No.

THE REPUBLIC OF KENYA
KENYA POWER & LIGHTING CO., LTD.

THE PREPARATORY SURVEY ON KISUMU-LESSOS-OLKARIA TRANSMISSION LINE UPGRADING PROJECT

SUMMARY

MARCH 2010

JAPAN INTERNATIONAL COOPERATION AGENCY

NIPPON KOEI CO., LTD.
TOKYO ELECTRIC POWER SERVICES CO., LTD.
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Chapter 1 Introduction

1.1 Background

The Republic of Kenya has politically maintained a stable administration compared with other countries in Africa, and the annual economic growth achieved to 7.0% in 2007 according to the World Bank. In this connection, the annual growth of electricity demand has also reached more than 6.0% in the last five (5) years. At present, the peak power demand in Kenya is 1,086 MW, whereas the generation capacity in 2008 is 1,135 MW in total, i.e. the margin of the generation capacity is less than 5%. The balance of supply and demand for electric power is always tight because the existing generation facilities are extremely aged, and hydropower stations which are the main sources of electrical supply in the country are easily affected by recent shortage of rainfall.

The Government issued Long Term National Development Policy “VISION 2030” in 2008 to aim to maintain 10% annual economic growth and to turn this country to Newly Industrializing Economy by 2030. For this purpose, the Government has been promoting to increase the electrification ratio in the remote areas, while to improve the reliability/quality of electricity supply in urban areas.

On the other hand, the construction of the Bujagali Hydropower Plant is on-going to commence the operation with generation of 250MW in 2011 in the neighbor country of Uganda. This generation will achieve to 50% of the whole existing generation capacity in Uganda. Therefore, Kenya may be able to import the power from Uganda at a low cost without investing for a new hydropower plant of higher cost in Kenya.

Under the circumstance, the Ministry of Energy in Kenya planned to construct new transmission lines connecting through Kisumu, Lessos, and Olkaria. The Government of Kenya applied for Overseas Development Assistance (ODA) loan to the Government of Japan for construction of those transmission lines. A planned transmission line between Lessos and Olkaria is to function as parts of the international interconnecting transmission line for connecting between Bujagali Hydropower Plant in Uganda and Mombasa where there are several thermal power stations in Kenya. This cross-border interconnection line will transmit very inexpensive power from Uganda, and even from Ethiopia, and will contribute to increase power supply reliability & capacity which meet the requirement of energy demand for social/economical development of Kenya. Besides, another planned transmission line between Lessos and Kisumu is to be used for feeding the power generated by the Sondu/Miru Hydropower Plant to the national grid in Kenya. Sondu/Milu Hydropower Plant was also constructed under the finance of Japan’s ODA Loan.

1.2 Objective of Survey

After structural reform of power sector through 1996 to 2000 in Kenya, five organizations in charge of activities in Power Sector have been incorporated into the two organizations; (i) Kenya Electricity Generating Company Ltd. (KenGen) for Generation, and (ii) Kenya Power & Lighting Company Ltd. (KPLC) for the transmission, distribution and retail of electricity. This KPLC was the counterpart of this Preparatory Survey.

This Preparatory Survey aims to evaluate the justification of the project implementation for construction of Kisumu-Lessos-Olkaria transmission lines Upgrading Project planned by KPLC from the view points of technical, economic and financial aspects. The Survey will also formulate the implementation plan of this candidate project under Japanese ODA Loan(s). Target areas of this Survey covered Nairobi, Kisumu, Lessos,, Olkaria, the transmission line route from Olkaria to Kisumu in Kenya side, and in addition, also cover Uganda (Kampala & Bujagali power station site), and Ethiopia (Addis Ababa).

Chapter 2 Status of Power Sector in Kenya

2.1 Current Status of Politics and Economy

2.1.1 Economy

Per capita GDP in the year 2008 was US$ 829 (IMF estimation), that is classified in the Low-income Countries by DAC of OECD.

The economy of the country stagnated from the end of 1990s to the beginning of 2000s due to slump in agricultural produce caused by draught and political inability. As a result, average GDP growth rate during the five years from 1997 onward remained at meager +2.3%. Since then the economy turned around thanks to the worldwide economic recovery around 2004 and economic growth rate attained a remarkable +7.0% over the previous year in 2007, the highest in 20 years. However, the growth rate was forced to drop considerably down to +2.0% in 2008 owing to the worldwide financial crisis.

Kenya is the member of, in addition to East African Community (EAC), COMESA (Common Market of Eastern Southern Africa) that is constituted of 19 countries residing in the south east segment of the African continent, the fact that will certainly accelerate regional economic cooperation through free trade and improvement of regional macro-economic environs

2.1.2 National Development Plan

The new national development plan was launched under the name of "Vision 2030" and its 1st Edition has got under way in 2007. It envisions upgrade of Kenya into Newly Industrializing Economy by 2030 through maintaining a steady GDP growth of 10%, that in 2007 stands at 4.9%. The Vision 2030 intends to go forward in step-wise manner working out a mid-term development plan every five year. In the first mid-term plan (FY 2008-2012), the government has committed to inject investment in 6 priority sectors, namely tourism, agriculture, manufacturing, marketing, information technology, and financial services, where 20 flagship projects are to be designated.

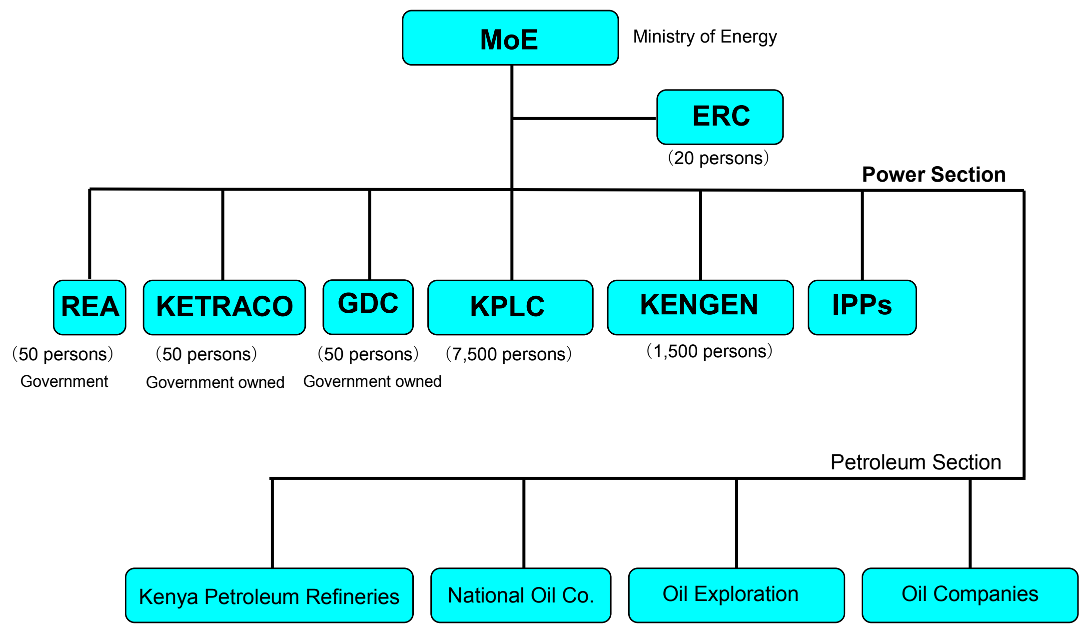
Goal of the said development plan is to achieve "a society in which people can live in hygienic and safe environment and everyone is equal, fairly treated" and "a democratic political system under which everyone follows rules of law and is guaranteed of basic human rights and freedom.

Power sector is recognized as one of the basic infrastructures to sustain this goal and the central government has been endeavoring in enhancing reliability of power supply, specifically by eliminating power failures in urban areas and expanding rural electrification which currently stands at less than 15% of the total coverage.

2.2 Outline of Power Sector

1.2.1 Power Companies in Kenya

The electric power sector of Kenya is under the jurisdiction of Ministry of Energy (MoE) that is responsible for national energy policy and rural electrification plan, under which Kenya Power Generating Company (KenGen), Kenya Power & Lighting Company (KPLC), Independent power producers (IPP), Kenya Electricity Transmission Company (KETRACO), Geothermal Development Company (GDC), and Rural Electricity Authority (REA) are placed. As an independent party, Energy Regulation Commission (ERC) is supervising the sector. In addition, companies/organizations relating to petroleum are also under control of MoE.



Source : KPLC

Fig. 2-2.1 MoE and Organizations/Companies in Power Sector

KenGen is owned by the central government by 70% (End of June 2009) of its stock, whose stock is although open for public. Meanwhile, KPLC is owned by the government by 40.4% (End of August 2009) of its stock, whose stock is also open for public.

1.2.2 Kenya Power & Lighting Company Limited (KPLC)

(1) KPLC and KETRACO

Power transmission business in Kenya has been undertaken solely by KPLC. As a consequence, the field survey and investigation of the Survey Team for the Project were conducted with full cooperation of this company. On the other hand, in an effort to establish reliable nationwide power distribution network, Kenya Electricity Transmission Company (KETRACO) was founded in 2008 with full capital investment by the government, that is now engaged in preparatory activities, recruiting staff and personnel, setting up offices etc. for a smooth kick-off. As a transitional measure, existing transmission lines are to be maintained by KPLC while new transmission lines by KETRACO. Accordingly, the transmission lines under this Project will come under the responsibility of the latter upon its implementation.

As the power transmission facility would not generate revenue unlike power generation, operation cost of KETRACO will have to be subsidized by the government, but this does not necessarily mean ceding the revenue of KPLC. Since capability of KETRACO has not been proven yet and KPLC is the mother of the former, let us examine the capability of project execution of KPLC at this stage. The detail is given in Chapter 9 of the Final Report.

1.3 Present Power Transmission Network

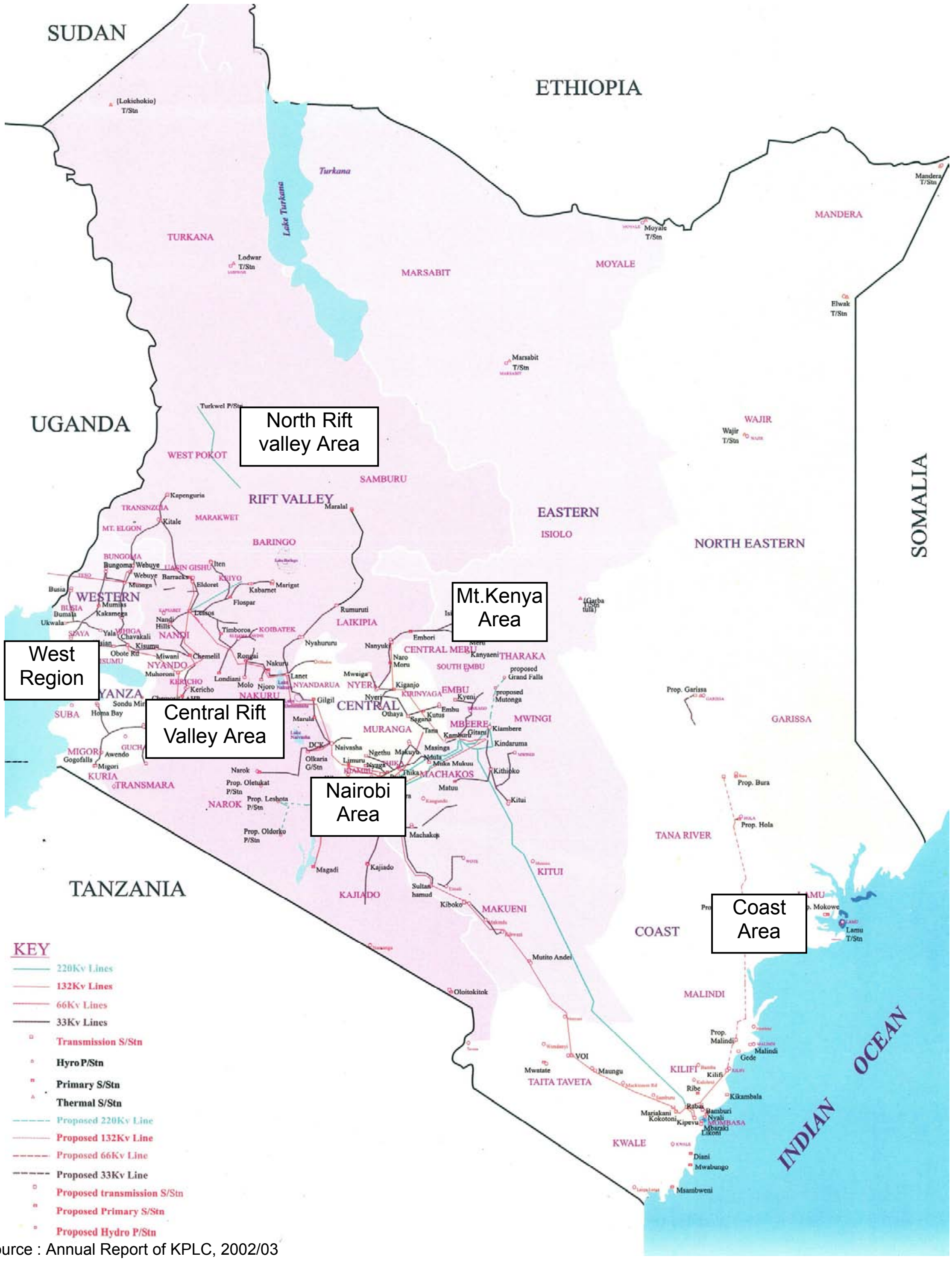
1.3.1 Power Transmission Network

Current power transmission network of Kenya as of 2008 is illustrated in Fig. 2-3.1. As northern part of the country is mountainous, habitat is concentrated in the southern segment, where the capital city Nairobi having 2 million populations are located. The city also constitutes the center of power consumption. Power generation in the country is comprised of thermal power plants mainly by diesel engines located along the eastern seaboard, geo-thermal power generation in the central region, and hydro-power plants in the northern and western regions. These power generations are linked with 132kV trunk transmission lines in 800km total length along east-west stretch, supplemented by 220kV lines connecting the east power stations and central power demand.

1.3.2 Geographical Distribution of Load Demand and Power Sources

Zonal classification of Kenya from east to west is as follows.

- Coast area centers on Mombasa
- Nairobi area centers on Nairobi
- Mt. Kenya area skirts around the Mt. Kenya and at northern Nairobi
- Central Rift Valley area at center of Great Rift Valley
- North Rift Valley area at northern part of Great Rift Valley
- West Region area centers on Kisumu, the 3rd biggest city of Kenya.

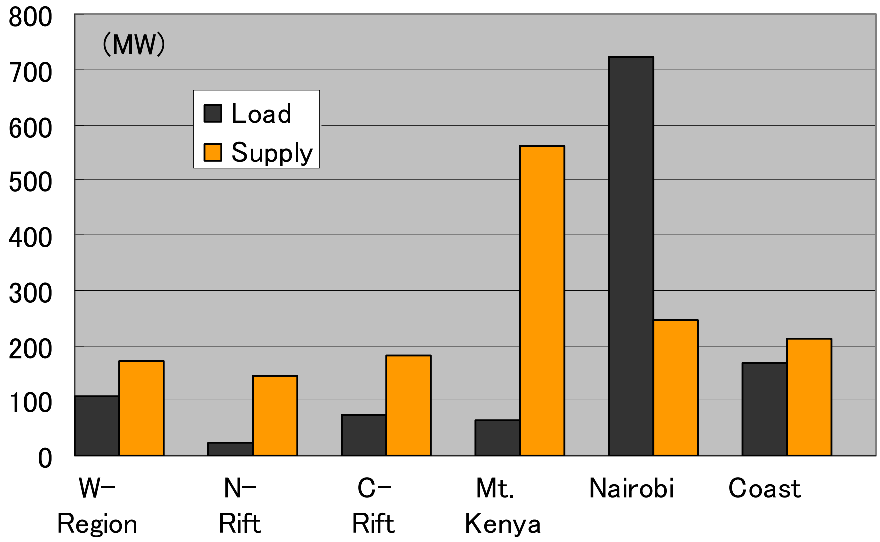


Source : Annual Report of KPLC, 2002/03

Fig. 2-3.1 Power System in Kenya and Six Zones in Kenya

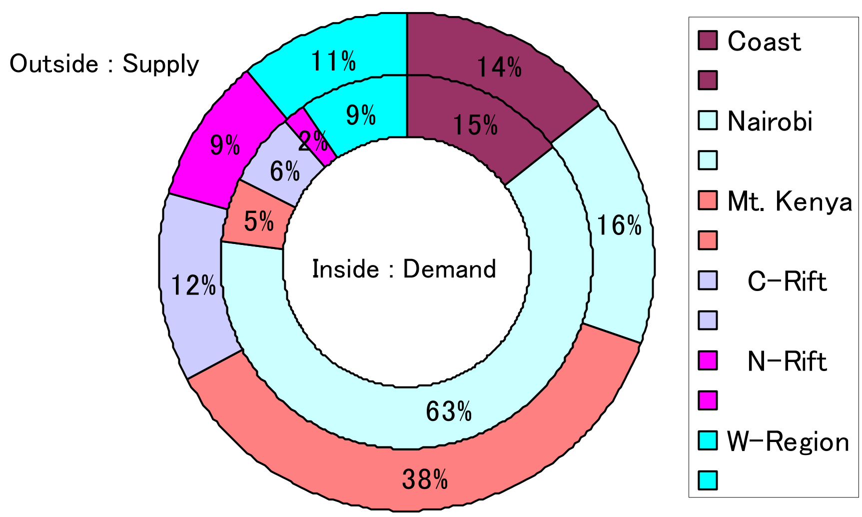
Distribution chart of load demand and power sources of the above mentioned six zones are shown in Figure 2-3.2. Area-wise proportional comparison of demand and power sources are shown in Figure 2-3.3.

Nairobi area is in majority of total load demand (62%). Meanwhile, Mr. Kenya area is in majority of total power sources (37%). Thermal power plants and geo-thermal power plants are main sources in Coast Area and Nairobi area respectively. Coast area sourced by thermal power generation and Nairobi area sourced by geo-thermal power generation are under stable power supply through the year. But other areas mainly sourced by hydro-power generation are facing to seasonal variation of power supply due to dry and rainy seasons.



Source : JICA Survey Team

Fig. 2-3.2 Distribution Chart of Load Demand and Power Sources



Source : JICA Study Team

Fig. 2-3.3 Area-wise Proportional Comparison of Demand and Power Sources

1.3.3 Status of Demand

Even though Kenya is located right on the equator, because of its elevation of 1,700m, average temperature of each month is between 15℃～19℃ and relatively cool. This results in small demand of air conditioners. The peak is made at around 20:00 p.m. because the loads are for lighting purpose, according to the daily load curve obtained from KPLC.

1.3.4 Power-Generation Infrastructure

List of Power-Generating facilities (as of June 2009) is shown in Table 2-3.1. Classification of the generating facilities are shown in Figure 2-3.4.

Total generation capacity of main network system is 1,293 MW at installed capacity and 1,253 MW at actual output capacity. As shown in the Table 2-3.1, classification of generation consists of, hydro-power: 52%, geo-thermal power: 13%, thermal power: 33% and cogeneration : 2%. Because majority of power supply is by hydro-power, seasonal variation of power generation occurs according to the amount of rain fall.

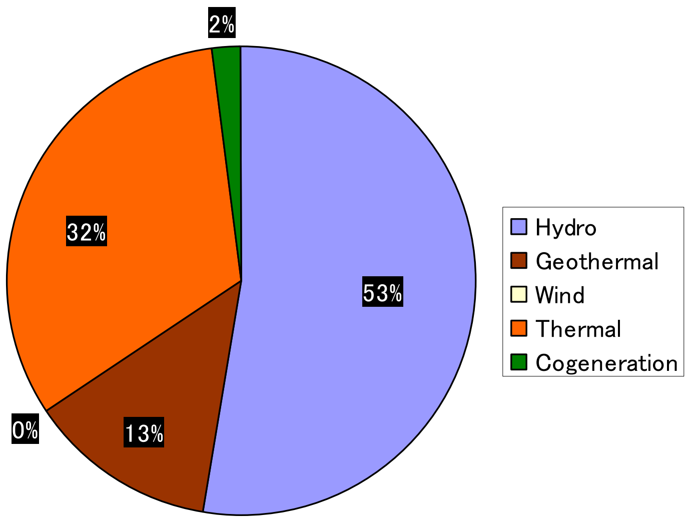
Table 2-3.1 Power-Generating Facilities (as of June 2009)

Type		Ref. No.	Name	Installed capacity (MW)	Effective capacity (MW)
Hydro		G-1	Tana	14.4	10.4
		G-2	Wanjii	7.4	7.4
		G-3	Kamburu	94.2	90
		G-4	Gitaru	225	216
		G-5	Kindaruma	40	40
		G-6	Masinga	40	40
		G-7	Kiambere	82	82
		G-8	Small Stations	6.3	5.6
		G-9	Turkwel	106	106
		G-10	Sondu	60	60
		Total Hydro		**675.3** (52%)	**657.4** (52%)
Geothermal		G-11	Olkaria I (KenGen)	45	45
		G-12	Olkaria II (KenGen)	70	70
		G-13	Olkaria III (IPP)	48	48
		Total Geothermal		**163** (13%)	**163** (13%)
Wind		**G-14**	**Ngong**	**0.4** (0%)	**0.4** (0%)
Thermal	Kengen	G-15	Kipevu I Diesel	75	60
		G-16	Kipevu GT1 and GT2	60	60
		G-17	Nairobi Gas Turbine	13.5	10
	IPP	G-18	Iberafrica Diesel	56	56
		G-19	Tsavo Power Diesel	74	74
	Emergency	G-20	Aggreko Power	150	146
	Total Thermal			**428.5** (33%)	**406** (33%)

Cogeneration	G-21	Mumias Cogeneration	**26** (2%)	**26** (2%)
Total Interconnected System			**1,293** (100%)	**1,253** (100%)
Isolated Stations	G-22	KenGen Diesel Stations	5.2	4.6
	G-23	REF Diesels and Wind Off-grid Stations	6.1	5.1
	Total Off-grid Capacity		11.3	9.7
Gross Capacity			**1,305**	**1,263**
Interconnected System Peak Demand				**1,071**

Source: KPLC

Ref. No. shown in Table 2-3.1 refers to the location shown in Figure 2-3.5.



Source : KPLC

Fig. 2-3.4 Classification of Power Plants (Main System)

In addition to the above, there are isolated system mainly in northern part of the main land and islands having generating capacities of around 11MW. Rural Electrification programme is going on by applying the best measures according to their distances from the main system, namely, integrating the isolated system into the main system, or use of diesel generation, solar system, wind power system, etc. case by case. Rural Electrification will be described in the separate clause.

1.3.5 Power Transmission Facilities

Total length of transmission lines are, 220 kV: 1,330 km, 132 kV: 2,055 km, and 66 kV: 610 km, and the total reaches 3,995 km. Main trunk line system is made by 220 kV and 132 kV transmission lines. 66 kV transmission lines are for regional supply. In addition, distribution line network is made by 33 kV lines: 11,163 km, and 11 kV lines: 21,918 km, then 33,081 km in total.

Transmission capacity of 132 kV transmission lines constructed in early times have only 73~81 MVA due to small size conductors. This conductor capacity is not enough and soon be overload in very near future.

1.3.6 Substation Facilities

Installed capacities are 1,720MVA, 862.5MVA, and 1,099MVA in 7 locations of 220kV, 14 locations of 132kV, and 29 locations of 66kV substations respectively. Total capacity of those substations reaches to 3,682MVA.

Source: KPLC

Fig. 2-3.5 Location of Generating Equipment, Transmission Lines, & Substations

220kV circuit breakers have been installed recently, therefore they have rated breaking current of over 31.5kA, however, those for 132kV lines have a variety of rated current ranging 1250～3150A, and rated breaking current ranging 12.5~40kA.

1.3.7 Power System

(1) System Configuration and Transmission Capacity

Figure 2-3.6 shows power system configuration and transmission capacities.

Kenya's transmission system is constituted of a 132kV transmission line that runs from east to west direction in a length of 800km, and another 132kV line internationally connecting Musaga substation in the western Kenya with Tororo substation in Uganda in a length of 70km, which is serving for cross-border power transaction between the two countries.

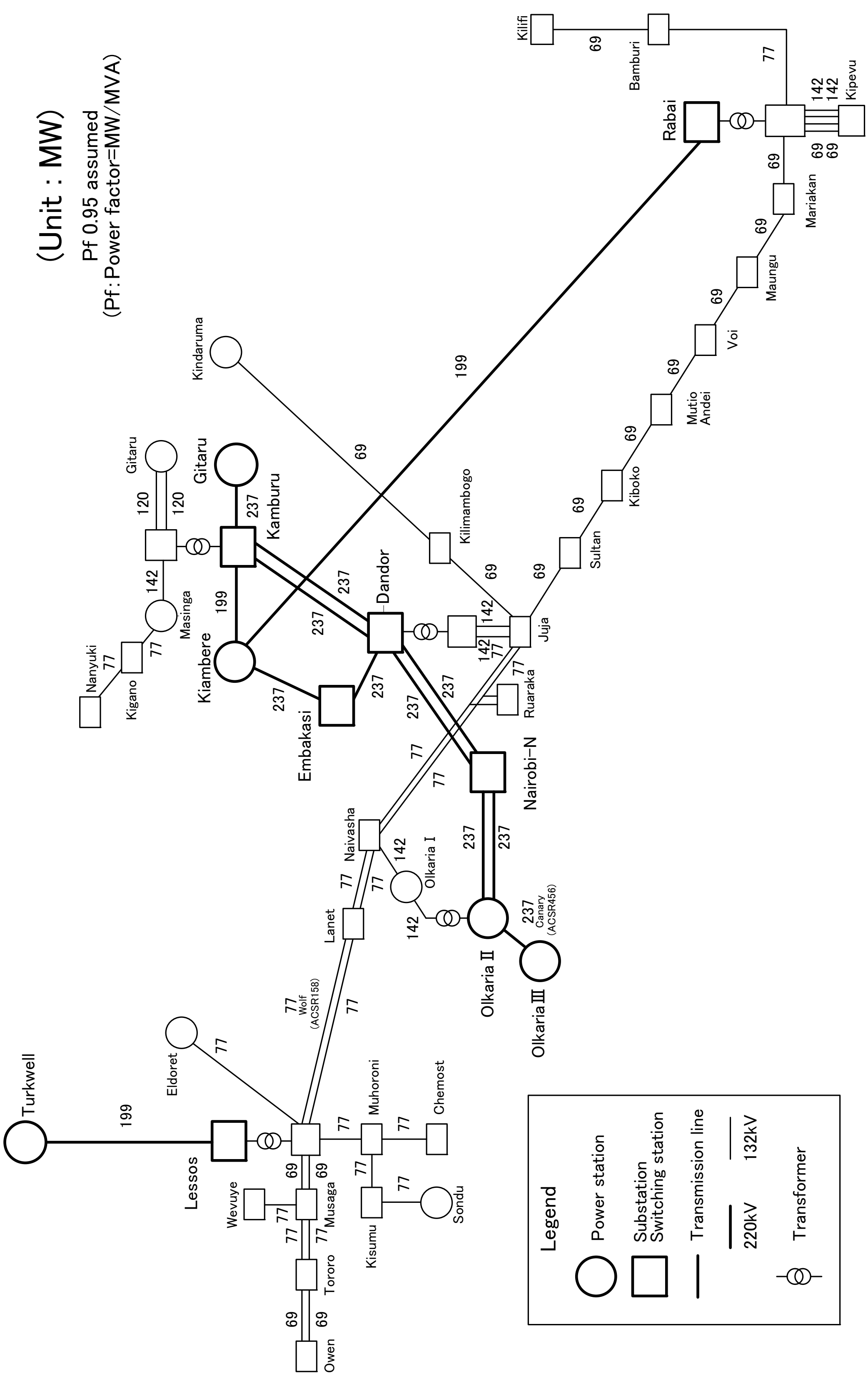
Power supply to capital city Nairobi which accounts for majority of power demand is carried out by collecting power from Olkaria geo-thermal power plant in the central south and Gitaru hydro-power station in the north, to 220kV Nairobi North substation, Dandora substation, Embakasi substation, and 132kV Ruaraka substation where stepping down of voltage is executed, for power distribution in Nairobi.

Eastern region of Kenya including the second largest city Mombasa on the eastern seaboard facing Indian Ocean is catered by local diesel engine generators and gas turbine generators. The system here is connected with the central system with two lines, namely 220kV single circuit transmission line (assumed to have a capacity 199MW under power factor 95%) and 132kV single circuit transmission line (assumed to have a capacity 69MW under power factor 95%).

In western region of Kenya, hydro-power is the main source of power and main consumer is the third largest city Kisumu and surroundings. The power system here is connected to the central system with two circuits of 132kV transmission line. This line was however constructed more than 50 years ago and aged, then the size of power conductor is very small with sectional area of 158mm^2 (ACSR 158, code name Wolf) having transmission capacity of only 77MW per circuit (under power factor 95%). Further, the line supplying power to Kisumu is only 132kV Kisumu-Muhoroni-Lessos line (transmission capacity 77MW under power factor 95%). As this line is single circuit, power supply to Kisumu area is quite unreliable. Power interruption can not be avoided at fault or overload condition on the transmission line.

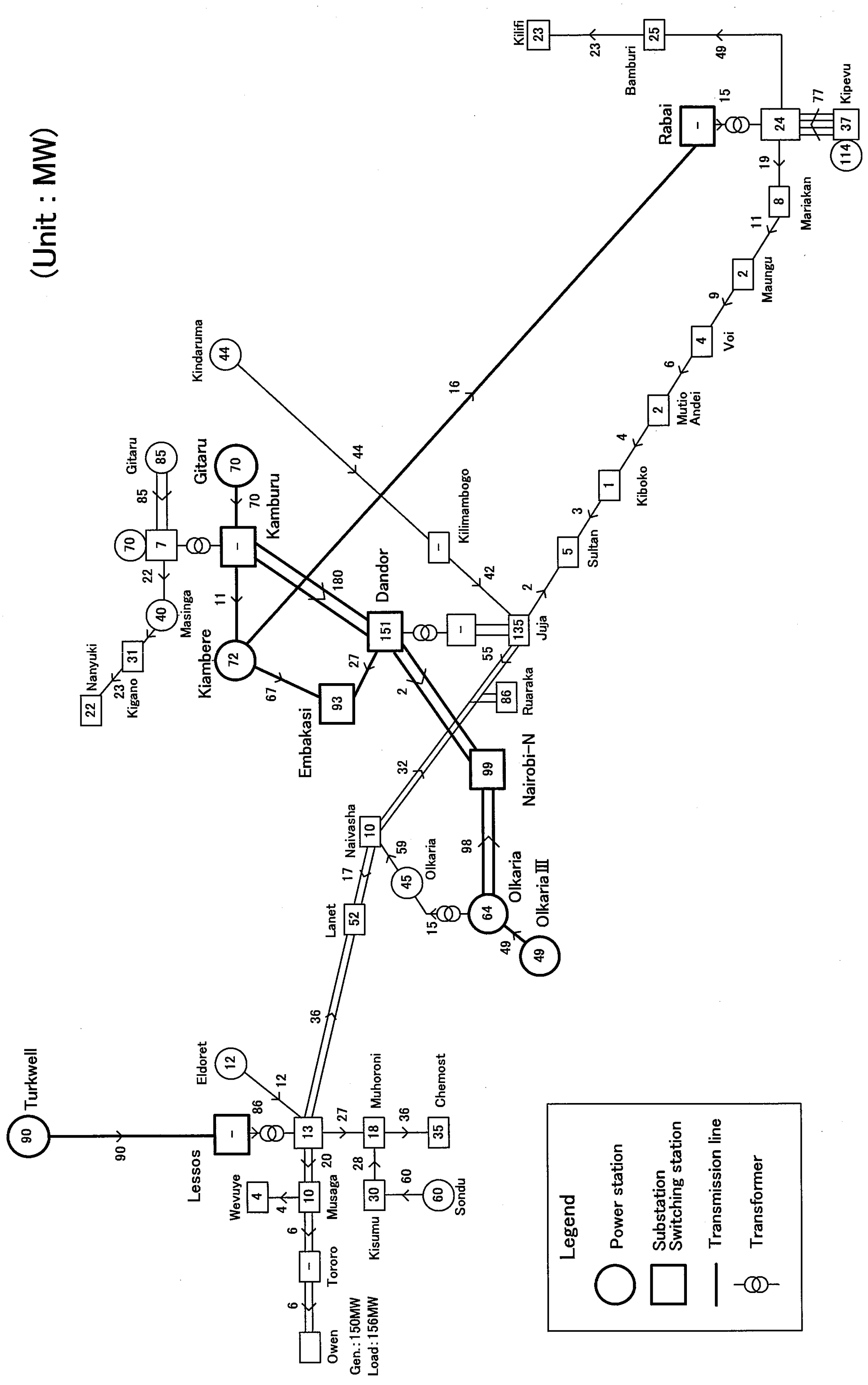
(2) Power Flow

Figure 2-3.7 indicates result of power flow analysis during wet season in 2009. Power is generated at almost full rated capacities at all power stations. As a consequence, balance of demand and supply is maintained within the central system centering around Nairobi owing to Olkaria geo-thermal power station plus Gitaru and other hydro-power stations. East and west systems are also balanced owing to local thermal power plant in the former and local hydro power station in the latter. As a consequence, power flow on 220kV transmission line connecting east and central systems and 132kV line turns out to be negligibly small, 16MW between Kianblin－Rabai (220kV) and 6MW between Voi－Mutio Andei (132kV) respectively. Likewise, power flow on 132kV line connecting central and west systems is also small as 17MW between Naivasha－Lanet. Thus any overload on the lines is unlikely.



Source: The Survey Team

Fig. 2-3.6 Power System Configuration and Transmission Capacity



Source: The Survey Team

Fig. 2-3.7 Result of Power Flow Analysis (2009 year system in wet season)

(3) Stability

Breaking times which are determined based on the operating time of breaker upon fault must comply with Kenya Grid Code, Schedule 3.1, Article S3.1.9 as listed below:

400kV:100ms、220kV:120ms、132kV:120ms

As there is no 400kV system existing in Kenya in 2009, stability analysis was conducted as described below.

Three phase short circuit fault on one circuit of transmission line, then breaker to operate and isolate faulty circuit after 120ms of the fault

Further, faulty line was selected under the following criteria:

Object transmission line of the Project is Olkaria－Lessos line, function of which is to link central system with west system of Kenya. The line performing the same function is existing 132kV Juja－Naivasha－Lanet line. Under the circumstances, this existing 132kV line is selected as the faulty line in the analysis. Further in view of the fact that a fault on transmission line carrying large power flow tends to affect stability of the system more severely, existing 220kV Olkaria II－Nairobi North line was also placed under analysis.

After operation of breaker and isolation of faulty line, previous power flow on the said line is surcharged on the sound line. It turned out that in every case, the system appears to remain stable because the power flow before fault is relatively small and phase-voltage fluctuation curves appear to attenuate and converge with time.

Chapter 3 Long Term Power Development Plan in Kenya

3.1 Load Forecast

3.1.1 Introduction

It is very important to forecast the peak demand correctly because it is the basis for calculating the installed capacity and revenue to manage the project for decades to come. The survey team will carefully examine the load forecast based on the current economic situation and the Least Cost Power Development Plan (LCPDP) by the Ministry of Energy and KPLC.

3.1.2 Forecast by Kenyan Authorities

The load forecast in the LCPDP is based on the assumption that the GDP of Kenya will keep growing by 10% each year, which the Vision 2030 aims to achieve. Kenyan authorities including KPLC officially state that the peak demand of electricity will grow in accordance with that GDP growth forecast.

The Update of the LCPDP 2009-2029, announced in September 2008, also follows this GDP forecast and calculates the electricity demand in base, low and high cases for the next 20 years. The update predicts that the peak demand will keep growing by 10 ~ 11% annually in the 2010s and beyond. However, the December 2008 modified version of the LCPDP predicts that, reflecting the immediate economic downturn and slow recovery, the peak demand growth will remain at 8.0% until fiscal year (FY) 2012, which is lower than the previous forecast. At the same time, the peak demand is still expected to grow by around 10% annually in the mid- and long term. It is estimated that the peak demand will be 1,715MW in FY 2013[1], when this project is planned to start operation, an increase of 58% since FY2008. It is expected to reach 3,474MW in FY2020, and 8,183MW in FY2029, which are an increase of 320% and 750%, respectively, since FY2008.

3.1.3 Updating of LCPDP

The authorized development plan in Kenya, LCPDP had prepared for the first time in around 1966. According to planning section of KPLC, the full version of LCPDP had been made in 1980's with assistance of the World Bank. From description in LCPDP (Sep. 2008), the complete development plan of Kenya system was first prepared by Acres International Limited (Canada) in 1986. Then, the version has been updated according to the changes of economical

[1] Commissioning year of 2013 for Olkaria~ Lessos Line is forecasted by LCPDP. However, in this study, it is forecasted to start commissioning in 2016.

situation and power demand. The version Sept. 2008 targeted 2008 - 2029 had employed 10% of GDP for the coming 10 years as per Vision 2030. Later, this GDP was slightly revised downward by KPLC and the version Dec. 2008 has been internally prepared. This version (Dec. 2008) is employed in this study. However, this version is still under preparation and will soon be finalized as the Version 2010-2030.

LCPDP, First Report (Sep. 2009) provided by KPLC consists of Executive Summary, Introduction, Demand forecast, Forecast of fuel price, List of possible development plans for generating equipment & transmission lines, Planning method of generating equipment (by using software called Generation simulation or GENSIM). As the output, the recommendable priority of development, the sequential patterns of "Geothermal + coal + Import (Hydro) + Gus turbine" etc. are listed.

Official report of Sep. 2009 version exists and there are Base Case, Low Case & High Cases in demand forecast, while Dec. 2009 version has only Base Case and only electric file exists. In the study afterward, where LCPDP is referred to, this means the version of Dec. 2009.

3.1.4 Demand Forecast and Economic Condition

While the Government of Kenya aims to achieve more than 10% of GDP growth in the mid- and long term, some international organizations see more modest prospects for the Kenyan economy. According to the latest World Economic Outlook (WEO) released by the International Monetary Fund (IMF) in April 2009, Kenya’s GDP growth rate at constant prices, affected by the global economic downturn, was 2.0% in the calendar year (CY) 2008, which is significantly lower than 7.0% in the previous year. The IMF estimates that the growth rate will recover to 6.3% in CY2012 and reach 6.5% in CY2013, the same level as before the global economic crisis in 2008, but will not increase further.

Through interviews with analysts of various agencies in Kenya, such as World Bank or Japan External Trade Organization (JETRO), they have the same opinion as IMF regarding 6.5% of GDP growth.

The LCPDP assumes that electricity demand grows on par with GDP growth. Hence, the survey team applied the same forecast method as the LCPDP to the load forecast based on the IMF’s GDP outlook. Since the IMF data are CY-based, they need to be adjusted to KPLC’s FY (July to June)-based ones to be comparable.

Table 3-1.1 GDP Growth Forecast by LCPDP and IMF

Fiscal Year	Low Forecast	**Basic Forecast**	High Forecast	**IMF Forecast***
2007/2008	4.5%	**4.5%**	4.5%	**4.5%**
2008/2009	6.9%	**7.9%**	8.4%	**2.5%**
2009/2010	7.7%	**8.7%**	9.1%	**3.5%**
2010/2011	8.4%	**9.4%**	9.9%	**4.5%**
2011/2012	9.0%	**10.0%**	10.5%	**5.7%**
2013/2013	10.0%	**11.0%**	11.5%	**6.4%**
After 2014	10.0%	**11.0%**	11.5%	**6.5%**

*Modified CY data for FY

Sources: LCPDP (September 2008), IMF: The World Economic Outlook, updated in April 2009

The IMF forecast shown in Table 3-1.1 considers the effect of the global economic crisis in 2008. Therefore it is more realistic than the LCPDP whose forecast was released before the crisis. As the LCPDP assumes that the GDP growth in the low forecast is 1% lower, and 0.5% higher in the high forecast, than that in the basic forecast, the demand forecast in Table 3-1.1 which is based on the IMF GDP growth data may vary between +0.5% and -1.0% from the basic case. Here, the growth of System peak demand (recorded in MW) and GDP growth rate will be compared. Table 3-1.2 shows System peak demand (actual MW) and System effective capacity of the generating equipment (MW) in Kenya.

Table 3-1.2 System Peak Demand and Effective Capacity

Fiscal Year	1994/95	1995/96	1996/97	1997/98	1998/99	1999/00	2000/01
System Peak Demand (MW)	605	648	680	721	734	708	724
System Effective Capacity (MW)	Not av.	723	754	791	831	909	988
Fiscal Year	2001/02	2002/03	2003/04	2004/05	2005/06	2006/07	2007/08
System Peak Demand (MW)	760	786	830	884	916	979	1,036
System Effective Capacity (MW)	1,096	1,047	1,142	1,067	1,135	1,153	1,267

Note: System Peak Demand excludes export demand. "Not av." means "Data not available".

Source : KPLC Annual Report (1999-2008)

Detail of the methodology of demand forecast was described in the Final Report.

Anyway, slight difference in the GDP growth can be a substantial one in the peak demand of each case in the future, even if the same calculation method is used. For example, the LCPDP, assuming an annual GDP growth of 10%, estimates the peak demand in 2014/15 to be 2,112MW, which is about 129% of the basic case in the IMF forecast. In 2028/29, however, the LCPDP forecast is 8,183MW and the IMF forecast is 4,517MW. The ratio between the two will expand to about 180%.

In this study, the demand forecast in LCPDP is to be mainly referred because it is the officially authorized forecast. While, IMF based forecast will also be taken into consideration to avoid the overinvestment.

In designing transmission system for long-term future, differences in the employed demand will cause the different development plan of the system. However, this difference is the difference of the timing of construction for each plants or lines, and anyway the targeted system will be unchanged basically. Therefore, in power system study we will indicate fiscal year based on the LCPDP forecast.

3.2 Power Development Plan

3.2.1 Vision 2030 and Power Development Plan

In Vision 2030, objectives of maintaining average 10% GDP growth for coming 25 years, and achieving 40% of electrification rate in 2020 were presented, and based on those objectives, the Least cost power development plan (LCPDP) and the Rural electrification master plan (REM 2009) are prepared. On the other hand, the master plan for the East African Power Pool (EAPMP) was prepared by EAC employing BKS Acres of Canada, and it envisaged future power interconnection network among member countries of NBI.

LCPDP of Kenya and REM 2009 are prepared based on Vision 2030. EAPMP for the East African Power Pool is for inter-border connections for countries and its target area is much wider than the target area of LCPDP.

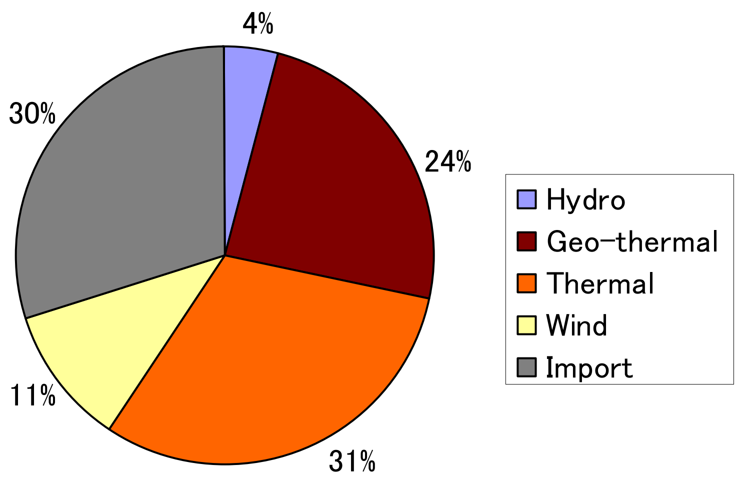
3.2.2 Power Development Plan in Kenya by LCPDP

Power development plan up to 2020 from LCPDP (Dec. 2008) is as follows. Summary of the plans are 1) development of power resources during the period of 12 years from 2008/09 to 2019/20, 70.6 MW of hydro power, 795.1 MW of geo-thermal power, 1,028 MW of thermal power and 355.1 MW of wind power, 2,248.8MW in total (including decommissioning of old plants by 2019/20), and 2) import of 1,000 MW from Ethiopia.

Proportion of power resources to be developed from 2008/09 to 2019/20 including imported power is shown in Figure 3-2.1. Major sources of energy supply to be developed are geo-thermal and thermal (principally coal-thermal), imported power is also high percentage.

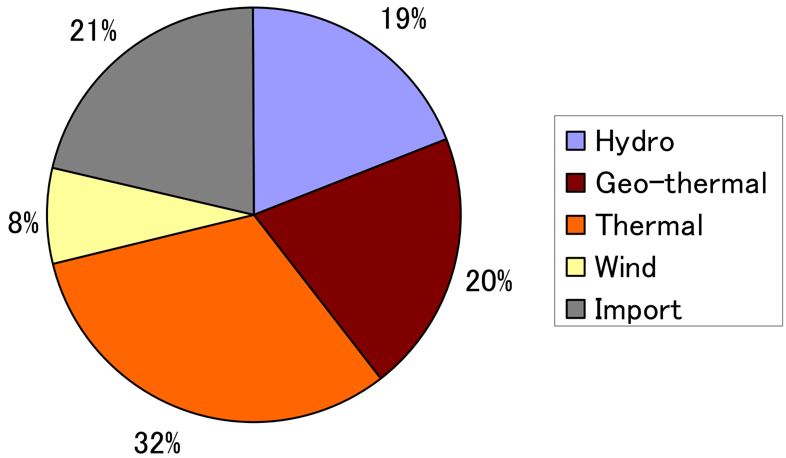
Figure 3-2.2 shows Proportion of Power Resources at 2020 stage. Comparing with the existing system in Chapter 2, ratio of hydro power will be drastically reduced from 52% to 18%, ratio of thermal power will be maintained as 32%, geo-thermal power from 13% to 20%, wind power from 0% to 8%, and import will take up 22%.

Because hydro power is in majority of power source at present, variation of power output between dry and wet seasons causes huge impact on unbalance of supply and demand. Shortage of power occurs in dry season. However, the ratio of hydro power decrease in future, so that variation of power output between dry and wet seasons will less affect the power supply in future.



Sources: Prepared by Survey Team based on data from KPLC

Fig. 3-2.1 Proportion of Power Resources to be developed (Planned in the period of 2008/09 - 2019/20)



Sources: Prepared by Survey Team based on data from KPLC

Fig. 3-2.2 Proportion of Power Resources at 2020
(Targeted Proportion in 2019/20)

3.2.3 Balance of Supply and Demand

Severe condition on balance of supply & demand is going to continue for a while. Reserve margin is expected to drop to 11 % at 2010/11. By inauguration of coal-power plant of 300 MW at 2011/12 and start of power import from Ethiopia amounting 200 MW at 2012/13, reserve margin of around 15 % will be secured in the plan.

3.2.4 Power Import from Ethiopia

Import power from Ethiopia increases step by step to 200 MW at 2012/13, 400 MW at 2014/15, 600 MW at 2016/17, 800 MW at 2018/19 and 1,000 MW at 2019/20. Details of Ethiopian power sources for import are hereinafter described in Chapter 4. Those power sources are hydro power plants, such as Gibe III Power Station (P/S) (1,800 MW: 900 MW at 2011 and 900 MW at 2012), Mendaya P/S (2,000 MW: to inaugurate in 2018). Power generation cost of Gibe III P/S is of US$0.0457 (from: Ethiopia-Kenya Power System Interconnection Project Draft Final Report May 2008 by Fichtner). Even if the transmission line cost of long distance of 1200 km is added to the generation cost, total cost is still expected to be lower than the cost of thermal power generation. The power importing from Ethiopia is considered attractive for Kenya.

Additionally, it is advantage to utilize power from Ethiopia to compensate decreased output of Kenyan hydropower in dry season. Because Kenya and Ethiopia are positioned on opposite sides of the equator, Ethiopia has rainy season while Kenya has dry season. Especially, in the hottest dry season called “Kiangazi” from June to September in Kenya, Hydro generations in

Ethiopia enjoy rainy season with maximum rainfall of a year. Power trading by cross-border interconnection between Kenya and Ethiopia has the huge advantage for both countries.

3.3 Network Augmentation Plan

In 2011/12, the first 400 kV transmission line in Kenya will be inaugurated between Mombasa (Mariakani P/S) and Nairobi (Isinya S/S) to utilize power from Mariakani P/S, large scale coal thermal power plant at coastal area. In 2012/13, direct-current interconnection line with Ethiopia will be inaugurated and power import of 200 MW will be started. To transmit the imported power to inland of Kenya a 400 kV transmission line (Logonot-Isinya line) will be inaugurated. And another 400 kV transmission line (Arusha-Isinya line) will also be completed to transmit power from/to Tanzania. Additionally, upgrading of existing 132 kV interconnection line with Uganda into 220kV system by inauguration of 220 kV Lessos-Tororo line will make drastic increase of power trading capacity.

Because existing 132 kV transmission line (Juja-Naivasha-Lanet-Lessos) is aged over 50 years and its carrying capacity per circuit of 77 MW (at power factor of 95%), as a measure against overload and reliability improvement, new 220 kV line (Olkaria-Lessos) is planned to inaugurate in 2012/13.

By construction of above mentioned trunk transmission lines, power highway network runs right across the east-west direction of Kenya will be built and a huge cross-border interconnection line with neighboring countries, such as Ethiopia, Uganda and Tanzania, will also be completed.

3.4 Rural Electrification

The ratio of electrification in Kenya in June 2007 is said to be around 17% on household base, but if rural areas are only counted it becomes from 7 to 8%. The Ministry of Energy established Rural Electrification Authority (REA), and set the target of 20% electrification by 2010, and 40% by 2020. This target, 40% by 2020, is also presented in KPLC's "5 Year Corporate Strategic Plan 2007/08 to 2011/12" as one of the important targets to contribute to Vision 2030.

Rural electrification basic plan was made in 1997, and also in 2007. At present, the rural electrification project is being implemented following the latest plan made March 2009 by revising the plan of 2007 mentioned above. This latest plan is "The Completion of the Rural Electrification Master Plan", and indicates its target period of 10 years from 2008 to 2018. The plan targeted electrification of additional 650,000 households in 2008 - 2013, and additional 850,000 households in 2014 - 2018, then additional 340,000 households by 2020, totaling 2,920,000 households. This value is 40% of total targeted households of REM, 7,240,000. In REM, through field survey and assistance of Local Community, the numbers of possible households which can have access to electricity by limited budget are estimated yearly base, and the study came to the conclusion that the value is to be 40% in 2020.

3.4.1 Rural Electrification Plan

The Government of Kenya, who considers the rural electrification as one of its important policy, established REA to proceed with the work quickly and efficiently. The position of REA in the government organization is shown in Chapter 2. The rural electrification plan consists of the following two plans according to the density of demands and access (distance) from the existing power grid.

- Grid Extension RE Project :
  Extension of the existing grid and extension of high voltage distribution lines (11－33kV)
- Off-grid RE Project :
  Construction of small scale isolated grid, in rural area apart from the existing grid

3.4.2 Investment and Project Outcome

Total amount of investment is US$ 1,203 mil. and numbers of households to be electrified will be 650,000. 626 GWh energy, and 305 MW of capacity will be increased through the project.

REM 2009 recommends the consumer price of Ksh. 20/kWh for rural consumers of low income category as "RE Social tariff. Meanwhile, the report says the economically feasible price is ; Ksh. 24/kWh for Grid Extension RE Project and Ksh. 48/kWh for Off-grid RE Project. Considering that the consumer price of ordinary small scale consumers connected to KPLC system in city area is nd Ksh. 9 /kWh, it can be easily understood the difficulty of the connection of rural consumers in Kenya to KPLC grid, or to connect isolated grid.

3.4.3 Measures of Increasing Electrification Rate

For increasing electrification rate, finding appropriate donors for realizing subprojects recommended in REM 2009 is off course important. However, as the measures of providing low income households with electricity, the government of Kenya established special tariff system and loan system. Stima Loan, i.e., KPLC's loan system with low interest for rural consumers to achieve new electricity connection, is one of the examples.

3.5 Energy Sector Donor Coordination Group Meeting

In order to examine current status of assistances to power sector of Kenya, Energy Sector Coordination Group Meeting is being held every 4 months in Kenya among representatives of every donor country where views are exchanged to maintain assistance on right track. As scope of assistance includes multi-national integration schemes of electric power systems, review is also made on relevant electric power development plans of not only Kenya but also the neighboring countries. The meeting is organized by Ministry of Energy, Kenya and chaired by the representative of Agence Francaise de Developpement (AFD). Given below are outline of assistance to power sectors by these donors that are being subjected to review at the meeting.

Chapter 4 Regional Cooperation in Power Sector

Kenya' s power grid is linked with that of neighboring Uganda on the west side with a 132kV transmission line through which power is mutually shared. Kenya and Uganda thus have their electric power grids integrated into a single system. Moreover, there is a plan in which large amount of power will be brought from neighboring Ethiopia on the north with a Direct Current transmission line. Under the circumstances, to conducted site survey on electric power sectors the study team visited both Uganda and Ethiopia.

4.1 Activities of East Africa Power Pool

4.1.1 East Africa Power Pool (EAPP)

In working out a national electric power development plan, not only power generation and power system (transmission lines and substation systems) of own country but to take such wide range view as "Regional Power Sharing" where power is shared with neighboring countries, is understood to be very important. It would enable Kenya to import inexpensive power from neighboring countries where primary energy such as hydro-power is abundant. This concept of sharing electric power among a group of countries has come to be recognized as very important policy in African continent, where economic growth and increase of population are quite remarkable, and a number of such power pooling systems can be found.

East African Power Pool (EAPP) in which Kenya is a member country was founded in May, 2005, upon signing of collective notes by the 9 member countries of Common Market for Eastern & Southern Africa (COMESA) and Nile Basin Initiative (NBI). Its headquarters is located in Addis Ababa where, it still is in infancy, preparatory activities are being performed such as organizing staff, laying down rules of operation etc. Member countries are Burundi, Ethiopia, Kenya, Rwanda, Sudan, Uganda, Tanzania, Congo, and Egypt. Among them though, only Kenya and Uganda and part of Tanzania have attained certain degree of integration of their electric power grids that could qualify as “power pool” in real sense of the word.

With a view to strengthen function of EAPP, ministers of energy of Eastern Africa Community (EAC) decided to prepare East African Power Master Plan (EAPMP). The contract between EAC and BKS Acres (Canadian consultant) was made for carrying out the Master Plan study in March 2003. Phase-I for EAPMP was completed in September 2004, and Phase-II for EAPMP was completed in March 2005. In the Master Plan, concrete action programs are presented concerning interconnection of electric power systems among Kenya, Uganda and Tanzania.

It is noteworthy that at present Uganda and Tanzania are suffering from shortage of power that was caused by drop of water table in water reservoirs for power stations under prolonged drought. This situation furthered expectation for a scheme to distribute cheap power from Ethiopia who has huge hydro-power potential within the region on medium to long term basis.

4.1.2 East African Power Master Plan (EAPMP)

The final Phase-II report of EAPMP submitted by BKS Acres in March 2005 recommends to formulate cross-border interconnection lines between Kenya, Uganda, and Tanzania, rather than to construct independent power system in each country, because of the profits of efficient utilization of generating facilities or cheaper generation cost, etc. This report is still effective.

(1) Demand Forecast

Demand forecast from EAPMP Phase-II is shown in Table 4-1.1. Comparing with the demand forecast in EAPMP, the same from KPLC's LCPDP is drastically increased. For example, EAPMP forecasts average rate of demand growth in Kenya from 2010 - 2025 as 5.45%, while LCPDP forecasts as 10.43%.

(2) Method of Establishing System Planning

For establishing future power system, the following 3 cases are compared in EAPMP.

i) Case-1: Independent System
To establish independent power system in each country

ii) Case-2: Interconnection
To construct cross-border transmission line between Kenya, Uganda, Tanzania, and also Zambia.

iii) Case-3: One integrated system
To construct one complete system integrating Kenya, Uganda, and Tanzania, as if those three are single country.

In the comparison of the planning, the following conditions are considered.

- LOLE : Loss of load expectation : 10days / year
- Discount rate : 12% (9% case and 15% case are also considered)
- Price of imported oil : US$ 25 / barrel
- Price of imported coal : US$ 27 / ton (Price at Mombasa port)
- Tax for emission of exhaust from thermal plants : US$ 10 / ton
- Loss for blackout : US$ 0.71 / kWh

Economical comparison of the 3 cases are made between capital investment in 20 years duration from 2004 to 2023, and operation cost (fuel cost and maintenance charge) in 35 years duration from 2004 to 2038. All the costs in future were converted to the value of the year 2004. However, in the period of 2024 ~ 2038, additional investment and additional increase of demand, change of fuel price, are not considered.

(3) Candidates of Power Development

Candidates of hydro and thermal power plants considered in EAPMP study were listed in its Final Report.

(4) Power Development and Its Cost

i) Case-1 : Independent System

In this case, each country will develop generating plants considering available energy sources (water or oil etc.) in their own countries. Each country will maintain appropriate Reserve Margin, and will construct transmission lines from generating plants to demand centers.

Amounts of necessary generating facilities during 2004－2023 to be constructed are ; 1,645MW in Kenya, 995MW in Uganda, 798MW in Tanzania, and 3,438MW in total.

For the transmission lines, 220kV Olkaria - Lessos, 2 circuits lines is also proposed. In this plan, one circuit of this line directly connects Olkaria and Lessos while another goes via. Nakuru (Lanet) S/S by constructing new 220kV Nakuru S/S. Lessos - Kisumu line is planned to be 220kV because the plan considered 360MW gas combustion turbine/combined cycle plant in Kisumu and thus, such new line becomes necessary.

The costs required by this case are shown below. The costs are calculated by converting investigation and operating costs for 35 years into the present values (year 2004).

Table 4-1.1 Cost for Case-1 (Independent System)

Country	Cost (Million US$)		
	Generation	Transmission	Total
Uganda	314	98	412
Kenya	2,409	142	2,551
Tanzania	823	115	930
Total	3,546	355	3,901

Source : The East African Power Master Plan Study Final Phase II Report

ii) Case-2 : One Integrated System

By integrating systems of three countries into one system, power source can be effectively utilized. This means the reserve margin can be shared by the member countries so that it can be minimized. Total capacity of the necessary generating system can also be minimized. Developed capacity of new generating facilities will be 1,015MW in Kenya, 1,073MW in Uganda, 942MW in Tanzania, and 3,030MW in total. This is 408MW less than the total capacity of Case-1, 3,438MW. The capacity decrease of coal fired thermal and combustion turbine/combined cycle are conspicuous.

For their effective power exchange becomes necessary so that cross-border interconnection lines, such as 220kV Tororo－Lessos line between Uganda and Kenya, and 330kV arusha－Embakasi line between Tanzania and Kenya are recommended. Meanwhile, increase of power import will affect internal power flow in Kenya. Rabai －Embakasi line is 330kV in Case-1, however, it becomes 220kV and it decreases investment. 220kV Lessos－Kisumu line which was recommended in Case-1 became unnecessary because the combustion turbine/combined cycle plant in Kisumu became much smaller. It shall be noted that this result is based on the smaller scale demand forecast in EAPMP.

Under such circumstances, differences of costs in transmission line augmentation between Case-1 and Case-2 are not large. Economical advantage of Case-2 is mainly due to reduction of development costs for generating facilities.

The costs required by this case are shown below. The costs are calculated by converting investigation and operating costs for 35 years into the present values (year 2004).

Table 4-1.2 Cost for Case-2 (One Integrated System)

Cost (Million US$)		
Generation	Transmission	Total
2,955	489	3,445

Source : The East African Power Master Plan Study Final Phase II Report

(5) Economical Analysis

Cost comparison of Case-1 (Independent system) and Case-2 (One integrated system) is shown in Table 4-1.3. In this table, rate of loan is set as 12%. And the cases of 9% and 15% are also shown.

Efficient use of generating facilities and decrease of reserve margin will decrease the investment cost for Case-2. Case-2 has advantages.

Table 4-1.3 Cost Comparison of "Independent System" and "One Integrated System"

Scenario	9%	12%	15%
(a) Independent System	US$5,094 mil.	US$3,901 mil.	US$3,099 mil.
(b) One Integrated System	US$4,401 mil.	US$3,445 mil.	US$2,784 mil.
Benefit (a-b)	US$693 mil.	US$456 mil.	US$315 mil.
B/C Ratio (a/b)	1.16	1.13	1.11

Source : The East African Power Master Plan Study Final Phase II Report

(6) System Recommended under EAPMP

220kV Olkaria－Nairobi North line, augmentation of Olkaria－Lessos line inside of Kenya, and 330kV Arusha－Embakashi line as an interconnection line with Tanzania, augmentation of 220kV Tororo－Lessos line as an interconnection line with Uganda, are recommended in EAPMP. 220kV Olkaria－Nairobi North line had been already constructed.

4.2 Power Sector in Uganda and Export to Kenya

4.2.1 Power Sector

In Uganda, electric power had been generated and distributed solely by Uganda Electricity Board (UEB). In 1999, restructuring the power sector was executed according to revision of the electric power law, where pyramid-type management of UEB was converted to function-oriented management creating Uganda Electricity Generation Co. Ltd (UEGCL), Uganda Electricity Transmission Co. Ltd (UETCL), Uganda Electricity Distribution Co. Ltd (UEDCL), and Rural Electrification Agency (REA).

4.2.2 Power Demand

(1) Peak Demand and Energy Demand

In 2007, water intake to Owen Falls power station was restricted to counter drop in water level of Victoria Lake under prolonged drought allowing only 80% of full output capacity. This in turn worked as an oppressive force on the power demand resulting in a negative growth in 2007. This trend since has turned around to upward trend.

Demand forecast was carried out on three scenarios, with a result of growths high 9.7%, moderate 7.7% and low 5.0%.

(2) Load Curve

Peak normally appears at the time of switching-on of lighting in the evening. Yearly load factor is reported to be about 60%.

4.2.3 Power Development Plan

Predominant is hydro-power accounting for 71% of all. Owen Falls power station comprising Kiira and Nalubaale stations with Victoria Lake as water source is the most outstanding power source. Heavy reliance on hydro-power makes the country's power system vulnerable to climate. Drought in 2007 induced drop of power generation at this station and the shortage of power had to be countered by introduction of scheduled load shedding and installation of two sets of diesel engine power plants manufactured by Aggreko, UK at Lugogo and Kiira cities.

During coming 14 years, total 1710.5MW is expected to be generated, hydro-power 1460.5MW, thermal power 200MW (incl. solar energy) and co-generation 50MW. Among others, Bujagali power station is slated to play primary role in the immediate future generating 50MW in 2010 plus 200MW in 2011.

4.2.4 Power Export

Uganda is exporting surplus electric power to neighboring countries based on bilateral agreements. It is noted though that power output from Owen Falls power station, primary power producer source of the country, has been declining recently due to drop of water level in Victoria Lake under prolonged drought and the same trend is also found in export of power. Uganda's future plan of demand and supply expects that Bujagali, Ishima, and Ayago power stations are completed in due course allowing export of surplus power.

4.2.5 Power Grid

Electric power grid in Uganda is constituted mainly of 132kV lines including some 66kV lines which, however, are going to be phased out. At present in 2008, there are 132kV transmission lines in 1366.5km in total plus 66kV lines of 38km long and 13 primary substations. 132kV power is dropped to 33kV at substations and placed on 33kV distribution lines. This is further dropped to 11kV at 33/11kV substations near consumers.

It is reported that there is a plan to introduce a 220kV transmission line in future as trunk line running east-west to meet growing scale of domestic electric power demand, which is also expected to be integrated into the cross-border regional grid. Moreover introduction of 400kV line is reported being considered.

4.2.6 Power Flow

Expected power output varies tremendously between rainy and dry seasons in Uganda because hydro-power is the mainstay. It is thus a normal practice to figure out circulation of electric power based on the average power output between the two seasons.

The present power flow in Uganda in 2008 is presented in the Final Report. Output of Owen Falls power station rules the total flow of the country so that the flows exist from the station as the center to the west, Kampala, and the other flow to east, Tororo.

4.2.7 Foreign Donors' Activities in Uganda

Major activities of foreign donors in Uganda in the power sector are shown in EAPMP's Final Report. Due to the political unrest in the past and uncertain repayment capacity, there are not so much activities by foreign donors in construction of generating facilities and transmission facilities.

4.3 Electric Power Sector in Ethiopia and Export Potential

4.3.1 Power Sector in Ethiopia and Export to Kenya

Power transmission, distribution and selling in Ethiopia are being undertaken only by EEPCo (Ethiopian Electric Power Corporation), sole public corporation in electric power sector. It comes under the jurisdiction of Ministry of Mine and Energy (MoME). EEPCo was founded in 1997 by restructuring its predecessor Ethiopian Electric Light and Power Agency (EELPA), which had been founded in 1956 succeeding the business of an Italian enterprise then doing electric business in the country.

4.3.2 Power Demand

(1) Peak Demand and Energy Demand

During the recent 10 years period, demands demonstrated high growth rates, average 7.8% and 8.5% in peak demand and energy demand respectively, thanks to the 2-digit economic growth. Particularly in 2005, the growth rates jumped high to max. 20.6% and max. 14.5% in peak demand and energy demand respectively.

(2) Daily Load Curve

From the daily load curve on a day in January, 2008 in Ethiopia, peak demand appears between 19-20 p.m. when lighting starts in the evening. Average yearly load factor is reported to be around 58%.

(3) Demand Forecast

The peak demand in 2008 should be taken as a suppressed demand caused by deficiency of supply, namely it was believed to be obscured latent demand. The forecast for the succeeding years assumes that there will be sufficient supply. As a consequence, average growth rates from 2008 thru 2011 turned out to be rather high 29% and 21% in target scenario and moderate scenario respectively. Afterwards, demand levels off from 2011 thru 2018, 13% and 11% in target scenario and moderate scenario respectively. Expectation is that from 2011 onwards, power could be exported to Kenya, Sudan and Djibouti by as much as 1,250MW thanks to completion of large scale hydro-power stations by that time.

4.3.3 Power Development Plan

(1) Existing Power Plants

Power sources in Ethiopia is predominantly hydro-power, 86%. Remaining is from diesel (13%) and very small geo-thermal (1%). As hydro-power generation is dependent on climate (precipitation), the country tends to suffer from severe power shortage under prolonged drought.

In fact, the Study Team witnessed scheduled load shedding being exercised in Addis Ababa during the stay in the beginning of July, when it was just the beginning of rainy season but residual effect of dry season was still pervading.

(2) Power Development Plan

The Ethiopia's power development plan intends to develop 7,984MW of power in total in ten years from 2009 thru 2018, mainly from hydro power generation, to meet domestic demand as well as for export. Gibel Gibe II power station (output 420MW) was substantially completed and impounding water into reservoir is in progress at present in July, 2009. It will start power generation in September of the same year. In addition, Tekeze and Beles power stations will also start operation, increasing the total output to 1,798MW, almost two times that of the previous year. Shortage of power could be eliminated at a stroke and even export of power materialized.

Gibe III power station will be located at lower reach of Gibe II power station on Gibe river, accompanied with the highest dam in the world (240m). It will generate whopping 1800MW of power with 10 units of 180MW generators. Progress of the project in July, 2009 was around 30%. Power output will be in two steps, 900MW in 2011 and another 900MW in 2012. Although it was planned in the initial stage to start transmitting power to Kenya through a direct current 400kV transmission line in 2012, delay of this line will push back the start to 2013. Electric power delivery will step-wisely be increased from 200MW in 2013 to 1000MW in 2020.

4.3.4 Expansion of Transmission Lines

(1) Existing Transmission Lines

Voltage is classified into 230kV, 132kV, 66kV and 45kV and lengths of them are 2,194km、2,743km、1,782km, and 399km respectively.

As for progress of Ethiopia - Kenya interconnection line, even though the project office of EEPCo for the line exists Addis Ababa, the donor for the line construction is not yet fixed according to the officials in the office.

(2) Expansion Plan of Transmission Lines

For the first time, ultra-high voltage 400kV transmission lines are going to be put in operation in 2009 to accommodate power generation at Gibe II power station. Power demand scale in 2018 is estimated at approx. 5 times larger than that of 2008. Expansion of transmission lines will be carried out accordingly, expansion total being 6,460.9km comprised of 2,556km of 400kV, 2,941.6km of 230kV, and 963.3km of 132kV.

4.3.5 Foreign Donors' Activities in Ethiopia

Major activities of foreign donors in Ethiopia were shown the Final Report. Similar to Uganda, donors do not easily offer their loan for the planned generating and transmission facilities. Especially the donors for most of the planned transmission lines are not yet determined.

Chapter 5 Power System Analysis

5.1 Conditions for the Power System Analysis

Power system analysis was conducted in this chapter for the following purposes based on LCPDP (Dec. 2008) :

- To confirm the needs for construction of 220kV transmission lines between Olkaria and Lessos, and 132kV (original proposal) transmission line between Lessos and Kisumu,
- To determine the scale/size of plants, and
- To verify the advantage by construction of those transmission lines

The targeted years for the analysis were 2013 that LCPDP defined as the commencement year for the operation of transmission line between Olkaria and Lessos, and also 2020 in order to verify a long term function after construction of the line. In addition, since there are much hydropower stations in the whole countries, both scenarios for wet season and dry season were analyzed for obtain the different patterns of load flow.

5.1.1 Demand Forecast, and Augmentation Plan of Generating Plant & Grid

The power demand, power sources and reinforcement plan of the grid for the analysis were from LCPDP (Dec. 2008). This was obtained as the latest edition from KPLC during the first site survey. LCPDP has been now internally revised by KPLC from the LCPDP dated September 2008.

The power demand forecast was already discussed in Chapter 3.1, and the forecast for maximum power demand is again mentioned in Table 5-1.1. The augmentation plans of generating plant & grid which were discussed in Chapters 3 are used for the analysis.

Table 5-1.1 Power Demand Forecast used for Analysis

Year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Peak load (MW)	1,086	1,173	1,267	1,368	1,477	1,715	1,905	2,112	2,339	2,586	2,856	3,151	3,474

Source: LCPDP, December 2008

5.1.2 Software for Analysis and Modeling

The software PSS/E (Version 31) was used for the power system analysis. KPLC provided the Survey Team with necessary input data in PSS/E format which the Survey Team could utilize for this analysis.

For the analysis this time, the data from LCPDP (Sept. 2008 and Dec. 2008) were updated for the year 2013 by Survey Team.

The loads of each substation in 2020 was calculated based on 2013 data and were made commensurate with total demand rate between 2013 and 2020. Power generating plan and the system augmentation were fitted the data in LCPDP (Dec. 2008).

The model of grid for analysis as of 2013 reflects all generating facilities and 400kV, 220kV, 132kV and 66kV transmission line networks in detail, as shown in Table 5-1.2 below.

Table 5-1.2 Scale of Model for Analysis

Item	Demand	No. of busses				No. of lines				No. of generators
		400kV	220kV	132kV	66kV	400kV	220kV	132kV	66kV	
Quantity	1711MW	4	19	47	59	6	25	58	63	50

Source: JICA Survey Team

5.2 Result of Power Flow Analysis of 2013

5.2.1 Geographical Distribution of Power Sources and Loads

The load flow is influenced by the balance of electrical supply and load, regionally. In case that the electrical supply and load balance regionally, the load flow is to be small, meanwhile in case unbalance, the load flow is to be large.

Nairobi area has 56% of the entire electricity demand in Kenya but the power sources do not exist in the area so as to import the power from other regions such as Coast area, Mt. Kenya area, and Central Rift Valley area. In connection to the variety of power generation, there are thermal power plants less subject to the amount of precipitation in wet and dry seasons, such as Olkaria geo-thermal power plant in the Central Rift Valley area and large scale thermal power plants in the Coastal area. On the other hand, there are a lot of hydropower plants in the areas of Mr. Kenya, North Rift Valley and West Region, so that the output varies in the wet and dry seasons.

The 132kV transmission line Naivasha-Lanet-Lessos will be loaded by the balance between demands and generation outputs both in the West Region (including Lanet substation) and North Rift Valley Region. The West Region has a large power demand for supply to Kisumu-city and Nakuru-city being the third and fourth-most populous cities respectively. Meanwhile, the power sources around these regions are not sufficient even including the power import from Bujagali P/S in Uganda. Although the deficit power must be supplied through the 132kV transmission line of Naivasha-Lanet-Lessos from eastern side, those lines were constructed more than 50 years ago and tend to be overloaded. The current carrying capacity of the 132kV transmission lines is only 77 MW (under power factor of 95%) per one circuit.

5.2.2 Result of Load Flow

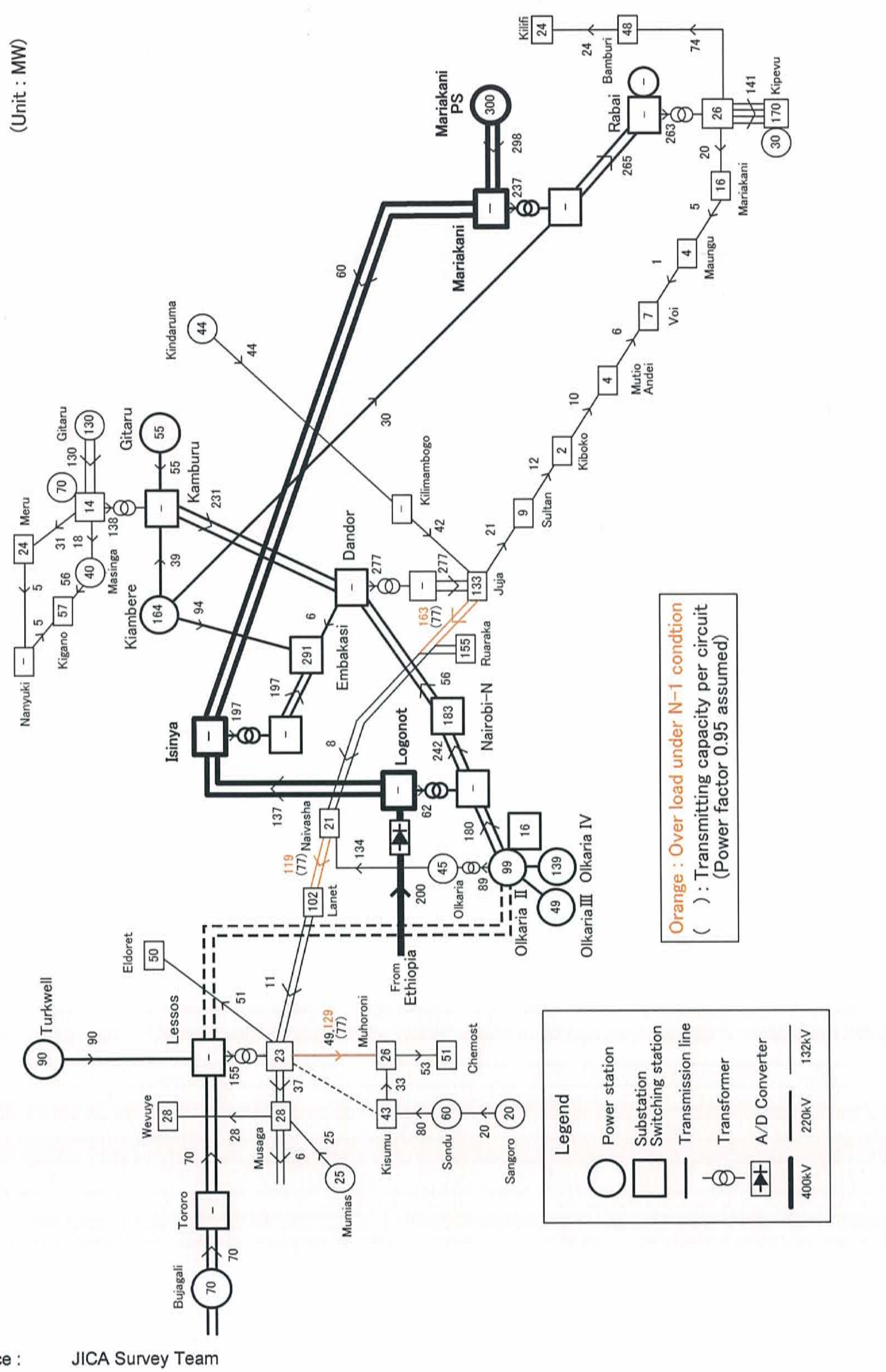
Before planned upgrading of the transmission lines during the rainy season, there is not any overload on transmission lines under the normal operating condition, whereas there are overload on 132kV transmission lines of Naivasha－Lanet line, Lessos－Muhoroni line, and Juja－

Ruaraka line under N-1 conditions. According to the regulation of electricity supply reliability in KPLC, it is ruled that the any fault under N-1 conditions should not cause blackout. Therefore, some countermeasures must be needed for major facilities against the operation under N-1 conditions.

Before completing of planned upgrading of the transmission lines during the dry seasons, there are a lot of overloading on the lines. Especially, the overload may occur on 132kV lines of Olkaria－Naivasha, Naivasha－Lanet, and Juja－Ruaraka, even under the normal operating condition.

Among those transmission lines, the overload on the 132kV line Juja－Ruaraka will not be settled even after completion of planned upgrading of the transmission lines because this transmission line is used for the purpose of feeding a large power (155MW) to Ruaraka substation. Therefore, this problem should be resolved separately, and would not be considered in this survey.

Most of the problems of overload on many transmission lines will be settled after implementation of planned upgrading of the transmission lines. However, overload of two lines, 132kV Lessos－Muhoroni and 132kV Naivasha－Lanet will remain under N-1 conditions.



Source : JICA Survey Team

Fig. 5-2.1 Load Flow Analysis for Year 2013
(Before reinforcement of T/L, Wet season)

5.2.3 Measures of Overload on the Line between Naivasha and Lanet

The overload occurs on existing 132kV line from Naivasha to Lanet during the dry season even after completion of the upgrading of the line between Olkaria and Lessos. This overload is caused because the transmission capacity of the conductor for the line between Navasha and Lanet is only 77MW, but the demand of Lanet Substation at the end of this line is 102 MW. For this countermeasure, it is proposed that the transmission line for feeding Lanet Substation may be operated under 220kV, as mentioned in the following two cases.

Case1: The Existing Lanet substation supply the load up to 2009 without any augmentation. The increased load after 2009 is supplied partly by new Lanet 220kV substation. This case is recommended because Case 2 requires a new 132kV transmission line.

Case2: A new 220/132kV Lanet Substation is constructed and connected with 220kV feeder from Olkaria－Lessos line. And a new 220/132kV Lanet Substation is connected to the existing 132kV Lanet Substation and all loads in Lanet substation are supplied by the 220kV transmission line.

5.2.4 Result of Fault Current Analysis

Since the interconnection with Ethiopia is planned as D.C. operation, this interconnection itself increase the fault current. Hence, the fault current will be comparatively small such as 4.30kA at 400kV Isinya Substation, 8.89kA at 220kV Dandor Substation and 11.59 kA at 132kV Kamburu Substation. Those current values are much less than the rating 40kA of circuit breakers.

5.2.5 Stability Analysis

(1) Conditions for Stability Analysis

Kenya Grid Code regulates that the fault breaking time is at <u>100ms for 400kV</u>, <u>120ms for 220kV</u> and <u>120ms for 132kV</u> according to Article S3.1.9 of Schedule 3.1.

Therefore the stability analysis was conducted under the conditions that transients were initiated by three phase faults on the system, and the circuit breaker will open the circuit in <u>100ms</u> or <u>120ms,</u> then the faulted circuit will be isolated.

(2) Result of Stability Analysis

The outline of result of analysis is mentioned below.

[Before the upgrading of planned transmission lines]

During the rainy season, since the supply of power by hydropower plants is secured, the load flow from the east to the west, which normally occurs, is relatively small. Even when a line fault happens, the fluctuation may continue for some period but will fade away in time. All the cases are stable.

During the dry season with 70% rated output by hydropower plants, since the load flow from the east to the west increases, the conditions for stability becomes severe. The swing transient may occur and be damped for a long period except the case #10. In case #10 that a fault happened on the 132kV transmission line Olkaria I to Naivasha, the swing transient will occur and increase, then stability cannot be secured.

During the extremely dry season with 50% rated output by hydropower plants, all the cases will be unstable. Especially, in case of the fault at 132kV Naivasha－Lanet（case #14）、132kV Olkaria I －Naivasha (case #16) and 220kV Logonot－Nairobi North (case #17), the phase-voltage fluctuation increases in a very short period and becomes unstable.

[After the upgrading of planned transmission lines]

During both wet and dry seasons including extremely dry season, the swing of the phase-voltage fluctuation is small, and capable to be damped until stable condition.

5.2.6 Outline of Power Flow Analysis

The summary of result of power system analysis is shown in Table 5-2.1.

Since the 132kV transmission line Juja to Ruaraka is to be judged out of the project scope, overload on this line was not considered.

According to the result of this analysis, it is concluded that the planned 220kV transmission line Olkaria II to Lessos and 132kV transmission line Lessos to Kisumu are essential for dissolution of overload condition as well as maintain the reliability of the transmission system. It shall be noted that individual solutions are additionally necessary for 132kV Naivasha－Lanet line and 132kV Lessos－Muhoroni line.

Table 5-2.1 Summary of Result

Item	Season	Before augmentation of lines	After augmentation of lines
Overload line	Wet	132kV Naivasha-Lanet 132kV Lessos-Muhoroni	132kV Lessos-Muhoroni
	Dry(70%)	132kV Naivasha-Lanet 132kV Olkaria I -Naivasha 132kV Lessos-Muhoroni	132kV Naivasha-Lanet 132kV Lessos-Muhoroni
	Dry(50%)	132kV Naivasha-Lanet 132kV Olkaria I -Naivasha 132kV Lessos-Muhoroni 132kV Lanet-Lessos	132kV Naivasha-Lanet 132kV Lessos-Muhoroni
Stability	Wet	Stable	Stable
	Dry(70%)	Unstable	Stable
	Dry(50%)	Unstable	Stable

Red:Overload under normal condition Orange:Overload under N-1 condition

Source: JICA Survey Team

5.3 Result of Power Flow Analysis of 2020

The system analysis of 2020 system was conducted in order to verify a long term serviceability after completion of planned upgrading of the transmission line Olkaria－Lessos and Lesson-Kisumu. Tow cases of the generating power of hydropower station was selected, namely wet season and extremely dry season.

Case 1 described in 5.2.3 is assumed to be the supply method to New Lanet Substation. Furthermore, the Survey Team studied the transmission method of new Menengai geo-thermal power plant which will be located at northern area of Nakuru city, and the output will be 140MW in 2019 and another 140MW in 2020, totaling 280MW. The result of analysis is mentioned below.

5.3.1 Result of Load Flow

It is envisaged that Menegai geo-thermal power plant is connected to 220kV transmission line Olkaria－Lessos, because Menegai Power Plant will be located northern area of Nakuru and near the 220kV transmission line Olakaria－Lessos and the generating power of Menegai geo-thermal power plant will be as large as 280MW. Therefore, the Survey Team studied two cases about the connection of Menegai geo-thermal power plant for analysis, one is to connect to New Lanet substation as mentioned in 5.2.3, and another case is to connect to 220kV Olkaria II substation.

In case of the extremely dry season with 50% rating of hydropower, the 220kV transmission line OlkariaII－Lessos transmits the largest power flow. In case that Menegai geo-thermal power plant is connected to New Lanet substation, the load flow between New Lanet substation and Lessos substation is 501MW, whereas in case that Menegai geo-thermal power plant is connected to Olkaria II power plant, the load at the Olkaria II power plant and New Lanet substation is 705MW. Consequently, connecting Menengai geo-thermal power plant to New Lenat Substation is recommended because the load flow will be less and the transmission length is shorter than the connection to Olkaria II power plant.

For the new lines Olkaria－lessos and Lessos－Kisumu, the conductor size and even voltage can be determined to suit the envisaged current to be loaded in future. However, the countermeasure for overloads of the existing transmission lines Lessos－Muhoroni and Muhoroni－Chemosit shall be considered. The countermeasure is described in 5.3.2.

As mentioned in 5.2.2, although the 132kV transmission line Juja－Naivasha will be overloaded in 2013 as well as 2020, this problem should be resolved separately, and would not be considered in this survey.

5.3.2 Measures of Overload on 132kV Line between Lessos and Muhoroni

In case the transmission line Kisumu-Lessos of this project applies 132kV and one circuit as originally planned, the countermeasure of existing 132kV transmission line Lessos－Muhoroni will be necessary even the wet season because the power flow for this line will be overloaded against the transmission capacity 77MW under normal operating conditions.

Until now, although the voltage of transmission lime Kisumu－Lessos has been assumed as 132kV, the Survey Team recommends to apply 220kV. The transmission line Lessos－Muhoroni during both of wet and dry season will be overloaded by 97MW and 106MW respectively against the transmission capacity 77MW under normal operating conditions.

Furthermore, the line of Kisumu－Muhoroni will be overloaded at 162MW under N-1 condition.

Therefore, at the appropriate timing after augmentation of the 220kV transmission line Kisumu－Lessos, the transmission line of Lessos－Muhoroni or Kisumu－Muhoroni shall have countermeasures, for example, to add another circuit, or to replace size of conductor having larger capacity.

Additionally, the existing 132kV line Muhoroni－Chemosit will also be overloaded under normal operating conditions, and since this transmission line is the only supply line to Chemosit substation which has 104MW load, the same countermeasure is necessary.

5.3.3 Result of Fault Current Analysis

The increase of fault current is relatively small although the system scale will become doubled. The maximum fault current is comparatively estimated small such as 6.78kA at 400kV Mariakani Substation, 12.24kA at 220kV Olkaria II Power Plant, and 15.00kA at 132kV Dandor Substation. Those current values are less than the rating 40kA or 31.5kA of circuit breakers.

5.3.4 Result of Stability Analysis

As mentioned in 5.3.1, the recommended transmission methods from Menengai geo-thermal power plant is to connect itself to New Lanet Substation, and this method is also applied to the stability analysis. In addition to the wet season, the extremely dry season with 50% rating of hydropower is applied to the stability analysis. The conditions of analysis are the same as the system of 2013 in 5.2.5, which is very strict.

The outline of result of analysis is mentioned below.

After the fault, the swing of the phase-voltage fluctuation in all cases is relatively large because the power flow in dry season is severer than wet season. However, the swing of all the cases will fade away in time and are stable, and then the effect of augmentation of transmission line can be confirmed.

The stability will be severe when the fault occurs at the transmission lines having a long length and a large power flow. The reason is because the fault line is opened and the power flow before the fault will be additionally loaded on the transmission line without fault. The swing of the phase-voltage fluctuation of 132kV line Juja－Naivasha (case #1 and #8), 220kV line Olkaria II－New Lanet (case #4and #11) and 220kV Logonot－Nairobi North (case #5 and #12) are relatively large. These transmission lines are having large power flow before the fault and a long length, but it is no problem about stability.

5.3.5 Outline of Power Flow Analysis

It has been found out that, by implementing the proposed Project, all the problems in respect to overloading, fault current, and stability, can be solved in long term.

5.4 Necessary Transmission Capacity and Scale of Transmission Line

When augmentation of the system facility is made to select the excessive capacity, it will not be economical because the facility cannot be fully utilized until its lifetime ends. Meanwhile, to select the insufficient capacity also is not economical because it will soon be overloaded and the augmentation of the facility will be necessary again. Therefore, it is important to select the facility's capacity adequately. The Survey Team studied the necessary transmission capacity of Olkaria II－Lessos and Kisumu－Lessos.

As mentioned in 5.3.1, the 220kV transmission line Olkaria-II－Lessos in 2020 will carry 501MW power flow. And the transmission line Kisumu－Lessos under N-1 conditions during dry season will carry 237MW flow when the transmission line Lessos－Muhoroni is opened by a fault.

To calculate the power flow to the transmission line in long term future is not practical because the power generating plans and system augmentation plans in far future are not correctly determined.

The necessary transmission capacity will be determined by calculation the balances between demand and supply, because the transmission loss can be small enough to be ignored.

5.4.1 Demand and Supply of Kenya Western Region

The 220kV transmission line Olkaria-II－Lessos supplies to the power demands in the area of West Region, North-Rift Region and Lanet Substation in Central-Rift Region. Whereas, the power stations which located in the areas off Wesr Region and North-Rift Region are hydropower stations of Sondu/Miriu, Sang'oro and Turkwell, and Mumias Co-genetation power station. In addition, there is an imported power from Bujagari hydropower station in Uganda. Since the Survey Team assumed that Menengai geo-thermal power plant which will operate on 2019 and 2020 is to be connected to Lanet Substation planned to be located at the middle of transmission line of Olakaria II－Lessos, the transmission line Olkaria II－Lessos will increase its power flow by the rate of the balance between the generating power of Menengai geo-thermal power plant and the loads of New Lanet Substation.

At the transmission line Olkaria－Lessos, the power flow of transmission line of the New Lanet-Lessos will be larger than that of the line of Olkaria－New Lanet until the load of New Lanet Substation exceed the generating power of Menengai geo-thermal Power Plant (280MW).

5.4.2 Necessary Transmission Capacity of Olkaria - Lessos Line

(1) Power Flow Forecast of Olkaria - Lessos Line

The forecasted power flow of transmission line Olkaria-Lessos in 2020 based on LCPDP demand forecast is 229MW at Olkaria－New Lanet and 356MW at New Lanet－Lessos. However, power flow at Olkaria－New Lanet will overtake after 2025 when the load of New Lanet Substation exceed the generated power of Menengai geo-thermal power plant (280MW). The power flow of transmission line of Olkaria－New Lanet will become 1,192MW at 2029.

(2) Necessary Transmission Capacity of Olkaria - Lessos Line

Based on the demand forecast of LCPDP, the forecasted power flow in 2029 which means final year of this study will be extremely large as much as 1,192MW. However, demand forecast based on the Survey Team (IMF base forecast), the power flow in 2033, 20 years after construction of the transmission line, will be 779MW. Average annual growth 7.2% of the demand forecast of the Survey Team between 2009 and 2029 can be reasonable, because, from the past example, the economic growths in many countries have repeated the growth and stagnation. Thus, since the new facility is expected to be utilized effectively over 20 years, 700MW of design capacity for the new transmission line is recommended.

(3) Recommended Transmission Line Scale

Although the conductor of existing 220kV transmission line which has been applied by

KPLC is single conductor of Canary, the Survey Team adopt double-conductor because a single conductor cannot secure the transmission capacity in future need.

Permissible highest temperature of conductor is 75 degree C of KPLC but 90 degree C in Japan considering the fatal deterioration of conductor due to heat. Higher permissible temperature increases the transmission capacity drastically, if it is technically allowed. This is because the transmission capacity is determined by the conductor temperature and ambient temperature. Cooling efficiency of the conductor is determined by the balance of conductor temperature and ambient temperature. Whereas, the sag and the stretch of the transmission line conductors are also increased with its temperature rise. Therefore, it is necessary to heighten the tower in order to secure enough ground clearance. In case that the permissible highest temperature of conductor becomes 90 degree C, additional tower height of only 0.5m will be necessary and it will not be huge increase in the construction cost, comparing with drastic increase of transmission capacity..

As above, employing double-conductor of Grackle, 604mm^2, and 90 degree C permissible temperature is recommended. Transmission capacity of Grackle is 788MVA (748MW), when power factor 95% is applied, it is big enough for necessary transmission capacity (700MW).

5.4.3 Necessary Transmission Capacity of Kisumu - Lessos Line

(1) Expectation Power Flow of Kisumu - Lessos Line

The transmission line Kisumu－Lessos will be loaded by the difference between the loads of Kisumu Substation, Muhoroni Substation, and Chemosit Substation as the demand, and the power sources of Sondu/Miriu Hydropower Station and Sangoro Hydropower Station as the supply.

(2) Necessary Transmission Capacity of Kisumu - Lessos Line

Based on the demand forecast of LCPDP, the forecasted power flow is 517MW in 2029 which is the final year of the target period of this study. It is extremely large and it requires ultra large conductor. As well as Olkaria－Lessos line described in paragraph 5.4.2 (2), 350MW of design capacity is recommended so that the new facility can be fully utilized for more than 20 years without over-design.

(3) Recommended Transmission Line Scale

132kV is not practically high enough to carry the target transmission capacity of 350MW, it is suggested that the transmission line operates by 132kV at the initial stage during small power flow and then substations of the both ends shall be augmented by 220kV facilities at later stage. Such operation strategy is sometimes used for cost saving purpose. As well as Olkaria－Lessos line, the conductor of Grackle (but single conductor) and 90 degree C permissible temperature is recommended. The transmission capacity of Grackle is 394MVA (374MW), under power factor of 95%. It is enough for the design transmission capacity (350MW).

Chapter 6 Financial Analysis of KPLC

6.1 Current Financial Status

6.1.1 Introduction

This survey is being conducted in cooperation with KPLC as it has been in charge of the entire transmission business in Kenya. In December 2008, however, the Government of Kenya established a wholly state-owned transmission company named the Kenya Electricity Transmission Company (KETRACO). To start operation in the near future, KETRACO is now conducting preparatory tasks such as staff recruiting and office installation. While KETRACO will handle the newly built transmission lines from now on, KPLC will continue to take charge of the existing facilities.

Nevertheless, KPLC now represents the counterpart for the preparatory survey on Kisumu-Lessos-Olkaria Transmission Line Upgrading Project. When KETRACO will take over the project from KPLC is undetermined. Thus it is necessary to check the financial stability of KPLC in any case.

In this section, the team analyzes KPLC's financial situation, referring to KPLC's annual reports in the last ten years. Since the financial statements of KPLC are based on the International Financial Reporting Standard (IFRS), they can be compared to other foreign competitors on the same basis, and an objective financial analysis is possible. The fiscal year (FY) of KPLC is between July and the next June. The latest data used in this report are those of FY2009.

The Government of Kenya is the largest shareholder of KPLC, but the percentage of its shareholding is gradually falling: the government's share is 40.4% at the end of August 2009. More than half of KPLC's shares are currently owned by private capital. KPLC is listed on the Nairobi Stock Exchange, and, along with KenGen that was listed in 2006, is highly valued as one of the excellent companies in Kenya.

6.1.2 Financial Results

At the beginning of the 2000s, KPLC's financial performance was sluggish, posting a net loss for four years in a row from FY2000. However, since 2005, sales have rapidly increased with the recovery of the domestic economy, and KPLC has returned to profitability by continuous cost reduction. With the stable growth in recent years, KPLC now achieves good financial results in general.

In FY2009, sales were 66.4 billion Kenyan Shillings (Ksh) (about Japanese Yen (¥) 80 billion), up 58.9% from the previous year and the operating profit was Ksh 5.7 billion (about ¥6.8

billion), up 61.1%. They result from good sales to households and small-medium enterprises around Nairobi as well as the raise of electricity tariff and the strengthened bill collection. Cost reduction measures in the distribution and customer service sections also increased the profit margin to 8.6%. After a long stagnation, both sales and profit are now growing rapidly with the recovery of the Kenyan economy.

With the business process restructuring, efficiency in operation has also improved, particularly in the back-office section. The number of employees that had exceeded 10,000 in the mid 1990s was reduced to 7,015 at the end of June 2009. The total amount of personnel expenses is increasing as prices rise. However, in FY2009, the sales per employee rose to Ksh 9.46 million (about ¥ 12.3 million), an increase of 260% in the last ten years. Labor productivity, which means added value per employee, also rose by 920% for the same period, reaching Ksh 2.74 million (about ¥ 3.6 million)

6.1.3 Cost Structure

As a result of overhead cost reduction, the overall profitability of KPLC has improved since FY2004 despite the increasing power purchase expense.

The gross profit margin, which declined every year from 36.7% in FY2005, was 29.0% in FY2009. The main reason is that the fuel cost has more than quadrupled since 2005. Meanwhile, as for the administrative expense, the ratio of labor cost and depreciation remained flat. The overhead cost items such as sales expense have decreased. Thus the overall administrative expense ratio to sales declined from 31.4% in FY2004 to 20.4% in FY2009.

The increase in the power purchase expense has been offset by the reduction of the administrative expense, raising the operating margin from 3.6% in FY2004 to 8.6% in FY2009. It is fair to say that KPLC has become more profitable due to the sales growth and the reduction of fixed expenses including labor and administration costs

6.1.4 Management Indices Analysis

As shown above, KPLC maintained good financial performance in recent years through continuous cost reduction and other measures. Furthermore, to judge whether the profitability and balance sheet of KPLC are at an appropriate level as an electric power company, the survey team reviewed its financial ability in perspective of profitability and financial stability.

KPLC has sharply increased its sales due to the rapid electricity demand growth in Kenya. Average annual sales growth from FY2005 to FY2009 is 23.0%. Operating margin is 8.6% in FY2009, and it is improving as the sales increase.

The current ratio and the quick ratio are indices of the short-term financial stability of a company. In these indices, KPLC even outperforms some major electric power companies having strong financial ground in developed countries. KPLC is stable enough to pay short-term debts.

As for these indices, the financial performance of KPLC is not inferior to world's leading electric power companies. Considering difficulties in doing business in developing countries, it can be said that KPLC is well managed. Nevertheless, with the high expectation for economic growth in Kenya, donors and investors have recently funded KPLC in a large scale. KPLC's revenue is expected to grow rapidly, but KPLC needs to be more careful about the balance sheet and the decline of profitability caused by overinvestment.

6.2 Tariff System

6.2.1 Overview

KPLC's tariff system consists of power purchase tariff from power plant operators and retail tariffs to consumers.

KPLC buys electricity at a fixed rate based on the power purchase agreement (PPA) with each plant operator. The basic rate is around Ksh 2-3/kWh, but the fuel cost will be added if the plant is oil or gas thermal. Therefore, it costs much more to buy power from independent power producers (IPPs) with oil or gas thermal plants than from hydro or geothermal plants. In some cases, it costs over Ksh 10/kWh.

Retail tariffs are divided into five categories by purpose and scale, and two more categories, i.e., for export and the Rural Electrification Programme (R.E.P.) conducted by the Government of Kenya. Tariffs for customers in Kenya are categorized as DC (domestic), SC (small commercial), CI (commercial and industrial) IT (off-peak) and SL (street lighting). Before FY2008, tariffs were as follows: A (households and small commercial); B (irrigation and medium commercial/industrial); C (large commercial/industrial); D (off-peak demand); and E (street lighting). The categories B and C were also divided into subcategories by voltage. Tariffs for small consumers consist of a fixed charge and unit charge, while those for medium and large enterprises consist of a fixed charge, unit charge, and demand charge. As customers pay fuel costs which KPLC paid to electricity producers, they bear the risk of fuel price fluctuations as well. Moreover, effects of foreign exchange volatility and inflation are adjusted by retail tariffs so that KPLC can mitigate the risk of cost fluctuations. KPLC also has some programs for lower income households. For example, KPLC provides customers with loans which cover the initial cost for electricity connection, and with the quick and easy bill payment service by mobile phone money transfer system. For loan system to provide low income consumers with easier access to power, Chapter 3 refers to the more detail.

6.2.2 Electricity Demand by Customer

By customer category before FY2008, about 40% of the KPLC sales are A, 20% are B, and 40% are C, while D and E are about 1% each. In the last few years, the share of the category A0 (domestic) has been gradually increasing because the improvement of electrification and living standards may boost the electricity demand in households. For the category A, as the unit cost per kWh is higher than B or C, this tendency is more remarkable in sales than in kWh.

Since Kenya is a relatively industrialized country in Africa, the electricity demand for large industrial and commercial use is stable. However, rural areas are still much less electrified than cities. It means that rural areas will have a potentially large demand if electricity infrastructures are improved and electric appliances such as television and washing machine are widespread in households. Accordingly, strong electricity demand in households is expected to play an important role in KPLC's sales growth for the time being.

6.3 Loan Repayment Ability of KPLC

6.3.1 Capital Expenditure and Cash Flow

The capital inflow to KPLC has increased rapidly in recent years. Since the resumption of foreign aid to Kenya around 2004, KPLC has acquired a number of low-interest loans, which tripled the amount of its long-term debts in five years since FY2004.

Consequently, KPLC has rapidly increased the capital expenditures mainly on distribution system enhancement. The amount of capital expenditures in FY 2009 was Ksh 12.7 billion (about ¥ 15.0 billion), which quadrupled in only three years. The capital expenditure to sales ratio reached 19.2%, while it usually remained at less than 10% until FY2006.

Here is the state of KPLC's cash flow. Although KPLC gains cash flow from operations every year, the investment cash flow, which is the cash disbursement to investment, greatly exceeds the operating cash flow. The free cash flow, or cash income from business activities, resulted in a large deficit. Ksh 9.11 billion (about ¥ 11 billion) of cash flowed out in FY2008. This amount is nearly 20% of annual sales. Meanwhile, the financial cash flow has greatly increased since FY2007. It means that KPLC borrowed a huge amount of money to cover the burgeoning capital expenditures. The total amount of the financial cash flow in the last two years was Ksh 9.75 billion (about ¥ 13 billion), which is approximately double the operating cash flow in the same period. In FY2009, however, free cash flow turns positive as operating cash flow largely increases despite KPLC made massive investment, the same level as the previous year.

It is not unusual for a rapidly growing company to increase borrowing for a large investment.

But it is still necessary to examine the cash planning, profitability on investment, and interest payment.

6.3.2 Funding

In recent years, KPLC invests most of its huge capital expenditures on developing the distribution system for electrification. The development of such system is vital to meet the increasing demand for electricity from the economic growth. The electrification rate is below 20% in Kenya as a whole; the figure is even lower in rural areas. If more households are electrified to boost the potential demand, KPLC can increase its revenue and recover the investment easily.

Since the balance between the electricity demand and supply in Kenya is still tight, KPLC is expected to continue the large investment mentioned above. Thus it will be very important for KPLC to secure stable long-term and low-interest loans. KPLC has been recently shifting funding sources from short-term loans by commercial banks to long-term funds by international donors. In FY2007, KPLC managed to meet a sudden cash demand with temporary short-term loans. However, in 2008, it acquired some low-interest long-term funds by Japan, Europe and China. The loan by the Japan Bank for International Cooperation (JBIC) was at an annual interest rate of 0.75%, and the loans from Europe and China were at interest rates per annum of 2.5% and 3.97%, respectively. As of 2009, about 60% of KPLC's borrowings are long-term loans with more than two years of repayment term. The average annual interest rate is less than 5%. As borrowings increase rapidly, the instant coverage ratio (see 6.1.4) is getting lower. Nevertheless, that does not become a serious problem because the interest expense is still low.

In sum, KPLC is likely to keep growing with a high electricity demand and a stable profit structure. It will not face any major difficulty in repayment if funded properly.

Chapter 7 Environmental and Social Considerations

7.1 EIA & RAP Procedure and Relevant Legal Documents of Kenya

7.1.1 EIA System of Kenya

The statutory Environmental Impact Assessment (EIA) system in Kenya was established by the Environmental Management Coordination Act (EMCA) of 1999 and the Environmental (Impact Assessment and Audit) Regulations of 2003. The EMCA specifies the projects which are subject to the EIA in the Second Schedule and also requires the Environmental Audit (EA) under Sections 68 and 69 and the Strategic Environmental Assessment (SEA) for specific fields under Part IV Section 37 – 41 of the Act.

There are 7 objectives of the EIA described in "Draft Environment Impact Assessment Guidelines and Administrative Procedures" prepared by NEMA in November 2002.

- *To identify potential environmental impacts of proposed project, policies, plans and programmes;*
- *To assess the significance of these impacts;*
- *To assess the relative importance of the impacts of alternative plans, designs and sites;*
- *To propose mitigation measures for the significant negative impacts of the project on the environment;*
- *To generate baseline data for monitoring and evaluation of how well the mitigation measures are being implemented during the project cycle;*
- *To present information on the impact of alternatives; and*
- *To present results of the EIA in such a way that they can guide informed decision-making.*

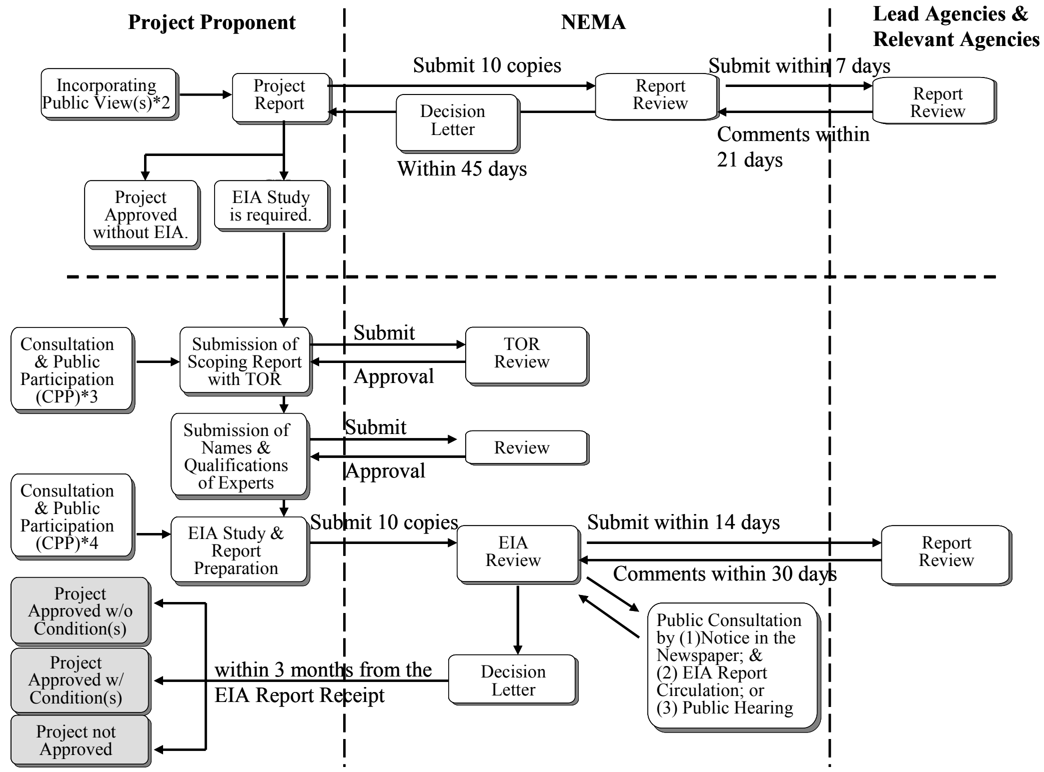
7.1.2 Project Types which require the Environmental Impact Assessment (EIA)

The project which is subject to EIA is specified by project type in the Second Schedule of the EMCA. The EMCA does not specify any threshold of the project which undergoes EIA, and whether EIA should be conducted is decided by NEMA based on the context of the Project Report (PR) which is initially required by NEMA.

As for the Kisumu-Lessos-Olkaria Transmission Upgrading Project, it is categorized under (b) Electrical transmission lines of "No. 9. Electrical Infrastructure" in the Second Schedule of EMCA. Therefore, the project is considered to be subject to EIA.

7.1.3 EIA Preparation & Review Procedure

The project proponent shall conduct an EIA and prepare an EIA report in accordance with the approved TOR. The stages of the procedure of the EIA preparation and review are summarized below and Figure 7-1.1.



Source: Prepared by JICA Survey Team based on the Environmental (Impact Assessment and Audit) Regulations 2003; and the Draft Environment Impact Assessment Guidelines and Administrative Procedure, Nov. 2002

Fig. 7-1.1 EIAS Report Preparation & Review Procedure

7.1.4 RAP Procedure/Requirements

Since the Kenyan resettlement procedure follows the WB O.P. 4.12 there are no fundamental discrepancies between the Kenyan procedure/requirements and the former JBIC guidelines.

7.2 Provided Assistance for the ESIA/RAP Study Implementation

The JICA Survey Team has provided technical assistance to KPLC in preparation of the ESIA study, such as 1) development of the ESIA's TOR for NEMA's approval; 2) technical assistance to KPLC to review the ESIA and 3) commissioning supplementary specialist studies on fauna & flora, landscape and socio-economic status of the landowners/occupiers. The ESIA study of the proposed project was competitively tendered by KPLC and was awarded to a local consulting firm, GIBB Africa. The work of the ESIA was started on 18th August 2009, completed on 22 Dec. 2009 and submitted to NEMA on 29 Dec. 2009. On the other hand, the RAP was started by another local consulting firm, Eco Plan Management Limited from Dec. 2009 and is planned to be competed by Feb. 2010.

7.2.1 Alternative Considerations on the Transmission Line Alignment

Two alternative alignments of the transmission line between Olkaria and Lessos as well as Lessos and Kisumu were proposed and studied in the Feasibility Study conducted in 2003 with the financial assistance from the US Trade Development Authority. In the present JICA Study, the alternatives suggested in the F/S were re-examined in terms of technical, economic, and environmental & social impacts, as a part of Strategic Environmental Assessment (SEA) as required by the Kenyan EIA regulations and the former JBIC Guidelines for Confirmation of Environmental and Social Considerations. In this section, environmental and social aspects of the alternative considerations are described in the following table, and the comprehensive results of the alternative considerations are described in Section 8.1.1 of the Final Report.

Table 7-1.1 Results of Alternative Considerations (Environmental and Social Aspects)

Impact	Olkaria-Lessos		Lessos-Kisumu	
	Alt. 1 (Existing Line)	Alt. 2 (New Line)	Alt. 1 (New Line)	Alt. 2 (Existing Line)
Corridor Length in Forests[1]	Approx. 35.5km: Passing 4 forests (Northern Tinderet; Nabkoi; Timboroa; and Mt. Londiani Forests)	Approx. 75.5km: Passing 3 forests (Eastern Mau; Western Mau; and Tinderet Forests)	0	0
Forest Status	More plantation forests	More degraded and non-degraded natural forests	-	-
Number of Residential Structures[2]	Approx. 262	Approx. 642	Approx. 268	Approx. 374
Social Issue	-	A complicated land title issue exists	-	-

Note 1: The length of the transmission wayleave in the forests was estimated based on the existing topographic maps with the scale of 1:250,000 (issued in 1973, 1979 and 1981).

Note 2: .The number of the residential structures was estimated based on the results of the topographic survey as of 15 Sept. 2009. The final number of the residential structures to be affected for Alternative 1 between Olkaria and Kisumu via Lessos (see Section 7.3.3. (2) on p. 7-12) differs from the above-mentioned number because the alignment was fine-tuned to minimize the affected structures after the alternative considerations,

Source：Prepared by JICA Survey Team

7.2.2 Summary of the Scoping Results for the Kisumu-Lessos-Olkaria Transmission Line Upgrading Project

The scoping results on environmental and social impacts of the proposed Project are summarized in the following table. The details of the potential positive/adverse impacts are discussed in Chapter 7 of the Final Report.

Table 7-2.1 Summary of Scoping Results on Environmental & Social Impacts of the Project

Impacts / Phase	1.Involuntary Resettlement	2.Local Economy suc as Employment & Livelihood, etc.	3.Land Use & Utilization of Local Resources	4. Social Institutions such as Split of Communities	5.Existing Social Infrastructures & Services	6.The poor, indigenous & ethinic people	7.Misdistribution of Benefit & Damage	8.Cultural Heritage	9.Local Conflict of Interest	10.Water Usage or Water Rights & Rights of Common	11.Sanitation	12.Hazards (Risk), Infectous Diseases such as HIV/AIDS	13.Topography & Geographical Features	14.Soil Erosion	15.Groundwater	16.Hydrological Situation	17.Coastal Zone	**18.Fauna, Flora & Biodiversity**	19.Meteorology	20.Landscape	21.Global Warming	22.Air Pollution	23.Water Pollution	24.Soil Contamination	25.Waste	26.Noise & Vibration	27.Ground Subsidence	28.Offensive Odor	29.Bottom Sediment	30.Accidents
	Social Environment												**Natural Environment**									**Environmental Pollution**								
Planning Phase	A-					C-	B-		C-																					
Construction Phase		B+/B-	B-		B-	C-		C-			B-	B-		B-				A-		B-		B-	B-	B-	B-	B-				C-
Operation Phase		A+	B-			C-	B-		C-			B-		B-				B-		B-										C-

A+/-: Significant positive/negative impact is expected.

B+/-: Some positive/negative impact is expected to some extent.

C+/-: Extent of positive/negative impact is unknown. (A further examination is needed, and the impact could be clarified as the study progresses)

Blank: No negative impact is expected.

Source: JICA Survey Team

7.2.3 Outcomes of the Public Consultation of KPLC's ESIA

Public consultation meetings, which are often called Consultation and Public Participation (CPP) in Kenya, of the first stage were organised at 11 venues by GIBB East Africa Ltd., between 28 Sept. 2009 and 4 Oct. 2009 in accordance with EIA regulations and guideline of Kenya. However, the first stage of CPP was organised as Focus Group Discussions (FGDs) and hearings which targeted local leaders, local government officials and selected local people who would be potentially affected in accordance with Kenyan regulations. Therefore, additional two stages of public consultation meetings at 12 venues were conducted between 29 Sept. and 4 Oct. 2009, and 26 and 31 Oct. 2009 respectively.

7.2.4 Topographic Survey Conducted by the Local Consultant

Due to the lack of the accurate and latest existing data on the land title, a preliminary survey of the affected residential structures was conducted by Geomatics Civil Engineering Surveyors Ltd. as a part of the Topographic Survey of JICA Survey Team. As a result of the survey, the alignment was reviewed by KPLC and JICA Survey Team at 4 sections listed below.

- Avoid the flower farms to the south of Lake Naivasha;
- Avoid the small town of Elmenteita;
- Avoid the southern end of Lake Nakuru National Park; and

- Avoid the heavily settled areas near the Kisumu sub-station.

7.2.5 Specialist Studies on Fauna & Flora, Landscape and Socio-economics

To supplement KPLC's ESIA, the impacts which were considered relatively significant were examined simultaneously as specialist studies commissioned by the JICA Survey Team. The specialist studies consisted of a fauna and flora study in selected forests, a landscape study in/near the scenic sites and tourist sites, and a socio-economic survey of the landowners and occupiers.

(1) Results of the Specialist Study on Flora and Fauna

The study was conducted to examine the impacts on forest reserves along the transmission routes, in order to supplement KPLC's ESIA report. The study concludes that in the project area, indigenous forest was only found along a stretch of about 4–5 kilometres in the Timboroa Forest. The rest of the forest stands are plantations of exotic tree species planted during the Kenyan colonial era. A potential negative impact on one of the Red List plant species (but the status is "Vulnerable", http://www.iucnredlist.org/apps/redlist/details/33631/0), *Prunus Africana* (Red Stinkwood), was also identified in Londiani, Mau Summit and Timboroa Forests.

(2) Results of the Specialist Study on Landscape

This study also aims to supplement KPLC's ESIA study and especially focuses on potentially negative impacts on landscape in selected scenic/sightseeing sites. The study included site visits, a photographic survey including photocollage, and the systematic evaluation of landscape and visual impacts (ranked major, highly, moderately, minor or not significant). The study identifies some negatively affected areas such as south of Mount Londiani Forest, Sinedet Area towards Dorereine Forest, Kibwoso Tea Estate and Kapsumbweiwa of Nandi Hills, and suggests minor local diversions and minimum tree clearing.

(3) Results of the Specialist Study on Socio-economics

The socio-economic study of landowners and occupiers was primarily conducted to understand the social impacts of the project and estimate the scale of potentially affected persons.

The study identified 319 registered land title holders who are potentially affected in the Alternative 1 and 344 registered land title holders in the Alternative 2 based on the title deed survey plan. It was initially planned to sample 20-25% of the potentially affected persons within the Alternative 1 (319 land title holders); however, it was changed and increased to 160 land title holders by the expert judgement of Norken (I) Pvt. Ltd. which is equivalent to approx. 50% of the affected land title holders of the Alternative 1. Several negative impacts of the project were identified according to the respondents: 60.6% are likely to lose their residential house(s)/building(s); 41.3% will lose their commercial building(s); 51.3% will lose agricultural land, 32.5% will lose incomes and livelihoods; 20% indicated there will be a loss of scenic beauty; 19.4% feared diseases; 23.1% feared loss of security and 19.4% thought they would not be able to access certain public facilities due to the project.

7.3 Evaluation of KPLC's ESIA Report

Overall, the KPLC's ESIA is well prepared compared with the average EIA reports in Kenya. It is considered by JICA Survey Team that the contents of the ESIA report meet the requirements of the Kenyan EIA regulations. However, there are seven contents need to be clarified or updated, such as alternative considerations, the comprehensive ecological survey, the landscape survey, the impacts on cleared forests, the Environmental Management Plan (EMP), the Environmental Monitoring Plan (EMoP), and public consultation meetings.

7.4 Environmental Checklist in Accordance with the JBIC Guidelines for Confirmation of the Environmental and Social Considerations

The Environmental Checklist No. 14 for Power Transmission and Distribution Lines was prepared assuming that the proposed mitigation measures will be implemented (see Annex 7-13 of the Final Report).

Chapter 8 Basic Design of Project Facility

8.1 Outline of Basic Design

8.1.1 Transmission Line Route

Study on two alternatives routes for Olkaria－Lessos line (220kV, double-circuit in the original request to JICA) and two alternatives routes for Lessos－Kisumu line (132kV, single circuit in the original request to JICA) was performed and the result is as given below.

(1) Olkaria－Lessos Line, Alternative-1

This is a route running parallel to the existing 132kV line and a main public road taking easy access into main consideration.

(2) Olkaria－Lessos Line, Alternative-2

This is an idea to connect two substations as short length of line as possible, as the crow flies, and runs to the west than the alternative-1.

(3) Selection of Alternatives for Olkaria－Lessos Line

Alternative-1 is recommended.

(4) Lessos－Kisumu Line, Alternative-1

This is the idea to connect both substations as short as possible in distance.

(5) Lessos－Kisumu Line, Alternative-2

The line runs in parallel with existing 132kV transmission line.

(6) Selection of Alternatives for Lessos－Kisumu Line

Alternative-1 is recommended.

8.1.2 Basic Design of Transmission Line Facility

(1) Tower

It is noted that latticed tower type has been recommended as well in the existing F/S report (2003) Volume I, page IV-7 from the view point of resistance to destructive acts.

(2) Insulators

The polymer insulator is recommended as per KPLC's wish.

(3) Electric Conductor and Overhead Ground Wire

For electric conductor, Aluminum Conductor Steel Reinforced (ACSR) is recommended.

For overhead ground wire, Composite Fiber Optic Overhead Ground Wire (OPGW) is recommended in order to enable SCADA system to function via. transmission lines..

(4) Tower Foundation

No special foundations such as huge piles will be necessary and ordinary reversed T-type foundation will be employed. However, soil investigation for confirming purpose shall also be included in the scope of Check Survey work by the contractor.

(5) Substation Extension

Extension of the 2 numbers of transmission line bays each in 220kV Olkaria Power House switchyard, 220kV Lessos Substation switchyard, 132kV Lessos Substation switchyard, 132kV Kisumu Substation switchyard will be needed.

8.1.3 Study on Double-circuit Transmission Line between Kisumu-Lessos

In the original request made by the Government of Kenya to JICA, 132kV single circuit transmission line between Kisumu－Lessosis is proposed to supply power to the third largest city Kisumu.

However, the system analyses conducted by the Survey Team recommends to employ double circuits for Kisumu－Lessos line.

8.1.4 Adoption of 220kV Transmission Voltage between Kisumu－Lessos

Request was made by KPLC for the Survey Team to look into the possibility of introducing 220kV transmission voltage between Kisumu－Lessos, instead of 132kV originally requested.

The Final Report recommends to employ 220kV.

KPLC's idea is while design and construction are made based on 220kV, actual operation at the beginning will be made at 132kV rating.

8.2 Project Cost

8.2.1 Preliminary Cost Estimate

(1) Contractual Packages

Regarding contractual packages, Olkaria－Lessos line and Kisumu－Lessos line will be in the separate packages.

(2) Preliminary Cost Estimate for Procurement/Construction

Total cost including consulting fee, administration cost (of KETRACO), compensation for resettlement or wayleave, interest for loan, for the case of 220kV double circuit design for all segment, is shown in Annex 8-1.

The total cost for all the segment with recommended design is ¥ 13,749 mil..

8.3 Schedule of Project Implementation

Time Schedule for Project Implementation from the Loan Agreement (L/A) is estimated in Annex 8-2.

Annex 8-1 Total Cost for the Project Implementation (220kV for All Segments)

Cost Estimation (220kV, 2cct for Olkaria-Lessos, and 220kV, 2cct for Lessos-Kisumu Lines)

Base Year for Cost Estimation:	Oct, 2009			FC & Total: million JPY
Exchange Rates	Ksh = Yen		1.21	LC : million Ksh
Price Escalation:	FC:	3.1%	LC: 11.3%	
Physical Contingency	10%			
Physical Contingency for Consultant	10%			

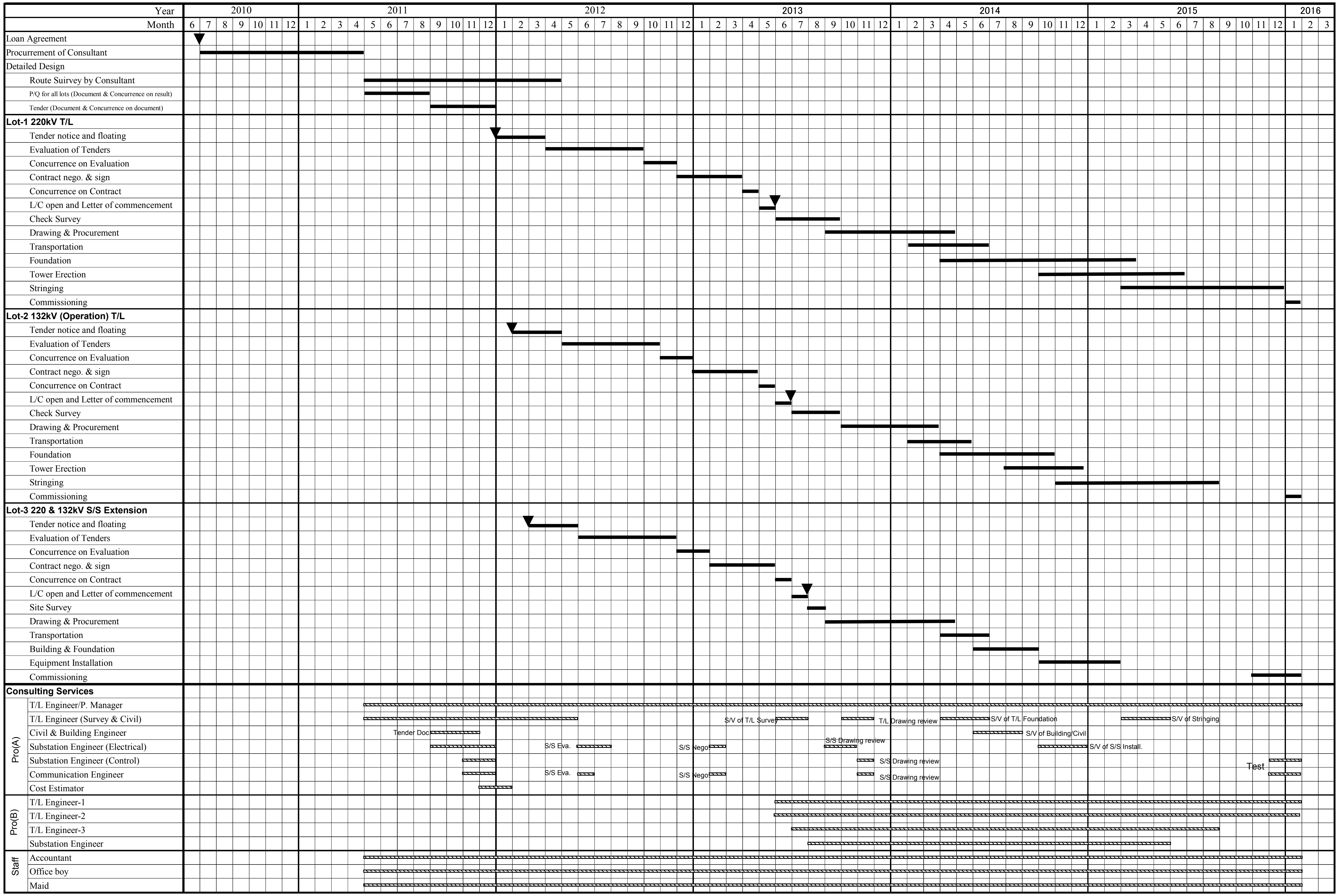
Item	Total			2010			2011			2012			2013			2014			2015		
	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total	FC	LC	Total
A.																					
Ⅰ) Procurement / Construction	8,286	2,769	11,636	0	0	0	0	0	0	0	0	0	1,213	380	1,672	6,250	704	7,103	859	1,882	3,136
220kV Transmission Line	4,555	1,041	5,814	0	0	0	0	0	0	0	0	0	683	156	872	3,416	260	3,731	456	624	1,211
132kV (Operation) Transmission Line	1,403	346	1,822	0	0	0	0	0	0	0	0	0	210	52	273	1,052	87	1,157	140	208	392
Substation	546	113	683	0	0	0	0	0	0	0	0	0	82	17	102	410	28	444	55	68	137
Base cost	6,504	1,500	8,319	0	0	0	0	0	0	0	0	0	976	225	1,248	4,878	375	5,332	650	900	1,739
Price escalation	1,029	1,017	2,260	0	0	0	0	0	0	0	0	0	127	120	272	804	265	1,126	131	811	1,112
Physical contingency	753	252	1,058	0	0	0	0	0	0	0	0	0	110	35	152	568	64	646	78	171	285
Ⅱ) Consulting services	595	34	636	109	1	110	45	6	52	64	7	72	157	7	166	150	8	159	70	5	76
Base cost	481	21	506	96	1	97	39	4	44	53	4	58	126	4	131	117	4	122	53	3	56
Price escalation	59	10	72	3	0	3	2	1	4	5	2	7	16	2	19	19	3	23	11	2	13
Physical contingency	54	3	58	10	0	10	4	1	5	6	1	7	14	1	15	14	1	14	6	0	7
Total (Ⅰ + Ⅱ)	8,881	2,803	12,272	109	1	110	45	6	52	64	7	72	1,369	387	1,838	6,400	713	7,262	929	1,887	3,213
B.																					
a Compensation for resettlement	0	891	1,079	0	0	0	0	164	198	0	728	881	0	0	0	0	0	0	0	0	0
Base cost	0	600	726	0	0	0	0	120	145	0	480	581	0	0	0	0	0	0	0	0	0
Price escalation	0	210	255	0	0	0	0	29	35	0	182	220	0	0	0	0	0	0	0	0	0
Physical contingency	0	81	98	0	0	0	0	15	18	0	66	80	0	0	0	0	0	0	0	0	0
b Administration cost	0	110	134	0	1	1	0	2	3	0	8	10	0	15	18	0	60	73	0	27	32
c VAT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
d Import Tax	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total (a+b+c+d)	0	1,002	1,212	0	1	1	0	166	200	0	736	890	0	15	18	0	60	73	0	27	32
TOTAL (A+B)	8,881	3,805	13,484	109	2	111	45	171	253	64	742	962	1,369	402	1,856	6,400	773	7,335	929	1,914	3,245
C. Interest during Construction	190	0	190	0	0	0	0	0	0	0	0	0	13	0	13	66	0	66	90	0	90
Interest during Construction(Const.)	190	0	190	0	0	0	0	0	0	0	0	0	13	0	13	66	0	66	90	0	90
Interest during Construction (Consul.)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GRAND TOTAL (A+B+C)	9,146	3,805	13,749	122	2	124	58	171	265	76	742	975	1,395	402	1,881	6,479	773	7,414	1,032	1,914	3,347

Administration Cost = 1%
VAT= 0% of the expenditure in local currency of the portion A.
Import Tax= 0%

Source : JICA Survey Team

Annex 8-2 Time Schedule for Project Implementation

Construction Schedule of 220kV Olkaria-Lessos Transmission Line and 132kV (Operation) Lessos-Kisumu Transmission Line



Source : JICA Survey Team

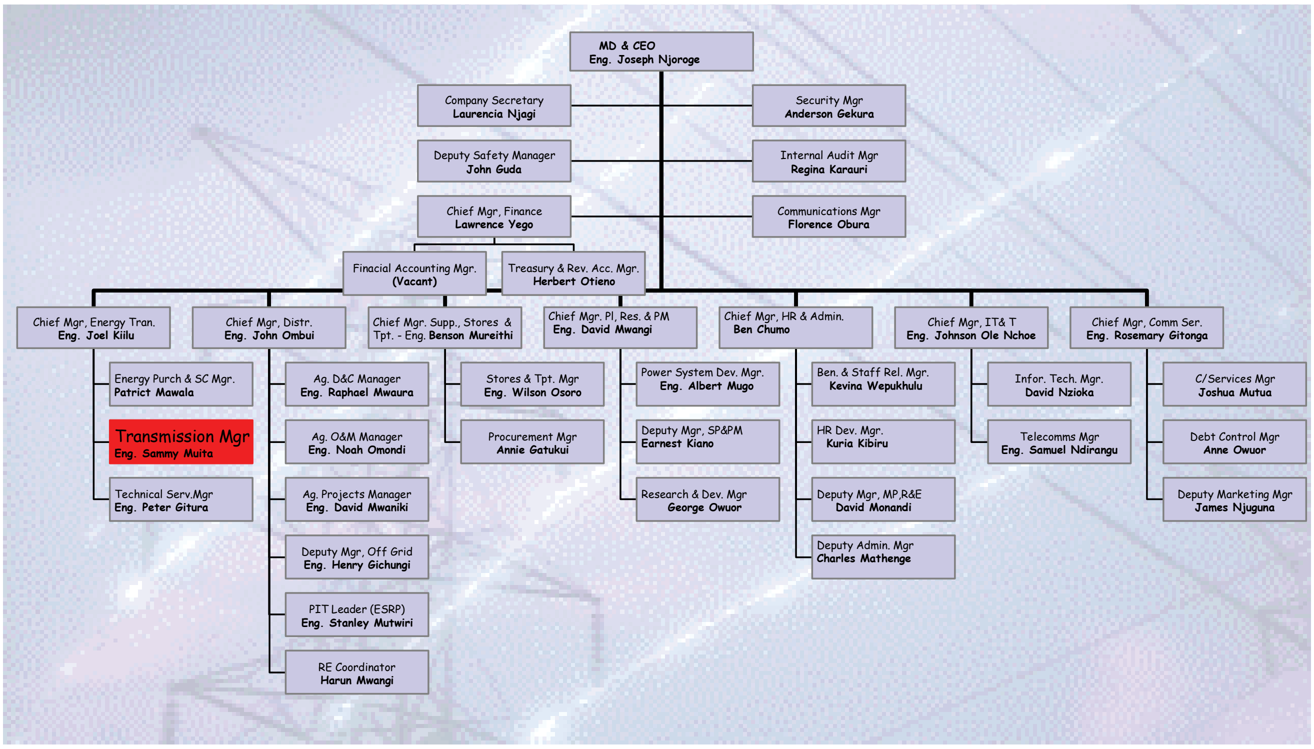
Chapter 9 Operation of the Project by KETRACO

9.1 Project Implementation Unit of KETRACO

As explained in foregoing Chapter, when the project is implemented, ownership of the new transmission lines and responsibilities of construction supervision belong to KETRACO. However, at this survey stage, KETRACO has not yet started its normal operation so that KPLC, the mother body of KETRACO, will be examined in regard to the capability of project implementation. The facts described below are the cases for the past project of KPLC. The same Project Implementation Organization (PIO) will be organized for this proposed project.

9.1.1 Project Execution Organization

KPLC's organization as of August 2009 is as illustrated in Fig. 9-1.1, where new transmission line projects are normally undertaken by Transmission Department under Transmission Manager.



Source : KPLC

Fig. 9-1.1 KPLC's Organization (Aug. 2009)

This Transmission Line Department has, as shown in Figure 9-1.1, Operation & Maintenance Department and Project Department. The Project Department nominates Chief Engineer for each project office, under whom the project teams will be organized. It can be envisaged that the KPLC has capable enough to conduct project implementation for the Project.

9.1.2 Operation and Maintenance Organization

For the capability of operation and maintenance, KPLC owns transmission lines of 4,000km in length from voltage range of 66kV to 220kV, and conducting operation and maintenance at this stage. There is no problem in the operation and maintenance after completion of the Project.

The new transmission lines will be owned and operated by KETRACO and not KPLC. There may be some concern of KETRAO's capability of the operation & maintenance as well as the project management because of the immaturity of KETRACO. However, an agreement was signed between KPLC and KETRACO to the effect that as requested by KETRACO, KPLC would provide human resources and technical assistances for proper functioning of the former. Hence, there is no problem in capability of KETRACO.

9.2 Technical Assistance Recommendation

For technical assistance, the following program is proposed. The detail is described in the Final Report.

- 400kV Transmission Line Design
- Power System Analysis
- Contract Sample Document
- Construction Supervision
- Environmental Impact Assessment
- Operation & Maintenance

Chapter 10 Benefit and CO_2 Reduction

10.1 Reduction of Coal-fired Thermal Plants

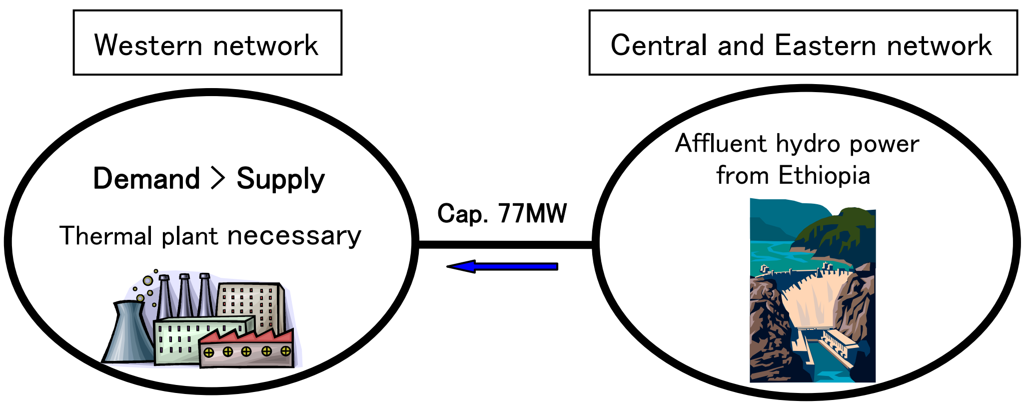
The proposed project will enable Kenya system to import low cost electricity from hydro-plants in Ethiopia for nationwide distribution, which reduces the cost of power distribution and CO_2 emission.

While, without the project, due to the limited capacity of the existing 132kV transmission lines, i.e., 77kW, imported power cannot be efficiently transmitted to Western region such as Kisumu. The power deficit in the Western region shall be fulfilled by additional thermal plants in the region and it will increase the cost of power distribution and CO_2 emission.

10.1.1 Additional Thermal Plant in Western Region due to Restriction of Transmission Capacity of Olkaria-Lessos

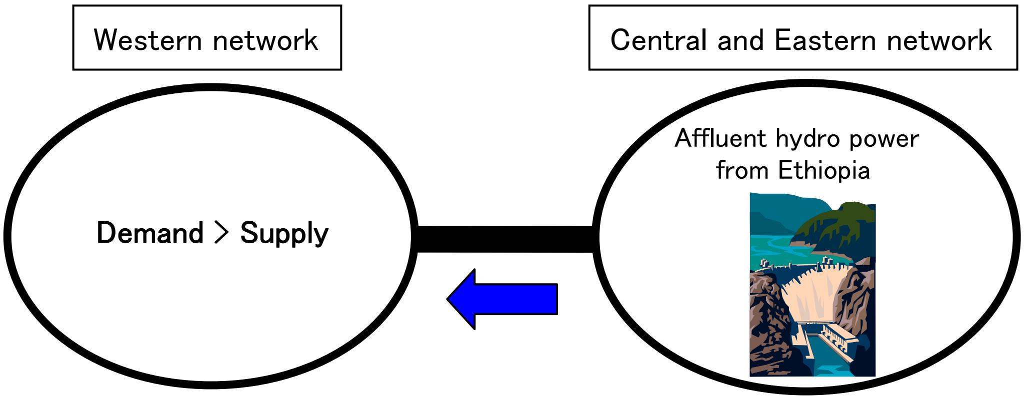
Under consideration of N-1 criterion, current carrying capacity of the existing 132kV Olkaria-Lessos line is only 77MW. Hence, the deficit in Western region shall be limited to 77MW as shown in the figure 10-1.1, and if no upgrading of the existing line is scheduled, construction of thermal plants mainly consisting of diesel generators is essential in Western region.

On the other hand, Figure 10-1.2 shows that, if the existing Olkaria－Lessos line is upgraded, transmission of low cost power can be transmitted to Western region from Nairobi where the new cross-border interconnection line from Ethiopia is planned. The use of power from Ethiopia will reduce the power distribution cost and CO_2 emission.



Source : JICA Survey team

Fig. 10-1.1 Restriction of Transmission Capacity and Necessity of Thermal Plants



Source : JICA Survey team

Fig. 10-1.2 Transmission of Low Cost Power from Ethiopia by Upgrading of Existing Transmission Line

10.2 Benefits by Utilization of Imported Power

The capacity limit of transmission line will be resolved by interconnection with Nairobi direction by the construction of 220 kV Olkaria－Lessos line. Accordingly, reduction of generation cost and CO_2 emission will be realized by receiving the low priced power from Ethiopia generated by large scale hydropower.

10.2.1 Cost Reduction

Economical benefit of 220 kV Olkaria－Lessos line is evaluated by comparison between the unit prices of the low priced imported power from Ethiopia and of power generated by new thermal plants which are to be constructed in West region without the new transmission line.

The amount of cost reduction for each year can be obtained as shown in Table 10-2.1 and Table 10-2.2. The total energy of 22,378 [27,508] GWh from thermal generation can be replaced by imported power from Ethiopia within 17 [23] years from 2013 [2015] to 2029 [2037]. The cost reduction will reach US$ 1,511 [1,857] mil. in total.

Table 10-2.1 Cost Reduction by Imported Power from Ethiopia (LCPDP base)

Unit : GWh, US$ mil.

Year	2013	2014	2015	2016	2017	2018	2019	2020	2021
Thermal generation	20	80	188	363	602	892	318	57	203
Cost reduction	1.3	5.4	12.7	24.5	40.7	60.2	21.5	3.8	13.7
Year	2022	2023	2024	2025	2026	2027	2028	2029	Total (2013-29)
Thermal generation	478	849	1312	1887	2563	3322	4161	5081	22378
Cost reduction	32.3	57.3	88.6	127.4	173.0	224.3	280.9	343.0	1510.5

Source : JICA Survey team

Table 10-2.2 Cost Reduction by Imported Power from Ethiopia (IMF base)

Unit : GWh, US$ mil.

Year	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Thermal generation	10	30	76	145	243	379	548	746	972	314	37	111
Cost reduction	0.7	2.0	5.1	9.8	16.4	25.6	37.0	50.4	65.6	21.2	2.5	7.5
Year	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	Total (2015-37)
Thermal generation	252	467	738	1059	1440	1887	2396	2955	3563	4217	4922	27508
Cost reduction	17.0	31.6	49.8	71.5	97.2	127.4	161.7	199.5	240.5	284.7	332.2	1856.8

Source : JICA Survey team

10.2.2 CO_2 Reduction

CO_2 reduction becomes possible to replace thermal generating power by the imported power based on hydropower which does not make CO_2 emission.

The amounts of reducing CO_2 emission in every year is obtained and shown in Table 10-2.3 and Table 10-2.4. The amounts of reducing CO_2 emission will be reached 14.14 million ton [17.39 million ton]in total in 17 [23] years from 2013 [2015] to 2029 [2037], since the total generation energy of 22,378 [27,508] GWh from thermal generation can be replaced by imported power.

Table 10-2.3 Amounts of Reducing CO_2 Emission by Imported Power from Ethiopia (LCPDP base)

Unit : GWh, 10^6 CO_2 kg)

Year	2013	2014	2015	2016	2017	2018	2019	2020	2021
Thermal generation	20	80	188	363	602	892	318	57	203
CO_2 reduction	12.5	50.3	119.0	230	381	564	201	36.0	129
Year	2022	2023	2024	2025	2026	2027	2028	2029	Total (2013-29)
Thermal generation	478	849	1312	1887	2563	3322	4161	5081	22378
CO_2 reduction	302	537	829	1193	1620	2100	2630	3211	14143

Source : JICA Survey team

Table 10-2.4 Amounts of Reducing CO_2 Emission by Imported Power from Ethiopia (IMF base)

Unit : GWh, 10^6 CO_2 kg)

Year	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Thermal generation	10	30	76	145	243	379	548	746	972	314	37	111
CO_2 reduction	6.4	19.0	47.9	91.8	154	239	346	472	614	198	23.2	70.2
Year	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	Total (2015-37)
Thermal generation	252	467	738	1059	1440	1887	2396	2955	3563	4217	4922	27508
CO_2 reduction	159	295	466	669	910	1193	1514	1868	2252	2665	3111	17385

Source : JICA Survey team

10.3 Benefit of Transmission Loss Reduction

By the construction of 220kV Olkaria－Lessos Line and 220kV designed (initially 132kV operation) Lessos－Kisumu Line, the electric current, which has passed through 132kV, small sized conductor so far, will pass through 220kV, large sized (and partly doubled) conductors. This will drastically reduce the transmission loss due to the reduction of conductor resistance.

The amount of loss to be reduced in 2013 based on LCPDP based forecast is shown in Table 10-3.1. The following conditions are assumed in the calculation.

Table 10-3.1 Transmission Loss Reduction (2013 : LCPDP base)

	220kV Olkaria－Lessos		132kV Lessos－Kisumu	
Season	Power loss decrease	Energy loss decrease	Power loss decrease	Energy loss decrease
Wet	2.804 MW	6,792 MWh	0.2229 MW	540 MWh
Dry	13.553 MW	32,827 MWh	1.6614 MW	4,024 MWh
All year	—	39,619 MWh	—	4,564 MWh

Source : JICA Survey team

10.4 Improvement of Quality and Reliability of Power

Impedance of 220kV Olkaria－Lessos Line will become 10.05% (100MVA base), which is 1/3 of the present 28.94% for 132kV Olkaria－Naivasha－Lanet－Lessos Line. Due to this change, stability of transmission line described in Chapter 5 will be improved. Also voltage fluctuation which occurs at the time of sudden load increase/decrease or of 1 circuit fault will be decreased.

During wet season, voltage fluctuation of 132kV bus in Lessos substation after 1 circuit of 132kV line is isolated, is shown in Table 10-4.1. Before the augmentation of 220kV Olkaria－Lessos Line, the rate of fluctuation is 2.7%, however, after the augmentation, it will be 0.8% and drastically improved.

Table 10-4.1 Voltage Fluctuation after 1 Circuit Isolation (Wet season at 132kV Bus in Lessos S/S)

220kV T/L	Section to be isolated	Voltage before isolation (a)	Voltage after isolation (b)	Rate of fluctuation (a-b)
Before augmentation	132kV Naivasha－Lanet－Lessos*	100.2%	97.5%	2.7%
After augmentation	220kV Olkaria－Lessos	103.3%	102.5%	0.8%

*: In Lanet S/S, there are no 132kV circuit breakers so that when line fault occurs, whole section from Naivashya to Lessos will be isolated.

With regard to the reliability, higher voltage transmission line normally has less chance of faults. The new 220kV transmission lines will, in comparison with the existing 132kV lines, have less rate of line faults, and thus, numbers of black out will be decreased.

10.5 Beneficiaries

10.5.1 Better Municipal Services and Employment Opportunity

Target municipalities will be 6 districts of 2 Province, because Olkaria－Lessos line and Lessos－Kisumu runs through the areas. The total population of 4.71 million will be beneficiaries of the project.

10.5.2 Inexpensive Electricity Tariff and Stable Electrical Supply

Introduction of less priced electricity tariff and stable electrical supply in long-term will be expected by inexpensive imported power from Ethiopia. The population who will receive these benefits can be considered as the beneficiaries.

The areas where the residents can enjoy the power supply from the new lines under the project. Considering the electrification rate of 15% as of 2008, it is assumed that the population who receive the benefits of inexpensive electricity and long-term stability is 2.98 million, among the total population of about 19.84 million in these areas. In addition, considering that future growth rate of the population will be 2.88% and the electrification rate is targeted to reach 40% by 2020, the beneficiaries are estimated to reach 11.2 million in 2020.

10.6 FIRR/EIRR

10.6.1 Introduction

Profitability of an electric power project is generally evaluated by the internal rate of return (IRR). The major IRR calculation methods are financial internal rate of return (FIRR) and economic internal rate of return (EIRR).

The benefit from this project would be, as mentioned in foregoing sections in this Chapter, that the relaxation of transmission capacity makes it possible to import inexpensive electricity from Ethiopia instead of building thermal plants in order to meet the growing demand in the project area. The electricity procurement cost saving for the project operation is the benefit in FIRR analysis, while the socio-economic benefit from supplying more electricity to consumers is that they can save the energy expense by replacing kerosene or diesel with inexpensive electricity. The price for additional electricity supply which consumers think it reasonable to pay is called Willingness To Pay (WTP). WTP is the basis for EIRR analysis.

10.6.2 IRR Calculation

The result of the IRR calculation is shown in Tables 10-6.1 and 10-6.2.

Table 10-6.1 FIRR/EIRR (Kisumu-Lessos 132kV as per Original Request)

(US$ '000)

	FIRR				EIRR			
Fiscal Year	Benefit	Cost		Net Cash Flow	Benefit	Cost		Net Cash Flow
		Initial	O&M			Initial	O&M	
2010	0	8,561	0	▲ 8,561	0	8,329	0	▲ 8,329
2011	0	25,683	0	▲ 25,683	0	24,986	0	▲ 24,986
2012	0	25,683	0	▲ 25,683	0	24,986	0	▲ 24,986
2013	0	25,683	0	▲ 25,683	0	24,986	0	▲ 24,986
2014	0	25,683	0	▲ 25,683	0	24,986	0	▲ 24,986
2015	683	0	1,669	▲ 986	1,386	0	1,624	▲ 239
2016	2,026	0	1,669	357	4,108	0	1,624	2,484
2017	5,113	0	1,669	3,444	10,366	0	1,624	8,742
2018	9,805	0	1,669	8,135	19,877	0	1,624	18,253
2019	16,421	0	1,669	14,752	33,290	0	1,624	31,666
2020	25,554	0	1,669	23,884	51,805	0	1,624	50,180
2021	37,001	0	1,669	35,331	75,011	0	1,624	73,387
2022	50,386	0	1,669	48,716	102,146	0	1,624	100,522
2023	65,625	0	1,669	63,956	133,040	0	1,624	131,416
2024	21,197	0	1,669	19,528	42,973	0	1,624	41,349
2025	2,474	0	1,669	804	5,015	0	1,624	3,391
2026	7,498	0	1,669	5,829	15,201	0	1,624	13,577
2027	17,002	0	1,669	15,332	34,467	0	1,624	32,843
2028	31,552	0	1,669	29,882	63,964	0	1,624	62,340
2029	49,794	0	1,669	48,125	100,947	0	1,624	99,323
2030	71,471	0	1,669	69,802	144,893	0	1,624	143,268
2031	97,203	0	1,669	95,534	197,059	0	1,624	195,435
2032	127,409	0	1,669	125,740	258,295	0	1,624	256,671
2033	161,745	0	1,669	160,075	327,903	0	1,624	326,279
2034	199,502	0	1,669	197,832	404,446	0	1,624	402,822
2035	240,483	0	1,669	238,814	487,527	0	1,624	485,903
2036	284,687	0	1,669	283,018	577,142	0	1,624	575,518
2037	332,241	0	1,669	330,572	673,547	0	1,624	671,923
2038	332,241	0	1,669	330,572	673,547	0	1,624	671,923
2039	332,241	0	1,669	330,572	673,547	0	1,624	671,923
Total	**2,521,355**	**111,294**	**41,735**	**2,368,325**	**5,111,503**	**108,274**	**40,603**	**4,962,626**

FIRR	**17.3%**	**EIRR**	**23.6%**
NPV	**130,193**	**ENPV**	**356,558**
Discount Rate	**11.0%**	**Discount Rate**	**11.0%**

Source: Survey Team

Table 10-6.2 IRR Calculation Table (Kisumu-Lessos 220kV)

(US$ '000)

	FIRR				EIRR			
Fiscal Year	Benefit	Cost		Net Cash Flow	Benefit	Cost		Net Cash Flow
		Initial	O&M			Initial	O&M	
2010	0	8,956	0	▲ 8,956	0	8,706	0	▲ 8,706
2011	0	26,867	0	▲ 26,867	0	26,118	0	▲ 26,118
2012	0	26,867	0	▲ 26,867	0	26,118	0	▲ 26,118
2013	0	26,867	0	▲ 26,867	0	26,118	0	▲ 26,118
2014	0	26,867	0	▲ 26,867	0	26,118	0	▲ 26,118
2015	683	0	1,746	▲ 1,063	1,386	0	1,698	▲ 312
2016	2,026	0	1,746	280	4,108	0	1,698	2,410
2017	5,113	0	1,746	3,367	10,366	0	1,698	8,668
2018	9,805	0	1,746	8,059	19,877	0	1,698	18,180
2019	16,421	0	1,746	14,675	33,290	0	1,698	31,592
2020	25,554	0	1,746	23,807	51,805	0	1,698	50,107
2021	37,001	0	1,746	35,254	75,011	0	1,698	73,313
2022	50,386	0	1,746	48,639	102,146	0	1,698	100,449
2023	65,625	0	1,746	63,879	133,040	0	1,698	131,343
2024	21,197	0	1,746	19,451	42,973	0	1,698	41,275
2025	2,474	0	1,746	728	5,015	0	1,698	3,318
2026	7,498	0	1,746	5,752	15,201	0	1,698	13,503
2027	17,002	0	1,746	15,255	34,467	0	1,698	32,770
2028	31,552	0	1,746	29,805	63,964	0	1,698	62,267
2029	49,794	0	1,746	48,048	100,947	0	1,698	99,249
2030	71,471	0	1,746	69,725	144,893	0	1,698	143,195
2031	97,203	0	1,746	95,457	197,059	0	1,698	195,361
2032	127,409	0	1,746	125,663	258,295	0	1,698	256,597
2033	161,745	0	1,746	159,998	327,903	0	1,698	326,205
2034	199,502	0	1,746	197,755	404,446	0	1,698	402,749
2035	240,483	0	1,746	238,737	487,527	0	1,698	485,830
2036	284,687	0	1,746	282,941	577,142	0	1,698	575,444
2037	332,241	0	1,746	330,495	673,547	0	1,698	671,849
2038	332,241	0	1,746	330,495	673,547	0	1,698	671,849
2039	332,241	0	1,746	330,495	673,547	0	1,698	671,849
Total	**2,521,355**	**116,425**	**43,659**	**2,361,270**	**5,111,503**	**113,180**	**42,443**	**4,955,880**

FIRR	**17.0%**	**EIRR**	**23.2%**
NPV	**126,143**	**ENPV**	**352,686**
Discount Rate	**11.0%**	**Discount Rate**	**11.0%**

Source: Survey Team

10.7 Index for Project Evaluation

For the evaluation of the new transmission line, effects of the transmission line shall be evaluated after the completion of the Project. For this purpose, the following indexes and evaluation method are proposed in Table 10-7.1. .

It is anticipated that "Target Value" in the table is to be obtained approximately 2 years after completion of the Project, i.e., the year 2017/18.

Table 10-7.1 Indexes to be Collected for Future Evaluation

Indexes	Definition of Indexes	Target Value	Method of Measuring Target Value	Purpose
Capacity Operating Rate (%)	Max. power transmitted (MW) / T/L capacity (MW)	Principally, less than 100%	Maximum power (MW) is to be measured at source end S/S of T/L	Capacity Operating Rate shall be within target value after Project.
Facility Operating Rate (%)	Yearly transmitted energy (MWh) / T/L capacity (MW)x24x365	To be calculated based on Demand Forecast.	Total energy (MWh) is to be recorded at power source end S/S of T/L	Facility shall be efficiently utilized.
Outage per a house (min./year)	Outage duration per a house in a target area	0 or nearly 0	To be calculated from statistics of consumers in the target area, and from actual energy (MWh) consumed in the target area.	To confirm power supply system becomes more reliable.
Outage per substation (min./year) in a target area	Outage duration per a substation in a target area	0 or nearly 0	To confirm outage duration of T/L & related S/S, from operation record of S/S.	To confirm power supply system becomes more reliable.
Voltage Drop at End user (%)	Max. voltage drop (V) / Nominal voltage (V)	To be within the standard value	To confirm from operation record of distribution S/S for the target area.	To confirm whether supplied power becomes more stable.
Outage Times (times/year) at Target Area	Outage times in the target area	0 or nearly 0	To confirm from operation record of distribution S/S in the target area.	To confirm whether power supply system becomes more reliable.
Electricity Supply (GWh)	Energy transmitted through target T/L per year	To be calculated based on Demand Forecast. Approx. 1,000,GWh/ year or more is envisaged for Olkaria-Lessos, and approx. 150GWh/ year for Lessos-Kisumu.	Energy (GWh) is to be recorded at S/S of power source end.	Facility shall be efficiently utilized. To confirm increased energy transmitted by target T/L.

Transmission Loss (%)	[Energy at power source end S/S (GWh) ─ Energy at load side end S/S (GWh)] / Energy at power source end S/S (GWh)	To be calculated from T/L specification.	Energy (GWh) is to be recorded at power source end S/S, and load side end S/S.	To confirm loss reduction after completion of Project.

Source : JICA Survey Team   Legend : T/L - Transmission Line, S/S - Substation

Chapter 11 Conclusion and Recommendation

11.1 Conclusion

Through implementation of the project as recommended, problems of power transmission between east and west in the country can be solved during long-term, such as 20 years. Especially in Kisumu and surroundings, where concentration of population and increase of power demand are becoming serious, the same problems can be solved.

On the other hand, if the project is not implemented, power supply for the whole country will be hindered and social & economical activities will be paralysed. Just for solving power shortage, then application of diesel generators in western area will also do. However, this idea has so much disadvantages in regard to economical efficiency and CO_2 emission.

11.2 Recommendation

Based on the above conclusion, the following recommendations are made.

(1) It is recommended to construct new 220 transmission line of 2 circuits from Olkaria to Kisumu, via Lessos. The route of the line is Alternative-1 described in Chapter 8 for both segments.

(2) The project is essential to provide reliable power supply to the West Region of Kenya where electricity demand is rapidly growing. The project needs to be implemented to minimize adverse effect to socio-economic activities of the country.

(3) To utilize the constructed transmission lines for long life period efficiently, the technical assistances recommended in Chapter 9 need to be carried out as well as implementation of the project.

11.3 Power System in Kenya and Projects under Japanese ODA Loan

11.3.1 Necessity of Two Segments under the Project

To Nairobi having the largest demand in the country, the powers from thermal plants in the eastern region, hydro plants in the northern region, and geo-thermal plants near Nairobi itself flow. While to the other load center, Kisumu, the powers from hydro plants in the north-western region and Sondu/Miriu, which was constructed under Japanese ODA loan, flow. There is not huge power exchange between Nairobi and the western region including Kisumu and Lessos.

However after 2013, there should be huge power flow from especially Olkaria geo-thermal plants to Lessos or Kisum area, and such measure to transmit huge power from east to west becomes necessary. Without any one of the proposed transmission lines, Olkaria－Lessos and Lessos－Kisumu, transmission capacity in the target area will have serious shortage. Thus, the construction of the both segments becomes essential. By constructing those two segments under the same project, the upgraded transmission capacities of the both segments can be fully utilized. In addition, requirement of N-1 criterion which the existing transmission lines cannot fulfill, will be satisfied.

11.3.2 Other Benefits to be Introduced by the Project

Apart from solving overload problems, implementation of the Project will also contribute to the transmission loss reduction as described. By employing 220kV transmission voltage which is 1.7 times higher than the existing voltage, and by employing larger size conductor which has less resistance comparing with the existing conductor, and by employing double conductor per phase (Olkaria－Lessos), 44,000MWh/year transmission loss can be eliminated in the first year after completion of the both segments.

Additionally, by employing larger size conductor, impedance is reduced and it will suppress the voltage fluctuation, when sudden load increase or 1 line isolation (fault or maintenance) occur. After the upgrading, the voltage fluctuation of 132kV bus in Lessos substation in wet season will be improved to be 0.8% instead of 2.7% before upgrading.