2016
  The Rural Electrification Act 2004
- The Liquid Fuels and Gas (Production and Supply) Act 2004

And in Malawi Energy Policy under Malawi vision 2020, aiming to become middle income country in 2020, following quota are put up,

✓ Ensure that all households and businesses have access to electricity services from current access rate of about 10% to 30% by 2030

✓ Maintain reliability of power supply with no blackout and lesser loss of load expectation (LOLE), which is less than 25 hours per annum.

✓ Minimize the cost for electricity services, including power trade with Mozambique by 2018, in short term to long term.

(4) Regulatory body

As for regulation on the electricity business, the National Electricity Council was founded in 1999. Main rules and regulations on electricity were established in 2004, and under the Electricity Regulation Act No.20, one of these, the Malawi Energy Regulation Authority (MERA) was founded. MERA is monitoring the fairness, transparency, etc., of power sector.

(5) Electricity tariff

Revision of electricity tariff of ESCOM needs to the permission of MERA, and MERA uses automatic tariff adjustment system (ATAF) which permits the tariff revision in accordance with 5% ascent of commodity price and / or with currency rate. Further, the electricity tariff table is shown in Table 3.5-1.

Table 3.5-1 Electricity tariff structure - Malawi

Electricity Traiff -Malawi (2016)

Tariff Code	Description	Type of Charge per month	Rate (MWK)
ET1	Domestic, Prepaid, Single Phase Supply	Unit charge per kWh	38.46
ET2	Domestic, Postpaid, Single Phase Supply	Fixed Charge	2,600.70
		Unit charge per kWh	0.33
ET3	Domestic, Prepaid, Three Phase Supply	Unit charge per kWh	59.57
ET4	Domestic, Postpaid, Three Phase Supply	Fixed Charge	7,430.55
		Unit charge per kWh	53.87
ET5	General, Prepaid, Single Phase Supply	Unit charge per kWh	66.21
ET6	General, Postpaid, Single Phase Supply	Fixed Charge	5,201.38
		Unit charge per kWh	79.35
ET7	General, Prepaid, Three Phase Supply	Unit charge per kWh	69.50
ET8	General, Postpaid, Three Phase Supply	Fixed Charge	7,430.55
		Unit charge per kWh	66.21
ET9	Maximum Demand - Low Voltage Supply (Large power for industrial users, supplied at three phase supply and metered at 400 Volts)	Fixed Charge per Month	26,000.00
		On peak Unit charge per kWh	73.00
		Off peak Unit charge per kWh	20.00
	Capacity Charge per KVA based on the customers annual declared demand		3,076.25
	Demand Charge per kVA based on actual monthly demand reading		4,978.04
ET10	Maximum Demand - Low Voltage Supply (Large power for industrial users, supplied at three phase supply and metered at 11kV or 33kV)	Fixed Charge per Month	26,000.00
		On peak Unit charge per kWh	65.00
		Off peak Unit charge per kWh	18.00
		Capacity Charge per kVA based on the customers annual declared demand	2,787.65
		Demand Charge per kVA based on actual monthly demand reading	4,270.70
ET11	Public Service, Prepaid, Three Phase Supply, High Current Metering	Unit charge per kWh	79.71

On Peak periods are from 7:00 to 12:00 hrs and 17:00 to 20:00 hrs from Monday to Friday. Off Peak periods are from 12:00 hrs to 17:00 and 00:00 to 07:00 hrs from Monday to Friday. All Saturdays, Sundays and Official Public Holidays are Off peak periods

Source : ESCOM Webpage (2016)

Trial calculation of electricity tariffs is made for typical customers, the results of which are shown in Table 3.5-2.

Table 3.5-2 Reference electricity tariff - Malawi

Customer Category	Assumed consumption (kWh / month)	Electricity Tariff (US cents/kWh)
Domestic (Residential)	100	3.61
Small Commercial	1,000	11.58
Large Commercial/Industry	10,000	10.36

1 USD = 0.00137 MWK, as of December, 2016
Source : JICA Survey Team

3.5.2 **Existing facilities and development plan**

Detail data of demand record was not find out. Table 2.1-3 can be seen the part of this information instead.

(1) Existing facilities

1) Generation facilities

ESCOM facilities are shown in Table 3.5-3. Power is exclusively supplied from hydropower. 98 % of all electric power supply is from hydropower generation along the Shire River. Upgrading of aging facilities is planned to rehabilitate by support of WB, etc.

Diesel power generation facilities (1.1MW) located in Mzuzu are not connected to the system.

Table 3.5-3 Generation facilities of ESCOM (Malawi)

Power Station	Capacity (MW)	Unit	COD
Nkula Falls A	24	8 MW × 3	1966
Nkula Falls B	60	20 MW × 3	1980
	20	20 MW × 1	1986
	20	20 MW × 1	1992
Tezani Falls I	20	10 MW × 2	1973
Tezani Falls II	20	10 MW × 2	1977
Tezani Falls III	52.7	26.35 MW × 2	1996
Wovwe Mini Hydro	4.35	1.45 MW × 3	1995
Kapichira Falls I	64.8	32.4 MW × 2	2000
Kapichira Falls II	64.8	32.4 MW × 2	2013
Muzuzu Diesel	1.1	1.1 MW× 1	N/A
Likoma island Diesel	0.75	0.25 MW × 3	N/A
Chizumulu Island Diesel	0.3	0.15 MW × 2	N/A
Total	351.8		

Source : ESCOM WEB Site

2) Transmission facilities (Interconnector)

As for interconnector in Malawi, the following 33kV transmission line is applied to satisfy not power trade but obligation to supply the power to vicinity.

Table 3.5-4 Interconnector (Malawi)

Zambia	Chikangara – Lundazi 33kV, 1 line

Source : JICA Survey Team

(2) Power system development plan

1) Generation development plan

ESCOM plans to expand existing power generation plants along the Shire River and builds new power plants. Nkula A hydropower plant upgrading project will be planned by support of MCC. On the other hand, Japan will support Tedzani upgrading project, adding 18MW-generator(s) in Tedzani Ⅳ power plant.

By support of WB, feasibility study for Lower Fufu River hydropower plant and feasibility study for Mpatamanga hydropower plant (230MW) have conducted. Further, by support of AfDB, feasibility study for Kholombidzo hydropower plant conducted, and then the government of Malawi stated this project will be started in 2018. The Songwe River Basin development programme is ongoing by support of AfDB's grant, it's funded 4.8 million Euros. The Songwe River is the international river lying under border between Malawi and Tanzania. And the project includes three dam constructions and power plants constructions, namely Songwe Upper (30MW), Songwe Middle (160MW), and Songwe Lower (150MW).

With regard to projects involving thermal power generation, Kam'mwanba and Pamodzi are making progress by way of ESCOM and IPP[32]. Both have plans for coal-fired power generation and are being supported by China.

2) System planning

Transmission projects are enumerated as follows.

- Malawi - Mozambique Interconnector Project (Phimbeya – Matambo, 400kV, 1 line)
- Malawi – Zambia Interconnector Project (Nkhoma – Chipata West, 400kV, 1line)
- Malawi – Tanzania line (Karonga – Kayelekera, 66kV, 1 line)
- Zambia – Malawi line (Lundazi – Chikangawa, 132kV, 1 line)
- Salima – Chintheche - Karonga reinforcement

As for transmission line for Chikangawa, the government of Malawi plans to extend to Chinteche, 71km far from Chikangawa, to feed 30MW more.

In the meanwhile, Malawi – Mozambique interconnector project has another phase to touch the northern Mozambique. Phase 2 of this project is to connect the transmission line between Phombeya and Nacala port. Feasibility study of phase 1 (mentioned above list) is ongoing by support of WB and the government of Mozambique. Further Zambia – Malawi interconnector is studying. This concept is supported by WB with 330kV transmission line between Lilongwe and Chipata West, Zambia. As for the statement from the government, this study will be terminated in May, 2017, and will operate by 2019.

3) Power system master plan

In Malawi, there is no power system master plan authorized by the government or the power utilities. However, by support of MCC, Malawi's Mini Integrated Resource Plan 2016 – 2020 (IRP) (hereinafter, "Malawi IRP") was established.

Malawi IRP shows strategic road-map in 2016 – 2020 to be realized. Further, publication of

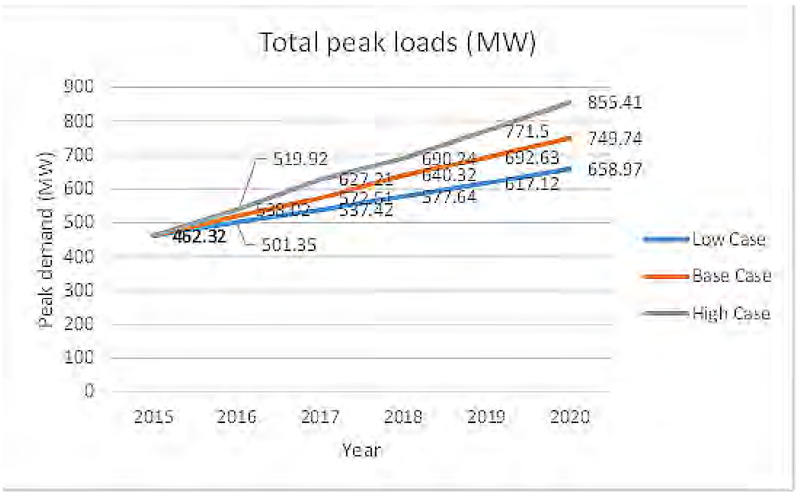
[32] Tete area, Mozambique will provide its coal resources.

Malawi National Energy Policy is now programming, and as of November 2016, it is final-draft stage. Malawi IRP has been programmed by the Ministry of Natural Resources, Energy and Mining (MNREM), Department of Energy (DoE), and ESCOM. And several data and historical record to realize it was given by MERA and Malawi Investment and Trade Centre (MITC).

Unfortunately Malawi IRP is not authorized by the government, and represented only 5 year future. But it will be the baseline for future master plan study.

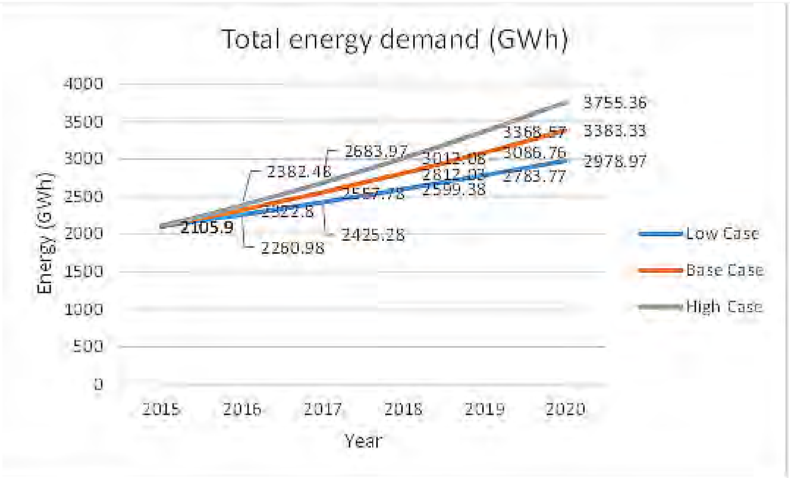
- Demand forecast

Malawi IRP represents only five-year demand forecast in 2015 – 2020 (Figure 3.5-2, Figure 3.5-3). This predicts three future demands. One is the low case based on the current electricity sales. Second is the base case based on the electrification ratio in 2030, 30%, minimum target. Third is the high case (50%, maximum target of electrification ratio in 2030). In base case, annual growth rate is beyond seven (7) parentage.



Source : Malawi's Mini Integrated Resource Plan 2016-2020

Figure 3.5-2 Peak demand forecast (Malawi)



Source : Malawi's Mini Integrated Resource Plan 2016-2020

Figure 3.5-3 Energy forecast (Malawi)

For reference, documents in relation to MMC are cited here.

Table 3.5-5 Demand forecast of Malawi

Year / [MW]	2014	2018	2022	2026	2030
Peak Demand	378	720	1,300	1,950	2,550
Reserve Margin	69	104	162	227	287
Total Capacity Requirement	447	824	1,462	2,177	2,837
ESCOM Supply	351	429	429	429	429
Capacity Supply Shortfall	-96	-395	-1,022	-1,748	-2,408

Source : Millennium Challenge Corporation, Business Opportunities in the Malawi Power Sector, spring 2015

- Generation development

Malawi IRP recommends following generation projects shown in Table 3.5-6 on the point of demand and supply balance. If development will be realized in line with this schedule, capacity will be beyond the demand in 2020.

Table 3.5-6 Generation development list (Malawi)

電源候補	2015	2016	2017	2018	2019	2020
Existing Power Plants	386*1	386	362*2	386	386	386
Kanengo Diesel		10	10	10	10	10
Bagasse Illovo Phase 1			11	11	11	11
Zambia – Malawi 132kV Interconnector (Import)			30	30	30	30
Mzuzu Diesel			6	6	6	6
Nkula A Hydropower (Upgrade)				12	12	12
Bagasse Illovo Phase 2				40	40	40
Kanengo Diesel				10	10	10
Mapanga Diesel				20	20	20
Lweya Hydropower					15	15
Tedzani Ⅳ Hydropower					18	18
Mpongodzi Hydropower					41	41
Chizuma Hydropower					50	50
Mozambique – Malawi Interconnector (Import)					50	50
Kmmwamba Coal-fired Power					50	250
Kholombidzo Hydropower						200
Total	386	396	419	525	749	1,149

*1 : includes captive power

*2 : decline the capacity due to Nkula A's rehabilitation

Source : Malawi's Mini Integrated Resource Plan 2016-2020

➢ System planning

Malawi – Mozambique Interconnector was designed with 220kV trunk line, but nowadays it has been revised to 400kV trunk line. In accordance with the designing, interconnector with neighboring countries are studied with 400kV grid linkage.

In line with this concept, nation grid will be revised to 400kV grid integration. In Malawi IRP recommends that two transmission routes, such as Phombeya – Makanjira and Nkhoma – Bwengu would be introduced by 2020.

Table 3.5-7 Status of Interconnector study (Malawi)

#	Project	Status	Year on line
1	400kV Mozambique – Malawi Interconnection	Firms procured for Feasibility study	2018/19
2	400kV Malawi – Mozambique (extension)	Feasibility start 2016	Not known
3	400kV Malawi - Tanzania	Feasibility 2016	By 2022
4	400kV Malawi - Zambia	Feasibility 2016	Not known

Source : Malawi's Mini Integrated Resource Plan 2016-2020

➢ Other

MMC provides support for the energy sector strengthening. 350.7 MUSD in total is being supported and covers the following three fields[33].

① Development of infrastructure (257.1 MUSD): expansion of power generation facilities

② Management of environment and natural resources (27.9 MUSD): reinforcement of water utilization and management of the Shire River

③ Reform of the power sector (25.7 MUSD): strengthening of governance, including deregulation of ESCOM.

[33] Millennium Challenge Corporation, Business Opportunities in the Malawi Power Sector, spring 2015

3.6 Mozambique

3.6.1 **Power Sector**

(1) Overview of Power Sector

1) Electricidade de Moçambique (EDM)

Power supplyers were merged into EDM, a state own company, by the government of Mozambique. And in July 1995, EDM met organizational restructuring and as a result integrated generation, transmission and distribution businesses.

2) Hidroelectrica De Cahora Bassa (HCB)

HCB owns the Cahora Bassa hydropower generation plant, and feeds power to Eskom, RSA with long term power purchase agreement. Also HCB feeds power to ZESA, Zimbabwe and EDM. As of 2014, the government held 92.5% of total shares of HCB[34].

3) Mozambique Transmission Company (MOTRACO)

Under the leadership of each government of South Africa, Mozambique and Swaziland, MOTRACO was founded as a transmission company in 1998. The stocks of MOTRACO are shared to Eskom, RSA, EDM, Mozambique and SEC, Swaziland, and each power utility has same amount of stocks, 33.33% of total stocks. The main task of MOTRACO is feeding the power to MOZAL, Aluminum smelter and feeding the power to Swaziland and Mozambique.

(2) Administrative body

1) Government

Ministry of Mineral Resources and Energy (MIREME) is in charge of a national energy planning, policy formulating, energy sector's operation, administration of development. The National Director of Electrical Energy (DNEE) established in MIREME takes surveillance to EDM. EDM controls the domestic system under the supervision of the Government.

Further, another organization for electrification, namely Fundo de Energia (FUNAE), and the Technical Unit for the Implementation of Hydroelectric Projects (UTIP) which is a technical department for promoting a large-scale hydropower project are set in the government of Mozambique.

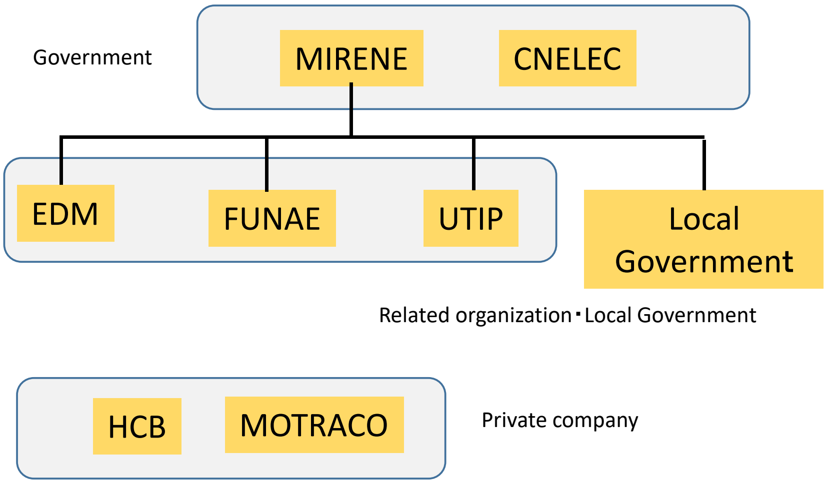
2) Regional government

A small-scale system in local area is controlled through a related office of local government. The Central Government manages these areas though the regional government.

[34] HCB was established by support of the government of Portugal. Now stocks of HCB have been taken over to the government of Mozambique.

(3) Regulatory body

Conselho Nacional de Electricidade (CNELEC) (National Electricity Advisory Council) is a regulatory organization launched in 1997 by promulgation of the Electricity Act.



Source : JICA Survey Team

Figure 3.6-1 Configuration of power sector in Mozambique

(4) Electricity laws

1) Electricity Act No.2197

The Act promulgated in 1997 defines a management policy of energy sectors such as generation, transmission, distribution, and electricity sales, power trade and laws for vested right of power supply.

2) Decree No.42/2005 of 29 of November 2005

This is legal imperatives defining the development plan of generation, transmission, distribution, and electric power sales, and financial planning. Further indicates proprietary rights of electric facilities, maintenance and operation plan, standards etc.

3) Decree No.43/2005 of 29 November 2005

This is legal imperatives to define EDM as a system operator and transmission company.

(5) Electricity tariff

The electricity tariff system in Mozambique generally classifies customers into small-size consumer, large-size consumer with categorized demand. And tariff can be calculated by two factors, demand and energy, except small-size consumer, consuming less than 100kWh per a month.

Trial calculation of electricity tariffs is made for typical customers, the results of which are shown in Table 3.6-2.

Table 3.6-1 Electricity tariff (Mozambique)

Electricity Tariff -Mozambique (2016)

Tariff categories: Social, Domestic, Agricultural and General (Low Voltage)

Registered Consumption (kWh)	Social Tariff (MZN / kWh)	Domestci Tariff (MZN / kWh)	Agriculture Tariff (MZN / kW)	General Rate (MZN / kW)	Flat Rate (MZN)
0 - 100	1.07				
0 - 300		4.04	3.4	5.8	152.37
301 - 500		5.72	4.84	8.29	152.37
More than 500		6	5.3	9.07	152.37
Prepayment	1.07	5.14	4.71	8.31	

Note: For customers who fit the parameters for the social tariff (power 1.1 kVA and not consumption above 100 kWh / month), whose installations use the Prepayment type counter (CREDELEC), will set a current limit 5 Amperes.

Large consumers of low voltage, medium voltage, medium voltage agri., and High Voltage

Consumer Caterogy	(MZN / kWh)	(MZN / kW)	Flat Rate (MZN)
Large Consumer BT (GCBT)	3.13	446.13	n/a
Medium Voltage (MT)	2.78	289.47	2,094.07
Medium Voltage Agriculture (MTA)	1.93	221.99	2,094.07
High Voltage (AT)	2.66	340.18	2,084.07

Note: For Tariff Category "Average Agricultural Voltage" Power to the invoice must be equal to the power socket.

The High Voltage Rate is subject to negotiation on the terms and conditions of the applicable law, whenever the power to hire and technical conditions so warrant, to ensure in relation to EDM (i) reasonable compensation for the costs of operation, production, purchase and / or import of electricity (ii) a compatible return on capital invested in electricity infrastructure and (iii) the amortization, over time, incurred capital costs.

Connection Fee for BT Large Consumers

Amount to be collected (VAT - MZN)	VAT (MZN)	Amount to be collected (with VAT - MZN)
163.71	27.83	191.54

Connection fee for Big MT and AT Consumers

Amount to be collected (VAT - MZN)	VAT (MZN)	Amount to be collected (with VAT - MZN)
768.42	130.63	889.05

Source : EDM (2016)

Table 3.6-2 Trial calculation of electricity tariff (Mozambique)

Customer Category	Assumed consumption (kWh / month)	Electricity Tariff (US cents/kWh)
Domestic (Residential)	100	5.38
Small Commercial	1,000	12.08
Large Commercial/Industry	10,000	7.76

1 USD = 0.01332 MZN, as of December, 2016
Source : JICA Survey Team

3.6.2 **Power demand, existing facilities and development plan**

(1) Power demand

Table 3.6-3 and Table 3.6-4 show the tracks of power demand and supply. The annual increase in excess of 10%. Further, About 60% of demand is consumed in the South area including Maputo, and each area has dramatical demand growth, around 10 % per annum.

Table 3.6-3 Demand tracks (Mozambique)

	2007	2008	2009	2010	2011	2012
Peak demand (MW)	364	416	481	534	616	706
Generation (GWh)	224	352	386	368	389	263
Purchased (GWh)	2,381	2,653	2,775	3,118	3,588	3,904
Import (GWh)	17	27	39.1	67	91	84
Total Energy (GWh)	2,622	3,032	3,193	3,553	4,068	4,251

Source：Master Plan Update Project, 2012-2027, Final Master Plan Update Report (2014)

Table 3.6-4 Demand tracks in each region (Mozambique)

GWh	2005	2006	2007	2008	2009	2010	2011	2012	AAG*
3	1,153	1,239	1,373	1,550	1,731	1,909	2,905	2,297	10.3%
Center	393	427	467	497	558	603	739	870	12.0%
North	190	218	244	255	302	363	428	502	14.9%
Total	1,736	1,884	2,084	2,302	2,591	2,875	3,262	3,669	11.3%

*Annual average growth

Source：Master Plan Update Project, 2012-2027, Final Master Plan Update Report (2014)

(2) Existing facilities

1) Generation facilities

Large-scale hydropower generation facilities are mainly located in central and north-central area of Mozambique. In addition, thermal power generation facilities and small-scale hydropower generation facilities are located in the vicinity of Maputo and in the vicinities of Cuamba and Lichinga, northern areas.

Table 3.6-5 shows existing hydropower fleets and Table 3.6-6 also shows existing thermal power fleets.

Table 3.6-5 Existing hydropower plants (Mozambique)

Unit Name	Region	Installed Capacity (MW) (Units x Cap.)	Generated Energy*1 (GWh)	Remarks
Corrumana	South	16.6 (2 x 8.3)	30.4	Multi-purpose dam The power plant belongs to EDM Dam does not belong to EDM
Mavuzi	Central	52 (3 x 14, 2 x 5)	240.8	Run off river type
Chicamba	Central	34 (2 x 17)	78.9	Multi-purpose dam
Cahora Bassa	North-central	4,075 (5 x 415)	3,118.0	
Cuamba	North	1.1 (2 x 0.55)	0.5	One unit out of service
Lichinga	North	0.75	0.6	

*1 EDM's own production 2010

Source : Master Plan Update Project, 2012-2027 Final Master Plan Update Report (2014)

Table 3.6-6 Existing thermal power plants (Mozambique)

Type	Name	Number of units	Unit capacity (MW)	Total capacity(MW)
Gas-fired	Aggreko	55	1.00	55.00
	Beloluane	40	1.00	40.00
	Ressano garcia EDM/Sasol	18	9.73	175.14
	Ressano garcia Gigawatt	13	9.34	121.42
	Temane	6	0.31	1.86
	Temane 2	2	2.60	5.20
	Subtotal			398.62
Diesel	CTM 1	1	20.0	20.0
	Nacala	18	1.0	18.0
	Tavene	-	-	3.6
	Inhambane	-	-	4.5
	Subtotal			46.1
Total				444.72

Source : EDM's evidence（2016）

➢ Current condition of Cahora Bassa hydropower plant

The construction of Cahora Bassa hydropower Plant (2,075 MW, 5 units × 415 MW) was started in 1965 and then started in operation in 1975. From 2003 to 2007, the plant was modernized and dramatically improved its performance and reliability. Lifetme of facilities has been increased 20 years at least. The generation unit, 415 MW x 5, was automated by this reinforcement. And this reinforcement made it possible to control each generation fleet from Songo substation.

2) Transmission facilities (Interconnector)

In Mozambique, two HVAC systems exist currently, one is in north-central and another is in southern area, and these are not connected yet. Further, the HVAC systems are operated by following three areas.

➢ Southern system

The southern system covers Maputo province from Maxixe to Maputo, and Gaza province, Inhambane provinces. In this area, two transmission lines owned by MOTRACO with 400 kV spread to RSA and Swaziland. Additionally, transmission line with 275kV and that with 110kV also spread to Komatipoort, RSA.

➢ Central system

The central system covers Manica province and Sofala province. Facilities of transmission belong to EDM.

➢ North-central and northern system

The north-central and northern system cover the area from Cahora Bassa at Songo (Tete Province) to Zambezia, Nampula, Niassa, and Cabo Delgado Provinces. Interconnector between Songo and Bindura, Zimbabwe is operating 330kV HVAC[35]. And another evacuation route is from Songo to Appollo, RSA with HVDC[36].

The north-central system and the northern area system have been connected over the last decade with a 220kV HVAC transmission line between Matambo and Chibata.

Interconnection between the southern system and the central system will be achieved by STE backbone project.

3) Interconnector

The following five routes exist as the interconnector of Mozambique.

Table 3.6-7 Interconnector (Mozambique)

RSA	Songo (Cahora Bassa) - Apollo DC500kV, Two lines
	Maputo – Arnot (via Swaziland), 400kV 1 line
	Maputo – Carnden, 400kV 1line
Zimbabwe	Songo (Cahora Bassa) – Bindura, 400kV 1line
	Manica – Mutare, 220kV 1line

Source : JICA Survey Team

(3) Power system development plan

1) Generation development plan

Table 3.6-8 shows generation development plan in Mozambique.

[35] Design of this transmission line is 400kV

[36] HVDC is belongs to HCB.

Table 3.6-8 Generation development plan (Mozambique)

		Site name	Number of units	Rated capacity (MW)	Total capacity (MW)	Fuel / Hydro types	COD	Expected Commissioning year	Decommissioning year
Existing	Thermal	Aggreko	55	1	55	Natural Gas	2013		2018
Existing	Thermal	Beloluane	40	1	40	Natural Gas	2015		―
Existing	Hydro	Cahora Bassa	5	415	2,075	RoR	1970		―
Existing	Hydro	Chicamba	2	24	44	RoR	N/A		―
Existing	Hydro	Corumane	2	8.3	8.3	RoR	N/A		―
Existing	Hydro	Mavuzi 1-3	3	13	49	RoR	N/A		―
Existing	Hydro	Mavuzi 4-5	2	5	10	RoR	N/A		―
Existing	Thermal	CTM 1	1	20	20	Diesel	N/A		―
Existing	Thermal	Nacala	18	1	18	Diesel	2013		2016
Existing	Thermal	Ressano garcia EDM/Sasol	18	9.73	175.14	Natural Gas	2014		―
Existing	Thermal	Ressano garcia Gigawatt	13	9.34	121.42	Natural Gas	2016		―
Existing	Thermal	Temane	6	0.31	1.86	Natural Gas	N/A		―
Existing	Thermal	Temane 2	2	2.6	5.2	Natural Gas	2014		―
Existing	Thermal	Tavene	―	―	3.6	Diesel	N/A		―
Existing	Thermal	Inhambane	―	―	4.5	Diesel	N/A		―
Committed	Thermal	Kuvaninga	10	4.01	40.1	Natural Gas	―	2017	―
Committed	Thermal	CTM JICA 1	2	48.065	96.13	Natural Gas	―	2018	―
Committed	Thermal	CTM JICA 2	1	28.87	28.87	Natural Gas	―	2018	―
Committed	Thermal	MGTP EDM/Sasol	―	―	400	Natural Gas	―	2022	―
Committed	Hydro	Mphanda Nkuwa	2	750	1,500	RoR	―	2024	―
Committed	Hydro	Cahora Bassa Norte	2	622.5	1,245	RoR	―	2026	―
Committed	Thermal	Tete 1200	―	―	1,200	Coal	―	2022	―
Committed	Thermal	Jindal	―	―	150	Coal	―	2018	―
Committed	Thermal	Nacala	―	―	40	Diesel	―	2019	―
Committed	PV	Mocuba	―	―	30	Solar	―	2019	―
Committed	PV	Metoro	―	―	30	Solar	―	2019	―
Committed	Hydro	Moamba Major	―	―	15	RoR	―	2022	―
Candidate	Hydro	Lurio 2	―	―	120	RoR	―	2022	―
Candidate	Hydro	Massingir	―	―	27	RoR	―	2025	―
Candidate	Thermal	Moatize	―	―	300	Coal	―	2025	―
Candidate	Thermal	ENRC	―	―	300	Coal	―	2025	―
Candidate	Thermal	Ncondezi	―	―	300	Coal	―	2025	―
Candidate	Hydro	Tsate	―	―	50	RoR	―	2023	―
Candidate	Thermal	ENI	―	―	75	Natural Gas	―	2025	―
Candidate	Thermal	SHELL	―	―	80	Natural Gas	―	2025	―

RoR : Run off river type

Source : JICA Survey Team using evidence from EDM

2) System planning

Table 3.6-9 shows system planning in Mozambique.

Table 3.6-9 System planning (Mozambique)

Project	Length	Expected year	Status	Project cost [M USD]
STE backbone HVAC 400kV Songo-Cataxa	53 km	2020	FS done (2011) EIA updating (2016)	37[*1]
STE backbone HVAC 400kV Cataxa-Matambo	65 km	2020	FS done (2011) EIA updating (2016)	
STE backbone HVAC 400kV Matambo-Inchope	370 km	2020	FS done (2011) EIA updating (2016)	951[*2,*3,*4]
STE backbone HVAC 400kV Ichope-Vilaculos	352 km	2020	FS done (2011) EIA updating (2016)	
STE backbone HVAC (phase 1) 400V Vilanculos-Maputo	554 km	2020	FS done (2011) EIA updating (2016)	
STE backbone HVDC Phase I 535kV Cataxa-Maputo	1276 km	2020	FS done (2011) EIA updating (2016)	848[*2,*3,*4]
STE backbone HVDC Phase II 535kV Cataxa-Maputo	1276 km	2020	FS done (2011) EIA updating (2016)	319[*2,*3,*4]
MoZiSa 400kV Inchope-Border (Zim)		2021	Under FS, Technical study	132.2[*5]
MoZiSa 400kV Border-Orange Grove (Zim)		2021	Under FS, Technical study	
Zambia interconnection 400kV Matambo-Border (Zam)	315 km	2025	Inter-government MoU concluded Under EIA	415[*6]
Zambia interconnection 400kV Border-Chipata West (Zam)	86 km	2025	Inter-government MoU concluded Under EIA	
Malawi interconnection 220kV Matambo-Border (Mal)		2020	EIA screening Ongoing FS	39.34[*2]
Malawi interconnection 220kV Border-Phomebeya (Mal)		2020	EIA screening Ongoing FS	42.82[*2]
Tanzania interconnection 400kV Namialo-Border (Tan)			Inter-Utility MoU Concept stage Request for funding for FS	N/A
Tanzania interconnection 400kV Border-Mtwara (Tan)			Inter-Utility MoU Concept stage Request for funding for FS	N/A
400kV Caia-Namialo			FS and Technical study done	600 MUSD[*5]
400kV Inchope-Caia	265 km	[*7]	Under planning	158 MUSD[*5]

*1 Master Plan Update Project, 2012-2027 Final Master Plan Update Report (2014) – EDM

*2 SADC Infrastructure Investment Conference 2013 Sector Document

*3 Length and project cost are tentative. Route is being revised.

*4 Except Interest During Construction (IDC), Financing Cost/Fees and Price Contingencies

*5 JICA Survey team

*6 Feasibility Study on Coal and Gas Fired Power Plant Project in Republic of Mozambique Preliminary Report June 2016

*7 Expected year is after completion STE and Qaia-Namialo project

Source : JICA Survey Team

3) Power system master plan

The latest power system master plan is Technical assistance to strengthen EDM's capacity for investment and network development planning, Master plan update project, 2012 – 2027 Final Master plan update report, published in 2014. Brief explanation is mentioned below.

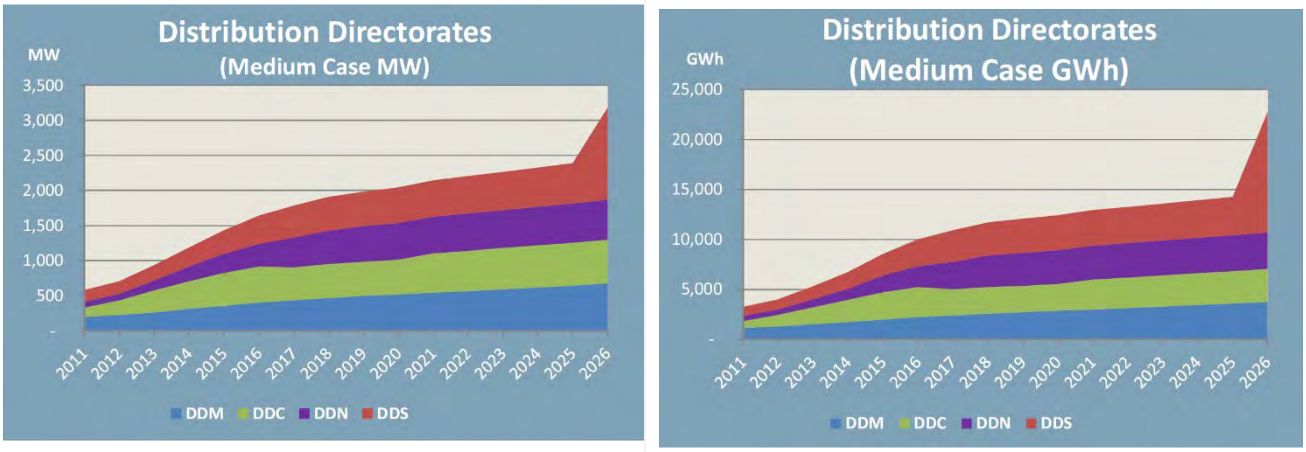
➢ Demand forecast

The Demand was forecasted toward 2026 with GDP growth, income elasticity rate and price elasticity rate and bulk power consumption of large scale consumers.

Table 3.6-10 Medium forecast by region consolidated national total

Medium Forecast	Coincident MW Delivered at S/S					GWh				
Region	2011	2016	2021	2026	AAG*1	2011	2016	2021	2026	AAG*1
South	368	807	1,061	2,213	12.7%	2,085	4,934	6,546	15,802	14.5%
Center	129	512	561	624	11.1%	676	3,020	2987	3,313	11.2%
North	85	324	523	568	13.5%	494	2,065	3,396	3,638	14.2%
Total	563	1,589	2,075	3,293	12.5%	3,255	10,019	12,930	22,753	13.8%

Source : JICA Survey Team

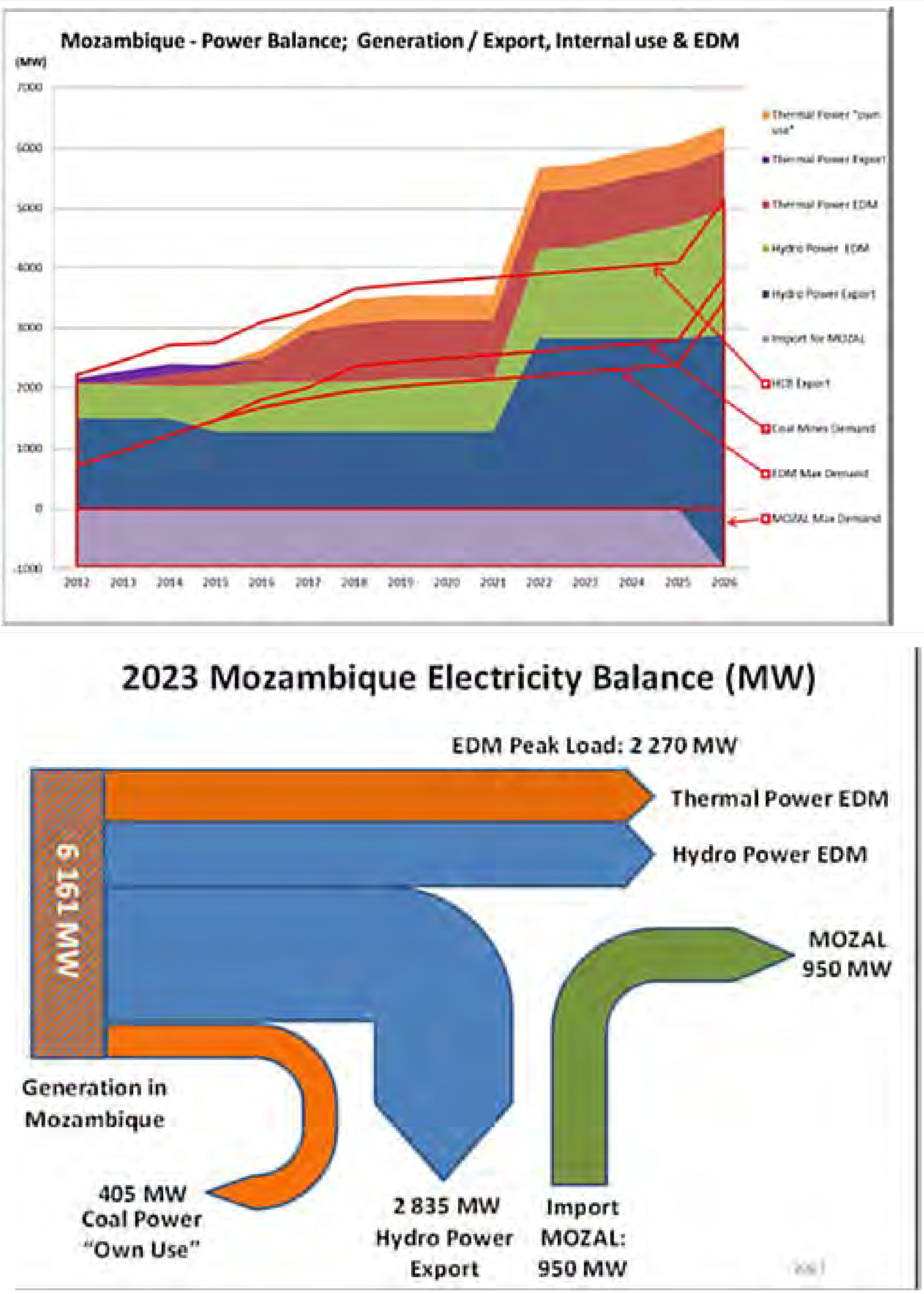


Source : Master Plan Update Project 2012-2027 Final Master Plan Update Report, EDM (2014)

Figure 3.6-2 Demand forecast (Peak demand, Energy)

➢ Generation development plan, system planning

In this master plan, the generation development plan was explained in detail, but concrete power system plan was not studied systematically. The regional power system improvement with STE backbone project and supply for large scale consumer such as MOZAL were only mentioned in this master plan.



Source : Master Plan Update Project 2012-2027 Final Master Plan Update Report, EDM (2014)

Figure 3.6-3　Generation development plan in Mozambique

4) Cooperation by the donor organizations

Support details of individual projects, etc., are shown below.

Table 3.6-11 Support detail by donors in Mozambique

Donors	Type	Projects	Remarks
China	Generation	Mphanda Nkuwa Hydropower (375 MW×4)	IPP (EDM holds 20% of share) Application for nationalization is conducting.
Brazil	Generation	Moamba Major Hydropower (15 MW)	Construction
WB	Transmission	Malawi-Mozambique Interconnector Inchope – Malawi 220kV	FS
India	Transmission	Reinforcement of Maputo Transmission Grid Phase 1A Infulene – Marracuene 275kV SE7 – Marracuene 275kV	
Islamic Development Bank	Transmission	Chimuara – Namialo 400kV	Planning to co-finence.

Source : JICA Survey Team

3.7 Namibia

3.7.1 Power Sector

(1) Overview of Power Sector

1) Nampower

In 1964, German South West Africa, Namibia as it is, was put on the control by Union of South Africa, RSA as it is. At that time South West Africa Water and Electricity Corporation (SWAWEK) was established by the government of Union of South Africa to develop the hydropower generations.

SWAWEK was the affiliated company of Industrial Development Corporation[37], and constructed Ruacana hydropower plant (240MW) and regional grid. After the completion of these projects, SEAWEK reorganized, and moved to Nampower in 1996.

Nampower is state owned company and operates generation and transmission in Namibia.

2) Regional distributors

Since 2000, the power industry has been restructured under governmental initiative. As a result, distribution business has been transferred to Regional Electricity Distributors (REDs). As of the end of 2013, three REDs were in operation in each region, namely NORED in northern part (established in 2002), CENORED (established in 2005) in northern central part, and Erongo RED in Erongo province (established in 2005). The remaining two REDs (Central RED, Southern RED) are scheduled to be established in near future.

(2) Administrative body

1) Government

Ministry of Mines and Energy takes the management of the power sector.

2) Electric eergy policy

(a) VISION 2030

The government of Nambia published VISION 2030 in 2004 in order to achieve the aim of the nation and inform the development plan. VISION 2030 focuses on the following eight (8) themes in order to realize a long-term national vision.

- Equality of human rights and social welfare
- Human resource development and capacity building of organizations
- Macro-economic issues
- Population, health and its development

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[37] The Industrial Development Corporation of South Africa Limited (IDC) was established in 1940 by an Act of Parliament (Industrial Development Corporation Act, No. 22 of 1940) and is fully owned by the South African Government. The IDC was mandated to develop domestic industrial capacity, specifically in manufactured goods, to mitigate the disruption of trade between Europe and South Africa during the Second World War.

- Natural resources and its development
- Knowledge, information and its utilized technology
- External environmental factors

(b) Fourth national development plan (NDP4) 2012/2013 – 2016/2017

NDP4 was adopted as the executable plan by the government of Namibia for accomplishment of VISION 2030. And its focusing issues are below,

- High and sustainable economic growth
- Increase of revenues
- Employment creation

(c) The White Paper on Energy Policy

The White Paper on Energy Policy was published in May 1998 by the Ministry of Minerals and Energy, which focuses on the following objectives.

- Effective management of energy sector
- Securing supply capacity
- Social upliftment
- Investment and growth
- Economic competitiveness and efficiency
- Sustainability

The paper describes the specific objectives that Namibia should supply electric power to meet peak demand fully and supply electricity to meet 75% of energy consumption at least by 2010.

(3) Regulatory body

Under the Electricity Act of 2000, Electricity Control Board (ECB), the regulatory authority of power sector was established. ECB manages electricity tariff pricing and certification of licenses. Also she manages the regulation of electricity business, such as generation, transmission, distribution and power trade.

(4) Electricity tariff

Electricity tariff system in Namibia is shown in Table 3.7-1. The electricity tariff is classified two types, such as a fixed charge (service tariff, supply tariff, electricity demand tariff and access tariff, etc.) and energy charge. The energy charge is set by seasons and by usage hours.

Trial calculation of electricity tariffs is made for typical customers, the results of which are shown in Table 3.7-2.

Table 3.7-1 Electricity tariff (Namibia)

Electricity Tariff -Namibia (2015)

	CUSTOMER SERVICE CHARGE	POINT OF SUPPLY (PoS) CHARGE		MAXIMUM DEMAND CHARGE	NETWORK ACCESS CHARGE	REACTIVE ENERGY USED	REACTIVE ENERGY INJECTION
	NAD / Customer / month	NAD / PoS / month		NAD / kVA	NAD / kVA	NAc / kVarh	NAc / kVarh
		No Diversity / = < 10 MW	With Diversity / > 10 MW	Peak and Standard	All Periods	Peak and Standard	Off peak
Tariff > 33kV	9,680.00	4,670.00	6,350.00	58.05	54.04		n/a
Tariff =< 33 kV	9,680.00	4,670.00	6,350.00	60.37	56.2		n/a

ENERGY CHARGE

SEASON	HIGH DEMAND (Jun-Aug)			LOW DEMAND (Jan-May, Sept-Dec)			NEF LEVY	ECB LEVY
Period	Peak	Standard	Off peak	Peak	Standard	Off peak	All	All
Unit	NAc / kWh	NAc / kWh	NAc / kWh	NAc / kWh	NAc / kWh	NAc / kWh	NAc / kWh	NAc / kWh
Tariff > 33kV	202.37	121.42	80.95	122.48	97.98	61.24	1.08	1.601
Tariff =< 33 kV	205.41	123.24	82.16	124.32	99.45	62.16	1.08	1.601

TIME PERIODS FOR TIME-OF-USE TARIFFS (2015/2016)

Season Time Periods Months Day	Low Demand Season RSA Time September (year n) to May (year n+1)		Time Periods
	Peak	Standard	Off peak
Week Day	08h 00 – 13h 00	06h 00 – 08h 00	22h 00 – 06h 00
	18h 00 – 21h 00	13h 00 – 18h 00	
		21h 00 – 22h 00	
Saturday		07h 00 – 12h 00	00h 00 – 07h 00
		18h 00 – 20h 00	12h 00 – 18h 00
			20h 00 – 24h 00
Sunday			00h 00 – 24h 00
Season	High Demand Season Namibia Time		Time Periods
Time Periods Months	June (year n) to August (year n)		
Day	Peak	Standard	Off peak
Week Day	07h 00 – 12h 00	05h 00 – 07h 00	21h 00 – 05h 00
	17h 00 – 20h 00	12h 00 – 17h 00	
		20h 00 – 21h 00	
Saturday		06h 00 – 11h 00	00h 00 – 06h 00
		17h 00 – 19h 00	11h 00 – 17h 00
			19h 00 – 24h 00
Sunday			00h 00 – 24h 00

Please note that the day light saving in Namibia is not consistent with the respective low demand season and high demand season times. The respective seasons refer to Namibian time in high demand season and South African time during low demand season.

Source : Namibia Electricity Control Board Web Site

Table 3.7-2 Trial calculation of electricity tariff (Namibia)

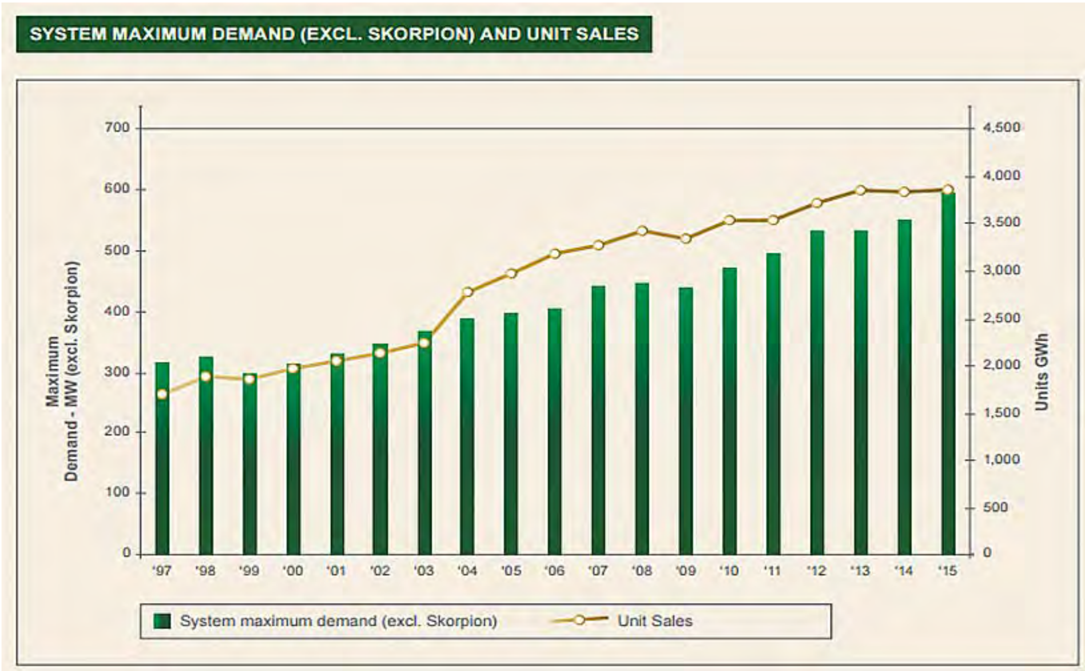
Customer Category	Assumed consumption (kWh / month)	Electricity Tariff (US cents/kWh)
Domestic (Residential)	100	8.81
Small Commercial	1,000	9.86
Large Commercial/Industry	10,000	8.86

1 USD = 0.00071NAD, as of December, 2016
Source : JICA Survey Team

3.7.2 Power demand, existing facilities and development plan

(1) Power demand

Peak demand in 2015 was 597 MW (including Skorpion Zic. Mining company, 657MW). Around 60% of total energy sales in 2014/2015 (FY) was dependent on import. The breakdown of this import was ZESA (19%), Aggreko (Emergency Diesel in Mozambique, 14%), ZESCO (12%) and Eskom (10%).



Source : Nampower Annual report 2015

Figure 3.7-1 Track of peak demand (Namibia)

(2) Existing facilities

1) Generation facilities

Capacity of generation fleets of Nampower as of 2015 is shown in Table 3.7-3.

Table 3.7-3 Nampower generation capacity

Power Plants	Rated capacity (MW)
Ruacana Hydropower	337
Van Eck Coal-fired	120
Anixas Diesel	23
Paratus Diesel	12
Import	600
Total	1,092

Source : NamPower Annual Report 2015

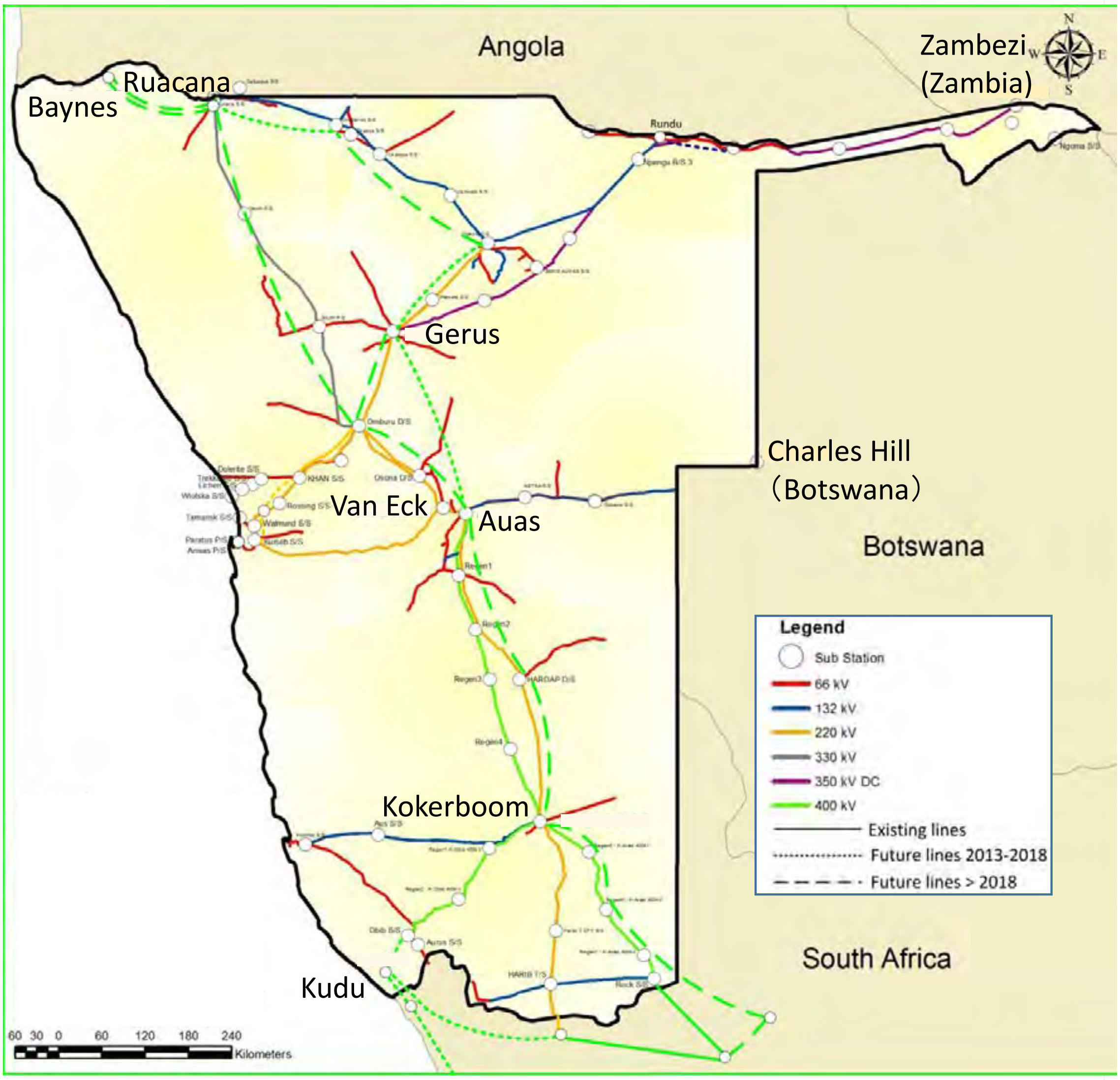
2) Transmission facilities

The transmission configurations in 2015 are shown in Table 3.7-4 and its diagram is shown in Figure 3.7-2.

Table 3.7-4 Nampower transmission Length (2015)

Voltage Class	Total length (km)	Voltage Class	Total length (km)	Voltage Class	Total length (km)
400kV	988	330kV	522	132kV	2,318
350kV	953	220kV	3,013	66kV	3,537

Source: NamPower Annual Report 2015



Source : JICA Survey Team using evidence from Nampower Web page

Figure 3.7-2 Power system diagram (Namibia)

3) Interconnector

So far, three interconnectors are stretching in Namibia.

Table 3.7-5 Interconnector (Namibia)

RSA	Keetmanshoop – Kenhardt, 400kV 1 line
	Harib – Aggneis, 220kV 1 line
Botswana	Omaere – Chrles hill, 132kV 1 line
Zambia	350kV HVDC (Caprivi Link) Gerus - Katima Mulilo (Zambezi Substation)

Source : JICA Survey Team

(3) Power system development plan

1) Generation development plan

Table 3.7-6 shows generation projects information in short term given by Nampower.

Table 3.7-6 Generation project (Namibia)

Project Name	Source	Capacity (MW)	Construction Cost	Commercial Operation	developer
Kudu*1	Gas (CCGT)	800	N/A	2017	KuduPower Pty. Ltd. (Nampower & partner)
Baynes*1	Hydropower	600	1,200 MUSD	N/A	Nampower
Diaz*2	Wind	60	N/A	N/A	Electrawind & Innowind
Keetmanshoop*2	Solar	10	N/A	N/A	GreeNam
Arandis*2	Heavy fuel	120	N/A	N/A	Natural Energy Power Plant

*1 Nampower Web page (2016)
*2 Namibian news Web page

2) System planning

Table 3.7-7 shows system planning information given by Nampower.

Table 3.7-7 System development plan (Namibia)

Project name	Voltage	Expected year	Status
Rundu-Cuito Strengthening	132kV	Second half of 2015 (Not yet done)	EIA have commenced
Kunene-Omatando	400kV	Second half of 2015 (Not yet done)	EIA have commenced
Kudu Transmission Intergration Two 400kV feeders to the Eskom network and one 400kV feeder to the Nampower network	400kV		Planning stage
West Coast Strengthening -Walmund-Rossing(double circuit T/L) -Khan-Lithops, Walmund-Kuiseb -New Husab Mine 132kV double circuit T/L	220kV		
Keiseb Walvis Bay Line	132kV	Last quarter of 2016	

Source : Nampower Website (2016)

3) Power system master plan

The latest power system master plan, National Integrated Resource Plan (NIRP) Report was published in 2012 by ECB with support of WB.

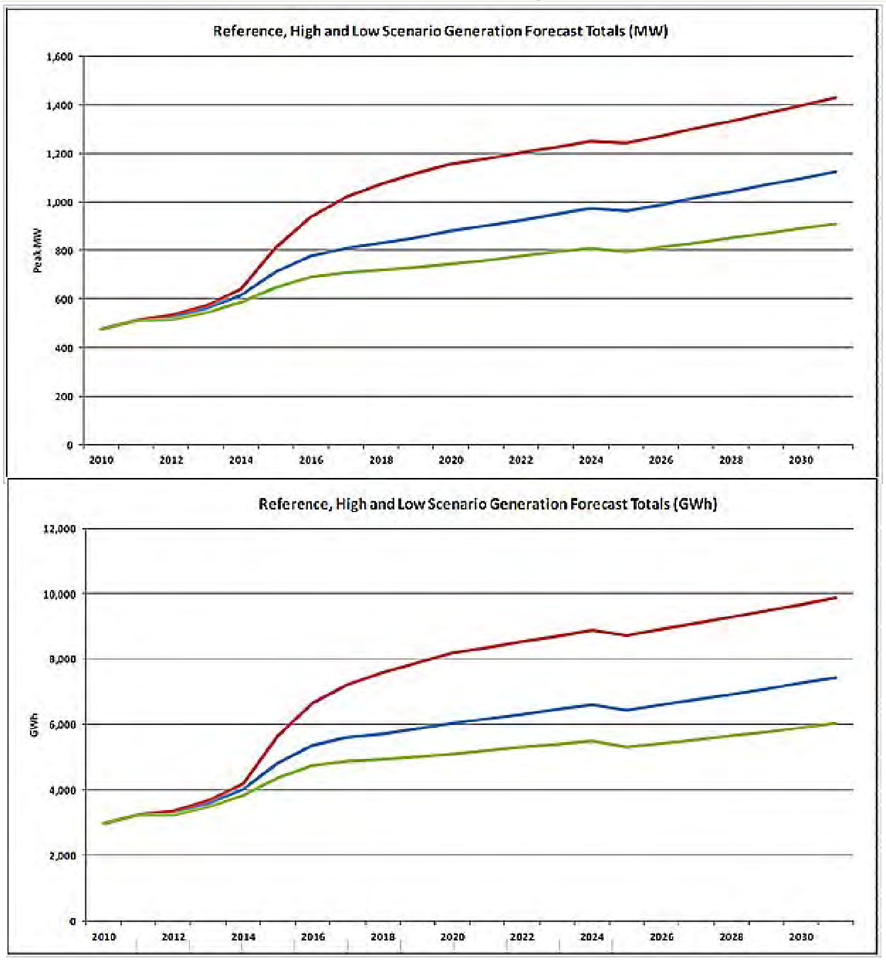
✓ Demand forecast

Power demand was forecasted toward 2031, and it applies GDP growth rate and population increase in urban areas, two of which are key factors, electricity tariff hike as negative factor for prediction.

Table 3.7-8 Demand forecast (Namibia)

Year	Low		Reference		High	
	Energy (GWh)	Peak (MW)	Energy (GWh)	Peak (MW)	Energy (GWh)	Peak (MW)
2008	2,763	443.7	2,763	443.7	2,763	443.7
2009	2,802	470.1	2,802	470.1	2,802	470.1
2010	2,976	477.0	2,976	477.0	2,976	477.0
2011	3,231	511.7	3,231	511.7	3,231	511.7
2012	3,245	513.8	3,316	525.7	3,349	531.3
2013	3,482	542.8	3,601	562.8	3,668	573.8
2014	3,842	585.9	4,011	614.0	4,183	639.0
2015	4,381	648.1	4,829	710.6	5,667	812.0
2016	4,746	690.9	5,357	774.9	6,650	936.9
2021	5,197	758.9	6,173	901.3	8,358	1178.8
2026	5,424	811.5	6,608	988.5	8,911	1272.0
2031	6,028	910.4	7,432	1124.4	9,865	1429.1
2011-2031	3.17%	2.92%	4.25%	4.02%	5.74%	5.27%

Source : The World Bank Group & Electricity Control Board of Namibia,
National Integrated Resource Plan Load Forecast Final Report (2012)



Upper : Peak demand, Lower : Generation Energy
Source : The World Bank Group & Electricity Control Board of Namibia,
National Integrated Resource Plan Load Forecast Final Report (2012)

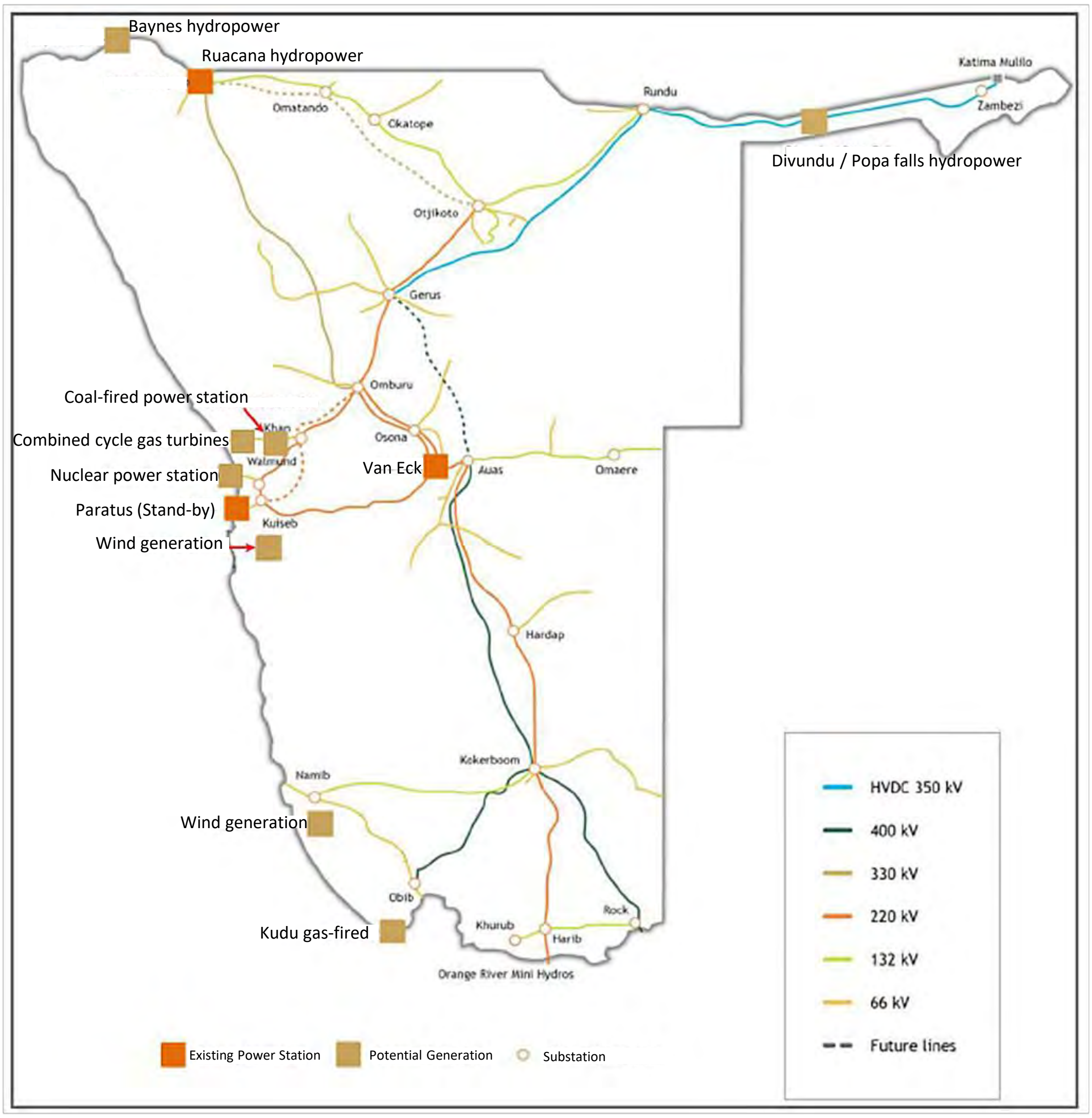
Figure 3.7-3 Demand forecast (Namibia)

✓ Generation development plan, System planning

Generation development scenario comprehensively reviews the generation mix, including nuclear power generation by uranium which can be produced in the country. As a result, as the most probable generation development scenario, development of hydropower (Baynes), gas-fired (Kudu), and coal-fired (Erongo), was adopted.

System planning was conducted based on described scenario plus power import to meet the balance.

Especially interconnector project, an interconnector with Angola via Baynes, ZiZaBoNa by Caprivi link (HVDC), are described.



Source : The World Bank Group & Electricity Control Board of Namibia
National Integrated Resource Plan Load Forecast Final Report (2012)

Figure 3.7-4 Power plant candidates on power system master plan (Namibia)

3.8 South Africa (RSA)

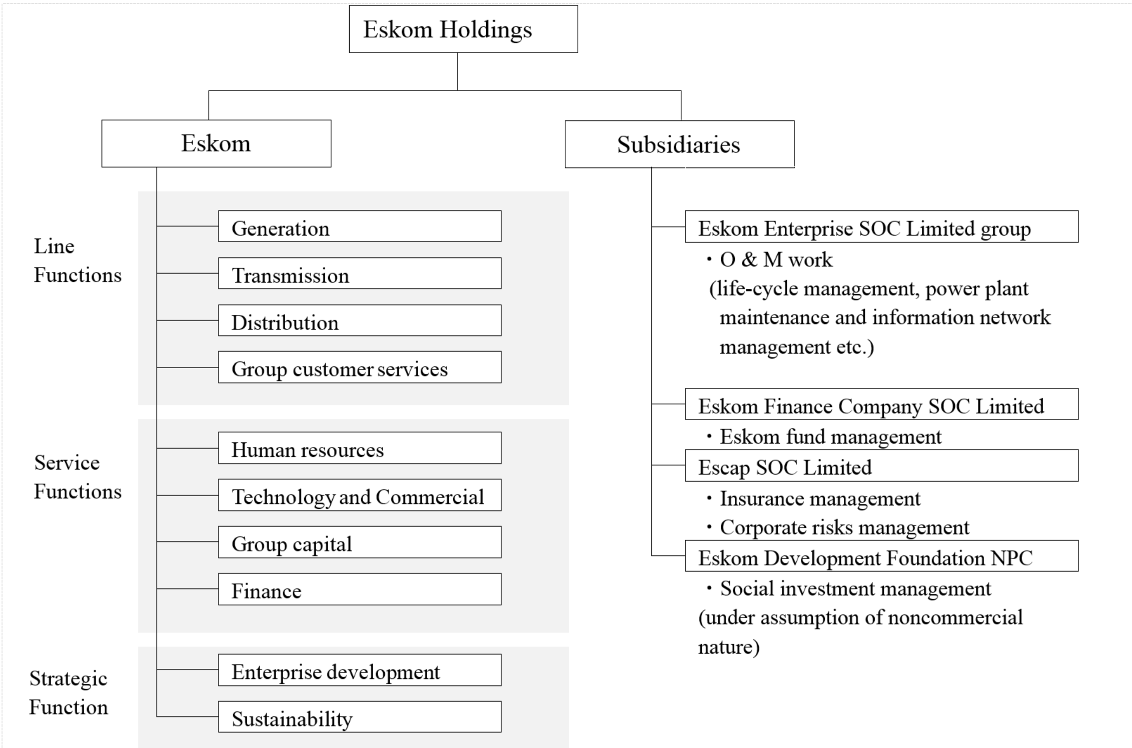
3.8.1 **Power Sector**

(1) Overview of Power Sector

1) Eskom

Electric power supply in RSA is operated by Eskom, a public enterprise company under the administration of the Department of Public Enterprises (DPE)[38].

Eskom generates over 95% of electric energy consumed in RSA. It means that generated power by Eskom is 45% of the electric energy consumed on the African continent. And Eskom constructs, holds and manages national transmission lines and interconnectors in her operation area. Eskom was restructured as a limited company from a governmental organization by the Eskom Reorganization Act of 2001. However, all shares of Eskom are held by the government of South Africa.



Source : Eskom Integrated Report 2015

Figure 3.8-1 Organization and operating structure of Eskom group

38 Objective of DPE is to drive investment, productivity and transformation in the department's portfolio of State Owned Companies (SOCs), their customers and suppliers so as to unlock growth, drive industrialization, create jobs and develop skills.

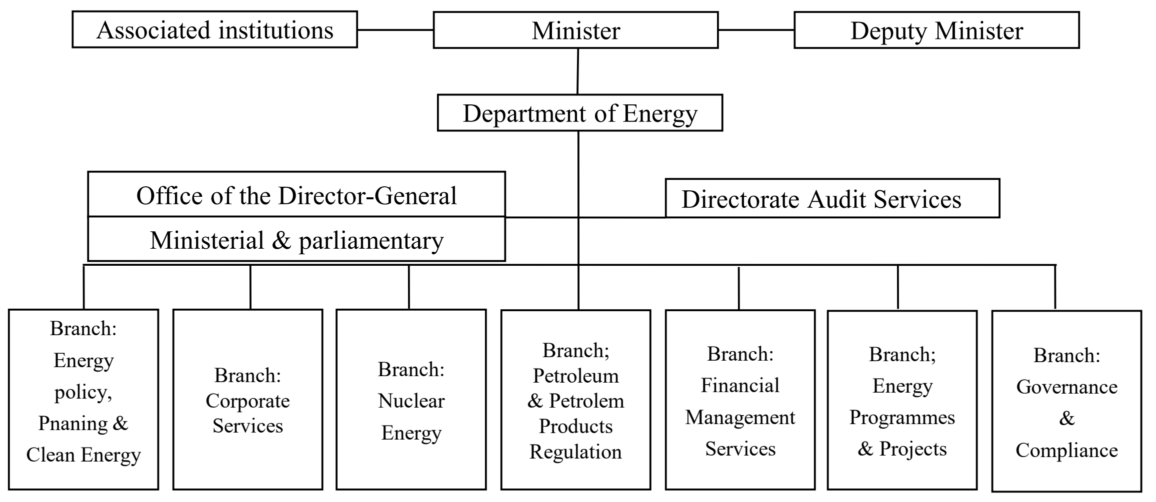
2) Other companies

Local government operates pumped storage hydropower in Cape Town and IPPs are driving generation fleets except Eskom in RSA. Local government, supplying the power to meet peak demand in this area, is not independent supplier for Cape Town area. IPPs have various power sources such as coal-fired, gas-fired and renewable energy promoted by the Department of Energy (DoE) IPP Office. And all generated power by IPP is purchased to Eskom in duty.

(2) Administrative body

1) DoE

DoE is administrative organization that operates power sector in RSA and reorganized in 2009.



Source : JICA Survey Team using evidence from DoE Strategic Plan 2015-2020

Figure 3.8-2 Organization of DoE in RSA

DoE is supervisory authorities of six (6) following organizations and companies.

(Regulatory authorities)

① National Nuclear Regulation

② National Energy Regulator (NERSA)

(Research institutes)

③ Nuclear Energy Corporation of South Africa

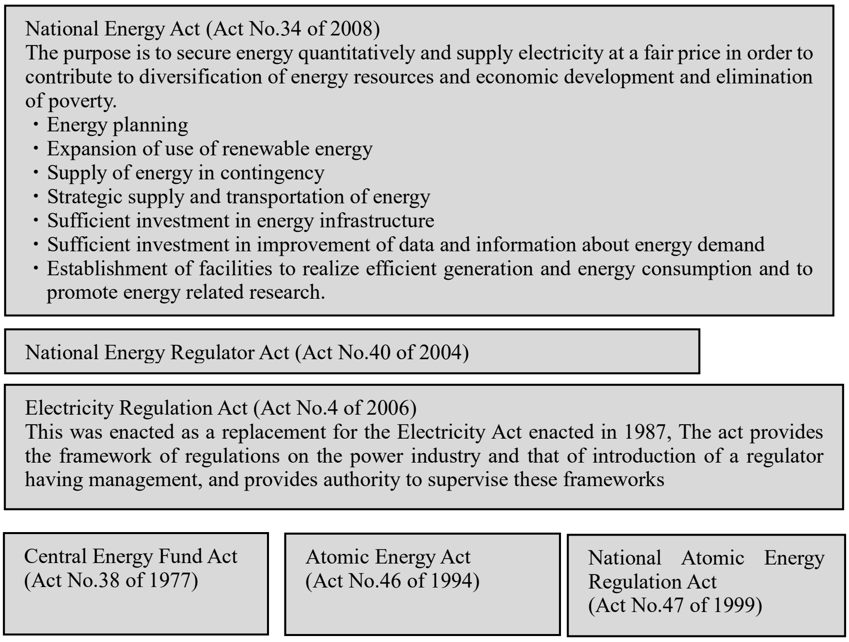
④ Central Energy Fund Group

⑤ The Petroleum, Oil and Gas Corporation of South Africa (Petro SA)

⑥ Sanedi

2) Electricity-related laws

Electricity-related laws and regulations of RSA are shown in Fig. 3.8-3.



Source : Strategic Plan 2015-2020, DoE

Figure 3.8-3 Legal system in power sector in RSA

3) Energy policy

(a) Strategic Plan 2015-2020

Strategic Plan 2015-2020 published by the DOE in 2015 focuses on the objectives to be realized in near five years. Table 3.8-1 shows the objectives on this plan.

Table 3.8-1 Strategic Plan 2015 – 2020 (RSA)

Improvement of energy security
・Energy source diversification, application of high energy-efficiency technologies ・Introduction of competition effect in energy sector (introduction of renewable energy with competitive bidding) ・Expansion of energy infrastructure in line with policies on IEP (Integrated Energy Plan), IRP (Integrated Resource Plan), 20-Year Liquid Fuels Roadmap, Gas Utilization Master Plan and power transmission and distribution plan, etc.
Securing energy security by enhancing power generation facilities
・Promotion of framework for base-load generation, renewable energy, liquefied fuels and gas, etc. ・Utilization of Strategic Fuel Fund, and utilization improvement of liquefied petroleum gas, shale gas, fuel gas, biomass, and promotion of "Operation Phakisa[39]" ・Implementation of competitive bidding for REIPPPP, Stage 1,2,3 and 4 by March 2019. (Total 6,725MW) ・Utilization of Inga hydropower and hydroelectric resources in Mozambique
power access improvement on households
・Accomplishing on-grid electrification in rural area, its amount is 1,089,000 households, by March 2019. (75% of the object, 1,452,000 households) ・Accomplishing off-grid electrification in rural area, its amount is 78,750 households by March 2019. (75% of the object, 105,000 households)
Improvement of nuclear power security
・Promulgation of the Amended National Nuclear Power Regulation Act ・Promulgation of the Amended Nuclear Energy Act ・Legislation of the Radioactive Waste Management Fund Act ・Construction of nuclear fuel recycling facilities ・Construction of new nuclear reactors ・Preparation of a roadmap for the new nuclear development program, nomination of advisers and establishment of the program management office.
Clean energy promotion
・Increase renewable energy capacity, 42% (or 17,900MW) of total capacity by 2030. ・Increase cross-border hydropower capacity, 6% (or 2,600MW) by 2030. ・Introduction of renewable energy for off-grid electrification, 15MW. ・Introduction of 105,000-unit- home solar system. ・Introduction of one million-solar water heater and promotion of biogas collection and its usage. ・Introduction promotion of roof-top solar panels.

Source : Strategic Plan 2015- 2020

[39] Operation Phakisa is an initiative posted by the South African government, which advocates fast-track promotion toward resolution of important development problems. (Phakisa means "hurry up" in the Sesotho Language)
(http://www.operationphakisa.gov.za/Pages/Home.aspx)

(b) Procurement Programme

To embody the Strategic plan aforementioned, DoE, especially DoE IPP Office promotes introduction of the diversified IPPs.

✓ Coal Baseload IPP Procurement Programme[40]

Promotion of the baseload IPP coal-fired power plants, 2,500MW in total, and 600MW or less per one development project.

✓ Renewable IPP Procurement Programme (REIPPPP)[41]

Promotion of renewable IPP projects such as PV, WF, CSP and biomass, 17,800MW in total by 2030.

✓ Gas to Power Programme[42]

Promotion of gas-fired power plants, 3,126MW in total under governmental decision in 2012. Prior to the generation introduction, following issues should be solved.

- Natural gas import from abroad
- Establishment of chained business model, gas procurement, transportation and generation[43].

(c) Activity plan of Eskom

Eskom, establishes her short-mid term strategy as an Integrated Report annually. In this report (Integrated Report 2016), following strategies can be seen in accordance with governmental policies and its activities.

・Securing stability and reliability of electric power supply

・Securing sustainability of Eskom in management and funds.

・Decreasing the carbon dioxide emissions and impact on the environment（compliance with the environmental regulations and carbon dioxide emission trading, etc.）

・Promotion of IPP introduction based on policies and approaches of the government, and expansion of energy sector to rural areas.

・Acceleration of industrialization and economic reform

(3) Regulatory body

Regulations of power industry are conducted by the National Energy Regulator of South Africa (NERSA), which was established under the National Energy Regulator Act of 2004 (Act No. 40 of 2004). NERSA regulates not only power sector but energy sectors, such as gas, oil and pipelines.

NERSA conducts the following regulations under the Electricity Regulation Act of 2006 (Act No.4 of 2006).

・Issuance of operator licenses in electric power business (generation, transmission, distribution,

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40 https://www.ipp-coal.co.za/
41 https://www.ipp-smallprojects.co.za/
42 https://www.ipp-gas.co.za/
43 According to the news of October 2016, it was decided construction of gas terminal at Richards Bay and Coega, and construction of gas-fired thermal power plant of 2,000MW at Richards Bay and 1,000MW at Coega.

and power trade) and supervision of operations.

・Regulations on electricity tariff (the tariff guidelines and the tariff framework, methodology of determination of tariffs, etc.)

・Planning of electric power infrastructure (demand forecast to set on IRP, development promotion of alternative generation technologies, including renewable energy and co-generation, etc., and promotion of DSM[44])

・Regulatory Reform (reorganization distribution business, and framework of international power trade)

(4) Electricity tariff

The electricity tariff of RSA is shown in Table 3.8-2

The electricity tariff of RSA is generally classified into business and general purpose use. The electricity tariff for business is classified into commercial, industry, agriculture and street lighting, and the electricity tariff for general purpose use is classified into domestic (residential) customer use independent houses, apartments and condominiums and schools, etc.

The breakdown of the electricity tariff consists of a fixed tariff and metered tariff for business and the electricity tariff for general purpose use is only metered. The breakdown of the metered tariff, rural electrification subsidies and environmental tax, etc., are included and the tariff is set based on highly detailed information according to the voltage of receiving electricity, distance of transmission lines and hours of use by season, etc.

Trial calculation of electricity tariffs is made for typical customers, the results of which are shown in Table 3.8-3.

[44] Demand Side Management

Table 3.8-2 Electricity tariff (RSA)

Sample Tariff Table -NIGHTSAVE Urban Large -Mon local autortiy rates- -South Africa (2015)

Transmission Zone	Voltage	Active Energy Charge (ZAc / kWh) High demand season (Jun - Aug) VAT excl.	Active Energy Charge High demand season VAT incl.	Active Energy Charge Low demand season (Sep - May) VAT excl.	Active Energy Charge Low demand season VAT incl.	Energy Demand Charge (ZAR / kVA / month) High demand season (Jun - Aug) VAT excl.	Energy Demand Charge High demand season VAT incl.	Energy Demand Charge Low demand season (Sep - May) VAT excl.	Energy Demand Charge Low demand season VAT incl.	Transmission Network Charges (ZAR / kVA /month) All Season VAT excl.	Transmission Network Charges All Season VAT incl.
≤ 300km	< 500V	61.48	70.09	47.80	54.49	187.08	213.27	26.14	29.8	7.12	8.12
	≥ 500V & < 66kV	58.23	66.38	45.45	51.81	181.07	206.42	25.31	28.85	6.51	7.42
	≥ 66kV & ≤ 132kV	57.80	65.89	44.90	51.19	174.48	198.91	24.39	27.8	6.34	7.23
	>132kV*	54.07	61.64	42.04	47.93	168.31	191.87	23.52	26.81	8.01	9.13
> 300km and <600km	< 500V	62.31	71.69	48.32	55.08	189.01	215.47	26.4	30.1	7.18	8.19
	≥ 500V & < 66kV	59.44	68.45	46.37	52.86	182.91	208.52	25.54	29.12	6.57	7.49
	≥ 66kV & ≤ 132kV	59.00	67.93	45.81	52.22	176.21	200.88	24.62	28.07	6.39	7.28
	>132kV*	55.74	63.54	42.90	48.91	170.03	192.83	23.74	27.06	8.09	9.22
>600km and <900km	< 500V	62.89	71.69	48.79	55.62	190.94	217.67	26.67	30.4	7.27	8.29
	≥ 500V & < 66kV	60.04	68.45	46.85	53.41	184.74	210.6	25.82	29.43	6.63	7.56
	≥ 66kV & ≤ 132kV	59.59	67.93	46.27	52.75	177.98	202.9	24.86	28.34	6.43	7.33
	>132kV*	55.74	63.54	43.34	49.41	171.73	195.77	23.98	27.34	8.2	9.35
>900km	< 500V	63.56	72.46	49.29	56.19	192.8	219.79	26.93	30.7	7.29	8.31
	≥ 500V & < 66kV	60.62	69.11	47.30	53.92	186.6	212.72	26.04	29.69	6.71	7.65
	≥ 66kV & ≤ 132kV	60.20	68.63	46.73	53.27	179.8	204.97	25.12	28.64	6.48	7.39
	>132kV*	56.33	64.22	43.81	49.94	173.46	197.74	24.22	27.61	8.26	9.42

* >132kV or Transmission connected

Distribution network charges

Voltage	Network capacity charge (ZAR / kVA / m) VAT excl.	Network capacity charge VAT incl.	Network demand charge (ZAR / kVA / m) VAT excl.	Network demand charge VAT incl.	Urban low voltage subsidy charge (ZAR / kVA / m) VAT excl.	Urban low voltage subsidy charge VAT incl.
< 500V	14.15	16.13	26.83	30.59	0	0
≥ 500V & < 66kV	12.98	14.8	24.62	28.07	0	0
≥ 66kV & ≤ 132kV	4.63	5.28	8.58	9.78	11.43	13.03
>132kV / Transmission connected	0	0	0	0	11.43	13.03

Voltage	Ancillary service charge (ZAc / kWh) VAT excl.	Ancillary service charge VAT incl
< 500V	0.33	0.38
≥ 500V & < 66kV	0.32	0.36
≥ 66kV & ≤ 132kV	0.30	0.34
>132kV*	0.28	0.32

Customer categories	Service charge (ZAR / Account / day) VAT excl.	Service charge VAT incl.	Administration charge (ZAR / PoD / day) VAT excl.	Administration charge VAT incl.
> 1 MVA	162.48	185.23	73.23	83.48
Key customers	3,183.88	3,629.62	101.68	115.92

* PoD : Point of Demand

Electrification and rural network subsidy charge (ZAc / kWh) All seasons VAT excl.	Electrification and rural network subsidy charge All seasons VAT incl	Affordability subsidy charge (ZAc / kWh) Only payable by non- local authority tariffs All seasons — All seasons VAT excl.	Affordability subsidy charge All seasons VAT incl
6.33	7.22	2.44	2.78

* >132kV or Transmission connected

Source : Eskom's Tariffs & Charges 2015/16

Table 3.8-3 Trial calculation of electricity tariff (RSA)

Customer Category	Assumed consumption (kWh / month)	Electricity Tariff (US cents/kWh)
Domestic (Residential) (*1)	100	4.52
Small Commercial (*2)	1,000	4.44
Large Commercial/Industry (*3)	10,000	6.96

*1 Nightsave Urban Small - non local authority rates
*2 Nightsave Urban Large - non local authority rates
*3 Business Rate -non local authority urban tariff (Business rate 2)

1 USD = 0.00071ZAR, as of December, 2016
Source : JICA Survey Team

3.8.2 Power demand, existing facilities and development plan

(1) Power demand

Power demand tracks and electricity sold, etc., by Eskom are shown in Table 3.8-4.

Table 3.8-4 Electricity statistics in RSA

Items \ FY	2010	2011	2012	2013	2014	2015
Power transmission to systems (GWh)	252,876	254,436	252,612	244,225	243,653	238,599
(Generated by Eskom)	237,428	237,289	241,398	231,129	226,300	215,933
(Generated by IPP)	1,835	4,109	3,516	3,671	6,022	9,033
(Imported from outside of the country)	13,613	13,038	7,698	9,425	10,731	9,703
Ratio of power generated by Eskom	94%	93%	96%	95%	93%	91%
Electricity sold within South Africa (GWh)	211,150	211,590	202,770	205,525	216,274	214,487
Export to outside of the country (GWh)	13,296	13,195	13,791	12,378	11,911	13,465
Transmission loss rate (%)	3.0	3.2	2.8	2.34	Total 8.79	Total 8.59
Distribution loss rate (%)	5.7	5.0	7.12	7.13		
Actual maximum electricity demand (MW)	36,970	36,986	36,437	36,273	35,343	N/A

Source : Eskom Integrated Report （2012, 2013, 2014 and 2015) and
Eskom Transmission Distribution Plan (2015-2024 and 2016-2025

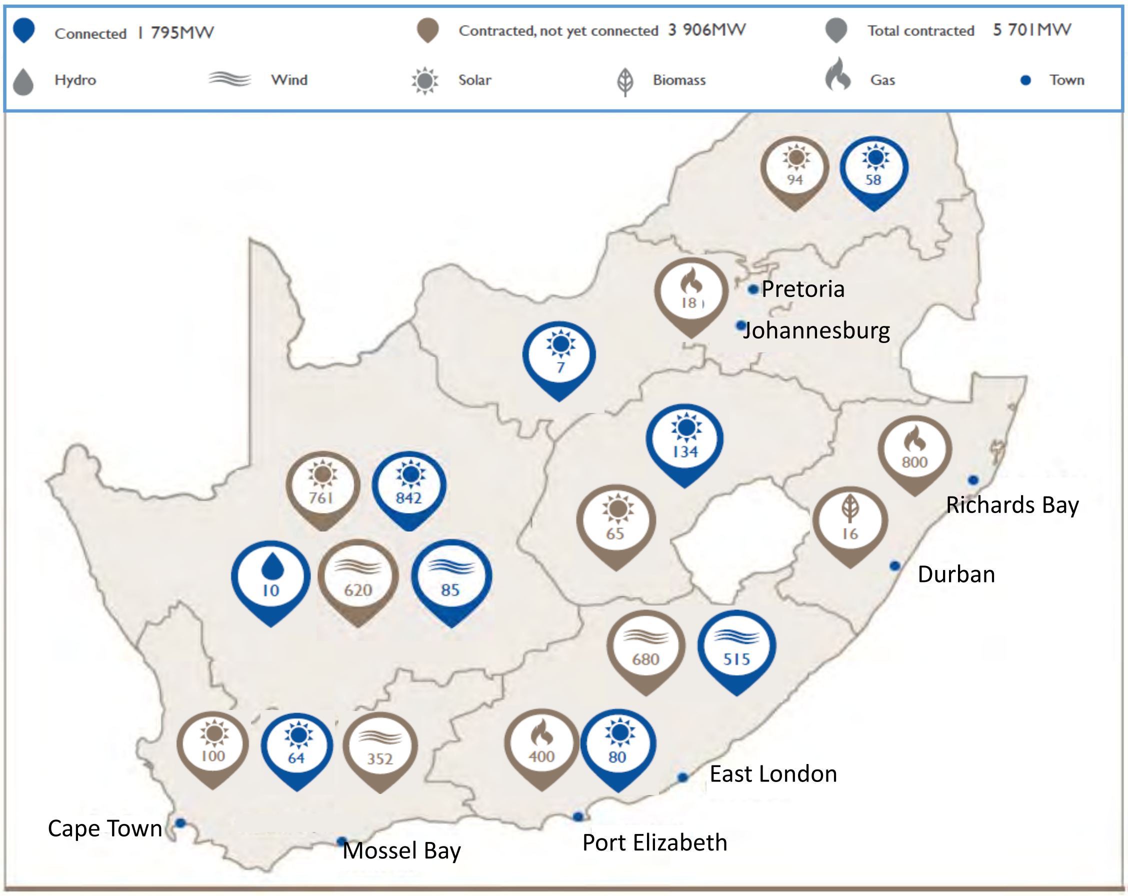
(2) Existing families

1) Generation facilities

The generation fleets of Eskom are shown in Figure 3.8-5.

In the meanwhile, Eskom purchases electricity from IPPs actively. As of March 2015, total capacity of IPPs is 1,795MW. Further total power generation capacity of contracted IPPs (not yet in operation) is 3,906MW. The total generation capacity of RSA by provinces and by categories is shown in Figure 3.8-4[45].

[45] Eskom prepared the "Generation Connection Capacity Assessment of the 2022 Transmission Network" (GCCA-2022) in June 2015, published the information of available transmission capacities of transmission lines by area to push the construction plan for new power plants by IPPs, etc.



Source : JICA Survey Team using Eskom Integrated Report 2015

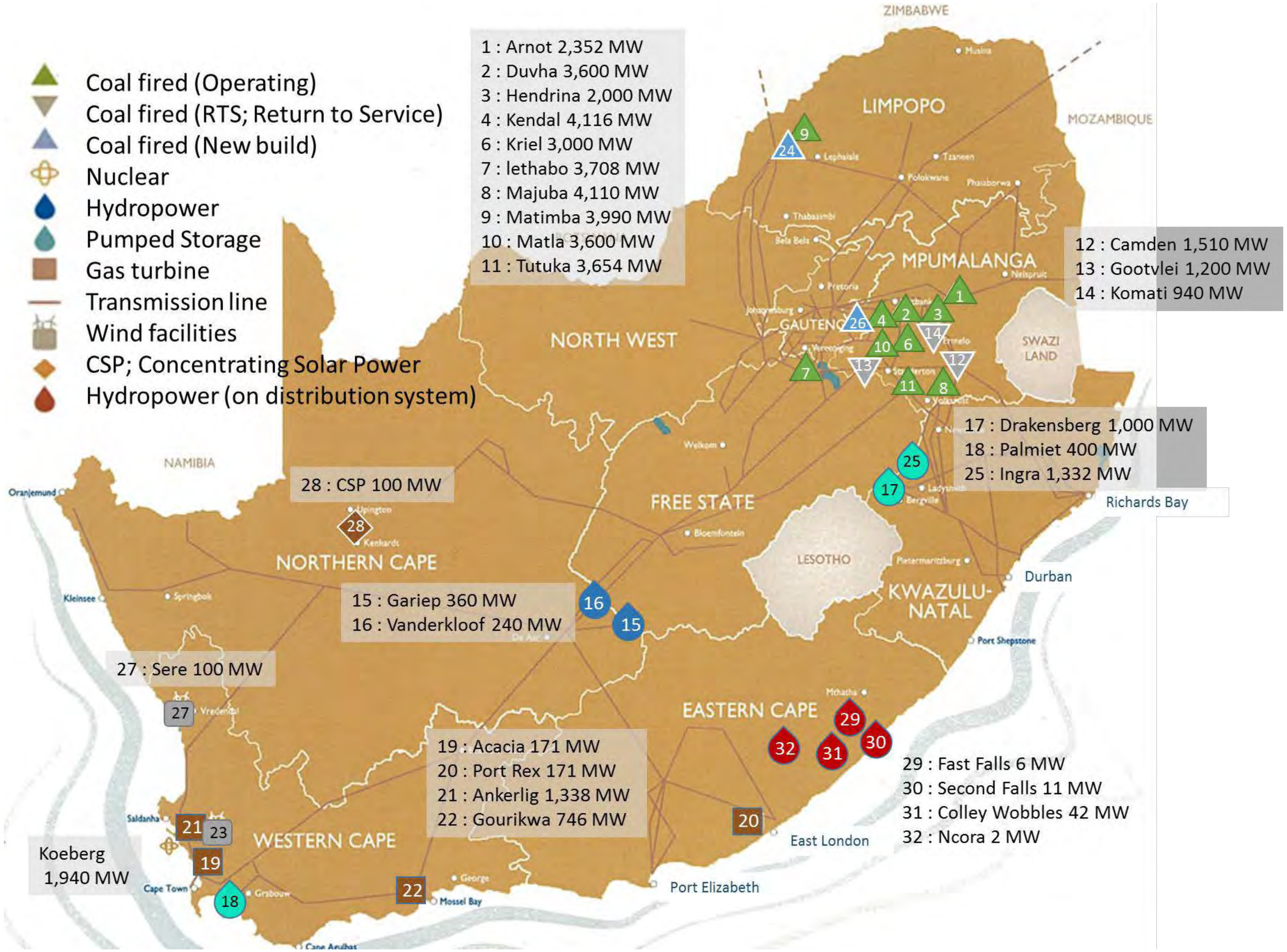
Figure 3.8-4 IPPs' generation capacity by provinces and by types (RSA)

DoE individually conducted bidding for an open cycle gas turbine power source under the Open Cycle Gas Turbine (OCGT) programme, already terminated, and as a result, the following two thermal power plants were constructed by IPP. Japanese companies have participated in both plants. Currently these two plants are OCGT and are planned to be converted to CCGT in accordance with Gas to Power Programme in the future.

Table 3.8-5 IPPs (thermal power plants) in RSA

Site	Type	Capacity (MW)	Construction Cost	Commission	Developer
Dedisa	OCGT (Diesel)	335	0.78 billion Euro	2015	Dedisa Peaking Power (RF) Proprietary Limited
Avon	OCGT (Diesel)	670		2016(schedule)	Avon Peaking Power (RF) Proprietary Limited

Source : MITSUI & CO., LTD's Website



Source : JICA Survey Team using Eskom Web site

Figure 3.8-5 Eskom's existing generation facilities

2) Transmission facilities (Interconnector)

Table 3.8-6 shows the configuration of transmission lines in RSA as of 2013. Further, Figure 3.8-6 shows transmission diagram in RSA.

Table 3.8-6 Transmission lines in RSA

Voltage Class	Total length (km)
765kV	2,235
DC533kV	1,035
400kV	17,011
275kV	7,361
220kV	1,217
132kV	1,065

Source : Overseas Electric Power Industry volume 2 (Japan Electric Power Information Center, 2015)

3) Interconnector

Eight interconnectors are stretching into RSA.

Table 3.8-7 Interconnector (RSA)

Mozambique	Apolo – Songo (CahoraBassa hydro P.P.) DC500kV 2 lines
	400kV Arnot – Maputo, 1 line
	400kV Carnden – Maputo, 1 line (via MOTRACO)
Botswana	400kV Matimba – Phokoje, 1 line
	132kV Spitskop – Gabotone, 1 line
	132kV Heuningvlei - Tshabong, 1 line
Namibia	400kV Kenhardt – Keetmanshoop, 1 line
	220kV Aggneis – Harib, 1 line

Source：JICA Survey Team

(3) Power system development plan

1) Generation development plan

(Hydropower)

Table 3.8-8 shows existing hydropower fleets in RSA.

Table 3.8-8 Hydropower projects in RSA

Sites	Capacity (MW)	COY	Current Status	Developer
Ingula (pumped storage)	1,332 (4×332 MW)	2015	Under Construction	Eskom
Tubaste (pumped storage)	1,500 (4×350 MW)	2022	Planning	IPP

Source : JICA Survey Team using evidence from Eskom, etc.

(Thermal power)

Table 3.8-9 shows ongoing project of thermal power plants of Eskom.

The unit No. 6 at Medupi coal-fired power plant started operations in March 2015. And Kusile coal-fired power plant is preparing the operation of unit No. 1. It will be in operation in the second half of fiscal year.

Table 3.8-9 Thermal power construction plan in RSA

Sites	Type	Capacity (MW)	Construction Cost	Commission	Developer
Medupi	Coal-fired (supercritical)	4,764 (6×794MW)	> 105 billion ZAR	2019	Eskom
Kusile	Coal-fired (supercritical)	4,800 (6×800MW)	118.5 billion ZAR	2016-2021	Eskom

Source : JICA Survey Team using evidence from Eskom

(Renewable energy)

The government of South Africa launched REIPPPP and states 3,725 MW is the capacity to be procured from IPP. At the present, fourth round of bidding has been completed.

Table 3.8-9 shows the breakdown of each window.

Table 3.8-10 REIPPP program (Window 1,2 and 3)

	Capacity awarded（Upper MW）, Num. of project (Lower)							
	Wind power	Solar power	CSP[46]	Hydro-power	Biomass	Biogas	Landfill	Total
WINDOW 1 (Contracted in May, 2012)	634 (8)	631.5 (18)	150 (2)	0 (0)	0 (0)	0 (0)	0 (0)	1,415.5 (28)
WINDOW 2 (Contracted in May, 2013)	562.5 (7)	417.1 (9)	50 (1)	14.3 (2)	0 (0)	0 (0)	0 (0)	1043.9 (19)
WINDOW 3 (Contracted in Dec., 2014)	787 (7)	435 (6)	200 (2)	0 (0)	16 (1)	0 (0)	18 (1)	1,456 (17)
Total	1,984 (22)	1,484 (33)	400 (5)	14 (2)	16 (1)	0 (0)	18 (1)	

Source : South Africa's Renewable Energy IPP Procurement Program: Success Factors and Lessons, World Bank Group (2014)

(Nuclear)

Under the determination of Integrated Resource Plan (IRP), new nuclear development is planned to introduce. Initially, Brazil and Schulpfontein in Northern Cape province, Duynefontein and Bantamsklip in Western Cape province and Thyspunt in Eastern Cape province were nominated as candidates. And Thyspunt was selected as a construction site due to the result on the environmental assessment report of March 2010, In September 2014, an agreement was executed with Rosatom, a Russian Nuclear Power Company on 9.6 GW nuclear power construction by 2030. Therefore Russian nuclear reactors will be introduced. Thereafter, the South African government entered into nuclear power cooperation agreements with France and China.

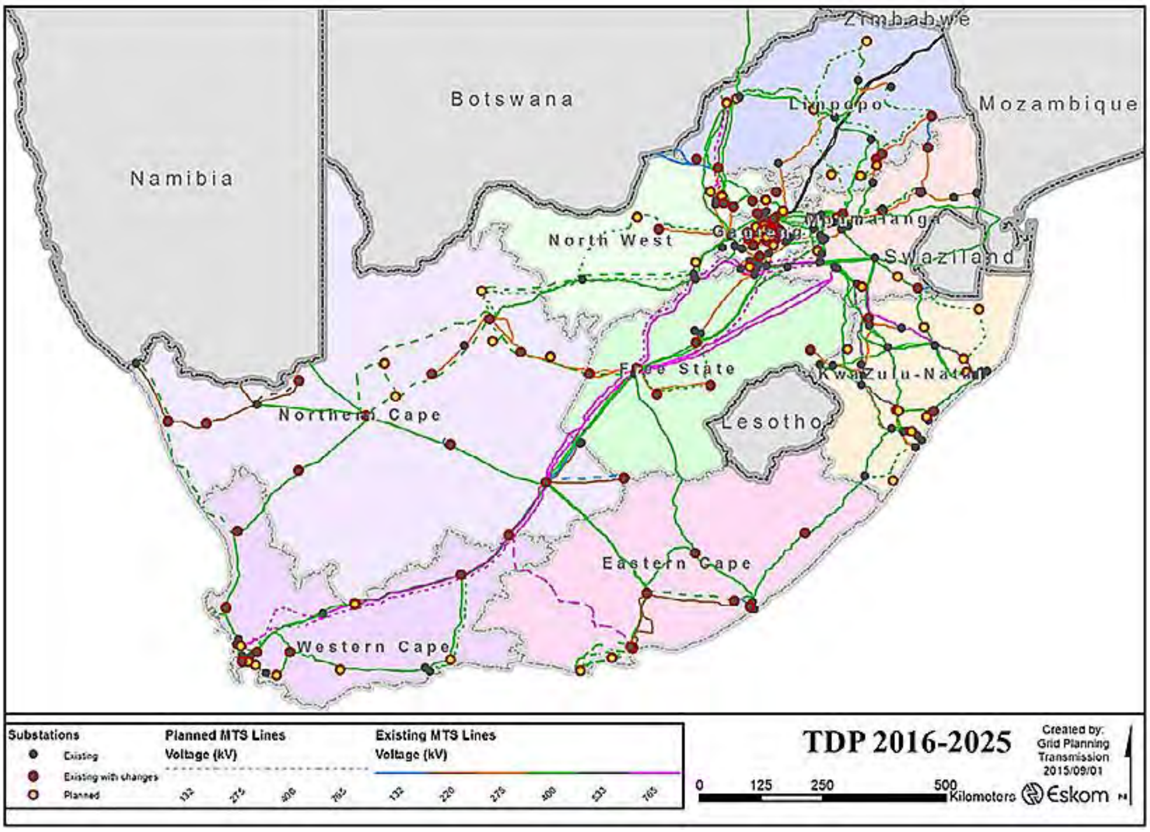
2) System planning

Eskom releases practical system development plan, namely Transmission Development Plan (TDP) of decade power system plan, every year. TDP is deliberated on supply balance and reinforcement of power system through consultation in public forums.

Another system planning by Eskom, namely Strategic Grid Plan (SGP) is the grand design. In this plan

[46] Concentrated Solar Power

solution for bulk power flow from widespread renewable introduction in Grate Cape area and nuclear site(s) was advocated by introduction of nationwide corridors.



Source : Transmission mission development plan 2016-2025

Figure 3.8-6 System planning diagram (RSA) (TDP 2016 – 2025)

3) Power system master plan

Three kinds of plan shown in Table 3.8-11, especially IRP and TDP have the role for implementation of power system in RSA.

Table 3.8-11 Power system master plan in RSA

Master plan	Organization	Contents, etc.
Integrated Resource Plan 2010 – 2030, update 2013 (IRP)	DoE	・Developed as a national electric power master plan ・Developed on the aspect of energy diversification ・Evidence for certification of new generation construction license.
Strategic Grid Plan (SGP)	Eskom	・Developed long-term transmission plan (20 year span) ・Developed by the scenario on IRP ・Reviewed every 2 to 3 years.
Transmission Development Plan 2016-2025 (TDP)	Eskom	・Developed with practical aspect to estimate investment cost. ・10-year span practical plan ・Reviewed every year

Source : JICA Survey Team

Here, the latest edition of IRP, Integrated Resource Plan for Electricity 2010-2030 Update Report 2013 (hereinafter IRP), published by DoE and the Transmission Development Plan 2016-2025 (hereinafter TDP), published by Eskom would be mentioned precisely. The relationship between both plans is shown in Table 3.8-12.

Table 3.8-12 Correlation between IRP and TDP

	IRP	TDP
Published year	2013	2015
Planning period	20 years (~2030)	10 years (～2025)
Demand forecast	Toward 2030 (supplementary assuming by 2050) ・Developed in 2009 ・Assuming nationwide with a macroscale.	Toward 2025 ・Developed in 2015 ・Carried out by provinces
Generation development plan	Planned on the aspect of national primary emery utilization, plus power import	Eskom's assets development plan Quotes IRP's perspectives
System planning	Not specifically	Specific planning

Source : JICA Survey Team

(Demand forecast)

(a) IRP

Power demand forecast is calculated using the average GDP growth rates on original version, Integrated Resource Plan 2010 - 2030, published in 2010.

Table 3.8-13 Conditions for calculation of demand forecast on IRP

Case	Average GDP growth	GDP calculation base
High	5.5%	6.0% growth in the first half of forecasted period and 5.3% growth in the latter half, thus set 5.5% as the reasonable figure for the period.
Moderate	4.5%	4.5%, the average in recent years
Low	3.5%	Minus 1.0% from moderate case

Source : JICA Survey Team

On IRP, published in 2013, adjustment by the system operator (Eskom) was added based on the power demand records. And the electricity demand forecast was studied in consideration with forecasting scenarios reflecting economic atmosphere. Figure 3.8-6 shows the details of the atmosphere, which is the combination with domestic industrial perspectives (primary, secondary, and tertiary) and global economy.

As a result, Green Shoots scenario was selected as the suitable demand forecast.

Source : Integrated Resource Plan for Electricity (IRP) 2010-2030 Update Report 2013

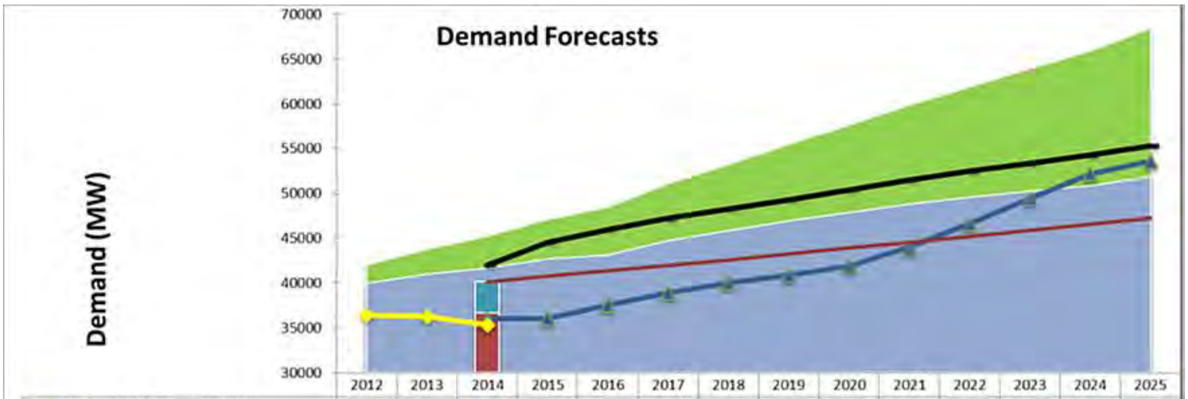
Figure 3.8-7 IRP's Preparation work for updated version of power demand forecast

(b) TDP

TDP forecasts the peak demand in a decade, with demand tracks and prediction models of each bulk supply points (substations). It is noted that TDP can predict only peak demand in terms of judgement of system reliability. TDP comments that RSA has suppressed demand due to power deficit and lesser transmission capacity. Therefore, this plan represents two prospects, one is net demand based on this restriction (Constrained) and another is the one including suppressed demand (Unconstrained).

Table 3.8-8 shows demand forecast on TDP. Eskom estimates the demand lower than that on IRP.

Demand forecast by IRP and TDP are shown in Table 3.8-14.



	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
2010 IRP High Demand (MW)	42027	43839	45255	47124	48479	51090	53276	55573	57649	59885	61932	63955	65870	68458
2010 IRP Low Demand (MW)	40002	41040	41669	42666	43157	44710	45815	46952	47848	48828	49596	50299	50872	51903
Mid Size Customer NMD (MW)			3472											
Top Customer NMD (MW)			36676											
2015 TDP Demand (MW) - Constrained			36000	36065	37536	38885	40036	40904	41921	43990	46629	49427	52193	53600
2015 TDP Demand (MW) - Unconstrained			42000	44536	45998	47220	48271	49328	50398	51528	52501	53403	54296	55310
Actual Peak Demand (MW)	36437	36276	35343											
NMD growth at 1.5%			40148	40750	41361	41982	42612	43251	43900	44558	45226	45905	46593	47292

IRP : Integrated Resource Plan 2010-2030 (DOE,2013)
TDP: Transmission Distribution Plan 2016-2025 (Eskom, 2015)
Source：Eskom Transmission Distribution Plan 2016-2025

Figure 3.8-8 TDP demand forecast (RSA)

Table 3.8-14 Demand forecast on IRP and TDP

	Peak demand(MW)			Generation (Send out) (GWh)
FY	IRP	TDP		IRP
		Constrained	Unconstrained	
2015	39,703	36,065	37,536	271,424
2016	40,608	37,536	45,998	279,384
2017	41,679	38,885	47,220	287,479
2018	42,485	40,036	48,271	296,379
2019	43,713	40,904	49,328	305,418
2020	44,977	41,921	50,398	314,790
2021	46,481	43,990	51,528	324,303
2022	47,952	46,629	52,501	333,929
2023	49,442	49,427	53,403	343,561
2024	50,895	52,193	54,296	353,651
2025	52,593	53,600	55,310	364,056
2030	60,509	-	-	409,140
2040	72,495	-	-	479,589

Source : Integrated Resource Plan for Electricity (IRP) 2010-2030 Update Report 2013

(Generation development plan)

(a) IRP

IRP proposes various power source combinations, considering comprehensive aspects, such as domestic primary energy utilization, environmental impact, electricity tariff, introduction of domestic technology, employment creation, prospect of introduction of IPP, and import of electric power from abroad[47], and states the better scenario.

Currently in RSA, the ratio of coal-fired power generation, especially elder generation is very high. Under the circumstance, generation capacity could not meet demand and return to service plan was accomplished to meet demand. Near future, large scale coal-fired generators in Medupi, Kusile will be installed to meet demand, but in the medium and long-term, definitely elder coal-fired fleets will be decommissioned due to aging. The plan to overcome this perspective, nuclear power generation is pointed out. IRP mentioned that 4,800MW nuclear power should be installed in 2030 and further 11,200MW should be installed in 2040.

(b) TDP

TDP only refers to individual power source in terms of grid access.

47 Here, power import from six large scale hydroelectric power sources in Mozambique and Zambia are mentioned on IRP. According to research by the Survey it is assumed that six power sources are Cahorra Bassa, Mphanda Nkuwa, HCB North Bank, Kariba, Kafue, Itezi Tezhi.

Table 3.8-15 Generation development plan (Base Case) on IRP2010-2030 Update ver.

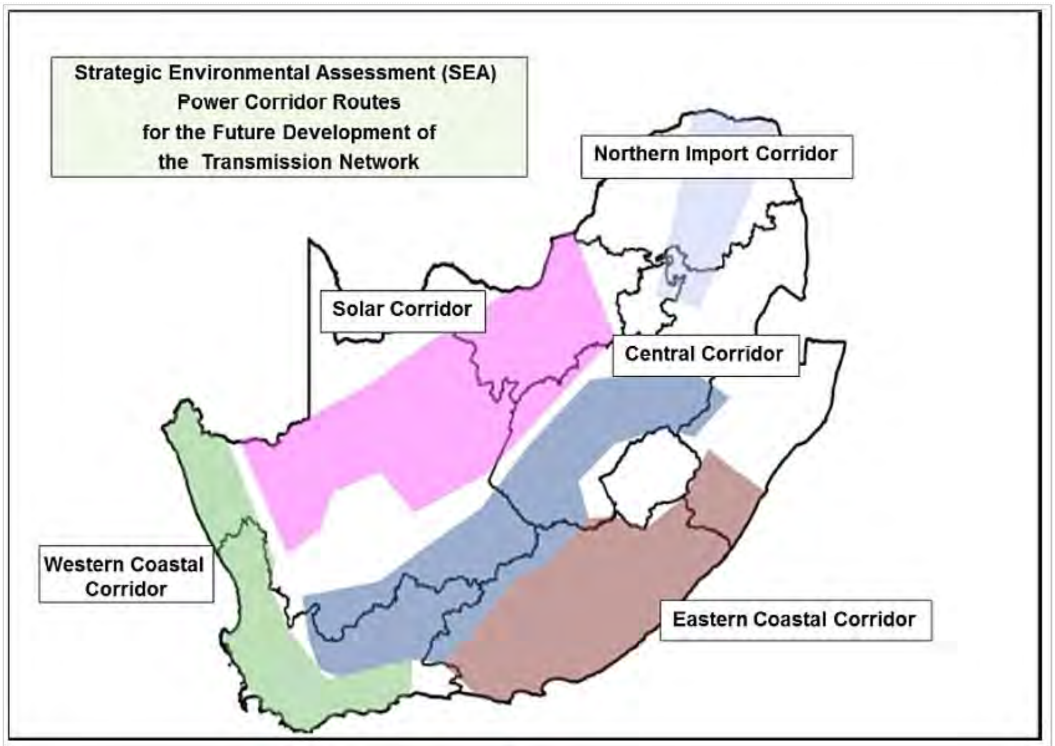
Year	Existing/Committed										New											Peak demand
	Coal	OCGT	Hydro Import	Hydro RSA	PS	Nuclear	PV	CSP	Wind	Other	Coal	CCGT	OCGT	Hydro Import	Hydro RSA	PS	Nuclear	PV	CSP	Wind	Other	
2013	36860	2550	1500	670	1580	1860	0	0	0	3200	0	0	0	0	0	0	0	0	0	0	0	38280
2014	37580	2460	1500	680	1580	1860	910	0	940	3200	0	0	0	0	0	0	0	0	0	0	0	38924
2015	39010	2460	1500	690	2900	1860	1050	200	1300	3450	0	0	0	0	0	0	0	0	0	0	0	39703
2016	41070	3480	1500	690	2900	1860	1070	200	1300	3700	0	0	0	0	0	0	0	0	0	0	0	40608
2017	43210	3480	1500	690	2900	1860	1070	200	1300	3700	0	0	0	0	0	0	0	0	0	0	0	41679
2018	44640	3480	1500	690	2900	1860	1070	200	1300	2700	0	0	0	0	0	0	0	0	0	0	0	42485
2019	45350	3480	1500	690	2900	1860	1070	200	1300	2700	0	0	0	0	0	0	0	0	0	0	0	43713
2020	44970	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	0	0	0	0	0	140	0	0	0	44977
2021	44400	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	0	0	0	0	0	420	0	0	0	46481
2022	43390	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	0	1125	0	0	0	980	0	0	0	47952
2023	42760	3480	1500	690	2900	1860	1070	300	1300	2700	0	0	0	1500	0	0	0	1770	0	0	0	49442
2024	42310	3480	1500	690	2900	1860	1070	300	1300	2700	750	0	0	1500	0	0	0	2700	0	320	0	50895
2025	40420	3480	1500	690	2900	1860	1070	300	1300	2700	1950	2840	0	1500	0	0	1600	3700	0	640	0	52593
2026	39390	3120	1500	690	2900	1860	1070	300	1300	640	1950	2840	840	1500	0	0	1600	4700	0	960	0	52995
2027	38090	3120	1500	690	2900	1860	1070	300	1300	640	1950	3550	3240	1500	0	0	1600	5700	0	1600	0	54745
2028	36670	3120	1500	690	2900	1860	1070	300	1300	640	1950	3550	4560	1500	0	0	3200	6700	0	1920	0	56482
2029	36270	3120	1500	690	2900	1860	1070	300	1300	640	2450	3550	4680	1500	0	0	4800	7700	0	2560	0	58547
2030	36230	3120	1500	690	2900	1860	1070	300	1300	640	2450	3550	4680	1500	0	0	4800	8700	3000	3060	0	60509
2031	36210	3120	1500	690	2900	1860	1070	300	1300	640	2450	3550	4800	1500	0	0	6400	9700	3000	3700	0	62159
2032	35050	3120	1500	690	2900	1860	1070	300	1300	640	3700	3550	5160	1500	0	0	6400	10700	3400	4340	0	63463
2033	33890	3120	1500	690	2900	1860	1070	300	1300	640	4450	3550	5160	1500	0	0	6400	11700	5200	4980	0	64969
2034	33310	3120	1500	690	2900	1860	1070	300	370	640	5200	3550	6240	1500	0	0	8000	12700	5200	5620	0	66210
2035	33310	3120	1500	690	2900	1860	1070	300	0	640	5200	3550	6240	1500	0	0	9600	13700	5200	6260	0	67414
2036	32840	3120	1500	690	2900	1860	1070	300	0	280	5950	3550	6840	1500	0	0	9600	14700	5200	6580	0	68341
2037	32370	1020	1500	690	2900	1860	1070	300	0	280	6700	3550	9720	1500	0	0	11200	15700	5200	6900	0	69621
2038	31900	1020	1500	690	2900	1860	1070	300	0	280	8200	3550	9720	1500	0	0	11200	16700	5200	7220	0	70777
2039	30390	1020	1500	690	2900	1860	160	300	0	280	9700	3550	9720	1500	0	0	11200	17700	5200	7860	0	71736
2040	28110	1020	1500	690	2900	1860	20	300	0	280	11950	4970	9840	1500	0	0	11200	18700	5200	8500	0	72495
2041	26970	1020	1500	690	2900	1860	0	300	0	0	12700	4970	9840	1500	0	0	11200	19700	5200	9020	0	73599
2042	26970	1020	1500	690	2900	1860	0	300	0	0	13450	5680	10800	1500	0	0	11200	20700	5200	9480	0	74482
2043	26820	1020	1500	690	2900	1860	0	300	0	0	13450	5680	10800	1500	0	0	11200	21700	5800	10120	0	75368
2044	26820	1020	1500	690	2900	0	0	200	0	0	13450	5680	10800	1500	0	0	12800	22700	7200	10440	0	76112
2045	25650	1020	1500	690	2900	0	0	0	0	0	14950	5680	10800	1500	0	0	12800	23560	7900	10760	0	77059
2046	23900	0	1500	690	2900	0	0	0	0	0	16450	6390	12000	1500	0	0	12800	24280	8000	11080	0	77841
2047	22100	0	1500	690	2900	0	0	0	0	0	18700	6390	12000	1500	0	0	12800	24720	8000	11080	0	78603
2048	19100	0	1500	690	2900	0	0	0	0	0	21700	6390	12000	1500	0	0	12800	24930	8100	11080	0	78969
2049	17900	0	1500	690	2900	0	0	0	0	0	23200	6390	12240	1500	0	0	12800	25000	8100	10760	0	79640
2050	16120	0	1500	690	2900	0	0	0	0	0	24700	6390	12240	1500	0	0	12800	25000	8100	10520	0	80163

Source : Integrated Resource Plan for Electricity (IRP) 2010-2030 Update Report 2013

(System planning)

(a) IRP

IRP mentioned the impact of demand and supply balance with allocation of generation development against extra high voltage transmission systems, namely five corridors, based on SGP.



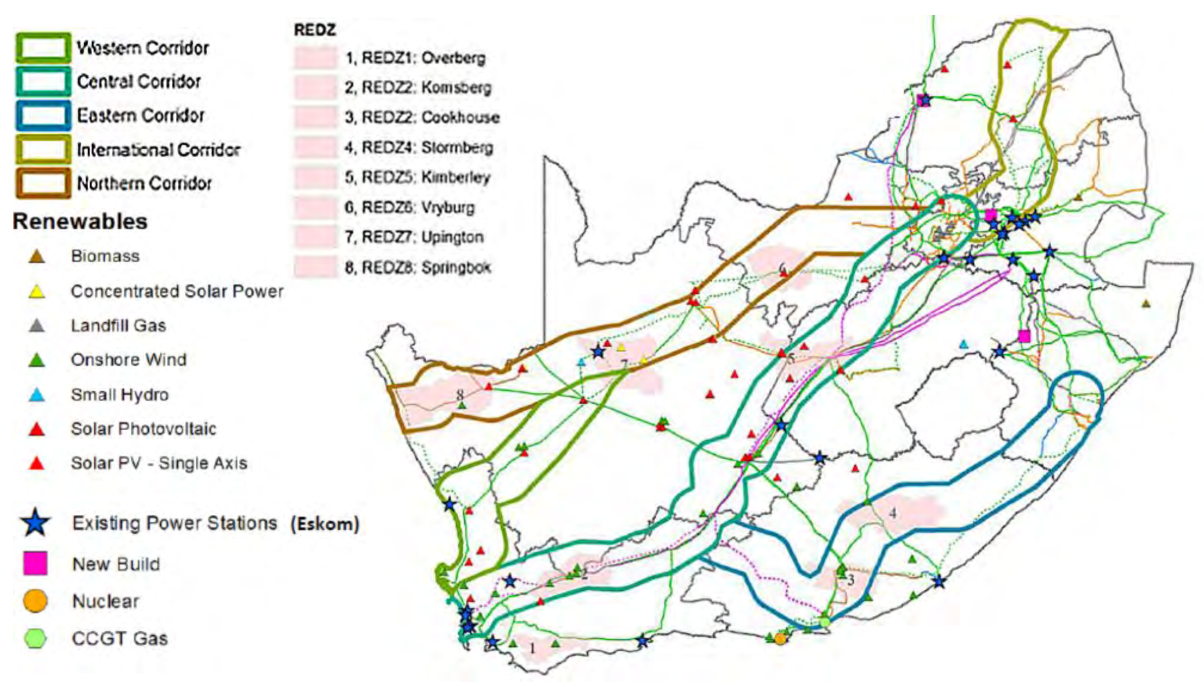
Source : Integrated Resource Plan for Electricity (IRP) 2010-2030 Update Report 2013

Figure 3.8-9 Trunk system block policy illustrated on IRP

(b) TDP

TDP describes the transmission and substation development precisely in terms of investment cost calculation and technical designing.

Corresponding to Figure 3.8-9, TDP wrapped up practical overview for these corridors. Eskom is planning to come up with extra high voltage lines (765 kV) and high voltage lines (400kV) to connect various generation sources to meet the concept on IRP and TDP (Figure 3.8-10).



Source : Transmission Development Plan2016-2025 Public Forum (2015)[48]

Figure 3.8-10 Specific trunk system blocks in Strategic Grid Plan

4) Integrated Resource Plan 2016

IRP was bone in 2013, therefore revise of IRP is needed to fit the current condition. DoE released the new resource plan to be evaluated and to establish the IRP.

Currently, DoE is holding several public workshops in RSA to explain the methodologies and the findings. Comments against the evidences of DoE are gathered until the end of March 2017, after the consultation of the comments and updating the data, new IRP, namely Integrated Resource Plan 2016 will be published in 2017.

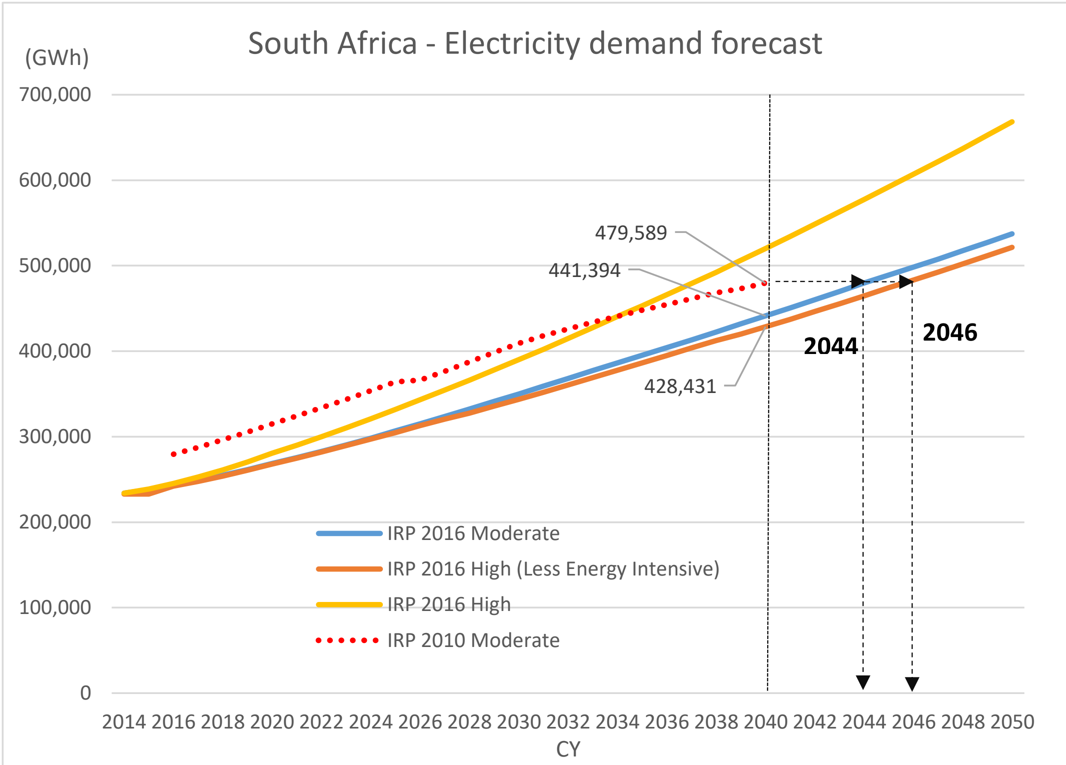
Here, information disclosed at public work shop would be explained briefly. By the way, this information is called "IRP 2016" for the explanation.

(a) Demand forecast on IRP 2016

Figure 3.8-11 shows the demand forecast on IRP 2016. Demand is forecasted by the regression equitation for several sectors, such as agriculture, transportation, commerce, manufacture, mining and retail. Further, three cases of GDP growth, namely low, high and moderate are applied for this prediction. These are common procedure.

Remarkable point of this forecast is calibration with energy intensity, thus high case demand forecast is revised downward by the effect of energy intensity in commerce and manufacture. Therefore, perspective of this case, High (Less energy intensity sectors) is lesser than that of moderate case, as shown Figure 3.8-11. In fact, demand forecast on High (Less energy intensity sectors) is informed the one to be chosen instead of that on moderate case.

[48] Renewable Energy Development Zones (REDZ) is the region for energize renewable energy development acceleration.



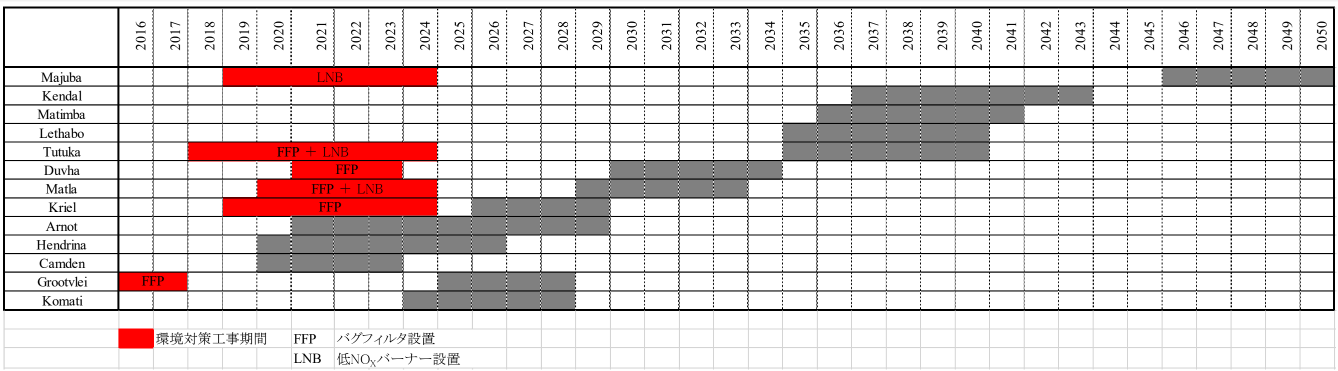
Source： JICA Survey Team using Forecasts for electricity demand in South Africa (2014 – 2050) using the CSIR sectoral regression model (2016) Project report

Figure 3.8-11 Demand forecast on IRP 2016

(a) Generation development plan

On IRP 2016, generation development plan is analyzed by following requisites.

- ✓ Generation development plan of Eskom's assets
- ✓ Generation development plan by IPPs,
- ✓ Generation installation schedule by REIPPPP
- ✓ Demand response effect
- ✓ Eskom coal-fired generation fleets' retrofit schedule for emission abatement, and decommission schedule
- ✓ Power import



Source： JICA Survey Team using Integrated Resource Plan Update – Assumptions, base case results and observations Revision 1 (2016) – DoE

Figure 3.8-12 Eskom's coal-fired plant rehabilitation schedule and decommission year perspectives

Eskom coal-fired generation fleets' retrofit schedule is the retrofit construction to set the environmental protection facilities to meet the Minimum Emission Standards under National Environmental Management Act advocated in April 2010 (Table 3.8-12).

Table 3.8-16 shows the result of generation development plan on IRP 2016[49]. Toward 2050, generation capacity in RSA will be 128GW in total, e.g. 18GW by PV, 37GW by wind generators, 20GW by nuclear, 22GW by CCGT, 13GW by OCGT 15 GW by coal-fired, and 2.5GW by power import from Inga 3.

As for nuclear power, IRP 2016 proposes the installation in 2037, but in 2025 on IRP. And coal-fired power is proposed in 2028 on IRP 2016, but in 2021 on IRP. As for gas-fired, OCGT is proposed in 2024 and CCGT is in 2025 on IRP 2016, but in 2010 (OCGT) and in 2023 (CCGT) on IRP.

In this way, comparison of the result between on IRP and IRP 2016 shows that gas-fired generation development is relatively same but nuclear power development and coal-fired development are changed to be late.

Below is the assumption on the point of power supply allocation.

(Base load)

As for power import, IRP 2016 apparently states the power from Inga 3. That means clear intention to develop Inga 3.

Capacity of nuclear power on IRP 2016 is twice as much as that on IRP. Thus, RSA plans to introduce nuclear power as the main base load fleets in future.

Coal-fired power is also the driving fleet to supply the base load. It assumes that most of the plants are mine mouse generation and they will apply fluidized Bed Combustion (FBC) and Pulverized Coal-fired (PC) technologies. Further on the point of environmental constraints, flue gas desulfurization (FGD) and carbon dioxide capture and storage (CCS) are examined to set as the standards.

(Middle load, peak load)

OCGT and CCGT are the driving fleets to supply as middle load and peak load generators. On IRP 2016, these plants are analyzed as the ordinary facility set or as ordinary facility plus CCS on the point of carbon dioxide reduction.

Especially, OCGT will be able to absorb the fluctuated output from PV, e.g. to be a balancing generator.

These are set on the coastal area in RSA.

By the way, Integrated Resource Plan introduces useful technologies to be adopted. On IRP 2016, NaS battery system and advanced lead storage battery, Japanese technologies are published for the first time.

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[49] Just the one case on IRP. IRP Formal version has a lot of cases with several aspects. Therefore this might not be the right one.

Table 3.8-16 Geneeration development plan on IRP 2016

	PV	Wind	CSP	Landfill gas	DR	Nuclear	OCGT	CCGT	Coal IPP Procurement Programme	Coal	Co-generation	Inga	Yearly acculumated capacity (MW)	Yearly accumulated capacity excluding RE (MW)	Peak demand (MW)
2016	1,328	1,373	200												
2017	1,478	1,994	300	13							11				
2018	1,842	2,378	600	13											
2019	2,412	3,188	1,050	28											
2020	2,811	4,006	1,050												44,916
2021	160								900				160		46,130
2022	160												320		47,336
2023	370	200											890		48,547
2024	440	500			1,000		396						2,226	396	49,656
2025	650	1,000		15	1,000		2,376	732					6,999	3,504	51,015
2026	580	1,000		5	1,000		264	1,464					10,312	5,232	52,307
2027	580	1,000		230	1,000		264	2,196					14,582	7,692	53,561
2028	580	1,000			500		396	1,464		1,500			19,522	11,052	54,567
2029	580	1,100			1,000			1,464		1,500			24,166	14,016	56,009
2030	580	1,200			1,000		1,716			2,250		1,000	30,912	18,982	57,274
2031	580	1,200			1,000		1,584			750			35,026	21,316	58,630
2032	580	1,000			500			732		1,500		1,000	39,838	24,548	59,878
2033	580	1,200						1,464		750		500	44,332	27,262	61,388
2034	580	1,600			1,000		1,452						47,964	28,714	62,799
2035	580	1,600			500			1,464		1,500			53,108	31,678	64,169
2036	580	1,600			1,000					1,500			56,788	33,178	65,419
2037	580	1,400			500	1,359		732		2,250			63,109	37,519	66,993
2038	580	1,600					1,848	1,464		750			69,351	41,581	68,375
2039	650	1,500				1,359		2,928					75,788	45,868	69,584
2040	650	1,600			1,000		1,056	732					79,826	47,656	70,777
2041	650	1,600			1,000	4,077	792			750			87,695	53,275	72,343
2042	650	1,600			500			2,196					92,141	55,471	73,800
2043	650	1,600			500								94,391	55,471	75,245
2044	650	1,800			500	1,359							98,200	56,830	76,565
2045	770	1,600				2,718		2,196					105,484	61,744	78,263
2046	790	1,600			500	1,359	924						110,157	64,027	79,716
2047	720	1,800			1,000	1,359		732					114,768	66,118	81,177
2048	720	1,600			500	2,718	264						120,070	69,100	82,509
2049	660	1,500			500	1,359							123,589	70,459	84,213
2050	720	1,400			500	2,718							128,427	73,177	85,804
Total (MW)	17,600	37,400		250		20,385	13,332	21,960		15,000		2,500			

Red shows the prospects which DoE's procurement programmes executed

Source : JICA Survey Team using Integrated Resource Plan Update – Assumptions, base case results and observations Revision 1 (2016) – DoE

3.9 Swaziland

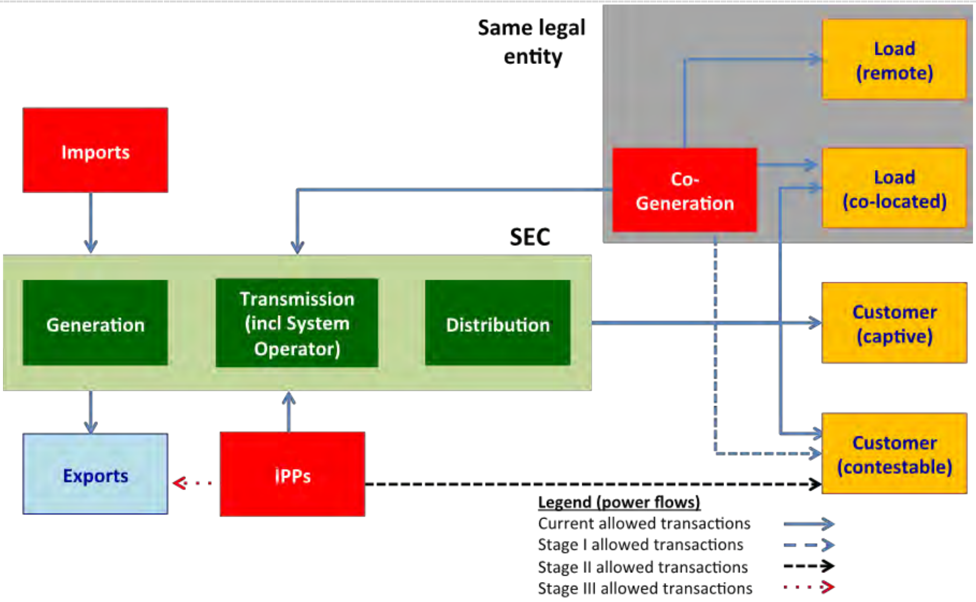
3.9.1 Power Sector

(1) Overview of power sector, administrative body, and regulatory body

Electric power supply had been operated by the Swaziland Electricity Board (SEB), established in 1963 under the administration of the Department of Energy of the Ministry of Natural Resources & Energy. In 2007, the Swaziland Electricity Company Act was amended, which prompted the restructuring the Board to the Swaziland Electricity Company (SEC). SEC is a vertically integrated business utility so that it can carry out generation, transmission, distribution and retail businesses in Swaziland.

In 2007, the Energy Regulatory Act was enacted and the Swaziland Energy Regulatory Authority (SERA) was established as the regulatory authority of the power industry. SERA carries out the approval of electricity tariffs, licensing power industry (issuing six kinds of licenses for generation, transmission, distribution, retail, export and import) and preparation of standards such as Grid Code. SEC also received approval from SERA.

In generation business, IPPs, i.e. Ubombo Sugar Limited and Royal Swaziland Sugar Corporation have participated. (These companies participate generation business using the squeezed residue of sugar cane, etc., as fuel). The power generated by SEC is only approximately 25% of the power sold, and most of the power procures from IPPs and import from Eskom, RSA and EDM, Mozambique.

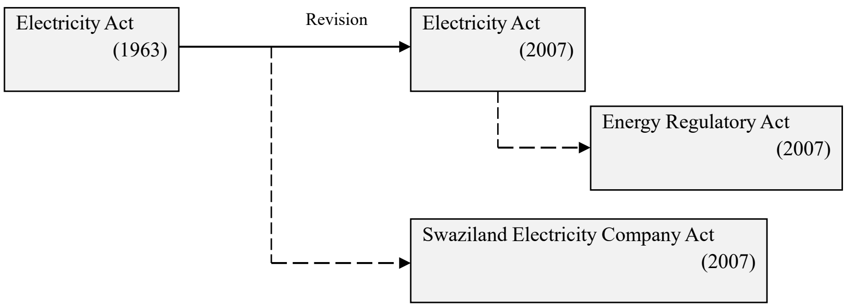


Source : SERA WEB Site

Figure 3.9-1 Power sector in Swaziland

(2) Electricity-related laws and regulations

Correlation between electricity-related laws and regulations in Swaziland are shown in Figure 3.9-2. The Energy Regulatory Act allows participation of IPPs.



Source : JICA Survey Team (based on SAPP)

Figure 3.9-2 Framework of legal system in power sector

(3) Energy policy

Ministry of Natural Resources & Energy focuses on the following objectives to power sector in His Majesty's Government Programme of Action 2013-2018 (Ministries' Action Plans to 2018 and 2022).

➢ Promotion of rural electrification

To improve the electrification ratio of ordinary households from 60% to 75% by December 2018. All the people of the nation will be connected to power system by 2022.

➢ Enhancement of generation facilities

To construct thermal power plant(s), its capacity is over 300MW, applying PPP model in order to achieve 100% of domestic generating capacity (rate) and to divert exports to RSA. To increase the number of substations and construct transmission lines. To improve the quality of electricity.

➢ Introduction of renewable energy

To increase the ratio of renewable energy including hydropower generation on capacity, e.g. to increase the capacity to 50% of demand in 2018 from 28% in current situation.

(4) Electricity tariff

Electricity tariff system in Swaziland classifies customers into life line (for poverty), domestic (residential), general purpose, commercial (small size prepaid, small size metered and large size), irrigation (small and large size) and industry, etc. Only electricity tariffs are charged for domestic (residential) customer use, and facility tariffs (fixed) and electricity tariffs are charged to general purpose and small size commercial. Customers in industry and large commercial pay electricity demand tariffs and access tariffs in addition to facility tariffs (fixed) and electricity tariffs. The electricity tariff is also determined by receiving voltage and usage hours, especially time of use (TOU).

Table 3.9-1 Electricity tariff (Swaziland)

Electricity Tariff -Swaziland

Notice of SEC Tariff Schedule 2015-2016

Type	NON-TOU TARIFFS	Facility Charge SZL / Month	Energy Charge SZL / kWh	Demand Charge SZL / kVA	Access Charge SZL / kVA (12 months highest)
S10 Life Line			1.0431		
S1	Domestic		1.1235		
S2	General Purpose	172.5303	1.5579		
S3	Small Commercial - prepayment	172.5303	1.5579		
S3	Small Commercial- credit meter	345.0607	1.5579		
K4	Small Holder irrigation	1,528.7756	0.5910	99.2514	41.2150
K5	Large Commercial and Industrial	1,798.5503	0.6954	116.7633	48.5004
K6	Large Irrigation	1,798.5503	0.6954	116.7633	48.5004

TOU TARIFFS	T1	T2	T3	T4
	TOU at MV at HV network	TOU at MV	TOU at LV	TOU small irrigation < 100kVA
Facility Charge SZL / month	4,171.91	2,007.86	1,510.40	1,283.85
Demand Charge SZL / kVA	106.1516	111.2048	116.7633	99.2514
Access Charge SZL / kVA	48.2923	50.5942	48.4963	45.1533
Energy - Low Demand - Peak SZL / kWh	1.0821	1.1115	1.1312	0.9767
Energy - Low Demand - Standard SZL / kWh	0.7695	0.7895	0.8029	0.6977
Energy - Low Demand - Off SZL / kWh	0.6205	0.636	0.6465	0.5646
Energy - High Demand - Peak SZL / kWh	3.0798	3.1722	3.2337	2.7488
Energy - High Demand - Standard SZL / kWh	0.9437	0.9721	0.9909	0.8423
Energy - High Demand - Off Peak SZL / kWh	0.6205	0.636	0.6465	0.5646

Source : SEC (2016)

Trial calculation of electricity tariffs is made for typical customers, the results of which are shown in Table 3.9-2.

Table 3.9-2 Trial calculation of electricity tariff (Swaziland)

Customer Category	Assumed consumption (kWh / month)	Electricity Tariff (US cents/kWh)
Domestic (Residential)	100	8.03
Small Commercial	1,000	13.60
Large Commercial/Industry	10,000	14.89

1 USD = 0.07149 SZL, as of December, 2016

Source : JICA Survey Team

3.9.2 Power demand, existing facilities and development plan

(1) Power demand

Statistics of power demand in Swaziland are shown in Table 3.9-1.

Table 3.9-3 Electricity statistics of SEC (Swaziland)

Items \ FY		2010	2011	2012	2013	2014
Energy send out (GWh)		1,186.3	1,138.1	1,129.8	1,108.6	1,205.2
(SEC internal generation)		(288.1)	(333.4)	(279.8)	(239.8)	(302.3)
SEC's internal generating rate (%)		24	29	24	22	25
Electricity Sold (GWh)		1,018.6	976.8	955.1	939.3	1,034.6
Electricity sold Breakdown (GWh)	Industrial	389.6	360.2	338.0	318.8	352.5
	Agricultural	218.3	211.1	231.3	218.1	241.2
	Commercial	102.7	100.9	71.2	93.0	102.8
	Domestic	308.0	304.6	314.6	309.4	338.2
System Loss (%)		14.9	14.2	15.5	15.2	14.2
Peak Demand (MW)		204.5	200.8	203.0	213.7	221.2

Source : SEC Annual report (2013, 2014)

(2) Existing facilities

1) Generating facilities

The table below shows existing generation facilities of SEC.

Table 3.9-4 Generation facilities of SEC in Swaziland

Power Plants	Type	Capacity (MW)	Remarks
Maguga	Hydro	19.8 (9.9MW×2)	
Ezulwin	Hydro	20.0 (10.0MW×2)	
Edwaleni	Hydro	15.0（2.5 MW×4、5.0 MW×1）	
Maguduza	Hydro	5.6（5.6MW×1）	
Edwaleni	Diesel	9.0（4.5MW×1）	Not operated due to high generation cost

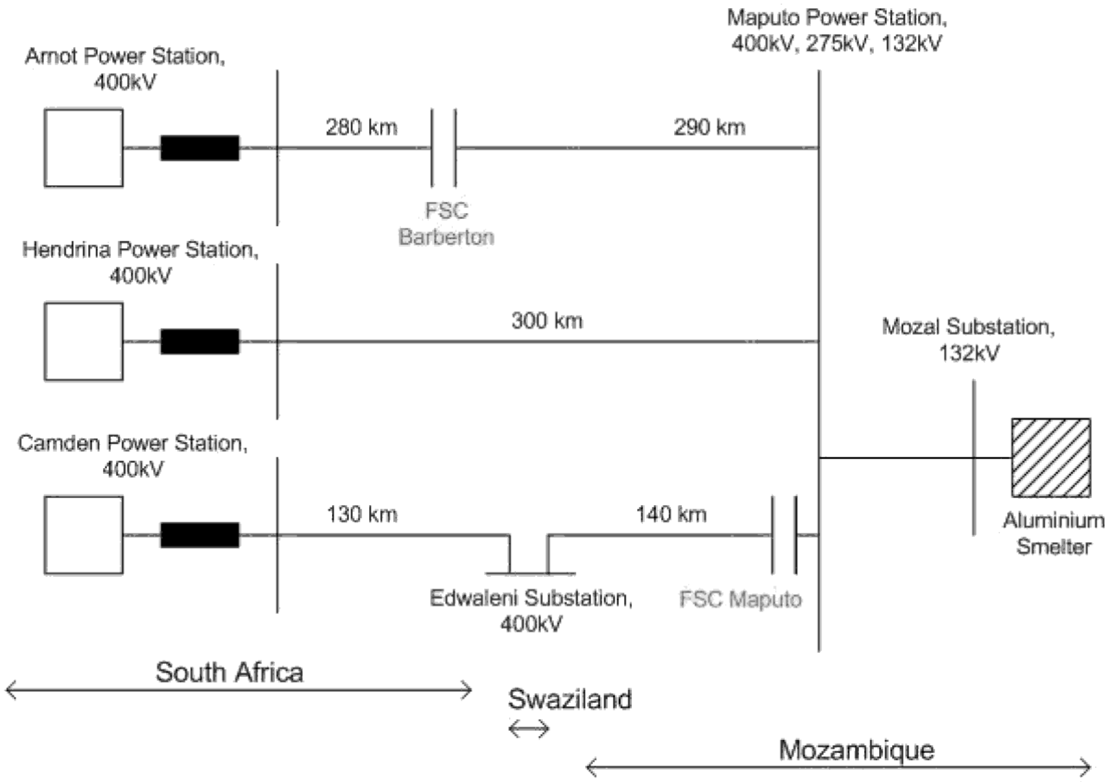
Source : SEC Website

2) Transmission facilities

SEC possesses only load system transmission lines. Bulk power is given by the trunk system operated by Mozambique Transmission Company (MOTRACO). MOTRACO is a transmission company, and she gives bulk power from RSA to Mozambique and to Swaziland (Figure 3.9-3).

3) Interconnector

Two routes of interconnectors exist in Swaziland as shown in Table 3.9-5. Construction and maintenance of these lines are conducted by MOTRACO.



FSC: Fixed Series Capacitor

Source：Increased Power Transmission for Aluminum Smelter in Maputo, Siemens technical news

Figure 3.9-3 Power system in Swaziland

Table 3.9-5 Interconnector (Swaziland)

RSA	EdwaleniII － Camden 400kV, 1 line
Mozambique	EdwaleniII － Maputo 400kV, 1 line

Source : JICA Survey Team

(3) System development plan

1) Generation development plan

SEC launched a survey on the hydroelectric potential on the Ngwempisi Valley in 2015 with support by AfDB.

As for the energy policy, it focuses on development of thermal power plants. Definitely, preparation of FS for coal-fired power development based on the coal inventory study[50].

2) System planning

SEC only has load system, and there is no specific plan for an ultra high voltage system installation by MOTRACO.

3) Power system master plan

Power system master plan does not exist. In the Regional Infrastructure Development Master Plan, Energy Sector Plan, 2012 by SADC, for electric energy policy and masterplan in Swaziland, it is determined

50 http://www.times.co.sz/business/107381-good-news-as-ample-coal-reserves-found.html

that there exists no master plan in Swaziland.

4) Cooperation by the donor organizations

Status of support to individual projects for system development is shown in Table 3.9-6.

Table 3.9-6 Support detail by donors in Swaziland

Donors	Types	Projects	Remarks
India	Generation	Ngwempisi hydropower (120 MW[51])	Pre-FS
India	Generation	Coal-fired power plant	Pre-FS
India	Generation	PV	Pre-FS
India	Generation	Gas-fired power plant	Pre-FS

Source : JICA Survey Team

51 http://www.observer.org.sz/news/76874-indian-energy-company-keen-on-thermal-plant.html

3.10 Tanzania

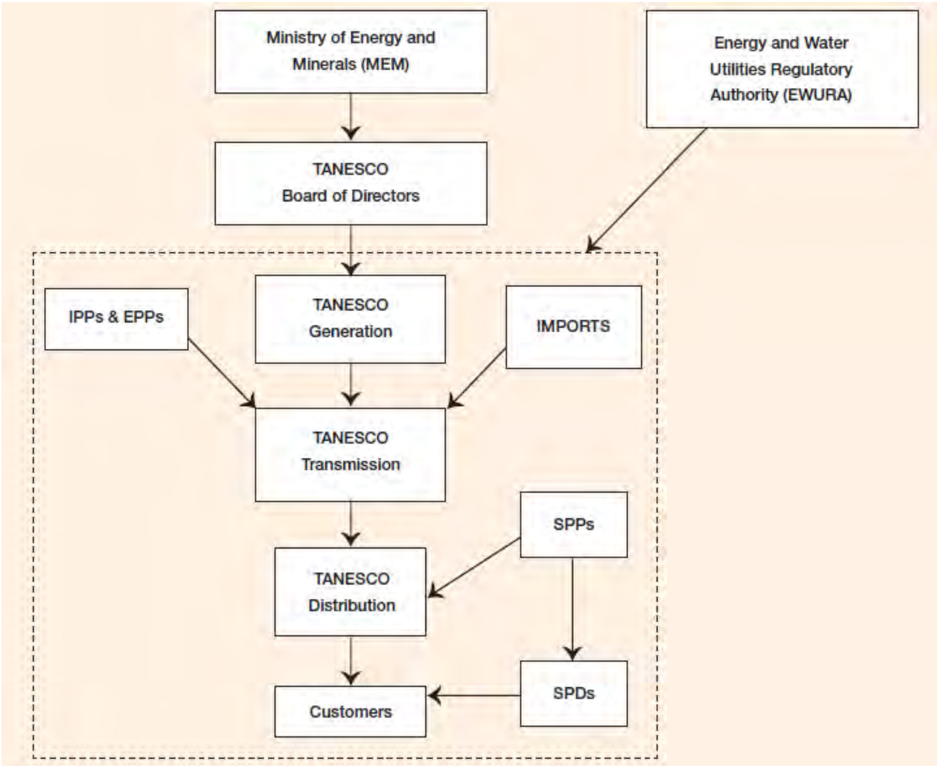
3.10.1 Power Sector

(1) Overview of Power Sector

1) Tanzania Electric Power Supply Corporation (Tanesco)

Electric power supply in Tanzania is operated by Tanesco, which was established in 1964, under the Electricity Act of 2008 and the administration of the Energy Division of the Ministry of Energy and Minerals (MEM).

However, it operates only on the mainland of Tanzania and on Zanzibar Island, a separate authority operates the power grid. Tanesco is a vertically integrated business so that it can carry out generation, transmission, distribution and retail businesses.



Source : EWURA 9th Annual Report (2015)

Figure 3.10-1 Formation of power sector (Tanzania)

2) Zanzibar Electricity Corporation (ZECO)

On Zanzibar, ZECO provides electricity to all customers. ZECO has no generator, so ZECO buys electricity from Tanesco through submarine cable between main land and the island.

3) Other companies

As of 2015, in generation business the seven companies, such as Independent Power Tanzania Limited (IPTL), Songas Tanzania Limited, Tanzania Wattle Company (TANWAT), Ngombeni, Angoya, Mwenga Hydropower Limited and Tanganyika Planting Company Limited (TPC) participates in power sector.

Also Symbion Power Tanzania Limited and Aggreko participate in power sector as Emergency power producer (EPP).

(2) Administrative body

1) Ministry of Energy and Minerals (MEM)

Energy Division of Ministry of Energy and Minerals (MEM) controls Tanesco under Electricity Act, 2008.

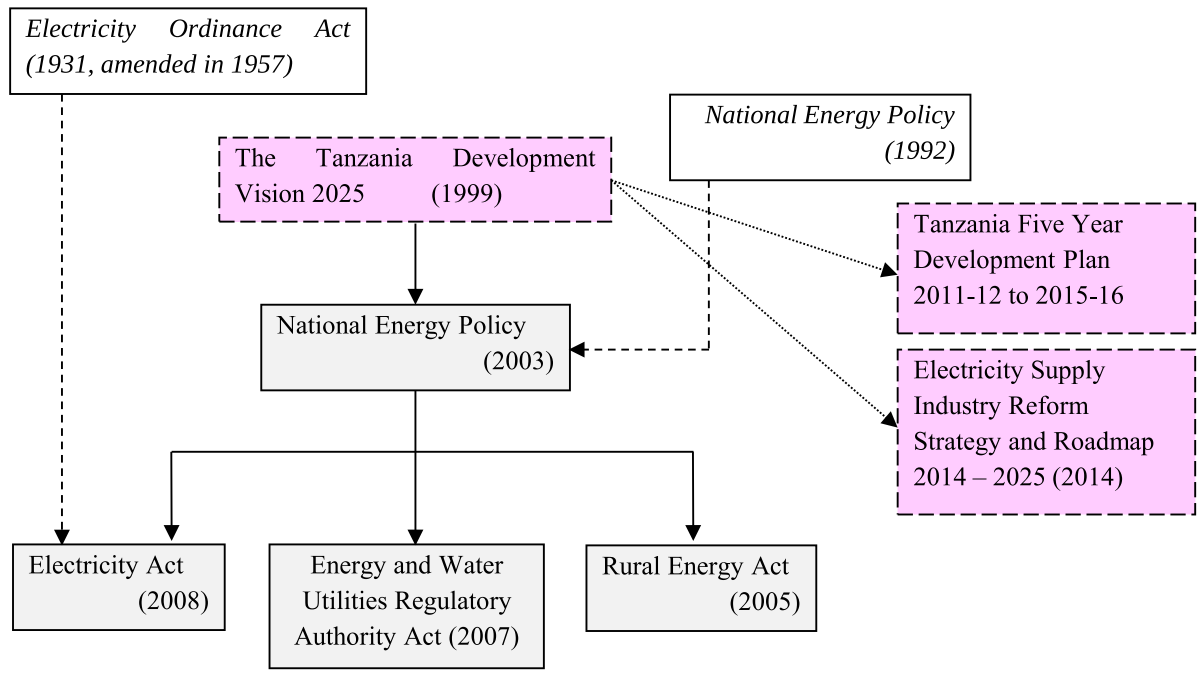
As for Zanzibar, it has another body. Ministry of Land, Water, Energy and Environment (MLWEE) controls ZECO.

2) Rural Energy Agency

Activities of rural electrification in Tanzania is promoted by the Rural Energy Agency and Rural Energy Fund, which were established under the Rural Energy Act of 2005.

(3) Electricity related laws and policies

Electricity-related laws and policies in Tanzania are shown in Figure 3.10-2.



Source : JICA Survey Team (based on Tanesco and EWURA)

Figure 3.10-2 Electricity-related laws and policies (Tanzania)

(a) The Tanzania Development Plan 2025 (1999)

The Tanzania Development Plan 2025, which was published in 1999, set out that the government takes the lead in investments related to infrastructure in energy field and promotes investment from private sector and local communities. Further, it aims to have benefits of not only investment but job creation.

(b) National Energy Policy (2003)

National Energy Policy, established in 2003, provides the vision, striving to improve the economic growth and life of the nation through sustainable efforts with considering the environment. The power sector focuses on the following approaches specifically.

- Power supply capacity should be grown to triple in coming 20 years and aggressive participation of private sector should promoted.
- Economic growth should be achieved by interconnection with neighboring countries with securing

reliability

- Promotion of rural electrification should be done to develop economic activities in rural areas.

And strategies in energy sector is introduction of a market economy, cooperation and accommodation of electric energy with surrounding countries, energy savings and efficient energy use, environmental management and promotion of gender justice, etc.

(c) Tanzania Five Year Development Plan 2011-12 to 2015-16

This plan is short term plan and the objectives to be aimed are as follows.

- Utilization of new potential energy resources such as geothermal, solar power, wind power, gas and coal.
- Enhancement of Tanzania's regional trade share by connecting to at least 50% of grids of its riparian countries.
- Increase of management capacity regarding generation, transmission and electricity sales.
- Expansion of rural electrification.

(d) Electricity Supply Industry Reform Strategy and Roadmap 2014 – 2025 (2014)

Based on the gist of the Tanzania Development Plan 2025, this describes the grounds and mechanisms related to restructure of power sector in Tanzania. Father, this describes the restructuring schedule, personnel, funds and market structure.

(4) Regulatory body

Energy and Water Utilities Regulatory Authority (EWURA)

Under the Energy and Water Utilities Regulatory Authority Act, enacted in 2001, EWURA was established. It conducts, as regulatory authorities related to the energy sector, management of laws and regulations, approval and licensing of power industry and electricity tariffs, supervision of operators, handling of complaints and litigation, etc.

As for Zanzibar, another body exists. Zanzibar Utilities Regulatory Authority (ZURA) manages the regulatory works.

(5) Electricity tariff

Electricity tariffs are determined as shown in Table 3.10-1.

The electricity tariff system of Tanzania is generally classified into domestic (residential) customer use, general purpose, low voltage, high voltage and, for Zanzibar, according to the voltage and electric energy of customers. The tariff breakdown is comprised of an electricity tariff, a service tariff and an electricity demand tariff and tariffs are set according to customer category.

The simulation of electricity tariffs in Tanzania is as shown in the following Table 3.10-2.

Table 3.10-1 Electricity tariff (Tanzania)

Electricity Tariff -Tanzania (2015)

	Domestic Low Usage (D1)	General Usage (T1)	Low Voltage Max (T2)	High Voltage Max (T3)	Zanzibar
	TZS	TZS	TZS	TZS	TZS
Low Energy (0 - 50kWh) - per kWh	60.00				
High energy charge per kWh (above 50 kWh)	273.00				
Service Charge per Month		3,841.00	14,233.00	14,233.00	14,233.00
Demand Charge per kVA			16,944.00	14,520.00	12,079.00
Energy Charge per kWh		221.00	132.00	118.00	106.00

Note : All the charges above exclude VAT

Tariff Categories

Domestic Low Usage Tariff (D1)	This category covers domestic customers who on average have a consumption pattern for 50 kWh. The 50 kWh are subsidized by company are not subjected to service charge. Under the category any unit exceeding 50 kWh is charged a higher rate up to 283.4 kWh. In this tariff category, power is supplied at a low voltage, single phase (230 V).
General usage Tariff (T1)	This segment is applicable for customers who use power for general purposes: including residential, small commercial and light industrial use, public lighting, and billboards. In this category the average consumption is more 283.4 kWh per meter reading period. Power is given at low voltage single phase (230 V), as well as three phase (400V).
Low voltage maximum Demand (MD) usage tariff (T2)	Applicable for general use where power is metered at 400 V and average consumption is more than 7,500 kWh per meter reading period and demand doesn't exceed 500 kVA per meter reading period.
High Voltage Maximum Demand (MD) usage tariff (T3).	Applicable for general use where power is metered at 11kV and above.

Source : Tanesco (2015)

Table 3.10-2 Trial Calculation of Electricity Tariff (Tanzania)

Customer Category	Assumed consumption (kWh / month)	Electricity Tariff (US cents/kWh)
Domestic (Residential)	100	12.29
Small Commercial	1,000	10.12
Large Commercial/Industry	10,000	13.63

1 USD = 0.00045TZS, as of December, 2016
Source : JICA Survey Team

3.10.2 Power demand, existing facilities and development plan

(1) Power demand

The recent power demand and electricity sales, etc. by Tanesco are shown in Table 3.10-3

Table 3.10-3 Electricity statistics of TANESCO (Tanzania)

Items \ FY	2010	2011	2012	2013	2014
Power Transmission to System (GWh)	-	-	-	6,086	6,164
(Power generated by Tanesco, Gwh)	-	-	-	3,415	4,028
Tanesco in-company generation rate (%)	-	-	-	56	65
Electricity Sold (GWh)	4,175	4,093	4,443	4,776	-
Power loss (%)	-	21.4	21.9	19.0	18.2
Distribution loss (%)	-	15.3	15.8	12.9	12.1
Transmission loss (%)	-	6.1	6.1	6.1	6.1
Peak Demand (MW)	832.6	-	890	890	935

Source : Power System Master Plan 2012 Update (2013), and Tanesco Financial Statement (2012, 2013, 2014, 2015), EWURA9th annual report (2015) etc.

(2) Existing facilities

1) Generating facilities

(Hydropower)

Main hydropower fleets in operation in Tanzania are shown in Table 3.10-4. Table 3.10-5 shows hydropower by IPP as of January 2016.

Table 3.10-4 Existing hydropower plants (Tanzania)

	Hydropower						
	Kidatu	Kihansi	Mtera	New Pangani Falls	Nyumba ya Mungu	Hale	Uwenba
Rated capacity (MW)	204	180	80	68	8	21	0.843
Number of unit	4	3	2	2	2	2	3
Types	Reservior	RoR	Reservoir	RoR	Reservior	RoR	RoR

RoR : Run off river type

Source : JICA Survey Team using information from Tanesco Website etc.

Table 3.10-5 Hydropower by IPP (Tanzania)

Sites	Rated capacity (MW)	Number of unit	Owner
Mwenga	4	1	Mwenga Hydro Ltd.
Mapembasi	10	3	Mapembasi Hydropower Co., Ltd.
EA Power	10	2	EA Power Ltd
Darakuta	0.24	—	—

Source : Tanesco (2016)

(Thermal power)

Major thermal power generation fleets in operation in Tanzania are shown in Table 3.10-5.

Table 3.10-6　Existing thermal power plants in Tanzania

Owner	Sites	Types	Rated capacity (MW)	Commissioning year	Remarks
Tanesco	Ubungo 1	Gas	102（12 Units）	2007	
	Tenga GT	Gas	45（5× 9 MW）	2009	
	Ubungo 2	Gas	105（3×35 MW）	2012	
	Zuzu Diesel	Diesel	7（1× 7 MW）	2012	
Songas Power Limited	Songas 1	Gas	42（2×21 MW）	2004	
	Songas 2	Gas	120（3×40 MW）	2005	
	Songas 3	Gas	40（1×40 MW）	2006	
IPTL	Tegeta IPTL	Heavy oil	103（10 Units）	2002	
TPC (Sugar industry)	TPC	Biomass	17	2011	
TANWAT	TANWAT	Biomass	2.7	2010	.
Symbion Power Limited	Symbion Ubungo	Gas etc.	120	2011	Tanesco rents the facilities
Aggeko as EPP	Aggeko (Ubungo)	Diesel	50	2011	
	Aggeko (Tengeta)	Diesel	50	－	
Symbion Power Limited as EPP	Symbion Dodoma	Heavy oil	55	2012	
	Symbion Arusha	Heavy oil	50	2012	

Source : JICA Survey Team using information from Tanesco

2) Transmission facilities (Interconnector)

Tanesco's transmission system comprises 48 substations on grid and 6,071 km transmission lines (3,340 km on voltages 220kV, 2,063 km on 132kV and 668 km on 66kV).

Total installed capacity of 48 on grid substations and 3 off grid substations is 3,674.9 MVA.

3) Interconnector

Tanzania has no interconnector with SAPP as of 2016.

(3) System development plan

1) Generation development plan

(Hydropower)

According to the information on the website, etc., the construction schedule of hydropower generation, which are now planned or viable prospects in Tanzania are shown in Table 3.10-6.

Table 3.10-7 Hydropower development plan (Tanzania)

Sites	Capacity (MW)	Project cost (M USD)	Status	Developer
Kakono	53	379	Pre-FS	-
Igamba Falls	8	-	-	Tanesco
Stiegler's Gorge Phase 1	300	-	Planning	Tanesco
Stiegler's Gorge Phase 2	600	-	Planning	Tanesco
Stiegler's Gorge Phase 3	1,200	-	Planning	Tanesco
Mpanga	144	-	-	-
Taveta-Mnyera	144	-	-	Tanesco
Ruhundji	358	-	-	Tanesco (WB supports)
Masigira	118	-	-	N/A (China supports)
Rumakali	222	-	RFP	Tanesco (WB supports)
Songwe	340	329	-	Tanesco

Source : JICA Survey Team using information from Tanesco, etc.

(Thermal power)

According to the information on Website, etc., the construction schedule of thermal power generation plants, which are now planned or viable prospects in Tanzania are shown in Table 3.10-8.

Table 3.10-8 Thermal power development plan (Tanzania)

Sites	Types	Capacity (MW)	Project cost (M USD)	Developer
Mchuchuma Coal Phase 1	Coal-fired (Sub-C)	200	—	Sichuan Hongda Co. (China)
Mchuchuma Coal Phase 2	Coal-fired (Sub-C)	200	—	Sichuan Hongda Co. (China)
Kiwira Coal Phase 1	Coal-fired (Sub-C)	50	—	STAMICO
Kiwira Coal Phase 2	Coal-fired (Sub-C)	150	—	STAMICO
Kinyerezi 2	Gas-fired	240	344	Tanesco
Mtwara	Gas-fired	600	—	JV (Symbion Power and Tanesco)
Kinyerezi 3	Gas-fired	600	401	Tanesco
Kinyerezi 4	Gas-fired	350	300	Tanesco
Ubungo-Wartsila	Gas-fired	100	—	Wartsila Power

Source : JICA Survey Team using information from Tanesc, etc.

2) System planning

(Interconnector)

ZTK project are set as the priority project of SAPP. Among these, for Kenya, interconnector will be extended from Singida, Tanzania through Arusha to Nairobi in Kenya. This interconnector is scheduled to be constructed from 2016 with joint financing from JICA and AfDB. For Zambia, they are scheduled between Mbeya, Tanzania and Nakonde, Zambia with 400kV transmission line as Chapter 3 mentioned.

(Regional system)

Regional transmission line projects, especially trunk lines are shown in Table 3.10-8. A

Table 3.10-9 Main fleets of regional power system in Tanzania

Site name	Voltage (kV)	Section, Length	Construction Cost (M USD)	Developer
Iringa-Shinyanga TL	400	Iringa – Dodoma, 225km	463	IDA
		Dodoma－Singida, 217km		ADF, JICA
		Singida－Shinyanga, 228km		－
－	400	Iringa －Mufindi － Mchuchuwa－Mbeya	－	－
－	400	Dar es Salaam － Dodoma	230	－
Chalinze – Dodoma TL	400	Chalinze – Dodoma	175	－
North East Grid	400	Dar es Salaam － Arusha, 700km	820.5	China Exim Bank
North West Grid Phase1	400	Mbeya － Sumbawanga, 340km	145.4	China Exim Bank
Nyakanzi －Kigoma TL Phase 1	400	Nyakanzi －Kigoma	293	
Nyakanzi －Kigoma － Mpanda, TL Phase 2	400	Nyakanzi －Kigoma －Mpanda	568	
Mtwara - Songea	400	Mtwara Power station － Songea	1,300(*)	－
Mtwara – Lindi －Somanga	400	Mtwara － Somanga		

(*) The cost includes construction cost of Mtwara Gas Power Plant (600MW)

Source : JICA Survey Team using information from Tanesco, SAPP, etc.

3) Power system master plan

Government of Tanzania published power system master plan 2012 update (PSMP 2012) in 2012. In the meanwhile, analyses, such as demand forecast, generation development plan are insufficient to roll by herself. Here, JICA has been supported to revise this with JICA Study from June 2014 to March 2017[52]. Under this JICA study, government of Tanzania prepares power system master plan 2016 (PSMP 2016) and delivered it in December 2016 to relevant organizations. This has been published formally at MEM website.

Therefore, contents on PSMP 2016 should be explained in this section.

- Demand forecast

Three scenarios are applied for demand forecast of Tanzania.

Table 3.10-10 Scenarios for demand forecast (PSMP2016)

High growth (High)	Gas industries will be energized and after 2025 this business skyrockets and Tanzanian economy reaches the target on Vision2025.
Basic growth (Base)	Population growth and development of manufacture are firm like current situation. And after 2025 economic growth moderately slowdowns.
Low growth (Low)	International incident gives Tanzanian economy negative impact though Tanzanian economic condition is same as Base case.

Source：Power System Master Plan 2016

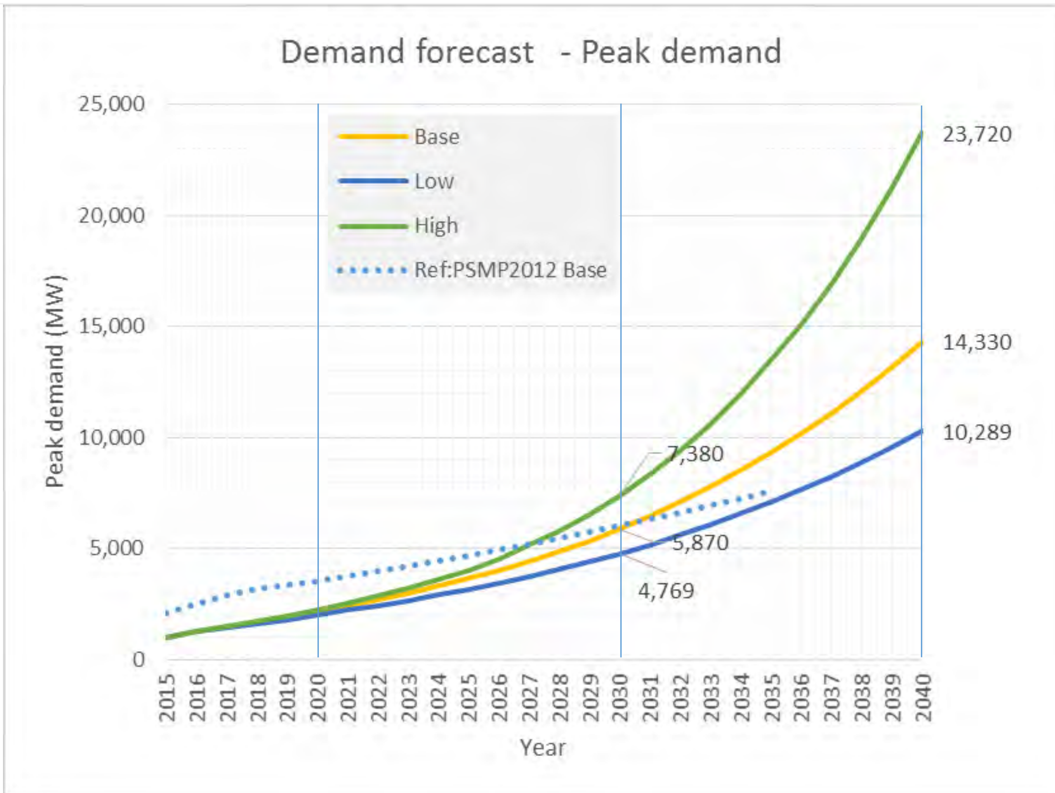
Figure 3.10-3, Figure 3.10-4 show the demand forecasts on PSMP2016. On these figures tracks of PSMP2012 are illustrated for the reference.

Demand forecasted by basic scenario indicates 11% on average in the period, 25 years. Therefore magnitude in 2020 will be twice as much as current situation, and that in 2030 will be six fold as much as

52 https://www.jica.go.jp/tanzania/office/activities/project/47.html

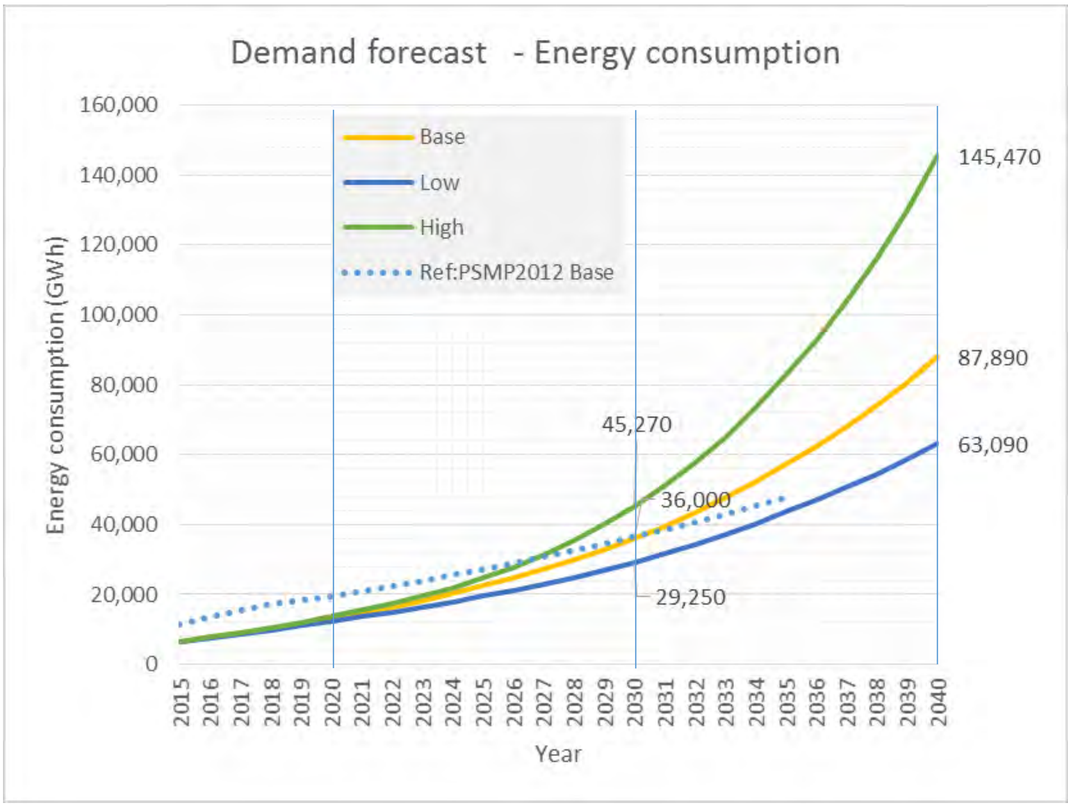
current situation. Further, demand forecasted on PSMP 2016 will be higher than that on PSMP 2012 beyond 2030.

Demand was created with comprehensive aspects, such as total energy consumption perspective in Tanzania, past records of power consumption, population growth, GDP growth, probability of bulk power consumer, grid access of rural area etc.



Source : JICA Survey Team using POWER SYSTEM MASTER PLAN 2016, PSMP2012

Figure 3.10-3 Demand forecast (peak demand, Tanzania)



Source : JICA Survey Team using POWER SYSTEM MASTER PLAN 2016, PSMP 2012

Figure 3.10-4 Demand forecast (energy consumption, Tanzania)

- Generation development plan, system planning

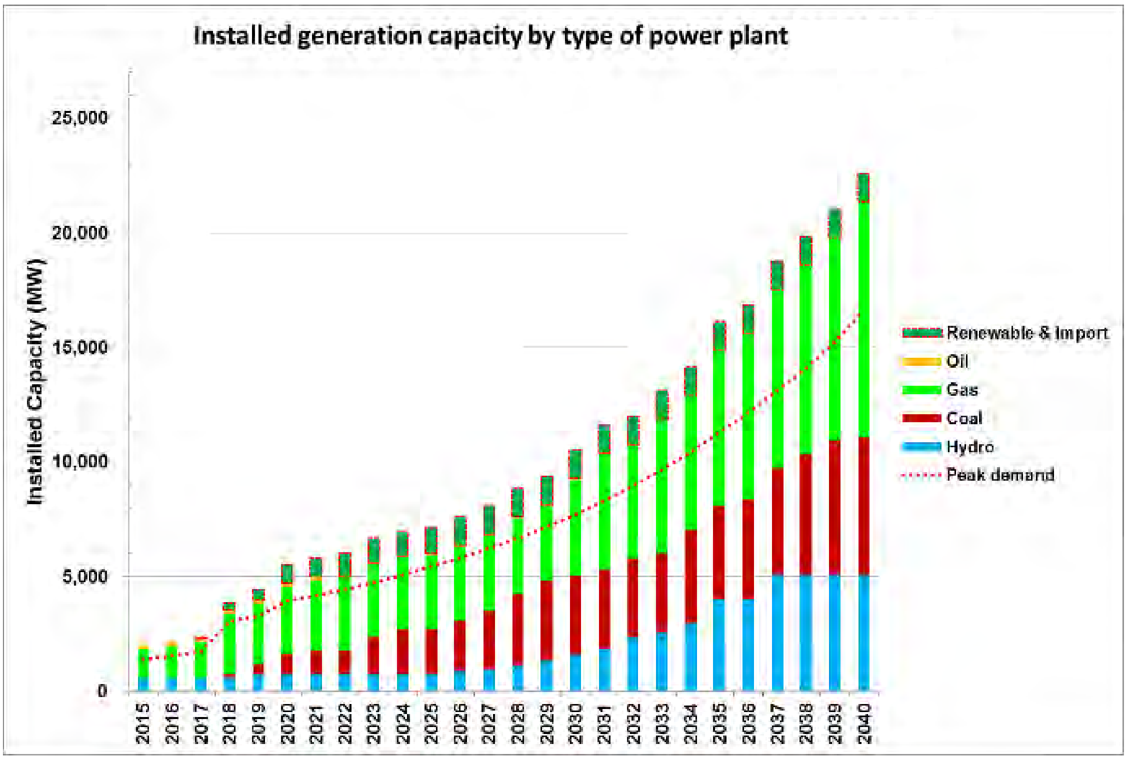
Generation development plan is created based on the beneficial utilization of national primal energy and the better allocation of generation mix by WASP simulation. As the result, 40% of gas-fired, 35% of coal-fired, 20% of hydropower and 5% of renewable is the better.

As for power trade through interconnectors, power import from Eastern Africa Power Pool (EAPP) with firm contract, the amount is 200MW as usual, 400MW at maximum will be planned. Further it is mentioned that aggressive power interchange dealt between SAPP and EAPP gives the least cost of electricity.

In the meanwhile, peak demand on Figure 3.10-5 has a deviation on that on Figure 3.10-3.

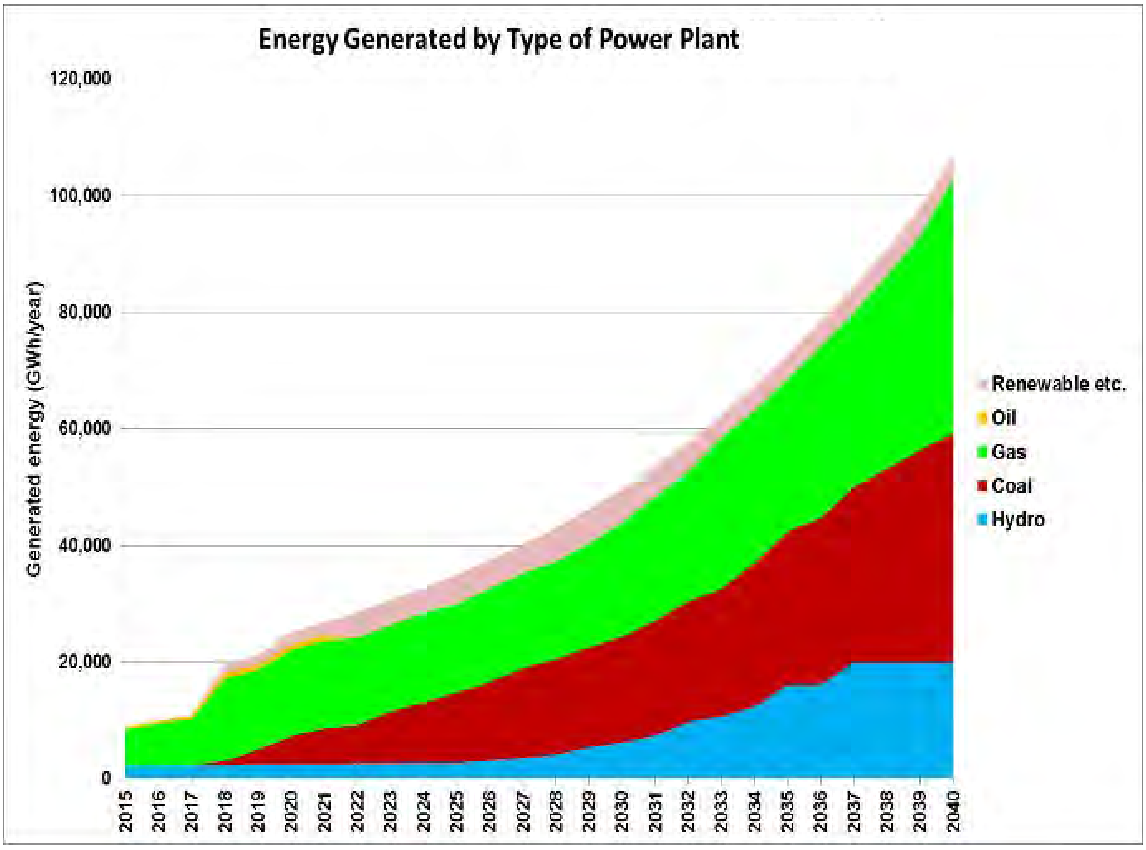
Demand on Figure 3.10-5 includes the norm by the government of Tanzania which strives to uplift the capacity to 4,915 MW by 20200 for industry development. Thus, in 2020 net capacity is 2,190 MW and capacity for power export (685 MW), and further 1,041 MW for stand by generator for captive power are estimated.

As for system planning, wide-spread integration of national grid and enhancement of interconnectors are planned. Remarkable point of this plan is trunk system has normally double circuits on the point of reliability. (Figure 3.10-7Figure 3.10-8)



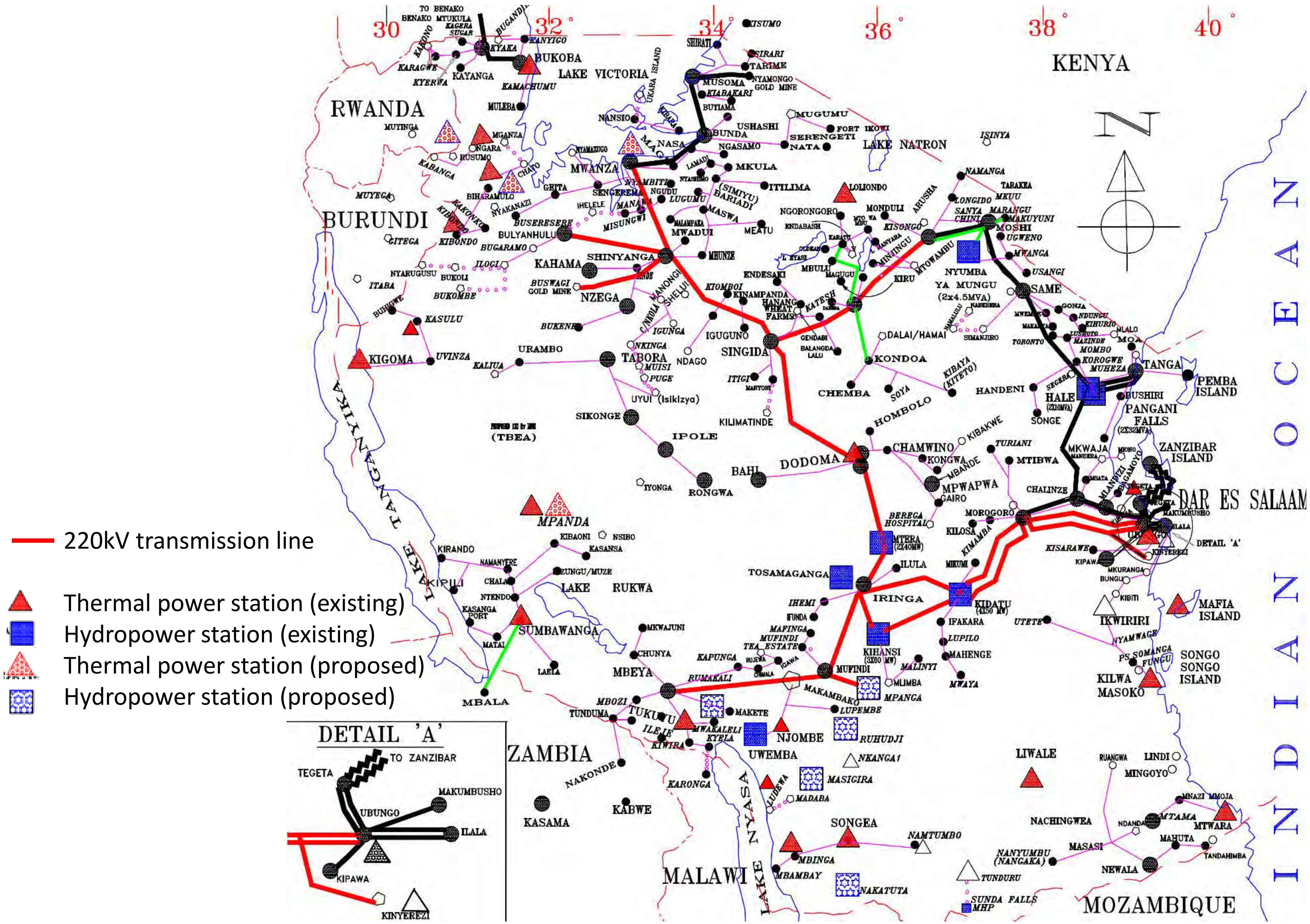
Source：POWER SYSTEM MASTER PLAN 2016

Figure 3.10-5 Generation development plan (capacity, Tanzania)



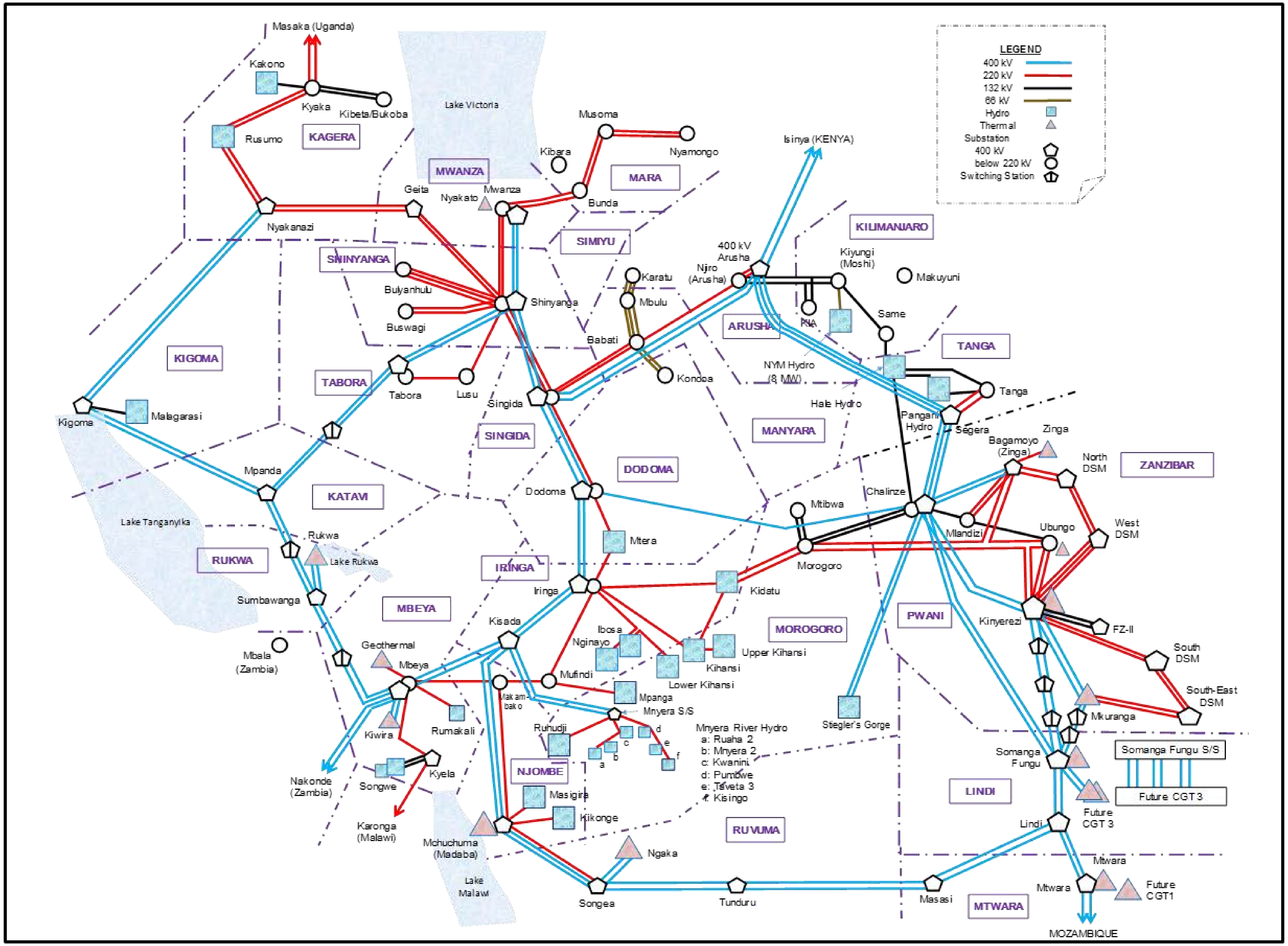
Source：POWER SYSTEM MASTER PLAN 2016

Figure 3.10-6 Generation development plan (energy generated, Tanzania)



Source：Source : POWER SYSTEM MASTER PLAN 2016

Figure 3.10-7 Tanzanian grid



Source：Powewr system master plan 2016

Figure 3.10-8 Tanzanian power system development plan, as of 2040

4) Cooperation by the donor organizations

Status of support to individual projects for system development is shown in Table 3.10-11.

Table 3.10-11 Support details by donors in Tanzania

Donor etc.	Type	Project	Others
WB	Generation	Rusumo Falls Hydropower (27 MW)	Construction
WB	Generation	Ruhudji Hydropower (358 MW)	Generation project is developed by private developer (British Company) and transmission lines connected to the system are assumed by Tanesco.
China	Generation	MasigiraHydropower (118 MW)	Construction
China	Generation	RumakaliHydropower (222 MW)	Construction
MCC-USA	Generation	Malagarasi Hydropower	Construction (Tanzanian regional grid integration)
AfDB, EDCF(Korea), EIB, WB, JICA	Transmission	Iringa–Shinyanga TL Iringa – Dodoma 400kV Dodoma – Singida 400kV Singida – Shinyanga 400kV	
SIDA	Transmission	Makambako – Songea 220kV	
China	Transmission	North East Grid Dar es Salaam – Arusha 400kV	
AfDB, JICA	Transmission	ZTK Isinya – Kenya – Singida 400kV Tanzania - Kenya	Kenyan side
China	Transmission	North West Grid Phase 1 Mbeya – Sumbawanga 400kV	
BADEA	Transmission	North West Grid Phase 1-A Bulyanhulu – Geita 220kV	
EIB, AfDB, KfW	Transmission	Geita – Nyakanazi 220kV	Incl. electrification project

Source : JICA Survey Team

3.11 Zambia

3.11.1 Power Sector

(1) Overview of power sector

There are main three electric power business operators, ZESCO, CEC, and LHPC in Zambia. ZESCO is a state-owned electric company, vertically integrating generation, transmission and distribution, CEC is a private, specific supply company for mining companies in Copperbelt. LHPC is a hydropower generation IPP doing business with ZESCO. Below shows an overview of these three companies.

1) ZESCO

Zambia Electricity Supply Corporation（ZESCO）was established under the Companies Ordinance of 1969, and in 1970 it succeeded her businesses to three organizations, such as Central Electricity Corporation Limited, Northern Electricity Supply Corporation and Victoria Falls Electricity Board.

Table 3.11-1 Utilities before ZESCO in Zambia

Utilities	Description
Central Electricity Corporation Limited（CEC）	Established in 1953, for the purpose of supplying power to Lusaka. Thereafter, the distribution network was expanded to Chilanga, Kafue and Monze around Lusaka and in 1960, it was interconnected to Kariba-Kitwe transmission line at Leopards Hill Substation.
Northern Electricity Supply Corporation（NESCO）	This was established in 1960, and her business was succeeded from rural electrification projects operated by North Rhodesia in Mongu, Kasama, Mbala and Mansa. Electricity to use is purchased from Copperbelt Power Company (CPC) and her distribution network has been expanded to unelectrified areas in Copperbelt.
Victoria Falls Electricity Board	In order to operate Victoria Falls Power Plant established in 1951, and thereafter, generation capacity was expanded and it took over electric power supply to Choma and Kalomoin 1964.

Source : JICA Survey Team

In 1972, ZESCO accepted electric power supply business which had been conducted by local governments such as Livingstone, Ndola, Kabwe, etc., and expanded supply areas throughout the nation. However, power supply to the mining companies in Copperbelt has been continued by CPC (currently, CEC). In 1988, under the Company Act, the organization was changed from a corporation to a joint stock company, which made it possible to pursue profits. In this regard, in 1994, the name was changed to ZESCO Limited from Zambia Electricity Supply Corporation.

2) Copperbelt Energy Company Plc. (CEC)

In Copperbelt area, electricity was supplied in connection with mining development and CEC originates from one of the electric power companies across the border from former Rhodesia and Congo owned by the mining company in the 1950's. In connection with the independence of Zambia in 1964, the name of the Company was changed to CPC, and in connection with a merger of the mining company, CPC became the electricity division of the Zambia Consolidated Copper Mines Limited (ZCCM) in 1982. In 1997, through division and privatization of ZCCM, CEC was spun off again and became independent as Copperbelt Energy Corporation Plc. (CEC).

At the initial establishment in 1997, CEC was sold to National Grid and Duke Energy of the UK and in 2006, Zambia Energy Corporation (Zam-En) owned 77% of the shares through MBO.

Business content of CEC fundamentally remained the same as at the time of establishment, which basically purchases electricity from ZESCO and SNEL (DR Congo). Electricity supply to mining companies is primary business while other demand in the Copperbelt area, such as residential demand is assumed by ZESCO.

Original generation facilities of CEC, oil-fueled gas turbine facilities, are backup power plants for emergency and therefore CEC is broadly known as a power transmission company[53].

Recently, CEC is planning to add some generation business out of her area in addition to power system operation business. In SAPP area, CEC concluded a joint development contract with Nampower for Kudu gas-fired power plant project in Namibia, also acquires stocks of Arandis Power[54] in Namibia and participates wholesale power.

3) Other Private Companies

Lunsemfa Hydro Power Corporation is an IPP, which was established by division and privatization of ZCCM which sells all the electricity generated to ZESCO.

SN Power, a Norwegian hydroelectric power generation investment company owns 51% of the shares. Coal-fired power plant(s) using the domestic coal is under construction[55] in Zambia, and supplies electricity as base load power. Also the renewable IPPs[56] are outstanding recently.

(2) Administrative body

1) Government

The agency in charge of power administration is the Ministry of Energy and Water Development (MEWD), Under this organization, four (4) affairs, including Energy department[57, 58] are set.

- Energy
- Water Resource Development
- Planning Information
- Human Resource and Administration

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53 CEC is planning to participate in the Lupanula River hydropower development in addition to PV development and Kabompo Gorge hydro power (40MW).

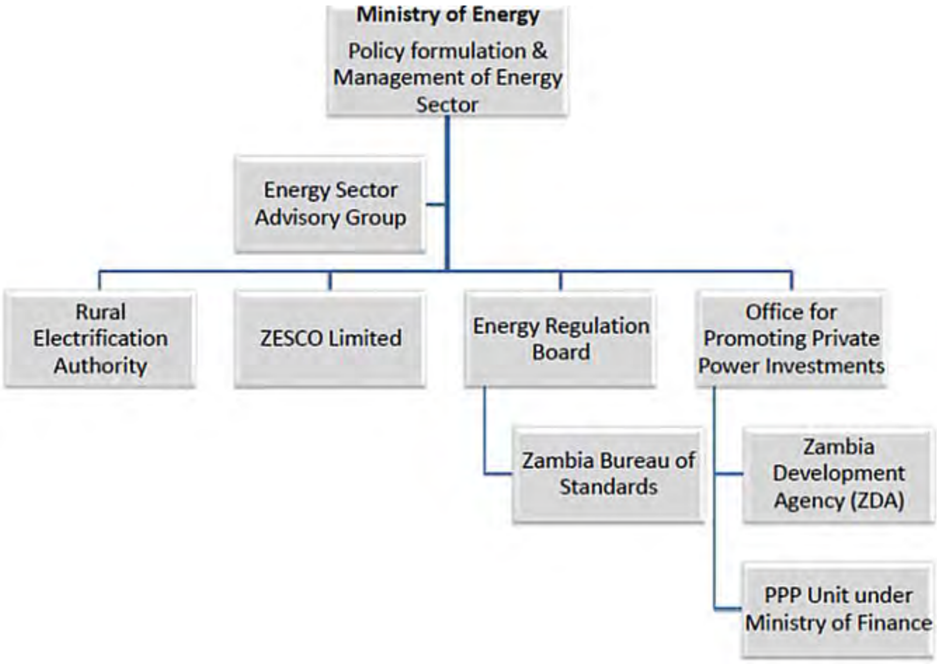
54 Arandis Power supply electricity for uranium mine in Arandis area of the central part of Namibia, and owned hybrid generation facility which combined diesel with RE.

55 http://www.maambacoal.com/power.htm

56 NEON S.A.S./First Solar, and Enel Green Power SpA (EGP) of Italy. First Solar has bid for one 50 MW project at a tariff of $0.062/kWh, while EGP's bid is expected to be around $0.078/kWh. These proposed tariffs would remain fixed for 25 years and would be Zambia's first large-scale independent power producers (IPP) supported by the World Bank.

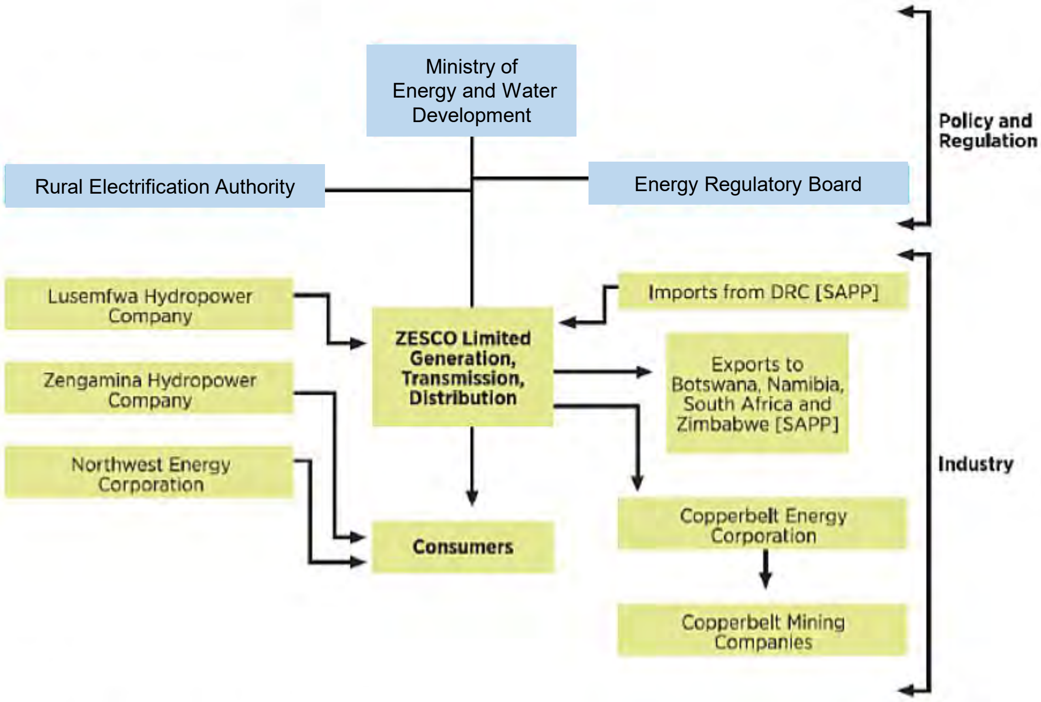
57 MEWD WEB Site, http//www.mewd.gov.zm

58 MEWD was reconstruct to Ministry of Energy in August 2016 in accordance with election. Actual operations of this division are not confirmed.



Source : GRIPS July 2015, Energy Policy in Zambia, Ministry of Mines, Energy and Water Development

Figure 3.11-1 Administrative organization of power division (Zambia)



Source : GRIPS July 2015, Energy Policy in Zambia, Ministry of Mines, Energy and Water Development

Figure 3.11-2 Overview of power sector (Zambia)

2) Office for Promoting Private Power Investments (OPPPI)

By the national energy policy, National Energy Policy (NEP) promulgated in 1994, introduction of power sub-sector was pointed to promote private investments of hydropower. Further, in 1998, Framework and Package of Incentive for Hydropower Generation and Transmission Development (FPI), which provided for the incentives for investment in hydropower generation and transmission development, was adopted and in 1999, and then OPPPI was launched as an implementation organization under MEWD.

OPPPI was realized so-called one-stop operation to simplify the procedures and legal regulations for approval of investors in the power sector and issuing licenses.

3) Zambezi River Authority (ZRA)

Development of the Zambezi river has been jointly carried out by both governments since the Zambezi river is located on the border of the former South and North Rhodesia, now Zambia and Zimbabwe.

In 1956, under the government of Rhodesia Nyasaland Federation (Central Africa Federation), the Federal Power Board (FPB) was established, to which authority was granted to construct dams and power generation plants on the main stream of the Zambezi river. In connection with dissolution of the Federation in 1963, FPB was reorganized into Central African Power Corporation (CAPCO) together with another organization which conducts collection of hydrological data on the Zambezi river.

CAPCO applied the form of co-owning by the South and North Rhodesian governments. And Zambia in 1964 and Zimbabwe in 1980 became independent, and the Zambezi River Authority (ZRA) was established in 1987 in place of CAPCO.

ZRA conducts maintenance and management of the Kariba Dam, organization of hydrological data and such various surveys as the water quality survey under the Zambesi River Authority Act of 1987 and manages water usage of the power plants located on both sides of the Kariba Dam (North, South) and renews every year the water volume allocated to both power plants by analysis of hydrological data.

Operation of ZRA is appropriated by water use fees from power plants on both sides of the Kariba Dam and a new generation development project on the main stream of the Zambezi river. Thus Batoka Gorge, Devil’s Gorge, Mpata Gorge will be carried out by ZRA.

(3) Regulatory body

Energy Regulation Board (ERB)[59] is an organization established under the Energy Regulation Act, promulgated in 1997. ERB conducts regulations and supervision of the overall energy sector, including electricity.

Electricity-related laws and regulations are as follows.

- The Energy Regulation
- The Electricity Act

(4) Electricity tariff

Under Electricity Act, electricity tariffs of Zambia are determined by the determination from ERB.

The electricity tariff system of Zambia classifies (domestic) residential, commercial, social, maximum demand types. Further, the system has fix rate and metered rate respectively. Maximum demand contract

customer use with capacity limitation, public lighting, mining, industry, commercial and pumps, the maximum demand type has several basic rates as the rank of contract. As for residential type, prepaid menu is applied.

The simulation of electricity tariffs is made for typical customers, such as residential, commercial, and industry. Y the results of which are shown in Table 3.11-2.

[59] ERB WEB Site, http//www.erb.org.zm

Table 3.11-2 Electricity tariff (Zambia)

Electricity Tariff -Zambia (2010)

Category	Tariff Description	Unit	Tariff (ZMK)
Commercial Tariffs - Capacity 15kVA	Commercial	Fixed charge / month	47,753.27
	Commercial - Consumption up to 700 kWh	Energy Charge / kWh	266.70
Maximum Demand Tariffs	MD1 - Capacity from 16 - 300 kVA	MD1 - Charge / kVA / month	11,690.90
		MD1 - Energy charge / kWh	167.90
		MD1 - Fixed charge / month	114,497.45
	MD2 - Capacity 301 - 2000 kVA	MD2 - Charge / kVA / month	21,870.70
		MD2 - Energy charge / kWh	143.75
		MD2 - Fixed charge / month	228,992.60
	MD3 - Capacity from 2001 - 7500 kVA	MD3 - Charge / kVA / month	39717.44
		MD3 - Energy charge / kWh	127.68
		MD3 - Fixed charge / month	551,563.04
	MD2 - Capacity above 7500 kVA	MD4 - Charge / kVA / month	39,938.08
		MD4 - Energy charge / kWh	105.28
		MD4 - Fixed charge / month	1,103,124.96
Metered Residential Tariffs -Capacity 15kVA	Metered Residential	Fixed charge / month	14,628.75
	Prepaid Meter Tariff	Energy charge / kWh	277.77
	R1 -Consumption up to 100 kWh	Energy charge / kWh	152.28
	R2 -Consumption from 101 - 400 kWh	Energy charge / kWh	250.98
	R3 -Consumption above 400 kWh	Energy charge / kWh	408.90
Social Services Tariffs	Schools, Hospitals, Orphanages, Water pumping, Street lighting	Energy charge / kWh	239.40
	Social Services	Fixed charge / month	41,515.95

Source : ERB Web Site (2015)

Table 3.11-3 Reference electricity tariff (Zambia)

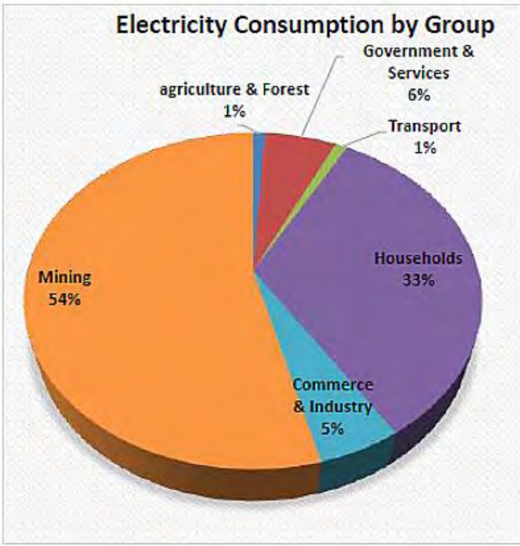
Customer Category	Assumed consumption (kWh / month)	Electricity Tariff (US cents/kWh)
Domestic (Residential)	100	2.89
Small Commercial	1,000	5.97
Large Commercial/Industry	10,000	5.63

1 USD = 0.00019ZMW, as of December, 2016
Source : JICA Survey Team

3.11.2 Power demand, existing facilities and development plan

(1) Power demand

As one of the features of Zambian economy is a monoculture dependent on the production of copper, power demand by the mining industry accounts for more than half as shown in Figure 3.11-3.



Source : GRIPS July 2015, Energy Policy in Zambia, Ministry of Mines, Energy and Water Development

Figure 3.11-3 Power consumption in Zambia

(2) Existing facilities

1) Generation facilities

Generation facilities of ZESCO are shown in Table 3.11-4, and that of IPPs are shown in Table 3.11-5.

Table 3.11-4 Generation facilities of ZESCO in Zambia

Power Station	Installed Capacity (MW)	Available Capacity (MW)	Capacity after uprating (MW)	Project Capacity by 2017 (MW)
Kafue Gorge	900	900	-	900
Kariba North Bank	720	690	720	720
Victoria Falls	108	108	-	108
Kariba North Bank Extension	360	360	-	360
Kafue Gorge Lower	750	-	-	-
Itezhi Tezhi[60]	120	-	-	120
Lunzua	0.75	0.75	14.8	14.8
Lusiwai	12	11	101	-
Chishimba	6	6	15	15
Musonda	5	4	10	10
Shiwang'andu	1	1	-	1
Total	2,982.75	2,080.75		2338.8

Source : ZESCO WEB Site

[60] Itezi Tezhi hydropower started operation in April 2016, and its capacity is 2 x 67 MVA. Demand record was 110 MW as of December 2016.

Table 3.11-5 Generation facilities of IPPs in Zambia

Power Station	Installed Capacity (MW)	Operator
Lusemfwa and Mulungushi	56	Lusemfwa Hydro Corporation
Gas Turbine (Stand by)	80	CEC
Ndola	50	Ndola Energy
Total	186	

Source：JICA Survey Team

2) Transmission facilities

The facilities are as shown in Table 3.11-6.

Table 3.11-6 Transmission line of ZESCO (Zambia)

Voltage	Transmission Assets
	Length(km)
330 kV	2,241
220 kV	571
132 kV	202
88 kV	734
66 kV	1,037

Source : JICA Survey Team using information on ZESCO WEB Site

In addition, CEC owns 220kV transmission line in Northern part of Zambia including interconnector to DR Congo. CEC starts to operate new second interconnector from Zambia to DR Congo of 220kV transmission line.

3) Interconnector

Five routes of interconnectors exist as follows.

Table 3.11-7 Interconnector (Zambia)

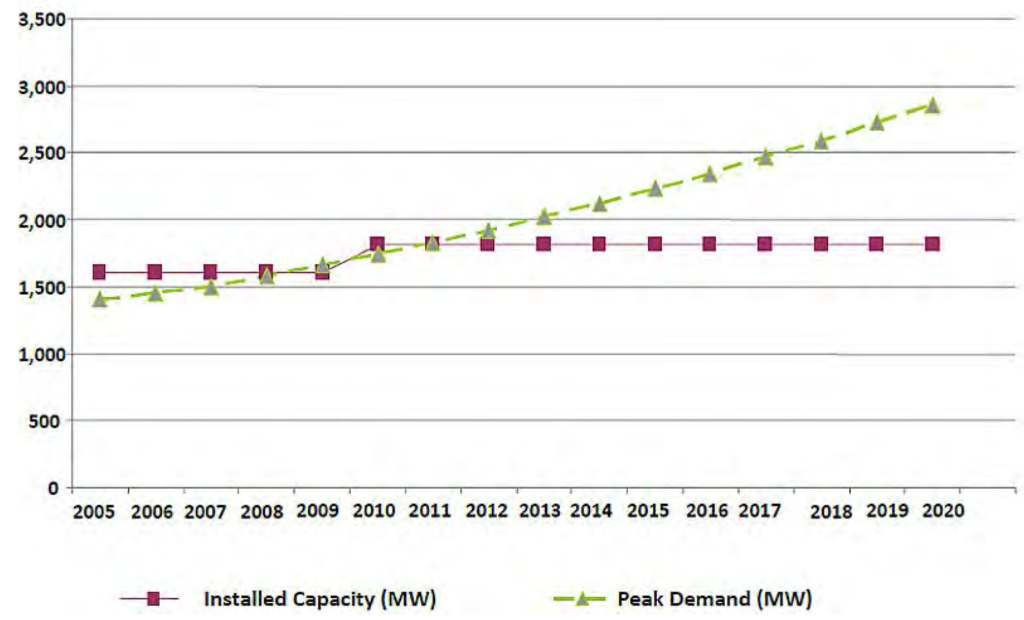
Malawi	Chipata －Malawi 33kV, 1 line
Zimbabwe	Kariba North － Kariba South 330k, 3 lines
	Livingstone － Vicctoria Falls 330kV, 1 line
Namibia	Shsheke － Zambezi 220kV, 1 line
DR Congo	Luano － Kolwesi 220kV, 2 lines

Source : JICA Survey Team

(3) System development plan

1) Demand forecast

After publication of power system master plan study in 2010, no authorized demand forecast has been created. However, some institutional analysis existed. Figure 3.11-4 represents peak demand perspective in Zambia. (Nevertheless definitely no energy forecast exists)



Note ; As of 2015, Installed capacity is above 2,000MW

Source : Zambia Development Agency, Zambia Energy Sector Profile,2014

Figure 3.11-4 Perspective of installed capacity and peak demand in Zambia

2) Generation development plan

Projects indicated by ZESCO are as follows.

- ✓ Shiwangandu Mini-Hydro Power Project

  ZESCO and Global Environmental Facility (GEF) develop it by contribution of 93% and 7%, respectively.

3) System planning

Projects announced by ZESCO are shown as following

- ✓ Connection of North Western Province to National Grid
- ✓ Kalumbila Transmission Project
- ✓ First Quantum Minerals (FQM) hope to do the mining at Kalumbila and therefore hope to access bulk power for this issue up to 230MW[61].

4) Power system master plan

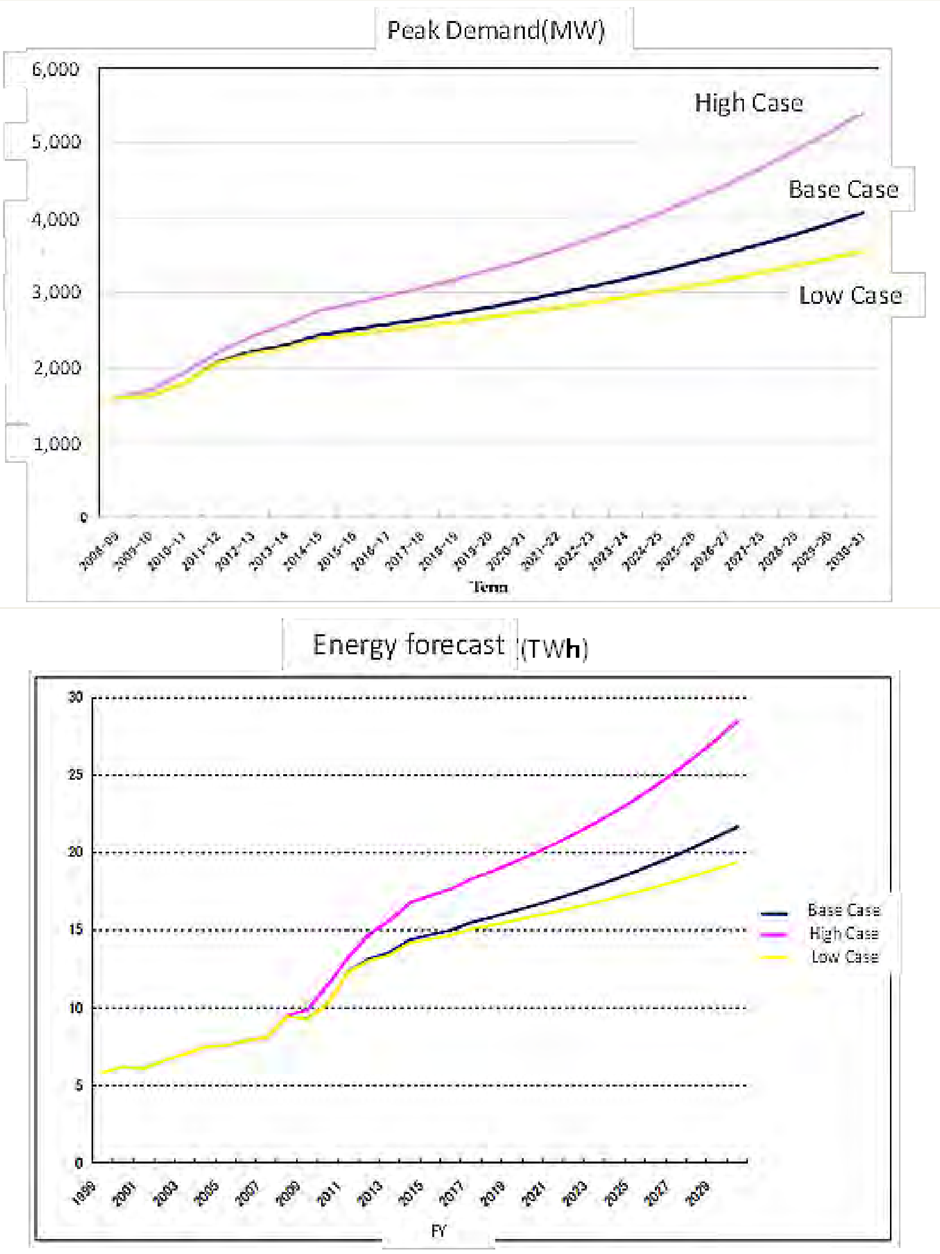
Zambia Power System Development Master Plan Study organized by JICA (2010) is considered to be the latest power system master plan in Zambia. Therefore, we will analyze this version.

Brief explanation of this master plan are as follow.

- ✓ Demand forecast

Demand forecast in Zambia is made by macro and micro models applying the parameters, such as GDP growth rate and GDP value of elasticity as the key and the prospects for mining demand as extrapolated figures.

[61] This project starts operation in October 2016



Upper : Peak demand, Lower : Energy generated

Source : JICA Zambia Power system master plan study (2010)

Figure 3.11-5　Demand forecast (Zambia)

- ✓ Generation development plan / System planning

In terms of energy security, generation capacity hopes to develop generation mix which combines introduction of coal-fired power and hydropower kept as the maximum use of national primary energy. Regarding the commercial operation year, two scenarios of satisfying peak demand and satisfying energy consumption are reviewed. As a result, there is no difference with each other in terms of the number and operation year of generation introduction.

The power system plan was revised due to the demand of customer. To secure the transmission capacity, addition of Lusaka West – Kalumbila and improvement of north-eastern grid arises (Figure 3.11-6).

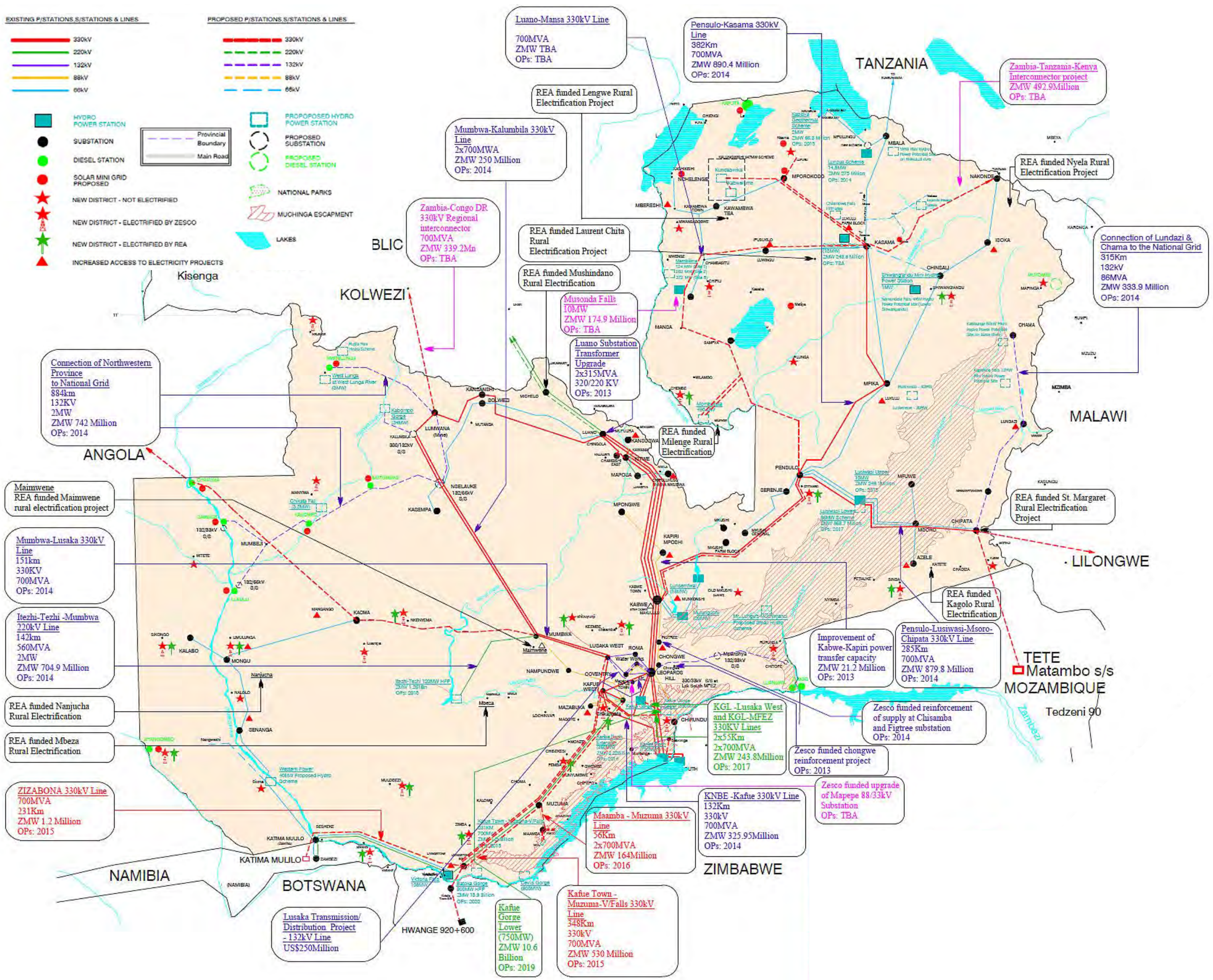
5) Cooperation by the donor organizations

Status of support to individual projects for system development is shown in Table 3.11-8.

Table 3.11-8 Support detail by donors in Zambia

Organizations	Category	Projects	Remarks
WB	Generation	Batoka Gorge Hydropower (1,200 MW)	FS
China	Generation	Kafue Gorge Lower Hydropower (187.5 MW×4)	Construction
WB	Transmssion	Kafue - Victoria Falls	Construction
EIB, AfDB	Transmssion	Itezhi Tezhi 220/330kV TL Itezhitezhi – Mumbwa 220kV	Construction (2016 operation)
AfDB	Transmssion	DR Congo - Zambia interconnector Solwezi(Zambia) – Kolwezi(DR Congo) 330kV	
WB	Transmssion	2nd DR Congo – Zambia interconnector Michelo – Karavia(DRC) 220kV	2016 operation (CEC owns)
JICA	Transmssion	Kafue West – Muzuma 330kV	Construction (L/A not yet)
JICA	Transmssion	Muzuma – Livingstone 330kV	Construction (L/A not yet)
WB	Transmssion	Kafue West – Muzuma 330kV	Upgrading from 220kV to 330 kV
WB	Transmssion	Muzuma – Livingstone 330kV	Upgrading from 220kV to 330 kV

Source ; JICA Survey Team



Source : ZESCO (2016)

Figure 3.11-6 System planning (Zambia)

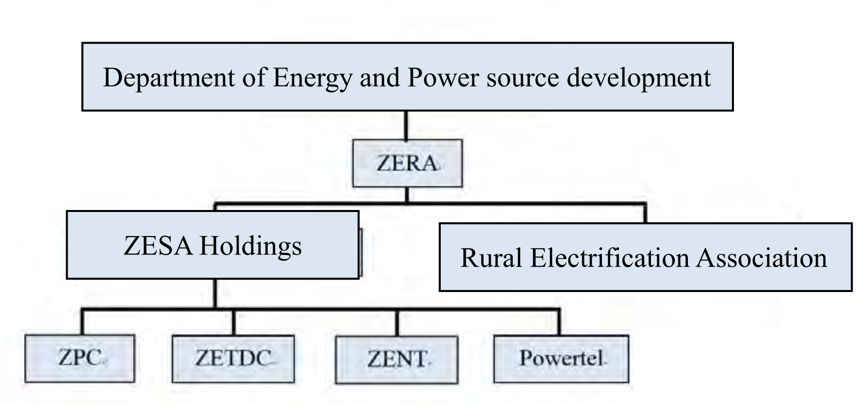
3.12 Zimbabwe

3.12.1 **Power Sector**

(1) Overview of Power Sector

ZESA Holdings Private Limited

The Zimbabwe Electricity Supply Authority (ZESA) was established under the Electricity Act enacted in 1985 and controlled by Ministry of Energy and Power Development (MoPD). ZESA had supplied electricity in a vertically integrated organization. Thereafter, by the amendment of the Electricity Act in 2003, ZESA was divided and four subsidiaries, namely Zimbabwe Power Company (ZPC) which is conducting power generation, Zimbabwe Electricity Transmission and Distribution Company (ZETDC) which is conducting transmission and distribution, ZESA Enterprise (ZENT) which is conducting manufacture and transportation, and Powertel Communications (Powertel), under ZESA Holdings, private company.



Source : ZERA, ZESA Web site

Figure 3.12-1 Configuration of power sector in Zimbabwe

The generation business is carried out by ZPC, aforementioned. The generation capacity of ZPC is 1,541MW as of 2015, which is lesser than the total demand, approximately 2,000 MW in Zimbabwe. Therefore, the deficit is imported from HCB and EDM in Mozambique, Eskom in South Africa and ZESCO in Zambia, etc.

The transmission and distribution business is carried out by ZETDC, which improves the transmission infrastructure and develops a long-term transmission development plan to maintain an appropriate balance between demand and supply. Also she is engaging power trading in SAPP.

1) IPPs

According to Zimbabwe Electricity Regulatory Authority (ZERA), 23 IPPs include small hydropowers participate in power sector in Zimbabwe. However, contribution of total capacity from IPPs is only two percentage (2%). It can be seen afterwards, energetic IPP player(s) prepare the participation with a lot of generators having huge-sized capacity.

(2) Power policies

"National Energy Policy" developed by MoEPD states energizing the investment of infrastructure in Zimbabwe and investment promotion from private sector and regional communities.

Regarding the power sector, the following approaches are established.

(a) To steadily promote deregulation of power utility and to energize regional power trading market.

(b) Promotion of generation development and Securing reliability and efficiency of regional grid with system integration

(c) Establishment of electricity tariff reflecting reasonable costs.

(3) Regulatory body

In 2011, the Zimbabwe Energy Regulatory Authority (ZERA) was established under the Ministry of Energy and Power Development as an energy regulation organization by electricity regulation act based on Electricity act (chapter 13:19). ZERA carries out regulations on energy, including electricity and issuing business licenses, and settlement of electricity tariff.

(4) Electricity tariff.

The electricity tariff table is shown in Table 3.12-1.

Table 3.12-1 Electricity tariff (Zimbabwe)

Electricity Tariff -Zimbabwe (2014)

1. Domestic Metered Customer

1.1 Conventional Meter	Tariff (ZWD)
a) Fixed Monthly Charge	0
b) Energy charge per (i) 1st 50 kWh	0.02
(ii) 51 to 300 kWh	0.11
(iii) Balance	0.15

1.2 Prepayment Meter	Tariff (ZWD)	
	Standard	Standard
(i) 1st 50 kWh	0.1	0.02
(ii) 51 to 300 kWh	0.1	0.11
(iii) Balance	0.1	0.15

2. Domestic Load Limited

Average Tariff (ZWD)	1.0 A	2.5 A	5.0 A	7.5 A	10.0 A	15.0 A	22.5 A	30.0 A
a) Fixed Monthly Charge	0	0	0	0	0	0	0	0
b) Fixed Amperage Charge	4.64	7.08	11.14	15.21	19.28	27.41	37.01	43.39

3. Public Lighting

Tariff (ZWD)	Metered	Unmetered
a) Fixed Monthly Charge	0	n/a
b) Energy charge per kWh	0.11	n/a
c) Monthly charge per watt of installed capacity of luminaire	n/a	0.03

4. Mining, Industrial, Commercoal & Pumping Works

Low Voltage Supply	Tariff (ZWD)
(i) Fixed Monthly Charge	0
Energy charge per kWh	0.12

5. Mining, Industrial, Commercial & Pumping Works -Maximum Demand Tariff (ZWD)

Tariff (ZWD)	11kV Supply	33 kV Supply	Secondary Distribution
a) Fixed Monthly Charge	0	0	0
b) A monthly capacity charge oer unit of demand	5.54	4.07	2.6
c) An interruptable demand charge	n/a	n/a	1.95
d) On-peak energy charge per kWh	0.13	0.13	0.13
e) Standard energy charge per kWh	0.07	0.07	0.07
f) Off-peak energy charge per kWh	0.04	0.04	0.04

6. Agricultural Customers Tariff (ZWD)

Low Voltage	11 kV Supply	33 kV Supply
0	0	0
n/a	5.54	4.07
n/a	n/a	n/a
0.12	0.13	0.13
0.12	0.07	0.07
0.12	0.04	0.04

7. Institutions: (Government, Municipal, Mission Schools, Hospitals and Clinics)

	Low Voltage	11 kV Supply	33 kV Supply
a) Fixed Monthly Charge	0	0	0
b) A monthly capacity charge oer unit of demand	n/a	5.54	4.07
c) An interruptable demand charge	n/a	n/a	n/a
d) On-peak energy charge per kWh	0.12	0.13	0.13
e) Standard energy charge per kWh	0.12	0.07	0.07
f) Off-peak energy charge per kWh	0.12	0.04	0.04

8. Prepayment Tariffs

	Low Capacity (ZWD)
Energy charge per kWh	0.12

Source : ZETDC (2014)

The electricity tariff system of Zimbabwe classifies customers into seven (7) categories. These include (domestic) residential customer use with capacity limitation, public lighting, mining, industry, commercial and pumps, the maximum demand of the same, agriculture, public facilities and prepaid. The tariff breakdown differs depending on the customer, which is comprised of fixed tariff, electricity tariff, electricity capacity tariff, etc. A tariff by hour is also applied to industrial customers and governmental organizations, which are the largest customers.

The simulation of electricity tariffs is made for typical customers, such as residential, commercial, and industry the results of which are shown in Table 3.12-2.

Table 3.12-2 Trial calculation of electricity tariff (Zimbabwe)

Customer Category	Assumed consumption (kWh / month)	Electricity Tariff (US cents/kWh)
Domestic (Residential)	100	11.00
Small Commercial	1,000	8.66
Large Commercial/Industry	10,000	12.00

dustr1 USD = 0.00266 ZWD, as of December, 2016

Source : JICA Survey Team

3.12.2 **Power demand, existing facilities and development plan**

(1) Power demand

Unfortunately, long tracks of power demand by ZESA is not found out. According to SAPP annual report, power demand in Zimbabwe is indicated in Table 3.12-3. It shows Zimbabwe has been in chronic tight supply due to the delay of domestic power sources by failures.

Table 3.12-3 Power demand in Zimbabwe

Year	Peak demand (MW)	Generation sent out (GWh)	Electricity sales (GWh)
2014/15	1,671	6,951[62]	7,367
2013/14	1,546	6,951	7,367
2012/13	2029	6,951	7,367

Source : JICA Survey Team

(2) Existing facilities

1) Generating facilities

Generation facilities owned by ZPC are as follows. All thermal power plants use coal as fuel.

Table 3.12-4 Generation capacities of ZPC

Type	Power plant	Capacity (MW)	Type	Power plant	Capacity (MW)
Coal -fired	Hwange	700	Hydro	Duru	2.2
	Harare	30		Nyamingura	1.1
	Bulawayo	20		Pungwe A	2.7
	Munyati	20		Pungwe B	15
				Kariba	750
	Subtotal	770		Subtotal	771
Total		1,541			

As of the end of 2016

Source : ZETDC

[62] Record of generation send out and electricity sale are stable in three years. This strange evidence has not been made clear by ZETDC and SAPP C.C.

2) Transmission facilities (Interconnector)

Interconnectors in Zimbabwe secure exports and imports of electricity with surrounding countries as follows.

Table 3.12-5 Interconnector (Zimbabwe)

Zambia	Kariba south ― Kariba north 330kV, 2 lines
Mozambique	Bindura ― Sonfo(Cahora Bassa) 400kV, 1 line
	Mutare ― Xigodora 220kV, 1 line
Botswana	Insukamini ― Matimba 400kV, 1 line
	― Francistown 220kV, 1 line

Source : JICA Survey Team

(3) System development plan

1) Generation development plan

According to interview with ZETDC, the construction plan of new power plants which are planned or viable prospects in Zimbabwe are as follows.

Table 3.12-6 Generation projects in Zimbabwe

Projects	Types	Capacity (MW)
Hwange 7&8	Coal-fired	600
Kariba South Extension	Hydropower	300
Gokwe North	Coal-fired	1,200
Lusulu	Coal-fired	1,000
Batoka	Hydropower	1,200

Source : JICA Survey Team

2) System planning

(a) Interconnector

Interconnector among Zimbabwe―Zambia―Botswana―Namibia（ZiZaBoNa） is a priority project of SAPP. In addition, interconnectors with Mozambique and RSA are planned. Main interconnectors are shown in the Table below.

Table 3.12-7 Interconnector projects (Zimbabwe)

Projects / Countries	From -- To	Length (km)	Voltage (kV)
ZiZaBoNa (Zambia, Botswana, Namibia)	Hwange - Victoria Falls	100	420
	Victoria Falls - livingstone		420
	Victoria Falls - Pandamatenga	60	420
MoZiSa (Mozambique) (*)	Orange Grove - Inchope	170	400
MoZiSa (RSA) (*)	Triangle - Nzhelele	220	400

(*) a component of MoZiSa Project

Source : JICA Survey Team using information from ZETDC

(b) Regional system

The plans for regional system integration are comprised by power lines for the planned power plants and trunck line ehancements. Main regional systems plans are shown in the Table 3.12-8.

Table 3.12-8 Regional system's projects in Zimbabwe

Sites	From - To	Length (km)	Voltage class (kV)
Orange Grove - Triangle TL	Orange Grove - Triangle	300	400
Bindura - Mutorashanga TL	Bindura - Mutorashanga	80.2	400
Second Alaska - Sherwood TL	Alaska - Sherwood	160	400
Connection of Hwange 7&8 Power Plant	Hwange - Insukamini	310	400
	Marvel - Insukamini	42	400
Connection of Gokwe North Power Plant	Gokwe North - Sherwood	150	400
	Gokwe North - Selous	350	400
	Selous - Dema	140	400
Connection of Lusulu Power Plant	Lusulu - Alaska	350	330

Source : JICA Survey Team using information from ZETDC

3) Power system master plan

ZETDC System Development Plan (2015) was obtained as latest power system master plan of Zimbabwe. The overview are shown below.

✓ Demand forecast

Table 3.12-9 shows the demand forecast on power system master plan.

Table 3.12-9 Demand forecast (Zimbabwe)

Year	Energy Demand forecast (GWh)	Power demand forecast (MW)
2012	9,341	1,846
2013	9,811	1,866
2014	10,964	2,086
2015	11,122	2,116
2016	11,421	2,173
2017	11,768	2,239
2018	12,803	2,436
2019	13,087	2,490
2020	13,534	2,575
2021	14,349	2,730
2022	15,221	2,896
2023	15,926	3,030
2024	16,677	3,173
2025	17,461	3,322
2026	18,280	3,478
2027	19,142	3,642
2028	20,057	3,816
2029	21,008	3,997
2030	22,012	4,188
2031	23,069	4,389
2032	24,172	4,599
2033	25,345	4,822
2034	26,569	5,055
2035	27,862	5,301
2036	29,249	5,565
2037	30,679	5,837
2038	32,182	6,123

Source : ZETDC System Development Plan (2015)

This power system master plan forecasts regional demand toward 2038 and the forecast assumes a social condition in which economic recovery is delayed, reflecting the present serious tight supply.

- ✓ Generation development plan

The plan describes the scenario dependent on imports in response to supply shortages, considering energy security in Zimbabwe and focusing priority on development of national primary energy. Remarkable issue is that it treats development of Batoka Gorge, a large scale hydropower plant, as the key to meet regional power demand. This power system master plan evaluates the sensitivity of uncertainty of Batoka Gorge hydropower development.

Table 3.12-10　Generation development plan (Zimbabwe)

YEAR	GAIREZI	POWER IMPORTS	ZPC DIESEL	HW7&8	KARIBA	BATOKA	SOUTHERN ENERGY	DEVIL'S GORGE	LUSULU	GOKWE NORTH	CASECO	SOLAR PV	HWANGE STG1	HWANGE STG2	HARARE REHAB	BULAWAYO REHAB	MUNYATI REHAB
2015		200															
2016		200													100	90	90
2017		200	120												100	90	90
2018	2x15		120		2X150						2x300				100	90	90
2019	2x15		120	2x300	2X150						2x300				100	90	90
2020	2x15		120	2x300	2X150						2x300		4x120	2x220	100	90	90
2021	2x15		120	2x300	2X150						2x300		4x120	2x220	100	90	90
2022	2x15		120	2x300	2X150	4X200					2x300		4x120	2x220	100	90	90
2023	2x15		120	2x300	2X150	4X200					2x300		4x120	2x220	100	90	90
2024	2x15		120	2x300	2X150	4X200					2x300		4x120	2x220	100	90	90
2025	2x15		120	2x300	2X150	4X200		3X200			2x300		4x120	2x220	100	90	90
2026	2x15		120	2x300	2X150	4X200		3X200			2x300		4x120	2x220	100	90	90
2027	2x15		120	2x300	2X150	4X200		3X200			2x300		4x120	2x220	100	90	90
2028	2x15		120	2x300	2X150	4X200		3X200			2x300		4x120	2x220	100	90	90
2029	2x15		120	2x300	2X150	4X200		3X200			2x300		4x120	2x220	100	90	90
2030	2x15		120	2x300	2X150	4X200		3x200			2x300		4x120	2x220	100	90	90
2031	2x15		120	2x300	2X150	4X200		3x200			2x300		4x120	2x220	100	90	90
2032	2x15		120	2x300	2X150	4X200		3x200	1x250		2x300		4x120	2x220	100	90	90
2033	2x15		120	2x300	2X150	4X200		3x200	1x250	1X300	2x300		4x120	2x220	100	90	90
2034	2x15		120	2x300	2X150	4X200		3x200	1x250	1X300	2x300		4x120	2x220	100	90	90
2035	2x15		120	2x300	2X150	4X200		3x200	1x250	1X300	2x300		4x120	2x220	100	90	90
2036	2x15		120	2x300	2X150	4X200		3x200	2x250	1X300	2x300		4x120	2x220	100	90	90
2037	2x15		120	2x300	2X150	4X200	1x330	3x200	3x250	1X300	2x300		4x120	2x220	100	90	90
2038	2x15		120	2x300	2X150	4X200	2x330	3x200	4x250	1X300	2x300	50	4x120	2x220	100	90	90

Source : ZETDC

- ✓ System planning

Although the power system master plan does not mentions system planning, it implies construction of the power lines from generation projects and grid integration such as CEC, like Table 3.12-8.

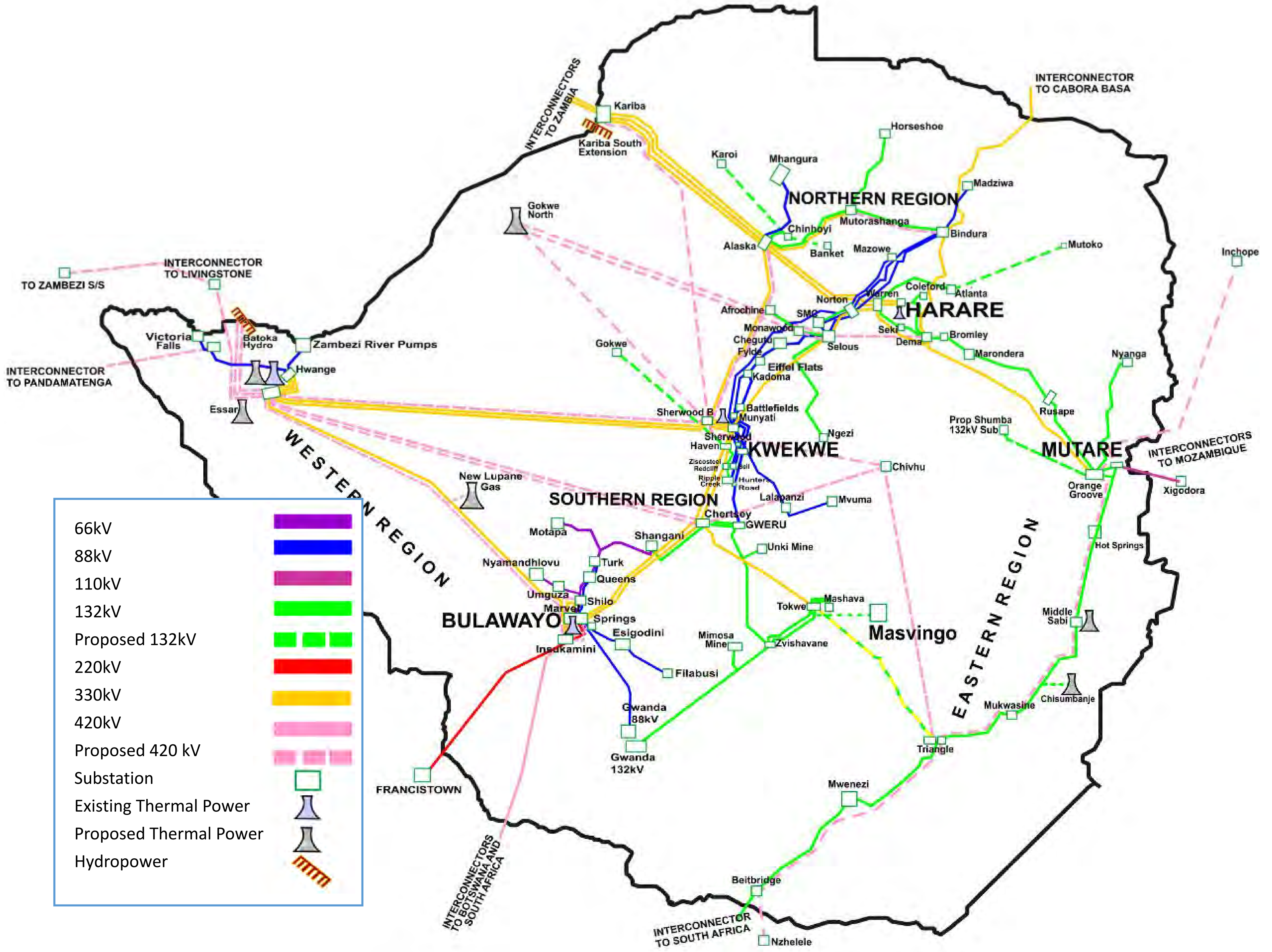
2)　Cooperation by the donor organizations

Status of support to individual projects for system development is shown below.

Table 3.12-11　Support detail by donors in Zimbabwe

Donors	Type	Projects	Remarks
WB	Generation	Batoka Gorge hydropower (1,200 MW)	FS
India	Generation	Hwange coal-fired (920 MW)	Rehabilitation
China	Generatioin	Kariba South Extension hydropower (150 MW×2)	Construction
China	Generation	Hwange7-8 Coal-fired power plants (300 MW×2)	Construction

Source : JICA Survey Team



Source : ZETDC (2015)

Figure 3.12-2 System planning diagram (Zimbabwe)

3.13 Issues of SAPP member states

Following table shows issues of SAPP member utilities. This is wrapped up with comments from SAPP member utilities and observation of the Survey team. This is focusing on the technical issues, especially.

Table 3.13-1 Issues of SAPP member utilities

	Issues
Angola	・Establishment of power system master plan is imperative. ・Capacity development for studying power system master plan by right organization individually ・System capacity enhancement for interconnecting isolated systems (Northern, center and southern) with transmission loss reduction. ・System operation improvement for national grid to prepare system integration. ・Interconnector construction to participate power pool.
Botswana	・Capacity development for studying comprehensive power system master plan ・National grid integration with North – West project and transmission loss reduction. ・Diagnosis technique of the existing coal thermal power facilities, and rehabilitation ・System stabilization and system operation for large scale renewable introduction ・Capacity development for maintenance technique of power system facilities
DR Congo	・Establishment of power system master plan is imperative. ・Capacity development for studying power system master plan by right organization individually ・acceleration of hydropower projects, such as Inga 3 ・Introduction of river water management system and its capacity development ・Distribution improvement in Kinshasa metropolitan area
Lesotho	・Capacity development for studying power system master plan by right organization individually
Malawi	・Capacity development for studying long term power system master plan by right organization individually ・Interconnector construction to participate power pool.
Mozambique	・Establishment of transmission loss reduction method ・Distribution improvement in load center and establishment of smooth operation ・Establishment of system operation by generation mix including large scale renewable in northern area ・Capacity development for studying long term power system master plan by right organization individually
Namibia	・Capacity development for studying long term power system master plan by right organization individually

RSA	・Measurement for environmental facilities for existing coal-fired facilities ・Operation for high efficiency gas-fired power facilities and power transportation from coastal area. ・System stability measures for large scale renewable introduction ・Measurement to increase transmission capacity for ultra high voltage grid in the metropolitan area (Gauteng) ・Improvement methodology of transmission facilities for crowded area such as metropolitan area (Gauteng) (Multi-circuit tower) ・Bulk power transmission technology (HVDC)
Swaziland	・Capacity development for studying long term power system master plan by right organization individually
Tanzania	・Capacity development for studying long term power system master plan by right organization individually ・Capacity development for maintenance technique of power system facilities
Zambia	・Revise of power system master plan is imperative. ・Capacity development for studying long term power system master plan by right organization individually ・Measure for tight demand and supply balance by drought condition ・Wheeling charge model to deal with EAPP.
Zimbabwe	・System stability issue against introduction of coal fired power plant with huge capacity ・Capacity development for maintenance technique of power system facilities

Source : JICA Survey Team

Capacity development for independent investigation to establish power system master plan by power utility is definitely the issue for all SAPP member countries. In most of the states, work force to establish power system master plan is quite a few and formation for it is very fragile. Truly, the wishes that BPC or ZESCO hope to be grown their capacity were heard through interviews.

Achievement of active power trade and wide-area system operations with interconnectors need discipined framework, all SAPP member states syncronizes to establish their regional power system master plan with an almost constant level and periodical interval and then compile all members' master plans to negotiate it.

As for technical issue, especially issues for grid integration on the aspect from Table 3.13-1 are as below,

.... Transmission loss reduction on long distance power transfer

.... Introduction of power system stabilization

(a) Transmission loss reduction on long distance power transfer

Transmission loss reduction is the common issue in SAPP region, the vast land, around 4,000 km from north to south and 3,000 km from east to west, and further, load centers are apart from large scale genetation plants, especially hydropowers.

The simple resolution to feed the power from far end to load center is HVDC application. However, another important issue for SAPP member countries, namely electrification and on-grid integration in local area. Therefore, HVAC integration for trunk system and load system is the common sence. And that is why to have a chance to infroduce special conductor which enabling loss reduction to connect between the points apart from each other.

In the meanwhile, regional load centers, such as capital city or following lagest cities will grow their demand in line with rapid population growth and economic activities at the points. In terms of this, special conductor, which can feed around threefold of power than conventional one is th solution to be applied wiht reasonable manner.

(b) Introduction of power system stabilization

In case that situation stretching around SAPP member states by interconnecctors, critical disturbance, namely one disturbance occurs at certain area causes another critical disturbance at another point, arises[63].

To prepare this, introduction of control and protection system securing demand and supply balance in a certain area (block) and preventing restraint of the repercussion of disturbance is important for future SAPP grid.

This needs higher skills and knowledge, hence from now on it is necessary to study and analyze the past incidents and trial and error of designing of the grid control.

Recently, imbalance caused by fluctuation of output from renewables are non-negligible theme for grid control and supply balance controls. In terms of them, system stabilization technology should be prioritized for SAPP.

Of cource, generation facilities with high-efficiency and cepacity development of maintenance skill for generation and transmission facilities are primitive issue for all member states.

[63] https://energy.gov/oe/services/electricity-policy-coordination-and-implementation/august-2003-blackout