DETERMINANTS OF RESIDENTIAL DEMAND FOR ELECTRICITY IN TANZANIA (1974-2009)

JAMES B. DIU

A THESIS SUBMITTED IN (PARTIAL) FULFILLMENT OF THE REQUIREMENTS FOR THE MASTERS OF ARTS (ECONOMICS) DEGREE OF THE OPEN UNIVERSITY (OUT)

2011

CERTIFICATION

The undersigned certifies that he has read and hereby recommends for acceptance by The Open University of Tanzania (OUT) a thesis titled ñ***Determinants of Residential Demand for Electricity in Tanzania (1974-2009)"*** in partial fulfillment of the requirements for the degree of Master of Arts (Economics).

é é é é é é é é é é é é é é é é é é é ..

Dr. Felician Mutasa

(Supervisor)

Date é é é é é é é é é é é é é é é é é é

COPYRIGHT

DECLARATION

I, James B. Diu, declare that this thesis is my own original work and that it has not been presented to any other university for a similar or any other degree award.

é é é é é é é é ..é é é é é é é é

James B. Diu

Date é é é é é ..é é é é é é é é é é é

DEDICATION

This thesis is dedicated to my beloved mother Anna John Ngaa, my father Bennedict Paschal Diu, my beloved wife Beatrice Deogratius Kawili and my Children, Suzanne, Florida, Michael, Deogratius, Anna Joan and my brother Ignas Diu and Sister Lucy Diu and all those who have inspired me.

ACKNOWLEDGEMENT

In accomplishment of this thesis I am indebted to a lot of people. Since these people are many I feel sorry that I cannot mention all of them by names in a single page. I wish therefore, to thank the Energy and Water Utilities Regulatory Authority (EWURA) for permission to attend my M.A studies. Sincere gratitude should go to my supervisor Dr. Felician Mutasa of The Open University of Tanzania for their invaluable criticisms, comments and contributions without which this thesis would not have been a success.

I am indebted to all the members of staff of the Faculty of Arts, Department of Economics and Postgraduate Studies of The Open University of Tanzania and that of the University of Dar es Salaam. Just to mention a few, sincere gratitude should go to Prof. Emmanuel Mbogo, Prof. Waane, Prof. Sengo, Prof. Mbwiliza, Dr. Fungameza, Dr. W.Pallangyo, Dr. D.Ngaruko and Dr. J.P.A. Msindai and Dr. K. Kazungu. Their contribution is in both laying the foundation that led me to this stage and in giving contributions in writing my thesis.

To my former classmates and college mates at the University of Dar es Salaam Dr. Edward Hosea, Dr. Eliab Luvanda, Mr. Deo Lyatto, Mr. Harry Ndambala, Dr. Johnson M. Ishengoma, and Mr.Alphonce Mwasakyeni, I would like to thank them for the challenges they gave me during the hard times of our undergraduate studies and assisted me in one way or another for my postgraduate studies. Lastly, I would like to declare that any omissions and/or errors contained in this work are solely my responsibility.

ABSTRACT

This thesis attempts to review some crucial aspects in determination of electricity demand for residential customers in the country. In this connection, it estimates the price elasticity of residential demand for electricity in Tanzania. It does so by using cointegration and error correction procedures, with key variables identified as the domestic electricity tariff, per capita income, size of the population, price of kerosene, and overall energy utilization from 1974 till 2009.Major findings of the thesis are that electricity demand for residential customers is inelastic in both short run and long run. In addition, the short run elasticity of residential demand for electricity is higher than the long run electricity contrary to the empirical literature. The thesis concludes that the investment requirements to fulfill the projected demand for the next 15 years towards our national development vision 2025 are enormous. The high projected demand emanates from the rapidly increasing demand and the need to increase availability of electricity service to the population. In addition, tariff reforms are necessary to support competitive power market development and to strengthen the power utilitiesô financial position.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ACRONYMS

ADF	Augmented Dickey Fuller
ARCH	Autoregressive Conditional Heteroscedasticity
CFL	Compact Fluorescent Lamps
CPI	Consumer Price Index
ECM	Error Correction Mechanism
EPPs	Emergency Power Producers
ESMAP	Energy Sector Management Program
EWURA	Energy and Water Utilities Regulatory Authority
GDP	Gross Domestic Product
GoT	Government of Tanzania
GWh	Gegawatt hour
IFC	International Financial Corporation
IPPs	Independent Power Producers
IPTL	Independent Power Tanzania Limited
kV	KiloVolts
KWh	Kilowatt hour
LRMC	Long Run Marginal Cost
LV	Low Voltage
MEM	Ministry of Energy and Minerals
MW	Megawatt
NBS	National Bureau of Statistics
NPF	National Provident Fund

O&M	Operating and Maintenance
OLS	Ordinary Least Squares
PP	Phillips Perron
PSMP	Power Sector Master Plan
PSRC	Parastatal Sector Reform Commission
RESET	Regression Specification Test
SAPP	Southern African Power Pool
SPPs	Small Power Producers
TANESCO	Tanzania Electricity Supply Corporation
TANWAT	Tanzania Wattle Company Limited
TOE	Tons of Oil Equivalent
TOU	Time of Use
TPDC	Tanzania Petroleum Development Corporation
TZS	Tanzanian Shilling
USc	United States Cent
ZECO	Zanzibar Electricity Corporation

CHAPTER ONE

1.0 BACKGROUND INTRODUCTION

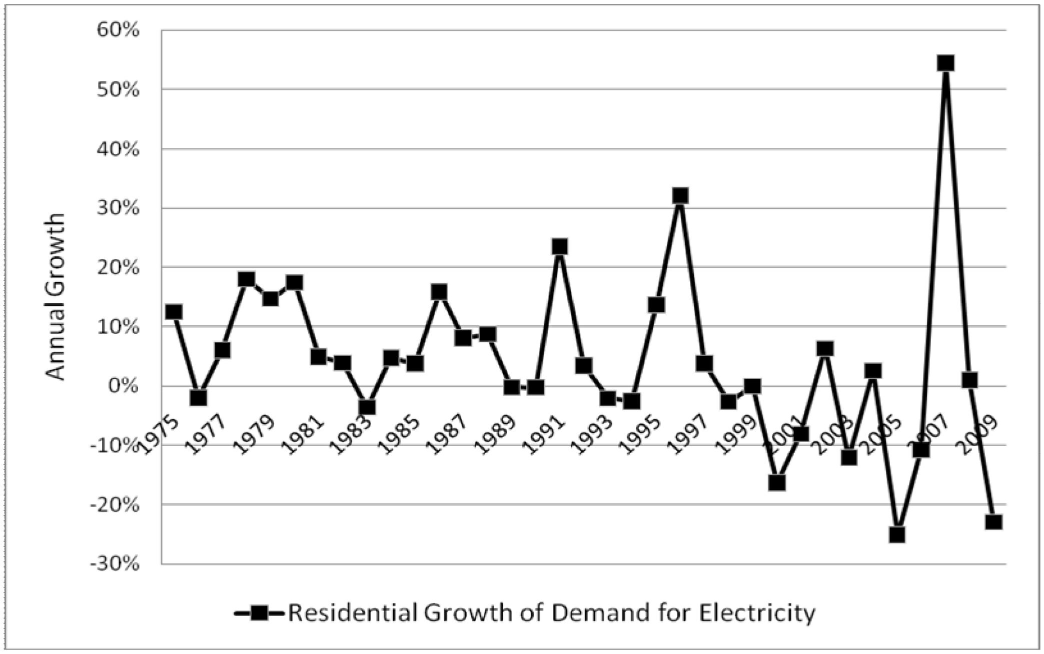
1.1 Background

The purpose of this thesis is to estimate the determinants of residential demand for electricity in Tanzania. The change in price elasticity of demand is the major focus of the issues addressed in this thesis. With the fluctuating trend in the electricity demand, there are increased challenges in deciding how much to increase tariff in order to reach the cost recovery level and obtain the needed cash to finance expansion activities. The primary concern is to set proper and efficient tariffs for electricity.

There are a number of factors that form the basis for this study. For instance, increasing demands for electricity is a fact of life. In many developing countries, there is a vast reservoir of unsatisfied demand on the part of people without lighting, refrigeration, sanitary water supplies, television, air conditioning, and other electricity services; and economic development will surely provide a driving force for demand (Mueller, 1991). When demand increases, both utility obligations and market prices signal the need for new investments in generation and power delivery. This phenomenon occurs even as the cost of providing electricity services increases. Electricity demand in most developing countries has been growing at a very rapid rate over the last decade. Given, current trends in population growth, industrialization, urbanization, modernization and income growth, electricity consumption is expected to increase substantially in the coming decades as well.

This implies enormous new financial investments will be needed to meet demand in this sector. Currently, the electricity sector in most of the developing countries is characterized by chronic power shortages and poor power quality. With demand exceeding supply, severe peak and energy shortages continue to plague the sector. The elementary problem being faced by the power sector is the poor financial conditions of power utilities in developing countries. This has resulted in inadequate investment in additional generation capacity, which is likely to further exacerbate the existing gap between power supply and demand (Filippini. and Pachauri, 2002).

In Tanzania, the demand for electricity has been growing rapidly and quite often exerting pressure on the production capacity of power generating plants. More specifically, the residential demand for electricity over the period 1974-2009, increased at the average annual rate of 10%, which is higher than the demand for electricity by the commercial and industrial customers which increased at the average growth rate of 5%. According to the most recent data, that is 2000-2009 the lowest residential consumption of electricity was recorded in 2006 with 871GWH after the country experienced acute power shortage and the highest being 1,647GWH recorded in 2008. For commercial and electricity customers during 2006 and 2008, the respective consumption levels measured as annual demand for electricity by commercial and industrial customers were 1,593GWH and 1,722GWH, indicating power rationing of 2006 exclusively targeted the residential customers. Meanwhile, the share of residential electricity consumption rose from 16% in 1974 to 62% in 1999 and remains above this 40% ever since with the exception of power crisis years of 2005 and 2006 where the consumption composition dropped to 35% and 33%, respectively. There is no doubt that the residential demand for electricity will be increasingly an important element in any policy decision.



Note: Computed from Data on Domestic Electricity Sales (1975-2009)

Figure 1: Growth in the Residential Demand for Electricity in Tanzania

Source: Data used in the Regression Analysis

1.2 Statement of the Problem

Electricity is one of the vital utilities for development. Tanzania, like many developing countries faces shortage of electricity supply. In addition, the demand for electricity in Tanzania has been increasing rapidly due to the growing economic and social conditions in the country. To address the shortage of electricity energy, large investments in electricity generation are required. Undertaking such large investment for a developing country like Tanzania is a daunting task and therefore although turning to cheaper energy sources is an important option, efficient use of the available electricity energy through demand side management (DSM) programs is equally important for the country to implement its development plans.

Previous funded programs in demand side management in Tanzania have focused on industries and power station units and the main player in implementing the DSM has been only TANESCO (Kabadi J., 2010). For example, in 1995 under Energy Sector Management Assistance Program (ESMAP) funds, TANESCO engaged a consultant to come up with the DSM program. Between 1995 and 1996, TANESCO carried out DSM program in major industries and factories. Activities looked at power factor correction, efficient motors, and use of use of Compact Fluorescent Lamps (CFL). However, in 1997 funds were depleted and the program paralyzed. In 2010, TANESCO secured funds from International Finance Corporation (IFC) to engage a consultant who will advise TANESCO on DSM power station units that will be made up of DSM technologies rolled out as technology matures and enough verification methods developed.

However, residential demand for electricity is a major component of electricity demand. Programs towards demand side management should therefore focus residential customers. Prices are one of effective ways of controlling demand. Like all other normal goods, economic research and industry experience have confirmed that an increase in the real price of electricity will lead to a reduction in the growth of power demand. The recent introduced regulator that is, EWURA charged with the responsibility of regulating rates, can also play part in DSM. The electricity industry is likely to go through a period of real price increases, it is important to examine the extent to which expected rate increases might reduce future expected demand growth, which influences utility forecasts of required investment.

1.3 Objective of the Study

The main objective of the thesis is to estimate the determinants of demand for electricity in Tanzania. In this thesis our focus is on the residential demand for electricity, because this is the bigger and at the same time more volatile component of the total demand for electricity and also is the component whose determinants are amenable to theorization and quantification. In addition, co-integration method is employed in this thesis in order to overcome a limitation of simple econometric forecasts which make factors appearing to have significant causal effects when one or more series follow the same pattern in the long run.

Specifically the study will:

(a) Assess the current performance of electricity sub-sector in Tanzania;

(b) Estimate the price elasticity of demand for the residential consumers in Tanzania;

(c) Compare the long-run and short-run price elasticity of demand for residential consumers in Tanzania; and

(d) Examine how to balance the interests of service providers of financial sustainability and the residential customers on their ability to pay through tariff.

1.4 Hypotheses of the Study

The study intends to test the following hypotheses:

(a) Per capita income positively impacts the demand for electricity;

(b) Increase in electricity tariff impacts negatively the demand for electricity;

(c) The higher the population growth the higher the demand for electricity in a country;

(d) Kerosene is substitute to the electricity energy in Tanzania; and

(e) Efficient use of electricity energy in industries will reduce the demand for electricity.

1.5 Significance of the Study

There are a host of reasons why the understanding of demand response of a tariff increase is important. These explanations span, among others, from challenges of a successful reform, effective regulations, and poverty reduction. Specifically, the study is important in understanding the demand for expansion of capacity for electricity generation. Through this, the government will be assisted to know to what extent the electricity generation needs to be opened up. The study is also important in addressing the financial situation of TANESCO which has affected the utility investments and resulted in inadequate generation reserve, transmission network constraints, overloaded transformers, and degraded distribution networks. In addition, the study intends to aid effective regulation by fulfilling the desire to have tariffs that reflect economic costs and yet that are affordable to consumers. The study is also intended to contribute towards poverty reduction efforts in the country by addressing the need to increase electrification throughout the country.

1.6 Organization of the Study

After the introduction in Chapter 1, which discusses the nature of demand in the electricity sub sector with an overview of challenges of reforms in the electricity sector worldwide, the remainder of this paper is structured as follows:

Chapter 2 of the thesis presents an overview of the performance of reforms in the electricity sub sector in Tanzania. This includes a discussion on changes in policies and reforms in an effort to develop a sustainable electricity sector in the country and a discussion on the performance of the vertically integrated utility company in Tanzania, namely TANESCO. The thesis proceeds in Chapter 3 with the review of the literature on the underlying theoretical framework of demand. The chapter also summarizes empirical literature on the estimation of demand for electricity in terms of the methodologies used and estimates obtained.

In Chapter 4, the thesis estimates a time series error-correction model of residential demand for electricity. The proposed factors that are hypothesized to influence residential demand for electricity include residential tariff, the price of kerosene, per capita income, population growth and efficiency improvement in the consumption of energy. In Chapter 5, the thesis interprets the results and gives policy implications. In Chapter 6, the thesis concludes drawing on findings obtained in Section 5. In this final section, the paper also reveals areas for further research.

CHAPTER TWO

2.0 OVERVIEW OF THE PERFORMANCE OF REFORMS IN THE ELECTRICITY SUB SECTOR IN TANZANIA

2.1 The Beginning of Reforms

The initiation of electricity sector reforms in Tanzania was catalyzed by a combination of macro-reform priorities, national energy policy, electricity sector conditions, and international donor priorities. In 1992, the Government expanded macro-economic reforms started under structural adjustment in the mid-1980s to include sector focused objectives (Wangwe et al., 1998). Also in 1992, the first National Energy Policy, which included intentions to involve the private sector in development of the energy sector (MEM, 1992). In the same year, facing a drought-induced electricity crisis and extensive load shedding, the Government lifted the state utilityos monopoly on generation to attract private generation and alleviate shortages. The reform paved the way for the country two IPPs, namely Songas and IPTL. The reform imperative was reinforced by changes in World Bank lending policy, as the World Bank made electricity sector reforms a condition for electricity sector lending in 1993 (World Bank, 1993).

2.2 Early Efforts to Commercialize and Restructure TANESCO, 1992-2001

The driving model of Tanzaniaos electricity reform was originally aimed at restructuring and unbundling the electricity sector for eventual privatization. At the time of initial reforms, TANESCO, the national utility, was already corporatized, with the firm operating under Tanzaniaos Company Ordinance Act since 1931.

During the 1970ôs to mid-1980ôs the national utility performed adequately, yet toward the end of the 1980ôs utility performance gradually declined (Katyega, 2004). Despite its corporatized status, from the early 1990s, the firm recorded poor technical and financial performance, making status quo operations increasingly untenable. In 1992, the utility was forced to shed 130 MW (TANESCO Annual Report and Accounts, 1992) due to lack of generation availability. By 1994, load shedding amounted to 100 MW, still nearly one third of maximum demand in the grid system (Katyega, 2004). Combined technical and non-technical losses amounted to 20% in 1992 up from 15% a decade earlier. Losses reached a high of 28% in 2001, after briefly improving between 1995 and 1998 to 12-14%. TANESCO was unable to cover its operation and maintenance costs and debt service repayment from its collection, which fell during the 1990ôs.

In the early 1990ôs, the average tariff was below costs due to reluctance to increase tariffs during prescribed currency devaluations. However, efforts were made to correct the trend, and average tariff reached a strong position in mid-1990s, a situation that continued throughout the decade. Additionally, TANESCO faced difficulties in enforcing payments for services and arrears. Debt collection days deteriorated from 203 days in 1990 to 413 days in 1999 (Katyega, 2004). Particularly difficult were collections from public institutions. In 1991, arrears of public institutions amounted to a 20% loss in annual revenue (Mwandosya and Luhanga, 1993). With diminished revenues for maintenance, outages and distribution losses increased during the same period. Efforts were made to commercialize and improve TANESCOôs operations in the 1990ôs via the support of the World Bankôs projects including the Power VI project, the Energy Sector Management Program (ESMAP), the Power Loss Reduction Study, and the Technical Assistance to TANESCO project. However, despite these efforts (including introduction of prepayment electricity meters, loss reduction measures, and contracting out services), TANESCO remained in a weak financial position by the late 1990ôs, and utility performance deteriorated to unprecedented levels.

In 1997, TANESCO was put under the Presidentôs Parastatal Sector Reform Commission (PSRC), created in 1992 to oversee the privatization of state-owned enterprises in industry and manufacturing. Formal intentions to restructure the power sector to achieve unbundling and eventual privatization were spelled out in a 1997 letter of intent to the World Bank, including restructuring plans to unbundle TANESCO into two generation companies, one transmission company and two distribution companies. A 1999 Cabinet decision outlined an electric industry policy and restructuring framework to move ahead on restructuring and unbundling in preparation for privatization. However, so far no progress was made with unbundling.

2.3 The Management Contract and Future Reforms

Seeking more dramatic financial turn-around in preparation for privatization, the MEM issued a request for proposals for a management contract for TANESCO in 2001, which was won by the South African company NET Group Solutions in 2002. Under NET Group Solutions and with the support of the Government, TANESCO doubled revenue collection from US$ 11 to over 22 million per month between May

2002 and May 2004 (Davies, 2004). These gains were achieved mainly through enforcing collections and arrears payment, with high-profile service disconnections and collections from the police, the national post offices, and even the entire island of Zanzibar in addition to private customers.

In 2004, the management contract was extended for two years, through to the end of 2006. The extension expanded the mandate of the consultants to include technical turn-around in addition to financial-turn around, specifically including electrification and reliability targets. As of the end of 2005, outcomes of technical turn-around have been limited. Stakeholders cite financial constraints external to the contract, namely poor hydrological conditions, costs of IPP power, and insufficient tariff rates ï to be limiting TANESCOôs ability to make investments to improve electrification or reliability.

Under eroding hydro capacity and more costly IPP generation, revenue gains achieved under the management contract increased generation costs, rather than much needed investments to improve technical performance. Conditions went from bad to worse in early 2006, as hydro shortfalls became higher than IPPs could make up, and TANESCO was forced to resort to load shedding. The 60MW plant at Ubungo and the 45MW plant at Tegeta were part of an emergency power project which was funded by the Government together with concessionary loans and grants, which were due online in April and December 2006, respectively. A further state-led initiative, which has been in the planning stages since the mid-1990s, is the interconnector to link Tanzania with the Southern African Power Pool (SAPP).

In a few short years, TANESCO went from being optimistic about prospects for financing service investments from utility revenues to crisis conditions where TANESCO now need large tariff increases and emergency supply to account for increasing generation costs, supply shortfalls, and load shedding. The shift represents an impossible context for TANESCOös finances to support independently. These conditions have hindered the performance of the management contract and the ability to make necessary investments in reliability and electrification. The prospect of making up the difference of increasing generation costs via large tariff hikes, raises the question of affordability, namely how high tariffs the economy and society can bear. Residential rates have already tripled between 2004 and 2006, and access remains only 10%.

The MEM considered different options for TANESCO after the end of the management contract extension, including possibilities for a further contract extension, contracting specific consulting services, issuing a new request for proposals, and/or reverting some or all of the managerial responsibility to Tanzania management. The latter option was adopted. As of late 2005, TANESCO was taken off the list of utilities specified for privatization, under an internal decision of the Government. This represents a shift in earlier reform goals and timetables. De-specification simplifies oversight and makes it possible for government financed investments ï a more flexible arrangement while the Government considers a range of possible future arrangements for TANESCO (including commercialization, concession, privatization, and leasing). Presently the MEM is pursuing an incremental restructuring plan for TANESCO, called internal ring-fencing, which separates utility operations into separate business areas with the aim of efficiency gains, while maintaining state-ownership and a single institutional structure. For the time being more elaborate privatization and unbundling options seem unlikely.

2.4 Current Level of Suppressed Demand

TANESCO maintains statistics of load shed on its interconnected system. Significant load shedding occurred in 1994, 1995 and 2006. During 2006, the estimated un-served load amounted to 287.5 GWh, as compared to sales of 2,667.7 GWh. There were systematic and significant power cuts during most of the year, generally to the domestic customers but also occasionally to industrial customers. Power cuts lasting eight to twelve hours affecting one third or more domestic customers up to three days per week have taken place (PSMP, 2007).

During 2006, the estimated unserved load amounted to 287.5 GWh, as compared to sales of 2,784 GWh. A review of the TANESCO load-shedding schedule, as shown in Table 3-5, suggests that, except during June and July when the load shedding was stopped due to water availability, there were systematic and significant power cuts during the remainder of the year, generally to the domestic customers but also occasionally to industrial customers. Power cuts lasting eight to twelve hours for one third or more domestic customers up to three days per week have taken place. Table 3-6 provides a summary of the amounts of load shedding, as calculated by TANESCO, on a monthly basis since 1992. This table indicates that the utility had undertaken at least three load-shedding programs since 1992. The 2006 shedding program has differed from previous programs as it endeavoured to waive power shedding to the industrial customers, so as to minimize adverse effects in the growth of the Tanzania economy.

The policy for the 1992 to 1995 load-shedding program was primarily to restrict residential supply during the day and industrial supply at the evening peak and night. Similar approach was employed in the 1997; however, the load-shedding period was from 06:00 to 24:00 and the schedule has been adjusted to allow industries to operate for 5 days per week. The implementation of the load shedding programs in all load centres on the grid is an inherent feature in all programs, including the 2006. The following is an estimate of the level of severity of these power cuts each year:

Table 1: Estimate of Load Shed (1992-2006)

Year	Load Shed (Gwh)	Load Required	Percent Shed
1992	91	1,615.00	5.60%
1993	98.8	1,746.80	5.70%
1994	207.8	1,797.20	11.60%
1995	152.4	1,834.00	8.30%
1996	1.5	1,826.90	0.10%
1997	75.6	1,846.90	4.10%
1998	0.4	2,045.90	0.00%
1999	0.9	2,101.70	0.00%
2000	29.1	3,283.60	0.90%
2001	2	2,477.10	0.10%
2002	1.9	2,617.90	0.10%
2003	2	2,879.90	0.10%
2004	0.1	3,096.70	0.00%
2005	9.5	3,325.20	0.30%
2006	287.5	3,542.10	8.10%

Source: GoT, Long-Term Power System Master Plan Study (PSMP, 2007), December 2007, pages 2:18-3:19

Table.1 above presents the load shedding as a percentage of total sales. However, most of the power cuts were to domestic customers, which amount to about two thirds of the sales in category T1, which accounted for 1,353.4 GWh or 48.6% of sales in 2006. Thus domestic sales amounted to about 900 GWh (or 1,353.4 times 2/3). If it is assumed that all of the power cuts were to domestic customers only, this would suggest that Domestic customers on the grid system wanted 30% (i.e. 287.6/900) more power than they were provided with. If it is assumed that the power cuts applied to all T1 customers only, this implies that T1 customers on the grid system wanted about 20% (i.e. 287.6/1,353.4) more power than they were provided with.

From the above, there was rationing of between 20% and 30% of the power demand by T1 customers on the grid during 2006. Similar statistics are not available for the isolated generation but it is understood that there is a significant shortage of thermal generation in each of these centres.In addition to these planned power cuts, there are several other factors that need to be taken into account in an estimate of the amount of un-served energy in the system:

(a) The inertia of the customers in their reactions to the power cuts. The power cuts are measured as the load on the feeder before the power cut multiplied by the number of hours the power cut on that feeder lasts. However, a consumer may not react immediately that power is restored to resume its activities.

(b) There are inaccuracies in measuring the power cut in that the shape that the load would have followed in the absence of the power cut is not known; therefore, the calculations of the amount of unserved energy can only be considered an estimate.

(c) Most industries and many commercial establishments have their own standby generation.

(d) Many customers will refrain from buying sensitive electrical or electronic equipment through fear of it being damaged due to poor quality power.

There are no estimates of the extent of the impact of these factors on the level of unserved energy. In the context of the general economy, load shedding has the following impacts:

(a) A general slowdown in economic activity and income;

(b) Deferment in plant expansion plans due to power shortages;

(c) A slowing in the rate of growth of average consumption in residential and small commercial categories;

(d) During the most severe periods of load shedding, customers substituted other forms of energy for electricity or purchased diesel-powered generation sets to replace a now unreliable service. The loss of revenue to TANESCO reduces its ability to make investments in system expansion and system rehabilitation.

2.5 TANESCO Tariff Reforms

Tariff revisions and restructuring have been a key subset of TANESCOôs commercialization. Tariff reforms have focused on: (i) increasing tariffs toward commercial rates and in line with inflation, (ii) reducing the cross subsidy from industry to domestic consumers, and (iii) reducing the lifeline tariff subsidy for domestic and light commercial customers. These changes were initiated in the early

1990s, then ramped up again under NET Group Solutions management of TANESCO since 2002, and since 2006 made under EWURA following the new regulatory framework.

Up to the mide-1980s electricity tariffs were generally in line with supply costs. However, post-1986 when Tanzania began its Structural Adjustment Program, the real value of electricity tariffs eroded, as tariff revisions did not keep pace with prescribed currency devaluations (Wangwe *et al*., 1998). An average tariff of 11 USc/kWh in 1985 eroded to 5.5 USc/kWh in 1992. Tariff revisions in the 1990ᾰs raised the average tariff to 9.3 USc/kWh by 1995 and 10.3 USc/kWh in 1998, indicating a strong tariff throughout most of the decade. The real value of the average tariff eroded again to 7.0 USc/kWh by 2001 due to inflation (Katyega, 2004). Under the management of NET Group Solutions, average tariffs increased from 7.0 USc in 2002 to 7.6 USc/kWh in 2005.

In 1993, the cross-subsidy from industry to domestic customers amounted to the average residential tariff being only 30% of industrial customers (Wangwe *et al.,* 1998). Extensive efforts to reduce the industrial cross-subsidy began with the tariff revision just prior to NET Group Solutions assuming TANESCOᾰs management in May 2002. The 2005 average residential selling price was 160% of the average high voltage selling price, largely undoing earlier cross-subsidy. Tariff restructuring was aimed at reducing Tanzaniaᾰs industrial energy tariffs to be competitive with its neighbours, Uganda and Kenya, in order to improve prospects for foreign investment in the country.

In 1992, residential and light commercial customers enjoyed a formal lifeline subsidy of 1,000 kWh per month. However, the effective lifeline level had reached 2,500 kWh with the erosion of real tariffs with inflation (Hosier and Kipondya, 1993). The lifeline subsidy was decreased to 500 kWh in 1995 and then again to 100 kWh in 2002. In 2004, under NETGroup Solutions, the lifeline tariff was decreased from a 100 kWh universal subsidy to a 50 kWh per month targeted subsidy.

As a result of tariff rebalancing and restructuring (i.e., increases in the average tariff, reduction in cross-subsidy, and decrease in the lifeline tariff), industrial consumers have seen their tariff decrease while domestic consumer have seen their tariffs rise. Between 2002 and 2005, the average high voltage selling price decreased from 7.6 to 5.2 USc/kWh. The average residential selling price increased from 6.9 to 8.2 USc/kWh during the same period.

Notably, residential consumers have seen significant increase in rates, particularly those experiencing a loss of lifeline subsidy benefits. For example, residential customers of 100 kWh per month have experienced a tripling of their monthly bill for the same amount of electricity comparing December 2005 to January 2002. Meanwhile the Consumer Price Index (CPI) has increased 1.2 times between January 2002 and December 2005. This implies that the increase in electricity tariffs was more than twice the increase in the Consumer Price Index (CPI). A review of the tariff structures in Tanzania shows that there have been several major changes in structure during that period:

(a) From 1980 to 1987 there were residential, small commercial, light industry, low voltage supply, high voltage supply, street lighting and Zanzibar.

(b) In 1987, agriculture, energy intensive and the National Urban Water Authority were added; however, it is not clear how the previous categories were split in order to obtain the new ones.

(c) In 1990 the structure remained the same but the definition of the prior categories was changed slightly.

(d) In 1995, the structure was changed significantly:

(i) The new Tariff T1 (General Use) grouped the loads from the previous residential, small commercial and light industrial;

(ii) The new T2 (Low Voltage Supply) appears the same as the previous low voltage supply;

(iii) The new T3 (High Voltage Supply) grouped the categories High Voltage Supply and High Intensive Supply Energy;

(iv) Those Agriculture and the NUWA accounts customers that are served at 11 kV or higher would become T3 customers and the others would be either T1 or T2, depending upon the size of the monthly bills. Given the size and type of customers, it has been assumed that all of these customers are served at 11 kV or above and therefore would become T3 customers;

(v) Public lighting remains as before except that places of worship were added;

(vi) Zanzibar remains as before.

In 2003 another tariff structure change occurred and remains in effect to date whereby Tariff T1 was split into D1 (domestic low usage) and T1 (general use) and added public lighting

2.6 Status of the Electricity Sector

The electricity sector in Tanzania is dominated by the Tanzania Electric Supply Company Limited (TANESCO) in a vertically integrated structure carrying out generation, transmission, distribution and supply. TANESCO operates the grid system and isolated supply systems in Kagera, Kigoma, Rukwa, Ruvuma, Mtwara and Lindi. Due to slow development in the sector and the general global trend in the electricity supply industry, the government in 1992 through the National Energy Policy, lifted the monopoly by the public utility to allow involvement of the private sector in the electricity industry. This major policy reform enabled Independent Power Producers (IPPs) to operate in the generation segment. Private players include the Independent Power Tanzania Limited ï IPTL (100MW), Songas (190MW) and Artumas Inc. operating a gas to power scheme in Mtwara and Lindi regions (18MW).

Others generators include the leased emergency plants namely Aggreko (40MW), Dowans (100MW) and Alstom (40MW). Further, interconnections with Zambia and Uganda enable imports of relatively small amounts of electricity. The generation capacity was on a 60:40 hydro/thermal proportion before 2005. Following introduction and expanded use of natural gas usage in power generation, the hydro-thermal mix is now standing at 51:49 (including the emergency plants).

Table 2: Grid System Energy Generation (GWh) - 2009

Source	January – June	July - December	Total
Hydro (T)	1,419.9	1,277.4	2,697.3
Thermal (T)	225.7	413.6	639.3
IPPs	637.4	750.6	1,388
Total	**2,283.0**	**2,441.6**	**4,724.6**

Source: TANESCO

The network consists of a total of 2624 km of 220 kV, 1442 km of 132 kV, and 486 km of 66 kV transmission line. There has been high growth in the transmission network. Recent growths include high voltage network expansion, where the 220 kV from Shinyanga ï Buzwagi transmission line and the 132 kV Musoma ï Mugumu transmission line were commissioned. On the other hand, the distribution network expansion has been growing at a slow rate (See Table 2). The slow distribution network expansion does not improve the network reliability, hence the high level of power outages.

Significant high system outages have been experienced caused both from transmission and distribution networks. Some faults in the distribution network result in grid system failure, a typical sign of a weak system. Distribution networks (mainly 33 kV) contributed about 99% of interruption time during the first half of 2009. This is mainly due to dilapidated and overloaded distribution networks, where some of the lines need replacement or upgraded to higher voltages. With about 785,270 customers, electricity was available to only about 11% of the population by first quarter of 2007, with more than 80% supplied in the urban areas. Efforts are being made to increase access in rural areas, and the Rural Energy Agency has been established to oversee the implementation of rural electrification projects, using Rural Energy Fund as provided in the Rural Energy Act. The electricity is supplied to consumers at 33kV, 11 kV and 415/230 V. The Maximum demand of electricity on the TANESCO grid system recorded in May 2007 was 607MW.

Table 3: Distribution Network: Route length in Km - 2009

Voltage Level -kV	Period	
	By June	By September
220	3,221	3,311
132	2,136	2,226
66	647	647
33	11,880	11,921
11	4,998	5,017
0.4	25,075	25,324

Source: TANESCO

Table 4: Customer Base- 2009

Customer Category	Period	
	By June	By September
D1 Domestic	408,251	410,774
T1- General	370,606	371,583
T2 – High Consumption LV	1,716	1,719
T3 Industrial	269	269
T4- Zanzibar	1	1
T6 – TANESCO Accounts	307	924
Total No.	**781,150**	**785,270**

Source: TANESCO

The structure of electricity industry in Tanzania is summarized in the following chart

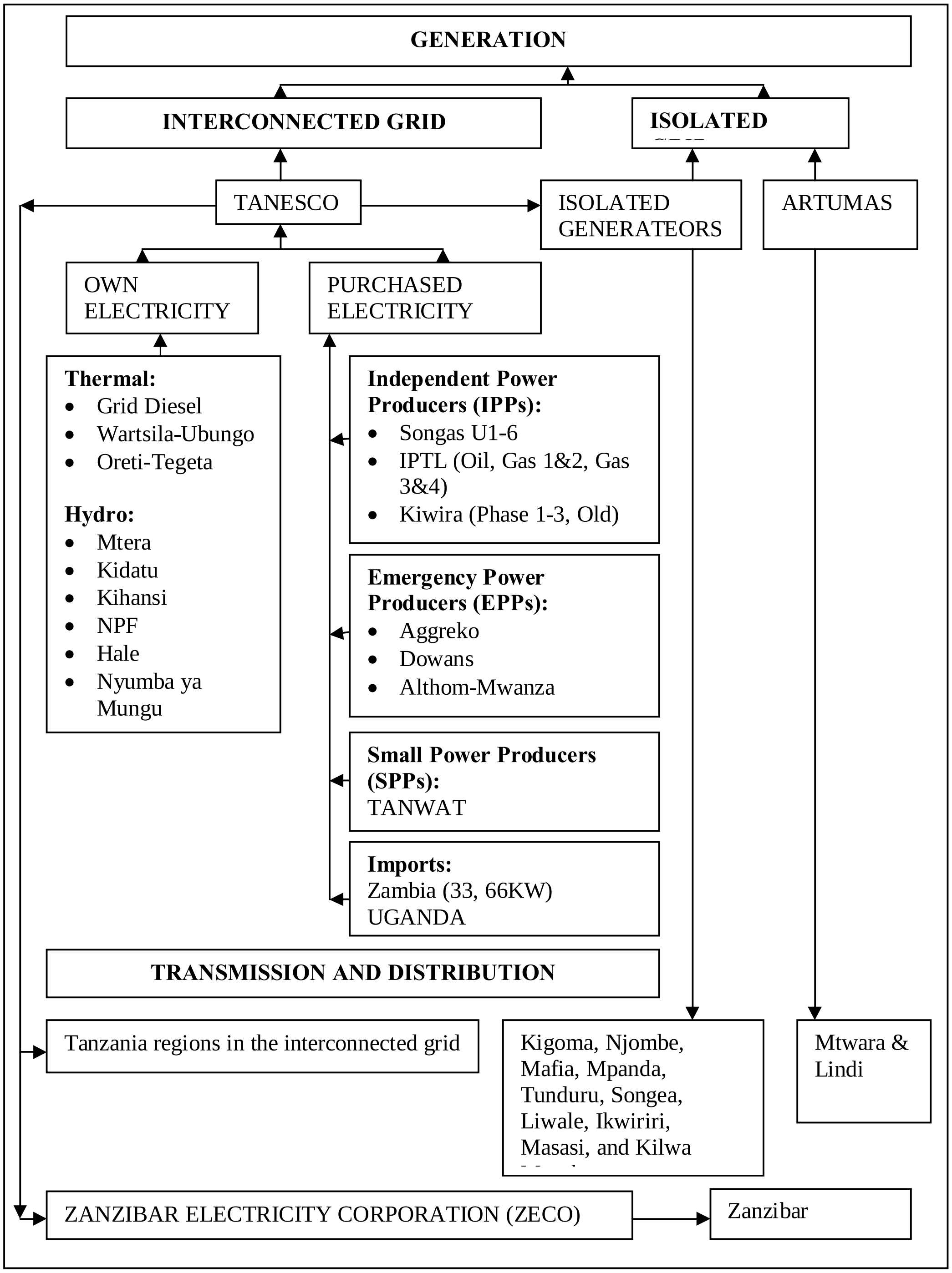


Figure.2 Structure of Tanzanian Electricity Sector

Source: Author's gathered information

CHAPTER THREE

3.0 A REVIEW OF THE LITERATURE ON THE PRICE ELASTICITY OF DEMAND FOR ELECTRICITY

3.1 Theoretical Review

3.1.1 Theory of Demand

In economics, demand is defined as the quantity of a good or service that consumers are willing and able to buy at a given price in a given time period (Fan and Hyndman, 2008). The level of demand at each market price reflects the value that consumers place on a product and their expected satisfaction gained from purchase and consumption. Market demand is the sum of the individual demand for a product from each consumer in the market. If more people enter the market and they have the ability to pay for items on sale, then demand at each price level will rise.

Demand in economics must be effective which means that only when a consumers' desire to buy a product is backed up by an ability to pay for it does demand actually have an effect on the market. Consumers must have sufficient purchasing power to have any effect on the allocation of scarce resources. Latent demand is probably best described as the potential demand for a product. It exists when there is willingness to buy among people for a good or service, but where consumers lack the purchasing power to be able to afford the product. Latent demand is affected by advertising ï where the producer is seeking to influence consumer tastes and preferences. The demand for a product X might be strongly linked to the demand for a related product Y ï giving rise to the idea of a derived demand.

The Law of Demand states that other factors remaining constant (ceteris paribus) there is an inverse relationship between the price of a good and demand.

(i) As prices fall, there will be an expansion of demand

(ii) If price rises, there will be a contraction of demand.

A demand curve shows the relationship between the price of an item and the quantity demanded over a period of time. There are two reasons why more is demanded as price falls:

(i) The Income Effect: There is an income effect when the price of a good falls because the consumer can maintain current consumption for less expenditure. Provided that the good is normal, some of the resulting increase in real income is used by consumers to buy more of this product.

(ii) The Substitution Effect: There is also a substitution effect when the price of a good falls because the product is now relatively cheaper than an alternative item and so some consumers switch their spending from the good in competitive demand to this product.

3.1.2 Price Elasticity of Demand

The consumerǿs sensitivity to price changes can be measured by the coefficient of price elasticity ï the percentage change in demand divided by the percentage change in price (Fan and Hyndman, 2008). Price elasticity is a normalized measure (for the relative price change) of the intensity of how usage of a good (in this case electricity) changes when its price changes by one percent. It facilitates a comparison of the intensity of load changes among customers since the price change has been factored out; the price elasticity is a relative measure of response.

Two kinds of price elasticity coefficients are reported in the scholarly literature: own-price elasticity and substitution elasticity. Own-price elasticity is a useful measure of how customers adjust to increases in the price of electricity by adjusting their consumption of electricity. This is especially useful when evaluating longer term adjustments to changes in electricity price. Own price elasticities are typically in the negative range, indicating the reciprocal relationship between demand and price (Fan and Hyndman, 2008).

Own-price elasticities are generally of two types, inelastic and elastic, and the range of each type differs by region and system. For a commodity, the range of inelasticity is usually within absolute values of 0 to 1, and the elastic range begins with values greater than 1. Thus, price inelastic demand means a less than proportional change in demand for a given change in the price. In the elastic range, consumer demand responds with a greater than proportional change for a given price change (Fan and Hyndman, 2008).

Substitution elasticity, which takes on only positive values, is also reported by some researchers. It focuses on how consumers substitute one good for another, or goods in different time periods for one another, when relative prices change. Specifically, if the price of electricity varies substantially from one time period to another, and customers can shift usage among those periods, then the appropriate measure of price response is how relative usage changes in those periods. The substitution elasticity is therefore defined as the relative change in usage in the two periods (e.g., the ratio of the peak to off-peak usage) for a one percent change in the relative prices in those periods (the ratio of the off-peak to peak price). Note that the price term uses the inverse price ratio, which is why substitution elasticities are positive (e.g., a higher peak price decreases the off-peak to peak price ratio, causing peak load to be reduced and therefore the peak to off-peak load ratio to decline) (Fan and Hyndman, 2008).

On an absolute value basis, ignoring the sign, own-price and substitution elasticities are similar in that they both measure relative changes, so a value of zero corresponds to no change in usage regardless of the change in price (i.e., perfectly price inelastic), and absolute values progressively greater than zero indicate relatively higher price response. They are roughly similar measures of intensity on a nominal basisð a substitution or an own-price elasticity of 0.50 both indicates relatively high changes in load in response to price changes. But because these two elasticity values measure a different characterization of how usage is adjusted to price changes (i.e., price in one period vs. relative prices in two periods), there is no simple way to cross-map reported values. They should be used in the appropriate context: the own-price elasticity when the circumstances involve reduced electricity usage and the substitution elasticity when shifting from one time to another characterizes price response (Fan and Hyndman, 2008).

In this thesis, we will focus on the own price elasticity since our major concern is how the possible changes of retail electricity price will affect the annual electricity demand. For simplicity, we use ñprice elasticityò instead of ñown-price elasticityò in the rest of this thesis. In the next section, we conduct a literature review covering published results from different countries to identify the best methodology available, and we discuss the possibility of applying these techniques to enhance the current demand model used in long-term load forecasting.

3.1.3 Empirical Review

One of the earliest studies on residential household demand is provided by Houthakker (1951), using observations from 42 provincial towns in the United Kingdom between 1937 and 1938. The annual average electricity consumption per customer was regressed on average money income per household, the marginal price of electricity, the marginal price of gas and average holdings of heavy equipment. Houthakker reports that the income elasticity of demand for electricity was about 1.2, while the price elasticity of demand was -0.9. One of the main shortcomings of this early study was that the author did not explicitly attempt to model either the short-run or the long-run.

In a follow-up study, however, Houthakker and Taylor (1970) use a two-equation model of personal consumption expenditures on electricity, where consumption is modelled as a function of stocks, income and relative prices, while the change in stocks of durable goods is equal to electricity consumption and depreciation. The study finds that while in the long-run the absolute values for income and price elasticity of demand are around 2, in the short-run, electricity demand tends to be relatively price and income inelastic (about 0.1); comparable results are obtained by Mount et al., (1973), Anderson (1973), Houthakker et al., (1973) and Griffin (1974).

Taylor (1975) notes that most of this early literature finds that the price and income elasticity of demand for electricity is larger in the long-run and electricity demand tends to be fairly price and income elastic in the long-run. These results were by and large derived from highly aggregated data. Given this criticism of the early literature of using highly aggregated data, Parti and Parti (1980) employ a database of more than 5,000 individual households from the San Diego County in 1975. By noting that the consumption of electricity is derived from the utilisation of appliances, the study first attempts to account for the expected electricity usage given the appliances in the household. Actual usage is then explained by the presence of the following characteristics: an air conditioner; square footage of residence; weighted average of the average electricity prices in the previous two months; household income; presence of electric space heater; presence of electric water heater; number of people in household; number of appliances in the common effect category, and; the number of non-refrigerator appliances in the common effect category possessed by the household. The results suggest that the short-run price elasticity of demand was about -0.6 and the income elasticity of demand was 0.2.

Bohi (1981) gave a good survey of early price elasticity studies, and he categorized the related works by types of data (aggregated, disaggregated, by industry, and whether marginal or average prices were used) and by the model used. Bohi (1984) concluded that the short-run price elasticity for the residential sector is -0.2 and the long-run price elasticity is -0.7. They further concluded that the wide variance of the elasticity estimates from available studies make it difficult to report the price elasticity for either the commercial or industrial sector. There are several surveys summarizing price elasticity studies based on a fixed pricing scheme (Lafferty, Hunger, Ballard, Mahrenholz, Mead, and Bandera, 2001). Bohi (1981) gave a good survey of early price elasticity studies, and he categorized the related works by types of data (aggregated, disaggregated, by industry, and whether marginal or average prices were used) and by the model used. Bohi (1984) concluded that the short-run price elasticity for the residential sector is 0.2 and the long-run price elasticity is -0.7. They further concluded that the wide variance of the elasticity estimates from available studies make it difficult to report the price elasticity for either the commercial or industrial sector.

Filippini (1999) estimated the residential demand for electricity using aggregate data at a city level for 40 Swiss cities over the period 1987 to 1990. A log-linear stochastic equation was employed to estimate electricity consumption. The price elasticity was estimated to be 0.30, which shows a moderate responsiveness of electricity consumption to changes in prices. He then suggested that there is little room for discouraging residential electricity consumption using general electricity price index increases, and an alternative pricing policy, time-of-use pricing, can be an effective instrument for achieving electricity conservation.

Beenstock, Goldin, and Natbot (1999) used quarterly data for Israel to compare and contrast three dynamic econometric methodologies for estimating the demand for electricity by households and industrial companies. The methodologies are the Dynamic Regression Model and two approaches to co-integration (OLS and Maximum Likelihood) National Institute of Economic and Industry Research (2007) undertook a review of the long-run price elasticity of electricity demand for the Australian National Electricity Market, and recommended the values of -0.25, -0.35 and -0.38 for residential, commercial, and industrial customers, respectively.

King and Chatterjee (2003) reviewed price elasticity estimates from 35 studies of residential and small commercial customers published between 1980 and 2003. They report an average own-price elasticity of -0.3 among this group of studies, with most studies ranging between -0.1 and -0.4. Espey and Espey (2004) conducted a meta-analysis to quantitatively summarize previous studies of residential electricity demand to determine if there are factors that systematically affect estimated elasticities. In this study, price and income elasticities of residential demand for electricity from previous studies are used as the dependent variables, with data characteristics, model structure, and estimation technique as independent variables, using both least square estimation of a semi-log model and maximum likelihood estimation of a gamma model. The short run and long run price elasticities of residential demand for electricity were found to be 0.28 and 0.81, respectively.

Reiss and White (2005) developed a model for evaluating the effects of alternative tariff designs on electricity use. The model concurrently addresses several interrelated difficulties posed by nonlinear pricing, heterogeneity in consumer price sensitivity, and consumption aggregation over appliances and time. He estimated the model using extensive data for a representative sample of 1300 California households, and obtained the mean annual electricity price elasticity for California household to be -0.39.

Faruqui and George (2005) investigated a recent residential critical peak pricing (CPP) pilot experiment in California; they estimated a statewide average elasticity of substitution of 0.09 on critical peak days occurring between July and September and reported that the average statewide reduction in peak period energy use on critical peak days was about 13%. They indicated that residential and small-to-medium commercial and industrial customers conclusively reduced peak-period energy use in response to time-varying prices. The price responsiveness varied with rate type, climate zone, season, air conditioning ownership, and other customer characteristics.

Taylor, Schwarz, and Cochell (2005) estimated average hourly own-price and substitution elasticities for real time pricing (RTP) programs in the U.K., and they found a substantial range in own-price elasticity values over the course of the day and among customers. They observed larger load reductions during higher priced hours, as industrial customers gained experience with hourly pricing. As compared to a time of use (TOU) rate, net benefits were $14,000 per customer per month, approximately 4% of the average customerȏs bill, and much greater than metering cost. This study also concluded that many large commercial and industrial customers exhibit complementary electricity usage across blocks of afternoon hours. That is, high prices in one hour result in reduced usage in that hour as well as in adjacent hours. This is consistent with industrial batch process loads that, once started, must continue for a specified period.

In summary, the results from different researchess and sources are not very consistent. The numbers that come up most often are -0.2 to -0.4 for the short run elasticity, and -0.5 to -0.7 for the long run. These come up several times, and are in the same range as other potential estimates, such as the medians from the Espey and Espey (2004) survey (0.28 and 0.81) and the results of the study preferred by Bohi

(0.25 and 0.66). These results are mostly for residential demand. Table 4 summarizes the results from different studies. Note that Bohi (1981) was a particularly good early survey, while Espey and Espey (2004) have the most recent and comprehensive list of estimates.

Table 5: Summary of Empirical Review

Researcher	**Year**	**Region**	**Sector**	**Elasticity**	**Comments**
Bohl & Zimmerman	1984	U.S (various utilities)	Residential, industrial and commercial	Residential sector Short-run: 0.2 Long-run: -0.7	Difficult to report the price elasticity for either the commercial or industrial sector.
Filippini	1999	Swiss (40 cities)	Aggregation	-0.3	Suggested TOU pricing for achieving electricity conservation, instead of general electricity price index increases.
Beenstock et al.	1999	Israel	Residential and industrial	Residential -0.21 to -0.5, Industrial -0.002 to -0.44	Compared dynamic regression model and OLS and maximum likelihood method for estimating the demand
NIER	2007	Australia	Residential, industrial and commercial	Residential: 0.25, Industrial: 0.38 and commercial: 0.35	The long-run price elasticity of electricity demand for each State of the Australia was also estimated
King & Shatrawka	1994	England	Residential and industrial	Substitution elasticity Inter-day: 0.1-0.2, Intra-day: 0.01-	Between 33% and 50% of participating customers responded to time-varying prices.

				0.02	
King & Chatterjee	2003	California	Residential and commercial	from -0.1 to -0.4	An average own-price elasticity of 0.3 was reported
Reiss & White	2005	California	Residential	-0.39	Developed a model for evaluating the effects of alternative tariff designs on electricity use
Faruqui & George	2005	California	Residential, Industrial and commercial	Substitution elasticity: 0.09	Residential, commercial and industrial customers conclusively reduced peak-period energy use in response to time-varying prices
Yoo et al	2005	South Korea	Residential	from -0.1 to -0.6	An average long run income elasticity of 0.593 was reported
Ziramba	2008	South Africa	Residential	from -0.1 to -0.4	An average long run income elasticity of 0.33 was reported
Babatunde & Shuaibu	2007	Nigeria	Residential	Substitution short run 0.03 and long run 0.057	Methodology used is cointegration within an autoregressive distributed framework
De Vita et al	2005	Namibia	Residential	from -0.1 to -0.5	An average long run income elasticity of 0.41 was reported

Source: **Author**

3.1.4 Gap Analysis

This study based on the research by Lin (2003), who suggests a model for estimating the price elasticity of householdsô electricity demand. In his model, household electricity consumption is regressed (including intercept) by OLS on electricity price, GDP per capita, population, structural change, and efficiency improvement. The point of departure in our study is to include the price of ñother goodsò, and in this case the price of kerosene. Price of kerosene is an important substitute for electricity energy in Tanzania, (Kilahama F. 2010).

Most of the studies that have been done in Tanzania have not examined the role of residential demand in determination of the revenue and investment requirement in relation to demand elasticities. For example, Hosier and Kipondya (1993) examined the energy use specifically by the urban households in Tanzania. Kipondya (1993) did not pay much importance on demand of electricity by the rural household in Tanzania. In addition, Kipondya (1993) did not address the price elasticities of demand.

Moreover, very few have considered tariff reforms. For example Katyega (2004) examined the real value of the average tariff in his study which focused outsourcing opportunities for Small and Medium Enterprises in the ongoing utility reforms in Tanzania. Wangwe et al. (1998) examined industrial cross-subsidy so that Tanzaniaôs industrial energy tariffs become competitive with its neighbours, Uganda and Kenya, in order to improve prospects for foreign investment in the country. However, these studies focused on industrial benefits and could not pay much attention to consumers.

Mwandosya and. Luhanga (1993) examined general issues on the energy and development in Tanzania including investments. However, their study could not capture the recent development in electricity generation involving independent power producers, emergency power producers and small power producers. The Power Sector Master Plan Studies which are used to estimate demand projections in the power sector, have not taken into account the new developments in time series econometrics such as error correction models.

The present study therefore attempts to examine the role of demand responsiveness to tariff in providing insights into financial position of the power utilities and investment requirements taking into consideration the role of residential demand responsiveness to price, new developments in power generation, and new developments in time series econometrics such as the error correction model which differentiate between short run and long run effects. This study adds to the existing knowledge in that it discusses the factors necessary for the change of residential demand in Tanzania in balancing the utility companiesô need for fiscal stability and the need for investments with the desire to continue to keep prices affordable for consumers, and preventing negative impacts such as reduced income, substitution to unclean fuels, dramatic declines in consumption, or creating barriers to access.

3.2 Policy Framework

The Tanzaniaôs main policy document is the long run National Development Vision 2025, from which sectoral policies both short and medium term are drawn. The National Energy Policy of Tanzania was adopted in 2003 and replaced the previous energy policy from 1992. The policy from 2003 takes into account the structural changes that occurred over the last decade in terms of changes in the economy and political transformations at national and international levels. The main goal of the national energy policy is to improve the welfare and living standards of Tanzanians and the national policy objective for the development of the energy sector is: to provide input in the development process of the country by establishing a reliable and efficient energy production, procurement, transportation, distribution and end-use system in an environmentally sound manner and with due regard to gender issues.

The main elements of the energy policy and strategy are to:

(a) Develop domestic energy resources which are shown to be least cost options.

(b) Promote economic energy pricing.

(c) Improve energy reliability and security and enhance energy efficiency.

(d) Encourage commercialization and private sector participation.

(e) Reduce forest depletion.

(f) Develop human resources.

Tanzaniaôs National Energy Policy recognizes the importance and contribution of indigenous energy resources, in particular in providing modern energy services in rural areas. With respect to rural energy, the policy stipulates the following development areas:

(a) To support research and development into rural energy;

(b) To promote the application of alternative energy sources, other than wood fuels, in order to reduce deforestation, indoor health hazards and time spent by rural women collecting firewood;

(c) To promote entrepreneurship and private initiatives in the production and marketing of products and services for rural and renewable energy;

(d) To ensure continued electrification of rural economic centers and make electricity accessible and affordable to low-income customers;

(e) To facilitate an increased availability of energy services including grid and non-grid electricity in rural areas; and

(f) To establish norms, codes of practice, standards and guidelines for cost effective rural energy supplies.

The main challenges include low levels of commercial energy use and low levels of electricity access. Less than 10 percent of the total energy consumption in Tanzania is today from commercial energy sources (petroleum, hydropower and coal). So far, with the exception of hydro and natural gas, little of the other energy resources (hydro, biomass, natural gas, coal, wind and solar) have been commercially exploited. The bulk of energy consumed is from traditional biomass (fuelwood and charcoal) and represents more than 90 percent of the total energy consumption. More than 80 percent of total primary energy (mainly in the form of biomass) is consumed in rural areas. As regards low levels of electricity access, in a country of almost 40 million people, barely 10 percent of the population is connected to the national power grid, and in rural areas only 1 percent of the population has access to grid electricity.

Many countries have been instituting new regulatory regime of their infrastructure sectors, setting up independent regulatory agencies, and putting in place transparent control instruments and processes for the regulator to ensure that Utilities do not abuse their monopoly powers. In Tanzania, the Energy and Water Utilities Regulatory Authority (EWURA) was established as an autonomous multi-sectoral regulatory authority through the Energy and Water Utilities Regulatory Authority Act, Cap 414. It is responsible for technical and economic regulation of the electricity, petroleum, natural gas and water sectors in Tanzania pursuant to Cap 414 and sector legislation.

There is a number of legal provisions establishing EWURA's obligation to approve tariffs for electricity utilities in Tanzania. The following pieces of legislation are important in that context:

(a) EWURA Act of 2001, as amended in 2003;

(b) Licenses issued by EWURA;

(c) EWURA's Guidelines for setting tariffs; and

(d) Electricity Act (2008).

EWURA Act in its Article 7 (1) (iv) imposes on this organization a general obligation to regulate tariffs for utilities. The purpose of this section is to provide assessment of the legal framework as set out by this Act.

Articles 17, 19, 24 and 40 are of direct relevance to EWURA's tariff setting obligation. In reviewing those following issues and consequences are noted:

1. In accordance with Art 17, EWURA will perform regular reviews of tariffs, with a special attention given to the following:
    (a) costs of operations;
    (b) return on assets;
    (c) comparison with the best industry standards;
    (d) protection of customersô interest; and
    (e) competition promotion.
    (f) and subsequently will publish approved tariffs (Art 17 (3) and 24 (4) (c));
2. EWURA may implement enquiries in the tariff setting process (Art. 19 (2) (b));
3. While setting out the rules for setting tariffs EWURA should consult the Minister (Art 40 (1) (g)).

It should be noted that in July 2008 an Electricity Act was enacted. This Act sets out in a greater detail rules for approving tariffs. More specifically, its Article 24:

1. Reiterates EWURAös right to approve tariffs and connection charges;
2. Sets out further guidance for EWURAös tariff policy, such as:
    (a) enabling the recovery of the regulated businessesô costs as well as return on investment,
    (b) tariff stability,
    (c) limitation to subsidization,
    (d) promotion of efficient consumption by customers.
    (e) Provides for that tariffs may include automatic adjustment schemes, reflecting changes to economic environment (such as cost of fuel, purchased power or inflation).

Meanwhile, Rural Energy Agency (REA) is an autonomous body under the Ministry of Energy and Minerals of the United Republic of Tanzania. Its main role is to promote and facilitate improved access to modern energy services in rural areas of Mainland Tanzania. REA became operational in October 2007.98% of rural Tanzanians have no access to modern energy services. The government maintains that rural Tanzania cannot be transformed into a modern economy, and that rural Tanzaniansô livelihoods cannot be improved significantly without a dramatic improvement in their access to modern energy services.

REA derives its powers from The Rural Energy Act no.8 of 2005. Being an autonomous body, REAês powers also emanate from sector legislations: In terms of principal legislation in the electricity sector, it derives its powers from the Electricity Act, 2008; and in the petroleum sector, from the Petroleum Supply Act, 2008. As for regulatory framework, REA works closely with multi-sectoral regulatory authority, EWURA which is responsible for technical and economic regulation of the energy and water sectors in Tanzania.

CHAPTER FOUR

4.0 RESEARCH METHODOLOGY

4.1 Conceptual Framework for the Determination of the Price Elasticity Model

In specifying the model equation of electricity demand, as mentioned earlier, this study is based on the research by Lin (2003). In general, electricity demand is mainly determined by two important factors, tariff and GDP. This is a general accepted definition of demand function. In a modern economy, electricity is a necessary input in the production process and peopleĝs daily activities and is not an ordinary good. Electricity is bought for the end-use service it provides. As a result, a number of important and sometimes countervailing factors change the pattern of electricity demand (Gellings 1996).

Therefore, factors affecting economic activities and consumption patterns will have an important impact on electricity consumption. There could be many other factors that require proper attention in determining the demand for electricity in Tanzania. An important one, for example, is the weather. Cold days mean that more electricity will be used for heating and lighting. In winter, longer nights mean that lights are turned on much longer.

Further, the growth rates of electricity demand also vary for different consumer categories and for different regions. For a particular region or power grid, electricity demand forecast could be made for the short term and the long term on a sector basis. However, to provide an aggregate electricity demand forecast for Tanzania, it is difficult to gather sufficient data for a meaningful sector-base electricity demand forecast. Regional demand forecast is also limited by data availability. The focus of this thesis is to develop a forecasting model that could be used for analyzing relationships between electricity consumption and macroeconomic variables and for providing key information for macroeconomic planning, such as total install capacity increase, investment requirement, and environmental impact. To achieve this, an aggregate approach using macroeconomic data at the national level is considered suitable.

4.2 Empirical Modeling

The vast majority of the literature on price elasticity in electric markets attempts to measure precisely the change in demand for electricity due to a change in price (price elasticity) using rigorous econometric analysis. A major issue with econometric methods is the high data requirements (information on household-specific appliance holdings and residence features), and creates heterogeneity in consumption responses related to the characteristics of these durable goods.

Generally, these differences in techniques lead to criticism and counter-criticisms over the techniques used, but no one technique has been shown to be either especially good or bad in price elasticity estimation. Based on availability of data, this study uses the error correction model to estimate the residential price elasticity of demand for electricity. The following five factors have been identified for their significant contribution to long-term electricity demand in Tanzania.

(i) Gross Domestic Product

GDP is considered to be the most important determinant for electricity consumption in the literature. Economic growth and its impact on living standards is the main driving force of electricity consumption growth. In this study, we use GDP per capita in order to approximate the average household income and therefore the living standard. Empirical studies show that there should be a significant and stable positive correlation between GDP and electricity demand.

(ii) Electricity Prices

As with income effects, electricity price is another important factor affecting electricity demand. However, electricity tariffs in Tanzania have been set administratively according to the supply cost, including all fuel and operating and maintenance (O&M) costs, as well as recovery of construction costs and a reasonable profit. Despite this, electricity tariffs are an important variable in the electricity demand function because of its impact on electricity consumption. Tariff levels in Tanzania do not vary from region to region and therefore, it is possible to provide an estimated national average. However, since Tanzania has been using non-linear pricing, it is difficult to estimate the average price of domestic customers due to lack of data on the consumption of each band. In addition, domestic customers in the past have been mixed with other consumer categories such as the light commercial customers. In order to solve these problems, this study has used the simple average tariff of the consumption band consuming 0 to 100 kWh per month. It is expected that there exists a negative correlation between electricity demand and electricity price.

(iii) Population Growth

Population growth is another important factor to determine electricity demand. Higher population growth is expected to increase electricity consumption. Population growth in Tanzania has been kept at constant levels for a long time. However, most people in Tanzania do not have access to electricity services. It is estimated that only 14% of the population have access to electricity. In this case, it is difficult to expect a normal positive correlation between population growth and electricity demand. In this thesis, we expect either positive or negative correlation between population growth and electricity demand.

(iv) Price of other Goods: Kerosene

Household sector consumes the largest share of energy resources in Tanzania in the broad sense of the word. A total of 6.8 million households in the mainland was estimated to be the size of the sector by the 2002 national census. Currently, based on the projected population of 37.5 million people the estimated household size is 750,000. The most used energy source being from biomass-charcoal mainly for cooking. In urban areas a combination of fuel options may be available including electricity, LPG and kerosene but invariably along with charcoal for most of the households. In rural areas firewood and charcoal are the predominant sources of energy for cooking whereas for lighting kerosene, candles and in better to do households solar pv is a preferred option. Hence kerosene is used in this study as a substitute to electricity energy. It is expected that as the price of kerosene increase, people will tend to substitute their consumption of electricity for the consumption of kerosene.

(v) Efficiency Improvement

According to the ñEnergy Sector Review: Situational Analysisò, a publication by the Ministry of Energy in 2007, (MEM, 2007), national energy demand (consumption) in Tanzania is relatively low at 22 million tons of oil equivalent (TOE) per annum or 0.6 TOE per capita during 2009 (MEM 2010). Energy intensity declined during the 2000s, when GDP grew by 9.7 percent per year and energy consumption grew at 2.3 percent per year. As a result, the energy intensity index dropped from 61.4 in 2000 to 30.3 in 2009.

These indicate that energy conservation measures have produced significant positive results. Therefore, efficiency improvement, that is, value-added produced by industry divided by electricity consumed by industry, is considered to be another important variable that determines electricity consumption. As new technologies and energy conservation measures are introduced in the industries, this ratio is expected to have a negative relationship with electricity demand.

Demand for electricity is influenced by changes in price of electricity, *GDD* represents GDP per capita, *POP* is population, PK is price of kerosene, and *EF* is efficiency. The relationship can be represented by a electricity demand function of the following form:

$$(1) \qquad Q=f\,(Tariff,\ GDPpc,\ POP,\ PK,\ EFF) \quad f_{tariff}<0$$

Where *Q* is electricity demand, *Tariff* is price of electricity, *GDDpc* represents GDP per capita, *POP* is population, PK is price of kerosene, and *EFF* is efficiency.

From Equation (1) the following logarithmic model can be formulated:

$$(2) \quad LQ_t = \alpha_0 + \alpha_1 LTariff_t + \alpha_2 LGDPpc_t + \alpha_3 LPOP_t + \alpha_4 LPK_t + \alpha_5 LEFF_t + \varepsilon_t$$

Where, *LQ* is the logarithm of electricity demand, *LTariff* is the logarithm of price of electricity, *LGDPpc* represents the logarithm of GDP per capita, *LPOP* is the logarithm of population, LPK is the logarithm of price of kerosene, and *LEFF* is the logarithm of efficiency. The subscript *t* denotes the relevant variable in year *t*. It is postulated, in the model, that the demand for electricity will tend to decrease with the price of electricity but increase with real GDP per capita, and price of kerosene. The level of population is expected to have a mixed effect on electricity consumption due to the fact that only 14% of the population have access to electricity.

4.3 Data Sources

The basic data to be used in this research contains the following indicators:

1. Electricity tariffs for households (per 1 kWh) estimated from 0-100 kWh consumption band on residential or general customers for the period from 1974 to 2009 on annual basis. Source: EWURA and TANESCO.

2. Physical (million kWh) amounts of electricity consumed by domestic customers for the period from 1974to 2009 on annual basis. Source: EWURA and TANESCO.

3. GDP per capita (TZS per capita) expressed as GDP at factor cost at 1992 prices divided for the population for the period from 1974to 2009 on annual basis. Source: NBS
4. Efficiency improvement expressed as unit of energy consumed per unit of GDP in 1992 constant prices, with the index set at 100 for 1992. Source: MEM.
5. Population (Million) for the period from 1974to 2009 on annual basis. Source: NBS
6. Price of kerosene (TZS per litre). Source: TPDC and EWURA.

Based on the data described above, the empirical model of electricity demand is estimated to obtain estimates of price elasticities.

4.4 Estimation Technique

A time series is defined to be an ordered set of data values of a certain variable. Time series models are, essentially, econometric models where the only explanatory variables used are lagged values of the variable to be explained and predicted. The intuition underlying time-series processes is that the future behavior of variables is related to its past values, both actual and predicted, with some adaptation/adjustment built-in to take care of how past realizations deviated from those expected. Thus, the essential prerequisite for a time series forecasting technique is data for the last 20 to 30 time periods.

The difference between econometric models based on time series data and time series models lies in the explanatory variables used. It is worthwhile to highlight here that in an econometric model, the explanatory variables (such as incomes, prices, population etc.) are used as causal factors while in the case of time series models only lagged (or previous) values of the same variable are used in the prediction. In general, the most valuable applications of time series come from developing short-term forecasts, for example monthly models of demand for three years or less.

Econometric models are usually preferred for long term forecasts. Another advantage of time series models is their structural simplicity. They do not require collection of data on multiple variables. Observations on the variable under study are completely sufficient. A disadvantage of these models, however, is that they do not describe a cause-and-effect relationship. Thus, a time series does not provide insights into why changes occurred in the variable. Often in analysis of time series data, either by using econometric methods or time series models, there do exist technical problems wherein more than one of the variables is highly correlated with another (multi-collinearity), or with its own past values (auto-correlation). This sort of a behavior between variables that are being used to arrive at any forecasts demands careful treatment prior to any further analysis. These, along with other similar methodological options, need a careful assessment while working out forecasts of demand for any sector.

Co-integration method attempts to overcome some of the limitations of the simple econometric forecasts wherein we prescribe a growth rate to the explanatory economic factors. The underlying concept here is that the overall pattern or relationship between any set of variables is likely to persist into the future as well. It is observed that some economic variables tend to behave in a similar fashion in the long run. That is to say that there is an implicit time-trend in the pattern of variables. In such a case, it is often found that these factors have significant causal effects on each other. When two time series follow the same pattern, we say that the two series are co-integrated. The long run (common) equation capturing the relationship between the variables involved is called the co-integrating vector.

If any two series are co-integrated, the process of building the model differs slightly from that in the case of a simple econometric model. We use a system of equations to build the model as against just one equation, as in the case of a simple econometric or time series model. In addition we also include an additional term called, the ñerror correction termò to account for the long run effects, while the short run effects are captured by the co-integrating vector. The advantage of this technique is that one does not need to prescribe the growth rates of any of the variables that are co-integrated with one another. The system of equations internally generates the forecasted values of the variables involved, based on the long-run pattern established in the past. In addition, introducing shocks into the system could capture the effect of policy implications. The major disadvantage of this approach is the need for a consistent time-series spanning at least 30 time-period as a pre-requisite.

4.5 Empirical Analysis

Although Ordinary Least Squares (OLS) method does not require normality of the variables, the latter may affect the normality of the resultant residuals. Non-normality may be associated with the presence of heteroscedasticity and may highlight outliers. It was, therefore, necessary to carry out the normality tests on the semi-logarithmic model presented in this study. The results of normality test in Table 6 show that only two out of eight variables are normally distributed. These variables are the logarithm of electricity tariff *(LT)* and that of population *(LPOP)*. Since most of the variables are not normally distributed, this is likely to cause econometric problems mentioned earlier in the section.

Table 6: Descriptive Data Analysis for the Variables Used to Estimate the Demand for Electricity

Variable	Mean	Standard deviation	Skewness	Excess Kurtosis	Minimum	Maximum	Normality Test Statistic	Normality Probability Value
LQ	7.259	0.496	-0.4595	2.175	6.142	8.036	0.295	0.863
LTariff	1.466	1.997	0.354	1.494	-0.799	4.712	8.335	0.015*
LPK	3.895	2.381	-0.269	1.588	0.020	7.086	2.174	0.337
LGDPpc	10.886	0.122	1.434	4.075	10.758	11.218	0.717	0.699
LPOP	3.214	0.299	-0.038	1.815	2.701	3.706	20.965	0.000**
LEFF	1.362	0.632	-0.397	1.923	0.197	2.209	0.913	0.634

Source: Appendix F: STATA Output

Notes: * and ** implies the hypothesis of normality of the variable is rejected at 5 percent and 1 percent significance level respectively.

4.6 Econometric Methodology

4.6.1 Unit Root Test

Equation (2) is estimated by the Ordinary Least Squares (OLS). However, in order to avoid spurious regression results the test for stationarity is conducted for each of the variables in the equation. The Augmented Dickey Fuller (ADF) and Phillips Perron

(PP) tests are employed to check whether the variables in the system are stationary. If the variables are not stationary at their levels, they will be differenced until stationarity is achieved. This section provides the results of the order of integration for each of the variables. The unit root tests were performed using the Augmented Dickey Fuller (ADF) test whose general equation is specified as Equation (3). The results of the unit root test are presented in Table 7 using the ADF equation specified in Equation (3) and the PP equation specified in Equation (4). The ADF equations are generally expressed for each of the variables as follows:

(3) $$\Delta x_t = a_{1j} + a_{2j} x_{t-1} + a_{3j} t + \sum_{i=1}^{k} a_{4j} \Delta x_{t-1} + \varepsilon_t$$

(4) $$\Delta x_t = a_{1j} + a_{2j} x_{t-1} + \varepsilon_t$$

for x_t = Q_t, $Tariff_t$, $GDPpc_t$, POP_t, PK_t, *and* EFF_t, where t = trend; a_{ij} are coefficients with a_{2j} representing the coefficient used in the unit root test. The null hypothesis in the ADF Equation (Equation 3) is that a_{2j} = 0 (there is a unit root) against the hypothesis that a_{2j} < 0 (the variable is stationary). The null hypothesis in the PP Equation (Equation 4) is a_{2j} = 1 (there is a unit root).

The PP test tends to be more robust to a wide range of serial correlation and time dependent heteroskedasticity. The PP test uses a consistent covariance matrix of error terms to get a t-statistic. The results of the unit root test show that all variables are I (1) (integrated of order one). This result is based on the Phillips Perron test with two lags as per the Schwarz information criterion (SIC).

4.6.2 Cointegration Test

Engle and Granger (1987) provide a two step procedure for testing cointegration. In the first step, the test for the order of integration for each of the variables is undertaken.

Table 7: Unit Root Test for the Variables

	Level		Nature of Selected ADF equation	First Difference		Nature of Selected ADF equation	Order of Integration
Series	**ADF Test Statistic**	**PP Test Statistic**	**2 lags**	**ADF Test Statistic**	**PP Test Statistic**	**2 lags**	**I(1)**
LQ	-0.899	-1.339	2 lags	-5.157***	-5.795***	2 lags	I(1)
LTariff	-2.195	-1.816	2 lags	-2.617	-4.697***	2 lags	I(1)
LPK	0.279	0.008	2 lags	-2.849	-5.724***	2 lags	I(1)
LGDPpc	-0.664	0.66	2 lags	-2.325	-3.889**	2 lags	I(1)
LPOP	-3.318*	-3.285*	2 lags	-3.421**	-6.409***	2 lags	I(1)
LEFF	-0.627	-0.818	2 lags	-3.22*	-4.72***	2 lags	I(1)

Source: Author STATA Output

Notes: ***, ** and * means that the differenced equation is stationary at the one percent, five and ten percent level of significance, respectively.

The second step states that if the cointegrating vector is unknown a priori then it must be estimated using Ordinary Least Squares (OLS) and the resulting residuals or in other words, the linear combination of the variables referred to as the Error Correction Mechanism (ECM_t) tested for stationarity. was estimated and the results obtained were as presented in Table 8.

Table 8: Estimated Long Run Relationship of the Demand for Electricity Function in Tanzania

Variable	Estimated Coefficient	Standard Error	t-Statistic	P-Value
CONSTANT	1.782825	4.781701	0.37	0.712
LT	-0.0858935	0.0405062	-2.12	0.042*
LIKP	0.2611863	0.0794213	3.29	0.003**
LGPC	0.9503944	0.4913585	1.93	0.063

LPOP	-2.185263	0.6982616	-3.13	0.004**
LEFF	0.9264116	0.1672034	5.54	0.000**

Source: Appendix F: STATA Output

Notes: d means the difference operator Xt-Xt-1, (-n) means variable at lag n], ** and * means variables are significant at 1% and 5% level, respectively. Adjusted R2 = 0.92; DW Test =1.23; Jarque Bera Normality test=33.399**; and F-Test (0 slopes) = 87.95**

According to the Engle and Granger (1987) two or more series are said to be cointegrated if a linear combination of them is I(0) (is stationary). The static long run relationship

4.6.3 Error Correction Model

Cointegration models augmented by Error Correction Mechanism (ECM) have been found to be useful tools to analyse both economic theory relating to the long run relationship between variables and short run disequilibrium. Since a differenced model normally loses its long run properties, an attempt will be made to restore these long run properties by including an Error Correction Mechanism (ECM) in the model. Assuming all the variables are integrated of order one, then the error correction model can be expressed as:

$$\Delta Qt = \alpha_0 + \sum_{j=1}^{k-1} \alpha_{1j} \Delta x_{1t-j} + \sum_{j=1}^{k-1} \alpha_{2j} \Delta x_{2t-j} + \ldots + \sum_{j=1}^{k-1} \alpha_{7j} \Delta x_{7j=1} + D_t + ECM_{t-1} + \varepsilon_t \quad (5)$$

where *Δx's* are the first differences of the explanatory variables (that is, ΔLT_t, *ΔLGD*

Ppc_t, $\Delta LPOP_t$, ΔLPK_t, and $\Delta LEFF_t$,); ECM_t is the Error Correction Mechanism derived from residuals of the regression of Q_t as specified by Equation (2) with all the explanatory variables as at year t; and ε_t is the error term. The Error Correction Model as presented in Equation (5) was estimated and the results of the parsimonious model are presented in Table 9.

Table 9: Estimated Error Correction Model of the Demand for Electricity Function in Tanzania

Variable	Estimated Coefficient	Standard Error	t-Statistic	P-Value
Constant	0.4945	0.1951	2.5300	0.0180*
dLT |	-0.2510	0.0551	-4.5600	0.0000**
dLT(-2)	0.1143	0.0541	2.1100	0.0450*
dLPK	0.2765	0.0833	3.3200	0.0030**
dLGDPpc	1.4571	0.6686	2.1800	0.0390*
dLPOP(-1)	-9.1534	4.4141	-2.0700	0.0490*
dLPOP(-2)	-11.3250	4.1654	-2.7200	0.0120*
dLEFF	1.0854	0.1178	9.2100	0.0000**
ECM(-1)	-0.8764	0.1309	-6.6900	0.0000**

Source: Appendix F: STATA Output

Notes: d means the difference operator Xt-Xt-1, (-n) means variable at lag n], ** and * means variables are significant at 1% and 5% level, respectively. Adjusted R^2 = 0.81; DW = 1.28; F (0 slopes) = 18.52** [0.000]; ARCH 1F(3, 20) = 0.268 [0.8746]; Normality chi2 (2) = 20.8612 [0.4920]; RESET F(3, 21) = 7.49 [0.0014]. Where numbers in the brackets are the probability value of rejecting the null hypothesis.

CHAPTER FIVE

5.0 EMPIRICAL RESULTS

5.1 Introduction

5.1.1 Long-Run Results

The results from the static long run equation (Table 8) show that in the long run demand for electricity is significantly explained by all variables in the model at one and five significant levels with the exception of the GDP per capita. However, the variable is explained at 10% significant level. Diagnostic tests show the adjusted coefficient of determination to be very high at 92%. There is lack of normality of residuals. However, the Durbin - Watson statistic of 1.23 is enough to rule out the presence of autocorrelation while the F-statistic shows the presence of overall significance of the model.

Residuals from the long run relationship were tested for stationarity using the general ADF equation and the PP equation of the form presented in Equation (3) and (4). The residuals (ECM_{t-1}) were found to be stationary with the ADF statistic of -3.981 at one percent level of significance and at the first lag. This implies that the variables are cointegrated in the long run. The results allowed formulation of an Error Correction model by making use of the above-obtained residuals (ECM_{t-1}).

In short, in the long run, the model predicts a price elasticity of demand for electricity of -0.86 on average in the short run as the elasticity value is less than 1. This implies that in the short run, the demand for electricity is inelastic, that is, consumers are not likely to change their behaviors on electricity consumption due to a tariff increase in the long run. This implies that for any percentage increase in domestic electricity tariff, electricity consumption is expected to decrease by an average of 86 percent in the long run. Therefore, other things constant, tariff increases are not an appropriate means to raise revenues.

In the long run, the price of ñother goodsò as proxied by the price of kerosene has the expected positive sign. According to the results of Table 8 electricity seems to be consumed more when the price of the substitute good, that is, kerosene is rising. This can be explained by the substitution of kerosene consumption for electricity consumption as postulated in the demand theory. When the kerosene price is rising in the country, it seems more people increase their consumption of electricity. Quantitatively, it can be argued that when the price of kerosene increases by one percent, the consumption of electricity will increase by 26 percent.

The Gross Domestic Product (GDP) per capita has been hypothesized to have a positive sign. According to the demand theory, as the purchasing power increases, demand also increases. In this case, purchasing power is proxied as the GDP per capita. GDP per capita is seen in our model to be a statistically significant determinant of the demand for electricity. From the estimated coefficients it is expected that a one percent increase in the GDP per capita growth rate is expected to increase the demand of electricity by 95% growth rate. With the current annual GDP per capita growth of 2% as in 2009, other things constant, electricity consumption is expected to double in the long run.

Population growth rate has the unexpected negative sign. As population grows the demand for electricity is also expected to grow. This is not the case since the population growth is not translated into electricity demand growth as not 100% of the population has access to electricity. As mentioned earlier in the thesis, around 10% (3.3 million people) of the entire population of Tanzania has access to electricity. The low access to the electricity services could therefore hamper the impact of the growth in the population on the electricity demand.

This implies that as the population grows, less efforts is put by TANESCO in increasing the customer base. The observed to be inverse relation between population and the electricity demand means that TANESCO efforts to connect customers do not go in tandem with the population growth. More efforts should be made in increasing availability of electricity services to the population. The model predicts that when population increases by 1 percent, electricity consumption decreases by about 219 percent.

It was postulated that an increase in the efficiency in the consumption of energy has a negative impact in its determination of the level of consumption of electricity. In the long run however, there is a positive sign. This means the ratio of the value-added produced by industry divided by electricity consumed by industry will tend to grow with demand in the long run. This means that in the long run in Tanzania, there will not be significant new technologies and energy conservation measures which will be introduced in the industries as expected. Consequently, this implies that the growth of the industrial sector will continue to exert upward pressure on the demand for electricity. This will lead to an increased need for investment in the electricity generation. In the long run as energy efficiency increases by one percent electricity consumption increases by 92 percent.

5.1.2 Short-Run Results

The results of the estimation of the Error Correction model and the diagnostic statistics reported in the previous section are for the parsimonious model after using a general-to-specific strategy. The results of estimation of the Error Correction model show all the variables to be significant at one or five percent level. Residential electricity tariff as an explanatory variable has the expected negative sign at the year of reference (year *t*) but has an unexpected positive sign at the second lag (year *t-2*). However, the combined effect for the period is negative since the absolute value of the negative coefficient is larger than the absolute value of the positive coefficient of the residential electricity tariff.

According to the demand theory, price and quantity demanded are negatively related. It follows that an increase in the electricity tariff will lower the level of electricity consumption. The positive sign in the coefficient of the residential electricity tariff thus implies that past signals of electricity tariff do not last for a two year period as to affect the current consumption of electricity and consequently leading to a reverse change in the level of demand.

Therefore, the model predicts a price elasticity of demand for electricity of -0.137 on average in the short run. This implies that in the short run, the demand for electricity is inelastic, that is, consumers are not likely to change their behaviors on electricity consumption due to a tariff increase in the short run. This implies that for any percentage increase in domestic electricity tariff, electricity consumption is expected to decrease by an average of 13.7% within a three year period.

Price of ñother goodsò as proxied by the price of kerosene has the expected positive sign. According to the results of Table 9 electricity seems to be consumed more when the price of the substitute good, that is, kerosene is rising. This can be explained by the substitution of kerosene consumption for electricity consumption as postulated in the demand theory. When the kerosene price is rising in the country, it seems more people increase their consumption of electricity. Quantitatively, it can be argued that when the price of kerosene increases by one percent, the consumption of electricity will increase by 27 percent.

The Gross Domestic Product (GDP) per capita has been hypothesized to have a positive sign. According to the demand theory, as the purchasing power increases, demand also increases. In this case, purchasing power is proxied as the GDP per capita. GDP per capita is seen in our model to be a statistically significant determinant of the demand for electricity. From the estimated coefficients it is expected that a one percent increase in the GDP per capita growth rate is expected to increase the demand of electricity by 146% growth rate. With the current annual GDP per capita growth of 2% as in 2009, other things constant, electricity consumption is expected to more than double.

Population growth rate has the unexpected negative sign at both lag one (year *t-1*) and the second lag (year *t-2*). As mentioned earlier in the thesis, around 10% (3.3 million people) of the entire population of Tanzania has access to electricity. The low access to the electricity services could therefore hamper the impact of the growth in the population on the electricity demand. This implies that as the population grows, less efforts is put by TANESCO in increasing the customer base. We observed that even in the long run (Table 8), the population growth is inversely related to the growth of the electricity demand. More efforts should be made in increasing availability of electricity services to the population.

Currently, the rural electrification levy has been introduced. There are several programs of rural electrification for all of Tanzania that are being implemented by TANESCO and the Government with strong support from development partners. The program of TANESCO was to add 3,000 to 5000 rural customers per month. The government program is more ambitious ï to electrify 100,000 urban, peri-urban and rural customers per year over the next five years. We will soon expect a positive relationship between the growth of the population and the growth of electricity demand. Therefore, in the near future there is a room for research to examine this relationship. Thus, about 20.5 percentage decrease in the electricity consumption is expected to be associated with a one percent increase in the population growth.

It was postulated that an increase in the efficiency in the consumption of energy has a negative impact in its determination of the level of consumption of electricity. This means the ratio of the value-added produced by industry divided by electricity consumed by industry will tend to grow with demand in the short run. This means that in the short run in Tanzania, there will not be significant new technologies and energy conservation measures which will be introduced in the industries as expected. The model predicts that in the short run when the efficiency in the consumption of energy increases by one percent electricity consumption increases by 108 percent.

The coefficient of the error correction term has the expected negative sign and the expected position at a value lying between zero and one. The magnitude of the coefficient of the error correction term implies that there is a high speed as residential demand adjusts to its long run trend. Thus, the term predicts that about 87 percent of the discrepancy between short and long run trend of residential demand is corrected each year.

Diagnostic tests are also discussed as follows. AR 1-2 F(2, 8) is the serial autocorrelation statistic for an autoregressive error process of order one to two. The AR statistic and the Durbin Watson statistic show that there is some autocorrelation of a higher order than what the Durbin Watson statistic measures. It is noteworthy here that the Durbin Watson statistic is of use here as the model does not incorporate an autoregressive variable.

ARCH is the Autoregressive Conditional Heteroscedasticity. The null hypothesis of no ARCH in the model is not rejected at 5 percent level of significance. The Jarque Bera Normality test of the error terms shows that the error term is normally distributed. This means that estimates are both efficient and consistent. RESET is the Regression Specification Test. This test is used to detect mis-specification due to non-linearity of the model. The statistic shows that there is no mis-specification about non-linearity of the model. The F statistic with the null hypothesis of zero slopes is rejected at one percent significant level. This signifies the overall significance of the model. Lastly, the coefficient of determination (adjusted R^2) shows that about 81 percent of the variations in the demand for electricity function are explained by the variations of the specified explanatory variables in the model.

5.2 Discussion of the Results

This Section presents a discussion of the results in terms of investment requirements, environmental impact that may arise if the investment plan is implemented and the justification of TANESCO multiyear tariff proposal.

5.2.1 Investment Requirements

The analysis of investment requirement is based on the fact that Tanzania envisages attaining its goal on social and economic development vision by the year 2025.

Table 10: Projected Investment Requirements for Electricity

	Average	**Projections**			
	Growth	**2010**	**2015**	**2020**	**2025**
Residential Tariff	23%	137	390.8	1,112.5	3,167.3
GDP per capita	1%	75,190	79,080	83,171	87,474
Population	3%	41.9	48.4	55.9	64.5
Kerosene Price	24%	1,074.5	3,089.5	8,883.3	25,542.2
Energy Use Efficiency	6%	6.4	8.4	11.0	14.5
Residential Demand Growth (%)	4%	1,709.7	2,073.2	2,514.13	3,048.79
Sales Growth (%) - Model Projections		1,568.2	2,469.5	3,889.00	6,124.39
Add (1-Residential to Total Demand Ratio)	66%	3,010	4,740	7,465	11,755
Add Power Losses	19%	714.9	1,125.8	1,772.88	2,791.93
Total Generation Required		3,725	5,866	9,237	14,547
Current Capacity - All Existing Plants (by 2009)	4,984.0				
2025 Investment Gap (Current vs 2025 Demand)	9,563				
Add: Songas Retirement	1,284				
Total Investment Required by 2025	**10,847**				

Source: Research Finding 2011

Table 10 above presents the demand projections covering the years 2010 to 2025. Projections of demand for electricity were calculated from the results of the long run relationship given in Table 8, from which each variable was projected based on the average growth rate derived in the sample data. According to the projections, the demand would almost double from 4,984 GWh in 2009 to about 10,847 GWh by 2025, which translates to the investment requirement of about 9,563 GWh. Note that about 1,284 will be lost when some of the Songas generators are retired during 2023, 2024 and 2025 (See Appendix B). Note that the projected demand does not take into account increase in the access of population with the electricity services, and therefore maintains the status quo.

A major concern in power sector development in Tanzania is therefore the enormous amount of investment that will be needed to meet not only the demand growth for electricity but also to improve access of electricity to the population. Raising such a large amount of capital will not be easy for Tanzania and for the multilateral and bilateral financing institutions. Mobilizing domestic savings for the power sector will become an important measure because foreign capital will not be able to satisfy future investment requirements. In Tanzania, domestic savings is about 38.5 percent of GDP, which could be mobilized through the domestic bond and stock market. Tanzania is currently attracting Small Power Producers (SPP) which can assist in augmenting investment. Privatization of power plants could be another effective way of fund raising.

5.2.2 Environmental Impact

Tanzaniaös high dependency on coal for electricity generation is expected to continue due to (i) the need to maintain low electricity tariffs, and (ii) abundant domestic coal supply. A major share of the increase in power supply during the period is expected to come from coal-fired power plants, that is, about 36%, second after hydro power (41%) (See Figure 3 below).

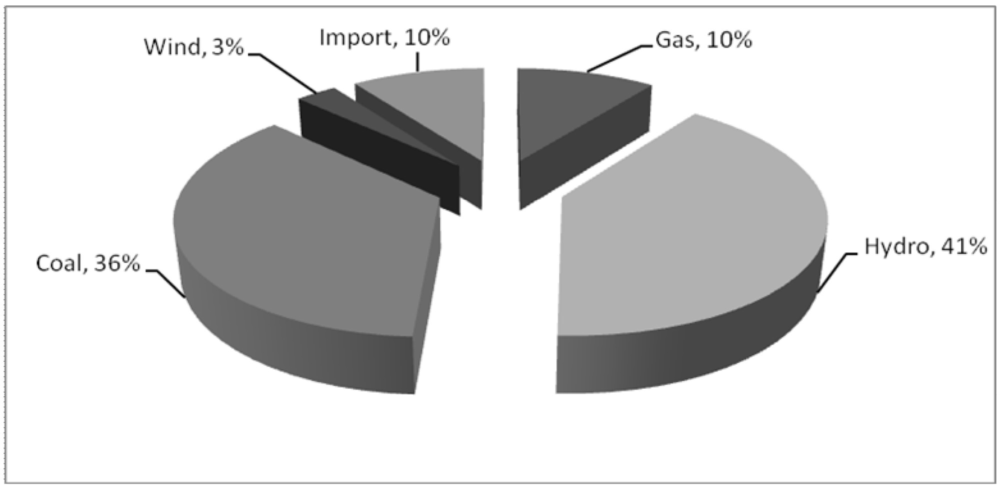


Figure: 3 Distributions of Additional Power Sources during 2010-2025

Source: TANESCO Investment Plan (2008-2031)

The rapid growth of power demand in Tanzania and high dependency on coal for electricity generation will make the environmental impact of coal consumption of great concern. In the total incremental capacity of 14,215 GW between 2010 and 2025, 5,156 GW is expected from coal-fired power plants (See Appendix B). Environmental laws and regulations require that newly constructed or expanded thermal power plants that emit sulfur dioxides (SO_2) exceeding the pollutant emission standards or total amount of control targets should install facilities for sulfur and dust removal or adopt other measures to meet the standards. In reality, electric precipitators, selective catalytic reduction processes, and flue gas desulfurization are used for most new power plants in the world.

According to the PSMP (2008), the impact of coal-powered fuel is global and can result into increased green house gases emissions, acid rain emissions, and health issues related to air pollutant emissions. The impact of coal-powered fuel is long term and lasts even after plant shutdown. PSMP (2008) ranks coal-powered fuel the highest is its adverse impacts on the environment (See Appendix E). The government should consider it a main environmental objective to reduce the growth of coal consumption for power development and the environmental pollution that such consumption causes. For this, the government should promote:

(i) The introduction of clean coal technologies throughout the entire process of coal production, handling, transportation, and consumption;

(ii) Where possible, substitution of coal by natural gas, hydropower, and renewable energy; and

(iii) Demand-side management to decrease the growth rate in electricity consumption.

5.2.3 TANESCO Tariff Determination

In May 2010 TANESCO submitted a Tariff Application to EWURA by proposing multi-year tariff increases of 34.6% in 2011, 13.8% in 2012, and 13.9% in 2013 (See Table 11below).

Table 11 Proposed Tariff by TANESCO

Year	Revenue Requirements (TZS Billion)	Proposed Tariff (TZS/kWh)	Reflected Tariff Increase (%)
2009		118.8	
2010	512.00	118.8	
2011	785.60	159.9	34.6%
2012	1,012.20	181.9	13.8%
2013	1,301.10	207.2	13.9%

Source: TANESCO Tariff Application 2010

This study uses an analysis of long run marginal cost to determine the reasonableness of the TANESCOôs tariff proposal. From an economic perspective the long run marginal cost is the cost of supplying an incremental kWh to the system at a future date. In practice, such a cost cannot be determined directly mainly due to the fact that the investment required to meet the incremental kWh is ñlumpyò. Adding to the complexity, it is the system as a whole that supplies the incremental kWh.

The rationale for using marginal costs as a basis for electricity pricing is to direct the customer, through the price charged for electricity, towards the most efficient use of resources available. Theoretically, if the price is equal to the marginal cost of supply, an optimal allocation of resources takes place and economic efficiency will result. Marginal cost is one of many considerations used in the development of electricity tariffs. The long run marginal costs (LRMC) of electricity supply are computed to satisfy the criterion of economic efficiency. The the long run marginal costs (LRMC) were computed using the following formula.

$$LRMC = \frac{\sum_{k=1}^{T} \frac{C_{t+k} - C_t}{(1+i)^{k-1}}}{\sum_{k=1}^{T} \frac{Q_{t+k} - Q_t}{(1+i)^{k-1}}} \qquad (6)$$

Where, C_t is the projected revenue requirement in year t while Q_t is the demand forecast in year t. This implies that LRMC is calculated as the present value of the stream of incremental revenue requirements needed to satisfy the projected demand divided by the present value of the stream of demand itself. Two main variables are required to compute the long run marginal costs ï projections of revenue requirements and projections of demand. The projections of revenue requirements are obtained from the Power Sector Master Plan (PSMP) 2008 which range from year 2008 to year 2031, while the projections of demand are obtained from findings of the present study. The discount rate is assumed at 8% which is equivalent to the interest rate on 10 year Treasury bond. Basing on the long run marginal cost analysis, TANESCO needs an average tariff of about TZS 276.22 per kWh during the period 2010-2025 in order to satisfy the projected demand by 2025. This average tariff is higher than the long run marginal costs calculated based on the TANESCOøs investment plan proposed in the PSMP, 2006 of TZS 183.76 per kWh. However, the current proposed tariff aiming at reaching TZS 207.2 per kWh by 2013 seems to be justifiable as it is still lower than the required average tariff of TZS 276.22 per kWh.

It should be noted that these findings are based on very low electrification. According to our study, percentage of population with access to electricity is assumed to increase from 11% in 2009 to 16% in 2025. In addition, this study assumes a discount rate of 8%. The higher the discount rate the higher the long run marginal cost estimate. Therefore, under the current demand conditions as estimated in the study and TANESCOøs investment plan as per the Power Sector Master Plan 2008, TANESCO needs more tariff increases.

5.3 Conclusion

According to the empirical results, the thesisøs findings were found to be in conformity with the results from the empirical literature in the sense that the elasticity of residential demand for electricity was found to be inelastic in both the short run and the long run. However, the short run elasticity of residential demand for elasticity was found to be higher (-0.14) than the long run elasticity (-0.088) contrary to the empirical literature. In addition, population growth seems to be inversely related to the electricity demand at a very high magnitude growth. Poor electrification efforts are blamed for this unexpected relationship. The main policy implications from the empirical results of the residential demand for electricity are as follows:

1. Investment requirement to fulfill the projected demand of the next 15 years towards our national development vision in 2025 were found to be enormous. The high projected demand emanates from the rapidly increasing demand and the need to increase availability of electricity services to the population. Raising such a large amount of capital to cater for the high projected demand will not be easy for Tanzania and for the multilateral and bilateral financing institutions. Privatization of power plants could be an effective way of fund raising. In addition, tariff reforms are necessary to support competitive power market development and to strengthen the power utilitiesô financial position.

2. Tanzaniaœ high dependency on coal for electricity generation is expected to continue due to the need to maintain low electricity tariffs, and abundant domestic coal supply. The government should consider it a main environmental objective to reduce the growth of coal consumption for power development and the environmental pollution that such consumption causes. For this, the government should, among others, promote the introduction of clean coal technologies throughout the entire process of coal production, and where possible, substitution of coal by natural gas, hydropower, and renewable energy.

3. TANESCO has not yet reached the full cost recovery. Consequently, more increases in tariffs are expected. If Tanzania is to transform into a successful market economy, the electricity tariffs will have to increase to cover the costs in the long run. The challenge is to balance the utility companiesô need for financial sustainability with the desire to continue to keep prices affordable for consumers. With inelastic demand in both short and long run, there is still ample room to undertake tariff increases.

CHAPTER SIX

6.0 CONCLUSION, POLICY IMPLICATIONS AND LIMITATIONS

6.1 Introduction

This final chapter of the study is divided into four brief sections. Section one gives an overview of the study; section two deals with policy implications of the findings and suggests policy recommendations; section three gives the limitations of the study and based on these limitations the final section suggests areas for further research.

6.2 Summary

This study covers the period between 1974 and 2009. The main objective of this study was to estimate the price elasticity of residential demand for electricity in Tanzania. The study is significant due to challenges caused by rapidly increasing demand in the country, and particularly the demand for residential customers. The study is also important due to the need to expand electrification, how to address the costly investment requirements, and the need to undertake proper economic regulations through tariff that balances the interests of service providers and consumers.

Factors that were hypothesized to influence the residential demand for electricity in Tanzania include the domestic electricity tariff, per capital income, population, price of kerosene and overall energy utilization. Whereas domestic electricity tariff and the overall energy utilization are postulated to have a negative relationship with the demand for electricity, per capita income, population and price of kerosene were expected to grow with the level of residential demand for electricity.

Using time series analysis, empirical results were found to be in conformity with the results from the empirical literature in the sense that the elasticity of residential demand for electricity was found to be inelastic in both the short run and the long run. However, the short run elasticity of residential demand for elasticity was found to be higher (-0.14) than the long run elasticity (-0.088) contrary to the empirical literature. In addition, population growth seems to be inversely related to the electricity demand. Poor electrification efforts are blamed for this unexpected relationship.

The main policy implications from the empirical results of the residential demand for electricity are as follows: First, investment requirement to fulfill the projected demand of the next 15 years towards our national development vision in 2025 were found to be enormous. Second, Tanzaniaös high dependency on coal for electricity generation is expected to continue due to the need to maintain low electricity tariffs, and abundant domestic coal supply. The government should consider it a main environmental objective to reduce the growth of coal consumption for power development and the environmental pollution that such consumption causes. Third, TANESCO has not yet reached the full cost recovery. Consequently, more increases in tariffs are expected. With inelastic demand in both short and long run, there is still ample room to undertake tariff increases.

6.3 Limitations of the Study

The Thesis centers on the analysis of time series data. Most of the time series data are available since 1974. Normally, time series analysis assumes that the longer the series, the higher the efficiency of the estimates in the model. In addition, there are some crucial variables in the determination of electricity demand such as electrical appliance holdings and use which had to be left because such data is rarely available on time/yearly basis. The time series data was also highly aggregated. The analysis of residential demand by regions, would have improved the efficiency of the elasticity estimates.

The analysis was also focused on the residential demand whose tariff structure is nonlinear and has been blurred and mixed with other tariffs such as commercial tariffs, making it difficult to separate the impact of domestic tariff on domestic electricity consumption. In addition, focusing on the residential demand deprives of any attempt to estimate investment requirements basing on maximum demand. Domestic tariff in Tanzania has not included the demand charge component. In most cases, maximum demand capacity is an important determinant of the investment requirement. The study did also take into account the extent of the suppressed demand. It was noted that most of the power cuts were to domestic customers. This would suggest that Domestic customers on the grid system wanted more power than they were provided with for consumption.

6.4 Areas for Future Research

Basing on the limitation of the studies as discussed in the above section, there is ample opportunity for further research. Further research may include panel data analysis which an increasingly popular form of longitudinal data analysis among social and behavioral science researchers. A panel is a cross-section or group of people (for example, people living in the administrative regions) who are surveyed periodically over a given time span. The analysis of the environmental impact of electricity expansion is also another area for further research. According to the trend, power generation is now shifting from hydro to thermal. However, thermal energy has been advocated to possess relatively high adverse impact on the environment. There is therefore a need to quantify this impact for the case of Tanzania.

Last but not least is the impact of the Independent Power Projects in Tanzania. While, the IPPs have been advocated to supplement the energy capacity in the country, there have been controversies surrounding this advantage vis-a-vis other disadvantages such as the high capacity costs.

REFERENCES

Anderson, K.P. (1973) óResidential Energy Use: An Econometric Analysis,ô *Rand Corporation*, R-1297-NSF, October.

Babatunde M. A and M. I. Shuaibu (2007), ñThe Demand for Residential Electricity in Nigeria: A Bound Testing Approachò

Beenstock, M., E. Goldin, and D. Natbot (1999), The Demand for Electricity in Isreal. *Energy Economics* 21, 168ï 183.

Berman, M. B., Hammer, M. J., and Tihansky, D.P. (1972), ñThe Impact of the Electricity Price Increases on Income Groups: Western United States and Californiaò, The Rand Organization, Prepared for the California State Assembly with Support of the National Science Foundation, November, 1972

Berndt, E. R., (1978), ñDemand for Electricity: Comment and Further Resultsò, Working Paper No. MIT-EL 78-021WP, August 1978

Bernstein, M.A. and J. Griffin, (2005), ñRegional Differences in the Price-Elasticity of Demand For Energyò, The Rand Organization, Infrastructure, Safety and Environment, Paper Prepared for the National Renewable Energy Laboratory

Bohi, D. R. (1981), *Analyzing Demand Behavior: A Study of Energy Elasticities*. Baltimore: Johns Hopkins Press.

Bohi, D. R. (1984), An Update of Econometric Studies of Energy Demand. *Annual Review of Energy* **9**, 105ï 154.

Bohi, Douglas R. (1981), *Analyzing demand behavior: a study of energy elasticities*, 1st ed. Baltimore: Johns Hopkins University Press, 1981.

Bohi, Douglas R. and Mary Beth Zimmerman, (1984), ñAn Update on Econometric Studies of Energy Demand Behavior,ò *Annual Review of Energy*, vol. 9(1), pp 105-154.

Borenstein, S., Jaske, M.m and A. Rosenfeld (2001), ñDynamic Pricing, Advanced Metering and Demand Response in Electricity Marketsò, University of California, Center for the Study of Energy Markets (CSEM) Working Paper Series, October 2002.

Carter, A., Craigwell, R., and W. Moore, (2009), ñPrice Reform and Household Demand for Electricityò, September, 2009.

Davies, I. (2004), ñManagement Contracts in the Electricity Sector: A Case Study ï Tanzaniaò, Campell Davies Consulting.

Dergiades, T. and L. Tsoulfidis, (2009), ñRevisiting Residential Demand for Electricity in Greece: New Evidence from the ARDL Approach to Cointegrationò, Department of Economics, University of Macedonia, Discussion Paper Series, Discussion Paper No. 12/2009.

De Vita, G., Endresen, K., Hunt, L.C. (2006) ñAn empirical analysis of energy demand in Namibiaò *Energy Policy* 34, 3447ï 3463.

Electricity Act (2008), The Electricity Act, 2008, Cap 131, United Republic of Tanzania, Dar es Salaam, Tanzania.

Engle, R. F., and C. W. J. Granger, (1987), .Cointegration and Error Correction: Representation, Estimation and Testing.. *Econometrica* 55:251-76.

Espey, J. A., and Espey, M., (2004) ñTurning on the Lights: A Meta-analysis of Residential Electricity Demand Elasticities,ò *Journal of Agricultural and Applied Economics*, April 2004, 36:1, pp. 65-81.

Energy and Water Utilities Regulatory Authority Act (2003), The Energy and Water Utilities Regulatory Authority Act, 2003, Cap 414, United Republic of Tanzania, Dar es Salaam, Tanzania.

Fan, S., and Hyndman, R.J., (2008), ñThe Price Elasticity of Electricity Demand in South Australia and Victoriaò Monash University, Business and Economic Forecasting Unit, Project 08/04 ESIPC and VenCorp, 22 October 2008.

Faruqui, A. and S. George (2005), Quantifying Customer Response to Dynamic Pricing. *The Electricity Journal* 18, pp. 53ï 63.

Filippini, M. (1999), óSwiss Residential Demand for Electricity,ô *Applied Economic Letters*, 6: 533-538.

Filippini, M. and Pachauri, S. (2002), ñElasticities of Electricity Demand in Urban Indian Householdsò CEPE, Working Paper No. 16, March 2002.

Filippini, M. and S. Pachauri, (2002), ñElasticities of Electricity Demand in Urban Indian Householdsò CEPE Working Paper Nr. 16, March 2002.

Gellings, G., (1996), *Demand Forecasting in the Electric Utility*, 2nd ed. Oklahoma: PennWell Publishing Company.

Gratwick, K., Ghanadan, R., and A. Eberhard (2006), ñGenerating Power and Controversy: Understanding Tanzaniaôs Independent Power Projectsò, University of Cape Town, Graduate School of Business, Working Paper, March 2006.

Griffin, J.M. (1974) óThe Effects of Higher Prices on Electricity Consumption,ô *Bell Journal of Economics and Management Science*, 5(2): 515-539.

Hosier, R. H. and W. Kipondya (1993), ñUrban Household Energy Use in Tanzaniaò, Energy Policy 21(5): 454-473.

Houthakker, H. and L. Taylor, (1970), *Consumer Demand in the United States: Analyses and Projections*, Cambridge: Harvard University Press, 1970.

Houthakker, H. S. (1951), ñSome Calculations of Electricity Consumption in Great Britain.ò *Journal of the Royal Statistical Society (A)*, No. 114, Part III, 351-371.

Houthakker, H.S., Verleger, P.K. and Sheehan, D.P. (1973) óDynamic Demand Analyses for Gasoline and Residential Electricity,ô Data Resources Inc., Lexington, Massachusetts.

Kabadi, John (2010), ñDemand Side Management Program in Tanzaniaò, A Presentation to Workshop On Global Energy Efficiency Washington, DC ï 8th March 2010.

Katyega, M. (2004), ñOutsourcing Opportunities for Small and Medium Enterprises in the Ongoing Utility Reforms in Tanzaniaò, ESMAP/AFREPREN Report.

Kilahama, F (2010), Impact Of Increased Charcoal Consumption To Forests And Woodlands In Tanzania, *Discussion Paper for Tanzania Association Of Foresters.*

King, C. S. and S. Chatterjee (2003), Predicting California Demand Response. *Public Utilities Fortnightly* 141, 27.

King, K. and P. Shatrawka (1994), Customer Response to Real-Time Pricing in Great Britain. In: *Proceedings of the ACEEE 1994 Summer Study on Energy Efficiency in Buildings*.

Lafferty, R., Hunger, D., Ballard, J., Mahrenholz, G., Mead, D., and D. Bandera, (2001), ñDemand Responsiveness in Electricity Marketsò, Federal Energy Regulatory CommissionOffice of Markets, Tariffs and Rates, Revision Date: January 15, 2001.

Lin, B.Q., (2003), ñElectricity Demand in the Peopleŝ Republic of China: Investment Requirement and Environmental Impactò, Asian Development

Bank (ADB), Economics and Research Department (ERD) Working Paper No. 37, March 2003.

Meetamehra (2009), ñDemand Forecasting for Electricityò, Body of Knowledge on Infrastructure Regulation.

Ministry of Energy and Minerals (1992), ñThe Energy Policy of Tanzaniaò. Dar es Salaam, United Republic of Tanzania, Ministry of Energy and Minerals.

Ministry of Energy and Minerals (2007), ñEnergy Sector Review: Situational Analysisò. Dar es Salaam, United Republic of Tanzania, Ministry of Energy and Minerals.

Mount, T.D., Chapman, L.D. and Tyrrell, T.J. (1973), ôElectricity Demand in the United States: An Econometric Analysis,ô ORNL-NSF-49, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Mueller, T. (1991), ñEnergy and electricity supply and demand: Implications for the global environmentò, *An overview from the Helsinki symposium.*

Mwandosya, M. J. and M. L. Luhanga (1993), ñEnergy and Development in Tanzania: Issues and Perspectivesò, *Energy Policy* May: 441-453.

National Institute of Economic and Industry Research (2007), *The own price elasticity of demand for electricity in NEM regions*. Tech. rep. National Electricity Market Management Company.

Parti, M. and Parti, C. (1980), ôThe Total and Appliance-Specific Conditional Demand for Electricity in the Household Sector,ô *Bell Journal of Economics*, 11(1): 309-321.

Phillips, P.C.B and P. Perron (1988), "Testing for a Unit Root in Time Series Regression",Biometrika, 75, 335ï 346

Politukha, O. (2002), ñAnticipating the Impact of the Planned Increase in Electricity Tariffs on the Ukranian Economyò, Economics Education and Research Consortium (EERC) MA Program at the National University of "Kiev-Mohyla Academy"

Power Sector Master Plan (2007), Long-Term Power System Master Plan Study, Load Forecast Final ï Main Report, September 2008, United Republic of Tanzania, Dar es Salaam, Tanzania.

Power Sector Master Plan (2008), Power Sector Master Plan Study, Final Report, Volume II ï Main Report, September 2008, United Republic of Tanzania, Dar es Salaam, Tanzania.

Reiss, P.C. and White, M.W. (2005), ôHousehold Electricity Demand, Revisited,ô *Review of Economic Studies*, 72(3): 853-883.

Tanzania Electricity Supply Corporation (2010), ñTANESCO Tariff Review Applicationò, Dar es Salaam, Tanzania, May 2010.

Taylor, L. (1975), ôThe Demand for Electricity: A Survey,ô *Bell Journal of Economics*, 6: 74-110.

Taylor, T., P. Schwarz, and J. Cochell (2005), 24/7 Hourly Response to Electricity Real-Time Pricing with up to eight summers of experience. *Journal of Regulatory Economics* **27**(3), 235ï 262.

Vela, J.A.A., and Miranda, H., (2007), ñAnalysis of the Electricity Market in Brazilò, World Congress 20th World Energy Congress November 11-15 2007 ï Rome

Wangwe, S., H. Semboja*, et al.* (1998), ñTransitional Economic Policy and Policy Options in Tanzaniaò, *Tanzania Political Economy Series I*, Dar es Salaam, Tanzania, Economic and Social Research Foundation

World Bank (1993), The World Bankôs Role in the Electric Power Sector, Washington DC., World Bank

Yoo, S.H., Lee, J.S., Kwak, S.J., (2007), ñEstimation of residential electricity demand function in Seoul by correction for sample selection biasò Energy Policy 35, 5702ï 5707.

Ziramba, E., (2008), ñThe demand for residential electricity in South Africaò *Energy Policy* 36 (2008) 3460ï 3466.

APPENDICES

Appendix 1: Data Used in the Regression Analysis

Year	Domestic Electricity Sales (Million kWh)/1	Domestic Tariff (TZS/KWh)/2	Price of Kerosene (TZS/litre)/3	Population (in Million)/1	GDP at factor cost at constant 1992 prices/1	GDP at factor cost Index (1992=100)/1	Number of Domestic Customers (In Million)/2
1976	86	0.55	1.33	15.9	876872.1	68.7	0.1
1977	93	0.60	1.40	16.4	880395.5	69.0	0.2
1978	112	0.66	1.90	17.0	899146.2	70.5	0.2
1979	131	0.73	2.50	17.5	925348.7	72.5	0.2
1980	157	0.80	3.05	18.1	948432.8	74.3	0.2
1981	168	0.80	3.35	18.6	943654.0	74.0	0.2
1982	178	0.80	4.60	19.2	949242.8	74.4	0.2
1983	175	0.77	5.35	19.6	926685.2	72.6	0.2
1984	187	0.90	7.50	20.2	958031.0	75.1	0.2
1985	198	0.75	10.00	20.7	983221.0	77.1	0.2
1986	234	0.83	11.25	21.3	1001349.0	78.5	0.2
1987	269	0.60	16.90	21.9	1071541.0	84.0	0.2
1988	311	0.60	20.00	22.6	1119016.0	87.7	0.2
1989	330	0.75	37.00	23.2	1147745.0	90.0	0.2
1990	350	0.80	83.00	23.9	1219237.0	95.6	0.2
1991	460	1.00	83.00	24.6	1253132.0	98.2	0.2

1992	506	3.00	92.00	25.3	1275916.0	100.0	0.3
1993	527	5.00	148.00	26.0	1281008.0	100.4	0.3
1994	546	10.00	160.00	26.7	1298942.0	101.8	0.3
1995	660	11.50	160.00	27.5	1345247.0	105.4	0.3
1996	927	11.50	170.00	28.3	1401711.0	109.9	0.3
1997	1023	18.00	257.00	29.1	1448089.0	113.5	0.4
1998	1059	23.00	257.00	30.0	1505827.0	118.0	0.4
1999	1126	24.00	332.83	30.9	1577291.0	123.6	0.4
2000	1002	24.00	408.66	31.9	1654408.0	129.7	0.4
2001	980	24.00	484.49	32.9	1753674.2	137.4	0.5
2002	1108	25.90	560.32	33.6	1879282.0	147.3	0.5
2003	1029	25.90	636.14	34.2	2008636.3	157.4	0.5
2004	1131	78.33	711.97	35.3	2165848.5	169.7	0.6
2005	900	82.67	787.80	36.2	2325404.3	182.3	0.6
2006	871	86.33	863.63	37.5	2481942.1	194.5	0.6
2007	1420	91.33	939.46	38.3	2659798.6	208.5	0.7
2008	1647	111.33	1195.10	39.3	2857000.2	223.9	0.8
2009	1432	111.33	869.89	40.7	3029505.7	237.4	0.9

Sources:

/1 Economic Survey, (various issues), National Bureau of Statistics (NBS), Dar es Salaam

/2 TANESCO and EWURA/3 TPDC

Appendix 2: TANESCO Investment Plan (2008-2031)

Year	Plant	Fuel	Addition (GWh)	Firm Energy Supply (GWW)	Energy Demand (GWW)	Energy Reserve (%)
2007	All existing Plants			5495	4656	18%
2008	Lease end: Aggreko	Gas	-262			
	Lease end: Alstom	Diesel	-237			
	Lease end: Dowans 1	Gas	-206			
	Lease end: Dowans 2	Gas	-465	4325	5244	-18%
2009	Tegeta	Gas	300			
	Small diesel retirements	Diesel	-309			
	Ubungo retirements	Diesel	-69			
	Kinyerezi 1	Gas	687	4934	6003	-18%
2010	Kinyerezi 2	Gas	687			
	Kiwira 1	Coal	1289	6910	6659	4%
2011				6910	7310	-5%
2012	Kiwira 2	Coal	1289	8199	7900	4%
2013	Tegeta IPTL Conversion	Gas		8199	8495	-3%
2014	Ruhudji	Hydro	1333			
	ZTK Interconnector	Import	1402	10934	9103	20%
2015	Wind	Wind	217			
	Rusumo Falls	Hydro	138	11289	9671	17%
2016				11289	10378	9%
2017	Kakono	Hydro	335	11624	10994	6%
2018	Mpanga	Hydro	646			
	Wind	Wind	217	12487	11649	7%
2019	Mchuchuma 1	Coal	1289	13776	12364	11%
2020				13776	13118	5%
2021	Rumakali	Hydro	908	14684	13946	5%
2022	Masigira	Hydro	492	15176	14835	2%
2023	Retire Songas 1	Gas	-275	14901		
	Mnazi Gas	Gas	1030	15931	15785	1%

Year	Plant	Fuel	Addition (GWh)	Firm Energy Supply (GWW)	Energy Demand (GWW)	Energy Reserve (%)
2024	Retire Songas 2	Gas	-755			
	Mnazi Gas	Gas	1030			
	Mchuchuma 2	Coal	1289	17495	16809	4%
2025	Retire Songas 3	Gas	-254			
	Stiegler's Gorge 1	Hydro	1908	19149	17928	7%
2026	Mchuchuma 3	Coal	1289	20438	19121	7%
2027	Local Gas	Gas	1030			
	Stiegler's Gorge 2	Hydro	855			
	Retire Tegeta IPTL	Gas	-687			
	Retire Tegeta GT	Gas	-300	21336	20423	4%
2028	Coastal GT CNG	Gas	2060	23396	21820	7%
2029	Stiegler's Gorge 3	Hydro	464			
	Coastal CC LNG 1	LNG	1188			
	Retire Kinyerezi 1	Gas	-687	24361	23344	4%
2030	Local Coal	Coal	1289			
	Retire Kinyerezi 2	Gas	-687			
	Coastal CC LNG 2	LNG	1188	26151	25033	4%
2031	Coastal CC LNG 3	LNG	1188			
	Coastal CC LNG 4	LNG	1188	28527	26838	6%

Source: Power Sector Master Plan, 2008

Appendix 3: Projections of Revenue Requirement and Energy Supply

Year	ARR (Mill. USD)	Energy Supply (GWh)	Unit Cost of Supply (US c/kWh)
2008	104	3015	3.4
2009	169	3177	5.3
2010	239	3958	6.0
2011	380	4614	8.2
2012	576	7928	7.3
2013	655	6082	10.8
2014	756	8085	9.4
2015	848	8380	10.1
2016	945	8767	10.8
2017	1055	9684	10.9
2018	1187	10862	10.9
2019	1294	12278	10.5
2020	1408	12873	10.9
2021	1589	13882	11.4
2022	1770	14891	11.9
2023	1937	16069	12.1
2024	2082	16266	12.8
2025	2227	17780	12.5
2026	2390	17535	13.6
2027	2579	18008	14.3
2028	3156	23376	13.5
2029	3548	26009	13.6
2030	3779	28357	13.3
2031	4094	29528	13.9

Source: Power Sector Master Plan, 2008

Appendix 4: Environmental Impact of Electricity Generation Options

Type of Equipment	Geographic Scope	Issues	Time Frame	Other Activities that Could Affect the Issues
Hydropower	Watershed	Change in flow regime,	Plant life (except for GHG in reservoir)	Deforestation in the watershed
		Sedimentation, erosion and water quality.		Changes in agricultural activities
		Proliferation of invasive aquatic vegetation		Urban and industrial activities
		Aesthetics and tourism		Greenhouse gases from reservoirs
Coal-fired Thermal Power Options	Global	Greenhouse gas emissions	Long-term, even after plant shutdown	Other human activities leading to greenhouse gas emissions and acid rain
		Acid rain emissions		
		Health issues related to air pollutant emissions		
Natural gas fired Thermal Power Options	Regional, mainly in prevailing wind direction	Similar to but significantly lower than for coal-fired thermal options	Plant life	Other human activities leading to greenhouse gas emissions and acid rain

Source: Power Sector Master Plan, 2008

Appendix 5: Ranking The Environmental Impact Of Electricity Generation Options

Criteria	Weight (%)	Class of Importance
Impact on Resource Depletion	25	Important
Impacts of Greenhouse Gas Emissions	10	Less Important
Impacts of Air Pollutant Emissions on Biophysical Environment	10	Less Important
Land Requirements	25	Important
Waste Disposal	5	Less Important
Environmental Impacts on the Downstream Reaches	25	Important

Source: Power Sector Master Plan, 2008