The Republic of Uganda
Ministry of Energy and Mineral Development

PROJECT FOR MASTER PLAN STUDY ON HYDROPOWER DEVELOPMENT IN THE REPUBLIC OF UGANDA

FINAL REPORT

March 2011

Japan International Cooperation Agency

Electric Power Development Co., Ltd.
Nippon Koei Co., Ltd.

IDD
JR
11-022

Location Map

Kalagala Site

Isimba Site

Karuma Site

Oriang Site

Ayago Site

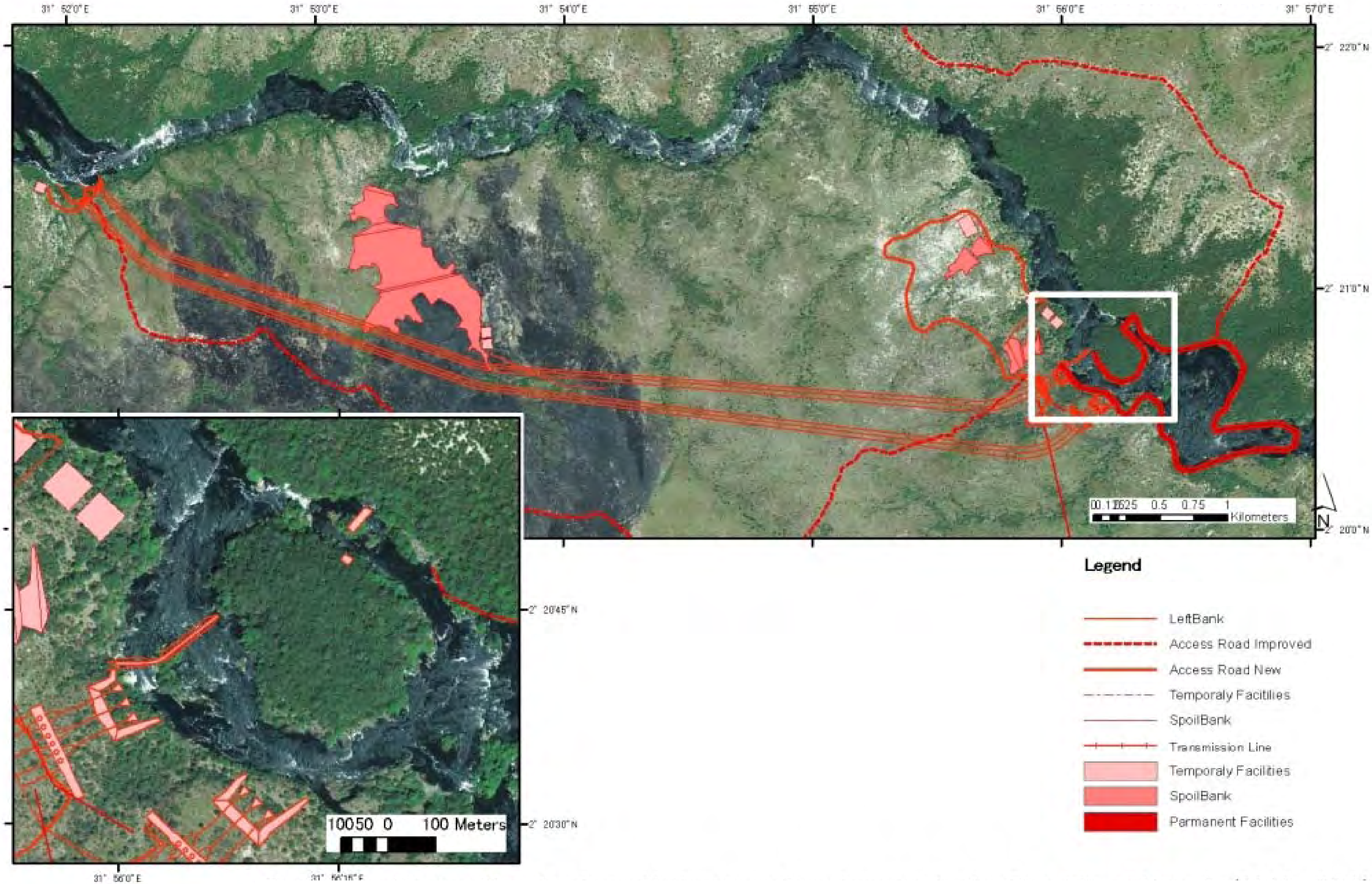
Kiba Site

Murchison Site

1st Stakeholder Meeting in Kampala (11 December, 2009)

2nd Stakeholder Meeting in Kampala (19 February, 2010)

3rd Stakeholder Meeting in Kampala (20 January, 2011)



Ayago Left Bank Plan

ABBREVIATIOM

Short Title	Formal Nomenclature
AfDB	African Development Bank
BEL	Bujagali Energy Ltd.
CAPP	Central Africa Power Pool
DSM	Demand Side Management
DWD	Department of Water Development
DWRM	Department of Water Resource Management
EAC	East African Community
EAPL	East Africa Electric Power & Lighting Company Limited
EAPMP	East African Power Master Plan
EAPP	Eastern Africa Power Pool
EEPCO	Ethiopian Electric Power Corporation
EIA	Environmental Impact Assessment
EIB	European Investment Bank
EPC	Engineering, Procurement, Construction
ERA	Electricity Regulatory Authority
ERC	Energy Regulatory Commission
F/S	Feasibility Study
GDP	Gross Domestic Product
GNI	Gross National Income
HIPC	Highly Indebted Poor Countries
IDA	International Development Association
IEA	International Energy Agency
IFC	International Finance Cooperation
IMF	International Monetary Fund
IPP	Independent Power Producer
IREMP	Indicative Rural Electrification Master Plan
IUCN	International Union for Conservation of Nature and Natural Resources
JICA	Japan International Cooperation Agency
KCCL	Kasese Cobalt Mine Limited
KenGen	Kenya Electricity Generating Co. Ltd.
KfW	Kreditanstalt fur Wiederaufbau
KML	Kilembe Mines Limited
KPC	Kenya Power Corporation
KPLC	Kenya Power and Lighting Co. Ltd.
Ksh	Kenya Shilling
LA	Local Authority
LCPDP	Kenya's Least Cost Power Development Plan
LRA	The Lord's Resistance Army
MAAHF	Ministry of Agriculture, Animal, Husbandry and Fisheries

MCA	Multi-Criteria Analysis
M/P	Master Plan
MEMD	Ministry of Energy and Mineral Development
MFPED	Ministry of Finance, Planning and Economic Development
MOH	Ministry of Health
MOU	Minute of Understanding
MTTI	Ministry of Tourism, Trade and Industry
MWE	Ministry of Water and Environment
NPA	National Planning Authority
NBD	Nile Basin Discourse
NBI	Nile Basin Initiatives
NDF	Nordic Development Fund
NBS	Net Basin Supply
NELSAP	Nile Equatorial Lakes Subsidiary Action Program
NEMA	National Environmental Management Authority
NFA	National Forest Authority
NORAD	Norwegian Agency for Development Cooperation
OJT	On the Job Training
PEAP	Poverty Eradication Action Plan
PPA	Power Purchase Agreement
PPP	Public Private Partnership
Pre-F/S	Pre-Feasibility Study
PSIP	Power Sector Investment Plan
PSRPS	The Power Sector Reform and Privatization Strategy
PSS/E	Power System Simulator for Engineering
PV	Photovoltaic
REA	Rural Electrification Agency
REB	Rural Electrification Board
REF	Rural Electrification Fund
RESP	Rural Electrification Strategy and Plan
SADC	Southern African Development Community
SAPP	Southern Africa Power Pool
SCADA	Supervisory Control And Data Acquisition
SEA	Strategic Environmental Assessment
SHM	Stakeholder Meeting
SIDA	Swedish International Development Agency
TANESCO	Tanzania Electric Supply Co. Ltd.
UBS	Uganda Bureau of Statistics
UEB	Uganda Electricity Board
UEDCL	Uganda Electricity Distribution Co. Ltd.
UEGCL	Uganda Electricity Generation Co. Ltd.
UETCL	Uganda Electricity Transmission Co. Ltd.

UMEME	(Swahili)
Ush	Uganda Shilling
ULC	Uganda Land Commission
UMD	Uganda Meteorological Department
UTB	Uganda Tourist Board
UWA	Uganda Wildlife Authority
WAPP	West Africa Power Pool
WB	the World Bank
WWF	World Wildlife Fund for Nature

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Conclusions and Recommendations

Conclusions and Recommendations

Conclusions

This study (the Study) was conducted under the name of the Project for Master Plan Study on Hydropower Development in the Republic of Uganda (the Project) from November, 2009 to March, 2011. The Study consists of a master plan study on hydropower development and a pre-feasibility study on a selected prospective site. As the result of the Study, Ayago hydropower project was selected as the selected prospective site and judged feasible from technical, economic, financial and environmental viewpoints. Taking the current situation of power supply into account, there is a need for Ayago hydropower project to proceed to the next step, feasibility study, as early as possible. The conclusions are summarized below.

(1) Background of the Study

The power demand in the Republic of Uganda has been increasing rapidly against a background of recent economy growth and it is predicted that the growth rate of power demand continues to be around 8%. Uganda is a member of Eastern Africa Power Pool and is expected to play a role of “Power Supply Country” utilizing wealthy hydropower resources.

Meanwhile, in the present circumstances, there is a lack of power generation infrastructures of installed capacity of about 600MW in total, low operation rate of hydropower stations that is actual power generation of 140-200MW against Installed capacity of 409MW and chronicle power shortage in Uganda. The maximum power demand is 391MW, while the maximum possible power supply is 387MW. Such situation would be one of disincentives to reinforce Eastern Africa Power Pool.

Under those circumstances, the government of Uganda (GoU) recognized that the development of power infrastructures was one of the top priorities and aimed to increase power supply with domestic energy sources, mainly hydropower and to expand electrification rate from the present 10% to 20% by 2014/2015. GoU also planned an aggressive hydropower development as an important source of foreign exchange from power export to neighbor countries including Kenya.

(2) Selection of Prospective Project

The Study conducted a strategic environmental assessment (SEA) pursuant to the JICA Guideline on Environmental and Social Consideration issued April 1, 2004. Firstly, a comparative study was made to verify the advantage of hydropower developments on the Victoria Nile between conceivable alternative energy sources. The alternative energy sources compared were geothermal, diesel engine, solar thermal, wind power, biomass and nuclear power. As the result of the Study, hydropower was judged as an indispensable and essential energy source in Uganda. Secondly, seven candidate hydropower projects (Kalagala, Isimba, Karuma, Oriang, Ayago, Kiba and Murchison) were identified and evaluated from various standpoints: technical, economic, environmental and social ones. Then, three hydropower projects -Ayago, Karuma, and Isimba- were selected as prospective hydropower projects. Finally, Ayago hydropower project was selected as selected prospective hydropower project, considering that feasibility studies (F/S) on Isimba and Karuma Hydropower projects were already underway. Therefore, a pre-feasibility study (Pre-F/S) on Ayago hydropower project was conducted. The stakeholder consensus on that procedure was built through a stakeholder meeting. In addition, the above information was disclosed on Internet WEB.

The selected Ayago hydropower project is of the run-of-river type with a firm capacity of 300MW and a maximum capacity of 600MW. In Uganda, low-cost power supply for base load is needed and also such a firm power source is worthy of power export because Ayago hydropower project could generate 300MW of stable energy at low cost. Hence, it is highly necessary to develop Ayago hydropower project.

(3) Power Demand Forecast and Power Development Plan

In the Grid Development Plan 2009-2025 (herein referred to as “GDP 2009-2025”), the annual growth rate of power demand from 2009 through 2025 is assumed at around 8%. The Study Team confirmed that this demand forecast was basically acceptable. The Study Team set three cases for power demand forecast from 2009 through 2023 in Uganda. Annual increase rate of Middle case of the power demand forecast by the Study Team is the same as that of GDP 2009-2025. Annual increase rate of High case is Middle case plus 1% and that of Low case is Middle case minus 1%. The Study Team prepared a power development plan in Uganda for five scenarios, I, II, III, IV and V, corresponding respectively to: Scenario I- Middle case of power demand forecast, Scenario II- High case, Scenario III- Low case, Scenario IV- Middle case plus export to Kenya and Scenario V and VI- Case considering the targeted demand of Uganda government. As the result of this Study, the conclusion was that Ayago hydropower project should be developed in stages from 2019 or 2020 with 100MW in each stage up to 2023.

(4) Main Features of Ayago Hydropower Project

A comparative study was conducted in technical, economic, environmental and social viewpoints to select the best type of Ayago hydropower project from three alternative layouts: Dam and water-way type, run-of-river type (right bank) and run-of-river type (left bank). As the result, the run-of-river type (left bank) was selected.

Main features of Ayago hydropower project is as follows.

Head.................................... 87m

Power Discharge 840m3/s

Annual Energy 4,095GWh

Intake Weir.......................... Concrete gravity type,
.... Height: 15 m, Crest length: 250 m
Headrace Tunnel .... Concrete lining, 6lines, Length: 113m
Penstock.............................. 6-12lines, Length 85 m
Tailrace................................ Concrete lining, 6lines, Length: 7,400-7,890 m
Powerhouse......................... Underground type
.... Width 23 m × height 40 m ×length 150 m ×2 Units
Turbine................................ Francis, 51 MW/unit × 12 units
Generator .... 55.5MW /unit × 12 units

The estimated construction cost for 600MW was around US$1,600 million at 2010 cost basis, including preparatory construction cost, environmental mitigation cost, civil works, hydro-mechanical equipment, electromechanical equipment, transmission lines, administrative and engineering costs and physical contingency. The construction period was estimated to be 5 years and 6 months.

(5) Economic and Financial Evaluation

Economic and financial evaluation was made for Scenario I and IV. The result of economic evaluation was that EIRR for Scenario I and IV were 24.36% and 24.44% respectively. Both Scenarios were confirmed as feasible from an economic point of view because both of them show EIRR over capital opportunity cost of 10%. This evaluation was done on the condition that power supply was limited to 300MW on account of its firm capacity and the benefit was the cost of alternative thermal power plant.

And also, as the result of financial evaluation and cash flow analysis, both scenarios were profitable and repayable because FIRR of Scenario I and IV were 12.83% and 18.46% respectively and DSCR of Scenario I and IV were 2.68 and 3.75 respectively. The above evaluation was done on the condition that electricity tariff was US$6 ¢ /kWh.

Recommendations

Ayago hydropower project is a valuable domestic energy to cover the increasing demand at an annual rate of over 8%. Development of Ayago hydropower project is expected to bring about the following effects:

- Contribution to stable power supply in Uganda;
- Cost saving by suspension of diesel thermal power plants; and,
- Carbon dioxide emissions reductions, over 500kt annually by suspending diesel and other HFO thermal power plants.

In addition, economic effect by earning foreign exchanges from power export is expected.

Nevertheless, there are plans for a series of large hydropower developments (Karuma, Isimba and Ayago), far exceeding the actual capabilities of Uganda in terms of financial requirements and human resources, bringing about a lot of uncertainties and issues to be solved financially, environmentally and organizationally on account of the perspective to 2020s of global economy and Uganda's situation as well as environmental change and uncertainty. In developing those hydropower projects, it is vital to give due consideration to capacity building of Ugandan human resources and to tackle the mounting issues flexibly according to future change of the situation.

Hence, suggested below are several recommendations and considerations in proceeding to the next stage -feasibility study (F/S).

(1) Environmental Impact Assessment (EIA)

Ayago hydropower project has few social impacts because it is located in the Murchison National Park, while adequate investigations and countermeasures for natural environment conservation are necessary. In order to mitigate impacts on natural environment as much as possible, this Pre-F/S adopted the run-of-river type with underground powerhouse and tunnel for waterway. Considering the limited nature of the environmental impact assessment made at SEA level in this Pre-F/S, it is necessary that a more in-depth study should be conducted at EIA level in such a way as to satisfy pertinent Ugandan law and donors' guidelines at F/S stage. It is especially to be noted that amenity flow on water reducing zone should be determined through consultation with related organizations in consideration of impacts on fauna and flora due to change in width and depth of river water as well as cumulative effects by other hydropower developments upstream and downstream of Ayago project.

A particular consideration should be paid to compatibility of development with tourism because national parks are important tourism sources for Uganda.

Moreover, as the Nile River is an international river, so it is desirable to fulfill accountability of development plan to downstream countries.

(2) Staged Development

Being of the run-of-river type, Ayago hydropower project has two kinds of output: firm energy produced by 300MW, dependable capacity for a period of 90 % of a year, and secondary energy produced only at the time of much river flow (Max 300MW). Generally, in a power system with thermal power as main supplier and hydropower as supplementary, the secondary energy will contribute to fuel saving of existing thermal power plants. Meanwhile, in Uganda with hydropower as main supplier and thermal power as supplementary, the secondary energy governed by rainfall is not dependable, so the secondary energy should not be counted into a power development plan.

Therefore, although the eventual development scale of Ayago project was determined to be 600MW, it is suggested to develop Ayago project to 300MW till the first half of 2020s and, as for the remaining potential of 300MW, it is wise to proceed to the development when power export negotiations with neighboring countries has been favorably concluded.

It should be noted that it is suggested to implement staged development with 100MW in each stage according to actual increase of power demand. In this case, the estimated construction costs of 1st stage, 2nd stage, 3rd stage, 4th stage 5th stage and 6th stage are US$436 mil, US$213 mil, US$213 mil, US$295 mil, US$221 mil, US$220 mil respectively.

(3) Funding plan

Bujagali hydropower project, now under construction, has been implemented by IPP scheme and also Isimba hydropower project, of which a feasibility study is under way, is planned to be implemented by IPP. Comparing with those projects, Ayago hydropower project requires a larger amount of funds. And there is not much likelihood in attracting foreign, private investment on favorable conditions to Uganda, which does not have strong export industries. It is therefore advisable to develop Ayago project in staged development, which is more likely to increase the possibility of obtain ODA loans.

(4) Restructuring the organization for project execution

Currently, in Uganda, except for tasks regarding demand forecast and grid expansion conducted by UETCL, a combined number of less than 10 of staff of MEMD and HPDU (UEGCL) are engaged in different tasks for Karuma, Isimba and Ayago hydropower projects. In proceeding to further stages of detail design and construction, the current organization and system will not be able to handle all tasks related to those projects.

Therefore, it is suggested to restructure the organization and system for project execution to form a dedicated agency for hydropower developments to properly cope with technical, environmental and financial issues.

(5) Development of Human Resources

Uganda has a serious lack of engineers necessary for hydropower development, especially geologists and civil engineers. As a short-term solution to such lack of human resources, it is more realistic to employ foreign consultants and experts dispatched by foreign governments under ODA scheme, who will provide capacity building through OJT.

In a longer term, it is suggested to reinforce higher education institutions by establishing special courses on hydropower for example.

(6) Technical Standards

There is no technical standard for hydropower development in Uganda. It is strongly suggested to establish the technical standards related to execution of hydropower projects from planning and design to construction and maintenance appropriately.

(7) Recommendation for Feasibility Study

It is recommended to implement the following items at the next Feasibility Stage, not covered by the Pre F/S.

1) Environmental Impact Assessment (EIA)

Particular points of consideration for EIA are as follows.

- Countermeasures and monitoring for water reducing area
- Compatibility with tourism
- Consideration for landscape impact, especially transmission line

2) Site investigation works and experiment for design and construction planning

It is necessary to execute additional topographical survey, river section survey and geological investigation for more in-depth basic design and construction planning.

It is recommended that a hydraulic model experiment should be conducted in order to grasp impacts on aquatic animal by flow condition around the intake.

3) Additional study for power system stability analysis and unit capacity

In addition to power flow and accident current analysis executed at this Pre-F/S, it is necessary to conduct power system stability analysis and, if necessary, additional study for determination of unit capacity, in order to build up highly reliable transmission system, in consideration of long-distance transmission line over 200km, which may become a governing factor in sound power system operation.

Chapter 1

Background of the Study, Objectives and Scope of the Study

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1.1 Background of the Study

The power demand in the Republic of Uganda is increasing by around 8% every year against a background of recent economy growth. As a member of the East African Power Pool, Uganda could become a regional power supplier using an abundance of water resources. On the other hand, the chronic lack of power supply resulting from the lack of power facilities, low availability of hydropower plants, that is actual power generation of 140-200MW against Installed capacity of 409MW, and undeveloped transmission lines has become a problem, which may lead to the disincentive of the East African Power Pool.

Under the prevailing condition, the government of Uganda (hereinafter referred to as "GOU") recognizes the urgent need for the development of new electric power plants and the expansion of power grids as prerequisites for economic growth. Therefore, GOU plans to increase the ratio of electrification from the present about 10% to 20% by 2014/2015 and to supply energy by using the domestic energy (especially hydropower) mainly. GOU is also willing to develop hydropower resources to accrue foreign currency by means of power export to neighbor countries (Kenya, etc.).

Based on this background the government of Japan decided to conduct the Project for Master Plan Study on Hydropower Development in Uganda (hereinafter referred to as "the Study") in response to the request of GOU.

1.2 Objectives of the Study

The Study aims at the preparation of Master Plan (hereinafter referred to as "M/P") of hydropower development in the Republic of Uganda in line with the long term power and transmission development plan. The Study includes the prioritization of potential hydropower sites based on consideration of technical, environmental, economical and financial aspects for the development in the period of 15 years as well as the optimal scale, basic layout and the framework of development so that the GOU can implement the projects. Technology transfer and capacity development for the counterpart personnel (hereinafter referred to as "C/P") shall be also carried out in the course of the joint study. Finally the Study aims at the implementation of necessary power supply plan that would support economic growth in the Republic of Uganda as well as the East African region.

1.3 Scope of the Study

The scope of the Study is based on S/W and M/M signed on August 31^{st}, 2009 and February 4^{th}, 2009 respectively. The contents of the Study, the demarcation of duties and responsibilities between the Study Team and the C/P and the Study schedule shall be as prescribed in the S/W and M/M. The Study shall be carried out in four stages as follows.

Stage 1: Basic Research
Stage 2: Selection of Prospective Sites
Stage 3: Preliminary Design on the Selected Prospective Hydropower Project
Stage 4: Preparation of Hydropower Development M/P

1.4 Schedule of the Study

The Study is composed of 2 parts: i) The preparation of hydropower development M/P and ii) The preliminary technical design of the Selected Prospective Project (basic layout, general design and construction cost). The work flow of study implementation is shown in Figure 1.4-1.

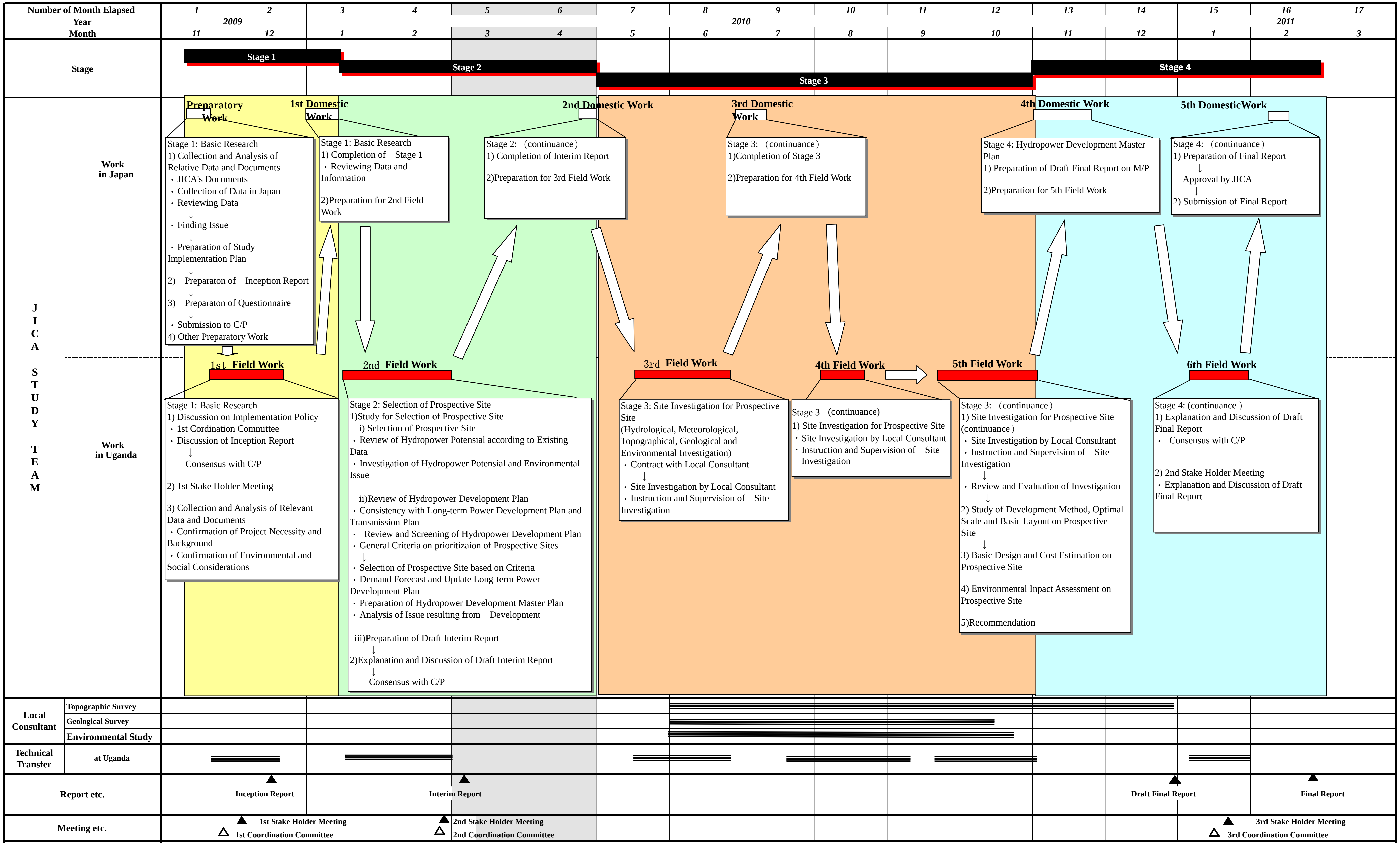


Figure 1.4-1 Work Flow of Master Plan Study Implementation

1.5 Contents of the Study

In this section, the Study items are described as follows.

Stage 1 Basic Research

(1) Preparatory Work: November, 2009

1) Collection and Analysis of Relevant Data and Documents
2) Preparation of Inception Report
3) Preparation for 1st Field Work

(2) 1st Field Work: November, 2009 - December, 2009

1) Presentation and Discussion of Draft Inception Report
2) 1st Stake Holder Meeting
3) Collection and Analysis of Relevant Data and Documents
   i) Necessity and Background of Project
   ii) Necessity of Hydropower Development and Confirmation of Prospective Site
   iii) Confirmation of Environmental and Social Considerations

(3) 1st Domestic Work: December, 2009 - January, 2010

1) Reviewing Data and Information collected in 1st Field Work
2) Preparation for 2nd Field Work

Stage 2 Selections of Prospective Sites

(1) 2nd Field Work：January, 2010 - February, 2010

1) Identification of Selected Prospective Site
2) Discussion of Draft Interim Report
3) 2nd Stake Holder Meeting
4) Preparation for Investigation of Prospective Sites

(2) 2nd Domestic Work：April, 2010

1) Completion of Interim Report
2) Preparation for 3rd Field Work
3) Confirmation of Future Investigation Plan, if necessary

Stage 3 Preliminary Designs on the Selected Prospective Hydropower Project

(1) 3rd Field Survey in Uganda (May-June, 2010)

Meteorological/Hydrological study, Topographic survey, Geological investigation and Environmental study at the project site

(2) 3rd Home work in Japan (June - July, 2010)

Follow-up of field survey, data analysis and preparation of 4th Field survey in Uganda

(3) 4th Field Survey in Uganda (August, 2010)

Follow-up Topographic survey, Geological investigation and Environmental study

(4) 5th Field Survey in Uganda (September - October, 2010)

The survey outputs will include:
1) Data analysis and interpretation of subletting field surveys
2) Development plan, optimum project size and basic layout study
3) Preliminary design and Cost estimate (Pre-F/S level)
4) Recommendation for the development of the hydropower project

Stage 4 Preparation of Hydropower Development M/P

(1) 4th Domestic Work (November, 2010)

1) Preparation of Draft Final Report for Hydropower Development M/P
2) Preparation for 5th Field Work

(2) 6th Field Work (January, 2011)

1) Discussion on Draft Final Report
2) 3rd Stake Holder Meeting (SHM)
3) Preparation of Data Base and Implementation Plan etc.
4) Preparation of Check List for Environmental Social Consideration and Guideline of SHM

(3) 5th Domestic Work (February, 2011)

Preparation of Final Report

1.6 Record on Dispatch of Study Team and Submission of Report

JICA commenced the Study in November 2009, based on S/W, and dispatched the Study Team to Uganda as described below:

1st Work in Uganda	November 30, 2009 to December 23, 2009
2nd Work in Uganda	January14, 2010 to February 28, 2010
3rd Work in Uganda	May 14, 2010 to June 6, 2010
4th Work in Uganda	August 2, 2010 to August 19, 2010
5th Work in Uganda	September 17, 2010 to November 2, 2010
6th Work in Uganda	January 5, 2011 to February 3, 2011

The Stake Holder Meetings (SHM) were held during the stay of the Study Team as below.

1st SHM	December 11th, 2009
2nd SHM	February 19th, 2010
3rd SHM	January 20th, 2011

The Study Team submitted the following reports on the Study to JICA/MEMD:

Inception Report	December 2009
Interim Report	March 2010
Draft Final Report	December 2010
Final Report	March 2011

1.7 Counterparts and Study Team

1.7.1 Counterparts

The MEMD counterparts are listed in Table 1.7.1-1

Table 1.7.1-1 Ministry of Energy and Mineral Development (MEMD)

No.	Name	Job Title	Organization
1	Paul Mubiru	Director	MEMD
2	James Baanabe	Acting Commissioner	MEMD
3	Henry Bidasala – Igaga	Ass. Commissioner	MEMD
4	Cecilia N Menya	Principal Energy Officer	MEMD
5	Jimmy C. Omona	Hydromechanical Engineer	Hydro Power Unit, UEGCL
6	Dan Walakira Mayanja	Technical Manager	UEGCL
7	Moses Kaizzi	Civil Engineer	UEGCL
8	Otim Moses	Environmental Specialist	Hydro Power Unit, UEGCL
9	Jackson Twinomujuni	Ass. Commissioner	MWE
10	Kitayimbwa Godfrey	Electrical Specialist	Hydro Power Unit, UEGCL
11	Gerald Muganga	Manager Project Planning	UETCL
12	Ziria Tibalwa	Principle Engineer, Project	UETCL

No.	Name	Job Title	Organization
		Planning	
13	Emmanuel Ajutu	Head Sector Planning Unit	MEMD
14	Paul Omute	Surveyor	Hydro Power Unit, UEGCL
15	Zachary Baguma	Assistant Commissioner	MEMD (GSMD-Entebbe)
16	Joan Mutiibwa	Energy Officer	MEMD
17	Fred Sajjabi	Senior Energy Officer	MEMD
18	Edgar Buhanga	Senior Planning and EIA Coordinator	UWA
19	Arnold Waiswa	EIA coordinator	NEMA
20	Angella Rwabutomise	Desk officer Energy	MFPED

1.7.2 JICA Study Team

The JICA Study Team members are listed in Table 1.7.2-1.

Table 1.7.2-1 JICA Study Team

No.	Name	Job Title	Occupation
1	Kazumoto Onodera	Team Leader /Power Development Planning	Electric Power Development Co., Ltd.
2	Masayuki Seino	Hydropower Planning /Hydro Civil Engineering A-1	Electric Power Development Co., Ltd.
3	Tatsuya Miyazato	Hydropower Design /Hydro Civil Engineering A-2	Nippon Koei Co., Ltd.
4	Tetsuaki Mori	Hydropower Construction Planning and Cost Estimation /Hydro Civil Engineering B	Electric Power Development Co., Ltd
5	Yasushi Momose	Geography /Geology	Nippon Koei Co., Ltd.
6	Sohei Uematsu	Hydrology	Nippon Koei Co., Ltd.
7	Eiji Tsuchiya	Transmission Planning /Electromechanical Equipment	Electric Power Development Co., Ltd.
8	Yoshiaki Miyagawa	Power Demand Forecast / Power System and Interchange Planning	Nippon Koei Co., Ltd.
9	Nobuyuki Kinoshita	Power Demand Forecast / Power System and Interchange Planning	Nippon Koei Co., Ltd.
10	Tetsuro Tanaka	Economics /Finance /Investment Planning	Electric Power Development Co., Ltd.
11	Akiko Urago	Natural Environment and GIS (Environment and Social Considerations A)	Electric Power Development Co., Ltd.
12	Riai Yamashita	Social Environment (Environment and Social Considerations B)	Electric Power Development Co., Ltd.
13	Takeshi Washizawa	Coordination	Electric Power Development Co., Ltd.

Chapter 2

General Condition of Uganda

Chapter 2 General Condition of Uganda

2.1 Outline

The Republic of Uganda is a landlocked country surrounded by Kenya, Tanzania, Sudan, the Democratic Republic of Congo and Rwanda. Kampala, the capital city of Uganda, is located at latitude 1° north and longitude 32° east and at 1,300 m elevation approximately.

The Republic of Uganda with 4 big lakes has abundant water resources. Victoria Nile River which forms the upper section of the Nile River is main the river in Uganda and it flows from the northern end of Lake Victoria through Lake Kyoga to Lake Albert. After Lake Albert, the Nile River flows through northern Uganda to Sudan. Uganda has other natural resources, including nickel, copper, cobalt, gold, limestone, peat, crude oil and natural gas.

Administrative division in Uganda consists of 112 District (including capital city of Kampala) as of July 2010. The total population of Uganda in 2002 was 24,227,300 according to the census, and; it was estimated at 32,360,558 in 2009. The population growth rate in 2009 was estimated at 2.692 % per year. The population density is comparatively high in the north coast of Lake Victoria and lower in the north and north-eastern area. The population of Uganda is made up of different ethnic groups. Fifty six tribal groups are listed in the 1995 Constitution of Uganda. The Buganda, which accounts for 17.7 percent, is the largest group followed by the Banyankole, 10.0% and the Basoga, 8.9%. Catholics are the largest religious denomination (42%) followed by the Anglicans (36%), Muslims (12%) and the Pentecostals (4.6%) according to the census.

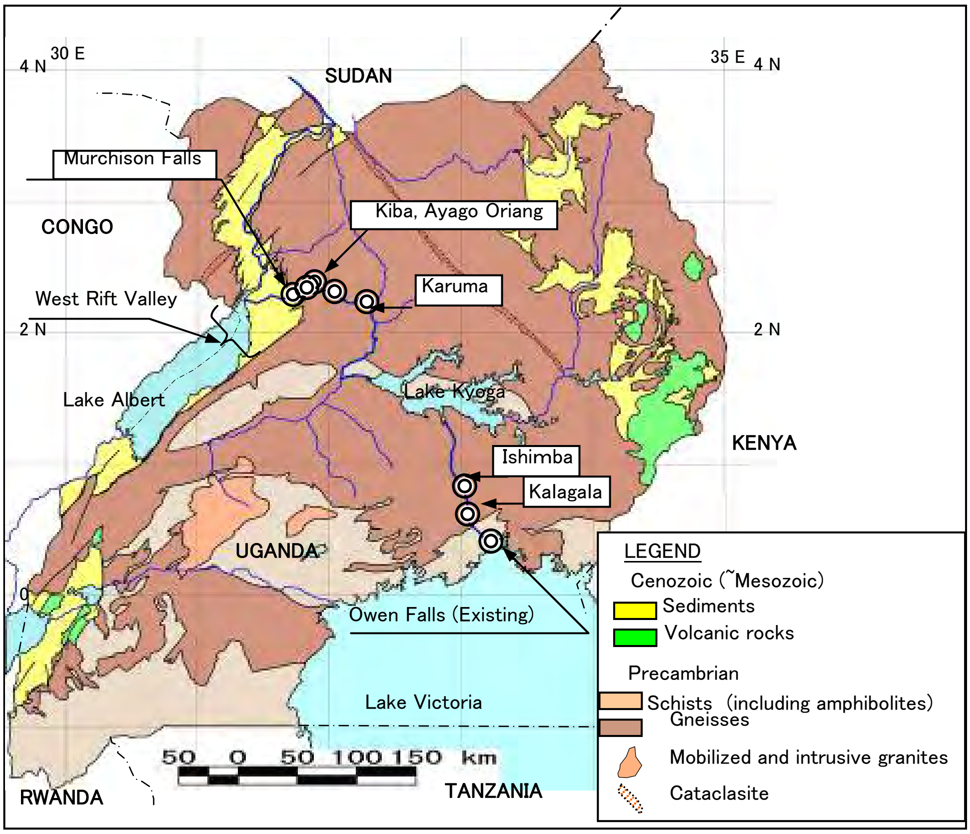
Uganda has seen an average annual growth rate of GDP at about 7.6% from 2001 through 2009 at constant 2002 price. GDP as of 2009 was 34,166 billion shillings (about US$ 18 billion) at current prices. Per capita GDP as of 2009 at current prices was 1,116,300 shillings (about US$ 589).

2.2 Topography and Geology

The Republic of Uganda is a landlocked state of East Africa, bordered on the east by Kenya with the more than 3000 m high mountain Elgon (highest peak: Mt. Elgon, 4,321 m), and on the west by the Democratic Republic of Congo with the western leg of the East African Rift Valley and the Rwenzori Mountains (highest peak: Mt.Stanley 5,109 m) . The central part of the country forms a gentle sloping plateau of over 1000 meters above sea level. The Victoria Nile River outflows from Lake Victoria and cuts across the central plain in its northward journey via Lake Kyoga, to Sudan and Egypt in the north of Uganda.

Uganda is underlain mainly by Precambrian gneisses, and schist including amphibolites that occurs along the southern part of the country. The Rift Valley is active and expanding. The bottom of the valley is covered by thick Cenozoic sediments (including volcanic rocks). Cenozoic volcanic rocks are also distributed in the southeastern parts of Uganda.

The geology of Candidate Hydropower Projects sites of the Victoria Nile River are underlain by gneisses as shown in Figure 2.2-1. Consequently, hard bedrocks, suitable for structural foundations, can be expected at all the sites



(Source: 1:1,500,000 Geological Map, Department of Geological Survey and Mines, Uganda, 1966)

Figure 2.2-1 Geology of Candidate Hydropower Projects

2.3 Climate

Uganda is a landlocked country crossed by the equator at its southern part. The climate belongs to the tropical type which is subject to the movement of the Inter-tropical Convergence Zone (ITCZ). The movement of the ITCZ from the southern to the northern hemisphere causes two rainy seasons a year in the surrounding equatorial area of Uganda. In the area, rainy season generally occurs between March to May, and October to November. The northern area has single rainy season with a peak in August as the ITCZ moves towards high north latitude. The area has the dry season around January. The annual precipitation in Uganda varies from 500 mm to 2,500 mm, and the average for the whole country is about 1300 mm. The average temperature of the country is 21°C and temperature varies from 15°C to 30°C. The monthly average temperature and rainfall in the major cities in Uganda are shown in Figure 2.3-1.

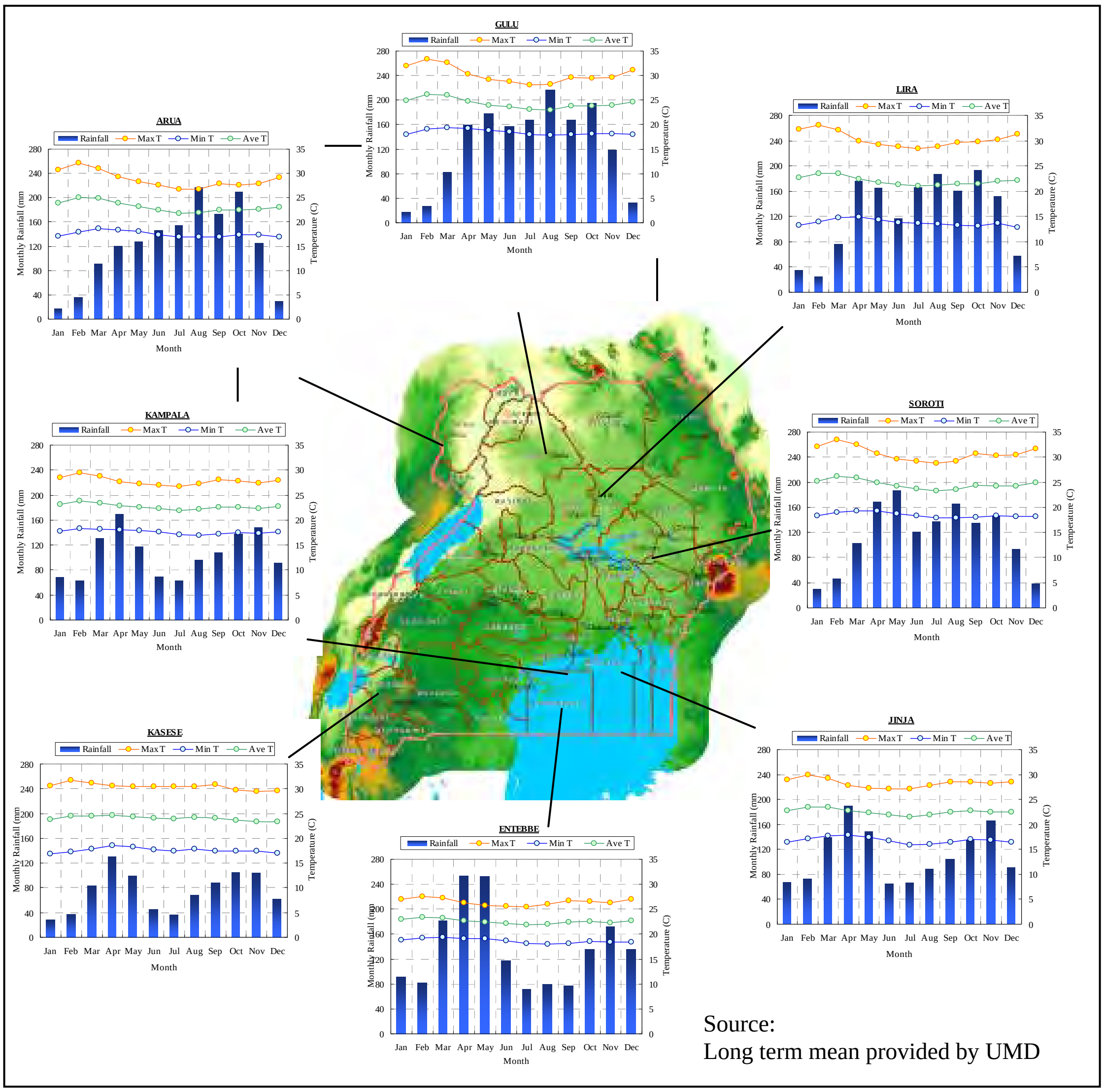
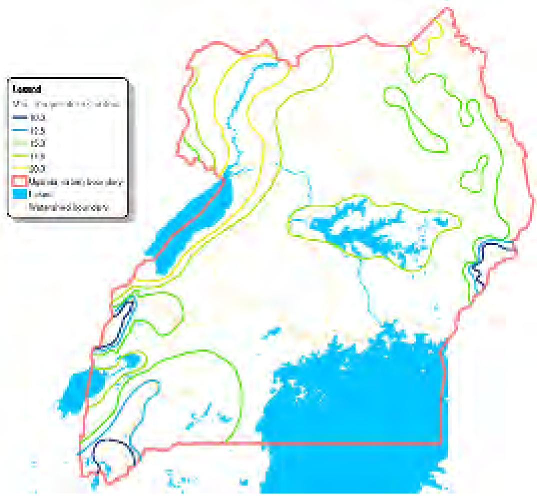


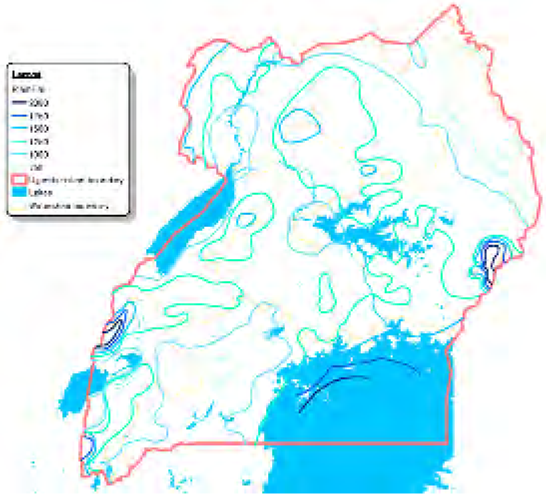
Figure 2.3-1 Temperature and Average Rainfall in the Major Cities in Uganda

Isohyet, isothermal (temperature), and evaporation of Uganda is shown in Figure 2.3-2.

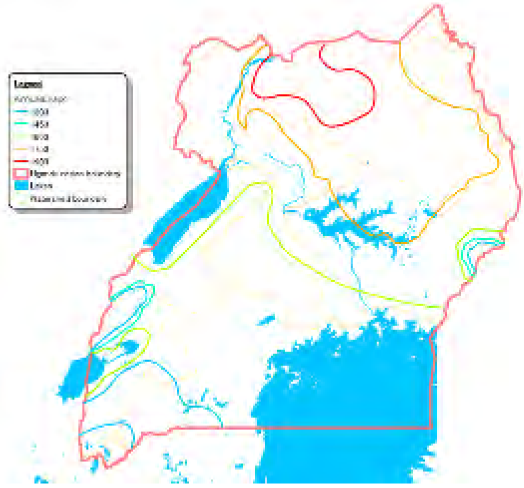
Maximum Temperature (°C)



Minimum Temperature (°C)



Annual Rainfall (Isohyet Map in mm)



Annual Evaporation (mm)

(Source: ATLAS, Macmillan Uganda)

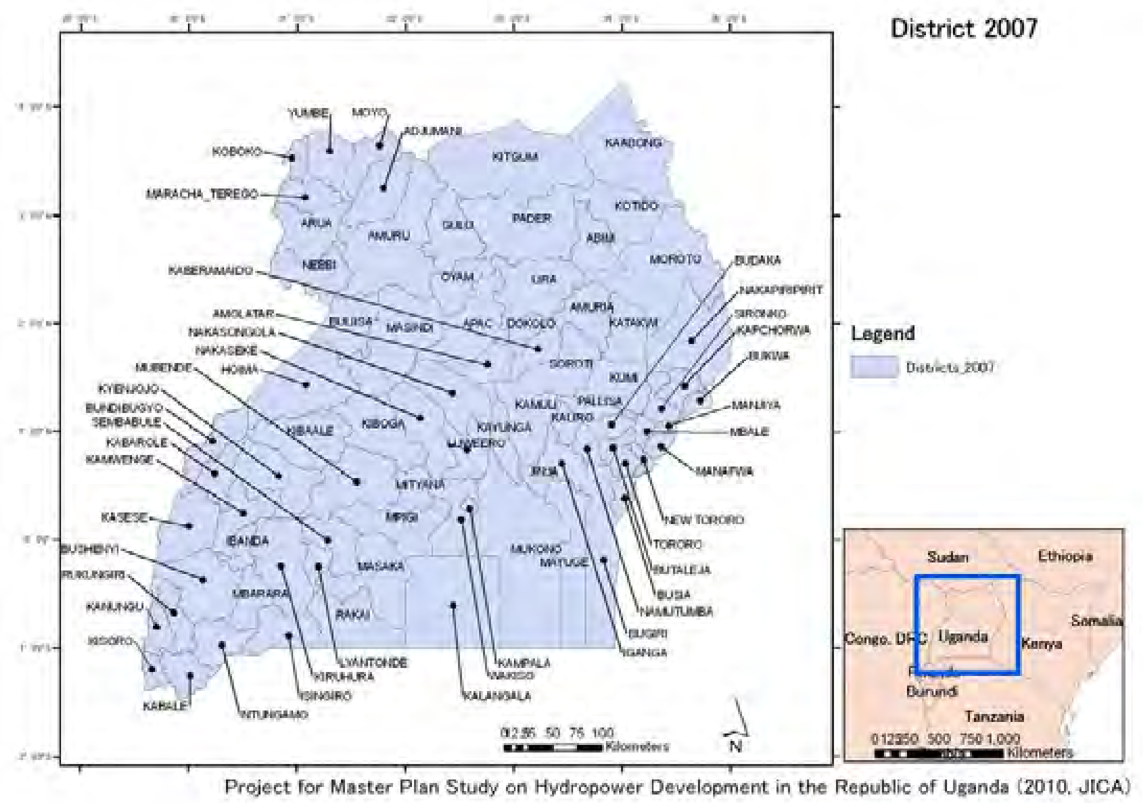
Figure 2.3-2 Isohyet, Isothermal and Evaporation Map of Uganda

The difference between maximum and minimum temperatures around Lake Victoria is small due to heat retention by the lake body. Northern area has a large difference in temperature because of its inland climate. The annual evaporation varies between 1300 mm to 1900 mm in the country, and northern area has larger evaporation height than that of southern area.

2.4 Social environment

2.4.1 Administrative Boundaries

Administrative divisions in Uganda consist of Districts (Local Councils: LC5), Counties (LC4), Sub-counties (LC3), Parishes (LC2), and Villages (LC1) in rural areas, and Districts/Cities (LC5), Municipalities (LC4), Towns/Divisions (LC3), Wards (LC2), and Cells (LC1) in urban areas. Since establishment of the decentralization policy in 1991, the number of Districts has increased, reaching 80 in July 2006 (see Figure 2.4.1-1) and 112 in July 2010 (GIS data is not available).

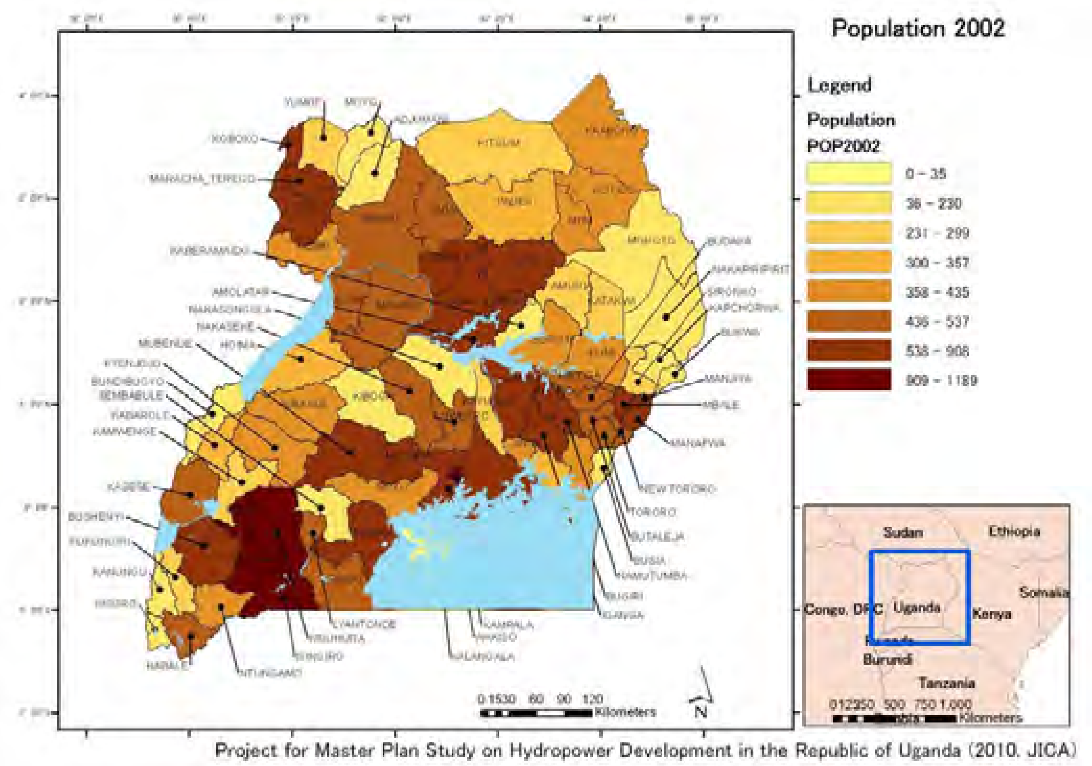


(Source: Uganda Bureau of Statistics)

Figure 2.4.1-1 Administrative Boundaries by District, 2007

2.4.2 Population

The total population of Uganda in 2002 was 24,227,300 according to the census, and it was estimated at 32,360,558 in 2009. Population growth rate in 2009 was estimated at 2.692% per year. Population density is comparatively high on the north coast of Lake Victoria and lower in the northeast area (see Figure 2.4.2-1).

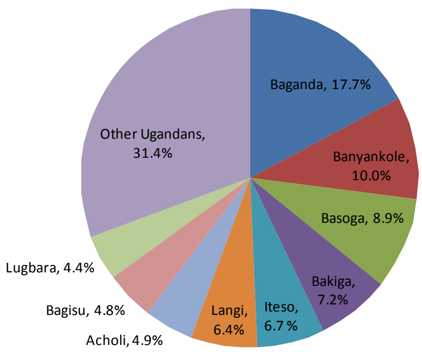


(Source: 2002 Population and Housing Census)

Figure 2.4.2-1 Population Density (Person/Km2) by District, 2002

2.4.3 Ethnic Groups

The population of Uganda is made up of different ethnic groups. Fifty-six tribal groups are listed in the 1995 Constitution of Uganda. As the figure below shows, the Baganda, accounting for 17.7 percent, constitutes the largest group, followed by the Banyankole (10.0 percent) and the Basoga (8.9 percent). The ethnic groups are headed by traditional kings or chiefs, who are not politically elected but have a significant influence in community governance and moral formation. They play a major role in shaping the behaviours and ways of life of the people in the region.



(Source: 2002 Population and Housing Census)

Figure 2.4.3-1 Distribution of Population by Ethnic Groups, 2002

2.4.4 Agriculture and Livestock

Agriculture is the dominant economic activity in Uganda. According to 2009 Statistical Abstract, its contribution to total GDP in 2008 was 21.5 percent. Similarly, the sector employs/occupies over 70 percent of the working population[1]. However, most farmers are subsistence farmers; they produce primarily for their own consumption but may sell some of the products. Livestock production plays a key role in raising incomes of households and providing a source of protein to many people. The production of crops, distribution of crops, number of livestock and distribution of livestock are shown in Table2.4.4-1, Figure 2.4.4-1, Figure 2.4.4-2, and Figure 2.4.4-2, respectively.

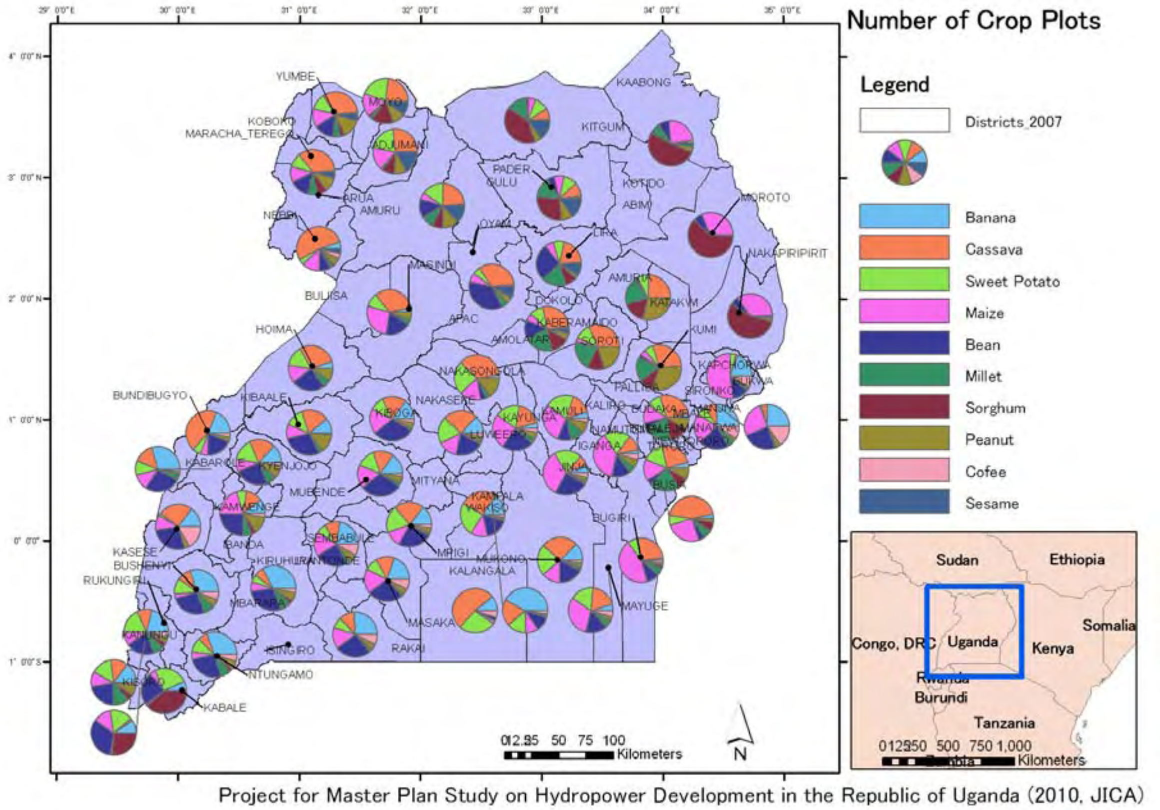
Table 2.4.4-1 Production of Selected Food Crops 2003-2008

(Thousand tonnes)

	2003	2004	2005	2006	2007	2008
Banana	9,700	9,686	9,380	9,052	9,233	9,371
Cassava	5,450	5,500	5,576	4,924	4,973	5,072
Maize	1,300	1,080	1,237	1,258	1,262	1,266
Millet	640	659	672	687	732	783
Sweet Potatoes	557	573	585	628	650	670
Sorghum	421	399	449	440	458	477
Beans	525	455	478	424	430	440
Peanuts	150	137	159	154	162	173
Sesame	120	125	161	166	168	173

(Source: Uganda Bureau of Statistics)

[1] All persons aged five years and above whose status is paid employee, self employed, or unpaid family worker.



(Source: Agricultural Statistics 2002)

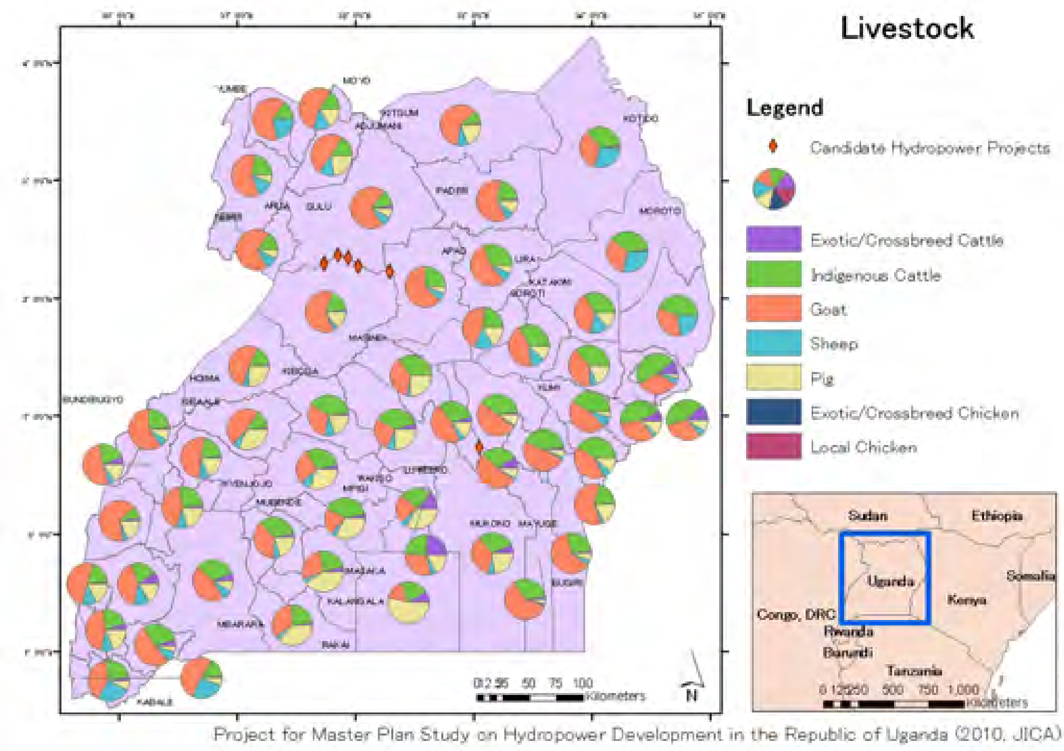
Figure 2.4.4-1 Number of Crop Plots by District

Table 2.4.4-2 Number of Livestock 2003-2008

(thousand animals)

	2003	2004	2005	2006	2007	2008
Cattle	6,519	6,567	6,770	6,973	7,182	7,398
Sheep	1,175	1,552	1,600	1,648	1,697	1,748
Goats	7,092	7,566	7,800	8,034	8,275	8,523
Pigs	1,778	1,940	2,000	2,060	2,122	2,186
Poultry	35,903	31,622	32,600	26,049	26,950	27,508

(Source: Ministry of Agriculture, Animal Industry and Fisheries and Uganda Bureau of Statistics)



(Source: Agricultural Statistics 2002)

Figure 2.4.4-2 Number of Households with Livestock by District

2.4.5 Fishery

Fishing is carried out on almost all lakes in Uganda. Lake Victoria is the largest body of water in Uganda. As the table below shows, more than half of the fish caught are from Lake Victoria. Albert Nile (a part of the River Nile from Lake Victoria to Lake Albert) contributes only 1.3 percent of total catch.

Table 2.4.5-1 Fish Catch by Water Body 2003 -2007

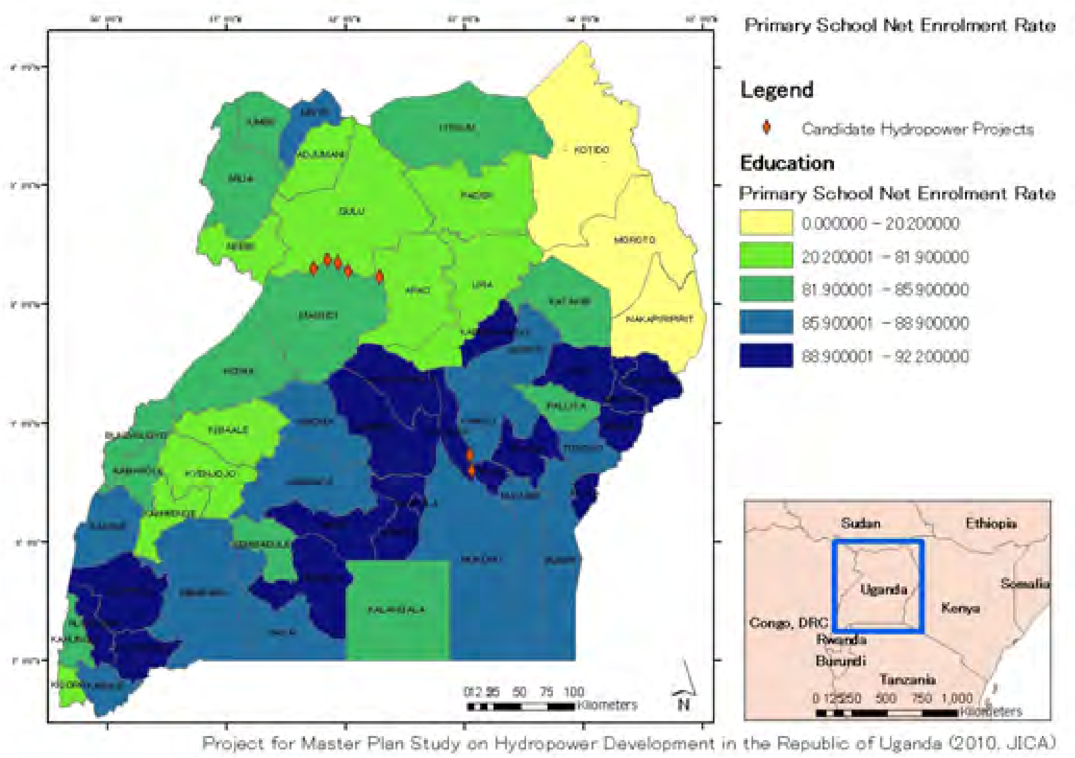
(thousand tonnes)

	2003	2004	2005	2006	2007
Lake Victoria	175.3	253.3	253.3	215.9	223.1
Lake Albert	19.5	56.4	56.4	56.4	56.4
Albert Nile	5.6	6.4	5	5	5
Lake Kyoga	32.9	68.5	68.4	60	60
Lake Edward, George & Kazinga Channel	5.9	9.6	9.6	8.8	8.8
Other Waters	8.3	40.6	24.1	21.1	21
Total	**247.5**	**434.8**	**416.8**	**367.2**	**374.3**

(Source: Fisheries Department, Ministry of Agriculture, Animal Industry and Fisheries)

2.4.6 Education

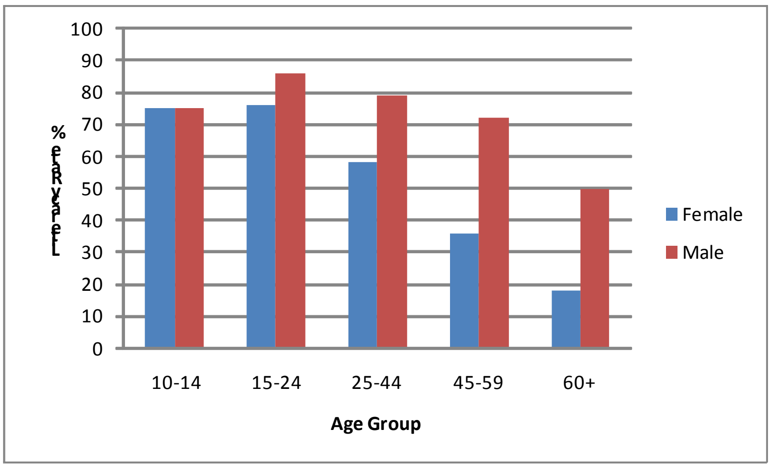
Net enrolment rate (NER) for primary school in Uganda is 89% (Planning Unit, Ministry of Education and Sports,2008) . NER by District is shown in Figure 2.4.6-1.



(Source: 2002 Population and Housing Census)

Figure 2.4.6-1 Primary School Net Enrolment Rate by District

According to the 2002 Population and Housing Census, the proportion that had never been to school was much higher among females (25 percent) than males (14 percent). Similarly, gender disparity in literacy rates exists in all age groups except ten to fourteen years (Figure 2.4.6-2) .

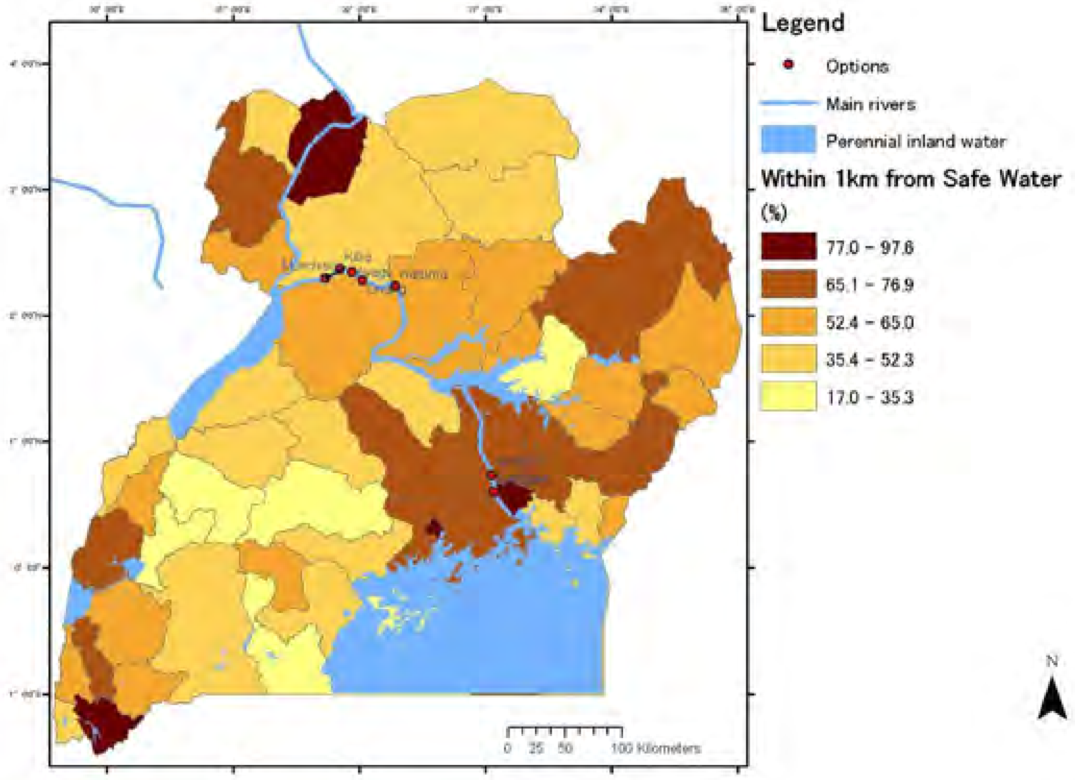


(Source: 2002 Population and Housing Census)

Figure 2.4.6-2 Literacy Rates by Age and Gender

2.4.7 Health

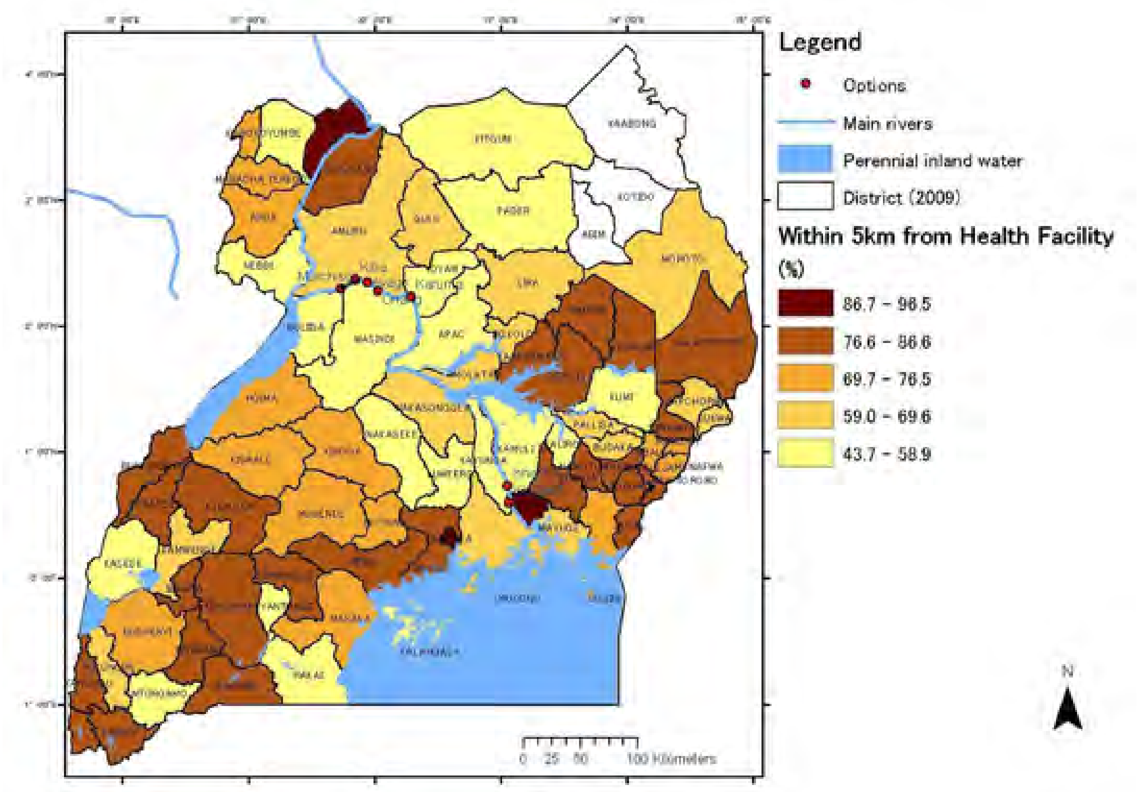
The 2002 Census showed that 61 percent of households had access to safe water. According to the figure below, access to safe water is much higher in urban areas.



(Source: 2002 Population and Housing Census)

Figure 2.4.7-1 Household within 1km from Safe Water by District

Similarly, the figure below shows the disparity between urban and rural areas in relation to access to health facilities such as hospitals and health centres. It reveals that the proportion of the households which are within five kilometres from a health facility is lower in the Northern region (around 66 percent) and higher in the Central region (78 percent).



(Source: 2002 Population and Housing Census)

Figure 2.4.7-2 Household within 5km from Health Facility by District

2.4.8 Tourism

In 1960s, Uganda was the main tourism destination in East Africa. Tourism was one of the main economic sectors in the country. However, during the period of turmoil in 1970s and 1980s, wildlife was hunted virtually in many protected areas and tourism infrastructure was destroyed. Today, the security situation has improved and the tourism industry has strong potential for re-establishment and growth.

Tourism Policy for Uganda (2003) described the way forward for strong development of the tourism sector, leading to an increase of tourist arrivals to Uganda from about 200,000 to 500,000 over the last ten years prior to 2005. It aims at ensuring e that tourism becomes a vehicle for poverty reduction through wide participation of Ugandan and foreign investors. The policy particularly seeks to assist in the effort to promote the economy and the livelihoods of the people, through encouraging the development of quality tourism that is culturally and socially acceptable environmentally sustainable and economically viable.

The way forward described in the tourism policy builds on the following key strategic principles.

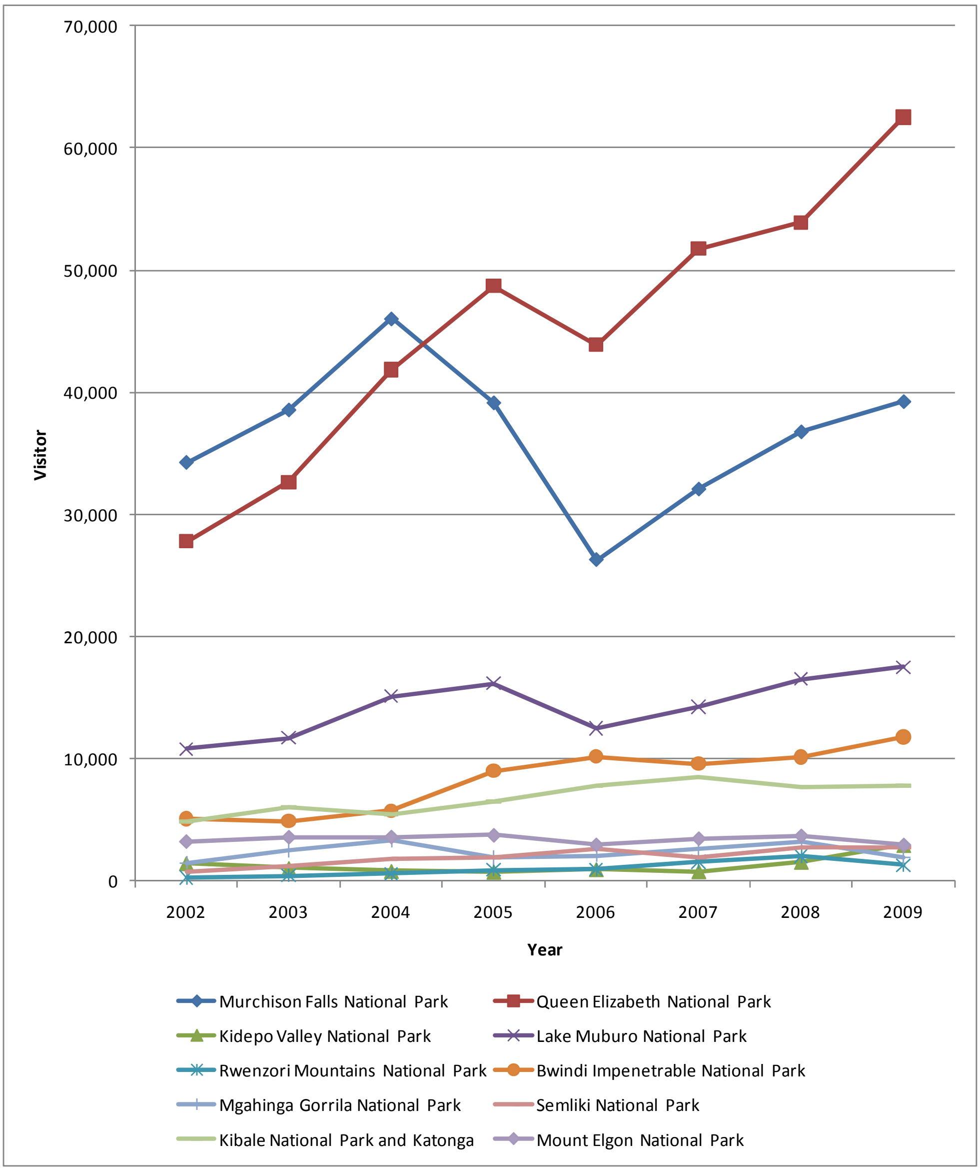
- Mobilisation and participation of stakeholders.
- Capacity building for the private sector to enable it to gradually take a lead role.

- Formation of linkages between private and public sectors on all levels.
- Formation of linkages between the districts and the national centre.
- Introduction of a bottom-up principle with support to developments at district level and with focus on community based tourism development.
- Focus on sustainable development forming links between the parks and the surrounding districts/communities and focus on protection of natural and cultural resources in the districts aiding at present and future tourism development through a sensitisation process.

In addition, the Ministry of Tourism, Trade and Industry formulated an action plan as follows.

- A committee consisting of persons from relevant ministries, departments and private sector institutions will be established to coordinate the policy implementation.
- The Ministry will encourage the formation of membership-driven, tourism sector umbrella organizations such as Uganda Tourism Association (UTA), and with assistance from the Private Sector Foundation, UTA will be strengthened.
- A tourism Bill will be presented to Parliament after due consultations and processing, and when passed, will guide operations of all stakeholders in the industry.
- Stable funding sources for effective implementation of this policy will be established through tourism levy as a means of providing stable funding to the Uganda Tourist Board and for the private sector support.
- Continue dialogue for the implementation of policies, which enhance incentives to the private sector such as, zero rating of VAT, providing of low interest rate development loans and reduction on import duties for tourism related imports.
- Strengthening UTB, UTA and other trade associations to enhance tourism development and marketing.
- Building capacity in districts to assist in the registration and licensing of tourism focal points and inspection of facilities.
- Ensuring full implementation of the Wildlife Protected Areas Systems Plan (WPASP).

Uganda’s major tourist attractions are its national parks and wildlife reserves. The tourism industry has expanded in recent years as a result of improved security and better facilities for tourists. Figure 2.4.8-1 provides the number of visitors to the ten main national parks within the country. These parks offer different tourism activities, such as gorilla tracking, nature guided walks, village walks, butterfly watching, bird watching, and rare fauna species.



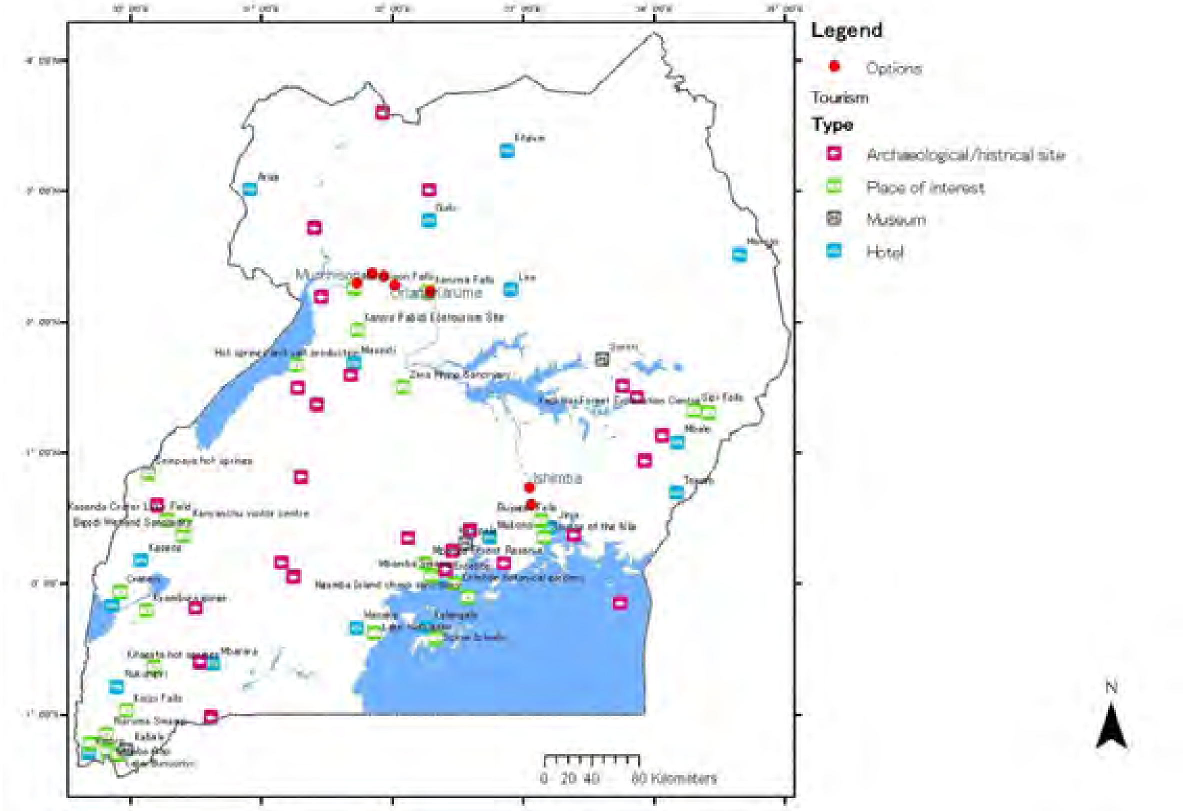
(Source: Uganda Wildlife Authority)

Figure 2.4.8-1 Number of Visitors to the National Parks (Citizen and Foreigners) 2002-2009

The total number of tourists into the country has steadily increased from 468,000 in 2005 to 844,000 in 2008. However, in 2009 there has been a 5 percent decline in the number of tourists to 817,000 (the Ministry of Tourism, Trade and Industry)[2].

Tourists also like to visit natural features such as lakes, rivers, waterfalls, mountains, and hot springs and cultural sites such as forts, shrines, palaces, caves, rocks, and museums. Since Uganda has a long history of kingdoms, as indicated in Figure 2.4.8-2, there are many cultural assets and archaeological properties.

2 Statistics and figures are available at the webpage of the Ministry of Tourism, Trade and Industry (http://www.mtti.go.ug/).



(Source: Uganda Museum)

Figure 2.4.8-2 Tourism Sites in Uganda

2.5 Macroeconomic Situation

2.5.1 Overview

The economy of Uganda, once in decline under Amin's regime between 1971 and 1979, has been revived under the regime of President Museveni since 1986, by promoting structural adjustment policy backed by IMF and World Bank to become one of the fastest growing sub-Saharan countries.

The following table shows key economic indicators of Uganda.

Table 2.5.1-1 Key Economic Indicators

Key Indicators	2005	2006	2007	2008	2009	Average
GDP growth rate (%)	10.0	7.0	8.1	10.4	5.2	8.1
Inflation rate (%)	8.6	7.2	6.1	12.0	13.0	9.4
Fiscal balance (of GDP: %)*	-	-0.7	-2.0	-4.6**	-	-2.43
Fiscal balance (excl. grants)	-	-7.0	-4.6	-9.1**	-	-6.9
Current account balance of payments (of GDP: %)	0.38	-3.07	-3.01	-4.56	-2.42	-2.54
Current account balance of payments (excl. grants)	-6.22	-8.66	-5.90	-6.88	-4.81	-6.49
Foreign exchange reserves (months of import)	5.4	5.52	5.8	5.3	5.58	5.52
DSR (debt service/export: %)	11.75	14.24	3.94	2.60	2.42	6.99

(Source: UBOS Statistical Abstract 2010 & Bank of Uganda Annual Report 2008/09)

Notes: * fiscal year (beginning in July) 2005=2005/06 and so on.

** provisional

GDP was growing rapidly at rates over 7% up to 2009, when it dropped to 5.2%. The average growth rate was 8.1%. It can be said that Uganda economy has so far been growing steadily, although 2009 saw a lower growth rate than expected. In the meantime, inflation rate was increasing since 2008 against the government's target at below 7% and inflation rate reached a warning level of 12% and 13% in 2008 and 2009, respectively.

As for the government fiscal balance, the deficit was 4.6% of GDP (provisional figure) including grants in 2008/2009, while without grants it would have been 9.1% of GDP (provisional figure) in the same fiscal year. It can be said that Uganda government's finance was being supported by grants from donors.

Regarding the balance of international payments, the current account balance continued to be in deficit, 4.81% of GDP excluding grants in 2009, against 2.42% with grants included. It can, therefore, be said that the balance of international payments was also supported by grants from donors. Foreign exchange reserves were being maintained at around 5 months of future imports and DSR (debt service ratio) was declining since 2007, improving considerably from 14.24% in 2006.

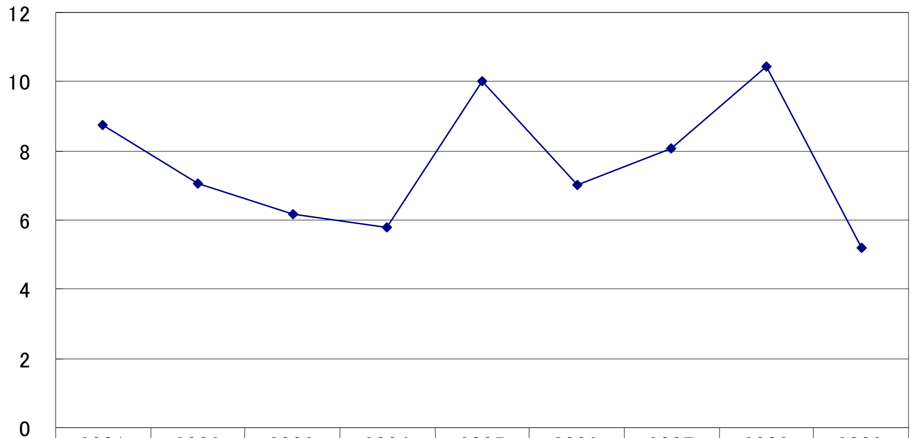
Overall, Uganda economic performance was good, nevertheless in 2009, there were some alarming signals such as a drop in GDP growth rate and a double-digit inflation rate.

2.5.2 Gross Domestic Product

Uganda has seen an average annual growth rate of GDP at about 7.6% from 2001 through 2009 at constant 2002 price. GDP as of 2009 was 34,166 billion shillings (about US$ 18 billion[3]) at current

[3] Exchange rate: Shs. 1,896.64/US$ as of December 2009

prices. Per capita GDP as of 2009 at current prices was 1,116,300 shillings (about US$ 589).



Year	2001	2002	2003	2004	2005	2006	2007	2008	2009
(%)	8.8	7.1	6.2	5.8	10.0	7.0	8.1	10.4	5.2

(Source: UBOS Statistical Abstract 2010)

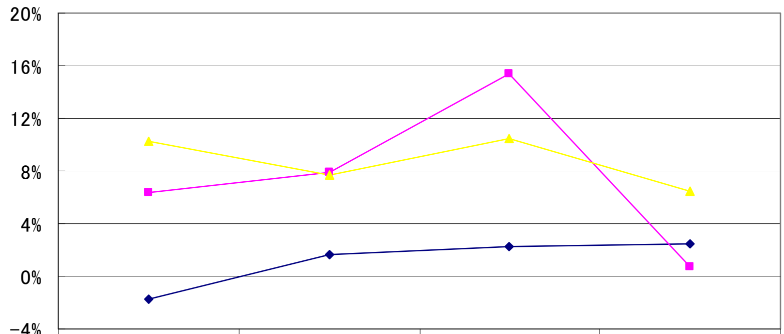
Figure 2.5.2-1 GDP growth rate

Global economic recession and international price hike in foods and oil affected Uganda's economy since mid-2008 but its GDP grew at 5.2% in 2009. As can be seen from Figure 2.5.2-2, the service sector growth contributed most to the GDP growth, followed by Industry Sector except for the year 2009.

Major activities of Services Sector were wholesale & retail trade, followed by transport & communications and real estate activities. Wholesale and retail trade experienced a growth rate of 5% in 2009, a decrease in growth rate of 9% compared to 2008 (14%). Transport and communications grew at 10% in 2009, a decrease in growth rate of 13% compared to 2008 (23%), since transport dropped from 7% of growth rate in 2008 to 2.4 % in 2009, while posts and telecommunications grew by 16,5%, a drop in growth rate by 23% with respect to 2008 (about 40%).

Major activities of Industry Sector were construction followed by manufacturing. The year 2008 saw such a high growth rate as 21.6% mostly due to public civil construction of roads and bridges but declined to -4.4% in 2009. The growth rate of Manufacturing was 10.1% in 2009, an increase of growth rate of about 3% compared to 2008. Electricity grew at 18.8% in 2009, although its contribution to GDP was only 1% in 2009.

Agriculture Sector has been growing but at lower rates compared to those of other sectors, i.e. at 2.4% in 2009. Cash crops such as coffee, cotton, and tobacco grew at 4.9% in 2009, a drop of 7% with respect to 2008 (11.9% of growth rate). Food crops showed a constant growth rate of over 2% except 2006 (-3.9%). Meanwhile, fishery continued to drop in recent years and, in 2008 and 2009, grew at -9.6% and -7.2%, respectively.

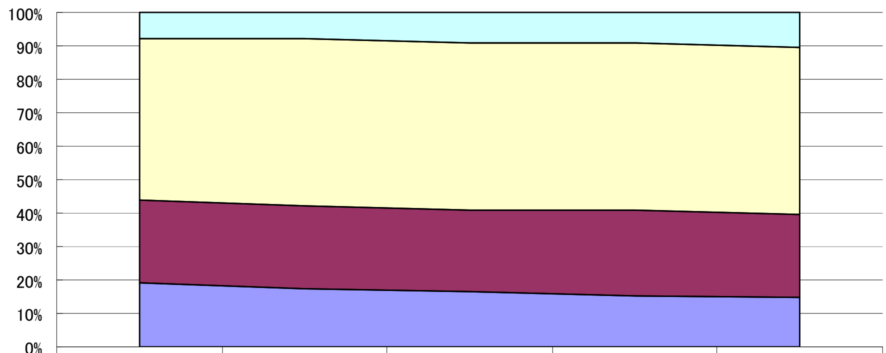


year	2006	2007	2008	2009
Agriculture	-1.8%	1.7%	2.3%	2.4%
Industry	6.4%	7.9%	15.4%	0.7%
Services	10.3%	7.7%	10.5%	6.4%

(Source: UBOS Statistical Abstract 2010)

Figure 2.5.2-2 GDP growth rate by sectors

Services Sector has been growing to come to account for about 50% of GDP and Industry Sector 25% in recent years as shown in Figure 2.5.2-3. Agriculture was the largest sector in terms of employment, representing about 70% of the working population,[4] but was declining in terms of GDP contribution to arrive at only 15% of GDP as shown in Figure 2.5.2-3.



year	2005	2006	2007	2008	2009
Other	8%	8%	9%	9%	10%
Services	48%	50%	50%	50%	50%
Industry	25%	25%	25%	26%	25%
Agriculture	19%	18%	17%	15%	15%

(Source: UBOS Statistical Abstract 2010)

Figure 2.5.2-3 GDP component ratio by sectors

4 Total labor force was 10.9 million persons in 2005/2006 and unemployment/underemployment rate was 14% according to Uganda National Household Survey 2005/2006

2.5.3 Balance of Payments

Table 2.5.3-1 shows the balance of payments from 2005 through 2009.

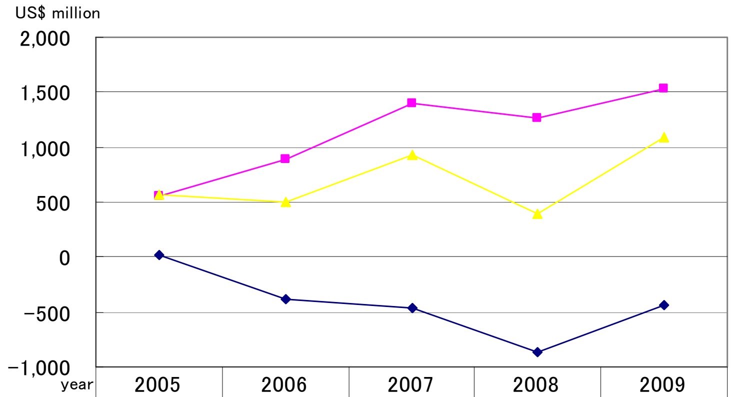
Table 2.5.3-1 Balance of Payments (US$ million)

	2005	2006	2007	2008	2009
A. Current Account Balance (A1+A2+A3+A4)	**14.96**	**-380.34**	**-463.73**	**-870.49**	**-439.12**
A1. Goods Account (Trade Balance)	**-729.78**	**-1,027.94**	**-959.15**	**-1,335.45**	**-751.42**
a) Total Exports (fob)	1,015.79	1,187.64	1,999.03	2,703.46	3,092.57
b) Total Imports (fob)	-1,745.57	-2,215.58	-2,958.18	-4,038.91	-3,843.98
Services and Income	**-356.18**	**-525.81**	**-680.99**	**-821.90**	**-824.09**
A2. Services Account (services net)	**-107.08**	**-286.74**	**-438.29**	**-523.35**	**-537.57**
a) Inflows(credit)	501.76	483.74	538.73	732.73	902.78
b) Outflows(debit)	-608.84	-770.48	-977.02	-1,256.08	-1,440.34
A3. Income Account (Income net)	**-249.10**	**-239.07**	**-242.71**	**-298.55**	**-286.52**
a) Inflows(credit)	49.82	71.85	97.06	130.24	41.89
b) Outflows(debit)	-298.92	-310.92	-339.76	-428.79	-328.41
A4. Current Transfers (net)	**1,100.92**	**1,173.40**	**1,176.42**	**1,286.85**	**1,136.38**
a) Inflows (Credit)	1,245.75	1,358.90	1,379.63	1,610.53	1,490.29
b) Outflows (Debits)	-144.83	-185.50	-203.21	-323.68	-353.91
B. Capital & Financial Account Balance (B1+B2)	**549.88**	**886.32**	**1,392.18**	**1,256.89**	**1,530.00**
B1. Capital Account	**0.00**	**3,554.91**	**0.00**	**0.00**	**0.00**
a) Capital Transfers inflows (credit)	0.00	3,554.91	0.00	0.00	0.00
B2. Financial Account; excl. financing items	**549.88**	**-2,668.60**	**1,392.18**	**1,256.89**	**1,530.00**
a) Direct Investment	**379.81**	**644.26**	**792.31**	**808.92**	**603.75**
i) Direct investment abroad	0.00	0.00	0.00	0.00	0.00
ii) Direct investment in Uganda	379.81	644.26	792.31	808.92	603.75
b) Portfolio Investment	**-13.36**	**21.65**	**44.92**	**17.60**	**19.98**
Assets	0.00	0.00	0.00	-12.06	-0.01
Liabilities	-13.36	21.65	44.92	29.66	19.99
c) Financial derivatives, net	**0.00**	**0.00**	**1.36**	**6.89**	**-6.17**
Financial derivatives, assets	0.00	0.00	-7.64	-25.75	21.20
Financial derivatives, liabilities	0.00	0.00	9.00	32.64	15.02
d) Other Investment	**183.43**	**-3,334.52**	**553.59**	**423.48**	**912.45**
Assets	52.71	-45.11	26.21	54.79	116.42
Liabilities	130.73	-3,289.40	527.38	368.70	796.03
C. Overall Balance (A+B)	**564.84**	**505.98**	**928.45**	**386.40**	**1,090.88**
D. Reserves & related items	**-564.84**	**-505.98**	**-928.45**	**-386.40**	**-1,090.88**
a) Reserve assets	-91.59	-404.06	-748.51	2.24	-343.39
b) Use of Fund credit and loans	-42.65	-123.91	0.00	0.00	0.00
c) Exceptional Financing	-27.86	-28.26	-18.62	-19.50	-11.49
d) Errors and Omissions	-402.74	50.26	-161.32	-369.14	-736.01

Source: Bank of Uganda

(Source: UBOS Statistical Abstract 2010)

Figure 2.5.3-1 shows that Current Account continued in deficit since 2006 and its deficit was covered by Capital & Financial Account.

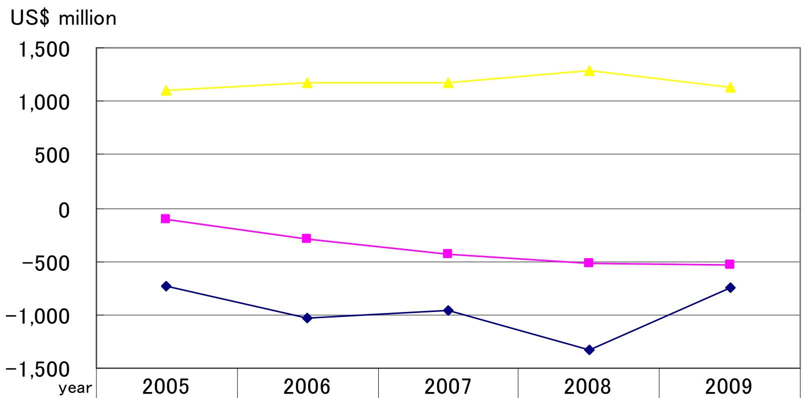


year	2005	2006	2007	2008	2009
Current Account	14.96	-380.34	-463.73	-870.49	-439.12
Capital & Financial Account	549.88	886.32	1,392.18	1,256.89	1,530.00
Overall Balance	564.84	505.98	928.45	386.40	1,090.88

(Source: UBOS Statistical Abstract 2010)

Figure 2.5.3-1 Balance of Payments (US$ million)

That deficit in Current Account was attributed to the deficit in Trade & Services Account, set off by Current Transfers as shown in Figure 2.5.3-2, mainly coming from grants provided by donors.

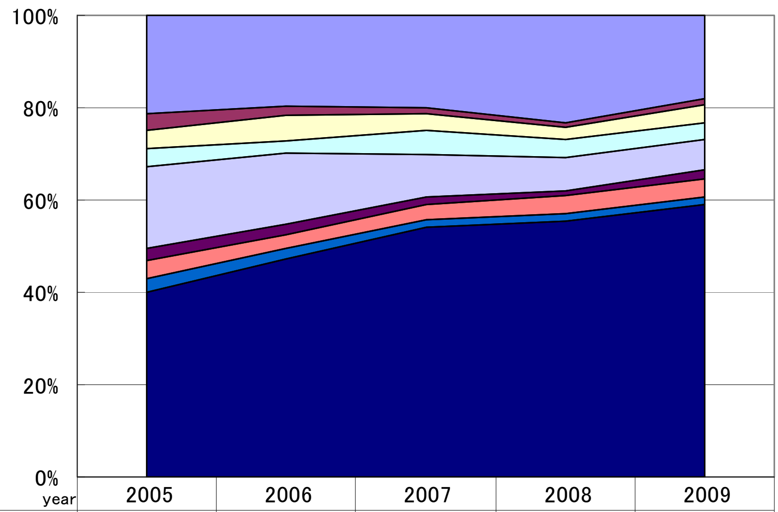


year	2005	2006	2007	2008	2009
Goods Trade Account	-729.78	-1,027.94	-959.15	-1,335.45	-751.42
Services Account	-107.08	-286.74	-438.29	-523.35	-537.57
Current Transfers	1,100.92	1,173.40	1,176.42	1,286.85	1,136.38

(Source: UBOS Statistical Abstract 2010)

Figure 2.5.3-2 Major Components of Current Account in Balance of Payments (US$ million)

Regarding trade in goods[5], the so-called traditional exports, such as coffee, cotton, tea and tobacco, accounted for about 27% of the exports as of 2009. It is to be noted that fish/fish products and roses/cut flowers have been decreasing in recent years.



year	2005	2006	2007	2008	2009
Coffee	21.3	19.7	19.9	23.4	17.9
Cotton	3.5	2.1	1.5	0.8	1.5
Tea	4.2	5.3	3.6	2.7	3.8
Tobacco	3.9	2.8	5	3.9	3.6
Fish and Fish products	17.6	15.2	9.3	7.2	6.6
Maize	2.6	2.5	1.8	1.1	1.9
Other farm produce	4.0	3.0	3.1	3.8	4.1
Roses and Cut flowers	3.0	2.2	1.7	1.7	1.7
Other products	39.9	47.2	54.1	55.4	58.9

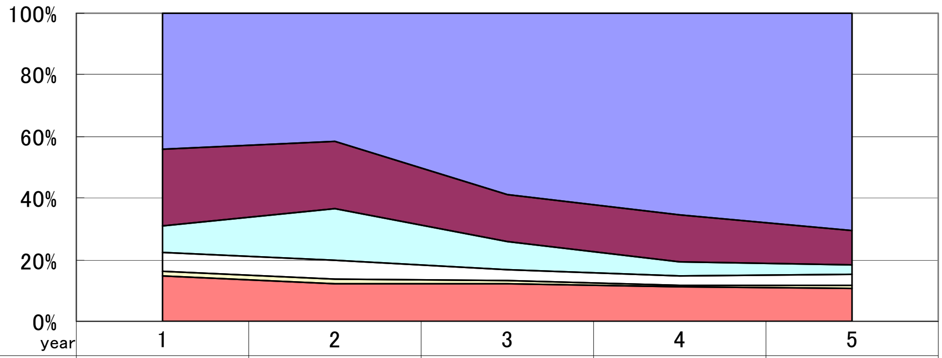
(Source: UBOS Statistical Abstract 2010)

Figure 2.5.3-3 Exports by Goods

As for export destination, as shown in Figure 2.5.3-4, COMESA (Common Market for Eastern and Southern Africa) has been a major export destination accounting for about 70% of the exports as of 2009. A large portion of this is taken by Sudan (44.6%), D.R. Congo (9.6%) and Kenya (8.9%).

For Europe, Switzerland (2.8%) and Netherlands (2.5%) were the largest importers from Uganda in 2009, although they accounted for 7% to 8% in 2005. For Middle East, United Arab Emirates were the largest importers (2.7%) in 2009 but also dropped from about 8% in 2005. Among Asian countries, Singapore, India and China were the largest importers but accounted each for less than 1%.

[5] Informal trade amounted to US$ 1,558 million of export and US$ 82 million of import in 2009, with Sudan as the largest trade partner (74%), followed by DR Congo and Kenya.



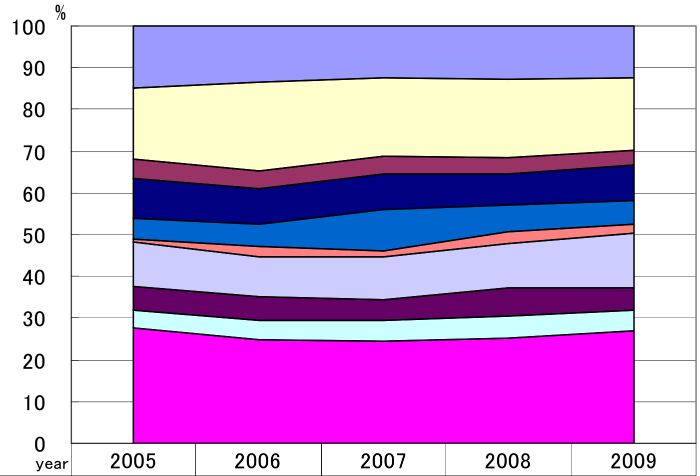
year	1	2	3	4	5
COMESA	44.1%	41.4%	58.9%	65.6%	70.7%
EU	24.9%	22.1%	15.4%	15.0%	11.0%
Middle East	8.7%	16.6%	9.0%	4.5%	3.1%
ASIA	6.0%	6.3%	3.4%	3.2%	3.3%
USA	1.6%	1.2%	0.9%	0.5%	1.2%
Others	14.7%	12.4%	12.4%	11.2%	10.7%

(Source: UBOS Statistical Abstract 2010)

Figure 2.5.3-4　Exports by Destination

Regarding imports, fuel and foods jointly accounted for about 30% in recent years. Vehicles and telecommunications/sound apparatus came next, followed by iron/steel and medical products.

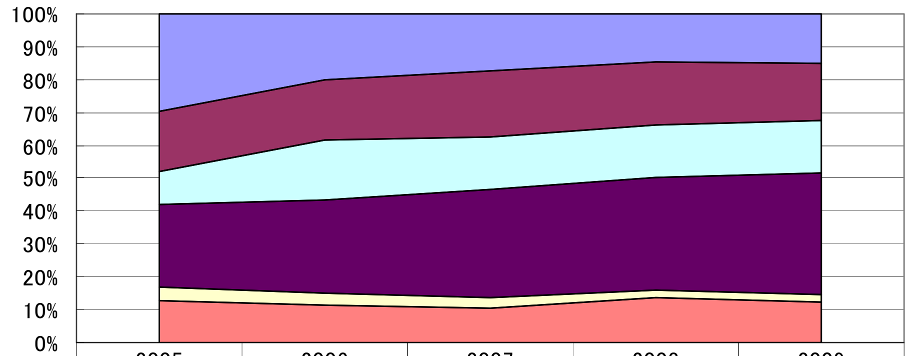
In 2009, among the COMESA countries, Kenya accounting for 15.2% was the largest exporter to Uganda, followed by India (12%), United Arab Emirates (9.6%), China (8.7%), Japan (6.2%) and South Africa (5.7%). It is notable that Kenya once took a share of 26.6% in 2005, decreasing year by year, while India increased from 6.2% in 2005 to 12% in 2009 and China from 5.2% to 8.7%. United Arab Emirates increased its share from 6.4% in 2005 to 9.6% in 2009.



	2005	2006	2007	2008	2009
Foods	15.0	13.6	12.3	12.8	12.4
Fuel	16.9	21	18.8	18.8	17.4
Textile	4.7	4.5	4.3	3.7	3.5
Vehicles	9.4	8.5	8.4	7.5	8.7
Telecom. & sound appratus	4.9	5.4	10.0	6.6	5.4
Power generating machines	1.0	2.3	1.5	2.6	2.2
Other machines	10.4	9.6	10.3	10.7	13.3
Iron/steel	5.8	5.5	5.0	6.8	5.2
Medical	4.2	4.8	5.0	5.4	5.0
Others	27.7	24.8	24.4	25.1	26.9

(Source: UBOS Statistical Abstract 2010)

Figure 2.5.3-5 Imports by Goods



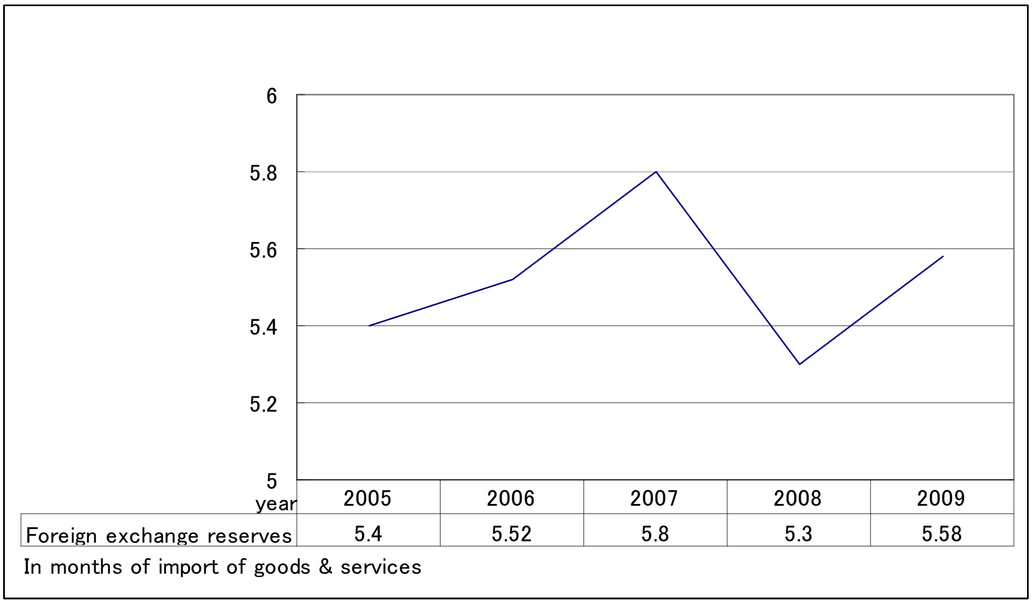
	2005	2006	2007	2008	2009
COMESA	29.7%	20.0%	17.3%	14.5%	15.2%
EU	18.3%	18.2%	20.2%	19.1%	17.3%
Middle East	9.8%	18.5%	15.9%	16.1%	15.9%
ASIA	25.5%	28.4%	33.1%	34.2%	37.2%
USA	3.7%	3.4%	2.8%	2.5%	2.1%
Others	13.0%	11.5%	10.7%	13.6%	12.3%

(Source: UBOS Statistical Abstract 2010)

Figure 2.5.3-6 Imports by Region

The foreign exchange reserves amounted to US$2,769 million as of December 2009, equivalent to 5.4 months of future imports, up by about 20% from US$ 2,300 million as of December 2008, or 4.5 months of future imports.

The following figure shows the evolution of foreign exchange reserves in months of future import of goods and services.

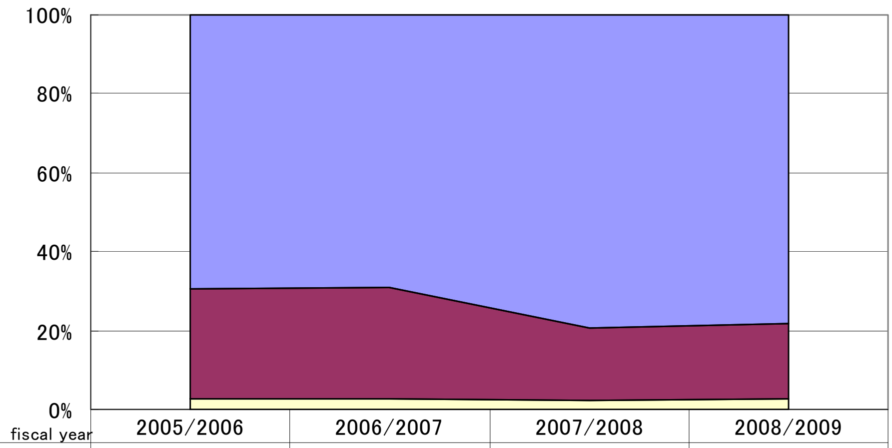


(Source: Bank of Uganda)

Figure 2.5.3-7 Foreign Exchange Reserves (in months of import of goods & services)

2.5.4 Fiscal Balance

Uganda government fiscal revenue was planned to be 5,322 billion shillings (US$2.8 billion) for 2009/2010, about 17% of GDP. Figure 2.5.4-1 shows Uganda government's fiscal revenue structure from fiscal year 2005/2006 through 2009/2010 (projection). The government finance depended on donors' grants but its dependence was decreasing in recent years.



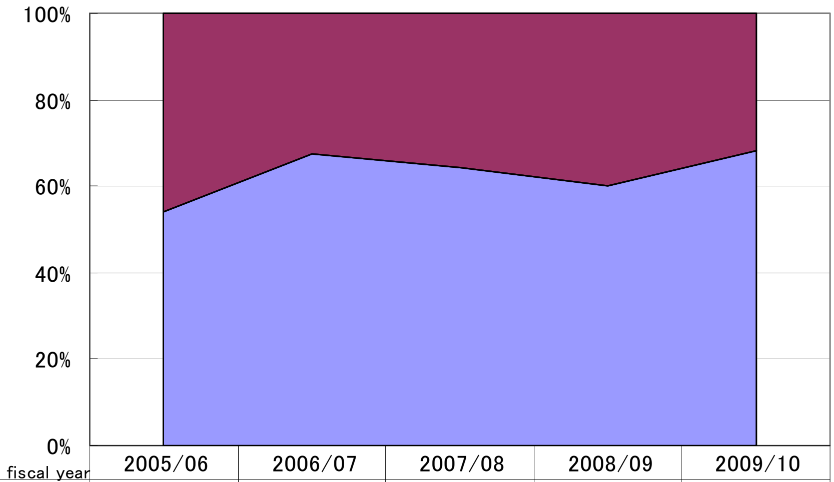
fiscal year	2005/2006	2006/2007	2007/2008	2008/2009
Taxes	69%	69%	79%	78%
Grants	28%	29%	19%	19%
Other revenue	3%	3%	2%	3%

(Source: UBOS Statistical Abstract 2010)

Note: Figures of 2009/10 are projections.

Figure 2.5.4-1 Government Fiscal Revenue

Figure 2.5.4-2 shows the share in the donors' grants of budget support and project support to the Uganda government finance.



fiscal year	2005/06	2006/07	2007/08	2008/09	2009/10
Project Support	413.15	354.57	263.25	353.95	292.67
Budget Support	484.36	733.22	475.23	530.85	631.93

in billion shillings

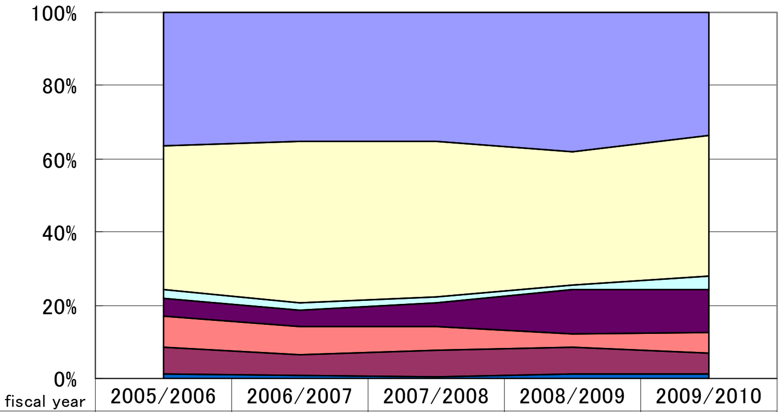
(Source: UBOS Statistical Abstract 2010)

Figure 2.5.4-2 Donor's Fiscal Support

As for government expenditure, projected at 6,318 billion shillings (about US$3.3 billion) as of

2009/2010, Figure 2.5.4-3 shows the share of major expenditure items from 2005/2006 through 2009/2010 (projection).

Out of grants and subsidies, over 60% went to local governments. As for development, the government has been endeavoring more with its own finance than donors' funds.



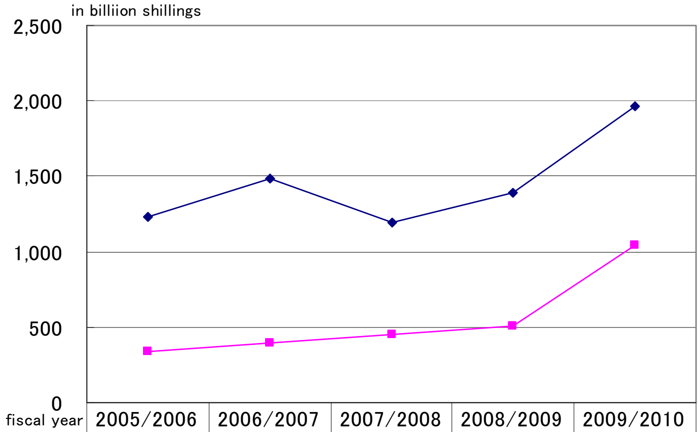
fiscal year	2005/2006	2006/2007	2007/2008	2008/2009	2009/2010
Employment & procurement costs	36.6%	35.4%	35.2%	38.2%	33.7%
Grants & subsidies	39.3%	44.1%	42.5%	36.1%	38.4%
Social benefits	2.4%	2.0%	1.8%	1.6%	3.6%
Domestic development	4.7%	4.4%	6.3%	12.0%	11.7%
Donor projects	8.7%	7.5%	6.6%	3.7%	5.9%
Interest payments	7.2%	6.0%	7.2%	7.2%	5.6%
Other	1.2%	0.7%	0.4%	1.2%	1.1%

(Source: UBOS Statistical Abstract 2010)

Figure 2.5.4-3 Government Expenditure Structure

The fiscal balance continued to show negatively, 1,965 billion shillings (about US$ 1 billion) in overall deficit excluding grants and 1,041 billion shillings (about US$ 0.5 billion) in overall deficit including grants as projected for 2009/2010. The balance was planned to be financed with domestic and external borrowings, about 40% and 60% respectively.

Fig 2.5.4-4 shows that the grants from donors continued to play an important role in the government finance.



fiscal year	2005/2006	2006/2007	2007/2008	2008/2009	2009/2010
Overall deficit excluding grants	1,235	1,486	1,192	1,388	1,965
Overall deficit including grants	337	398	454	504	1,041

(Source: UBOS Statistical Abstract 2010)

Figure 2.5.4-4 Fiscal Deficit

2.5.5 Inflation, Bank Interest and Exchange Rates

The year 2009 experienced a double-digit inflation rate following 2008 because of higher prices of foods due to scarcity, seasonal factors and rising local and foreign demand for fruits and vegetables, manufactured foods and fish among others.

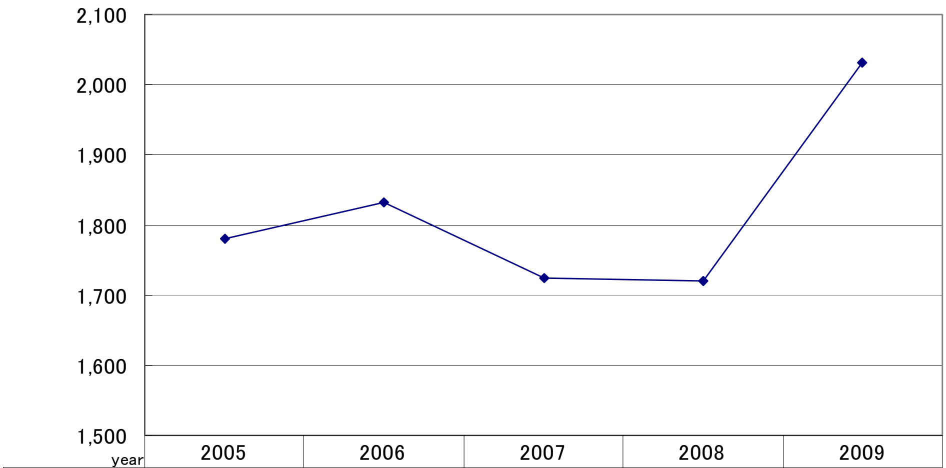
In 2009, the lending interest rate rose by about 8% to 21.8% against about 3 to 4% increase in interest rate of the previous years.

year	2005	2006	2007	2008	2009
inflation rate	8.6%	7.2%	6.1%	12.0%	13.0%
interest rate	18.1%	18.6%	19.4%	20.2%	21.8%

(Source: UBOS Statistical Abstract 2010)

Figure 2.5.5-1 Rate of Inflation and Interest (lending)

Figure 2.5.5-2 shows that Uganda shilling was depreciated against US dollar by about 15% in 2009 against relatively moderate change of the previous years.



year	2005	2006	2007	2008	2009
exchange rate	1,780.70	1,831.50	1,723.50	1,720.40	2,030.50

(Source: UBOS Statistical Abstract 2010)

Figure 2.5.5-2 Rate of Exchange against US$ (inter-bank middle rate)

2.5.6 Policy for Economic and Industrial Development

2009 Industrial strategic plan of the Ministry of Tourism, Trade and Industry issued in 2008 aims to increase the share in GDP of manufacturing sector to 25% in 10 years and the export to 30%. The target market is East Africa region with a population of 120 million and a combined GDP of over US$ 102 billion. For southern Sudan, east Congo, Burundi, Rwanda and northern Tanzania, among others, Uganda occupies a strategic geographic position.

To enhance its market under globalization, the plan considers it a necessity to foster competitive industries, in order to accelerate private investment, public infrastructure and measures to curtail business costs as important policy measures.

Public infrastructure is planned to be promoted by PPP as for roads, railroads, ports, airports, power, water and telecommunications. Meanwhile, to add value to domestic resources, export processing zones (EPZ) will be established and industrial parks will be established in major cities.

For small enterprises, Luzira industrial park and other industrial parks will be established. With those policy measures, the plan intends to coordinate industrial agglomeration and value chain among enterprises.

As for power, to strengthen the competitiveness of Ugandan economy, the plan demand that investment in power must be made in line with economic development and industrial policy, so that uninterrupted power supply can be realized at competitive prices.

Chapter 3

Current Situation of Power Sector

Chapter 3 Current Situation of Power Sector

3.1 Organization

3.1.1 Historical Background of Power Sector

Power industry in Uganda started with supply of electricity by East Africa Electric Power & Lighting Company Limited -EAPL- founded in Kenya in 1922 during the colonial era of UK. Since then, during the years of 1948 to 1999, Uganda Electricity Board -UEB- was involved in generation, transmission and distribution for power supply under the jurisdiction of the Ministry of Energy and Mineral Development -MEMD. A new Electricity Act (Electricity Act 1999） approved by the parliament in 1999 determined the establishment of Electricity Regulatory Authority -ERA- and privatization of the power sector except the transmission sector. In 2001 UEB was unbundled into the following three companies as seen up to the present date.

- Uganda Electricity Generating Company Limited: UEGCL
- Uganda Electricity Transmission Company Limited: UETCL
- Uganda Electricity Distribution Company Limited: UEDCL

3.1.2 Institutional Frame Work of Power Sector

MEMD has jurisdiction over the whole energy sector including the power sub-sector and is in charge of formulation of energy sector policy including power sector policy. ERA is responsible for regulating the power sector. Generation and distribution sectors are partially privatized by operation concession to the private sector. Generation business is carried out by two private operation companies: ESKOM Uganda and Aggreko; and by two IPPs: Kilemba Mines and Kasese Cobalt Minas. Distribution business is carried out by UEDCL and UMEME a private company with distribution concession of the metropolitan area. Transmission business is carried out by UETCL, the single buyer of the whole power system.

【UEGCL】

UEGCL is a state-owned power utility and owns Nalubaale and Kiira hydropower plants. Operation and maintenance of those hydropower plants are conducted by Eskom (Uganda), a locally incorporated company of South African Eskom through a 20-year concession contract starting from 2003. The main business of UEGCL is asset management of the two hydropower plants. The administration costs of the company are fully covered by concession fee to Eskom (Uganda).

【UETCL】

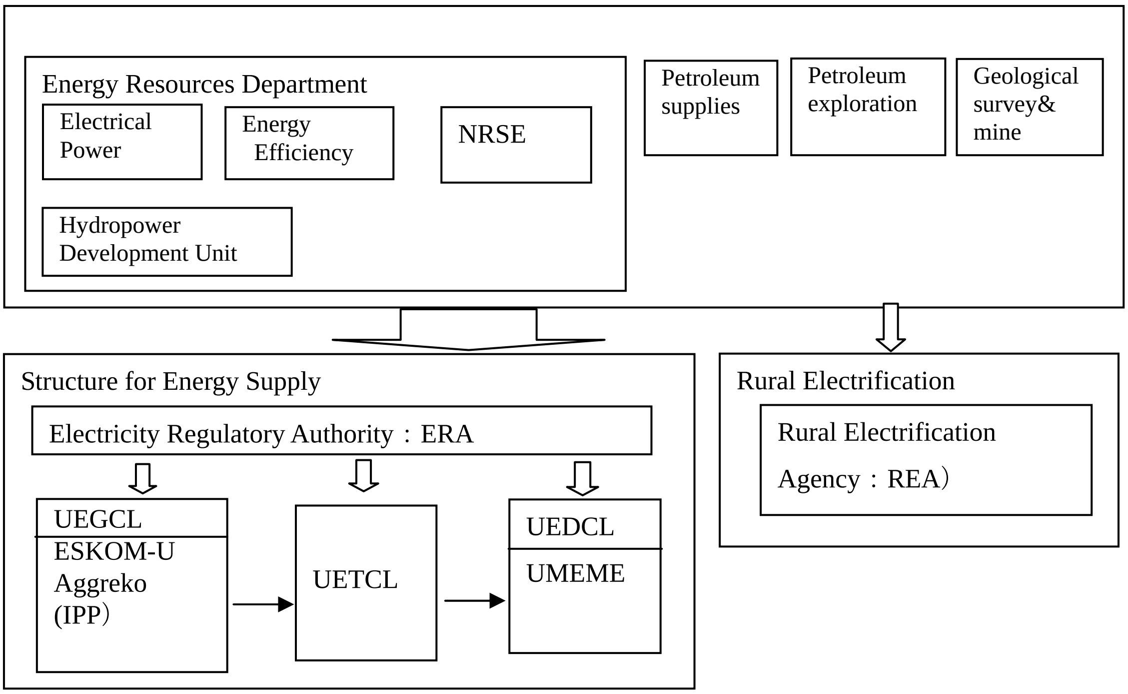
UETCL is a state-owned power utility, the sole power utility with operating department among the three state-owned power utilities created by the power sector reform and unbundling UEB, which was in charge of generation, transmission and distribution before the power sector reform. The company owns Ugandan transmission network and is the system operator of the country's power grid. Uganda has adopted 'Singly Buyer Model' as a model for the power sector reform. UETCL accordingly purchases all electricity generated and sell it to the distribution company and make power export to and import from neighboring countries. The company assumes the final responsibility for power supply to end users.

Major revenue sources of UETCL are bulk supply tariff to UMEME. Its major expenses include payment of generation tariff, investment for grid expansion and others including operation and maintenance of the grid. Thermal power generation costs are quite high and so is the generation tariff for power purchases of UETCL. The end user tariff of UMEME is suppressed low, so that government subsidies are provided to UETCL and reflected in bulk supply tariff to UMEME.

【UEDCL】

UEDCL is a state-owned power distribution utility and owns distribution network of Uganda. Operation and maintenance of the distribution network is conducted by UMEME, a consortium formed by CDC (Commonwealth Development Corporation) of United Kingdom and South African Eskom through a 20-year concession contract starting from 2005. The major business of UEDCL is asset management of the distribution network. The administration costs of the company are fully covered by concession fee to UMEME.

Organization chart for electrical power structure is shown in Figure 3.1.2-1.



(Source: UETCL)

Figure 3.1.2-1 Organization Structure of Power Sector

3.2 Existing Transmission Line and Substation

3.2.1 Generating Facility

Figure 3.2.1-1 shows generating facilities in Uganda. The main power resources in Uganda comprise hydropower (Kiira-Nalubale Complex and several small hydro power plants), thermal power from HFO (Jacobsen), diesel oil power (Aggreko and others) and co-generation utilizing the bagasse. Presently Hydro power contributes about 67% of the total generation, 380 MW of the Nalubaale and Kiira projects cover about 58 % of the total capacity of the Uganda system.

Table 3.2.1-1 Main Power Generation Plant in Uganda in 2009

Category	Name of Power Station	Installed Cpacity (MW)	Year of Commisioning
Hydropower	Nalubaale	200	1954~1968
	Kiira	180	2000~2005
	Other Hydro	61	
	Sub Total	441	
Diesel	Aggreko2	50	2006
	Mutundwe	50	2008
	Namnve	50	2009
	Electromaxx	50	2009
	Sub Total	200	
Co-generation	Kakira Sugar Work	12	
	Kinyara Sugar Work	5	2009
	Sub Total	17	
Total		658	

(Source: UETCL GDP 2010-2026)

3.2.2 Transmission Line

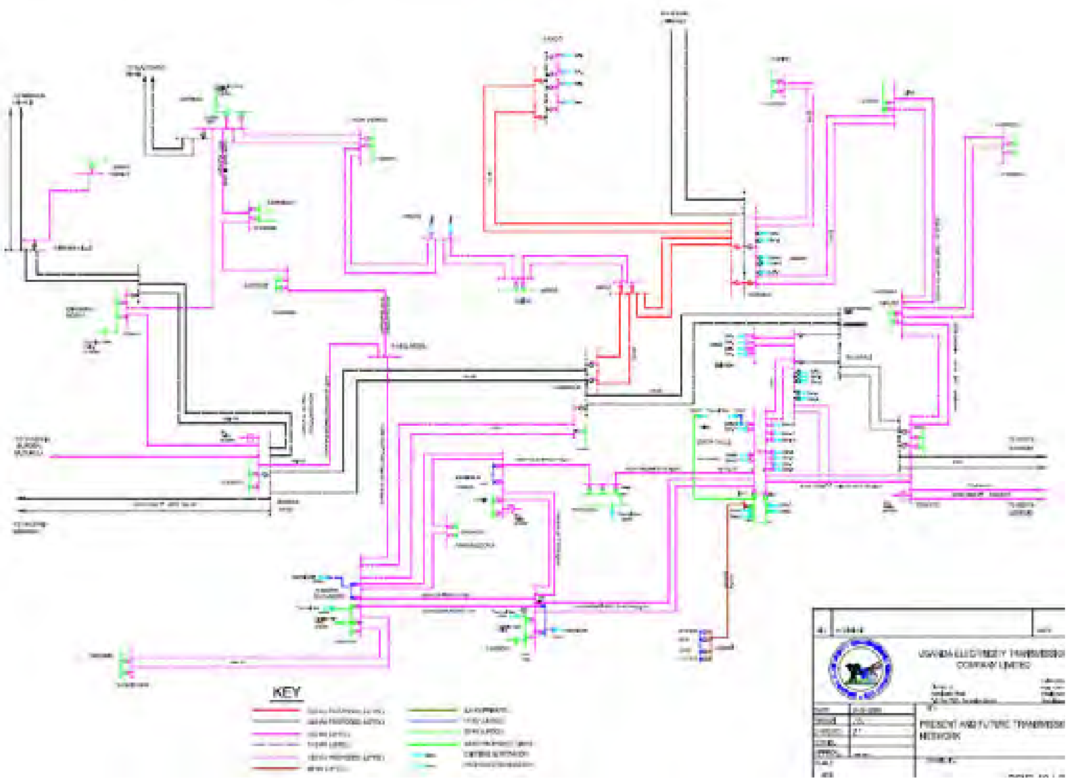
The main transmission line in Uganda consists of 132kV or 66kV of transmission line, which are operated and maintained by UETCL. The transmission line with voltage less than 66kV is operated and maintained by UEDCL.

The generated electric power mainly from Nalubaale and Kiira hydropower power station is transmitted to Kampala and the western and southwestern part of country by 132kV, 66kV transmission lines and to the northern part of the country by 132 kV to Lira through Tororo substation. As for the interconnections to the neighboring countries, 2 circuits of 132kV transmission line connects between Tororo substation in Uganda and Musaga substation in Kenya, 1 circuit of 132kV transmission line between Masaka substation in Uganda and Kyaka substation in Tanzania. The brief characteristics of main transmission lines over 132kV is shown in Table 3.2.2-1 below and some transmission lines have been in use for over 50 years and wooden materials are still used.

Single Line Diagram of Transmission Line and Transmission Line Network also are shown in Figure 3.2.2.-1 and 3.2.2-2.

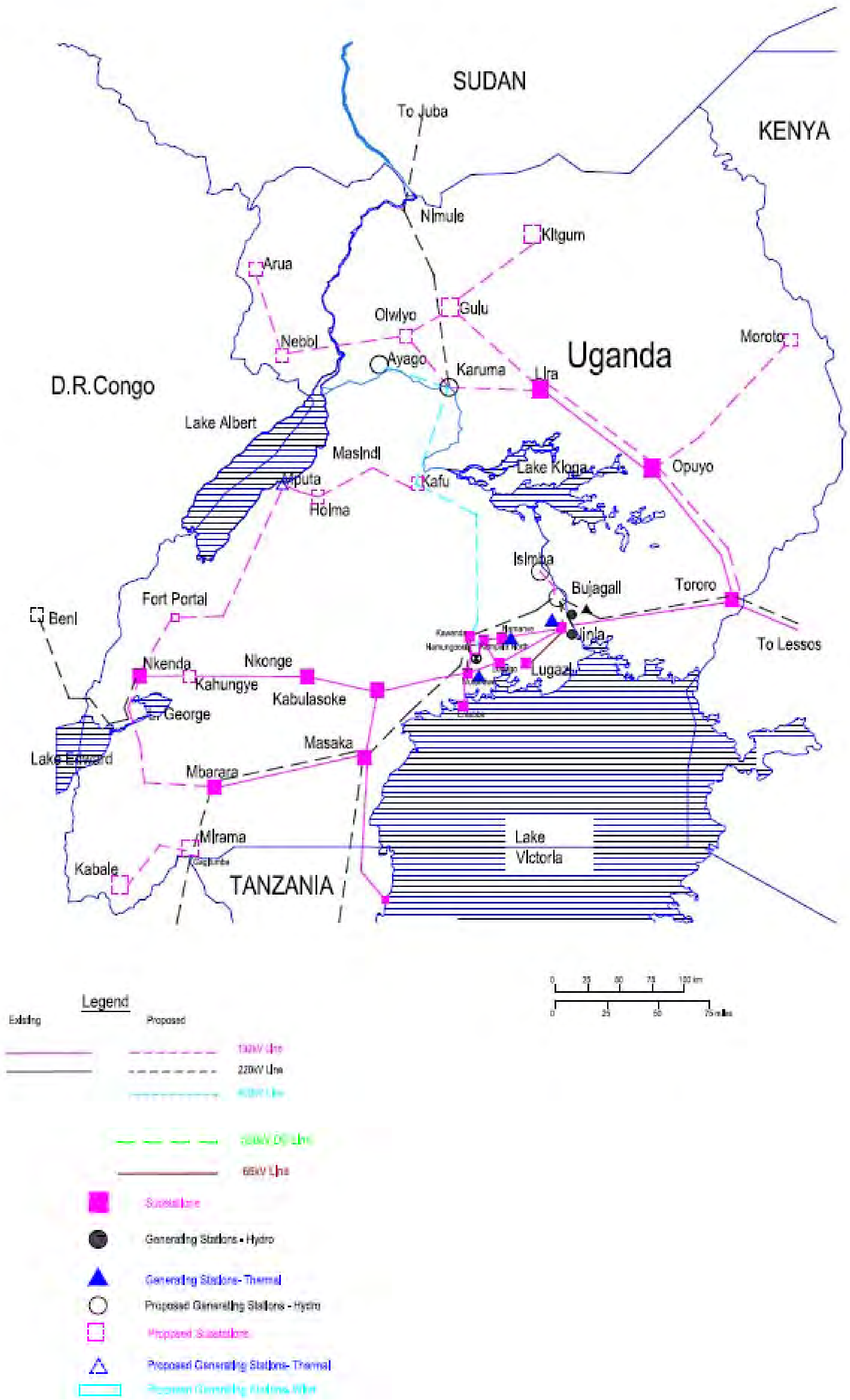
Table 3.2.2-1 Existing Transmission Line (Over 132kV)

Line	System Voltage (kV)	Length (km)	No. of Circuit	Type of Tower	Completion Year	Line Capacity (MVA)
Kabulasoke-Masaka West	132	59.5	1	Wooden	1963	63.1
Kabulasoke-Nkonge	132	78	1	Wooden	1963	63.1
Kampala North-Mutundwe	132	8.9	1	Steel	1959	79.1
Lugogo-Kampala North	132	5.5	1	Steel	1997	73.2
Lugogo-Mutundwe(1)	132	10.4	1	Steel	1997	180
Lugogo-Mutundwe(2)	132	10.4	1	Steel	2008	180
Masaka West-Kyaka	132	85	1	Steel	1994	73.8
Masaka West-Mbarara North	132	129.6	1	Steel	1995	151.6
Mutundwe-Kabulasoke	132	84.5	1	Wooden	1963	63.1
Nkonge-Nkenda	132	138.11	1	Wooden	1963	63.1
Nalub-Kampala North	132	68.8	1	Steel	1954	147
Nalub-Ligazi	66	38	1	Steelr	1963	10.6
Nalub-Lugogo	132	75	2	Steel	1998	180.6
Nalub-Tororo	132	116.8	2	Steel	1954	78
Opuyo-Lira	132	141.2	1	Wooden	1963	63.1
Tororo-Kenya	132	10.6	2	Steel	1954	78
Tororo-Opuyo	132	119.5	1	Wooden	1963	63.1



(Source: UETCL)

Figure 3.2.2-1 Single Line Diagram of Transmission Line



(Source: UETCL)

Figure 3.2.2-2 Transmission Line Network

3.2.3 Substation

In order to transmit generated electric power to Kampala and other areas of Uganda, the Sub Stations shown in Table 3.2.3-1 below are used.

In comparison to the transmission lines, most of the substations are relatively new and replacement work is not necessary at this moment. However, the fast growth rate of the electric power system capacity means that extension of transformer capacity is advisable at every step..

Table 3.2.3-1 Existing Substation (over 132kV)

Substation	Transformer	Year of Manufacture	Capacity (MVA)	Voltage
Namanve	Transformer 1 Transformer 2	2007 2007	32/40 32/40	132/33kV 132/33kV
Lugogo	Transformer 1 Transformer 6 Transformer 3 Transformer 5	1997 1991	32/40 32/40 32/40 32/40	132/11kV 132/33kV 132/33kV 132/11kV
Mutundwe	Transformer 1 Transformer 2 Transformer 3 Transformer 4	1991 1995 2003 2003	32/40 32/40 15/20 15/20	132/33kV 132/33kV 132/11kV 132/11kV
Kampala North	Transformer 1 Transformer 3 Transformer 4	1995 2006 2006	32/40 32/40 32/40	132/33kV 132/11kV 132/11kV
Kawaala	Transformer 1 Transformer 2	1972 1972		132/11kV 132/11kV
Masaka West	Transformer 1 Transformer 2	1991 1991	15/20 15/20	132/33kV 132/33kV
Mbarara North	Transformer 1 Transformer 2	2007 2007	15/20 15/20	132/33kV 132/33kV
Nkonge	Transformer 1	1970	7.5	132/33kV
Nkenda	Transformer 1 Transformer 2	1991 2005	15/20 15/20	132/33kV 132/33kV
Lugazi	Transformer 1 Transformer 2	2007 2007	14 14	66/11 66/11
Tororo	Transformer 1	1988	15/20	132/33kV
	Transformer 2 Spare Trans.	1985 2007	15/20 32/40	132/33kV 132/33kV
Opuyo	Transformer 1 Spare Trans.	1993 2007	10 15/20	132/33kV 132/33kV
Lira	Transformer 1 Transformer 2	1974 2007	15/20 15/20	132/33kV 132/33kV

(Source: UETCL)

3.3 Power Demand and Supply

3.3.1 Actual Record of Power Demand and Supply

The electric producers who supplies to the national grid operated by UETCL are UEGCL as owners of the Kiira hydropower station (200MW) and Nalubaale hydropower station (180MW) operated by ESKOM under a concession agreement, Kilimbale Mines Ltd. (hydro), Kasese Cobalt Co. Ltd. (hydro), Kakira Sugar Works (co-generation), EPP (Emergency Power Producers, Aggreko and Jacobsen), Tronder Power Ltd. (hydro), etc. as of the end of 2009. That total generation capacity is around 500MW. Actual records of the energy purchased by UETCL in the past 4 years are given in Table 3.3.1-1.

Table 3.3.1-1 Actual Record of Purchased Energy of UETCL（GWh）

Year	KCCL	Kilembe	Kakira	Aggreko	Jacobsen	Eskom	Total
2005	1.1	20.2		140.3		1,698.5	1,860.1
2006	1.6	28.4		369.5		1,160.5	1,560.0
2007	0.7	29.6		539.0		1,263.5	1,832.9
2008	1.2	29.8	55.1	429.0	117.2	1,373.3	2,005.6

(Source: ERA)

UETCL sells the purchased energy to the distributors over its power transmission system. UMEME who has obtained the concession for the distribution system from UEDCL since May 2005 is the biggest distributor in the country. The sold energy records by UETCL in the past 5 years are given in Table 3.3.1-2.

Table 3.3.1-2 Actual Record of Sales Energy of UETCL（GWh）

Year	UMEME	Ferdsult	Export			Total
			Kenya	Tanzania	Rwanda	
2005	1,741.2	-	15.3	32.5	2.8	1,791.8
2006	1,503.0	-	10.4	40.0	2.5	1,556.0
2007	1,759.2	-	22.0	42.8	0.7	1,824.7
2008	1,948.5	1.2	23.9	43.0	0.1	2,016.8

(Source: ERA)

UETCL sells power to neighboring countries under an ERA Licence for power exchange issued only to UETCL. Although electric power has been exported to Tanzania and Rwanda though UMEME’s MV distribution system, such sales are accounted as a part of business of UETCL.

The load dispatching of the national grid is made by the Load Dispatching Center of UETCL which is located in the ground of Lugogo substation. In the load dispatching center, hourly operation plan of each power plants to meet forecast power demand are decided and instructed to each power plants. The plan of load shedding which is continuously required in the peaking time due to power supply deficit is also decided from time to time and managed by the load dispatching center. The sent-out power/energy from power producers to the grid, sold energy to the distributors from UETCL, power supply to high-voltage distribution lines, power export/import to the neighboring countries, etc. are observed and also recorded by the load dispatching center. In addition to the above works, all the accidents which have occurred on the facilities of the grid have also been recorded, including high-voltage distribution lines managed by UMEME. Then, hourly base actual situation of the power supply system will be easily grasped from such records.

That function, and duty of the load dispatching center was taken over by UETCL from UEB, and similarly the role of control and monitoring of the power supply system was also taken over by UETCL from UEB. However, the function and role of control and monitoring on the MV system will soon be transfer to UMEME, because UMEME has established its own load dispatching center for the power distribution system in 2009.

The maximum hourly observed values of the major items in the past 5 years are given in the table 3.3.1-3. It is noted that there are no mathematical relations among the figures in the table, because the maximum value that an occurrence date and time is respectively different of each item is being used. For example, total value of the Domestic Demand (MW) and the Export (MW) is not equal to the Total Demand (MW).

Table 3.3.1-3 Maximal Value of Main Item

	2005 May.-Dec.	**2006 Jan.-Sep.**	**2007**	**2008**	**2009**
Total demand (MW) (Domestic + Export)	365.7	409.6	394.9	389.5	400.7
Domestic demand (MW)	356.9	403.1	379.7	380.0	392.9
Load shedding (MW)	110.2	217.1	152.1	100.9	70.8
Export (MW)	42.0	40.0	35.4	42.3	46.7
Generation (MW)	291.4	248.9	321.9	360.9	391.4
ESKOM-U	244.7	198.4	218.1	220.2	237.6
Others	46.7	50.5	103.8	140.7	153.8

(Source: UETCL Load Dispatching Center, JICA Study Team)

So far, detail analysis of load dispatching records was made for the one week which contained the monthly maximum demand which included estimated values of load shed by shutdown of MV feeders from the grid in each month. However, the numerical values of Table 3.3.1-3 on the basis of the yearly records could be shown, because it came to be changed to going through the year from May, 2005 and recording it. Demand of 2006 (Jan-Sep) showing high value compared with others is considered to be caused by the over-estimate of load shedding in that year.

The situation of power supply to the national grid from power producers is given in Figure 3.3.1-1 by using weekly averaged daily load curves in July of 2005and 2009.

"Captive Plant" of the figure means mini-hydro plants, thermal plants etc. owned by mine companies and/or sugar manufacturing companies. Form the figure, the maximum use of EPP (emergency power producers) is also clear, of which 150MW diesel power plants have been introduced for mitigating load shedding in peak loading time.

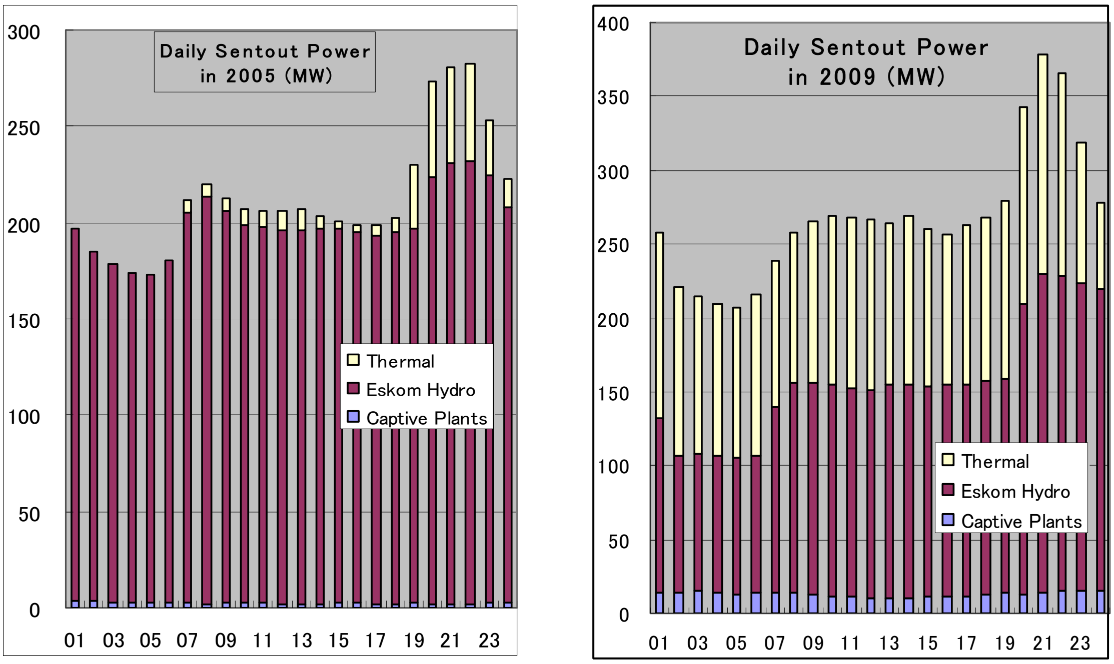


Figure 3.3.1-1 Daily Demand and Supply

Monthly energy of July of 2005 to 2009 of which monthly records have been analyzed and recorded are given in Table 3.3.1-4.

Table 3.3.1-4 Demand Energy in July from 2005 to 2009（GWh）

Year	2005	2006	2007	2008	2009
Generation	147.6	132.0	157.4	170.7	200.1
Load shedding	3.4	66.5	17.1	15.4	0.6
Export	1.4	0.0	1.0	2.8	6.5
Domestic demand	149.6	198.5	173.5	183.3	194.1
Total demand	153.0	202.1	178.8	188.2	201.7

(Source: Load Dispatching Records of UETCL)

As shown in the Table 3.3.1-4 and Figure 3.3.1-1, it is very clear that the power supply in the country is remarkably improved by introduction of EPP.

Out of power supply through the national power grid, there are some isolated and small-scale power supply systems owned by power producers. For example, as given in Table 3.3.1-5, three isolated (off-grid) power supply systems having a diesel power unit of 750kVA are owned and operated by UEDCL.

Table 3.3.1-5 Example of Off-Grid System

Place (District)	Moyo	Adjumani	Moroto
Generator	750kVA	750kVA	750kVA
Generated Energy (MWh)	146.1	210.5	107.9
Customer Nos.	371	313	461

(Source: UEDCL)

Table 3.3.1-6 shows outage time and not supplied energy caused in transmission and distribution system in 2007. The outage of total 97,800 hours was recorded, and equivalent 195,000MWh was not supplied in 2007. The outage time caused in 11kV distribution system made up 72% of total outage time, and 60% of total equivalent energy not supplied. Moreover, the load shedding made up 72% of total outage time and 74% of total equivalent energy not supplied.

This fact means that the resolution of power shortage by power development is urgent issues.

Table 3.3.1-6 Outage Time and Not Supplied Energy in 2007

	Outage Time (hrs)				Equivalent Energy Not Supplied (MWh)			
Voltage Level	11kV	33kV	132kV	Total	11kV	33kV	132kV	Total
Faults	4,098	7,404	572	12,075	5,461	13,855	3,690	23,006
Load Shedding	51,677	19,046	55	70,779	99,194	45,110	629	144,933
Shutdown	8,526	5,191	1,229	14,946	12,796	12,680	1,585	27,061
Total	64,302	31,641	1,856	97,800	117,450	71,646	5,904	195,000

(Source: UETCL)

Table 3.3.1-7 shows not supplied energy caused in generation system in 2007. Not supplied energy reached 442,605MWh, and frequency control and hydrological constraint caused by drought made up 84%.

This fact also means that the resolution of power shortage by power development is urgent issues.

Table 3.3.1-7 Not Supplied Energy caused in Generation System in 2007

Generator Faults	31,209
Generator Shutdown	40,881
Frequency Control and Hydrological Constraint	370,515
Generation Total	442,605

(Source: UETCL)

3.3.2 Actual Record of Power Demand

As shown in Table 3.3.1-3, the maximum power demand of the national grid including load shedding and power export at the end of October, 2009 is estimated at 401MW. The actual situation of energy demand will be explained hereunder based on data/information obtained from UMEME.

The electric tariff structure and charge is decided by ERA and made up of "Domestic Demand (Code 10.1)", "Commercial Demand (Code 10.2/10.3)", "Medium Industrial Demand (Code 20)", "Large Industrial Demand (Code 30)" and "Street Lighting (Code 50)". Actual situation of power sales will be explained based on the tariff categories.

The actual number of customers by tariff categories is given in Table 3.3.2-1.

Table 3.3.2-1 Number of Customers of UMEME

Tariff Categories	2005	2006	2007	2008	2009	Increase Rate (%)
Domestic	263,262	271,984	277,393	276,255	292,348	2.7%
Commercial	27,838	24,718	24,602	20,484	23,654	-4.0%
Large Industrial	115	139	161	159	200	14.8%
Medium Industrial	698	870	954	864	983	8.9%
Street Lighting	324	315	334	291	209	-10.4%
Total	292,237	298,026	303,444	298,053	317,394	2.1%

(Source: UMEME)

As shown in the table, the number of domestic customers of 2008 was decreased in comparison with that of 2007.

Though UMEME continues a connection to the new domestic customers in accordance with the contract with UEDCL , but number of domestic customers of whose power supply were stopped due to delay of electric charge in accordance with their contract exceed number of new domestic customers.

According to the data published by ERA, the movement of domestic customers in 2008 is given hereunder.

- Actual connected customers for applications 32,409
- Un-connected customers for applications 27,235
- Number of customers stopped due to delay payment 89,922
- Number of customers re-started power supply due to payment 36,931
- Actual increase of number of domestic customers 20,584

The above customers' movement is considered to be limited in 2008. However, it is counted for the promotion of increasing electrification ratio that about 1/3 of total domestic customers were stopped their power supply due to the monthly payment and a little more than 40% of them could restart to receive electric power by payment. The averaged annual increase rate of domestic customers' number of 2.7% is in the similar level of the increase rate of population.

On the other hand, increase of number of industrial customers, especially large industrial customers, is remarkable. However, such remarkable increase is considered to be caused not only pure increase of industrial customers, but also the present tariff structure i.e. the domestic and street lighting demands are classified as a group served by single phase of LV (240V), commercial and medium industrial customers by 3-phase of LV (415V) and large industrial customers by MV (11kV and 33kV). There is no detail classification with voltage for the commercial customers. As that result, the large customers who have no direct relation with the production, such as large commercial buildings, hotels, large restaurants and banks, office buildings of the government agencies and foreign organizations, etc. are required to submit their applications for power supply as "Large Industrial Customer", who should be essentially classified as the commercial customers.

Annual sold energy by tariff categories in the past 5 years is given in Table 3.3.2-2.

Table 3.3.2-2 Actual Record of UMEME's Annual Energy Sales (GWh)

Tariff Categories	2005	2006	2007	2008	2009	Increase Rate (%)
Domestic	331.8	290.2	293.5	327.4	363.7	2.3%
Commercial	128.1	136.8	150.6	176.7	208.5	12.9%
Large Industrial	359.0	389.0	482.1	549.5	593.9	13.4%
Medium Industrial	194.9	173.3	211.2	222.9	232.7	4.5%
Street Lighting	0.9	0.9	0.7	1.9	2.2	24.1%
Total	1,014.7	990.1	1,138.1	1,278.5	1,400.9	8.4%

(Source: UMEME)

The increase levels of domestic and large industrial demand are within the similar level of that of number of customers. On the other hand, demand of street lighting is remarkably increased without regard to the decrease of number of customers. Moreover, the increase rate of the medium industrial demand is about half of that of number of customers.

3.3.3 Power Supply and Demand of the Neighboring Countries

As for Kenya and Tanzania, recent situation of power supply and demand is explained based on the collected materials. For other counties, the situation of power supply and demand will be based on the report of "The Study on Interconnection of Electrical Network of Nile Equatorial Lakes Countries, Oct. 2007". The study report aims to construct interconnection transmission systems among DR Congo, Kenya, Burundi and Rwanda of NEL (Nile Equator Lake) counties.

(1) Power Supply and Demand of Kenya

According to the annual report 2008/2009, the generating plants of Kenya are owned and operated by the government own power generation company (KenGen), IPP and EPP (Emergency Power Producers). The total installed generating capacity is 1,361MW and its effective output is 1,310MW. Installed capacity of plants owned by KenGen is occupied with hydropower: 749MW (effective: 730MW), thermal (diesel & gas turbine): 154MW (effective:

135MW), geothermal: 115MW and wind: 0.4MW, and accounted for 75% of the total capacity of Kenya. As of the end of 2009, KenGen holds all of hydropower plants which accounts 55% of the total capacity.

Power plants of IPP are composed of diesel and geothermal power plants. EPP is diesel power plants of 150MW (HFO) owned and operated by Aggreko Service.

Total sent-out energy to the transmission system including off-grid was 6,489GWh, of which details are KenGen: 4,339GWh (66.9% of total), IPP: 1,189GWh (18.3%), EPP: 914GWh (14.1%). And, in the above total supplied energy, power import of 29GWh from UETCL is included. Annual maximum power demand except for power export was recorded at 1,070MW.

Annual energy sold by the government own transmission company (KPLC: Kenya Power & Lighting Company) was 5,115GWh, of which details are domestic demand: 1,254GWh (24.4% of total), small commercial and industrial demand: 823GWh (16.0%), medium and large scale of commercial and industrial demand: 3,020GWh (58.6%) of which share of medium scale is considered at about 1/3 from the information in the annual report in 2007/2008. In the annual report 2007/08, commercial and industrial demand was divided into medium and large scale.

Total number of customers of 1,267,198 is consisted with 1,061,911 of KPLC customers and 205,287 of REP (Rural Electrification Program).

(2) Power Supply and Demand of Tanzania

A Tanzanian electric power industry is managed by a government own company (TANESCO). Total installed capacity generating plants is 960MW at the end of September of 2009, of which breakdown is 6 hydropower plants owned by TANESCO: 561MW (59% of total), 19 diesel power plants: 11% of the total of which 4 plants are connected with the national power grid. The remaining 30% are owned and operated by IPP under the short- and/or long-tem contracts. The Tanzania keeps their power supply system in hydropower dominant.

Total sent-out energy in the fiscal year 2008 was 4,425GWh, of which 2,985GWh (67.5%) was supplied by TANESCO and 1,440GWh (32.5%) by IPP. Power supply from hydropower plants was 2,649GWh which is 89% of power supply by TANESCO (60% of whole). In the annual report, it is reported that averaged utilization factor of hydropower was 54% due to drastic improvement of river inflow.

The maximum power demand of Tanzania was recorded at 740MW up to the end of September of 2009. In addition to this demand, power import agreements have been concluded for the power import of 10MW from Uganda for the western Kabera region and 3MW from Zambia for the southern regions.

New construction of diesel power plants having 282MW capacity is under construction, of which breakdown is 182MW: TANESCO and 100MW: IPP.

Total energy sold by TANESCO in 2008 was reached to 3,377GWh; domestic demand: 425 GWh (a little under than 13% of the whole), general demand: 995GWh (a little over than 29%), low voltage demand: 507GWh (15%) and MV demand: 1,037GWh (a little under than 31%) and special large demand like mine companies: 413GWh (12%). Total number of customers at the end of 2008 was 723,873.

In the following NEL countries including Uganda, new connection of domestic customers has been commonly restricted by chronic power supply deficit, shortage of the power transmission facilities, poor distribution networks, and so on. In addition to these problems, load shedding in peak time becomes normal, though there is a difference in degree for each country.

(3) Power Supply and Demand of Burundi

The installed capacity of generating plants which are connected a main power grid is 46.0MW including a diesel power plant having its capacity of 5.5MW and 13.3MW shared to Burundi of Ruzizi I & II hydro power plants in DR Congo. Its effective output is 26.3MW, averaged annual generated energy is 175GWh and effective annual energy generation is 131GWh.

At the time of 2005, the maximum demand is estimated at 35MW, number of customers: 27,000, total sold energy: 130.8GWh and total required energy: 180GWh which includes losses of 27%. These demands exceed in comparison with the above available power supply capacity. The electrification ratio at 2005 is 1.8%.

There are 4 projects under construction and/or planning. Total capacity of such projects is 58.3MW including allocation to Burundi (1/3) of Ruzizi III (47.8MW) and Rusumo Falls (61.5MW) and their averaged energy generation is estimated at 458GWh per annum.

(4) Power Supply and Demand of DR Congo

Congo is vast and there is north-south extent and east-west extent no less than 1,900km. The supply areas of the national grid having huge generating capacity of Inga are limited in the western parts of the country. And, it is said that there is a little possibility of grid extension from the Inga to the eastern area up to 2020. At present, therefore, the existing Kivu network is interconnected with Burundi and Rwanda and is operated as isolated system from the national grid.

The generating plants are Ruzizi I and Ruzizi II only which use the discharge water from the Kivu Lake. The generated energy of these hydropower plants are shared 1/3 each by DR Congo, Burundi and Rwanda. A water level decline of the Kivu Lake is remarkable, and it is continued that actual annual energy production is greatly lower than the planned one.

At the time of 2005, the maximum demand of the Kivu system is estimated at 50MW, number of customers: 36,000, total sold energy: 168GWh and total required energy: 210GWh which includes losses of 20%. These demands exceed in comparison with the above available power supply capacity. The electrification ratio at 2005 is 1.9%.

The 220kV system of Uganda is planned to be extended to DR Congo and interconnected with the Kivu system under the Interconnection of Power Networks of NEL Countries of NELSAP .

(5) Power Supply and Demand of Rwanda

Total installed capacity of generating plants is 68.2MW which is composed with 39.9MW of 7 hydropower plants including Ruzizi I & II in DR Congo and 28.3MW of diesel power plants. The averaged annual energy generation of hydropower plants is 157.4GWh.

At the time of 2005, the maximum demand of the Rwanda system is estimated at 50MW, number of customers: 65,000, total sales energy: 196.5GWh and total required energy: 262GWh which includes losses of 25%. In comparison with the above available supply capacity, the above available power supply capacity is narrowly kept a balance with those demands. The electrification ratio at 2005 is 3.8%.

There are 4 projects under construction and/or planning. Total capacity of such projects is 58.3MW including Rwanda (1/3) of Ruzizi III (47.8MW) and Rusumo Falls (61.5MW) and their averaged energy generation is estimated at 458GWh per annum.

As described the above, in the following NEL countries including Uganda, new connection of domestic customers has been commonly restricted by chronic power supply deficit.

3.4 Tariff of Electricity

(1) Electricity Tariff System

The principles of electricity tariff system is stipulated Electricity (Tariff Code) Regulations, 2003, while tariff setting method is clarified in Tariff Determination in The Uganda Electricity Sector (2006). Electricity tariff is regulated by ERA and required to be approved by ERA.

The current tariff system adopts ‘Rate Base Method’, in which the annual revenue requirements submitted by each power utilities will be assessed by ERA and the assessed revenue requirements will be the basis on which a fair rate of return (ROR) is added to reach the final revenue requirements. With a view to improving management efficiency of power utilities, ERA sets goals regarding losses, operation and maintenance costs, and bad debts (in case of distribution company), thereby setting the rate of return according to performance.

Tariff is revised yearly and tariff adjustments are made quarterly taking into account fuel costs, rate of inflation and foreign exchange rate.

There are 3 categories of tariff at each stage along the supply chain: generation, bulk supply (transmission) and retail and plus export and import tariff to neighboring countries. Tariff setting and the current level of tariff are described below.

(2) Generation Tariff

Generation tariff is payable by UETCL to generation companies. As for large hydropower such as Kiira and Nalubaale, the tariff includes only capacity price for 1kW per hour. The revenue requirements for tariff calculation are composed of the following costs:

Investment: depreciation, return on capital investments and income tax

Operation and maintenance costs

Concession fee: lease fees paid to UEGCL by Eskom Uganda (debt services and administrative expenses of UEGCL)

Regulatory fees and loyalties

As for thermal power, the tariff includes capacity price for recovery of capital costs and a energy charge for fuel costs and operation and maintenance costs. Fuel costs are revised periodically reflecting international fuel prices.

The tables below show the current generation tariff for hydropower and thermal power.

Table 3.4-1 Hydropower Generation Tariff

As from January 2010

Hydropower	Unit: Ush./MW per hour
Eskom Uganda	30,558

(Source: UETCL)

Table 3.4-2 Thermal Power Generation Tariff

As from February 2009

Thermal power	Unit: US$/MWh
Aggreko Kiira	155.75
Aggreko Mutundwe	160.78
Jacobsen Namanve	185.26

(Source: ERA web page)

The power purchased and imported by UETCL was 2,355GWh (preliminary figure) as of 2009 and the purchase cost was Ush.482.117billion[1]. Hence, the average power purchase cost to UETCL was about Ush.205 (US$10.8 ¢)[2].

(3) Bulk Supply Tariff

Bulk supply tariff is payable by the distribution company to UETCL, adopting time-of-use energy charge for peak, shoulder and off-peak. This tariff comprises operation and maintenance

[1] Based on 2010 Budget of UETCL downloaded form ERA’s Web page.
[2] Exchange rate: US$=Ush.1900

costs, power purchase costs and debt service. The power purchase costs are composed of the total cost of power purchase from generating companies and imports short of export revenues.

The table below shows the current bulk supply tariff.

Table 3.4-3 Bulk Supply Tariff

Peak	178.11 Ug.shs/kWh
Shoulder	157.29 Ug.shs/kWh
Off-peak	131.42 Ug.shs/kWh

(Source: UETCL)

(4) Retail Tariff

Retail tariff is for end users. Supply costs differ depending on categories of demand, so that tariff is so set as to recover the supply costs for each category of demand and to avoid cross subsidy. Revenue requirements for tariff calculation comprise the following costs:

- Operation and maintenance costs
- Depreciation
- Return on assets
- Return on working capital
- Allowance for bad debts and losses
- Income tax

  Retail tariff is composed of monthly fixed customer charge, capacity (demand) charge (kVA) and energy charge. The type and level of retail tariff applied to customers differ depending on the category of demand. The category of demand and the applied type of retail tariff are mentioned below.
- Domestic consumers

  Consumers supplied by 240V low voltage single phase, mainly residential houses and small shops. Lifeline rates are applied to consumers with small demand of 15kWh or under. Lifeline rates are below the supplying costs being subsidized.
- Commercial consumers

  Consumers supplied at three-phase low voltage not exceeding 100 Amperes.
- Medium-scale industries

  Consumers supplied at 415V not exceeding 500kVA.
- Large-scale industries

  Consumers supplied at 11,000V or 33,000V with maximum demand from 500kVA to 10,000kVA.
- Street lighting

  The new tariff effective from January 2010 has generally lowered the tariff level but the lifeline rates have been raised from 62Ush./kWh to 100Ush./kWh.

Table 3.4-4 End-User Retail Tariff

As from Ist January 2010

Consumer Category	Time of Use	Rates Ush/kWh
Domestic	First 15 kWh	100
	Above 15 kWh	385.6
	Fixed Monthly Service Charge	2,000
Commercial	Peak	405.1
	Shoulder	358.6
	Off-Peak	299.4
	Average tariff per month	358.6
	Fixed Monthly Service Charge	2,000
Medium-scale Industries	Peak	376.1
	Shoulder	333.0
	Off-Peak	276.6
	Average tariff per month	333.2
	Fixed Monthly Service Charge	20,000
	Maximum Demand Charge per kVA per month	5,000
Large Industrial Users	Peak	217.4
	Shoulder	186.8
	Off-Peak	148.9
	Average tariff per month	184.8
	Fixed Monthly Service Charge	30,000
	Maximum Demand Charge per kVA per month	3,690 per kW/month
	Maximum Demand Charge between 2,000 and 10,000kW	3,354 per kW/month
	Reactive Energy Charge	40 per kVArh/month
	Reactive Energy Reward	20 per kVArh/month
Street Lighting	Average tariff per month	364.6

(Source: ERA web page)

(5) Export and Import Tariff

UETCL is not allowed to make power export at prices equal to or lower than the average or marginal cost of power purchases.

The table below shows the current export and import tariff to neighboring countries.

Table 3.4-5 Export and Import Tariff

Unit: US$ cents/kWh

	Import	Export
Kenya (KPLC)	20.9	
Tanzania (TANESCO)		13.04
Rwanda	8.25	

(Source: UETCL)

Chapter 4

Long Term Power Development Plan

Chapter 4 Long Term Power Development Plan

4.1 Review of Demand Forecast

4.1.1 Assumption of Demand Forecast

UETCL formulates and publishes annual long-term power development plan known as “Grid Development Plan.” The Study Team discussed with Ministry of Energy and Mineral Development (MEMD) and agreed to use the latest version of Grid Development Plan 2009-2025 by UETCL in 2009 (hereinafter GDP2009) which is published in the beginning of the year 2010. The basic assumption of the demand forecast is described in this section.

(1) GDP (Gross Domestic Product) Growth Rate

GDP (Gross Domestic Product) growth rate is referred to the commercial and industrial values assumed by World Bank Uganda office. The agriculture section is accounted for a quarter of GDP, but it is not considered since it does not consume electricity.

According to the statistics of Word Bank, the GDP of Uganda is composed of 50% of commercial, 25% of industrial, and 25% of agriculture. The growth rates of combining of industrial and commercial portion are shown in the table below.

Table 4.1.1-1 Gross Domestic Product(GDP) Growth Rate(%)

Year	2008	2009	2010	2011	2012	2013-23
Commercial	7.7	8.35	7.55	7.9	7.9	7.9
Industrial	7.5	7.4	7.4	7.4	7.4	6.4
Combined (Commercial,Industrial)	7.6	8.0	7.5	7.7	7.7	7.4

(Source: World Bank Uganda Office, Study Team)

(2) New Connection of Domestic Demand

Table 4.1.1-2 shows the number of new connection of domestic demand. The rural electrification rate is expected to be 10% by 2012 on the basis of the Rural Electrification Strategy and Plan of the Government. As for the new connection of residential customers in urban area (areas supplied by UMEME), the rate of new connection is 17,000 per annum up to 2012 and 30,000 per annum thereafter up to 2023, in accordance with the concession agreement between GoU and UMEME Ltd. In addition, taking into account the fluctuation risks, the new connection of residential customers is assumed to 12,000 up to year 2010, and 17,000 per annum thereafter in the low case, and in high case the number is assumed to be 25,000 per annum up to 2012 and 30,000 per annum.

Table 4.1.1-2 Rate of New Connections in Urban Area

Year		2009	2010	2011	2012	2013-23
Commercial	High Case	25,000	25,000	25,000	25,000	30,000
	Base Case	17,000	17,000	17,000	17,000	30,000
	Low Case	12,000	12,000	17,000	17,000	17,000

(Source: Grid Development Plan 2009-2025 UETCL)

(3) Annual Load Factor

Table 4.1.1-3 shows the annual load factor which includes power export. On the basis of the actual record of annual load factor of 65% from 2002 to 2008, it assumes 67% for the period from 2009 to 2012, and 69% thereafter 2013.

Table 4.1.1-3 Load Factor（Export included）(%)

Year	2001	2002-04	2005-06	2007-08	2009-12	2013
Load factor	68	65	65	65	67	69

(Source: Grid Development Plan 2009-2025 UETCL)

(4) System (Transmission and Distribution) Losses

Table 4.1.1-4 shows the assumed system losses. The system losses are assumed gradually decreased from 36% in 2009 to 18% in 2022. Then it is assumed the system losses are not changed after 2022. Decreasing of the system loss rate is achieved by improving the power distribution losses, since transmission losses vary little from year to year. Generally, the distribution losses consist of 1) technical losses derived from overload of distribution lines or pole-mounted transformers, and 2) non-technical losses derived from power theft and inaccurate meter reading. The technical losses can be improved by expanding distribution system and maintaining distribution voltage properly. The non-technical losses can be improved by reinforcing system of the inspection and the meter reading. It is recommended that the countermeasures should be conducted step by step from now on.

Table 4.1.1-4 Loss Rate of Transmission and Distribution (%)

Year	2009	2010	2011	2012	2013	2014	2015
Transmission	4	4	4	4	4	4	4
Distribution	33	31	30	28	27	25	24
Total	36	35	34	32	31	29	28
Year	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022-25**
Transmission	4	4	4	4	4	4	4
Distribution	22	21	19	18	16	15	14
Total	26	25	23	22	20	19	18

(Source: Grid Development Plan 2009-2025 UETCL)

4.1.2 Result of Demand Forecast

Table 4.1.2-1 and Fig. 4.1.2-1 show the demand forecast of the middle case. The domestic energy demand will be increased 3.53 times from 2,171 GWh in 2009 to 7,665 GWh in 2025. The average growth rate is 8.20%.

On the other hand, the domestic power demand is increased for 3.59 times from 375 MW in 2009 to 1,346 MW in 2025, and the average growth rate is 8.31%. The average growth rate of 8.31% is slightly larger than the domestic energy growth rate of 8.20%. This is due to that the trend of load factor of the domestic demand without export will be gradually decreased.

Table 4.1.2-1 Result of Load Forecast （Growth Rate: Middle Case）

Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Domestic Energy Demand (GWh)	2164	2051	2171	2302	2449	2595	2793	3003	3232	3554
Growth Rate (%)		-5.21	5.86	6.04	6.39	5.93	7.64	7.52	7.63	9.94
Domestic Power Demand (MW)	371	352	375	398	424	449	483	519	559	615
Growth Rate (%)		-5.21	6.51	6.19	6.39	5.93	7.64	7.52	7.63	9.94
Year	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2009-25**
Domestic Energy Demand (GWh)	3915	4242	4604	4986	5406	5889	6428	7019	7665	
Growth Rate (%)	10.16	8.37	8.53	8.30	8.43	8.93	9.16	9.18	9.21	8.20
Domestic Power Demand (MW)	677	769	834	903	980	1034	1129	1233	1346	
Growth Rate (%)	10.16	13.53	8.53	8.30	8.43	5.58	9.16	9.18	9.21	8.31

(Source: Grid Development Plan 2009-2025 UETCL)

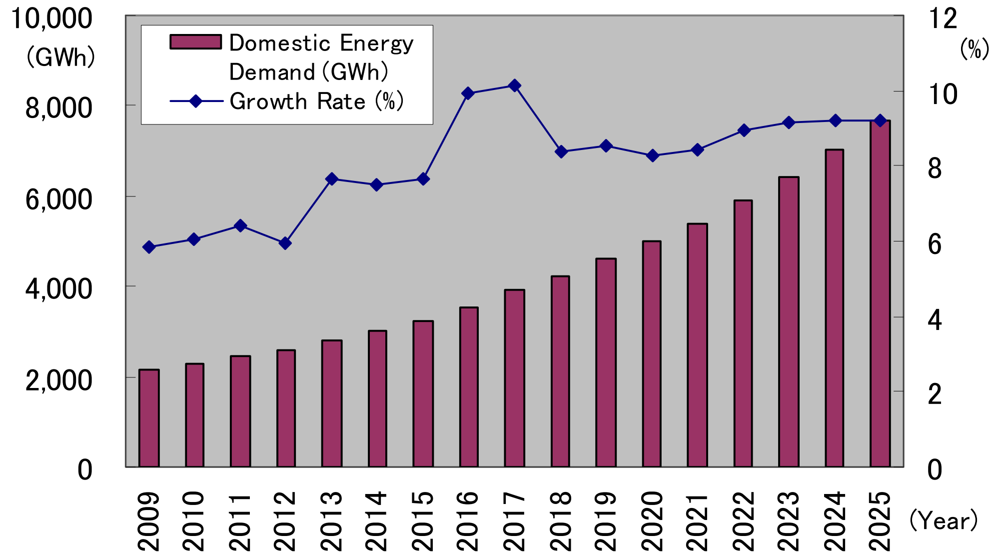


Figure 4.1.2-1 Result of Load Forecast (Growth Rate: Middle Case)

4.1.3 Verification of Demand Forecast

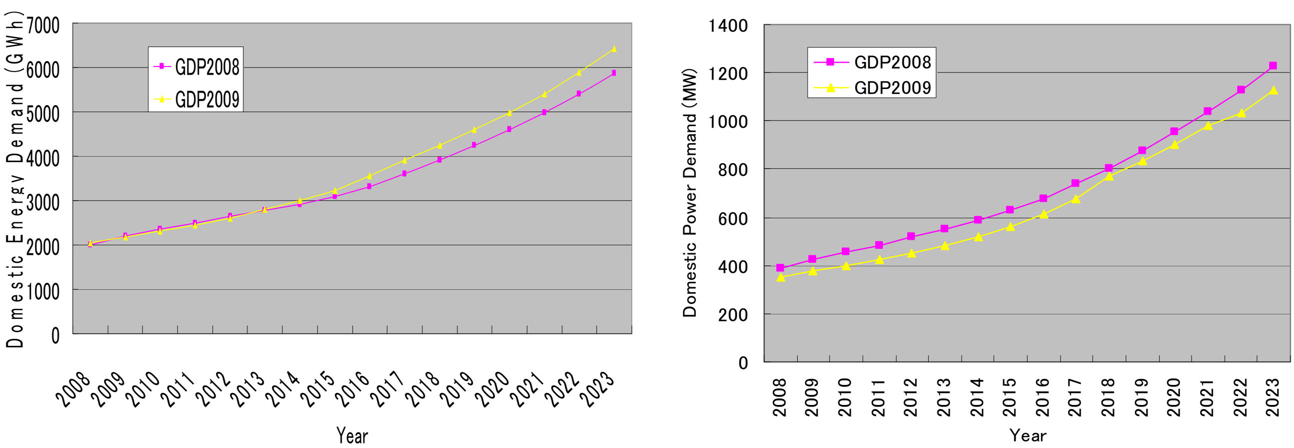
(1) Comparison to the Previous Forecast

Table 4.1.3-1 and Fig. 4.1.3-1 shows the comparison result of GDP2009 and the previous demand forecast of GDP2008. The average growth rate of the energy demand for 14 years from 2009 to 2023 is 7.22% in GDP2008 and 8.06% in GDP2009, therefore the difference is 0.84%. The growth rate of the power demand is also slightly increased as 8.06% in GDP2008 and 8.19% in GDP2009.

Table 4.1.3-1 Comparison of Demand between GDP2008 and GDP2009

Year		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Growth Rate 2009-23
Domestic Energy Demand (GWh)	GDP2008	1999	2209	2362	2489	2635	2770	2914	3087	3311	3595	3903	4236	4596	4985	5407	5864	7.22%
	GDP2009	2051	2171	2302	2449	2595	2793	3003	3232	3554	3915	4242	4604	4986	5406	5889	6428	8.06%
Domestic Power Demand (MW)	GDP2008	387	425	456	485	519	552	588	629	678	739	804	875	953	1037	1128	1227	7.87%
	GDP2009	352	375	398	424	449	483	519	559	615	677	769	834	903	980	1034	1129	8.19%

(Source: Grid Development Plan 2009 and 2008 UETCL)



Energy (GWh) Power (MW)

(Source: Grid Development Plan 2009 and 2008 UETCL)

Figure 4.1.3-1 Comparison of Demand between GDP2008 and GDP2009

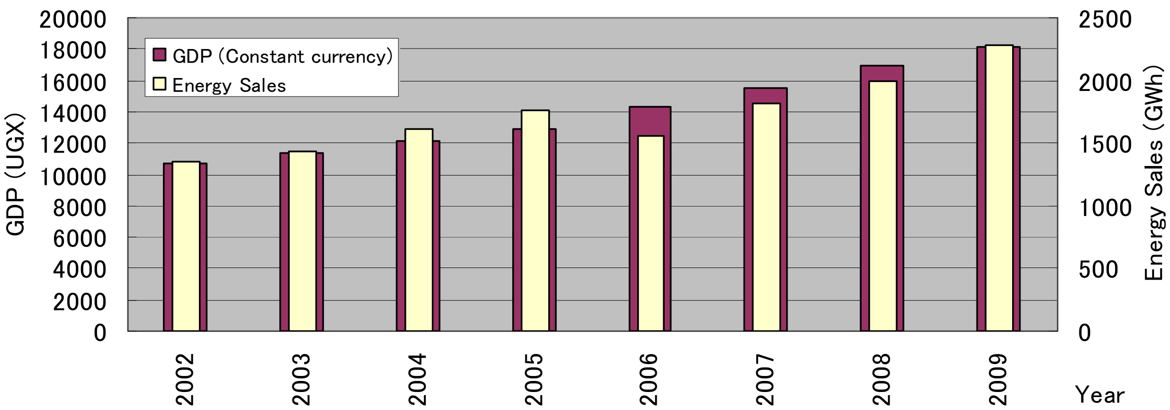
(2) Elasticity of Energy Demand to Gross Domestic Product (GDP)

The energy demand is generally closely correlated to the economic activity. Therefore, it is important to understand the tendency of the past gross domestic product and energy demand to estimate the future energy demand. Table 4.1.3-2 and Fig. 4.1.3-2 show the domestic energy demand, which excludes energy import and export, and the constant currency base GDP which excludes inflation that is published by IMF. Fig. 4.1.3-3 shows the GDP elasticity of the energy demand by growth rates. As it can be seen, the elasticity fluctuate in the wide range between -1.12 to 2.03, while the average of it from 2003 to 2009 is 0.99, and this indicates that the growth rate of GDP and energy demand is similar trend during this period.

Table 4.1.3-2 Actual Record of Gross Domestic Product and Domestic Energy Sales

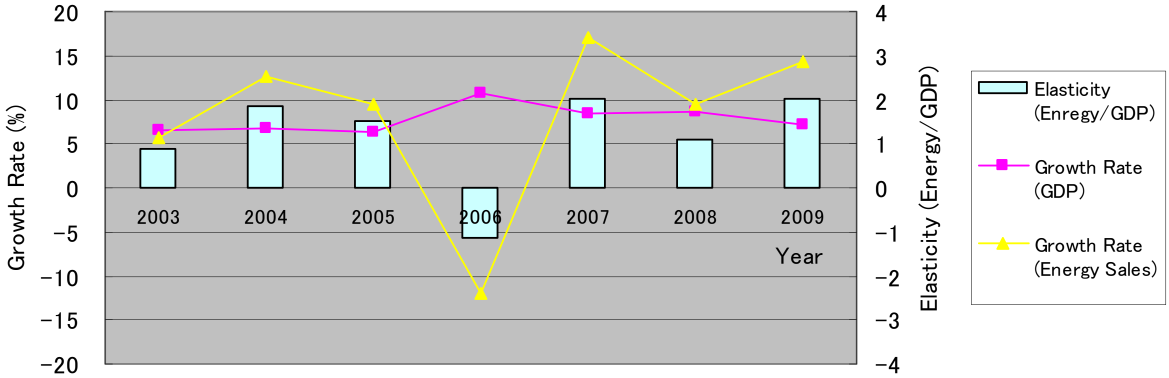
Year	Gross Domestic Product (GDP)		Domestic Energy Sales		Elasticity (Energy/GDP)
	Constant currency (billion UGX)	Growth Rate (%)	(GWh)	Growth Rate (%)	
2002	10709	8.73	1356		
2003	11403	6.47	1433	5.68	0.88
2004	12179	6.81	1614	12.65	1.86
2005	12950	6.33	1767	9.47	1.50
2006	14347	10.78	1554	-12.05	-1.12
2007	15554	8.41	1819	17.03	2.02
2008	16908	8.71	1993	9.53	1.09
2009	18103	7.06	2278	14.32	2.03
Average 2002-2009		7.79		7.69	0.99

(Source: IMF Home Page, UETCL)



(Source: IMF Home Page, UETCL)

Figure 4.1.3-2 Actual Record of Gross Domestic Product and Domestic Energy Sales



(Source: IMF Home Page, UETCL)

Figure 4.1.3-3　GDP Elasticity of Energy Demand

(3) Elasticity of GDP to Demand Forecast

The growth rates of energy demand in GDP2009 and Gross Domestic Product (GDP) published in April 2010 by IMF are shown in Table 4.1.3-3 and Fig. 4.1.3-4. The table and figure also show the elasticity which is the ratio of growth rates of energy demand to GDP. The GDP value estimated by IMF is provided up to year 2015, hence the same rate is assumed after 2015.

The growth rate of energy demand in the period from the year 2009 to 2023 is 5.86% at minimum and 10.16% at maximum, while the growth rate of GDP in the same period is 5.59% at minimum and 7.50% at maximum. The elasticity is calculated to 0.83 at minimum, and 1.35 at maximum. The average growth rate of energy demand and the GDP in the period is 8.06% for the domestic energy demand, 7.22% for the GDP. This means the elasticity can be calculated to 1.11.

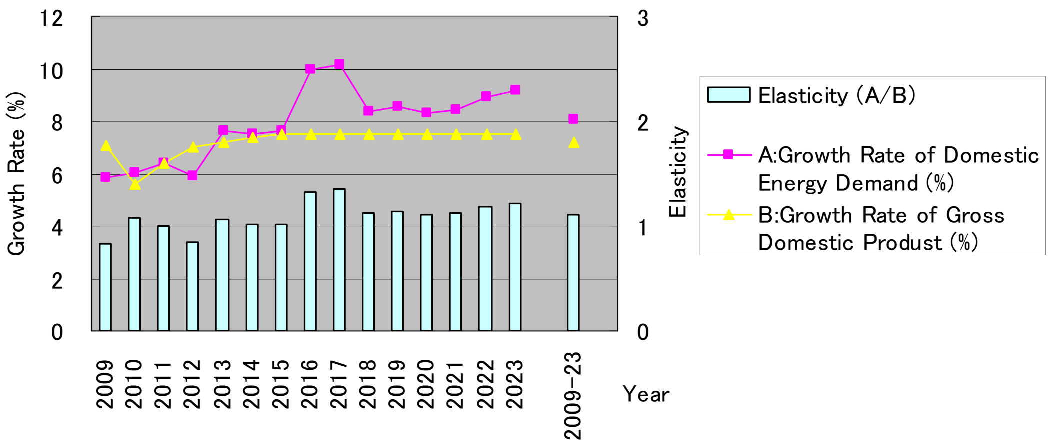
The value of 1.11 during 2009 to 2023 is compared to the average elasticity during the period from 2002 to 2009. As shown in Table 4.1.3-2, the actual average of the elasticity in the period is 0.99. Therefore the value of 1.11 is slightly larger than the actual record. However, this can be explained by load shedding caused by power deficit due to low water level of the Lake Victoria experienced in the period. Considering the actual record of elasticity in the many countries is around 1.0, the average growth rate of energy demand of 8.06% in GDP2009 is acceptable if these factors are considered.

Table 4.1.3-3 Comparison of Growth Rate

Year	2009	2010	2011	2012	2013	2014	2015	2016
A:Growth Rate of Domestic Energy Demand (%)	5.86*	6.04	6.39	5.93	7.64	7.52	7.63	9.94
B:Growth Rate of Gross Domestic Produst (%)	7.06	5.59	6.40	7.00	7.20	7.40	7.50	7.50
Elasticity (A/B)	0.83	1.08	1.00	0.85	1.06	1.02	1.02	1.33
Year	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2009-23**
A:Growth Rate of Domestic Energy Demand (%)	10.16	8.37	8.53	8.30	8.43	8.93	9.16	8.06
B:Growth Rate of Gross Domestic Produst (%)	7.50	7.50	7.50	7.50	7.50	7.50	7.50	7.22
Elasticity (A/B)	1.35	1.12	1.14	1.11	1.12	1.19	1.22	1.11

(Source: Grid Development Plan 2009-2025 UETCL, Study Team)

*Note：This growth rate of energy demand differs from one in Figure 4.1.3-2 that shows energy sales



(Source: Grid Development Plan 2009-2025 UETCL, JICA Study Team)

Figure 4.1.3-4 Comparison of Growth Rate

(4) Result of Demand Forecast

Since the growth rate of the energy demand presented in GDP is verified, therefore, the growth rate of 8.06% is applied for the study. The study assumes that the growth rate of 8.06% is the middle case. Considering the fluctuation of the growth rate, it is assumed with adding 1.0% (9.06%) as a high case, and with minus 1.0% (7.06%) as a low case. In order to estimate the maximum power demand, observed load factor of 66% is adopted.

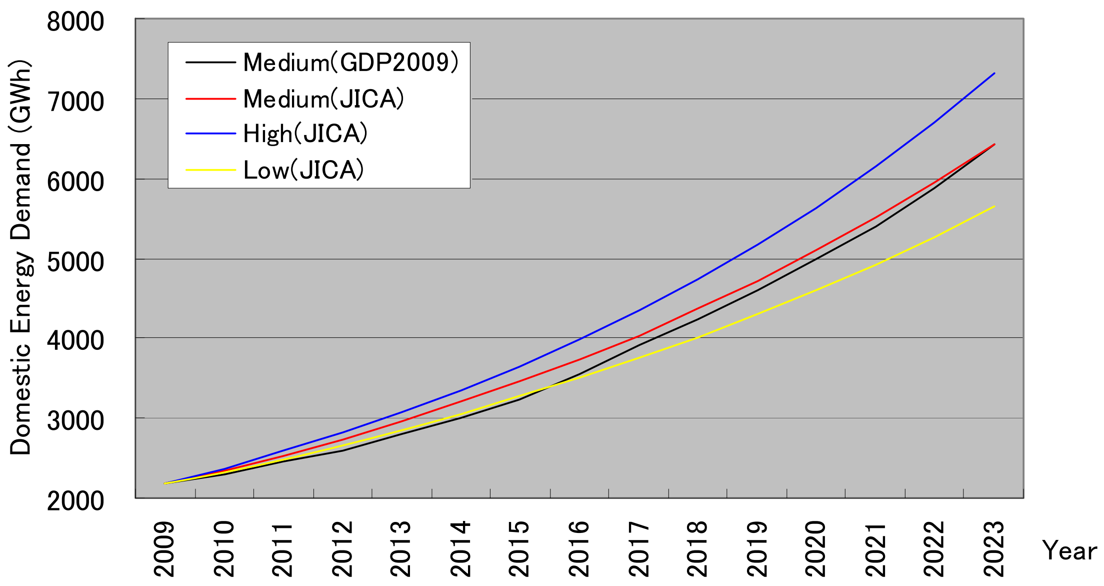
Table 4.1.3-4 ad Fig. 4.1.3-5 shows the forecasted result of the domestic energy demand. As the growth rate in GDP2009 is verified, the energy demand of 6,428GWh in 2023 coincides to that of GDP 2009. Focusing on the growth rate, while the study employs constant growth rate of

8.06% through the year, therefore the domestic energy demand curves have smooth shape as shown in the Figure 4.1.3-5. On the other hand, as shown in Table 4.1.2-1, minimum growth rate estimated by GDP 2009 is 6.04% in 2010 and maximum growth rate is 10.16% in 2017. The growth rate estimated by GDP2009 is varying widely. Since accuracy for the demand forecast in later yeas is limited, the growth rate, except in recent years, should be taken constant value generally. Hence, the staggered growth rate in the GDP2009 is considered as inadequate value.

Table 4.1.3-4 Result of Domestic Energy Demand Forecast (GWh)

Year		2009	2010	2011	2012	2013	2014	2015	2016
GDP2009	Medium	2,171	2,302	2,449	2,595	2,793	3,003	3,232	3,554
JICA	Medium	2,171	2,346	2,535	2,740	2,961	3,199	3,457	3,736
	High	2,171	2,368	2,582	2,816	3,072	3,350	3,654	3,985
	Low	2,171	2,324	2,489	2,664	2,852	3,054	3,270	3,500
Year		**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	
GDP2009	Medium	3,915	4,242	4,604	4,986	5,406	5,889	6,428	
JICA	Medium	4,037	4,363	4,714	5,094	5,505	5,949	6,428	
	High	4,346	4,740	5,169	5,637	6,148	6,706	7313	
	Low	3,748	4,012	4,296	4,599	4,924	5,272	5,644	

(Source: Study Team)



(Source: Study Team)

Figure 4.1.3-5 Result of Domestic Energy Demand Forecast (GWh)

Table 4.1.3-5 and Fig.4.1.3-6 shows the forecasted power demand. Difference of the forecasting between the study and GDP2009 arises from different employment of the annual load factor in addition to the different energy demand forecasting as shown in Table 4.1.3-4. The study team employs the constant annual load factor of 0.66. On the other hand, the annual load factor in GDP2009 fluctuates as 0.66 in the first period, 0.63 in the middle period, and 0.65 in the last period. For forecasting the power demand, annual load factor should be employed gradually decreasing or increasing constantly in common. The annual load factor in the GDP2009 shifts in the middle period from decreasing to increasing tendency. This can be achieved by means of conducting load leveling. Therefore, the power demand forecast in the GDP2009 is considered as unnatural.

Table 4.1.3-5 Result of Domestic Power Demand Forecast (MW)

Year		**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
GDP2009	Medium	375	398	424	449	483	519	559	615
JICA	Medium	375	406	439	474	512	553	598	646
	High	375	410	447	487	531	579	632	689
	Low	375	402	430	461	493	528	566	605
Year		**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	
GDP2009	Medium	677	769	834	903	980	1,034	1,129	
JICA	Medium	698	755	815	881	952	1,029	1,112	
	High	752	820	894	975	1,063	1,160	1,265	
	Low	648	694	743	795	852	912	976	

(Source: Study Team)

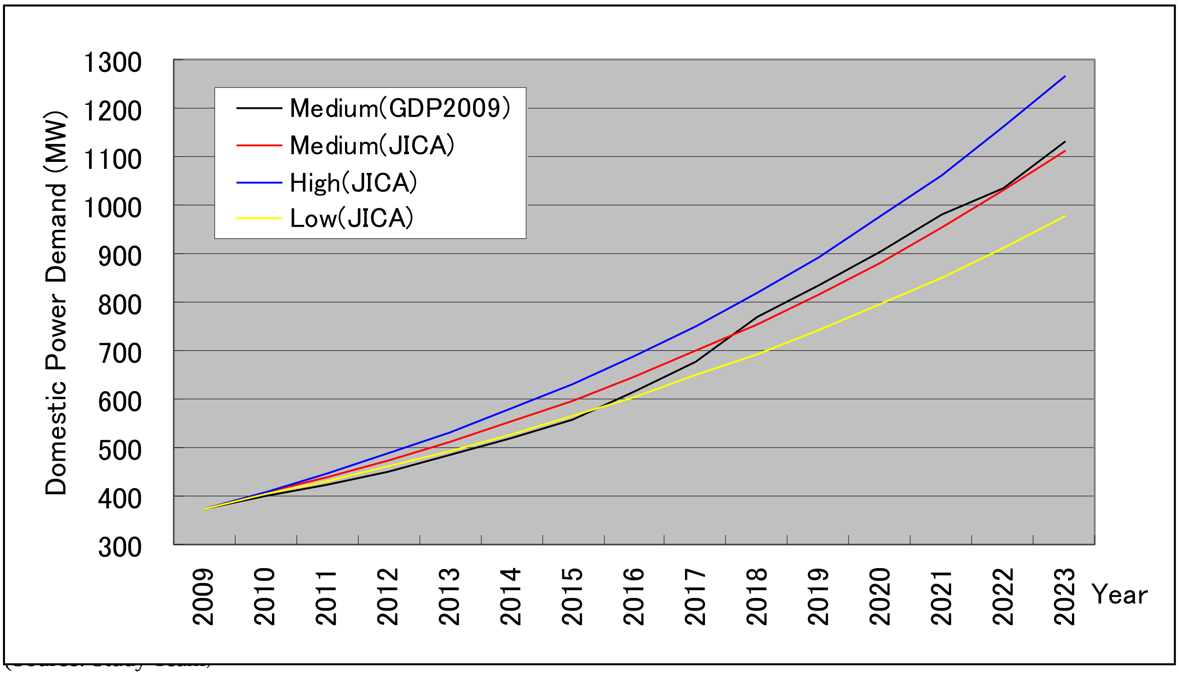


Figure 4.1.3-6 Result of Domestic Power Demand Forecast (MW)

4.2 Regional Power Exchange Plan

Uganda is neighboring to five countries of Kenya, Tanzania, Rwanda, DR Congo, and Sudan. The grid is interconnected to Kenya, Tanzania, and Rwanda. And it is planned to connect with DR Congo and Sudan in future.

4.2.1 Actual Power Exchange with Neighboring Countries

Table 4.2.1-1 shows the record of energy import and export. As shown in the table, the energy export after 2005 is dropped largely due to decreasing power output of Owen Falls hydropower station. This decrease is resulted from the drop of water level of the Lake Victoria. However, before 2005, the surplus energy is actively exported as 239.6GWh are exported in year 2002. This amount of export is accounted for 15% of total sale energy of 1,620 GWh,

Table 4.2.1-1 Actual Record of Export and Import Energy (GWh)

Year		2002	2003	2004	2005	2006	2007	2008
Kenya	Export	239.6	190.7	167.8	28.5	10.4	22.0	23.9
	Import	1.1	1.2	6.0	25.4	46.7	58.3	40.92
Tanzania	Export	23.9	25.4	30.1	32.5	39.8	42.8	43.1
Rwanda	Export				2.9	2.8	0.68	0.078
	Import				1.5	2.0	2.2	2.3

(Source: Annual Report 2008 UETCL）

4.2.2 Power Exchange with Kenya

The power exchange between Uganda and Kenya was started in 1955 by Kenya-Uganda Electricity Agreement 1955 agreed upon UETCL (Uganda Electricity Transmission Company Limited) and KPLC (Kenya power & Lightening Company Limited). At present, the grids of the both countries are interconnected via 132kV transmission line, and the power is exchanged actively. The current version of the agreement was made in 2004 through experiencing many revisions. The main contents of the current version of the agreement are summarized in Table 4.2.2-1.

Table 4.2.2-1 Contents of Kenya-Uganda Electricity Agreement

	Uganda→Kenya		Kenya→Uganda		
Time	**Minimum Guarantee Power (MW)**	**Price (US ¢ /kWh)**	**Minimum Guarantee Power (MW)**	**Price (US ¢ /kWh)**	**Fuel Cost**
5:00-18:00	20	6.1	0	-	-
18:00-23:00	0MW (6MVar)	6.1	10	6.1	Average fuel cost of thermal plants in KPLC
23:00-5:00	20	4.6	0	-	-

(Source: 7th Supplemental Agreement of Kenya-Uganda Electricity Agreement)

The power export from Uganda to Kenya is mainly provided by hydropower stations. The minimum guaranteed power should be ensured except the peak hours period between 18:00 to 23:00. The tariff of the power supply is 6.1 US ¢ /kWh for 5:00 to 23:00 and 4.6 US ¢ /kWh for 23:00 to 5:00, while, the amount of power exchange from 18:00 to 23:00 is 0MW. However, the 6MVar of reactive power is exchanged on the basis of the agreement. This indicates the system operation between Uganda and Kenya maintains the cooperative manner to stabilize the voltage of power system during the peak hours.

While, the power export to Uganda from Kenya is specified to 10MW of the minimum guaranteed power with 6.1 US ¢ /kWh in the period from 18:00 to 23:00. However, the source of the power in Kenya is thermal plants and it is required to pay the average fuel cost of KPLC. This rule determines the tariff of the power import from Kenya to Uganda as the tariff is 10.2 US ¢ /kWh in 2005, 19.3 US ¢ /kWh in 2006, 25.9 US ¢ /kWh in 2007, 34.5 US ¢ /kWh in 2008 and 23.0 US ¢ /kWh in 2009.

Therefore, it can be concluded that Uganda and Kenya developed the cooperative system considering the characteristics of the power system.

4.2.3 Power Exchange between Uganda and Kenya

Uganda plans to export the surplus energy to the neighboring countries after 2015 when the Karuma hydropower station commences the operation, and export large energy after 2018 when the Ayago hydropower station will produce large increment of energy. The Study Team sent the questionnaire to Kenya whether Kenya side has an intension to accept the additional energy from Uganda. The Study Team members visited to Kenya to confirm the answers. The results are as follows.

(1) Power Exchange Plan with Kenya

Kenya regards the following issues as the merits and important points for import energy from Uganda.

- Unifying the power system of both countries is an effective measure to reduce the reserve margin.
- It is planned that large amount of electricity will be imported from Ethiopia. Importing from electricity from Uganda can contribute to diversify the risk rather than importing large amount of electricity from a single country.
- Reinforcement of geothermal plants and importing electricity from Ethiopia will increase the westward power flow from Nairobi which is almost in the center of Kenya. The import electricity from Uganda will contribute to reduce the westward power flow; however, such impact is limited
- The import tariff and supply reliability are important factors for power import.

(2) Kenya's Power Import Capacity from Uganda

In order to confirm the acceptable energy from Uganda to Kenya, the questionnaire was sent to Kenya with the expected exporting electricity from Uganda to Kenya which was presented in GDP 2009. The results are shown in Table 4.2.3-1.

It was confirmed that acceptable energy of Kenya is the same to the expected energy export from Uganda. This indicates that both of the countries has closely communicated regarding to the power exchange. The questionnaire is also including acceptable power tariff by Kenya, but the question was unanswered.

The Kenya's Least Cost Power Development Plan (LCPDP) expected installation of the coal-fired thermal plant for 300MW in 2014, 300MW increment in 2018, 300MW increment in 2020, 600MW increment in 2021, and the total capacity of coal-fired thermal plant will be 1,500MW. However, considering the possible delay of the installation of the coal-fired thermal plant due to the environmental issues, importing energy from Uganda can be the alternative power source to compensate the delay.

The acceptable import energy from Uganda to Kenya is a just plan and is variable in future. The amount of the energy will be adjusted together with the import tariff.

Table 4.2.3-1 Acceptable Energy from Uganda (GWh)

Year	2015	2016	2017	2018	2019	2020	2025
Uganda's Planned Export Energy	102	102	263	438	701	745	701
Kenya's Acceptable Energy	102	102	263	438	701	745	701

(Source: Study Team)

(3) Power Import from Ethiopia

The Study Team obtained the LCPDP which is annually published by KPLC. The details of the power development plan are shown in Table 4.2.3-2.

According to the LCPDP, the power import in 2014 will be increased starting at 200MW in the year 2014. And the power import will reach to 1,100 MW in 2023. The most of the energy import from Ethiopia is production of Gibe III hydropower station. The power will be transmitted over 1,200 km distance by direct current ±500kV transmission line, and power is converted to alternate current at AC-DC converter stations located at suburb of Nairobi city. The transmission line capacity will be 1,000 MW by 2020, and the AC-DC converter stations will be expanded to 2,000 MW after 2020.

However, there is no legitimate contract between Kenya and Ethiopia, therefore this issue should be discussed between the high level government talks.

Table 4.2.3-2 LCPDP (Least Cost Power Development Plan)

Fiscal Year	Plants	Type	Added Capacity (MW)	Total Capacity (MW)	Peak Load (MW)	Reserve Margin (MW)	Reserve Margin (%)
2009	Existing			1,312	1,205	107	9
2010	Aggreko Nairobi	Thermal	-20				
	Aggreko Nairobi	Thermal	80				
	Aggreko Naivasha	Thermal	60				
	Olkaria 2	Geothermal	35				
	Geothermal	Geot.Well head	5				
	Tana upgrade	Hydro	10	1,482	1,278	204	16
2011	Aggreko Nairobi	Thermal	-80				
	Aggreko Naivasha	Thermal	-60				
	Athi river thermal	Thermal	80.9				
	Athi river thermal	Thermal	84				
	Kipevu 3	Thermal	120	1,627	1,352	275	20
2012	Sangro	Hydro	20.6				
	Athiriver coal plant	Coal	19.5				
	Thika thermal Plant	Thermal	80				
	Aggreko Nairobi	Thermal	-90				
	Wind	Ngong 3	15				
	EBURRU	Geothermal	2.2	1,674	1,454	220	15
2013	Olkaria 4	Geothermal	140				
	Turkana wind	Wind	300				
	Olkaria 1	Geothermal	-45				
	Olkaria 3	Geothermal	50				
	Kindaruma upgrade	Hydro	32				
	Olkaria 1-4,5	Geothermal	140	2,291	1,581	710	45
2014	Import	Import	200				
	Kipevu GT1	Thermal	-30				
	Kipevu GT2	Thermal	-30				
	Coal	Coal	300	2,731	1,789	948	53
2015	Import	Import	100				
	Geothermal	Geothermal	140	2,971	2,038	933	46
2016	Import	Import	100				
	Geothermal	Geothermal	140	3,211	2,328	883	38
2017	Import	Import	100				
	Geothermal	Geothermal	280	3,591	2,661	930	35
2018	Import	Import	100				
	Coal	Coal	300	3,991	3,040	951	31
2019	Import	Import	100				

Fiscal Year	Plants	Type	Added Capacity (MW)	Total Capacity (MW)	Peak Load (MW)	Reserve Margin (MW)	Reserve Margin (%)
	Iberafrica 1	Thermal	-56				
	Mumias suger Cogen	Cogeneration	-26				
	Muronga Hydro	Hydro	60				
	Lower Grand Falls	Hydro	140				
	Geothermal	Geothermal	280	4,489	3,474	1,015	29
2020	Geothermal	Geothermal	280				
	Import	Import	100				
	Medium Speed Diesel	Thermal	-60				
	Coal	Coal	300	5,109	3,970	1,139	29
2021	Coal	Coal	600				
	Tsavo power	Thermal	-74				
	Import	Import	100	5,735	4,536	1,199	26
2022	Nuclear	Nuclear	600				
	Athiriver mining coal	Coal	-19.5				
	Import	Import	100	6,416	5,183	1,233	24
2023	Import	Import	100				
	Nuclear	Nuclear	600				
	Geothermal	Geothermal	140	7,256	5,923	1,333	23

(Source: KPLC)

4.2.4 Expected Power Import Tariff from Ethiopia to Kenya

It is expected that the power import from Uganda to Kenya will be realized after 2018, when the KPLC will import power of 600 MW and the majority of the import is Ethiopia. This means Ethiopia precedes Uganda in exporting to Kenya. This situation necessitates that the import tariff from Uganda should be attractive enough for Kenya.

In the questionnaire to KPLC, the import tariff from Ethiopia is unanswered. Therefore the import tariff is estimated by the Study Team.

The majority of power source for export in Ethiopia is accounted by electricity production of Gibe III and Mendaya hydropower station. The generation cost of these hydropower stations is estimated to US$0.0457/kWh according to Ethiopia-Kenya Power System Interconnection Project Draft Final Report 2008.5 by Fichtner. The transmission cost should be added to the price since the power is transmitted over the 1,200km distance from Ethiopia to Kenya. The transmission cost is estimated as follows.

(1) Transmission Method and Construction Cost

According to the aforementioned report (Ethiopia-Kenya Power System Interconnection Project Draft Final Report 2008.5 Fichtner), transmission method is recommended to direct current 500kV transmission. The construction cost assuming transmission line capacity of 1,000MW is expected to 312 million Euro (467 MUS$) for the Phase 1 work of transmission line facilities, and 439 million Euro (658MUS$) for substation facilities.

(2) Calculation of Annualized Cost

Equivalent life service cost factor for the depreciation period is expressed as below.

$$E = \left(\frac{(1+i)^n}{(1+i)^n - 1} \right) \times i$$

E: annualized cost factor : discount rate n: service life

In the study, the statutory useful life is assumed for n=36 for transmission line, and n=22 for substation, which are applied in Japan. Discount rate adopts 0.1 (10%) which is an average value.

By entering these figures, the annualized cost factors are calculated to 0.10334 for transmission line and 0.1140 for the substation. Moreover, 0.05 (5%) for the maintenance, taxation, labor costs are added. Further, the residual value after the service life is assumed to be zero. In this regards, the annualized cost for the transmission is estimated to; 71.6MUS$ for transmission line, and 107.9MUS$ for substations.

(3) Calculation of Annual Transmitted Energy

Phase 1 construction installs the transmitting capacity to 1,000MW, therefore transmitted power is set to 1,000MW, and the annual utilization factor is assumed 80%. If these values are applied, the expected transmitted energy between Ethiopia to Kenya is estimated to 7,008GWh per annum.

(4) Calculation of Transmission Cost

The transmission cost per kWh is estimated to;

(71.6 + 107.9)/7008 = 0.0256 US$/kWh

(5) Unit Price of Kenya's Receiving Power

The unit price of receiving power of Kenya is a sum of the generation and transmission cost which is;

0.0457 + 0.0256 = 0.0713 US$/kWh

The kWh price of the import power from Ethiopia is 0.0457 US$/kWh for generation cost, and 0.0256 US$/kWh for the transmission cost and the sum is 0.0713 US$/kWh. If the unit price of import power from Uganda is less than this value, the power of Uganda can compete to Ethiopia power.

4.2.5 Power Export Plan

Uganda network system is interconnected to Kenya and Tanzania with 132kV transmission lines. The 132kV lines will be reinforced to 220kV in future. Currently, small amount of power is exchanged with Rwanda; however the power exchange will be expanded after installation of the 220kV transmission lines between Uganda and Rwanda. Further, large-scale hydropower developments accrue the surplus export power and this surplus will be exported to DR Congo and Sudan via 220kV interconnection line.

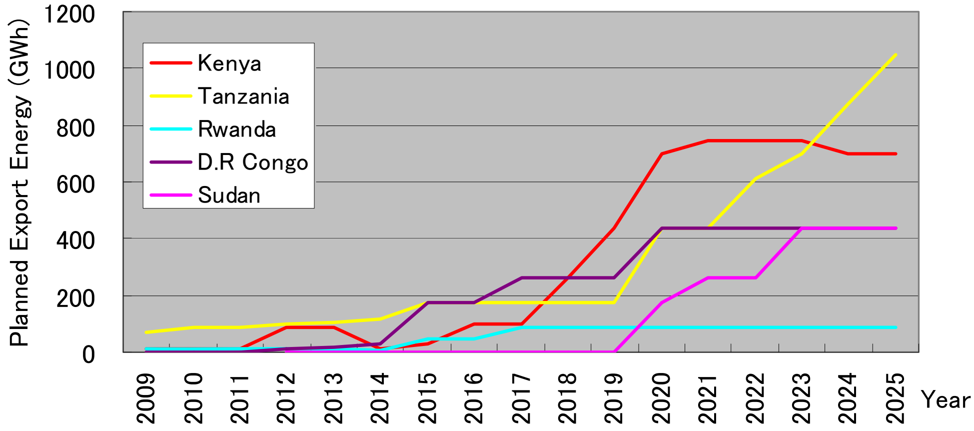
The planned export energy to the neighboring countries are given in GDP2009 as shown in Table 4.2.5-1 and Fig. 4.2.5-1, while planned export power is shown in Table 4.2.5-2, and Fig. 4.2.5-2. After the year 2018 when Ayago hydropower station is commenced, the power exports to the neighboring countries are sharply increased.

The load factor of the power export, which is calculated by dividing the export energy by 8760 hours (total number of hours in one year), is planned to 50% for Rwanda, and other countries are assigned over 80% in average This indicates that the power export is planned for the base power supply.

Table 4.2.5-1 Planned Export Energy (GWh)

Year	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Kenya	10	10	88	88	13	26	102	102	263
Tanzania	88	88	96	105	114	175	175	175	175
Rwanda	9	9	9	9	4	44	44	88	88
D.R Congo			9	18	26	175	175	263	263
Sudan			0	0	0	0	0	0	0
Total	107	107	201	219	158	420	496	627	788
Year	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	
Kenya	438	701	745	745	745	701	701	701	
Tanzania	175	438	438	613	701	876	1051	1051	
Rwanda	88	88	88	88	88	88	88	88	
D.R Congo	263	438	438	438	438	438	438	438	
Sudan	0	175	263	263	438	438	438	438	
Total	964	1840	1971	2146	2409	2540	2716	2716	

(Source: GDP2009)



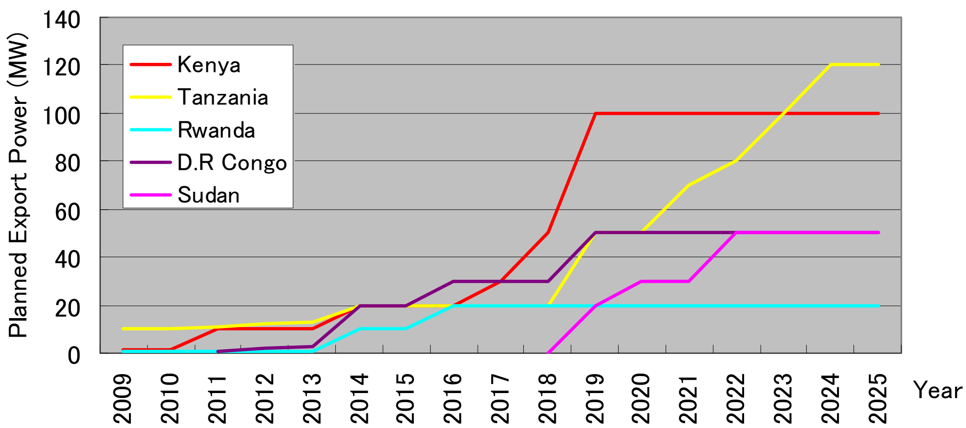
(Source: GDP2009)

Figure 4.2.5-1 Planned Export Energy (GWh)

Table 4.2.5-2 Planned Export Power (MW)

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017
Kenya	1	1	10	10	10	20	20	20	30
Tanzania	10	10	11	12	13	20	20	20	20
Rwanda	1	1	1	1	1	10	10	20	20
D.R Congo			1	2	3	20	20	30	30
Sudan									
Total	**12**	**12**	**23**	**25**	**27**	**70**	**70**	**90**	**100**
Year	2018	2019	2020	2021	2022	2023	2024	2025	
Kenya	50	100	100	100	100	100	100	100	
Tanzania	20	50	50	70	80	100	120	120	
Rwanda	20	20	20	20	20	20	20	20	
D.R Congo	30	50	50	50	50	50	50	50	
Sudan	0	20	30	30	50	50	50	50	
Total	120	240	250	270	300	320	340	340	

(Source: GDP2009)



(Source: GDP2009)

Figure 4.2.5-2 Planned Export Power (MW)

4.3 Result of Demand Forecast (Domestic and Export)

The power demand which is composed of domestic demand (the middle case scenario) and export power is presented in GDP2009 and also estimated by the Study Team as shown in Table 4.3-1 and Fig.4.3-1 for the energy, and in Table 4.3-2 and Fig.4.3-2 for the power.

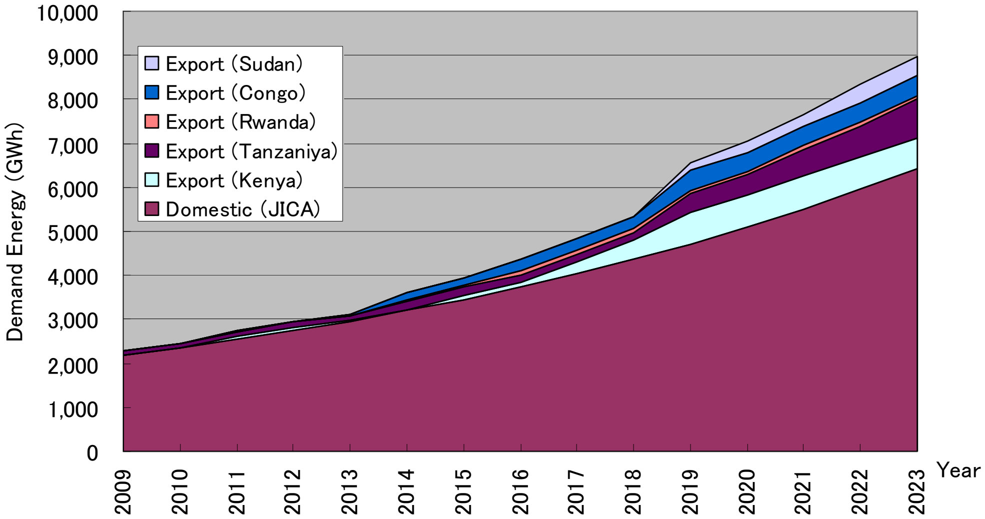
The difference of the GDP2009 and JICA study team estimates can be seen only in the domestic demands, and the export is almost the same for the both cases. The export energy is calculated by applying the policy of GDP 2009 such that the surplus of power supply is allocated for power export. As the power supply is dependent on power source capacity, therefore, if the power development schedule is changed, then the power export plan should be revised.

The load factor in the year 2023 is 66% for the domestic demand (JICA Study Team), while the load factor of export is a large value of 91%. This results in the load factor or 71% in total.

Table 4.3-1 Result of Demand Energy Forecast (GWh)

Year		2009	2010	2011	2012	2013	2014	2015	2016
Domestic	Forecasted by JICA	2171	2346	2535	2740	2961	3199	3457	3736
	GDP2009	2171	2302	2449	2595	2793	3003	3232	3554
Export	Kenya	10	10	88	88	13	26	102	102
	Tanzania	88	88	96	105	114	175	175	175
	Rwanda	9	9	9	9	4	44	44	88
	Congo			9	18	26	175	175	263
	Sudan			0	0	0	0	0	0
Total	Forecasted by JICA	2278	2453	2737	2959	3118	3620	3953	4363
	GDP2009	2278	2409	2651	2814	2951	3424	3728	4181
Year		**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	
Domestic	Forecasted by JICA	4037	4363	4714	5094	5505	5949	6428	
	GDP2009	3915	4242	4604	4986	5406	5889	6428	
Export	Kenya	263	438	701	745	745	745	701	
	Tanzania	175	175	438	438	613	701	876	
	Rwanda	88	88	88	88	88	88	88	
	Congo	263	263	438	438	438	438	438	
	Sudan	0	0	175	263	263	438	438	
Total	Forecasted by JICA	4825	5326	6554	7065	7651	8358	8969	
	GDP2009	4703	5206	6444	6957	7552	8298	8969	

(Source: Study Team, GDP2009)



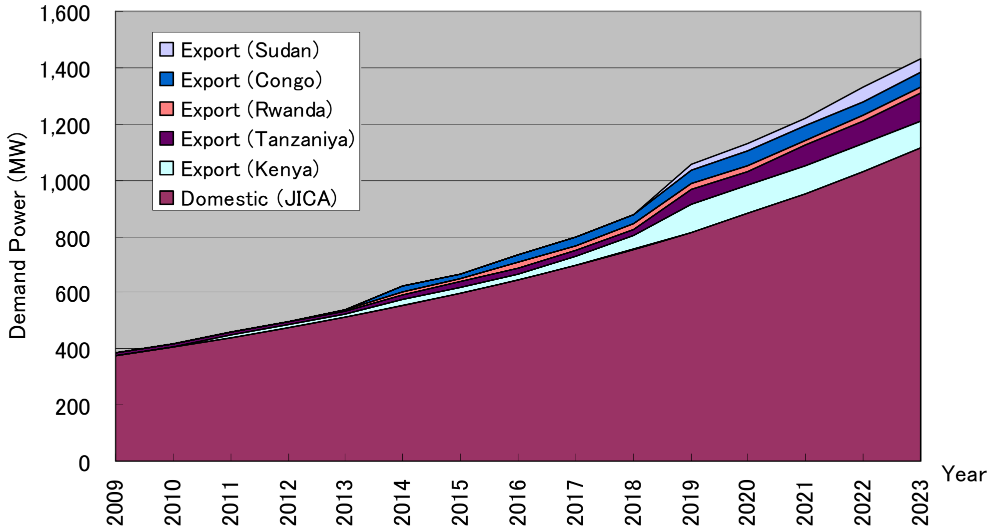
(Source: Study Team, GDP2009)

Figure 4.3-1 Result of Demand Energy Forecast (GWh)

Table 4.3-2 Result of Demand Power Forecast (MW)

Year		2009	2010	2011	2012	2013	2014	2015	2016
Domestic	Forecasted by JICA	375	406	439	474	512	553	598	646
	GDP2009	375	398	424	449	483	519	559	615
Export	Kenya	1	1	10	10	10	20	20	20
	Tanzania	10	10	11	12	13	20	20	20
	Rwanda	1	1	1	1	1	10	10	20
	Congo			1	2	3	20	20	30
	Sudan								
Total	Forecasted by JICA	387	418	462	499	539	623	668	736
	GDP2009	387	410	447	474	510	589	629	705
Year		**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	
Domestic	Forecasted by JICA	698	755	815	881	952	1029	1112	
	GDP2009	677	769	834	903	980	1034	1129	
Export	Kenya	30	50	100	100	100	100	100	
	Tanzania	20	20	50	50	70	80	100	
	Rwanda	20	20	20	20	20	20	20	
	Congo	30	30	50	50	50	50	50	
	Sudan		0	20	30	30	50	50	
Total	Forecasted by JICA	798	875	1055	1131	1222	1329	1432	
	GDP2009	777	889	1074	1153	1250	1334	1449	

(Source: Study Team, GDP2009)



(Source: Study Team, GDP2009)

Figure 4.3-2 Result of Demand Power Forecast (MW)

4.4 Network Development Plan

4.4.1 Transmission line and substation

(1) Expansion plan for transmission line and substation

According to Grid Development Plan 2009-2025 prepared by UETCL, transmission line between newly hydropower station and core substation, transmission line between core substation and Kampala area, transmission line to be located on western part of country and extension of substation have been planned following table 4.4.1-1, 4.4.1-2.

Table 4.4.1-1 Expansion Plan for Transmission Line

	Project Name	Section	Length (km)	Voltage (kV)	Completion Year
1	Karuma Interconnection Transmission Line Project	Karuma-Kawanda	264	400	2014
2	Karuma Interconnection Transmission Line Project	Karuma-Lira	80	132	2014
3	Karuma Interconnection Transmission Line Project	Karuma-Olwiyo	60	132	2014
4	Mputa Interconnection Transmission Line Project	Mputa-Nkenda	180	132	2013
5	Mputa Interconnection Transmission Line Project	Mputa-Hoima	50	132	2013
6	Isimba Interconnection Transmission Line Project	Isimba-Bujagali	40	132	2013
7	Ayago Interconnection Transmission Line Project	Ayago-Karuma	60	400	2015
8	Tororo-Opuyo-Lira Transmission Line Project	Troro-Opuyo-Lira	260	400	2013

	Project Name	Section	Length (km)	Voltage (kV)	Completion Year
9	Mbarara-Nkenda Transmission Line Project	Mbarara-Nkenda	160	132	2013
10	Kawanda-Masaka Transmission Line Project	Kawanda-Masaka	142	220	2013
11	Mutundwe-Entebbe Transmission Line Project	Mutundwe-Entebbe	50	132	2013
12	Opuyo-Moroto Transmission Line Project	Opuyo-Moroto	200	132	2012
13	Masaka-Mbarara Transmission Line Project	Masaka-Mbarara	144	220	2015
14	Mirama-Kabale Transmission Line Project	Mirama-Kabale	76	132	2013
15	Nalubaale-Lugazi Transmission Line Project	Nalubaale-Lugazi	38	132	2016
16	Hoima-Kafu Transmission Line Project	Hoima-Kafu	70	132	2014
17	Lira-Gulu Transmission Line Project	Lira-Gulu	100	132	2015
18	Gulu-Nebbi Transmission Line Project	Gulu-Nebbi	175	132	2015
19	Nebbi-Arua Transmission Line Project	Nebbi-Arua	74	132	2018
20	Bujagali-Tororo-Lessos Transmission Line Project	Bujagali-Tororo-Lessos	127	220	2013
21	Masaka-Mutukula-Mwanza Transmission Line Project	Masaka-Mutukula-Mwanza	85	220	2014
22	Mbarara-Mirama-Birembo Transmission Line Project	Mbarara-Mirama-Birembo	66	220	2013
23	Nkenda-Mpondwe Transmission Line Project	Nkenda-Mpondwe	70	220	2014

(Source: UETCL)

Table 4.4.1-2 Expansion Plan for Substation

	Project Name	Substation	Capacity (MVA) or No. of Bay	Voltage (kV)	Completion Year
1	Olwiyo 132/33kV Substation Project	Olwiyo	2×15/20	132/33	2014
2	Lira Substation Extension Project	Lira	Bus bar extension	132	2014
3	Kawanda Substation Upgrading Project	Kawanda	3×250	220/132	2015
4	Bujagali Switchyard Upgrading Project	Bujagali	3×250	220/132	2015
5	Nkenda Substation Extension project	Nkenda	Two(2) 132kV bay	132	2012
6	Hoima Substation Project	Hoima	2×15/20	132/33	2012
7	Mputa Substation Project	Mputa	Three(3) 132kV bay	132/33	2012

	Project Name	Substation	Capacity (MVA) or No. of Bay	Voltage (kV)	Completion Year
8	Kawanda Substation Addition Project	Kawanda	3×350MVA, two(2) 400kV bay	400/220	2017
9	Karuma Substation Addition Project	Karuma	2×250MVA, two(2) 400kV bay	400/220	2017
10	Fort Portal Substation Project	Fort Portal	2×15/20MVA	132/33	2013
11	Masaka West Substation Project	Masaka West	2×125MVA	220/132	2012
12	Entebbe Substation Extension Project	Entebbe	2×32/40MVA	132/33	2013
13	Moroto Substation Project	Moroto	2×15/20MVA	132/33	2013
14	Kabaale Substation Project	Kabaale	2×15/20MVA	132/33	2014
15	Lugazi Substation Extension Project	Lugazi	2×32/40MVA	132/11	2017
16	Kafu Substation Project	Kafu	32/40MVA two(2) 400kV bay	400/132/33	2014
17	Gulu Substation Project	Gulu	1×15/20MVA	132/33	2016
18	Nebbi Substation Project	Nebbi	1×15/20MVA	132/33	2017
19	Arua Substation Project	Arua	1×15/20MVA	132/33	2019
20	Tororo Substation Extension Project	Tororo	32/40MVA	132/33	2011
21	Kampala North Substation Extension Project	Kampala North	32/40MVA	132/33	2011
22	Mutundwe Substation Extension Project	Mutundwe	32/40MVA	132/11	2011
23	Opuyo Substation Extension Project	Opuyo		132/33	2010
24	Kawaala Substation Extension Project	Kawaala	1×15/20MVA	132/33	2009
25	Kahungye Substation Project	Kahungye	2×20MVA	132/33	2010
26	Kabulasoke Substation Extension Project	Kabulasoke	1×15/20MVA	132/33	2011
27	Mbale Substation Extension Project	Mbale	1×15/20MVA	132/33	2012
28	Tororo Substation Extension Project	Tororo	2×60MVA	220/132	2014
29	Mbarara Substation Upgrading Project	Mbarara	2×60MVA	220/132	2013
30	Mirama Substation Project	Mirama	2×15/20MVA	132/110/33	2013
31	Nkenda Substation Upgrading Project	Nkenda	2×60MVA	220/132	2014

(Source: UETCL)

(2) Problem to be solved for the transmission line and substation

Karuma Interconnection Project has been planned in order to transmit generated electric power from Karuma Hydropower station to Kampala metropolitan area and fragile northwestern area of Olwiyo and Lira substation.

The project is supposed to be commissioning on 2014 at present and it is desirable to complete the project before commissioning test of Karuma hydropower station for power receiving from the system. Furthermore, the project has close relation to Ayago Interconnection Project and construction work shall be collaborated each other.

Mputa Interconnection Project has been planned in order to evacuate electric power from Mputa thermal power station to Nkenda, Hoima substation and it is also desirable to complete the project before commissioning test of Mputa thermal power project for power receiving from the system.

Isimba and Ayago Interconnection Project have been planned in order to evacuate electric power from Isimba and Ayago hydro power station to Kampala and it is also desirable to complete the project before commissioning test of Isimba and Ayago project for power receiving from the system.

4.4.2 Network Analysis

The quality of power supply is dependent on the duration and frequency of power outage, voltage and frequency fluctuation. To keep power supply with few power outage and stable voltage and frequency, it is important to carry out proper system operation and running facilities. This includes the prior identification of the system issues considering system characteristics in future power system. The network analysis takes important role in this procedure.

In order to realize the high reliability of power supply, it is important to be familiar with network behavior under the steady state conditions as well as the conditions of fault occurrence. Hence, the power facilities, which are mainly represented by the transmission line, are exposed in the air for the long distance. And this fact makes unavoidable from fault occurrence by natural phenomena such as lightening. The impact of fault occurrence in trunk line network will go widespread in the system. Therefore redundant facilities such as duplex or diversion circuit are required to maintain the high reliability on power supply. This concept is called as N-1 criteria (fault occurrence in any one unit out of N unit facilities should not affect to the supply), and the concept is employed for planning the trunk line network in many countries and it is no exception for Uganda.

(1) Software for Power System Analysis and Simulation Method

The system analysis software used in UETCL is PSS/E (Power System Simulator for Engineering) which was developed by PTI company in US and retailed by Siemens. This software is de facto standard software used in electric power companies in many countries. The Study Team member is also familiar with the software and the data can be shared with UETCL. The Study Team obtains the PSS/E analysis data for year 2009, 2015, 2020 and 2025 given by UETCL. The Study Team carries out the analysis using the data. It is noted that the data except the year 2009 given by UETCL are just for the test cases, therefore these are not matched to the GDP contexts.

(2) Analysis of Present 2009 Network

In order to grasp the current network, the Study Team analyzed network using the year 2009 PSS/E data provided by UETCL. The results are as follows.

1) Network Simulation Scale

The network simulation scale for the 2009 network is summarized in Table 4.4.2-1. It was confirmed that the model represents the full-scale transmission network from the maximum voltage of 132kV to 11 kV except distribution network.

Table 4.4.2-1 Network Simulation Scale of 2009 Network

Item	Number	Remarks
Bus	274	132kV:17, 66kV:2, 33kV:161, 11kV:94
Transmission Line	228	
Transformer	166	
Generator	30	

(Source: Study Team)

2) Regional Distribution of Power Sources and Load

As shown in Fig. 4.4.2-1, Area of Uganda can be split to four regions for central, east, west, and north.

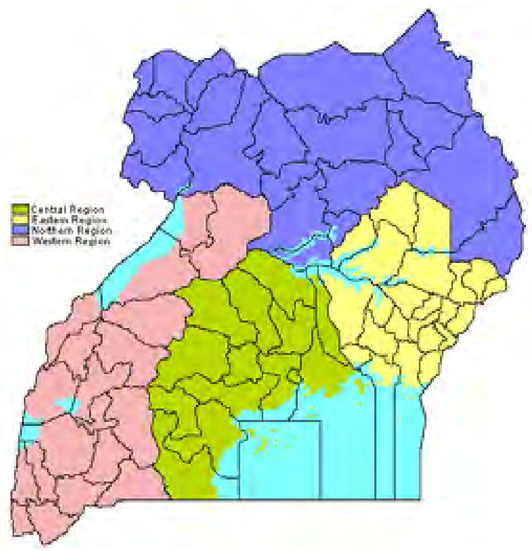


Figure 4.4.2-1 Uganda Region

The network system analysis data designates the power source and load area. Analyzing this data will provide the regional distribution of power source and load. Within the network analysis data, the nation area is divided into four regions on the geographical aspects. Furthermore, the central region is divided to Kampala and other area, and eastern area is divided to the Lake Victoria area, and the Nile River area. Hence the whole national area is divided into six regions by Kampala, central, Nile, east, north, and west.

From the network system data, regional distribution of power source and load can be obtained. The results are shown in Table 4.4.2-2 and Fig. 4.4.2-2. Kampala region holds the 255MW load which is 61% of the total load of 417MW. While the power source is only diesel power plant which has the capacity of 120MW.

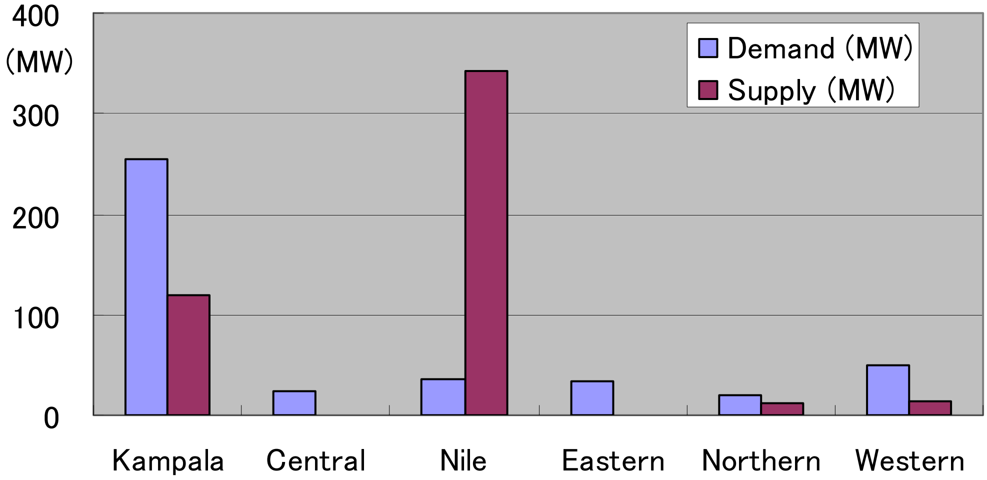
The Nile region has large-scale hydropower stations which are Kiira and Nalubaale. Total capacity of power sources in the region is accumulated to 342MW which is 70% of total power source of 489MW. Therefore this region is power source of Uganda.

On the other hand, other area has small-scale loads and small-scale power sources.

Table 4.4.2-2 Area Distribution of Demand and Supply in 2009

Area	Demand (MW)	Supply (max. power) (MW)
Kampala	255.3	120.0
Central	23.1	
Nile	35.8	342.0
Eastern	33.6	
Northern	20.0	12.0
Western	49.3	14.5
Total	417.1	488.5

(Source: PSS/E Data UETCL)



(Source: PSS/E Data UETCL)

Figure 4.4.2-2 Area Distribution of Demand and Supply in 2009

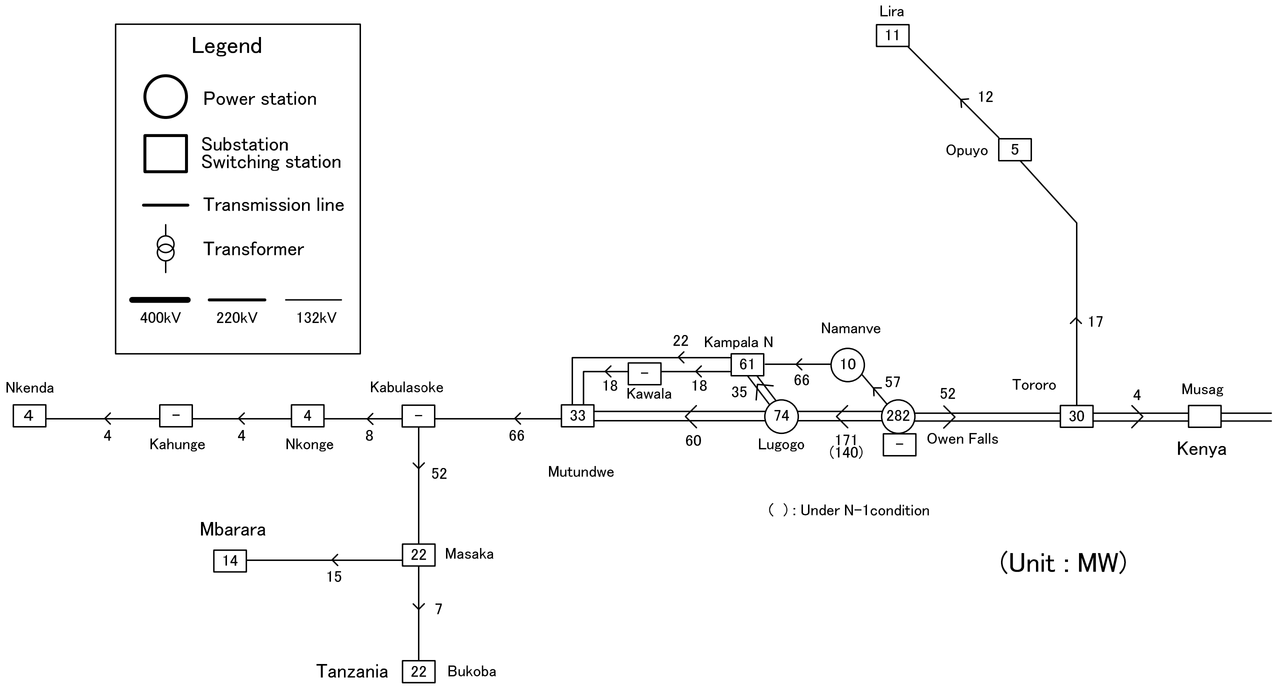
3) Result of Power Flow Analysis

The Study Team carries out the power flow analysis using the 2009 network data given by UETCL. The result of analysis illustrated on the 132kV network as shown in Fig.4.4.2-3.

As shown in the figure, the power flow originated from power capacity of 282 MW from Kiira and Nalubaale (Owen Falls Power station) goes westward. The flow is received at Kampala North and Mutundwe substations to supply load of Kampala district.

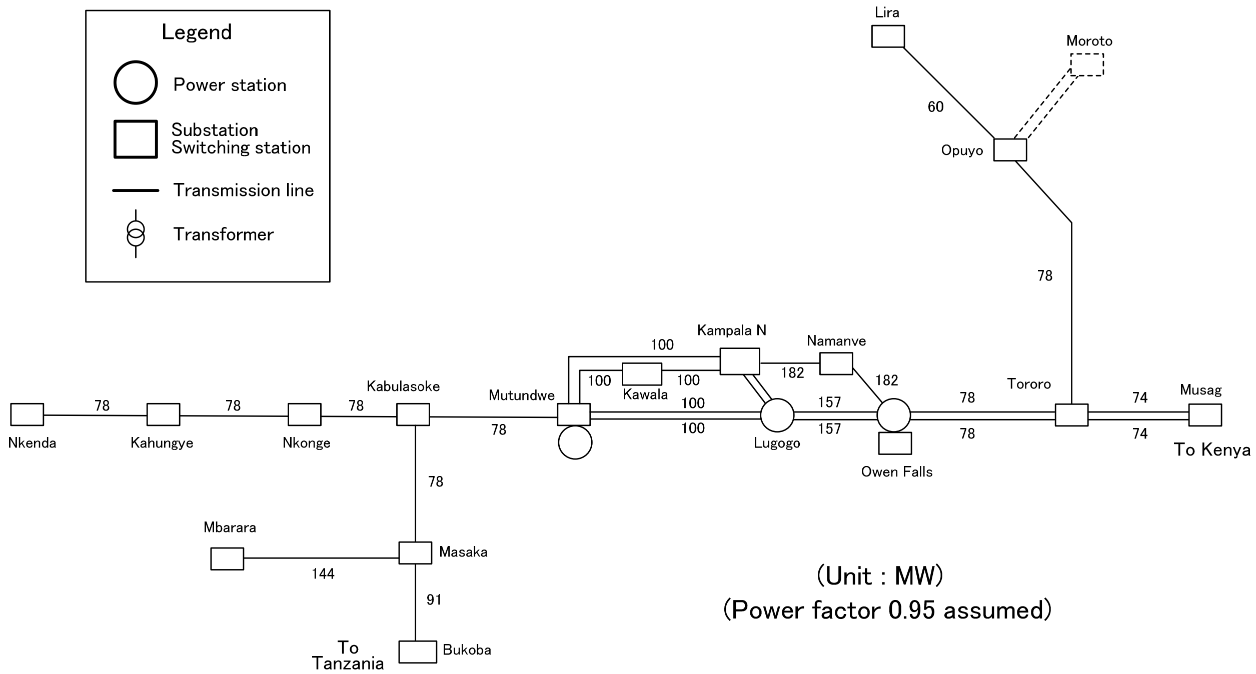
The maximum power flow is seen in Owen Falls-Lugogo line at 171 MW (total of 2 circuits). Under the N-1 condition, the part of power flow is bypassed to lines through Namanve and the power flow is reduced to 140MW. Therefore, the maximum flow is less than the transmission line capacity of 157 MW and it is confirmed there is no over loading and it fulfills the N-1 criteria.

The capacity of 132kV network is shown in Fig.4.4.2-4. The transmission lines in the Kampala area were constructed in a early stage as the capacity of transmission line is around 100MW. It is expected that over loading to the network is possibly occurred in future as increasing in demand.



(Source: Study Team)

Figure 4.4.2-3　Power Flow in 2009



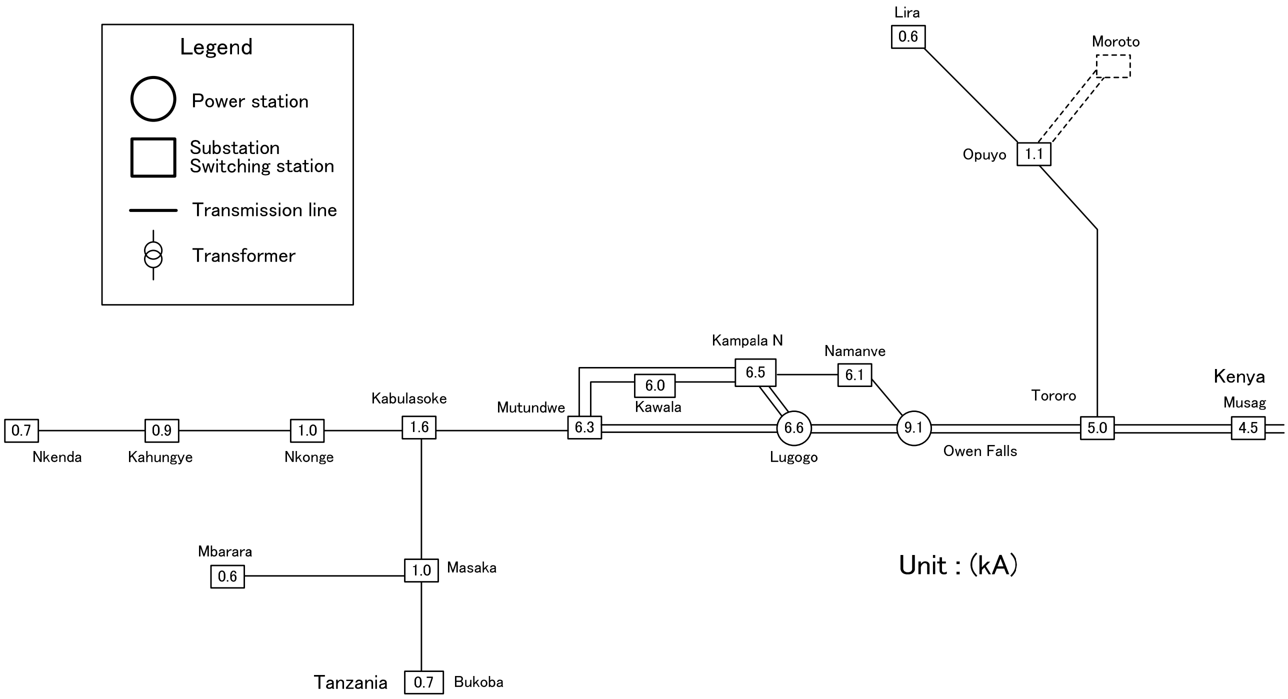
(Source: Study Team)

Figure 4.4.2-4　Transmitting Capacity

4) Result of Fault Current Analysis

If the fault is occurred in the power facilities, the large fault current will keep flowing through the facilities. Therefore the faulted facilities should be separated from the network by the circuit breaker. Circuit breaker specifies the maximum rated breaking current, and fault current should be lower than this value.

The result of the fault current analysis is shown in Fig. 4.4.2-5. The maximum fault current is 10.3kA which is occurred at Owen Falls power station. This maximum fault current is enough smaller than the rated breaker capacity of 31.5kA. Therefore it is acceptable.



(Source: Study Team)

Figure 4.4.2-5 Fault Current in 2009

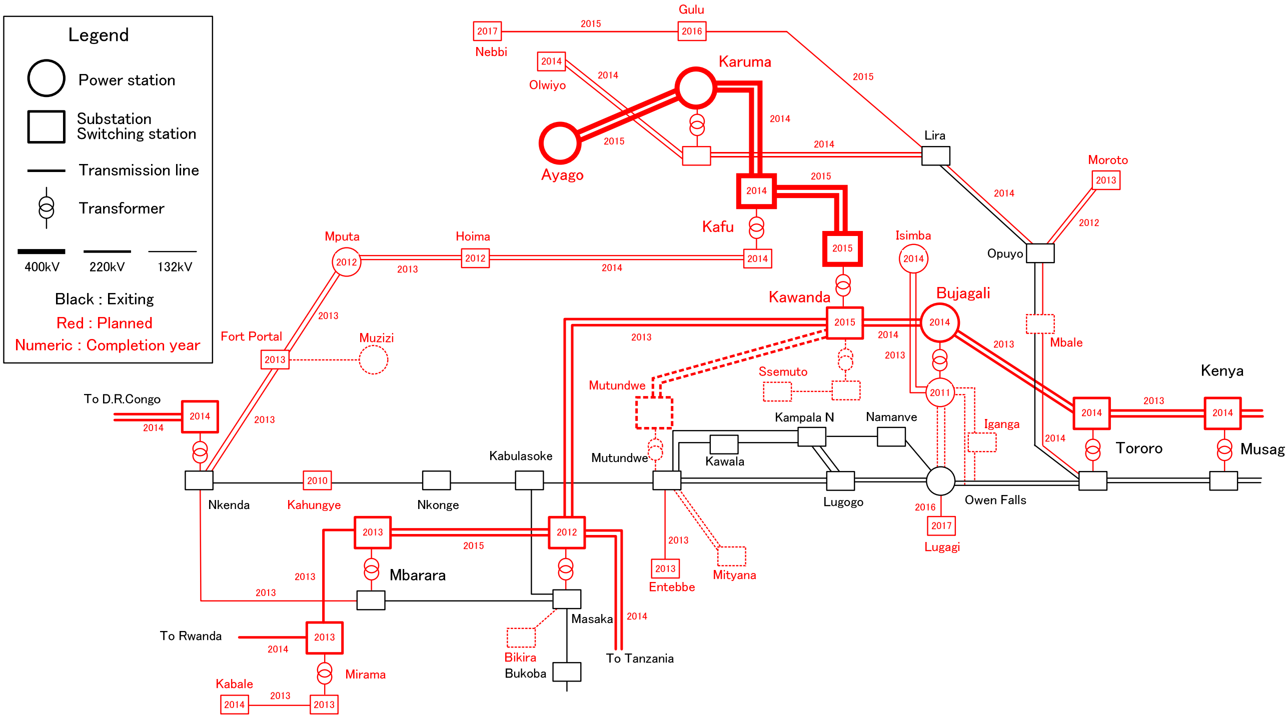
(3) Network after Ayago Hydropower Station Completion

1) Subject Network

Fig.4.4.2-6 shows the subjective network used in the analysis. Objects in black color is existing facilities, the objects in red color is planed facilities. The red solid line is planned in GDP2009 and red dashed line is not listed in GDP2009 but is added by the Study Team, which is considered to be necessary.

The present maximum voltage is 132kV, and 220kV network going half around Kampala area will be constructed by 2014, and interconnection between Kenya will be reinforced from 132kV to 220kV. In 2015, 400kV network for Karuma power station will be constructed between Karuma to Kawanda.

It is assumed that Mutundwe substation will be upgraded from 132kV to 220kV and Kwanda-Mutundwe 220kV line will be installed to supply power to Kampala area.



(Source: GDP2009, Study Team)

Figure 4.4.2-6 Network to be Simulated

2) Network Analysis Data

The Study Team received the PSS/E data from UETCL for the year 2020 network and 2025 network. And these data is rectified by the Study Team. The revisions are made for the following items.

(a) Target Year and Demand Scale

Target year is selected to the year 2023 and the year when the Ayago hydropower station commence the operation. In the GDP2009, the Ayago hydropower station is planned to start 100MW operation in 2018. The Study Team examined the realistic schedule and the Study Team assumes to start 150MW in 2020. The Study Team also presumes 300MW generation in 2023 while GDP2009 allocates 400MW.

As shown in Table 4.4.2-3, the Study Team adopted the domestic demand of 881MW in 2020, and 1,112MW in 2023. The export power shown in GDP2009 is adopted in the study.

Table 4.4.2-3 Demand Power and Export Power for Network Analysis

Year	Domestic Demand (MW)	Export (MW)					Total (MW)
		Kenya	Tanzania	Rwanda	Congo	Sudan	
2020	881	100	50	20	50	30	1,131
2023	1,112	100	100	20	50	50	1,432

(Source: Study Team)

(b) Power Output of Power Station

The purpose of this study is to grasp the impact of installation of Ayago hydropower station into the network system. The severe case for the system presumes full power output of the Ayago and Karuma hydropower stations. The full power supply by these stations exceeds the demand and becomes over-supply condition. Therefore, the diesel power output is reduced to balance the demand and supply.

3) Result of the Analysis

(a) Result of Power Flow Analysis

The result of the power flow analysis for the year 2020 and 2023 are shown in Fig. 4.4.2-7 and Fig. 4.4.2-8, respectively. The maximum power flow in the 220kV network in the year 2020 emerges in Kawanda-Mutundwe line of 238MW and becomes 267MW in the year 2023. The Kawanda-Mutundwe line is not listed in GDP2009 however it is for sure that this line is important for power supply of the capital area. Therefore, it is necessary to consider the line in GDP2009 and ensure the transmission capacity.

The maximum power flow in the 400 kV network in the year 2020 is emerged in Karuma-Kafu line of 632MW and becomes 748MW in the year 2023. Currently, the line is under planning stage, therefore the capacity of the transmission line has not been decided yet. However, the 400kV transmission lines can be the main frame of the grid and it is necessary to ensure the transmitting capacity since there will be possibility to develop other power stations such as Murchison hydropower station.

(b) Result of Fault Current Analysis

The result of the fault current analysis for 2020 and 2023 are shown in Fig. 4.4.2-9 and Fig. 4.4.2-10, respectively. The maximum fault current for each voltage level is shown in Table 4.4.2-4.

The maximum current in 400kV system is found at Karuma. The value is 6.9kA in 2020 and increased to 7.6kA in 2023. The reason of the increasing the current is due to expansion of the Ayago power station. The maximum value in 220kV system is found in Kawanda for 9.3kA in 2020 and 9.6kA in 2023.

The maximum fault currents found in 400kV and 220kV system are less than the allowable maximum value of 50kA, therefore it is acceptable.

The maximum fault current in 132kV system is 9.1kA at Owen Falls in 2009, 16.5kA at Bujagali in 2020, and 17.6kA at Bujagali in 2023. It has the trend to increase as the scale of the network system expanded. However, the maximum fault current is less than the allowable maximum value of 31.5 kA and it is acceptable.

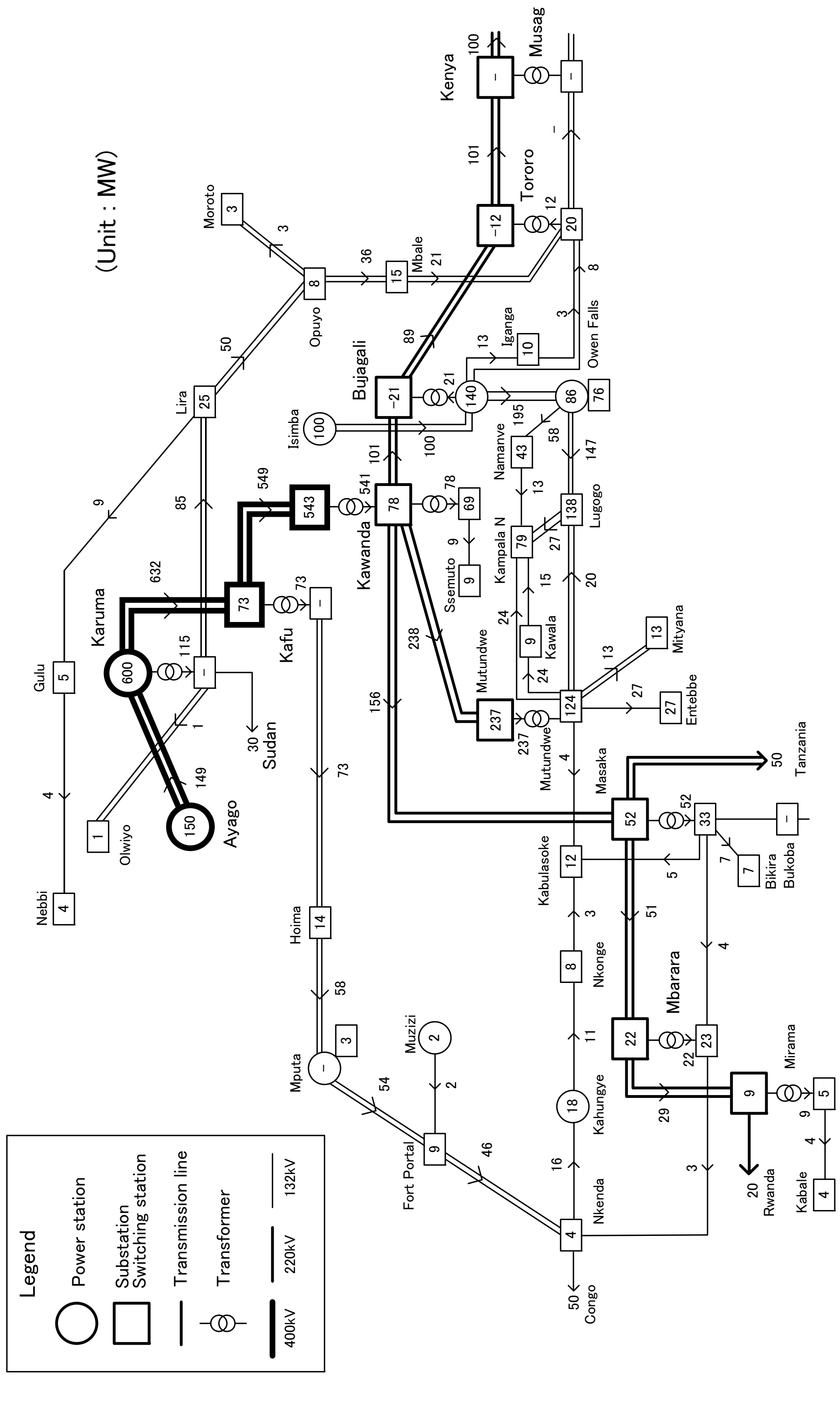
Table 4.4.2-4 Maximum Fault Current

Year	400kV		220kV		132kV	
	Station	Fault Current	Station	Fault Current	Station	Fault Current
2009	-	-	-	-	Owen Falls	9.1 kA
2020	Karuma	6.9 kA	Kawanda	9.3 kA	Bujagali	16.5 kA
2023	Karuma	7.6 kA	Kawanda	9.6 kA	Bujagali	17.6 kA

(Source: Study Team)

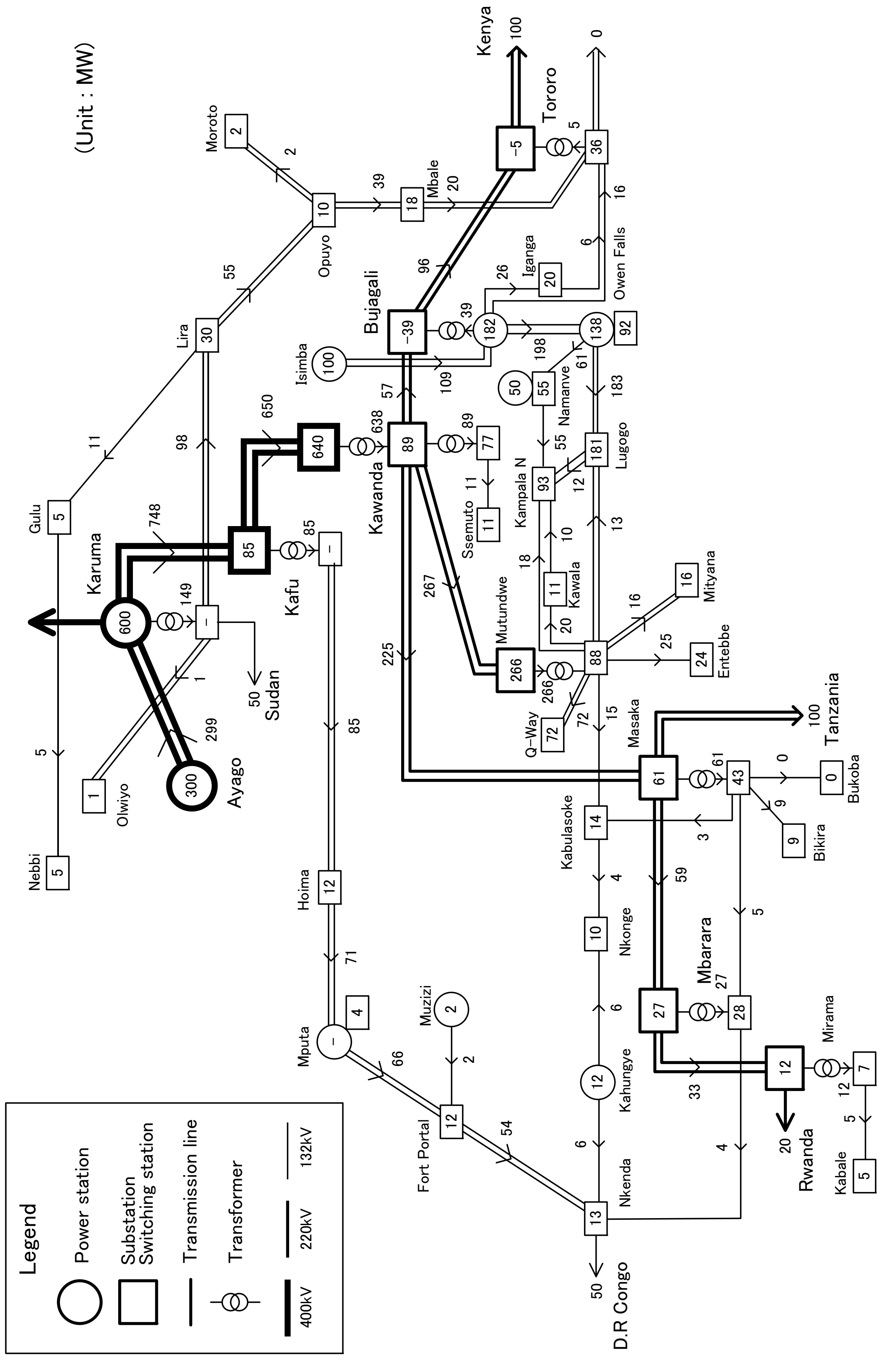
4) Necessity of Stability Analysis

In this study, stability analysis is not undertaken because the study is master plan stage. Therefore it is necessary to carry out stability analysis in the feasibility study which is in the next stage as it is mandatory for project realization.



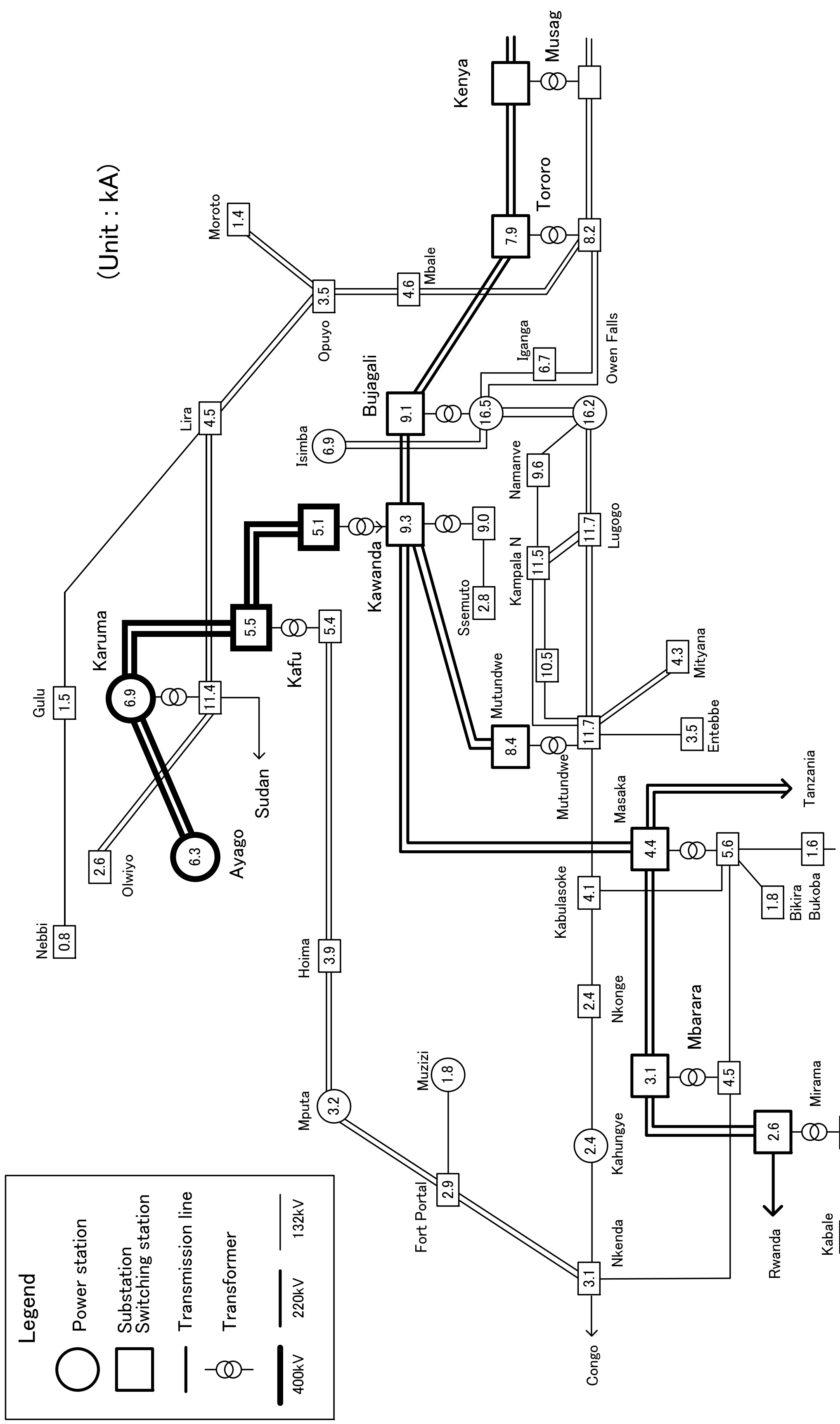
(Source: Study Team)

Figure 4.4.2-7　Power Flow Analysis Result in 2020



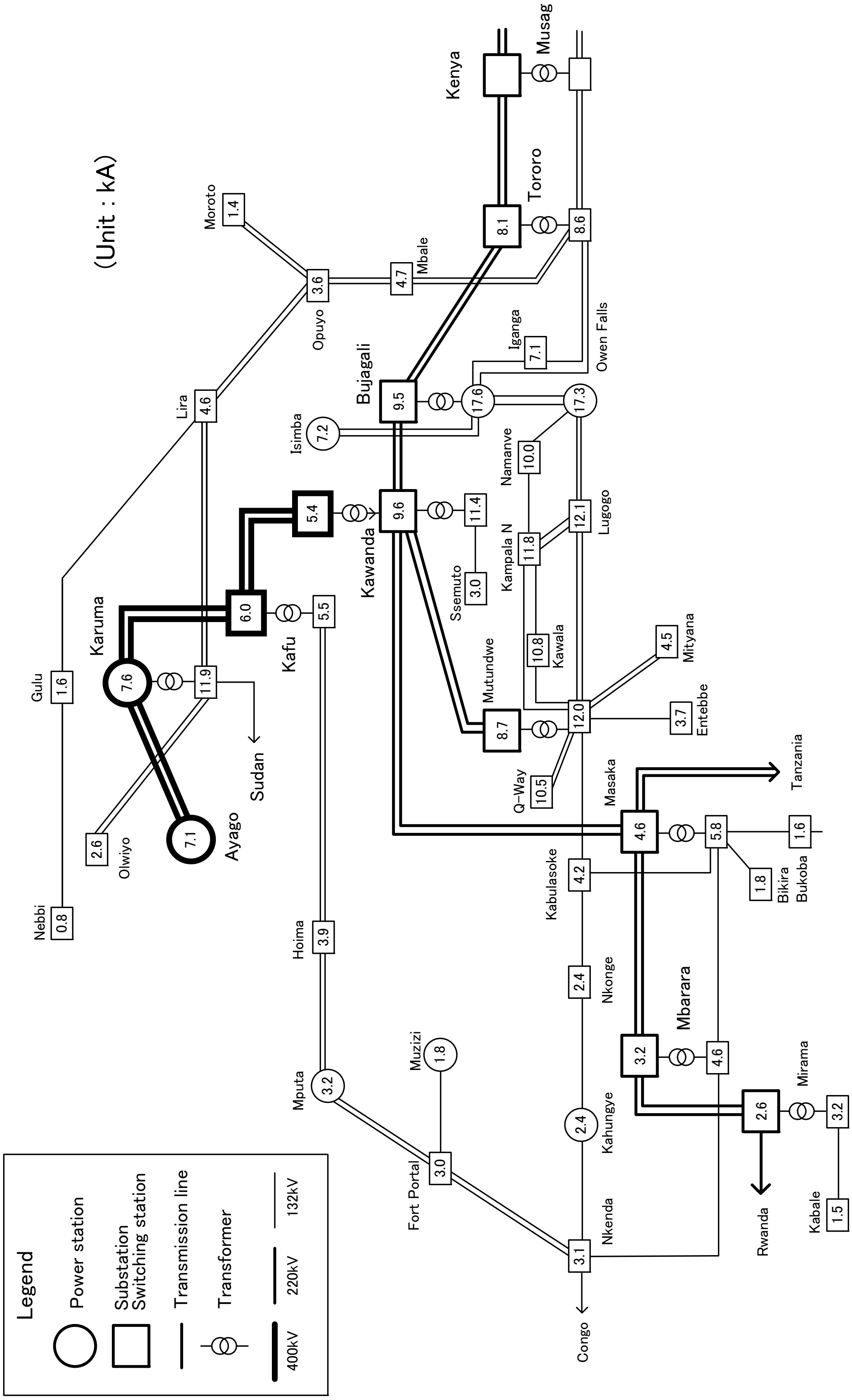
(Source: Study Team)

Figure 4.4.2-8 Power Flow Analysis Result in 2023



(Source: Study Team)

Figure 4.4.2-9 Fault Current Analysis Result in 2020



(Source: Study Team)

Figure 4.4.2-10 Fault Current Analysis Result in 2023

4.4.3 Interconnected Transmission Line

There are two interconnection transmission lines at present, i.e. Tororo-Lessos (Kenya) double circuit 132kV line and a single circuit 132kV line for exporting electric power to the northern region of Tanzania.

The followings are interconnection transmission line projects under the leaderships of NELSAP (Nile Equatorial Lakes Subsidiary Action Program). The outline of those plans is given in Figure 4.4.3-1.

(1) Uganda-Kenya Interconnection Project

The project consists of constructing a 256km double circuit 220kV transmission line between Bujagali hydropower plant to Lessos substation (Kenya) via Tororo substation (Uganda). The transmission line will be enable power transfer up to 300MW. It will include upgrading Tororo substation from 132kV to 220kV.

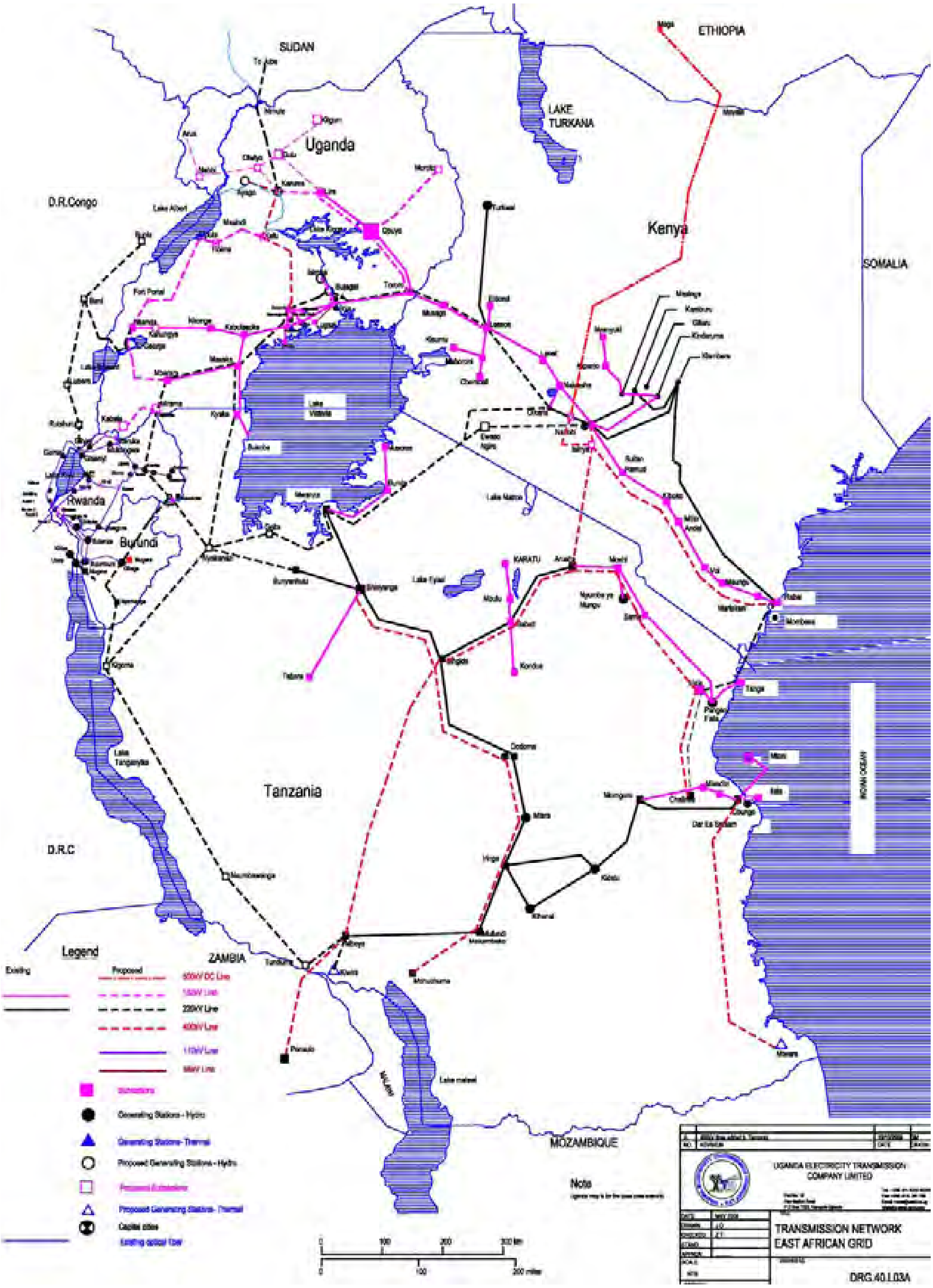
(2) Uganda-Rwanda Interconnection Project

The project consists of constructing a 172km 220kV transmission line between Mabarara North substation (Uganda) and the new Birembo substation in Kigali (Rwanda). Though designed for 220kV, it will be initially operated in 132kV. Initial power export to Rwanda maybe minimum 20MW to meet its generation deficit, and long term the possibility up to 150MW based on development scenarios (Source: Aide Memory AfDB Interconnection Appraisal Mission). The project will include three substations, namely the expanding existing Mbarara North substation and developing Mirama substation (Uganda) and Birembo substation.

(3) Uganda-DR Congo Interconnection Project

The project includes construction of Nkenda (Uganda)-Beni (DR Congo) double circuit 220kV transmission line. According to the single-line diagram showing UETCL's plan, the present 132kV will be upgraded to 220kV at the Nkenda substation. The project will include transmission lines for connecting with the existing Goma network and extending the network to northern regions of DR Congo.

In addition to the above, 220kV transmission line is planed to export power to Sudan from Karuma hydropower station. GDP planned the power export from Uganda to Sudan starting from 20MW in 2019 and thereafter.



(Source: UETCL)

Figure 4.4.3-1 East African Interconnection Plan

4.5 Consistency of Long term Power Development plan in Uganda

Consistency of power demand forecast described in Grid Development Plan 2009-2025 and power supply plan in Uganda is described below.

At for demand forecast, we studied for Grid Development Plan 2009-2025 (GDP2009-2025), the newest Grid Development Plan issued by UEGCL. Initially, we planed to use Grid Development Plan 2008-2023 (GDP2008-2023), but during the Study, GDP2009-2025 was issued and approved by MEMD. So, we decided to use GDP2009-2025. As the result, demand forecast of GDP2009-2025 is reasonable as whole as described above clause 4.3.

As for supply, we studied using by MCDA described in 5 and confirmed that Hydropower is the most competitive and usable power source for Power Development Plan until 2023 in Uganda as shown in Table 4.5-1

So we conclude that Power Development Plan by UEGCL has enough consistency. However it is requested that supply plan should be studied more carefully in terms of treatment of firm power and energy output and for planning the individual, site the feature of project site and generation type should be considered.

Diesel thermal power is one of main power sources in Uganda at the present moment. Installed Diesel Thermal can be installed easily and it is not a permanently power source. In addition, its cost is relatively high. Therefore, power sources with reasonable cost are required in Uganda. Current electricity rate in Uganda is around 10% in whole area, especially about 6% in rural area. These rates is too low and It is necessity to increase these number. In order to increase these rates, It is needed to increase power supply by new power sources. Because of the above situation, development of new power sources with reasonable cost is strongly required.

Table 4.5-1 GDP2009-2025 Demand-Supply Balance

	POWER BALANCE	Installed Capacity (MW)	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
			Firm Capacity																			
Hydro Generation	Owen Falls Complex (Kiira and Nalubaale)	380	140	170	138	138	138	138	138	138	138	138	138	138	138	138	138	138	138	0	0	0
	Bujagali	250						40	150	150	150	150	150	150	150	150	150	150	150	150	150	150
	Karuma	700										100	100	200	200	300	300	300	300	410	410	410
	Isimba	110									109	109	109	109	109	109	109	109	109	109	109	109
	Ayago	550													100	250	300	300	300	400	400	400
	Murchison	600																		0	100	200
	Mobuku 1 (KML)	5	2.0	5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	Mobuku 3 (KCCL)	9.5	3	9	5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Maziba	1						1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Ishasha	6.5					3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	5
	Paidha	3										1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
	Kikagati	10						5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Bugoye	13				7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
	Waki	5																				
	Muzizi	10																				
	Mpanga	18					8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
	Kyambura	8.3																				
	Buseruka	9					6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
	Muyembe	10																				
	Subtotal:	**2948.3**	**145**	**184**	**145**	**148**	**165**	**211**	**321**	**321**	**430**	**532**	**532**	**632**	**732**	**982**	**1032**	**1132**	**1209**	**1281**	**1382**	**1483**
Thermal and Solar Generation	Aggreko 1, Lugogo	50	50	50	50																	
	Aggreko 2, Kiira	50	50	50	50	50																
	Mutundwe	50			50	50	50	50														
	Namanve	50				50	50	50	50	50	50	50	50	20	50	50	50	50	50	50	50	50
	Invespro, Nalubaale	50					50	50	50													
	Electromaxx	20				18	18	18	18													
	Mputa	85						50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
	Kabaale Peat	30								20	20	20	20	20	20	20	20	20	20	20	20	20
	Namugoga Solar	50						10	20	20	30	30	30	30	40	40	40	40	40	40	40	40
	Subtotal:	**435**	**100**	**100**	**150**	**168**	**168**	**228**	**188**	**140**	**150**	**150**	**150**	**120**	**160**	**160**	**160**	**160**	**160**	**160**	**160**	**160**
Cogeneration	**Cogeneration, Bagasse**																					
	Kinyara Sugar Works	50				5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Kakira Sugar Works	12		6	6	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
	SCOUL, Lugazi	6																				
	Subtotal:	**68**		**6**	**6**	**17**	**17**	**17**	**17**	**17**	**17**	**17**	**17**	**17**	**17**	**17**	**17**	**17**	**17**	**17**	**17**	**17**
	Total Power Production (MW)		**245**	**290**	**301**	**333**	**350**	**456**	**526**	**478**	**597**	**699**	**699**	**769**	**909**	**1159**	**1209**	**1309**	**1386**	**1458**	**1559**	**1660**
	Spinning Reserve Capacity (MW)		**25**	**29**	**30**	**33**	**35**	**46**	**53**	**48**	**60**	**70**	**70**	**77**	**91**	**116**	**121**	**131**	**139**	**146**	**156**	**166**
	Domestic Power Demand (MW)		371	**371**	**352**	**375**	**398**	**424**	**449**	**483**	**519**	**559**	**615**	**677**	**769**	**834**	**903**	**980**	**1034**	**1129**	**1233**	**1346**

Chapter 5

Possibility of Alternative Energy Sources other than Hydropower in Victoria Nile

Chapter 5 Possibility of Alternative Energy Sources other than Hydropower in Victoria Nile

5.1 Alternative Energy Sources

5.1.1 Prospective Energy Sources

(1) Outline of Alternative Energy Sources

The technical outline of the alternative Energy Sources in this assessment are as shown in following table.

Table 5.1.1-1 Outline of Energy Source

Energy Source	Energy Production Method
Hydropower (Large Scale Hydro)*1)	Hydropower is power that is derived from the force of moving water, which may be harnessed for useful purposes.
Geothermal	Geothermal is the power extracted from heat stored in the earth.
Diesel Engine (Heavy Oil) *2)	Diesel engine is the most popular type of reciprocating engine which drives an electrical generator.
Solar thermal*3)	Solar power is the generation of electricity from sunlight.
Wind Power	Wind power is the conversion of wind energy into a useful form of energy, such as using wind turbines to make electricity.
Biomass Cogeneration*4)	Biomass Cognation is the power that is producing thermal energy by burning biomass material with heat recycles system. Steam turbine or gas turbine type can be selected.
Nuclear	Nuclear is the power that is derived from atomic energy. The heated steam by water reactor spin a steam turbine which either droves an electric generator.

(Source: Study Team)

*1) Noted: Study Team aims to develop hydropower energy source in order to meet the energy demand on national grid until year of 2023. Target power demand is over 800MW and more than 50MW may be suitable for development scale of a power plant. According to the ERA survey development potential of the mini and/or micro hydro is about 184MW in Total and development of the mini and/or micro hydro should be proceed in parallel with the large scale hydro. However, dependable output, during dry season, of the mini and/or micro hydro is too small comparing with their installed capacity due to unstable discharge of their small river basin. Such small dependable outputs of the mini and/or micro hydro might not contribute to stability of the power system in the national gird. Hence, mini or micro hydropower is excluded from the study.

*2) Noted: Government of Uganda (herein after mentioned as "GoU") surveyed oil potential in Uganda and planned to extend diesel engine with domestic produced heavy oil fuel power plant. The plan is most feasible development plan of fossil thermal development.

*3) Noted: As described in *1), our target development is more than 50MW/Plant, and only solar thermal can achieve mote than 50MW of the large scale power generation among the solar energy development at present. Hence, we selected the solar thermal as one of competitive energy source of large scale energy development.

*4) Noted: Large scale biomass cogeneration plants with utilizing the bagasse have been planned in Uganda and the cogeneration plants are most feasible type to develop over 50MW. There are two kinds of biomass material, 1) wood chip, waste crop and/or garbage, peat, bagasse and 2) bio fuel such as bio diesel ethanol. Biomass cogeneration plant can be planned both of the above materials, however, production amount of bio fuel is too small in Uganda's market. Hence we assume that biomass cogeneration plant using wood, waste crop and/or garbage.

(2) Development Potential of Alternative Energy Sources

1) Renewable Energy

According to "The Renewable Energy Policy for Uganda November 2007" issued by the Electricity Regulatory Authority (herein after mentioned as "ERA"), development potential of renewable energy, such as the large scale hydro, mini-hydro, solar, biomass, geothermal, peat, and wind power, is estimated by 5,300MW in total.

Summary of the development potential of the renewable energy in Uganda is as shown in following figure.

Table 5.1.1-2 Development Potential of the Renewable Energy

Energy Source	Estimated Electrical Potential (MW)
Hydro (mainly on the Nile)	2,000
Mini-Hydro	200
Solar	200
Biomass	1,650
Geothermal	450
Peat 注 1)	800
Wind 注 2)	-
Total	5,300

(Source: The Renewable Energy Policy for Uganda, (2007 年 11 月)」)

*1) Noted: Peat is not technically a renewable energy source, however, GoU aim to utilize the 10% of peat resources which will make generation of about 800MW for the next 50 years. However, we considered that the peat resources classified into the fossil fuel in this JICA Study

*2) Noted: Recent study by the Electricity Regulatory Authority (herein after mentioned as ERA) indicate that the wind speed in most areas of Uganda is moderate, with average wind speeds low velocities ranging from 1.8m to about 4m/s. The wind record indicates that the wind resource in Uganda is only sufficient form small scale electricity generation and for special application such as water pumping mainly in the Karamoja region. Small industries in rural areas where targets for a mill range from 2.5kV to 10kV could benefit the wind resource.

2) Fossil Fuel Thermal

According to GoU survey, current estimates of the country's oil potential are around 1.0 to 1.5 billion. In terms of production levels, Tullow (UK's oil Company) estimates an output of between 100,000–150,000 barrels per day (bpd) over a possible 25-year production period and heavy oil is planned to utilize for energy production.

Since, energy production rate of heavy oil is around 0.45 MWh per barrel, at least 500MW, which is less than 1% of theoretical energy of heavy oil resources, of thermal power may be developed.

3) Nuclear Power

Development potential of the nuclear power depends on procurement of the nuclear fuel, such as uranium or plutonium, and disposing method of the nuclear fuel. Therefore, it is difficult to estimate development potential of the nuclear power in Uganda.

In order to carry out the alternative study, Study Team has roughly estimated the development potential of the nuclear power based on the example of prospective nuclear power holder country. As shown in following figure, 600 to 2000 MW of the nuclear development may be suitable for the prospective nuclear power holder country. Therefore, development potential of the nuclear power in Uganda may take around 600 to 2000MW.

Table 5.1.1-3 Nuclear Power - Prospective Nuclear Holder Country

Country	Reactors Planned		Reactors Proposed	
	No.	MWe	No.	MWe
Bangladesh	0	0	2	2,000
Belarus	2	2,000	2	2,000
Egypt	1	1,000	1	1,000
Indonesia	2	2,000	4	4,000
Israel	0	0	1	1,200
Kazakhstan	2	600	2	600
Poland	0	0	6	6,000
Thailand	2	2,000	4	4,000
Turkey	2	2,400	1	1,200
UAE	4	5,600	10	14,400
Vietnam	2	2,000	8	8,000

(Source: Reactor data: WNA to 4/1/10 IAEA- for nuclear electricity production & percentage of electricity (% e) 5/09.)

4) Energy Import

n case of applying energy import from neighboring countries without no domestic power development, the back up Energy Source during trouble of the power transmission line is required. Allowance of the power output from the Nalballe, Killa and Bujagali power station can be utilized as the back Energy Source. Since total install capacity of the power stations are 630 MW and dependable out put of the power stations are 323MW, about 300MW out put of the power stations can be utilized as emergency back of the imported energy. Hence development capacity of the energy import may is not more than 300MW.

5.1.2 Technical Assessment of Alternative Energy Sources

(1) Technically Feasible Potential at Present

Based on GDP 2008-2023, Power Sector Investment Plan (drat December 2009), Indicative Rural Electrification Master Plan Report (January 2009), Developments and Information from MEMD and Internet, some projects, as shown in following table might be feasible technically at present. 5 Grade rating, A is highest and E is lowest, was applied to the evaluation.

Table 5.1.2-1 Technically Feasible Potential at Present

Project Name		Installed Capacity (MW)	Present Status	Rating
Large Scale Hydro				**A**
H-1	Kalagala	330	Preliminary Study	
H-2	Isimba	130	Preliminary Study	
H-3	Karuma	580	Under Feasibility Study	
H-4	Oriang	390	-	
H-5	Ayago	610	Preliminary Study	
H-6	Kiba	290	-	
H-7	Murchison	650	Preliminary Study	
Sub		**2,980**		
Geothermal				**C**
G-1	Katwe	50	Potential Survey	
Thermal (Diesel Engine on heavy Oil)				**D**
T-1	Mputa (extension)	35 to 50	Preliminary Study	
Biomass				**B**
B-1	Kawala	33	Negotiation in progress	
B-2	Kinyara Sugar Works	50	Preliminary Study	
Sub		**83**		
Solar				**C**
S-1	Namgoga Solar-Thermal	50 (10+40)	Contract Negotiation in progress	
Sub		**50**		

(Source : GDP 2008-2023, Power Sector Investment Plan (drat December 2009), Indicative Rural Electrification Master Plan Report (January 2009), and information from MEMD, prepared by Study Team)

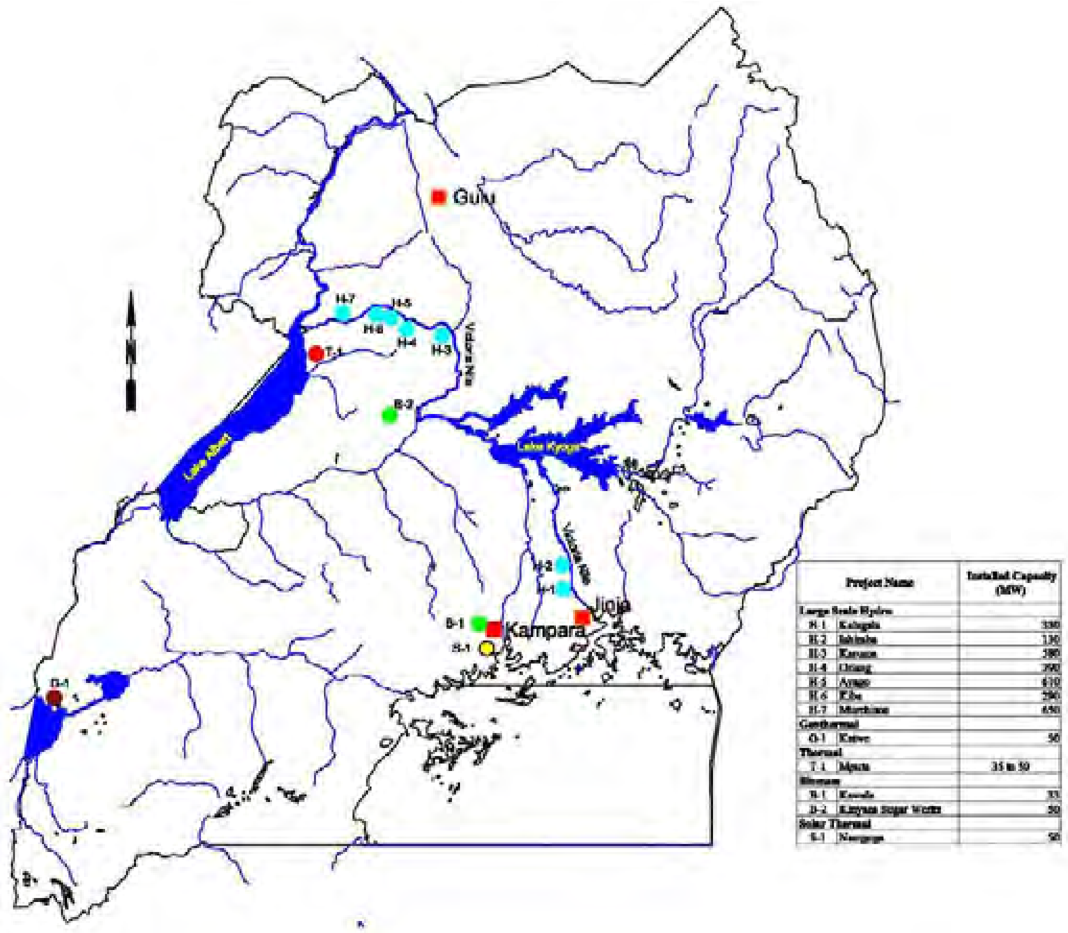


Figure 5.1.2-1 Technically Feasible Potential at Present

(Source: GDP 2008-2023, Power Sector Investment Plan (drat December 2009), Indicative Rural Electrification Master Plan Report (January 2009), and information from MEMD, prepared by Study Team)

(2) Availability of Energy Source

Availability of energy sources have to be assessed in the view point of 1) supply stability and 2) enough reserve volume.

Results of the assessment for availability of the energy sources are as shown in following table.

Table 5.1.2-2 Availability of Energy Sources in Uganda

Energy Source	Supply Stability	Reserves	Rating
Large Scale Hydro*1	B (long-term fluctuation) *1)	A	B
Geothermal	A	A	A
Heavy Oil	A	D*2) (25-50 year)	D
Biomass	C*3) (long tern/seasonal fluctuation)	C*4) (depends on plantation management)	D
Solar-thermal	C*5) (seasonal/daily fluctuation)	A	C
Nuclear	E *6) (Unknown)	E*6) (Unknown)	E
Energy Import	E*6) (Unknown)	E*6) (Unknown)	E

(Source: Study Team）

*1): Supply of the runoff water in the Victoria Nile river which is energy source of the hydro power is basically stable. Since the released water from the Lake Victoria has been fluctuated about few to few ten (10) years and the supply stability of the hydro power is lower than the geothermal power, rating “B” is adopted as the evaluation of the energy supply stability of the hydropower.

*2): Estimated amount of oil deposit is about100,000− 150,000 barrels per day over a possible 25 to 50 years. The limited energy source of the heavy oil is evaluated lower than the other energy sources except the nuclear power and the energy import which energy reserves have not confirmed yet at present. Hence, rating “D” is adopted as the evaluation of the energy reserves of the heavy oil and rating “D” is one (1) lank higher rate than the nuclear power and the energy import.

*3): Supply of wood and waste crops as utilizing biomass material have seasonal and long term fluctuation due to climate fluctuation. It seems that the supply stability of the biomass material is lower than the hydro energy source (means runoff water). Hence rating “C” is adopted as the evaluation of energy supply stability of the biomass material and rating “C” is one (1) lank lower than the hydro energy source.

*4): Biomass is classified into one of renewable energy source, however, in order to obtain stable amount of the biomass material, plantation and recycle system of waste crops material will be required. The sustainable operation of biomass material procurement is very difficult and some of large scale biomass power plant was terminated due to inappropriate operation of biomass material procurement. Hence, rating “C” is adopted as the evaluation of energy reserves of the biomass material rating “C” is two (2) lank lower than the other renewable energy sources.

*5): Sun light, energy source of solar thermal, can be obtain stably over the long term period. However, the sun right has daily and seasonal fluctuation and it is lower supply stability than the other renewable energy sources except the biomass material. Hence, rating “C” is adopted as the evaluation of energy supply stability of the solar energy source.

*6): Development plans of the nuclear power and energy import over 50MW are not considered at present. Hence, rating “E” is adopted as both evaluations of the energy supply stability and energy reserves.

(3) Survey Maturities of Alternative Energy Sources

Survey maturity of the alternative Energy Sources at preset is as shown in following table.

Table 5.1.2-3 Survey Maturity of Each Energy Source

Energy Source	Survey Maturity	Rating
Large Scale Hydro	Under feasibility study.	B
Geothermal	Under potential investigation.	C
Diesel Engine (Heavy oil)	Study is not required.	A
Wind Power	Micro scale development only	-
Biomass	Contract Negotiation in progress.	A
Solar-thermal	Contract Negotiation in progress.	A
Nuclear	Initial study has just started.	E
Energy Import	Not considered	E

(Source: Study Team)

(4) Lead Time for Construction

Lead time for construction of power development projects depend on financial ability of the country and/or guideline, such as environmental issues, of donor. However, in order to estimate the lead time simply, the financial aspects are eliminated and the lead time estimated from the technical point of view based on similar projects experience.

Table 5.1.2-4 Lead Time for Construction

Energy Source	Potential Survey	Pre-F/S	F/S	D/D	Contract & Procurement	Total Lead Time	Rating
Large Scale Hydro	0.5	0.5	1.0	1.5	1.5	5.0	C
Geothermal	5.0	1.0	1.0	1.5	1.5	10.0	D
Diesel Engine (Heavy oil)	-	-	-	-	0.5	0.5	A
Biomass	0.5	0.5	0.5	-	1.0	2.5	B
Solar-thermal	0.5	0.5	0.5	-	1.0	2.5	B
Nuclear	20	10	10	1.5	1.5	43	E
Energy Import	0.5	0.5	1.0	1.0	1.0	4.0	C

(Source: Study Team)

(5) Initial Starting Time

Each Energy Source has function of energy stability and classified into a) spinning reserve, b) hot reserve, and c) cold reserve, based on initial staring time of the Energy Sources. Spinning reserve absorbs rapid time emery fluctuation, about 1 to 3 minutes, in the power grid system and only large scale hydro can be utilized as spinning reserve. Hot reserve absorbs relatively short time energy fluctuation, about 8 to 10 minutes, in the power grid system. High speed diesel engine and gas turbine can be classified into the hot reserve. Cold reserve absorbs long term energy fluctuation, about few hours to few days, in the power grid system. The other Energy Sources are classified into the cold reserve.

General classification of reserve type depending on initial stating time of the energy sources is as listed below;

Table 5.1.2-5 Initial Starting Time of Energy Sources

Energy Sources	Reserve Type	Initial Starting Time	Rating
Hydropower	Spinning Reserve	1 to 3 min.	A
High speed diesel engine, Gas turbine,	Hot Reserve	8 to10 min.	B
Biomass thermal, Solar thermal, Geothermal	Cold Reserve	2 to 3 hours	C
Nuclear Power		5 to 6 days	D
Energy Import*1)	-	unknown	E

(Source: Study Team)

*1): Initial starting time of energy import depends on the formation of the Energy Sources of the energy exporting country and on the conditions of the transmission line. Since those information are unknown at present, lowest rating of "E" is adopted as the evaluation of the initial starting time of the energy import.

(6) Energy Stability

Energy stability means stability of each Energy Source to meet the peak demand during night time. Assessment results of energy stability of each Energy Source are as shown in following table.

Table 5.1.2-6 Energy Stability

Energy Source	Energy Stability	Rating
Large Scale Hydro	long term fluctuation*1)	B
Geothermal	Stable	A
Diesel Engine (Heavy oil)	Stable	A
Biomass	seasonal fluctuation*2)	C
Solar-thermal	daily fluctuation*3)	E
Nuclear	Stable	A
Energy Import	seasonal fluctuation*4)	C

(Source: Study Team)

*1) The large scale hydro is stable Energy Source to meet the peak demand during night time, however, the hydro power has some possibility of deficit of the peak demand due to long term climate fluctuation. Hence rating "B" is adopted, which is one (1) lank lower than the highest rating, as the evaluation of energy stability of the large scale hydro.

*2) The biomass thermal has possibility of deficit of the peak demand due to seasonal fluctuation of procurement of biomass materials. Since seasonal discharge volume in the Victoria Nile river basin is mostly consistent and collecting operation of the biomass material is very difficult, rating "C", which is one (1) lank lower stability than the large scale hydro power, is adopted as the evaluation of the energy stability of the biomass thermal.

*3) Solar thermal power can be generated during night time, however, in case of the cloudy condition, the solar thermal power cannot meet the peak demand and cloudy weather condition will be happen frequently in Uganda. Hence the solar thermal power should not count as the Energy Source which meets peak demand in the national power grid. Hence, a lowest rate of “E” is adopted as the energy stability of the solar thermal Energy Source.

*4) Energy stability of the energy import can be taken by the contract agreement with the exporting country. However, energy import might be affected seasonal power supply fluctuation of the export countries. Since stability of the energy import is lower than large scale hydro, rating “C” is adopted as the energy stability of the energy import.

(7) Power Supply Stability

Each energy source has some characteristics of the power supply stability in long-term, seasonal and daily time scale.

Power supply stability for each energy source is explained below;

a) Large Scale Hydro

Large scale hydro project along the Victoria Nile river has secure seasonal power supply stability that can be obtained consistent flow from a huge reservoir of the Victoria Lake, however, even huge reservoir, long-term water inflow fluctuation exists but generally sustainable inflow.

b) Geothermal

Needless to say, the energy source of the geothermal power is stable in all time scale aspects.

c) Diesel Engine (Domestic Product Heavy Oil Only)

Heavy oil can be obtain from domestic product, hence, power generation by the diesel engine might not be affected by the seasonal oil price fluctuation, however, oil resources are limited and all potential of the oil resource might not be developed.

d) Biomass Cogeneration Thermal

Biomass thermal is one of renewable energy, however, in order to keep long term sustainability of the large scale biomass thermal plant, extensive plantation area, transportation system and stock are should be required. Even if utilizing waste disposal of crops or gavages, management of long term or seasonal supply, transportation and stock is very difficult. In addition, seasonal production of the vegetation is strongly affected by the climate fluctuation. Generally, the large scale biomass thermal plants are facing to such problem.

e) Solar Thermal

Solar thermal is improved hourly fluctuation deriving from the sunlight fluctuation. However, daily stability to the solar thermal is still lower than other energy source, since the solar energy cannot be obtained 24hours. In addition, seasonal and long term climate fluctuation causes lower stability of the solar energy supply.

f) Nuclear

Nuclear power is one of stable energy source in sort term (less than few years), however, long term availability of uranium or other materials is not sure at present.

g) Energy Import

Power supply stability by the energy import is depending on operation of exporting country. Short term power stability of the imported energy may be kept by the agreement but it is difficult to keep the long term power supply stability due to energy demand development of the energy exporting countries.

Table 5.1.2-7 Power Supply Stability of Energy Sour in Uganda

Energy Source	Long-term	Seasonal	Daily	Rating
Large Scale Hydro	B (log-term climate fluctuation)	A	A	B
Geothermal	A	A	A	A
Diesel Engine (Domestic product heavy 0il)	D (limited)	A	A	C
Biomass Cogeneration	C (Difficult to keep sustainability)	C (seasonal climate fluctuation)	A	D
Solar-thermal	B (log-term climate fluctuation)	C (seasonal climate fluctuation)	E (daily climate fluctuation)	E
Nuclear	E (Unknown)	A	A	D
Energy Import	E (Unknown)	A	A	D

(Source: Study Team)

(8) Life Span

Life spans of the alternative Energy Sources are as shown in following table. Lower value of the life span is economic life span based on legal life span in Japan. Upper value of the life span is actual life span estimated by experience of existing projects.

Table 5.1.2-8 Life Span of Power Plants

	Hydro	Geothermal	Diesel Engine (Heavy Oil)	Wind Power	Biomass Thermal Cogeneration	Solar Thermal	**Nuclear+**	Energy import
Life Span (Year)	50 to 100	20 to 40	10 to 20	-	20 to 40	20 to 40	20 to 40	
Rating	A	C	E	C	C	C	C	A

(Source: Quarterly Journal of Nuclear Power No.26, Japan and the other information, prepared by Study Team)

5.1.3 Cost Evaluation

(1) Cost for Development and O&M

Cost data of each power source are based on the existing and planned power plants which belong to OECD countries, because there are not enough precedents in the Republic of Uganda. The data consist of 130 power plants, which are compiles by the International Energy Agency (IEA). The costs shall be evaluated with some price-range because of the variety of unit size, fuel, material, labor cost and so on.

1) Hydropower

Hydro power plants vary enormously in size, from several megawatts for micro-hydro facilities to thousands of megawatts. The specific construction costs vary widely between 500USD/kW and 2,000USD/kW because hydro power plants depend mainly on site specific characteristics. The annual O&M costs also vary widely between 4USD/kW/year and 90USD/kW/year. Thus average generation costs range between 40USD/MWh and 80USD/MWh.

2) Geothermal

Geothermal technology depends on the type and location of the natural resource. Geothermal power plants tend to be in 20MW to 60MW range and the capacity of a single geothermal well usually ranges from 4MW to 10MW. The specific construction and O&M costs are unknown because there is few significant data for cost estimation. However the generation cost is estimated 27USD/MWh as reference according to one plant in the United States.

3) Gas Thermal Power

Gas thermal power plants tend to be enormous capacities which are more than 300MW in order to pursue scale merits because they require much cost for the incidental facilities such as pipe lines. The specific construction costs range between 400USD/kW and 1,000USD/kW, 620USD/kW in average of 20 plants. The annual O&M costs vary widely between 5USD/kW/year and 45USD/kW/year, 24USD/kW/year in average. Thus average generation costs range between 40USD/MWh and 60USD/MWh, 48USD/MWh in average.

4) Diesel Thermal Power

Internal-combustion plants like diesel engines vary from a few kilowatts to over 60MW depending on the numbers of units. In case of Kiira diesel power plant, the average generation costs are 210-240 USD/MWh. It is noted that diesel engines are restricted to use in most industrialized countries due to high fuel costs and air pollution concerns.

5) Wind Power

Wind power plants vary from several megawatts to hundreds of megawatts depending on the numbers of units and wind conditions. The specific construction costs range in most cases between 1,000USD/kW and 1,700USD/kW, 1,310USD/kW in average of 14 plants except for the offshore plants. The annual O&M costs vary widely from country to country even in the same region, ranging between 15USD/kW/year and 60USD/kW/year, 31USD/kW/year in average. Thus average generation costs range between 35USD/MWh and 95USD/MWh, 58USD/MWh in average.

6) Biomass

Biomass plants generally vary from several megawatts to dozens of megawatts depending on the feedstock and process. The specific construction costs range between 1,100USD/kW and 5,500USD/kW. The annual O&M costs are unknown because of no data. The average generation costs are in the range between 50USD/MWh and 130USD/MWh.

7) Solar Power

Solar power plants generally vary from several megawatts to dozens of megawatts depending on the numbers of photovoltaic module and solar conditions. The specific construction costs range between 3,000USD/kW and 5,500USD/kW, 4,100USD/kW in average of 5 plants. The annual O&M costs vary widely between 10USD/kW/year and 50USD/kW/year, 35USD/kW/year in average. Thus average generation costs range between 150USD/MWh and 500USD/MWh, 300USD/MWh in average.

8) Nuclear Power

Nuclear power plants tend to be more enormous capacities than thermal power plants, which are more than 1,000MW in order to pursue scale merits. The specific construction costs range between 1,000USD/kW and 2,500USD/kW, 1,700USD/kW in average of 13 plants. The annual O&M costs vary widely between 50USD/kW/year and 80USD/kW/year, 67USD/kW/year in average. Thus average generation costs range between 21USD/MWh and 48USD/MWh, 30USD/MWh in average.

The costs for each power source are summarized in Table 5.1.3.-1

Table 5.1.3-1 Power source cost

Evaluation items		Hydro	Geothermal	Diesel Engine (Heavy Oil)	Wind Power	Biomass Thermal Cogeneration	Solar Thermal	Nuclear+
Cost**	Development cost (US$/kW)	500-2,000	-	-	1,000-1,700	1,100-5,500	3,000-5,500	1,000-2,500
	Operation & Maintenance cost (US$/kW/year)	4-90	-	-	15-60	-	10-50	50-80
	Unit cost of power generation (US$/MWh)	40-80	27	210-240	35-95	50-130	150-500	21-48

5.1.4 Environmental Impacts on Alternative Energy Sources

(1) Air Pollution

The impact on air pollution was estimated based on life cycle assessment, which included the periods of manufacturing, construction, operation, and closing. The results are shown in Table 5.1.4-1. While the impacts on air pollution by hydropower, geothermal, and nuclear power are relatively low, the impact by diesel engine is the worst. The air pollution substances used for the assessment were SO_2, NO_x, and Particulate Matter. Most figures were quoted from the results in the EIA report. However, the data of solar power are substituted by PV, since the data for solar thermal were not available.

Table 5.1.4-1 Air Pollution of Electricity Generation Technology

Technology	SO_2 (t SO_2/TWh)	NO_x (t NO_x/TWh)	Particulate Matter	Rating*3
Hydro*1	1-60	1-68	1-5	A
Geothermal*2	0.03	0	0	A
Diesel Engine (Heavy Oil) *1	8013-9595+	1386		E
Wind Power*1	21-87	14-50	5-35	B
Biomass*1	12-160	701-2540	190-320	D
Solar*1	24-490	16-340	12-190	B
Nuclear*1	3-50	2-100	2	A
Energy import*1	4-32 321+	0.3-12300	1-663+	D

*1: IEA. May 2000. Hydropower and the Environment: Present Context and Guidelines for Future Action. Vol. II: Main Report, Ch. 3: "Comparative Environmental Analysis of Power Generation Options".

*2: Adam Serchuk 2000. THE ENVIRONMENTAL IMPERATIVE FOR RENEWABLE ENERGY: AN UPDATE. Renewable Energy Policy Project

*3: Evaluation by study team

(2) Water Pollution

The impact on water pollution was briefly evaluated from possibility, severity, and immitigability, since the quantitative figures by each power source were not available. Wind power is the best, because there is no water pollution except in the manufacturing stage and operation stage, which produce wastewater. Geothermal, nuclear power, and energy import are worse because of thermal water and boiler cleaning wastes.

Table 5.1.4-2 Water Pollution of Electricity Generation Technology

Technology	Impacts	Probability of occurring	Severity of consequences	Immitigability	Rating
Hydro*1	• Release from reservoirs of anoxic waters. • Modification of the thermal regime. • Proliferation of waterborne diseases in shallow stagnant areas. • Increased turbidity associated with banks erosion. • Modifications to the flow regime.	Medium	Low	Medium	C
Geothermal*2	• Blowouts can pollute surface water. • Spent geothermal fluid with high concentrations of chemicals can pollute surface water.	Medium	Medium	Medium	D
Diesel Engine (Heavy Oil)*3	• Boiler blowdown • Boiler cleaning wastes • Thermal pollution	High	High	Low	C
Wind Power	• Wastewater during Manufacturing process • Sewage contamination during operation	High	Low	Low	A
Biomass	• Boiler blowdown • Boiler cleaning wastes • Thermal pollution	High	High	Low	C
Solar	• Wastewater during Manufacturing process • Sewage contamination during operation	High	Low	Low	B
Nuclear	• Boiler blowdown • Boiler cleaning wastes • Thermal pollution	High	High	Low	D
Energy import	• Boiler blowdown • Coal pile run-off • Coal pile run-off • Boiler cleaning wastes • Thermal pollution	High	High	Low	D

*1: IEA. May 2000. Hydropower and the Environment: Present Context and Guidelines for Future Action. Vol. II: Main Report, Ch. 3: "Comparative Environmental Analysis of Power Generation Options".

*2: Mary H. Dickson and Mario Fanelli, "What is Geothermal Energy?" (Pisa, Italy: Istituto di Geoscienze e Georisorse, CNR, February 2004)

*3: How can electricity production impair water quality? (The Power Scorecard Web site http://powerscorecard.org/)

(3) Consumption of Natural Resources

The impact of consumption of natural resource was evaluated based on the extraction of natural resources and dependence on local resources. The evaluations of hydropower, wind power, and solar thermal are high because of availability of local resources.

Table 5.1.4-3 Natural resource consumption of Electricity Generation Technology

Technology	Extraction[*1]	Dependence on local resources	Rating
Hydro	No	High	A
Geothermal	No	High	B
Diesel Engine (Heavy Oil)	Yes	Medium	E
Wind Power	No	High	A
Biomass	No	Medium	C
Solar	For manuf. only	High	A
Nuclear	Yes (Uranium)	Low	C
Energy import	Yes (Oil, Coal)	Low	E

*1: Canadian Electricity Association, 2006. POWER GENERATION in CANADA

(4) CO_2 Emission

CO_2 emission was evaluated by the figures calculated by life cycle assessment. The emissions from hydropower and nuclear power are relatively low and the emissions from diesel engines and energy import are relatively high. The emission from solar thermal is substituted by PV, because of unavailability of data.

Table 5.1.4-4 CO_2 emission of Electricity Generation Technology

Technology	Greenhouse gas emissions (kt eq.CO_2/TWh)	Rating
Hydro[*1]	1-48	A
Geothermal[*2]	47-97	B
Diesel Engine (Heavy Oil)[*1]	686-726+	E
Wind Power[*1]	7-124	C
Biomass[*1]	15-118	C
Solar[*1]	13-731	D
Nuclear[*1]	2-59	A
Energy import[*1]	686-726+	E

*1: IEA. May 2000. Hydropower and the Environment: Present Context and Guidelines for Future Action. Vol. II: Main Report, Ch. 3: "Comparative Environmental Analysis of Power Generation Options".

*2: Adam Serchuk 2000. THE ENVIRONMENTAL IMPERATIVE FOR RENEWABLE ENERGY: AN UPDATE. Renewable Energy Policy Project

(5) Waste

Industrial waste from each energy source was evaluated by type of waste and relative amount of waste, due to lack of figures. The results are shown in Table 5.1.4-5. The evaluation of wind power and solar thermal is high because of little industrial waste. On the other hand, the evaluation of nuclear power is low because of the difficulty in nuclear waste disposal.

Table 5.1.4-5 Industrial Waste

Technology	Waste	Amount[*1]	Rating
Hydro	Drifted waste Sediment Sludge	No	B
Geothermal		Large	C
Diesel Engine (Heavy Oil)	Burned Ash	Large	C
Wind Power	No	No	A
Biomass	Burned Ash	Large	D
Solar	No	No	A
Nuclear	Nuclear waste	Large: Radioactive	E
Energy import		Large	D

*1: Canadian Electricity Association, 2006. POWER GENERATION in CANADA

(6) Water Use

Impact on water use was evaluated through relative assessment by type of impact, probability, and severity of consequences. The results are shown in Table 5.1.4-6. The impact by wind power is the lowest because of limited wastewater. The impact by hydropower is the highest because of changing flow pattern downstream.

Table 5.1.4-6 Impact on Water Use

Technology	Water use impacts[*1]	Probability of occurring	Severity of consequences	Rating
Hydro	Low: Flow pattern changed	High	High	D
Geothermal	Low	High	Low	B
Diesel Engine (Heavy Oil)	Low-Medium: Thermal discharge	High	Medium	C
Wind Power	None	None	None	A
Biomass	Low	High	Low	B
Solar	Low	High	Low	B
Nuclear	Low: Thermal discharge	High	Medium	C
Energy import	Low-Medium: Thermal discharge	High	Medium	C

*1: Canadian Electricity Association, 2006. POWER GENERATION in CANADA

(7) Ecosystem

Impact on the ecosystem was evaluated by type of impact, impact on local ecosystem, impact on biomass, and impact on genetic diversity at the world level. The results are shown in Table 5.1.4-7. Solar thermal is the best for the ecosystem and hydropower is the worst, because of the big impact which may affect not only the terrestrial ecosystem but also the aquatic ecosystem.

Table 5.1.4-7 Impact on Natural Ecology

Technology	Source of final significant impacts on biodiversity	Local and regional ecosystem	Biomass	Genetic diversity at world level	Total*2
Hydro*1	• Barriers to migratory fish • Loss of terrestrial habitat • Change in water quality • Modification of water flow	X	X	X	E
Geothermal	• Loss of terrestrial habitat	X			C
Diesel Engine (Heavy Oil) *1	• Climate change • Acid precipitation • Mining and transportation of coal	X	X	X	D
Wind Power*1	• Risks for some species of birds	X			B
Biomass		X	X		C
Solar*1		X			A
Nuclear*1	• Radioactive substances	X			C
Energy import		X	X	X	D

*1: IEA. May 2000. Hydropower and the Environment: Present Context and Guidelines for Future Action. Vol. II: Main Report, Ch. 3: "Comparative Environmental Analysis of Power Generation Options".

*2: Rating by study team

5.1.5 Social Impacts on Alternative Energy Sources

(1) Agriculture

Impacts on agriculture were evaluated by types of impact, probability, and land requirements. The results are shown in Table 5.1.5-1. The evaluations of geothermal, diesel, and nuclear power are relatively high because of small land requirements. The evaluation of hydropower is the lowest because of vast land requirements.

Table 5.1.5-1 Impact on Agriculture

Technology	Impact	Probability of occurring	Land Requirements*1 (km2/TWh/y)	Rating
Hydro	Loss of land Impact on Irrigation water quantity	High	0.1-152	D
Geothermal	Loss of land Impact on irrigation water quality	High	-	A
Diesel Engine (Heavy Oil)	Loss of land	High	-	A
Wind Power	Loss of land	High	24-117	C
Biomass	Loss of land Create new farming Steep rise in commodity prices	High	0.9-2,200	E
Solar	Loss of land	High	27-45	B
Nuclear	Loss of land	High	0.5	A
Energy import	Loss of land	High	-	A

*1: IEA.(May 2000). Hydropower and the Environment: Present Context and Guidelines for Future Action. Vol. II: Main Report, Ch.3: "Comparative Environmental Analysis of Power Generation Options".

(2) Resettlement

The evaluations on resettlement were based on land requirement, severity, and immitigability. The results are shown in Table 5.1.5-2. The evaluations of geothermal, diesel engine, and nuclear power are relatively high because of small land requirement. The evaluation of hydropower is the lowest because of vast land requirement.

Table 5.1.5-2 Impact on Resettlement

Technology	Land Requirements*1 (km^2/TWh/y)	Severity of consequences	Immitigability	Rating
Hydro	0.1-152	Low-Medium	Low	D
Geothermal	-	Low	Low	A
Diesel Engine (Heavy Oil)	-	Low	Low	A
Wind Power	24-117	Low	Low	C
Biomass	0.9-2200	Low-High	Low	E
Nuclear	0.5	Low	Low	B
Solar	27-45	Low	Low	B
Energy import	-	Low	Low	A

*1: IEA.May 2000. Hydropower and the Environment: Present Context and Guidelines for Future Action. Vol. II: Main Report, Ch.3: "Comparative Environmental Analysis of Power Generation Options".

(3) Fisheries

Impacts on fisheries were evaluated by types of impact, probability, severity, and immitigability. The results are shown in Table 5.1.5-3. The rating of solar thermal and wind power is A, since there is no impact on fisheries. On the other hand, the rating of hydropower is E because of barriers to migratory fish, changing in water quality, and modification of water flow.

Table 5.1.5-3 Impact on Fishery

Technology	Impacts	Probability of occurring	Severity of consequences	Immitigability	Rating
Hydro	• Barriers to migratory fish • Change in water quality • Modification of water flow	High	High	High[1]	E
Geothermal	•Change in water quality •Change in water temperature	High	Medium	Low	C
Diesel Engine (Heavy Oil)	•Change in water quality •Change in water temperature	High	Medium	Low	D
Wind Power	-	-	-	-	A
Biomass	•Change in water quality •Change in water temperature	High	Medium	Low	D
Solar	-	-	-	-	A
Nuclear	•Change in water quality •Change in water temperature	High	Medium	Low	D
Energy import	•Change in water quality •Change in water temperature	High	Medium	Low	D

(4) Tourism

Impact on tourism was evaluated by types of impact, probability, severity, and immitigability. The results are shown in Table 5.1.5-4. The ratings of diesel engine, biomass, and energy import are A because of low probability and severity. The ratings of hydropower is E because of the possible impact on fishing, trekking, nature observation, rafting, and landscape.

[1] It is impossible to compensate completely without removing the barrage, if the barrages of hudropower projects interupt fish migration and cause serious damage on fisheries. But partially mitigation might be possible by fish raddert or other mitigation measures.

Table 5.1.5-4 Impact on Tourism

Technology	Impacts	Probability of occurring	Severity of consequences	Immitigability	Rating
Hydro	Fishing, Trekking, Nature watching, Rafting, kayaking Landscape	High	High	High	E
Geothermal	Fishing, Landscape	Medium	Medium	Low	B
Diesel Engine (Heavy Oil)	Fishing, Landscape	Low	Medium	Low	A
Wind Power	Bird Watching, Landscape	High	Medium	High	D
Biomass	Fishing, Landscape	Low	Medium	Low	A
Solar	Landscape	Medium	Medium	High	C
Nuclear	Fishing, Landscape	High	Medium	Low	C
Energy import	Fishing, Landscape	Low	Medium	Low	A

(5) Legal Aspects

Legal aspects were evaluated from the difficulty of legislative points of view. The results are shown in Table 5.1.5-5. The ratings of hydropower, diesel engine, and wind power are A because of few legislative problems. The rating of nuclear power is E because of little legislative progress on management of nuclear waste treatment.

Table 5.1.5-5 Legal Problems of the energy sources

Technology	Problems	Rating
Hydro	No regulation on Residual flow	A
Geothermal	No technical Standard or guideline for Geothermal Power Plant	C
Diesel Engine (Heavy Oil)	-	A
Wind Power	-	A
Biomass		A
Nuclear	No regulation or guideline on Impact Assessment, No technical standard on Radioactivity, No technical regulation on Nuclear Power Plant	E
Solar	-	A
Energy import	-	A

(6) Human Health

Impact on human health is evaluated by type of impact, probability, severity, and immitigability. The results are shown in Table 5.1.5-6. The rating of solar thermal is A, since there is no health impact. The ratings of geothermal and diesel engine are D because of wastewater discharge and polluted air emission.

Table 5.1.5-6 Impact on Human Health

Technology	Impact on Human Health*1	Probability of occurring	Severity of consequences	Immitigability	Rating
Hydro	• Risks from water-borne diseases, particularly when there is irrigation*1 • Polluted water	Medium-Low	High	High	D
Geothermal	• Polluted water • Polluted air	High	High	Low	D
Diesel Engine(Heavy Oil)	• Acid precipitation*1 • Photochemical smog*1 • Particulate matter*1 • Toxic metals*1 • Polluted water	High	High	Low	D
Wind Power	• Low frequency noise	High	Medium	Low	B
Biomass	• Photochemical smog • Particulate matter	High	High	Low	D
Solar	-	-	-	-	A
Nuclear	• Radioactive substances*1	Low	High	High	D
Energy import	• Climate change*1 • Acid precipitation*1 • Photochemical smog*1 • Particulate matter*1 • Toxic metals*1	High	High	Low	D

*1: IEA.May 2000. Hydropower and the Environment: Present Context and Guidelines for Future Action. Vol. II: Main Report, Ch.3: "Comparative Environmental Analysis of Power Generation Options".

(7) Risk of Accident

The risk of accident was evaluated by number of actual accidents, number of fatalities, and experience of operation in Uganda. The results are shown in Table 5.1.5-7. The rating of diesel is E because of the high number of accidents. The ratings of wind power and solar thermal are A because of no record of accidents.

Table 5.1.5-7 Risk of Accident

Technology	Impact	Number of Severe accidents with fatalities, world-wide	Number of immediate fatalities (per GWe year)	Experience in Uganda	Rating
Hydro	Dam failure	9	$8.8*10^{-1}$	Yes	D
Geothermal		No data	No data	No	B
Diesel Engine (Heavy Oil)	Road accidents during Transport to Refinery and Regional Distribution (oil)	334 (oil)	$4.2*10^{-1}$ (oil)	Yes	E
Wind Power		No data	No data	No	A
Biomass		No data	No data	No	B
Solar		No data	No data	No	A
Nuclear	Nuclear reactor accidents	1	$8.4*10^{-3}$	No	D
Energy import		No data	No data	Yes	E

*1: Hirschberg S., Spiekerman G., Dones R. & Burgherr P. (2001) Comparison of severe accident risks in fossil, nuclear and hydro electricity generation", Invited paper, EAE 2001, International Conference on Ecological Aspects of Electric Power Generation, 14-16 November 2001, Warsaw, Poland.

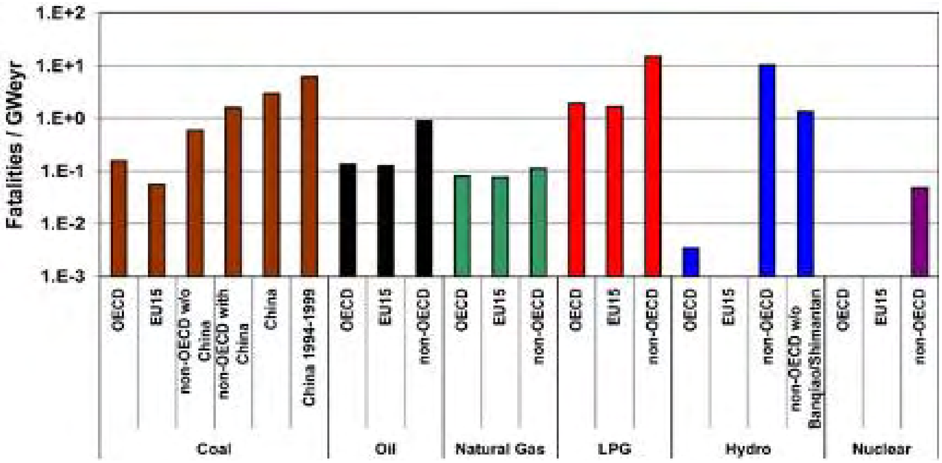


Figure 5.1.5-1 Comparison of aggregated, normalized, energy-related damage rates*2

*2: Comparison of aggregated, normalized, energy-related damage rates, based on historical experience of severe accidents that occurred in OECD countries, non-OECD countries and EU15 for the period 1969-2000, except for data from the China Coal Industry Yearbook that were only available for the years 1994-1999. For the Hydro chain non-OECD values were given with and without the largest accident that ever happened in China, which resulted in 26'000 fatalities alone. No reallocation of damages between OECD and non-OECD countries was used in this case. Note that only immediate fatalities were considered here, although latent fatalities are of particular relevance for the nuclear chain.

5.2 General Evaluation of Alternative Energy Sources

5.2.1 Evaluation Criteria of Alternative Energy Sources

The general evaluation method of alternative energy sources is multi-criteria decision analysis. The total number of criteria was twenty seven, including economic and technical items such as development cost and existing potential, environmental items such as air pollution and waste, and social items such as resettlement and tourism. After giving ratings from A to E, the ratings were converted into the value of 5 to 1 for each, multiplied by weight, and summed up by energy source. The weighting patterns were divided into three cases; namely, even case, environmental weighting case, and economic weighting case. The weighting patterns are shown in Table 5.2.1-1.

Table 5.2.1-1 Evaluation Items and Weighting

<table>
<tr><th colspan="3">Evaluation Items</th><th colspan="3">Even Case</th><th colspan="3">Environment Weighting Case</th><th colspan="3">Economin Weighting Case</th></tr>
<tr><td rowspan="13">Economic and technical</td><td rowspan="3">Cost</td><td>Development cost(USD/kW)</td><td rowspan="13">34</td><td rowspan="3">12</td><td>4</td><td rowspan="13">25</td><td rowspan="3">9</td><td>3</td><td rowspan="13">55</td><td rowspan="3">6</td><td>2</td></tr>
<tr><td>Operation & Maintenance cost (US$/kW/year)</td><td>4</td><td>3</td><td>2</td></tr>
<tr><td>Unit cost of power generation (USD/MWh)</td><td>4</td><td>3</td><td>2</td></tr>
<tr><td rowspan="3">Development potential</td><td>Existing potential (MW)</td><td rowspan="3">12</td><td>4</td><td rowspan="3">9</td><td>3</td><td rowspan="3">24</td><td>2</td></tr>
<tr><td>Technically feasible potential at present (MW)</td><td>4</td><td>3</td><td>20</td></tr>
<tr><td>Availability of Energy Source</td><td>4</td><td>3</td><td>2</td></tr>
<tr><td rowspan="2">Construction</td><td>Survey maturity</td><td rowspan="2">5</td><td>3</td><td rowspan="2">2</td><td>1</td><td rowspan="2">10</td><td>9</td></tr>
<tr><td>Lead time for construction</td><td>2</td><td>1</td><td>1</td></tr>
<tr><td rowspan="4">Operation</td><td>Initial Starting Time</td><td rowspan="4">4</td><td>1</td><td rowspan="4">4</td><td>1</td><td rowspan="4">13</td><td>1</td></tr>
<tr><td>Energy stability</td><td>1</td><td>1</td><td>10</td></tr>
<tr><td>Power supply stability</td><td>1</td><td>1</td><td>1</td></tr>
<tr><td>Life Span (Year)</td><td>1</td><td>1</td><td>1</td></tr>
<tr><td colspan="2">Contribution to national economy</td><td>1</td><td>1</td><td>1</td><td>1</td><td>2</td><td>2</td></tr>
<tr><td rowspan="7">Environmental</td><td colspan="2">Air pollution</td><td colspan="2" rowspan="7">33</td><td>4</td><td colspan="2" rowspan="7">42</td><td>5</td><td colspan="2" rowspan="7">23</td><td>2</td></tr>
<tr><td colspan="2">Water pollution</td><td>5</td><td>5</td><td>3</td></tr>
<tr><td colspan="2">Consumption of natural resource</td><td>5</td><td>7</td><td>4</td></tr>
<tr><td colspan="2">CO2 emission</td><td>4</td><td>5</td><td>3</td></tr>
<tr><td colspan="2">Waste</td><td>4</td><td>5</td><td>3</td></tr>
<tr><td colspan="2">Water right/ water resource</td><td>5</td><td>7</td><td>3</td></tr>
<tr><td colspan="2">Impact on natural ecology</td><td>6</td><td>8</td><td>5</td></tr>
<tr><td rowspan="7">Social</td><td colspan="2">Impact on Agriculture</td><td colspan="2" rowspan="7">33</td><td>5</td><td colspan="2" rowspan="7">33</td><td>5</td><td colspan="2" rowspan="7">22</td><td>3</td></tr>
<tr><td colspan="2">Resettlement</td><td>5</td><td>5</td><td>3</td></tr>
<tr><td colspan="2">Impact on fishery</td><td>6</td><td>6</td><td>4</td></tr>
<tr><td colspan="2">Impact on tourism</td><td>5</td><td>5</td><td>3</td></tr>
<tr><td colspan="2">Legal aspects</td><td>4</td><td>4</td><td>2</td></tr>
<tr><td colspan="2">Human health hazard+</td><td>4</td><td>4</td><td>3</td></tr>
<tr><td colspan="2">Risk of accident</td><td>4</td><td>4</td><td>4</td></tr>
</table>

5.2.2 General Evaluation of Alternative Energy Sources

The results from 5.1.2 to 5.1.5 were gathered and assessed based on the several scenarios. The result shows that hydropower, geothermal and solar thermal get relatively high scores (see Table 5.2.2-1).

Table 5.2.2-1 General Evaluation of various energy sources

Evaluation items			Weight			Hydro	Geothermal	Diesel Engine (Heavy Oil)	Wind Power	Biomass Thermal Cogeneration	Solar Thermal	Nuclear	Energy import
Economic and technical	Cost	Development cost(USD/kW)	34	12	4	3	3	5	1	1	1	1	5
		Operation & Maintenance cost (USD/kW/year)			4	5	3	3	5	3	5	1	5
		Unit cost of power generation (USD/MWh)			4	5	5	1	5	3	1	5	1
	Development potential	Existing potential (MW)		12	4	5	3	3	1	4	2	4	2
		Technically feasible potential at present (MW)			4	5	3	2	1	4	3	1	1
		Availability of Energy Source+			4	4	5	2	1	2	3	1	1
	Construction	Survey maturity		5	3	4	3	5	1	5	5	1	1
		Lead time for construction			2	3	2	5	1	4	4	1	3
	Operation	Initial Starting Time		4	1	5	3	4	1	3	3	2	1
		Energy stability			1	4	5	5	1	3	1	5	3
		Power supply stability			1	4	5	3	1	2	1	2	2
		Life Span (Year)			1	5	4	3	4	4	4	4	5
	Contribution to national economy			1	1	5	5	1	3	5	3	5	3
	Sub Total (without weighting)					57	49	42	26	43	36	33	33
Environmental	Air pollution		33		4	5	5	1	4	2	4	5	2
	Water pollution				5	3	2	3	5	3	4	2	2
	Consumption of natural resource*				5	5	4	1	5	3	5	3	1
	CO2 emission				4	5	4	1	3	3	2	5	1
	Waste				4	4	3	3	5	2	5	1	2
	Water right/ water resource				5	2	4	3	5	4	4	3	3
	Impact on natural ecology				6	1	3	2	4	3	5	3	2
	Sub Total (without weighting)					25	25	14	31	20	29	22	13
Social	Impact on Agriculture		33		5	2	5	5	3	1	4	5	5
	Resettlement				5	2	5	5	3	1	5	4	5
	Impact on fishery				6	1	3	2	5	2	5	2	2
	Impact on tourism				5	1	4	5	2	5	3	3	5
	Legal aspects				4	5	3	5	5	5	1	5	5
	Human health hazard				4	2	2	2	4	2	5	2	2
	Risk of accident				4	2	4	1	5	4	5	2	1
	Sub Total (without weighting)					15	26	25	27	20	28	23	25
General Evaluation		Even Case				328	363	291	344	295	368	285	264
						A	A	B	A	B	A	B	C
		Environment weighting case				320	367	277	367	291	378	298	261
						A	A	B	A	B	A	B	C
		Economic Weighting Case				367	361	299	266	332	348	260	219
						A	B	C	C	C	B	C	C

As seen the figures below, results of there cases, neutral case, environment priority case, and technical and economical priority case, show same tendency basically. Solar thermal power is most suitable case for minimizing environment impacts; however, the solar thermal has not advantage from the technical and economical point of view. Geothermal has balanced advantage from the environmental, technical and environmental point of view. The large scale hydro, even has less advantage from the environmental point of view, has definite advantage of technical and economical aspect.

Hence, Geothermal, Solar thermal and large scale hydro powers have been evaluated as superior energy source than the other sources in Uganda.

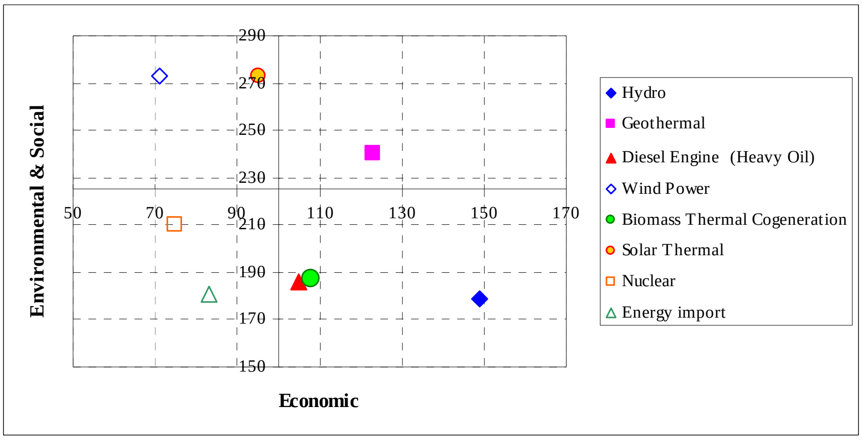


Figure 5.2.2-1 Evaluation Results (Neutral Case)

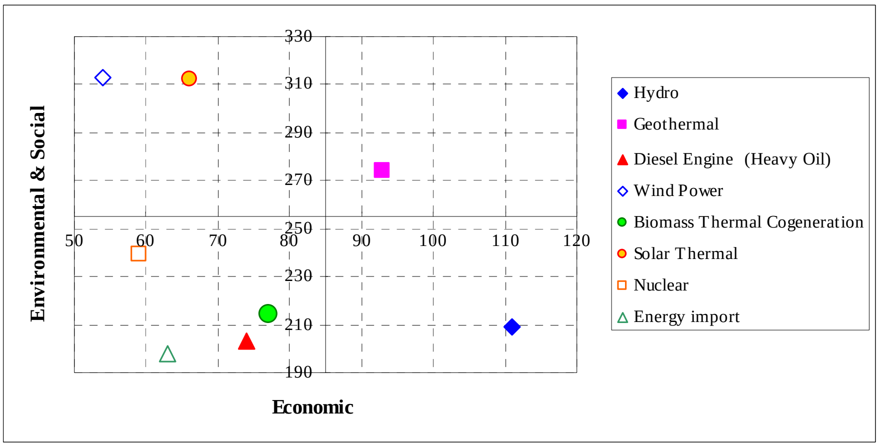


Figure 5.2.2-2 Evaluation Results (Priority for Environment Case)

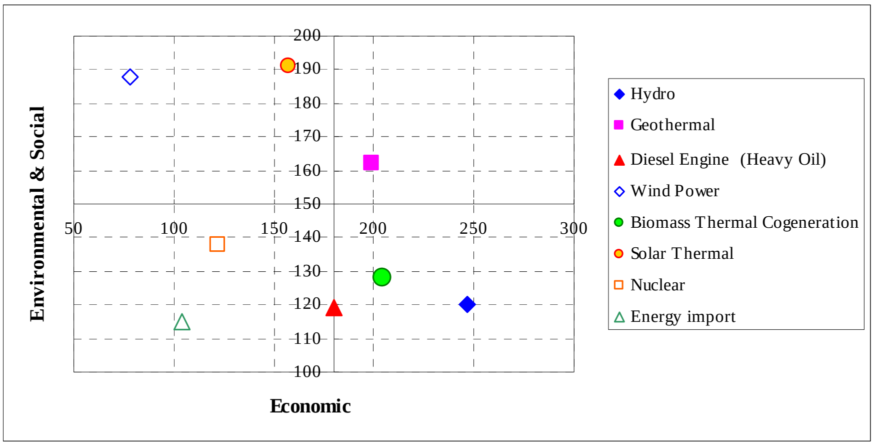


Figure 5.2.2-3 Evaluation Results (Priority for Economy Case)

5.3 Necessity for Development of Large Scale Hydro

As described in section 5.2, the large scale hydro as well as Geothermal and Solar thermal is superior to the other energy sources. Geothermal, which has balanced advantage from the environmental, technical and environmental point of view, has high evaluation score. However, as shown in Table 5.1.2-1, technically feasible potential of the Geothermal is about 50MW at present. The energy peak demand of 900MW by 2023 cannot be supplied by only geothermal energy source practically.

On the other hand, technically feasible potential of the large scale hydro is 2,980 MW (refer to Table 5.1.2-1) at present. The large scale hydro has by far the largest potential and was evaluated as third superior energy source after the Geothermal and the Solar thermal.

The other energy sources also are essential to realize secure energy supply. It is recommended to develop all kind of the Energy Sources except for nuclear power, which has many unknown factors in technical aspects, in balance to realize secure and economical energy supply with achieving minimum environmental impact. Well balanced power development plan was planned in Uganda by the GDP 2009-2025 taking in to consideration with the secure energy supply.

The large scale hydro can achieve secure and economical energy supply in Uganda. As shown in Figure 5.3-1, about 90% of the energy demand by 2023 will be supplied by the large scale hydro which was planned by the GDP2009-2025. Hence, it is concluded that the large scale hydro is most essential energy source for power development plan in Uganda.

The JICA Study has conducted optimized master plan study on hydropower development which is most essential and superior energy source in Uganda.

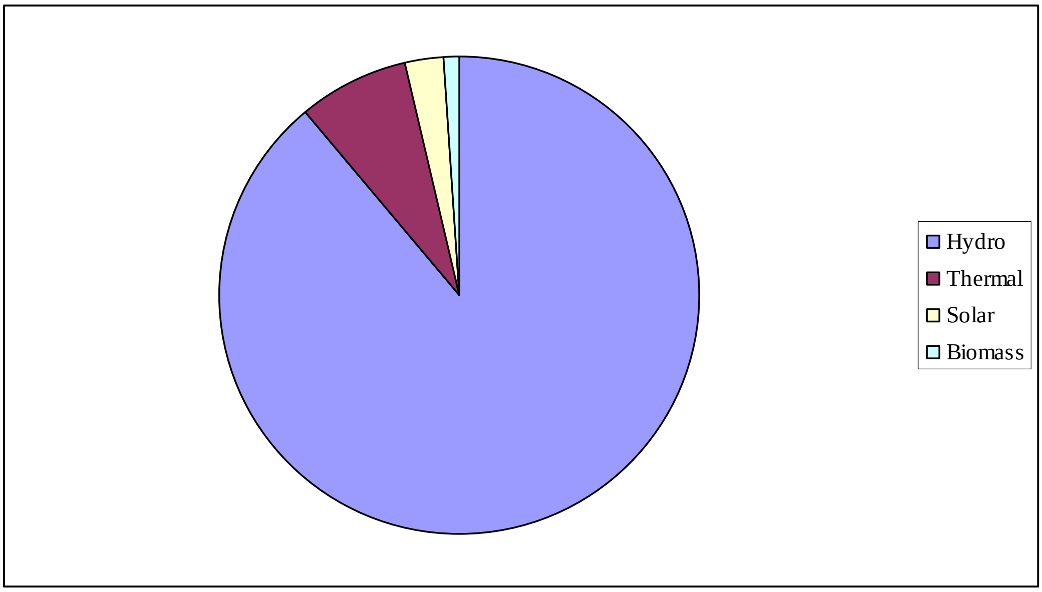


Figure 5.3-1 Power Balance in Year 2023 by GDP2009-2025