

**AVAILABILITY OF HYDRO POWER PLANTS AND ELECTRICITY  
CONSUMER PRICES: A CASE STUDY OF KENYA ELECTRICITY  
GENERATING COMPANY LIMITED**

**BY**


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## DECLARATION

This research project is my original work and has not been submitted for a degree in any other university.

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This research project has been submitted with my approval as the University Supervisor.

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## **DEDICATION**

To God, almighty ..... From whom all good things come.

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## ABSTRACT

The objectives of this study were to determine whether the availability of the KenGen Hydropower plants impacts on electricity consumer prices; to determine the general impact of the Power Purchase Agreements on the electricity consumer prices; and to interrogate the impact of liberalization in the electricity subsector on the electricity consumer prices. Primary data was collected by way of questionnaires which were administered to senior KenGen Management Staff while secondary data was obtained from Kenya Power and validated by the same data from Energy Regulatory Commission and KenGen. Primary data was analyzed using descriptive statistics while secondary data was analyzed using regression analysis model.

One major finding of the study is that there is a negative relationship between consumer prices and Availability of the KenGen Hydropower plants. The study further demonstrated that Availability of the KenGen Hydropower plants does not affect the consumer prices. The use of the model developed to forecast the consumer electricity price is therefore not recommended as one might get predictions that are inaccurate.

The study found that about 70 percent of KenGen's power generation consisting of hydropower was not a good strategy for consumers and KenGen needed to invest more in other energy sources. The study also emphasized that KenGen has the capacity and strategy to bring down electricity prices at the same time electricity prices would be lower if other independent producers also owned hydro power plants. This is also in line with the opinion of majority of the respondents that electricity prices would come down in the future.

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## LIST OF ABBREVIATIONS

EAP&L	East Africa Power and Lighting
EPA	Electric Power Act
EPP	Emergency Power Plant
ERC	Energy Regulatory Commission
GDC	Geothermal Development Company
GoK	Government of Kenya
GWh	Gigawatt Hours
IPP	Independent Power Producer
KENGEN	Kenya Electricity Generating Company
KETRACO	Kenya Electricity Transmission Company
KPLC	Kenya Power & Lighting Company
kWh	Kilowatt Hours
KVDA	Kerio Valley Development Authority
LCPDP	Least Cost Power Development Plan
MOE	Ministry of Energy
MT	Metric Tonne
MW	Megawatt
MWh	Megawatt Hours
NAPA	National Adaptation Programmes of Action (Malawi)
NCC	National Control Centre
OSE	Optimum Sediment Exclusion
PPA	Power Purchase Agreement
REA	Rural Electrification Authority
RFP	Request For Proposal
RoR	Run-of- River
SFC	Specific Fuel Consumption
TARDA	Tana and Athi River Development Authority
USD	United States Dollar

# CHAPTER ONE: INTRODUCTION

## 1.1 Background of the Study

The common denominator in the operation across the entire spectra of production; be it manufacturing, electricity generation, catering is the operation strategy which determines the product characteristics in terms of; quality, flexibility, cost and competitiveness.

According to Chase, Jacobs, Aquilano and Agarwal (2008), operation strategy is concerned with setting broad policies and plans for using the resources of a firm to best support its long term competitive strategy. The strategy involves a long term process that must foster inevitable change. An operations strategy involves decisions that relate to design of the process and the infrastructure needed to support the process. Operations strategy can be viewed as part of a planning process that coordinates the operational goals with those of the larger organization. Since the goals of the larger organization change over time, the operations strategy must be designed to anticipate future needs.

From the foregoing argument, it is clear that operation strategy is a key element in operating a power plant given that the running of the plant is based on some set out goals of the organization which have to be achieved. These goals may range from attaining high plant availability, quality power, affordable power and reliable power. High plant availability majorly depends on the maintenance strategy adopted by the generating company; however, the availability of a hydro power plant also depends on the dam reservoir levels because there are critical dam levels below which electricity generation may be compromised.

### **1.1.1 Plant Availability, Maintenance and Consumer Prices**

The availability of a power plant is determined by its availability factor which is defined as the amount of time it is able to produce electricity over a period of time divided by the total time in the period. Availability factor should not be confused with the capacity factor which is the ratio of the actual output of a power plant over a period of time and its potential if it had operated at full capacity in the entire period. The availability of the plant varies depending on the fuel used, design of the plant or how the plant is used. The major determinant of plant availability is the maintenance strategy applied by the operator (Editorial for the American Society for Mechanical Engineers journal, 2004).

Mahmoud and Sotudeh (2000) explain that the quality of electrical energy, from a customer point of view is combined of technical and economic components. Technical concept can be indicated in availability and reliability indices while the economical concept are integrated in the electrical energy price which is required to be in the lowest possible range. According to Least Cost Power Development Plan (LCPDP, 2011), thermal generation has been rising in Kenya in recent years as new thermal plants are constructed and also due to reducing output from hydropower plants as a result of recurrent drought. In the fiscal year 2009/10, thermal plants produced over 40% of electricity supplied using imported fossil fuels. The electricity tariffs policy allows for pass through of fuel cost to consumers and therefore consumer price which the weighted prices calculated from generation costs of all plants fluctuates with monthly fuel usage and fuel prices. This study therefore attempts to determine the link between the availability of hydropower plants in the generation mix and the respective consumer prices.

### **1.1.2 Evolution of the Power Subsector**

Kenya's power sector history dates back to 1922, the year in which the then East African Power and Lighting Company (EAP&L) was formed by merging two companies namely, Mombasa Electric Power and Lighting Company (Established in 1908 by a Mombasa merchant called Harrali Esmailjee Jeevanji) and Nairobi Power and Lighting Syndicate, also established by Eng. Clement Hertzal in 1908.

In 1954 Kenya Power Company (KPC) was formed as a subsidiary of EAP&L and its mandate was to construct electricity transmission lines between Nairobi in Kenya and Tororo in Uganda with the objective of importing power generated at the Owen Falls Dam in Uganda. The operations of EAP&L were mainly concentrated in Kenya and the company was later renamed Kenya Power and Lighting Company Limited (KPLC) in 1983 and was 100% owned by the Government of Kenya (GoK). KPLC was performing all the three operations namely, generating, transmitting and distributing electricity nationally. (Kenya Power Information Manual)

In 1990s the Government of Kenya (GoK) initiated the Structural Adjustments Program and electricity generation was liberalized which saw the introduction of Independent Power Producers (IPPs) into the Kenyan electricity generation market in 1996. In 1997, KPLC was unbundled and Kenya Electricity Generating Company (KenGen) was created and took over the generation assets while KPLC remained with the mandate of transmission and distribution of electricity. In the same year (1997), Electricity Regulatory Board was established pursuant to the 1997 Electric Power Act (EPA), as a regulator.

The GoK continued with the reforms in the power sector and in particular, the energy policy development of 2004 and subsequently the enactment of the Energy Act of 2006 which established the Energy Regulatory Commission (ERC) and the Rural Electrification Authority (REA). Similarly, under the Sessional Paper no. 4 of 2004 on energy, Geothermal Development Company (GDC) and Kenya Electricity Transmission Company (KETRACO) were formed. GDC is a special purpose vehicle for geothermal resource development and KETRACO is a transmission company. Both are 100% GoK owned (LCPDP 2011).

### **1.1.3 Kenya Electricity Generating Company (KenGen)**

According to ERC Annual report (2011), KenGen is the main electricity generating company in Kenya with a total installed capacity of 1,176MW. The company is listed at the Nairobi Stock Exchange with a shareholding of 70% for GoK and 30% for private shareholders. KenGen's generation capacity accounts for 75% of the national generation capacity and is generated from various sources which include, hydropower, thermal, geothermal and wind.

KenGen hydropower plants are categorized into two namely, main and small hydros depending on the size and location of the power plant. The main hydros are located in the eastern and western parts of the country whereas the small hydros are scattered throughout the country.

The main hydropower plants are five large cascaded hydro stations located along Tana River in the eastern part of the country with a total installed capacity of 563MW. The five stations are Kindaruma (40MW), Kamburu (94MW), Gitaru (225MW), Masinga (40MW), and Kiambere (164MW). The other major hydro stations are Turkwel power station which was commissioned in 1991 with an installed capacity of 106 MW and Sondu Miriu (60MW) commissioned in early

2008. Both Sondu Miriu and Turkwel are located in the western part of the country. Consequently, an additional 73MW comprising of Sangoro (21MW), Tana Redevelopment (20MW) and Kindaruma 3<sup>rd</sup> Unit (32MW) are currently being commissioned simultaneously.

Small hydro power stations in Kenya are defined as plants whose installed capacity is greater or equal to 500kW but less than 10MW. Such plants may be connected to the conventional electrical distribution networks as a source of low cost renewable energy. Alternatively, small hydro projects may be built in isolated areas that would be uneconomical to serve from a network, or in areas where there is no national electrical distribution network.

Several small hydroelectric power plants in Kenya were commissioned between 1925 and 1958. The first small hydro-electric power station known as Ndula with an installed capacity of 2MW on Thika River was constructed in 1925 and has since been decommissioned. The other small hydros which are currently operational are Mesco(0.35MW), Sosiani (0.4MW), Sagana (1.5MW), Gogo (2MW) and Wanjii (2MW) (KenGen Annual Report 2010)

## **1.2 Statement of the Problem**

Hydro power plants are severely affected by drought. The machines may be mechanically sound and available but the plant is not available because of low dam levels which are caused by water inflows or siltation. Tavanir, et al (2000) argues that electrical energy has been the basis of economic planning and that most plans intend to minimize cost and maximize both availability and reliability of electrical energy to increase customer satisfaction but they are in conflict and a trade-off could often cause one or the other to be compromised and lead to customer dissatisfaction, whereas Bishwakarma (2007), in his study on sedimentation, points out that the

design approach based only on the availability of water for power production is not always realistic during operation. Sediment concentration in the available water most often limits the production significantly during the dry season and hence, it is important to incorporate such losses in the analysis during planning and design.

In his study, Wambugu (2010) postulates that, hydropower is relatively a cheaper and renewable source of energy which can easily be exploited for the economic growth of a country that has river basins, however, in Kenya, the dangers of over-reliance on hydropower have been experienced in both the industrial and domestic consumption. Due to high cost of fuel used to generate thermal power, the consumer prices are pushed up and some industries have actually relocated to countries where consumer prices are favourable.

From the Kenya Power Annual Report for the Financial Year 2010/2011, the national electricity generation mix was as follows; Hydro 749MW (55%), Thermal 446MW (32.77%), Geothermal 163MW (11.98%), Wind 0.4MW, Cogeneration 26MW and others 0.25%, giving a total of 1,361MW as installed capacity and an effective capacity of 1,310MW. Hydropower depends on the inflows and is rain dependent. This means that during the rainy seasons, the dam levels are good and hence a lot of the generation in the mix is from hydro plants. However, during the dry season, the dam levels are depleted and much of the generation is from thermal power plants which use expensive petroleum based fuels and the fuel surcharge ends up in the consumer bills. Most of these thermal plants are operated by the Independent Power Producers which in turn have signed Power Purchase Agreements with Kenya Power.



The IPP and KenGen Plants are despatched in accordance to the Economic Merit Order which means the cheapest plant in terms of generation cost is despatched first, then followed by the next in rank as per the merit order. The consumer price for that month shall therefore be the weighted generation cost of all the plants which were despatched as per the merit order in that particular month (ERC Grid Code, 2009).

KenGen hydro plants can therefore impact on the consumer prices and this will be determined by the availability of such plants which in turn is dependable on the maintenance. The aforementioned Power Purchase Agreements are structured in such a way that the fuel cost is a pass through component and appears in the electricity bill as Fuel Cost Adjustment. In this regard, the more the hydro plants are operated the less fuel cost is attributed to the bill.

Several studies have been conducted worldwide on managing drought effects on hydropower generation and below are some of the findings: Molle, Jayakody, Ariyaratne and Somatilake (1994) in their study on balancing irrigation and hydropower reports that in some particular cases, hydropower is generated by diverting water into a contiguous basin. In such instances, third party impacts on third party riparian users are potentially much higher, although often mitigated by releasing a minimum flow to the river. Upadhaya and Strestha (2002) discuss the case of Kali Gandaki “A” hydroelectric project in Nepal, which diverts water from Kali Gandaki and returns it at a point 50 km further downstream with significant impact on fisheries. The same phenomena are experienced in Sondu Miriu which is run-of-river power plant where water is diverted into the power plant through the intake and released for other uses downstream.

Braga, Rocha and Tundisi (2000) in their study on hydropower in Brazil, point out that although standard planning and design of dams and reservoirs takes into account hydro climatic variability in the historical record, the underlying climate regime is assumed to be constant whereas Simone, Coelho, Cavalcanti, Feritas and Ito (2001) in their study to address the issue of persistent and widespread drought conditions during 2000-2001, which were the apparent cause of the decline of water levels in the reservoirs of Brazilian hydroelectric power plants found that neither changes in frequency nor magnitude of extreme hydrological events (droughts and floods) nor in annual rainfall amounts can be detected from the existing climate record.

Kiiru (2002) studied pricing of electricity by bulk power producers in Kenya and noted that prices can be minimized by investors ensuring least cost per kilowatt, signing long-term strategic supply agreements with suppliers of spares and fuel whereas Njenga (2003) noted that the major obstacles on financing the electric power sub-sector were political risks, lack of well established legal and regulatory framework including an independent regulator, skewed policies to foreign investment, power theft, fraudulent billing and commercial risks attributed to the adverse financial performance of the sole electricity transmission and distribution company as well as lack of sufficient capital in the domestic capital market.

Similarly, Mwaka (2007) has indicated that factors affecting productivity in the large thermal power generation stations in Kenya were, lack of spares, low plant availability, plant size and location, and government regulations and capacity utilization by KPLC while Chelimo (2008) studied on strategic responses to challenges on energy regulation in Kenya by the Energy Regulatory Commission and postulated that the regulator was operating in an ever changing

environment which has forced it to adopt strategies in response to the changes like setting hydro risk mitigation fund and introduction of time of use consumer tariffs.

From the foregoing analysis, the studies so far carried out were attempting to determine the effect of drought, dam management and spares availability on the operations or availability of the power plants, however, no distinct and specific study has been carried out to determine the link between the availability of hydropower plants in the generation mix and the tail end consumer prices.

The study therefore sought to answer the following questions:

- i. What is the relationship between the Availability of KenGen Hydro Plants and the Consumer Prices in Kenya?
- ii. What is the impact of Power Purchase Agreements and how they are structured and the consumer prices in Kenya?
- iii. What is the general impact of liberalization of the electricity subsector on the consumer prices

### **1.3 Objectives of the Study**

- i. To determine whether there is a relationship between the Availability of the KenGen Hydropower plants and electricity consumer prices
- ii. To determine the general impact of the Power Purchase Agreements on the electricity consumer prices
- iii. To interrogate impact of liberalization in the electricity subsector on the electricity consumer prices

#### **1.4 Value of the study**

The study would be of benefit to the government policy makers on electric power capacity expansion and how they could use the information to recommend the types of power projects to be fast-tracked. Similarly, the outcome of the study would help KPLC and ERC in re-evaluating the existing and the yet to be signed power purchase agreements in order to control consumer prices and, also generation utilities like KenGen in reevaluating its position on over-reliance of hydropower in their electricity generation mix. Lastly, the academicians and researchers would need the findings to bridge the existing knowledge gaps in the studies so far carried out in the energy sector for the purpose of providing affordable and reliable power to the citizenry. The study would thus contribute to the existing body of knowledge.

## CHAPTER TWO: LITERATURE REVIEW

### 2.1 Introduction

Molle, et al (1994) in their study have indicated that although hydropower does not directly consume water, its generation frequently conflicts with other uses, notably irrigation, because its release schedule does not always correspond to the timing of water used for other activities. In some cases water passing through the turbines is not returned to the river but diverted to an adjacent basin which greatly alters natural regimes in the river and potentially impacts on users located downstream of the dam.

Briscoe (1999) in his study found that hydropower generation meets 19 percent of the world's energy needs and this has been the driving force behind the construction of the 45,000 dams that can be found worldwide. He postulates that the generation of electricity impacts little on the quantity of water (it is limited to the loss by evaporation in the dams) but it alters the hydrograph of stream flows, as the timing of water releases is governed by the demand curve for electricity.

Wazad and Ahmed (2009) in their study of hydroelectric power generation at Sapchari Waterfall in Bangladesh indicated that a dam serves two purposes at a hydro plant. First, a dam increases the head or height of a waterfall. Secondly, it controls the flow of water by releasing it when needed for electricity production. Modern times are calling for clean and efficient renewable energy source which can be achieved by the implementation of hydropower systems. The major advantage of hydroelectricity is the elimination of the cost of fuel. Secondly, hydropower plants are immune to increase in the cost of fossil fuels such as oil, natural gas or coal. Hydropower plants tend to have longer operation lifespan than fuel fired plants.

According to Beckett (2006), not only are hydropower plants a non-polluting energy source but they also are much more efficient than the burning of fossil fuels for electricity generation. In respect to coal burning, the most common energy source, hydropower plants are greatly more efficient with an efficiency range of between 60% and 90%, whereas, coal burning units are 43% to 60% efficient. Hydroelectricity eliminates the flue gas emissions from fossil fuel combustion, including pollutants such as sulfur dioxide, nitric oxide, carbon monoxide, dust and mercury in coal. Compared to the nuclear power plant, hydropower generates neither nuclear waste nor nuclear leaks. Unlike uranium, hydropower is also a renewable energy source and is cheaper than nuclear and wind power

### **2.1.1 Current Status of Hydropower Generation in Kenya**

According to ERC annual report (2011), hydropower generation in Kenya stands at 55 percent of the energy mix or 749MW. KenGen generates all the commercial hydropower in Kenya. There are several community-based mini-hydro plants around Mount Kenya region which are used for domestic electricity consumption. Most of the mini-hydro power plants generate less than 1MW and they have no surplus capacity which they could sell to KPLC. Similarly, a number of Tea Factories located near rivers have shown interest in building mini-hydro power plants to provide electric power to the factories and reduce cost of electricity supplied to them by KPLC and wood fuel that they may be using now.

Hydroelectric power is generated by river water flowing through turbines. As the flow of that water diminishes during drought, the hydropower generation is drastically reduced with significant losses in revenue from lost energy unit sales. In 2009, Kenya experienced a severe

drought which not only adversely affected the agricultural activities and water for domestic usage but also reduced the capacity of hydropower to the extent that KPLC, the sole electricity distributor in Kenya had to load shed in order to manage the available electric power. KenGen's Masinga power plant was shut down in June 2009 due to lack of water in the reservoir and the lower water intake gate was opened to allow dead stock water to pass to the lower Kamburu dam in the 7-Forks cascade to allow low hydropower generation.

## **2.2 Optimum Sediment Handling in Run-Of- River Hydropower Plants**

KenGen's Sondu Miriu hydropower plant is an example of run-of-river hydropower plant where the river is diverted for electricity generation after which it is released back to its course downstream for other related activities such as irrigation.

Bishwakarma (2007) in his study indicates that the standard guidelines for Optimum Sediment Exclusion (OSE) in Run-of-River (RoR) hydropower plants are not well developed to date. Optimization of sediment exclusion has therefore, been a challenge for the design and operation of hydropower plants built on sediment loaded rivers. Stole and Karki (1999) established that there is a level at each high head RoR hydropower plant where the costs are higher than the benefits of continued generation due to excessive sediment induced wear and resulting maintenance cost. In developing hydropower projects on rivers carrying high sediment loads, appropriate attention should be given to the sediment exclusion aspect. Design of RoR hydropower plants based only on the availability of water is not realistic because the content of the sediment in water limits the production. When a hydropower plant is operated for a period of about 10 minutes with sediment concentration of about 24,500 parts per million, the estimated cost of repair is about 10 times higher than the generated revenue during the operation. This

therefore means that it is not always economical to operate power plants without understanding the economic value of the water utilized for power generation.

### **2.3 Hydropower Operation**

Zahraie and Karamouz (2004) in their study of hydropower reservoir operation contend that among the energy production methods, electricity is the most environmentally sound energy production method and has been given more attention over the years. The development of hydropower electricity generation, which has high efficiency and negligible environmental pollution, is one of the major concerns in planning for the sustainable development of the economy. Hydropower units often operate as part of a larger system. Performance of a hydropower reservoir in supplying water demands might only affect local users downstream of the reservoir, but the power generation has regional effect on the power network. Operation of the hydropower reservoir depends on different parameters that are mostly region specific. Peng and Buras (2000) adds that; considering the hourly variation of the electrical load and limitations of thermal units for short term changes in generation, hydropower units play a significant role in supplying the high valued peak loads. Therefore, operating planning for hydropower reservoirs is more focused on peak generation, although the ability to shift from one unit to another increases the power network reliability.

Vasiliadis and Karamouz (1994) on their long term planning model assert that hydropower plants have less loading and unloading limitations compared with thermal plants. Therefore, in case of emergency situations, such as shutdown in some of the hydro or thermal plants and breakdown in the electricity network, hydropower plants can be loaded in a short time to supply the load of the system in that specific time. Hence, a part of the capacity of the hydropower plants, which is



called the spinning reserve, is usually unloaded to supply the power loads in emergency situations. Rangarajan (1999) confirms this hypothesis and postulates that besides meeting power loads, the system should have enough capacity to supply the expected peak load plus additional reserved energy in case of breakdown and necessary maintenance shut down.

They further go ahead to define the reliability in a hydropower system in terms of system's adequacy and security. Adequacy relates to the existence of sufficient energy within the system to satisfy the power loads or system operational constraints. Security refers to the ability of the system to respond to disturbances such as power network breakdowns within the system.

#### **2.4 Impacts of Increased Electricity Prices on Consumer Demand**

Lange (2008) in his study on the impact of electricity prices on consumer demand concludes that every government's electricity pricing policy is to achieve a balance between equity, economic growth and environmental goals. This, therefore, means that a balance has to be established between affordable electricity prices for households, low cost electricity for industrial consumers, prices that provide efficient market signals by accurately reflecting the cost of supply and a general price level that ensures the financial sustainability of the electricity utilities.

According to Niemeyer (2001), certain factors are likely to affect the degree of consumers' electricity price responsiveness. That is, a small retail sales customer for whom electricity expenditures are relatively unimportant is likely to respond less to the price changes than a large manufacturer with electric-intensive processes. In the short run, the manufacturer will make an effort to reduce the usage during high price periods and take advantage of low price periods. In the long run, it will make plant expansion or relocation decisions on the level of electricity

prices. Abrate (2003) argue that the marginal cost of producing electricity varies considerably over time, since demand is highly variable, whereas production is subject to rigid short term capacity constraint. Furthermore, during off-peak times there is plenty of capacity and the cost of producing an additional kilowatt-hour only reflects fuel and some operating and maintenance cost, while during peak periods, the capacity constraint will be binding and the incremental cost can increase greatly. This means that the end-use consumer faces a fixed retail price, which does not give a signal of the actual system load and demand does not play an active role in determining prices.

Fiorio and Florio (2009) contend that consumers' satisfaction about prices is higher in countries where public ownership of the electricity industry is large. Liberalization seems, however, to be associated with a more positive perception of electricity prices in the series of time.

## **2.5 Deterioration and Maintenance of Hydropower Plants**

Trondheim (2008) observes that, high reliability is an indispensable requirement for the operation of technical systems and infrastructure, such as power plants, oil platforms, aircrafts, railway lines and bridges. Failures can result in high costs and hazards to humans and the environment. Practically, all technical systems are subject to deterioration and a failure is often the consequence of excessive deterioration. Hence, inspection and maintenance are undertaken to uncover deterioration and to prevent failures and damage. Trondheim (2008) further argues that the improvement and optimization of maintenance has great potential for cost savings.

Bakken, et al (2002) in their study reaffirms that, traditionally, maintenance decisions have been based on experience, however, there is a paradigm shift where operating conditions are changed and companies try to produce electricity during periods when the prices are highest to maximize their profit thereby disregarding the maintenance schedules. The operator of the plant must conduct inspections and maintenance to detect deterioration and to prevent failures. Preventive maintenance is the most beneficial strategy for many components in a hydropower plant. Condition based maintenance is used for major equipment such as generator and the turbine.

## **2.6 Challenges of Hydropower Generation**

Campbell (2010) in his study on small hydro technologies and prospects believes that power generation from rivers and streams is not without controversy, and the capability to produce energy from these sources will have to be balanced against environmental and other public interest concerns. The balance can be aided by research into new technologies and forward thinking regulations that encourage the development of these resources in cost effective, environmentally friendly ways which recognize that such facilities when built can last for at least 50 years. Hydropower project development depends largely on the characteristics of a particular site. The site will determine the improvements and structural works which are necessary for the project.

Campbell (2010) further asserts that small hydropower plants will be on run-of-river facilities and therefore will be dependent upon river or stream flows. Availability can therefore be an issue since water flow can vary at certain times due to seasonal drought or rainfall conditions and hence the capacity factor shall be reduced. Similarly, hydropower project developers must

comply with regulatory requirements. For many small and low head hydropower projects, the cost of meeting environmental regulations and connecting to the grid can constitute a considerable hurdle.

## **2.7 Summary and Conclusions**

Hydropower is relatively a cheaper, environmentally friendly and renewable energy resource that can be beneficially exploited for the economic growth of a country that has river basins and predictable good rainfall seasons. It is very clear from the literature review that hydropower generation can be severely affected by climatic variability, sedimentation and hydrological drought to the detriment of economic growth of a country. Hydrological drought has been significantly singled out as the biggest threat to sustenance and enhancement of hydropower generation because of reduced dam levels.

Kenya produces over 60% of her electricity from hydropower and hence the dangers of over-reliance on hydropower have been experienced by both the industrial sector and the domestic consumers. Due to high cost of fuel used to generate thermal power, some large industrial consumers have even closed down or relocated to other countries where electricity is relatively cheaper. The cost of emergency rental power has been passed on to electricity consumers as the fuel cost adjustment component in their electricity bills.

KenGen Company owns and operates all the 749MW of installed commercial hydropower capacity in Kenya and it is paramount for KenGen to address the issue of drought effects on hydropower generation and therefore the plant availability of hydropower plants. This study will

endeavour to evaluate and address this problem in the long run mitigate high electricity consumer prices.

## **CHAPTER THREE: RESEARCH METHODOLOGY**

### **3.1 Research Design**

The research design was a case study and it gave interviewees an opportunity to give in-depth reasons to questions asked. The case study used secondary data in addition to primary data from KenGen to carry out both qualitative and quantitative analysis.

Dooley (2000) defines Case Study as one method that excels at bringing us to an understanding of a complex issue and can add strength to what is already known through previous research while Orodho (2003) defines research design as the scheme, outline or plan that is used to generate answers to research problems.

To carry out the study of drought effects on hydropower generation in Kenya, and in particular the case of Kenya Electricity Generating Company (KenGen), the case study design was found to be the most appropriate as it could not be generalized. Yin (1994) has defined a case study as an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when boundaries between phenomenon and context are not clearly evident and Merriam (1998) has indicated that delimiting the object of study, the case, is the single most defining characteristic of the case study research.

### **3.2 Data Collection**

The Case Study was based on KenGen, an electricity generating utility which generates about 70% of Kenya's electricity. This approach was informed by the fact that currently only KenGen generates bulk hydropower in Kenya and the community based and private mini-hydro plants

were very few and not for commercial but self-supply of electricity and hence their availability or lack of it did not affect the consumer price calculation . Data were mainly obtained from Business Strategy, Power Purchase Agreements (PPAs), Project Reports, and load shedding reports.

Merriam (1998) indicates that a case study research enables the researcher to draw upon many approaches to data collection because “case study does not claim any particular methods for data collection” whereas Yin (1994) has shown that data for case studies may come from many sources, but he identifies six important sources for data collection that are widely used: documentation, archival records, interviews, direct observation, participant observation, and physical artefacts. In this case study the phenomenon is managing plant availability of hydropower plants in Kenya, and specifically how KenGen management was dealing with the issue. This method was preferred because it uses both primary and secondary data which can be collected and analysed easily. Since all the hydropower generation in Kenya is carried out by KenGen, the research endeavoured to create a database on information extracted from KenGen documents, project reports, archival records, load shedding reports and interview questionnaires. The interviews were administered to the senior Managers of KenGen tasked with execution of the company’s strategies.

### **3.3 Data Analysis**

According to Yin (1994), maintaining a database that documents case study notes, documents, narratives resulting from the case research, and other pertinent information enables the researcher to connect answers to the evidence collected in the case study. The primary purpose of

organizing data was to enable pre-processing of the data to correct problems that were identified in the raw data.

In this study correlation and regression analysis was used to determine the nature and strength of the relationship.

Specifically the model was of the form

$$Y = \beta_0 + \beta_1 X_1 + \epsilon$$

Where Y = Electricity Consumer Prices

$\beta_0$  = Constant

$\beta_1$  = Coefficient of Availability of the KenGen Hydropower Plants

$X_1$  = Availability of the KenGen Hydropower Plants

$\epsilon$  = Error Term



## **CHAPTER FOUR: DATA ANALYSIS, FINDINGS AND INTERPRETATIONS**

### **4.1: Introduction**

The research objectives were; to determine whether there is a relationship between the Availability of the KenGen Hydropower plants and electricity consumer prices, to determine the general impact of the Power Purchase Agreements on the electricity consumer prices and to interrogate impact of liberalization in the electricity subsector on the electricity consumer prices. The findings are presented in percentages and frequency distributions, coefficients pie charts, bar graphs and a regression analysis model;  $Y = \beta_0 + \beta_1 X_1 + \epsilon$ , where the parameters have the same meaning as previously defined.

### **4.2: General Information**

A total of 11 questionnaires were issued out. The completed questionnaires were analyzed for completeness and consistency. Of the 11 questionnaires issued, 8 were returned representing a response rate of 72.73%, which the study considered adequate for analysis.

The respondents have worked at KenGen for periods ranging from one year to over 10 years and 50% of the respondents had worked at KenGen for 10 years and above, 25% had worked for a period of 5 to 10 years, 12.5% had worked for a period of 3 to 5 years and 12.5% had worked for a period of 1 to 3 years. Most of the respondents have worked at KenGen for over 5 years, thus there is a high level of understanding of the organization.

### **4.3 Impact of the Hydro Power Plants Availability on the Electricity Consumer Prices**

The respondents were asked to give their opinion on the use of hydropower to generate power to the tune of 70% by KenGen. The respondents unanimously agreed that this was not a good strategy for consumers thus KenGen needed to invest more in other energy sources. The respondents' further pointed out that the national security is beyond the business strategy of KenGen. It is therefore imperative for the Government to review the policy on electricity generation mix so that the country does not over depend on hydro power especially with the phenomena of global warming

The respondents were asked to indicate whether or not the Current Hydro Power Purchase Agreement between KenGen and KPLC Guarantee Affordable Consumer Prices. 75% of the respondents were of the opinion that the current hydro power purchase agreement between KenGen and KPLC guarantee affordable consumer prices while 25% felt that the current hydro power purchase agreement between KenGen and KPLC does not guarantee affordable consumer prices. This therefore means that there is need to review the respective Power Purchase Agreements to be in tandem with the ever changing operating environment. Similarly, the Government should review the reforms already taken in the electricity sub-sector and in particular Single-Buyer Model as is the case with KPLC

#### **4.3.1 Impact of Periodic Droughts on Kengen Hydropower Plant Availability.**

The respondents were asked to state whether the occasional periodic droughts experienced in the country over the years has affected KenGen hydropower plant availability in any way. As shown in table 4.1, 87.5% of the respondent indicated that the periodic droughts experienced in the

country over the years had adversely affected KenGen hydropower plant availability. On the other hand 12.5% felt that the periodic droughts experienced in the country over the years has not affected KenGen hydropower plant availability since KenGen has other mitigating factors. The impact of the drought on KenGen to a larger extent affects the economy of the country because of reduced electricity generation from hydro power plants which caters for about 70% of the national electricity generation. This can have a long term spiralling effect because some industries can even relocate to countries with adequate affordable and reliable power.

**Table 4.1 Impact of Drought on the Hydropower Availability**

	Frequency	Percent	Cumulative Percent
No KenGen has other mitigating factors	1	12.5	12.5
Adversely affected	7	87.5	100.0
Total	8	100.0	

#### **4.3.2 Role of the Energy Regulatory Commission in their Mandate to Bring Down Electricity Prices**

When asked to rate the mandate of Energy Regulatory Commission to bring down electricity prices, 37.5% of the respondents rated their performance to be either fair or poor while the remaining 25% felt that their performance on bringing down electricity prices has been good. The respondents further indicated that in power generation, load factor (plant) carries more weight than plant availability factor. Majority felt the ERC has not achieved its mandate and thus there is need to understand this low rating. There is need to review the mandate of the regulator by the Government and also to inform the public of the duties of the regulator vis-à-vis the

electricity utilities. There should be clear set guidelines on the objectives of the regulator in terms of electricity pricing and tariff setting.

**Table 4.2 Role of Weather Forecasting in Hydropower Generation**

Ratings	Percent
Good	25.0
Fair	37.5
Poor	37.5
Total	100.0

#### **4.3.3 Role of KenGen’s Strategy in Electricity Prices**

75% of the respondents were of the opinion that KenGen has the capacity and strategy to bring down electricity prices. On the other hand 25% of the respondent felt that KenGen does not have the capacity and strategy to bring down electricity prices since this is more of a national/government challenge than KenGen business strategy.

KenGen being a business entity may not be the suitable institution to entrust the task of ensuring that electricity prices are affordable because KenGen cannot regulate itself. This mandate should therefore be wholly housed at ERC.

When asked to state whether KenGen maintain high availability for hydro power plant, 87.5% of the respondents indicated that KenGen does maintain high availability for hydro power plant while 12.5% were of the opinion that KenGen does not maintain high availability for hydro power plant.

#### **4.3.4 The respondents were asked to indicate whether KPLC dispatch KenGen’s hydropower plants in accordance to the merit order**

57.1% of the respondents were of the opinion that KPLC only dispatches hydro plants fully during peak time, 25% felt that KPLC has not been dispatching the hydro plants fully and the remaining 12.5% were of the opinion that KPLC has always dispatched the hydro plants fully. This clearly indicates that ERC has not fully implemented the Grid Code which stipulates all the plants in the national grid should be despatched on merit i.e. the cheapest plants being dispatched before the expensive plants depending on the electricity demand.

#### **4.3.5 Respondents were asked to indicate whether electricity prices are lower during good hydrology**

87.5% of the respondents indicated that they do pay low electricity bills during good hydrology. On the other had a significant 12.5% were of the opinion that there was no difference in the electricity bills in periods of good hydrology.

#### **4.3.6 Impact of new Parastatals on Electricity Subsector and Electricity Prices**

When asked to state whether the creation of additional parastatals in the electricity subsector has contributed to higher electricity consumer prices, 71.4% indicated that additional parastatals in the subsector was not a cause of higher electricity prices. On the other hand 28.6% felt that more parastatals have caused higher electricity prices. Of those who said that more parastatals have contributed to higher electricity bills all of them recommended the merger of the parastatals so that operation cost could be reduced with anticipation that these reductions will be reflected in the electricity consumer prices.

#### **4.3.7 Impact of Availability of Hydro Power Plant on the Electricity Prices**

When asked to state whether the availability of hydro power plants affects electricity bills, all the respondents unanimously agreed that availability of hydro power plants actually affects

electricity bills. The respondents further recommended that hydro power plants be despatched to their maximum capacity.

#### **4.3.8 Respondents were asked to state whether they believed that unavailability of the hydro power plants is due to machine breakdown other than water**

75% of the respondents indicated that unavailability of the hydro power plants was not due to machine breakdown while 25% felt that the unavailability of the hydro power plants was due to machine breakdown other than water. Of those who felt that the unavailability of hydro power plants was due to machine breakdown 50% again indicated machine breakdowns were as a result of poor maintenance of the hydro power plants.

#### **4.3.9 Respondents were asked to state whether they believed that Electricity Prices would be Lower if Other Independent Producers Also Owned Hydro Power Plants**

62.5% of the respondents were of the opinion that electricity bills would be lower if other independent producers also owned hydro power plants. However 37.5% had a reservation that this would not be possible because it would depend on the investment cost.

#### **4.3.10 Possibility of Electricity Prices Ever Coming Down**

When asked to state whether electricity prices would ever come down, 85.7% of the respondents were optimistic that electricity prices would ever come down while 14.3% felt that it would not be possible for electricity prices to ever come down.

### 4.3.11 Relationship between the Availability of KenGen Hydropower plants and electricity consumer prices

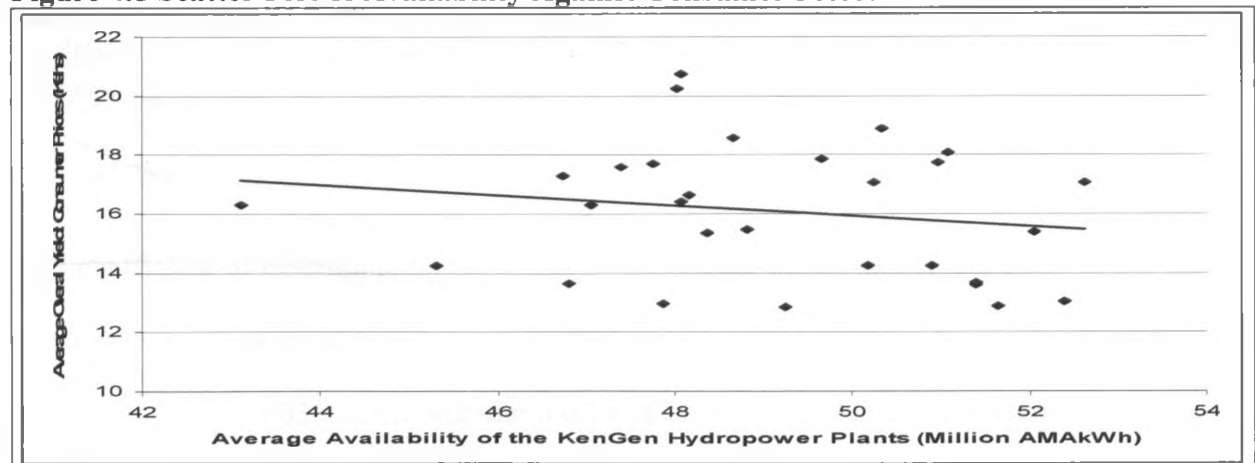
This section covers regression and correlation analysis of the data, discussions and interpretation. The first step in analysing the data was through descriptive measures and scatter graph. This was followed by model building and testing.

**Table 4.3 Descriptive Statistics**

	Mean	Std. Dev
Consumer price	16.0738	2.24421
Availability of the KenGen Hydropower plants	49.1140	2.24063

The average consumer price over the period July 2009 through June 2012 was kshs 16.07/kWh. During the same period the average Availability of the KenGen Hydropower plants was 49.1140 AMA (kWh).

**Figure 4.1 Scatter Plot of Availability Against Consumer Prices**



The scatter plot shows a downward trend over the period. The trend seems to be linear and as such a linear regression analysis can be used for further analysis. The Pearsonian Correlation was computed as shown in Table 4.15

**Table 4.4 Pearson Correlation**

	Consumer Price	Availability of the KenGen Hydropower plants
Consumer Price	1.000	
Availability of the KenGen Hydropower plants	-.176	1.000

The Correlation Coefficient shows that there is a weak negative correlation of 0.176 between the Availability of the KenGen Hydropower plants and Consumer price. This is an indication that Electricity Consumer price is inversely related to Availability of the KenGen Hydropower plants.

**Table 4.5 Model Summary**

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
dimension0 1	.176 <sup>a</sup>	.031	-.005	2.24979	.031	3.861	1	27	.003

a. Predictors: (Constant), Availability of the KenGen Hydropower plants

b. Dependent Variable: Consumer Price

$$Y = -0.176X_1 + 24.722$$

The coefficient of determination ( $R^2$ ) equals 0.031. This shows that Availability of the KenGen Hydropower plants explain only 3.1% of the Consumer Price leaving 96.9 percent unexplained. The P- value of 0.003 implies that the model of Consumer Price is significant at the 5 percent significance level. This clearly indicates that other factors like investment costs, dollar fluctuation and inflation indices could be the other parameters which affect the Electricity Consumer Prices.



**Table 4.6 Regression Coefficient**

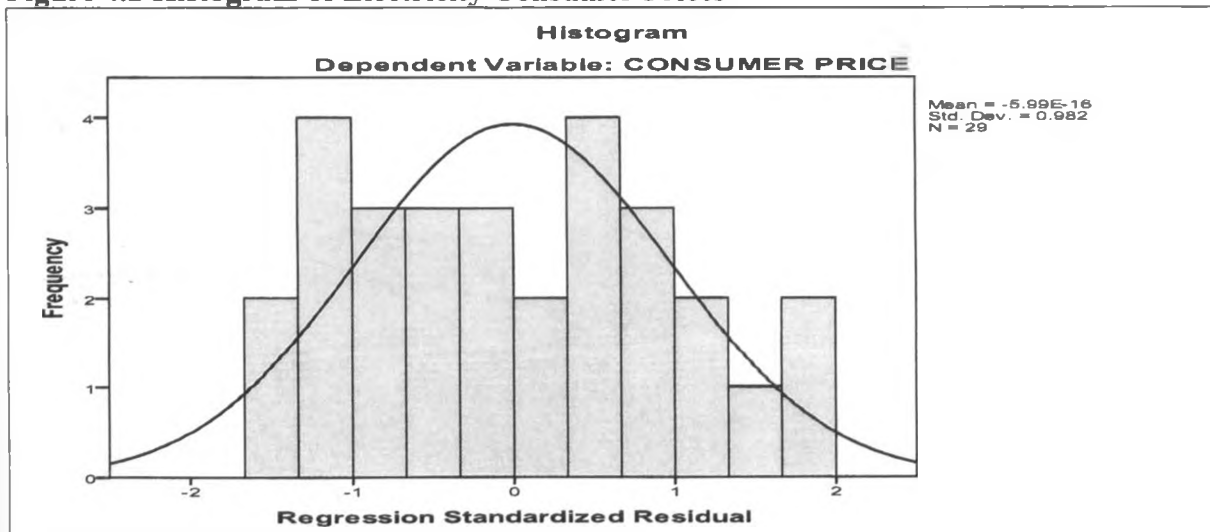
	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	24.722	9.329		2.650	.013
Availability of the KenGen Hydropower plants	-.176	.079	-.176	-2.227	.003

a. Dependent Variable: Consumer Price

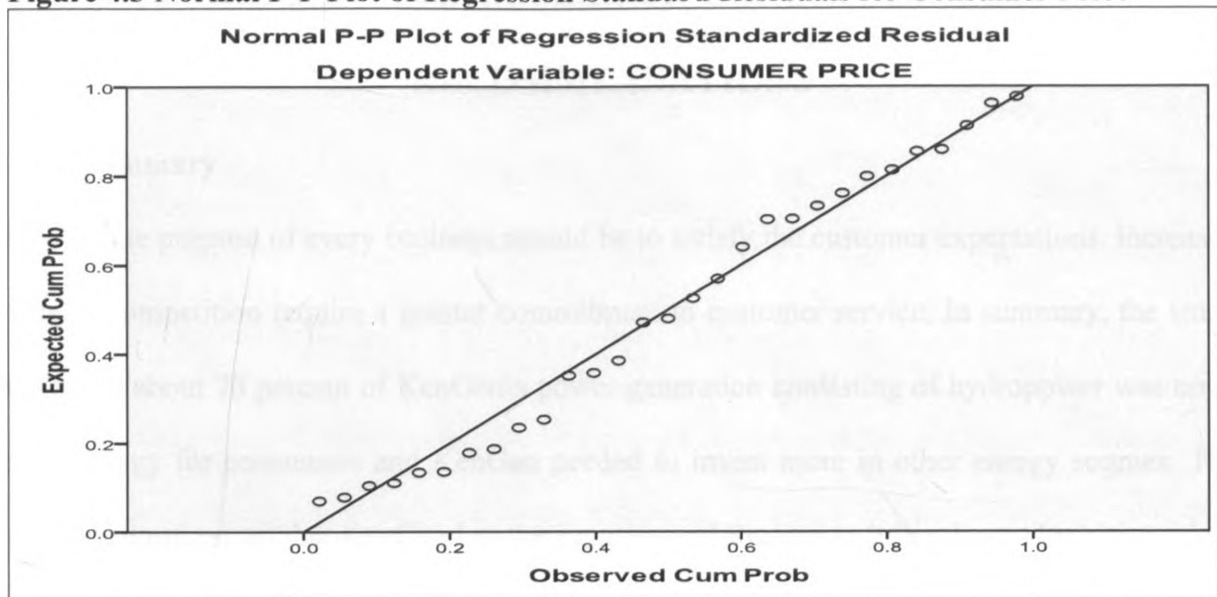
The coefficients in Table 4.17 above were used to write the regression equation for the consumer price model as follows

Consumer Price =  $-0.176(\text{Availability of the KenGen Hydropower plants}) + 24.722$ , that is, the consumer price at any time irrespective of Availability of the KenGen Hydropower plants will be Kshs 24.722 and the price is expected to decrease at the rate of 0.176 per Availability of the KenGen Hydropower plants. The P- value of 0.03 implies that, Availability of the KenGen Hydropower plants as an independent variable is significant at the 5 percent significance level.

**Figure 4.2 Histogram of Electricity Consumer Prices**



**Figure 4.3 Normal P-P Plot of Regression Standard Residuals for Consumer Price**



Normality uses histogram or plot of residuals. It is assumed that the distribution from the histogram will take the shape of a normal curve and the plot of the residuals will form 45 degrees diagonal line for the normality test. The histogram/frequency polygon depicts a normal distribution as shown in Figure 4.2. Figure 4.3 shows, the data seem to be clustered around the 45 degree line indicating that the consumer price data is normally distributed

# CHAPTER FIVE: SUMMARY, CONCLUSION AND RECOMMENDATIONS

## 5.1 Summary

The ultimate purpose of every business should be to satisfy the customer expectations. Increased levels of competition require a greater commitment to customer service. In summary, the study shows that about 70 percent of KenGen's power generation consisting of hydropower was not a good strategy for consumers and KenGen needed to invest more in other energy sources. The study also emphasized that KenGen has the capacity and strategy to bring down electricity prices at the same time electricity prices would be lower if other independent producers also owned hydro power plants. This is also in line with the opinion of majority of the respondents that electricity prices would come down in the future. It was noted that availability of hydro power plants actually affects electricity bills thus hydro power plants should be despatched to their maximum capacity.

The study used regression analysis to forecast the consumer electricity prices. Forecasting model was developed and then tested for accuracy in obtaining predictions. One major finding of the study is that there is a negative relationship between consumer prices and Availability of the KenGen Hydropower plants. The study further demonstrated that Availability of the KenGen Hydropower plants was not a major determinant of consumer prices, that is, coefficient of determination ( $R^2$ ) equals 3.1 percent. The usage of the model developed to forecast the consumer electricity price is therefore not recommended as one might get predictions that are inaccurate.

## **5.2 Conclusion**

The study concluded that Availability of the KenGen Hydropower plants was not a major determinant of consumer prices. This is supported by coefficient of determination of 3.1 percent. It is therefore important for KenGen to forecast on load factor (plant) which carries more weight than plant availability factor.

The study also concluded that consumer electricity prices could be brought down when KenGen adopted other strategies of power generation and not by allowing other independent producers to own hydro power plants, since independent producers will still sale power based on the investment cost incurred.

## **5.3 Recommendations**

Based on the study findings, it is recommended that KenGen should put more emphasis on load factor (plant) as it carries more weight than plant availability factor in order to reduce consumer electricity price. Further the consumer electricity price depends on cost of investment and therefore, this cost can only be reduced if the government waives taxes on independent power producers which will translate in to a lower unit cost.

## **5.4 Limitations of the Study**

The study used secondary data and therefore the accuracy may not be guaranteed. Apart from the accuracy other factors such as availability of substitutes, cost of investment, cost of fuel, competition and inflation would affect the purchasing power of the consumers and hence affect

consumer electricity price. There is therefore room for isolating all these factors in order to generate better predictive model for consumer electricity price.

### **5.5 Suggestion for Further Research**

In this study only one predictor variable (Availability of the KenGen Hydropower plants) was singled out and used, it is recommended that a number of the independent variables be included and a multiple linear regression model be used.

## REFERENCES

- Abrate, G (2003). *Time-of-Use pricing and Electricity Demand Response*. International Journal of Water Resource Development.
- American Society of Mechanical Engineers Journal (2004). *Plant Capacity and Availability Factors*.
- Acres International Limited (1996). *Survey Study of Least Cost Poer Development Planning in Kenya*. Acres International, United Kingdom, 1996
- Amarapathy, A., (2001). *Analysis of drought and Drought Occurrence in the dry zone of Sri Lanka*. BSc. Project Report, University of Peradeniya.
- Beckett, R. (2006). *Water Resources and drought mitigation*. Australian Journal of Basic and Applied Sciences.
- Bishwarkarma, B., (2007). *Research on Optimum Sediment Handling in Run-of-River Hydropower plants*. Conference Paper on Small Hydropower, Sri Lanka 2007.
- Braga, B., Rocha, O., Tundisi, J. (2000). *Dams and Environment: The Brazilian Experience*. International Journal of Water Resource Development.
- Brekke E., and Levi, D., (2009). *Assessing reservoir operation risks under climate change*. Water Resources Research 45(4).
- Briscoe, R., Prieto, N., Bauer L. (1999). *Hydroelectric Power Generation in Chile*. International Journal of Water Resource Development
- Cambell, R., (2010). *Small Hydro and Low Hydro Power Technologies and Prospects*. Congressional Research Service Report 2010.
- Chase, R., Jacobs, F., Aquilano, N., Agarwal, N., (2006). *Operations Management for Competitive Advantage*. New Delhi. Tata McGraw-Hill Publishing Limited, New Delhi
- Chelimo, F., (2008). *Strategic Responses to Challanges of Energy Regulation in Kenya by Energy Regulatory Commission*. Unpublished MBA Report of University of Nairobi.

Dooley, L., *Advances in Developing Human Resources*, Vol 4 (2004), Sage Publications

Kothari, C. (2004). *Research Methodology: Methods and Techniques*. New Delhi: New Age International Publishers, New Delhi

Energy Regulatory Commission (2011). *Annual Report 2011*. Nairobi

Fiorio, C., Florio M.,(2009) *Consumer Satisfaction and Utility Reforms*. Research Paper, University of Milan.

Kiiru, J., (2002). *Pricing Electricity by Bulk Power Producers in Kenya*. Unpublished MBA Report of University of Nairobi.

Lange, D., (2008). *The Impact of increased Electricity Prices on Consumer Demand*. MBA Report. University of Pretoria.

Mahmoud, A., Sotudeh, R., (2000). *Identification of the Relationship between Availability, Reliability and Productivity*. Research Paper, University of Hertfordshire, UK.

Mwaka, M., (2007). *Factors Affecting Productivity in the Large Thermal Power Generation Stations in Kenya*. Unpublished MBA Report of University of Nairobi

Niemeyer, V., (2001). *Insights on Electric Sector Impacts and its role in Climate Policy*. Research Paper, Electric Power Research Institute

Njenga, W., (2003). *The Financing Problem in the Electric Power Subsector*. Unpublished MBA Report of University of Nairobi.

Rangarajan, N.,(2008). *Performance Testing*. New Delhi. Prentice Hall of India Publishers. New Delhi.

Simone, Coelho, Cavalcanti, Feritas, Ito (2001). *Climate diagnostic of three major drought events in the Amazon and illustrations of their seasonal precipitation*. Research Paper, Chile University.

Zahraie, B., Karamouz, M., (2004). *Hydropower Reservoirs Operation: A Time Decomposition Approach*. Research Paper, Sharif University of Technology, Iran

## APPENDICES

### Appendix 1: Letter of Introduction

Dear respondent,

#### **RE: MBA Research Project**

I am a post graduate student at the School of Business, University of Nairobi, doing a research on the effect of the availability of hydropower plants on electricity consumer prices at Kenya Electricity Generating as part of the requirements for the degree of Master of Business Administration (MBA).

Kindly spare some of your time for an interview to enable me finalize my studies. You had been selected for this study due to your familiarity with hydropower generation at the organization.

The information collected will be used only for academic purposes and will be treated with strict confidence. Your name will not be mentioned in the report. Where possible a copy of the research report will be availed to you on request.

Your assistance and cooperation will be highly appreciated.

---

**Eng. Collins Gordon Juma**

**MBA student**



## Appendix II: Questionnaires

The questionnaires have been designed to collect information from senior management staff and/or Senior Managers of KenGen for academic purposes only. Please complete as instructed. The information will be treated in confidence.

Position held in the company: \_\_\_\_\_

### **please tick as appropriate**

1) How long have you worked in KenGen?

1 to 3 years

3 to 5 years

5 to 10 years

10 years and above

2) About 70 percent of KenGen's power generation consists of hydropower, is this good strategy for the consumer?

Yes, hydropower power is cheaper for the country and always available

No, KenGen needs to invest more in other energy sources

3) Does the current Hydro Power Purchase Agreement between KenGen and KPLC guarantee affordable consumer prices?

Yes

No

I don't know

4) Kenya has occasionally experienced periodic droughts over the years, has this affected KenGen's hydropower plant availability in any way?

No, KenGen has other mitigating factors

Moderately affected

Adversely affected

5) In your own opinion, how do you rate the Energy Regulatory Commission in their performance on the mandate to bring down electricity prices?

- Excellent
- Good
- Fair
- Poor

6) Does KenGen have the capacity and strategy to bring down electricity prices?

- Yes
- No
- I don't know

7) Does KenGen have maintain high availability for hydro power plants throughout the year ?

- Yes
- No
- I do not know

8) Does KPLC dispatch KenGen's hydropower plants in accordance to the merit order?

- KPLC has not been dispatching the hydro plants fully
- KPLC has always dispatched the hydro plants fully
- KPLC only dispatches hydro plants fully during peak time
- KPLC prefers to fully dispatch KenGen's thermal plants

9) In periods of good hydrology do you pay low electricity bills?

- Yes
- No

10) Do you think that the creation of additional parastatals in the electricity subsector has contributed to higher electricity consumer prices?

Yes

No

11) If yes to above question, do you recommend the merging of some parastatals under the electricity subsector:

Yes

No

I don't know

12) In your own opinion, do you think the availability of hydro power plants affect your electricity bill?

Yes

No

13) If yes to above question, do you recommend that hydro power plants be despatched to their maximum capacity?

Yes

No

14) Do you think that most of the unavailability of the hydro power plants is due to machine breakdown other than water?

Yes

No

15) If answer to above question is Yes, do you think that this is due to poor maintenance of the hydro power plants

Yes

No

16) Would electricity be lower if other Independent Producers also owned hydro power plants?

Yes

No

17) Do you think electricity prices will ever come down?

Yes

No

### Appendix III: Secondary Data

Period	Average Overall Yield: Consumer Prices (Kshs)	Average Availability of the KenGen Hydropower plants (Million AMAkWh)
Jan-10	18.10	51.08323
Feb-10	16.31	43.11839
Mar-10	17.30	46.72914
Apr-10	16.63	48.1639
May-10	14.26	50.90062
Jun-10	14.26	50.16346
Jul-10	13.02	52.40192
Aug-10	12.87	51.65279
Sep-10	12.86	49.23766
Oct-10	12.96	47.87251
Nov-10	13.65	46.79917
Dec-10	13.67	51.40346
Jan-11	13.60	51.38506
Feb-11	14.25	45.31357
Mar-11	15.39	52.06378
Apr-11	16.40	48.06483
May-11	17.05	52.62591
Jun-11	17.71	47.74442
Jul-11	17.86	49.66316
Aug-11	17.75	50.96118
Sep-11	18.90	50.34058
Oct-11	20.25	48.02741
Nov-11	20.73	48.06997
Dec-11	18.57	48.65309
Jan-12	15.35	48.36623
Feb-12	15.47	48.8174
Mar-12	17.07	50.23974
Apr-12	17.58	47.38732
May-12	16.32	47.05472



**UNIVERSITY OF NAIROBI**  
**SCHOOL OF BUSINESS**  
**MBA PROGRAMME**

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P O. Box 30197  
Nairobi, Kenya

DATE 3-8-2012

**TO WHOM IT MAY CONCERN**

The bearer of this letter ENG. COLLINS GORSON O. JUMA

Registration No. 061/70034/2007

is a bona fide continuing student in the Master of Business Administration (MBA) degree program in this University.

He/she is required to submit as part of his/her coursework assessment a research project report on a management problem. We would like the students to do their projects on real problems affecting firms in Kenya. We would, therefore, appreciate your assistance to enable him/her collect data in your organization.

The results of the report will be used solely for academic purposes and a copy of the same will be availed to the interviewed organizations on request.

Thank you.



*[Handwritten signature]*  
**JIMMACULATE OMANO**  
**MBA ADMINISTRATOR**  
**MBA OFFICE, AMBANK HOUSE**



# KenGen

**Kenya Electricity  
Generating Company Ltd.**

Stima Plaza, Kolobot Road, Parklands  
P.O. Box 47936 - 00100, Nairobi, Kenya

Telephone: 254-20-3666000 Fax: 254-020-2248848

Website: [www.kengen.co.ke](http://www.kengen.co.ke)

Our Ref: STAFF/KENGEN//JMM/jn

Date: 20<sup>th</sup> August, 2012

Collins Juma  
P.O. Box 62287 – 00200  
**NAIROBI**

Dear Collins,

## **RESEARCH APPROVAL**

Further to your request to use KenGen as a source of data for your MBA Research on “*Effect of Availability of the Hydropower Plants on Electricity consumer Prices*”, I am pleased to inform you that approval has been granted.

We note you have been a Senior Officer in this company and you will have no difficulty in approaching the right persons in the organization to get the relevant data.

We shall be pleased if you could also share the results of your findings for future reference in our planning.

We wish you the very best in your studies.

Yours faithfully

**For: KENYA ELECTRICITY GENERATING CO. LTD.**

**JOHN MAINA**  
**HUMAN RESOURCES MANAGER**



**The Kenya Power & Lighting  
Co. Ltd.**

---

*The Kenya Power & Lighting Co. Ltd.  
Central Office - P.O. Box 30099 Nairobi, Kenya  
Telephone - 254-20-3201000 - Telegrams 'ELECTRIC'  
Fax No. 254-20-3514485  
Stima Plaza, Kolobot Road*

**Our Ref:**

KP1/5BA/42D/AAA/go

**Your Ref:**

22<sup>nd</sup> August 2012

**TO WHOM IT MAY CONCERN**

**RESEARCH APPROVAL – COLLINS GORDON JUMA**

Reference is made to the subject matter mentioned above.

Kindly allow Collins Gordon Juma, a student at Nairobi University and also a Kenya Power staff to carry out a research project in the Company on *“Effect of the Availability of Hydropower Plants on Electricity Consumer Prices”*.

This authority notwithstanding, discretion must be exercised in the use of company information including business strategies and policy documents.

The Research Project should also not disrupt normal working hours and Company's flow of work.

Yours faithfully,

For: KENYA POWER & LIGHTING CO. LTD.

AGUSTINE A. AMBOKA

For: HUMAN RESOURCE DEVELOPMENT MANAGER

