INDEPENDENT POWER PRODUCERS OPERATION COST AND ELECTRICITY TARIFFS IN KENYA

BY

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D61/67812/2013

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A RESEARCH PROJECT SUBMITED IN PARTIAL FULFILMENT OF REQUIREMENT FOR THE AWARD OF THE DEGREE OF MASTER OF BUSINESS ADMNISTRATION, SCHOOL OF BUSINESS, UNIVERSITY OF NAIROBI

2016

DECLARATION

STUDENT DECRALATION

This project is my original work and has not been submitted for the award of degree in another University.

Signed:…………………………… Date…………………………

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APPROVAL

The project has been submited for the examination with my approval as the supervisor.

Signed:…………………………… Date…………………………

Supervisor name:……………………………………………………………………………

ACKNOWLEDGEMENT

First, I thank the Almighty God for giving me a vision and bestowing me with ability to carry out this research

Secondly, I wish to acknowledge Mr. Tom Kongere my supervisor and lecturer. In the spirit of mentorship you guided me with passion and determination.

Finally I wish to acknowledge my moderator Dr. X. N. Iraki, all members of the Department of Management Science and friends who in one way contributed to the success of this work.

Thank you all.

DEDICATION

I dedicate this work to my family members. You are the happiness and joy of my life. God bless you.

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BBREVIATIONS AND ACRONYMS

IEA	International Energy Agency
KP	Kenya Power
MW	Measure of Electricity energy (Mega Watts)
ERC	Commission for Energy Regulation
IPP	Independent Power Producer generating more than 40MW
ANOVA	Analysis of Variance

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ABSTRACT

While electricity supply and demand is affected by various exogenous variables such as amount of power generated, number of customers connected to the grid and various policy regulations from the government, the burden of high electricity costs is a major concern to most stake holders. The study aimed at establishing a relationship between IPPs operation cost and the cost of electricity in Kenya. The objectives of the study were: to find out the relationship between operation cost of IPPs and electricity tariff in Kenya and to test the input output model in determining electricity tariff. The target population consisted of five licensed IPPs in Kenya. A census approach was used in the study where all the 5 licensed commercial IPPs were studied by the researcher. Descriptive survey design was used in obtaining data from five IPPs in Kenya namely Westmont, Iberafrica, OrPower4-Kenya, Tsavo Power Company (TPC) and Rabai. Questionnaires were administered to obtain primary data from the respondents. Secondary data was obtained from published annual reports from Energy Regulation, Kenya power and IPPs annual reports ranging from 2012 to 2015. Quantitative data analysis, regression and ANOVA were used to analyze data. Graphs and tables were used to present the results. It was found out, from the study, that operation costs of Independent Power Producers affect the cost of electricity in Kenya. The study recommended that the Energy Regulation Commission ought to review the pricing strategy for electricity and that Kenya Power ought to determine a favourable generation mix by IPPs and minimize system loses to reduce electricity tariffs paid by consumers.

CHAPTER ONE: INTRODUCTION

1.1. Background of the Study

Energy is an essential factor of production and its total consumption is a major determinant of performance in the world economy (Stern, 2003). Stability of power tariffs a major factor in development and growth (Ministry of Energy, 2013). According to the IEA (2011), 80% of people who live in rural areas have no access to electricity in Southeast Asia. However, with major efforts made in putting up electricity plants in remote and urban areas, the electricity supply has move from 43.8% to 59.2% in only 7 years. Singapore has led this crucial process by 100%, as others like Brunei Darussalam (88.8%); Malaysia (87%), Thailand (88%), and Vietnam (82%) take up the challenge. This was as a result of introduction of Independent Power Producers in the energy supply chain through private partnership.

For comparison, more than 20% of the population globally had no connection to power by 2009 of which 85% live in remote areas (IEA, 2011). Since 2002, there is a decrease by 161 million worldwide, although the world population has grown by 500 million people. However, in global terms, power connectivity is going up since there is great uptake of power from IPPs investments. As for Latin America and Asia they have greatly increased power generation from IPPs but it is contrary with most of Sub Saharan Africa which are lacking behind and do not even match the growing population of the continent. In Sub-Saharan Africa less that 15% of the people who live in remote areas have been connected to power. However, the population is growing very fast. It is therefore undisputed that the people without power connection will be increasing in Africa.

In Kenya as spelt out in vision 2030, electricity connectivity was cited as one of the major determinants of a sustainable growth and development of our economy. Therefore energy is a social economic pillar that is vital for the Kenyan government to sustain its vision and meet the increase in per capita income for the citizen. According to vision 2030, the generation of electrical energy is expected to be approximately 15,026MW in 2030 against a capacity of 1,194MW available in 2011, a growth of 1,258%. Similarly, 70% of the Kenyan's households are expected to be connected to electricity during the same period (Ministry of Energy, 2011-2012). However, energy management and sustainability of electrical power tariffs in Kenya has been a concern for consumers over time. In the 2011/2016 strategic plan, Kenya Power proposes engaging independent consultants to carry out power market study and make recommendations on tariff changes that can minimize burden to customers (KPLC, 2011).

Stern (2003) evaluated the dissatisfaction of the energy stakeholders in assessing demand and supply of electrical energy and found out that while energy managers argue that reliance on hydro power is the cause of upward review of power tariffs when thermal generators are used during dry seasons, consumers perceive cost fluctuations on attitude of Kenya Power as a major player in the electric energy sector. Since the current cost of power has also been associated with high inflation rates, the government and other stakeholders have been prompted to diversify power generation sources to feed more power into the national grid. Off the grid sources are also being exploited (ERC, 2013).

Although the government intends to reduce the cost of power by forty percent by increasing the current capacity from 2,000 to 5,538 Megawatts, energy economics argue that with the constrained public funding, increased power production can only be attained by engagement of more IPPs in the energy supply chain (ERC, 2013). While it is important for government and other stakeholders to recognize the need for generating more power, it is crucial to evaluate the operation cost of Independent Power Producers (IPPs) in relation to cost of electricity in Kenya.

1.1.1. Operational Cost of Independent Power Producers

An Independent Power Producer (IPP) is private investment in electricity generation (IEA, 2009). Operation is the transformation of resources in a defined system to add value and achieve organizations goals through efficient acquisition and utilization of resources (Boyles and Krajewski, 2007). While energy strategies provide estimates, operations are determined by performance numbers in performance management

According to McEwan, (2001) in early 1990s, most power generation activities were from donor funding by loans given to the state from financial institutions in the world. This latter changed due to changes that were beyond the understanding of the beneficiaries. These changes were occasioned by the withdrawal of such funds as a matter of political re-alignment and balance of trade. Most countries were affected by such withdrawals thus forcing them to use local resources for power generation. This necessitated the introduction of IPPs to handle the growing demand for power as a result of the growing population in the affected countries. Private firms were introduced to compete in energy the projects (Dhole, 2010). IPPs were started with regulated power purchase agreements to supplement power production and hence enable many people to be connected to the national grid. (Iloranta, 2008). Dhole (2010) laments that although

IPPs were mean to help in reducing the stain on the state facility, their establishment Kenya and other African countries is very low. This therefore does not provide a clear benchmark in their operations and the intended competition as it was initially thought.

Strong growth in electricity demand in Kenya is being driven by a combination of normal economic growth, increased efforts towards rural electrification, and reinforcement of the transmission and distribution grids (KPLC, 2013). On the supply side, drought conditions in 2006 reduced the capability of the hydro-electric plants to produce. This spotlighted the high risk of over-reliance on hydro-electric power plants to secure power supply to the country. Meanwhile, the government cannot sustain the power demand since the funding of the energy sector is constrained thus electricity supply against demand is still a challenges without IPPs (Ministry of Energy, 2011)

According to ERC (2011), although IPPs were introduced in 1996, the state still dominate the generation of power in Kenya at 80% while IPPs range from 18% to 20%. Other generation at 2% are from imports and small scae generator which means that IPP investment is still low in Kenya.

Although KenGen's IPO of 30% of its shares of 2004 brought in more funds to facilitate state capacity to generate more power, the country's population growth is higher in rural areas which require that private investment is invetiable (IEA, 2011). This is a major challenge to the economy.

1.1.2. Electricity Tariff in Kenya

A power tariff is the cost of electricity which is made up of capital costs of owning the distribution network, the costs of purchasing power from power generators and the post-acquisition costs in the form of operations and maintenance (McEwan, 2001). Operation cost remains a significant determinant in the cost of electricity distribution which is broadly categorized into variable and fixed costs (KPLC, 2011). While variable costs will fluctuate based on the volume of electricity distributed, and therefore controllable, fixed costs like depreciation of power equipment cannot be controlled.

Kenya Power acquires its electricity from various generators. Energy Regulation Commission (2014) analyzed sources of electricity and tariff in Kenya and found out that the major contributor to the national grid is KENGEN with most of its activities in hydro-electric generation and most recently, geothermal. Other sources of electricity in Kenya include the use of diesel as source of fuel for electricity generation and wind energy. Solar energy and coal also contribute to the national grid but to a less extent. The problem of overreliance on hydro-power generation is the periodic reduction of water levels during periods of drought. Fuel generated electricity tariff on the other hand is expensive and fluctuates with global fuel economics of demand and supply (KPLC, 2013).

A study by IEA, (2011) found out that politics had played a major role in determining electricity tariff yet energy is major economic measure that requires a sound economic theory base. Price discriminations are dominant arguing that most industrial sector has the power to pay yet the price of commodities form this sector are high due to power costs. It is also argued that household and agricultural customers do not have the ability to pay and hence require a lower tariff. The high cost of power to industries translates into high cost of goods produced which is passed to consumers. As a result, power tariffs are a political theory yet they are supposed to be founded on an economic policy.

Energy Regulation Commission (2014) analyzed tariff reviews and found out that the upward review of tariff is as a result of fuel cost arrears that needed to be recovered during periods of diesel generated power. The consumer paid 7.22 shillings per unit of electricity higher compared to 5.19 in March. Although it was expected that there would be 20% decrease in power cost by September 2014. A report published by consumer Federation of Kenya (COFEK) (2015) indicated that consumers were still paying more for electricity despite efforts by the government to reduce energy bills yet there was a drop in crude oil prices. Mostly, power generators and distributors have not been reliable and sometimes they do not meet consumer demand thus the need for this study. There is need to reform the energy sector in developing countries.

1.2. Research Problem

Although demand and supply are dependent on price, Coy (2010) found out that pricing of most goods and services is based on 'cost-plus' model which sets a price for a product that is sufficient to recover the full cost with some profit margin. Therefore when demand increases firms strive to produce more at minimal operational cost to attain a competitive price (Bernard, Andrew & Redding, Stephen & Schott, Peter, 2010). However with increased electricity demand in Kenya, IPPs have reduced with government focus on public utility power generation. Due to low capital to fund such large projects, future power demand may not be realized (ERC, 2013).

Since electricity generated must be used or lost (Mehta, 2012), Kenya Power determines the amount power that is supplied by IPPs into the national grid. In order to recover the operation cost, IPPs negotiate power purchase agreements with Kenya Power which also determines the electricity tariff.

Input output model developed by Wassily Leontief can be used to determine price of products when consumption is equal to production (Dietzenbacher, Erik & Michael, 2011). By use of the Leontief model and taking p as price per unit (X) and production value for X_j units of good j as $p_1X_{1j} + p_2X_{2j} + ... + PnXnj$, the model is expressed as (I - (1+r) A) p = 0 where I is identity matrix and (1+r) stands for profit rate (Michael *et at*., 2011). The research sought to test this model in relation to the operation cost of IPPs and the electricity tariff.

World Bank (2000) studied the economic impact of power generation in Asian countries and found out that IPPs have generally been perceived as expensive and that producers take advantage to reap from lack of water for hydro-generation. Parsons (2012) found out that integrated wind power in the USA reduced the operation cost of power hence reducing the overall power tariff. Although had to allow the operations of IPPs to overcome power shortage, there is still need to encourage investment in IPPs as their uptake is still low. There is very little competition realized since 1996. Studies by Hannele, Meibom, Orths, Lange, Malley, Tande, Estanqueiro, Gomez, Söder and Hulle (2010) in America indicate that turning to IPPs during emergence is not only a risk affair but also an expensive venture. Hannele *et al.*, (2010) further explicitly tested the hypothesis regarding sequence of privatization and the introduction of competition in government utility reforms in developing countries, and they found that delays in the introduction of competition may adversely affect operation performance even after competition is eventually introduced.

Odiambo (2010) analyzed the relationship between energy consumption and economic growth and found out that African countries needed to augment government utility with IPP energy supply in order to meet long run energy demand. However, studies by Njoroge (2008), IEA (2011) and Kamau (2009) in Kenya depict power from IPPs as expensive and that vandalism of electrical equipment which are outsourced using foreign currency increase tariff depending on inflation and global energy rates. Yet, there is little study on the operation cost of IPPs and the electricity tariff. Moreover, there is little accurate description of the state's ability to finance and build competitive plants within a short timeframe. As a result, unstable sourcing of power during emergencies will always lead to unstable tariffs (IEA, 2011).

While it appears that some IPPs are closing down (Aggreko), their operation cost may be among the factors influencing future investments in IPPs and the cost of electricity hence the need for this study. This study sought to examine the operation cost of IPPs and the electricity tariff in Kenya. Through the study, the government will be able to assess how effective the IPPs have contributed to the stability of power and tariffs since their inception. This will establish an effective power purchase agreements and electricity tariff by answering the following research questions.

i. What is the relationship between operation cost of IPPs and cost of electricity

ii. How can the input output model be used to determine electricity tariff given the production cost of power

1.3. Research Objectives

The general objective of the study was to evaluate the operations cost of IPPs and electricity tariffs in Kenya

The specific objectives of the study were:

1. To establish the relationship between operation cost of IPPs and electricity tariff

2. To test the input-output model in determining power tariff

1.4. Value of the Study

The study provides an insight to Kenya Power management on areas of improvement on the purchase of power operation cost. The study can also be used by other stakeholders in the electrical energy sub sector in analyzing and determining best performing models for the sector.

The research will provide an opportunity for further research and development in the field of electrical energy management.

It is hoped that the findings of the study will be used by the energy sector regulators for policy formulation, energy sector restructuring and standardization.

CHAPTER TWO: LITERATURE REVIEW

2.1. Introduction

This chapter details the study, location and analysis of documents containing information related to the research problem being investigated. It reviews various theories related operations of IPPs and electricity tariffs. The chapter also focuses on the conceptual framework, empirical review and summary.

2.2. Theoretical review

Various theories have been fronted by various scholars on operation sectors of the energy economy. To evaluate the operation cost of IPPs and the electricity tariff in Kenya, the study is guided by the following theories: theory of constraints, product switching theory and systems theory.

2.2.1. Theory of Constraints

According to this theory, a constraint is any aspect of a system or company, from product design and marketing to manufacturing and distribution, which limits it from achieving the system goal. Therefore, it is evident that the actions of marketing are guided by the concept of cost and margins, even more than the actions of production (Birkin, Thomas and Linda, 2009). Operation productivity can be improved by managing bottle necks through elimination of bottlenecks and adding capacity (Birkin *et al.*, 2012). This is achieved when value added processes are emphasized while non-value added processes are reduced or eliminated.

The operations of IPPs in Kenya is based on the on the decisions made by the company that guide the signing of the power purchase agreements hence operation cost remains a significant determinant in the cost of electricity generation and distribution (Jason, 2013). While studying increase in operation costs due to drastic load fluctuations, Mungata (2012) found out that use of automated voltage regulator stabilizes power systems and minimizes such costs hence reducing tariff. Therefore, there is need to study the relationship between IPP operation costs and electricity tariff.

2.2.2. Product Switching Theory

The theory is based on models on industry dynamics where firms that are heterogeneous in productivity are assumed to produce a single product. As a result, the firm and product-market entry and exit are equivalent (Bernard, Andrew, Redding and Schott, 2005). When firms add and drop a product, large changes are induced in the firms operations. Hence product switching contributes to reallocation of resources within firms towards their most efficient use (Schott *et al.*, 2007).

Existing empirical work on multiple-product firms typically examines product switching at a point in time. Bush (2004) examined product diversification as a mode of market entry distinct from plant birth, while Roberts (2010) investigated the empirical relationship between the mode of market entry and plant death. It was found out that a firm has the discretion to decide whether to enter or exit in participation of the production of a certain product. This implies that a firm produces and supplies a certain product with limited profit maximization problems during periods of low and high sales (Schott *et al.*, 2010).

Although large firms produce wider range of products which generate higher revenues to cover fixed costs, IPPs reliance on power generation leads to idle equipment during low demand periods. Although product switching theory does not provide options for idle equipment during low power demand, it will help in determining its effect on tariff changes.

2.2.3. Systems Theory

According to economics, the art of determining per unit cost of electrical energy is the driving factor in energy economics in which costs are incurred during energy transformation, power system demands that electrical energy generated must be used or lost (Barnes, 1996 and Mehta, 2006). Wassily Leontief developed an input output model an analyzed how an output from one industry becomes an input of another. This model can be used in production planning and use of economic resources (Dietzenbacher, Erik and Michael, 2004). It possible to view production and use of energy resources as hierarchically nested systems; where the force of supply and demand is the context within which a particular production system operates (Teunter, 2003). The interconnection and synthesizing of the parts of the systems helps in organization learning by sieving vital information for decision making (Kaplan, 2008). Systems adapt purposely in pursuit for better fitness (Braun, 2007).

Sanchez and Mahoney (1996) while carrying out systems analysis found out that when modularity in systems is increased, idle capacity is minimized. This implies that systems principles are used to determine optimal decision making and thus can help an organization deliver well with its principle goals (Sanchez *et al.*, 1996 and Patrick, 2011).

Managing operations in power systems are vital in energy supply chain and pricing decision making process since cost of energy is related fixed costs, cost proportional to maximum demand and costs proportional to amount of power generated. Since more demand requires new plant facility which may not be utilized during low demand. This can be a cost to the organization and more losses are incurred. Capacity cannot be costless thus this results in inefficiencies which can only be recovered from high cost (Hassan, 2010).

2.3. Operation Costs

According to power systems, (Mehta, 2012) defines operation cost as all process costing that are consumed in power generation, maintenance and supply to determine the cost of the output energy. Generation costs will entail plant and equipment acquisition, utilization and depreciation whereas maintenance and supply cost will entail labour and capacity utilization costs. Stern (2003) found out that while the existing IPPs appear to be here to stay (save Westmont), future development remains uncertain due to recent investments to the power sector which have been supported by multilateral agencies in alliance with KenGen.

Energy economics do estimate the cost of energy using cost-plus method. This technique compares the cost of centralized dispatch under and rate of transmission supply dispatch, costs associated with rate of transmission start-up and operation costs (Eto, 2005 and Black & Veatch, 2009). These costs are critical in determining tariffs.

2.4. Electricity Tariffs

Due to exogenous variables such as energy demand, water inflows, availability of generation units and fuel costs, Fabra and Toro (2012) found out that the analysis of electricity time series reflects a switching nature depending on discrete changes in participants’ strategies. They further proposed that input-output model can be used in analyzing and forecasting electricity spot prices. Such electricity spot prices are called tariffs.

According to the taxonomy of electricity price models, Agron (2009) and Fabra *et al.*, (2012), used three models to study power tariff and found out that when price evolution is studied stressing the analysis of the strategic behavior of the agent is called game theory model. In this model the prices are set using the market equilibrium. The second model is based on time series analysis where prices are set from a statistical analysis without examining the underlying process detail. The third model is the structural model where prices are set not only basing on production costs but also the impact of the agents behavior on market price. It is evident that the input-output model can be tested in determining tariff.

2.5. Input Output Model

According to Nagales (2010) electricity price is said to evolve through different market states which is characterized by the interaction of demand and participants' strategies which are reflected in electricity price time series. He further found out that if the market is a particular state today, it is important to estimate both the probability that the market remains in the same state tomorrow and the probability that the market changes to other positions. Thus S (state) = {S1, S2 …Sn)

The model determines the market on a probabilistic method where a set of functions can be from either hydro, thermal or nuclear resources. This is in line with the different relationships among the variables and prices. Hence transitional state probability matrix from a set of N emission probability density function is as follows: A = (a_{ij} = P (s_t+$_1$

$=S_i/S_t = S_j))$ ε [0, 1]^{NxN} this can be related to the function $A = Z (X^D)^{-1}$ since the inputs are proportional to the outputs.

2.6. Empirical Studies

A considerable number of studies have been undertaken on IPPs. During state monopoly in the 1990s there were no IPPs. After their introduction in 1996, IPPs were perceived as expensive and therefore little emphasis was put onto them. This led was coupled with higher power outages in Asian countries (World Bank, 2004). However, It was later found out that IPP would not only help the government reduce cost in energy sector but also lead to further concentration in other areas of the economy thus efficient utilization of energy resources.

Studies by Kamau (2009) show that outsourcing can help firms reduce production costs by specializing in what they produce at least costs. However, Njoroge (2008) had attributed vandalism of electrical equipment as a major contributor to power outages and increased electrical tariff. This was augmented by Aberhard (2010) who assessed the success of IPPs in Sub Sahara Africa using sample survey and found out that contracting and outsourcing of power from IPPs that are well financed could curb power outages. Nzila, (2010) attributes power outages in Africa to little emphasis on renewable energy and recommended use of alternative sources of renewable energy to avert global energy crisis. These studies did not analyze the operation cost of IPPs which will be addressed by the proposed study.

According to Mustafa (2013) who carried out research on the benefits of IPPs in Bangladesh using descriptive sample survey, IPP power is expensive and uneconomical due to lack of government subsidy. They however did not relate IPP operation cost with changes in tariff. This study intends to use census survey to relate IPP operation cost to changes in power tariff.

Mujeri and Chaoudery (2013) found out that power outages were from inefficiencies and poor production controls other than inadequate capacity. This studies do not relate operations cost of IPPs and roles played by IPPs in electricity supply and tariff changes.

Kenya relied primarily on concessionary funding from multilateral and bilateral agencies to finance new power investments but due to poor donor funding, the country's power generation by private sector gradually emerged in the mid-1990s, paving the way for contracting the first set of IPPs in 1996 (McEwan, 2001). While studies by International Energy Agency (2011), classifies cost of power based on fixed and variable consumption rates, ERC (2013) findings show that inflation and global sourcing causes tariff instability. These studies do not exploit the relationship between IPP operation cost and the power tariff.

According to Wendle (2013) while assessing the impact of new IPPs in Kenya found out that the economic cost of not having power is higher than generating power from diesel plants. Although Newbery and Commander (2013) found out that government incentive and the isolation of power distribution from generation should prevail over decisions to undertake private participation in power generation, their study did not exploit the relationship between IPP operation cost and tariff changes.

2.7. Summary of Literature and Research Gaps

Table 2.1 literature review, findings and research gaps

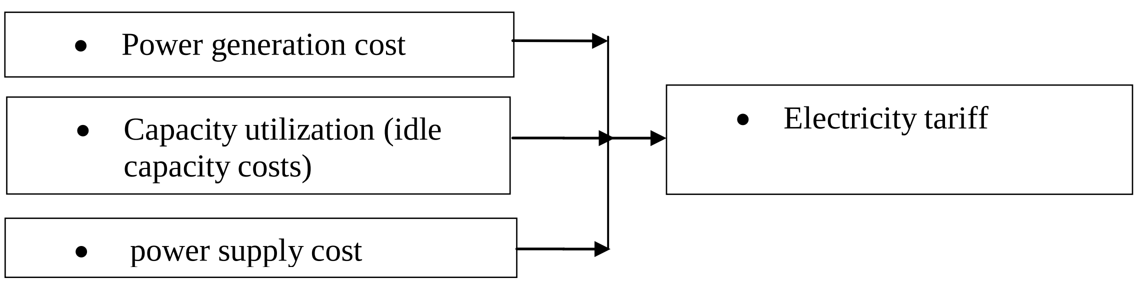
Study	Issues examined and findings	Gap	How the proposed study fills the gap
Jason, 2013	Issues: Assessed the impact of new IPPs in Kenya. It estimated the economic cost of not having power in relation to generating power from diesel plants	Did not establish the relationship between energy from IPPs and tariff charges	The study exploited the economic relationship between IPPs and tariff changes.
ERC, 2013	Issues: causes of power and tariff instability. Attributed power and tariff instability to inflation and global sourcing of raw materials	Did not distinctly state the effect on IPPs on the power tariff. This study focused on oil prices and other materials that are affected by global sourcing	This study interrogated the use of IPPs sources against public utility sources.
IEA, 2011	Issues: classification of cost components of electricity. That electricity pricing is based on variable cost per unit of power consumed and a fixed charge to cater for operations and maintenance	The source of power, government subsidies as a determinant of tariff base is silent in the study	This study exploited the source of power and the supplier to determine the final price.
World Bank, 2004	Issues: Economic Effects of privatization of energy source. Found that investing in IPPs will discourage monopolization and relieve countries of inefficiencies caused in managing energy resources.	The study does not show how the IPPs will compete with state owned utilities for power purchase.	This study used a cost benefit analysis for both IPP and Utility energy.
Commander	Issues: sought to find out the relationship between	Study did not show how Kenya power	This study proposes a power purchase mix

et *al.*, 2013	electricity demand and government incentives. It was found out that government incentives can encourage IPPs investment to cater for increasing power demand	could buy the power from IPPs and reduce off peak capacity underutilization that lead to peak load pricing problems	that discourages peak load pricing dilemmas.
Mujeri and Chaoudery (2013)	Issues: sought to find out the relationship between outages and energy efficiency. Showed that inefficiency is not from inadequate capacity but from breakdowns, poor maintenance and losses.	The study could not show how losses from inefficiencies affected tariff bearing in mind the various sources of power	This study aimed at finding out how the source of power and losses from inefficiencies contribute to tariff changes

2.8. Conceptual framework

Independent variables **Dependent variable**

Operations cost of IPPs Cost of power



Source: compiled by author, 2016

A process costing systems analyses the net cost of power generation and hence the unit cost of generating power, which will be passed on to the power distributor on demand, affects the cost of tariff passed on to the consumer. Activity based costing demands that costs are incurred during idle capacity. These costs are passed to the consumer tariff and because power cannot be stored; the distributor determines the amount of power the IPPs can generate and supply. No matter the installed capacity, sometimes IPPs operate bellow optimal level hence idle capacity. Since all power generated (supply) has to be consumed or lost, the amount of power supplied and distributed (demand) affects consumer tariff.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1. Introduction

This chapter outlines the research methodology that was used in collection and analysis of data and presentation of the research findings. The chapter is divided into the following parts; research design, target population, data collection methods, instruments of data collection and finally the data analysis.

3.2. Research Design

Descriptive survey design was used in this study since it could provide accurate, reliable and up to date information on the operation cost of IPPs and electricity tariff (Ravindra, 2014). Survey is an attempt to collect data from members of a population to determine the current status of that population with respect to one or more variables. This design allowed the researcher to collect information and examine single units of the variables hence demonstrating relationships and describing the operation cost of IPPs and Kenya Power tariff. Data collected was described to answer questions on the relationship of operation cost of IPPs and the power tariff.

3.3. Target Population

Since the researcher was dealing with a small population, the study was a census of all the five IPPs which are: Westmont, Iberafrica, OrPower4-Kenya, Tsavo Power Company (TPC) and Rabai. Kenya Power was further studied to get the relationship on power tariff.

3.4. Data Collection

Data collection instruments for this study were questionnaires which were used to provide in depth information on operations of IPPs and Kenya Power tariff. Due to time and resource constraints, the respondents were operational managers or their equivalent selected from the IPPs. Open and closed ended questions were mailed to the respondents to respond and return them to the researcher by post paid mail. The researcher preferred the question since they were easy to administer and the research questions were developed to focus on the specific objectives. Secondary data forms (appendix 2) were also used to obtain annual information on operation cost and tariff. Secondary data sources were obtained from ERC reports, Kenya Power tariff data and individual IPPs operation cost data.

3.5. Data Analysis

Data collected was edited, coded, classified, summarized and analyzed using descriptive statistics. The first objective, portrayed in the cost of generation, supply, and demand was analyzed using summary statistics in the initial stages of the data analysis. This was followed by cross tabulation of the variables, correlation analysis, and paired t tests. For the second objective, ANOVA and regression analysis was used to measure the strength of the relationship between operations of IPPs and the electricity tariff. The regression model was in the form:

$$Y= \beta_0+ \beta_1 X_1+\beta_2 X_2+ \beta_3 X_3+\alpha$$

Where, Y is the dependant variable (Electricity tariff), β_0 is the regression coefficient (Y-intercept), $\beta_1, \beta_2, \beta_3,$ are the slopes of the regression equation, X_1 is the generation cost, X_2 is the capacity utilization cost, X_3 is the supply and demand cost while α is the error term at 95% confidence level.

The input output model was used to determine power generation mix in the form:

$$x = (I - A)^{-1} y.$$

Where: x is price demanded from IPP and y is price demanded from Kenya Power Consumers. The (I - (1+r) A) p = 0 of the Leontief matrix was tested to determine changes in power tariff. Where (I) is identity matrix, (1+r) is a rate of profit and p is tariff cost. Data was presented in form of bar charts and graphs for further illustrations so as to be meaningful to all information users.

CHAPTER FOUR: DATA ANALYSIS, RESULTS AND DISCUSION

4.1. Introduction

The chapter presents research findings to establish the relationship between the IPPs operations cost and electricity tariff. Relative frequencies, means and multiple linear regressions were used in analyzing the results.

4.2. Response Rate

The study was conducted in all the five IPPs and Kenya Power where a questionnaire was given to the operation managers or equivalent. All the questionnaires were filled and returned making response rate 100%. This was considered adequate as Zikmund (2012) considers that a 40% to 80% response rate can be generalized to give the opinion of the entire population.

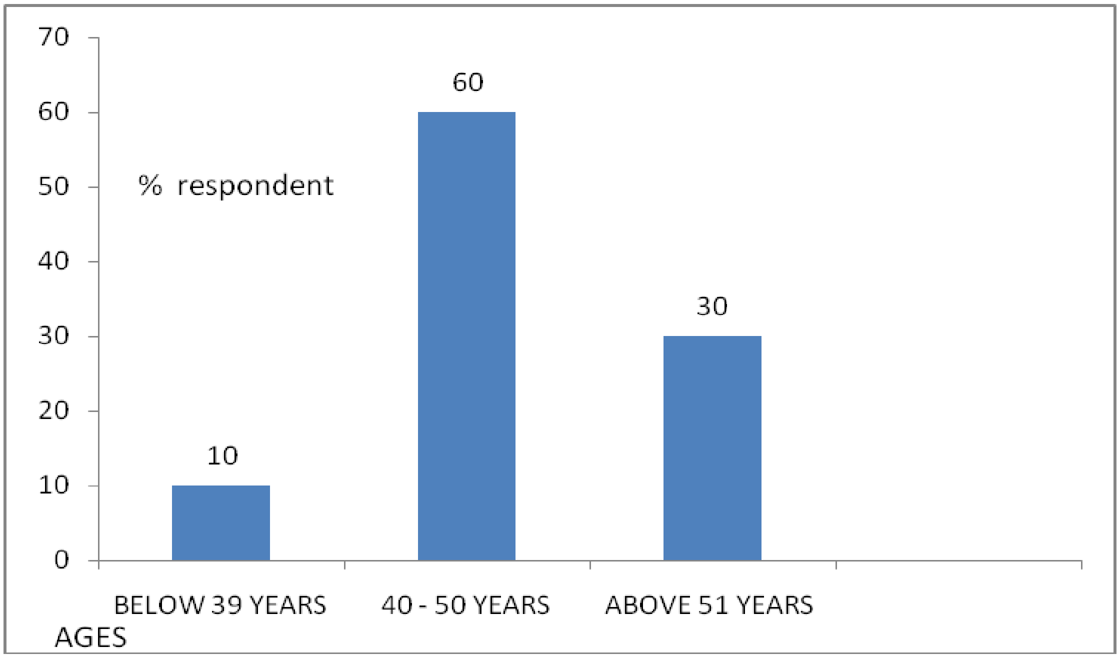
4.3. Demographics

The researcher set out some demographics in order to understand the respondents and validate the quality of the response given. These included gender, age and academic qualification

4.3.1. Gender and Age Distribution of the Respondents.

The study sought to identify the gender distribution of the respondents in this decision making level and found that it was male dominated at 100%. In all the companies under study, it was established that majority of the respondents were between 40-50 years at 60% followed by 51 years and above at 30% and finally below 39 years at 10%. Therefore most of the responded were in the best age to respond to the questions appropriately.

Figure 4.1: Respondents and age brackets

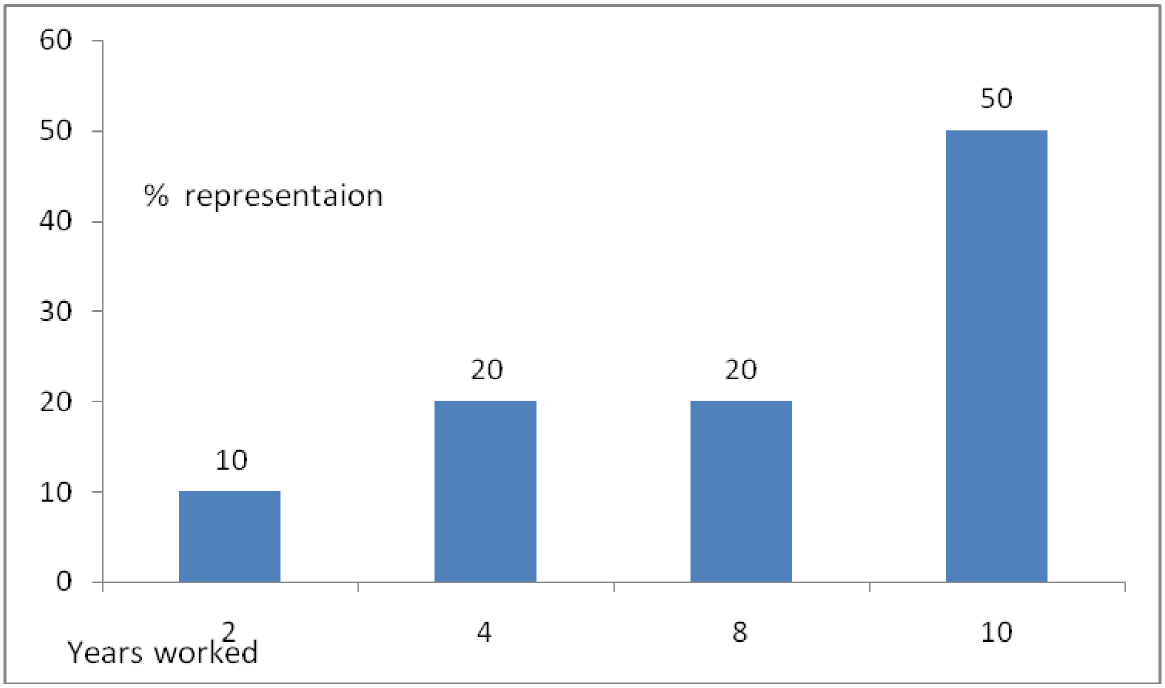


(Source: research data, 2016)

4.3.2. Number of Years Worked at the Company by the Respondents

The study sought to find out the length of time the respondent had worked in the company under study. This was very important in determining the decision process and makes the researcher determine an appropriate conclusion from the responded. 50% of the respondents had worked in the same company for more than 10 years, 19% of the respondents had worked the same company between 6-9 years, and 21% of the respondents had worked in the same company between 3-5 years while only 10% of the respondents had worked in the same company for less than 2 years. It is therefore clear that the respondents were conversant with the operation process within their area of work and that their title meant they were the senior most in those operation departments.

Figure 4.2: Respondents and years worked

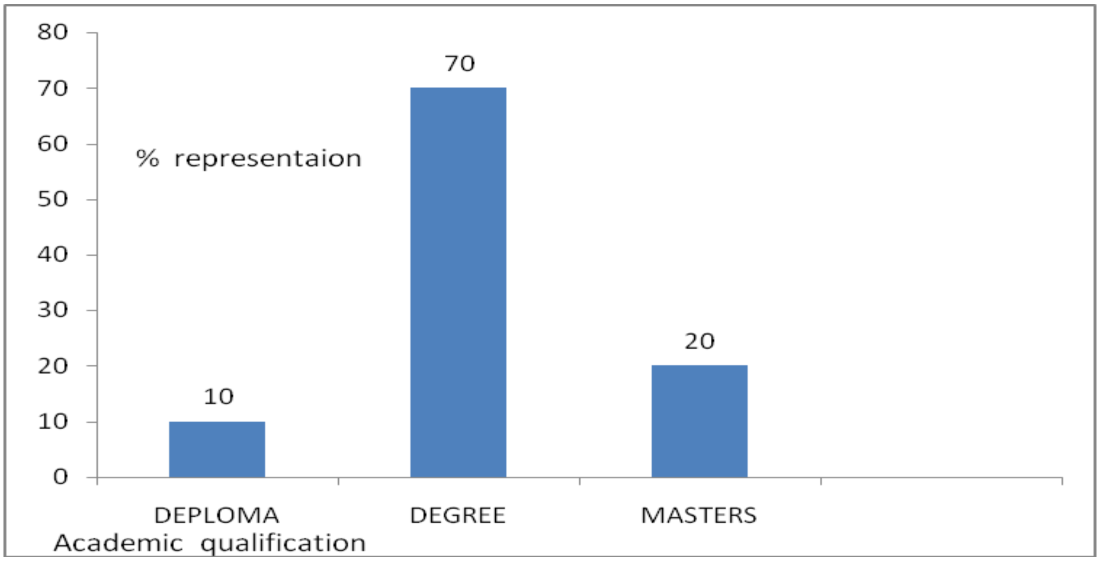


(Source: research data, 2016)

4.3.3. Highest Level of Academic Qualification of the Respondents

This was necessary to determine and ascertain whether they were in a position to respond the queries from the researcher. From the study, it was established that a majority of the respondents had a degree in a technical course 70%, 20% of the respondents had a masters degree, 10% of the respondents had higher diploma while none of the responds had doctoral and diploma levels. This findings indicate that majority of the respondents were informed and can understand the concept of the study.

Figure 4.3: respondents and academic qualification



(Source: research data, 2016)

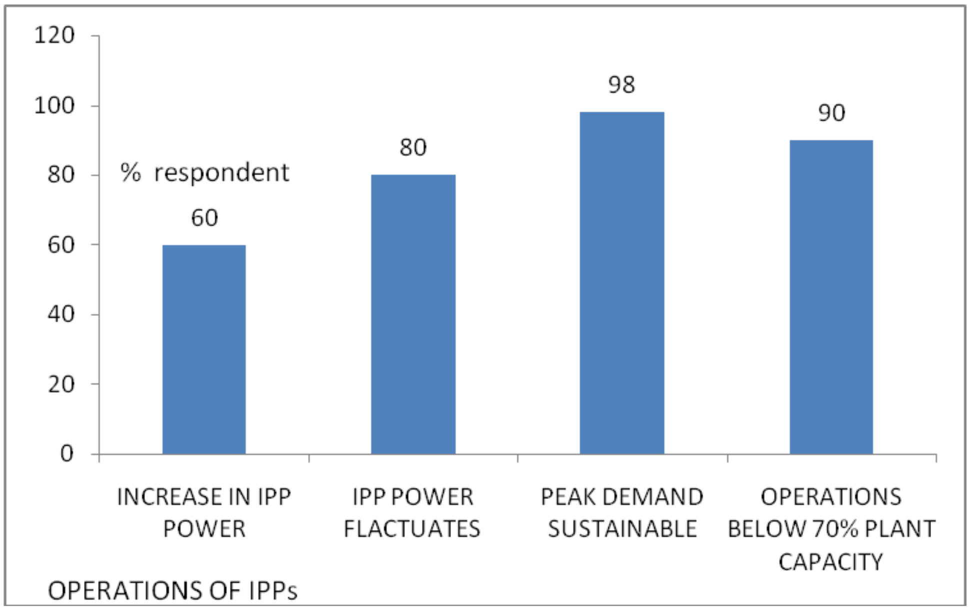
4.3.4. Operations and Planning

The study sought to find out various parameters that determine the stability of power supply from the IPPs and their future going concern. From the findings, 60% showed that the amount of power generated has increased in the last five years, 80% indicated that power generated fluctuated with demand, while 98% showed that peak demand was sustainable.

From the findings, 70% indicated that the number of employees working in the company had increased in the last five years, 40% indicated that power supply rate was fixed throughout the year, 80% indicated that the rate for peak demand for power was equal to that during low demand. It was also found out that 86% of those interviewed were trained in operations and system efficiency and that 93% of them knew the bases for electrical tariff which implies that they could negotiate for better power purchase agreements.

In regard to plant capacity and peak demand, from the findings, 90% of the respondents indicated that operations were below 70% plant capacity while 10% indicated above 70% plant capacity during peak demand.

Figure 4.4: Respondents views on operation of IPPs



(Source: research data, 2016)

From the findings, 10% of the respondents indicted fossil fuels as the convenient source of power generation, 50% indicated hydro while geothermal was rated at 40%. It was noted that fuel is expensive in terms of operation cost and that it led to some IPPs closing down (Aggreko) and also high cost tariff when they used to supply power to the grid.

In regard to supply and demand, from the findings, 90% of the respondents indicated that there was adequate energy capacity to meet the increasing electricity demand, 50% indicated that there was sufficient established reserve capacity for export. However, 90% disagreed that power generated was always equal to power sold. This indicated that in most cases, the companies have to put in place measure to reduce power loses. This is because power sold is equal to power produced minus losses. If losses increased less power would be sold expensively to mitigate the loss otherwise the company recorded loss of revenue.

4.4. Generation Cost and Cost of Electricity

According to the findings, secondary data showed that generation cost affected electricity tariff. This was as a result of several operation cost involved in electricity generation process. This was tabulated as in table 4.1 below with a mean generation cost of 10.1 per KWh and a standard error of 0.05

Table 4.1 Mean generation cost per KWh electricity generated

Company		Westmont		Iberafrica		Orpower4-Kenya		Tsavo Power		Rabai	
Item		Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
1	Cost of generation material	4.8	0.01	4.2	0.05	3.1	0.03	5.0	0.02	3.2	0.03
2	Logistics and transport of equipment	3.1	0.03	3.4	0.02	2.8	0.03	3.0	0.04	2.7	0.01
3	Disposal cost of non recyclable material	1.2	0.02	1.4	0.01	1.0	0.01	2.0	0.02	1.0	0.02
4	Labour	2.4	0.04	1.5	0.02	1.1	0.04	1.8	0.02	1.4	0.02

Source: research data, 2016

4.5. Capacity Utilization and Cost of Electricity

According to the findings capital utilization affected the cost of electricity. In most companies this cost does not depend on the power generated and therefore has to be incurred whether the plant is operational or not. The costs are fixed and therefore must be recovered from the sale of power that is supplied to the distributor. They vary from company to company as shown in table below with a mean cost of 12.5 per KWh and standard error of 0.03.

Table 4.2: Capacity capitation per KWh of electricity generated

Company		Westmont		Iberafrica		Orpower4-Kenya		Tsavo Power		Rabai	
Item		Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
1	Capacity infrastructure utilization	3.1	0.02	2.4	0.03	3.0	0.01	3.5	0.04	2.7	0.00
2	Regular maintenance	2.2	0.02	1.4	0.01	2.3	0.02	1.4	0.01	2.1	0.02
3	Capital cost for design and project management	9.1	0.01	8.1	0.02	8.7	0.02	8.2	0.01	8.2	0.01
4	Labour	2.0	0.05	1.2	0.03	1.1	0.01	1.6	0.03	1.3	0.02

Source: research data, 2016

4.6. Power Supply Cost and Cost of Electricity

According to the findings supply and demand influenced the cost of electricity as shown in table below with a mean cost of 5.3 and a standard error of 0.02.. The respondents agreed that since power produced must be sold, Kenya power has the sole discretion to determine how much power it will purchase and distribute to the connected customers. The monopolistic competition enjoyed by the company leaves IPPs without any other to sell power. The controls that are put in place by ERC compel IPPs to sign power agreements with Kenya power hence putting them under its sole control. Those IPPs that which cannot sustain the power purchase agreement are therefore forced to shut down by capacity constraints.

Table 4.3: cost of power distribution

Company		Westmont		Iberafrica		Orpower4-Kenya		Tsavo Power		Rabai	
Item		Average …	Std. Dev	Average …	Std. Dev	Average …	Std. Dev	Average …	Std. Dev	Average …	Std. Dev
1	Distribution cost	2.6	0.04	3.3	0.01	3.1	0.02	3.0	0.03	3.4	0.03
2	System loses	1.0	0.02	0.9	0.03	1.2	0.01	0.8	0.02	1.0	0.03
3	Other levies	1.2	0.05	1.1	0.01	1.0	0.01	1.0	0.01	0.9	0.01
4	Cost of energy and other supplies	2.2	0.01	1.3	0.02	1.4	0.02	1.0	0.01	0.9	0.02

Source: research data, 2016

4.7. Correlation Analysis

Pearson moment correlation analysis was used in the study to determine whether there was a relationship between the study variables. The independent variables had the following Pearson moment correlation coefficients. Generation cost (r = 661), capacity utilization cost (r = 560) and supply and demand cost (r = 184).

4.7.1. Generation Cost

In order to establish a relationship between generation cost and the cost of electricity, the results showed a strong correlation between the generation cost and the electricity cost.

4.7.2. Capacity Utilization Cost

In order to establish a relationship between capacity utilization cost and the cost of electricity, the results showed s strong positive correlation between the generation cost and the electricity tariff.

4.7.3. Supply and Demand Cost

In order to establish a relationship between supply and demand cost and the cost of electricity, the results showed a strong correlation between supply and demand of the distributed electricity and the electricity tariff.

Table 4.4: Correlation of the study variables at 0.05 significance level

		Generation cost	Capacity utilization cost	Supply and demand cost	Electricity tariff
Generation cost	Pearson correlation	1			
	2- tailed				
	N	41			
Capacity utilization	Pearson correlation	0.433	1		
	2- tailed	0.005			
	N	41	41		
Supply and demand cost	Pearson correlation	0.732	0.642	1	
	2- tailed	0.001	0.003		
	N	41	41	41	
Electricity cost	Pearson correlation	0.621	0.614	0.721	1
	2- tailed	0.000	0.002	0.001	
	N	41	41	41	41

4.7.4. Cost of Electricity from IPPs per KWh

In order to establish the relationship between the operation cost of IPPs and the cost of electricity, secondary data showed that the cost of electricity from all the IPPs was above the operation cost. From the findings, the IPP operation cost was (10.1 + 12.5 + 5.3) 27.9

per KWh which was equivalent to Tsavo power as shown in table 4.5. This showed that the cost was set using the cost plus margin model as discussed in chapter two and therefore means that operation cost of IPPs affects the cost of the tariff.

Table 4.5: Cost of electricity from IPPs data reports.

Company		Westmont		Iberafrica		Orpower4-Kenya		Tsavo Power		Rabai	
Item		Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
1	Cost	17.6	0.04	21.4	0.02	8.1	0.02	27.8	0.03	17.9	0.03

Source: research data, 2016

4.8. Regression Analysis

In determining the relative importance of the three variables on the cost of electricity, a regression model was applied to the variables. The model was in the form:

$Y= \beta_0+ \beta_1X_1+\beta_2X_2+ \beta_3X_3+\alpha$

Using values from the table 4.5 below

$Y= 1.45 + 0.420X_1 + 0.210X_2 + 0.140X_3$

Where,

Constant = 1.45, when the value of the independent variable is zero, the electricity cost will be the constant value set by the government under KenGen

X_1 = 0.420, one unit change in the generation cost results to 0.420 unit change in the electricity cost

X_2 = 0.210, one unit change in the capacity utilization cost results in 0.210 unit change in the electricity cost.

X_3 = 0.140, one unit change in the supply and demand cost results in 0.140 unit change in the electricity cost.

Table 4.6: Regression coefficients

Item	coefficients	
	B	Std Error
Constant	1.45	0.006
Generation cost	0.420	0.002
Capacity utilization cost	0.210	0.004
Supply and demand cost	0.140	0.003

From the findings electricity cost is a dependant variable while generation cost, capacity utilization cost and supply and demand cost as independent variables. From the results in the table 4.4, the coefficient of regression (R = 0.6) shows a good strength of relationship between the independent variables and the dependant variable. The coefficient of determination ($R^2 = 0.4$) show the predictive power of the model at 40% variation which is explained by the various operation process costs within the independent variables.

Table 4.7: ANOVA

Model	R	R^2	Standard error of the estimate
1	0.720	0.518	0.003

From the ANOVA findings, the P-Value is of 0.001. This is less than 0.05 at 95% confidence level indicating the existence of a strong relationship between the independent and the dependant variables. The variable fits the regression model since from the results the significance of P-Value and the F ratio at 0.000 shows that there was no much deference in means between the dependent and the independent variables

4.9. Input Output Model

The input output analysis was used to show economic relationship between two economic sectors (the IPPs operation costs and the electricity tariff). In testing the use of the input output model in determining electricity tariff, the Leontief Matrix was applied as shown in table 4.8

Table 4.8: Input output table for the electricity energy sector

	Sector 1	Sector 2	Final demand (D)	Total
Sector 1 (IPPs)	Production Cost(IPPs)/KWh	Distribution cost/KWh	% power distributed from IPPs in relation to total power distributed	
Sector 2 (Kenya Power)	Selling price (IPPs)/KWh	Selling price (consumer)/KWh		
Primary inputs	Capital/KWh	Capital/KWh		
Total	-	-	-	-

The Leontief matrix was obtained from the figure above as shown in table 4.8

Table 4.9 Intersectional demand for the electricity sector restricted to two players

	Sector 1	Sector 2	Final demand (D)	Total
Sector 1 (IPPs)	Mean 0.20	Mean 1.75	25% of per distributed by Kenya power is from IPPs and 75% is from KenGen	2.20%
Sector 2 (Kenya Power)	Mean 0.89	Mean 0.70		2.34%
Primary inputs	10.0	40.0		50.0
Total	11.09	40.45	100%	

From the findings, the variables fit in the input output model.

Table 4.50: Technological matrix of the electricity sector

	Sector 1 (IPPs)	Sector 2 (Kenya Power)
Sector 1 (IPPs)	0.2/11.09	1.75/40.45
Sector 2 (Kenya Power)	0.89/11.09	0.7/40.45

From table 4.9 the technological matrix was simplified as:

$$\begin{Bmatrix} 0.02 & 0.04 \\ 0.08 & 0.02 \end{Bmatrix}$$

If x is cost of power from IPPs and y is the cost of power (tariff) from Kenya power demanded by customers, then applying

$x = (I - A)^{-1} y$.

From the findings,

$$(I - A)^{-1} = \begin{Bmatrix} 13 & -12 \\ -12 & 13 \end{Bmatrix} \quad \text{as Leontief inverse matrix}$$

From the findings, the installed capacity fluctuations from IPP power ranges from 20% to 30%. Applying the model above, IPPs stand to lose 12 shillings per unit when they are switched off by Kenya Power and therefore it is prudent that IPP power can be bought at a minimum of 13 shillings per unit throughout the year without switch off in order to maintain their stability.

The objective of using the input output analysis is to balance the shifting in demand of the amount of power purchased from the IPPs with that from the state utility. It also helps to determine the amount money paid to the IPPs by the distributor hence avoiding payment for power not delivered as the case when IPPs are portrayed as expensive in demanding payment for power not delivered.

CHAPTER FIVE: SUMMARY, CONCLUSSION AND RECOMMENDATIONS

5.1. Introduction

The chapter provides summary of the findings from chapter four. It also gives the conclusions and recommendations of the study based on the research objectives. The objectives of this study were to establish the relationship between operation cost of IPPs and electricity tariff and to test the input output model in determining power tariff.

5.2. Summary of the Findings

Operations involved in the generation and distribution of power play a significant role in determining the electricity cost passed on to the consumer. This is because power generated must be used or lost yet the cost of generating remains a factor whether power has been used or lost. Activity based costing remains a significant base for tariff. Generation cost, capacity utilization cost and supply and demand costs are some of the determinants of the electricity tariff in Kenya.

The correlation analysis for generation cost by IPPs was reported as 0.6. This means that changes in the cost of generating power affected the electricity cost. This was depicted when there was drought season that led to the shift from hydro generation to fuel thermal generation making the electricity tariff to rise sharply.

During the period, capacity utilization and supply and demand costs showed positive correlation. This means that when capacity is under-utilized, electricity tariff increases in the long run in order to mitigate and recover invested capital and labour. It was also found out that if electrical losses are not minimized, then it led to lost revenue by companies or increased tariff which is passed on the customer.

On ANOVA test, since the P-value was less than 0.05, it therefore implies that the cost of electricity in Kenya is dependent on the generation cost, capacity utilization cost and supply and demand cost.

5.3. Conclusions

The study concludes that operation cost of IPPs significantly affect the cost of electricity in Kenya. Generation cost affects tariff in that the bills that get to consumer have to bear a cost that goes into fuel charges especially when thermal generator are used during dry seasons. Depending on the fuel used to generate power, the study established that consumers have to bear the price if the source for generating power changes.

The study established that when some plants fail to be commissioned on time yet capital costs remain, the cost of electricity from such plants will be recovered from the consumer through higher tariff as fixed cost.

The study found out that supply and demand of power affect the cost of power supplied to the consumer. The study established that the cost of labour and distribution materials was charged from consumers through fixed charges. Over the period Kenya power increased fixed charge from one hundred and twenty shillings to one hundred and fifty shillings. Therefore, even if the ERC policy were to determine the tariff per unit consumed, consumers have to pay other factors that appear in the final bill. These charges include forex charge, fuel adjustment, energy levy and monthly fixed costs.

5.4. Recommendations

Recommendations have been made by various stakeholders in the energy economy, especially the electricity sector. In this study, which is about the determinants of the cost of electricity, operation costs of IPPs were found to play a major role in determining the final electricity tariff that consumers pay from their monthly bills. The findings of the study formed the basis of the following recommendations:

a. The generation mix need to reviewed to give equal opportunity for the power supply from the IPPs and the state utility (KenGen). IPP power should not only be used during emergency hence a clear generation mix needs to be determined.

b. Kenya power needs to minimize energy distribution losses by adopting modern technology and enhanced demand side energy management.

c. The pricing strategy should be reviewed to avoid passing the system inefficiency costs to the customer. This can be done through management of the shifting in demand hence avoiding switching of IPP power.

d. Further research and benchmarking need to be undertaken the determine better pricing mechanism for power tariff to avoid high cost that are passed to consumer as a result underutilized capacity in power generators.

5.5. Limitations of Study

The researcher faced a number of limitations while undertaking the study. In input output model was only restricted to two players yet it can be extended to other player in the energy sector. It was evident that some energy data kept by most IPPs were incomplete or rather the parties did not give classified energy data. Secondly, there was limited time and financial resources to collect date beyond five years yet IPPs have been in operation since 1996. Lastly, there is need to study operations by KenGen which is also a power generating company that sell power to Kenya power so that a clear comparison can be made on the tariff.

5.6. Suggestion for Further Research

Future research should use census survey to study on the operation cost of all the electricity plants both private and state owned relation to cost of electricity. It will be also necessary to study the relationship between power purchase agreements and the price of electricity set by the energy regulation commission. This will help in determining better policies hence adopting favorable pricing models for electrical power.

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APPENDICES

QUESTIONAIRRES

The questionnaire is divided into two parts as follows: personal data and operations and planning. Please answer the questions as guided by the instructions in each part.

RESERCH QUESTIONAIRE

Part I. PERSONAL-DATA

Instructions: Please write in the space provided or tick ( ) appropriately as applies to you.

1. Name of employer ……………………number of years worked ………area of work…………….
2. What is your highest level of Academic Qualification? [ ] Doctoral Degree [ ] Masters

   [ ] Bachelors [ ] Higher Diploma [ ] Diploma [ ]

   Other……………………..

Part II: operation and planning

3. What would you say about the following statements? (Please tick in the box)

General operations	Yes	NO
Amount of power generated has increased in the last five years		
Power generated fluctuate with demand		
Peak demand is sustainable		
Planning		
The number of employees working in the company has increased in the last		

five years		
Power supply rate is fixed throughout the year		
The rate for peak demand for power is equal to that during low demand		
I am trained in operations and system efficiency		
I know the bases for electrical tariff (explain……………………..…………………………)		

4. Please state the approximate plant capacity ……………….......and peak demand -----------------
5. Choose which power source is the most convenient for your operations

   (a.) fossil fuel [ ] Yes [ ] No. **(b.)** hydro [ ] Yes [ ] No **(c.)** Any other, specify…………………
6. What is your major source of fuel and why

   ……………………………………………………………….
7. Please rate the following statements regarding supply and demand for power

Demand and supply	**Yes**	**NO**
There is adequate energy capacity to meet the increasing demand		
There is sufficient established reserve capacity and need to export excess		
Reactive power compensation has been well utilized hence power generated is equal to power sold		

Any other comment on power demand and supply..