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NILE EQUATORIAL LAKES SUBSIDIARY ACTION PROGRAMME (NELSAP)

STUDY ON THE INTERCONNECTION OF THE ELECTRICITY NETWORKS OF THE NILE EQUATORIAL LAKES COUNTRIES

FEASIBILITY REPORT
VOLUME 1 – POWER SUPPLY AND DEMAND ANALYSIS

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LIST OF ABBREVIATIONS

AFSEC	African Electrotechnical Standardization Commission / Commission Electrotechnique Africaine de Normalisation
BAD	Banque Africaine de Développement
CAPP / PEAC	Central Africa Power Pool / Pool énergétique de l'Afrique Centrale
CEEAC	Communauté Economique des Etats de l'Afrique Centrale (ECCAS)
CEPGL	Communauté Economique des Pays des Grands Lacs
DEM	Digital Elevation Model
DRC / RDC	Democratic Republic of Congo / République Démocratique du Congo
EAPP	East African Power Pool / Pool énergétique de l'Afrique de l'Est
EGL	Energie des pays des Grands Lacs (Burundi, RDC, Rwanda)
EDF / FED	European Development Fund / Fond Européen de Développement
ERA	Electricity Regulatory Authority (Uganda)
KenGen	Kenya Electricity Generating Company Ltd
KPLC	The Kenya Power and Lighting Co. Ltd
MEM	Ministère de l'Energie et des Mines / Ministry of Energy and Mining
MoI	Ministry of Infrastructures / Ministère des Infrastructures
MNT	Modèle numérique de terrain
NBI / IBN	Nile Basin Initiative / Initiative du Bassin du Nil
NEL	Nile Equatorial Lakes
NEL-CU	Coordination unit for NELSAP
NELSAP	Nile Equatorial Lakes Subsidiary Action Programme
PAALEN	Programme Auxiliaire d'Action des pays des Lacs Equatoriaux du Nil
PPA	Power Purchase Agreement / Contrat d'achat d'énergie
PREBU	Programme de réhabilitation du Burundi
SADC	Southern Africa Development Community / Communauté pour le développement de l'Afrique Australe
SAPP	Southern Africa Power Pool / Pool énergétique de l'Afrique Australe
SINELAC	Société internationale d'électricité des pays des grands lacs
SNEL	Société National d'Electricité (RDC)
SRTM	Shuttle Radar Topography Mission
UEGCL	Uganda Electricity Generation Company Ltd
UETCL	Uganda Electricity Transmission Company Ltd
UPDEA	Union des Producteurs, Transporteurs et Distributeurs d'Energie Electrique d'Afrique / Union of Producers, Transporters and Distributors of Electric Power in Africa
USAID	Agence pour le Développement International des Etats Unis
WAPP	West Africa Power Pool

1. INTRODUCTION

1.1. PROJECT BACKGROUND

The technical services described below relate to services provided by the Consultants for the Study on the interconnection of the electricity networks of the Nile Equatorial Lakes Countries.

The sectoral objective of this study is to improve the rate of access to electrical power for the peoples of the Equatorial Nile Basin. The specific study objective is:

- on the one hand, to examine the technical, financial, economic and environmental feasibility of the interconnection of the electricity networks between Kenya, Uganda Burundi, Rwanda and the Democratic Republic of the Congo (DRC),
- and, secondly, for the above mentioned projects, to prepare investment documentation.

The project started in July 2004 when an agreement was signed between Nile Basin Initiative and the African Development Fund for the study on the interconnection of the electricity networks of the Nile Equatorial Lakes Countries. Then, the following stages can be noted:

- In August 2004 started the procurement process for the above mentioned consultant services,
- In October 2005 the contract between NELSAP and the Consultants, SOGREAH, RSWI, HQI and HIFAB Oy, was signed,
- In February 2006 the contract between NELSAP and the Consultants came into force.
- In October 2006 the final Prefeasability Study report was issued.

1.2. PRESENTATION OF THE PROJECT

The characteristics of the project can briefly be summarised as follows:

- Five countries concerned
  - Burundi,
  - Kenya,
  - Uganda,
  - Democratic Republic of Congo, DRC
  - Rwanda
- Four main projects
  - Uganda - Rwanda interconnection
  - Burundi - Rwanda interconnection
  - Uganda - Kenya interconnection
  - strengthening of the interconnection between Burundi, DRC and Rwanda

- three study phases
  - pre-feasibility
  - feasibility
  - detailed studies and tender documents

To these characteristics, the large distances between projects could also be added. As an example, the Jinja - Lessos interconnection is more than 800 km from Bujumbura.

The five countries are also members of various structures and international organizations, mainly:

- The Uganda-Kenya interconnected network
- The EGL interconnected network
- SINELAC
- CEPGL
- CAPP
- EAPP
- UPDEA
- AFSEC

These organizations are described in Annex A

The location of the interconnections is given in Annex C, there characteristics are summarised below.

a. Uganda – Rwanda interconnection

The project consists in constructing an HV power line, 230 km long, between the substations at Mbarara in Uganda and Kigali in Rwanda. This line should enable Rwanda to import first a minimum amount of 20 MW of power to overcome its production shortfall, thereby benefiting from the development of the Ugandan hydro-electric resources, and in the longer term, to have the possibility to export (or import) up to 150 MW according to the periods and expension scenarios.

b. Burundi – Rwanda interconnection

The project consists in constructing an HV power line, approximately 109 km long, between the Rwegura hydroelectric power station in Burundi and the Kigoma substation in Rwanda. The purpose of the line is (i) to improve the stability of the grid linking the electricity production and distribution systems of Burundi, eastern DRC and Rwanda, and (ii) to improve the security of the electricity supply and the working flexibility of these networks by creating a loop passing through Butari.

c. Uganda – Kenya interconnection

The purpose is to strengthen the interconnection between the Kenyan and Ugandan networks so that the hydro-electric power station at Bujagali, which is planned to be commissioned in 2011/12, can export surplus power from Uganda to Kenya. The project consists in constructing a 230 km HV power line between Jinja in Uganda and Lessos in Kenya, duplicating the existing 45-year old, double 3-phase 132 kV power line.

d. Strengthening the interconnection between Burundi, DRC and Rwanda

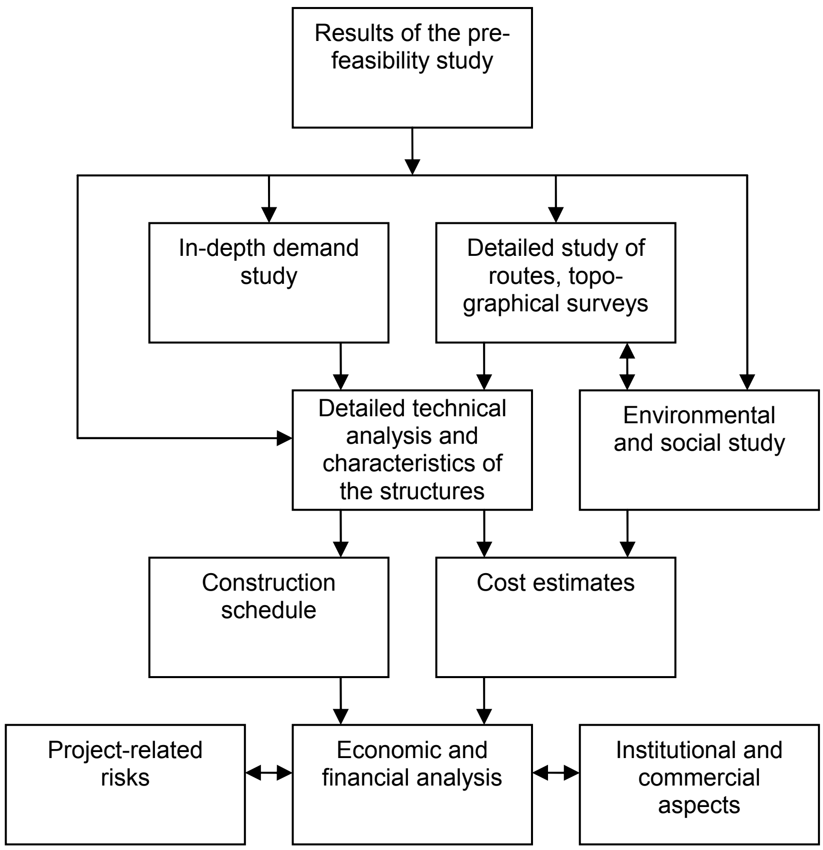
The purpose of the project is to increase the transmission capacity and working flexibility of the transmission network and to improve the security of the electricity supply in Burundi, DRC eastern grid and Rwanda. The project involves:

- increasing the operating voltage of the 112 km power line between the hydro-electric power station at Rusizi I (DRC) and Bujumbura (Burundi) from 70 kV to 110 kV,
- increasing the operating voltage of the 150 km power line between Rusizi I and Goma in DRC from 70 kV to 110 kV,
- constructing a 62 km, 110 kV power line between Goma (DRC) and Mukungwa (Rwanda), closing thereby the loop around Lake Kivu and
- constructing a 15 km, 110 kV power line between Bujumbura and Kiliba (DRC).

Appropriate techniques used to connect the villages along the routes of the different interconnections to the power lines will also form part of the study.

1.3. SCOPE OF WORK AND PROCESS FOLLOWED

The scope of work of this Feasibility study as defined in the terms of references includes the key tasks which are presented in the following flow chart:



1.4. ORGANISATION OF THE REPORT

The present report (**Volume 1**) includes the following analyses:

- Approach and Methodology;
- Review of electricity supply and demand, electricity market forecast by country;
- Regional Approach, including:
  - Analysis of supply and demand balance for main interconnected networks;
  - Proposed power transit capabilities for future interconnections.

The Whole report is made up of the following volumes:

- **Volume 1 – Power Supply and Demand Analysis**, including mainly :
  - Approach and Methodology,
  - Review of electricity supply and demand, electricity market forecast by country,
  - Regional Approach, including:
    - Analysis of supply and demand balance for main interconnected networks;
    - Proposed power transit capabilities for future interconnections.
- **Volume 2 - Uganda – Kenya interconnection**, including mainly :
  - The selection of the line routes Bujagali (Ouganda) - Tororo (Ouganda) - Lessos (Kenya),
  - The preliminary technical characteristics of transmission lines and substations,
  - The cost of equipment,
  - The study of environmental and social impacts,
  - The economic and financial studies.
- **Volume 3 - Uganda – Rwanda interconnection**, including mainly :
  - The selection of the line routes Mbarara (Ouganda) – Mirama (Ouganda) – Birembo (Rwanda),
  - The preliminary technical characteristics of transmission lines and substations,
  - The cost of equipment,
  - The study of environmental and social impacts,
  - The economic and financial studies.
- **Volume 4 - Burundi – Rwanda interconnection**, including mainly :
  - The selection of the line routes Rwegura (Burundi) – Kigoma (Rwanda),
  - The preliminary technical characteristics of transmission lines and substations,
  - The cost of equipment,
  - The study of environmental and social impacts,
  - The economic and financial studies.
- **Volume 5 - Burundi –DRC – Rwanda interconnections and upgrade**, including mainly :
  - The selection of the line routes Mukungwa (Rwanda) – Goma (DRC) et Bujumbura (Burundi) – Kiliba (DRC),
  - The preliminary technical characteristics of transmission lines and substations,
  - The study of the upgrading from 70 kV to 110 kV of the lines Bujumbura – Ruzizi 1 – Goma.

- The cost of equipment,
- The study of environmental and social impacts,
- The economic and financial studies.

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2. APPROACH AND METHODOLOGY

2.1. INTRODUCTION

The present report is an update and a more detailed review of the supply and demand analysis which was performed during the Pre-feasibility study. The update has been mainly applied to the supply part, since during the year 2006, several important events have occurred which have modified the main supply assumptions for the study. In particular, one of the most promising projects in the region, namely the Kibuye Gas power station in Rwanda, has been almost phased out due to important uncertainties on its technical, environmental and institutional feasibility. In addition, several interconnection possibilities with neighboring countries have been gaining interest from the main interested financial institutions (World Bank, AfDB, AFD in particular). For these reasons, a review of the overall available supply has been performed in this Feasibility Study.

In the Feasibility Study, a particular emphasis has to be made on the review of the power market of each country and the presentation of detailed forecast analyses. Indeed, the study area has been characterized by important supply deficits (see below), essentially due to chronic low investment, and more recently the recurrence of particularly dry years which have caused severe shortages of hydropower generation. As a consequence, the “real” power demand of the countries and its growth potential, is not known with precision (with the exception of Kenya), and the Consultant has to use somewhat rough and non-official “unsupplied demand” estimates from the local electric utilities. For these reasons, the demand forecast exercise, which is always a difficult one under normal circumstances, must be considered according to contrasted growth scenarios.

That being said, and according to the Terms of Reference of the Feasibility Study, the Consultant has performed a more detailed analysis of the basic drivers of demand growth in each country: urban and rural electrification objectives, present and expected future consumers’ income, overall economic growth and its expected breakdown by main sector. In addition, an analysis of the relationship between these drivers and electricity consumption has been performed whenever the available information has been sufficient.

2.2. OVERALL REVIEW OF SUPPLY AND DEMAND ISSUES IN THE CONCERNED COUNTRIES

The concerned countries are just recently removed from major crises in the 90’s and the beginning of the 2000’s, either political crises with lengthy armed conflicts (DRC, Rwanda, Burundi) or economic crises (Uganda, Kenya). In addition, the region has been affected by a long-term draught with some severely dry years, and this from 1998 at least, when the Lake Victoria level has started to decrease. The draught had additional negative effects on the already weakened economies of the concerned countries, and on the availability of power. It is believed that an important amount of the countries’ power demand has remained unsatisfied. Load-shedding has been applied in all countries in the last few years, sometimes systematically and in wide areas (Uganda in 2005-2006) and the connection of new consumers has been severely constrained due to lack of generation, transmission and distribution capacities. Overall, the Consultant has tried to estimate the amount of unsupplied (or suppressed demand) of each country in 2006. The values are presented in each country analysis below.

Another important aspect of the concerned countries is that most of their energy needs are not fulfilled by electricity. The main source of energy in these countries is wood fuel, while primary electricity currently represents less than 10% of primary energy consumption in Rwanda and Burundi, around 1% in Uganda and 7% in Kenya. In addition, the access to electricity is extremely low in all the countries of the region, even in Kenya where the electrification ratio is estimated at less than 15%; this electrification ratio is currently less than 5% in Uganda, and less than 2% in Eastern DRC, Burundi and Rwanda. When compared to similar countries in the world, it is clear that the very low demand and electrification patterns of the region are supply-constrained.

When we consider the hydroelectric potential of these countries other than Kenya (see the detailed country review of generation projects) on one side, and the theoretical demand growth possibilities associated with the expected economic and population growth, it appears that the development of such a potential associated with international interconnections should bring the following benefits:

- Provide the whole region with cheap renewable energy, especially Kenya which is deprived of such resources in the future;
- Give opportunities to Eastern DRC, Rwanda, Burundi and Uganda to become electricity exporters, thus reduce the need of hard currency to import fuels and increase hard currency reserves through electricity exports;
- As a consequence of the availability of secure and cheap energy resources, as well as new sources of hard currency, contribute to future economic development of all concerned countries.

The main conclusion of this preliminary review is that there is an important growth potential for electricity demand in the concerned countries; for this reason, and because the respective economies seem to finally recover and embark on rapid growth, relatively optimistic assumptions should be considered when performing demand forecasts.

For all these reasons, the proposed forecasting methodology considers three contrasted economic growth scenarios, one “Median”, which is often referred to as “Base Case” or “Reference” in similar studies, one “High Growth” scenario based on optimistic assumptions, and one “Low Growth” scenario based on conservative assumptions.

This is being developed in more detail in the following paragraphs.

2.3. LOAD FORECASTING METHODOLOGY

2.3.1. GENERAL CONSIDERATIONS

The power requirements of each system are based on the following variables:

- Consumer demand ;
- Power losses

In order to evaluate consumers’ electricity demand, several methods can be used, which are classified into two main types: the econometric one, and the analytical one.

Econometric models consist generally in finding « explicative » variables, like the GDP, the « Urban » or « Non-Agriculture » GDP, the urban population, the average electricity tariffs, and other possibilities and looking for statistical links between total consumption and one or two of these explicative variables. Typical relationships used are as follows:

Consumption = k × GDP $^{\alpha}$ × Tariff $^{\beta}$

In these types of relationships, α and β are called « elasticity » coefficients; generally the first one is greater than 1, and the second is negative.

However, for the types of countries as considered here (excepting Kenya) with extremely low and constrained demand values, huge GDP variations and important non-technical losses (which diminish the tariff effect), these types of relationships are not well adapted. The presence of high suppressed demands in the last years is another blow to any intent to use such a relationship determination of the global consumption.

Analytical methods are normally more adapted to these types of countries, since they consist in studying separately each type of consumers (domestic, commercial, industrial, others…), eventually broken down into several sub-types. For each one, a significant economic indicator must be chosen (family income, economic or physical production…) with the associated unit electricity consumption. But for the analytical methods to be successful, they must be based on detailed and reliable historical information over long periods (at least 10 years). This is not the case of the countries included in the present study, with the exception of Kenya. The collected information, either on the demand side or on the macroeconomic side, is clearly not sufficient to build an analytical load forecast, especially taking into account the deep economic, social and political crises which have affected the region. In addition, and also with the exception of Kenya, very high amounts of unserved energy have been observed in the region, together with high levels of non-technical losses. Existing losses in the 4 other countries of the studied region vary from 25% to 40%, which by experience (see further below) would mean that the non-technical losses range from around 12-15% to 20-25% (in Uganda). It can be concluded that analyses of historical sales values are of little use and even could be misleading for future evaluations.

2.3.2. PROPOSED APPROACH

For all these reasons, the Consultant considers that a mix of the above-mentioned approaches should be considered, including the introduction of key estimates based on its overall and regional experience, and also, when necessary, simple common sense. For each country excepting Kenya, the general approach for estimating consumer demand shall be as follows:

2.3.2.1. DOMESTIC CONSUMERS

Here it is proposed to forecast separately the number of consumers and the unit consumption. The number of consumers can be separated into “Urban” and “Rural” ones; its growth depends on the following:

Number of Consumers

It depends on the following parameters: population; number of persons per family, electrification ratio (percentage of families with electricity). The key parameter, and the most difficult to forecast, is the electrification ratio, which is itself depending on several factors: network accessibility (which depends on the geographical extension of the distribution network), or the percentage of population with access to the network; family income (which depends on the economic activity, or the GDP, ideally split into “Urban” and “Rural” GDP); and electricity tariffs (connection costs in particular).

In the countries of the region, the extension of the distribution networks (especially for the medium and long term) is very limited, due to lack of investment in electricity infrastructure in general. As explained before, future availability of cheap electricity in the region should boost future connections, which itself should allow power utilities to invest in distribution extensions, first in urban areas, then in rural areas. But unfortunately, the rate of new connections resulting from this phenomenon is impossible to predict. So what is proposed here is to work on the basis of development scenarios, where targets are set for electrification ratios for the medium and long terms. Such targets shall be consistent with economic growth scenarios:

Table n° 1 - SCENARIOS

ECONOMIC GROWTH	Low	Medium	High
ELECTRIFICATION RATIOS	Low	Medium	High

For each examined country, assumptions will be made on the basis of country consumption statistics, previous load forecasts, comparison with similar countries, and the consultant's overall experience. Estimates for urban and rural electrification ratios shall be proposed.

For population and number of persons per family, several forecasts are available from national and international sources. In principle, latest available World Bank information shall be taken into account. Breakdown into Urban and Rural populations shall also be estimated on the basis of available information and/or reasonable assumptions.

Unit Consumption

Unit consumption of residential consumers depends on their installed electrical appliances and their use. It is generally admitted that this consumption is mainly linked to the family income and the electricity tariffs. But past relationships are difficult to establish, due to the level of past suppressed demand, and to the extremely low access rate of the concerned countries.

In this analysis, it is proposed to proceed with rough estimates of suppressed demand and real number of consumers, in order to determine average unit consumption for the last known year (2005), and its breakdown into urban and rural areas. Then, for each country and each area, determine an average pattern of electricity uses, like in the following example:

Table n° 2 - TYPICAL EXISTING CONSUMERS' ELECTRICITY USES

ELECTRICITY USES	URBAN				RURAL			
	%	Use / day		Annual Use (kWh)	%	Use / day		Annual Use (kWh)
		Hrs	Avge power			Hrs	Avge power	
Lighting	100	4	300 W	440	100	4	150 W	220
Food Conservation	25	24	200 W	440	5	24	200 W	90
Basic Appliances (iron, fan,…)	100	2	300 W	220	50	2	300 W	100
Modern Appliances	25	2	500 W	100	5	2	500 W	20
Air Conditioning	5	12	2000 W	440	1	12	2000 W	90
TOTAL				**1640**				**520**

Ideally, such values should be based on detailed surveys. In this study, no such surveys were available from the national utilities, which is not surprising since such surveys are relatively expensive and are generally performed by large utilities. But using the Consultant's experience it is possible to propose "reasonable" values which are consistent with the available information on a country's electricity consumption patterns.

When new consumers are added to the network, their future use of electricity is difficult to predict, even when detailed socio-economic surveys are available; by experience, new consumers in areas already served by the distribution network, tend to show lower consumption patterns than existing ones. In developing countries with very low electrification ratios, this phenomenon is observed more in urban areas than in rural ones. In the latter, it is generally admitted that consumption of new consumers is roughly the same than existing ones; and in urban areas, the average consumption of new consumers can be estimated at 50% of the existing consumers' average. The following example illustrates this assumption:

Table n° 3 - TYPICAL NEW CONSUMERS' ELECTRICITY USES

ELECTRICITY USES	URBAN				RURAL			
	%	Use / day		Annual Use (kWh)	%	Use / day		Annual Use (kWh)
		Hrs	Avge power			Hrs	Avge power	
Lighting	100	4	200 W	290	100	4	150 W	220
Food Conservation	10	24	200 W	180	5	24	200 W	90
Basic Appliances (iron, fan,…)	50	2	300 W	110	50	2	300 W	100
Modern Appliances	15	2	500 W	60	5	2	500 W	20
Air Conditioning	2	12	2000 W	180	1	12	2000 W	90
TOTAL				**820**				**520**

The unit consumption of the different categories (Urban – Existing/New and Rural) is also supposed to increase according to the consumers' revenue, which is itself linked to the country's GDP per capita and the price of electricity. A typical relationship can be expressed as follows:

Unit Consumption = k × (GDP/Cap) $^{\alpha}$ × Tariff $^{\beta}$

In our study, since the interconnections should allow for important reductions of electricity costs in the region, it will be assumed that the existing domestic tariffs would not increase on average (in constant prices). As a consequence, it is assumed that Unit Consumption will only depend on the GDP per capita, with an elasticity coefficient (α) between 1 and 2 according to experiences in developing countries. Elasticity coefficients can be different according to the areas (Urban or Rural).

2.3.2.2. OTHER CATEGORIES

Commercial and Public

When their consumption is relatively low, these categories are generally considered together; the forecasts can use several types of methods: analytical, econometric, hybrids. Analytical methods need to consider several types of commercial customers (traditional and modern) and several types of public services; in this study very little information is available to apply such a method, which is also relatively complex and generally concerns low if not negligible consumptions. Econometric models are more commonly applied in developing countries, with explicative variables being population (in urban areas, in particular), GDP (or GDP per capita), and tariffs. Another commonly used possibility is to consider that commercial and public consumption is a fixed percentage of domestic consumption. For the concerned countries, both types of relationships will be compared whenever possible.

Industrial

In developing countries, industrial consumption is generally considered in two parts: all small and medium-sized industries (sometimes several "classic" large industries can be added) on one side, and several specific "large" industrial projects whose projected electricity consumption is relatively high (around 10% of total demand or more). In most cases, the consumption of the first type of industries is linked to their economic activity, where econometric models are most commonly used:

Consumption = k × GDP $^{\alpha}$

Here, various types of GDP can be used, depending on the available economic information: the total GDP, the "Urban" GDP (total minus agriculture), or the industrial GDP. Influence of tariffs is generally not significant, but availability of continuous power with a good supply quality (in particular regarding voltage and frequency) is often fundamental.

2.3.2.3. POWER LOSSES

In the countries of the region, power losses are generally high (20% of generated energy or more) and mostly concern the distribution networks. It is believed that a good proportion of these losses (probably more than half of them) are "Non-technical" losses, resulting from illegal connections, tampered meters, billing and recovery problems…

In principle, all demand forecasts assume that power losses will decrease over time; in this study, reasonable assumptions will be made on overall percentage of losses at short, medium and long term.

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3. BURUNDI POWER SECTOR

3.1. INSTITUTIONAL FRAME WORK

3.1.1. LEGAL PROVISIONS FOR THE POWER SECTOR

Activities dealing with generation, transmission and distribution of electricity are organized by the Law number 1/014 dated 11 August 2000 setting liberalization and regulation of public service for drinking water and electric energy.

According to this law, the power sector remains a public service under state responsibility, but it becomes open to Burundi's public or private entities, chosen after a call for tender specifying the criteria used for selection. These entities are entrusted with the management of the public service through delegation granted by the state.

According to the law, a decree yet to be issued will create a specific body in charge of control and regulation of the power sector.

3.1.2. CURRENT STATUS OF POWER SECTOR

Although above mentioned legal framework exists since 2000, for all practical purposes the current situation remains close to that which was prevailing before the law.

The public service of electricity is entrusted to the state owned company REGIDESO "Régie de production et de distribution d'eau et d'électricité », as it was already prior to the enforcement of the law, and to the « Direction Générale de l'Hydraulique et des Energies Rurales (DGHER) ».

REGIDESO, which is in charge of production, transport and distribution in urban zones, is a public utility with industrial and commercial character. It is provided with personality and financial autonomy and is under supervision of the ministry of Energy and mines. The DGHER is a department of the Ministry of Rural Development (MRD) that is in charge of rural electrification.

There is also a small autonomous production, essentially from religious missions. REGIDESO is presently supplying of more than 99% of consumed power provided by REGIDESO/ DGHER.

In fact, operation of power plants is hardly the purpose of DGHER and the micro power plants that it runs are affected by high rates of unavailability. So, the country is turning towards a REGIDESO national interconnected network getting main supply from some hydropower plants with high capacity. Its achievement is facilitated by small distances to be covered. For example, the hydropower plants of Buhiga (240 KW) and Ruyigi (70KW), which respectively supplies to the cities of Buhiga/Karuzi and Ruyigi and were previously run by DGHER, have been handed over in 1991 to REGIDESO for operation.

In addition to domestic generation, power is exchanged between REGIDESO and DRC, with the two companies SINELAC and SNEL.

3.2. TARIFF STRUCTURE AND LEVEL

3.2.1. TARIFF STRUCTURE

The current tariff schedule is in force since 1st January 2004. It is displayed in the table herewith. One single schedule is enforced throughout the country.

At low voltage level, customers pay only for energy charge, while a demand charge exists at medium voltage level.

A progressive tariff is used for LV customers, with 4 blocks for households and a rate multiplied by a factor 3 between first block (up to 150 kWh per month) and fourth block (beyond 750 kWh per month).

At medium voltage, the structure in force is closer to marginal costs, with a fixed charge and an energy charge divided by 2 between the first block (150 h per month of subscribed demand) and the third block (beyond 450 hours).

Medium voltage customers are subsidising low voltage customers since the former pay average higher prices than the latter, while costs hierarchy follows the opposite pattern. Moreover, these subsidies are directed to the 1.8% of the population who already benefit from power supply.

3.2.2. TARIFF LEVEL

Between years 2000 and 2004, the average selling price has been multiplied by a factor 2.6 at MV level, and 2.2 at LV level.

In the years 2004 and 2005, average selling prices were the following:

	FBU/kWh	cUSD/kWh
MV level	95	9.6
LV level	70	7.1

Table n° 4 - BURUNDI TARIFF SCHEDULE IN FORCE SINCE 01.01.04

Categories of customers	FBU/kWh	cUSD/kWh
1 – Low voltage supplies		
1.1 – Households, blocks per month		
Social rate: Up to 150 kWh Beyond 750 kWh	 32 36	 3.2 3.6
High standing rate: From 301 to 1000 kWh Beyond 1000 kWh	 67 100	 10.1 10.9
1.2 - Business: Up to 300 kWh From 301 to 1000 kWh Beyond 1000 kWh	 91 100 108	 9.2 10.1 10.9
2 - Medium voltage supplies		
2.1 – With Demand charge Monthly demand Charge	FBU/kVA 7632	USD/kVA 7.7
Energy charge (per kVA) Up to 150 hours Between 150 to 450 hours Beyond 450 hours	FBU/kWh 96 61 41	cUSD/kWh 9.7 6.2 4.1
2.2 – Without demand charge, single rate	109	11.0
3 – Supplies from DGHER	42	4.2

Note: 1 USD = 989 FBU

3.3. GENERATING FACILITIES

3.3.1. HYDROPOWER PLANTS

The interconnected network is presently and mainly supplied by 4 hydropower plants of which two are national and two external. Here they are:

- National Power Plants:
  - Rwegura (18 MW)
  - Mugere (8 MW)
  - Ruvyironza (1,275 MW), connected to the substation of Gitega.
  - Nyemanga (1,44 MW)
- External Power Plants:
  - Ruzizi I (RDC, operated by SNEL)
  - Ruzizi II (Communauté Economique des Pays des Grands Lacs or CEPGL, operated by SINELAC)

Progressively, the small isolated national plants are joined to the interconnected network.

- The Gikonge power plant (850 kW) at Muramvya,station
- The Nyemanga power plant is connected to the south network by the Itaba substation (Bururi), this network being itself connected to Ijenda substation.
- The Plants of Marangara (280 kW), Buhiga (240 kW) and Kayenzi (800 kW) will soon be connected with the construction of Musasa substation connected by 30 kV line to NGOZI substation (PREBU financing).

In practice, the production of the interconnected network presently comes from 2 national plants, Rwegura and Mugere and from the external plants, Ruzizi I and 2. Technical problems prevent the small plants from being joined to the interconnected network.

3.3.1.1. NATIONAL HYDROPOWER PLANTS

Table n° 5 - CHARACTERISTICS OF BURUNDI MAIN POWER PLANTS

Name	Turbine Type	Number of units	Power	Installed capacity	Guaranteed power	Guaranteed annual energy	Average annual energy
MUGERE	Pelton	4	2 MW	8 MW	2,17 MW	19 GWh	40 GWh
RWEGURA	Pelton	3	6 MW	18 MW	4,08 MW	35,7 GWh	55 GWh
NYEMANGA	Pelton	2	0.85 MW	1.7 MW	1.39 MW	12.2 GWh	12.2 GWh

The power plants production on the interconnected network is presently 160 GWh per year (13,5 GWh per month in 2004). In July the peak was 29.5 MW.The theoretical peak is higher because REGIDESO is obliged to proceed with load shading.

3.3.1.2. EXTERNAL HYDROPOWER PLANTS

3.3.1.2.1. GENERAL

Burundi is also supplied by two hydropower plants situated on the river Ruzizi in Congo and Rwanda territories. Here they are:

- Ruzizi I for the National Power Society (SNEL) from DRC (Democratic Republic of Congo). Its installed capacity is 28.2 MW. The SNEL is also the owner of the 70 kV line connecting the power plant to Bujumbura and the owner of the 70/6.6 kV SNEL substation of Bujumbura.
- Ruzizi II, power plant of the CEPGL community with the installed capacity of 40 MW, supervised and exploited by SINELAC.

Table n° 6 - CHARACTERISTICS OF RUZIZI I ET RUZIZI II

Name	Turbine Type	Number of units	Power	Installed capacity	Guaranteed power	Guaranteed annual energy	Average annual energy
RUZIZI I	Kaplan	4	2x6.3 MW 2x7.8 MW	29.8 MW	11.9 MW	105 GWh	165 GWh
RUZIZI II	Francis	3	13.36 MW	40 MW	16.1 MW	141 GWh	220 GWh

Note: the average energy corresponds to the high hypothesis (see below)

Even if these two power plants do not belong to REGIDESO, a short description is given hereafter since their future production partly depends on the investment strategy of Regideso (Burundi), Electrogaz (Rwanda) and SNEL (DRC). A third of Ruzizi II production belongs to Burundi by right. As for Ruzizi I the situation is more complex since Burundi has substantial electricity credit from this power plant.

3.3.1.2.2. *RUZIZI I*

The power plant was commissioned with two units in 1958. It was completed by two other units in 1974. The Ruzizi I plant is situated at some kilometres from Lake Kivu release, at Mururu waterfalls. It comprises one dam with 4 radial gates. The plant is situated at the foot of the dam. It includes 4 Kaplan units (2x6.3 MW) in 1958, 2x7.8 in 1974) operating under a 24.7 m head and totalling 28.2MW.

Since the power plant was built on Congo territory for all the countries during the period of colonial administration, DRC pays its share back to Burundi by providing electricity for 1.8 GWh/month free of charge. Moreover, Burundi undertakes to buy 1.0 GWh/month for participation in the power plant exploitation. So, this is a total of 33.6 GWh/year that Burundi should buy. Presently, Burundi has a substantial power credit (of the order of 200 GWh for 21.6 GWh / year, equivalent to the consumption of 9 years), but the power plant condition can not permit to get it at the appointed rate.

The Ruzizi I annual energy based on the 1981-1989 Ruzizi river modules is 165 GWh. In any case, Burundi can only get a small part, which, in fact, marginally depends on the energy estimation. The imports from Ruzizi I are limited by three factors:

- Power reduction from incidents and rehabilitation works
- Limitation of supply to Burundi: even if the transformer 6.6/30 KV of SNEL substation in Bujumbura, whose connection (wrong phase displacement) could not let SNEL and RN1 substations be connected, has been changed, the supply to the interconnected network presently remains impossible. The Bujumbura area relying on SNEL substation, as well as Uvira (DRC), is, therefore, an isolated network supplied by the only Ruzizi I power plant which can not export more than what this network requires. Nevertheless in order to better use the importation possibilities from Ruzizi I, REGIDESO can manually connect or disconnect some Bujumbura districts to SNEL substation, but the fact that the operation is manual does not permit to use the full capacity of Ruzizi I power plant.
- Needs of the Kivu region

During the period 1987-2006, exports to REGIDESO varied from 5.8 GWh to 28.2 GWh per year according to years. In the present study, it is assumed that SNEL would be able to provide Burundi with **20 GWh** for the next years, with a firm capacity of **2.25 MW**.

3.3.1.2.3. *RUZIZI II*

The Rusizi 2 project was commissioned in May 1989 by SINELAC. It is located at some kilometres downstream of the Rusizi 1 power plant.

The power plant is composed of 3 Francis turbine of 14.6 MW running under a 28.5 m head. Two units are in service since 1989. The third unit was commissioned at the end of 2001. Even if its influence on the power plant producible power is modest, it considerably improves the power plant reliability. This third unit was exclusively financed by SINELAC (Regideso and Electrogaz lend money to SNEL which will pay them back in the form of electricity from Ruzizi I).

For the present study, and taking the very low level of Lake Kivu into account, we use the value of 141 GWh as Ruzizi II average annual energy, a quota of 47 GWh and 5.4 MW guaranteed being given to Burundi.

3.3.2. THERMAL PLANTS

The only important thermal plant for Burundi is in Bujumbura. It is situated in the western industrial area, near the harbour. It was commissioned in 1996 following the initiative of the Burundi Government at the time of the incidents which occurred on the transport lines in the north-west and prevented the capital from getting electricity. After its installation, it has functioned for about 4 months continuously during the period of repairing the lines. From this period it has only functioned too little, except for the periodical starting for maintenance. Its use is always kept under the Government agreement.

Considering the very high cost of the produced energy, the generators are only used in extreme emergency or on particular occasions such as Christmas day and a New Year day.

The power plant is composed of 2 generators of 1.25 MVA under 6.6KV and 2 generators of 1.5 MVA under 6.6 kV. It is directly connected to SNEL substation by 2 6.6 kV cables. With four generators in operation and 0.9 power factor, the total power available is 5500 kW.

The capacity of the others thermal plants of Regideso is very low. They are situated in regional centres, and they are generally used for emergency and only permit to partly satisfy network needs, mainly the pumping of drinking water.

3.3.3. COMMITTED AND PLANNED POWER PLANTS

3.3.3.1. GENERAL REMARKS

In 1995, in the frame of the updating of the generation master development plan, SOGREAH had selected 10 candidate projects and then compared them using an optimisation model (Hillmix SOGREAH programme). In this way, SOGREAH was following the recommendations from the analysis done about PDNE in 1988 by the “Burundi-Energy problems and choice-January 1991”a study which was carried out within the joint project ESMAP/ PNUD Wold Bank.

These 10 projects were the following:

- Mpanda,
- Kabu 16,
- Kabu 23,
- Rushiha,
- Mule 34,
- Jiji 03,
- 3rd group: Rusizi 2
- Rusizi 3
- Rusumo Falls
- Diesel Units

It is important to mention that the twofold increment of Nyemanga hydropower plant (so far unachieved by 2005) was considered complete for the year 2000, which is why it was not mentioned in this list.

Another study for network development has been achieved by SOGREAH in 2001 within the technical examination of the production tool of the REGIDESO. In comparison with 1995, the pre-feasibility of the Mule 34 and Jiji 03 hydropower plants have been achieved providing more accurate information to production and cost estimates. On the other hand The Rusizi 2 third Unit installation was under way.

However, the hydropower plant of Sikuvyaye 90 MW which had been rejected in the previous study, was finally added to the list at the request of Regideso. Finally, the hydropower plants considered within the framework of this study are mentioned hereunder:

- Nyemanga doubling
- Mpanda,
- Kabu 16,
- Mule 34
- Jiji 03
- Rusizi 03
- Sikuvyaye 90 MW
- Diesel Units

The selected planning in 2001 was the following:

- 2004: Nyemanga doubling
- 2004: Connection of the northern hydropower plants to the interconnected network (under way at the beginning of 2006).
- 2006: Commissioning of Mpanda (considered as operative on Regideso proposal).
- 2011: Commissioning of Kabu 16 in case the thermal plant of Bujumbura is not considered otherwise to be commissioned by 2015

By early 2006, Mpanda had not been constructed and then all candidate plants remained in the same state .You will find hereafter, a presentation of each of these plants.

3.3.3.2. NYEMANGA DOUBLING

The present installed capacity of Nyemanga plant is 2 x 722.5 kW but its civil engineering is planned in order to add 2 additional and similar generators bringing its installed capacity up to 2.8 MW. Owing to the rapid increase of consumption in the South of the country, and due to connection of this network to the interconnected network, the doubling is to be achieved in the short term, with the average production exceeding 16.2 GWH, and guaranteed production of 15.2 GWH.

A study of the load flow on the connection between Bururi and Ijenda has shown that it was possible to let through a maximum capacity of 900 kW between Nyemanga and the interconnection network while keeping on acceptable voltage level. This value is to some extent a manoeuvre margin for the management of the Southern network in the short term i.e before the achievement of the 110 kV lines between Gitega and Bururi, but it can not be considered as genuine interconnection. Whatever the case may be, the rapid development of consumption, within the Southern part will not allow the supply of a maximum capacity of more than 900 kW to the interconnected network (difference between the capacity provided by Nyemanga and the capacity consumed in the South). That capacity is not sufficient enough to play an important role in strategies of starting new means of production. However, given the small investment that is necessary (therefore, its cost effectiveness), the doubling of the Nyemanga hydropower plant has already been considered as active since 2008, this corresponding to one year and a half for consultation phase/ awarding and one year for delivery and assembling.

Thus, strictly speaking it is not to a candidate hydropower plant but it is about a programmed investment whose cost amounts1.4 MUSD.

3.3.3.3. MPANDA

After having abandoned the Kagunuzi C, the Ministry of Energy and Minerals has searched for another site enabling the irrigation of the plain of Imbo. That research was realised by a feasibility study of the hydro agriculture and hydropower plant of Kagunuzi achieved in 1992 by the Hydroplan / Fichtner grouping and whose leading out line has clearly shown several reservoir sites along the river Mpanda.

Following that study, the same grouping started in 1994 the first phase (detailed pre-feasibility project) of the "Execution Studies of Mpanda Multipurpose Project" whose reports were published in 1997. So this is the most advanced national project at the present moment. The project is located on the Mpanda river (whose source comes from the same location as the Gitenge), in Musigati commune, in the Province of Bubanza at around 15 Km to the east of the HT Substation of Bubanza. Its dam is located near the place where the Mpanda gets out of the national park of Kibira.

The proposed layout is the following:

- The dam: earth embankment type. The height is 35m, determining a reservoir of 13 million m^3, the top of the dam at a dimension of 2220.0 meaning a maximum dimension of exploitation of 2219.0 m and a minimum of 2192.0 m.
- Water passage: from the concrete tower of the water collection then water is transferred to the power house through a steel pipe of 4.5 km of length with 700 mm of the main diameter buried or placed on concrete contacts.
- The plant: located at around 1267 m above sea-level; the net average drop amounts to 869m (based on the turbine axis and not 874 m as indicated in the PDA because it was focussed wrongly on the level of the tank leakage). The equipment out put flow is amounting to 1.4 m^3/s in two Pelton generators giving a total of 2x5.3= 10.6 MW.
- The connection to the network: it comprises a 110 kV substation at the hydropower plant, a line of 15.3 km in length is joined to the substation of Bubanza and then a corresponding expansion of that substation.

In 1995, during the revision of the master plan, SOGREAH, benefiting from the fact that Mpanda was getting its source at the same place as Gitenge and with the good knowledge of the hydrology of the region, had estimated the average flow of Mpanda to the dam at 0.63 m^3/s instead of 0.75 m^3/s as proposed in the previous reports. The report from the PDA has adopted the same quote as the one proposed by SOGREAH. However, the irrigation management does not allow pump all the water because from July to October the necessary inflow to agriculture overtakes the equipment out put of the hydropower plant. This limits the electricity production to 29.4 GWh in average per year instead of the available 40 GWh. The monthly flows given in the detail design report show that the plant should be stopped during the 3 months, December, January and February. That absence of production is not compatible with the management imperatives. The corresponding monthly output which is mentioned in the PDA report that the hydropower f the electricity production network because it would soon lead to commissioning other production means in order to cover the lapse lasting 3 months.

The total cost of the hydroelectric project is linked to the sharing of the common work, the dam, between the hydro agricultural side and the hydroelectric one. The economic assessment of September 1997 plans the following 4 cases of the coverage of the dam costs (investment and operation expenses).

Hydroelectric section	Hydro agricultural section	Hydroelectricity investment
100%	0%	53.05 MDM
67%	33%	48.06 MDM
50%	50%	45.49 MDM
0%	100%	37.93 MDM

Another approach has been suggested by SOGREAH that consists of allocating of the dam cost that is proportional to the benefits gained. Referring to the economic assessment of1997, the benefits are the following:

- For the hydroelectric section: 29.4 GWh at 25FBU/KWh that is 735MBUF per year.
- For the hydro agricultural section: 3.2MBUF per year.

On this basis, the investment in hydroelectric section is amounting to 52.99 MDM, the retained quote for the candidate hydropower plants. That quote corresponds to the rate of the Dollar, at the beginning of 2001, to 24.7 MUSD. On the other hand if the whole dam is allocated to the hydro agricultural section the plant cost falls to 19.4 MUSD.

The production detail was established in reference to the results published within the pre-feasibility project concerning the average and dry years and was estimated in comparison with Kabu 16 production for the rainy year since the flow of their rivers is similar. The hydropower plant could be commissioned in mid 2011 in case the finalising process for the bids and consultations could be achieved within one year.

3.3.3.4. KABU 16

The Kabu 16 project is located at 16Km from the confluence of the Kaburantwa whence the name Rusizi in the Province of Cibitoke, at around 60 km in the north of Bujumbura. Many studies on it have been carried out within the last decade, all of which have classified it as the best project of the Kaburantwa/ Gitenge basin. It concerns the arrangement of high fall (gross head = 191.6 m) with a daily reserve which permits a useful variation of the inflow whose average is 10.4 m^3/s. The total plant flow is 12.85 m^3/s with two Francis generators, the total capacity of which is 20 MW, leading to an annual average production of 117 GWh. The project, whose feasibility has been achieved in 1995, comprises the following undertakings:

- A concrete dam with gates, the reservoir of which is used as a daily reserve and a discharger.
- A water intake that is integrated to the self-cleaning type dam.
- A gallery covered with 3020m of length and 2.50m of diameter.
- A diaphragm balance chimney.
- A buried penstock that is 563m long, with diameters of 2.5 and 2.0m.
- A powerhouse equipped with 2 vertical Francis generators.
- A 110 kV substation and a 6 km long transmission line, connected to the Bubanza-Cibitoke line.
- Access roads and an area of operation.

The total cost of the initial project 1995 was 44.85 MUSD including research, supervision and miscellaneous. The earliest commissioning date may be planned for mid 2012, it is based on one year of detailed study and attainment of bids files, 1year for consultation and 4years for construction.

3.3.3.5. MULE 034

It concerns the development of a high water flow (net head is 235m) with the daily reserve which permits an important modulation of the incoming water flows whose average is 4.2 m3/s. the equipment out put is 8.55 m3/s for 3 Pelton generators with the total power of 16.5 MW, for an annual average production of 147 GWh. The development site is located on the river Mulembwe, a tributary of the Siguvyaye, at around 13Km in the Northwest of the town Bururi as the crow flies. The height of the river bed is 1400m at the water intake and 1160m on releasing.

The development comprises:

- A dam that is 10m high in rock and earth with core of clay, which determines a reservoir for daily regulation.
- A bottom gate serving as de-sedimentation of the reservoir water.
- An inlet gallery that is 900m long with a 22m diameter, at the end basin for eliminating sand and a water intake with screen and a guard gate for the penstock.
- A steel penstock that is 600m long with a 1.8m diameter.
- The external type power plant.

The total project cost is 33 MUSD, including the energy evacuation line. Owing to the advancement of the study (pre-feasibility), one has to be more cautions about the project cost.

The detail of the production have been established on the one hand on the basis of hydrologic estimates for the years 1980-1995 pre-feasibility report, on the other hand on basis of the Kabu 16 production which also has a reservoir for daily regulation and by making an hypothesis of annual distribution of fairly identical water flows. If we refer to a normal process, feasibility, PDA, DAO, consultation and selection of enterprises, construction, the commissioning of that development cannot happen before nine years, i.e. in 2015. In case of an express procedure or a BOT, we may hope to reduce that deadline by one year.

3.3.3.6. JIJI 03

The project site is located on the Jiji River, a tributary of Mulembwe, at around 3 Km from the confluence of the two rivers and at around 8 Km in the North of the town of Bururi as the crow flies. The study of the pre-feasibility has shown that this development is less interesting than one of Mule 34 due to the following reasons:

- The hydrologic studies provide a generated energy of over 25% for Mule 34.
- Topographical, geological and geotechnical studies also favour Mule 34.
- The installed KW cost is 1782USD for Mule 34 against 2734USD FOR Jiji 03.

Finally a more precise assessment done by SOGREAH has shown that the updated average cost of a Mule 34 KWH is much weaker than the one of Jiji 03 (7.1 cent USD for 12 cent with an updated rate of 10%. As for the studied period, it will not be possible to commission two plants; we will not select Jiji 03 to compare it to the other plants.

3.3.3.7. RUZIZI 3

This community development, whose project was launched by the EGL, would be located on the Ruzizi, at around 8 km downstream of Ruzizi 2. It is described in the chapter concerning the regional approach. The equipment out put is about 158 m3/s for three Francis generators giving the total power of 82 MW (3X27.3 MW). The guaranteed power is 47.8 MW corresponding to an output with 92 m^3/s and the annual average production being 456 GWh, which is 15.9 MW and 152 GWh respectively for Burundi’s side. The earliest possible year for the commissioning is 2015 (Refer to Annex A for details).

3.3.3.8. RUSUMO FALLS HYDROPOWER PLANT

The Rusumo Falls Hydroelectric community project is described in the chapter dedicated to Regional Approach because it was initially identified under the work programme of the Organization for the Management and the Development of the Kagera River Basin (KBO) and then, by the Nile Equatorial Lakes riparian countries (Burundi, Rwanda and Tanzania) as a component of the NELSAP.

The Rusumo Falls Project would have a capacity of 61.5 MW and a guaranteed energy of 308 GWh. It is contemplated that the hydroelectric power station would supply power to Burundi and Rwanda by way of 110 kV transmission lines and Tanzania by way of 220 kV transmission line. Each country would be entitled to an equal share of the station's output.

The portion of the average electricity production assigned to Burundi is hence 134 GWh and 15.3 MW (Refer to Annex A for details).

3.3.3.9. SIKUVYAYE 90 MW

This hydroelectric development of high water fall was studied in 1979-1980 by the Italian company ITS. Its main purpose was to supply with electricity the nickel mine, which was planned to be established in the region of Musongati (some 40Km in the South-West of Gitega) where a promising deposit was located.

The development is very complex and consists of:

- An earth dam that is 72m high, located on the Sikuvyaye river, around 8 km upstream from the present Nyemanga dam and creating a 200Hm3 reservoir.
- Two dams, one located on the Jiji (at around 7km upstream of JIJI 03 plant project, the other located on the Nyembwe, aimed at supplying additional water to the reservoir.
- Two tunnels 6 and 5.5 km long, diameter 2.8 m, connecting these dams to the reservoir.
- An inlet tunnel 16.8 km in length, 2.8 in diameter, ending with a surge tank.
- A penstock that is 4.1 km long and 1.8 m of diameter.
- An underground plant with three 30 MW Pelton turbines under a gross head of 1022m.
- Finally, a discharge tunnel, 3 km long, realises pumped water directly into lake Tanganyika.
- The energy is transmitted by a 150 kV line that is 94 km long.

This development has been dropped from the national development at middle term due to the following reasons:

- The capacity of that plant could not anticipated, due to the absence of a nickel mine as well as in the broad regional sense.
- Its commissioning would eliminate the Nyemanga plant supply, since the waters are directly discharged into Lake Tanganyika.
- Finally, the great lengths of the galleries (about 32Km and the underground plant constitute a non-negligible uncertainty on the costs and the achievement's time dues.

For a reminder, the total cost of the development was estimated in 1980 at 216.9 MUSD (rate of 90 FBU to USD) and 3300 MBUF.

3.4. TRANSMISSION NETWORKS

The network is described by the electricity network map and the single line diagram RN UR 000 0 (see Annex C), it consists of:

- The transmission network: historically, Bujumbura was first supplied by Ruzizi I power plant and the 70 kV line which always belong to SNEL in the same way as the Bujumbura SNEL substation. Then the Mugere power plant was commissioned. It is near Bujumbura and is connected to Ozone substation by a 33 kV line. Next, Rwegura power plant was commissioned and it required a 110 kV line: Rwegura-Bubanza substation –Bujumbura. Finally, Ruzizi II was commissioned in 1989 and it required the creation of a 110 kV line: Ruzizi II – Mururu 2 substation –Cibitoki substation –Bubanza substation. This network was extended towards Gitega in 1991.
- Little transport and distribution networks: around isolated small production centres functioning with isolated networks, 6.6 kV, 10 kV, 15 kV, 30 kV and 35 kV are used. This network is mixed and most of the time it carries out two simultaneous functions of transport and distribution. These tree-like networks, which extended with the passing years, are partly interconnected now or are in the process of being interconnected. Their characteristics corresponded to proximity needs and they have been progressively adapted to the constraints of a more extended network.

3.4.1. SUBSTATIONS

The 15 main substations of the country are divided up into 5 zones:

- Ruzizi valley: Bubanza, Cibitoki, Mururu 2
- North: Rwegura, Kayanza, Ngozi
- Bujumbura: SNEL, RN1, Ozone
- Gitega: Gitega
- South: Ijenda, Nyemanga, Itaba, Rumonge.

3.4.1.1. GENERAL CONDITION OF 110 KV EQUIPMENT

Most of the oldest 110 kV circuit breakers, especially those which belong to Rwegura and RN1 station, are subject to high SF6 gas leakages. On the other hand, great damages due to fighting in Bubanza region have consumed all the spare parts and even more since the Bubanza substation operates without circuit breaker on the transformer section, and the Cibitoke substation operates with a very old circuit breaker lent by Rwanda, all this being done under dangerous conditions for the equipment. It is also noted that 2 voltage transformers are missing, which deteriorates the network operation. At 70 KV SNEL station level, the circuit breaker is a little oil volume type which is dated from 1966 and requires replacement.

The three 70KV power transformers at the SNEL substation have tap changer in blocked charge; which does not facilitate the adjustment of the secondary voltage.

3.4.1.2. THE 30 KV EQUIPMENT

Despite the fact that the project does not cover the distribution network, it is important to mention that the main distribution networks operate within a system of isolated neutral. The transformer's inductance coils have been either switched off or unplanned for initial substation planning. It is also important to mention that none of the present substations is equipped with reactive compensations.

3.4.1.3. PROTECTION EQUIPMENT OF THE HV NETWORK

Some distance protection of the 110 kV network are partly out of operation. They are so old that spare parts cannot be ordered; they must be changed.

Most of the "Oscillo-perturbographes", the single-phase reclosing systems and the fault locators are out of use.

3.4.1.4. HV TELETRANSMISSION NETWORK

It can be considered that most of the teletransmission equipment must be changed and the minimum requirement is an operational telephone system to insure the normal network operation.

3.4.1.5. REMOTE CONTROL

The remote control system has broken down for several years now, on one hand due to the problem of data transmission (PLC) and on the other hand because of the failures of the substations data collection units (RTU). The absence of information about the network in proper time deteriorates greatly its operation efficiency.

3.4.1.6. HV SUBSTATIONS REFURBISHMENT

In 2004, the government of the Republic of Burundi entrusted SOGEAH with the completion of a study for the revision of the high voltage substations, modernization and improvement of the electric systems protection, telecommunication and remote control and the rehabilitation of protections against fire. This study has been financed by the FED and the delegate client was the PREBU – rehabilitation program of Burundi. The Government of the Republic of Burundi is still waiting for finances in order to start revision works related to the substation of high voltage.

Most of the work required in order to repair the substation 110 kV of the interconnected network of Burundi are included in this program. The substation of Mururu II and the 70kV substation of the SNEL in Bujumbura are however excluded from this program.

3.4.2. TRANSMISSION LINES

There are presently two types of high voltage lines in Burundi: the 110 kV lines and the SNEL line at 70 kV between Bujumbura and Ruzizi I.

3.4.2.1. 70 KV LINE (SNEL)

This line, of 112 km in length is supported by four-legs towers in wire-mesh of galvanized steel of LP type as they are illustrated within the design RL BG 0010 (see in Annexes of Volume 6).

This line constructed in 1958 transmits power produced from the hydroelectric plant of Ruzizi I to the substation SNEL in Bujumbura. The main features (characteristics) of that line are described within the following table:

Phase arrangement	Single circuit, horizontal
Phase conductors	3 x 135/22 AL/AC
Shield wire	2 x 48 mm2 galvanized steel
Characteristic power	29 MW à 110 kV 12 MW à 70 kV
Maximal thermal power	87 MVA à 110 kV 56 MVA à 70 kV
Insulators	Cap and rod in toughened glass 7 per chain, distance 146 mm
Distance between arcing horns	900 mm

For operation at 110 kV, the isolation level of that line marginal according to CEI standards. Considering the reduced distance between the horn's arch and the fact that it is located within a region of high altitude and with a Keraunic level estimated between 120 and 150 of storm per year, this line has a reliability level which is very low.

3.4.2.2. 110 KV LINES (REGIDESO)

Three sections of 110 kV lines have been constructed in Burundi by REGIDESO. The first section, comprising 67 km of length, is supported by towers of universal type, in galvanized steel lattices, as illustrated in Annexes of 6. This line, constructed in 1958, transmits the power produced by Rwegura plant to the substation of Bubanza, then finally towards the substation of RN-1 in Bujumbura. The second section of 110 kV line was built in 1989 during the construction of substations Mururu II, Cibitoke, Bubanza. It comprises 53,7 km and facilitates the connection between substation Bubanza and Cibitoke to Mururu II. The third and last section comprises 72 km and facilitates the connection between the substation Gitega to that of RN-1 in Bujumbura. This last section was constructed in 1992 during the construction of the substation of Gitega. The two last sections of the line use similar towers as the line constructed between Rwegura and the substation of RN-1.

a. The line between the power plant of Rwegura and the substation RN-1 : the main features of that line are described the following table :

Phase arrangement	Single circuit, triangle
Phase conductors	3 x 240/40 AL/AC
Shield wire	1 x 95/55 AL/AC
Characteristic power	32 MW
Maximal thermal power	130 MVA
Insulators	Cap and rod in toughened glass 10 per chain, distance 127 mm
Distance between arcing horns	850 mm

b. The line connecting the substations Mururu II, Buganza and Cibitoke:

This line was constructed in 1989.Tough we do not possess any document concerning this line, documents showing the electrical characteristic of this line makes us conclude that it is similar to the line constructed between the plant of Rwegura and substation RN-1. The conductors used at a 39,2 km distance around the substation Mururu II are however ACSR 288 mm2.

c. The line connecting the Gitega substation to the substation RN-1.

A visit to the RN-1 substation has helped us to conclude that this line is similar to the substation RN-1

3.5. DEMAND - SUPPLY BALANCE AND DEMAND FORECAST

Following the civil war that erupted in 1993 and continued until the beginning of present decade, Burundi's development was stopped and economic activities declined. In the power sector, sales had reached 123 GWh in 1992, and then decreased down to 92 GWh at the lowest point, in the years 1996-1997. They came back to their previous level only from 2001 onwards. While activities are recovering, the power sector undergoes increasing shortage of supply since investments which had been planned in the nineties have never been implemented.

3.5.1. POWER SUPPLY

Interconnected grid concentrates the major part of the power sector, since isolated centers represent only 4% of global generation. There are two sources of supply: domestic generation and imports from RDC.

3.5.2. GENERATING FACILITES IN BURUNDI

The main characteristics of existing facilities are summarised hereunder:

Interconnected network	Installed Capacity MW	Firm Capacity MW	Average Output GWh	Firm output GWh
Bujumbura TPP	5,5	5,5	-	-
Rwegura HPP	18	4,1	55	36
Mugere HPP	8	2,2	40	19
Ruvyironza HPP	1,2	1,2	11	10
Total	32,7	13,0	106	65
Isolated HPP	4,8	-	8	-

3.5.3. POWER IMPORTS

An increasing part of power supply comes from the Ruzizi I and 2 HPPs located in DRC.

One third of the CEPGL power plant Ruzizi II, operated by the SINELAC Company, comes to Burundi. Consequently, global supply is increased as follows:

Interconnected network	Installed Cap. MW	Average Output GWh	Firm Output GWh
Domestic generation	32,7	106	65
Ruzizi II– Share for Burundi	13,3	69	66
Global supply for Burundi	46,0	175	131

Additional energy imports are coming from the SNEL Ruzizi HPP

3.5.4. GLOBAL SUPPLY

It is indicated herewith for the period 2001-2005, together with sales and losses for interconnected network and isolated centres.

(All values in GWh)	2001	2002	2003	2004	2005
1- NET SUPPLY					
Interconnected network					
1.1. Domestic Generation					
Rwegura	62.4	67.7	48.3	43.5	49.6
Mugere	39.2	46.7	44.4	39.6	41.8
Ruvyironza	3.1	3.4	3.6	1.2	2.6
Total generation	104.7	117.8	96.3	84.3	94.0
1.2. Imports					
Imports from SINELAC (Ruzizi II)	4.2	2.1	29.9	42.1	50.9
Imports form SNEL (Ruzizi I)	30.0	28.0	26.1	30.3	20.3
Total imports	34.2	30.1	56.0	72.4	71.2
Total interconnected	138.9	147.9	152.3	156.7	165.2
Isolated HPP	8.7	8.8	7.7	6.5	7.0*
Global generation	147.6	156.7	160.0	163.2	172.0
2. SUPPLIED DEMAND					
Sales MV level	42.0	50.0	42.3	44.2	43.9
Sales LV level	80.1	68.9	81.8	80.8	75.9
Total sales	122.1	118.9	124.1	124.8	119.8
Losses technical & non technical	25.5	37.8	35.9	38.4	52.4
Global supplied demand	147.6	156.7	160.0	163.2	172.2
Distribution loss ratio	17%	24%	22%	24%	30%

* estimated

Sources: REGIDESO annual activity report year 2004

Provisional documents issued by REGIDESO for year 2005, Generation Electricity Department.

3.5.5. POWER DEMAND

3.5.5.1. CURRENT SUPPLY DEFICIT

Since 2003, available supply cannot meet the demand because of insufficient rains and insufficient installed capacity. Therefore, the gap between supply and demand is widening.

At the end of 2005, this gap would be assessed as follows, according to REGIDESO and for the interconnected network:

	MW	GWh
Supplied demand	22	165.2
Un-served demand	13	25
Potential demand	35	180.2

In fact, the supplied peak load may actually reach up to 32 MW, but only when favourable conditions are met. This was for instance the case in June 2005 because of a short rainy period.

3.5.5.2. DEMAND ANALYSIS

The estimated population in 2005 was 7.5 Million, with a growth rate of 3.6% per annum (World Bank, April 2006).

About 93% of the population lives in rural areas (2002 Estimate). The GDP per capita, which was already below 100 USD in 1991, has been even divided by a factor two between 1991 and 2003. Consequently, the population living under the poverty line has almost doubled in the period, soaring up to 68% in 2002.

However, in 2004, GDP per capita started again increasing with a rate of 4.8%, translating the fact that peace has returned, and the GDP per capita was estimated at 100 USD in 2005. Electrification ratio remains extremely low, since 1.8% of households have access to electricity; the whole electricity consumption is only 22 kWh per capita (year 2004).

Concerning end user consumption, the share of main sectors remained relatively stable over the last years, as follows:

Households	35%
Industry	40%
Commercial and public services	25%

Added values by industry and services have sharply decreased in the period 1992-1996. In 2004, services had fully recovered, while industry was still at 50% of the level recorded in 1992.

The following breakdown for sales can be estimated for the year 2005, based on the potential demand of the interconnected network:

Table n° 7 - ESTIMATED EXISTING CONSUMPTION BREAKDOWN

2005 Consumption Estimate	Urban	Rural	Total
Households (or domestic)	**45.1 GWh**	**0.7 GWh**	**45.8 GWh**
Population (Million)	0.5	7.0	7.5
Electrification Ratio	25.6%	0.1%	1,8%
Number of Consumers	25600	1400	27000
Average Consumption	1760 kWh/year	500 kWh/year	1700 kWh/year
Commercial and public			**32.7 GWh**
Industry			**52.3 GWh**
TOTAL			**130.8 GWh**

3.5.5.3. REMARK ON COST OF UNSERVED ENERGY

The fact that REGIDESO cannot afford using thermal facilities for filling the gap due to insufficient hydro supply does not mean that un-served energy cost equals zero. Actually, when public supply stops because of load shedding, private generation takes over at least when they exist. These generations supply power at a much higher cost than REGIDESO selling price.

End of 2005 and early 2006, the selling price for one litre of diesel oil was the following:

	FBU	USD
CIF Bujumbura	706,90	0,98
Other costs or margins	259,30	
Taxes in Burundi	183,80	0,19
Total	1 150,00	1,17

On this basis and taking into account a specific consumption of 300g/kWh and a density of 0.8, proportional cost of kWh amounts to 44 cUSD including taxes or 37 cUSD excluding taxes.

Consideration of capital expenses would further increase above costs. In comparison and according to the tariff schedule currently in force, the highest energy charge is paid by MV customers during off peak hours at a rate of 95.23 FBU/kWh, or 9.6 cUSD/kWh in early 2006.

This shows that REGIDESO is not incited to reduce load shedding using thermal generation, and that a cost of at least 0.5 USD for un-served kWh seems adequate.

3.5.6. ELECTRICITY MARKET FORECAST

3.5.6.1. DEMAND FORECAST

It is proposed to design this forecast according to power needs assessment in Burundi, and not according to what would be actually feasible. In the current situation, supply has already reached the upper limit of generating capacities, and supply should stop increasing at very short term, at least during peak hours; only limited amounts of additional energy remain available during off peak time.

The proposed methodology is a macroeconomic approach on the one hand, and a sector analysis on the other hand.

3.5.6.1.1. *MACROECONOMIC APPROACH*

According to the Ministry of Planning and Development, Burundi's economy should get back to the path of fast development in the next years.

The strategy prepared by the Ministry is based on the following hypotheses and action plan:

- Cancellation of existing debt
- Implementation of an emergency aid programme
- Return to normal precipitations, allowing good conditions for agriculture
- Return and relocation of refugees
- Reconstruction of industrial plants destroyed during the war, with the help of foreign donors
- Revival of handicraft activities.

In this context, GDP would increase by 6.6% in 2006 (2005 estimate, probably to be lowered to 5%), 7.9% in 2007 and 8.1% in 2008, i.e. an average of 7.5% growth per year.

However, all actions described here above may not be fully successful, thus it would be advisable to consider less optimistic future trends.

3.5.6.1.2. *SECTOR APPROACH*

A demand forecast study conducted in 2001 by Lahmeyer International and EPS Consultants had considered the following trends for the expansion of the city of Bujumbura:

	Yearly growth
Households	8.5%
Industry	6%
Commercial and public services	6%

Taking into account the respective weights of each sector, these trends would lead to a global growth of 6.7% per year. However, since peace seems to be back now, and for good, higher trends should be considered.

3.5.6.1.3. *PROPOSED FORECAST*

Based on the combined econometric and analytical approach as described above, an average trend of 8% per year is obtained for a demand forecast medium scenario. This includes progressive connection of isolated centres to the grid. The main assumptions and results are indicated hereafter, and detailed analyses are shown in the corresponding Excel files in Annex B: Load Forecast per country.

Low growth and high growth scenarios are also presented hereafter and in the above-mentioned Annex; they correspond to one, two or three years delay or advance with respect to the assumptions of the medium scenario, in the years 2010, 2015 and 2020 respectively.

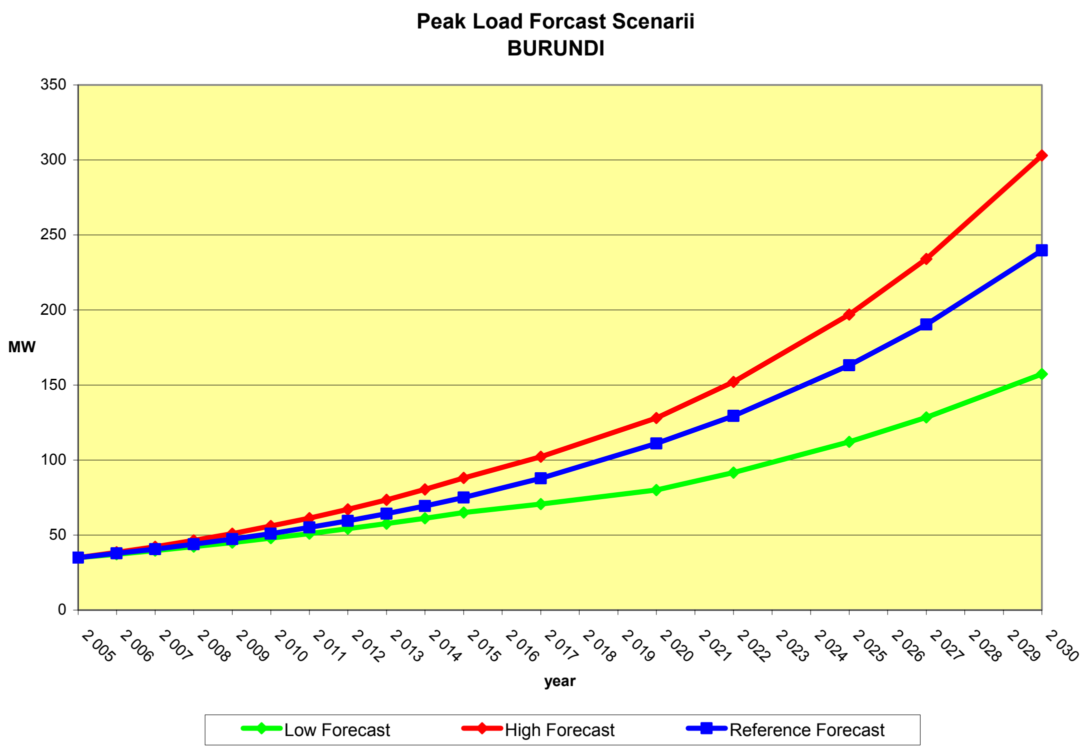
Table n° 8 - PROPOSED FORECAST FOR BURUNDI

Interconnected network	2005	2010	2015	2020	Average growth
LOW GROWTH SCENARIO					
Population (Millions)	7.5	8.8	10.1	11.3	2.8%
Electrification Ratio	1.8%	2.6%	4.7%	6.4%	8.8%
GDP Growth	4%	4%	4%	4%	4%
Number of Consumers (*1000)	27.0	46.5	94.2	144.7	
Average Consumption (kWh/y)	1695	1487	1279	1297	
Domestic Energy Demand (GWh)	**45.8**	**69.1**	**120.5**	**187.6**	**9.9%**
Commercial Energy Demand	**32.7**	**42.9**	**56.4**	**74.0**	**5.6%**
Industrial Energy Demand	**52.3**	**68.7**	**90.2**	**118.4**	**5.6%**
Energy Losses	27%	26%	20%	16%	
Total Energy Demand	**180**	**244**	**333**	**453**	**6.4%**
Potential Peak Load (MW)	**35**	**48**	**65**	**80**	

MEDIUM GROWTH SCENARIO					
Population (Millions)	7.5	8.8	10.1	11.3	2.8%
Electrification Ratio	1.8%	2.7%	5.3%	8.2%	10.7%
GDP Growth	5%	5%	5%	5%	5%
Number of Consumers (*1000)	27.0	47.8	106.7	185.8	
Average Consumption (kWh/y)	1695	1575	1333	1346	
Domestic Energy Demand (GWh)	**45.8**	**75.2**	**142.3**	**250.2**	**12%**
Commercial Energy Demand	**32.7**	**45.9**	**64.3**	**90.2**	**7%**
Industrial Energy Demand	**52.3**	**73.4**	**102.9**	**144.3**	**7%**
Energy Losses	27%	26%	20%	15%	
Total Energy Demand	**180**	**264**	**389**	**570**	**8%**
Potential Peak Load (MW)	**35**	**51**	**75**	**111**	

HIGH GROWTH SCENARIO					
Population (Millions)	7.5	8.8	10.1	11.3	2.8%
Electrification Ratio	1.8%	2.9%	5.9%	9.6%	11.8%
GDP Growth	6%	6%	6%	6%	6%
Number of Consumers (*1000)	27.0	51.9	118.8	216.7	
Average Consumption (kWh/y)	1695	1622	1427	1485	
Domestic Energy Demand (GWh)	**45.8**	**84.2**	**169.5**	**321.8**	**13.9%**
Commercial Energy Demand	**32.7**	**48.9**	**73.3**	**109.6**	**8.4%**
Industrial Energy Demand	**52.3**	**78.3**	**117.2**	**175.4**	**8.4%**
Energy Losses	27%	26%	20%	15%	
Total Energy Demand	**180**	**286**	**452**	**717**	**9.7%**
Potential Peak Load (MW)	**35**	**56**	**88**	**128**	

The curves below represent the forecast Peak Load (in MW) for the Low, Medium and High Scenarii (from 2005 until 2030)



3.5.6.1.4. SUPPLY FORECAST

The Ministry of Energy and Mines has set up the following programme for generation expansion during the period 2006-2008:

- Studies of three hydropower projects: Kabu 23, Mule 34, Buhiga extension.
- Investments for rehabilitation of Ruvyironza and Gikonge HPP for an amount of 2 MUSD.
- Investments for construction of two hydro projects: Kabu 16 (40 MUSD) and Rusumo Falls (340 MUSD).

At the moment, funding is only secured for Ruvyironza and Gikonge rehabilitations.

Therefore, and at least at short and medium terms, domestic supply will not expand beyond the current level mentioned here above, 185 GWh per year and 32 MW.

3.5.7. COMPARISON OF PROPOSED FORECAST WITH OTHER FORECAST

Two reports recently issued include a demand forecast for Burundi:

- The NELSAP study: "Strategic/Sectorial, social and environmental assessment of power development options in the Nile Equatorial lakes Region", dated November 2005.
- The EGL study "Power sector development in the Equatorial lakes countries" dated May 2005.

Table hereunder compares these two forecasts with the forecast proposed here above, in case of medium growth scenario:

Table n° 9 - COMPARISON OF FORECASTS FOR BURUNDI

FORECAST	2005	2010	2015	2020	Average growth
NELSAP Study (2005) **Energy Demand GWh** **Peak Load MW**	200 40	235 60	430 85	680 140	8.5%
EGL Study (2005) **Energy Demand GWh** **Peak Load MW**	198 41	253 52	355 73	498 101	6.4%
Present NELSAP Study (2006/07) **Energy Demand GWh** **Peak Load MW**	180 35	264 51	389 75	570 111	8%

Present forecast stands in between the two previous forecasts. It proves close to NELSAP study of 2005, although starting from a lower level in 2005.

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4. DRC POWER SECTOR

4.1. INSTITUTIONAL FRAME WORK

4.1.1. HISTORICAL BACKGROUND TO CREATION OF THE SNEL COMPANY

Initially in charge of conducting the Inga 1 project, SNEL or Société Nationale d'Electricité was created by Government Regulation n°73/033 dated 16th May 1970. Following commissioning of the Inga 1 HPP, SNEL became a power sector operator for generation, transmission and distribution activities, alongside the already existing public company REGIDESO and six other private power companies.

According to law n°74/012 dated 14th July 1974 SNEL took over the activities of the six private companies. In 1978, following Government regulations n°78/196 and 197, SNEL took over the REGIDESO activities and was established as single public service in charge of generation, transmission and distribution and marketing of electricity. The company is placed under control of both the Ministry of Energy for technical matters and the Ministry of Portefeuille for administrative and financial aspects. Within the Ministry of Energy the following institutions were created:

- In 1969, the General Secretariat for Energy.
- In 1982, the National Commission for Energy, in charge of energy policy;

Moreover, in 2003, the decree 03/027 has fixed the scope of various ministries, in particular Ministry of Energy.

4.1.2. INSTITUTIONAL ASPECTS OF POWER SECTOR IN DRC

From 1970 to 1991, SNEL operated as a monopoly, since it was the only company with an agreement from the State to carry out all electricity activities throughout the country. However, specific or local activities are carried out besides SNEL, such as:

- Generation and distribution of electricity power when SNEL is not present, for example, autoproducers as religious communities, mining companies, armed forces;
- Power generation and transmission of the SINELAC Company, which is a common undertaking of DRC, Burundi and Rwanda (see hereafter section 3.1.3).

Concerning liberalization of the power sector, the matter is not clearly addressed by existing texts which are from the colonial time. The main texts are the following:

- Decree dated 2nd June 1982 about general conditions of power sector;
- Decree dated 16th April 1931 about power transmission through private lands;
- Decree law dated 26th February 1953 about regulation of energy;
- The ruling 347/91 dated 27.12.1991 which opened the sector to private and broke the monopoly of SNEL.

In compliance with the law, the ministerial decrees n° 72 and 74 dated 16.11.1994 define clearly the condition for obtaining the authorization of erecting and operating hydropower plants.

4.1.3. THE SINELAC COMPANY

4.1.3.1. COOPERATION BETWEEN BURUNDI, RWANDA AND DRC IN THE ENERGY SECTOR

The three countries have signed several covenants in order to develop electrification in the region:

- In 1974 was created the association for the study of Electrification in the region of the Great Lakes (EGL). Headquarters of EGL are located in Bujumbura. Activities within the scope of EGL include questions about generation and transmission, load forecast studies, design of new power plants;
- In 1976 was created the Economic Community of the Great Lakes Countries, or CEPGL;
- In 1980, the scope of EGL was extended to all energies; and EGL became the Organization of CEPGL for Energy in the Great Lakes Countries;
- In 1983, the three countries have decided to consolidate their economic development within the CEPGL through implementation of Ruzizi 2 hydropower plant, to be constructed and operated by the SINELAC Company.

4.1.3.2. MAIN CHARACTERISTICS OF SINELAC COMPANY

Through a covenant jointly signed by Burundi, Rwanda and DRC in 1983, the three countries have established the Société Internationale d'Electricité des Pays des Grands Lacs (SINELAC) in charge of construction and operation of Ruzizi II HPP. Its headquarters are located in Bukavu (DRC).

Each one of the contracting States has financed one third of total capital expenditures for construction of the power plant. SINELAC is a commercial company, selling electricity to each regional power company, namely REGIDESO, ELECTROGAZ and SNEL. The related income should enable SINELAC to secure the debt service and to pay for operation and maintenance of the generating facility.

Each contracting State may buy one third of generated energy. Available energy which would be used by a given power company could be sold to another one. Electricity selling price is currently set at 55.29 DTS/kWh, about 8 cUS$/kWh.

For comparison purpose, exports from the SNEL Ruzizi I HPP are sold to Burundi and Rwanda at 0.57 cUS$/kWh.

4.2. TARIFF STRUCTURE AND LEVEL

Tariff policy presents some differences between major parts of DRC and East of DRC, where a special tariff structure is implemented in the recently liberated territories.

4.2.1. TARIFF POLICY IN DRC

According to economic ministerial decree dated 28th April 1998, electricity selling price is fixed according to the type of generation source, either thermal or hydroelectric:

- Concerning thermal generation, the tariff level is set after discussion between SNEL, the FEC and the politico-administrative authorities. This tariff takes into account the cost of fuel ;

- Concerning hydroelectric generation, which supplies most of the country, one single tariff schedule is enforced throughout the country (except for liberated territories). For households, electricity rates are fixed under their supply cost, meaning that other customers (at HV, MV and LV levels) are subsidising the 6% inhabitants who have already access to electricity.

4.2.2. TARIFF STRUCTURE AND LEVEL IN EASTERN DRC

4.2.2.1. TARIFF STRUCTURE

Table herewith displays the tariff schedule in force since 9th July 2001 for customers supplied by hydroelectric generation. The Consultant finds it difficult to understand the rationale behind such a detailed cost structure.

4.2.2.1.1. TARIFF LEVEL

According to the latest Activity report prepared in Bukavu, sales were the following in 2005:

	Sales in 10^3 USD	Sales in GWh	Selling price cUSD/KWh
MV level	2278	26.0	8.8
LV level	3566	61.2	5.8
Global	5844	87.2	6.7

Selling price hierarchy does not follow cost hierarchy, since the supply cost is lower at MV level than at LV level, while selling prices show the opposite situation.

Table n° 10 - SNEL – TARIFF SCHEDULE ENFORCED SINCE 9TH JULY 2001 IN EASTERN CONGO

(All prices are expressed in US dollars)

PART 1: MEDIUM VOLTAGE	Subscribed demand in kVA	Factor A $/kW	Factor B $/kWh
Industrial and Commercial Customers	1 to 100	6.4870	0.0968
	100 to 400	6.1697	0.0869
	400 to 1600	5.8732	0.0794
	1600 to 4000	5.3138	0.0732
	more than 4000	4.9359	0.0682
	Meter renting charge	30.69$/month	
Residential households	1 to 100	4.4475	0.0664
	100 to 400	4.2297	0.0596
	400 to 1600	4.0250	0.0544
	1600 to 4000	3.6425	0.0502
	more than 4000	3.3845	0.0468
	Meter renting charge	30.69$/month	

Steam Boilers	Hours of subscribed demand		$/kWh
	1 to 200		0.0210
	200 to 360		0.0208
	360 to 480		0.0206
	480 to 600		0.0204
	600 to 744		0.0201
	Meter renting charge	6.6$/month	
PART 2: LOW VOLTAGE			
Low income households	With meter	0.0260 $/kWh	
	Without meter Lifeline 300 kWh	7.8$/month in 5th rank urban districts	
Residential households Number 1	Blocks in kWh	S/kWh	
	1 to 100	0.0260	
	100 to 200	0.0264	
	200 to 300	0.0268	
	300 to 400	0.0272	
	400 to 500	0.0276	
	500 to 600	0.0280	
	More than 600	0.0852	
Residential households Number 2	Blocks in kWh	S/kWh	
	1 to 600	0.0852	
	600 to 800	0.0861	
	800 to 1000	0.0870	
	1000 to 1200	0.0879	
	1200 to 1400	0.0888	
	1400 to 1600	0.0897	
	More than 1600	0.1080	
Households without meter	1. Lifeline 300 kWh	7.92 $/month	4th rank urban districts
	2. Lifeline 400 kWh	10.64 $/month	3rd rank urban districts
	3. Lifeline 600 kWh	51.12 $/month	2nd rank urban districts
	4. Lifeline 900 kWh	77.04 $/month	1st rank urban districts

Semi industrial low voltage customers	Blocks in kWh	S/kWh
Commercial subscribers	1 to 500	0.1080
	500 to 1000	0.1090
	1000 to 1500	0.1100
	1500 to 2000	0.1110
	More than 2000	0.1460
Motive power	1 to 500	0.1460
	500 to 1000	0.1470
	1000 to 1500	0.1480
	1500 to 2000	0.1490
	More than 2000	0.1500

4.3. GENERATING FACILITIES

4.3.1. HYDRO POWER PLANTS

The DRC is a vast country of about 2 345 410Km2, this means more than 1900Km from the North to the South or from the East to the West. It includes the greatest part of the Congo River bassin hence the hydroelectric reserves of about 100 000 MW are immense. Particularly, 44000 MW are concentrated on the water falls of Inga, at 150Km from the mouth of river Congo. That power is practically guaranteed during the whole year due to the river Congo's regular discharge of about 42000 m3 /s and whose tributaries are found on both sides of the Equator. The first studies to emphasise the Inga site were achieved in 1937 and 1960. Owing to the electricity needs, the development was forecast in two phases:

- The fitting out of the Nkokolo valley, a useless valley whose extreme south was closed by the dam of Shongo which enables the use of a fraction of the low water under the waterfall of 60 m. It comprises three steps:
  - Inga 1 (351 MW) commissioned in 1972.
  - Inga 2 (1424 MW) commissioned in 1982.
  - Inga 3 (1700 to 3500 MW) underway presently
- The great Inga, which will require the construction of a dam on the Congo river in order to divert water in a nearly valley will produce 39000 MW. It will also require the construction of the interconnection power lines in order to supply almost the whole of Africa through 3axes:
  - Southern Africa (DRC- South Africa)
  - Western Africa (DRC- Nigeria)
  - Northern Africa (DRC- Egypt).

Presently the DRC holds not only one but several interconnected networks located around the main consumption centres. Owing to the country's size and the economic conditions the interconnection of the region of Kivu to the Inga network located at around 2000 km will not be achieved before the end of our study. We will therefore be strongly interested in the plants of the zone corresponding to the three provinces of the Northeast, the Maniema, the North Kivu and South-Kivu. Among the 8 plants of the SNEL starting with the interconnected networks in the DRC, one of them Rusizi I, is concerned with the interconnected network of the EGL covering Burundi, the DRC- Rwanda. The hydroelectric plant of the SINELAC, Rusizi 2, also supplies the Kivu network.

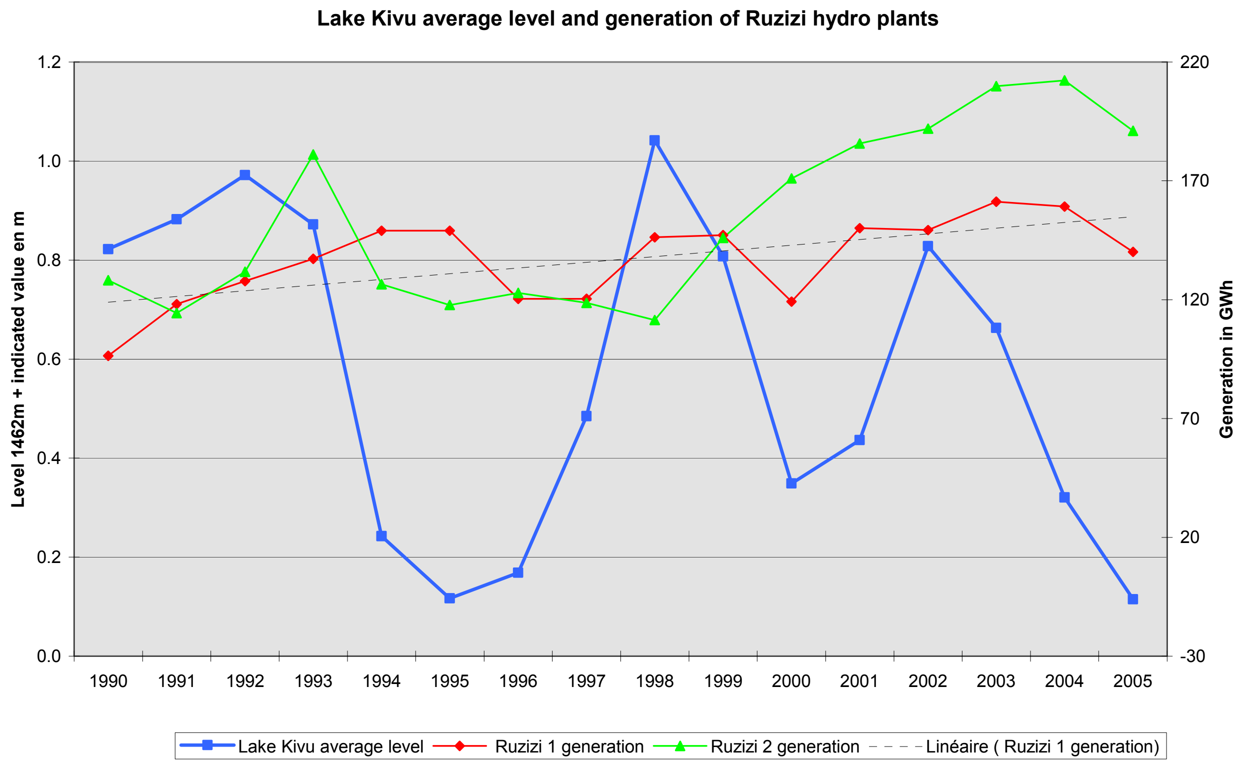
4.3.1.1.1. RUZIZI I

The power plant was commissioned with two units in 1958. It was completed by two other units in 1974. The Ruzizi I plant is situated at some kilometres from Lake Kivu release, at Mururu waterfalls. It comprises one dam with 4 radial gates. The plant is situated at the foot of the dam. It includes 4 Kaplan units (2x6.3 MW) in 1958, 2x7.8 in 1974) operating under a 24.7 m head and totalling 28.2MW. In March 2006, the generator n°4 was not yet functioning since 1994 because of a generator problem at the time of its putting back in service after rehabilitation (the ACEC Company left the country at the time of troubles and never come back). The present political situation in DRC does not suggest a rapid solution of this problem. The 3 other units have never been rehabilitated. The generators, in service since1957, have never been opened; discussions are currently being done to try to get financing. Electrogaz has already planned to pre-finance studies which would be paid back in kWh. The capacity would be brought up to 30 MW when the generators are completely renovated. The power plant must discharge downstream a minimum flow of 100 m3 /s towards Ruzizi II.

There is uncertainty in energy evaluation. When it was put in service, this one was estimated at 105 GWh per year on basis of flow registration during the period 1941-1959, hence giving a module of 62.3 m^3/s, but from 1960, the measured flows are higher. During the period 1981-1989, the module has been estimated at 100 m^3/s. This problem is specific of Ruzizi. In the same way, the question rises in Uganda about Owen falls power plant, situated on the Nile at the outlet of Lake Victoria. In 1960, all the lakes in this region rose suddenly up to several meters, and since then, the flows measured on the Ruzizi and the Nile are stronger than those ones which were measured during the previous period. Nevertheless, these last years, the lake level lowered to practically reach its minimum level at the end of 2000 and be below the minimum level in March 2006. Taking the lake area (4000 km2) into consideration, many years of reduced production will be necessary to reach the normal level again. The following characteristics of Ruzizi I were therefore considered:

Installed capacity	Guaranteed capacity	Guaranteed energy	Average energy
28.2 MW	11.9 MW	105 GWh/y	165 GWh/y

Actually, the lowering of the lake level can also be explained by too high exploitation of the water potential. In fact, as the graphic shows it hereafter, the production of Ruzizi plants is constantly increasing since 1990, particularly Ruzizi I on which the regulation of the lake level depends. From 1991 to 2005, the annual production of Ruzizi I has always been higher than 120 GWh with an average of 152 GWh during the period 2001-2005 comparatively to 105 GWh initially estimated



Finally, in the present study, it is assumed that Ruzizi I generation will not be higher than its guaranteed energy during the next 10 years in order to raise the Lake Kivu level. Owing to the supply of 20 GWh to Burundi and 20 GWh to Rwanda (as was the case these last years) the yearly energy available for SNEL is 65 GWh with a guaranteed capacity of 7.4 MW.

4.3.1.1.2. *RUZIZI II*

The Ruzizi 2 project was commissioned in May 1989 by SINELAC. It is located at some kilometres downstream of the Ruzizi 1 power plant.

Each of the 3 countries, Burundi, CDR and Rwanda, have the right to 1/3 of the plant annual energy. Taking the very low level of Lake Kivu into account, we use the value of 141 GWh/year as Ruzizi II average energy. That is 47 GWh for CDR with a guaranteed capacity of 5.4 MW.

4.3.2. THERMAL PLANTS

There are no thermal plants of any importance in the DRC connected to the interconnected network of the Kivu region. The latter suffers from serious power cuts because of low hydroelectric production. Many subscribers have electricity only some hours per week.

4.3.3. COMMITTED AND PLANNED POWER PLANTS

4.3.3.1. RUZIZI 3

This community development, whose project was launched by the EGL, would be located on the Ruzizi, at around 8Km downstream of Ruzizi 2. It is described in the chapter concerning the regional approach. The equipment out put is about 158 m3/s for three Francis generators giving the total power of 82 MW (3X27.3 MW). The guaranteed power is 47.8 MW corresponding to an output with 92 m^3/s and the annual average production being 456 GWh, which is 15.9 MW and 152 GWh respectively for the Congolese side. It is worth noting that EGL has identified an alternative site for the development of this project, named SISI 5, with a potential development of up to 205 MW of installed capacity and 1030 GWh of annual firm energy. A pre-feasibility study is foreseen by EGL as soon as possible (Minutes of 23rd meeting of EGL Board, Bukavu, 23-24/12/2005) (Refer to Annex A for details).

4.3.3.2. BENDERA HYDROELECTRIC PLANT

This existing plant that was constructed in 1959 is located on the river Kyimbi: 125 Km in the north of the town of Kalemi. It was equipped with 2 generators Pelton with a horizontal axis of Riva brand holding Unitary discharge of 1.5 m^3 /s under 674m, meaning an electric power of 8.6 MW.

Until now, the Plant has not yet been rehabilitated and its condition is critical. From 1993 the unit n°2 is stopped, its generator and electrical equipment seriously damaged. The unit n°1 functions alone, all this plunging the whole town of Kalemi, the Makala coal mine and the Kabimba cement works (60 Km from Kalemie) in obscurity. The plant has been designed for 5 units this leading from the present 17.2 MW to 43 MW. The SNEL plans to rehabilitate the hydropower plant and then complete its equipment to 5 Units so as to supply the interconnected network via a line of 110 kV Bendera-Kiliba of 172 Km in length. The estimated average yearly energy is 200 GWh. For memory, we shall cite here the hydropower plant of Piana-Mwanga located in the north of Katanga at 90km from the town of Manono along the river Luvua. It should also be rehabilitated and connected to interconnected network via a line of 110 kV nearly 180Km linking it to Kalemie.

4.3.3.3. OTHER PLANTS IN NORTH KIVU

The Semuliki plant (30 MW): Studies were performed in 1996-89 by the Canadian firm MagEnergie for the Ministry of Energy. This plant should allow the connection of DRC grid to Ugandan grid at Kasese. The studies could not be made available to the Consultant.

The Mugomba plant (40 MW): the Consultant understands that studies have been performed, but they were not available.

4.4. LAKE KIVU REGION INTERCONNECTED TRANSMISSION NETWORK

The interconnected transmission network of the SNEL in the lake Kivu region is described by the electrical network chart and the single –line diagram RN-1 UR 0000 (see Annex C)

The transmission network of the lake Kivu region was launched in 1958 with the construction of a 70 kV line comprising 112 km from the power plant Ruzizi I to Bujumbura. A second section of the 70 kV line consisting of 41,3 km and was built in order to supply the substations of Bralima, Kasha and Katana.

A last section of isolated line of 110 kV was constructed much later in order to supply the substation of Goma from the parking substation of Buhandahanda.

4.4.1. SUBSTATIONS

The SNEL transmission network within the lake Kivu's region consists of 6 substations as follows:

- Ruzizi I
- Kasha
- Bralima
- Buhandahanda
- Katana
- Goma

The substation of Bujumbura mentioned in chapter 2 also belongs to the SNEL.

4.4.1.1. GENERAL STATE OF THE 70 KV AND 110 KV EQUIPMENT

All the substation mentioned above are presently exploited at 70 kV. Only the substation of Goma is insulated at 110 kV. As it is planned to increase the lines' voltage from 70 kV to 110 kV, the general review of the appliances at 70 kV is not worthy. Unfortunately, the partial report that we have obtained from the SNEL's representative at Uvira does not deal with stations' infrastructures of SNEL. Nonetheless, following a visit to the substation of Goma we can confirm that there is mainly maintenance work to be achieved for the equipment at 110 kV of the substation.

4.4.1.2. 6,6 KV, 15 KV AND 30 KV EQUIPMENT

Despite the fact that the project does not cover the distribution networks at 15 kV and 30kv it is important to mention that none of the substation is equipped with a reactive compensation.

4.4.1.3. PROTECTION EQUIPMENT FOR THE HV NETWORK

The partial report that we have obtained from the SNEL'S representative at Uvira does not cover the protection of substations. However, following a visit to the substations in Bujumbura and Goma and also of the power plant Ruzizi I, it is clear that the majority of the existing protection is not functional and should be replaced.

4.4.1.4. THE TELETRANSMISSION SYSTEM

The partial report at hand does not cover the tele transmissions. However, following a visit to the substations of Bujumbura and Goma and also the plant Ruzizi I, it is clear that several teleprotection materials are old and should be replaced.

4.4.1.5. REMOTE CONTROL SYSTEM

The remote control system is probably out of service since several years. The absence of information in proper time impedes the network's operation.

4.4.1.6. HV SUBSTATIONS REVISION

To our knowledge, there is no program to rehabilitate the high voltage's substation.

4.4.2. TRANSMISSION LINES

The SNEL transmission network in the Lake Kivu region comprises the following lines:

a. The line of the power plant Ruzizi I to the SNEL substation in Bujumbura: this line is described in details in chapter 2 of this document.

b. The line of the plant Ruzizi I to the substation Buhandahanda : this line of 38,3 km in length is supported by the “for legs towers in wire-mesh of galvanized steel from type LM, as is illustrated in the chart RL BG 0020 (see annexes of Volume 6). This line, constructed in the end of fifties, transmits power coming from the hydroelectric plant of Ruzizi I towards the Bralima, Katana and Goma substations. The main features of this line are described in the following chart:

Phase arrangement	Single circuit, horizontal
Phase conductors	3 x 135/22 AL/AC
Shield wire	2 x 48 mm2 galvanized steel
Characteristic power	29 MW à 110 kV 12 MW à 70 kV
Maximal thermal power	87 MVA à 110 kV 56 MVA à 70 kV
Insulators	Cap and rod in toughened glass 7 per chain, distance 146 mm
Distance between arcing horns	900 mm

For operation at 110 kV the isolation level of the line is marginal in reference to the CEI standard. Considering the reduced distance between the horn’s arch and that it is located in a region of high altitudes and with a keraunic level at 210 storm per year, that line has a reliability level which is very low.

c. Branch line of the substation Buhandahanda to the substation Katana :

This line, consisting of 3 km in length is identical with the line between the plant Ruzizi I and the substation Buhandahanda described at b).

d. Branch line of the substation of Kasha to the substation Bralima :

This line, consisting of 3 km in length is supported by the towers in galvanized steel of type delta (see photo in Annexes of Volume 6) .The main features of this line are described below:

Phase arrangement	Single circuit, Triangle
Phase conductors	70 mm² copper (phase S and T) 2 x 50 mm² copper (phase R)
Shield wire	50 mm² in copper
Insulators	Cap and rod in toughened glass 7 per chain, distance 146 mm
Distance between arcing horns	900 mm

e. The line from Buhandahanda to the substation Goma :

This line, consisting of 104 km in length is supported by metal towers of universal type as is illustrated in the chart in annexes of Volume 6. This line constructed in 1983 transmits the required power to the substation of Goma. Although no pylon design is available they resemble the universal type of towers used in Rwanda and Burundi. This line has been constructed and insulated at 110 kV, although it is supplied with 70 kV. The main characteristics of this line are the following:

Phase arrangement	Single circuit, triangle
Phase conductors	3 x 135/22 AL/AC
Shield wire	2 x 48 mm2 galvanized steel
Characteristic power	32 MW
Maximal thermal power	123 MVA
Insulators	Cap and rod in toughened glass 10 per suspension chain, 11 per suspension chain, distance 146 mm
Distance between arcing horns	1330 mm

4.4.3. LINE PHYSICAL CONDITION

The following description has been taken from SNEL report dated January 2006:

Equipment	Present condition	Reasons	Actions et remarks
70 kV line Bukavu-Goma	Towers no9, 13, 21, 22 et 139 are the close to collapse	Soil erosion	We plan to construct the supporting walls around the towers base
Section Bukavu - Katana Tower type: Galvanized lattice tower cat head type. Number of towers : 144 Conductors: 3 phases : AL/AC horizontal. Section : 157 mm2 Shield wire: 2 steel conductors. Section : 48 mm² Section length: 42 km	The conductors are frayed at some points Several angle bars were stolen Several insulators are broken. The line has practically no corridor	Several machine gun shots during the war. Lack of regular control of the line. weather phenomena and others Many trees have grown under the conductors	We solicit the reparation of these conductors. Planning a control of the line and replacement of broken insulators broken and of the stolen angle bars Physical inspection of the line and the pruning of the section Bukabu –Goma
Section Buhandahanda - Goma Tower type: Galvanized lattice tower, universal type. Number of towers: 270 Conductors : 3 phases : AL/AC horizontal Section : 157 mm2 Shield wire: 1 steel conductor Section : 48 mm² Section length: 104 km	The diversion works of the line on the towers no 117,118 and 119 are ended. It remains to install the shield wire between the towers n° 118 and 119 at Mweha Several angle bars and bolts have been stolen Several insulators are broken This line has no corridor	Due to lack of cable, the shield wire between the tower n° 118 and 119 has not been installed Lack of regular inspection of the line, this causes insecurity. Weather phenomena. Many trees have grown under the conductors	We suggest to buy cable and to install it between the tower n° 118 and 119. We anticipate the rehabilitation of the line during the dry season's campaign. Plan the interruptions so that replacement of the broken insulators can take place Physical inspection and pruning of the section Buhandahanda Goma

Equipment	Present condition	Reasons	Actions et remarks
Diversion PS Kasha – Bralima Tower type: Galvanized lattice tower, universal type. Number of towers: 13 Conductors: 4 copper conductors (phase R is 2 x 50 mm², whereas S and T are 70 mm² each). Section length: 3 km	Some insulators are broken the line has no longer any corridor	Lack of regular inspection and weather phenomenon - several trees have grown under the conductors The conductors are frayed on several points.	Physical inspection and pruning of the line to detect the anomalies which may arise (occur) on the line. We solicit the repair of these conductors i.e. the conductors of 50 mm² and 70 mm²
Section Bukavu – Bujumbura Tower type: Galvanized lattice tower cat head type. Number of towers: 405 Conductors: 3 phases : AL/AC horizontal. Section : 157 mm² Shield wire: 2 steel conductors. Section : 48 mm² Section length: 112 km	There are 16 falling towers between Kamanyala and Bujumbura. The tower n° 92 is inclined. Several angle bars and bolts have been stolen. Several insulators are broken phase conductors frayed between the tower n° 2 and 3. The corridor does not exist the corridor on a great part of the line. The construction of a protection wall is required	Rebel sabotage Collapsing of the tower n° 92. Lack of regular physical inspection due to insecurity. Several machine gun shots during war. Several trees have grown under the line Water from the threatens the pylon n°93	Re-erecting the fallen tower. Dismantling and remounting of the tower n° 97. Replacement of the angle bars and bolts stolen on the tower. We suggest to plan the interruption for the replacement to take place We suggest the repair of the frayed conductor We suggest the construction of a 6 m protection wall in order to protect tower n° 93

4.5. DEMAND - SUPPLY BALANCE AND DEMAND FORECAST

In DRC, the power sector is entrusted to the state owned utility SNEL, Société Nationale d'Electricité, whose head office is located in Kinshasa.

The terms of reference of the present study specify that concerning future electrical links, DRC is involved in the interconnection with Burundi and Rwanda. Thus, the region under review would be defined as the North and South Kivu provinces, at least for the short and medium term as considered in this report. For the longer term, further development of the Inga site (potential of 40 000 MW) will completely change the electrical picture in the region. However, the next transmission lines to be implemented would just connect Kolwezi (in DRC) to Lumwana in Zambia, at 400 kV level (SAPMP project), then to Tanzania and Kenya. Therefore, in this first stage of development, the Eastern region of DRC would not be directly concerned by the Inga development.

4.5.1. PAST AND CURRENT SITUATION OF THE POWER SECTOR IN THE KIVU REGION

According to SNEL activity report of 2004, the Eastern region of DRC was outside the control of the SNEL administrative headquarters. This situation resulted in a poor maintenance of facilities and a continuous decrease in electricity sales. However, a National Master Plan aimed at power sector recovery is under implementation, hopefully reversing the past trend.

4.5.2. POWER SUPPLY

Apart from privately owned diesel plants, power generation is mostly made of hydropower stations: Ruzizi I and Ruzizi II, run-of-the river plants which turbine the waters coming from Lake Kivu, and supply the interconnected network of the Kivu Region plus Burundi and Rwanda.

The Ruzizi II HPP is operated by SINELAC established in Bukavu, equally owned by the three utilities SNEL, REGIDESO and ELECTROGAZ.

Main characteristics of the power plants are given hereunder:

HPP	Owner	Installed capacity	Yearly output
Ruzizi I	SNEL	2x6.3 = 12.6 MW (1958)	65 Gwh
		1x7.8 = 7.8 MW (1972)	
		Total = 20.4 MW	
		1 unit (7.8 MW) out of order since 1994	
Ruzizi II	SINELAC (CEPGL)	2x13.3 = MW (1989)	141 Gwh
		1x13.3 = MW (2001)	
		Total = 39.9 MW	

Each one of the three utilities is entitled to receive one third of the energy generated by Ruzizi II. Concerning SNEL, the theoretical supply is as follows:

Ruzizi I + 1/3 Ruzizi II: Energy: 152 GWh, Capacity: 28.2 + 13.3 = 41.5 MW

Practical operation of Ruzizi II does not stick to the theoretical share, since it depends upon actual needs of the three countries and energy swaps between RDC and Burundi for debt payment. Thus, electricity exchanges (exports and imports) take place between the four companies, involving obviously the Ruzizi II HPP but also Ruzizi I (refer to table herewith).

Table n° 11 - DRC – INTERCONNECTED GRID OF KIVU REGION: SUPPLY / DEMAND PAST TRENDS (GWH)

SUPPLY	1988	1999	2000	2001	2002	2003	2004	2005
1- Gross Generation in RDC								
Ruzizi I (SNEL) (A)	149.8	147.1	139.1	150.1	149.3	161.2	160.1	141.1
Ruzizi II (SINELAC)	111.4	146.0	171.0	185.7	191.9	209.4	212.2	189.1
Total	261.2	293.1	310.1	335.8	341.2	371.0	372.3	330.2
2- Energy purchases								
From SINELAC to SNEL (B)	50.6	58.3	69.7	80.9	58.1	60.9	73.0	68.9
From SNEL and SINELAC to REGIDESO and ELECTROGAZ (C)	34.4	35.2	40.9	48.7	35.4	36.0	53.4	38.9
Internal supply in RDC (A)+(B)-(C)	166.0	170.2	167.9	182.3	172.0	186.1	179.7	171.1
DEMAND								
Emissions at MV level	*	*	*	138.4	116.9	*	112.2	110.2

* These data were not available

Sources: - SINELAC – Activity Report year 2004

EGL – Power sector in Eastern DRC (March 2004)

SNEL – Activity Reports, years 2001 to 2005 – Regional Directorate of Kivu.

Correct understanding of available figures is not always simple, therefore attached table showing the situation in the years 1998-2005 should be carefully reviewed. For instance, in 2005, energy supply ranges between 110 and 170 GWh.

Whatever the series of data considered, supply as well as demand show a decreasing trend until 2005.

4.5.2.1. POWER DEMAND

4.5.2.1.1. ENERGY

Emissions seem far below supply, a discrepancy which would require further explanations. According to SNEL annual activity report for the Kivu region, results were as follows in 2005 for the regions of Goma, Bukavu and Uvira:

Year 2005	Gwh	Number of customers	Average selling price
Emitted energy	110.2		
Sales MV level	26.0	80	8.8 cUSD/kWh
Sales LV level	61.2	39778	5.8 cUSD/kWh
Total sales	87.2		
Losses	23.0 (20.8%)		

4.5.2.1.2. PEAK LOAD

According to SNEL estimates, the peak load reached 33 MW in 2005, resulting in a load factor of 38%.

4.5.2.2. COMPARISON BETWEEN SUPPLY AND DEMAND

The current situation shows that peak load is close to available capacity. Thus, there is no margin during peak hours, and limited amounts of energy remain available during off peak hours. However, this situation may change in the coming years according to SNEL expansion plans.

4.5.3. ELECTRICITY MARKET FORECAST

4.5.3.1. SNEL PROJECTIONS

The National Master Plan prepared by SNEL (dated 2003) indicates the general outlines of the future electricity development until 2015.

4.5.3.1.1. DEMAND FORECAST

In addition to the Kivu provinces, it is also important to consider consumption that would develop in the province of Maniema, in particular its capital city Kindu, in the southern area of the Kivu. Currently, about 2.9%of households have access to electricity in the Kivu, and only 0.1% in Maniema province. Its total population amounts to 9.6 Million, among which 2.2 Million live in urban centres where electricity supply is feasible.

The table hereafter displays the projected population and power demand forecast until 2015 according to SNEL Master Plan. SNEL projections are based on a growth of 2.5% per year in the interconnected network. Isolated loads and local power plants would be progressively connected to this network. This would be the case for most of them in the Kivu region until 2015, beyond this date for the province of Maniema, for instance during the period 2016-2020.

Table n° 12 - PROVINCES OF NORTH KIVU, SOUTH KIVU AND MANIEWA PROJECTED POPULATION AND POWER DEMAND FORECAST

According to SNEL Master Plan (2003)

		2005	2010	2015
1- Projected population in cities to be electrified (in 1000)				
Province of North Kivu	Goma	239	285	340
	Other urban centres	722	878	1068
	Total	961	1163	1408
Province of South Kivu	Bukavu and Uvira	433	502	584
	Other Urban centres	261	314	377
	Total	694	816	961
Province of Maniema		262	297	338
Grand total		1917	2276	2707

2- Power demand forecast				
Energy demand in GWh				
Provinces of N & S Kivu	Goma	67	78	90
	Bukavu	77	82	89
	Uvira	17	21	26
	Total	161	181	205
	Other urban centres	18	24	32
	Total Kivu	179	205	237
Province of Maniema		12	17	29
Grand total		191	222	266
Peak load in MW				
Cities of Goma, Bukavu and Uvira		33	37	41
Other urban centers in Kivu provinces (aggregated)		5	6	6
Province of Maniema (aggrated loads)		3	4	6
Grand total		41	47	55

4.5.3.1.2. *SUPPLY FORECAST*

Until 2015 near 500 MUSD investment would be necessary to carry out the electrification programme as designed by SNEL. In this programme, about 170 MUSD would be dedicated to the construction of generating facilities, in particular for the Mwenga and the Ruzizi 3 HPP and the rehabilitation of the existing Ruzizi I power plant. However, the Master Plan does not include any information dealing with the feasibility of the programme, in particular as concerns possible sources of financing to be mobilized for implementation.

4.5.3.2. PROPOSED FORECAST

4.5.3.2.1. DEMAND FORECAST

The forecast proposed in the present study could be based on SNEL projections, with the two following changes:

First, taking into account the very low current electrification ratio, the proposed 2.5% yearly increase corresponds to a low growth scenario. In particular, It is proposed to consider a medium scenario with 3.5% yearly increase (very close to the area's population growth), and a high growth scenario with 4.5% yearly increase. In addition, as mentioned before, progressive connection of isolated centres will further increase above trends.

Second, the starting point of the projection seems low in comparison with the demand already reached in the past years. Since a decreasing trend is observed for the last years, a significant amount of suppressed demand should be considered, which would show up as soon as distribution networks are rehabilitated. Therefore, potential demand should be taken into account instead of actual demand, in order to present more realistic figures. The following adjustment is proposed:

Power demand for year 2005	GWh	MW
SNEL figures	161	33
Proposed potential demand	210	50

Based on the preceding information, the following breakdown can be proposed for consumption in 2005 of the provinces of North & South Kivu and Maniema (based on an estimate of 20% for the total losses):

2005 Consumption Estimate	Urban	Rural	Total
Households (or domestic)	**50.4 GWh**	**0 GWh**	**50.4 GWh**
Population (Million)	1.9	7.7	9.6
Electrification Ratio	9.5%	0%	1.9%
Number of Consumers	36000	0	36000
Average Consumption	1400 kWh/year	500 kWh/year	1400 kWh/year
Commercial and public			**58.8 GWh**
Industry			**58.8 GWh**
TOTAL			**168 GWh**

Based on the combined econometric and analytical approach as described above, an average trend of 5% per year is obtained for a demand forecast medium scenario. This includes connection of some isolated centres to the grid, and a minimal development of rural electrification. The main assumptions and results are indicated hereafter, and detailed analyses are shown in the corresponding Excel files in Annex B: Load Forecast per country.

Low growth and high growth scenarios are also presented hereafter and in the above-mentioned Annex.

Table n° 13 - PROPOSED FORECAST FOR EASTERN DRC

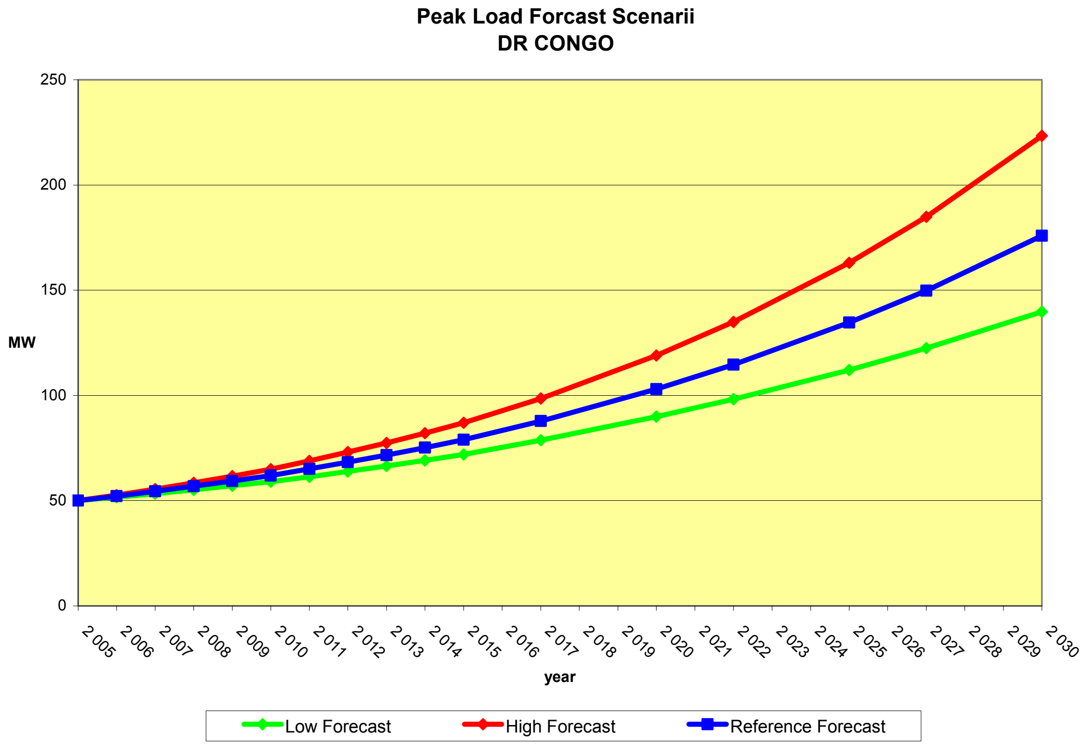
Interconnected network	2005	2010	2015	2020	Average growth
LOW GROWTH SCENARIO					
Population (Millions)	9.6	10.9	12.3	13.7	2.4%
Electrification Ratio	1.9%	2.3%	3.0%	3.9%	5.0%
GDP Growth	3%	3%	3%	3%	3%
Number of Consumers (*1000)	36.0	50.0	74.0	106.5	
Average Consumption (kWh/y)	1400	1268	1216	1215	
Domestic Energy Demand (GWh)	**50.4**	**63.4**	**90.0**	**129.5**	**6.5%**
Commercial Energy Demand	**58.8**	**70.2**	**83.7**	**99.9**	**3.6%**
Industrial Energy Demand	**58.8**	**70.2**	**83.7**	**99.9**	**3.6%**
Energy Losses	20%	18%	15%	13%	
Total Energy Demand	**210**	**248**	**303**	**376**	**4%**
Potential Peak Load (MW)	**50**	**59**	**72**	**90**	

Interconnected network	2005	2010	2015	2020	Average growth
MEDIUM GROWTH SCENARIO					
Population (Millions)	9.6	10.9	12.3	13.7	2.4%
Electrification Ratio	1.9%	2.6%	3.5%	5.0%	6.7%
GDP Growth	3,5%	3,5%	3,5%	3,5%	3,5%
Number of Consumers (*1000)	36.0	56.9	86.0	136.3	
Average Consumption (kWh/y)	1400	1239	1238	1184	
Domestic Energy Demand (GWh)	**50.4**	**70.5**	**106.4**	**161.3**	**8.1%**
Commercial Energy Demand	**58.8**	**72.2**	**88.7**	**109.0**	**4.2%**
Industrial Energy Demand	**58.8**	**72.2**	**88.7**	**109.0**	**4.2%**
Energy Losses	20%	18%	15%	13%	
Total Energy Demand	**210**	**262**	**334**	**436**	**5%**
Potential Peak Load (MW)	**50**	**62**	**79**	**103**	

Table – Continued

HIGH GROWTH SCENARIO					
Population (Millions)	9.6	10.9	12.3	13.7	2.4%
Electrification Ratio	1.9%	2.9%	4.1%	6.1%	8.2%
GDP Growth	4%	4%	4%	4%	4%
Number of Consumers (*1000)	36.0	63.2	100.6	168.2	
Average Consumption (kWh/y)	1400	1220	1234	1188	
Domestic Energy Demand (GWh)	**50.4**	**77.2**	**124.2**	**199.9**	**9.6%**
Commercial Energy Demand	**58.8**	**74.3**	**94.0**	**118.8**	**4.8%**
Industrial Energy Demand	**58.8**	**74.3**	**94.0**	**118.8**	**4.8%**
Energy Losses	20%	18%	15%	13%	
Total Energy Demand	**210**	**275**	**368**	**504**	**6%**
Potential Peak Load (MW)	**50**	**65**	**87**	**119**	

The curves below represent the forecast Peak Load (in MW) for the Low, Medium and High Scenarii (from 2005 until 2030)



4.5.3.2.2. *SUPPLY FORECAST*

According to the above section, available supply is the following:

- In energy: 207 GWh per year
- In capacity: 33.7 MW

If there is no actual investment provision for expanding the existing power system, any additional demand beyond these figures would remain un-served.

4.5.3.3. COMPARISON WITH OTHER FORECASTS

Two recently issued documents include a demand forecast for Eastern Congo:

- ·Under NELSAP, the "Strategic/Sectorial, social environmental assessment of power development options in the Nile Equatorial Lakes Region". This, report, dated November 2005, was prepared by SNC-Lavalin Consultants;
- The report "Power sector development in the Equatorial lakes countries", prepared by EGL, dated May 2005.

Table hereunder compares these two forecasts and SNEL projections with the present forecast, in case of medium growth scenarios:

FORECAST	2005	2010	2015	2020	Average growth
SNEL Master Plan (2003) **Energy Demand GWh** **Peak Load MW**	161 33	190 39	231 46	270 54	3.5
NELSAP Study (2005) **Energy Demand GWh** **Peak Load MW**	300 60	425 95	630 140	950 210	8.0%
EGL Study (2005) **Energy Demand GWh** **Peak Load MW**	227 47	290 59	391 79	549 111	6.1%
Present NELSAP Study (2006/07) **Energy Demand GWh** **Peak Load MW**	210 50	262 62	334 79	436 103	5.0%

The forecast of the present feasibility study is higher than the above-mentioned SNEL forecast but lower than the two other forecasts. As for this study, the 2005 NELSAP Study was based on the combination of the three usual factors: number of households, specific consumption, and electrification ratio, but leading to a yearly growth (8%) more than twice SNEL projections. As for the EGL study, the starting point is higher, and so is also the local growth (6.1% compared to 5%). In fact, the high growth scenario of the present study is very close to the EGL forecast (6% and 6.1% per year), but with a lower starting point.

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5. KENYA POWER SECTOR

5.1. INSTITUTIONAL FRAME WORK

5.1.1. LEGAL AND REGULATORY PROVISIONS FOR THE POWER SECTOR

Power sector activities (generation, transmission and distribution of electricity) have their main legal foundation in the Electricity Power Act, which was adopted Dec. 22nd, 1997 and was effective from January 1st, 1998; It established the Electricity Regulatory Board with powers to process and recommend applications for licences, set, review and adjust transmission and distribution tariffs, enforce environmental and safety regulations, investigate complaints, ensure there is competition and approve power purchase contracts, and transmission and distribution contracts.

The EPA establishes framework for the regulation of power sector in Kenya. Its provisions are broad and permit the enactment of subsidiary legislation to deal with specific aspects of regulation. The bulk of regulatory matters is being addressed through subsidiary legislation in order to maintain a fair degree of flexibility in dealing with ever-changing and fluid power sector needs.

The EPA should be amended by the 2004 Energy Bill which was proposed to the Parliament. When approved, it should become the 2004 Energy Act: an Act of Parliament to amend and consolidate the law relating to the generation, transmission, transformation, distribution, supply and use of electrical energy (the EPA); the importation, exportation, transportation, refining, storage and sale of petroleum; the regulation and development of other energy sources; the establishment of the Energy Regulatory Commission, the Rural Electrification Authority and the Energy Tribunal; the repeal of Electric Power Act, No 11 of 1997 and of the Petroleum Act (Cap 116); and for connected purposes.

5.1.2. CURRENT STATUS OF THE POWER SECTOR

Restructuring of Kenya's power sector, which started in 1997 with the EPA as mentioned above, separated the functions of generation from those of transmission and distribution. Under these reforms, the roles of key players in the power sector have been restructured as follows:

- KPLC, which owns all transmission and distribution assets, buys electricity in bulk from generating companies for transmission, distribution and retail to customers.
- The Kenya Electricity Generating Company (KenGen) which manages and develops all public power electricity generating facilities. It sells electricity in bulk to KPLC.
- Independent Power Producers (IPPs) which build own and operate power stations and sell the power in bulk to KPLC.
- Electricity Regulatory Board (ERB) reviews electricity tariffs and enforces safety and environmental regulations in the power sector as well as safeguarding the interests of electricity consumers.

- The Ministry of Energy formulates policy on the energy sector, in addition to administering the Rural Electrification Scheme.

This present structure is bound to further changes: in particular, it is expected that KPLC should lose its monopoly over Electricity Distribution;

5.2. TARIFF STRUCTURE AND LEVEL

5.2.1. TARIFF STRUCTURE

The structure of the tariff is designed to facilitate the recovery of the costs imposed on the system by consumers. These are the capacity-related costs, energy-related costs and consumer-related costs, respectively.

- Capacity-related costs are generation and usage-related costs. These costs are incurred as a result of a change in the level of peak demand on the system, and hence include costs of future additions of generation, transmission and distribution capacity as well as fixed operation and maintenance.
- Energy-related costs are design-demand related costs. They are incurred in the supply of an extra kWh of energy whenever it occurs, hence are dominated by expenditure on fuel and variable operation and maintenance.
- Consumer-related costs or customer-related costs are incurred on behalf of each consumer regardless of its electricity consumption and include metering, billing and revenue collection costs.

Capacity and consumer-related costs are recovered in a fixed monthly charge, while energy-related costs are recovered in a per unit energy charge.

The end-user-tariff (EUT) also includes adjustments which are the Fuel Cost Adjustment (FCA) and the Foreign Exchange Rate Fluctuations Adjustment (FERFA), respectively. The adjustments are instruments of parity between utilities and consumers, designed to ensure fair play in a dynamic regulated market in which pricing elements exhibit dynamic behaviour. The FCA is meant to cushion the utilities from increases in petroleum prices beyond the base rate used during tariff setting. The FCA also cushions the consumers when petroleum prices fall below the base rate ensuring that KPLC passes any gains to the consumers. The fuel costs are passed onto KPLC by KenGen and the IPPs in accordance with their respective power purchase agreements.

The tariff is also computed on the basis of a given base Foreign Exchange Rate. The base Foreign Exchange Rate at the time of setting the existing tariffs was KSh. 65.00 to the US Dollar. The exchange rate risks faced by the utilities are passed onto KPLC from KenGen and the IPPs in accordance with their respective power purchase agreements. The FERFA is therefore meant to cushion the utilities from increases in exchange rates beyond the base rate used during tariff setting. The FERFA also cushions the consumers when the exchange rates fall below the base rate, ensuring that KPLC passes any gains to the consumers.

The tariffs include also one tax (the Value Added Tax) and two statutory levies. The Value Added Tax is currently levied at 16% of the taxable value of electrical energy consumed with the exception of the first 200 kWh for domestic customers. The quantum of VAT has a significant impact on the level of the EUT, hence on the competitiveness of the outputs of industrial consumers.

Section 122(1) of the Electric Power Act, 1997 empowers the Minister to impose a levy on electricity sales in order to obtain funding for the Electricity Regulatory Board. This is the ERB levy, which is set at three (3) Kenya cents/kWh consumed.

The Rural Electrification Program (REP) Fund levy is established under Section 129 of the Electric Power Act, 1997 by the Minister for Energy. It sets the levy at rates of up to 5% of all the electricity consumed in the country. All electricity consumers in the country are expected to contribute to this fund. Its purpose is to support the electrification of rural and other areas considered economically unviable for electrification by Public Electricity Suppliers.

Since its inception ERB has undertaken one tariff setting exercise in August 1999 and a tariff review in May 2000. While the latter was a response to an unprecedented capacity crisis in 1999-2001, the 1999 tariff review was based on an expert study, which purpose was to review the existing and future level of electricity tariffs following a previous study undertaken 1993 and subsequent adjustments to the tariff levels. All studies used a similar approach which was based on the Long Run Marginal Costs of the system. The 9.4 cents US$/kWh value of the LRMC is the basis of the existing tariffs which came into force in August 1999 and were re-balanced in May 2000.

5.2.2. TARIFF LEVEL

The following basic tariffs are applied since May 29th, 2000. They do not include taxes, nor the application of the FCA and FERFA (see above).

Tariff	Type of Customer	Supply Voltage	Consumption Range (kWh/Month)	Fixed Charges (KSh/Mo. /cUSD/Mo.)	Energy Charges (KSh/Mo. /cUSD/Mo.)	Demand Charges (KSh/kVA/Mo. /cUSD/Mo.)
A0	Domestic	240 or 415 (V)	0-50	75/103.5	1.55/2.14	-
			51-300		6.65/9.18	
			301-3000		7.00/9.66	
			3001-7000		13.80/19.0	
A1	Small Commercial & Industrial	240 or 415 (V)	Up to 7000	150/207	6.70/9.24	-
B0	Medium Irrigation	240 or 415 (V)	7000 to 1 000 000	800/1104	6.40/8.83	-
B1	Medium Commercial & Industrial	240 or 415 (V)		2000/2760	5.16/7.12	300/414
B2		11 kV or 33 kV		2000/2760	4.60/6.35	200/276
B3		66 kV or 132 kV		7500/10350	4.40/6.07	100/138
C1	Large Commercial & Industrial	415 V	100000 to 5000000	600/828	5.10/7.04	300/414
C2		11 kV or 33 kV		2000/2760	4.40/6.07	200/276
C3		66 kV or 132 kV		7500/10350	4.17/5.75	100/138
C4		66 kV or 132 kV	5000000 to 7500000	7500/10350	4.07/5.62	80/110
C5		66 kV or 132 kV	More than 7500000	7500/10350	4.00/5.52	80/110
D0	Interruptible Off-Peak Supplies	240	Up to 7000	150/207	4.95/6.83	-
E	Street Lighting	240	No Limit	250/345	6.20/8.56	-

1 KES = 0.0138 USD

The application of the FCA and the FERFA, plus the taxes, in the first half of 2006, gives real tariff levels between 25% and 30% higher than the above. The fluctuations in exchange rates and above all, international fuel prices explain the variations in the effective selling prices as shown below.

The average selling prices of electricity in the past 4 fiscal years of KPLC have been the following:

Fiscal Year	Sales in 10^9 Sh.	Sales in GWh	Average KSh/kWh
2004/2005	**27786**	**4139**	**6.713**
HV	10891	1478	7.369
MV	6509	885	7.335
LV	10386	1776	5.848
2003/2004	**23000**	**3878**	**5.931**
HV	8816	1683	5.238
MV	5329	819	6.507
LV	8855	1376	6.435
2002/2003	**22804**	**3588**	**6.356**
HV	8743	1557	5.615
MV	5220	748	6.979
LV	8841	1283	6.891
2001/2002	**24615**	**3424**	**7.189**
HV	9682	1513	6.399
MV	4910	696	7.055
LV	10023	1215	8.249

In 2005, the average selling price could be estimated at 9.2 cUSD/kWh.

5.3. GENERATING FACILITIES

The interconnected system has an installed capacity of 1,083 MW comprising 677 MW hydro, 128 MW geothermal, 0.35 MW wind, and 277 MW thermal power stations. KenGen has an installed interconnected capacity of 944 MW while the IPPs have 143 MW.

Kenya is highly dependent on hydroelectricity. Hydroelectricity plants provide about 75% of all electrical output. Five major hydroelectric stations in the Tana River basin supply power to Kenya. They are: Kindaruma (44 MW), Gitaru (225 MW), Kamburu (94.2 MW), Masinga (40 MW) and Kiambere (144 MW). The Turkwel Gorge Hydroelectric station in the Turkana district has a capacity of 106 MW.

Table n° 14 - EXISTING KENYAN POWER PLANTS

Hydroelectric plants

Station	Location	No.of Units	Rating per Unit(MW)	Installed Capacity (MW)	Firm Generation (GWh)	Year Installed
Ndula	Thika River	2	1	2	22	1925
Mesco	Maragua River	1	0,38	0,38		1933
Selby Faite	Sosiani River	2	0,2	0,4		1952
Sagana Falls	Tana River	3	0,5	1,5		1955
Gogo Falls	Kuja River	2	1	2		1958
Tana 1 &2	Maragua River	2	2	4	50	1932
Tana 3	Maragua River	1	2,4	2,4		1952
Tana 5	Tana River	1	4	4		1954
Tana 6	Tana River	1	4	4		1955
Wanjii 1 &2	Maragua River	2	2,7	5,4	30	1952
Wanjii 3&4	Maragua River	2	1	2		1952
Kindaruma	Tana River	2	20	40	160	1968
Kamburu1&2	Tana River	2	31,4	62,8	336	1974
Kamburu 3	Tana River	1	31,4	31,4		1976
Gîta ru	Tana River	2	72,5	145	860	1978
Gitaru Unit 3	Tana River	1	80	80		1999
Masinga	Tana River	2	20	40	160	1981
Kiambere	Tana River	2	72	144	576	1988
Turkwel	Turkwel River	2	53	106	424	1991
Sub-Total Hydro		33		677,3	2 618	

Geothermal plants

Station	Location	No.of Units	Rating per Unit(MW)	Installed Capacity (MW)	Firm Generation (GWh)	Year Installed
Olkaria 1:1	Olkaria	1	15	15	315	1981
Olkaria I:2	Olkaria	1	15	15		1982
Olkaria I:3	Olkaria	1	15	15		1985
Olkaria II:1	Olkaria	1	32	35	491	2003
Olkaria II:2	Olkaria	1	32	35		2003
Sub-Total KenGen Geo		5		115,0	806	

Wind Power

Station	Location	No.of Units	Rating per Unit(MW)	Installed Capacity (MW)	Firm Generation (GWh)	Year Installed
Ngong	Nairobi	2		0.35	2	1993

Thermal plants

Station	Location	No.of Units	Rating per Unit(MW)	Installed Capacity (MW)	Firm Generation (GWh)	Year Installed	Fuel	Spec. Cons. (kg/kWh)
Kipevu GT 1	Mombasa	1	30	30	420	1987	Kerosene	0,3
Kipevu GT 2	Mombasa	1	30	30		1999	Kerosene	0,3
Nairobi Fiat GT	Nairobi	1	13,5	13,5	70	1973	AGO	0,41
Kipevu I	Mombasa	6	12,25	73,5	491	1999	HFO	0,21
Isolated Thermal								
Lamu		5		1,8		1989	IDO	0,29
Garissa		5		2,4		2003	IDO	0,26
Lodwar				0.7			IDO	0.29
Mandera				0,6			IDO	0.29
Marsabit				1.8			HFO	0.29
Waiir				1.4			HFO	0.29
Movale				0.7			HFO	0.29

IPP's

Station	Location	No.of Units	Rating per Unit(MW)	Installed Capacity (MW)	Firm Generation (GWh)	Year Installed	Fuel	Spec. Cons. (kg/kWh)
Iberafrica	Nairobi	1 1	44.5 12	44.5 12	396	1997 2000	LSFO LSFO	0.225 0.225
OrPower geothermal)	OlKaria	1	8 4	8 4		06.00 12.00		
Tsavo (Kipevu II)	Mombasa	1	74	74	519	2001	HFO	0.219
Mumias (Bagasse)	West Kenya	1	2	2			Bagasse	

IDO -Industrial Diesel Oil

HFO-Heavy Fuel Oil

AGO - Automotive Gas Oil

LSFO - Low Sulphur Fuel Oil

5.3.1. HYDROPOWER PLANTS

5.3.1.1. SEVEN FORKS HYDRO STATION

These stations are situated along the lower part of the Tana River. They comprise:

- Masinga Power Station.
- Kamburu Power Station.
- Gitaru Power Station.
- Kindaruma Power Station.
- Kiambere Power Station.

The five stations have an installed capacity of 543.2 MW.

Water has been cascaded from one station to the next, taking advantage of the head created by each dam to produce power. To provide adequate flow during the dry periods, water is stored at Masinga Reservoir and released during the dry season.

Two other sites along the river, Mutonga and Grand Falls are yet to be developed.

1. Masinga power station

Installed capacity - 40 MW (2 units of 20 MW)

Year of commissioning - 1981.

Two vertical Kaplan turbines drive two generators capable of generating 40 MW of power. Power generated is transmitted to Kamburu power station for transmission to Nairobi. In addition to the 40 MW produced by this station, Masinga serves as a crucial reservoir which has a capacity of 1.56 billion cubic meters of water. This reservoir is used for water regulation throughout the year. The dam occupies a surface area of 120 Km².

2. Kamburu power station

Installed capacity - 94.2 MW (3 units of 31.4 MW)

Year of commissioning – 1974 (2 units) and 1976 (1 unit).

Kamburu is the first underground power station in the complex. Electric power from Kamburu is conveyed to Nairobi via two 220 kV transmission lines from a primary 132 kV substation. Water is conveyed to Gitaru Power Station via a 2.9 km tailrace tunnel.

3. Gitaru power station

Installed capacity - 225 MW (2 units of 72.5 MW and 1 unit of 80 MW)

Commissioning date - 1978 (2 units of 72.5 MW) and 1999 (1 unit of 80 MW)

Gitaru is the biggest power station in Kenya in terms of installed capacity.

The power produced is transmitted to Kamburu 132 kV substation via one double circuit 132 kV and one 220 kV line. The discharge from Gitaru Station is conveyed through a 5 km tailrace tunnel which empties into Kindaruma reservoir.

4. Kindaruma power station

Installed capacity – 40 MW (2 units of 20 MW.

Commissioning date - 1968.

Kindaruma is the first station to be constructed in the Seven Forks Complex.

Despite its age the station is in good condition to prudent maintenance programme. Power from Kindaruma is transmitted directly to Nairobi via a 132 kV line or to Kamburu 132 kV substation. The water is then passed down to Kiambere - the latest development in the complex.

5. Kiambere power station

Installed capacity – 144 MW (2 units of 72 MW).

Year of commissioning - 1988.

Reservoir capacity - 585 Million M3.

As it is currently the last dam on the Tana, the machines run mostly as base load hence the large power output. The underground powerhouse is situated 4 km away from the saddle dam where the intake structure is located. The water conveyance is by a 6m diameter headrace tunnel. Electricité is transmitted to the grid via Kamburu.

5.3.1.2. TURKWEL POWER STATION

Installed capacity – 106 MW (2 units of 53 MW).

Year of commissioning - 1991.

Reservoir capacity – 1 600 million m^3.

This station is situated in West Pokot near the Kenya-Uganda border. Its storage lake is 6500ha.

Turkwel power station has consistently generated up to 106MW, which is approximately 20% of the national electricity supply. The station has a thin, double cambered arch dam with a maximum height of 150m. The headrace and penstock are 5.5 Km long with a diameter of 4.7m. The tailrace tunnel is 1.5Km long. The underground power station houses two 53.7 MW vertical Francis turbines and two 11 kV, 58 MVA generators and is connected to Lessos via one 220 kV transmission line.

5.3.1.3. MINI-HYDRO POWER STATIONS

KenGen runs seven mini hydro stations located in various parts of the country. All these stations were built before independence (between 1920s and 1950s) and are still in service. These are as follows:

Table n° 15 - EXISTING KENYAN MINI-HYDRO STATIONS

STATION	LOCATION	INSTALLED CAPACITY	YEAR OF COMMISSIONING
Tana	Upper Tana	14.4 MW	Machines 1&2 – 1932, Machine 3 – 1952, Machine 5 – 1954, Machine 6 – 1955
Mesco	Maragua	0.38 MW	1933
Ndula	Thika	2 MW	Machines 1&2 - 1925
Sagana	Upper Tana	1.5 MW	Machines 1, 2&3 - 1955
Gogo	Migori	2 MW	Machines 1&2 - 1958
Selby Falls	Sosiani	0.4 MW	Machines 1&2 – 1952
Wanjii	Maragua	7.4 MW	Machines 1, 2, 3&4 - 1955

5.3.2. GEOTHERMAL PLANTS

KenGen owns two geothermal power plants at Olkaria, Naivasha, namely Olkaria I and Olkaria II. The power stations are situated within Hell's Gate national Park, on the rift floor and adjacent to Lake Naivasha, about 120 km from Nairobi.

Currently, the Olkaria Geothermal Power stations have a combined generation capacity of 115 MW.

5.3.2.1. OLKARIA 1 POWER STATION

Installed capacity – 45 MW (3 units of 15 MW).

Year of commissioning – 1981, 1982 and 1985.

Olkaria I Power Station was the first geothermal power station in Africa. The 45 MW plant was commissioned in three phases and has three units each generating 15 MW of electricity. The first, second and third units were commissioned in June 1981, November 1982, and March 1985 respectively.

Thirty three (33) wells have been drilled and thirty one (31) of them connected to the steam gathering system in this field but only twenty six (26) of them are currently in production. The rest have become non-commercial producers due to decline in output over time and some of these are earmarked to serve as re-injection wells. Nine (9) of the wells were drilled as make-up wells.

The turbines are direct condensing 4-stage single flow running with an inlet steam pressure of 5 bars at a temperature of 152°C and steam consumption of 9.2 t/h/MW. The plant has had an average availability factor of 98% since commissioning. The power generated is connected to the national grid via a 132 kV transmission line.

5.3.2.2. OLKARIA 2 POWER STATION

Installed capacity – 70 MW (2 units of 35 MW).

Year of commissioning - 2003.

Olkaria II Power Station is Africa's largest geothermal power station.

40 wells were drilled between 1985 and 1993 but construction of the power plant was delayed until the year 2000 when funds became available. 20 of the wells are currently producing and connected to the power plant while the rest are used for either re-injection or reservoir monitoring while a few others are non commercial. The plant works on single flash plant cycle with a steam consumption of 7.5 t/h/MW. The turbines are single flow six stages condensing with direct contact spray jet condenser.

The power generated is transmitted to the national grid via 220 kV double circuit line to Nairobi. The power station is also connected to Olkaria I Power station by a 132 kV line.

5.3.3. THERMAL PLANTS

5.3.3.1. KIPEVU THERMAL STATION

Installed capacity – 63 MW (1 units of 30 MW and 1 unit of 33 MW).

Year of commissioning – 1972 and 1976.

Kipevu thermal power station was commissioned in 1955 with two steam units. In 1961, a third unit was installed. The station expanded gradually with four more units coming up between 1964 and 1976.

Currently, all units have been decommissioned due to aging.

5.3.3.1.1. KIPEVU 1 DIESEL PLANT

Installed capacity: 72.5 MW (6 units of 12.5 MW).

Year of commissioning – 1999

The station has 6 diesel engines and embedded generators each rated at 12.5 Megawatts nominal and four fuel oil tanks, two of them heavy fuel with a storage capacity of 9,000 million cubic meters each. The plant is designed to run on heavy fuel although to start the engines, distillate fuel is used.

5.3.3.1.2. GAS TURBINES

Two gas turbines have been installed at Kipevu:

- Gas turbine 1: Commissioned in 1987, Installed capacity 31 MW, capacity of generator 39200 kVA at 11000 volts.
- Gas turbine 2: Commissioned in 1999, Installed capacity 32 MW, capacity of generator 40662 kVA at 11000 volts.

5.3.3.2. NAIROBI SOUTH FIAT GAS TURBINE

Installed capacity – 13.5 MW (1 units of 13.5 MW).

Year of commissioning –1973

5.3.3.3. GARISSA POWER STATION

This is an isolated diesel power station feeding electricity to Garissa town in North Eastern Kenya. The station has three machines with an installed capacity of 2.4 MW

5.3.3.4. LAMU POWER STATION

Lamu is another isolated diesel plant with four diesel generators with an installed capacity of 1.5 MW. It feeds Lamu Island.

5.3.4. COMMITTED AND PLANNED POWER PLANTS

Committed Generation Projects are listed in the here-under table:

Table n° 16 - KENYAN COMMITTED GENERATION PROJECTS

Project	Type	Capacity (MW)	Firm generation (GWh)	Estimated commissioning year
Rabai GT	Thermal	70		Mar-07
EcoGen-KenGen JV	Wind	30		July-07
Eburru	Geo-Thermal	2.5		July-07
Re-Development of Tana	Hydro	20		Aug- 07
MSD	Thermal	80		Sept 07
Kipevu Combined Cycle	Combined Cycle	30	420	Sept-07
Sondu-Miriu	Hydro	60	240	Oct-07
Olkaria 3rd Unit	Geothermal	35	84	Apr-08
OrPower4 Additional	Geothermal	35		Apr-08
Kiambere Rehabilitation	Hydro	20		Aug-08
Kindaruma 3rd Unit	Hydro	20		Sept-08
Sondu Additional Power Plant	Hydro	20		Oct 09

Kenya future hydro power plants are listed here below

Future Plants	Installed capacity MW	Firm capacity MW	Average Energy GWh	Firm Energy GWh	Investment Cost MUSD	Year of cost estimate
Ewaso Ngiro	220		609	448	386	2005
Mutonga	60		328	293	197	2005
Low Grand Falls	140		715	324	378	2005

Because there are no indigenous fuel sources in Kenya, the thermal options would depend on imported oil or coal or LNG. Any such plants would probably be near Mombasa where new harbour and docking facilities would be required. These options would include mainly:

- Oil fired gas turbine, 2 x 60 or 90 MW, 3 x 60 or 90 MW if combined cycle.
- Oil fired or coal fired conventional steam, 2 x 100 of 150 MW.

5.4. TRANSMISSION NETWORKS

5.4.1. EXISTING

The transmission and distribution system is owned and operated by KPLC. As of June 2005, the transmission system consisted of 1,323km of 220kV, 2,035km of 132kV transmission lines and 600km of 66kV sub-transmission lines. The corresponding substation transformer capacities were 2,602MVA for 220/132/66/33kV and 1,384MVA for 66/33/11kV distribution.

Funding for transmission projects whose feasibility studies are complete has continued to be sought. The Governments of Kenya and Tanzania are currently seeking funding for the implementation of a 330kV transmission line project between Arusha in Tanzania, and Nairobi, Kenya. Other transmission projects that need immediate implementation are Kamburu-Meru 132kV 115km single circuit, Chemosit-Kisii 132 kV 61km single circuit line in Kisii area, and rehabilitation of Lanet and Naivasha 132kV substations.

5.4.2. TRANSMISSION LINES AND SUBSTATIONS PROJECTS EXPECTED

- Kamburu-Meru 132kV115km single circuit,
- Chemosit-Kisii 132 kV 61km single circuit line
- Rehabilitation of Lanet and Naivasha 132kV substations
- Sondu-Kisumu 132kV 50km line single circuit
- Arusha-Nairobi 330kV 260km line single circuit

5.5. DEMAND - SUPPLY BALANCE AND DEMAND FORECAST

In 2006, the Kenyan power sector has faced a critical supply situation: while the peak load reached 916 MW at the end of 2005 (the unconstrained peak demand was 930 MW), the available capacity of the Kenyan power plants was only 980 MW. In normal hydrological conditions, the effective available capacity reaches 1039 MW, which leaves a reserve margin of only 10% of the effective capacity. Normally, interconnected systems worldwide which are comparable to Kenya's one, need a reserve margin of at least 15% of the effective capacity in dry hydrological conditions (5% or 10% probability can be chosen). Facing a rapid demand growth (6.5% in the past two years), and a prolonged draught at the first half of 2006, the Kenyan Government sought to procure emergency thermal (Diesel) power plants at Embakasi (80 MW) and Eldoret (45 MW) to complement the on-going and planned new generation additions to the system.

5.5.1. POWER SUPPLY

To summarise the above-mentioned existing generating capacities at the beginning of 2006, the following table is proposed, based on Ministry of Energy's paper on Electricity Sub-sector Stakeholders Forum, January 2006:

Table n° 17 - KENYA'S GENERATION CAPACITY, JANUARY 2006

Companies	Type of Plant	Capacity (mW)		Energy (GWh, 2005)	
		Installed	Effective	Average	Firm
KenGen	Hydro	677	660	2871*	2618*
	Geothermal	115	115	806	806
	Thermal	147	133	980	980
	Wind	0.35	0.3	2	2
	Total	940	894	4659	4406
IPP Plants	Geothermal	13	13	91	91
	Thermal	130	130	915	915
	Bagasse	2	2	10	10
	Total	145	145	1016	1016
TOTAL		**1085**	**1039**	**5675**	**5422**

* Average and firm hydro generation are Consultant's estimates

5.5.2. GLOBAL SUPPLY STATISTICS

The following table summarises the overall energy supply in Kenya in the last 7 fiscal years (counted from July to June, in GWh) :

Table n° 18 - KENYA'S ENERGY SUPPLY (7 LAST YEARS)

Companies	1999/00	2000/01	2001/02	2002/03	2003/04	2004/05	2005/06	Average Growth (%)
KenGen	3831	2559	3230	3656	4293	4280	4538	2.9 %
Other	475	1324	1162	872	571	968	1114	
Imports	155	198	172	222	171	99	15	
Total Supply	4461	4081	4564	4750	5035	5347	5697	4.2 %
System Peak (MW)	708	724	760	786	830	899	920	4.5 %
Losses	957	869	936	949	946	968	1067	1.8 %
Sales	3504	3212	3628	3801	4090	4364	4606	4.7 %
Exports	0	0	0	0	0	15	24	
Losses (%)	21.5 %	21.3 %	20.5 %	20.0 %	18.8 %	18.1 %	18.7%	- 2.3 %

Source: KPLC, Annual Report, 2005-2006

The overall power supply is mostly dependant on KenGen capacity, which itself depends on the hydrological conditions ; an extremely low hydro output was already experienced in 2000/01, when 15% of the energy supply of the country came from emergency thermal power producers.

5.5.3. POWER DEMAND

In the past recent years, the power demand has been constrained due to the irregular hydrological conditions, but the un-served energy (in the electrified areas) has remained relatively low (less than 2% in 2005), with the exception of the 2000/01 period. The following table summarises the electricity sales to the different customers in the past 7 fiscal years:

Table n° 19 - KENYA'S ELECTRICITY SALES

Customer type	1999/00	2000/01	2001/02	2002/03	2003/04	2004/05	2005/06	Average Growth
Domestic / Small Commercial	1158	1064	1215	1283	1376	1478	1546	4.9 %
Commercial and Industrial	2123	1970	2209	2305	2502	2661	2810	4.8 %
Other	85	57	74	66	62	61	64	
KPLC Sales	3366	3091	3498	3654	3940	4200	4420	4.6 %
Export to Uganda	0	0	0	0	0	15	24	
REP Sales	138	121	130	147	150	164	186	5.1 %
TOTAL	**3504**	**3212**	**3628**	**3801**	**4090**	**4379**	**4630**	**4.8 %**

Table n° 20 - KENYA'S ELECTRICITY SALES

When compared to global supply, it is clear that the power demand (even constrained) has been growing at a faster pace than the available supply. This trend has been continuing all over 2005/2006, with an accelerated growth of the demand and the need to look for emergency power plants. Although the tariffs have been increasing sharply in the past two years due to the increasing international fuel costs, the demand has been driven by the strong economic growth as well as the increase of urban population (see below). The following breakdown could be estimated for the 2005 situation:

2005 Consumption Estimate	Urban	Rural	Total
Households (or domestic)	**982 GWh**	**35 GWh**	**1017 GWh**
Population (Million)	14.7	20.2	34.9
Electrification Ratio	22.9%	2.1%	10,8%
Number of Consumers	560400	69400	629800
Average Consumption	1752 kWh/year	500 kWh/year	1615 kWh/year
Commercial and public			**1677 GWh**
Industry			**1766 GWh**
TOTAL			**4460 GWh**

5.5.4. DEMAND FORECAST

Energy and power demand forecasts are regularly performed by KPLC ; the last load forecast update took place at the beginning of 2006, and the Consultant could get a preliminary version of this update from the Planning Department of KPLC. Although this document was not yet official, the Consultant considers this forecast as a good basis for the present study, Indeed, KPLC has a long experience in predicting the growth of Kenyan electricity demand. So the following analyses have been mostly taken from KPLC study : Update of Load Forecast, 2006.

5.5.4.1. BACKGROUND AND BASIC ASSUMPTIONS

The preparation of the load forecast was originally planned by using time series analysis and regression models, to be compared with another forecast based on the widely-used MAED model. Based on the respective results, KPLC and the Ministry of Energy would have to decide which forecast to use in order to prepare the Least Cost Power Development Plan. However, the MAED-based forecast was constrained by the unavailability of sufficient data; therefore several assumptions had to be used to prepare a MAED-based forecast, which has been used only for indicative purposes. KPLC and the Ministry agreed on the fact that the necessary database should be constructed before deciding on the official use of the MAED model.

5.5.4.1.1. OVERVIEW OF THE DOMESTIC ECONOMY

Indicators of activity in key sectors of the economy in 2005 continued to point that the economy recorded a positive GDP growth rate of 5 percent. In spite of the severe draught continuing in the beginning of the year, the economic performance has been strong in 2006, with a GDP growing at an estimated 5.5% (CIA World Factbook, 2007).

The improvement in output growth however remained below the real potential of this economy, due to the interplay of various factors including the delay of donor support, and the unavailability of resources to rehabilitate the country's dilapidated infrastructure. Economic recovery has been undermined partly by drought experienced in the year, the unprecedented increases in world oil prices and the slower than anticipated disbursement of balance of payments support by the IMF and programme aid from other bilateral donors.

Supported by the recovery in agriculture, Kenyan GDP growth was buoyed by key sectors like tourism, textile, agriculture (particularly tea), horticulture, manufacturing, transport and telecommunications. Improved output was mainly in tea, horticulture and sugar sectors. The relatively high interest rates and depreciating but stable exchange rate may not have a significant impact on the business environment. Growth is expected to benefit from accelerated tourism, following the recent resumption of European charter flights into the country. Tourism has picked up to grow at an average annualised rate of 18 per cent in 2005. The industry anticipates a boom, with peak demand expected to spill over to the year 2006.

The manufacturing sector is expected to continue benefiting from extension of third party textile sources under the African Growth and Opportunity Act (AGOA) until 2007. Consequently, the continued positive recovery partly reflects on the resilience of Kenya's economy to various destabilising factors.

5.5.4.1.2. LONG-TERM GROWTH FACTORS

In Kenya electricity is supplied to less than 15% of the total population, predominantly middle and upper income groups. KPLC strategy is to connect more customers to enhance sales growth and revenue through proactive marketing and speeding up of customer creation process, and this is now under full implementation: increasing the customer base by 100,000 customers a year. This is in addition to its normal customer growth of 40,000 a year. On average each of the new connected customers will consume 170kWh per month, leading to a direct growth on energy sales, revenue and electricity demand. This direct impact on energy sales has therefore been included in the forecast as an additional demand within the forecast period.

In conclusion, the long-term commercial sales growth will be driven by the following key factors :

- A growing population, which increases the demand for most general services using electricity ;
- Increases in electric intensity, a result of greater use of electronic and information end use technologies ;
- Continued growth in the manufacturing, agricultural sector and other sectors of the economy ;
- The company's initiative to connect new customers.

5.5.4.1.3. *ECONOMIC GROWTH ASSUMPTIONS*

The forecast is based on new GDP growth rates assumptions, which are higher than those used in the previous (2004) load forecast update. The Low, Reference and High forecast scenarios are dependent on the assumed GDP growth rates. The GDP growth rates assumptions used in the present forecast are shown in table below. It can be noted that estimates for 2006 seem to confirm the Reference Forecast scenario.

Table n° 21 - GDP ANNUAL GROWTH ASSUMPTIONS

Year	Low Forecast	Reference Forecast	High Forecast
2005 Provisional	5.0	5.0	5.0
2006	4.0	5.0	6.0
2007	5.0	6.0	7.0
2008 to 2030	6.0	7.0	8.0

5.5.4.1.4. *TARIFF ASSUMPTIONS*

The effects of energy price changes were examined by first establishing the scope customers have for the likely change in electricity use and its price (based on the current tariff structure). Elasticity factors were then applied to the main customer categories. Since estimates of elasticity are subject to considerable uncertainty, the current forecast includes elasticity and moving average tariff assumptions reflecting the customers' response to any tariff change. A tariff elasticity of 0.2 was assumed for the domestic customers, while the commercial/industrial model assumed a tariff elasticity of 0.1. These values were adopted from the 1997 National Power Development Plan study. The forecast assumes that there will be no change in real tariff for all customer categories, which means that the tariffs should globally follow the national inflation.

5.5.4.2. REGRESSION MODELS

Apart from GDP assumptions, forecast models were prepared for the four main customer groups. The models were updated using regression analysis on the available 20 to 30 year historical data. The following regression relationships were tested:

- Sales versus income (Gross Domestic Product) variable
- Sales versus price of electricity
- Sales versus time (time trend)
- Sales versus a combination of the above variables

The equation models for the four main customer categories take the linear or log linear form. Historical data up to the year 2004/05 were used in the regression analysis to update the coefficients of the four customer forecast categories. The domestic and off-peak tariffs were deflated to 1982 using the Consumer Price Index (CPI) deflator while the commercial and industrial tariffs were deflated to the same base year using the GDP deflator, as GDP statistics are recorded in the Government's economic survey data book. Future tariffs were calculated in constant 1982 prices based on the real tariff having reached 100% of the long run marginal cost. The coefficients on electricity sales as per the relevant independent parameters changed as a result of updating the historical data. All the models results registered low standard errors and high coefficient of multiple determinations (R2).

5.5.4.3. ASSUMPTIONS ON GENERATION REQUIREMENTS

Main generation requirement assumptions are the load factor, the system losses and station use as shown in the table below.

Table n° 22 - GENERATION ASSUMPTIONS

Year	Load Factor	System Losses as % of Net Generation	Station use as % of Net Generation
2005/2006	69 %	18.0	1.20
2006/2007	69 %	17.0	1.20
2007/2008	69 %	16.0	1.20
2008/2009	69 %	15.0	1.20
2009/2030	69 %	14.7	1.20

The load factor assumption is based on average total load of Domestic, commercial/industrial and rural electrification categories including related system losses.

5.5.4.4. RESULTS – PROPOSED LOAD FORECAST

Based on the KPLC analysis, the Consultant proposed to retain the forecast based on the time series analysis method and the regression models as explained before. The KPLC « Reference » forecast is named « Medium » growth scenario, and the results have been expressed according to official calendar years, instead of fiscal years as used by KPLC :

Table n° 23 - PROPOSED LOAD FORECAST

Growth Scenario		2005	2010	2015	2020	2025	2030	Average Growth
Low	Peak (MW)	916	1299	1846	2575	3550	4881	6.8 %
	Energy (GWh)	5436	7585	10756	14967	20604	28296	
Medium	Peak (MW)	916	1343	1985	2876	4121	5870	7.6 %
	Energy (GWh)	5436	7838	11552	16701	23891	33980	
High	Peak (MW)	916	1400	2151	3283	4825	7122	8.4 %
	Energy (GWh)	5436	8165	12506	18787	27943	41189	

Based on the estimated consumption breakdown for 2005, an analytical or "desegregated" forecast has been prepared, whose objective is to confirm the adequacy of the above presented results with the basic economic assumptions. The following estimates were obtained (for more details refer to Annex B):

Table n° 24 - ANALYTICAL FORECAST FOR KENYA

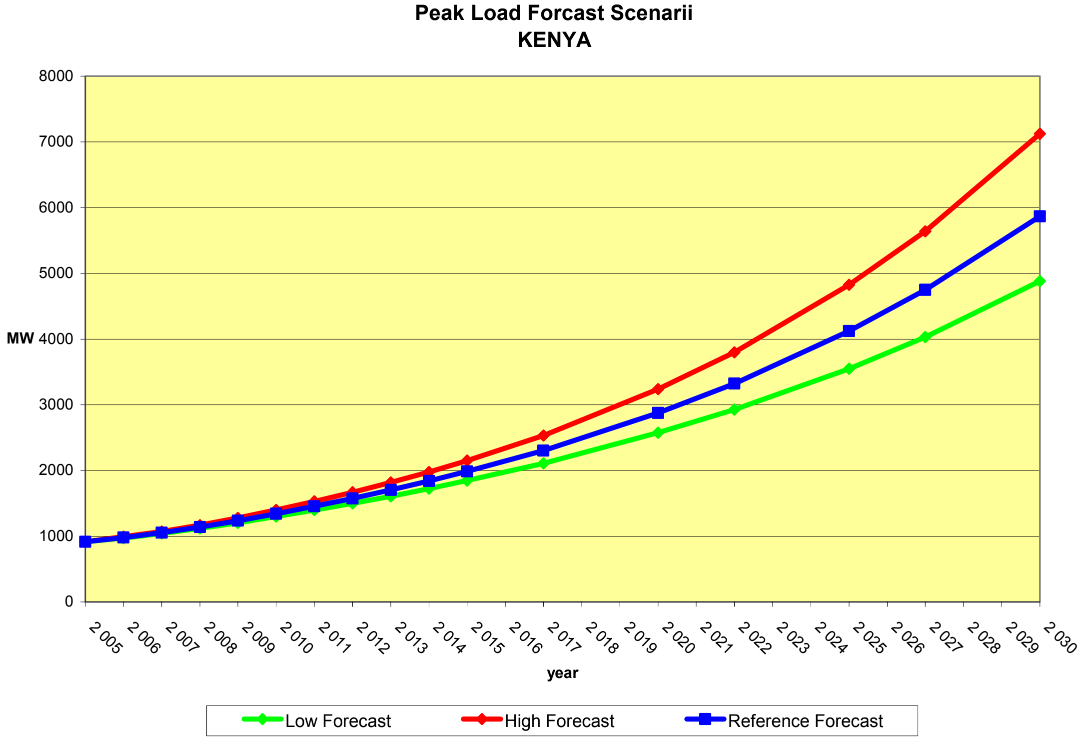
	2005	2010	2015	2020	Average growth
LOW GROWTH SCENARIO					
Population (Millions)	34.9	39.8	45.0	50.3	2.5%
Electrification Ratio	10.8%	14.6%	19.9%	25.4%	5.9%
GDP Growth	5%	6%	6%	6%	6%
Number of Consumers (*1000)	630	965	1492	2133	
Average Consumption (kWh/y)	1615	1638	1644	1712	
Domestic Energy Demand (GWh)	**1017**	**1580**	**2454**	**3651**	**8.9%**
Commercial Energy Demand	**1677**	**2308**	**3178**	**4374**	**6.6%**
Industrial Energy Demand	**1766**	**2431**	**3346**	**4606**	**6.6%**
Energy Losses	18%	15%	15%	14.7%	
Total Energy Demand	**5436**	**7435**	**10562**	**14808**	**6.8%**
Potential Peak Load (MW)	**916**	**1279**	**1817**	**2547**	

Table – Continued

MEDIUM GROWTH SCENARIO					
Population (Millions)	34.9	39.8	45.0	50.3	2.5%
Electrification Ratio	10.8%	14.6%	19.9%	25.4%	5.9%
GDP Growth	5%	7%	7%	7%	7%
Number of Consumers (*1000)	630	965	1492	2133	
Average Consumption (kWh/y)	1615	1724	1736	1811	
Domestic Energy Demand (GWh)	**1017**	**1663**	**2591**	**3863**	**9.3%**
Commercial Energy Demand	**1677**	**2430**	**3521**	**5102**	**7.7%**
Industrial Energy Demand	**1766**	**2559**	**3708**	**5373**	**7.7%**
Energy Losses	18%	15%	15%	14.7%	
Total Energy Demand	**5436**	**7826**	**11553**	**16810**	**7.8%**
Potential Peak Load (MW)	**916**	**1346**	**1987**	**2891**	

HIGH GROWTH SCENARIO					
Population (Millions)	34.9	39.8	45.0	50.3	2.5%
Electrification Ratio	10.8%	14.6%	19.9%	25.4%	5.9%
GDP Growth	5%	8%	8%	8%	8%
Number of Consumers (*1000)	630	965	1492	2133	
Average Consumption (kWh/y)	1615	1814	1832	1917	
Domestic Energy Demand (GWh)	**1017**	**1750**	**2734**	**4088**	**9.7%**
Commercial Energy Demand	**1677**	**2557**	**3898**	**5942**	**8.8%**
Industrial Energy Demand	**1766**	**2692**	**4105**	**6258**	**8.8%**
Energy Losses	18%	15%	15%	14.7%	
Total Energy Demand	**5436**	**8234**	**12631**	**19095**	**8.7%**
Potential Peak Load (MW)	**916**	**1416**	**2173**	**3284**	

The curves below represent the forecast Peak Load (in MW) for the Low, Medium and High Scenarii (from 2005 until 2030)



5.5.4.5. COMPARISON WITH OTHER FORECASTS

It is clear that the proposed forecast growth rates are close to the expected economy growth. The elasticity between GDP growth and global consumption is around 1.1, which is relatively low for a developing country like Kenya, but is consistent with the fact that future tariffs should remain relatively high as explained before.

Other recent forecasts were examined by KPLC, one performed on the basis of the MAED model as explained before, and another one proposed by the Government of Kenya in 2005, on which no detailed assumptions were presented. When compared to the proposed forecast (Medium scenario), the MAED forecast is constantly higher, with an overall growth rate of around 9% over the period (more than 10% until 2015). The GOK forecast is higher than the proposed Medium scenario until 2025, roughly coinciding with the MAED forecast until 2015. After 2025, the GOK forecast is below the Medium one, with annual growth rates decreasing to 3% around 2030.

The Consultant considers that the proposed forecast is the more adequate for the present study, since it is based on the long experience of KPLC on its system, and takes better into account the expected short-term difficulties and the likely high long-term growth potential of Kenya: economic perspectives, high urban population growth and huge number of potential new customers.

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6. RWANDA POWER SECTOR

6.1. INSTITUTIONAL FRAME WORK

In Rwanda, power sector is entrusted to the vertically integrated utility ELECTROGAZ. This company is state-owned, and controlled by RURA, the Rwanda Utilities Regulatory Agency.

At present time the electrification rate of Rwanda is yet a weak one, with the access to the electric network being 3.5% for the whole country and a portion below 1% for the rural zones some 60,000 subscribers are connected to Electrogaz network with a yearly increase estimated at 6%. The number of independent self producers (generators, photovoltaic installation etc) is weak. Recent figures number provided show that 20% of the electric energy is consumed by the industrial sector while 40% by the household sector and 40% by the business sector.

The energy sources diversification will prevent the country from the high dependence on the hydroelectric energy. The development of renewable (solar, gas and wind) and new energies would provide that diversification and will contribute to the rural development. The methane gas used, as domestic energy will lighten the pressure on the Biomass energy: Thus facilitating a better protection of the environment.

In order to improve the electric energy distribution, the Rwandan government should rehabilitate the existing network (lines and substation of high and low voltage), achieve the extension of the network through the construction of new lines and new high and low voltage substations.

6.1.1. THE PUBLIC UTILITY ELECTROGAZ

Governmental law n°18/76 dated 20 April 1976 has created the state-owned Public Establishment for Generation, Transmission and Distribution of Electricity, Water and Gas, a public utility placed under supervision of two ministries: Ministry of Infrastructures and Ministry of Lands, Environment, Forests, water and Natural Resources.

The organization and scope of Electrogaz Departments are defined by Presidential Decree n°279/75 dated April 1978.

According to Article 3 alinéa 3, Law n°18/76 conferred on Electrogaz the monopoly for generation, transmission and distribution of electricity, water and gas. A situation to which Law n°18/99 dated 30/8/1999 (Liberalization of economy and power sector) has put an end, since it abolished this alinea.

6.1.2. INSTITUTIONAL REFORMS

The Government of Rwanda has embarked on a programme of economic liberalization aimed at creating a more dynamic economy in the post-conflict environment, encouraging foreign investment and enhancing trade in goods and services.

This objective would be reached through implementation of improved efficiency, among which privatization of state-owned companies is a key component. A private sector participation is being developed in a number of industries such as: agricultural commodities (especially tea and coffee), light industries and utilities. Since the programme began, over 20 publicly owned enterprises have been sold, including warehouses, processing facilities and formerly state owned oil assets. The Privatization Secretariat and the National Tender Board have developed clear and transparent procedures for conducting the bidding and contracting for these transactions.

Two actions are part of institutional reforms:

- Regulatory reform (see hereafter),
- Investment promotion: law n°14/98 of 18th December 1998 has established the Rwanda Office of Investment Promotion, a tool of the Rwanda Government for achieving greater foreign investment in the country's economy. The Office has a wide mandate to promote investment and facilitate the development of industrial estates and free export zones.

6.1.2.1. REGULATORY REFORM

The government has enforced a law to create a Multi-Sector Regulatory Agency (RURA), for regulation of telecommunications, water, gas, electricity, transports and waste. This Agency was created in 2001. The agency has started working in 2003 and is currently staffed with 45 persons. This regulatory agency is independent of the ministries and has budgetary autonomy. It will issue operating licences and permits.

In concrete terms regulation is only effective for the telecommunication sector. For the power sector, the first step towards liberalization was taken with the law which has removed the monopoly of Electrogaz over electricity business. Additional regulation is under preparation and its promulgation is expected by the end of 2006.

6.1.2.2. PRIVATISATION OF POWER SECTOR

6.1.2.2.1. ELECTROGAZ MANAGEMENT

As part of its reform effort, the government has decided to introduce private sector management into Electrogaz. The objectives set to the utility are to develop and widen access to electricity, promote efficiency, improve quality of supply and improve the financial standing.

A first phase has started in 2003 with a private operator and performance targets to be reached in a proposed five-year management contract, which was in fact put to an end on 31/12/2005. A second phase would involve a greater role for the private management in terms of autonomy, risk and responsibility, likely a concession or a lease.

6.1.2.2.2. PRIVATE POWER GENERATION

It includes two components: for the very short term, diesel generation, with rented power plant up to 15 MW capacity which should operate awaiting for the availability of the Lake Kivu methane gas resources; and for the medium and long term, a 35 MW gas turbine power plant fired by this methane gas, to be commissioned in 2007, the Kibuye TPP which has an expected long term potential for a 200 MW total capacity.

Implementation of this project will mark the beginning of a new period in the power sector, with private funds contribution and the harnessing of a sustainable resource requiring much lower investment than hydroelectric power plant for a global cost which might prove very attractive if the power plant works out successfully.

For this purpose, a power purchase agreement was signed between The Purchaser, Electrogaz, and The Developer, Kibuye Power One (KP1), a subsidiary of the private company Dane Associates Limited for a duration of 25 years after the signature of a contract between the

Government of Rwanda and Dane Associates Limited for the of the Lake Kivu gas for a duration of 49 years.

Financial conditions of the PPA are shown hereunder.

6.2. TARIFF STRUCTURE

Since 1997, a single rate is used for all customers: it is an energy charge, the same at MV and LV levels. Recent changes in tariff are recorded hereunder:

			FRW/kWh	CUSD/KWh	Tariff increase
Tariff update in :	1997		42	7.5	-
	2004	Energy charge	81.46	14.5	+94%
	2005		112	20.0	+37%

Due to this single rate, average selling price and tariff are identical. This extremely simple structure is contrasting with often-used complicated structures. For instance, in DRC, more than 50 rates are proposed to the customers. Since the selling price is the same for LV and MV customers, it entails that this price does not reflect the costs, as supply cost is higher for LV customers. Thus, the latter are subsidized in comparison to MV customers.

More important is the price level in Rwanda, two times higher than in Burundi, three times higher than in DRC. Although the current level in Rwanda remains below average supply cost (about 125 FRW/kWh), it enables Electrogaz to purchase the fuel necessary for diesel generation. This brings a much better quality of supply, in line with the obligations of a public service. A relatively high selling price also means that private investors will be paid back, and curbs the demand, whose increase means costly fuel imports until commissioning of the Kibuye power plant.

For information hereafter a comparison of tariff in the NELSAP countries:

	CDR	Rwanda	Burundi	Uganda	Tanzania	Kenya
USD/kWh	ND	0,103	0,03	0.06	0.06	0.07
FRW/kWh	ND	48,3	13,95	27.9	27.9	32.55

1 USD=465 FRW April 2002

The different tariff increases that took place within these last years resulted in a very low domestic consumption of electricity. The industrial consumption share is rising from 50% to 65% of the total consumption.

6.3. GENERATING FACILITIES

6.3.1. HYDROPOWER PLANTS

The production of the electricity from hydraulic origin comes especially from 6 plants enumerated below in which 4 belong to Rwanda, the plants of Ntaruka, Mukungwa, Gihira and Gisenyi. The others belong to the community and are located on the Ruzizi whose hydroelectric potential is estimated at 500 MW. Presently, 72 MW are jointly exploited for the 3 countries: Rwanda, Burundi and DRC. The plants are:

- Ruzizi 1 of 28.2 MW, belonging to the Congo (DRC) and exploited by the SNEL and

- Ruzizi 2 of about 42 MW, which belongs to three countries and is exploited by SINELAC.

We will refer to the chapter concerning Burundi, the DRC and the regional approach for details concerning these two plants.

The generation of Rwanda interconnected network is summarised as follows:

	Plant (Inst. Power)	1998	1999	2000	2001	2002	2003
National Hydro Generation (GWh)	Ntaruka (11.25 MW)	45.638	39.062	32.697	24.162	28.911	36.170
	Gisenyi (1.2 MW)	2.776	7.751	6.269	6.551	5.670	4.780
	Gihira (1.84MW)	3.283	10.855	8.594	9.023	6.912	6.570
	Mukungwa (12.4 MW)	75.479	70.509	63.283	49.537	56.691	71.110
	Sub Total 1	**127.176**	**128.77**	**110.843**	**89.273**	**98.184**	**118.64**
Imports (GWh)	From SNEL	15.450	15.898	16.295	19.348	7.437	2.520
	From SINELAC	43.678	54.278	77.692	99.496	107.066	116.060
	From UEB	1.333	0.039	0.101	2.658	1.518	2.330
	Sub Total 2	**60.461**	**70.215**	**94.088**	**121.502**	**116.021**	**120.920**
Exports	Total export in GWh	0.897	0.876	1.068	1.429	8.394	3.31
Consumption	Total load in GWh	186.740	197.516	203.863	209.346	205.811	236.25

6.3.2. THERMAL PLANTS

During these past years, the Electrogaz has put in place several thermal plants around Kigali in order to cover the loss in production from hydraulic origin. The sole thermal plant existing in Kigali was the plant of Gatsata, equipped with 3 units and producing 2 MW. These units are now stopped and the thermal complex of the interconnected network comprises presently (March 2006):

- The plant of Gatsata: a generator of 4.7 MW of gas-oil, which is under repair,
- The plant of Jabana: 6 generators of 1.3 MW of gas-oil that production will be completed within one year from now by a plant of 20 MW of heavy oil that the world Bank finances within the framework of the project Urgent electricity rehabilitation.
- The plant rental: located on the industrial zone, near the substation of Gikondo, it comprises 14 generators of 1250KVA hired to the Greek company Aggreko. The energy is transferred to the network by 3 transformers 6.3 MVA and a transformer 2,5MVA. Its production is of about 10MW during the day and 8MW during the night, 2 generators being used as cold reserve.
- The plant of Mukungwa: built on the site of the hydroelectric plant of same name, it comprises seven generators and should provide 5MW by 2006.

This thermal production (34.4 MW installed and 26.9 MW available) enables Rwanda to avoid most of the power cuts but it has proved expensive for Electrogaz despite the different increases on the tariffs accrued recently. In fact the average consumption being 230l of gas-oil at 560Fr/l with taxes added the cost price of a KWH from generator is about 130Fr/l (80Fr/l, tax excluded).

In order to obtain the cost price for a delivered thermal kWh, one should take into account the auxiliary plants, technical losses related to transport and distribution, 10% and non-technical losses, 10% i.e. nearly a total addition of 40%. Thus one can easily understand the financial problems (difficulties) faced by Electrogaz, a company whose 50% of electricity production comes from thermal sources and its costs going beyond (over) 180Fr/KWH.

6.3.3. COMMITTED AND PLANNED POWER PLANTS

6.3.3.1. KIBUYE STAGE 1 POWER STATION

Note: Since the presentation of the Pre-Feasibility study last September 2006, a major event has occurred regarding the Kibuye power station project and its Stage 1 in particular. Effectively, it appears that according to existing knowledge of the Kivu Lake's environmental condition and the possible future impacts of massive extraction of methane, the project should be stopped until further and more thorough scientific and environmental studies are carried out. So the Feasibility Study has been realized assuming that Kibuye Power Station project is not carried out within the study period.

To make for this relatively unexpected event, the Government of Rwanda has decided to start an urgent 20 MW thermal (classic) power station project. This has just been considered as decided in the present Feasibility Study.

6.3.3.2. THE HYDROPOWER PLANT OF NYABARONGO

The characteristics of Nyabarongo, the hydro site of Rwanda with the higher capacity, are as follows:

Location	Central-Western Rwanda at 2h30 by road from Kigali via Gitarama
Reservoir	Useful capacity: 12.5 m3
Dam	A gravitated concrete dam, height 41m length in crest 225 m with sill discharging from 40m
Water way	Water intake on right bank at 14m, a inlet tunnel of 4m diameter, about 1165m long and a penstock 3.5m diameter, 100m long. Surge tank.
Power house	Build on right bank of the river at the loop's outlet comprising two turbine generators Francis with vertical axis.
HV Substation	Downstream of the power house, 110kV
Transmission line	110 kV, 27 Km long conveying the energy to Kilinda substation
Gross head	66.5m
Equipment out put	51 m3 /s
Installed power	27.5 MW
Guaranteed power 95% time	8.9 MW
Average power	17.2 MW
Average annual energy	147.84 GWh
Total cost based on 1998	77.5 MUSD

The tender documents being ready, the earliest date for operation is 2012.

6.3.3.3. RUZIZI 3

This community development, whose project was launched by the EGL, would be located on the Rusizi, at around 8Km downstream of Rusizi 2. It is described in the chapter concerning the regional approach. The equipment out put is about 158 m3/s for three Francis generators giving the total power of 82 MW (3X27.3 MW). The guaranteed power is 47.8 MW corresponding to an output with 92 m^3/s and the annual average production being 456 GWh, which is 15.9 MW and 152 GWh respectively for Rwanda's side. The earliest possible year for the commissioning would be 2015 (Refer to Annex A for details).

6.3.3.4. RUSUMO FALLS HYDROPOWER PLANT

The Rusumo Falls Hydroelectric community project is described in the chapter dedicated to Regional Approach because it was initially identified under the work programme of the Organization for the Management and the Development of the Kagera River Basin (KBO) and then, by the Nile Equatorial Lakes riparian countries (Burundi, Rwanda and Tanzania), as a component of the NELSAP.

The Rusumo Falls Project would have a capacity of 61.5 MW and a guaranteed energy of 308 GWh. It is contemplated that the hydroelectric power station would supply power to Burundi and Rwanda by way of 110 kV transmission lines and Tanzania by way of 220 kV transmission line. Each country would be entitled to an equal share of the station's output.

The portion of the average electricity production assigned to Rwanda is hence 134 GWh and an average power of 46/3=15.3 MW (Refer to Annex A for details).

6.4. TRANSMISSION NETWORKS

Rwanda's transmission network is described by the electric network map and the diagram RN UR 000 0. It comprises around 350 km and operates at 110Kv and 70 kV.

The Rwanda present transmission network was launched in 1960 with the construction of 70 kV line in order to transmit the energy from the plant of Ntaruka towards the substation of Jabana near Kigali and up to the substation of Rwinkwavu in the centre east of the Country.

A new line of 110 kV was constructed in 1976 and 1978 in order to transmit the power coming from Ruzizi I and subsequently from the power plant Ruzizi II and to the substation of Mururu II towards the substation of Jabana. A last section of the line 110/70 kV with double circuits was constructed in 1981 between the power plant of Mukungwa and the substation of Gifurwe in order to transmit energy from the power plant of Mukungwa towards Kigali.

The transmission lines that were in place before the civil war of 1994 have been used again under the framework of the program of rehabilitation of the ministry of Energy, Water and Natural resources.

6.4.1. SUBSTATIONS

The ELECTROGAZ transmission network comprises the following 16 substations which are divided in 4 zones:

- The North: Ntaruka, Mukungwa, Gifurwe, Rulindo :
- Kigali: Jabana, Gikondo, Mont Kigali,
- East: Gasozi, Musha, Kabarondo, Rwinkwavu,
- The South: Kigoma, Kirinda, Karongi, Kibogora, Mururu I

The substation Mururu I is operated by ELECTROGAZ although it is supplied by the plant of Ruzizi I, property of SNEL of the Democratic Republic of Congo. This substation is also connected to the substation Mururu II belonging to SINELAC. This last substation is described in the section 2.5 together with the substations of the Republic of Burundi.

6.4.1.1. GENERAL CONDITION OF THE 70 KV AND 110 KV EQUIPMENT

The three transformers connecting the plant of Ntaruka to the interconnected network were destroyed in February 1993 during the war which took place in that region. Two of the three units of the power plant were also damaged at that time and one of the three production units has been commissioned in December 1995 in order to supply the local charge. The rehabilitation of the plant of Ntaruka and its step-up substation was completed in July 1997. During this rehabilitation the connection to the network has gone from 70 kV to 110 kV.

The substation's power transformers of the substation of Gihurwe and Kibogora are presently out of use due to internal breaking. Hence these two substations are presently at zero voltage. The substation of Mont Kigali has been constructed lately and is aimed to supply the South of Kigali.The substation of Kabarondo has been completely rehabilitated during the two last years.

In 1998, the consortium Bérocan International Inc. Breton Banville and associates put forward a report on the rehabilitation of the high voltage lines and the substations interconnected national network. In that report, the replacement of several circuit breakers at 70 kV and 110 kV lines was recommended. The voltage transformers at 70 kV and 110 kV were to be replaced or added. Several power transformers must be repaired and their instrumentations replaced and the majority of the voltage regulators for power transformers must be replaced. According to the report, the line's inductances are recommended to the substations of Kibogora and Rulindo.

6.4.1.2. 15 KV AND 30 KV EQUIPMENT

Despite the fact that the project does not cover the distribution networks at 15 kV and 30 kV it is important to mention that no substation is equipped with reactive compensation.

6.4.1.3. PROTECTION EQUIPMENT OF THE HV NETWORK

In the consortium Bérocan International Inc. Breton, Banville and associates report, it is recommended to change the majority of the protection of lines and the transformers. It is either out of date, or faulty.

Several of the line's interlockers must also be changed or rehabilitated.

6.4.1.4. TELETRANSMISSION SYSTEM

In the report Assessment of protection and teletransmission of the HV network by Electrogaz elaborated in 1997 by Lahmeyer International, it is mentioned that several of the transmission units are out of use or faulty. However, during our inspection in March 2006, the personnel of Electrogaz informed us that the majority of these teletransmission units have been repaired or replaced. The telephone system is partly functional.

6.4.1.5. REMOTE CONTROL SYSTEM

The remote control is no longer functional and should be replaced completely. The personnel of Electrogaz must communicate by telephone.

6.4.1.6. COMMISSIONED AND FUTURE SUBSTATIONS

The new substation of Birembo is planned in Kigali. It will facilitate the supply of the new charges in the north of Kigali. It is located some kilometres from the substation of Jabana and will be supplied by the latter. It will supply the line of 70 kV towards Rwinkwavu, the line of interconnection towards Uganda and the interconnection line towards the future plant of Rusumo falls.

The new remote control substation of Electrogaz will be located at the substation of Birembo. A new substation is also planned at the plant of Kibuye.

6.4.1.7. REFURBISHMENT OF HV SUBSTATIONS

The government of Rwanda works presently on finalizing two programs of rehabilitation. The first called “Program of supplying water and electricity” PSWEis financed by the African Development Bank. The second called “Urgent Electricity Rehabilitation Project” is financed by the World Bank. Several of the recommendations submitted in the consortium Bérocan International Inc. Breton, Banville and Associate’s reports are included in these two programs. They cover mainly the rehabilitation of the following substations:

- Jabana
- Karongi
- Kigoma
- Kibogora
- Mururu I
- Rulindo
- Birembo

According to the oral information obtained from the personnel of Electrogaz, the following modifications are planned:

- The transformer 6 MVA of Kigoma substation must be replaced by a new transformer of 10 MVA. The current transformer of this substation will be installed at the substation of Kibogora.
- A transformer of 10 MVA must be installed at the substation Mururu I in order to replace the existing transformer of 4 MVA.

As these programs are still under approval, it has been impossible to obtain a copy of their technical documents. Any comments from Electrogaz official will be greatly appreciated.

6.4.2. TRANSMISSION LINES

There are currently three types of lines on the transmission network of Electrogaz. They have been constructed between 1960 and 1981.

6.4.2.1. DOUBLE CIRCUIT LINES

This type of line with a double circuit is used between the plant of Mukungwa and the substation of Gifurwe together with the two circuits exploited at 110 kV. The second circuit at 110 kV is not connected to the substation of Gifurwe but it binds the substation of the plant of Mukungwa to that of the plant of Ntaruka by connecting to the line sole circuit at 110 kV near the substation of Gifurwe. This line of 18,3 km was constructed in 1981 with the towers of steel lattice as illustrated in the chart in annexes of Volume 6. The technical data for this line are the following:

Phases	Double circuit in triangle
Phases conductors	6 x 240/40 AL/AC
Shield wire	1 x 95/55 AL/AC
Characteristic power	34 MW
Maximal thermal power	123 MVA
Insulators	With long barrel in porcelain 2 per chain
Distance between arcing horns	1 220 mm

This type of tower is also used between the substations Mururu I and Mururu II for a distance of 0,4 km. In this case, the two circuits are operated at 110 kV with shield wire of size 50 AC.

6.4.2.2. SINGLE CIRCUIT 110 KV LINE

The 110 kV line which extends one circuit of the line Mururu II – Mururu I towards the substations of Kibogora, Karongi, Kirinda, Kigoma, Gikondo and Jabana uses the type of towers shown in annexes of Volume 6. This line, constructed from 1976 up to 1978 with steel lattice towers, is 149 km long and transmits power from the power plants of Ruzizi II and Ruziz I towards the capital Kigali. The main technical data for this line are the following:

Phases	Single circuit in triangle
Phases conductors	3 x 240/40 AL/AC
Shield wire	1 x 95/55 AL/AC
Characteristic power	32 MW
Maximal thermal power	123 MVA
Insulators	À long fût en porcelaine 2 par chaîne
Distance between arcing horns	1 220 mm

6.4.2.3. SINGLE CIRCUIT 110 /70 KV LINE

Rwanda's actual transmission network was launched in 1960 with the construction of a line at 70 kV in order to transmit power from the power plant of Ntaruka towards the substation of Jabana near Kigali and up until the substation of Rwinkwavu in the center-East of the Country.

This line, consisting of 130 km in length, is supported by four legs lattice steel towers, type "ML" as illustrated in the chart RL BG 002 in annexes of Volume 6. It was the main skeleton of Rwanda network up until 1978, when the line 110 kV was commissioned connecting the plant of Ruzizi I to the substation of Jabana. In 1981, the section of 49 km between the substation of Gifurwe, Rulindo and Jabana was converted to 110 kV without any change on the line itself, the planning of which facilitated that conversion. The 67 km section connecting the substations of Jabana, Gasogi, Musha, Kabarondo and Rwinkwavu are still exploited up to now at 70 kV. The section of line between the plant of Ntaruka and the substation of Gifurwe has been converted to 110 kV during the convertion of the substation of the plant of Ntaruka at 110 kV without changing the line itself.

The main technical characteristics of these lines are described in the following chart:

Phases	Single circuit, horizontal
Phases conductors	3 x 135/22 AL/AC
Shield wire	2 x 50 AC
Characteristic power	29 MW à 110 kV 12 MW à 70 kV
Maximal thermal power	87 MVA à 110 kV 56 MVA à 70 kV
Insulators	Pin and cap toughened glass 7 per chain
Distance between arcing horns	900 mm

The isolation level of this line for the operation at 110 kV is marginal according to CEI standards. Considering the reduced distance is between the horn's arch and that it is located in a region of high altitude and with a Keraunic level comprising 150 days of storm per year, this line has a very low reliability level. The consortium Bérocam International – Breton, Banville and Associates report did not however recommend to raise the isolation level.

6.4.2.4. TRANSMISSION LINE REFURBISHMENT

The preliminary documents of the program (UERDP) recommend the continuation of the rehabilitation of the transmission lines. The works recommended in the consortium Bérocam International report will be achieved globally. This means that anomalies recorded during the inspection of the lines such as over stretched ranges, the bits of destroyed conductors abnormally swinging cables, the broken insulators etc., have to be repaired. To increase the lines insulation level as described in the previous article should equally be a priority.

6.5. DEMAND - SUPPLY BALANCE AND DEMAND FORECAST

Due to the civil war that took place in the last decade, economic activities and power sector have undergone a sharp decrease in the years 1994-1995. Previous normal level of consumption came back only from 1997-1998 and therefore the electricity balance presented in this section will focus on the period 1999-2005.

Consequence of the recent troubled period, investment in electricity generation has stopped, while consumption resumed. Thus, Rwanda is currently experiencing a shortage of power, which has been increased by the drought prevailing in the region.

This power sector is facing similar difficulties in Rwanda than in Burundi and DRC. In addition, the fact that the expected thermal power station using methane from Kivu Lake will probably be postponed is bad news for the short term. However, an urgent project for installing a 20 MW thermal power plant in Kigali is underway and the station should be operational in 2008.

6.5.1. PAST AND CURRENT SITUATION OF THE POWER SECTOR

6.5.1.1. POWER SUPPLY

Until 2003, only hydro generation contributed to Rwanda's supply. However, the combination of demand growth and scarcity of rains has obliged to increased use of thermal generation consuming imported diesel oil, producing electricity at a prohibitive cost.

Internal supply is generated by the facilities listed in the tables below. The total available capacity would therefore amount to more than 50 MW and 200 GWh in average year, but much less in case of dry year.

6.5.1.2. HYDROPOWER PLANTS

	Installed CapacityMW	Average OutputGWh
Mukungwa	12.5	48
Ntaruka	11.25	22
Gihira	1.6	10
Gisenyi	1.2	8.4
Total	26.5	88.4

6.5.1.3. DIESEL POWER PLANTS IN KIGALI

	Commissioning date	Installed Capacity
Jabana	2005	6×1.3 MW = 7.8 MW
Gatsata	2005	1×4.5 MW = 4.5 MW
Rental Power	2005/2006	16 MW
Total		28.3 MW

6.5.1.4. SUPPLY AND DEMAND BALANCE – PAST FEW YEARS

In addition to domestic supply, energy is imported from Ruzizi I and 2 (the plants are located in DRC), and from Uganda for smaller amounts.

As concerns Ruzizi II, it is a facility erected and operated by the CEPGL company SINELAC. One third of Ruzizi II average output comes to Rwanda, as follows: capacity = 13.3 MW and Average output = 69 GWh.

Table n° 25 - SUPPLY AND DEMAND BALANCE FOR RWANDA (1999 TO 2005)

	1999	2000	2001	2002	2003	2004	2005
1 – SUPPLY							
Domestic supply							
Hydro generation							
Mukungwa HPP	70.5	63.3	52.1	56.7	71.1	53.0	40.1
Ntaruka HPP	39.1	32.7	24.2	28.9	36.1	21.2	15.3
Gihira HPP	10.9	8.6	9.0	6.9	6.6	5.5	5.9
Gisenyi HPP	7.7	6.2	6.5	5.7	4.8	4.5	4.4
Total hydro	128.2	110.8	91.8	98.2	118.6	84.2	65.7
Thermal generation							
Gastsata diesel PP						2.7	14.1
Jabana diesel PP						3.6	25.8
Power purchases – Rental diesel PP						-	10.6
Total Thermal	-	-	-	-	-	6.3	50.5
Total domestic supply	128.2	110.8	91.8	98.2	118.6	90.5	116.2
Plus : Imports							
Ruzizi I HPP (SNEL-RDC)	15.9	16.3	19.4	7.4	2.5	20.1	21.0
Ruzizi II HPP (SINELAC-RDC)	54.3	77.7	99.5	126.8	116.1	91.4	64.6
Kabale (Uganda-EUDCL)	-	0.1	2.6	1.5	2.3	4.2	3.6
Total imports	70.2	94.1	121.5	135.7	120.9	115.7	89.2
Less: Exports to SNEL-RDC	0.9	1.1	1.4	8.4	3.3	2.2	1.8
Total internal supply	197.5	203.8	211.9	225.5	236.2	204.0	203.5
2 – SUPPLIED DEMAND							
Sales	129.4	135.9	136.5	168.9	176.0	147.7	n.a
Losses, technical & non technical	68.1	67.9	75.4	56.6	60.2	56.3	n.a
Total internal demand	197.5	203.8	211.9	225.5	236.2	204.0	203.5
Loss rate	34%	33%	36%	25%	25%	27%	n.a

Source: ELECTROGAZ

The above table calls for the following comments:

- From 1999 and due to persistent drought, hydro generation has been almost reduced to half its normal level;
- Diesel generation is sharply increasing and will play a major role until new hydropower and eventually domestic gas generation takes over;
- Because of diesel generation, imports from Ruzizi II have notably decreased, therefore leaving more power resources to be consumed by the two other CEPGL countries, in fact mostly Burundi.
- All in all, power generation has been steadily increasing until a maximum was reached in 2003, and thereafter it declined (2004 and 2005).

6.5.1.5. POWER DEMAND

6.5.1.5.1. SUPPLIED DEMAND AND POTENTIAL DEMAND

Supplied demand has decreased in 2004 and 2005 for the following reasons:

- Load shedding, mostly during peak hours, because of insufficient supply in comparison with actual demand;
- Major tariff increases, which are the likely cause of demand decrease.

In a context of insufficient supply, tariff increases curb the demand and thus play the regulation role that unfortunately most electricity utilities have seldom implemented. In case of Rwanda, tariff increases have been the following:

(one single price is enforced, energy charge, whatever the type of consumption)

- December 2004: change over from 42 to 81.46 FRW/kWh, or 94% increase (7.5 to 14.5 cUSD/kWh)
- December 2005: change over from 81.46 to 112 FRW/kWh or 37% increase (14.5 to 20 cUSD/kWh).

The tariff level has been almost multiplied by three (166% increase). The first increase was the stronger, and the customers' response was visible in 2005.

According to ELECTROGAZ, load shedding has started in 2003, and is estimated as follows:

In GWh	2002	2003	2004
Supplied demand	225.5	236.2	204.0
Suppressed demand	-	10	68
Potential demand	**225.5**	**246.2**	**272.0**
In MW	**2002**	**2003**	**2004**
Supplied peak load	44.5	45.6	44.2
Suppressed demand	-	5	6
Potential peak load	**44.5**	**50.6**	**50.2**

According to the above figures, tariff hikes have clearly stopped demand increase in 2005, and consequently contributed to restrain load shedding, thus call to expansive thermal generation.

6.5.1.5.2. DEMAND ANALYSIS

A comprehensive study has been carried out recently by Lahmeyer International for ELECTROGAZ (May 2004): Analysis and projection of Rwanda's electricity demand. Except for short term impacts of tariff increase, this study remains perfectly relevant, and the projections would need only limited updating for taking into account realizations of years 2004 and 2005.

At the end of 2004, there were about 62 000 customers. For a population of 8.3 M inhabitants and 4.7 persons per household, the electrification ratio reached 3.5% while consumption per capita is about 25 kWh per year.

LV and MV levels have almost the same relative weight among electricity consumption.

Sectoral shares are the following:

Households	32 %
Industrial sector	31%
Commercial activities	13%
Public services	24%

Based on 2004 information and 2005 population estimates, the following table could be estimated for the 2005 consumption

2005 Consumption Estimate	Urban	Rural	Total
Households (or domestic)	**52.9 GWh**	**10 GWh**	**62.9 GWh**
Population (Million)	1.9	6.6	8.5
Electrification Ratio	12%	1.5%	3,8%
Number of Consumers	45000	20000	65000
Average Consumption	1175 kWh/year	500 kWh/year	967 kWh/year
Commercial and public			**72.7 GWh**
Industry			**60.9 GWh**
TOTAL			196.5 GWh

6.5.2. ELECTRICITY MARKET FORECAST

6.5.2.1. DEMAND FORECAST

The basic assumptions of the projections of Rwanda's electricity demand which were carried out in 2004 remain valid provided that necessary adjustments are taken into account concerning the starting point of updated projections and recent changes in the power sector and economic context.

6.5.2.1.1. MAIN CHARACTERISTICS OF 2004PROJECTIONS

Three scenarios were considered, as follows, until year 2015:

	Energy growth	Load factor
Low growth scenario	6.3% per year	From 0.58 to 0.59
Medium growth scenario	8.0% per year	From 0.58 to 0.56
High growth scenario	10.5% per year	From 0.58 to 0.53

6.5.2.1.2. ECONOMIC CONTEXT

According to the Ministry of Economy and Finance (MINECOFIN), population will continue increasing at a fast rate, 2.3% per year. While GDP per capita had almost come to a standstill between 2000 (210 USD) and 2004 (212 USD), it should expand fast in the next years (6% per annum). A level of 900 USD per capita is expected in 2020.

6.5.2.1.3. *CONSEQUENCES ON THE POWER SECTOR*

An optimistic GDP expansion would justify an even higher power demand growth than the one established in 2004. Conversely, major electricity tarif hikes have been implemented since then, which will have to be maintained, if only partially, to ensure ELECTROGAZ financial soundness requested for further contribution of private sector to power sector expansion.

6.5.2.1.4. *PROPOSED PROJECTIONS*

The potential demand which was estimated for the year 2005 is taken as the starting point of the projections. The following is an analytical forecast which has been derived from the main economic assumptions (for more details refer to Annex B: Load Forecast per country):

Table n° 26 - PROPOSED FORECAST FOR RWANDA

	2005	2010	2015	2020	Average growth
LOW GROWTH SCENARIO					
Population (Millions)	8.5	9.5	10.7	12.0	2.3%
Electrification Ratio	3.8%	4.9%	6.6%	8.9%	5.8%
GDP Growth	5%	5%	5%	5%	5%
Number of Consumers (*1000)	65.0	93.9	141.7	213.3	
Average Consumption (kWh/y)	967	1008	1036	1078	
Domestic Energy Demand (GWh)	**62.9**	**94.7**	**146.8**	**229.9**	**9.0%**
Commercial Energy Demand	**72.7**	**97.3**	**130.2**	**174.2**	**6.0%**
Industrial Energy Demand	**60.9**	**81.5**	**109.1**	**146.0**	**6.0%**
Energy Losses	25%	23%	20%	16%	
Total Energy Demand	**262**	**355**	**482**	**655**	**6.3%**
Potential Peak Load (MW)	**50**	**69**	**94**	**127**	

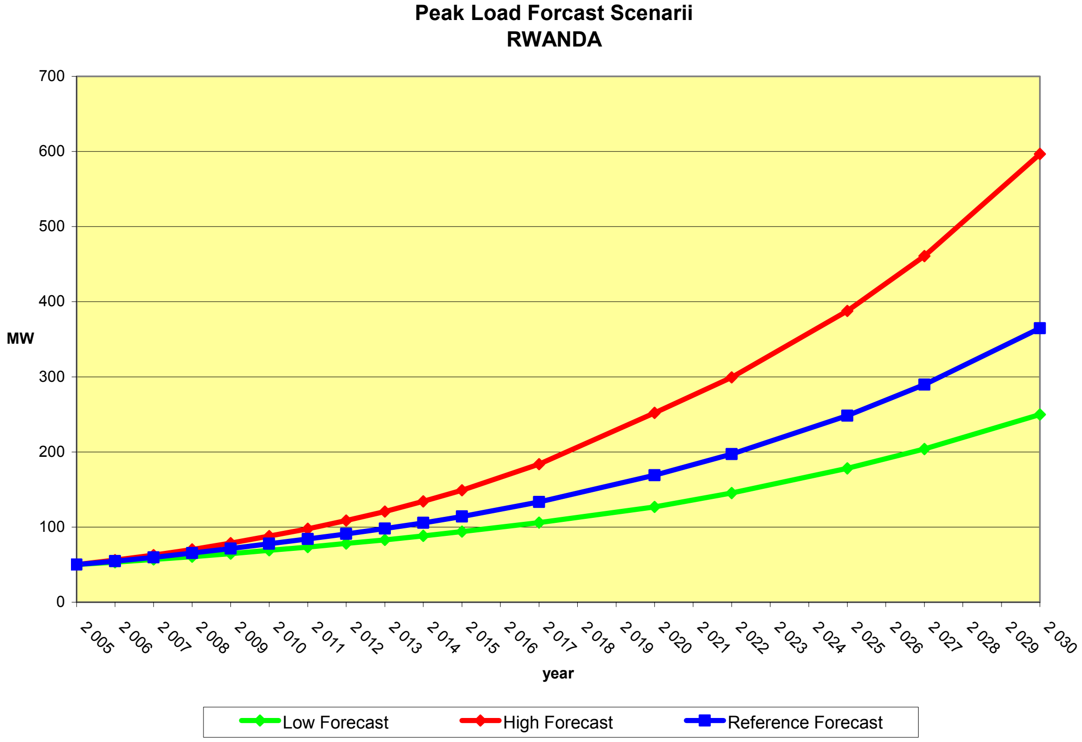
Table – Continued

MEDIUM GROWTH SCENARIO					
Population (Millions)	8.5	9.5	10.7	12.0	2.3%
Electrification Ratio	3.8%	4.9%	6.6%	8.9%	5.8%
GDP Growth	6%	6%	6%	6%	6%
Number of Consumers (*1000)	65.0	102.5	170.6	278.9	
Average Consumption (kWh/y)	967	1037	1080	1144	
Domestic Energy Demand (GWh)	**62.9**	**106.4**	**184.3**	**319.0**	**11.4%**
Commercial Energy Demand	**72.7**	**102.9**	**145.7**	**206.3**	**7.2%**
Industrial Energy Demand	**60.9**	**86.2**	**122.1**	**172.8**	**7.2%**
Energy Losses	25%	23%	20%	16%	
Total Energy Demand	**262**	**385**	**565**	**831**	**8.0%**
Potential Peak Load (MW)	**50**	**78**	**114**	**169**	

Table – Continued

HIGH GROWTH SCENARIO					
Population (Millions)	8.5	9.5	10.7	12.0	2.3%
Electrification Ratio	3.8%	6.8%	11.4%	18.6%	11.1%
GDP Growth	7%	7%	7%	7%	7%
Number of Consumers (*1000)	65.0	128.8	243.8	445.0	
Average Consumption (kWh/y)	967	1026	1110	1201	
Domestic Energy Demand (GWh)	**62.9**	**132.0**	**270.5**	**534.6**	**15.3%**
Commercial Energy Demand	**72.7**	**108.8**	**162.9**	**243.8**	**8.4%**
Industrial Energy Demand	**60.9**	**91.2**	**136.5**	**204.3**	**8.4%**
Energy Losses	25%	23%	20%	16%	
Total Energy Demand	**252**	**431**	**712**	**1170**	**10.5%**
Potential Peak Load (MW)	**50**	**88**	**149**	**252**	

The curves below represent the forecast Peak Load (in MW) for the Low, Medium and High Scenarii (from 2005 until 2030)



6.5.2.2. PROJECT ELECTRICITY BALANCE

Since supply constraints will be fully alleviated only in 2007, the actual supply of year 2006 is lower than potential demand. However, removing current generation constraints may result in a catching up of consumptions which had not been served for the past years. Therefore, supply could become identical to potential demand from 2007/08 onwards, until global supply becomes insufficient. Such situation would happen in the coming years as mentioned hereunder without taking into account diesel generation:

- For low growth scenario: energy and peak load reached in 2010
- For medium growth scenario: energy and peak load reached in 2009
- For high growth scenario: energy and peak load reached in 2008.

Therefore, a next generation system expansion will be needed at short term, whatever future growth scenario is considered.

6.5.2.3. COMPARISON OF PROPOSED FORECAST WITH OTHER RECENT FORECASTS

Three recent forecasts will be considered for comparison purpose:

- The forecast included in the NELSAP study: “Strategic/Sectorial, Social and Environmental Assessment of Power Development Options in the Nile Equatorial Lakes Region”, dated November 2005 and prepared by SNC – Lavalin Consultants
- The forecast prepared by EGL in the study: “Power Sector Development in the Equatorial Lakes Countries”, dated May 2005

- The ELECTROGAZ projections "Analysis and Projection of Rwanda's electricity demand", dated May 2004, and prepared by Lahmeyer International Consultants.

The table hereunder compares these three forecasts with the proposed forecast, in case of medium growth scenario:

	2005	2010	2015	2020	Average growth
NELSAP Study (2005) Energy demand GWh Peak load MW	 275 60	 405 80	 560 110	 820 160	 7.5%
EGL Study (2005) Energy demand GWh Peak load MW	 296 63	 416 87	 583 121	 818 169	 7.0%
ELECTROGAZ (2004) Energy demand GWh Peak load MW	 294 58	 446 84	 614 125	 - -	 8.0%
Proposed Forecast (2006/07) Energy demand Peak load MW	 262 50	 385 78	 565 114	 831 169	 8.0%

All four projections show close results. Among them, only the more recent one takes into account the actual values met by ELECTROGAZ in 2005; they reflect the impact of the two latest electricity tariff increases, and resulting estimates concerning suppressed demand this year.

oOo

7. UGANDA POWER SECTOR

7.1. INSTITUTIONAL FRAME WORK

The structure of the Ugandan power sector derives from the Electricity Act of 1999, which inter alias establishes the Electricity Regulatory Authority, its functions, powers and administration, and sets the bases for regulation of generation, transmission, distribution, sale and use of electricity in the country.

It also provides a framework to liberalise, and introduce competition in, the power sector. As a first consequence of this Act, the former Uganda Electricity Board ceased to exist, and generation, transmission and distribution activities were unbundled.

At the beginning of 2006, the situation of the power sector was the following:

7.1.1. ELECTRICITY REGULATORY AUTHORITY (ERA)

The functions of the ERA as stipulated in the Electricity Act 1999 are:

To receive, process, issue, define, modify licences and ensure their compliance for: (i) the generation, transmission, distribution or sales of electricity; and (ii) the ownership or operation of transmission systems;

To establish a tariff structure and to investigate tariff charges, approve rates and conditions of electricity services;

to review the organization of companies or other legal entities engaged in the generation, transmission and distribution of electricity to the extent that that organization affects or is likely to affect the operation of the electricity sector and the efficient supply of electricity;

to develop and enforce performance standards for the generation, transmission and distribution of electricity towards uniform industry standards and codes of conduct, including uniform account systems.

7.1.2. GENERATION

Electricity generation is composed of the state-owned Uganda Electricity Generation Company, which owns the existing Jinja hydroelectric power station (operated under a concession agreement by ESKOM Uganda Ltd.), plus an Independent Private Producer (Aggreko) which runs an emergency thermal power plant, and several private-owned isolated generation plants.

7.1.3. TRANSMISSION

The state-owned Uganda Electricity Transmission Company, Ltd. (UETCL) is the Transmission System Operator for Uganda, acting as single buyer (at the High voltage Level) and selling to the Distribution companies.

7.1.4. DISTRIBUTION

Since March 1st, 2005, the Distribution activity has been awarded for 20 years, in the form of a Concession, to the Ugandan-registered Umeme Company, which has two stakeholders, Globeleq and ESKOM. The Ugandan government has currently limited the Umeme Concession Area to a maximum of 10 kms from the existing distribution lines and transformers; any new area to be electrified should in principle be open to any licensed company.

7.2. TARIFF STRUCTURE

Tariffs in Uganda are set according to power sector activities : Generation, Transmission and Distribution. The following are the latest tariffs as set by the ERA on October 1st, 2005 :

GENERATION	**Eskom uganda Ltd.**							
	Capacity Fee		13274.26			UGX / MW /Hour		
TRANSMISSION – Bulk Supply Tariff	**Time of use**		**Uganda Electricity Transmission Company Ldt.**					
	Peak		84.0			UGX / kWh		
	Shoulder		62.2					
	Off-Peak		34.0					
DISTRIBUTION	**End-User Tariffs (Codes)**		**Umeme Limited**					
			10.1 (*)	**10.2, 10.3**	**20**	**30**	**50**	**Unit Count**
Standing & Maximum Demand Charges	**Monthly Fee**		2000	2000	2000	30000		UGX
	Max. Demand 1	**Up to 2000 kVA**			5000	3300		UGX / kVA / month
	Max. demand 2	**2000 to 10000 kVA**				3000		
Power Supply (S)	**Average**		100.2	100.2	100.2	72.6	98.9	UGX / kWh
	Peak			129.9	129.9	112.9		
	Shoulder			96.2	96.2	83.6		
	Off-Peak			52.5	52.5	45.7		
Distribution Charge (D)	**Average**		150.2	104.1	128.6	28.6	138.5	UGX / kWh
	Peak			168.1	154.3	34.4		
	Shoulder			140.1	128.6	28.6		
	Off-Peak			80.0	73.5	16.4		
Susidies (Govt.) and Levies	**Tariff Relief (TR)**		34.3	32.7	46.8	28.0	32.8	UGX / kWh
	Generation Levy (GL)		0.7	0.7	0.7	0.3	0.7	
Total Energy Tariff (S+D–TRL+GL)	**Average**		216.9	208.3	182.8	73.6	205.3	UGX / kWh
	Peak			265.9	238.2	119.6		
	Shoulder			204.3	178.8	84.6		
	Off-Peak			100.6	80.0	34.3		

Notes : * Above 15 kWh ; first 15 kWh are billed at 50 UGX/kWh

Codes : 10.1 Domestic, 240 V

10.2 Commercial, up to 100 A, 415 V

20 Medium-Scale Industries, 415 V, up to 500 kVA

30 Large Scale Industries, 11 kV or 33 kV, up to 10000 kVA

50 Street Lighting

The average selling price could be estimated at 10 cUSD/kWh at the end of 2005; this price is higher than in the neighbouring countries, but correctly reflects the high generation costs.

These tariffs are calculated for the main national companies, which mainly correspond to the interconnected systems in the country. For isolated centres (small towns or rural areas served by diesel plants, or decentralised renewable energy supply, the ERA calculates a tariff on the basis of the avoided electrification cost (based on extension of existing networks).

It is interesting to note that the mode of tariff calculation follows the principle of covering the real costs of supply at generation, transmission, distribution and end user level; however, due to the prevailing shortage of supply and the difficult economic conditions for the consumers, the Government grants a subsidy « tariff relief » to all consumer categories.

On October 1st, 2005, the subsidy amounted to 16% of the total end-user tariff for the Domestic, Commercial and Street Lighting categories, while it reached respectively 26% and 38% of the total « Medium » and « Large » Industrial categories.

Clearly, the Government has put its top priority on reducing the electricity costs for industries. It is a strategic choice since some of the industrial customers are tempted to move to Kenya, where the security of supply is currently better than in Uganda, with much less load shedding and incidents.

7.3. GENERATING FACILITIES

The principal source of power in Uganda is provided by the Hydro Complex at Jinja.

Ugandan power plants are listed in the following schedule:

Table n° 27 - EXISTING UGANDAN POWER PLANTS

Station	Location	No. of Units	Rating per Unit(MW)	Installed Capacity (MW)	Firm Generation (GWh)	Year Installed
HYDRO- SOURCES						
Nalubaale	Victoria Nile	10	18	180	403	1954 – 58 uprated 91-96
Kiira	Victoria Nile	5	40	200	892	2002, 02 and 06
Other (Mini)		-	-	16	0	-
Sub-Total Hydro				396	1 295	
IPP's						
Aggreko diesel station	Kampala	1	50	50	414	2005 for 3 years
Kakira bagasse plant		3	2.5	7.5		-

7.3.1. HYDROPOWER PLANTS

7.3.1.1. HYDRO COMPLEX OF JINJA

Jinja is 80 kilometres to the East of Uganda's capital Kampala, and 114 kilometres from Entebbe International Airport. The Hydro complex is about 4 kms from the source of Victoria Nile, at the outlet of Lake Victoria.

The Complex has two stations at the Owen Falls Dam:

- Nalubaale Power Station.
- Kiira Power Station.

The stations have an installed capacity of 380 MW.

The volume of the reservoir (Lake Victoria – 69000 km²) is 690 billion m^3 per cm of depth. The volume of Owen Falls reservoir, downstream of Ripon Falls, is 23.25 million m^3.

Other sites along the river, Bujagali, Kamdimi, Ayago South, Ayago North and Murchison are yet to be developed

1. Nalubaale power station

Installed capacity - 180 MW (10 units of 18 MW)

Year of commissioning – Between 1954 and 1968; Up rated between 1991 and 1996.

The power station was originally commissioned in 1954 with two 15 MW units. Over the period 1954 to 1968 a further eight units were progressively brought into service, thereby utilising the full 150 MW, design capacity of the original site.

In 1989 contracts were placed for the rehabilitation of the station. The aim of the project was to replace or refurbish key items of station plant with the aim of extending the life of the station by 25 years.

The rapid growth in the System demand has extended the rehabilitation programme such that the last generator to be up-rated was not commissioned until March 1996.

The rehabilitation contract has increased the output of each of the ten turbine-generators from 15 MW to 18 MW.

The power plant has been operated as "run-of-river", dictated by an Agreed Discharge Curve of river flow of the Victoria Nile. Average Annual Production is 1309 GWh

2. Kiira power station

Installed capacity - 200 MW (5 units of 40 MW)

Year of commissioning – 2000 (2 units), 2002 (1 unit) and 2006 (2 units).

The Kiira above ground power house is located on the east bank of the Nile, approximately 800 m downstream of the dam, with water supplied by means of a canal.

Contracts for the civil works and turbines were signed between November 1993 and July 1994 based on the larger capacity of 5x 40 MW units. Contracts for generators, switchyard and E&M services were all signed in the second half of 1995. The concept of an east bank development, fed by a canal has been retained.

The first and second units of 40MW were commissioned in May and October 2000, and the third unit in June 2002. The fourth and fifth units will be commissioned early 2006 giving a total installed capacity of 200 MW.

Eskom's operation of the power plant commenced on 1st April 2003.

7.3.1.2. MINI-HYDRO POWER STATIONS

Uganda has two other small hydro stations which are serviceable.

Table n° 28 - EXISTING UGANDAN MINI-HYDRO POWER STATIONS

STATION	LOCATION	INSTALLED CAPACITY	YEAR OF COMMISSIONING
Mubuku 1-3	Western region	5.4+10.5 MW	Rehabilitation Programme in 1990
Maziba	South East of Kibale	1 MW	Presently not in operation

1. Mubuku power station

Mubuku hydropower plant is located in the Western Region, north of Lake Edward, on the Mubuku River and is privately owned by Kilembe Mines. It is connected to the grid and is capable of being synchronised with System. The station was the subject of a rehabilitation programme in 1990 and now a total of 16 MW is available.

2. Maziba power station

The second station is at Maziba, located approximately 15 km south east of Kibale on the border with Tanzania. One 500 kW unit and one 250 kW unit have been under rehabilitation in 1996 and 1997. A third 250 kW unit has been under rehabilitation in 1997 and 1998. There is no provision for synchronising with the main network. In 2006, this plant was not in operation

7.3.2. THERMAL PLANTS

7.3.2.1. DIESEL STATIONS

Due to the severe drought, diesel power stations to be operated by Independent Power Producers have been planned.

A 50 MW emergency diesel power station is already operated by AGGREKO. The agreement is for three years only.

Two additional diesel power stations are under study:

- An other 50 MW (to be supplied by an independent power producer), and
- A 100 MW (World Bank financing).

7.3.2.2. KAKIRA SUGAR WORKS' AND OTHER BAGASSE PLANTS

The installed capacity is 2.5 MW. Exports are forecasted, but at present, the plant does not supply the public grid. Two other sugar companies (SCOUL and KINYARA) also have co-generation plants and have expressed interest in increasing their installed capacity and supplying the public electricity network.

7.3.2.3. ISOLATED DIESEL STATIONS

There are about 10 small diesel stations serving isolated networks. None of the stations have an installed capacity in excess of 0.84 MW and their combined capacity is not a significant factor for future hydropower planning.

7.3.3. COMMITTED AND PLANNED POWER PLANTS

Table n° 29 - UGANDAN COMMITTED AND PLANNED GENERATION PROJECTS

	Project	Type	Capacity (MW)	Firm Generation (GWh)	Estimated Commisioning Year
1	Independent power Producer	Thermal	50		2006 for 6 years
2	World Bank financing	Thermal	100		Before 2009
3	Kakira sugar works' Bagasse plant	Thermal	+12.5	68	2007
4	Kakira sugar works' Bagasse plant	Thermal	+5	27	2009
5	Bujagali	Hydro	200	1 390	2012
6	Karuma Falls	Hydro	180	1 619	Planned
7	Kalagala	Hydro	450	1 697	Potential
8	Ayago North	Hydro	304	1 820	Potential
9	Ayago South	Hydro	234	2 050	Potential
10	Murchison Falls	Hydro	642	1 773	Potential
11	Mini hydro plants	Hydro	65 to 74	-	Potential

7.3.3.1. INDEPENDENT POWER PRODUCER AND WORLD BANK FINANCING THERMAL PLANTS

The first thermal generators to generate 50 MW have been commissioned in October 2006. These 50 MW are supplied by an independent power producer (Aggreko II) under contract until December 2008; this period may be extended if necessary.

The remaining 100 MW will be installed under a World Bank financing process: 50 MW are planned for August 2007 until December 2010 at least, the other 50 MW for April 2008 (possibly under private financing).

7.3.3.2. KAKIRA SUGAR WORKS' AND OTHER BAGASSE PLANTS

An agreement has already been signed for increasing the power to be delivered to the UETCL grid. From September 2007, Kakira sugar works' bagasse plant exports to the public network will be 12 MW for 18 hours/day (from 6.00 to 24.00), 305 days/year.

This power should reach about 19 MW several months afterwards and 23 MW in 2009; to this value should be added other future supplies of co-generation plants run by sugar factories. The Ministry of Energy indicates that up to 42 MW of bagasse-fired co-generation plants should be available to the network in the short term.

7.3.3.3. BUJAGALI HYDRO PLANT

Main characteristics of Bujagali hydro plant are listed here under :

Location	On the Victoria Nile, a few kms downstream Jinja hydro complex
Reservoir	Live storage : 12.8 Mm^3
Dam	Rockfill/Earthfill embankment, estimated maximum height 28 m, approx crest length 880 m
Spillway	Maximum discharge 4500 m3/s : • 3000 m3/s low level outlets – 2 No. submerged radial gates 9.5 m wide x 10.5 m high approx. • 300 m3/s surface flap gate - 1 No. flap gate 12 m wide x 7 m high approx. • 1200 m3/s emergency air regulated siphon
Intake	Integral intake and power station with 4 turbine units
Power station	On surface in left channel around Dumbell island, Fitted with 4 No. Vertical Kaplan turbine units
Substation	On left bank, upstream of the dam, 220 and 132 kV
Transmission lines	Double circuit 220 kV line from Bujagali to Kawanda, Double circuit 132 kV line fom Kawanda to Mutundwe, Double circuit 132 kV line from bujugali to Owen falls, Double circuit 132 kV line from bujugali to the point of intersection with the existing Owen falls to Tororo double circuit line.
Gross head range	19 – 23.5 m
Maximum turbines discharge	1080 m^3/s
Nominal installed capacity	200 MW (250 MW according to the most recent project documents)
Firm capacity	-
Average power delivered on the grid	164 MW
Average annual energy	1438 GWh
Cost estimate	-

7.3.3.4. KARUMA FALLS HYDRO PLANT

Main characteristics of Karuma Falls hydro plant are listed here under:

Location	On the southern bank of the Nile River some 80 kms downstream of Lake Kyoga in north central Uganda
Reservoir	-
Dam	Concrete
Spillway	Concrete overflow weir containing a flood gate 20 x 8 m and two scour gates 2 x 3.5 m designed to maintained a constant intake level - 4500 m3/s :
Intake	Integral intake and power station with 5 turbine units
Power station	Cavern type on left bank, Fitted with 4 No. Vertical Kaplan turbine units
Substation	On left bank, downstream of the dam, 132 kV
Transmission lines	Reconstruction of the 260 km long 132 kV line from Tororo to Lira on steel towers Construction of the 70 km long ring section from Lira to Karuma Construction of a new 33 kV line from Karuma to Masindi (105 km)
Gross head range	Approx. 30 m
Maximum turbines discharge	800 m^3/s
Nominal installed capacity	200 MW
Firm capacity	-
Average power delivered on the grid	170 MW
Average annual energy	1490 GWh
1999 cost estimate	367 MUS$

7.4. TRANSMISSION NETWORKS

7.4.1. EXISTING TRANSMISSION NETWORKS

The main transmission network comprises a backbone of two double circuit 132 kV overhead lines which connect the capital Kampala with the major town of Jinja at Owen Falls power station, a distance of 69 km. One double circuit 132 kV overhead lines connect Owen Falls substation to Lugogo, and the other one used as single circuit (both circuits are connected to the same circuit breakers at each end of the line) connect Owen Falls to Kampala North.

Then a double circuit 132 kV overhead lines continues eastward for a further 117 km to Tororo. From Tororo the main double circuit line crosses into Kenya which has an agreement to take up to 30 MW of power from UEB, or more subject to mutual agreement.

From Tororo a single circuit line to the North West supplies the town of Lira over a distance of 260 km.

The Kampala area is served by three substations. The main 132/33 kV substation at Kampala North connects via a double circuit 132 kV overhead line to the station at Lugogo. The third substation in Kampala is at Mutundwe and this again connects with Kampala North via a 132 kV double circuit line and with Lugogo via a 132 kV double circuit line.

To the West of Kampala a single circuit 132 kV overhead line connects with Nkenda, via Kabulasoke and Nkonge, a total distance of 301 km. At Kubulaske a further single circuit 132 kV line connects with Masaka substation, some 60 km to the south, from there single circuit lines of 130 km serve Mbarara and provide a connection into Tanzania.

7.4.2. TRANSMISSION LINES AND SUBSTATIONS PROJECTS EXPECTED

Beside extension due to next hydro power stations, UEB's tentative plans for load driven reinforcement of the 132 kV network are listed here under:

- A single circuit connection northward from Mutundwe to Masindi, via Kawanda.
- The creation of a new bulk supply point (BSP) at Opuyo, between Tororo and Lira, and the extension of the single circuit from Lira to Olwiyo. Alternatively, if the next power station were to be at Murchison, or an adjacent site, Olwiyo might be supplied by means of an extension from Masindi.
- The completion of the Western Ring by the construction of a single circuit link from Mbarara.
- The construction of a 132 kV link with Rwanda to replace the existing 33 kV connection (which will be dedicated to distribution) with the aim of providing a supply of up to 20 MW.

7.5. DEMAND - SUPPLY BALANCE AND DEMAND FORECAST

In 2005 and the first half of 2006, the Ugandan power sector has been in a situation of severe supply shortage. The first reason is the severe draught in the whole Eastern African region, which has left the Victoria Lake far below its normal operating level, and the Jinja hydroelectric complex (Nalubaale and Kiira power stations), whose output is dependent on Victoria Lake level, has been widely affected by this situation. The second reason is the delay in committed generation investment, including the last phase of Jinja complex extension, and the new Bujagali power station, whose development was dropped by the previously selected private consortium led by AES.

As a result, the Government had to request emergency thermal power generation, through a 3-year agreement, expandable to 6 years, with the Aggreko private company, for a maximum 50 MW power supply. Even under these conditions, extensive load shedding was necessary: in December 2005, the national unconstrained interconnected system demand topped 365 MW, when the available maximum generation was close to 255 MW (205 MW from Jinja). The load shedding at peak time was therefore around 110 MW, or 30% of the unconstrained peak load.

7.5.1. POWER SUPPLY

At the end of 2005, the global supply situation can be summarised as follows:

Generator	Type	Capacity (MW)		Energy (GWh)	
		Installed	Effective	Average	Firm
Jinja Complex	Hydro	300	205	2100*	1700*
Aggreko	Diesel	50	50	300*	300*
Karika	Bagasse	N/A	2.5	15*	15*
Isolated	Diesel	N/A	5	15*	15*
Isolated	Small Hydro	7	N/A	35*	35*
TOTAL		**>360**	**260***	**2465***	**2065***

* Consultant's gross estimate

7.5.2. GLOBAL SUPPLY STATISTICS

The following table summarises the overall energy supply in Uganda, from 2000 to 2005 included, for the interconnected system and overall. The values have been extracted from UETCL and UEB generation, power flows and sales statistics ; some of them have been estimated.

GWh		2000	2001	2002	2003	2004	2005	Average Growth (%)
Net Generation	**Jinja**	1535	1578	1700	1756	1894	1699	
	Other						165	
Imports		7	7	1	1	8	27	
Exports		251	142	263	216	200	62	
Total DomesticSupply		1291	1443	1438	1541	1702	1804	7.0 %
System Peak* (MW)	Intercon.	261	288	272	294	334	357	6.5 %
	Overall	296	303	309	349	405	418	7.1 %
Load Shedding (MW)**		41	39	10	16	64	85	15.7 %
T&D Losses		448	576	552	558	671	729	
Sales		843	867	886	983	1031	1075	8.4 %
Losses (% Domestic)		35%	40%	38%	36%	39%	40%	

*Unconstrained demand

**Average on peak time

The overall power supply is extremely dependant on the hydrology of the Nile river and on the level of Victoria Lake. The whole 2000-2005 period was marked by a low hydrology and a decreasing level of the Victoria Lake (since 1998). As a consequence, in 2005 and 2006, there has been an acute power shortage which can be illustrated by the growth of load shedding over the years.

7.5.3. POWER DEMAND

As can be seen above, the power demand has been very much affected by unavailability of adequate supply, and this during the last 6 years at least. The following table summarises the electricity sales to the various customer categories in the period and the estimates of theoretically unconstrained sales (in GWh, sources Ministry of Mines and Energy and Bujagali II IFC Report, 2007).

Customer type	2000	2001		2002		2003		2004		2005		Average Growth	
		Const	Unc	Const	Unc	Const	Unc	Const	Unc	Const	Unc	Const	Unc
Residential	312	366	377	372	380	363	373	344	369	341	370	1.8%	3.5%
Commercial	122	133	135	137	138	148	150	137	142	133	139	1.7%	2.6%
Industrial	407	366	376	374	392	468	468	549	566	601	622	8.1%	8.9%
Street Lighting	2	2		3		4		1		1			
TOTAL	843	867	890	886	913	983	995	1031	1078	1075	1132	5.0%	6.1%

Because of the limited supply, the power demand has been severely constrained, and the unconstrained demand has been growing at a much higher rate, which is due to the recent economic recovery in the country. The lack of supply has been harmful to the industries, in particular the large ones. The situation of power supply in 2006 was so critical that some Uganda-based industries have been completely or partially moving to Kenya.

7.5.4. DEMAND FORECAST

7.5.4.1. BASIC ASSUMPTIONS

In 2006, there were difficulties to establish a precise load forecast for Uganda

- First, the supply-constrained situation, with an estimated 100 MW load shedding at peak time ; this has multiple consequences, like pushing industries out of the country (or preventing new ones to establish themselves in the country), stopping new connections, increasing use of small generator sets…so that the « potential » unsatisfied demand maybe much higher than the 100 MW ;
- Second, the fact that load forecasting duties have been changing hands in the last 6 years, from the former UEB to UETCL (from 2000) and Umeme (from 2005) ;
- Third, the important uncertainties regarding political situation of the country and its future economic growth, which in turn generates high uncertainty on short and medium term power generation investment (in particular for large power stations like Bujagali and Karuma Falls). The consequence is that it is extremely difficult to determine not only what will be the potential demand of the country, but also when this demand can be fully satisfied. ;
- And fourth, the extremely low electrification ratio (less than 5% overall, less than 2% in rural areas) combined with the uncertainty on the fulfilment of rural electrification plans (see below).

As a consequence, and also due to the difficulty to obtain precise basic information for 2005 and 2006, the Consultant used estimates of the 2005 load situation. An analytical forecast has been prepared on the following bases:

2005 Consumption Estimate	Urban	Rural	Total
Households (or domestic)	**303 GWh**	**38 GWh**	**341 GWh**
Population (Million)	3.5	25.3	28.8
Electrification Ratio	26.3%	1.5%	4,6%
Number of Consumers	184400	75900	260300
Average Consumption	1643 kWh/year	500 kWh/year	1310 kWh/year
Commercial and public			**133 GWh**
Industry			**601 GWh**
TOTAL			**1075 GWh**

7.5.4.2. PROPOSED LOAD FORECAST

UETCL submitted a demand forecast which was presented according to 3 growth scenarios: Low, Medium and High. The analytical forecast has been prepared with the main assumption that the overall losses, estimated at 40% of net generation, would decrease until 16% in 2020, and in order to verify the soundness of the proposed UETCL forecast in 2020. The following values have been obtained (for more details refer to Annex B: Load Forecast per country):

Table n° 30 - PROPOSED LOAD FORECAST

	2005	2010	2015	2020	Average growth
LOW GROWTH SCENARIO					
Population (Millions)	28.8	33.5	38.7	44.1	2.9%
Electrification Ratio	4.5%	8.1%	10.5%	13.2%	7.4%
GDP Growth	4%	4%	4%	4%	4%
Number of Consumers (*1000)	260.3	545.3	808.9	1162.4	
Average Consumption (kWh/y)	1310	1096	1181	1247	
Domestic Energy Demand (GWh)	**341**	**598**	**955**	**1449**	**10.1%**
Commercial Energy Demand	**133**	**175**	**229**	**301**	**5.6%**
Industrial Energy Demand	**601**	**789**	**1036**	**1361**	**5.6%**
Energy Losses	40%	26%	20%	16%	
Total Energy Demand	**1804**	**2110**	**2776**	**3704**	**4.9%**
Potential Peak Load (MW)	**318**	**364**	**470**	**614**	

MEDIUM GROWTH SCENARIO					
Population (Millions)	28.8	33.5	38.7	44.1	2.9%
Electrification Ratio	4.5%	9.7%	14.2%	18.6%	9.9%
GDP Growth	6%	6%	6%	6%	6%
Number of Consumers (*1000)	260.3	648.2	1098.2	1639.0	
Average Consumption (kWh/y)	1310	1183	1306	1450	
Domestic Energy Demand (GWh)	**341**	**767**	**1434**	**2377**	**13.8%**
Commercial Energy Demand	**133**	**199**	**298**	**446**	**8.4%**
Industrial Energy Demand	**601**	**900**	**1346**	**2015**	**8.4%**
Energy Losses	40%	26%	20%	16%	
Total Energy Demand	**1804**	**2521**	**3848**	**5760**	**8.0%**
Potential Peak Load (MW)	**318**	**439**	**663**	**982**	

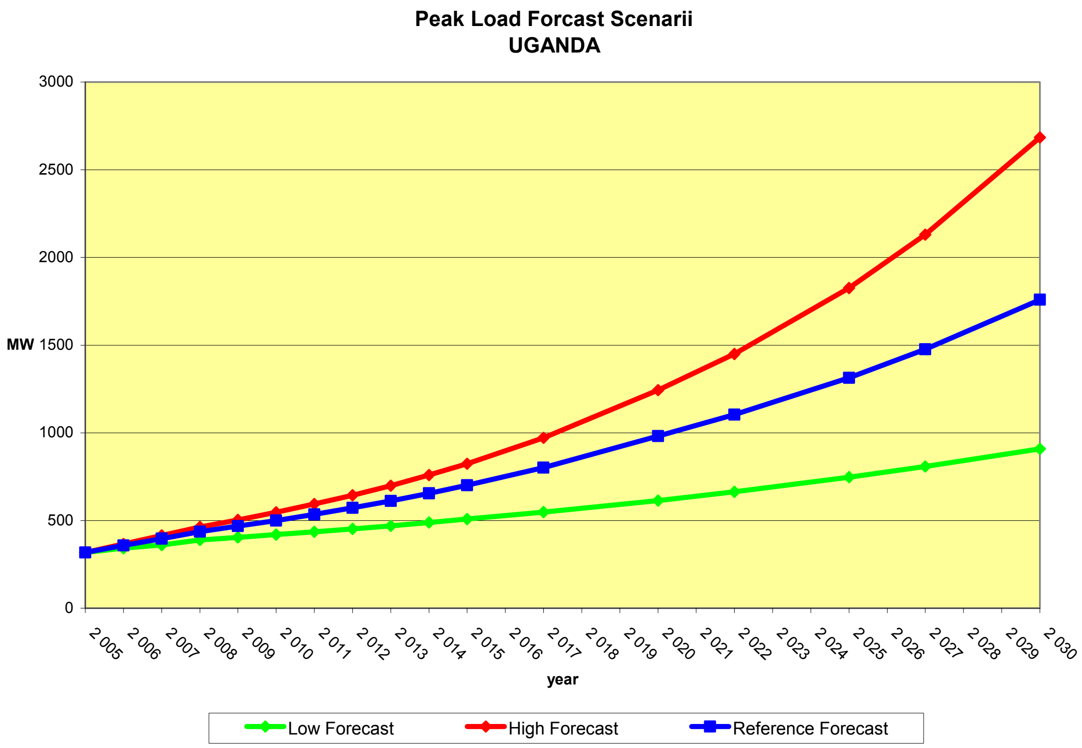
HIGH GROWTH SCENARIO					
Population (Millions)	28.8	33.5	38.7	44.1	2.9%
Electrification Ratio	3.8%	9.9%	15.9%	23.4%	11.6%
GDP Growth	7%	7%	7%	7%	7%
Number of Consumers (*1000)	260.3	666.1	1232.6	2063.2	
Average Consumption (kWh/y)	1310	1258	1397	1584	
Domestic Energy Demand (GWh)	**341**	**838**	**1722**	**3268**	**16.3%**
Commercial Energy Demand	**133**	**212**	**339**	**541**	**9.8%**
Industrial Energy Demand	**601**	**959**	**1531**	**2443**	**9.8%**
Energy Losses	40%	26%	20%	16%	
Total Energy Demand	**1804**	**2715**	**4490**	**7443**	**9.9%**
Potential Peak Load (MW)	**318**	**469**	**762**	**1243**	

The analytical forecast shows that the values proposed by UETCL for 2020 are corresponding to sound growth patterns for the different consumer categories. Some differences appear in 2010 and 2015, where the analytical forecast is slightly lower than the UETCL forecast; this is due to the fact that a high un-served energy demand should be connected to the main network in the next 10 years. For this reason, it is proposed to keep the 2010 and 2015 values from the UETCL forecast. As a consequence, the proposed load forecast for Uganda is the following:

Table n° 31 - PROPOSED LOAD FORECAST

Growth Scenario		2005	2010	2015	2020	Average Growth
Low	Energy (GWh)	1804	2435	3003	3703	**4.9%**
	Peak (MW)	318	420	508	614	
Medium	Energy (GWh)	1804	2874	4069	5761	**8.0%**
	Peak (MW)	318	500	701	982	
High	Energy (GWh)	1804	3164	4853	7443	**9.9%**
	Peak (MW)	318	547	824	1243	

The curves below represent the forecast Peak Load (in MW) for the Low, Medium and High Scenarii (from 2005 until 2030)



7.5.4.3. COMPARISON OF FORECASTS

During the writing of the present report, a new forecast has been prepared in the frame of the "Bujagali II – Economic and Financial Evaluation Study" Final Report, which was prepared in February 2007 by PPA under World Bank (IFC) financing. The results are presented in the following table and compared to the UETCL forecast (proposed here), and the above-described analytical forecast:

Table n° 32 - COMPARISON OF FORECASTS (MEDIUM GROWTH SCENARIOS)

	2005	2010	2015	2020	Average growth
Bujagali II Study (2007) Energy demand GWh Peak load MW	1921* 354*	2035 375	2959 545	4287 789	5.5%*
Analytical Forecast (above) Energy demand GWh Peak load MW	1804 318	2521 439	3848 663	5760 982	8.0%
Proposed Forecast (2006/07) Energy demand Peak load MW	1804 318	2874 500	4069 701	5761 982	8.0%

*** With estimate of un-constrained demand in 2005**

The Bujagali II study envisages a medium forecast (called "Base" forecast) which is lower (-25% in 2020) than the proposed medium forecast but higher (+15% in 2020) than the proposed low forecast; the “High” forecast of the Bujagali II study is slightly higher (+2.3% in 2020) than the “medium” proposed one.

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8. REGIONAL APPROACH

8.1. ANALYSIS OF SUPPLY AND DEMAND BALANCE FOR MAIN INTERCONNECTED NETWORKS

8.1.1. INTRODUCTION

Based on the above-mentioned individual supply and demand analyses and on the results of the pre-feasibility study, the countries which are the object of the interconnection studies between Rwanda and Uganda, and Uganda and Kenya, have been considered as three main load centres: the Burundi-Rwanda-Congo (DR) or B-R-C group, the Ugandan and the Kenyan interconnected systems. The objective of this chapter is to determine supply options for the following cases:

- Each main load centre is supplied independently (reference option),
- The three main load centres are interconnected via Rwanda-Uganda and Uganda-Kenya interconnections (option with project)

The analysis will be made according to the three proposed demand scenarios, and according to two main interconnection alternatives:

- Alternative 1: to satisfy only the national demand with interconnections whose capacity is adapted to exportable surpluses;
- Alternative 2: to satisfy at low cost the whole demand of the five countries, with interconnections adapted to the resulting energy flow.

8.1.2. FUTURE DEMAND

The individual country forecasts have been considered in order to determine the detailed annual demands of each group. The Tables hereafter provide, for the 2010-2030 period, the peak power and energy demand for the B-R-C, Uganda and Kenya, and for each of the demand scenarios (low, medium, high).

Table n° 33 - SYNTHESIS OF BURUNDI, DRC AND RWANDA DEMANDS

Scenario	Low		Medium		High	
	Energy (GWh)	Peak (MW)	Energy (GWh)	Peak (MW)	Energy (GWh)	Peak (MW)
2 005	652	135	652	135	652	135
2 006	687	142	697	145	709	147
2 007	724	150	745	155	771	160
2 008	762	158	796	166	838	175
2 009	804	167	852	178	912	191
2 010	847	176	911	191	993	209
2 011	895	186	976	204	1082	228
2 012	946	196	1046	219	1180	249
2 013	1000	207	1121	234	1287	272
2 014	1057	219	1201	250	1404	297
2 015	1117	231	1288	268	1532	324
2 017	1251	255	1485	309	1831	385
2 020	1484	297	1837	383	2393	499
2 022	1680	335	2120	441	2817	587
2 025	2023	402	2628	546	3597	748
2 027	2292	455	3036	630	4237	880
2 030	2764	547	3769	780	5418	1123

Table n° 34 - UGANDA DEMAND SCENARIOS

Scenario	Low		Medium		High	
	Energy (GWh)	Peak (MW)	Energy (GWh)	Peak (MW)	Energy (GWh)	Peak (MW)
2 005	1804	318	1804	318	1804	318
2 006	1949	342	2036	358	2092	366
2 007	2095	360	2269	397	2379	415
2 008	2240	389	2501	437	2667	464
2 009	2336	404	2681	468	2905	504
2 010	2435	420	2874	500	3164	547
2 011	2540	436	3081	535	3447	594
2 012	2648	453	3303	573	3755	644
2 013	2762	470	3541	612	4090	699
2 014	2880	489	3796	655	4455	759
2 015	3003	508	4069	701	4853	824
2 017	3266	548	4676	802	5758	971
2 020	3703	614	5761	982	7443	1243
2 022	4005	664	6473	1103	8681	1450
2 025	4505	747	7710	1314	10936	1826
2 027	4873	808	8663	1477	12755	2130
2 030	5481	909	10317	1759	16067	2684

Table n° 35 - KENYA DEMAND SCENARIOS

Scenario	Low		Medium		High	
	Energy (GWh)	Peak (MW)	Energy (GWh)	Peak (MW)	Energy (GWh)	Peak (MW)
2 005	5436	916	5436	916	5436	916
2 006	5659	970	5709	979	5784	993
2 007	6084	1041	6151	1054	6258	1071
2 008	6540	1119	6653	1139	6823	1169
2 009	7039	1205	7217	1236	7460	1279
2 010	7585	1299	7838	1343	8165	1400
2 011	8153	1397	8491	1456	8914	1530
2 012	8750	1500	9183	1576	9715	1668
2 013	9381	1609	9922	1703	10578	1817
2 014	10049	1724	10711	1840	11506	1978
2 015	10756	1846	11552	1985	12506	2151
2 017	12276	2109	13387	2302	14717	2533
2 020	14967	2575	16701	2876	18787	3238
2 022	17008	2928	19272	3321	22020	3798
2 025	20604	3550	23891	4121	27943	4825
2 027	23392	4032	27506	4747	32634	5638
2 030	28296	4881	33980	5870	41189	7122

8.1.3. FUTURE SUPPLY

The future supply will be the result of commissioning additional means of production to be added to those existing presently. The additional capacity to be installed will be defined through the demand to be satisfied, taking into account the needed quality of the service.

8.1.3.1. QUALITY OF SERVICE

In the planning studies, adjusting the production investment programs in relation to the demand is carried out using the cost of energy not served. For a production mix to be reinforced so as to satisfy a given demand, investment in additional production units is made until the production cost of the last unit is equal to the cost of energy not served. Practically, that adjustment is carried out thanks to the modelling of the electric system: according to the demand increase, the model shows necessary reinforcements year by year so as to respect the chosen value for the cost of energy not served.

It is proposed to adopt, from the year 2010, the same cost of energy not served for the five countries, that is to say the value presently chosen by Kenya: 0.8USD/kWh, KPLC source.

8.1.3.2. PRODUCTION MEANS USING LOCAL RESOURCES

The local resources are gas from Lake Kivu, hydroelectricity and geothermal resources. However, after the latest news received concerning the Kibuye project which is meant to use the Lake Kivu gas, this resource has not been considered in the study period

8.1.3.2.1. *EXISTING OR COMMITTED MEANS AVAILABLE IN 2010*

It results from the above-mentioned supply and demand analysis by country that the planned generation supply for 2010 would be set up in the following way:

Burundi-DRC-Rwanda

	Installed Capacity (MW)	Firm Capacity (MW)	Average generation (GWh)	Firm generation (GWh)
Burundi	27,7	7,6	107	67
RDC (Ruzizi 1)	29,7	11,9	167	105
Rwanda en 2006	26,7	5,0	112	92
Sinelac (Ruzizi 2)	43,8	16,2	219	141
TOTAL	128	41	605	405

In 2010, the foreseen need in these three countries is established at 191 MW and 911 GWh for the middle scenario: these numbers are higher than the available supply. The only way to fill the gap is to install urgent thermal generation of the Diesel-type, like decided for Rwanda (see below).

Uganda

	Installed Capacity (MW)	Firm Capacity (MW)	Average generation (GWh)	Firm generation (GWh)
Nalubaale	180	160	1295	1090
Kiira	200	195		
Mini-Hydro	7,1	0	40	0
Bujagali	200	164	1703	1390
TOTAL	587	519	3038	2480

It is to be noted that following the above-mentioned Bujagali II study which was finished in February 2007 and made available to the Consultant in April, the characteristics of the proposed project have been slightly changed; in particular, a 250 MW installed capacity is proposed and annual generation patterns seem to be slightly lower than the above, although no indication is given on Firm Capacity, Average Generation and Firm Generation. The impact of such changes on the interest of the regional interconnections is very limited; the Consultant believes that such changes only reinforce the need for such interconnections.

Kenya

	Installed Capacity (MW)	Firm Capacity (MW)	Average generation (GWh)	Firm generation (GWh)
Mini-Hydro	28,1	22	102	100
Kindaruma (Hy)	64	51	196	160
Kamburu (Hy)	94,2	75	388	336
Gitaru (Hy)	225	180	860	760
Masinga (Hy)	40	32	195	160
Kiambere (Hy)	184	147	806	576
Turkwel (Hy)	106	85	424	414
Sondu-Miriu (Hy)	80	64	420	336
Olkaria (Geo)	115	100	880	765
Eburru (Geo)	2,5	2	19	15
Olkaria 3,4 (Geo)	70	60	532	456
Eco-Gen (Eol)	30	25	228	190
Ngong (Eol)	0,35	0,3	2	2
TOTAL	**1039**	**843**	**5052***	**4270***

* Preliminary evaluations

8.1.3.2.2. CANDIDATE PROJECTS

Table n° 36 - CANDIDATE PROJECTS B-C-R

	Earlier year	Installed Capacity (MW)	Firm Capacity (MW)	Average generation (GWh)	Firm generation (GWh)
Nyemanga (Hy)	2008	1,7	1,4	4	4
Mpanda (Hy)	2010	10,6	3	29	29
Kabu 16 (Hy)	2013	20	9	117	104
Mule 34 (Hy)	2015	16,5	10,1	147	133
Ruzizi 3 (Hy)	2015	82	47,8	456	293
Rusumo (Hy)	2013	61,5*2/3	30*2/3	403*2/3	308*2/3
Nyabarongo (Hy)	2012	27,5	8,9	148	110
Bendera (Hy)	2012	43	16	160	59
TOTAL		**317**	**116**	**1958**	**937**

Table n° 37 - CANDIDATE PROJECTS UGANDA

	Earlier year	Installed Capacity (MW)	Firm Capacity (MW)	Average generation (GWh)	Firm generation (GWh)
Karuma (Hy)	2014	200	170	1747	1619
Kalagala (Hy)	2016	450	360*	2525	1697
Ayago North (Hy)	2025	304	243*	2624	2624
Ayago South (Hy)	2016	234	187*	2050	2050
Murchison (Hy)	2016	222	222	1773	1773
	2019	420	336*	3679	3679
Mini-Hydro (total)	2012	74	37*	530*	320*
Bagasse (total)	2009	42	36*	294*	294*
TOTAL		**1946**	**1591***	**15222***	**14056***

* Preliminary evaluation

Table n° 38 - CANDIDATE PROJECTS KENYA

	Earlier year	Installed Capacity (MW)	Firm Capacity (MW)	Average generation (GWh)	Firm generation (GWh)
Ewaso Ngiro (Hy)	2014	220	176*	609	448
Mutonga (Hy)	2014	60	48*	293	197
Low Gr. Falls (Hy)	2014	140	112*	715	324
TOTAL		**420**	**336***	**1617**	**969**

8.1.3.3. THERMAL MEANS USING IMPORTED FUELS

The only fuel which is presently consumed is the diesel oil. It should be added to it within a short time, heavy fuel oil, then coal, both of them in Kenya.

8.1.3.3.1. EXISTING OR COMMITTED MEANS AVAILABLE IN 2010

Unit B-C-R

Only Rwanda holds available diesel generators under normal operation. This is not the case for diesel generators of Burundi which in fact correspond to a cold reserve, for perusal of the government and not of REGIDESO. As it is mentioned earlier, the fixed generators are the following (if we exclude the presently hired machines which will be taken down as soon as possible):

POWER PLANT	Year of Commissioning	Installed Capacity (MW)
Gatsata	2005	7,8
Jabana	2005	4,5
New Diesel	2008	20
TOTAL		**32,3 MW**

Uganda

The sole existing thermal power station is that of Aggreko, using diesel generators, that has been installed in 2005 for 3 years. Before the horizon 2010, the following projects should be commissioned, all of them using slow diesel generators with heavy fuel oil (HFO).

POWER PLANT	Year of Commissioning	Installed Capacity (MW)
IPP (Diesel)	2006 (until 2012)	50 MW
Others - World Bank financing	2008-2009	100 MW
TOTAL		**150 MW**

Kenya

The list of thermal power stations (existing and committed up to 2010) may be summarized as follows:

POWER PLANT	Year of Commissioning	Installed Capacity (MW)
Nairobi Fiat GT	1973	13,5 MW
Kipevu GT	1987	60 MW
Kipevu I HFO	1999	73,5 MW
Iberafrica	1997-2000	56,5 MW
Tsavo (Kipevu II)	2001	74 MW
Isolated Diesels	Variable	9,4 MW
Rabai GT	2007	70 MW
MSD (Diesel)	2007	80 MW
Kipevu Combined Cycle	2007	60 MW
TOTAL		**497 MW**

8.1.3.3.2. FUTURE MEANS OF PRODUCTION OR CANDIDATE PROJECTS

Upgrading of thermal power stations after 2010 is planned only in Kenya; it consists of diesel generators burning fuel oil or powers stations using coal for base load operation and gas turbine. For the later ones, the price of fuels is negligible (insignificant) provided their use remains strictly limited to peak load and stand-by.

8.1.4. PRELIMINARY ECONOMIC CLASSIFICATION OF CANDIDATE PROJECTS

Before elaborating sequences of investments which are optimal for each case as defined above, one should proceed to a first classifying of projects on the basis of their cost. This enables to select the best projects in reference to the economic aspect and first, those which use the local resources, in the various sequence of investment, owing to a second criterion, the size of projects in comparison to the demand.

8.1.4.1. PROJECTS USING THE INDIGENOUS RESOURCES

The following table summarizes the main features of the projects with the corresponding costs of the energy produced. We obtain the following order, by rising costs and early commissioning date. The index 100 is assigned to the best project by country or by group of countries.

Table n° 39 - UNIT BURUNDI – DRC – RWANDA

Project	Earlier year of commissioning	Cost cUS$/kWh	Index
Nyemanga	2008	4,5	167
Mpanda	2010	11,1	411
Bendera	2012	4,5	167
Ruzizi 3	2015	2,7	100
Mule 34	2015	3,3	122
Kabu 16	2013	3,9	144
Rusumo Falls	2013	6,2	230
Nyabarongo	2012	7,4	274

The best project on the economic aspect is Ruzizi 3 hydroelectric plant, having a cost of 2.7 cents USD/kWh. For the sake of comparison, the kWh cost of the diesel power stations of the region are amounting to 25.5 cents USD/kWh (including the costs of the fuels identified at the start of 2006) of which 22.5 for the sole variable cost! The cost of un-served energy is estimated at 0.8 USD/kWh.

Table n° 40 - UGANDA

Project	Earlier year of commissioning	Cost cUS$/kWh	Index
Karuma (Hy)	2014	3,0	176
Kalagala (Hy)	2016	2,5	147
Ayago North (Hy)	2025	3,1	165
Ayago South (Hy)	2016	3,1	165
Murchison (Hy)	2016	2,5	147
	2019	1,7	100
Mini-Hydro (total)	2012	5,0	294
Bagasse (total)	2009	4,0	235

Table n° 41 - KENYA

Project	Earlier year of commissioning	Cost cUS$/kWh	Index
Ewaso Ngiro (Hy)	2014	7,8	173
Mutonga (Hy)	2014	7,4	164
Low Gr. Falls (Hy)	2014	6,5	144

8.1.4.2. CANDIDATE THERMAL PROJECTS (KENYA)

We will consider only the base load power stations as taken into account within the planning of the production means of Kenya (source : KPLC). That is to say those using slow or semi-rapid diesel generators using heavy fuel oil (unit capacity of 20 MW), able to be installed near the main zones of consumption and those using steam generators that use coal (unit capacity of 150 MW), installed in the neighbourhood of Mombasa. The following costs are provided for the basic hypothesis of specific costs of fuels.

Project	Earlier year of commissioning	Cost cUS$/kWh	Indice
Diesels	2009	14.3	318
Coal power plant	2012	4.5	100

8.1.5. REFERENCE OPTION: WITHOUT ANY INTERCONNECTION PROJECT

The study of the reference option will be broken down in three parts:

- Least cost expansion plan of electricity production within the whole unit B-C-R, in self – sufficient operation.
- Least cost expansion plan of electricity production in Uganda, with a possibility of exchange of 50 MW as base load (80 MW maximum) with Kenya;

- Least cost expansion plan of electricity production in Kenya, with a possibility of exchanges of 50 MW as base load (80 MW maximum) with Uganda.

The analysis is based on the kWh costs of the candidate power plants and the corresponding thermal plants named "reference" for each system. These costs are based on the best imported thermal option in each system. In order to avoid any confusion with the reference option as defined in the ToR, these thermal plants will be named "Complementary".

The following paragraphs present the way of calculation and the main aspects of each expansion plan listed above. We will proceed in the following way:

- It will be considered each scenario of the demand growth (Low, Reference, High).
- Determination of the priority orders in relation with the costs of the kWh and the peak loads and energies to supply, taking into account the necessary reserves;
- Determination of annual complements to provide in "Complementary" thermal generation ;

The Excel model which has been developed according to the above-mentioned principles, has been run first for each main system considered independently, and the following results have been obtained (here, only the main future generation candidate projects are mentioned; refer to Annex B for details):

B-R-C System

Demand scenario	Medium	Low	High
Nyemanga Hydro	2010	2010	2010
Ruzizi 3	2020	2024	2017
Mule 34	2015	2018	2016
Kabu 16	2013	2016	2013
Bendera	2012	2012	2012
Rusumo Falls	2017	2020	2014
Nyabarongo + Mpanda	2012	2012	2012

In addition, complementary thermal generation means are needed in the short and long terms according to the cases:

Demand scenario	Medium	Low	High
Period	**2010-12**	**2010-12**	**2010-14**
GWh max	198	117	304
MW max	58	39	84
Period	**2022-30**	**2022-30**	**2019-30**
GWh max	1695	689	3343
MW max	447	196	814

Uganda (with existing link to Kenya, limited to 50 MW)

Demand scenario	Medium	Low	High
Bagasse Plants	2010	2010	2010
Karuma Hydro	2014	2019	2014
Mini-Hydro (all)	2012	2015	2012
Kalagala	2019	After	2016
Ayago	After	After	2025
Murchison	2025	After	2021

In addition, complementary thermal generation means are needed in the short and long terms according to the cases:

Demand scenario	Medium	Low	High
GWh max	0	0	0
MW max	212	147	691

A large reserve generation is needed from 2025, mostly in the High Demand Scenario case.

Kenya (with existing link to Uganda)

Demand scenario	Medium	Low	High
300 MW Coal	2010	2010	2010
150 MW Coal Extension	2011	2011	2011
150 MW Coal (Further)	2012	2012	2012
300 MW " "	2014	2014	2013
idem	2016	2017	2015
600 MW Coal (Further)	2018	2019	2017
Idem	2021	2023	2020
Idem	2023	2026	2022
Idem	2026	2028	2024
Idem	2028	2030	2025
Idem	2029	After	2027
2*600 MW " "	After	After	2028

In addition, complementary thermal generation as described before will be needed throughout the whole planning period, from 89 MW (Medium demand), 40 MW (Low demand), and 151 MW (High demand) in 2010, to 568 MW, 416 MW and 745 MW respectively in 2030. Most of these means should be of the peak load type, plus reserve means in base and peak load.

It is to be noted that only in case of low demands in both Uganda and Kenya, there is an over-capacity in Uganda after the commissioning of Bujagali power station, and the existing interconnection can be used at full capacity (for normal hydrological years).

8.1.6. ANALYSIS OF ALTERNATIVE 1 INTERCONNECTIONS

8.1.6.1. POWER GENERATION AND EXCHANGES

This analysis assumes limited interconnection exchanges as defined above. A lot of interconnection set-ups are possible, as indicated in the description given further below. In order to simplify the analysis, and based on the real exchange possibilities in the short and medium terms, the following exchange capabilities have been considered:

Rwanda-Uganda

From 2010 to 2011: 20 MW

From 2012 to 2020: 50 MW

From 2021 onwards: 150 MW

Uganda-Kenya

From 2010 to 2013: 50 MW (no additional capacity over the existing one)

From 2013 onwards: 150 MW (50 MW existing plus 100 MW new)

In emergency cases, it can be possible to transmit more power for a limited time. However, as a conservative assumption the above-mentioned capacities shall be considered, with a maximum use of 8000 hours per annum, or about 90% of the time.

The main underlying assumptions for the generation development plans are that several key future generation means should be available at certain key dates. This is described in detail in the general description of the methodology for the economic evaluation, but the most important ones are the following:

- Karuma Hydropower station (Uganda): 2013
- Ruzizi 3 Hydro (Congo DR, Rwanda, Burundi): 2015

8.1.6.2. POWER GENERATION PLAN FOR THE 3 SYSTEMS INTERCONNECTED

With the above-mentioned assumptions, it is possible to exchange limited amounts of energy between the various systems. Using the above-mentioned Excel evaluation model, the Consultant could determine the power generation expansion plan which makes the best possible use of the interconnection capacities. The same method has been used as described before, considering energy exports like additional demands in the exporting counties, and energy imports like additional power stations. When, in a given year, there is not enough available energy from new candidate power stations, and important amounts of energy are needed from complementary thermal power stations, the exchanges through the interconnections have been reduced to zero.

The following main results have been obtained (for more details refer to Annex B enclosure 1: Load Forecast per country).

B-R-C System

Demand scenario	Medium	Low	High
Nyemanga Hydro	2010	2010	2010
Ruzizi 3	2016	2016	2015
Mule 34	2019	2022	2018
Kabu 16	2013	2021	2013
Bendera	2012	2023	2012
Rusumo Falls	2021	2025	2013
Nyabarongo + Mpanda	2012	2012	2012

In addition, complementary thermal generation means are needed in the short and long terms according to the cases:

Demand scenario	Medium	Low	High
Period	**2010-12**	**2010-14**	**2010-13**
GWh max	198	0	304
MW max	38	19	64
Period	**2027-30**	**2027-30**	**2020-30**
GWh max	495	0	2143
MW max	297	63	664

The availability of excess energy from the new hydropower stations, allows for limited exports towards Uganda (and Kenya, as can be seen further below) for periods depending on the demand of each country. For the medium demand scenario, it is possible to export up to 50 MW and 273 GWh each year from 2012 to 2019 included. For the low demand scenario, limited imports are considered due to excess capacity available in Uganda; and for the high demand scenario, exports are possible from 2013 to 2018, and then it is necessary to continuously import energy from Uganda and its large hydropower plants, and rely from important complementary generation, either from local thermal plants or from Tanzania (see below).

Uganda

Demand scenario	Medium	Low	High
Bagasse Plants	2010	2010	2010
Karuma Hydro	2014	2014	2014
Mini-Hydro (all)	2012	2014	2012
Kalagala	2018	2027	2016
Ayago	2029	After	2023
Murchison	2024	After	2020

From 2010 to 2013, the energy exported to Kenya flows through the existing interconnection. After 2013, when new large hydro like Karuma and Kalagala can be available in Uganda, then it is possible to continuously export 150 MW and 1200 GWh almost each year to Kenya, and this at least until 2030 (with the exception of the high demand scenario from 2028).

In addition, complementary thermal peak generation means are needed in the short and long terms according to the cases:

Demand scenario	**Medium**	**Low**	**High**
Period	**2010-21**	**2010-21**	**2010-21**
GWh max	0	0	215
MW max	79	0	156
Period	**2022-30**	**2022-30**	**2022-30**
GWh max	165	362	780
MW max	255	152	841

Important peak load and reserve generation means are needed in the long term, since most of the hydropower generation is base load and supplies the whole base load means of Uganda, while surpluses are used for base loas exports to Kenya.

Kenya

Demand scenario	**Medium**	**Low**	**High**
300 MW Coal	2010	2010	2010
150 MW Coal Extension	2011	2011	2011
150 MW Coal (Further)	2012	2013	2012
300 MW “ “	2014	2015	2013
idem	2017	2018	2015
600 MW Coal (Further)	2018	2020	2017
Idem	2021	2023	2020
Idem	2024	2026	2022
Idem	2026	2029	2024
Idem	2028	After	2025
Idem	2030	After	2027
2*600 MW “ “	After	After	2028-30

It is easy to note that the results in terms of new units and commissioning dates are very similar to those of the reference solution for Kenya. The main difference lies in the generated energy, which is reduced each year by up to 1200 GWh (after 2013). This is due to the fact that the method applied for this evaluation cannot take precisely into account the reserve needs of the systems, in particular in case of interconnection. .

In addition, complementary thermal generation is also needed in the case of Alternative 1; the needs in terms of installed capacities and generated energies are constantly lower than in the reference option.

8.1.7. ANALYSIS OF ALTERNATIVE 2 INTERCONNECTION

8.1.7.1. POWER GENERATION AND EXCHANGES

Alternative 2 analysis assumes the following exchange capabilities:

Rwanda-Uganda

From 2010 to 2014: 20 MW to 50 MW

From 2015 onwards: 100 MW to 200 MW

Uganda-Kenya

From 2010 to 2011: 50 MW (no additional capacity over the existing one)

From 2012 onwards: 100 to 300 MW (50 MW existing plus 50 to 250 MW new capacity)

Here again, as a conservative assumption the above-mentioned capacities shall be considered, with a maximum use of 8000 hours per annum, or about 90% of the time.

The main underlying assumptions for the generation development plans are the same as for Alternative 1.

8.1.7.2. POWER GENERATION PLAN FOR THE 3 SYSTEMS INTERCONNECTED

Using exactly the same method as explained before with Alternative 1 analysis, the following main results have been obtained (for more details refer to Annex B: Load Forecast per country):

B-R-C System

Demand scenario	**Medium**	**Low**	**High**
Nyemanga Hydro	2010	2010	2010
Ruzizi 3	2015	2015	2015
Mule 34	2015	2015	2015
Kabu 16	2013	2013	2013
Bendera	2012(	2012	2012
Rusumo Falls	2013	2013	2013
Nyabarongo + Mpanda	2010	2010	2010

In addition, complementary thermal generation means are needed in the short and long terms according to the cases:

Demand scenario	**Medium**	**Low**	**High**
Period	**2010-12**	**2010-12**	**2010-12**
GWh max	198	0	304
MW max	38	19	64
Period	**2017-30**	**2020-30**	**2017-30**
GWh max	95	0	1743
MW max	247	63	614

Until 2012, the lack of major hydro power plants in the B-R-C system (and also in Uganda) does not allow for important exchanges in the Rwanda-Uganda interconnection. Starting from 2013, the presence of several important power stations, in particular Rusumo Falls and Ruzizi 3 allows for several years of continuous exports towards Uganda, which in turn can export to Kenya. For the medium demand scenario, it is possible to export from the B-R-C system, 50 to 100 MW and 200 to 800 GWh each year from 2013 to 2020 included, while 100 MW to 200 MW and 400 to 1600 GWh will have to be imported each year from 2024 onwards.

For the low demand scenario, exports in variable amounts are possible from 2012 to 2025 and for the high demand scenario, exports are possible from 2013 to 2018, and then it is necessary to continuously import energy from Uganda and its large hydropower plants, and rely from important complementary generation, either from local thermal plants or from Tanzania (see below).

Uganda

Demand scenario	**Medium**	**Low**	**High**
Bagasse Plants	2010	2010	2010
Karuma Hydro	2014	2014	2014
Mini-Hydro (all)	2012	2012	2012
Kalagala	2016	2021	2016
Ayago	2027	After	2023
Murchison	2022	After	2018

In a first phase, which runs up to 2011, 2012 or 2013 according to the demand scenarios, the existing interconnection between Uganda and Kenya can allow for limited exports from the Ugandan system. After that, when new large hydro like Karuma and Kalagala can be available in Uganda, then it is possible to continuously export up to 300 MW and 2400 GWh each year to Kenya, and this at least until 2030 (with the exception of the high demand scenario).

In addition, complementary thermal generation means are needed in the short and long terms according to the cases:

Demand scenario	**Medium**	**Low**	**High**
GWh max	0	0	400
MW max	221	47	891

Important reserve generation is needed from 2026, mostly in the High Demand Scenario case (more than 200 MW, growing up each year.

Kenya

Demand scenario	**Medium**	**Low**	**High**
300 MW Coal	2010	2010	2010
150 MW Coal Extension	2011	2011	2011
150 MW Coal (Further)	2012	2015	2012
300 MW " "	2015	2016	2013
idem	2017	2018	2016
600 MW Coal (Further)	2018	2020	2018
Idem	2021	2023	2020
Idem	2024	2026	2022
Idem	2026	2029	2024
Idem	2028	After	2024
Idem	2030	After	2027
2*600 MW " "	After	After	2030

Here again, the main difference between Alternative 2 and the reference solution lies in the generated energy, which is reduced each year by up to 2400 GWh (after 2013).

In addition, complementary thermal generation is also needed in the case of Option 2; the needs in terms of installed capacities and generated energies are constantly lower than in the reference solution.

8.2. PROPOSED POWER TRANSIT CAPABILITIES FOR FUTURE INTERCONNECTIONS

Due to the high number of possible transit alternatives, which derive from an even higher number of combinations between available power stations and demand growth scenarios, it has been necessary to simplify the problem by fixing a development strategy for each considered alternative. The economic and financial analysis will then be considering two main transfer alternatives with a fixed investment schedule.

The selected transit capacities are mainly based on the expected generation development corresponding to the medium demand scenario; slight adjustments can be applied according to the countries' possible demand growth and generation investment variations. These transit capabilities shall define the different interconnection configurations to be considered in the network analysis and the economic and financial analyses, in terms of:

- Line voltages and characteristics (number of circuits and conductor size in particular);
- Substation voltages and transformer capacities.

This information will in turn be used in order to determine the corresponding investment amounts and schedule, and corresponding operation and maintenance costs.

The following transit capacities (MW) have then been considered (minimal values):

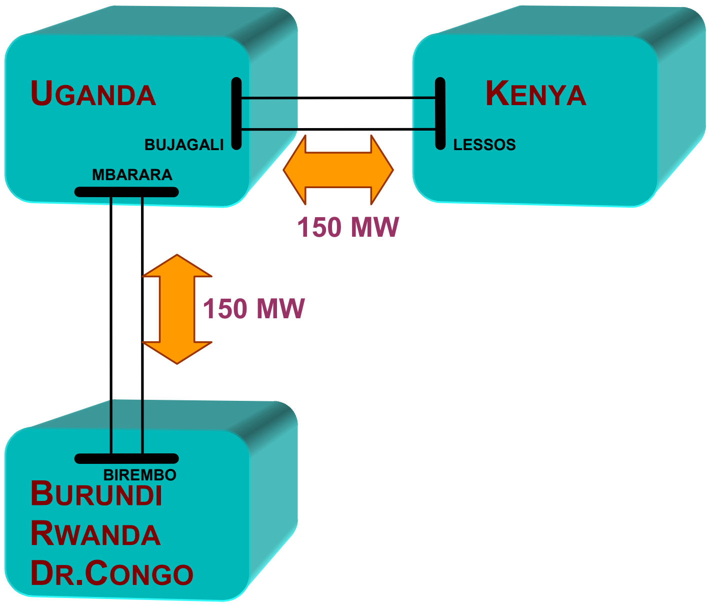
Table n° 42 - POWER TRANSIT CAPACITIES (INCLUDING EXISTING LINK)

Years	Alternative 1		Alternative 2	
	RWA-UGA	UGA-KEN	RWA-UGA	UGA-KEN
2010-11	20	50*	20	50*
2012-13	50	50*	50	100
2014	50	150	50	300
2015-20	50	150	100	300
2021	150	150	100	300
2022-24	150	150	150	300
2025-30	150	150	200	300

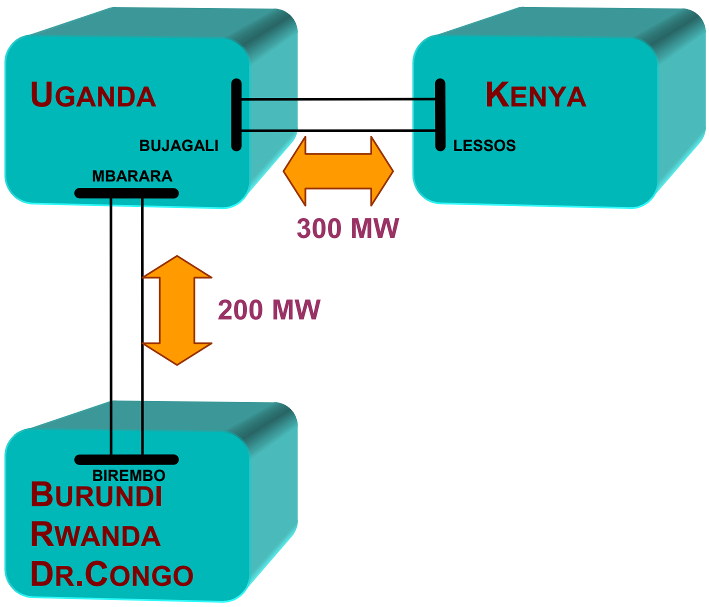
*Existing

The diagrams below represent the power capacities beetween Uganda and Kenya and between Uganda and Rwanda, for the Alternative 1 and the Alternative 2 for the years 2025-2030.

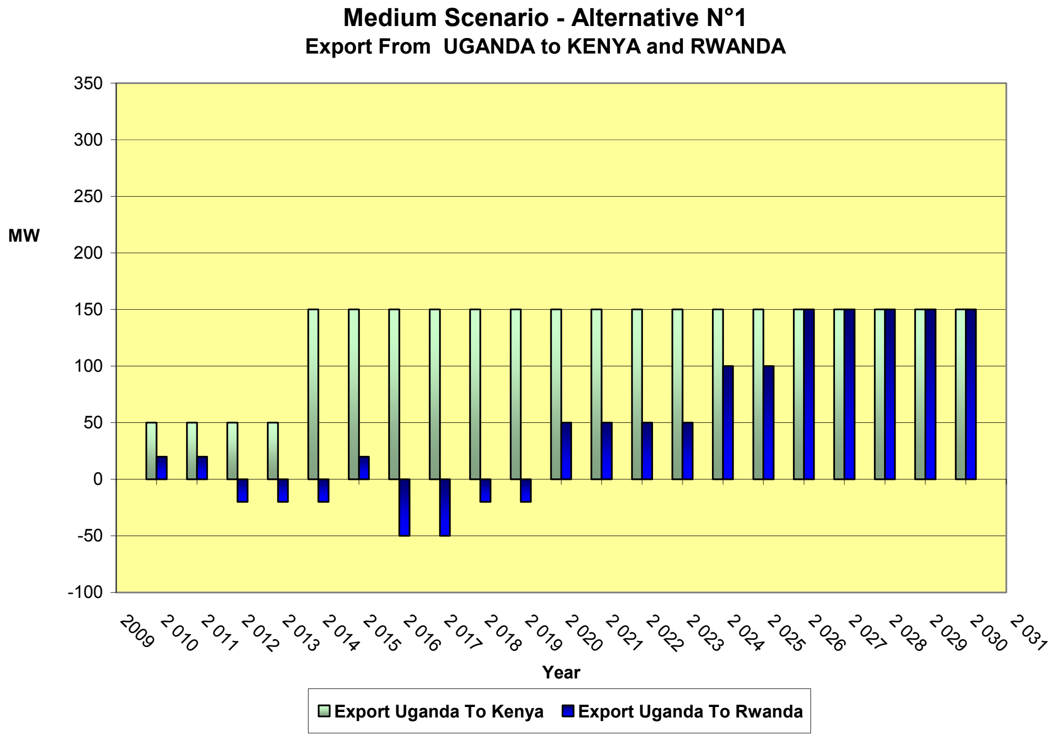
POWER TRANSIT CAPACITIES
ALTERNATIVE N°1

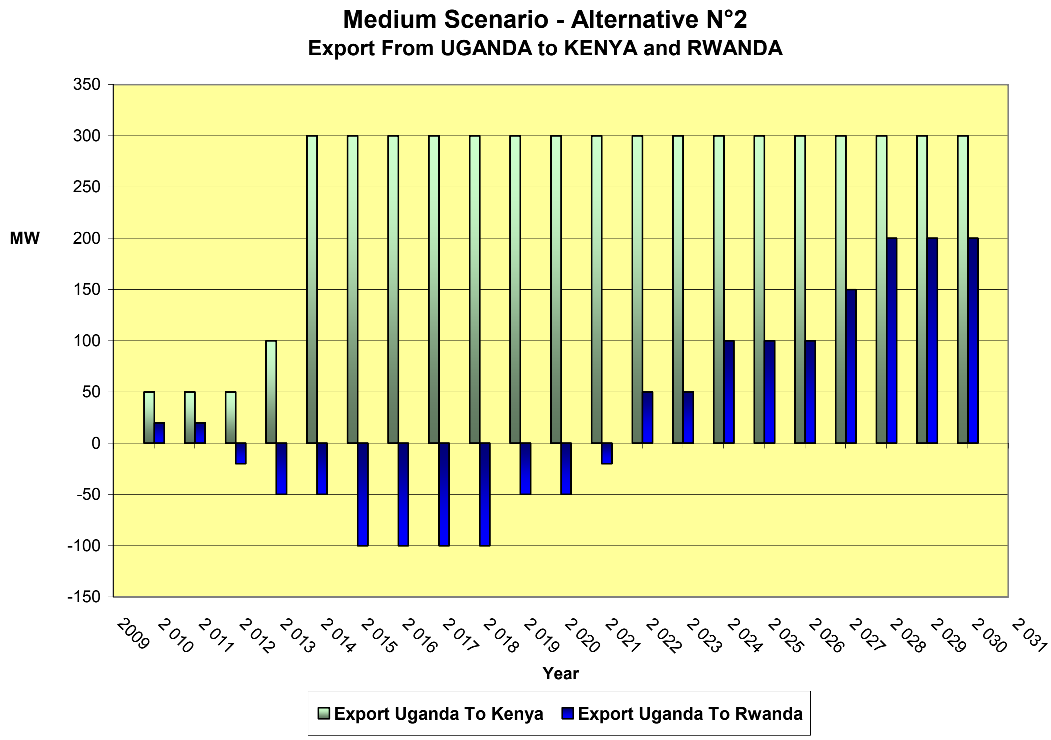


POWER TRANSIT CAPACITIES
ALTERNATIVE N°2



The curves below represent the power transits beetween Uganda and Kenya and between Uganda and Rwanda, for the Alternative 1 and the Alternative 2 (from 2005 until 2030)





ANNEX A: ELECTRICAL INTERNATIONAL STRUCTURES AND ORGANIZATIONS

1. ANNEX A – ELECTRICAL INTERNATIONAL STRUCTURES AND ORGANIZATIONS

1.1. INTRODUCTION

In addition to the NBI and NELSAP, the electric networks concerned by the study are part of various structures and international organizations, mainly:

- The Uganda-Kenya interconnected network
- The EGL interconnected network
- SINELAC
- CEPGL
- CAPP
- EAPP
- UPDEA
- AFSEC

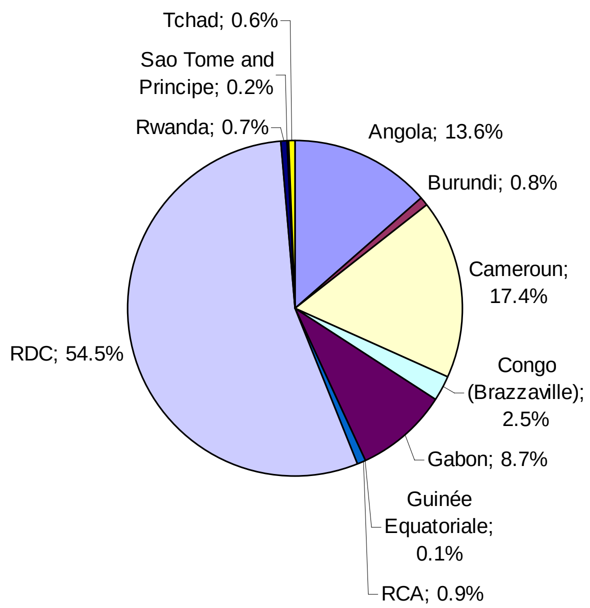
This annex presents the main data and characteristics of these structures and organisations which are useful to the study of the electrical interconnections of the Nile equatorial lake countries. Also is included a presentation of the electricity sector of Tanzania, country member of NELSAP.

1.2. PEAC

Although very rich in energy resources, Central Africa is characterized by low electrification rate and very moderate electricity consumption. The power sector within PEAC is the less developed in the whole Africa In a view of making up this shortcoming, the member countries set up in April 2004 the Central Africa Power Pool (PEAC), as a specialized organization of the CEEAC. The PEAC is in charge of the regional energy policy, of the development of the community infrastructures and of the management of the energy exchange activities over all the central African countries.

At the end, the PEAC will form a regional market for the exchange of electricity, operating according to pre-established technical-commercial rules. At the moment, the Permanent Secretary of the PEAC, the head office of which is in Brazzaville (Congo), is in charge of CAPP institutional development and the definition of its action programmes.

In 2002, the total generation capacity of the PEAC was 4647 MW, shared between member countries as follows:



The purpose of the PEAC is to play a large part in setting up favourable conditions for the forming of a regional electricity market. This market would meet the electricity need of the industries and populations by supplying reliable and cheap electricity, supporting the economical and social development of the region together while respecting environment.

The first master plan of the PEAC for the power market development within the Central Africa region (2005-2025) was issued in 2005 by PA Consulting Group on behalf of USAID. The final report which was issued in January 2006 shows that, for the countries members of NELSAP, DRC, Burundi and Rwanda, the plan only envisage a cooperation concerning the Ruzizi by 2015. Concerning 2025, it may be one connexion of these countries to other systems via import/export with EAPP (East African Power Pool). Obviously, the interconnection of the Kivu area network with the main CDR network is not on the agenda.

1.3. EAPP

The East African countries members of the COMESA and of the Nile Basin Initiative, Burundi, Kenya, Rwanda, Ethiopia, Tanzania, DRC and Uganda plus Egypt and Sudan signed in February 2005 an understanding agreement concerning the sharing, at a regional level, of the generation plants, the EAPP (East African Power Pool). The purpose of the EAPP is to channel the region energy resources in order to set up a frame facilitating the electricity exchange between members.

The EAPP is the last created power pool of sub-Saharan Africa. It is partly based on the works of the East African Federation which made an energy development plan in 2004. The main characteristics of the networks of the region and of its future interconnections are the very long and weak transmission lines.

Two projects to be financed by the African Development Bank should be mentioned:

- Zambie – Tanzanie – Kenya,
- Ethiopie – Kenya.

1.4. EGL

EGL has its origins in a non-profit association named « Association pour l'étude de l'électrification de la région des Grands Lacs », in abbreviated form EGL, created on 20th August 1974 by the 3 countries, Burundi, Rwanda and Zaïre.

On 29th March 1980 this association was integrated to CEPGL and re-named « l'Organisation de la CEPGL pour l'énergie des pays des Grands Lacs », in abbreviated form, EGL. The head office of the Organization is in Bujumbura.

The purpose and functions of the Organization are described in the Article 3 and 4 of the EGL's statutes which are reminded here after.

The purpose of the Organization is to ensure co-operation between member countries in the field of energy in all forms. As far as specific projects are concerned, the Organization role depends on whether the projects are national or regional ones:

- For national projects, the Organization will collect all data useful and sufficient on the projects, inform, and possibly advise member countries so that they can coordinate the exploitation policy of their national energy resources within the Community.
- For regional projects, the Organization will be the developer of the study and of the implementation of these projects.

To reach its objectives the Organization will carry out the following duties:

- Carry out the inventory of energy resources and the analysis of all problems related to generation, transmission and the distribution between member countries of the CEPGL.
- Carry out feasibility studies and implementation studies concerning new energy resources.
- Supply the member countries with study results and suveys in the various fields of the energy industry.
- Keep relationships with national and international organizations dealing with interconnection studies, economic, scientific, professional training or other issues which may be of interest for the Community in the field of energy.
- Initiate and continue all international measure which may be of interest for the Community and improve the means of generation, transmission and distribution of electricity within the member countries.
- Study the evolution of the energy demand in the Great Lakes Region and look for solutions allowing the making of the investments necessary for the achievement of its purpose.
- Cooperate with member countries for the rational use of their energy resources in order that their economies are more and more complementary with a view to the economic integration of the Region countries and to start an harmonious growth to their intra-regional industries.

1.5. SINELAC

1.5.1. GENERAL PRÉSENTATION

The SINELAC, Société Internationale d'Electricité des Pays des Grands-Lacs (International Electricity Company of the great lakes countries) was created in November 1983. It is a public establishment under international law with the form of a company and status of a legal entity. It is governed by an agreement between the Republics of Burundi, Rwanda and Democratic Congo. Each of these three countries own 1/3 of the issued capital of the SINELAC.

The SINELAC purpose is the implementation and the operation of the hydro power plant Ruzizi II and its outbuildings together with the marketing of the energy generated by this plant. The head office of the company is in Bukavu.

1.5.2. RUZIZI II

The Rusizi 2 project was commissioned in May 1989 by SINELAC. It is located at some kilometres downstream of the Rusizi 1 power plant. It is the second step of power equipment installations on the Rusizi River and is mainly made of a 33-meter long dam with 2 radial gate spillways and one water intake, a hydraulic canal and a power plant.

The power plant is composed of 3 Francis turbine of 14.6 MW running under a 28.5 m head. Two units are in service since 1989. The third unit was commissioned at the end of 2001. Even if its influence on the power plant producible power is modest, it considerably improves the power plant reliability. This third unit was exclusively financed by SINELAC (Regideso and Electrogaz lend money to SNEL which will pay them back in the form of electricity from Ruzizi I).

The evaluation of Ruzizi II power plant energy production raises the same problem as the case of Ruzizi I power plant with an additional complication due to the fact that the reservoir capacity of Ruzizi II is very small. The result is that Ruzizi II has to rely on Ruzizi I water releases (by turbine or water spilling). In case of coordinated functioning of the two power plants in cascade, the producible power would be 220 GWh on basis of 1981-1989 flows and it would only be 141 GWh on basis of flows prior to 1960. It is this low assumption that is retained and it gives a 47 GWh quota for each of the 3 countries, Burundi, RDC and Rwanda. From 1990 to 1999, the power plant production ranged between 114.2 GWh and 179 GWh with an average of 128.1 GWh.

In case of the high assumption, the third unit is necessary if we want the power plant to operate with the plant factor of 0.6 corresponding to the daily load curve of the network. In fact, 220 GWh correspond to permanent power of 25MW that is say, slightly inferior to the present power which is installed, with this power limitation, the functioning with the 0.6 charge factor only permits to use 150 GWh out of 220 GWh. On the other hand, we may also get the 220 GWh with a base operation; in this case, two units are enough. It is predictable that the third unit will practically be used as an emergency unit.

For the present study, and taking the very low level of Lake Kivu into account, we use the value of 141 GWh/year as Ruzizi II average energy, with a guaranteed capacity of 16.1 MW; that is a quota of 47 GWh being given to each of the 3 member countries.

The selling price of electricity from Ruzizi II is 55.29 DTS/MWh, which is rate of 1050 FBU per DTS, 58.05 FBU/kWh starting from the power plant. It is convenient to add 5% to this for losses in line.

A combined exploitation of the two power plants, Ruzizi I and 2 must absolutely be set up in the short run for the better management of Lake Kivu level which is presently very low. It is also to be added that, even if the two power plants are interconnected to Mururu 2 substation the lack of energy meters results in the fact that the electricity, produced by Ruzizi I which passes in transit through that substation, is sold in the same way as the electricity from Ruzizi II, at high price then.

1.6. FUTURE HYDROPOWER PLANTS

1.6.1. RUZIZI 3

This community development, whose project was launched by the EGL, would be located on the Rusizi, at around 8Km downstream of Rusizi 2.

A pre-feasibility study was carried out by Tractebel in 1992 in the frame of the Regional Master Plan for Energy Development, the site being named RD2.

The proposed scheme comprises:

- **Dam**: height 20 m, crest length 135 m, active capacity of the reservoir 500 000 m^3 . It consists of two parts, right bank one concrete structure for the spillway and bottom outlet, left bank one earth fill or rock fill dyke. The maximum water level is 1093.50.
- **Water way**: it consists of one water intake near the spillway, one 6 m diameter tunnel, 840 m long, one surge chimney and one 5.4 m diameter penstock, 160 m long.
- **Power plant**: located at elevation 1020, for an average net head of 61 m. The nominal discharge is 158 m^3/s through 3 Francis turbines totalling 82 MW. The guaranteed capacity is 47.8 MW and the average production is 456 GWh.
- **Connection to the grid**: it includes one 110 kV plant substation and one 110 kV transmission line, 23 km long between the plant and Mururu 2 substation where one bay will be added.

The total project cost is 86.5 MUSD which includes the access roads, the operators' camp, the study and supervision costs, the doubling of the line between Mururu 2 and Bubanza substation.

Based on a normal process, feasibility, detail study and Tender documents, the earliest possible year for the commissioning is 2015.

It is worth noting that EGL has identified an alternative site for the development of this project, named SISI 5, with a potential development of up to 205 MW of installed capacity and 1030 GWh of annual firm energy. A pre-feasibility study is foreseen by EGL as soon as possible (Minutes of 23rd meeting of EGL Board, Bukavu, 23-24/12/2005).

1.6.2. RUSUMO FALLS

The Rusumo Falls Hydroelectric Project was initially identified under the work programme of the Organization for the Management and the Development of the Kagera River Basin (KBO) and then, by the Nile Equatorial Lakes riparian countries (Burundi, Rwanda and Tanzania) as a component of the NELSAP. The most recent studies by Tractebel in 1992 proposed a dam 13 m high located at the border between Rwanda and Tanzania. It creates a reservoir of 850 Mm^3 live capacity extending in both Burundian and Rwandan territories. The water intake, the power tunnels, powerhouse and switchyard would be located on the right bank of the river, all in Tanzanian territory. Transmission lines to Rwinkwavu in Rwanda (60 km, 110 kV), Gitega in Burundi (165 km, 110 kV) and Mwanza in Tanzania (340 km, 220 kV) would link the plant to the interconnected grids.

In 2003 Acres International Limited of Canada was retained by the World Bank to perform the review of existing documents of the project. The primary objective of this assignment was to assess the available information and studies in order to determine next steps in preparing the project.

NELSAP is presently preparing the terms of references for the detailed feasibility study of the Rusumo hydroelectric project. The earliest date for operation is 2015.

The main features of the Rusumo falls scheme are the following:

Location	On successive concentrated falls of the Kagera river where this river demarcates the border between Rwanda and Tanzania.
Reservoir	Useful capacity: 850Mm3
Dam	Dam with central gated spillway (51.50m with 4gates, part of right bank being concrete) and part of the left bank rock fill (21m), height 13m, total length being in crest 124 m
Water way	Water intake of 23mx13m, inlet tunnel diameter 8.5m of 460m of length and penstock (3parts) diameter 4.5m, 45m long. Surge tank diameter 40m of 17m with a pit diameter 8m of 22m.
Power station	A superstructure power station (reinforced concrete) installed within a deep excavation against the rock at the tunnel outlet comprising three Francis turbine units of 20.5 MW
HV Substation	220/110/33 kV
Transmission lines	60Km towards Rwanda, 165Km towards Burundi and 496 Km towards Tanzania.
Gross head	About 35 m
Rated flow	-
Installed power	61.5 MW
Guaranteed annual Energy	308 GWh
Average power released to the network	46 MW
Average annual production	403 GWh
Total cost based 1995	168.5 MUSD

It is contemplated that the hydroelectric power station would supply power to Burundi and Rwanda by way of 110 kV transmission lines and Tanzania by way of 220 kV transmission line. Each country would be entitled to an equal share of the station's output.

1.7. TANZANIA POWER SECTOR

None of the interconnection projects, subject of the present study, is directly linked with the Tanzania grid. However this country is part of NELSAP and its main grid will be soon interconnected to the other NELSAP grids either by the Arusha-Nairobi interconnection or by the transmission lines associated with the Rusumo Falls project. A short presentation of the Tanzania Power Sector was therefore added to this regional overview.

1.7.1. GENERAL PRESENTATION OF TANZANIA

Tanzania is a large country, rich in natural resources. It has enjoyed a stable political climate. The move towards more market-driven economics away from the social vision of the founding president, Julius Nyerere, is more or less confirmed, and has been deepened by President Mkapa and his ruling CCM party over the past five years.

Tanzania's population was estimated at 37 million in 2004 and the country is sparsely populated (37 inhabitants/km2). Population growth is relatively high (2% annual growth in 2002) as is the fertility rate (5% in 2002). The bulk of the population (76%) lives in rural areas but the urbanization rate is among the highest in the world.

The Gross Annual Income has grown at an annual rate of about 5% since 2000, and encouraging future development prospects are driven by expected strong export revenues in both the agricultural and mining sectors, and especially in the gold mining and oil and gas sub-sectors.

1.7.2. ORGANIZATION OF THE ELECTRICITY SECTOR

The main legislation and regulation relative to electricity sector management and development in Tanzania consists of the Electricity Ordinance of 1957 - CAP 131. It covers:

- Setting of electricity tariffs;
- The obligation to supply electricity to outlying areas;
- The delivery of subsidies to vulnerable and low income groups;
- Expropriation; and
- The exportation of Electricity.

Following the adoption of the National Energy Policy, new framework legislation for the electricity sector will replace the Electricity Ordinance.

TANESCO is the sole vertically integrated electricity supplier in Tanzania. The following summarizes the legal framework of the company.

- It is incorporated under Company Ordinance-CAP 212;
- It has the attributes of a private company;
- Company Ordinance-CAP 212 sets out TANESCO's obligations with regard to financial and environmental reporting; and
- Since 1931, the Government has been its single shareholder.

The generation segment is opened to independent production and there are presently three independent power producers (IPPs) that also supply power to Tanesco. Tanzania also imports electricity through cross-border interconnections of about 10 MW and 5 MW from Uganda (to feed Bukoba town and surroundings) and Zambia, respectively. The Ministry of Energy and Minerals is the institution responsible for performing the regulatory powers over the power sector. An Energy and Water Utilities Regulatory Authority Act (Act No. 11) was adopted in June 2001, but is not yet in force.

1.7.2.1. GENERATION

TANESCO's generation system consists of hydro, thermal and gas. Hydro contributes the lion's share of TANESCO's power generation. The total generation from TANESCO own sources in 2003 was 2,662,027,682 kWh out of which 2,551,416,842 is from hydro power stations.

TANESCO operates an interconnected grid system comprising of hydropower generating stations. The installed capacity are: Kidatu 204 MW; Kihansi 180 MW; Mtera 80 MW; Pangani 68 MW; Hale 21 MW; and Nyumba ya Mungu 8 MW totaling to 561 MW of hydro generation.

There are several diesel generating stations connected to the national grid in Dar es Salaam, Mwanza, Tabora, Dodoma, Musoma and Mbeya. These have installed capacity of 80 MW but they effectively contribute about 35 MW due to running problems. Some regions, districts and townships are dependent on isolated diesel – run generators (Kigoma, Mtwara, Lindi, Njombe, Mafia, Mpanda, Tunduru, Songea, Liwale, Ikwiriri, Masasi and Kilwa Masoko). These have installed capacity of 31 MW but they effectively contribute about 15 MW due to aged machinery and lack of spare parts.

Two private independent power projects (IPP's) which are connected to TANESCO grid are IPTL (Independent Power Tanzania Ltd) with 100 MW installed capacity and SONGAS (Songo Songo gas – to electricity project) which by the end of 2004 had 120 MW capacity although more gas turbines were planned to be installed to increase the capacity to 200 MW before the end of year 2005. TANESCO also imports 10 MW of electric power for Kagera Region (Bukoba mainly) from Masaka substation in Uganda while Sumbawanga, Tunduma and Mbozi districts receive about 3 MW from neighbouring Zambia. Bulk supply of electricity is made to Zanzibar from Ras Kilomoni substation at the Indian Ocean coast in Dar es Salaam.

1.7.2.2. TRANSMISSION

The output from the generating plants is transmitted and distributed to mainland Tanzania with the following facilities:

- 2,986 Kilometres of 220 kV transmission line;
- 1,971 km of 132 kV lines;
- 554 km of 66 kV lines;

1.7.2.3. MASTER PLAN

The first power system master plan was drawn up in 1980 followed by another one in 1985 and the latest one in 1999, which is updated annually. Some of the projects recommended in the SPMP include:

Project	Year	Cost in MUSD
Conversion of IPTL diesel units to gas	2006	12.3
Installation of 4x60 MW GT + 2x60 MW ST	2008	
Zambia – Tanzania (200 MW) interconnector	2010	168.10
Ruhudji hydropower (358 MW)	2014	400.63
Mchuchuma Coal fired plant (400 MW)	2012	378
Rusumo Falls hydropower (61,5 MW / 3)	2015	168 / 3
Rumakali hydropower (222 MW)	2016	338.16

1.7.2.4. INTERCONNECTIONS

TANESCO actively cooperates with various Governments and other Power Utility bodies, in order to enhance power development in the country. The following are the major areas of cooperation:

SAPP: The Southern African Power Pool was created in 1995 by electricity utilities in 12 countries of the SADC region as an effort to pool their electricity-supply resources for their mutual benefit. The main goals of the SAPP are coordination and cooperation in the planning and operation of the various systems to minimize costs while maintaining reliability, and the equitable sharing of the resulting benefits. The SAPP Co-ordination centre is based in Harare, Zimbabwe. Some of the SAPP project include Zambia-Tanzania-Kenya interconnection, Malawi-Mozambique interconnection and DRC-Zambia interconnection. Most SAPP utilities recorded a positive demand growth of about 3% attributed to positive economic growth in most member countries.

Nile Basin Regional Power Trade Project: This proposal for a Nile Basin Regional Power Trade Project has been developed under the Shared Vision Program (SVP) of the Nile Basin Initiative (NBI). The project aims to establish the institutional means to coordinate the development of regional power markets among the Nile Basin countries and build analytical capacity and provide technical infrastructure to manage Nile Basin resources in development through equitable utilization of and benefit from the common Nile Basin water resources. The Dar es Salaam Declaration on Regional Electric Power Trade was signed on 20th May, 2003.

NELSAP: The Nile Equatorial Lakes- Subsidiary Action Program NELSAP Power Development and Trade projection aims at development of infrastructure consisting of small scale hydropower development in critical areas, and strengthening transmission interconnections between several countries in the NELSAP region (Burundi, DRC, Kenya, Rwanda, Tanzania and Uganda).

East African Regional Power Plan: East Africa, as a region, possesses adequate energy resources for her development. Under the auspices of the East African Community, the East African Power Master Plan Study is being carried out to define the least cost expansion programme for the development of combined power generation system for Kenya, Uganda and Tanzania.

TANESCO also participates fully in the East Africa Community Energy Committee whose major objective is to prepare the East Africa Power Master Plan and the Energy Committee for the proposed Zambia –Tanzania- Kenya interconnection.

There are also plans to set an Eastern Africa Power Pool (EAPP) whose objective is to set a framework for power exchanges between utilities of the member states.

1.8. NORMALIZATION AND STANDARDS

At the African level, there are no regulations or recommendations yet. Nevertheless, it is to be noted that, among the UPDEA (Union of Producers, Transporters and Distributors of Electric Power in Africa) study committees, the study committee n°4 is in charge of normalization. It is composed of 2 working groups whose topics have been mentioned at the time of the UPDEA scientific committee meeting (15-17 February 2006 in Nairobi):

- Group n° 1: support to the setting-up of the AFSEC (African Electrotechnical Standardization Commission);
- Group n° 2: setting up standards for AFSEC.

It is also to be noted that IEC is one of the stake holders of AFSEC. This is an indication that future AFSEC standardization will at least be partly based on IEC recommendations.

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ANNEX B: LOAD FORECAST PER COUNTRIES

BURUNDI	2005	2010	2015	2020	Average growth	Elasticities
LOW GROWTH SCENARIO	3,6%	3,0%	2,5%	2,0%	2,8%	
Total Population	7,5	8,8	10,1	11,3	2,8%	
Urban Pop.	0,5	0,6	0,8	1,0	5,0%	
Rural Pop.	7	8,2	9,3	10,3	2,6%	
Electrification Ratio	1,8%	2,6%	4,7%	6,4%	8,8%	
Urban	25,6%	30,0%	35,0%	40,0%	3,0%	
Rural	0,1%	0,5%	2,0%	3,0%	25,5%	
GDP Growth	4%	4%	4%	4%	4%	
Number of Consumers	27000	46472	94168	144675	11,8%	
Urban	25600	38288	57011	83157	8,2%	
Rural	1400	8184	37156	61518	28,7%	
Average Consumption	1695	1487	1279	1297	-1,8%	1,4
Urban	1760	1682	1685	1699	-0,2%	
Rural	500	573	656	752	2,8%	
Domestic Energy Demand	45,8	69,1	120,5	187,6	9,9%	
Commercial Energy Demand	32,7	42,9	56,4	74,0	5,6%	1,4
Industrial Energy Demand	52,3	68,7	90,2	118,4	5,6%	1,4
Energy Losses	27%	26%	20%	16%		
Total Energy Demand	180	244	334	452	6,3%	
Potential peak load MW	35	47	65	88		

PRE-FS Values

Energy Demand	180	244	333	453	6.4%
Peak Load	35	48	65	80	

BURUNDI	2005	2010	2015	2020	Average growth	Elasticities
MEDIUM GROWTH SCENARIO	3,6%	3,0%	2,5%	2,0%	2,8%	
Total Population	7,5	8,8	10,1	11,3	2,8%	
Urban Pop.	0,5	0,6	0,8	1,0	5,0%	
Rural Pop.	7	8,2	9,3	10,3	2,6%	
Electrification Ratio	1,8%	2,7%	5,3%	8,2%	10,7%	
Urban	25,6%	31,0%	37,0%	45,0%	3,8%	
Rural	0,1%	0,5%	2,5%	4,5%	28,9%	
GDP Growth	5%	5%	5%	5%	5%	
Number of Consumers	27000	47749	106714	185829	13,7%	
Urban	25600	39565	60269	93552	9,0%	
Rural	1400	8184	46445	92277	32,2%	
Average Consumption	1695	1575	1333	1346	-1,5%	1,4
Urban	1760	1774	1784	1771	0,0%	
Rural	500	612	749	916	4,1%	
Domestic Energy Demand	45,8	75,2	142,3	250,2	12,0%	
Commercial Energy Demand	32,7	45,9	64,3	90,2	7,0%	1,4
Industrial Energy Demand	52,3	73,4	102,9	144,3	7,0%	1,4
Energy Losses	27%	26%	20%	15%		
Total Energy Demand	180	263	388	572	8,0%	
Potential peak load MW	35	51	75	111		

PRE-FS Values

Energy Demand	180	264	389	570	8%
Peak Load	35	51	75	111	

BURUNDI	2005	2010	2015	2020	Average growth	Elasticities
HIGH GROWTH SCENARIO	3,6%	3,0%	2,5%	2,0%	2,8%	
Total Population	7,5	8,8	10,1	11,3	2,8%	
Urban Pop.	0,5	0,6	0,8	1,0	5,0%	
Rural Pop.	7	8,2	9,3	10,3	2,6%	
Electrification Ratio	1,8%	2,9%	5,9%	9,6%	11,8%	
Urban	25,6%	33,0%	41,0%	50,0%	4,6%	
Rural	0,1%	0,6%	2,8%	5,5%	30,6%	
GDP Growth	6%	6%	6%	6%	6%	
Number of Consumers	27000	51938	118803	216729	14,9%	
Urban	25600	42117	66785	103946	9,8%	
Rural	1400	9821	52019	112783	34,0%	
Average Consumption	1695	1622	1427	1485	-0,9%	1,4
Urban	1760	1848	1874	1888	0,5%	
Rural	500	653	853	1113	5,5%	
Domestic Energy Demand	45,8	84,2	169,5	321,8	13,9%	
Commercial Energy Demand	32,7	48,9	73,3	109,6	8,4%	1,4
Industrial Energy Demand	52,3	78,3	117,2	175,4	8,4%	1,4
Energy Losses	27%	26%	20%	15%		
Total Energy Demand	180	286	452	717	9,7%	
Potential peak load MW	35	56	88	139		

PRE-FS Values

Energy Demand	180	286	453	719	9,7%
Peak Load	35	56	88	128	

DRC	2005	2010	2015	2020	Average growth	Elasticities
LOW GROWTH SCENARIO	2,5%	2,5%	2,5%	2,0%	2,4%	
Total Population	9,6	10,9	12,3	13,7	2,4%	
Urban Pop.	1,9	2,3	2,7	3,2	3,5%	
Rural Pop.	7,7	8,6	9,6	10,5	2,1%	
Electrification Ratio	1,9%	2,3%	3,0%	3,9%	5,0%	
Urban	9,5%	10,5%	13,0%	15,0%	3,1%	
Rural	0,0%	0,1%	0,2%	0,5%	#DIV/0!	
GDP Growth	3,0%	3,0%	3,0%	3,0%	3,0%	
Number of Consumers	36000	50012	74036	106535	7,5%	
Urban	36000	48300	70200	96000	6,8%	
Rural	0	1712	3836	10535	#DIV/0!	
Average Consumption	1400	1268	1216	1215	-0,9%	1,2
Urban	1400	1294	1251	1284	-0,6%	
Rural	500	530	561	594	1,2%	
Domestic Energy Demand	50,4	63,4	90,0	129,5	6,5%	
Commercial Energy Demand	58,8	70,2	83,7	99,9	3,6%	1,2
Industrial Energy Demand	58,8	70,2	83,7	99,9	3,6%	1,2
Energy Losses	20%	18%	15%	13%		
Total Energy Demand	210	248	303	376	4,0%	
Potential peak load MW	50	59	72	90		

PRE-FS Values

Energy Demand	210	248	302	376	4%
Peak Load	50	59	72	90	

DRC	2005	2010	2015	2020	Average growth	Elasticities
MEDIUM GROWTH SCENARIO	2,5%	2,5%	2,5%	2,0%	2,4%	
Total Population	9,6	10,9	12,3	13,7	2,4%	
Urban Pop.	1,9	2,3	2,7	3,2	3,5%	
Rural Pop.	7,7	8,6	9,6	10,5	2,1%	
Electrification Ratio	1,9%	2,6%	3,5%	5,0%	6,7%	
Urban	9,5%	12,0%	14,5%	18,0%	4,4%	
Rural	0,0%	0,1%	0,4%	1,0%	#DIV/0!	
GDP Growth	3,5%	3,5%	3,5%	3,5%	3,5%	
Number of Consumers	36000	56912	85971	136270	9,3%	
Urban	36000	55200	78300	115200	8,1%	
Rural	0	1712	7671	21070	#DIV/0!	
Average Consumption	1400	1239	1238	1184	-1,1%	1,2
Urban	1400	1261	1301	1282	-0,6%	
Rural	500	545	594	648	1,7%	
Domestic Energy Demand	50,4	70,5	106,4	161,3	8,1%	
Commercial Energy Demand	58,8	72,2	88,7	109,0	4,2%	1,2
Industrial Energy Demand	58,8	72,2	88,7	109,0	4,2%	1,2
Energy Losses	20%	18%	15%	13%		
Total Energy Demand	210	262	334	436	5,0%	
Potential peak load MW	50	62	80	104		

PRE-FS Values

Energy Demand	210	262	334	436	5%
Peak Load	50	62	79	103	

DRC	2005	2010	2015	2020	Average growth	Elasticities
HIGH GROWTH SCENARIO	2,5%	2,5%	2,5%	2,0%	2,4%	
Total Population	9,6	10,9	12,3	13,7	2,4%	
Urban Pop.	1,9	2,3	2,7	3,2	3,5%	
Rural Pop.	7,7	8,6	9,6	10,5	2,1%	
Electrification Ratio	1,9%	2,9%	4,1%	6,1%	8,2%	
Urban	9,5%	13,0%	16,5%	22,0%	5,8%	
Rural	0,0%	0,2%	0,6%	1,3%	#DIV/0!	
GDP Growth	4,0%	4%	4%	4%	4%	
Number of Consumers	36000	63225	100607	168191	10,8%	
Urban	36000	59800	89100	140800	9,5%	
Rural	0	3425	11507	27391	#DIV/0!	
Average Consumption	1400	1220	1234	1188	-1,1%	1,2
Urban	1400	1258	1312	1282	-0,6%	
Rural	500	561	629	706	2,3%	
Domestic Energy Demand	50,4	77,2	124,2	199,9	9,6%	
Commercial Energy Demand	58,8	74,3	94,0	118,8	4,8%	1,2
Industrial Energy Demand	58,8	74,3	94,0	118,8	4,8%	1,2
Energy Losses	20%	18%	15%	13%		
Total Energy Demand	210	275	367	503	6,0%	
Potential peak load MW	50	66	87	120		

PRE-FS Values

Energy Demand	210	275	368	504	6,0%
Peak Load	50	65	87	119	

KENYA	2005	2010	2015	2020	Average growth	Elasticities
LOW GROWTH SCENARIO	2,8%	2,5%	2,5%	2,0%	2,5%	
Total Population	34,9	39,8	45,0	50,3	2,5%	
Urban Pop.	14,7	18,8	23,9	30,6	5,0%	
Rural Pop.	20,2	21,0	21,1	19,7	-0,2%	
Electrification Ratio	10,8%	14,6%	19,9%	25,4%	5,9%	
Urban	22,9%	27,5%	33,0%	38,0%	3,4%	
Rural	2,1%	3,0%	5,0%	6,0%	7,4%	
GDP Growth	5,0%	6,0%	6,0%	6,0%	6,0%	
Number of Consumers	629800	964968	1492445	2132866	8,5%	
Urban	560400	859895	1316961	1935482	8,6%	
Rural	69400	105073	175484	197384	7,2%	
Average Consumption	1615	1638	1644	1712	0,4%	1,10
Urban	1752	1763	1765	1794	0,2%	
Rural	500	609	743	905	4,0%	
Domestic Energy Demand	1017	1580	2454	3651	8,9%	
Commercial Energy Demand	1677	2308	3178	4374	6,6%	1,10
Industrial Energy Demand	1766	2431	3346	4606	6,6%	1,10
Energy Losses	18%	15%	15%	15%		
Total Energy Demand	5436	7435	10562	14808	6,9%	
Potential peak load MW	935	1279	1817	2547		

5,5%

PRE-FS Values

Energy Demand	5436	7585	10756	14967	7,0%
Peak Load	916	1299	1846	2575	

KENYA	2005	2010	2015	2020	Average growth	Elasticities
MEDIUM GROWTH SCENARIO	2,8%	2,5%	2,5%	2,0%	2,5%	
Total Population	34,9	39,8	45,0	50,3	2,5%	
Urban Pop.	14,7	18,8	23,9	30,6	5,0%	
Rural Pop.	20,2	21,0	21,1	19,7	-0,2%	
Electrification Ratio	10,8%	14,6%	19,9%	25,4%	5,9%	
Urban	22,9%	27,5%	33,0%	38,0%	3,4%	
Rural	2,1%	3,0%	5,0%	6,0%	7,4%	
GDP Growth	5,0%	7,0%	7,0%	7,0%	7,0%	
Number of Consumers	629800	964968	1492445	2132866	8,5%	
Urban	560400	859895	1316961	1935482	8,6%	
Rural	69400	105073	175484	197384	7,2%	
Average Consumption	1615	1724	1736	1811	0,8%	1,10
Urban	1752	1856	1858	1888	0,5%	
Rural	500	641	823	1056	5,1%	
Domestic Energy Demand	1017	1663	2591	3863	9,3%	
Commercial Energy Demand	1677	2430	3521	5102	7,7%	1,10
Industrial Energy Demand	1766	2559	3708	5373	7,7%	1,10
Energy Losses	18%	15%	15%	15%		
Total Energy Demand	5436	7826	11553	16810	7,8%	
Potential peak load MW	935	1346	1987	2891		

PRE-FS Values

Energy Demand	5436	7838	11552	16701	7,8%
Peak Load	916	1343	1985	2876	

KENYA	2005	2010	2015	2020	Average growth	Elasticities
HIGH GROWTH SCENARIO	2,8%	2,5%	2,5%	2,0%	2,5%	
Total Population	34,9	39,8	45,0	50,3	2,5%	
Urban Pop.	14,7	18,8	23,9	30,6	5,0%	
Rural Pop.	20,2	21,0	21,1	19,7	-0,2%	
Electrification Ratio	10,8%	14,6%	19,9%	25,4%	5,9%	
Urban	22,9%	27,5%	33,0%	38,0%	3,4%	
Rural	2,1%	3,0%	5,0%	6,0%	7,4%	
GDP Growth	5,0%	8%	8%	8%	8%	
Number of Consumers	629800	964968	1492445	2132866	8,5%	
Urban	560400	859895	1316961	1935482	8,6%	
Rural	69400	105073	175484	197384	7,2%	
Average Consumption	1615	1814	1832	1917	1,1%	1,10
Urban	1752	1953	1954	1987	0,8%	
Rural	500	675	911	1229	6,2%	
Domestic Energy Demand	1017	1750	2734	4088	9,7%	
Commercial Energy Demand	1677	2557	3898	5942	8,8%	1,10
Industrial Energy Demand	1766	2692	4105	6258	8,8%	1,10
Energy Losses	18%	15%	15%	15%		
Total Energy Demand	5436	8234	12631	19095	8,7%	
Potential peak load MW	935	1416	2173	3284		

PRE-FS Values

Energy Demand	5436	8165	12506	18787	8,6%
Peak Load	916	1400	2151	3283	

RWANDA	2005	2010	2015	2020	Average growth	Elasticities
LOW GROWTH SCENARIO	2,3%	2,3%	2,3%	2,3%	2,3%	
Total Population	8,5	9,5	10,7	12,0	2,3%	
Urban Pop.	1,9	2,4	3,0	3,9	5,0%	
Rural Pop.	6,6	7,1	7,6	8,1	1,3%	
Electrification Ratio	3,8%	4,9%	6,6%	8,9%	5,8%	
Urban	12,0%	14,0%	17,0%	21,0%	3,8%	
Rural	1,5%	1,9%	2,5%	3,1%	4,9%	
GDP Growth	5%	5%	5%	5%	5%	
Number of Consumers	65000	93946	141686	213298	8,2%	
Urban	45000	66826	103565	163279	9,0%	
Rural	20000	27120	38121	50019	6,3%	
Average Consumption	967	1008	1036	1078	0,7%	1,2
Urban	1175	1174	1155	1147	-0,2%	
Rural	500	597	713	852	3,6%	
Domestic Energy Demand	62,9	94,7	146,8	229,9	9,0%	
Commercial Energy Demand	72,7	97,3	130,2	174,2	6,0%	1,2
Industrial Energy Demand	60,9	81,5	109,1	146,0	6,0%	1,2
Energy Losses	25%	23%	20%	16%		
Total Energy Demand	262	355	483	655	6,3%	
Potential peak load MW	50	69	94	127		

PRE-FS Values

Energy Demand	262	355	482	655	6,3%
Peak Load	50	69	94	127	

RWANDA	2005	2010	2015	2020	Average growth	Elasticities
MEDIUM GROWTH SCENARIO	2,3%	2,3%	2,3%	2,3%	2,3%	
Total Population	8,5	9,5	10,7	12,0	2,3%	
Urban Pop.	1,9	2,4	3,0	3,9	5,0%	
Rural Pop.	6,6	7,1	7,6	8,1	1,3%	
Electrification Ratio	3,8%	5,4%	8,0%	11,7%	7,7%	
Urban	12,0%	15,5%	20,0%	25,5%	5,1%	
Rural	1,5%	2,0%	3,2%	5,0%	8,3%	
GDP Growth	6%	6%	6%	6%	6%	
Number of Consumers	65000	102534	170636	278942	10,2%	
Urban	45000	73986	121841	198267	10,4%	
Rural	20000	28547	48795	80675	9,7%	
Average Consumption	967	1037	1080	1144	1,1%	1,2
Urban	1175	1194	1193	1199	0,1%	
Rural	500	632	798	1009	4,8%	
Domestic Energy Demand	62,9	106,4	184,3	319,0	11,4%	
Commercial Energy Demand	72,7	102,9	145,7	206,3	7,2%	1,2
Industrial Energy Demand	60,9	86,2	122,1	172,8	7,2%	1,2
Energy Losses	25%	23%	20%	16%		
Total Energy Demand	262	384	565	831	8,0%	
Potential peak load MW	50	78	114	169		

PRE-FS Values

Energy Demand	262	385	565	831	8,0%
Peak Load	50	78	114	169	

RWANDA	2005	2010	2015	2020	Average growth	Elasticities
HIGH GROWTH SCENARIO	2,3%	2,3%	2,3%	2,3%	2,3%	
Total Population	8,5	9,5	10,7	12,0	2,3%	
Urban Pop.	1,9	2,4	3,0	3,9	5,0%	
Rural Pop.	6,6	7,1	7,6	8,1	1,3%	
Electrification Ratio	3,8%	6,8%	11,4%	18,6%	11,1%	
Urban	12,0%	19,2%	29,0%	42,5%	8,8%	
Rural	1,5%	2,6%	4,4%	7,1%	10,9%	
GDP Growth	7%	7%	7%	7%	7%	
Number of Consumers	65000	128759	243763	445004	13,7%	
Urban	45000	91647	176670	330446	14,2%	
Rural	20000	37112	67093	114559	12,3%	
Average Consumption	967	1026	1110	1201	1,5%	1,2
Urban	1175	1170	1192	1205	0,2%	
Rural	500	668	892	1192	6,0%	
Domestic Energy Demand	62,9	132,0	270,5	534,6	15,3%	
Commercial Energy Demand	72,7	108,8	162,9	243,8	8,4%	1,2
Industrial Energy Demand	60,9	91,2	136,5	204,3	8,4%	1,2
Energy Losses	25%	23%	20%	16%		
Total Energy Demand	262	431	712	1170	10,5%	
Potential peak load MW	50	88	149	252		

PRE-FS Values

Energy Demand	262	432	711	1170	10,5%
Peak Load	50	88	149	252	

UGANDA	2005	2010	2015	2020	Average growth	Elasticities
LOW GROWTH SCENARIO	3,2%	3,0%	2,8%	2,5%	2,9%	
Total Population	28,8	33,5	38,7	44,1	2,9%	
Urban Pop.	3,5	4,5	5,7	7,3	5,0%	
Rural Pop.	25,3	29,1	33,0	36,8	2,5%	
Electrification Ratio	4,5%	8,1%	10,5%	13,2%	7,4%	
Urban	26,3%	35,0%	42,0%	49,5%	4,3%	
Rural	1,5%	4,0%	5,0%	6,0%	9,7%	
GDP Growth	4,0%	4,0%	4,0%	4,0%	4,0%	
Number of Consumers	260300	545349	808930	1162378	10,5%	
Urban	184400	312689	478895	720349	9,5%	
Rural	75900	232660	330035	442030	12,5%	
Average Consumption	1310	1096	1181	1247	-0,3%	1,40
Urban	1643	1488	1547	1558	-0,4%	
Rural	500	570	649	739	2,6%	
Domestic Energy Demand	341	598	955	1449	10,1%	
Commercial Energy Demand	133	175	229	301	5,6%	1,40
Industrial Energy Demand	601	789	1036	1361	5,6%	1,40
Energy Losses	40%	26%	20%	16%		
Total Energy Demand	1804	2110	2776	3704	4,9%	
Potential peak load MW	318	364	470	614		

PRE-FS Values

Energy Demand	1804	2435	3003	3703	4,9%
Peak Load	318	420	508	614	

UGANDA	2005	2010	2015	2020	Average growth	Elasticities
MEDIUM GROWTH SCENARIO	3,2%	3,0%	2,8%	2,5%	2,9%	
Total Population	28,8	33,5	38,7	44,1	2,9%	
Urban Pop.	3,5	4,5	5,7	7,3	5,0%	
Rural Pop.	25,3	29,1	33,0	36,8	2,5%	
Electrification Ratio	4,5%	9,7%	14,2%	18,6%	9,9%	
Urban	26,3%	40,0%	50,0%	62,0%	5,9%	
Rural	1,5%	5,0%	8,0%	10,0%	13,5%	
GDP Growth	6,0%	6,0%	6,0%	6,0%	6,0%	
Number of Consumers	260300	648184	1098169	1638971	13,1%	
Urban	184400	357359	570113	902255	11,2%	
Rural	75900	290825	528056	736716	16,4%	
Average Consumption	1310	1183	1306	1450	0,7%	1,40
Urban	1643	1617	1735	1741	0,4%	
Rural	500	649	843	1095	5,4%	
Domestic Energy Demand	341	767	1434	2377	13,8%	
Commercial Energy Demand	133	199	298	446	8,4%	1,40
Industrial Energy Demand	601	900	1346	2015	8,4%	1,40
Energy Losses	40%	26%	20%	16%		
Total Energy Demand	1804	2521	3848	5760	8,0%	
Potential peak load MW	318	439	663	982		

PRE-FS Values

Energy Demand	1804	2874	4069	5761	8,0%
Peak Load	318	500	701	982	

UGANDA	2005	2010	2015	2020	Average growth	Elasticities
HIGH GROWTH SCENARIO	3,2%	3,0%	2,8%	2,5%	2,9%	
Total Population	28,8	33,5	38,7	44,1	2,9%	
Urban Pop.	3,5	4,5	5,7	7,3	5,0%	
Rural Pop.	25,3	29,1	33,0	36,8	2,5%	
Electrification Ratio	4,5%	9,9%	15,9%	23,4%	11,6%	
Urban	26,3%	42,0%	56,0%	70,9%	6,8%	
Rural	1,5%	5,0%	9,0%	14,0%	16,1%	
GDP Growth	7,0%	7,0%	7,0%	7,0%	7%	
Number of Consumers	260300	666052	1232589	2063175	14,8%	
Urban	184400	375227	638527	1031772	12,2%	
Rural	75900	290825	594063	1031403	19,0%	
Average Consumption	1310	1258	1397	1584	1,3%	1,40
Urban	1643	1696	1806	1841	0,8%	
Rural	500	692	958	1327	6,7%	
Domestic Energy Demand	341	838	1722	3268	16,3%	
Commercial Energy Demand	133	212	339	541	9,8%	1,40
Industrial Energy Demand	601	959	1531	2443	9,8%	1,40
Energy Losses	40%	26%	20%	16%		
Total Energy Demand	1804	2715	4490	7443	9,9%	
Potential peak load MW	318	469	762	1243		

PRE-FS Values

Energy Demand	1804	3164	4853	7443	9,9%
Peak Load	318	547	824	1243	

RWANDA-BURUNDI-DR CONGO SYSTEM INTERCONNECTED : RBC

ALTERNATIVE 1

SCENARIO: MEDIUM

R/B/C Group FORECAST	Net Energy GWh	Peak Load MW	Installed MW	Committed Local Resources GWh	MW	Complementary Thermal GWh	MW	Nyemanga GWh	MW	Ruzizi 3 GWh	MW	Mule 34 GWh	MW	Kabu 16 GWh	MW	Bendera GWh	MW	Rusumo GWh	MW	Nyabarongp + Mpanda GWh	MW	Import (+) Export (-) GWh	MW
2 010	911	186	185	745	148	75	24	4	1.7											29	11	58	20
2 011	976	199	199	745	148	198	38	4	1.7											29	11	0	20
2 012	1046	213	269	745	148	0	38	4	1.7							120	43			177	38	0	-20
2 013	1121	228	289	745	148	0	38	4	1.7					117	20	160	43			177	38	-82	-20
2 014	1201	244	289	745	148	0	38	4	1.7					117	20	160	43			177	38	-2	-20
2 015	1288	261	289	745	148	0	38	4	1.7					117	20	160	43			177	38	85	20
2 016	1386	281	371	745	148	0	38	4	1.7	456	82			117	20	160	43			177	38	-273	-50
2 017	1485	301	381	745	148	0	49	4	1.7	456	82			117	20	160	43			177	38	-174	-50
2 018	1602	325	381	745	148	0	49	4	1.7	456	82			117	20	160	43			177	38	-57	-20
2 019	1720	349	404	745	148	0	55	4	1.7	456	82	147	16.5	117	20	160	43			177	38	-86	-20
2 020	1837	373	404	745	148	0	55	4	1.7	456	82	147	16.5	117	20	160	43			177	38	31	50
2 021	1979	402	445	745	148	0	55	4	1.7	456	82	147	16.5	117	20	160	43	173	41	177	38	0	50
2 022	2120	430	445	745	148	0	55	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	45	50
2 023	2289	464	461	745	148	0	70	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	214	50
2 024	2459	498	461	745	148	0	70	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	384	100
2 025	2628	532	486	745	148	0	95	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	553	100
2 026	2832	573	486	745	148	0	95	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	757	150
2 027	3036	614	525	745	148	0	135	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	961	150
2 028	3281	663	579	745	148	6	189	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	1200	150
2 029	3525	712	633	745	148	250	243	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	1200	150
2 030	3769	761	687	745	148	495	297	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	1200	150

SCENARIO: LOW

2 010	847	172	169	687	148	0	8	4	1.7											29	11	127	20
2 011	895	181	179	745	148	0	19	4	1.7											29	11	117	20
2 012	946	191	206	745	148	0	19	4	1.7											177	38	20	50
2 013	1000	202	206	745	148	0	19	4	1.7											177	38	74	50
2 014	1057	213	206	745	148	0	19	4	1.7											177	38	131	50
2 015	1117	225	206	745	148	0	19	4	1.7											177	38	191	50
2 016	1184	237	288	745	148	0	19	4	1.7	258	82									177	38	0	50
2 017	1251	249	288	745	148	0	19	4	1.7	325	82									177	38	0	50
2 018	1329	263	288	745	148	0	19	4	1.7	403	82									177	38	0	50
2 019	1406	276	288	745	148	0	19	4	1.7	456	82									177	38	24	50
2 020	1484	290	288	745	148	0	19	4	1.7	456	82									177	38	102	50
2 021	1582	308	308	745	148	0	19	4	1.7	456	82			117	20					177	38	83	50
2 022	1680	327	325	745	148	0	19	4	1.7	456	82	147	16.5	117	20					177	38	34	50
2 023	1794	349	368	745	148	0	19	4	1.7	456	82	147	16.5	117	20	148	43			177	38	0	50
2 024	1908	371	368	745	148	0	19	4	1.7	456	82	147	16.5	117	20	160	43			177	38	102	50
2 025	2023	392	432	745	148	0	41	4	1.7	456	82	147	16.5	117	20	160	43	217	41	177	38	0	0
2 026	2157	418	432	745	148	0	41	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	82	50
2 027	2292	444	438	745	148	0	48	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	217	50
2 028	2449	473	438	745	148	0	48	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	374	100
2 029	2606	503	454	745	148	0	63	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	531	100
2 030	2764	533	454	745	148	0	63	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	689	150

SCENARIO: HIGH

2 010	993	204	204	745	148	215	43	4	1.7											29	11	0	20
2 011	1082	222	225	745	148	304	64	4	1.7											29	11	0	20
2 012	1180	243	295	745	148	94	64	4	1.7							160	43			177	38	0	0
2 013	1287	265	356	745	148	0	64	4	1.7					117	20	160	43	269	41	177	38	-185	-20
2 014	1404	289	356	745	148	0	64	4	1.7					117	20	160	43	269	41	177	38	-68	-20
2 015	1532	316	438	745	148	0	64	4	1.7	456	82			117	20	160	43	269	41	177	38	-396	-50
2 016	1682	345	438	745	148	0	64	4	1.7	456	82			117	20	160	43	269	41	177	38	-246	-50
2 017	1831	375	438	745	148	0	64	4	1.7	456	82			117	20	160	43	269	41	177	38	-97	-20
2 018	2018	412	473	745	148	0	83	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	-57	-20
2 019	2206	449	474	745	148	0	84	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	131	20
2 020	2393	487	485	745	148	0	95	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	318	50
2 021	2605	529	485	745	148	0	95	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	530	100
2 022	2817	572	485	745	148	0	95	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	742	150
2 023	3077	624	537	745	148	0	146	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	1002	150
2 024	3337	677	594	745	148	62	204	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	1200	150
2 025	3597	729	652	745	148	322	262	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	1200	150
2 026	3917	793	723	745	148	643	332	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	1200	150
2 027	4237	858	793	745	148	963	403	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	1200	150
2 028	4631	937	880	745	148	1356	490	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	1200	150
2 029	5024	1016	967	745	148	1750	577	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	1200	150
2 030	5418	1095	1054	745	148	2143	664	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	1200	150

RBC-UGANDA-KENYA SYSTEMS INTERCONNECTED : <u>UGANDA</u>

ALTERNATIVE 1

SCENARIO: MEDIUM

Uganda FORECAST	Net Energy GWh	Peak Load MW	Installed MW	Committed Local Resources GWh	MW	Complementary Thermal GWh	MW	Kakira GWh	MW	Karuma GWh	MW	Mini-Hydro GWh	MW	Kalagala GWh	MW	Murchison GWh	MW	Ayago GWh	MW	Import (+) Export (-) GWh	MW	Kenya GWh	MW	Rwanda GWh	MW
2 010	2874	500	629	3038	587	0	0	294	42											-458	-70	-400	-50	-58	-20
2 011	3081	535	659	3038	587	0	30	294	42											-251	-70	-251	-50	0	-20
2 012	3303	573	733	3038	587	0	30	294	42			371	74							-400	-30	-400	-50	0	20
2 013	3541	612	733	3038	587	0	30	212	42			530	74							-239	-30	-321	-50	82	20
2 014	3796	655	933	3038	587	0	30	234	42	1192	200	530	74							-1198	-130	-1200	-150	2	20
2 015	4069	701	941	3038	587	0	38	234	42	1552	200	530	74							-1285	-170	-1200	-150	-85	-20
2 016	4373	752	941	3038	587	0	38	212	42	1520	200	530	74							-927	-100	-1200	-150	273	50
2 017	4676	802	982	3038	587	0	79	234	42	1633	200	530	74							-759	-100	-933	-150	174	50
2 018	5038	862	1432	3038	587	0	79	234	42	1090	200	530	74	1289	450					-1143	-130	-1200	-150	57	20
2 019	5399	922	1432	3038	587	0	79	234	42	1245	200	530	74	1466	450					-1114	-130	-1200	-150	86	20
2 020	5761	982	1432	3038	587	0	79	294	42	1388	200	530	74	1742	450					-1231	-200	-1200	-150	-31	-50
2 021	6117	1043	1432	3038	587	0	79	294	42	1536	200	530	74	1919	450					-1200	-200	-1200	-150	0	-50
2 022	6473	1103	1432	3038	587	0	79	294	42	1747	200	530	74	2109	450					-1245	-200	-1200	-150	-45	-50
2 023	6885	1174	1491	3038	587	165	138	294	42	1747	200	530	74	2525	450					-1414	-200	-1200	-150	-214	-50
2 024	7298	1244	1713	3038	587	0	138	294	42	1747	200	530	74	1943	450	1330	222			-1584	-250	-1200	-150	-384	-100
2 025	7710	1314	1713	3038	587	0	138	294	42	1747	200	530	74	2365	450	1489	222			-1753	-250	-1200	-150	-553	-100
2 026	8186	1395	1911	3038	587	0	138	294	42	1733	200	530	74	1843	450	2705	420			-1957	-300	-1200	-150	-757	-150
2 027	8663	1477	1924	3038	587	0	151	294	42	1747	200	530	74	2236	450	2979	420			-2161	-300	-1200	-150	-961	-150
2 028	9214	1571	2028	3038	587	0	255	294	42	1747	200	530	74	2525	450	3480	420			-2400	-300	-1200	-150	-1200	-150
2 029	9766	1665	2262	3038	587	0	255	294	42	1747	200	530	74	2275	450	2703	420	1579	234	-2400	-300	-1200	-150	-1200	-150
2 030	10317	1759	2262	3038	587	0	255	294	42	1747	200	530	74	2409	450	3018	420	1681	234	-2400	-300	-1200	-150	-1200	-150

SCENARIO: LOW

2 010	2435	420	629	2704	587	0	0	258	42											-527	-70	-400	-50	-127	-20
2 011	2540	436	629	2763	587	0	0	294	42											-517	-70	-400	-50	-117	-20
2 012	2648	453	629	2774	587	0	0	294	42											-420	-100	-400	-50	-20	-50
2 013	2762	470	629	2942	587	0	0	294	42											-474	-100	-400	-50	-74	-50
2 014	2880	489	903	3038	587	0	0	294	42	349	200	530	74							-1331	-200	-1200	-150	-131	-50
2 015	3003	508	903	3038	587	0	0	294	42	532	200	530	74							-1391	-200	-1200	-150	-191	-50
2 016	3134	528	903	3038	587	0	0	294	42	472	200	530	74							-1200	-200	-1200	-150	0	-50
2 017	3266	548	903	3038	587	0	0	294	42	698	200	436	74							-1200	-200	-1200	-150	0	-50
2 018	3411	570	903	3038	587	0	0	294	42	797	200	482	74							-1200	-200	-1200	-150	0	-50
2 019	3557	592	903	3038	587	0	0	294	42	919	200	530	74							-1224	-200	-1200	-150	-24	-50
2 020	3703	614	903	3038	587	0	0	294	42	1143	200	530	74							-1302	-200	-1200	-150	-102	-50
2 021	3854	639	903	3038	587	0	0	294	42	1275	200	530	74							-1283	-200	-1200	-150	-83	-50
2 022	4005	664	931	3038	587	0	28	294	42	1377	200	530	74							-1234	-200	-1200	-150	-34	-50
2 023	4172	692	961	3038	587	0	58	294	42	1510	200	530	74							-1200	-200	-1200	-150	0	-50
2 024	4338	719	991	3038	587	31	88	294	42	1747	200	530	74							-1302	-200	-1200	-150	-102	-50
2 025	4505	747	991	3038	587	96	88	294	42	1747	200	530	74							-1200	-150	-1200	-150	0	0
2 026	4689	778	1055	3038	587	362	152	294	42	1747	200	530	74							-1282	-200	-1200	-150	-82	-50
2 027	4873	808	1505	3038	587	0	152	294	42	1123	200	530	74	1305	450					-1417	-200	-1200	-150	-217	-50
2 028	5075	842	1505	3038	587	0	152	294	42	1335	200	530	74	1452	450					-1574	-250	-1200	-150	-374	-100
2 029	5278	875	1505	3038	587	0	152	294	42	1527	200	530	74	1620	450					-1731	-250	-1200	-150	-531	-100
2 030	5481	909	1505	3038	587	0	152	294	42	1708	200	530	74	1800	450					-1889	-300	-1200	-150	-689	-150

SCENARIO: HIGH

2 010	3164	547	672	3038	587	0	43	294	42											-168	-70	-168	-50	0	-20
2 011	3447	594	723	3038	587	115	94	294	42											0	-70	0	-50	0	-20
2 012	3755	644	797	3038	587	0	94	294	42			530	74							-107	-50	-107	-50	0	0
2 013	4090	699	799	3038	587	215	96	294	42			530	74							13	-30	-172	-50	185	20
2 014	4455	759	999	3038	587	0	96	294	42	1747	200	508	74							-1132	-130	-1200	-150	68	20
2 015	4853	824	1006	3038	587	0	103	294	42	1747	200	530	74							-756	-100	-1152	-150	396	50
2 016	5306	898	1456	3038	587	0	103	118	42	1059	200	530	74	1515	450					-954	-100	-1200	-150	246	50
2 017	5758	971	1456	3038	587	0	103	294	42	1257	200	530	74	1742	450					-1103	-130	-1200	-150	97	20
2 018	6320	1062	1456	3038	587	0	103	294	42	1581	200	530	74	2020	450					-1143	-130	-1200	-150	57	20
2 019	6881	1152	1456	3038	587	78	103	294	42	1747	200	530	74	2525	450					-1331	-170	-1200	-150	-131	-20
2 020	7443	1243	1678	3038	587	0	103	294	42	1747	200	530	74	2525	450	827	222			-1518	-200	-1200	-150	-318	-50
2 021	8062	1346	1731	3038	587	0	156	294	42	1747	200	530	74	2525	450	1658	222			-1730	-250	-1200	-150	-530	-100
2 022	8681	1450	1929	3038	587	0	156	294	42	1747	200	530	74	2525	450	2489	420			-1942	-300	-1200	-150	-742	-150
2 023	9433	1575	2163	3038	587	0	156	294	42	1747	200	516	74	1919	450	2686	420	1435	234	-2202	-300	-1200	-150	-1002	-150
2 024	10184	1701	2171	3038	587	0	164	294	42	1747	200	530	74	2347	450	2972	420	1656	234	-2400	-300	-1200	-150	-1200	-150
2 025	10936	1826	2475	3038	587	0	164	294	42	1747	200	530	74	1827	450	2600	420	3300	538	-2400	-300	-1200	-150	-1200	-150
2 026	11846	1978	2476	3038	587	0	165	294	42	1747	200	530	74	2230	450	2822	420	3585	538	-2400	-300	-1200	-150	-1200	-150
2 027	12755	2130	2643	3038	587	0	332	294	42	1747	200	530	74	2525	450	3095	420	3926	538	-2400	-300	-1200	-150	-1200	-150
2 028	13859	2315	2846	3038	587	0	535	294	42	1747	200	530	74	2525	450	3679	420	4446	538	-2400	-300	-1200	-150	-1200	-150
2 029	14963	2499	2949	3038	587	0	638	294	42	1747	200	530	74	2525	450	3679	420	4674	538	-1524	-200	-324	-50	-1200	-150
2 030	16067	2684	3152	3038	587	780	841	294	42	1747	200	530	74	2525	450	3679	420	4674	538	-1200	-200	0	-50	-1200	-150

RBC-UGANDA-KENYA SYSTEMS INTERCONNECTED : KENYA

ALTERNATIVE 1

SCENARIO: MEDIUM

KENYA LOAD FORECAST	Net Energy GWh	Peak Load MW	Installed MW	Committed Local Resources GWh	MW	Complementary Thermal GWh	MW	Coal GWh	MW	Import (+) Export (-) GWh	MW
2010	7838	1343	1478	5052	1039	65	89	2321	300	400	50
2011	8491	1456	1628	5052	1039	65	89	3123	450	251	50
2012	9183	1576	1778	5052	1039	65	89	3667	600	400	50
2013	9922	1703	1874	5052	1039	135	185	4415	600	321	50
2014	10711	1840	2274	5052	1039	135	185	4324	900	1200	150
2015	11552	1985	2274	5052	1039	135	185	5165	900	1200	150
2016	12470	2144	2358	5052	1039	196	269	6022	900	1200	150
2017	13387	2302	2658	5052	1039	196	269	7206	1200	933	150
2018	14492	2493	3258	5052	1039	196	269	8043	1800	1200	150
2019	15596	2684	3258	5052	1039	196	269	9148	1800	1200	150
2020	16701	2876	3258	5052	1039	196	269	10252	1800	1200	150
2021	17987	3098	3858	5052	1039	196	269	11538	2400	1200	150
2022	19272	3321	3858	5052	1039	196	269	12824	2400	1200	150
2023	20812	3588	3946	5052	1039	261	357	14299	2400	1200	150
2024	22351	3854	4546	5052	1039	261	357	15839	3000	1200	150
2025	23891	4121	4546	5052	1039	261	357	17378	3000	1200	150
2026	25699	4434	5146	5052	1039	261	357	19186	3600	1200	150
2027	27506	4747	5222	5052	1039	316	433	20938	3600	1200	150
2028	29664	5122	5822	5052	1039	316	433	23096	4200	1200	150
2029	31822	5496	6045	5052	1039	479	656	25091	4200	1200	150
2030	33980	5870	6645	5052	1039	479	656	27249	4800	1200	150

SCENARIO: LOW

2010	7585	1299	1429	5052	1039	29	40	2104	300	400	50
2011	8153	1397	1579	5052	1039	29	40	2672	450	400	50
2012	8750	1500	1650	5052	1039	81	111	3217	450	400	50
2013	9381	1609	1800	5052	1039	81	111	3848	600	400	50
2014	10049	1724	1900	5052	1039	81	111	3716	600	1200	150
2015	10756	1846	2200	5052	1039	81	111	4423	900	1200	150
2016	11516	1977	2200	5052	1039	81	111	5183	900	1200	150
2017	12276	2109	2320	5052	1039	168	231	5855	900	1200	150
2018	13173	2264	2620	5052	1039	168	231	6752	1200	1200	150
2019	14070	2420	2662	5052	1039	199	273	7619	1200	1200	150
2020	14967	2575	3262	5052	1039	199	273	8516	1800	1200	150
2021	15988	2751	3262	5052	1039	199	273	9537	1800	1200	150
2022	17008	2928	3262	5052	1039	199	273	10557	1800	1200	150
2023	18207	3135	3862	5052	1039	199	273	11756	2400	1200	150
2024	19405	3343	3862	5052	1039	199	273	12954	2400	1200	150
2025	20604	3550	3905	5052	1039	231	316	14121	2400	1200	150
2026	21998	3791	4505	5052	1039	231	316	15515	3000	1200	150
2027	23392	4032	4505	5052	1039	231	316	16909	3000	1200	150
2028	25026	4315	4747	5052	1039	407	558	18367	3000	1200	150
2029	26661	4598	5347	5052	1039	407	558	20002	3600	1200	150
2030	28296	4881	5369	5052	1039	423	580	21621	3600	1200	150

SCENARIO: HIGH

2010	8165	1400	1540	5052	1039	545	151	2400	300	168	50
2011	8914	1530	1690	5052	1039	262	151	3600	450	0	50
2012	9715	1668	1840	5052	1039	110	151	4446	600	107	50
2013	10578	1817	2140	5052	1039	110	151	5244	900	172	50
2014	11506	1978	2240	5052	1039	110	151	5144	900	1200	150
2015	12506	2151	2540	5052	1039	110	151	6192	1200	1152	150
2016	13611	2342	2576	5052	1039	137	187	7223	1200	1200	150
2017	14717	2533	3176	5052	1039	137	187	8328	1800	1200	150
2018	16074	2768	3176	5052	1039	137	187	9685	1800	1200	150
2019	17430	3003	3303	5052	1039	230	314	10949	1800	1200	150
2020	18787	3238	3903	5052	1039	230	314	12305	2400	1200	150
2021	20404	3518	3903	5052	1039	230	314	13922	2400	1200	150
2022	22020	3798	4503	5052	1039	230	314	15539	3000	1200	150
2023	23995	4140	4554	5052	1039	267	365	17476	3000	1200	150
2024	25969	4483	5154	5052	1039	267	365	19450	3600	1200	150
2025	27943	4825	5754	5052	1039	267	365	21424	4200	1200	150
2026	30289	5232	5755	5052	1039	267	366	23770	4200	1200	150
2027	32634	5638	6355	5052	1039	267	366	26115	4800	1200	150
2028	35486	6133	6955	5052	1039	267	366	28967	5400	1200	150
2029	38337	6627	7290	5052	1039	585	801	32377	5400	324	50
2030	41189	7122	7890	5052	1039	585	801	35552	6000	0	50

RWANDA-BURUNDI-DR CONGO SYSTEM INTERCONNECTED : RBC

ALTERNATIVE 2

SCENARIO: MEDIUM

R/B/C Group FORECAST	Net Energy GWh	Peak Load MW	Installed MW	Committed Local Resources		Complementary Thermal		Nyemanga		Ruzizi 3		Mule 34		Kabu 16		Bendera		Rusumo		Nyabarongo + Mpanda		Import (+) Export (-)	
				GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW	GWh	MW
2 010	911	186	185	745	148	75	24	4	1.7											29	11	58	20
2 011	976	199	199	745	148	198	38	4	1.7											29	11	0	20
2 012	1046	213	269	745	148	0	38	4	1.7							160	43			177	38	-40	-20
2 013	1121	228	330	745	148	0	38	4	1.7					117	20	160	43	269	41	177	38	-351	-50
2 014	1201	244	330	745	148	0	38	4	1.7					117	20	160	43	269	41	177	38	-271	-50
2 015	1288	261	429	745	148	0	38	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	-787	-100
2 016	1386	281	429	745	148	0	38	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	-689	-100
2 017	1485	301	431	745	148	0	41	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	-590	-100
2 018	1602	325	458	745	148	0	68	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	-473	-100
2 019	1720	349	458	745	148	0	68	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	-355	-50
2 020	1837	373	461	745	148	0	71	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	-238	-50
2 021	1979	402	462	745	148	0	72	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	-96	-20
2 022	2120	430	462	745	148	0	72	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	45	50
2 023	2289	464	462	745	148	0	72	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	214	50
2 024	2459	498	462	745	148	0	72	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	384	100
2 025	2628	532	486	745	148	0	95	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	553	100
2 026	2832	573	530	745	148	0	140	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	757	100
2 027	3036	614	530	745	148	0	140	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	961	150
2 028	3281	663	530	745	148	0	140	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	1206	200
2 029	3525	712	583	745	148	0	193	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	1450	200
2 030	3769	761	637	745	148	95	247	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	1600	200

SCENARIO: LOW

2 010	847	172	169	687	148	0	8	4	1.7											29	11	127	20
2 011	895	181	179	745	148	0	19	4	1.7											29	11	117	20
2 012	946	191	249	745	148	0	19	4	1.7							160	43			177	38	-140	-20
2 013	1000	202	310	745	148	0	19	4	1.7					117	20	160	43	197	41	177	38	-400	-50
2 014	1057	213	310	745	148	0	19	4	1.7					117	20	160	43	254	41	177	38	-400	-50
2 015	1117	225	409	745	148	0	19	4	1.7	356	82	89	16.5	117	20	160	43	269	41	177	38	-800	-100
2 016	1184	237	409	745	148	0	19	4	1.7	365	82	147	16.5	117	20	160	43	269	41	177	38	-800	-100
2 017	1251	249	409	745	148	0	19	4	1.7	432	82	147	16.5	117	20	160	43	269	41	177	38	-800	-100
2 018	1329	263	409	745	148	0	19	4	1.7	403	82	147	16.5	117	20	160	43	269	41	177	38	-693	-100
2 019	1406	276	409	745	148	0	19	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	-669	-100
2 020	1484	290	419	745	148	0	28	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	-591	-100
2 021	1582	308	439	745	148	0	49	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	-493	-100
2 022	1680	327	439	745	148	0	49	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	-395	-50
2 023	1794	349	439	745	148	0	49	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	-281	-50
2 024	1908	371	439	745	148	0	49	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	-167	-20
2 025	2023	392	452	745	148	0	61	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	-52	-20
2 026	2157	418	452	745	148	0	61	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	82	20
2 027	2292	444	452	745	148	0	61	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	217	50
2 028	2449	473	452	745	148	0	61	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	374	100
2 029	2606	503	454	745	148	0	63	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	531	100
2 030	2764	533	454	745	148	0	63	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	689	150

SCENARIO: HIGH

2 010	993	204	204	745	148	215	43	4	1.7											29	11	0	20
2 011	1082	222	225	745	148	304	64	4	1.7											29	11	0	20
2 012	1180	243	295	745	148	94	64	4	1.7							160	43			177	38	0	0
2 013	1287	265	356	745	148	0	64	4	1.7					117	20	160	43	269	41	177	38	-185	-20
2 014	1404	289	356	745	148	0	64	4	1.7					117	20	160	43	269	41	177	38	-68	-20
2 015	1532	316	454	745	148	0	64	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	-543	-100
2 016	1682	345	454	745	148	0	64	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	-393	-50
2 017	1831	375	463	745	148	0	72	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	-244	-50
2 018	2018	412	473	745	148	0	83	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	-57	-20
2 019	2206	449	474	745	148	0	84	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	131	20
2 020	2393	487	485	745	148	0	95	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	318	50
2 021	2605	529	485	745	148	0	95	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	530	100
2 022	2817	572	485	745	148	0	95	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	742	150
2 023	3077	624	537	745	148	0	146	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	1002	150
2 024	3337	677	594	745	148	62	204	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	1200	150
2 025	3597	729	602	745	148	0	212	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	1522	200
2 026	3917	793	673	745	148	243	282	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	1600	200
2 027	4237	858	743	745	148	563	353	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	1600	200
2 028	4631	937	830	745	148	956	440	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	1600	200
2 029	5024	1016	917	745	148	1350	527	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	1600	200
2 030	5418	1095	1004	745	148	1743	614	4	1.7	456	82	147	16.5	117	20	160	43	269	41	177	38	1600	200

RBC-UGANDA-KENYA SYSTEMS INTERCONNECTED : UGANDA

ALTERNATIVE 2

SCENARIO: MEDIUM

Uganda FORECAST	Net Energy GWh	Peak Load MW	Installed MW	Committed Local Resources GWh	Committed Local Resources MW	Complementary Thermal GWh	Complementary Thermal MW	Kakira GWh	Kakira MW	Karuma GWh	Karuma MW	Mini-Hydro GWh	Mini-Hydro MW	Kalagala GWh	Kalagala MW	Murchison GWh	Murchison MW	Ayago GWh	Ayago MW	Import (+) Export (-) GWh	Import (+) Export (-) MW	Kenya GWh	Kenya MW	Rwanda GWh	Rwanda MW
2 010	2874	500	629	3038	587	0	0	294	42											-458	-70	-400	-50	-58	-20
2 011	3081	535	659	3038	587	0	30	294	42											-251	-70	-251	-50	0	-20
2 012	3303	573	733	3038	587	0	30	234	42			391	74							-360	-30	-400	-50	40	20
2 013	3541	612	733	3038	587	0	30	294	42			530	74							-321	-50	-672	-100	351	50
2 014	3796	655	971	3038	587	0	68	294	42	1747	200	530	74							-1813	-250	-2084	-300	271	50
2 015	4069	701	971	3038	587	0	68	294	42	1747	200	530	74							-1540	-200	-2327	-300	787	100
2 016	4373	752	1421	3038	587	0	68	200	42	1500	200	400	74	946	450					-1711	-200	-2400	-300	689	100
2 017	4676	802	1421	3038	587	0	68	200	42	1500	200	400	74	1348	450					-1810	-200	-2400	-300	590	100
2 018	5038	862	1421	3038	587	0	68	230	42	1500	200	400	74	1797	450					-1927	-200	-2400	-300	473	100
2 019	5399	922	1421	3038	587	0	68	230	42	1700	200	450	74	2026	450					-2045	-250	-2400	-300	355	50
2 020	5761	982	1421	3038	587	0	68	250	42	1747	200	500	74	2388	450					-2162	-250	-2400	-300	238	50
2 021	6117	1043	1427	3038	587	287	74	294	42	1747	200	530	74	2525	450					-2304	-280	-2400	-300	96	20
2 022	6473	1103	1649	3038	587	0	74	200	42	1500	200	500	74	2300	450	1276	222			-2341	-350	-2296	-300	-45	-50
2 023	6885	1174	1649	3038	587	0	74	250	42	1600	200	500	74	2400	450	1711	222			-2614	-350	-2400	-300	-214	-50
2 024	7298	1244	1847	3038	587	0	74	294	42	1747	200	530	74	2525	450	1948	420			-2784	-400	-2400	-300	-384	-100
2 025	7710	1314	1847	3038	587	0	74	294	42	1747	200	530	74	2148	450	2906	420			-2953	-400	-2400	-300	-553	-100
2 026	8186	1395	1935	3038	587	0	162	294	42	1747	200	530	74	2525	450	3209	420			-3157	-400	-2400	-300	-757	-100
2 027	8663	1477	2169	3038	587	0	162	294	42	1747	200	530	74	2021	450	2822	420	1572	234	-3361	-450	-2400	-300	-961	-150
2 028	9214	1571	2228	3038	587	6	221	294	42	1747	200	530	74	2393	450	3090	420	1722	234	-3606	-500	-2400	-300	-1206	-200
2 029	9766	1665	2532	3038	587	0	221	294	42	1726	200	530	74	1880	450	2708	420	3440	538	-3850	-500	-2400	-300	-1450	-200
2 030	10317	1759	2532	3038	587	0	221	294	42	1747	200	530	74	2067	450	2925	420	3716	538	-4000	-500	-2400	-300	-1600	-200

SCENARIO: LOW

2 010	2435	420	632	2704	590	0	0	258	42											-527	-70	-400	-50	-127	-20
2 011	2540	436	629	2757	587	6	0	294	42											-517	-70	-400	-50	-117	-20
2 012	2648	453	703	2414	587	0	0	294	42			530	74							-590	-80	-730	-100	140	20
2 013	2762	470	703	2518	587	0	0	294	42			530	74							-580	-150	-980	-200	400	50
2 014	2880	489	903	3038	587	0	0	294	42	1018	200	530	74							-2000	-250	-2400	-300	400	50
2 015	3003	508	903	3038	587	0	0	200	42	915	200	450	74							-1600	-200	-2400	-300	800	100
2 016	3134	528	903	3038	587	0	0	200	42	1046	200	450	74							-1600	-200	-2400	-300	800	100
2 017	3266	548	903	3038	587	0	0	200	42	1178	200	450	74							-1600	-200	-2400	-300	800	100
2 018	3411	570	903	3038	587	0	0	200	42	1430	200	450	74							-1707	-200	-2400	-300	693	100
2 019	3557	592	903	3038	587	0	0	294	42	1426	200	530	74							-1731	-200	-2400	-300	669	100
2 020	3703	614	903	3038	587	0	0	294	42	1650	200	530	74							-1809	-200	-2400	-300	591	100
2 021	3854	639	1353	3038	587	0	0	150	42	1300	200	400	74	873	450					-1907	-200	-2400	-300	493	100
2 022	4005	664	1353	3038	587	0	0	200	42	1400	200	400	74	972	450					-2005	-250	-2400	-300	395	50
2 023	4172	692	1353	3038	587	0	0	250	42	1500	200	500	74	1001	450					-2117	-250	-2398	-300	281	50
2 024	4338	719	1353	3038	587	0	0	250	42	1500	200	500	74	1283	450					-2233	-280	-2400	-300	167	20
2 025	4505	747	1353	3038	587	0	0	250	42	1500	200	500	74	1565	450					-2348	-280	-2400	-300	52	20
2 026	4689	778	1353	3038	587	0	0	250	42	1600	200	500	74	1783	450					-2482	-320	-2400	-300	-82	-20
2 027	4873	808	1353	3038	587	0	0	294	42	1700	200	530	74	1928	450					-2617	-350	-2400	-300	-217	-50
2 028	5075	842	1353	3038	587	0	0	294	42	1747	200	530	74	2240	450					-2774	-400	-2400	-300	-374	-100
2 029	5278	875	1363	3038	587	0	10	294	42	1747	200	530	74	2525	450					-2856	-400	-2325	-300	-531	-100
2 030	5481	909	1400	3038	587	0	47	294	42	1747	200	530	74	2525	450					-2653	-400	-1964	-250	-689	-150

SCENARIO: HIGH

2 010	3164	547	672	3038	587	0	43	294	42											-168	-70	-168	-50	0	-20
2 011	3447	594	723	3038	587	115	94	294	42											0	-70	0	-50	0	-20
2 012	3755	644	797	3038	587	0	94	294	42			530	74							-107	-50	-107	-50	0	0
2 013	4090	699	797	3038	587	43	94	294	42			530	74							185	20	0	0	185	20
2 014	4455	759	1015	3038	587	0	112	294	42	1747	200	530	74							-1154	-180	-1222	-200	68	20
2 015	4853	824	1056	3038	587	701	153	294	42	1747	200	530	74							-1457	-150	-2000	-250	543	100
2 016	5306	898	1506	3038	587	0	153	294	42	1747	200	530	74	1704	450					-2007	-250	-2400	-300	393	50
2 017	5758	971	1506	3038	587	0	153	294	42	1747	200	530	74	2305	450					-2156	-250	-2400	-300	244	50
2 018	6320	1062	1728	3038	587	0	153	200	42	1600	200	500	74	2400	450	925	222			-2343	-280	-2400	-300	57	20
2 019	6881	1152	1728	3038	587	0	153	250	42	1650	200	530	74	2400	450	1544	222			-2531	-320	-2400	-300	-131	-20
2 020	7443	1243	1728	3038	587	254	153	294	42	1747	200	530	74	2525	450	1773	222			-2718	-350	-2400	-300	-318	-50
2 021	8062	1346	1926	3038	587	0	153	294	42	1747	200	530	74	2525	450	2453	420			-2525	-400	-1995	-300	-530	-100
2 022	8681	1450	2045	3038	587	10	272	294	42	1747	200	530	74	2525	450	3679	420			-3142	-450	-2400	-300	-742	-150
2 023	9433	1575	2279	3038	587	0	272	294	42	1747	200	530	74	2402	450	3098	420	1726	234	-3402	-450	-2400	-300	-1002	-150
2 024	10184	1701	2583	3038	587	0	272	294	42	1747	200	530	74	1901	450	2770	420	3504	538	-3600	-450	-2400	-300	-1200	-150
2 025	10936	1826	2583	3038	587	0	272	294	42	1747	200	530	74	2413	450	2966	420	3870	538	-3922	-500	-2400	-300	-1522	-200
2 026	11846	1978	2676	3038	587	0	365	294	42	1747	200	530	74	2525	450	3383	420	4329	538	-4000	-500	-2400	-300	-1600	-200
2 027	12755	2130	2843	3038	587	268	532	294	42	1747	200	530	74	2525	450	3679	420	4674	538	-4000	-500	-2400	-300	-1600	-200
2 028	13859	2315	2946	3038	587	400	635	294	42	1747	200	530	74	2525	450	3679	420	4674	538	-3028	-400	-1428	-200	-1600	-200
2 029	14963	2499	2999	3038	587	400	688	294	42	1747	200	530	74	2525	450	3679	420	4674	538	-1924	-250	-324	-50	-1600	-200
2 030	16067	2684	3202	3038	587	1200	891	294	42	1747	200	530	74	2525	450	3679	420	4674	538	-1620	-250	-20	-50	-1600	-200

RBC-UGANDA-KENYA SYSTEMS INTERCONNECTED : KENYA

ALTERNATIVE 2

SCENARIO: MEDIUM

KENYA LOAD FORECAST	Net Energy GWh	Peak Load MW	Installed MW	Committed Local Resources GWh	MW	Complementary Thermal GWh	MW	Coal GWh	MW	Import (+) Export (-) GWh	MW
2010	7838	1343	1478	5052	1039	65	89	2321	300	400	50
2011	8491	1456	1628	5052	1039	65	89	3123	450	251	50
2012	9183	1576	1778	5052	1039	65	89	3667	600	400	50
2013	9922	1703	1874	5052	1039	98	135	4100	600	672	100
2014	10711	1840	2074	5052	1039	98	135	3477	600	2084	300
2015	11552	1985	2374	5052	1039	98	135	4075	900	2327	300
2016	12470	2144	2374	5052	1039	98	135	4920	900	2400	300
2017	13387	2302	2674	5052	1039	98	135	5837	1200	2400	300
2018	14492	2493	3274	5052	1039	98	135	6941	1800	2400	300
2019	15596	2684	3274	5052	1039	98	135	8046	1800	2400	300
2020	16701	2876	3274	5052	1039	98	135	9150	1800	2400	300
2021	17987	3098	3874	5052	1039	98	135	10436	2400	2400	300
2022	19272	3321	3874	5052	1039	98	135	11826	2400	2296	300
2023	20812	3588	3946	5052	1039	151	207	13209	2400	2400	300
2024	22351	3854	4546	5052	1039	151	207	14748	3000	2400	300
2025	23891	4121	4546	5052	1039	151	207	16288	3000	2400	300
2026	25699	4434	5146	5052	1039	151	207	18095	3600	2400	300
2027	27506	4747	5222	5052	1039	207	283	19848	3600	2400	300
2028	29664	5122	5822	5052	1039	207	283	22006	4200	2400	300
2029	31822	5496	6045	5052	1039	370	506	24001	4200	2400	300
2030	33980	5870	6645	5052	1039	370	506	26159	4800	2400	300

SCENARIO: LOW

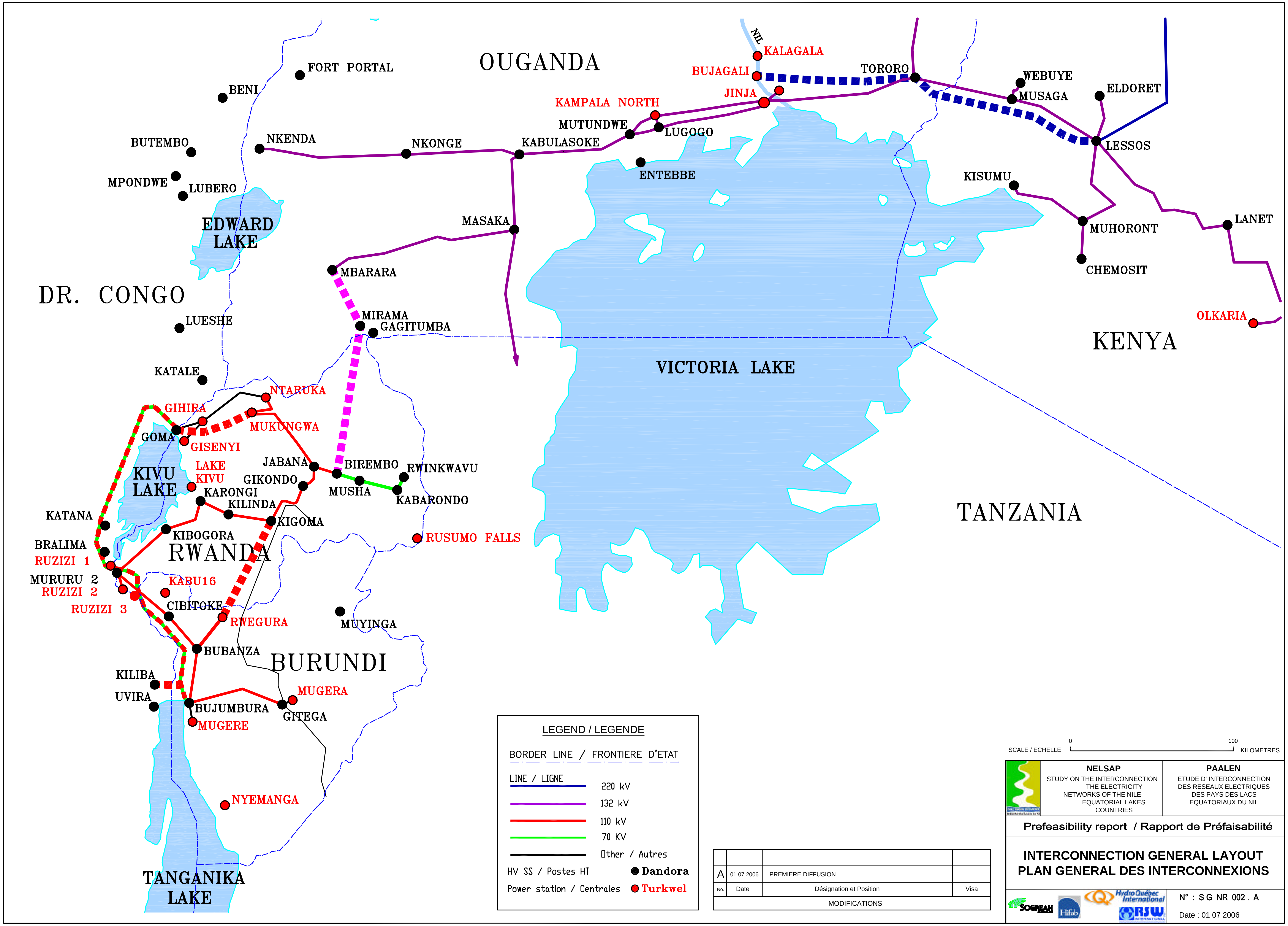
2010	7585	1299	1429	5052	1039	29	40	2104	300	400	50
2011	8153	1397	1579	5052	1039	29	40	2672	450	400	50
2012	8750	1500	1650	5052	1039	45	61	2923	450	730	100
2013	9381	1609	1770	5052	1039	59	81	3290	450	980	200
2014	10049	1724	1896	5052	1039	78	107	2519	450	2400	300
2015	10756	1846	2046	5052	1039	78	107	3226	600	2400	300
2016	11516	1977	2346	5052	1039	78	107	3985	900	2400	300
2017	12276	2109	2346	5052	1039	78	107	4745	900	2400	300
2018	13173	2264	2646	5052	1039	78	107	5642	1200	2400	300
2019	14070	2420	2662	5052	1039	89	123	6528	1200	2400	300
2020	14967	2575	3262	5052	1039	89	123	7426	1800	2400	300
2021	15988	2751	3262	5052	1039	89	123	8446	1800	2400	300
2022	17008	2928	3262	5052	1039	89	123	9467	1800	2400	300
2023	18207	3135	3862	5052	1039	89	123	10667	2400	2398	300
2024	19405	3343	3862	5052	1039	89	123	11864	2400	2400	300
2025	20604	3550	3905	5052	1039	121	166	13031	2400	2400	300
2026	21998	3791	4505	5052	1039	121	166	14425	3000	2400	300
2027	23392	4032	4505	5052	1039	121	166	15818	3000	2400	300
2028	25026	4315	4747	5052	1039	298	408	17277	3000	2400	300
2029	26661	4598	5347	5052	1039	298	408	18987	3600	2325	300
2030	28296	4881	5369	5052	1039	350	480	20930	3600	1964	250

SCENARIO: HIGH

2010	8165	1400	1540	5052	1039	545	151	2400	300	168	50
2011	8914	1530	1690	5052	1039	262	151	3600	450	0	50
2012	9715	1668	1840	5052	1039	110	151	4446	600	107	50
2013	10578	1817	2090	5052	1039	110	151	5416	900	0	0
2014	11506	1978	2290	5052	1039	110	151	5122	900	1222	200
2015	12506	2151	2366	5052	1039	129	177	5325	900	2000	250
2016	13611	2342	2716	5052	1039	129	177	6030	1200	2400	300
2017	14717	2533	2787	5052	1039	181	248	7084	1200	2400	300
2018	16074	2768	3387	5052	1039	181	248	8441	1800	2400	300
2019	17430	3003	3387	5052	1039	181	248	9797	1800	2400	300
2020	18787	3238	3987	5052	1039	181	248	11154	2400	2400	300
2021	20404	3518	3987	5052	1039	181	248	13176	2400	1995	300
2022	22020	3798	4587	5052	1039	181	248	14388	3000	2400	300
2023	23995	4140	4587	5052	1039	181	248	16362	3000	2400	300
2024	25969	4483	5787	5052	1039	181	248	18336	4200	2400	300
2025	27943	4825	5787	5052	1039	181	248	20310	4200	2400	300
2026	30289	5232	5787	5052	1039	181	248	22656	4200	2400	300
2027	32634	5638	6387	5052	1039	181	248	25002	4800	2400	300
2028	35486	6133	6887	5052	1039	181	248	28825	5400	1428	200
2029	38337	6627	7290	5052	1039	585	801	32377	5400	324	50
2030	41189	7122	7890	5052	1039	585	801	35532	6000	20	50

ANNEX C: HV GRID GENERAL LAY OUT

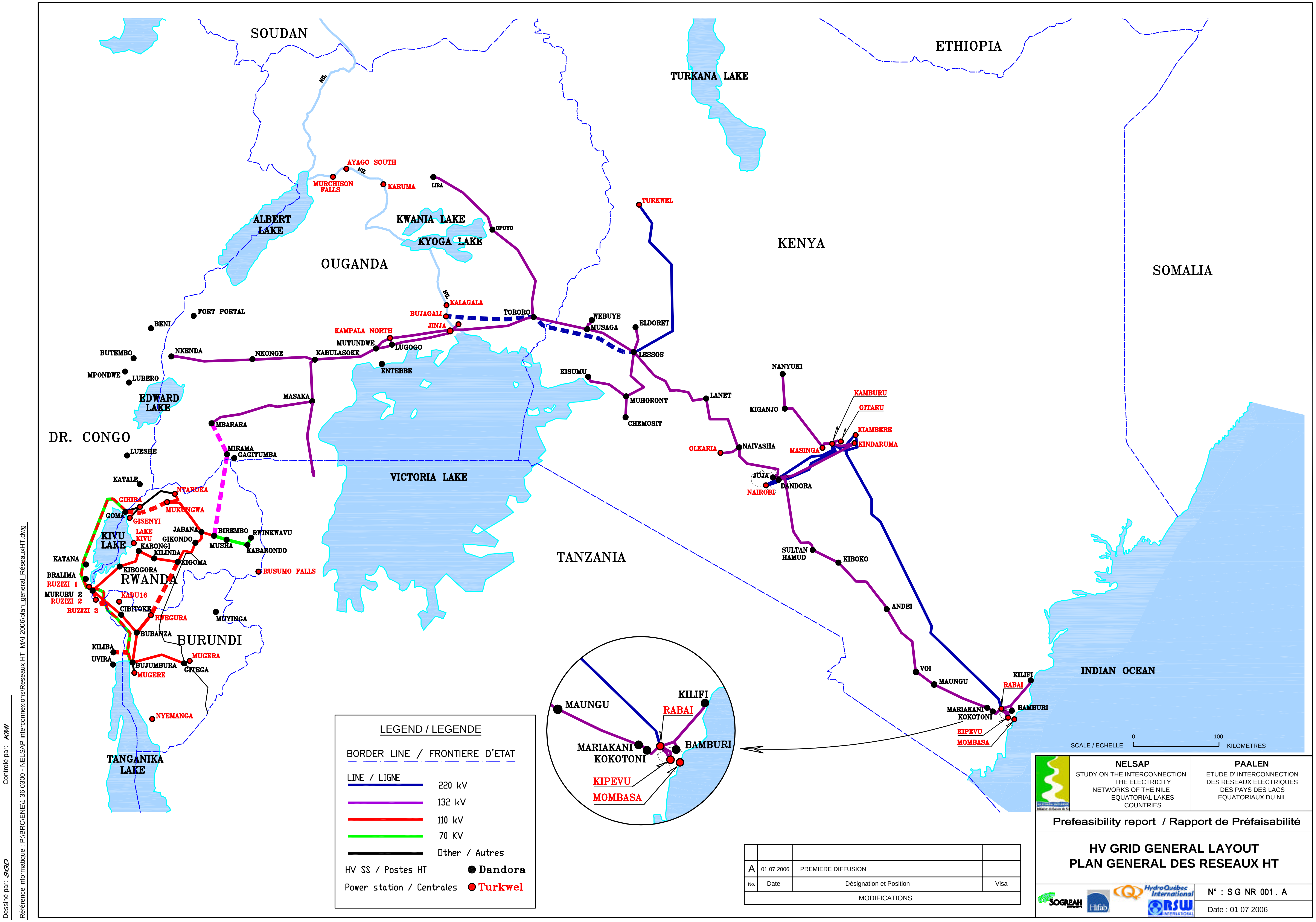
- HV grid general layout .... S G NR 001 A
- Interconnection general layout .... S G NR 002 A
- Single line diagram of existing network (C.E.P.G.E.L) ....R N UR 000 0

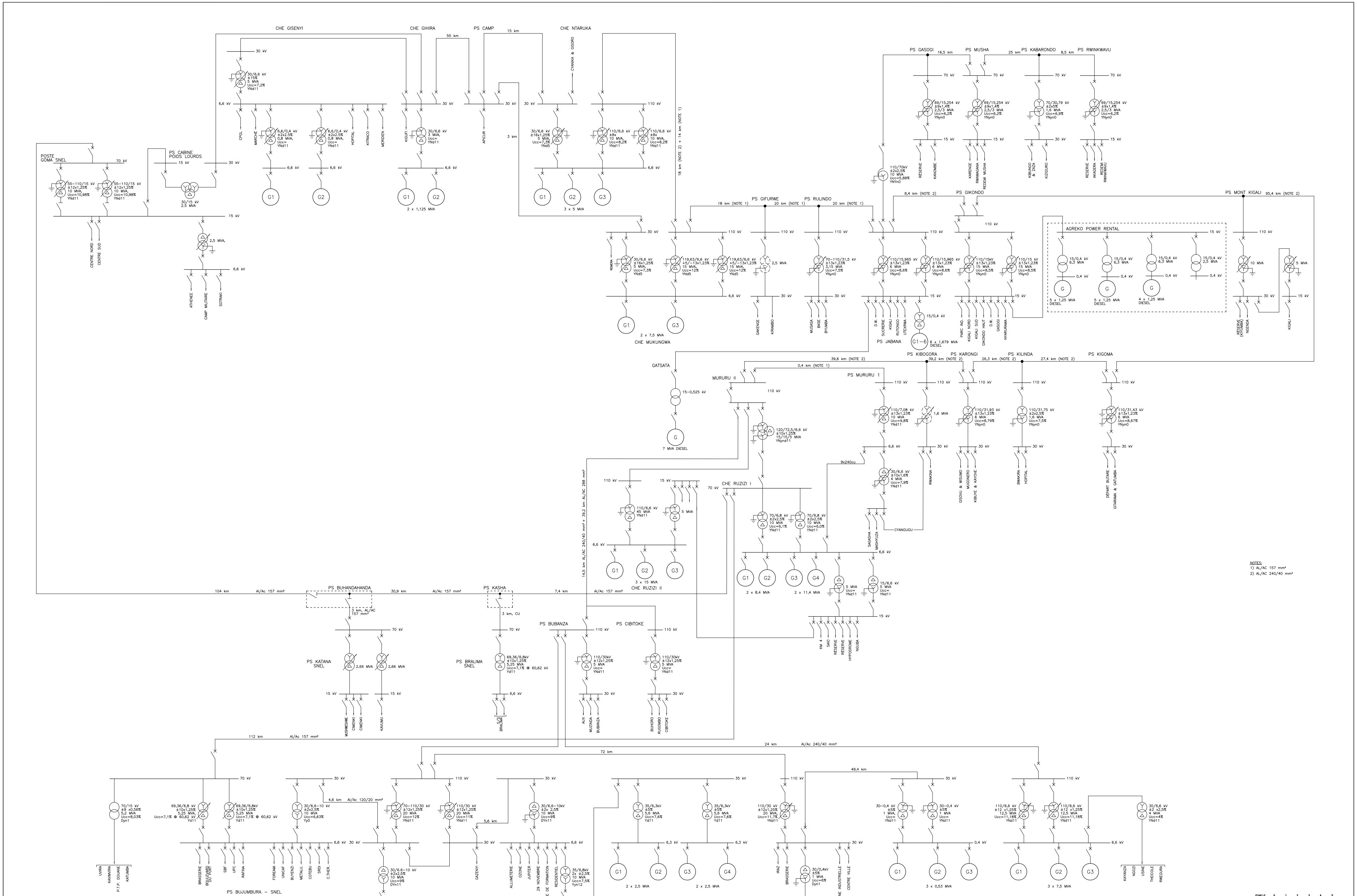


Dessiné par: SGD

Controlé par: KMI

Référence informatique : P:\BRCIENE\1 36 0300 - NELSAP interconnexions\Reseaux HT MAI 2006\plan_general_RéseauxHT.dwg


SOUDAN
ETHIOPIA
TURKANA LAKE
KENYA
SOMALIA
OUGANDA
ALBERT LAKE
KWANIA LAKE
KYOGA LAKE
VICTORIA LAKE
TANZANIA
DR. CONGO
EDWARD LAKE
KIVU LAKE
RWANDA
BURUNDI
TANGANIKA LAKE
INDIAN OCEAN
NIL
AYAGO SOUTH
MURCHISON FALLS
KARUMA
LIRA
OPUYO
TURKWEL
KALAGALA
BUJAGALI
TORORO
JINJA
KAMPALA NORTH
MUTUNDWE
LUGOGO
ENTEBBE
KABULASOKE
NKONGE
NKENDA
FORT PORTAL
BENI
BUTEMBO
MPONDWE
LUBERO
MASAKA
MBARARA
MIRAMA
GAGITUMBA
LUESHE
KATALE
WEBUYE
MUSAGA
ELDORET
LESSOS
KISUMU
MUHORONT
CHEMOSIT
LANET
NANYUKI
KIGANJO
KAMBURU
GITARU
KIAMBERE
KINDARUMA
MASINGA
OLKARIA
NAIVASHA
JUJA
DANDORA
NAIROBI
SULTAN HAMUD
KIBOKO
ANDEI
VOI
MAUNGU
KILIFI
RABAI
MARIAKANI
KOKOTONI
BAMBURI
KIPEVU
MOMBASA
NTARUKA
GIHIRA
MUKUNGWA
GOMA
GISENYI
LAKE KIVU
JABANA
GIKONDO
KARONGI
KILINDA
BIREMBO
RWINKWAVU
MUSHA
KABARONDO
KATANA
KIGOMA
KIBOGORA
RUSUMO FALLS
BRALIMA
RUZIZI 1
MURURU 2
RUZIZI 2
RUZIZI 3
KABU16
CIBITOKE
RWEGURA
MUYINGA
BUBANZA
KILIBA
UVIRA
BUJUMBURA
MUGERA
GITEGA
MUGERE
NYEMANGA
SCALE / ECHELLE 0 100 KILOMETRES
LEGEND / LEGENDE
BORDER LINE / FRONTIERE D'ETAT
LINE / LIGNE
220 kV
132 kV
110 kV
70 KV
Other / Autres
HV SS / Postes HT Dandora
Power station / Centrales Turkwel
A | 01 07 2006 | PREMIERE DIFFUSION
No. | Date | Désignation et Position | Visa
MODIFICATIONS
NELSAP
STUDY ON THE INTERCONNECTION THE ELECTRICITY NETWORKS OF THE NILE EQUATORIAL LAKES COUNTRIES
PAALEN
ETUDE D' INTERCONNECTION DES RESEAUX ELECTRIQUES DES PAYS DES LACS EQUATORIAUX DU NIL
Prefeasibility report / Rapport de Préfaisabilité
HV GRID GENERAL LAYOUT
PLAN GENERAL DES RESEAUX HT
N° : S G NR 001 . A
Date : 01 07 2006
Dessiné par: SGD
Controlé par: KMI
Référence informatique : P:\BRCIENE\1 36 0300 - NELSAP interconnexions\Reseaux HT MAI 2006\plan_general_RéseauxHT.dwg



NELSAP
STUDY ON THE INTERCONNECTION OF THE ELECTRICITY NETWORKS OF THE NILE EQUATORIAL LAKES COUNTRIES

PAALEN
ETUDE D'INTERCONNEXION DES RÉSEAUX ÉLECTRIQUES DES PAYS DES LACS ÉQUATORIAUX DU NIL

PREFEASIBILITY REPORT / RAPPORT DE PREFAISABILITE

UGANDA - RWANDA INTERCONNECTION
EXISTING GRID SINGLE LINE DIAGRAM (G.L.E.C.C.)
SCHÉMA EXISTANT DU RÉSEAU (C.E.P.G.E.L.)

N° R N UR 000 0
Date : Mars 2006