DOMESTIC ENERGY CONSUMPTION SURVEY IN TARABA STATE

BY

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APPROVAL PAGE

This research work carried out by **Silikwa Apagu Waba** was read and approved by the following panel of examiners as meeting the requirement for partial fulfillment for the award of M. Tech. {**ENERGY PHYSICS**} degree of the Federal University of Technology, Yola.

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CERTIFICATION

I certify that this thesis "Domestic Energy Consumption Survey in Taraba State" is my original work and have not being presented anywhere as project, seminar and term papers. All the authorities quoted in this work were duly acknowledged and the thesis supervisor Dr. J. B. Yerima and all other examiners have read the work and have given their approval.

Signed…………………………

Mrs. Silkwa Apagu Waba

(M. Tech./PH/05/0299)

DEDICATION

This thesis is dedicated to God Almighty who in His eminent mercy helped me throughout the studies and to my beloved husband and children.

ACKNOWLEDGEMENT

I give all the Glory to God Almighty for the health and guidance throughout the period of my studies. Special thanks to my beloved husband Mr. Ndumari Waida who has consistently given me more than I ever wanted.

My sincere thanks and appreciation goes to my supervisor who is also the PG Coordinator of (Physics department), Dr. J. B. Yerima who took time out of his tight schedules to meticulously go through my write-ups. In fact, he has always been there for me. His advice and guidance were sincerely meaningful and professional. I am most grateful to him. My heartily gratitude goes to the H.O.D (Physics), Dr. Osita Meludu, Dr. Odoh, Dr. Adam Usman, Dr. S. A. Oniku, Mr. Joseph Aidan and Mr. Pascal for their immense contributions for making this thesis a reality. Special thanks go to Prof. Dillipe De and his family for making the environment conducive for me during the course of my study. Thanks for your efforts. My sincere regards to both academic and non-academic staff of the Physics department for their moral support and encouragement to overcome the task of time in this work.

Finally, my special appreciation to my colleagues: viz; Maxwell Kanu, Amasuwa, N.S Muwa, Glandu Vasira, Njabba Augustine, Ali Shallangwa, Philip Abiu and all those who have been a source of inspiration to me.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

ABSTRACT

A survey of the consumption pattern of energy sources such as fuel wood, kerosene, gas, biomass, electricity and charcoal as consumed by households in rural, semi-urban and urban areas of Taraba State has been carried out. A total of 2000 household heads (200 from each local government area) were randomly selected and interviewed using a structured questionnaire. The study looked at the energy preference in locations and the level of income of respondents in such locations. It was discovered that; (i) the rural areas of Taraba State, Karim-Lamido, Lau and Gassol, the energy source preferred is fuel wood especially for cooking; (ii) in semi-urban areas like Sardauna, Gashaka and Ibi, the energy options preferred are electricity for lighting and fuel wood for cooking and (iii) in the urban centers like Jalingo, Wukari and Takum respondents prefer electricity for lighting and heating and fuel wood for cooking. The study further revealed that the policy makers as well as high income earners of Taraba State patronize the use of fuel wood for domestic cooking. Also the energy utilized (E_u) and thermal efficiency (η_T) of some common wood species (Kirya and Boushe), kerosene and charcoal in Taraba State have been investigated using standard Water Boiling Test (WBT) in a manner prevalent to the inhabitant of the study area. The E_u, from burning the wood species, charcoal and kerosene give an average value of 0.54275 $MJKg^{-1}$ and rate of burning (r_b) 3.200 $\times 10^{-4}$ $MJKg^{-1}$ with mean (η_T) of 9.547%. This mean will serve as a base line in maximizing energy utilization pattern from the fast depleting forest in terms of fuel efficiency and energy conservation.

CHAPTER ONE

INTRODUCTION

1.1 Relevance of Energy Surveys

Since the inception of the industrial revolution which has largely been described as a revolution in power availability, energy has become a very important production factor. In general, its availability is a crucial pre-requisite for development. However, end use energy consumption is characterized by considerable energy wastes both at the residential, commercial and industrial levels. The utilization of all forms of energy in a sustainable manner has been a global concern over the years. Sustainability can be understood either as using a resource in such a way that it continues to be available or ensuring that future generation have equal opportunities to it. It is certain that we must learn how to sustain our environmental resources so that they continue to provide benefits for people and other living things on our planet.

Energy production and utilization and its consequent effects on the environment have been a global concern. For instance, global, regional and national concerns have been expressed on environmental impacts on photochemical emissions from automobile, nuclear power generation, hydropower generation, particulate matter from farming, construction, demolition and cement factories (Gebeleia, 1997). This implies that the more we produce or use energy, the more we add emission of products such as (CO_2, CO, NO_2, SO_2) etc, that are harmful to life and plants and thus the more we degrade the environment.

$$2C_8H_{18} + 25O_2 \longrightarrow 14CO_2 + CO + O_2 + 18H_2O + \text{energy}$$

$$S\ (\text{in coal}) + O_2 \longrightarrow SO_2$$

$$N_2 + 2O_2 \longrightarrow 2NO_2$$

The solution to this is for us to compromise and select alternative energy sources that have low pollution tendencies in an integrated management system.

Over 70% of the population lives in the rural areas and depend solely on fuel wood as their major energy source (World Bank/UNDP, 1983). Botkin and Keller (1998) contended that human population impacts negatively on the environment. This is to say that there can be no long-term solution to our environmental problems unless the human population in Nigeria and Taraba State in particular stops growing at its present rate. As long as the human population in Nigeria continues to grow at the present rate of 3.2% per annum, it is doubtful that our environmental resource including energy source such as petrol, wood and coal can be made sustainable. The overall environmental effects of the rapidly growing human population are global. For example the increase in use of fossil fuels in western nations since the beginning of the industrial revolution has been affecting the entire globe.

According to Amadou (1994), Nigeria, especially in the Northern part of the country consumed more than a million tones of fuel wood each year. Forest have almost completely disappeared raising serious questions about fuel wood price hikes and shortages in the future. The present fuel supply in Nigeria is erratic and unreliable. The country is not meeting its energy demand for the increasing population and industrialization. The overdependence on petroleum products and fuel wood has serious disadvantages. For instance, for the past years, the price of petroleum products has always been increased to 200% during the rainy season, industries and other economic activities continue to experience energy crisis with incessant outage in electric supply. The use of energy in Nigeria is again characterized by wastage and poor conservation. Experts say that 82% of the energy generated for cooking in our stoves is wasted to the atmosphere leaving 18% as effective heat (Ogbuagu, 1993). This inefficiency in energy generation and usage is a product of ignorance and the use of poor equipment.

In order to provide basic information on energy use in any country, there is the need for energy consumption surveys of the world, nations, states or local government areas. The objective is to have increased efficiency in the use of energy, conservation and expanded use of alternative energy sources as essential goals for effective future energy plans. It is an important goal to move towards global sustainable energy planning or integrated energy approach.

1.2 Elements that are Needed to develop Integrated Energy Planning

The UN Conference on Sustainable Development Choices for Producing, Distributing and Consuming Energy (2002), has among others as its objectives: how to bring modern energy services to the 2 billion people in the world, predominantly in the rural areas of developing countries, who has no access to commercial energy; how to overcome energy poverty whenever it occurs and to meet the energy needs of the poor dispersed in rural communities.

The World Energy Council (WEC) views affordable energy access as a precondition for fostering economic development, improved health, welfare and social equity. For the developing nations, this means the need to make the transition from the predominant consumption of primary biomass energy (traditional fuels) in the rural communities to some sort of clean, convenient, and affordable commercial energy. This can be achieved by finding alternative fuels (biogas, natural gas etc), affordable electricity from a distributed generation, or a decentralized approach that can help in the development of the rural areas and above all, it will reduce the in-door pollution health hazards, which particularly affect the health of mothers and children (WEC, 2004).

The current energy system and practice are not sufficiently affordable or reliable to support global, regional, national, or state economic development growth in all its social, economic and environmental aspects. Renewable energy can be considered a new unlimited supply of energy if one compares the energy needs of mankind with the energy in flow to the earth from the sun. However, renewable energy will remain a fairly small component rather than a replacement for fossil fuels and nuclear power (WEC, 2003). Their role in meeting the rapidly growing demand for reliable and affordable energy in developing countries will grow in importance, principally in rural areas with targeted, temporary subsidies to support their use.

The removal of subsidies on petroleum products by the Nigerian government has almost made nonsense of the government campaign against deforestation (Alabe, 1995). This is so because the common man cannot afford the cost of kerosene (N100-120 per liter) even in the filling stations as against (10 - N15) per liter before deregulation. The findings of (Umaru and Wamakko, 1999) on price increase on fuel wood as a result of deregulation attest to this fact. That along with the erratic power supplies, it has gradually drawn consumers away from kerosene and natural gas back to local wood stove for cooking their food and other domestic activities.

Wood production in Nigeria is quite meager, with each hectare yielding more than an estimated 0.77 m^3 of wood annually. Nigerians especially in the Northern part of the country consume more than a million tones of fuel wood per annum (FAO,1999). Forest in the Northern part have almost completely disappeared translating it to deforestation of hundreds of hectares of woodland, soil- degrading, fuel wood price hike and expected shortage in the future. In 1994, the Nigerian government attempted to discourage fuel wood use by imposing taxes and controlling, logging; this effect was again rubbished by the recent deregulation of the downstream sector of the petroleum industry. The contribution of fuel wood consumption to environmental degradation can be associated with the population pressure, non-availability of alternatives that are cheap and readily available sources such as coal, kerosene, gas and policies of reforestation of degraded large lands (Dkaiyeto, 1990).

This present study is designed to investigate the domestic energy trend in urban, semi-urban and rural areas of Taraba state, Nigeria. To survey and examine the pattern and levels of energy consumption for households and their attitudes towards alternative energy sources. The study also intends to evaluate the energy utilized and thermal efficiency of the most commonly used fuel energy type in domestic activities in the study area. This is aimed at identifying those fuel energy sources that are good to cook food at specific time duration and those that are resistant to burning so that the users could be advised accordingly.

1.3 Aim and Objectives

Energy consumption survey is an important aspect of socio-economic development of a local government, state government or a country at large. It affords a state the privilege to expedite action on having an intergraded energy management system for sustainability of energy resources for future generation. Taraba State which was created on August 27, 1991 in the Northern Nigeria and is one of the states in the Northeast region has a population of 2,300, 736 (2006 census) and occupies a total land mark of 54,426 km^2. Exhaustive literature searches did not indicate the existence of any domestic energy consumption survey of the state; this has obviously created a need for this study.

The general objectives of the study are to:

i. determine domestic energy consumption patterns of fuel wood, kerosene, gas, biomass, charcoal and electricity for households;

ii. determine consumption pattern in household of civil servants, farmers and traders in urban, sub- urban and rural areas of Taraba State;

iii. identify energy options preferred by respondents;

iv. identify energy sources that is predominantly used for cooking by respondents;

v. determine whether there is a significant change in the energy options preferred in the rural, semi-urban and urban areas of Taraba state;

vi. to determine how much useful heat is obtained in burning certain quantity of fuel energy in a specific cooking time;

vii. to compare the rate of fuel type consumed in cooking a meal on different stoves;

viii. to identify those fuel types that are required to cook food at some specified time duration;

1.4 Expected benefits of the study include the followings:

(i) the survey study will serve as a data bank for the State Government in terms of information on domestic energy consumption patterns in Taraba state;

(ii) the study may provide a basis for increasing the demand for alternative energy sources that are environmentally friendly and sustainable;

(iii) the study might lead to a formation of a legal framework that will regulate the present indiscriminate destruction of the state forest reserves; and

(iv) enhance time saving and reduced energy wastage;

CHAPTER TWO

LITERATURE REVIEW

2.1 Energy Resources in Nigeria

Nigeria is endowed with abundant primary and conventional energy resources viz; fossil fuels (oil, coal, gas found in Port Harcourt, Calabar, Enugu), fissionable material (uranium in Gombe), wood fuels (forest and plants), solar energy (sun), hydro (rivers), wind, geothermal (e.g. from geysers and hot springs), waves and tidal. Biomass and biogas resources are also enormous (Ogbuagu, 1993). Presently, the potential of some of these like geothermal, waves, tidal and others especially the fossil fuels are available.

The energy availability and consumption survey of conventional energy sources in Nigeria is hereby presented.

2.1.1 Wood/Charcoal

Nigeria has a total land area of 911,000 km^2 with forest area of 130,000 km^2 and fuel wood production stands at 91.6 million tones as at 1999 (FAO, 2000). Wood/charcoal, the most commonly used-based fuels are vital to the nutrition of rural and low-income groups in urban households in Nigeria. In addition for being used for domestic cooking and heating, they are often essential in food processing industries for baking, brewing, smoking and curing. In Africa, in 1994, more than 80% of total consumption is attributed to the household sector (WEC, 1995). Dependence on fuel wood to meet household energy need is especially high in Sub-Sahara Africa, where 90-98% of residential energy consumption is met by fuel wood (FAO, 1995). Lucas (2003) has estimated that 8×10^7 m^3 of wood (about 43×10^9 kg) annually are used for cooking and other domestic purposes. Alabe (1995) carried out a study to investigate the household Energy consumption patterns in Borno and Yobe state. The study revealed that fuel wood seems to be the major sources of fuel in the region and that other sources of energy such as kerosene and electricity are not readily available due to inadequate supply. The result also indicated that there have been concerted efforts by the North-East Arid Zone Development Programme (NEADP) in finding short term and long-term solutions by encouraging tree planting as well as fabrication of improved metal and mud stoves.

Charcoal is the blackest residue consisting of impure carbon obtained by removing water and other volatile constituents from animal and vegetation substances. It is usually produced by slow Pyrolysis. The massive production of charcoal (at its height employing hundreds of thousands, mainly in Alphines and neighbouring forests) was a major cause of deforestation, especially in Central Europe (http//web,archive.org/web(2007). Charcoal is often used by blacksmiths for metalwork, cooking and for other industrial applications.

Hassan (2006) also carried out a survey to investigate the household energy consumption pattern in Gombe state. The study looked at energy preference in locations vis-à-vis the level of income of respondents in such location. Energy sources most preferred by respondents were determined so that those alternative energy sources that are environmentally friendly can be promoted and advertized. The study revealed that the policy makers as well as high-income earners of Gombe state patronize the use of fuel wood for domestic cooking greatly.

2.1.2 Oil and Gas

The main energy source for Nigeria is oil. The people of Nigeria consume 295,000 barrels of oil per day, while the country's natural gas consumption is 186 billion cubic feet. Estimate of Nigeria's proven oil reserves are found in relative range from 25 billion to 35.2 billion barrel (OPEC). The majority of these reserves are found to relatively simple geographical structures along the country's coastal Niger River Delta, but newer reserves have been discovered in deeper waters offshore of Nigeria. Nigeria's crude oil production averaged 2.1 million barrels per day (bbl/d) in 2003. Nigeria's OPEC crude oil production quota was raised to 2.14 million bbl/d as of August 1, 2004 as part of OPEC's two stage plan to increase production in the face of record-high crude oil prices. As of January 2007, Nigeria has 36.2 billion barrels of proven oil reserves. The Nigerian government plans to expand its proven reserves to four billion barrels per day by 2010 (EIA, 2007).

According to Klaus (2007), Nigeria is practically monoculture about 80% of the government income, 90-95% of the earnings and more than 90% of the foreign exchange revenues evolve from the oil sector. The countries national economy would be massively affected by a sustainable reduction of fossil energy consumption. However, during the last years the government of Nigeria tried to diversify. Special attention is nowadays paid to gas which emerges in the joint-production of oil.

Oil and Gas Journal (OGJ) estimates that Nigeria had an estimated 182 trillion cubic feet (tcf) of proven natural gas as at January 2007 which makes Nigeria the seventh largest gas reserves holder in the world and the largest in Africa (EIA, 2007b). However, due to inadequate gas infrastructure, Nigeria flare as mush as 75% of the gas it produces, accounting for about 20% of all gas flared world wide. New Nigeria policy seeks to reduce gas flaring by using the gas feedback in the Liquefied Natural Gas (LNG) processing facility. Beginning January 1, 2008, the Nigerian government enacted a policy to force companies to stop flaring gas. (M2M, 2005). (Http/www.methane tomarkes.org/resources/coalminer/docs/overview_ch22.pdf.).

2.1.3 Hydropower and Thermal Power Plant

Nigeria has approximately 5,900 MW of installed electric generating capacity from three hydro electric plants and five thermal power stations. The three hydropower plants are: Kainji (332MW), Jebba (333MW) and Shiroro (423MW). The thermal power stations are fired by gas, diesel or steam. Their locations and the respective installed capacities are as follows: Egbin-steam (560MW), Ajaokuta – steam (4 MW), A. E. S –Gas (232-90 MW), Sapele-steam 9157MW), Okpia-Gas ($52MW), Afam-Gas (195Mw), Delta-Gas (451 MW) and Calabar diesel (164 MW). The sector as a whole was generating only 1,600 MW at the start of the Obasanjo's administration in 1999, because of the chronic problems affecting the power industry such as mismanagement, lack of infrastructure, maintenance, vandarlization and power theft. Other problems include varying water levels in the dry season, insecure gas supplies, unavailability of spare parts for regular maintenance etc. Nigeria faces serious energy crisis due to declining electricity generation from domestic power plants. Power outages are frequent and the sector operates well below its estimated capacity. State-owned National Electricity Power Authority (NEPA) dominates the Nigerian power sector. As at the end of 1999, the Nigerian gross theoretical capacity of Hydropower generation stood at 43 TWh per year while the technically exploitable capacity is put at 30 TWh per year (WEC, 2001/2002; World Atlas, 2001).

The C1A World Fact Book (2004, USA) Surveyed the Nigeria energy profile showed that Nigeria has 5,900 MW of installed electric generating capacity and both its energy consumption and its energy intensity are still far below that of other African countries such as Egypt. The survey also revealed that only 10% of rural households and approximately 40% of Nigeria's total population have access to electricity. Power Holding Company of Nigeria (PHCN) has announced plans to boost this share to 85% in 2010.

This calls for 15,000 km of transmission lines, 16 new power plants and new distribution facilities. In May, 2004, the Nigerian government announced that it would fund up to USD 138.9 million of an estimated USD379 million for three power plant projects. Chinese firms CMEC and SEPCO would build plants in Ondo and Ogun states to be co-financed by China and EXIM Bank. Siemens will build one plant at Ajeokuta in Kogi State and Marubeni of Japan will replace a generating unit at one plant in Delta State. In early 2007, Nigeria awarded China Gezhonba Group Corporation (CGGC) and China Geo-Engineering Corporation (CGC) a hydroelectric Project to be constructed at Mambilla in Taraba State. Nigeria hopes the Mambilla National grid project would be completed by 2012 (EIA, 2007).

2.1.4 Coal

Nigeria coal resources are located in the Cretaceous Anambra, Makurdi basins and Afikpo Syncline. Nigeria estimates its coal reserves at over 2 billion tones with approximately 650 million tones (Mmt) as proven (Online Nig. 2008). The Nigerian Coal Corporation (NCC) is planning to develop the coal mining sector by offering concessions to local and foreign investors. Investors will be required to finance mine development and pay equivalent of 10-15% of mine output to the NCC in cash or coal: The daily operational Report (2006 Feb) of Transmission Company of Nigeria (TCN) shows that there is no thermal power plant that uses coal as fuel. The Nigerian government is seeking to increase the country's level of coal utilization to help stem the loss of its forest domestic fuel-wood harvest and to help reduce it's over dependant on oil. The Federal Government in 1980 established the National Centre for Energy Research and Development (NCERD) Nsukka. The Centre is involved in Coal - Briquette Technology and has demonstrated every competence in converting Nigeria's viable and non-agglutinating coal into compact solid smokeless fuel for domestic use.

Ashaka Cement Plc plans to use coal to generate electricity in order to increase its installed capacity from 27,000 to 29,000 metric tones. Although coal was the first energy resource to be exploited by Nigeria, a transition to diesel fuel for rail transport and to gas for electricity generation led to a decrease in coal production (EIA, 2007a). At present coal remains the smallest contributor to the overall fuel mix. It is not part of the Nigeria energy consumption mix (EIA, 2007b).

Nigeria has Africa largest deposits of lignite. Reserves from coal seams in excess of one metre thick are: Ogboyoga (100Mmt) in the North, Okaba (70Mmt), Orupka (60 Mmt), Ezimo (50Mmt) and Enugu (50Mmt) in the South. According to M2M Workshop-Nigeria (2005), Nigeria estimated that export demand for its coal could reach 15 Mmyt per year. In addition, environmentalist are concerned that coal mining will not only lead to environmental degradation, but they fear that using coal as a replacement for oil and firewood also will lead to increased carbon emission (IEA, 2001) (www.eia.doc.gov/emcu/cabs.nig.enr.html).

2.1.5 Solar, Nuclear, Wind, Tidal and Biomass Energy

There is no concrete record of solar and nuclear energy consumption survey in Nigeria because both are at their stages of experimentation and testing (especially nuclear energy). This trend is the same in most developing countries (WEC, Report 2004). For biomass energy, the cane sugar production record made available by the International Sugar Organization (ISO, 1999), indicates that Nigeria has an estimated potential availability of baggas of 55,000 tonnes and a corresponding cane sugar production of 32,000 tones per year. In the same vein Wind Energy was experimented on in the early 1980's in the respect of rural water supply (Alkaleri L.G.A) in Bauchi state by the Federal Ministry of

Water Resources; but the system could not be sustained because of the mechanical moving parts (FMWR, 1998).

2.2 Theory of Burning

The direct combustion of fuel energy is the simplest and easiest method of converting chemically stored energy into heat. The open wood fire was one of the first significant step by which man separated himself from the rest of the animal kingdom. It provides warmth and is a means of converting food into more readily digestible forms. The simple open wood fire is still widely used in the less developed areas but is an inefficient use as fuel.

When a piece of wood is burnt during cooking, the stored chemical (potential) energy in the fuel energy is converted into useful work in the cooking of the food. However, measurement of the useful work done to the food by heating the pot show that only a fraction of this energy was gainfully utilized while the remaining was wasted and lost to the surroundings either as heat or emission (Malgwi and Bajoga,2000). The wasted heat reflects the fact that no thermodynamic system can convert a quantity of heat entirely 100% into work.

Boiling Point: the local boiling point of water is the point at which the temperature no longer rises, no matter how much heat is applied. The local boiling temperature is influence by several factors including altitudes, minor inaccuracies in the thermometer and weather conditions. According to Rod et al (2007), for given altitudes h (in meters), the boiling point of water may be estimated by the relation

$$T_b = (100 - \frac{h}{300})^0 C \qquad 2.1$$

2.3 Measurement and calculation

The experimental procedure used in this work was the Water Boiling Test (WBT) method. It is a simple laboratory test used for a quick comparison of the performance of different stoves or the performance of the same stove under different

operating conditions so as to estimate expected stove performance. The method is also useful in determining the magnitude of heat utilized by a stove and can be expressed as Percentage Heat Utilization (PHU). Thus:

$$PHU = \frac{Total\ heat\ utilized}{Net\ heat\ supplied} \times 100 \quad \% \qquad 2.2$$

To compare different stove performance, the Specific Consumption (SC) which expressed the amount of fuel energy required to cook 1 kg of food is given by (Garba and Atiku, 1997) as

$$SC = \frac{M_{fc}}{M_{cf}} \qquad 2.3$$

where M_{fc} = Mass of fuel energy consumed, M_{cf} =Mass of cooked food.

Alternatively for WBT according to Rob et al (2007), specific fuel consumption can be defined for any number of cooking tasks and should be considered ‘the fuel energy required to produce a unit output’ whether the output is boiled water, cooked beans, or loaves of bread or some other. In the case of the cold-start high power WBT, it is calculated by the equation.

$$SC = \frac{f_{cd}}{P_{cf} - P} \qquad 2.4$$

where f_{cd} = equivalent dry wood consumed, P_{cf} = weight of pot with water after test and

P = dry weight of pot.

The time rate of boiling or burning rate (r_b) is a measure of a rate of fuel energy consumption while bringing water to a boil is given by (Rob et al 2007) as

$$r_b = \frac{f_{cd}}{t_{cf} - t_{ci}} \qquad 2.5$$

where t_{ci} = the initial time of burning, t_{cf} = the final time of burning.

The work done by heating and evaporating water $(100^0 C)$ at 760mmHg was calculated using the relation

$$E_u = (100 - t)m_1\alpha + m_2L \qquad 2.6$$

where t = initial temperature of water (^{0}C); α = specific heat capacity of water (=4186 $Jkg^{-1}K^{-1}$); L = latent heat of vaporization of water (=2.257x$10^6$$Jkg^{-1}$); m_1 = initial mass of water in Kg and, m_2 = mass loss of water in kg.

The work done by heating and evaporating water in a pot of known thermal capacity per unit of fuel consumed (or the energy supplied), e.g. for each fuel wood species is obtained by the relation

$$E_s = M \times LHV \qquad 2.7$$

where M= mass of the fuel type consumed in Kg and LHV is lower heating value or net heating value.

Therefore, the thermal efficiency in the form of that of Rob et al (2007)

$$\eta_T(\%) = \frac{\alpha(m_3 - m_1)(100 - t) + m_2L}{M \times LHV} \qquad 2.8$$

Where m_3 is the mass of water with pot before boiling, m_1 is the mass of the aluminum pot (0.33kg), LHV = 18.68 MJ/kg, 43.3 MJ/kg, 25.7 MJ/kg which are the typical values for dry hard wood (Rob et al, 2007), kerosene and charcoal respectively (Appendix ii) and m_2, L, M, α and t have their usual meanings.

2.4 Definition of Terms

- **Alternative energy-** Renewable and non-renewable energy sources that are alternative to fossil fuels and nucear.
- **Biomass:** The amount of living materials or the amount of organic materials contained in killing organisms both as life and dead materials, as in leaves (Live) and stem wood (dead) of trees.
- **Coal:** brittle carbonaceous rock that is by far the world's most abundant fossil, it is classified according to energy content as well as carbon and sulphur.
- **Cold – start high power**: simply refer to when the tester begins with the stove at room temperature and uses a pre – weighed bundle of wood or fuel to boil a measured quantity of water in a standard pot. The tester then replace a boiled water with a fresh pot of cold water to perform the second phase of the test
- **Deforestation:** Harvesting time for commercial and other uses and burning forest to convert lands for agricultural purposes.
- **Desertification:** the process of creating a desert where there was not one before e.g. farming in marginal grass land, which destroys the soil and prevents further recovering of natural vegetation.

- **Energy:** Ability or capacity to do work
- **Energy Consumption Survey:** Simply refers to energy potentials, production, capability and real consumption pattern of all the available energy sources in the world as surveyed by world energy council (WEC). This is done in order to achieve reliable, accessible, efficient, available and sustainable energy supply for the purpose of delivering a sustainable clean environment for the future generation. The first edition of the survey of energy sources by WEC was in 1934.
- **Environment:** All factor living an non living that actually affect an individual organism or population at any point in the life cycle.
- **Environmental Impact:** The effects of some action on the environment particularly the action of human beings
- **Fossil Fuel:** Are forms of energy extracted from incomplete biological decomposition of dead organic matters. Includes coal, oil and natural gas.
- **Geothermal Energy:** The useful conversion of natural heat to interior earth
- **Non-Renewable Energy:** Alternative energy source including nuclear and geothermal energy that are dependant on fuel or a source that may be used up much faster than is replenished by natural processes.
- **Non renewable Resources**: A resource that is cycled so slowly by natural Earth processes that once used, it and is essentially not going to made available within any useful time frame work.
- **Particulate Matter**: Small particles of solid or liquid substances that are released into the atmosphere by many activities including farming, demolition, construction works, volcanic eruptions, burning fossil fuels etc
- **Pollution:** The process by which something becomes impure, defiled, dirty or otherwise unclean.
- **Pyrolysis**: is the chemical decomposition of a condensed substance by heating.

- **Renewable Energy**: Alternative energy sources such as solar, water, rain and biomass that are more or less continuously made available in the time framework useful to people
- **Renewable Resources:** A source such as timber water or air that is naturally recycled or recycled by artificial processes in a time frame work useful to people.
- **Sustainable Energy**: A type of energy management that provides for reliable resources of energy while not causing environmental degradation and ensuring future generations have a fair share of the Earth's resources
- **Tidal Power:** Water utilizing ocean tides in places where favourable topography allows for construction of water plants
- **Water Power or Hydro power**: Alternative energy source drive from flowing water. It is one of the world's oldest and most common energy sources. Sources vary in size from micro hydro power system to large reservoirs and dams.
- **Wind Power:** Alternative energy source that has been used by people for centuries dependent on wind. More recently, thousands of wind mills have been installed to produce electric energy.

CHAPTER THREE

METHODOLOGY OF ENERGY SURVEY

3.0 Study Area

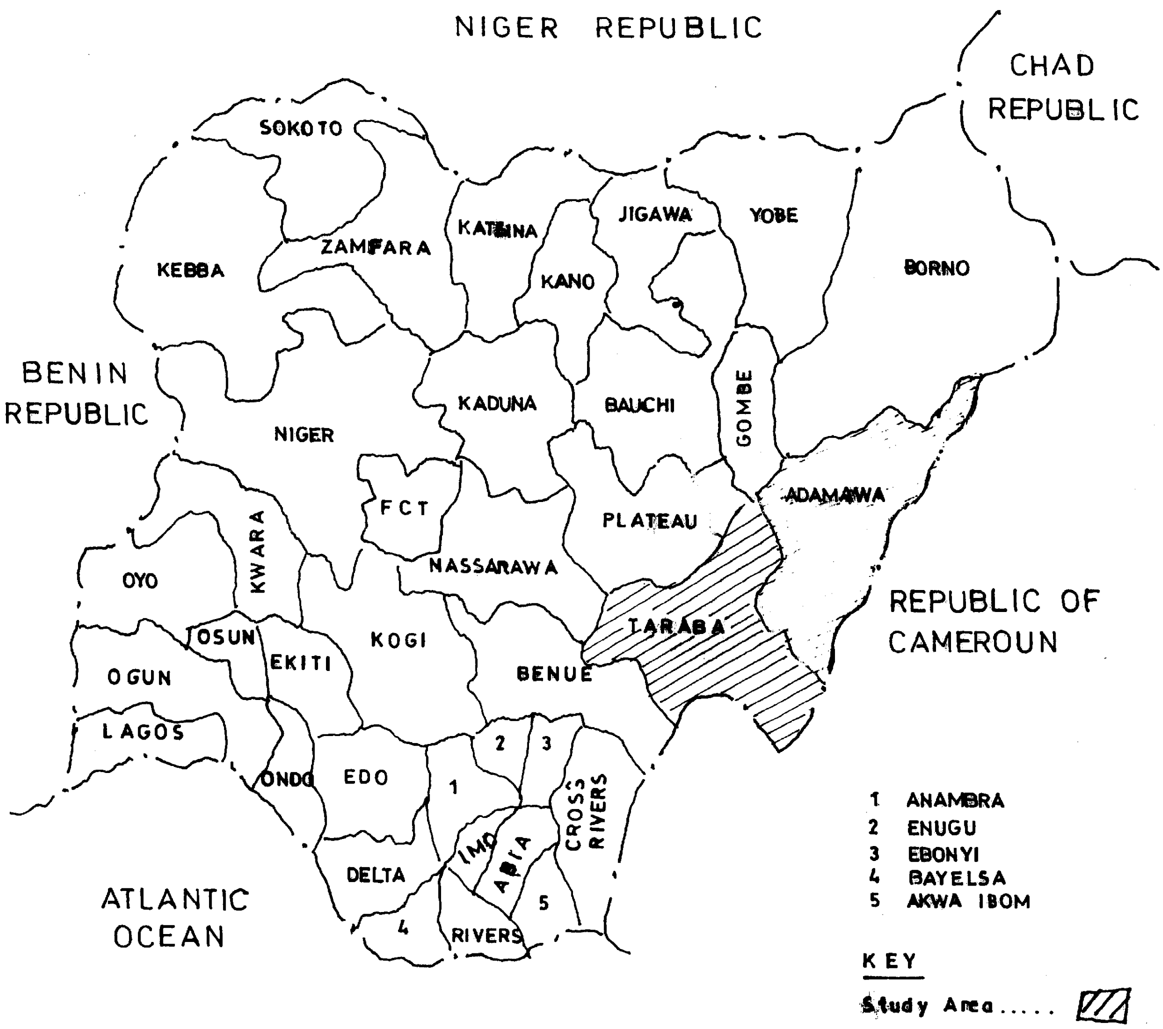

FIGURE 3.1: A map of Nigeria showing the study area

3.1 The Study Areas

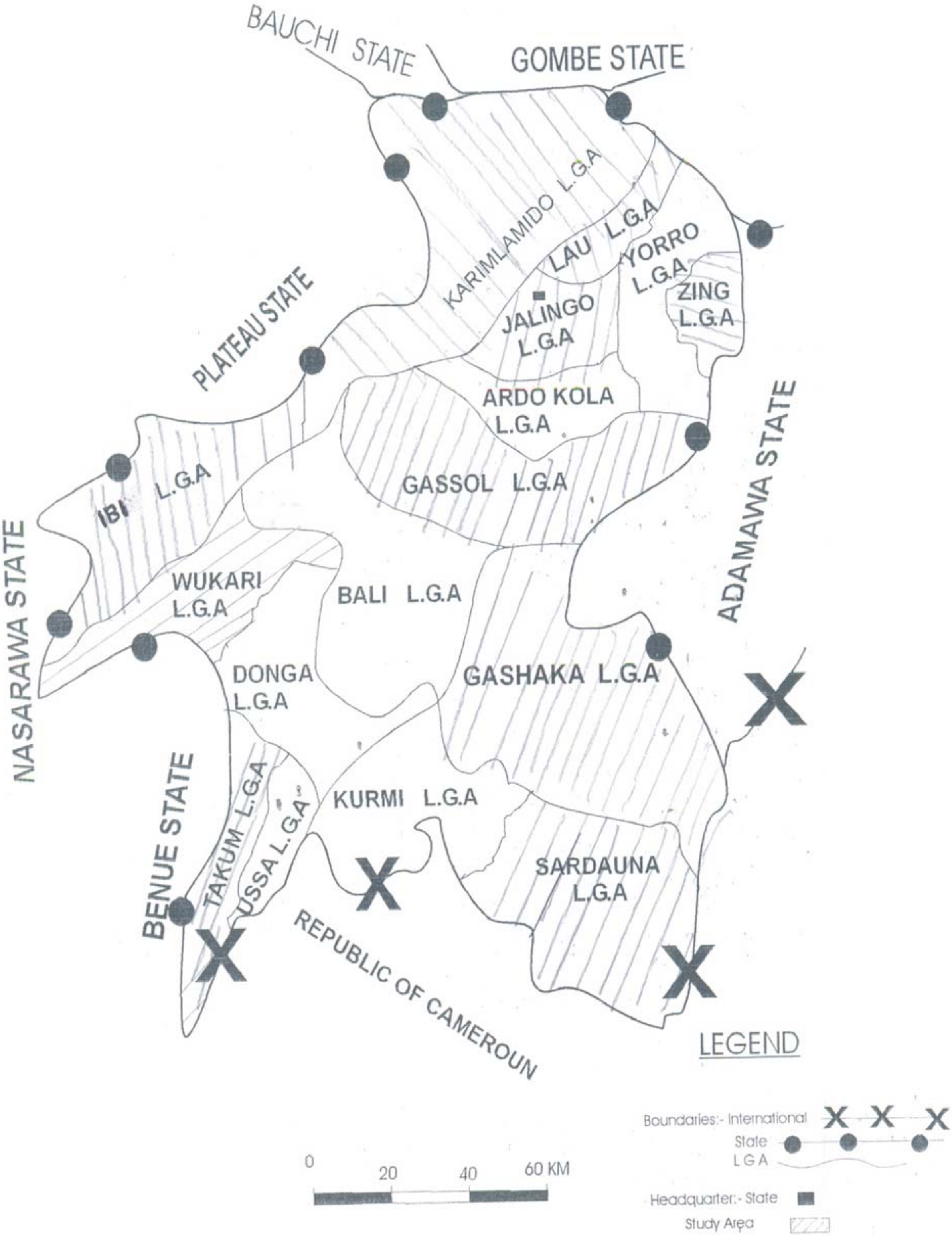

FIGURE 3.2 A map of Taraba State showing the study areas

Taraba State is located at the North Eastern part of Nigeria. It lies between latitude 6^0 30′ and 8^0 30′ North of the equator and between 9^0 and 12′ East of the Greenwitch Meridian. It shares boundaries with Bauchi and Gombe States in the North, Adamawa State in the East, and the Republic of Cameroon in the South. The state is bounded along its western side by Plateau, Nassarawa and Benue States and is divided into sixteen local government areas (Fig 3.2). The state has a land area of 54, 4261 km^2. (Adebayo, 2001)

The dry and rainy season common to tropical regions are also the dominant climatic features in Taraba State. The rainy season starts in April and ends in October while the dry seasons begins in November and terminate in March. The dry season reaches its peak in January and February when the dusty North East trade winds blow across the State. The vegetation of the State comprises three types of vegetational zones namely the guinea savannah, which is marked by mainly forest and tall grass found in the Southern part of the State like Wukari, Takum, Donga, the sub-Sudan type characterized by short grasses found in Jalingo, Lau Ardo-Kola, interspersed with short trees, while the semi-temperate zone, are marked by Luxuriant pasture and short trees found in the Mambilla Plateau. The population of Taraba State as recorded in 2006 population census was 2,300,736 as shown in Table 3.1 which also shows the grouping of local government areas into senatorial zones.

Table 3.1: Taraba State Population recorded in 2006 Census

S/N	L.G.A (a) Northern Senatorial Zone	Population	Male	Female
1	Jalingo	139845	77425	62420
2	Yorro	89410	45548	43862
3	Zing	127363	64602	62761
4	Ardo Kola	86921	44020	42901
5	Karim-Lamido	195844	99513	96331
6	Lau	96590	51859	4731
	(b) Southern Senatorial Zone			
1	Wukari	241546	124635	116911
2	Takum	135349	68863	66486
3	Donga	134111	68267	65844
4	Ibi	84054	45350	38704
5	Ussa	92017	50790	41227
	(c) Central Senatorial Zone			
1	Bali	208935	112014	96921
2	Sardauna	224437	113185	111252
3	Gassol	244749	125293	119456
4	Kurimi	91531	49188	42343
5	Gashaka	87781	48911	38870
Total		**2300736**	**1199849**	**1100887**

The Taraba State Government fully conscious of the role industrialization can play in the overall development of the state, has spared no effort in aggressively developing its industrial base by the establishment of such industries as the Taraba Gas Company. The Government also, in liason with the Federal Government and foreign business is embarking on the construction of the multibillion dollar Mambilla Plateau hydro-electric project which when completed will service the energy needs of the country and even beyond.

3.2 Materials and Methodology

The energy consumption survey was carried out in ten local government areas of Taraba State between the period of October 2007 and December 2008. The survey was carried out by the help of a carefully designed questionnaire (Appendix iv). A total of 2,000 copies of the questionnaire were distributed with 200 copies for each of the local government areas. The questionnaire consists of three sections and sought information on both the person, the material use for a particular energy source, the quantity used per week or month and the current energy prices of kerosene, gas, electricity, biomass, charcoal and firewood per kilograms was determined. The monthly bills were the basis for estimating electricity consumption. Data on other fuels, households were asked how much of each they consume in a day and each figure thereafter used in elevating their weekly or monthly equivalent values. The end–use energy values for fuel wood, biomass, kerosene, natural gas and charcoal was utilized. The average weight of a bundle of firewood, a bag of biomass, a bag of charcoal and value of gas and kerosene as purchased by households for cooking, lighting, heating and other domestic use were ascertained by spot assessment. The survey covers four local government areas in the Northern Senatorial Zone and three local government areas in each of the Southern and Central Senatorial Zones covering a total of ten local government areas namely: Jalingo, Zing, Lau, Karim Lamido, Gassol, Gashaka, Sardauna, Wukari, Takum and Ibi. The technique utilized in this study was the sampling technique. The samples collected from urban (Jalingo, Wukari, Takum, Sardauna), semi–urban (zing, Gassol, Gashaka) and Lau, Karim-Lamido, Ibi rural settlements were analyzed separately.

A sample of two towns in each of the ten local government areas was selected for the study that was made. These are Jalingo: Jalingo and Mayo Dasa, Lau: Lau and Garin Dogo, Zing: Zing and Yakoko, Karim-Lamido: Karim-Lamido and Jen Pettel, Gassol: Mutum Biyu and Tella, Gashaka: Serti and Jamtari, Sardauna: Gembu and Nguroje, Wukari: Wukari and Bantaji, Ibi: Ibi and Gindin Waya and Takum: Takum and Kwarnbai village. The population samples as a respondent for the carefully structured questionnaire was used to allow us clearly observe the energy consumption trend for households residing in urban, semi-urban and rural settings of the state. Also this approach was used in order to see whether there is a shift to the use of alternative energy sources as we move from rural towards urban setting.

A total of 2,000 household heads, were randomly sampled and interviewed using the questionnaire. The data collected were carefully analyzed using the frequency and percentage distribution tables. The selected commonly wood species and other fuel energy collected at different sites widely spread across Taraba State and it's environment were Prosopis Africana (Kirya in Hausa), Terminalia Ivoreasis (Boushe in Hausa), charcoal and kerosene. Other materials used include axe or cutlass, fabricated metallic stove, a small standard aluminum pot, physical weighing balance, thermometer (max-range 100^{o}C), stop clock, measuring cylinder, clean water and a lighter.

The experiments involved cooking tests: Water Boiling Test (WBT) to determine the amount of energy utilized. Here the mass of fuel energy samples consumed and the time taken to heat a specified quantity of water to local boiling point were determined. The water was heated in a small standard aluminum pot on a fabricated metal fuel wood, kerosene and charcoal stove under condition of uncontrolled combustion on typical of a normal kitchen situation in the study areas. The initial temperature of water and time taken to boil were recorded under normal changing environmental conditions in the kitchen throughout the experiment for the samples. The observed local boiling point of water was measured when the thermometer was positioned in the center 5 cm above the pot bottom. The maximum and minimum temperatures were recorded over a 2 minute period at full boil 5 times. The averaged maximum and minimum observed temperature calculated was T_b (obs)=98.6 ºC. The theoretical local boiling point was determined using equation 1 (page 13). For where the experiment was carried out, h =186 meters (Adebayo, 2001) giving T_b(theo)=99.38ºC. The difference between the T_b(obs) and T_b(theo) =0.78ºC. This difference may be due to minor inaccuracies in the thermometer and weather conditions. Some useful physical constants and properties of some substances listed (Appendices i-iii) in the thesis were used in calculations which may also be useful for interested readers.

3.3 Data Collection

Some data for the study were collected by means of questionnaire. The administration and retrieval of the questionnaire was achieved through direct personal contact with the respondent. The questionnaire begins with the preliminary section entitled general information, which was designed to collect information about the respondent's social status, academic status, occupation, place of work and other personal data that may be useful in this study.

The simple common wood species (Kirya and Boushe), charcoal and kerosene used in this investigation were obtained in Taraba State and environment. Rob et al (2007) reported that in 1985 VITA said that in order to minimize the variation that is potentially introduced by variations in fuel characteristics (type and size), only wood and charcoal that have been thoroughly air-dried were used. The fuel wood species were cut in the dimension of (breadth (2 cm)×width(2 cm)×height(25 cm) and stored in a way that allows air to circulate through it. These were kept for a period of thirteen months to ensure total air-dried. Subsequent weighing of the wood species and charcoal was done until a constant mass was obtained to ensure that it is completely moisture free.

CHAPTER FOUR

DATA ANALYSIS, RESULTS AND DISCUSSION

4.1 Data Analysis.

A statistical percentage and frequency distribution tally was used in analyzing the collected data in the study. The percentage fuel source graph was used to determine which energy sources the respondents mostly utilized. The percentage frequency table shows clearly, responses to the various questions raised in the sections (ACB) of the questionnaire by people in their respective areas. This statistical method has proved to be reliable as used by Alabe (1995) and Hassan (2006).

In this section, the specific energy consumption of households per month for rural, semi-urban and urban areas of Taraba state are presented along with their energy equivalent in Gigajoules (GJ) (Table 4.8). Results obtained from the questionnaire distributed were discussed based on Tables 4.1 - 4.9e presented. These are also compared with similar ones done by Umaru and Wamakko (1999) and Hassan (2006). Some bar charts of domestic energy consumption patterns are also presented as shown in fig. 4.1, fig 4.2 and fig 4.3.

Evaluation of energy utilization and thermal efficiency of some commonly used fuel energy was carried out. In this study, since T_b(theo) = 99.38 ^{o}C and considering the effect of altitude at the place of experiment it is close to the normal boiling point of water, 100ºC is used in calculations. Here the energy utilized E_u from fuel energy combustion was calculated based on the mass of fuel energy consumed (M) and the mass of evaporated water (m_2) as observed in the (WBT) whereby the initial temperature (t) and the initial mass of water (m_1) were 24° C and 1.05 kg respectively. The fuel energy consumed per unit time taken (T_{100}) from ignition to the boiling point of Water was computed. Here the initial and final mass of fuel energy was considered respectively. Table 4.9f presents results of mass of evaporated water and fuel energy consumed for the WBT. Variations between fuel energy types and the time taken for water to start boiling (T_{100}) shows that Kerosene took longer time than Kirya, charcoal and Boushe respectively. The energy utilized E_u was computed using the thermodynamic relation in Equation 7 (Page 15) for the fuel wood species, charcoal and kerosene respectively.

The thermal efficiency η_T, which is the ratio of the work done by heating and evaporating water to the energy consumed by burning a specific quantity (kg) of fuel energy type in the WBT was computed based on the expression in equation 9 (page 15).The denominator of the ratio is determined by taking the product of the fuel type consumed and the lower heating value (LHV). The result is shown in Table 4.9f_1. Similarly, Table 4.9f_2 shows the percentage heat utilized (PHU) and hence the rate of heat utilization (RE_u) or burning rate in the cooking experiment. The η_T of kerosene is lower than those of Kirya, Charcoal and Boushe.

4.2 Discussion of Results

Table 4.1 shows the socio economic characteristics of respondents. The result obtained revealed that most of them (43%) were between the ages of 31-40 yrs while those who were 50 or more years formed the least population. Also majority of the respondents were those from monopoly type of family (92%) and were predominantly male (88%). In addition, a large population (77%) was observed to possess one level of western education or the other. About 54% was found to be civil servant while 26% and 20% were found to be farmers (subsistence farmers) and businessmen (small scale) respectively. The results further revealed that only 9% are high income earners (GL. 13 and above). In fact, most of the respondents (76%) were low income earners (GL 1-6). However, people who earn high income are more likely to use alternative fuel sources in preparing their meals. For example, Bayero et al (1993) found that consumption of a particular type of energy source is positively related to family size, educational level and income. As income increases, household may substitute fuel wood for other more modern energy sources like kerosene, gas and electricity. However, it should be noted that rise in income does not show an increase in enlightenment as regards to benefits and uses of alternative source of energy (Alabe, 1995). Moreover, fuel wood is cheaper (a bundle fuel wood cost N100) and can cook three days meal for an average family(size of seven) than the other alternatives, so any increase in income of the consumer may only make him extend his use of fuel wood to areas he would not afford hitherto. Furthermore, in Taraba State the medium and high income earners are very much willing to adopt the use of alternative energy sources so long as they can be made efficient, reliable, affordable and sustainable. But reverse is the case for farmers and the low income earners who are still hesitant in changing from the traditional energy (fuel wood) to other alternative sources. This is quite different from the finding of Umaru and Wamakkco (1999) in Sokoto metropolis.

Table 4.1 Socio-economic characteristics of respondents

Attributes	Location	Age range < 30	Age range 31 – 40	Age range 41 – 50	Age range > 50	Total Resp.
	Jalingo	96	44	34	21	195
	Zing	63	58	51	28	200
	Lau	71	60	56	13	200
	K. Lamido	58	102	30	7	197
	Gashaka	39	110	29	22	200
	Gassol	46	80	54	16	196
	Sardauna	36	116	27	19	198
	Wukari	30	120	21	18	189
	Takum	28	113	41	11	193
	Ibi	88	48	36	23	195
	Total	**555**	**851**	**379**	**178**	**1963**
	%	**29%**	**43%**	**19%**	**9%**	**100%**
Family type	**Location**	**Mono**	**Poly**	**Total**		
	Jalingo	192	3	195		
	Zing	190	10	200		
	Lau	170	30	200		
	K. Lamido	155	42	197		
	Gashaka	185	15	200		
	Gassol	171	25	196		
	Sardauna	178	20	198		
	Wukari	181	8	189		
	Takum	190	3	193		
	Ibi	188	7	195		
	Total	**1800**	**163**	**1963**		
	%	**92%**	**8%**	**100%**		
Gender	**Location**	**Male**	**Female**	**Total**		
	Jalingo	152	43	195		
	Zing	162	38	200		
	Lau	169	31	200		
	K. Lamido	177	20	197		
	Gashaka	181	19	200		
	Gassol	184	12	196		
	Sardauna	190	8	198		
	Wukari	153	36	189		
	Takum	172	21	193		
	Ibi	185	10	195		
	Total	**1725**	**238**	**1963**		
	%	**88%**	**12%**	**100%**		

Table 4.1 Continues

Ed. Level	Location	Non	Primary Ed	Secondary Ed	Tartiary	Total
	Jalingo	20	69	32	74	195
	Zing	44	75	33	48	200
	Lau	77	73	26	24	200
	K. Lamido	80	42	61	14	197
	Gashaka	57	81	36	26	200
	Gassol	93	40	56	7	196
	Sardauna	33	73	55	37	198
	Wukari	15	39	67	68	189
	Takum	16	55	81	41	193
	Ibi	23	100	54	18	195
	Total	**458**	**647**	**501**	**357**	**1963**
	%	**23%**	**33%**	**26%**	**18%**	**100%**
Level of Income	**Location**	**Low**	**Medium**	**High**	**Total**	
	Jalingo	84	65	46	195	
	Zing	142	38	20	200	
	Lau	161	23	16	200	
	K. Lamido	179	11	7	197	
	Gashaka	138	34	28	200	
	Gassol	170	22	4	196	
	Sardauna	168	19	11	198	
	Wukari	140	30	19	189	
	Takum	156	20	17	193	
	Ibi	159	28	8	195	
	Total	**1497**	**290**	**176**	**1963**	
	%	**76%**	**15%**	**9%**	**100%**	
Occupation	**Location**	**Civil**	**Farmer**	**B/men**	**Total**	
	Jalingo	27	122	46	195	
	Zing	97	68	35	200	
	Lau	138	40	22	200	
	K. Lamido	145	38	14	197	
	Gashaka	129	48	23	200	
	Gassol	110	26	60	196	
	Sardauna	123	47	28	198	
	Wukari	67	40	82	189	
	Takum	114	53	26	193	
	Ibi	115	37	43	195	
	Total	**1065**	**519**	**379**	**1963**	
	%	**54%**	**26%**	**20%**	**100%**	

Low income N6, 500 – N10, 000 (GL 1-6)

Medium income N21, 000 – N28, 000 (GL 7-12)

High income N60, 000 – N150, 000 (GL 13 and above)

Table 4.2 Energy source per activity for fuel wood

Location	Cooking	Heating	Lighting	Total
Jalingo	128	16	0	144
Zing	171	23	0	194
Lau	188	10	0	198
K. Lamido	150	43	0	193
Gashaka	179	13	0	192
Gassol	165	18	0	183
Sardauna	162	17	0	179
Wukari	153	9	0	162
Takum	138	5	0	143
Ibi	168	16	0	184
Total	**1602**	**180**	**0**	**1782**
%	**90%**	**10%**	**0%**	**100%**

Table 4.3 Energy source per activity for kerosene

Location	Cooking	Heating	Lighting	Total
Jalingo	41	37	29	107
Zing	20	30	4	54
Lau	9	12	174	195
K. Lamido	6	0	158	164
Gashaka	11	22	142	175
Gassol	5	0	170	175
Sardauna	8	9	163	180
Wukari	21	34	96	151
Takum	17	20	18	55
Ibi	4	26	79	109
Total	**142**	**190**	**1033**	**1365**
%	**10%**	**14%**	**76%**	**100%**

Table 4.4 Energy source per activity for gas

Location	Cooking	Heating	Lighting	Total
Jalingo	8	0	0	8
Zing	0	0	0	0
Lau	0	0	0	0
K.. Lamido	0	0	0	0
Gashaka	0	0	0	0
Gassol	0	0	0	0
Sardauna	0	0	0	0
Wukari	2	0	0	2
Takum	4	0	0	4
Ibi	0	0	0	0
Total	**14**	**0**	**0**	**14**
%	**100%**	**0%**	**0%**	**100%**

Table 4.5 Energy source per activity for Electricity

Location	Cooking	Heating	Lighting	Total
Jalingo	1	50	145	196
Zing	0	0	82	82
Lau	0	0	0	0
K. Lamido	0	0	0	0
Gashaka	0	19	10	29
Gassol	0	0	0	0
Sarduna	0	30	5	35
Wukari	0	49	149	198
Takum	0	62	121	183
Ibi	0	38	152	190
Total	**1**	**248**	**664**	**913**
%	**1%**	**26%**	**73%**	**100%**

Table 4.6 Energy source per activity for Charcoal

Location	Cooking	Heating	Lighting	Total
Jalingo	15	19	0	34
Zing	2	45	0	47
Lau	10	9	0	19
K. Lamido	0	31	0	31
Gashaka	0	14	0	14
Gassol	0	26	0	26
Sardauna	4	30	0	34
Wukari	3	19	0	22
Takum	8	15	0	23
Ibi	6	28	0	34
Total	**48**	**236**	**0**	**284**
%	**17%**	**83%**	**0%**	**100%**

Table 4.7 Energy source per activity for Biomass

Location	Cooking	Heating	Lighting	Total
Jalingo	0	0	0	0
Zing	0	0	0	0
Lau	0	0	0	0
K. Lamido	0	0	0	0
Gashaka	0	0	0	0
Gassol	0	0	0	0
Sardauna	0	0	0	0
Wukari	0	0	0	0
Takum	0	0	0	0
Ibi	0	0	0	0
Total	**0**	**0**	**0**	**0**
%	**0%**	**0%**	**0%**	**0%**

Table 4.8 Energy sources consumption/month/household

Location	Electricity	Fuel wood	Kerosene	Charcoal	Gas
Jalingo	875	241.28	14.80	33.6	18.52
Zing	25.0	138.8	9.86	20.16	0.0
Lau	0.0	138.4	3.28	16.8	0.0
K. Lamido	0.0	152.24	6.41	11.76	0.0
Gashaka	0.0	189.28	11.59	10.08	0.0
Gassol	0.0	133.12	4.93	8.4	0.0
Sarduna	180	124.8	8.22	16.80	0.0
Wukari	500	141.96	11.22	13.44	13.8
Takum	687.5	223.6	13.152	26.88	15.92
Ibi	187.5	226.72	6.58	21.84	0.0

Table 4.8 is not good enough or sufficient for comparative consumption of energy, per month per household since the respondents in rural-areas do not spend their income on all the sources of energy. Therefore, in this case, Jalingo being the state capital where the respondents spend on all energy sources is considered (Table 4.9).

Table 4.9 Cost Comparative table for Jalingo

Energy source	Unit cost/kg	Average monthly cost
Fuel wood	N6.15	N1483.87
Kerosene	N143.25	N2120.10
Charcoal	N20.00	N672.00
Gases	N116.34	N2153.81
Biomass	0.00	0.00
Electricity	N4.00 - N6.00 (kw/h)	N1518.00

Table 4.9 indicates a cost comparative figure on the different energy options that are surveyed for Jalingo metropolis. In Jalingo the study revealed that kerosene and gas are the most expensive than the other energy sources. For a low income earner (GL. 1-6) that uses fuel wood, kerosene, charcoal, gases and electricity at a time for instance will have to spend about 19%, 27%, 9%, 29% and 19% of his income on energy consumption whenever he chooses to use any of the options. A medium-income (GL 7-12) making the same choice will have to spend about 6%, 9%, 3%, 9% and 6% respectively. For the high-income earner, the percentage goes lower irrespective of whatever choice of energy option he uses. A similar lead is obtained for other locations like Zing, Lau, Wukari, Takum etc.

4.3 Energy use per activity by respondent

From the survey results, it was observed that in the urban, semi-urban and rural areas of Taraba State, approximately 82% of population uses fuel wood, 7% uses kerosene, 1% gas, 2% uses charcoal and 1% electricity respectively for their domestic activities. The survey revealed that biomass is not been used in domestic activities. It was further observed that most respondents (89%) use fuel wood for cooking while only 11% use it for heating. The results revealed that none use fuel wood for lighting. (This percentage are calculated from the raw data presented in Tables 4.2 - 4.7)

Kerosene consumption on the other hand, was mainly for lighting purposes 76%, cooking 10% and for heating 14%. The low percentage usage in domestic cooking could be attributed to the cost of kerosene (N70 – N80) per liter as pump price and (N120 – N140) per liter in the black markets. Oral interviews conducted in Lau, Karim Lamido, Ibi, Gassol and Gashaka indicate that reasons advanced for the high patronage of fuel wood is that of its availability and affordability. The cost of fuel wood is still within the reach of the low income earners. Kerosene, gas, charcoal were used for cooking in few household as indicated in Tables 4.3, 4.4, 4.5 and 4.6. For instance, only 1 household uses electricity for cooking in Jalingo out of the 195 respondents and none in the other locations (Table 4.5). Respondents in Jalingo, Takum and Wukari uses it for heating compared to the usage of fuel wood in Table 4.2. Heating in the context of this research refers to the use of the five energy sources for the purpose of warming a room, boiling water or drying of some household items.

From the survey results, gas consumption is highly restricted to the educated class/the high-income earner categories of respondents in the sample areas. This is because of the delicate nature of using natural gas which is highly inflammable and also lack of awareness. The survey shows that gas consumption in all the sampled area of study was used for cooking only. The main reasons for the low number of respondents using gas was that of safety, availability and affordability i.e. its high cost and its state of being inflammable. As indicated in table 4.4, none of the respondents uses gas for heating and lighting. Some of the reasons for the use of gas in domestic cooking are; it is clean, cooks faster (efficient) and apparently less heat waste in the course of cooking.

Electricity a popular source of energy used mainly for lighting 73%, cooking 1% and heating 26% (Table 4.5). The study revealed that in the semi-urban (Zing. Gashaka, Sardauna, and Ibi) no respondents' uses electricity for domestic cooking and heating and in the rural areas (Lau, Gassol & Karm-Lamido) there was no electricity supply. However, findings from the study conducted by Umaru and Wamakko (1999) in Sokoto metropolis indicate a similar trend between 1992 and 1993. This means that none of the respondents was using electricity for cooking in the periods mentioned. The study further revealed that in Jalingo metropolis the average monthly electricity consumption for households stands at 875 kw/h (approximately N4812.5) PHCN, 2008, being and urban centre. The semi-urban (Zing, Gashaka, Sarduna, Ibi) has a monthly average consumption of about 130.83 kw/h (N719.6) (Lau, Gassol, Karim-Lamido) which is a typical rural areas do not spend their income on electricity due to lack of unavailability of power supply.

The low patronage of electricity in a semi-urban center compared to urban was attributed to the epileptic nature of power supply in the zone. The high electrical consumption in Jalingo may not be far from the fact that it is a state capital while Wukari and Takum are local government headquarters.

Nigeria has over 500 MW of generating capacity and its total national demand is less than 300 MW. However, supply is irregular because of lack of spare parts and absence of a good maintenance culture among other things (Alabe, 1988). It was also observed that a lot of power is wasted in the course of transmission from the site of production to the point of usage. In fact, this has been the major problem of power loses. This trend coupled with high distribution costs has restricted the use of electricity to most urban centers in Nigeria (Alabe, 1995).

Energy Consumption Pattern of Households

Table 4.9a: Energy Source per Activity: Cooking

Fuel Wood	Kerosene	Charcoal	Gas	Electricity	Biomass
82%	7%	2%	1%	1%	0%

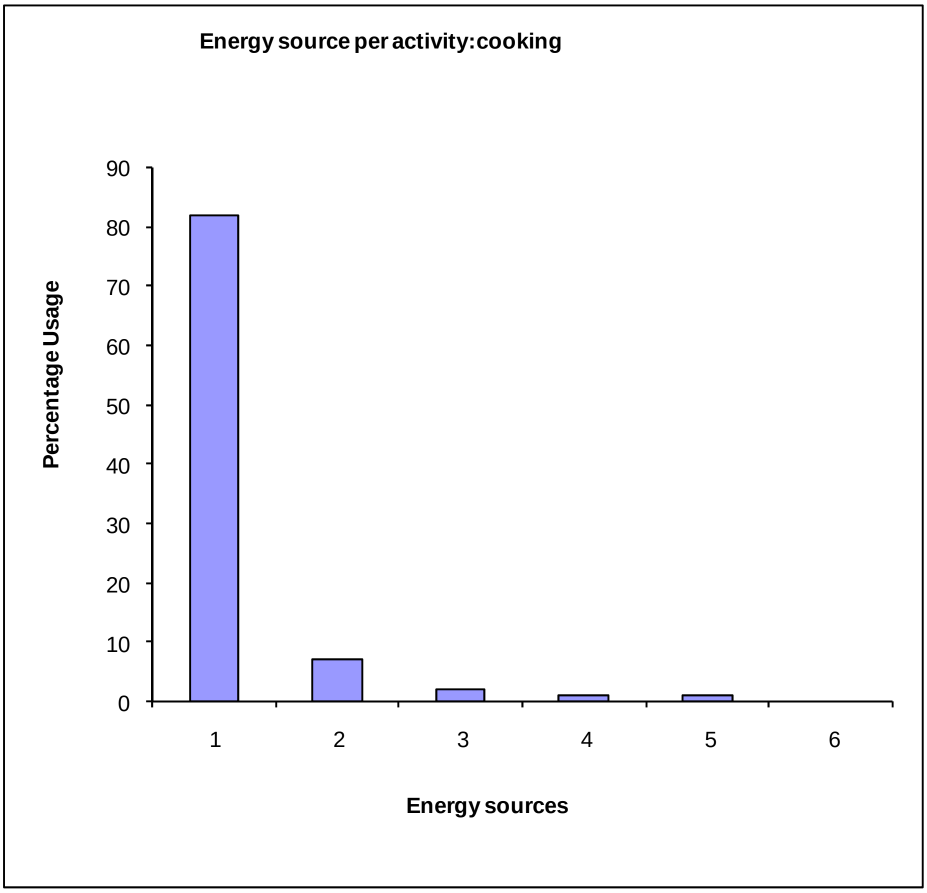

Fig. 4.1: Bar chart of Energy Source per Activity - Cooking of all sampled Households

Legend

Fuel Wood	=	1
Kerosene	=	2
Charcoal	=	3
Gas	=	4
Electricity	=	5
Biomass	=	6

Table 4.9b: Energy Source per Activity: Heating

Fuel Wood	Kerosene	Charcoal	Gas	Electricity	Biomass
11%	14%	81%	0%	2%	0%

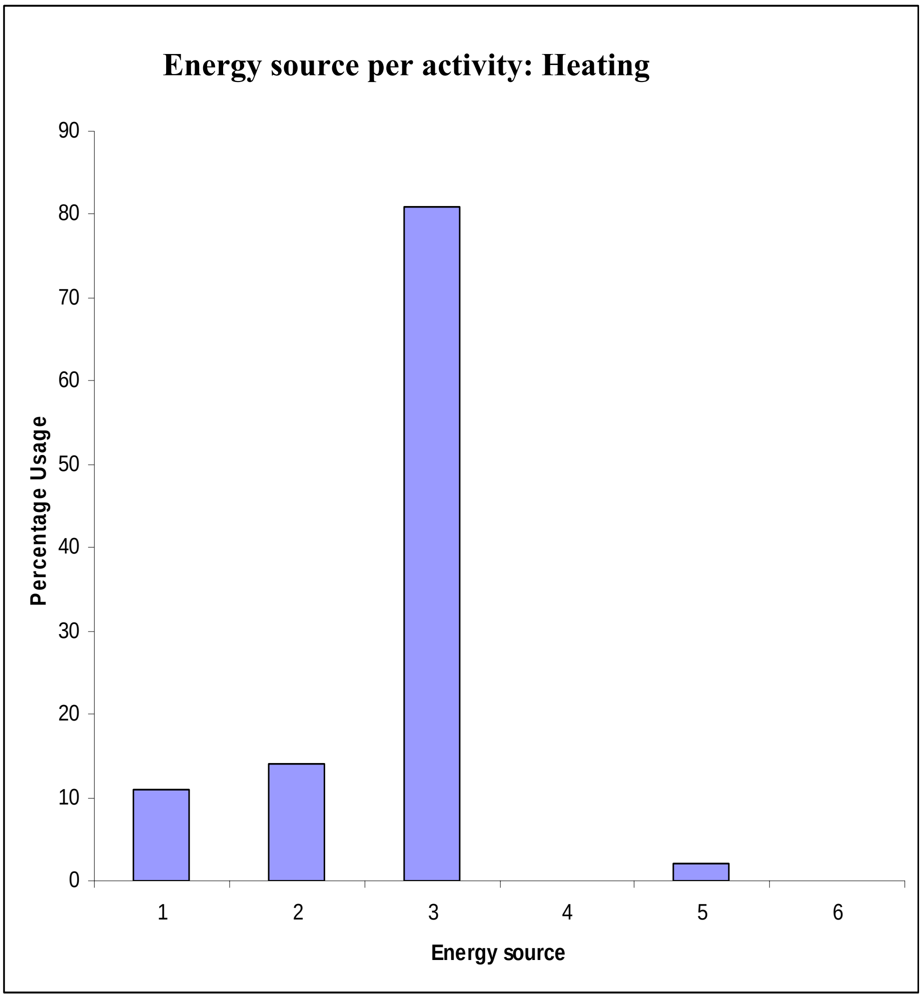

Fig. 4.2 Bar chart of energy source per activity: Heating of all sampled Households

Legend

Fuel Wood = 1
Kerosene = 2
Charcoal = 3
Gas = 4
Electricity = 5
Biomass = 6

Table 4.9c: Energy Source per Activity: Lighting

Fuel Wood	Kerosene	Charcoal	Gas	Electricity	Biomass
0%	76%	0%	0%	73%	0%

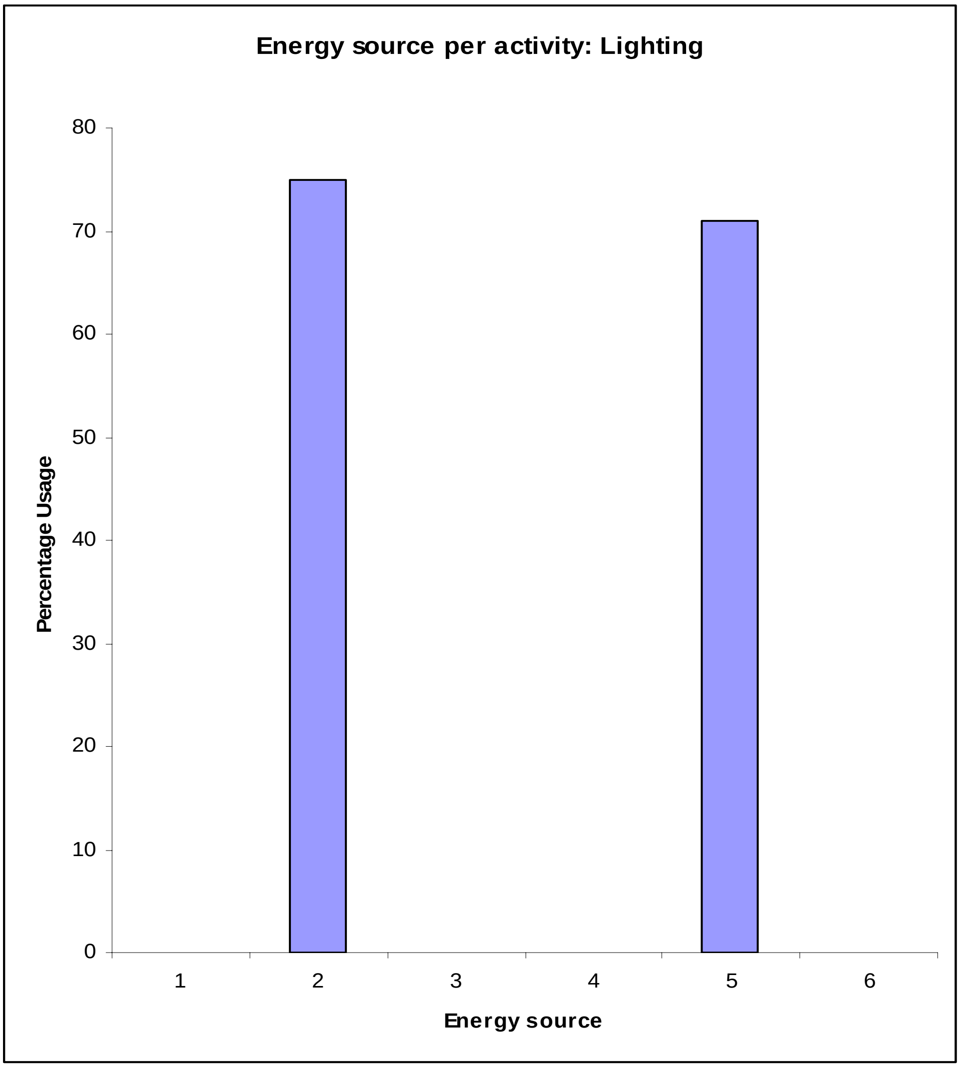

Fig. 4.3: Bar chart of Energy Source per Activity - Lighting of all sampled Households

Legend

Fuel Wood	=	1
Kerosene	=	2
Charcoal	=	3
Gas	=	4
Electricity	=	5
Biomass	=	6

Table 4.9a – 4.9c are sited from the data earlier presented in tables 4.2 – 4.7 which actually indicate the energy used per activity for the various energy being studied in this research work. Their resultant bar charts are indicated under each (Fig 4.1–4.3). In fig 4.1, we clearly see how the consumption of fuel wood dwarfed all other energy sources in their pattern of consumption by households in Taraba State. The Energy source per activity indicated on fig 4.1 for cooking by households, gas and electricity tops the list with 1% each (though limited to high income group) followed by charcoal, kerosene and fuel wood 2%, 7% and 82% while biomass was at 0% consumption. This does not necessarily mean that it is not being consumed in Taraba State, but rather those using this type of energy sources have inadvertently not been sampled in this study. For lighting operations by households, kerosene is in the forefront with 76% followed by electricity with 73% while other energy sources are not being used for lighting.

4.4 Energy options preferred by Respondents

In order to determine the significance of relationship between energy options preferred and the location of respondents, the chi-square test of significance was calculated for respondent's energy preference in the area studied.

Table 4.9d Chi-Square values for Energy options preferred by Respondents

	Energy sources						
Location	**Fuel wood**	**Kerosene**	**Charcoal**	**Gas**	**Electric**	**Total**	χ^2
Jalingo	10	5	9	3	168	195	194.75**
Zing	60	20	36	1	83	200	135.61**
Lau	139	41	0	0	20	200	139.2**
K. Lamido	160	10	0	8	19	197	108.9**
Gashaka	138	17	0	1	44	200	78.2**
Gassol	162	28	0	1	5	196	137.6**
Sardauna	96	20	14	0	68	198	6.73*
Wukari	35	5	10	1	138	189	100.5**
Takum	20	9	11	3	150	193	218.6**
Ibi	99	14	7	28	47	195	165.72**
Total	**919**	**169**	**87**	**46**	**742**	**1963**	

χ^2 = Value (P = 0.05) = 55.758: df = 36

* = Not significant

** = Significant

Results in Table 4.9d shows the calculated value of χ^2 at level of significance, P = 0.05 for the survey areas. This results shows that there is significant relationship in the choice of energy options in Jalingo, Zing, Lau, Karim Lamido, Gashaka, Gassol, Wukari, Takum and Ibi since the calculated value of χ^2 is greater than the critical value. However, there is no significant relationship between location of respondents and their preferred energy options in Sardauna, because the calculated value of χ^2 is less than the critical value.

Based on results of Table 4.9d which indicate that there is significant relation between preferred energy options, and location for the surveyed areas and bearing in mind that this is a combination of urban, semi-urban and rural communities, findings of Alabe (1995) and Hassan (2006) that fuel wood seems to be the major source of energy in both rural and urban areas agrees with the results of this study.

4.5 Reasons for change in preference of Energy options

To determine the level of significance of relationship between reasons for change in energy preference and location of respondents, the chi-square test of significance was calculated for respondent's reasons for change in preference for energy options in the survey areas.

Reasons for change in preference of energy options include availability, affordability, safety and efficiency (table 4.9e).

Table 4.9e Chi-Square values for Reasons for change in preference of Energy Use

Locations	Reasons				Total	χ^2
	Availability	Affordability	Safety	Efficiency		
Jalingo	116	58	9	12	195	45.86**
Zing	121	36	13	30	200	1.63*
Lau	108	30	12	50	200	13.98*
K. Lamido	131	26	10	30	197	0.72*
Gashaka	120	27	17	36	200	6.68*
Gassol	110	26	8	52	196	22.0*
Sardauna	151	23	10	14	198	14.62*
Wukari	128	21	18	22	189	11.56*
Takum	128	41	8	16	193	10.4*
Ibi	145	18	3	29	195	13.74*
Total	1258	306	108	291	1963	

$\chi^2 =$ Value (P = 0.05) = 40.12, df 27

* Not significant,

** Significant

4.6 Evaluation of Energy utilization and thermal efficiency of some common fuel energy used in Taraba State

The WBT gave the energy utilized E_u (MJ kg^{-1}) for fuel energy types; Fuel wood species (Kirya & Boushe), charcoal and kerosene with corresponding ratios 0.673: 0.447: 0.559 (Table 4.9f_2) whereas thermal efficiency η (%) in the ratio 12.420, 9.010, 8.950, 7.806 (Table 4.9f_1).

Table 4.9f: Mass of fuel energy consumed and evaporated water during the WBT

Type of Fuel Energy	Mass of fuel energy consumed (kg)			Mass of water loss (kg)			T_{100} (min)
	Initial	Final	Difference	Initial	Final	Difference	
Kirya	0.84	0.55	0.29	1.05	0.9	0.15	18.00
Boushe	0.84	0.65	0.19	1.05	1.0	0.05	6.56
Charcoal	0.84	0.80	0.04	1.05	0.98	0.07	16.21
Kerosene	0.84	0.695	0.145	1.05	0.95	1.00	18.21

Table 4.9f_1: Energy utilized and thermal efficiency

Type of Fuel Energy	Mass of Fuel Consumed (kg)	Mass energy ($MJkg^{-1}$)			Thermal efficiency η (%)	T_{100} (min)
		Water Loss	Supplied	Utilized		
Kirya	0.29	0.15	5.417	0.673	12.420	18.00
Boushe	0.19	0.05	3.549	0.447	9.010	6.56
Charcoal	0.04	0.07	1.028	0.492	8.950	16.21
Kerosene	0.145	1.00	6.270	0.559	7.806	18.21

Table 4.9f_2: Percentage and Rate of Heat Utilized

Fuel Energy burnt	Heat Energy ($MJkg^{-1}$)			Percentage Heat (%)		SC	T_{100} (mins)	Rate of burning ($Jkgs^{-1}$) $\times 10^{-4}$
	E_u	E_L	E_s	PHU	PHL			
Kirya	0.673	4.744	5.417	12.417	87.58	1.933	18.00	2.60
Boushe	0.447	3.102	3.549	9.010	90.99	3.800	6.56	4.80
Charcoal	0.492	0.536	1.028	8.950	91.050	0.500	16.00	4.10
Kerosene	0.559	5.711	6.270	7.806	92.194	0.200	18.21	1.30

The mean thermal efficiency η_T (%) 9.547 (Table 4.9f$_2$) of the fuel energy type is directly related to the average Percentage Heat Utilized (PHU) by the fuel energy stove. A fuel energy characteristic plays an important role in terms of desirability of the fuel wood species or types of fuel energy for cooking requirement and hence, a Desirability Rating Index (DRI) can be decided at a glance using the following concept deduced from this study.

η_T is directly related to RE_u, PHU, where

M_1 = mass of the fuel energy consumed (in kg)

E_u = heat energy utilized in the cooking (JKg^{-1}),

RE_u = rate of energy utilization or rate of burning (JKg^{-1}) per unit cooking time.

SC = specific heat consumption of the fuel energy

PHL = percentage heat lost

η_T = thermal efficiency of the fuel energy.

For the purpose of the fuel energy efficiency and energy conservation, this concept may serve as a good DRI criterion for experimental and modeling purposes. For example, the slightly higher value E_U exhibited by Kirya (wood species) in the WBT compared to Boushe (wood specie), charcoal and kerosene gives it a special character as the most desirable fuel energy for cooking a meal that required longer cooking time coupled with low energy input. Fuel wood species type Boushe, may be preferred if cooking of meals must be done quickly. The kitchen performance test result as shown in the table 4.9f$_2$ also indicated that Kirya and Boushe perform better in practical test than the rest of the fuel energy types considered. The higher the PHU, the better also the fuel.

Fuel wood seems to be the major sources of fuel in Taraba state. This is because of its availability and affordability. The other sources of energy, kerosene, charcoal, gas and electricity are not readily available due to inadequate supply whereas biomass and charcoal are readily used for domestic activities. However, with enlightenment the trend might change. The fears of danger associated with the use of natural gas and its resultant cost scare people away from patronizing it. Also the recent privatization of the downstream sector of the petroleum industry has made kerosene out of reach for the community. As at present, the pump price is between N80 – N100 per liter (2008) and can be as high as N140:00 per litre in the black markets. Power supply from power holding company of Nigeria (PHCN) since 1999 – 2008 has been so epileptic and exorbitant; bills are sent to customers at the end of every month. This was the same reason why most respondents do not use electricity for domestic cooking and heating but rather prefer to use fuel wood since it is available and affordable.

The survey further revealed that most respondents are aware of the negative environmental effects of falling trees and are willing to adopt fuel wood substitutes. However, household choices of fuel are affected by availability and affordability even among the high income earners in Taraba State.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The study has revealed that wide ranges of energy sources were utilized by the respondents with some of them switching from one source to the other during the study period (October 2007 – December 2008). It is obvious that no state/nation can develop economically without giving due attention to its energy consumption and supplying pattern (World bank/UNDP 1983). The consumption pattern of these surveyed energy sources are almost the same in house of civil servants as well as of those of farmers.

A relationship was also observed between education and family size on one hand and energy sources utilized on the other. Respondents who were not educated but having polygamous families had greater affinity for fuel wood than other sources. Conversely, kerosene and gas were mostly consumed by those who were educated and having monogamy families. The energy options preferred by most respondents in Taraba state are fuel wood, electricity and kerosene while the energy source that is predominantly used for cooking is fuel wood and it cuts across both income levels and educational status.

Number of characteristics namely; mass of the fuel wood type, rate of utilization, energy lost and initial efficiency of the wood influence the desirability for cooking requirement in Taraba State of Nigeria, they can be decided at a glance from this study. The study reveals that no one fuel wood species (Kirya & Boushe), charcoal and kerosene have all the desirable characteristic of good fuel energy. Fuel wood species that burn quickly and generate heat (energy) more rapidly such as Boushe and fuel energy charcoal may be preferred if cooking must be done quickly for example meals like Kamu, Kosai, etc. while those species or types that burn slowly and generate heat steadily over a longer period (such as Kirya and Kerosene) may be preferred for food which requires longer burning e.g. Tuwon Dawa and Bamta are typical traditional foods among the Mumuye tribes in Taraba State.

From the study, the lower the time spent in cooking, the better the PHU. It is evident that the quantity of fuel wood wasted daily during the cooking activities as a result of heat losses and use of partially-fire tolerant wood species could be reduced if appropriate wood species is used in improved wood burning stoves. One interesting development however, was the desire and willingness shown by most of the respondents to use kerosene if its price and supply were to be improved and stabilized. This will reduce fuel wood consumption, irritating smoke hazards, frequent felling of trees and consequently our forest would be reserved to prevent environmental degradation.

5.2 Recommendations

In the light of the above findings, the followings are recommended.

1. The Taraba State government needs to intensify enlightenment campaigns on the superiority of alternative energy sources over biomass fuel;
2. The state government should as a matter of urgency design an aggressive forestation programme backed up by a strong workable legal framework;
3. A more efficient and improved wood stoves should be promoted, especially in the rural areas where access to fuel such as electricity, gas and kerosene may continue to be a constraint;
4. The state government should intensify advocacy on the use of alternative energy source such as solar, biomass, wind;

5. Women are to be involved in the planning of household energy issues for getting a more realistic scenario of the end users of household energy;
6. Taraba State government and the users is to be advised to encourage the use of biomass fuels such as saw dust, ripe fruit, rice bark etc. because of their high calorific value e.g rice bark (20,500kJ/kg, Garba and Atiku);
7. The State government is advised to set up plantations of the best species of wood consumed. A typical example is prosopis Africana (kirya in Hausa), Terminalia Ivoreasis (Boushe in Hausa);
8. The Taraba State government needs to set up programmers to study the growing rate of these species in order to determine which among them are fast growing so that their plantation could be encouraged;

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APPENDIX I: TABLE OF PHYSICAL CONSTANTS

Table 1: Gross Energy Values (Calorific Values)

FUEL	Kg/g	Btu/Ib
Bagasse	9	4000
Lignite (Brown)	21	-
Coke	28	12100
Wood Green	10	4400
Wood dry	17	7310
Peat Mild	11	4800
Peat sod	14	6200
Bituminous	30	13000
anthracite	34	14500
electricity (UK)	24	10200
Coal Industrial (UK)	28	11800
Oil heavy fuel	43	18400
Oil medium fuel	44	18900
Oil gas/diesel	45	19200
	MJ/m^3	Btu/ft^3
Natural gas	39	1050
Manufacture gas (UK)	19	500
Liquefied petroleum gas	50	21300
	Cal/g	KJ/g
Protein	4.0	17
Fat	9.0	37
Carbohydrate	3.7	16
Ethyl alcohol	7.0	29

*Energy value refers to the quantity of heat or energy developed by the complete combustion of a given weight or volume of fuel. It is some times called as heat value or calorific value.

Table 2: properties of saturated water pressure

P, MPa	T, ^{0} C	u_f	u_g
0.000611	0.01	0.0	2375.3
0.0008	3.8	15.8	2380.5
0.001	7.0	29.3	2385.0
0.0012	9.7	40.6	2388.7
0.0014	12.0	50.3	2391.9
0.0016	14.0	58.9	2394.7
0.0018	15.8	66.5	2397.2
0.002	17.5	73.5	2399.5
0.003	24.1	101.0	2408.5
0.004	29.0	121.4	2415.2
0.006	36.2	151.5	2424.9
0.008	41.5	173.9	2432.1
0.01	45.8	191.8	2437.9
0.012	49.4	206.9	2442.7
0.014	52.6	220.0	2446.9
0.016	55.3	231.5	2450.5
0.018	57.8	241.9	2453.8
0.02	60.1	251.4	2456.7
0.03	69.1	289.2	2468.4
0.04	75.9	317.5	2477.0
0.06	85.9	359.8	2489.6
0.08	93.5	391.6	2498.8
0.1	99.6	417.3	2506.1
0.12	104.8	439.2	2512.1
0.14	109.3	458.2	2517.3
0.16	113.3	475.2	2521.8
0.18	116.9	490.5	2525.9
0.2	120.2	504.5	2529.5
0.3	133.5	561.1	2543.6
0.4	143.6	604.3	2553.6
0.6	158.9	669.9	2567.4
0.8	170.4	720.2	2576.8
1	179.9	761.7	2583.6
1.2	188.0	797.3	2588.8
1.4	195.1	828.7	2592.8
1.6	201.4	856.9	2596.0
1.8	207.2	882.7	2598.4
2	212.4	906.4	2600.3
3	233.9	1004.8	2604.1
4	250.4	1082.3	2602.3
6	275.6	1205.4	2589.7
8	295.1	1305.6	2569.8
9	303.4	1350.5	2557.8
10	311.1	1393.0	2544.4
12	324.8	1472.9	2513.7
14	336.8	1548.6	2476.8
16	347.4	1622.7	2431.8
18	357.1	1698.9	2374.4
20	365.8	1785.6	2293.2
22.088	374.136	2029.6	2029.6

Recalculated from equations given in steam by Keenan, Keyes, Hill, and Moore

(Wiley, 1969, by permission). Engineering Thermodynamics.

Table 3: Properties of Saturated Liquid (Water)

T, ^{0} C	ρ, kg/m^3	C_p , J/chg.	K, W/m.K	
0	1002.28	4.2178 x 10^3	0.552	
20	1000.52	4.1818	0.597	
40	994.59	4.1784	0.628	
60	985.46	4.1843	0.651	
80	974.08	4.1964	0.668	
100	960.63	4.2161	0.680	
120	945.25	4.250	0.685	
140	928.27	4.283	0.684	
160	909.69	4.342	0.680	
180	889.03	4.417	0.675	
200	866.76	4.505	0.665	
220	842.41	4.610	0.652	
240	815.66	4.756	0.635	
260	785.87	4.949	0.611	
280	752.55	5.208	0.580	
300	714.26	5.728	0.540	

Adapted from E.G.G Eckert and R. M. Drake, Analysis of Heat and Mass Transfer, M_cGraw-Hill Book Company, New York, 1972. By Permission. Engineering thermodynamics.

Table 4: Thermal Conductivity Of Aluminum

CONDITIONS		Thermal Conductivity (W/m K)
Temperature (K)	Pressure (Pa)	
1	101325	4110
2	101325	8180
3	101325	12100
4	101325	15700
5	101325	18800
6	101325	21300
7	101325	22900
8	101325	23700
9	101325	23900
10	101325	23500
15	101325	17600
20	101325	11700
30	101325	49500
40	101325	2400
50	101325	1350
60	101325	850
70	101325	585
80	101325	432
90	101325	342
100	101325	302
150	101325	248
200	101325	237
250	101325	235
300	101325	237
350	101325	240
400	101325	240
500	101325	236
600	101325	231
800	101325	218

http:// www. Efunda. Com/materials/elements/TC-Table. Cfin? Element-ID = Al.

Table 5 Properties of Metals

Metal	Temperature (^{0}C)	Density, ρ (kg/m^3)	Heat capacity c_p (kJ/kg K)	Thermal conductivity, k (W/m K)
Aluminum,		2707	0.896	204
pure	20			215
	200			249
	400			35
Lead	20	11373	0.130	29.8
	300			
Iron, pure	20			73
	300	7897	0.452	55
	1000			35
Wrought	20	7849	0.46	59
Carbon steel				
(max. 0.5% C)	20	7833	0.465	54
	20	7753	0.486	36
Carbon steel	400			33
(1.5%)	1200			29
		8954	0.383	12-45
	20			386
Stainless steel	20			369
Copper, pure	300	866	0.343	353
	600			26
Bronze	20	8522	0.385	111
(75%Cu, 25%		10524	0.234	407
Zn)	20	19350	0.134	163
	20			
Brass (70% Cu,	20			
30% Zn)				
Silver, pure				
Tungsten				

Adapted from E. R. G. Eckert and R. M. Drake, Analysis of Heat and Mass Transfer, 3d Ed. McGraw-Hill Book Company, New York, 1972.

APPENDIX II: CALORIFIC VALUE

Fuel	Calorific value (MJ/kg)	Source
Kerosene	43.	Zhang et al., 2000
	43.6	IEA, 2005
	43.1	Smith et al., 2001
LPG	49.0	Zhang et al., 2000
	47.1	IEA, 2005
	45.8	Smith et al., 2000
Natural gas	51.3	Zhang et al., 2000
Biogas	17.7	Smith et al., 2001
Charcoal	25.7@ 1.7% MC_{wet}	Smith et al., 2001
	27.6-31.5@~5% MC_{we}	Pennies et al., 2002
Maize stalks	16.1 @ 9.1% MC_{we}	Zhang et al., 2000
	15.4 @ 5.0% MC_{we}	RWEDP, 1993
What	14.0 @ 7.3% MC_{we}	Zhang et al., 2000
	15.4 @ 5.0% MC_{we}	RWEDP, 1993
Rice stalks	13.0 @ 8.8% MC_{we}	Smith et al., 2001
	14.2 @ 5.0% MC_{we}	RWEDP, 1993
Dung	11.8 @ 7.3% MC_{we}	Smith et al., 2001
	15.4 @ 5.0% MC_{we}	RWEDP, 1993
Coal		
China	22.5	IEA, 2005
China	27.3 @ 2.1% MC_{we}	Zhang et al., 2000
China (washed)	30.1 @ 4.7% MC_{we}	Zhang et al., 2000
US	26.2	IEA, 2005
India	18.4	IEA, 2005
South Africa	23.5	IEA, 2005

APPENDIX III: CONSTANTS USED IN CALCULATIONS

L_v = 2.26×10^6 J/kg or 540 cal/g

σ = 5.67×10^{-8} W/m^2 K^4

ε = 1 (assumed)

C_w = 4200 J/kg K

P_o = 101325 Pa

C_p = 896 J/kg K

K_p = 200 – 240 W/m K At temperature 77 ^{0}C to 127 ^{0}C

APPENDIX IV: QUESTIONNAIRES ON HOUSEHOLD ENERGY CONSUMPTION

SECTION A: Personal data of respondents (tick as appropriate)

1. Sex

   Male [ ] Female [ ]

2. Age range

   a. 21-30 [ ]

   b. 31-40 [ ]

   c. 41-50 [ ]

   d. Above 50 [ ]

3. Occupation:

   a. Farmer [ ] b .Housewife [ ] c. Trader [ ]

   d. Student [ ] e. Civil servant [ ] f. Others [ ]

4. Grade level:

   a. junior [ ] b. intermediate[ ] c. senior [ ]

5. Education status

   a. none [ ] b. Primary certificate [ ]

   c. SSCE [ ] d. tertiary institution [ ]

   e. Others (please specify) [ ]

6. Types of family:

   a. Monogamy [ ] b. Polygamy [ ]

SECTION B: Consumption pattern of energy sources

1. Types of energy used:

a. Electric cooker [ ]

b. Gas cooker [ ]

c. Kerosene [ ]

d. Charcoal [ ]

e. Fuel wood [ ]

f. Biomass [ ]

2. Types of energy preferred:

a. Electric cooker [ ]

b. Gas cooker [ ]

c. Fuel wood [ ]

d. Kerosene [ ]

e. Charcoal [ ]

f. Biomass [ ]

SECTION C: Energy sources used per activity

1. Energy source(s) use for the following activities

Description	Firewood	Kerosene	Charcoal	Gas	Electricity/kW
Heating					
Cooking					
Lighting					

2. Quantity of the energy(s) consume per week

Description	Firewood	Kerosene	Charcoal	Gas	Electricity/kW
Heating					
Cooking					
Lighting					

3. Reason(s) for choosing the preferred energy
