REPUBLIC OF KENYA

UPDATED LEAST COST POWER DEVELOPMENT PLAN

STUDY PERIOD: 2013 - 2033

MARCH 2013

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List of Acronyms

ERC	Energy Regulatory Commission
GDC	Geothermal Development Company
GDP	Gross Domestic Product
GoK	Government of Kenya
GT	Gas Turbine
GWh	Giga Watt hours
KenGen	Kenya Electricity Generating Company Limited
KenInvest	Kenya Investment Authority
KEPSA	Kenya Private Sector Alliance
KETRACO	Kenya Electricity Transmission Company
KPLC	Kenya Power & Lighting Company Limited
KNBS	Kenya National Bureau of Statistics
KNEB	Kenya Nuclear Electricity board
KWh	Kilo Watt hour
LCPDP	Least Cost Power Development Plan
LOLP	Loss of Load Probability
LRMC	Long Run Marginal Cost
MOEP	Ministry of Energy & Petroleum
MSD	Medium Speed Diesel
MW	Mega Watts
PV	Present Value
O & M	Operation and Maintenance
REA	Rural Electrification Authority
SRMC	Short Run Marginal Cost
TSDP	Transmission System Development Plan
WASP	Wien Automatic Simulation Package

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Acknowledgements

Section 5(g) of the Energy Act No.4 of 2006 confers the responsibility of preparing Indicative Energy Plans on the Energy Regulatory Commission (ERC). The electric power sub-sector has been preparing the Least Cost Power Development Plan (LCPDP) as the sub-sector indicative plan. The purpose of the LCPDP is to guide stakeholders with respect to how the sub-sector plans to meet the energy needs of the nation for subsistence and development at least cost to the economy and the environment. The LCPDP as indicated in the Vision 2030 medium term plan aims at enhancing national power generation and supply by identifying new generation and supply sources to ensure that the national electric power supply exceeds 3,000MW by 2018.

To prepare the LCPDP, ERC set up a multi-stakeholder committee to undertake this task on an annual basis. The stakeholder committee includes representatives from the following key players: the Ministry of Energy and Petroleum (MOEP), Ministry of Devolution and Planning, National Development and Vision 2030, Kenya Electricity Generating Company (KenGen), Kenya Power and Lighting Company (KPLC), Geothermal Development Company (GDC), Rural Electrification Authority (REA), Kenya Electricity Transmission Company Limited (KETRACO), Kenya Nuclear Electricity Board (KNEB), Kenya National Bureau of Statistics (KNBS), Kenya Investment Authority (KenInvest), and the Kenya Private Sector Alliance (KEPSA) . This update has also benefitted from the technical assistance of the French government under the French Development Agency (AFD).

I wish to sincerely commend the technical study team for a job well done. I further wish to extend my gratitude to the Steering Committee and the AFD technical assistance for ably guiding the process. This process would not have been successful without the support of various stakeholders including: the Principal Secretary, Ministry of Energy & Petroleum, the Commissioners and staff of ERC and the CEO’s and Boards of participating institutions. To them all I say: thank you very much.

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Director General
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1 INTRODUCTION

Kenya Vision 2030 envisions an improved economic growth of 10% per annum by the year 2015. This growth will be supported by three pillars: Political, Social and Economic. Electricity consumption has a strong correlation to the national Gross Domestic Product (GDP) and therefore a multiplier effect on the economic pillar. Thus the country requires to plan for its electricity requirement to achieve the envisaged high GDP growth rate.

Over the years, the Government of Kenya through the Ministry of Energy & Petroleum has undertaken long term electricity planning through annual 20 year rolling Least Cost Power Development Plan (LCPDP). The plan is categorised into three key areas;

Load forecasting – Encompasses review of load forecast assumptions, pertinent variables, historical data set and methodology, taking cognizance of the future macro-economy;

Generation Planning – Involves review and update of the power system simulation data including committed generation projects, candidate plant types, capital and operational costs and system constraints to ensure system expansion is optimal.

Transmission Planning - Involves power system simulations to ensure optimal transmission system expansion and a stable power system.

The LCPDP is now updated biennially. The current report is an update of the LCPDP of 2011/2031 and covers the period 2013- 2033. The main objective of this update is to take into account updated assumptions, new technologies as well as market dynamics that may impact on future power expansion plan.

The specific objectives of this report are to:

- Update the load forecast taking into account the performance of the economy and the Vision 2030 flagship projects;
- Update historical data, literature, committed and candidate projects;
- Estimate Short-Run Marginal Cost (SRMC) and Long Run Marginal Cost (LRMC) for the generation system;
- Develop an optimum generation expansion plan for the system (least cost generation development plan);- and

- Prepare a power transmission system development plan in line with the least cost generation development plan.

1.1 The updating methodology

The update of the 2013-2033 LCPDP was undertaken by the Least Cost Planning Committee comprising of officers from the Ministry of Energy & Petroleum (MoEP), Kenya Electricity Generating Company (KenGen), Kenya Power and Lighting Company (KPLC), Geothermal Development Company (GDC), Rural Electrification Authority (REA), Kenya National Bureau of Statistics (KNBS) , the Ministry of State for National Planning and Vision 2030, Kenya Electricity Transmission Company Limited (KETRACO), Kenya Nuclear Electricity Board (KNEB), Kenya Vision 2030 Delivery Secretariat, Kenya Investment Authority (KenInvest) and the Kenya Private Sector Alliance (KEPSA). The LCPDP was updated with the technical assistance of Mr. Yves Le Texier, a technical assistant to the Ministry of Energy & Petroleum under the French Development Agency (AFD), and Mr. Francis Jensen, an expert on the Model for Analysis of Energy Demand (MAED) also under the AFD support.

First, the load forecast was developed using excel worksheets based on the MAED methodology and assumptions. The load forecast derived was then used as an input in the Wien Automatic Simulation Package (WASP) which was simulated to determine the least cost generation sequence to meet this demand. Finally the least cost generation plan was used to develop a transmission system model using the Power System Simulation for Engineering (PSSE) software, and simulations carried out to derive a suitable transmission system development plan.

This report is the abridged version of the detailed LCPDP 2013-2033 report. The detailed reports can be requested from ERC or any of the institutions in the energy sector.

1.2 Improvements from the previous update

The update of this LCPDP took cognizance of feedback received from key policy makers and various stakeholders. The following were considered in this report:

a) The domestic category of the load forecast was separated into two regions covering Coast region and other regions in Kenya. The Coast region was treated separately because of its unique specific consumption arising from air conditioning.
b) Elasticity coefficient factor of 1.5 for electricity demand to GDP.

c) Reviewed population, urbanization and efficiency gains and technology in undertaking the demand forecast.
d) The results of a household survey undertaken in the Nairobi region were used in developing the domestic demand forecast.
e) Reviewed new potential demand arising from the effect of implementing Vision 2030 flagship projects and other investment projects which were considered to be included in the assumed 10% GDP growth rate.
f) Least cost generation expansion simulations included new candidate projects
g) The structure of the report improved with more information that is considered useful to those interested in the energy sector. The structure followed the guidelines provided by the AFD technical assistant to the Ministry of Energy & Petroleum.

2.1 Demand forecasting Methodology

2.1.1 General approach

The Model for Analysis of Energy Demand (MAED) developed by the International Atomic Energy Agency (IAEA) was used for energy demand forecasting in this update. As in previous LCPDP update, the MAED methodology was applied to design Microsoft Excel based models specific to the power sector in Kenya, which were used for the projections.

Three demand scenarios were developed based on assumptions which were defined to reflect both current and future economic and social outlook in the vision 2030. The low GDP forecast reflected a pessimistic case while the high scenario gives an optimistic case based on the vision 2030 aspiration while the reference scenario was the middle ground between the two scenarios.

2.1 Results of the forecast

The energy demand forecast and the peak load forecast are displayed in Table 1. The reference case ranges from 1370MW in 2012 to 3034MW in 2018 to 14446MW in 2030 and 21,075MW in 2033 while the energy demand increases from 8010GWh in 2012 to 17,719GWh in 2018 to 81,352GWh in 2030 and 118,680GWh in 2033.

Table 1: Energy forecast in GWh

	LOW SCENARIO			REFERENCE SCENARIO			HIGH SCENARIO		
YEAR	GWh	MW	Load factor	GWh	MW	Load factor	GWh	MW	Load factor
2012	8,010	1,370	66.76%	8,010	1,370	66.76%	8,010	1,370	66.76%
2013	9,387	1,606	66.74%	9,447	1,616	66.75%	9,499	1,625	66.74%
2014	10,450	1,785	66.84%	10,685	1,823	66.92%	10,850	1,851	66.92%
2015	11,572	1,978	66.78%	12,146	2,069	67.01%	12,514	2,130	67.06%
2016	12,739	2,184	66.59%	13,809	2,353	67.00%	14,478	2,462	67.12%
2017	13,989	2,410	66.26%	15,678	2,676	66.88%	16,740	2,849	67.07%
2018	15,275	2,649	65.83%	17,719	3,034	66.67%	19,282	3,288	66.94%
2019	16,689	2,913	65.39%	20,042	3,443	66.45%	22,236	3,799	66.82%
2020	18,242	3,207	64.94%	22,686	3,910	66.24%	25,671	4,395	66.68%
2021	19,941	3,530	64.48%	25,687	4,441	66.02%	29,657	5,087	66.56%
2022	21,847	3,895	64.03%	29,150	5,057	65.81%	34,357	5,904	66.43%

2023	23,933	4,298	63.56%	33,088	5,758	65.60%	39,827	6,857	66.30%
2024	26,229	4,745	63.10%	37,578	6,561	65.38%	46,208	7,972	66.17%
2025	28,754	5,242	62.62%	42,698	7,480	65.16%	53,657	9,275	66.04%
2026	31,532	5,793	62.14%	48,536	8,531	64.95%	62,355	10,801	65.91%
2027	34,588	6,404	61.65%	55,196	9,735	64.73%	72,515	12,587	65.77%
2028	37,951	7,084	61.16%	62,793	11,113	64.50%	84,389	14,680	65.62%
2029	41,651	7,839	60.66%	71,461	12,691	64.28%	98,270	17,132	65.48%
2030	45,723	8,641	60.41%	81,352	14,446	64.28%	114,502	19,940	65.55%
2031	50,204	9,541	60.07%	92,641	16,470	64.21%	133,492	23,248	65.55%
2032	55,135	10,538	59.73%	105,527	18,782	64.14%	155,712	27,122	65.54%
2033	59,135	11,318	59.65%	118,680	21,075	64.28%	179,850	31,237	65.73%

3 LEAST COST GENERATION PLANNING

3.1 Methodology of Least Cost Generation Planning

The generation expansion planning involved:

(a) Modeling the existing system in VALORAGUA software for hydro-thermal short term dispatch optimization model to project monthly hydropower generation and determine the short run marginal cost (SRMC) for the system;
(b) Assembling existing power system model in WASP containing the demand forecast, the existing and candidate power generation, projected hydropower outputs and assumed economic costs and factors. The objective of the model was to carryout simulations to meet projected demand over planning period;
(c) Carrying out WASP simulations to derive the optimal expansion plan;
(d) Carrying out sensitivity analysis
(e) Recommending a least cost generation expansion plan
(f) Determining the LRMC for the expansion of the power system.
(g) Evaluating the likely evolution of electricity tariffs over the planning period.

3.2 Candidate Generation Sources

Several potential power generation source/technologies were considered.

Hydropower - Two commercially viable large hydropower resource sites, Karura 90MW) and Low Grand Falls (140MW), were considered most promising for immediate development in the planning period.

Geothermal resources - mainly located within the Rift valley, and considered to have a potential between 7000-10000MW**.**

Wind power -The country has proven wind energy potential of as high as 346W/m2 in parts of Eastern, North Eastern and Coast Provinces.

Gas Turbine –it was assumed that gas turbines would operate on imported natural gas, mainly to provide peaking capacity.

Medium Speed Diesel Plants – The plants were assumed to run on heavy fuel oil, but typical plants installed in the country can also operate on natural gas.

Coal Fired Power Plants –the candidate projects were assumed to run on imported or local coal

Nuclear Power Plants - Nuclear plants being considered for development in Kenya are 300MW, 600MW and 1000MW units. A pre-feasibility study was underway during preparation of this LCPDP.

Power Imports –a maximum of 2000MW cumulative imports was assumed based on the capacity of the HVDC line committed for development between Ethiopia and Kenya.

3.2.1 Implementation constraints for candidate projects

The constraints applied in Base Case WASP simulations are shown in the table below.

Table 2: Implementation Constraints

Candidate Generation Plant	**Maximum**	**Date**
Geothermal	Maximum 3 x 140MW in a year pre 2030 and 4 x 140MW from 2030	Earliest date 2018
Coal	Maximum per year 3 x 300MW before 2030 and 4 x 300MW from 2030	Earliest date 2018
Medium Speed Diesel(160MW)	Maximum per year 3 x 160MW	Earliest date 2018
Gas Turbines –GT (180MW)	Maximum per year 3 x 180MW and 4 x 100 MW after 2030	Earliest date 2018
Wind (100MW)	Maximum 3 x 100 MW and 4 x 100 MW after 2025	Earliest date 2018
Nuclear (600MW)	Maximum 2x 600 MW per year pre 2030	First candidate in 2022
Nuclear2 (1000MW)	Maximum 2 x 1000 MW	From 2030
Karura (90MW) hydro		Earliest date 2021
Low Grand Falls (140MW) hydro		Earliest date 2021
Imports (200MW)	2 x 200 MW	Earliest date 2018

3.3 Committed generation projects

There are a number of projects committed to improve generation in the immediate to mid-term. Estimated committed generation between 2012 and 2018 is 2,639MW as shown in table 2.

Table 3: Committed generation projects

Developer	Project Name	Type	Capacity (MW)	Est. date of commission (2011/12)
IPPs				
	Thika MSD Plant (Melec)	Medium Speed Diesel	87	July-2013
	Kitengela MSD Plant (Triumph)	Medium Speed Diesel	83	February -2014
	Athi River MSD Plant (Gulf)	Medium Speed Diesel	80	February -2014
	*Kwale International Sugar Company	Cogeneration (Bagasse)	18	Dec-2014
	*Aeolus – Kinangop	Wind	60	Dec-2014
	*Gura	Hydro	3	July-2015
	Orpower 4 Expansion phase I	Geothermal	36	Marc-2013, Under Commissioning, on Reliability Test Run.
	*Genpro	Hydro	3	July-2015
	Lake Turkana Wind Power	Wind	300	March-2016
	AGIL	Geothermal	140	March-2018
	Orpower 4 Expansion phase II	Geothermal	16	March-2014
	*Prunus	Wind	50	July-2015
	*Kipeto	Wind	100	July-2015
	*Hydel	Hydro	15	July 2015
	Ethiopia Import	Hydro	400	July-2017
	Sub-total (IPP)		**1391**	
KENGEN				
	Olkaria I	Geothermal	140	Sep-2014
	Olkaria IV Project	Geothermal	140	Jun-2014
	Olkaria Wellhead units	Geothermal	65	25MW-Jun 2014 40MW-Dec 2014
	Ngong Phase II	Wind	13.6	Dec-2014
	Ngong I Phase II	Wind	6.8	Nov-2014
	Kindaruma 3rd	Hydro	8	4MW - Achieved

Developer	Project Name	Type	Capacity (MW)	Est. date of commission (2011/12)
	unit & rehab of unit 1&2			4MW Jul-2013
	Isiolo wind project (Phase I)	Wind	50	Jun-2017
	Olkaria I unit 6	Geothermal	70	Jun-2015
	Olkaria V	Geothermal	140	Jun-2017
	Eburru	Geothermal	25	Jun-2017
	Sub-total (Kengen)		**658.4**	
GDC				
	Well head Generation	Geothermal	10	2014
	Well head Generation Units	Geothermal	30	2014
	Bogoria - Silali Well Head Generation Units	Geothermal	75	2017
	Bogoria - Silali Well Head Generation Units	Geothermal	75	2018
	Menengai Phase I Power Project	Geothermal	400	300MW May-2017 100MW Sep-2017
	Sub-total (IPP/Kengen)		**590**	
	Total		**2639.4**	

*Feed in Tariff project

3.3.1 VALORAGUA Simulation Results

Figures 1, 2 and 3 provide the results from VALORAGUA Simulation tool. Figure 1 compares the VALORAGUA average annual output and the actual average output over a 5-year period. The results obtained from the model closely track the actual 5-year generation average.

Figure 1: Comparison of VALORAGUA Results with Five Year Actual Average Generation

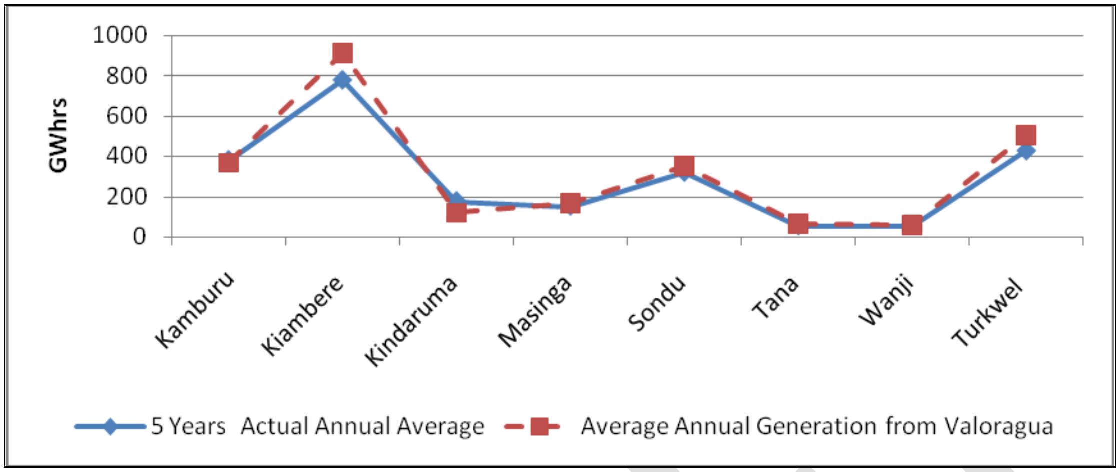
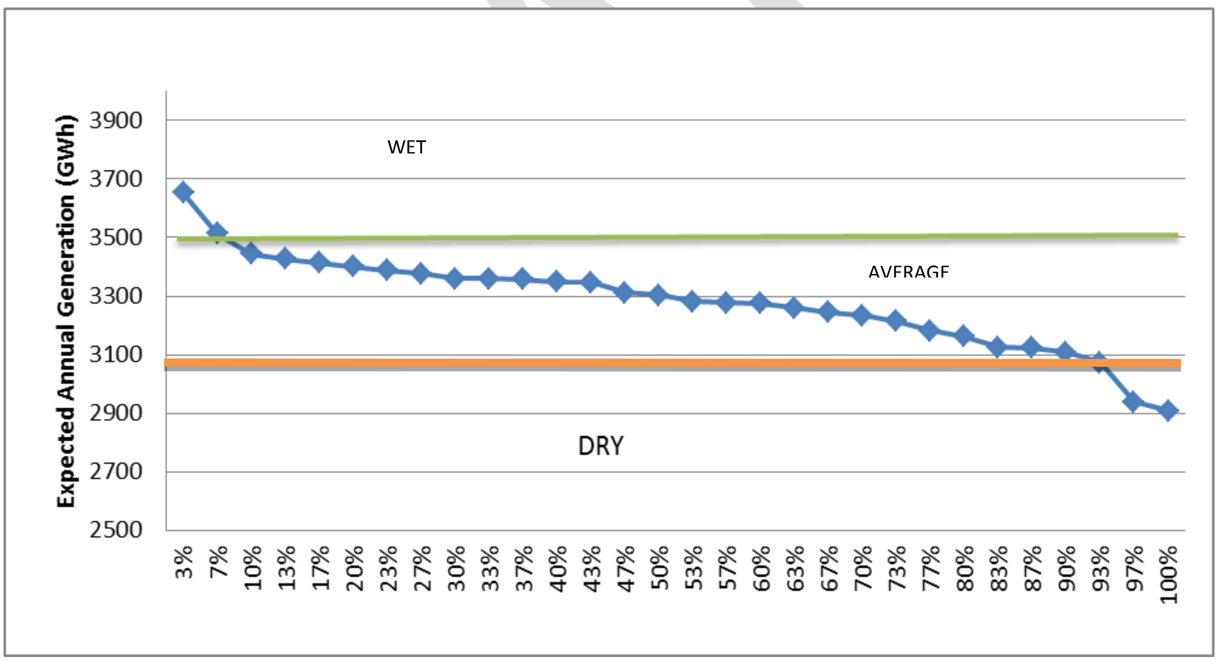


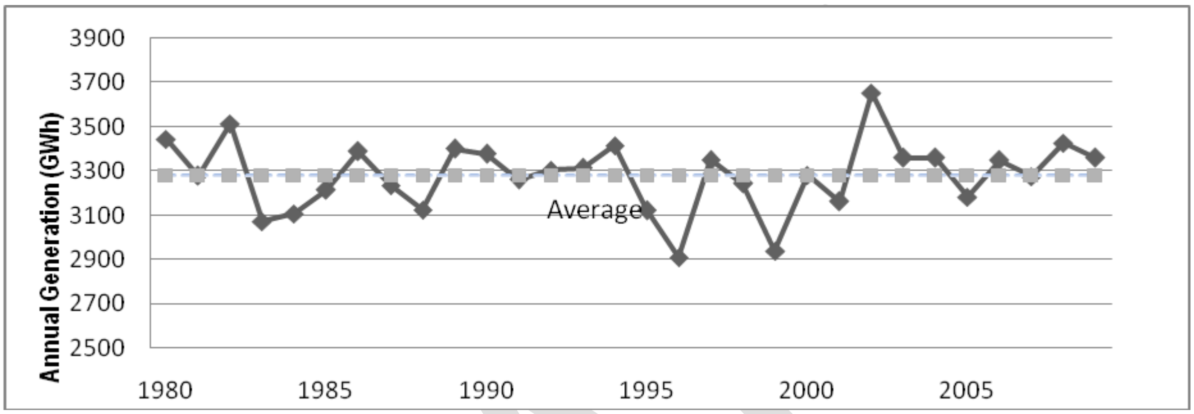
Figure 2: Probability of Hydro Generation – System Configuration



Based on the results of the VALORAGUA simulation, the probability of exceeding a given level of generation from hydro power plants can be determined from Figure 2 above. From the figure, it is evident that there is a 7% probability of generating 3,500 GWh or more annually which corresponds to the wet hydrological year of 1982. Likewise, there is a 50% probability of generating 3,300GWh or more annually which corresponds to the average hydrological year of 1992. In addition, there is a 90% probability of generating 3,100 GWh or more annually which corresponds to the dry hydrological year of 1984.

Figure 3 below shows the annual average generation from hydro power plants using historical inflow data for the period 1980 to 2009. The average generation for the period was 3280 GWh.

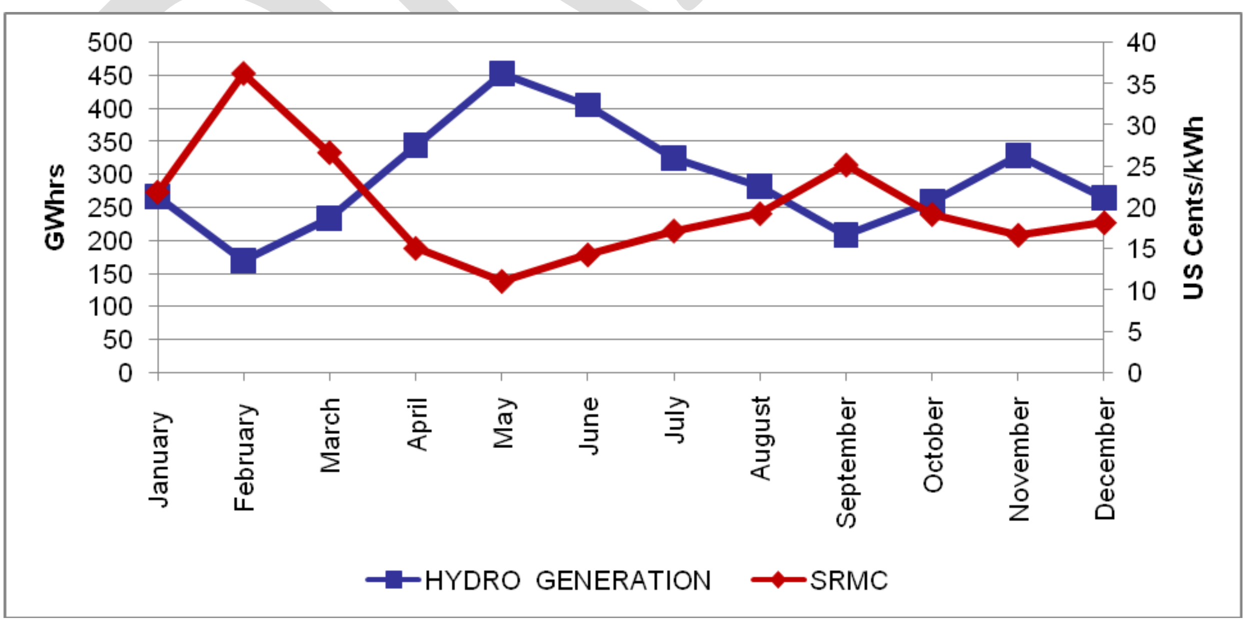
Figure 3: Output of VALORAGUA Results Using Historical Inflow Data



3.3.2 Short Run Marginal Cost Results (SRMC)

Figure 4 shows relationship between the SRMC and average monthly hydropower generation.

Figure 4: Monthly SRMC and Hydropower Generation



From the figure above it is apparent that the SRMC varies from month to month ranging from a high of 36.3 US cents/kWh in February to a low of 11 US cents/kWh in May. This is due to the inverse correlation between the SRMC of the system and energy generation from hydro power plants due to the substitution effect of thermal generation for hydro based generation during the wet seasons of the year and vice versa. Due to the high operation and maintenance costs of thermal based plants including fuel costs, the SRMC of the system increases as hydro capacity declines during short rains (September to November) and decreases as hydro capacity increase in the long rains (April to July). The average SRMC from the results was 20.1 US cents/kWh.

3.4 Long -term Optimization using WASP

System expansion analyses were performed using WASP to determine the least-cost path to meet the projected demand. The least cost development plan based on the optimum solution is presented in Table 4.

Table 4: Least Cost Expansion Program for the Base Case Analysis

Year ending 30th June	Configuration				Type	Added Capacity MW	Total Capacity MW	System Peak MW	Reserve Margin MW	Reserve Margin as % of Peak
2012							1,682	1,370	312	23%
2013	1	×	87	THIKA	MSD	87				
	2	×	18	ORP4	Geothermal	36	1,805	1,616	189	12%
2014	1	×	16	ORP4	Geothermal	16				
	1	×	6.8	Ngong	Wind	6.8				
	2	×	6.8	Ngong	Wind	13.6				
	2	×	70	OLK4	Geothermal	140				
	5	×	16	Triumph	MSD	80				
	5		16.6	GULF	MSD	83				
	2	×	70	OLK1B	Geothermal	140				
	4	×	5	OLKWH	Geothermal	20				
	8	×	5	MENW	Geothermal	40				
	10	×	-12	AGRKO	EMERG MSD	-120	2,228	1,823	405	22%
2015	10	×	5	OLKWH	Geothermal	50				
	5	×	10	PRUNUS	WIND	50				
	1	×	21	SMHYD	HYDRO	21				
	10	×	10	KIPETO	WIND	100				
	1	×	18	Kwale	congen	18				
	6	×	10	AELOUS	WIND	60	2,528	2,069	459	22%

Year ending 30th June	Configuration				Type	Added Capacity MW	Total Capacity MW	System Peak MW	Reserve Margin MW	Reserve Margin as % of Peak
2016	2	×	-30	KGT1&2	GT-KERO	-60				
	3	×	-15.1	OLK1	Geothermal	-45.3				
	1	×	70	OLK1B	Geothermal	70	2,493	2,353	140	6%
2017	1	×	26	Eburru	Geothermal	26				
	30	×	10	LTWP	Wind	300				
	5	×	10	Isiolo	Wind	50				
	4	×	100	Menengai	Geothermal	400				
	1	×	75	SILALI	Geothermal	70				
	2	×	200	Import	Import	400				
	8	×	-5	MENW	Geothermal	-40				
	2	×	70	OLKV	Geothermal	140	3,844	2,676	1,168	44%
2018	1	×	75	SILALI	Geothermal	75				
	1	x	200	Import	Import	200				
	2	×	70	Agil	Geothermal	140				
	3	×	15.3	OLK1	Geothermal	45.9	4,304	3,034	1,270	42%
2019	1	×	140	GEOT	Geothermal	140				
	10	×	-7.4	TSAVO	MSD	-74				
	1	×	200	IMPORT	IMPORT	200				
	10	×	-5.6	IBR1	MSD	-56				
	1	×	-26	Mumias	Congen	-26	4,488	3,443	1,045	30%
2020	1	×	100	Wind	Wind	100				
	3	×	140	GEOT	Geothermal	420	5,008	3,910	1,098	28%
2021	2	×	180	GT-NGAS	GT	360				
	1	×	100	Wind	Wind	100				
	1	×	140	GEOT	Geothermal	140	5,608	4,441	1,167	26%
2022	2	×	140	GEOT	Geothermal	280				
	2	×	180	GT-NGAS	GT	360				
	3	×	100	Wind	wind	300	6,548	5,057	1,491	29%
2023	1	×	140	GEOT	Geothermal	140				
	1	×	180	GT-NGAS	GT	180				
	1	×	600	Nuclear	Nuclear	600	7,468	5,758	1,710	30%
2024	3	×	140	GEO	Geothermal	420				
	1	×	300	COAL	Coal	300				
	2	×	100	Wind	Wind	200	8,388	6561	1,827	28%
2025	3	×	140	GEOT	Geothermal	420				
	6	×	-10	KDP1	MSD	-60				
	1	×	100	Wind	Wind	100				
	1	×	180	GT-NGAS	GT	180				
	2	×	200	IMPORT	IMPORT	400	9,428	7,480	1,948	26%
2026	1	×	200	IMPORT	IMPORT	200				
	3	×	180	GT-NGAS	GT	540				

Year ending 30th June	Configuration				Type	Added Capacity MW	Total Capacity MW	System Peak MW	Reserve Margin MW	Reserve Margin as % of Peak
	3	×	140	GEOT	Geothermal	420	10,588	8,531	2,057	24%
2027	3	×	140	GEOT	Geothermal	420				
	3	×	-12	ORP4A	Geothermal	-36				
	3	×	-4	ORP4B	Geothermal	-12				
	1	×	300	COAL	COAL	300				
	1	×	200	IMPORT	IMPORT	200				
	2	×	100	WIND	WIND	200	11,656	9,735	1,921	20%
2028	3	×	100	WIND	WIND	300				
	2	×	300	COAL	COAL	600				
	1	×	180	GT-NGAS	GT	180				
	5	×	-18	RABAI		-90				
	3	×	140	GEOT	Geothermal	420				
	1	×	200	IMORT	IMPORT	200	13,266	11,113	2,153	19%
2029	3	×	140	GEOT	Geothermal	420				
	3	×	300	COAL	COAL	900				
	3	×	-35	OLK2	Geothermal	-105				
	2	×	180	GT-NGAS	GT	360				
	2	×	100	Wind	Wind	200				
	1	×	200	IMPORT	IMPORT	200	15,241	12,691	2,550	20%
2030	4	×	140	GEOT	Geothermal	560				
	1	×	100	Wind	Wind	100				
	2	×	180	GT-NGAS	GT	360				
	1	×	1000	Nuclear	Nuclear	1000	17,261	14,446	2,815	19%
2031	3	×	180	GT-NGAS	GT	540				
	4	×	300	COAL	COAL	1200				
	4	×	140	GEOT	Geothermal	560	19,561	16,470	3,091	19%
2032	4	×	140	GEOT	Geothermal	560				
	4	×	300	COAL	COAL	1200				
	7	×	-16.5	KDP3	MSD	-115.5				
	4	×	180	GT-NGAS	GT	720				
	1	×	160	MSD	MSD	160	22,086	18,782	3,304	18%
2033	4	×	140	GEOT	Geothermal	560				
	3	×	300	COAL	COAL	900				
	7	×	-7.5	IBR2	MSD	-52.5				
	1	×	180	GT-NGAS	GT	180				
	1	×	1000	NUCL	NUCLEAR	1000	24,673	21,075	3,598	17%

Key: NUCL-Nuclear power, ORP4 -Orpower 4,OKWH-Olkaria Well Head, GEOT- Geothermal, , SANG – Sangoro, , ARMC - Athi River Mining Coal, THK - Thika MSD, LTWP- Lake Turkana Wind, KIND –Kindaruma, IBR-Iberafrica, , KGT-Kipevu GT, , LGF-Lower Grand Falls, GT- Gas turbines Natural Gas, MSD- Medium speed Diesel, OLK1- Olkaria 1, MENW - Menengai well head

Table 5 and Figure 5 show the installed capacity by fuel type for the least cost plan over the planning period. The results indicate that future capacity is likely to be dominated by Geothermal, Coal, GT (N-GAS), Nuclear and Wind.

Table 5: Installed Capacity by Type for the Least Cost Plan (Base case) MW

Year	Hydro	Nuclear	MSD	Import	Cogen	GT-KERO	GT-NG	Geothermal	Coal	Wind	Total	Peak Load	Reserve Margin	% LOLP
2012	814	-	568	-	26	60	-	209	-	5	1,682	1370	22.7	4.13
2013	814	-	655	-	26	60	-	245	-	5	1,805	1616	11.7	13.934
2014	814	-	698	-	26	60	-	604	-	26	2,228	1823	22.1	0.397
2015	835	-	698	-	44	60	-	655	-	236	2,528	2069	22.1	2.008
2016	835	-	698	-	44	-	-	680	-	236	2,493	2353	5.9	31.855
2017	835	-	698	400	44	-	-	1,281	-	586	3,844	2676	43.6	0.003
2018	835	-	698	600	44	-	-	1,541	-	586	4,304	3034	41.8	0.001
2019	835	-	568	800	18	-	-	1,681	-	586	4,488	3443	30.3	0.075
2020	835	-	568	800	18	-	-	2,101	-	686	5,008	3910	28	0.099
2021	835	-	568	800	18	-	360	2,241	-	786	5,608	4441	26.2	0.166
2022	835	-	568	800	18	-	720	2,521	-	1,086	6,548	5057	29.5	0.105
2023	835	600	568	800	18	-	900	2, 661	-	1,086	7,468	5758	29.7	0.169
2024	835	600	568	800	18	-	900	3,081	300	1,286	8,388	6561	27.8	0.256
2025	835	600	508	1,200	18	-	1,080	3,501	300	1,386	9,428	7480	26	0.248
2026	835	600	508	1,400	18	-	1,620	3,921	300	1,386	10,588	8531	24.1	0.195
2027	835	600	508	1,600	18	-	1,620	4,289	600	1,586	11,656	9735	19.7	0.744
2028	835	600	418	1,800	18	-	1,800	4,709	1,200	1,886	13,266	11113	19.4	0.968
2029	835	600	418	2,000	18	-	2,160	5,024	2,100	2,086	15,241	12691	20.1	0.801
2030	835	1,600	418	2,000	18	-	2,520	5,584	2,100	2,186	17,261	14446	19.5	0.844
2031	835	1,600	418	2,000	18	-	3,060	6,144	3,300	2,186	19,561	16470	18.8	0.747
2032	835	1,600	463	2,000	18	-	3,780	6,704	4,500	2,186	22,086	18782	17.6	0.791
2033	835	2,600	410	2,000	18	-	3,960	7,264	5,400	2,186	24,673	21075	17.1	0.829

Figure 5: Development of System Capacity for the Base Case under Reference Fuel Cost

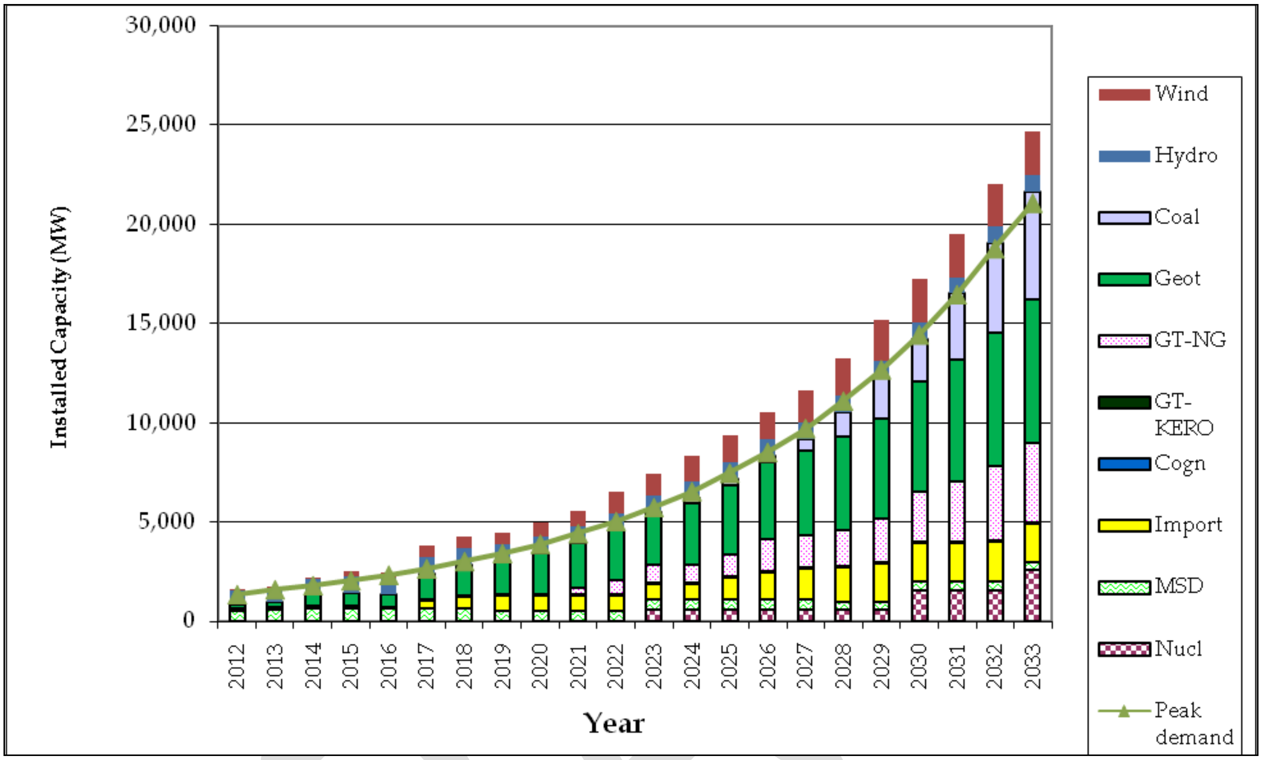


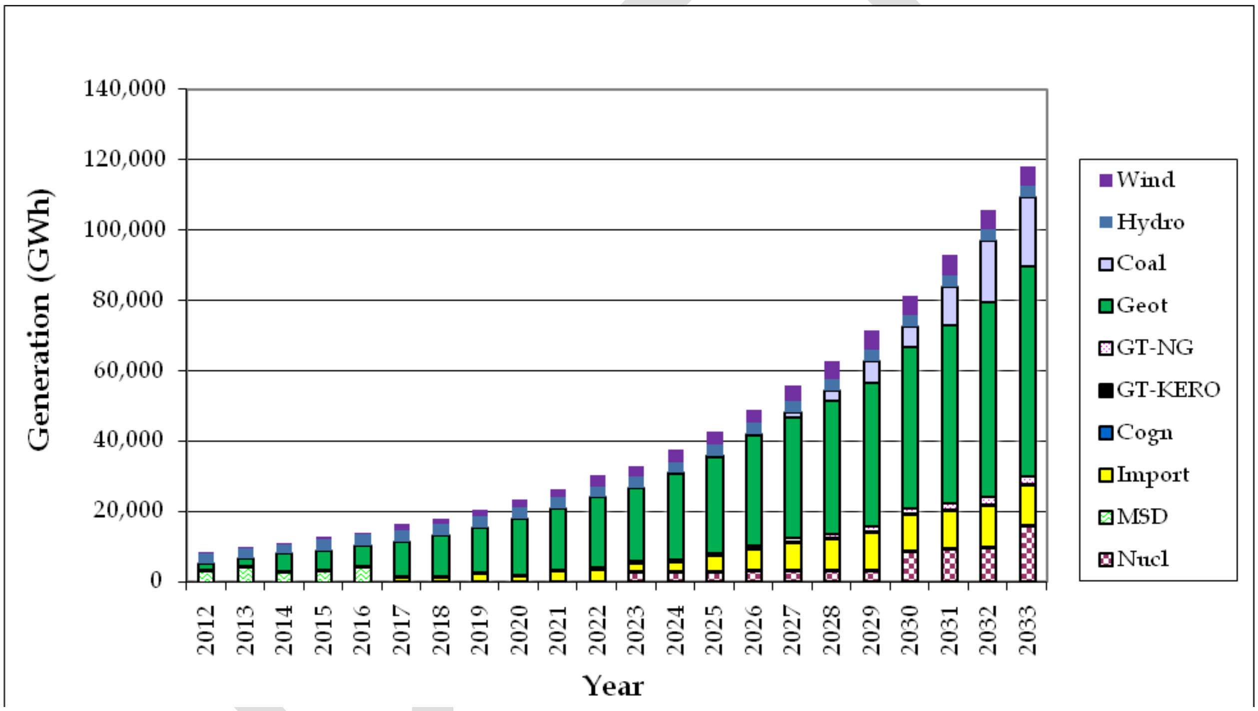
Table 6 and figure 6 show the energy outputs for the base case. Thermal power plants are expected to mainly provide the required system reserve capacity.

Table 6: Electricity Generation by Type (Base Case) GWh

YEAR	Hydro	Nuclear	MSD	Import	Cogen	GT-Kero	GT-NG	Geo-thermal	Coal	Wind	TOTAL
2012	3168	0	3190	0	221	55	0	1733	0	17	**8384**
2013	3168	0	4217	0	223	146	0	2033	0	17	**9804**
2014	3168	0	2767	0	209	3	0	4971	0	67	**11185**
2015	3204	0	3141	0	346	13	0	5406	0	576	**12686**
2016	3204	0	4237	0	362	0	0	5644	0	576	**14023**
2017	3204	0	94	1390	53	0	0	9915	0	1764	**16420**
2018	3204	0	38	1392	16	0	0	11689	0	1764	**18103**
2019	3204	0	75	2428	9	0	0	13062	0	1764	**20542**
2020	3204	0	74	1993	8	0	0	16037	0	2011	**23327**
2021	3204	0	139	3206	25	0	181	17482	0	2259	**26496**
2022	3204	0	213	3572	49	0	439	19694	0	3001	**30172**

2023	3204	2912	121	2537	24	0	389	20811	0	3001	**32999**
2024	3204	2931	113	3004	38	0	379	24081	354	3496	**37600**
2025	3204	2986	97	4573	28	0	403	27541	293	3744	**42869**
2026	3204	3064	136	6271	47	0	766	31182	478	3744	**48892**
2027	3204	3168	193	7963	73	0	1011	34483	1450	4238	**55783**
2028	3204	3195	51	9242	82	0	1059	37857	2995	4981	**62666**
2029	3204	3384	41	10903	95	0	1185	40950	6334	5476	**71572**
2030	3204	8903	39	10525	90	0	1391	45760	5827	5723	**81462**
2031	3204	9424	34	11075	100	0	1685	50592	11048	5723	**92885**
2032	3204	10057	37	11602	105	0	2376	55373	17447	5723	**105924**
2033	3204	16159	31	11414	104	0	2098	60066	19493	5723	**118292**

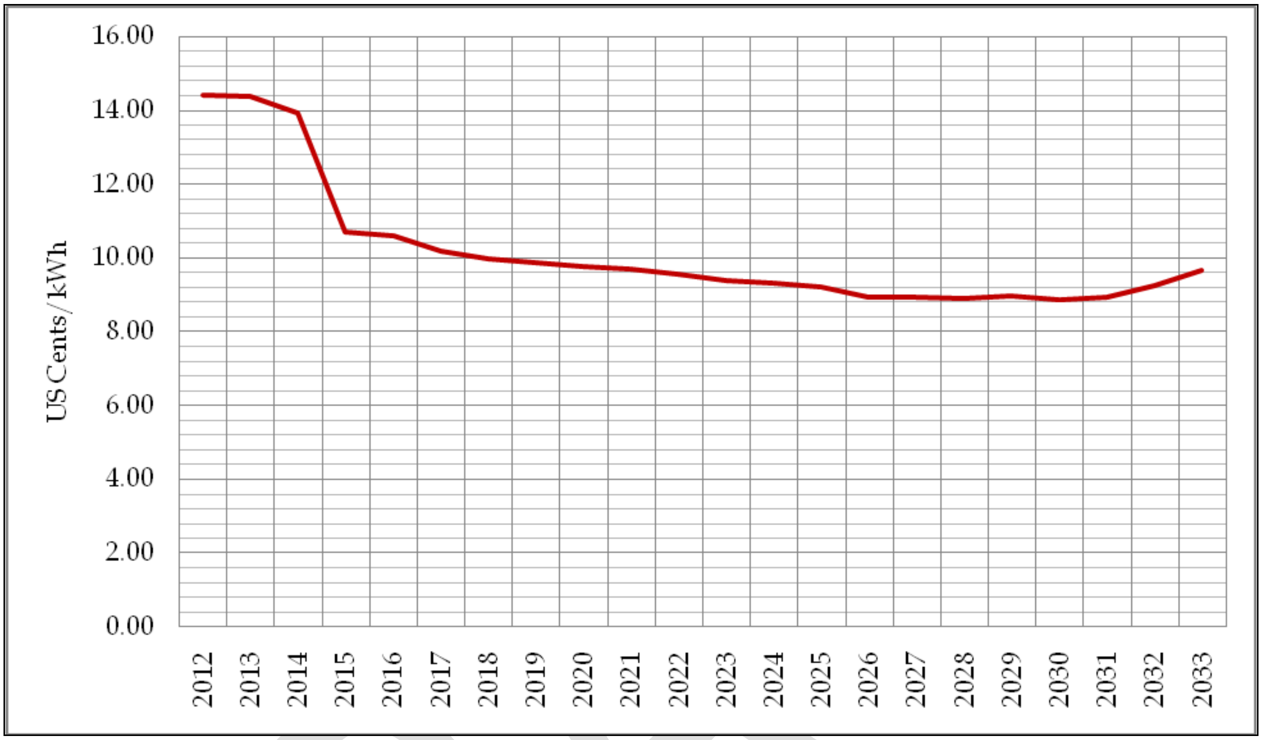
Figure 6: Electricity Generation by Type (Base Case) in GWh



3.5 Generation Tariffs

Based on the developed least cost generation plan an analysis of the evolution of generations tariffs was undertaken. The results are indicated in figure 7 below. If the plan is implemented as suggest the tariffs will continue declining to about 9.7US cents/kWh. As indicated in the graph the current tariffs are the highest the subsector will experience if the proposed plan is implemented.

Figure 7: Evolution of Electricity Generation Tariffs in Kenya: 2012 - 2033



4 TRANSMISSION PLANNING

4.1 Methodology

This transmission plan development employs the target network concept of transmission planning which ensures a coordinated investment strategy and therefore optimal network development using the Least Cost Planning concept. The transmission planning involved:

- Developing a set of transmission network solutions for the planning horizon year 2033 to be considered in selection and recommendation of a final target network on which the transmission plan shall be based.
- Preparing detailed alternative transmission development sequences for comparison and determination of the least cost transmission plan
- Developing and presenting cost estimates for the planned investments

The Transmission investment sequences were established by creating and optimizing network models at 5 year intervals between 2015 and 2030, with each of the investments conforming to the 2033 target network requirements. This was done by starting with the 2033 target network and developing 2025, 2020, and 2015 network models in reverse sequence by switching generators and loads as per the generation development plan and load forecast, and equipment not required as a result. Network models for each of the snapshot years were optimized through load flow, contingency and short circuit studies to ensure the transmission criteria was complied with at every stage.

The resultant transmission Lines, Substations and Reactive compensation requirements for the system are tabulated in tables 7, 8 and 9 below.

4.2 Kenya Power Transmission System Development Plan 2013-2033

Table 7: TRANSMISSION LINES INVESTMENT SEQUENCE

YEAR	TRANSMISSION LINE	CIRCUIT NO.	LENGTH (KM)	COST '000 USD		
				LINES	BAYS	NEW S/S
2013	KINDARUMA TOFF__MANGU__132kV	1	17	1646	783	4193
	MASINGA TOFF__KUTUS__132kV	1	12	1162	783	4193
	OLKARIA II__OLKARIA 1A__220kV	1	4	387	1566	0
	MANGU__ GATUNDU__132kV	1	20	1936	1566	4193
	MANGU__GITHAMBO__132kV	1	43	4162	1566	4193
	JUJA RD TOFF__MANGU__132kV	1	17	1646	783	0
	KIGANJO TOFF__KUTUS__132kV	1	12	1162	783	0
	LESSOS__KAPSABET__132kV	1	30	2904	1566	4193
	LESSOS__MAKUTANO__132Kv*	1	0	0	783	4193
	LANET__MAKUTANO__132kV*	1	0	0	783	4193
	MARIAKANI__RABAI__220kV	1	33	7260	2560	0
	MARIAKANI__RABAI__220kV	2	33	0	2926	0
	ISINYA__EMBAKASI__220kV	1	34	9180	2560	0
	ISINYA__EMBAKASI__220kV	2	34	0	2560	0
	ISINYA__MARIAKANI__220kV**	1	429	137280	4000	0
	ISINYA__MARIAKANI__220kV	2	429	0	4000	0
	RABAI__MALINDI__220kV	1	97	15520	2560	6863
	MALINDI__GARSEN__220kV	1	117	18720	2560	6863
	GARSEN__LAMU__220kV	1	108	17280	2560	6863
2014	KINDARUMA__MWINGI__132kV	1	32	3098	1566	4193
	OLKARIA 1__OLKARIA1A__132kV	1	3	290	1566	0
	OLKARIA1__OLKARIA1E__132kV	1	1	106	1566	0
	DOMES__OLKARIA1A__132kV	1	6	581	1566	0
	NANYUKI__ISIOLO__132kV	1	64	6195	1566	0
	ISIOLO__MERU__132kV	1	32	3098	1566	4193
	LESSOS__NAKURU WEST__132kV*	1	0	0	1566	4193
	LANET__NAKURU WEST__132kV*	1	0	0	1566	0
	LANET__NAKURU WWEST__132kV*	2	0	0	1566	0

YEAR	TRANSMISSION LINE	CIRCUIT NO.	LENGTH (KM)	COST '000 USD		
				LINES	BAYS	NEW S/S
	KYENI__ISHIARA__132kV	1	15	1452	1566	4193
	KYENI__KUTUS__132kV	1	18	1742	1566	0
	ISHIARA__MERU__132kV*	1	0	0	1566	0
	KISII__AWENDO__132kV	1	44	4259	1566	4193
	NAKURU WEST__MAKUTANO__132kV*	2	0	0	1566	0
	MWINGI__GARISSA__132kV	1	192	18586	1566	4193
	ISINYA__SUSWA__220kV**	1	100	32000	5000	0
	ISINYA__SUSWA__220kV**	2	100	0	5000	0
	ISINYA__ATHI__220kV	1	20	5387	2560	6863
	ISINYA__ATHI__220kV	2	20	0	2560	0
	TURKWEL__KAINUK__220kV	1	0	0	2560	6863
	OLKARIA II__SUSWA__220kV*	1	0	0	1280	0
	OLKARIA II__SUSWA__220kV*	2	0	0	1280	0
	OLKARIA II__OLKARIA1E__220kV	1	3	810	2560	0
	OLKARIA II__OLKARIA1E__220kV	2	3	0	2560	0
	SUSWA__OLKARIA1E__220kV	1	27	7290	2560	0
	SUSWA__OLKARIA1E__220kV	2	27	0	2560	0
	SUSWA__NBNORTH__220kV*	1	0	0	1280	0
	SUSWA__NBNORTH__220kV*	2	0	0	1280	0
	SUSWA__OLKARIAIV__220kV	1	25	6750	2560	0
	SUSWA__OLKARIAIV__220kV	2	25	0	2560	0
	SUSWA__NGONG__220kV	1	50	13500	2560	6863
	SUSWA__NGONG__220kV	2	50	0	2560	
	DANDORA__KOMOROCK__220kV	1	3	810	2560	6863
	DANDORA__KOMOROCK__220kV	2	3	0	2560	
	DANDORA__THIKA RD__220kV*	1	0	0	2560	6863
	DANDORA__THIKA RD__220kV*	2	0	0	2560	0
	EMBAKASI__ATHI__220kV	1	18	4860	2560	6863
	EMBAKASI__ATHI__220kV	2	18	0	2560	0
	NBNORTH__THIKARD__220kV*	1	0	0	2560	0
	NBNORTH__THIKARD__220kV*	2	0	0	2560	0
	LESSOS__TORORO__220kV**	1	127	40640	4000	0
	LESSOS__TORORO__220kV**	2	127	0	4000	0
2015	OLKARIA__NAROK__132kV	1	68	6582	1566	4193

YEAR	TRANSMISSION LINE	CIRCUIT NO.	LENGTH (KM)	COST '000 USD		
				LINES	BAYS	NEW S/S
	MTWAPA__KILIFI__132kV	1	25	2381	1566	4193
	MTWAPA__BAMBURI__132kV	1	25	2381	1566	0
	RABAI__BAMBURI__132kV	1	25	3870	1566	0
	NANYUKI__NYAHURURU__132kV	1	79	7647	1566	4193
	CHEMOSIT__SOTIK__132kV*	1	0	0	783	0
	KISII__SOTIK__132kV*	1	0	0	1566	0
	CHOGORIA__ISHIARA__132kV	1	40	3872	1566	4193
	LESSOS__KABARNET__132kV	1	65	6292	1566	4193
	NAIVASHA__AEOLOUS WIND__132kV	1	30	2904	1566	0
	SULTAN__KONZA__132kV*	1	0	0	1566	0
	SULTAN__WOTE__132kV	1	37	3582	1566	4193
	SULTAN__KITUI__132kV	1	86	8325	1566	4193
	VOI__TAVETA__132kV	1	90	8712	1566	4193
	GALU__LUNGA LUNGA__132kV	1	50	4840	1566	4193
	SONDU__HOMABAY__132kV	1	70	6776	1566	4193
	MERU__ISIOLO__132kV	1	32	3098	1566	4193
	MERU__MAUA__132kV	1	50	4840	1566	4193
	BOMET__SOTIK__132kV	1	30	2904	1566	4193
	NYAHURURU__RUMURUTI__132kV	1	20	1936	1566	9568
	KONZA__ISINYA__132kV	1	35	3388	1566	0
	KONZA__MACHAKOS__132kV	1	20	1936	1566	4193
	WAJIR__GARISSA__132kV	1	300	29040	1566	4193
	KAJIADO__ISINYA__132kV	1	10	968	1566	4193
	KAJIADO__NAMANGA__132kV	1	90	8712	1566	4193
	SULTAN__LOITOKITOK__132kV	1	120	11616	1566	4193
	AWENDO__NDHIWA__132kV	1	50	4840	1566	4193
	RUMURUTI__MARALAL__132kV	1	148	14326	1566	4193
	MWINGI__KITUI__132kV	1	30	2904	1566	4193
	HOMABAY__NDHIWA__132kV	1	15	1452	1566	4193
	ISINYA__KIPETO__220kV	1	30	4800	2560	0
	MATASIA__NGONG__220kV	1	25	6750	2560	6863
	MATASIA__NGONG__220kV	2	25	0	2560	0
	KAINUK__ORTUM__220kV	1	80	12800	2560	6863
	OLKARIAII__LESSOS__220kV**	1	203	64960	2560	6863
	OLKARIAII__LESSOS__220kV**	2	203	0	2560	0

YEAR	TRANSMISSION LINE	CIRCUIT NO.	LENGTH (KM)	COST '000 USD		
				LINES	BAYS	NEW S/S
	LESSOS__KISUMU__220kV**	1	103	32960	2560	6863
	LESSOS__KISUMU__220kV**	2	103	0	2560	0
	GARSEN__HOLA__220kV	1	96	15360	2560	6863
	GARISSA__HOLA__220kV	1	144	23040	2560	6863
	TURKWEL__KITALE__220kV	1	108	17280	2560	0
	ORTUM__KITALE__220kV	1	30	4800	2560	6863
2020	ELDORET__MOI BRKS__132kV*	1	18	0	1566	4193
	KIGANJ0__MURANGA__132kV	1	38	3630	1566	4193
	MUSAGA__BUNGOMA__132kV	1	30	2904	1566	4193
	LANET__GILGIL__132kV*	1	0	0	1566	4193
	LANE1__GILGIL__132kV*	2	0	0	1566	0
	NAIVSHA__GILGIL__132kV*	1	0	0	1566	0
	NAIVSHA__GILGIL__132kV*	2	0	0	1566	0
	MUMIAS__CHAVAKALI__132kV	1	30	2904	1566	4193
	NYAHURURU__KABARNET__132kV	1	90	8712	1566	4193
	KABARNET__KAPSOWAR__132kV	1	33	3146	1566	4193
	NAKURU WEST__KERINGET__132kV*	1	0	0	1566	4193
	AWENDO__MIGORI__132kV	1	30	2904	1566	4193
	KITALE__MOI BRKS__132kV*	1	42	0	1566	4193
	GITHAMBO__MURANGA__132kV	1	38	3630	1566	4193
	MAKUTANO__KERINGET__132kV	1	13	0	1566	0
	MWINGI__KITUI__132kV	1	30	2904	1566	0
	MARIAKANI__LIKONI__220kV	1	44	7040	2560	6863
	MARIAKANI__MARIAKANI__220kV	1	5	1350	2560	6863
	MARIAKANI__MARIAKANI__220kV	2	5		2560	0
	ISINYA__DANDORA__220kV	1	34	9180	2560	0
	ISINYA__DANDORA__220kV	2	34	0	2560	0
	ISINYA__MALILI__220kV**	1	90	28800	2560	6863
	ISINYA__MALILI__220kV**	2	90	0	2560	0
	ISINYA__ATHI__220kV	3	20	3771	2560	0
	MATASIA__PIPELINE__220kV	1	10	2700	2560	6863
	MATASIA__PIPELINE__220kV	2	10	0	2560	0
	MATASIA__ATHI__220kV	1	25	6750	2560	0
	MATASIA__ATHI__220kV	2	25	0	2560	
	KIAMBERE__MUTONGA__220kV	1	40	8800	2560	0

YEAR	TRANSMISSION LINE	CIRCUIT NO.	LENGTH (KM)	COST '000 USD		
				LINES	BAYS	NEW S/S
	KIAMBERE__MUTONGA__220kV	2	40	0	2560	0
	OLKARIA II__RONGAI__220kV*	1	0	0	2560	6863
	OLKARIA II__RONGAI__220kV*	2	0	0	2560	0
	SUSWA__SUSWA GEN__220kV	1	10	2700	2560	0
	SUSWA__SUSWA GEN__220kV	2	10		2560	0
	SUSWA__RUMURUTI__220kV**	1	101	32336	2560	68630
	SUSWA__RUMURUTI__220kV**	2	101	0	2560	
	ELDORET NORTH__ELDORET__220kV	1	10	1600	2560	6863
	GILGIL__NAIVASHA__220kV	1	30	8141	2560	6863
	GILGIL__NAIVASHA__220kV	2	30	0	2560	0
	GILGIL__LANET__220kV	1	37	9950	2560	6863
	GILGIL__LANET__220kV	2	37	0	2560	0
	KITALE__ORTUM__220kV	1	40	8800	2560	6863
	KISUMU EAST__1LESSO2__220kV*	1	0	0	2560	6863
	KISUMU EAST__1LESSO2__220kV*	2	0	0	2560	0
	KISUMU EAST__MUHORONI__220kV	1	28	6160	2560	6863
	KISUMU EAST__MUHORONI__220kV	2	28	0	2560	0
	KISUMU EAST__KISUMU__220kV*	1	0	0	2560	0
	KISUMU EAST__KISUMU__220kV*	2	0		2560	0
	MUSAGA__LESSOS__220kV*	1	0	0	2560	6863
	MUSAGA__LESSOS__220kV*	2	0	0	2560	0
	MUSAGA__TORORO__220kV*	1	0	0	2560	0
	MUSAGA__TORORO__220kV*	2	0	0	2560	0
	LESSOS__ELDORET__220kV	1	30	6600	2560	0
	LESSOS__RONGAI__220kV	1	0	0	2560	0
	LESSOS__RONGAI__220kV	2	0	0	2560	0
	MUHORONI__CHEMOSIT__220kV	1	31	6754	2560	6863
	MUHORONI__CHEMOSIT__220kV	2	31	0	2560	0
	KATHWANA__MUTONGA__220kV	1	20	4400	2560	6863
	KATHWANA__MUTONGA__220kV	2	20	0	2560	0
	JUJA RD__RUARAKA__220kV	1	15	4050	2560	6863
	JUJA RD__RUARAKA__220kV	2	15	0	2560	0
	RUARAKA__NAIVASHA__220kV	1	75	20250	2560	6863
	RUARAKA__NAIVASHA__220kV	2	75	0	2560	0
	NAIVASHA__KINANGOP WIND__220kV	1	30	6600	2560	0
	LANET__RONGAI__220kV	1	25	6750	2560	6863

YEAR	TRANSMISSION LINE	CIRCUIT NO.	LENGTH (KM)	COST '000 USD		
				LINES	BAYS	NEW S/S
	LANET__RONGAI__220kV	2	25	0	2560	0
	LOYANGALANI__RUMURUTI__220kV***	1	329	105264	2560	6863
	LOYANGALANI__RUMURUTI__220kV***	2	329	0	2560	0
	MARIAKANI__ISINYA__400kV***	1	0	0	5000	9568
	MARIAKANI__ISINYA__400kV***	2	0	0	5000	0
	ISINYA_ ARUSHA_400kV	1	100	42000	4000	0
	ISINYA_ ARUSHA_400kV	2	100	0	4000	0
	ETHIOPIA_KENYA_500kV HVDC	1	612	762000	2500	9568
	ETHIOPIA_KENYA_500kV HVDC	2	612	0	2500	0
	SILALI__PAKA__400kV	1	35	11200	4000	0
	SILALI__PAKA__400kV	2	35	0	4000	0
	PAKA__KOROSI__400kV	1	20	6400	4000	0
	PAKA__KOROSI__400kV	2	20	0	4000	0
	KOROSI__BOGORIA__400kV	1	50	16000	4000	0
	KOROSI__BOGORIA__400kV	2	50	0	4000	
	MENENGAI__RONGAI__400kV	1	20	6400	4000	9568
	MENENGAI__RONGAI__400kV	2	20		4000	0
	ISINYA__ARUSHA__400kV	1	200	64000	4000	0
	ISINYA__ARUSHA__400kV	2	200	0	4000	0
	ISINYA__PIPELINE__400kV	1	50	0	4000	9568
	ISINYA__PIPELINE__400kV	2	50	0	4000	0
	BOGORIA__RONGAI__400kV	1	60	19200	4000	0
	BOGORIA__RONGAI__400kV	2	60	0	4000	
	LONGONOT__SUSWA__400kV	1	20	6400	4000	0
	LONGONOT__SUSWA__400kV	2	0	0	4000	
	SUSWA__PIPELINE__400kV*	1	0	0	4000	0
	SUSWA__PIPELINE__400kV*	2	0	0	4000	0
2025	ISINYA__KOMOROCK__220kV	1	40	10800	2560	6863
	ISINYA__KOMOROCK__220kV	2	40		2560	0
	GALU__LIKONI__220kV	1	30	8100	2560	6863
	GALU__LIKONI__220kV	2	30	0	2560	0
	DONGOKUNDU__LIKONI__220kV	1	8	2160	2560	6863
	DONGOKUNDU__LIKONI__220kV	2	8	0	2560	0
	DONGOKUNDU__MBARAKI__220kV	1	10	2700	2560	6863
	DONGOKUNDU__MBARAKI__220kV	2	10	0	2560	0

YEAR	TRANSMISSION LINE	CIRCUIT	LENGTH	COST '000 USD		
		NO.	(KM)	LINES	BAYS	NEW S/S
	MATASIA__LANGATA__220kV	1	20	5400	2560	6863
	MATASIA__LANGATA__220kV	2	20	0	2560	0
	CITY SQR__EMBAKASI__220kV	1	17	22275	2560	6863
	CITY SQR__EMBAKASI__220kV	2	17	0	2560	0
	KARI WAIYAKI WAY__NBNORTH__220kV	1	15	20250	2560	6863
	KARI WAIYAKI WAY__NBNORTH__220kV	2	15	0	2560	0
	DANDORA__JUJA RD__220kV	1	3	810	2560	6863
	DANDORA__JUJA RD__220kV	2	3	0	2560	
	KOMOROCK__KAMULU__220kV	1	15	4050	2560	6863
	KOMOROCK__KAMULU__220kV	2	15	0	2560	0
	ISIOLO__MERU__220kV	1	35	7700	2560	6863
	ISIOLO__MERU__220kV	2	35	0	2560	0
	ISIOLO__NANYUKI__220kV	1	70	15400	2560	6863
	ISIOLO__NANYUKI__220kV	2	70	0	2560	0
	MURANGA__THIKA__220kV	1	46	12285	2560	6863
	MURANGA__THIKA__220kV	2	46	0	2560	0
	MURANGA__KIGANJO__220kV	1	45	12150	2560	6863
	MURANGA__KIGANJO__220kV	2	45	0	2560	0
	MERU__MUTONGA__220kV	1	70	15400	2560	6863
	MERU__MUTONGA__220kV	2	70	0	2560	0
	MUTONGA__LG FALLS__220kV	1	20	4400	2560	6863
	MUTONGA__LG FALLS__220kV	2	20	0	2560	0
	MANGU__THIKA__220kV	1	20	5265	2560	6863
	MANGU__THIKA__220kV	2	20		2560	0
	MANGU__THIKA RD__220kV	1	20	5400	2560	6863
	MANGU__THIKA RD__220kV	2	20	0	2560	0
	NANYUKI__KIGANJO__220kV	1	52	13905	2560	6863
	NANYUKI__KIGANJO__220kV	2	52	0	2560	0
	NANYUKI__RUMURUTI__220kV**	1	100	27000	2560	6863
	NANYUKI__RUMURUTI__220kV**	2	100	0	2560	0
	KILIFI__KILIFI PS__220kV	1	20	5400	2560	6863
	KILIFI__KILIFI PS__220kV	2	20	0	2560	0
	MARIAKANI__KILIFI PS__400kV	1	100	32000	5000	9568
	MARIAKANI__KILIFI PS__400kV	2	100	0	5000	0
	MARIAKANI__DONGOKUNDU__400kV	1	40	12800	5000	9568

YEAR	TRANSMISSION LINE	CIRCUIT NO.	LENGTH (KM)	COST '000 USD		
				LINES	BAYS	NEW S/S
	MARIAKANI__DONGOKUNNDU__400kV	2	40	0	5000	0
	LANET__UPLANDS__400kV	1	100	32000	4000	9568
	LANET__UPLANDS__400kV	2	100	0	4000	0
	LANET__MENENGAI__400kV	1	20	6400	5000	9568
	LANET__MENENGAI__400kV	2	20	0	5000	0
	UPLANDS__KIAMBU NORTH__400kV	1	40	12800	4000	9568
	UPLANDS__KIAMBU NORTH__400kV	2	40	0	4000	
	ISINYA__MALILI__400kV***	1	0	0	4000	9568
	ISINYA__MALILI__400kV***	2	0	0	4000	0
	RUMURUTI__SUSWA__400kV***	1	0	0	4000	9568
	RUMURUTI__SUSWA__400kV***	2	0	0	4000	0
	RUMURUTI__LOYANGALANI__400kV***	1	0	0	4000	0
	RUMURUTI__LOYANGALANI__400kV***	2	0	0	4000	0
	MARSABIT__LOYANGALANI__400kV	1	200	40000	4000	0
	RONGAI__OLKARIA II__400kV***	1	0	0	5000	9568
	RONGAI__OLKARIA II__400kV***	2	0	0	5000	0
	RONGAI__LESSOS__400kV***	1	0	0	5000	9568
	RONGAI__LESSOS__400kV***	2	0	0	5000	0
2030	NYALI__BAMBURI__132kV	1	8	1258	1566	4193
	NYALI__BAMBURI__132kV	2	8	0	1566	0
	KAJIADO__ISINYA__132kV	1	10	968	1566	0
	MARIAKANI__MIRITINI__220kV	1	20	4400	2560	6863
	MARIAKANI__MIRITINI__220kV	2	20	0	2560	0
	ISINYA__KITENGELA__220kV*	1	0	0	4000	6863
	ISINYA__KITENGELA__220kV*	2	0		4000	0
	KITENGELA__ATHI__220kV*	1	0	0	4000	0
	KITENGELA__ATHI__220kV*	2	0		4000	0
	KAMBURU__EMBU__220kV	1	40	8800	2560	6863
	KAMBURU__EMBU__220kV	2	40	0	2560	0
	MATASIA__PIPELINE__220kV	1	10	2700	2560	6863
	MATASIA__PIPELINE__220kV	2	10	0	2560	0
	CITY SQR__LANGATA__220kV	1	15	20250	2560	6863
	CITY SQR__LANGATA__220kV	2	15	0	2560	0
	CITY SQR__NGONG RD__220kV	1	10	13500	2560	6863
	CITY SQR__NGONG RD__220kV	2	10	0	2560	0

YEAR	TRANSMISSION LINE	CIRCUIT NO.	LENGTH (KM)	COST '000 USD		
				LINES	BAYS	NEW S/S
	ELDORET N__KITALE__220kV	1	60	9600	2560	0
	KOMOROCK__KANGUNDO__220kV	1	40	10800	2560	6863
	KOMOROCK__KANGUNDO__220kV	2	40	0	2560	0
	NBNORTH__UPLANDS__220kV	1	30	8100	2560	0
	NBNORTH__UPLANDS__220kV	2	30	0	2560	0
	RABAI__MALINDI__220kV	1	97	15520	2560	0
	DRIVE INN__RUARAKA__220kV	1	10	2700	2560	6863
	DRIVE INN__RUARAKA__220kV	2	10	0	2560	0
	LESSOS__ELDORET SOUTH__220kV	1	22	0	2560	6863
	CHEMOSIT__KISII__220kV	1	60	13200	2560	6863
	CHEMOSIT__KISII__220kV	2	60		2560	0
	MTITO ANDEI__SULTAN__220kV	1	129	34830	2560	6863
	MTITO ANDEI__SULTAN__220kV	2	129	0	2560	0
	MTITO ANDEI__VOI__220kV	1	90	24300	2560	6863
	MTITO ANDEI__VOI__220kV	2	90	0	2560	0
	GARSEN__LAMU__220kV	1	108	17280	2560	0
	KANGUNDO__KAMULU__220kV	1	30	8100	2560	6863
	KANGUNDO__KAMULU__220kV	2	30	0	2560	0
	KANGUNDO__KATANI__220kV	1	30	8100	2560	6863
	KANGUNDO__KATANI__220kV	2	30	0	2560	0
	MALILI__MACHAKOS__220kV	1	30	6600	2560	6863
	MALILI__MACHAKOS__220kV	2	30	0	2560	0
	MALILI__SULTAN__220kV	1	50	13500	2560	6863
	MALILI__SULTAN__220kV	2	50	0	2560	0
	MARIAKANI__VOI__220kV	1	114	30780	2560	6863
	MARIAKANI__VOI__220kV	2	114	0	2560	0
	NAKURU SOUTH__RONGAI__220kV	1	20	4400	2560	6863
	NAKURU SOUTH__RONGAI__220kV	2	20	0	2560	0
	NGONG__KIKUYU__220kV	1	20	5400	2560	6863
	NGONG__KIKUYU__220kV	2	20	0	2560	0
	NGONG__LAVINGTON__220kV	1	40	10800	2560	6863
	NGONG__LAVINGTON__220kV	2	40	0	2560	0
	KILIFI__BAMBURI__220kV	1	50	13500	2560	6863
	KILIFI__BAMBURI__220kV	2	50	0	2560	0
	KILIFI PS__MALINDI__400kV	1	75	24000	5000	9568
	KILIFI PS__MALINDI__400kV	2	75	0	5000	0

YEAR	TRANSMISSION LINE	CIRCUIT NO.	LENGTH (KM)	COST '000 USD		
				LINES	BAYS	NEW S/S
	MALINDI__LAMU__400kV	1	225	72000	4000	9568
	MALINDI__LAMU__400kV	2	225	0	4000	0
	KANGUNDO__THIKA__400kV	1	60	19200	4000	9568
	KANGUNDO__THIKA__400kV	2	60	0	4000	0
	KANGUNDO__KITUI__400kV	1	90	28800	5000	0
	KANGUNDO__KITUI__400kV	2	90	0	5000	0
	KANGUNDO__MALILI__400kV	1	50	16000	4000	0
	KANGUNDO__MALILI__400kV	2	50	0	4000	
	THIKA__LAMU__400kV	1	550	176000	5000	0
	THIKA__LAMU__400kV	2	550	0	5000	0
	THIKA__KIAMBU NORTH__400kV	1	40	12800	4000	9568
	THIKA__KIAMBU NORTH__400kV	2	40	0	4000	0
	THIKA__RUMURUTI__400kV	1	200	64000	4000	0
	THIKA__RUMURUTI__400kV	2	200	0	4000	0
	SILALI__LESSOS__400kV	1	160	51200	4000	0
	SILALI__LESSOS__400kV	2	160	0	4000	0
	RUMURUTI__BOGORIA__400kV	1	100	32000	4000	0
	RUMURUTI__BOGORIA__400kV	2	100	0	4000	0
	KITUI_MALILI_400kV	1	50	16000	5000	0
	KITUI_MALILI_400kV	2	50		5000	
	KISUMU EAST__LESSOS__400kV***	1	0	0	4000	9568
	KISUMU EAST__LESSOS__400kV***	2	0	0	4000	0
	SUSWA__NGONG__400kV*	1	0	0	4000	9568
	SUSWA__NGONG__400Kv*	2	0	0	4000	0
	PIPELINE__NGONG__400kV*	1	0	0	4000	0
	PIPELINE__NGONG__400kV*	2	0	0	4000	0
2033	ISINYA__KAJIADO WIND__220kV	1	30	6600	2560	0
	ISINYA__KAJIADO WIND__220kV	2	30	0	2560	0
	KAMBURU__KARURA__220kV*	1	0	0	2560	0
	KIAMBERE__KARURA__220kV*	2	0	0	2560	0
	ELDORET NORTH__ELDORET__220kV	2	10	1600	2560	0
	NGONG RD__LAVINGTON__220kV	1	10	13500	2560	6863
	NGONG RD__LAVINGTON__220kV	2	10	0	2560	0
	JUJA__MANGU__220kV	1	10	2700	2560	6863
	JUJA__MANGU__220kV	2	10	0	2560	0
	LESSOS__ELDORET__220kV	2	30	4800	2560	0

YEAR	TRANSMISSION LINE	CIRCUIT NO.	LENGTH (KM)	COST '000 USD		
				LINES	BAYS	NEW S/S
	KISII__AWENDO__220kV	1	44	9680	2560	6863
	KISII__AWENDO__220kV	2	44	0	2560	0
	KILIFI__MTWAPA__220Kv*	1	0	0	2560	6863
	KILIFI__MTWAPA__220kV*	2	0	0	2560	0
	BAMBURI__MTWAPA__220kV*	1	0	0	2560	0
	BAMBURI__MTWAPA__220kV*	2	0	0	2560	0
	KILIFI PS__MATSANGONI__400kV	1	30	9600	4000	0
	KILIFI PS__MATSANGONI__400kV	2	30	0	4000	0
	KISUMU EAST__SIRONGO NP__400kV	1	75	24000	5000	0
	KISUMU EAST__SIRONGO NP__400kV	2	75	0	5000	
	SILALI__EMURUANGALANG__400kV	1	40	12800	4000	0
	SILALI__EMURUANGALANG__400kV	2	40	0	4000	0
	EMURUANGALANG__BARRIER__400kV	1	80	25728	4000	0
	EMURUANGALANG__BARRIER__400kV	2	80	0	4000	0
	MARSABIT__LOYANGALANI__400kV	2	200	40000	4000	0

Key
***Transmission line sectionalizing and termination to establish a substation or switching station**
**** 400 kV line construction for initial operation at 220 kV**
***** Conversion from 220 kV operation to 400kV operation (400/220 kV substation)**

Table 8: TRANSFORMERS INVESTMENT SEQUENCE

	SS /TRANSFORMERS	CIRCUIT	CAPACITY	COST
		NO	MVA	000 USD
2014	OLKARIA IE__132__220kV	1	150	2014
	OLKARIA IE 132__220kV	2	150	2014
	MUHORONI__132__33kV	1	23	781
	BAMBURI__132__33kV	2	45	1040
	SONDU__132__33kV	1	23	781
	NAKURU WEST __132__33kV	1	23	781
	NAKURU WEST __132__33kV	2	23	781
	AWENDO__132__33kV	1	23	781
	KITALE__132__33kV	1	23	781
	MWINGI__132__33kV	1	23	781
	GARISSA__132__33kV	1	23	781
	KAINUK__220__66kV	1	45	1040
	LESSOS__220__132kV	3	75	1408

	SS /TRANSFORMERS	CIRCUIT	CAPACITY	COST
		NO	MVA	000 USD
	LESSOS__220__132kV	4	75	1408
	NGONG__220__66kV	1	200	2686
	NGONG__220__66kV	2	200	2686
	ATHI__220__66kV	1	200	2686
	ATHI__220__66kV	2	200	2686
2015	MTWAPA __132__33kV	1	45	1235
	MTWAPA __132__33kV	2	45	1235
	ELDORET__132__33kV	1	45	1235
	ELDORET__132__33kV	2	45	1235
	KISUMU__132__33kV	1	90	1950
	KISUMU__132__33kV	2	90	1950
	CHEMOS__132__33kV	1	45	1040
	CHEMOS__132__33kV	2	45	1040
	KIGANJ0__132__220kV	1	45	1040
	KIGANJ0__132__220kV	2	45	1040
	KILIFI__132__33kV	1	23	781
	CHOGORIA__132__33kV	1	15	509
	LANET__132__33kV	1	90	1950
	LANET__132__33kV	2	90	1950
	SULTAN__132__33kV	1	23	255
	GALU__132__33kV	1	23	781
	KYENI __132__33kV	1	23	781
	BOMET__132__33kV	1	23	781
	NYAHURURU__132__33kV	1	23	781
	KABARNET__132__33kV	1	23	781
	WAJIR__132__33kV	1	23	781
	KAJIADO__132__33kV	1	23	781
	KITALE__132__220kV	1	150	2014
	ORTUM__220__33	1	23	906
	MARALAL__132__33kV	1	7.5	255
	NAROK__132__33kV	1	23	781
	WOTE__132__33kV	1	23	255
	ISIOLO__132__33kV	1	23	781
	KITUI__132__33kV	1	23	781
	NAMANGA__132__33kV	1	23	781
	MACHAKOS__132__33kV	1	23	781
	ISIBENIA__132__33kV	1	23	781
	LUNGA LUNGA__132__33kV	1	15	509

	SS /TRANSFORMERS	CIRCUIT	CAPACITY	COST
		NO	MVA	000 USD
	MAUA__132__33kV	1	15	509
	KOMOROCK__220__66kV	1	200	2686
	KOMOROCK__220__66kV	2	200	2686
	THIKA RD__220__66kV	1	200	2686
	THIKA RD__220__66kV	2	200	2686
	HOLA__220__33kV	1	7.5	206
2020	MARIAKANI__400__220kV	1	350	4700
	MARIAKANI__400__220kV	2	350	4700
	ISINYA__400__220kV	1	350	4700
	ISINYA__400__220kV	2	350	4700
	ISINYA__400__220kV	3	350	4700
	SUSWA__400__220kV	1	350	4700
	SUSWA__400__220kV	2	350	4700
	SUSWA__400__220kV	3	350	4700
	PIPELINE__400__220kV	1	350	4700
	PIPELINE__400__220kV	2	350	4700
	KINDARUMA__132__33kV	1	23	529
	KIPEVU__132__33kV	1	200	2686
	KIPEVU__132__33kV	2	200	2686
	KIPEVU__132__33kV	3	200	2686
	JUJA RD__132__220kV	1	350	4375
	JUJA RD__132__220kV	2	350	4375
	1JUJA RD__132__66kV	1	150	2014
	JUJA RD__132__66kV	2	150	2014
	JUJA RD__132__66kV	3	150	2014
	ELDORET__132__220kV	1	150	2014
	ELDORET__132__220kV	2	150	2014
	ELDORET__132__33kV	1	45	1040
	ELDORET__132__33kV	2	45	1040
	KISUMU__132__220kV	1	150	2014
	KISUMU__132__220kV	2	150	2014
	1KISUMU__132__220kV	3	150	2014
	CHEMOS__132__220kV	1	150	2014
	CHEMOS__132__220kV	2	150	2014
	1CHEMOS__132__220kV	3	150	2014
	NANYUKI__132__33kV	1	23	781
	KILIF1__132__33kV	1	45	1040
	KILIF1__132__33kV	2	45	1040

	SS /TRANSFORMERS	CIRCUIT	CAPACITY	COST
		NO	MVA	000 USD
	1MUSAG__132__220kV	1	150	2014
	1MUSAG__132__220kV	2	150	2014
	LESSOS__132__33kV	1	150	2014
	LANET__132__220kV	1	150	2014
	LANET__132__220kV	2	150	2014
	1NAIVSH__132__220kV	1	150	2014
	1NAIVSH__132__220kV	2	150	2014
	NAIVSHA__132__33kV	1	45	1040
	NAIVSHA__132__33kV	2	45	1040
	MARIAKANI__132__220kV	1	150	2014
	MARIAKANI__132__220kV	2	150	2014
	RUARAKA__132__220kV	1	350	4375
	RUARAKA__132__220kV	2	350	4375
	RUARAKA__132__66kV	1	150	2014
	RUARAKA__132__66kV	2	150	2014
	RUARAKA __132__66kV	1	150	2014
	GALU__132__33kV	1	90	1950
	GALU__132__33kV	2	90	1950
	KYENI__132__33kV	2	23	781
	SONDU__132__33kV	2	23	781
	KUTUS__132__33kV	1	90	1950
	KUTUS__132__33kV	2	90	1950
	BOMET__132__33kV	2	23	532
	KISII__132__33kV	1	45	1040
	KISII__132__33kV	2	45	1040
	KAJIADO__132__33kV	1	45	1040
	KAJIADO__132__33kV	2	45	1040
	NAKURU WEST __132__33kV	1	45	1040
	NAKURU WEST __132__33kV	2	45	1040
	RUMURUTI __132__33kV	1	90	1950
	KITALE__132__220kV	1	150	2014
	KITALE__132__33kV	2	23	781
	GITHAMBO__132__33kV	2	23	781
	GARISSA__132__220kV	1	23	781
	GARISSA__132__33kV	2	23	781
	MACHAKOS__132__33kV	2	23	781
	HOMABAY__132__33kV	2	23	781
	MATASIA__220__66kV	1	200	2686
	MATASIA__220__66kV	2	200	2686

	SS /TRANSFORMERS	CIRCUIT	CAPACITY	COST
		NO	MVA	000 USD
	MATASIA__220__66kV	3	200	2686
	LIKONI__220__33kV	1	90	1950
	LIKONI__220__33kV	2	90	1950
	ELDORET NORTH__220__33kV	1	90	1950
	ELDORET NORTH__220__33kV	2	90	1950
	KOMOROCK__220__66kV	1	200	2686
	EMBAKASI__220__66kV	1	200	2686
	EMBAKASI__220__66kV	2	200	2686
	EMBAKASI__220__66kV	3	200	2686
	NBNORTH__220__66kV	1	200	2686
	NBNORTH__220__66kV	2	200	2686
	RABAI__220__132kV	1	350	4375
	RABAI__220__132kV	2	350	4375
	KISUMU EAST__220__33kV	1	45	1040
	KISUMU EAST__220__33kV	1	45	1040
	NGONG__220__66kV	3	200	2686
	RONGAI__220__33kV	1	90	1950
	RONGAI__220__33kV	2	90	1950
	RONGAI__220__400kV	1	750	7650
	KAPSOWAR__33__132kV	1	23	781
	CHAVAKALI__33__132kV	1	23	781
	GILGIL__33__132kV	1	23	781
2025	MARIAKANI__400__220kV	3	350	4700
	KIAMBU NORTH__400__220kV	1	500	5100
	KIAMBU NORTH__400__220kV	2	500	5100
	MALILI__400__220kV	1	350	4700
	MALILI__400__220kV	2	350	4700
	MALILI__400__220kV	3	350	4700
	MANGU__132__220kV	1	150	2014
	JUJA RD__132__220kV	1	350	4700
	JUJA RD__132__220kV	2	350	4700
	JUJA RD__132__66kV	1	200	2686
	JUJA RD__132__66kV	2	200	2686
	JUJA__132__66kV	3	200	2686
	ELDORET__132__33kV	1	90	1950
	ELDORET__132__33kV	2	90	1950
	1MUHORN__132__220kV	1	90	1950
	MUHORNI__132__33kV	2	90	1950

	SS /TRANSFORMERS	CIRCUIT	CAPACITY	COST
		NO	MVA	000 USD
	CHEMOSIT__132__220kV	1	150	2014
	CHEMOSIT__132__33kV	1	90	1950
	CHEMOSIT__132__33kV	2	90	2080
	KIGANJO__132__220kV	1	150	2014
	KIGANJO__132__220kV	2	150	2014
	KIGANJO__132__33kV	1	90	1950
	KIGANJO__132__33kV	2	90	1950
	NANYUKI__132__220kV	1	150	2014
	NANYUKI__132__220kV	2	150	2014
	NANYUKI__132__33kV	1	45	1040
	NANYUKI__132__33kV	2	45	1040
	KILIFI__132__220kV	1	200	2686
	KILIFI__132__220kV	2	200	2686
	KILIFI__132__33kV	3	90	2080
	KILIFI__132__33kV	1	90	2080
	BAMBURI__132__33kV	1	90	1950
	BAMBURI__132__33kV	2	90	1950
	MUSAGA__132__33kV	1	45	1040
	MUSAGA__132__33kV	2	45	1040
	LANET__132__33kV	1	200	2686
	LANET__132__33kV	2	200	2686
	NAIVSH__132__33kV	1	90	1950
	NAIVSH__132__33kV	2	90	1950
	SULTAN__132__33kV	1	15	509
	GALU__132__33kV	1	200	2686
	GALU__132__33kV	2	200	2686
	GALU__132__220kV	1	200	2686
	GALU__132__220kV	2	200	2686
	KYENI__132__33kV	1	23	781
	MERU__132__220kV	1	200	2686
	MERU__132__220kV	2	200	2686
	BOMET__132__33kV	1	45	1040
	BOMET__132__33kV	2	45	1040
	KISII__132__33kV	1	45	1040
	KISII__132__33kV	2	45	1040
	KAJIADO__132__33kV	1	90	1950
	KAJIADO__132__33kV	2	90	1950
	GATUNDU__132__33kV	1	23	781
	GITHAMBO__132__33kV	1	45	1040

	SS /TRANSFORMERS	CIRCUIT	CAPACITY	COST
		NO	MVA	000 USD
	GITHAMBO__132__33kV	2	45	1040
	NAROK__132__33kV	1	23	781
	WOTE__132__33kV	1	7.5	255
	MURANGA__132__220kV	1	90	1950
	MURANGA__132__220kV	2	90	1950
	ISIOLO__132__220kV	1	150	2014
	ISIOLO__132__220kV	2	150	2014
	ISIOLO__132__33kV	1	23	781
	ISIOLO__132__33kV	2	23	781
	KITUI__132__33kV	1	45	1040
	KITUI__132__33kV	2	45	1040
	MACHAKOS__132__33kV	1	45	1040
	MACHAKOS__132__33kV	2	45	1040
	HOMABAY__132__220kV	1	23	781
	DONGOKUNDU__220__400kV	1	750	7650
	DONGOKUNDU__220__400kV	1	750	7650
	LIKONI__220__33kV	1	200	2686
	LIKONI__220__33kV	2	200	2686
	OLKARIA II__220__400kV	1	350	4700
	OLKARIA II__220__400kV	2	350	4700
	CITY SQR__220__66kV	1	350	4700
	CITY SQR__220__66kV	2	350	4700
	CITY SQR__220__66kV	3	350	4700
	LANGATA__220__66kV	1	350	4700
	LANGATA__220__66kV	2	350	4700
	MBARAKI__220__33kV	1	200	2686
	MBARAKI__220__33kV	2	200	2686
	LESSOS__220__400kV	1	350	4700
	LESSOS__220__400kV	2	350	4700
	LESSOS__220__132kV	1	75	1750
	LESSOS__220__132kV	2	75	1750
	MALINDI__220__33kV	1	45	1040
	MALINDI__220__33kV	2	45	1040
	LAMU__220__33kV	1	45	1040
	LAMU__220__33kV	2	45	1040
	KIAMBU NORTH__220__66kV	1	350	4700
	KIAMBU NORTH__220__66kV	2	350	4700
	KAMULU__220__66kV	1	350	4700
	KAMULU__220__66kV	2	350	4700

	SS /TRANSFORMERS	CIRCUIT	CAPACITY	COST
		NO	MVA	000 USD
	ATHI__220__66kV	1	200	2686
	ATHI__220__66kV	2	200	2686
	RONGAI__220__400kV	1	750	7650
	RONGAI__220__400kV	2	750	7650
	CHAVAKALI__33__132kV	1	23	781
2030	MALINDI__400__220kV	1	350	4700
	MALINDI__400__220kV	2	350	4700
	KANGUNDO__400__220kV	1	500	5100
	KANGUNDO__400__220kV	2	500	5100
	KANGUNDO__400__220kV	3	500	5100
	THIKA__400__220kV	1	750	7650
	THIKA__400__220kV	2	750	7650
	THIKA__400__220kV	3	750	7650
	LAMU__400__220kV	1	350	4700
	LAMU__400__220kV	2	350	4700
	UPLANDS__400__220kV	1	350	4700
	UPLANDS__400__220kV	2	350	4700
	ISINYA__400__220kV	3	350	4700
	KITUI__400__132kV	1	150	2014
	KISUMU EAST__400__220kV	1	500	5100
	KISUMU EAST__400__220kV	2	500	5100
	KISUMU EAST__400__220kV	3	500	5100
	PIPELINE__400__220kV	1	500	5100
	NGONG__400__220kV	1	750	7650
	NGONG__400__220kV	2	750	7650
	KITENGELA__220__66kV	1	200	2686
	KITENGELA__220__66kV	2	200	2686
	KITENGELA__220__66kV	3	200	2686
	NYALI__132__33kV	1	90	1950
	NYALI__132__33kV	2	90	1950
	KIPEVU__132__33kV	1	200	2686
	KIPEVU__132__33kV	2	200	2686
	KIPEVU__132__33kV	3	200	2686
	MANGU__132__66kV	1	200	2686
	MANGU__132__66kV	2	200	2686
	MTWAPA__132__33kV	1	90	1950
	MTWAPA__132__33kV	2	90	1950
	RABAI__132__33kV	1	90	1950

	SS /TRANSFORMERS	CIRCUIT	CAPACITY	COST
		NO	MVA	000 USD
	RABAI__132__33kV	2	90	1950
	MUHORN__132__220kV	1	200	2686
	MUHORN__132__220kV	2	200	2686
	MUHORN__132__33kV	1	90	1950
	KISUMU__132__33kV	1	200	2686
	KISUMU__132__33kV	2	200	2686
	KIGANJ0__132__33kV	1	200	2686
	KIGANJ0__132__33kV	2	200	2686
	CHOGORIA__132__33kV	2	15	509
	BAMBURI__132__220kV	1	200	2686
	BAMBURI__132__220kV	2	200	2686
	LESSOS__132__33kV	1	45	1040
	LESSOS__132__33kV	2	45	1040
	SULTAN__132__220kV	1	150	2014
	SULTAN__132__33kV	2	15	509
	MTITO ANDEI__132__220kV	1	150	2014
	VOI__132__220kV	1	150	2014
	RUARAKA__132__66kV	1	350	4700
	RUARAKA__132__66kV	2	350	4700
	KAPSABET__132__33kV	1	23	781
	KAPSABET__132__33kV	2	23	781
	GALU__132__400kV	1	350	4700
	KYENI__132__33kV	1	45	1040
	KYENI__132__33kV	2	45	1040
	SONDU__132__33kV	1	23	781
	KUTUS__132__220kV	1	200	2686
	KUTUS__132__220kV	2	200	2686
	KUTUS__132__33kV	1	90	1950
	KUTUS__132__33kV	2	90	1950
	BOMET__132__33kV	1	90	1950
	NYAHURURU__132__33kV	1	23	781
	KISII__132__220kV	1	150	2014
	KISII__132__220kV	2	150	2014
	KISII__132__33kV	1	90	1209
	KISII__132__33kV	2	90	1209
	RANGALA__132__33kV	1	45	1040
	KITALE__132__33kV	1	90	1950
	KITALE__132__33kV	2	90	1950
	NAROK__132__33kV	1	23	781

	SS /TRANSFORMERS	CIRCUIT	CAPACITY	COST
		NO	MVA	000 USD
	WOTE__132__33kV	1	23	781
	ISIOLO__132__33kV	1	45	1040
	ISIOLO__132__33kV	2	45	1040
	MACHAKOS__132__220kV	1	200	2686
	MACHAKOS__132__33kV	1	150	2014
	MACHAKOS__132__33kV	2	150	2014
	HOMABAY__132__220kV	1	90	1950
	HOMABAY__132__220kV	2	90	1950
	DONGOKUNDU__220__33kV	1	200	2686
	DONGOKUNDU__220__33kV	1	200	2686
	DONGOKUNDU__220__400kV	2	750	7650
	MATASIA__220__66kV	1	350	4700
	MATASIA__220__66kV	2	350	4700
	MATASIA__220__66kV	3	350	4700
	ELDORET N__220__33kV	1	200	2686
	1EMBAK2__220__66kV	1	350	4700
	1EMBAK2__220__66kV	2	350	4700
	NGONG RD__220__66kV	1	350	4700
	NGONG RD__220__66kV	2	350	4700
	MBARAKI__220__33kV	1	200	2686
	DRIVE INN__220__66kV	1	350	4700
	DRIVE INN__220__66kV	2	350	4700
	MIRITINI__220__33kV	1	350	4700
	MIRITINI__220__33kV	2	350	4700
	KISUMU E__220__33kV	1	150	2014
	KISUMU E__220__33kV	2	150	2014
	1LESSO2__220__400kV	1	500	5100
	1LESSO2__220__132kV	2	200	2686
	MALINDI__220__33kV	1	200	2686
	MALINDI__220__33kV	2	200	2686
	LAMU__220__33kV	1	90	1950
	LAMU__220__33kV	2	90	1950
	THIKA__220__66kV	1	200	2686
	THIKA__220__66kV	2	200	2686
	NAKURU S__220__33kV	1	200	2686
	NAKURU S__220__33kV	2	200	2686
	THIKA RD__220__66kV	1	350	4700
	THIKA RD__220__66kV	2	350	4700
	HOLA__220__33kV	1	23	781

	SS /TRANSFORMERS	CIRCUIT	CAPACITY	COST
		NO	MVA	000 USD
	CHAVAKALI__33__132kV	1	45	1040
	KATANI__66__220kV	1	200	2686
	KATANI__66__220kV	2	200	2686
	KATANI__66__220kV	3	200	2686
	ELDORET S__33__220kV	1	200	2686
	ELDORET S__33__220kV	2	200	2686
	KIKUYU__66__220kV	1	350	4700
	KIKUYU__66__220kV	2	350	4700
	LAVINGTON__66__220kV	1	350	4700
	LAVINGTON__66__220kV	2	350	4700
2033	MARIAKANI__400__220kV	1	500	5100
	MARIAKANI__400__220kV	2	500	5100
	MARIAKANI__400__220kV	3	500	5100
	KILIFI PS__400__220kV	1	500	5100
	KILIFI PS__400__220kV	2	500	5100
	KANGUNDO__400__220kV	3	500	5100
	UPLANDS__400__220kV	3	350	4700
	ISINYA__400__220kV	1	500	5100
	ISINYA__400__220kV	2	500	5100
	ISINYA__400__220kV	2	500	5100
	ISINYA__400__220kV	4	500	5100
	KITUI__400__132kV	1	150	2014
	PIPELINE__400__220kV	3	500	5100
	NGONG__400__220kV	3	750	7650
	ISINYA__220__132kV	1	350	4700
	ISINYA__220__132kV	2	350	4700
	NYALI__132__33kV	2	200	2686
	JUJA RD__132__66kV	1	200	2686
	1JUJA RD__132__66kV	2	200	2686
	ELDORET__132__33kV	1	150	2014
	ELDORET__132__33kV	2	150	2014
	MUHORNI__132__33kV	1	200	2686
	MUHORNI__132__33kV	2	200	2686
	KISUMU__132__220kV	1	350	4700
	KISUMU__132__220kV	2	350	4700
	KISUMU__132__220kV	3	200	2686
	KISUMU__132__33kV	1	200	2686
	CHEMOS__132__33kV	2	200	2686

	SS /TRANSFORMERS	CIRCUIT	CAPACITY	COST
		NO	MVA	000 USD
	CHEMOS__132__33kV	2	200	2686
	KIGANJ__132__220kV	1	350	4700
	KIGANJ__132__220kV	2	350	4700
	NANYUKI__132__33kV	1	90	1950
	NANYUKI__132__33kV	1	90	1950
	KILIFI__132__220kV	2	200	2686
	KILIFI__132__33kV	1	200	2686
	KILIF1__132__33kV	2	200	2686
	BAMBURI__132__33kV	1	200	2686
	BAMBURI__132__33kV	2	200	2686
	MUSAGA__132__33kV	1	90	1950
	MUSAGA__132__33kV	2	90	1950
	LESSOS__132__33kV	1	90	1950
	LESSOS__132__33kV	2	90	1950
	LANET__132__220kV	1	200	2686
	LANET__132__220kV	2	200	2686
	LANET__132__220kV	3	200	2686
	NAIVSH__132__33kV	1	200	2686
	NAIVSH__132__33kV	2	200	2686
	SULTAN__132__33kV	1	23	781
	SULTAN__132__33kV	2	23	781
	MARIAKANI__132__220kV	1	350	4700
	MARIAKANI__132__220kV	2	350	4700
	KAPSABET__132__33kV	1	45	1040
	KAPSABET__132__33kV	2	45	1040
	GALU__132__400kV	1	350	4700
	KUTUS__132__33kV	1	200	2686
	KUTUS__132__33kV	2	200	2686
	MERU__132__33kV	1	90	1950
	MERU__132__33kV	2	90	1950
	BOMET__132__33kV	1	90	1950
	NYAHURURU__132__33kV	1	45	1040
	NYAHURURU__132__33kV	2	45	1040
	KABARNET__132__33kV	2	23	781
	KAJIADO__132__33kV	1	90	1950
	AWENDO__132__33kV	2	23	781
	RANGALA__132__33kV	2	45	1040
	GATUNDU__132__33kV	1	45	1040
	GATUNDU__132__33kV	1	45	1040

	SS /TRANSFORMERS	CIRCUIT	CAPACITY	COST
		NO	MVA	000 USD
	GITHAMBO__132__33kV	1	90	1950
	GITHAMBO__132__33kV	2	90	1950
	MAKUTANO__132__33kV	2	23	781
	GARISSA__132__33kV	1	45	1040
	GARISSA__132__33kV	2	45	1040
	ISIOLO__132__33kV	1	90	1950
	ISIOLO__132__33kV	2	90	1950
	HOMABAY__132__33kV	1	45	1040
	HOMABAY__132__33kV	2	45	1040
	LUNGA LUNGA__132__33kV	2	15	509
	MAUA__132__33kV	2	15	509
	DONGOKUN__220__400kV	3	750	7650
	OLLARIA II__220__400kV	3	350	4700
	KOMOROCK__220__66kV	1	500	5100
	KOMOROCK__220__66kV	2	500	5100
	KOMOROCK__220__66kV	3	500	5100
	NBNORTH__220__66kV	1	350	4700
	NBNORTH__220__66kV	2	350	4700
	RABAI__220__132kV	3	350	4700
	JUJA__220__66kV	1	350	4700
	JUJA__220__66kV	2	350	4700
	LESSOS__220__400kV	1	500	5100
	LESSOS__220__400kV	2	500	5100
	LESSOS__220__132kV	1	90	1950
	LESSOS__220__132kV	2	90	1950
	LESSOS__220__132kV	3	200	2686
	RONGAI__220__33kV	1	200	2686
	RONGAI__220__33kV	2	200	2686
	CHAVAKALI__33__132kV	1	90	1950
	CHAVAKALI__33__132kV	2	90	1950
	GILGIL__33__132kV	2	23	781
	MTWAPA__33__220kV	1	200	2686
	MTWAPA__33__220kV	2	200	2686

Table 9: REACTIVE COMPENSATION INVESTMENT SEQUENCE

YEAR	SUBSTATION	VOLTAGE	COMPENSATION	
		KV	MVAR	COST '000 USD
2014	GARISSA	132	-7.5	83

YEAR	SUBSTATION	VOLTAGE KV	COMPENSATION	
			MVAR	COST '000 USD
	MARIAKANI	400	-65	670
2015	CHEMOSIT	33	12	313
	KIGANJO	33	12	313
	SUSWA	220	-100	1031
2020	ELDORET	33	10	261
	KISUMU	33	12	313
	KILIFI	33	12	313
	GALU	33	16	418
	RUARAKA	66	38	992
	NGONG	66	43	1122
	THIKA RD	66	80	2088
	MANGU	132	76	1984
	KIGANJ0	132	53	1383
	LANET	132	10	261
	SONDU	132	-7.5	83
	GARISSA	132	-7.5	83
	SUSWA	220	-113	1254
	KILIFI PS	220	-70	777
	RUMURUTI	400	-222	2464
	MARSABIT	400	-67	744
	LOYANGALANI	400	-252	2797
2025	MARIAKANI	220	-180	1998
	KIPEVU	132	27	692
	LANET	132	10	261
	SULTAN	132	9.5	248
	WAJIR	132	-7.5	83
	HOMABAY	132	23.5	613
	SUSWA	220	-71	788
	CHEMOSIT	33	9	235
	KISII	33	9	235
	BOMET	33	25	653
	RUARAKA	66	80	2088
	JUJA RD	66	120	3132
	EMBAKASI	66	25	653
	JUJA RD	66	90	2349
	EMBAKASI	66	55	1436

YEAR	SUBSTATION	VOLTAGE	COMPENSATION	
		KV	MVAR	COST '000 USD
2030	MARIAKANI	400	150	3915
	LAMU	400	240	6264
	KOROSI	400	240	6264
	MARIAKANI	220	-84	932
	ISINYA	220	180	4698
	KISUMU	132	64	1655
	CHEMOSIT	132	60	1566
	KIGANJ0	132	12.5	319
	LANET	132	10	261
	GALU	132	-30	333
	BOMET	132	30	783
	KISII	132	16	422
	KITALE	132	16	407
	HOMABAY	132	4	88
	MATASIA	220	150	3915
	LANGATA	220	150	3915
	KOMOROCK	220	150	3915
	NGONG RD	220	150	3915
	RABAI	220	30	783
	DRIVE INN	220	150	3915
	KATHWANA	220	47	1214
	KIAMBU NORTH	220	90	2349
	KAMULU	220	150	3915
	THIKA RD	220	150	3915
	JUJA RD	66	30	783
	EMBAKASI	66	30	783
	KIKUYU	220	90	2349
	LAVINGTON	220	90	2349
	KATANI	220	90	2349
2033	SUSWA	400	270	7047
	KIGANJO	132	140	3596
	LANET	132	10	261
	BOMET	132	30	783
	KISII	132	14	361
	RUMURUTI	132	12	313
	MURANGA	132	90	2349
	KARI WAIYAKI WAY	220	130	3393

YEAR	SUBSTATION	VOLTAGE KV	COMPENSATION	
			MVAR	COST '000 USD
	LANGATA	220	30	783
	KOMOROCK	220	30	783
	NGONG RD	220	30	783
	DRIVE INN	220	120	3132
	JUJA	220	180	4698
	KATHWANA	220	44	1135
	MANGU	220	270	7047
	KIAMBU NORTH	220	90	2349
	THIKA	220	270	7047
	MALILI	220	50	1305
	KAMULU	220	30	783
	THIKA RD	220	30	783
	RUARAKA	220	270	7047
	NGONG	220	270	7047
	UPLANDS	220	180	4698
	NAIVASHA	220	90	2349
	LESSOS	400	180	4698
	RUARAKA	66	30	783
	LAVINGTON	220	90	2349
	KATANI	220	40	1044

5 CONCLUSION AND IMPLEMENTATION PLAN

This study sought to update the 2011-2031 LCPDP taking into account changes in demand in line with anticipated macroeconomic performance, committed power generation and transmission projects and update the power system simulation data including plant types, system constraints and costs. ERC, MOE, KenGen, GDC, KNBS, REA, KETRACO, KNEB and KPLC staff participated actively in the studies and new team members received training in the operation of these models. MAED based excel worksheets were used for the development of electricity forecasts, VALORAGUA and WASP models were used to optimize the hydro-thermal generation mix of Kenya power system and select the least cost power plants to be added in future years while PSSE was used to determine the transmission system plan. The planning team reviewed the assumptions that were made in this study and ran additional sensitivity scenarios to test new inputs. From the study the following conclusions and recommendations emerge.

5.1 Conclusions

5.1.1 Load Forecasting

The load forecast was done using an excel model developed in 2011, but in this update, primary data collected through the AFD technical assistance was utilized. The excel model follows the MAED principles and assumptions which indicate that the nature and the level of demand for goods and services are driven by several determinants including; population, household size, specific consumption (kWh/household/year) and expected social and economic evolution of the country.

Based on the assumptions the load forecast indicates that the peak demand is estimated at 1370 MW in 2012 and in 2033, the peak demand grows to 11,318MW in low scenario, 21,075MW in reference scenario and 31,237MW in the high scenario. The energy demand increases from 8010GWh in 2012 to 17,719GWh in 2018 to 81,352GWh in 2030 and 118,680GWh in 2033. The current peak load is expected to grow 10 times by the year 2030.

There is a very slight difference between this and the load forecast done in the last update of 2011-2031. The reference peak demand for 2030 in the last update was 15, 026MW which compares very closely to the peak demand projected in the current review, of 14,446MW.

5.1.2 Least Cost Generation and Transmission plan

Using annual data for the last 30 years (1980-2009) VALORAGUA hydrothermal optimization indicated that the average hydro generation in Kenya is about 3,280GWh with the highest hydro generation being experienced in May during the long rains and the lowest in February. The study also found a strong inverse correlation between the SRMC of the system and energy generation from hydro power plants due to the substitution effect of thermal generation. SRMC varies from month to month ranging from a high of 36.3 US cents/kWh in February to a low of 11 US cents/kWh in May.

The optimal development program is dominated by Geothermal, Coal, GT(N-GAS), Nuclear and Wind. Geothermal resources are the choice for the future generating capacity in Kenya. The optimum solution indicates that geothermal capacity should be increased from the current 209MW to 7,264 MW in 2033 contributing 27% of the total energy required by the system. The present value of the total system expansion cost over the period 2013-2033 for the base case development plan amounts to US$ 31.4 billion (committed projects excluded), expressed in constant prices at the beginning of 2012.

Using the least cost generation development plan, a transmission system plan was developed for the period beginning 2013 to 2033. The transmission development plan indicates the need to develop approximately 11,231km of new lines (18,173Circuits) by 2033 at an approximated present value cost of US$ 3.55 Billion.

5.2 IMPLEMENTATION PLAN

5.2.1 Medium term 2014-2018

Generation projects

1. Timely implementation of committed power generation projects in order to attain an additional capacity of at least 2,639MW by 2018. This will require an investment of approximately US$ 6.5 billion.

Transmission projects

2. Timely implementation of 5,438Km of committed and proposed transmission lines by 2015. The total non-discounted cost of this project is approximately US$ 2.1 Billion which include bays & sub stations, transformers and reactive compensation.

Load forecast

3. In order to develop an energy database for use in the complete MAED model a survey is required. ERC has already embarked on preparing the terms of reference and has initiated discussions with the KNBS on undertaking a national survey based on MAED model data requirements. World Bank has been approached for financing.

4. All the institutions involved in the LCPDP preparation; i.e. MOE, ERC, KPLC, KETRACO, GDC, REA, KNEB and KenGen should continue training the members of the planning team in their respective institutions.

Nuclear

5. KNEB shall undertake preparatory work for the nuclear power plant expected to come on stream in 2023. The completion of the prefeasibility study should give priority as this will give direction on the key activities that will require to be done to have a plant by the year 2023.

6. KNEB should develop a clear programme of action showing the activities to be undertaken to deliver the nuclear power plant by the year 2023.

Coal

7. In order to realize the development of first 300 MW coal plant by the year 2024; KETRACO/KPLC should float tenders for the development of the coal plant latest by 2015 to accommodate a 4 year construction period.

8. Ministry of Energy & Petroleum shall continue exploration and subsequent mining of local coal to meet the high demand for coal arising from the proposed coal plants of up to 5400MW. The coal plants proposed in the plan will be located in the Mwingi/Kitui area to minimize transportation costs.

Geothermal

9. Geothermal Development Company shall develop and implement a rigorous monitoring and evaluation framework for the Geothermal Development Plan of drilling at least 1,200 wells to provide steam to the planned 5,880MW of new capacity by 2033. Timely implementation of the drilling programme is vital for the realization of this least cost generation

plan since the commissioning of the proposed geothermal plants track the drilling plan.

10. GDC should strictly implement the plans to start drilling the Bogoria/Silali in 2013/14 as planned. Any delays in this will affect the implementation of the generation projects planned for 2017.

11. Geothermal Development Company shall immediately invite Expressions of Interest from companies willing to develop power plants and well head generating units in line with the drilling plan. This is will ensure that for every well drilled a company will be in line to develop a plant and hence avoiding delays in the projects implementation.

Hydro

12. MOEP should get information on all hydro projects being proposed by other government agencies for implementation for consideration in the next LCPDP update.

5.2.2 Long term 2018-2033

Geothermal

13. In order to ensure continuity in drilling until the full geothermal potential of 10,000MW is achieved GDC shall prepare a drilling plan for completion of drilling in the remaining sites by the year 2020. The Current drilling plan will also continue being adhered to strictly.

Nuclear

14. In order for the first 600MW nuclear plant to be commissioned by 2023, the following will require to be done:

    - Establish a legal framework that will see the establishment of the Nuclear Regulatory Authority

    - The Nuclear Regulatory Authority will issue three licenses for the identified sites: a license to prepare the sites, a license to construct the plants and a license to operate the nuclear power plant, respectively. The licensing process must be completed at least six years (2016) ahead of the commissioning dates.

- In the years when Nuclear is coming (i.e. 2023, 2030 and 2033) investment cost is very high. This requires preparedness in terms of sourcing for adequate financing.

15. Commission the first 600 MW nuclear plants in 2023 and issue necessary operating licenses for the other nuclear power plants.

Coal

16. The Ministry of Energy & Petroleum shall complete assessment and development of the coal resources in the Mui Basin and invite bids for the commencement of mining and exploitation of the resource by 2020

17. The tenders for the other coal plants will be advertised in 2022 for the remaining coal plants to be commissioned between 2027 and 2033. The coal plants will be located in Kitui/Mwingi area which is near the Mui basin.

Transmission System Development Plan

18. A total of 11,231 km of new lines (18,173 km new circuits) will be developed in the period of 2013-2033. The approximated discounted cost is US$ 3.55 Billion.