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ADDRESSING GAPS ON ENERGY ACCESS IN RURAL AND URBAN AREAS IN GHANA: A CASE STUDY ON SELECTED COMMUNITIES IN THE ASHANTI REGION

BY

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CERTIFICATION

I hereby declare that this submission is my own work towards the MSc. Economics (Energy and Resource option) and that, to the best of my knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any other degree of the University, except where due acknowledgment has been made in the text.

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DEDICATION

I dedicate this work to my lovely Parents Mr Daniel Anto and Mrs Faustina Amponsah as an encouragement to your efforts. It's my prayer you ascend to higher heights.

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LIST OF ABBREVIATIONS AND ACRONYMS

AGECC	-	Advisory Group on Energy and Climate Change
CSPro	-	Census Processing System
CWE	-	Water and Electric Corporation
DEA	-	Development and Energy in Africa
DPs	-	Development Partners EC
	-	Electoral Commission
ECG	-	Electricity Company of Ghana
EPRAP	-	Energy for Poverty Reduction Action Plan
ESMAP	-	Energy Sector Management Assistance Program
FAO	-	Food and Agriculture Organization
GAMA	-	Greater Accra Metropolitan Area
GEA	-	Global Energy Assessment
GJ	-	Giga Joules
GoG	-	Government of Ghana
GPRS I	-	Ghana Poverty Reduction Strategy
GPRS II	-	Growth and Poverty Reduction Strategy
GSGDA	-	Ghana Shared Growth and Development Agenda
GSS	-	Ghana Statistical Service
HDI	-	Human Development Index
HEP	-	Hydro Electric Power

IFAD	-	International Fund for Agricultural Development
KMA	-	Kumasi Metropolitan Area
KWh	-	Kilowatt Hour
LPG	-	Liquefied Petroleum Gas
MDAs	-	Ministries, Departments and Agencies
MDGs	-	Millennium Development Goals
MJ	-	Mega Joules
MoE	-	Ministry of Energy
MoFA	-	Ministry of Food and Agriculture
n.d.	-	No Date
NED	-	Northern Electricity Department
NEP	-	National Energy Policy
OECD	-	Organization of Economic Co-operation and Development
OFID	-	OPEC Fund for International Development
OPEC	-	Organization for Petroleum Exporting Countries
PSIA	-	Poverty and Social Impact Analysis
REP	-	Rural Electrification Programme
SHEP	-	Self-Help Electrification Programme
SNEP	-	Strategic National Energy Policy
SRID	-	Statistics, Research and Information Directorate
SSA	-	Sub-Saharan Africa
STATA	-	Statistics and Data
TEC	-	The Energy Center
UN	-	United Nations
UNCTAD	-	United Nations Conference on Trade and Development

UNDP	-	United Nations Development Programme
UNEP	-	United Nations Environmental Programme
US	-	United States
USAID	-	United States Agency for International Development
WB	-	World Bank
WHO	-	World Health Organization
WSSD	-	World Summit on Sustainable Development

ABSTRACT

There are several contemporary surveys which are essential for the energy planning purposes in Ghana, there are still energy access gaps that ought to be addressed. Subsequently, the survey *"Addressing Gaps on Energy Access in Rural and Urban Areas in Ghana"* is designed to bridge the identified gaps and validate the available data with new set of data gathered from rural, small/medium towns and large towns of selected communities in the Ashanti region. The project is expected to provide data that can be used for the Global Energy Assessment (GEA) modelling exercise. The survey is being undertaken to provide data to address the following issues: the per capita quantities of different energy types used in Ghana by various income decile groups; the numbers of Households in each income decile group using the different energy types found in the country; the per capita expenditures on different types of energy used in Ghana by each of the income decile groups; the price per Mega Joule (MJ) of the different types of energy used in Ghana and the number of Households using different cooking stove types and their cooking location. However, based on the objectives of the study, the following conclusions were drawn. The survey results indicate that about 81% of the households had access to grid-connected electricity in their dwellings. A key finding from the survey was that households paid an average of GH¢121.22 for the consumption of an average of 196.052 KWh of electricity per month. The quantity of electricity households consumed increased with increasing income levels. In addition, the majority (20.41%) of the households within the 10th income decile (GH¢15,601+) consume the largest quantities of LPG of varying sizes. The least (4.08%) proportion of households that use LPG were within the 1st income deciles (0 – GH¢505). Again, the survey results revealed that households consumed an average of 235.15kg of charcoal per annum. Quantities of charcoal consumed by households varied from locality to locality and income deciles. The mean quantity of

charcoal in the small-medium towns was 254.2kg per annum; which was 6.2% and 18.8% higher than the mean quantities consumed by households in the large towns (238.4kg) and rural town (206.38kg), respectively. The survey results also indicated all the households that used wood fuel converted with the traditional three-stoned stove. Households in the rural communities were mostly using the traditional coal pots and the traditional threestoned stove simply because of its affordability, availability and accessibility to the energy source particularly charcoal and fuel wood. Based on the key findings from the survey, the study recommended that institutions such as the Ministry of Energy, The Energy Center and the private sector must be engaged to develop more efficient and affordable energy conversion equipment which increases productivity while minimising fuel consumption.

CHAPTER ONE

GENERAL INTRODUCTION

1.0 Background

According to the United Nations' Development Programme (UNDP, 2010), energy access has a profound multiplier effects on human development. The per capita availability of clean, efficient, affordable and reliable energy services determines countries' material standard of living (AGECC, 2010; NDPC, 2008; UNCTAD, 2001; Youngquist, 2000). The UNDP opines that none of the Millennium Development Goals (MDGs) can be met without major improvements in the quality and quantity of energy services in developing countries (UNDP, 2010). The nexus between expanded access to modern and reliable energy services for the poor, and the achievement of the Millennium Development Goals (MDGs) is explained by the productive uses of energy service towards poverty reduction and job creation (MDG 1); women empowerment through liberation from time-consuming tasks thereby saving time for education and economic activity (MDG 2 and 3); improving health conditions (MDGs 4, 5 and 6); and reducing carbon emission towards environmental sustainability (MDG 7).

Countries with high access to clean, efficient, affordable and reliable energy services have strong and resilient economies which manifest in high income per capita and improved standard of living. The UNDP (2004) observes a correlation between a country's human development index (HDI) ranking and per capita energy use. An HDI of 0.8 or higher requires a minimum energy use of about 42 giga joules (GJ) per capita. In OECD Europe and OECD Pacific per capita energy use is about 142 and 180 GJ, respectively, while the per capita energy use in OECD North America is 281 GJ. In sub Saharan Africa (SSA), however, per capita energy consumption is only about 25 GJ (UNDP, 2004). Energy access

and consumption thus hold pivotal stakes in developing countries' quest for sustainable development (The World Bank, 1997; UNEP, 2008).

The Government of Ghana (GoG) and her Development Partners (DPs) have subsequently initiated several programmes and projects intended to make available up-to-date and reliable energy access data to inform the effective energy planning process in Ghana. The energy access data was to enhance government's commitments to expanding and improving people's access to modern and safe energy services for sustainable poverty reduction.

In 2010, the Ghana Statistical Service (GSS) undertook a national population and housing census during which some energy data were collected. The energy data gathered from households during the exercise were *'main fuel for lighting'* and *'main fuel for cooking'*. The Service has also carried out a series of living standard surveys during which data on *'main fuel for lighting and cooking and their share as a proportion of household total expenditure'* were gathered (Ghana Statistical Service, 2014). The Ghana Statistical Service's survey made some energy access data available.

The Energy Commission (EC) also undertook a *'Survey on Energy Use in Ghana'* in 2010. The study was intended to: determine the energy use profile in all sectors of the economy; establish an energy database for the country; and to make reliable data available for other planning purposes (including updating the Strategic National Energy Policy) (Energy Commission, 2011). The survey addressed energy access data which provide insight into households and firms' energy use profiles.

The United Nations Development Program (UNDP) has also initiated several projects aimed at not only enhancing people's access to modern energy forms for their productive

activities but also improving the efficiency of the energy end use equipment towards optimum efficiency of biomass (UNDP Ghana, 2006). The projects include *'LPG Substitution for Woodfuel'*, '*Household Energy for cooking',* and *'Improving the Supply Chains for LPG Access in the Tamale Metropolis'*.

The Energy Center (TEC) with support from the Energy Sector Management Assistance Program (ESMAP) of the World Bank (WB) also undertook a study in three slums (viz. Old Fadama in Accra, Amui Dzor in Ashaiman and Akwatia Line in Kumasi) in Ghana. The study analysed the slum dwellers' access to and productive uses of various energy forms. The Energy Center noted that the illegitimate slums though are excluded from the energy access planning process, have access to and make productive uses of various forms of energy. The survey thus provided an insight into the types of energy services available in the slums and the purposes for which they are used.

Although the above surveys are essential for the energy planning purposes in Ghana, there are energy access gaps that ought to be addressed. Subsequently, the survey *"Addressing Data Gaps on Energy Access in Rural and Urban Areas in Ghana"* is designed to bridge the identified gaps and validate the available data with new set of data gathered from rural, small/medium towns and large towns of selected communities in the Ashanti region. The project is expected to provide data that can be used for the Global Energy Assessment (GEA) modelling exercise. The survey is being undertaken to provide data to address the following issues: the per capita quantities of different energy types used in Ghana by various income decile groups; the numbers of Households in each income decile group using the different energy types found in the country; the per capita expenditures on different types of energy used in Ghana by each of the number of Households using different cooking stove types and their cooking location.

1.2 Research Problem

The OPEC Fund for International Development (OFID, 2008) remarks that Ghana's low productive capacity is the result of her energy poverty situation. Low access to modern, efficient, reliable and affordable energy resources is thus counter-productive to Ghana's accelerated growth and development agenda and sustainable poverty reduction.

In Ghana however, about 64% of energy consumption comes from biomass (viz. fuel wood, crop residues, and animal dung) converted with inefficient cooking stoves (Amissah-Arthur and Amonoo, 2004; Bensah and Brew-Hammond, 2010; Government of Ghana, 2005). About 44% of the population also lacks access to electricity for domestic and productive uses. The proportion of households without access to electricity is even higher (75.1%) in the rural areas (Amissah-Arthur and Amonoo, 2004). Latest estimates by the Ministry of Energy using populations in communities that have access to electricity suggest that about 76% of Ghanaians have access to electricity as last quarter of 2014. Vital as the above surveys are for the energy planning purposes in Ghana, there are still energy access gaps that ought to be filled in our attempt to address energy poverty in Ghana. This observation was made after comparing the outputs of the surveys, programmes and projects to the data requirements for the Global Energy Assessment (GEA) modelling. For instance, data on the quantities of fuel consumed by households in income deciles; households' energy expenditures by income deciles; household energy end use equipment, sources of household energy, among others were not gathered by the earlier surveys, programmes and projects according to the GEA modelling scenario.

13. Purpose of Survey

Intended to fill the identified gaps in the preceding surveys, this study will generate the new and complementary data for the establishment of an up-to-date and reliable energy

access data to enhance planning in Ghana. The survey is thus aimed at providing disaggregated data on energy access in Ghanaian households. The survey results would be used to validate the findings of the earlier surveys for the identification of generic and peculiar findings. The validity in the results of all the surveys is pivotal for energy planning in Ghana. The output of the survey will facilitate the GEA initiative of providing a strong technical and scientific basis for energy decision-making.

Furthermore, this survey will feed into the options for the way forward - both on a global and regional level- to inform policymakers, the business and investment sectors, and society at large, on the key opportunities and challenges facing the global energy system in its quest for sustainable development. The modelling/scenario analysis will strengthen the capacity of other researchers in undertaking related studies in national and sub-regional survey in future.

1.3 Objectives of Survey

The general objective of the survey is to obtain energy access data to fill gaps and validate available energy access data on rural and urban areas in Ghana. The output of the survey will feed into the GEA modelling/scenario building. Specifically, the survey is designed:

- To determine the per capita quantities of different energy types used in Ghana by various income decile groups;
- To determine the number of households in each income decile group using the different energy types found in the country;
- To determine the per capita expenditures on different types of energy used in Ghana by each of the income decile groups;
- To determine the price per Mega Joule (MJ) of the different types of energy used in Ghana;

- To determine the number of households using different cooking stove types and their cooking location.

1.4 Scope

The scope is sectioned into three parts, namely, the geographical, contextual and the time scopes.

1.4.1. Geographical Scope

The survey took place in randomly selected communities in the Ashanti Region. The country is divided into three different agro-climatic zones, namely; Savannah, Forest and Coastal-agro climate zones which are thought to have an effect on the types and quantity of energy used by households. The Ashanti Region is geographically located within the forest-agro climatic zone. Subsequently, the region was demarcated into rural, small-tomedium-sized town and large town to have a fair representation of the units in the sample. Three each of rural community, small-medium sized town and urban town was selected from the region. The large town was sub divided into three groups guided by the economic status (measured in terms of average incomes) of inhabitants. The large town was demarcated into high income, middle income and low income community. In sum, the survey was implemented in 5 selected communities in the Ashanti region (see Table 1.1). The categorisation of the towns into large and small-to-medium towns was informed by the Ministry of Local Government and Rural Development's criteria for the delineation of areas into metropolises (large towns) and municipalities (small-to-medium). Similarly, the Ghana Statistical Service's definition of rural community was adopted for the selection of the rural community for the survey.

Table 1.1: The Classification of the Study Communities by Agro-Climatic Zone, Economic Status and Urbanity

Region	Study Communities	Economic Status	Size of Community	Agro-climatic zone
Ashanti	Kumasi: ▪ *Ahinsan Estate* ▪ *Gyinyase* ▪ *Dompoase*	▪ High income ▪ Middle income ▪ Low income	Large Town	Forest
	Kumawu	-	Small-medium	
	Wonoo	-	Rural	

Source: Authors' construct, July, 2015

1.4.2 Contextual Scope

The survey is designed to elicit responses from households for the development of an upto-date energy access database for energy access planning in Ghana. Specifically, the report analysed data on the per capita quantities of different energy types used in Ghana by various income decile groups; the numbers of Households in each income decile group using the different energy types; the per capita expenditures on different types of energy by each of the income decile groups; and the price per Mega Joule (MJ) of the different types of energy. It also analysed the number of households using different cooking stove types and their cooking location.

1.4.3 Time Scope

The primary data to be used for the compilation of this research was collected in the month of August, 2015. However, for triangulation purposes, secondary sources of information were used as well. The Ghana Living Standard Survey 6 published in 2014 was a major

source of secondary information. TEC's 2010 survey on "the productive uses of energy by the urban poor" provided useful information for the validation of the primary data.

Ghana's energy policies over the years (from 2000 to date) were also reviewed. The intention is to understand the policy direction of the country regarding energy access which could provide opportunities for the implementation of the recommendations made in this research. Finally, the analysis of supportive theories for household energy access was traced. Theories such as "the energy ladder" and "agricultural household model" were reviewed since it provides the relevant theoretical underpinning for the project.

1.5 Methodology

This chapter explains the methods to be employed to elicit the responses to the research questions. The methodology starts with the research framework, research approach, study population, method of determining the sample size and the sampling techniques used to select the respondents for the study. The earlier part of this section presents the survey methodology and data collection processes addressing the following topics: scope and coverage of the survey, questionnaire, sampling design, pre-testing, data processing, response rates and weighting, and reliability of estimates.

The researcher used historical data (2010) for the estimation of the 2015 populations for the study communities. The researcher used the inter-censal growth rate (2.5%) of 2010 population and housing census as a benchmark for estimating the projected population for 2015 for each community. A total of 60, 30 and 10 households was interviewed in the large towns, small-medium town and rural community, respectively, as indicated in Table 1.1.

The random sampling technique was used in selection of households to be interviewed in each of the selected settlements. The researcher used the systematic sampling technique

for the selection of household units from the study communities. In each settlement, heads of households were interviewed and in all, one hundred (100) questionnaires were administered throughout the region for the purpose of this research.

1.6 Method of Data Analysis

The quantitative data collected from family unit heads was synthesised with the use of CSPro. Descriptive statistics such as the measures of central tendency, percentages and frequency distribution tables was used to present the household data. These descriptive statistics was generated with the aid of the statistical package, STATA.

1.7 Limitations to the Study

This section of the report details the factors that constrained the smooth implementation of the survey in the selected agro-climatic zone. First, household heads, particularly in the affluent areas for fear of having their privacy invaded, were unwilling to disclose their monthly earnings and expenses. Households who do not understand the relationship between energy access and household income levels were reluctant to answer all the questions. Also, household members were uncooperative due to factors such as interview fatigue, unfulfilled expectations from previous survey, lack of prior information about the survey, etc. The study's interference with the working hours of the respondents protracted the survey period and thus distorted the project's milestone.

1.8 Organisation of the Report

The report was organised in five chapters. Chapter one provides an overview of the project discussed under the project background, purpose, objectives, scope and limitations. Chapter two provides an explanation to the conceptual issues and theoretical framework issues to be used in the report which supports households' energy access. Chapter three explains the empirical strategy the researcher adopted for the provision of the required

answers to the research questions. The research approach, sampling techniques, research variables, sources of data, and methods of data collection and analysis was discussed in chapter three of the report. Chapter four presents the analysis of the primary data gathered from the selected Forest agro-climatic zone. Chapter five finally presents the recommendations made to address identified issues regarding households' access to energy. The report includes two other important sections which were not addressed in any of the five chapters. The report opens with preliminary pages which contains the executive summary and the tables of contents. The other section captures a list of appendices and glossaries which was presented after chapter five.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter focuses on the literature review which comprises of two sections. Section one provides an explanation to the conceptual issues to be used in the report. The conceptual issues are; definitions and characteristics of rural, peri-urban and large towns in Ghana, the role of energy in national development, typology of energy used by rural and urban households in Ghana and finally, Ghana's energy access policies. Section two analyse the theoretical framework which supports households' energy access.

2.2 Conceptual Framework

This section of the chapter defines and describes key terminologies used in the topic sentence in the Ghanaian context. It provides a brief overview of the meaning and characteristics of rural, small-medium sized towns and large towns in Ghana.

2.2.1 Definition and Characteristics of Rural Areas in Ghana

The term 'rural' varies from place to place (United Nations, 1991; Mba, 2002). Precise definition of rural areas is, however, indispensable for policy makers, as well as service providers (energy) and researchers.

In the United States, any area which is nonmetropolitan is considered as rural while in the many European Countries, areas with less than 26% of its population living in a market town or settlement with less than 2,500 populations is a rural area (Tacoli, 2004; Yusuf and Ukoje, 2010). In many developing countries, however, it often refers to areas in the country which are agricultural and less densely populated. For instance in Nigeria rural areas are characterised by low population density, predominance of agricultural related livelihood and poor infrastructural services (Yusuf and Ukoje, 2010).

The Ghana Statistical Service's definition of a rural area as an area with a population of less than 5,000 (Ghana Statistical Service, 2008) is widely used and somehow accepted as the definition of "rural areas" in Ghana, notwithstanding the criticism that what constitute rural today will most likely change as Ghana moves on into the new millennium with changing demographics (IFAD, 2010; Tacoli, 2004). The National Center for Education Statistics (2010) classifies rural areas into three categories depending on how accessible they are from urban areas. They range from the rural/urban fringe, accessible rural areas to the extreme (remote) rural areas. However, rural areas change over time due to: economic factors (such as tourism income, farming profitability, and primary sector jobs), environmental factors (such as land use, pollution, conservation) and social factors (such as population change and migration, leisure time, and retirement population).

It is very difficult to generalise the characteristics of rural areas in Ghana, even if one confines himself to the Ghana Statistical Service's definition of rural area. This is because there are enormous variations both between and within areas classified as rural (Food and Agricultural Organisation (FAO), 2010). For example, in rural areas near cities or where the agricultural system is highly commercialised, external linkages are obviously stronger than in isolated communities dependent primarily on subsistence production. Most people in rural areas are dependent directly or indirectly on the natural resources of the area for their livelihood (Hens and Boon, 1999). Also most rural societies in Ghana are integrated, in the sense that the various components of life (e.g. agricultural and non-agricultural, 'economic', 'social and political', religious and secular) are closely interrelated (FAO, 2010; Hens and Boon, 1999).

There are strong social and economic ties within rural communities and a tradition of cooperative effort for certain activities between the various individuals and groups in

Ghana. There are also important external linkages which take many forms, including links through marriage outside the community, the movement of temporary migrants (and/or their remittances) in and out of the community for economic or educational purposes, trading links, and links resulting from the use of social and administrative services (e.g. hospitals, government offices) outside the community (FAO, 2010). Furthermore, there is a high degree of traditional cooperation. It must be emphasised that rural communities willingly and easily embark upon other forms of cooperative activity, especially if these are of a commercial nature.

Based on the Ghana Statistical Services definition of rural areas (i.e. areas with populations of less than 5,000 people), the research team selected localities whose populations are less than 5000 people as rural areas. Accessibility was a major factor in selecting these rural communities. The rural communities selected are thus in tandem with the second category of rural areas as defined by the National Center for Education Statistics.

2.2.2 Definitions and Characteristics of Small –Medium Towns in Ghana

In Ghana, urban focuses are characterized as settlements with populations of 5000 or more (Ghana Statistical Service, 2008). Be that as it may, no official definitions exist for the different urban classes, for example, 'small', "medium" and "large" towns. Utilizing Ghana's official urban definition, Owusu (2005) makes three principle arrangements to be specific; residential communities, medium-sized/middle of the road towns, and vast towns/urban communities. The urban framework accordingly shows a three-level chain of importance. At the highest point of the chain of command are the expansive towns/urban areas of Accra, Kumasi, Tema and Sekondi-Takoradi, with populations of 250,000 or more (Oduro-Kwarteng, 2011; Owusu, 2005). In the progression, the large towns are trailed by the medium-sized towns with populations of 50,000 to 250,000, exemplified by the

regional capitals. After this are the residential areas, exemplified by district capitals with populations somewhere around 5000 and 50,000 (Owusu, 2004; 2005).

Municipal Assemblies are established for a single compact settlement with population of 95,000 people and above but less than 250,000 people. A district is created when the population of an area is 75,000 people and above but less than 95,000 under a Legislative Instrument (Ministry of Information and National Orientation, 2008).

This classification and definition of the urban hierarchy above is, however, an oversimplification of Ghana's urban system, because with the exception of the administrative status criterion, many centres exhibit a variety of functional and population complexities which make the process of putting them into categories problematic (Owusu, 2005). Acknowledging that the criterion is subjective, the author used the administrative capitals as the small-medium sized towns and did not make any attempt at distinguishing between the two categories (i.e. small and medium towns).

Small towns are not unmistakably delimited autonomous elements about which one can without much of a stretch sum up and create ideas and models (Owusu, 2005). The procedures and strategies molding little and large towns may be the same, yet their dynamism inside of the urban chain of importance may contrast. This point turns out to be more significant as accessible statistics shows that the quantity of settlements termed as residential areas had expanded from 114 in 1970 to 336 in 2000 yet the extent of the urban populace in these focuses has changed almost no or declined somewhat from around 49% in 1970 to around 46% in 2000 (Ghana Statistical Service, 2005).

To these, broader socio-economic factors can be added to the effects of the continuing high population growth rate. Besides these broader factors, in the context of small towns there

are also regional or local factors, such as peasant agricultural expansion and commercialisation combined with favourable location factors, including location on main trunk roads and location closer to mining activities (Owusu, 2005).

Analysts such as Briggs and Yeboah (2001 cited in Owusu, 2005) argued that economic liberalisation and privatisation have improved linkages between settlements, allowing small towns to have access to both higher-order centres (large and medium-sized towns) and lower-order settlements (rural areas). This, coupled with improved infrastructure, has enabled some economic activities, especially commerce and services to be introduced in small towns, though not on the same scale as the large towns and cities.

2.2.3 Definitions and Characteristics of Large Towns in Ghana

As already elaborated in subsection 2.2.2, large towns in Ghana are exemplified by the metropolitan areas which have populations of not less than 250,000 people (Ministry of Information and National Orientation, 2008; Owusu, 2005). These large towns are at the apex of the three-tier urban hierarchy (Owusu, 2005). The large towns include Accra, Kumasi, Tema, Sekondi-Takoradi and Tamale, with populations of 250,000 or more (Oduro-Kwarteng, 2011; Owusu, 2005).

Large towns are characterised by heterogeneity in terms of differences in ethnicity, income and expenditure levels, and occupation. There are areas in the large towns that are characterised by high taxable property values, well-defined sector layouts and well-laid infrastructural base with low population densities. The people living in these areas are said to command high economic power because of their high incomes and who are mostly senior public servants, politicians or are investors who employ other people in the urban areas. The housing units in these areas are mostly owner-occupied.

The second segment of the large towns is characterised with moderate property and relatively higher population densities. The inhabitants are mostly junior staff in the public service or own moderately valued enterprises. The last category of the urban areas is the low income suburbs which are mostly informal settlements located outside the planning zones. Majority of the inhabitants are economic migrants who have migrated to the cities in search of jobs (TEC/ESMAP, 2010). Access to basic services in the low income informal suburbs is limited because utility service providers fear extending the services to them may be construed as legitimising them (King, 2010).

2.2.4 The Role of Energy in National Development

No country in modern times has substantially reduced poverty without a massive increase in its use of energy and/or a shift to more efficient energy sources that provide higher quality energy services (UN-Energy, 2005; UNDP, 2005). Most economic activities will not possible be without energy (UN-Energy, 2005). Energy, thus, plays an impeccable role in national socioeconomic development.

The link between energy services and poverty reduction was explicitly identified by the World Summit on Sustainable Development (WSSD) (UNDP, 2005). However, about 2.5 billion people have limited economic opportunities which negatively affect their living standards because of their lack of access to modern energy services (UNDP, 2005). The WSSD therefore called for joint actions and improved efforts for the enhancement of people's access to reliable and affordable energy services for sustainable development (ESMAP, 2002 cited in UNDP, 2005).

Energy's crucial role in national development is further explained by its link with other sectors for the attainment of the economic growth that is central to sustainable poverty

reduction. Economic growth creates jobs and raises incomes, even for the small and medium-scale enterprises that are the main source of jobs for the masses (USAID, 2001). Energy's pivotal role in sustainable development is also explained by its importance in promoting access to water, enhancing agricultural and industrial productivity, improving health care delivery, enhancing education, job creation and climate change impacts. The UNDP (2005) sums up the crucial role energy plays in national development by linking energy to the attainment of the MDGs. The UNDP argues that failure to include energy considerations in national MDG strategies and development planning frameworks will severely limit the ability to achieve the MDGs (UNDP, 2005). Energy poverty is one of the many manifestations of poverty and a prevailing feature of deprived rural and urban households in developing countries. Lack of access to modern cooking fuels and electricity, already represents a barrier which limits progress towards achieving the MDGs.

Cooking with fuel wood, crop residues, and dung is associated with a significantly higher disease burden than other forms of cooking, due to indoor air pollution. Cleaner fuels and cook stoves that facilitate lower smoke exposures, as well as improved ventilation of cooking areas, can reduce the disease burden from smoke, lower child mortality rates, and improve maternal health (Staton and Harding, 2004.). Efficiency and biomass availability can also reduce the time and transport burden of women and young girls whose duty is to collect the fuel. The time saved could increase and enhance their participation in education and income- generating work (Modi et al., 2005). These and other improvements can all lessen the pressure on fragile ecosystems (Modi et al., 2005; Staton and Harding, 2004; UNDP, 2005).

The lack of electricity in the rural areas constrains effective health care delivery. Sterilising health instruments, water supply and purification, sanitation, and refrigeration of essential

medicines are all challenged by the lack of electricity. In these rural areas, access to electricity can encourage trained staff who are often reluctant to stay in these areas because of the lack of electricity, to live and work there (Modi et al., 2005; UNDP and WHO, 2009).

National government must thus make conscious efforts to promote their citizenry's access to modern, efficient, safe and affordable energy services; the surest way to sustainable poverty reduction and wealth creation. This process begins with the available of up-to-date and reliable data on energy access to dictate the starting point of energy access planning.

2.3 Typology of Energy used by Rural and Urban Households in Ghana

In Ghana biomass is the most dominant source of energy and is used significantly in the domestic sector for cooking and other heat applications. Biomass accounts for about 64% of national energy supply **(**Duku et al., 2011**).** Wood fuels, as firewood, charcoal and wood preparing buildups are the most overwhelming biomass forms of energy being used in Ghana (Ghana Statistical Service, 2008). About 22.3% of Ghanaian households use LPG as their primary source of fuel for cooking (Ghana Statistical Service, 2014). Of this proportion, 52.7% reside in Greater Accra and 28% in other urban communities.

The main source of lighting for households in Ghana is electricity at 70.6% with torches (flashlights) ranked second at 24.3% (Ghana Statistical Service, 2014). Solar energy plays a significant role in the agric sector and is mostly used for crop drying (Ahiataku-Togobo, 2005). Energy access patterns in Ghana have varied from region to region, between and within households. Due to this and for the purpose of the survey, literature on energy access in Ghana has been reviewed specifically to address the variations in access between rural and urban areas.

2.3.1 Typology of Energy used by Urban Households

A wide range of energy resources are used by urban households in Ghana for diverse purposes. The Ghana Statistical Service (2014) indicates that charcoal is the dominant source of cooking fuel for urban households accounting for about 43.6% of the total cooking energy-mix. About 35.8% and 14.3% of urban households use Liquefied Petroleum Gas (LPG) and wood-fuel (firewood), respectively for cooking. The proportion of urban households who use LPG as cooking fuel is about 52.7% in the national capital, Accra.

For lighting, approximately half of Ghana's overall population has access to electricity and, of this; much of it is in urban areas. About four-fifth (88.6%) of households in urban areas has electricity for lighting. Currently, about 70.8% of households in Ghana have access to electricity, with rural access at only 48.6% (Ghana Statistical Service, 2014). Petroleum products such as petrol and diesel are largely used by urban households for automobiles, motor bikes and tricycles albeit insufficient data on the quantity of the petroleum products consumed by households. These two petroleum products accounted for about 59% of the total petroleum products consumption-mix. Other petroleum products contributed to about 32% of the total petroleum consumption-mix (Amissah-Arthur and Amonoo, 2004). The consumption of the petroleum products is expected to rise as Ghana's population continues to grow with an influx of automobiles and machines.

2.3.2 Typology of Energy used by Rural Households

The Ghana Statistical Service (2014) indicates that wood fuel (firewood) is the main source of cooking fuels for rural households accounting for about three-quarters (74.8%) of the total cooking energy mix. Furthermore, about 16.5% and 5.5% of rural households use charcoal and LPG, respectively as cooking fuel. In these rural areas, 5.6% of households

use kerosene, candles and other traditional fuels as sources of light with electricity consisting 48.3%, compared to 88.6% for urban households (Ghana Statistical Service, 2014).

A previous survey conducted by Amissah-Arthur and Amonoo, 2004, reviewed that only 17.1% of rural households obtain their lighting from grid-connected electricity. Selfgenerators, dry-cell and automotive batteries together make up the remaining 7.8% (Amissah-Arthur and Amonoo, 2004). Petrol and diesel fuels are also used significantly to run motor bikes and tricycles by some rural households. It can be said further that an insignificant proportion of rural households predominantly from the northern region of Ghana uses cow dung for cooking. However, there is no quantifiable data to validate the proportion of this energy usage in that regard.

2.4 Energy Access Policies in Ghana

Emanating from the nexus between energy access and poverty reduction, this part of the literature reviews the energy access policies in Ghana which are intended to enhance households' access to modern and safe energy services. The intent is to identify the opportunities that exist for the implementation of the recommendations that have been made in this project report beyond enhancing the GEA initiative. The review emphasises energy access policies for lighting and cooking in the national development frameworks identified to include the Ghana Poverty Reduction Strategy (GPRS I), the Growth and Poverty Reduction Strategy (GPRS II) and the Ghana Shared Growth and Development Agenda (GSGDA, Volume one). Energy policy documents such as the National Energy Policy (NEP), Energy for Poverty Reduction Action Plan (EPRAP) and the Strategic National Energy Policy (SNEP) were reviewed.

2.4.1 Energy Policies in the National Development Frameworks

Electricity is a recognised essential tool for developing local and regional markets and allowing for the extension of basic services such as telephone and for the development of supportive productive enterprises. In this vein, the GPRS I aimed to develop reliable and affordable energy delivery systems to support economic activities especially in the rural areas. The specific projects that were implemented in hope of enhancing consumers' access to reliable electricity included the West Africa Gas Pipeline, the Bui Dam, and the expansion of the thermal plant at Takoradi.

GPRS I recognised that energy for domestic use is predominantly biomass based which are hard to come by in some areas due to depletion. The following strategies were used to enhance people's access to cooking fuel:

- assist communities to develop woodlots;
- introduce renewable energy technologies such as solar PV and biogas; and
- introduce and promote energy efficiency technologies for domestic users.

Succeeding the GPRSI, GPRS II also ensured the supply of reliable and quality energy services. The development framework intended to increase access to alternative forms of energy by the poor and vulnerable; modernise and expand power infrastructure; improve the regulatory environment in the power sector; and ensure full cost recovery for power supply and delivery while protecting the poor. The other areas of emphasis were promoting productive and efficient use of energy, and minimising the environmental impacts of energy supply and consumption. GPRS II also aimed to diversify the national energy mix by implementing programmes to support renewable energy sources (such as hydro, wind, solar photo voltaic) in Ghana. All these energy policy statements were intended to enhance users' access to adequate, reliable, high quality and safe energy services.

The current development framework, the Ghana Shared Growth and Development Agenda –volume one (GSGDA), also gives priority attention to the energy sector of the economy. The GSGDA hopes to improve industries and households' access to energy supply. This policy is aimed at addressing identified issues such as:

- limited access to the national electricity grid especially in the rural areas;
- over-dependence on few sources of energy (HEP and thermal) and the neglect of potential indigenous sources;
- low adoption of energy efficiency technologies among domestic users; ▪ absence of renewable energy in the national energy mix;
- unreliable and inadequate supply of energy to households and industry.

Due to these problems, the GSGDA in the medium term aims to diversify the national energy mix as a means to generating adequate, safe, reliable and modern energy services in Ghana. Strategies to achieve this objective include the following:

- rehabilitate and expand energy infrastructure to ensure adequate and reliable supply of energy;
- increase access to the modern forms of energy to the poor and vulnerable through the extension of national electricity grid;
- ensure the reduction in the cost of electricity production and distribution; and
- promote energy efficient technologies that safeguard the health of domestic users especially women and children.

In the area of cooking fuel, the GSGDA aims to convert wastes generated from municipal, urban and rural activities and from industrial and agricultural operations to energy. The specific waste-to-energy policy is to maximise energy production from waste, if it is cost effective; and provide access to waste-to-energy technologies for other sectors.

With regards to gender and energy, the GSGDA aims to promote increased access to modern forms of energy by women in order to reduce the tedium in their activities; and ensure that concerns of women and children are taken into account in all aspects of energy production and utilisation. Subsequently, the development framework hopes to promote the use of modern forms of energy in households; support the capacity development of women in the energy sector; and ensure participation of women in the formulation and implementation of energy interventions. The specific strategies include:

- promoting and facilitating the use of LPG as a cheaper and cleaner alternative fuel and promote manufacturing of simple and cheap gas burners; and
- promoting the use of improved wood fuel burning equipment for cooking in households and other commercial activities.

In the petroleum subsector GSGDA aims to ensure equitable access to, and uniform pricing of petroleum products. It hopes to accomplish this by addressing the high cost of transportation and distribution of petroleum. In sum, the development frameworks recognise access to reliable, affordable, adequate and safe energy services as important national development tools. The strategies do not only hope to expand access to electricity but also to improve access to cooking fuels to all users in Ghana.

2.4.2 Energy Policies in National Energy Policy Documents

Within the ambit of the national development frameworks, the Government of Ghana in SNEP, NEP and EPRAP hopes to achieve universal electricity coverage by 2020. Additionally, urban households' and commercial establishments' dependence on wood fuels for cooking is to be reduced to 40% by 2020, by promoting LPG and electricity as safer and environment-friendly alternatives (Ministry of Energy, 2010b; TEC/ESMAP, 2010). In achieving universal access to electricity, the specific policy objectives under the

NEP and SNEP include:

- securing long term fuel supplies for the thermal power plants;
- reducing technical and commercial losses in power supply;
- expanding energy infrastructure to meet growing demands and ensure reliability;
- increasing production and use of renewable energy and make energy delivery efficient;
- ensuring cost recovery for energy supply and delivery; and
- promoting and encouraging private sector participation in the energy sector.

The objective of EPRAP was to give a guide to the focused on conveyance of energy services to boost productive activities to accomplish national development poverty reduction objectives and systems outlined for the execution of seven key areas under the GPRS II (Service of Vitality, 2006; TEC/ESMAP, 2010). The seven areas are agribusiness, small and medium enterprises, health, education, water and sanitation, communication and technology and households.

The general goal of EPRAP is to center consideration on the energy needs of poor people and the underserved amid the execution of the GPRS II and beyond. Thus EPRAP hopes to integrate the energy needs of the poor who are often marginalised into the national energy planning process. The pro-poor recommendations made in EPRAP included:

- grid extension to fish landing and freezing facilities;
- establishment of woodlots and transfer of improved technology for charcoal production;
- promotion of access to LPG in rural and poor peri-urban/urban communities; and
- promotion of improved cook stoves in households.

EPRAP explicitly recommends the promotion of LPG and improved cook stoves to rural, poor peri-urban and urban communities.

The synoptic review of the national development frameworks and national energy policy documents has revealed that priority attention is given to the energy sector due to the impeccable stake energy holds in the national poverty reduction agenda. The Government of Ghana (GoG) intends to improve the supply and use of electricity for domestic and commercial uses. The supply and demand sides are thus accorded attention in the energy planning process. Another area of emphasis is the supply and use of cooking fuels by households and enterprises. The overall intent is to ensure sustainable access to environment-friendly sources of energy for use by households and enterprises.

2.5 Energy Access Programmes in Ghana

This section of the report is not an attempt to review all the energy access programmes and projects implemented in Ghana. It is however, a synoptic review of some of the energy access programmes and projects which follow from the energy access policies reviewed under section 2.5. It thus complements the lessons learned from the review of energy policies with practical lessons learned from the implementation of some of the proposals in the energy documents. The latter informs the nature of recommendations made in this report.

2.5.1 Self-Help Electrification Project (SHEP)

The Energy Commission of Ghana is mandated to promote competition in the supply, marketing, and sale of renewable energy products and other forms of energy as well as ensure the productive uses of electricity. Subsequently, the SHEP (phases 1-4) was commissioned and implemented under the joint auspices of the GoG and Development Partners (DPs). The Ministry of Energy in 1989 initiated the

National Electrification Scheme (NES) as government's essential strategy to stretch out power to all parts of the nation over a 30 year period from 1990-2020 (Energy Commission, 2011).

The SHEP is a complementary electrification system established to boost the fundamental National Electrification Scheme (NES) with the rationale of speeding up the connection of communities to the national power grid (Ministry of Energy, 2010c). The goal is to encourage the self-developmental initiatives of both provincial and urban groups in Ghana. SHEP has been executed in stages. Stages 1 and 2 were started from 1989-1992 and 19921996, separately while stages 3 and 4 were executed between 1996-2005 and 2005-2008, respectively (Ministry of Energy, 2009). The number of communities that were earmarked for electrification in 2011 and beyond was 3,515 (Energy Commission, 2011).

The Electricity Company of Ghana (ECG) continues to assist the Ministry of Energy in the extension of electricity to rural communities through the Self Help Electrification Projects (SHEP). Currently, a total of 123 townships within ECG's operational area have been farmed out by the Ministry of Energy (MoE) to contractors for electrification in the country (Ministry of Energy, 2010a). Consequently, the GoG in 2010 signed a US$90 million contract with China International Water and Electric Corporation (CWE) for the electrification of over 570 townships in six regions across 24 political districts of Ghana. Construction work in 480 of these townships was implemented by ECG within its area of jurisdiction.

Nevertheless, as showed by the Energy Commission of Ghana (2011), around 4,813 communities have been connected with the grid fulfilling a national average of around 67% as of December 2010 including all regional and district capitals.

2.5.2 The UNDP/GoG LPG Substitution for Wood Fuel

The project started in December 2003. The project sought to minimise desertification in the three regions in northern Ghana (Northern, Upper East and Upper West regions). Fundamentally, the project sought to address the following problems:

- unawareness of the rural people on the benefits of using LPG for cooking as compared with using firewood and charcoal;
- the present and current low and non-availability of LPG and LPG infrastructure or equipment and accessories in the rural northern regions;
- the prevalent use of wood fuel and charcoal in boarding schools, bakeries and chop bars in Northern Ghana; and
- unavailability of credit system to make conversion from firewood/charcoal usage to LPG usage.

After a final evaluation of the outcomes of the project, the evaluators identified that tremendous awareness has been created on the benefits of using LPG for cooking as against the use of wood fuel especially in the area of health in areas such as Tamale, Savelugu, Navrongo, Bawku and Tumu (UNDP, 2006). The project has also enhanced households' physical access to LPG with the installation of a single 4.5-ton capacity distribution outlet in Bawku, and a second distribution outlet in Tamale belonging to Tropic Oil. Under the project, three institutional kitchens of boarding schools were converted to the use of LPG. A significant number of chop bars had their kitchen converted to use LPG. As a result of these interventions the demand of LPG in the Tamale Metropolis alone has increased from 10 tons per month in 2004 to over 60 tons per month as of December 2007, reaching additional 3,000 new clients and 12 educational institutions. However, some of the chop

bar[1] operators have packed their accessories because they consider the current price of LPG as expensive relative to wood-fuel (UNDP, 2006).

2.5.3 Improving Supply Chain for LPG access in the Tamale Metropolis of Northern Ghana

The broad mandate of the project is to improve access to LPG in the Tamale Metropolis. This programme builds on the key learning of the UNDP-Ghana LPG Substitution project completed in Northern Ghana (UNDP, 2007).

The programme is expected to contribute to the achievement of MDG 1 by increasing the economic opportunities for both households and businesses that will be providing energy services; MDG 3, freeing up women's time for productive activity; MDG5 by improving maternal health through reduction in exposure to toxic fumes from wood fuel. The programme will also contribute to MDG 7 by reducing the pressure on scarce fuel wood energy resources in the already fragile savannah ecosystem. The programme's approach involves:

- Creation of Sustainable Distribution Infrastructure for LPG in the Metropolis
- Local Community Involvement; and
- Gender mainstreaming.

The direct beneficiaries consist of the inhabitants of Tamale Metropolis, which will include the outlying districts of Savelugu/Nanton, West Gonja, Central Gonja, and Tolon Districts in the Northern Region. The programme aims to reach between 50,000-55,000 beneficiaries in the metropolis (UNDP, 2007). It will also benefit health clinics in the area of vaccine refrigeration, sterilisation of equipment, and emergency lighting. Up to 10 boarding schools will benefit from a reliable LPG supply. The LPG users and

[1] Local jargon for canteens in Ghana.

entrepreneurs in the Metropolis will get the opportunity to participate in the ownership and operation of a modern profitable LPG business enterprise.

Furthermore the development of a viable market for gas will benefit communities and local entrepreneurs with the creation of jobs, and increase the sales of LPG marketers, cylinder manufacturers, and appliance traders and manufacturers (UNDP, 2007).

2.5.4 The Appolonia Biogas Project

The Ministry of Mines and Energy's Renewable Energy Programme in Appolonia produces biogas for electrification purpose (Ackom, 2005; Mensah, 2000). Biogas, produced from cow dung and human excreta, is used to fuel a combustion engine for generating electricity (Mensah, 2000). The system generates 12.5kW of electric power which is fed to a local grid, supplying 230V electricity for domestic use (Ackom, 2005; Mensah, 2000).

The electricity generated is transmitted at 230V through a local grid over a total distance of about 1km benefitting more than 27 houses. These homes use the biogas for cooking (Ackom, 2005; Mensah, 2000). In addition, various social centres (churches, mosque, video centre and drinking bars) have also been connected (Mensah, 2000). Twenty streetlights powered by electricity from the biogas plants have been installed throughout the village. Through the project, Appolinia has acquired access to potable pipe-borne water. This has also resulted in a saving of women's time and drudgery they went through searching for water. School children are able to read and study at night and adult literacy classes are held in the evenings. The village has become a tourist attraction as people make excursions to the project site to see the potential benefits of biogas technology and its socio-economic impact on the people of Appolonia (Mensah, 2000).

2.5.5 The Ghana Stove Project

The Ghana Stoves project came up with the Gyapa, an insulated and productive cook stove, to families in Ghana (Climate Care, 2009). The Gyapa stove cooks food more rapidly, requires less fuel and is less smoky. Carbon finance permits the stoves to be promoted at a reasonable value, whilst building on manufacturing skills, marketing channels and the fuel supply chain (Morgan, 2011).

The project aims to:

- reduce fuel costs for families and free up money for other uses;
- reduce emissions of hazardous air pollutants and improve the health of the cooks;
- create employment and build capacity throughout the supply chain i.e. in manufacturing, distribution, retailing, quality control and project management;
- reduce greenhouse gas emissions through a reduction in charcoal consumption; and
- slow widespread deforestation and aid biodiversity conservation.

The carbon finance is subsidising the cost of the stove to make it affordable (The Gold Standard, 2009). About 110,000 stoves have been distributed in Ghana.

2.6 Theoretical Framework

There are multiple theories that support endeavours directed at enhancing people's access to efficient, safe, modern and affordable energy service. This report, however, aligns itself to the "energy ladder" and "agricultural household model".

2.6.1 The Energy Ladder

Household fuel choice has often been conceptualized using the "energy ladder" model. This model places overwhelming accentuation on income in analysing fuel choice and fuel switching (Heltberg, 2003).

The energy ladder model envisage a three-stage fuel switching procedure. The primary stage is manifest by all inclusive dependence on biomass. In the second stage household move to transition fuels such as kerosene, coal and charcoal because of higher wages and factors such as deforestation and urbanization. In the third segment of the model, households switch to LPG, natural gas, or electricity. The components that influence the movement up the energy ladder are income and relative fuel costs (Leach, 1992; Barnes et al, 2002; Barnes and Floor, 1999 all refered to in Heltberg, 2003).

The second phase (transition stage) of the energy ladder may better explain the dominance of charcoal (43.6%) in the urban households' energy-mix. Majority of urban households (88.6%) in Ghana use electricity from the national grid as their main source of energy for lighting. Relating this to the energy ladder, the authors identify the third stage of the energy ladder to best explain the phenomenon. However, since about 11.4% of the urban households still do not have access to electricity and only about 35.8% of them use LPG as cooking fuel, the transition stage but not the third phase explains the phenomenon.

Rural territories are still in the first phase of the energy ladder because of the dominance of wood-fuel in families' cooking fuel-blend. Where families don't have admittance to present day energy, they are undermined in gainful undertakings or in their endeavors to raise their living standards (Barnes and Floor, 1996 cited in Heltberg, 2003). An increase in access to cutting edge types of energy in Ghana at the family level would minimize the negative effects of energy on human wellbeing as a smoke's aftereffect created by conventional biomass stoves, on the earth, from inefficient energy generation, and in the type of inferior energy services.

Barnes and Floor (1996 cited in Heltberg, 2003), opine that move from the traditional energy forms requires the formation of enabling conditions for income development, cost

reduction and increased access to modern energizes, while prices ought to as a rule reflect genuine scarcities instead of being subsidized. An effective intervention to promote the transition from the first to the second and subsequently the third phase should have incentives for the development of agriculture. Access to modern energy ought to be identify with social and financial infrastructure, for example, water supply, wellbeing interventions, training, and street lives up to expectations, which make energy procurement more meaningful (DEA, 2005; Heltberg, 2003).

2.6.2 An Agricultural Household Model

Nearly, 3.4 million family units in Ghana own or work a farm or keep livestock. Around 75% of the employed in Ghana were involved in agriculture (Ghana Statistical Service, 2008). On the other hand, around 44.7% of the active populace are currently employed by the agriculture, forestry and fishery industry in Ghana. In the rural areas, the agricultural sector is the most dominant sector with around 71.1% in rural Ghana (Ghana Statistical Services, 2014).

A standout amongst the most widely recognized intends to examining household livelihood generation in developing countries is by the utilization of the "agricultural household model" (Nakajima, 1970; Singh et al,

1986). Typically, the model is connected to investigate how changes in different costs influence household's allocation of time into agriculture home production, off-farm pay work and leisure. The model in this report simply looks at the role of energy services in household's production activities and development.

It is valuable to conceptualize family unit production to rise above agricultural production Households' activities can be arranged into households' activities and domestic activities, (for example, cooking, infant sitting and gathering of kindling or water). The model adjusts

itself to the accord that entrance to affordable, modern energy can facilitate cooking, water warming, lighting and operation of tools or appliances, which thusly can enter an extensive variety of home production activities (DEA, 2005).

The model runs with the supposition that family units can afford to invest in equipment and so improved energy services can enhance work efficiency in the utilisation of these equipment. Access to energy services can likewise empower the family unit to take part in new wage creating activities which get to be possible with tools or machines driven by modern energy (AGECC, 2010; DEA, 2005). Cooking and water warming may turn out to be less time expending, less expensive, and/or less awkward with equipment driven by present day energizes. Improved light may enhance education and extend business or domestic activities into the evening hours.

At last, access to modern energizes reduces the burden on local natural resources and time spent in the collection of firewood and in addition enhancing the utilization of water for irrigation purposes.

The issue of time allocation is at the heart of the model. It accept that time may be moved between distinctive activities, as the productivity of labour is increased with modern technology and/or the requirement for labour in specific activities is minimized. The degree to which time spared is an advantage significantly depends on the returns to time in alternative uses.

Mekonnen (1997) summarises the significance of the agricultural household model in the following:

- increase work efficiency in family unit production;
- enable the family unit to take part in new productive activities;
- facilitate or minimize labour time assigned to some activities;

- expand the number of hours available to activities previously reliant on (strong) sunlight;
- improve access and processing of information;
- enhance leisure activities;
- facilitate access to water
- minimize environmental degradation; and
- yield a more beneficial allocation of household time.

2.7 Summary of Literature and Lessons Learnt

Generally, the literature reveals that improving households' access to modern, safe, affordable and reliable energy services has the propensity to reduce poverty and boost economic development. The literature has revealed that there are several health and environmental ramifications from cooking with fuel-wood, crop residues, and dung. However, clean fuels and cook-stoves that facilitate lower smoke exposures can reduce the disease burden from smoke, lower child mortality rates, and improve maternal health.

Efficiency coupled with improvements in biomass fuel availability can also reduce the time burden of women and young girls who collect biomass. The immediate impact of the enhanced access to biomass is felt on education and income-generating activities. Electricity is crucial for the provision of basic health services such as sterilisation, water supply and purification, sanitation, and refrigeration of essential medicines. Electricity also powers machines for income-generating activities towards national development. The literature has also revealed that the lack of modern energy services in rural areas is the result of the reluctance of more-educated workers to reside and contribute to the development of these areas.

The kingpin role energy plays in national development is summarised by its correlation with the MDGs. Even though none of the MDGs refers to energy explicitly, the literature has demonstrated that there is a positive correlation between energy access and the MDGs. Improved energy services — *including modern cooking fuels, improved cook-stoves, increased sustainable biomass production, and expanded access to electricity and mechanical power*—is necessary for meeting all the MDGs. The correlation between energy access and the attainment of the MDGs is crucial in development planning since the MDGs are used as the benchmarks for the measurements of developing countries' progress towards improving the living conditions of their citizenry.

Notwithstanding this positive nexus, the literature has revealed that traditional energy forms/resources are dominant in the households' energy consumption mix. Biomass in the forms of wood-fuel and charcoal, accounts for 41.3% and 31.5% of households' cooking energy consumption mix in Ghana. The proportion of households using wood-fuel in the rural areas is even higher (74.8%).

The literature has also revealed that there is limited access and utilisation of modern and efficient energy forms such as LPG and grid-connected electricity in Ghana. However, about 70.6% of households are connected to the national electricity grid in Ghana. The intensity of the problem is higher in the rural areas where only 48.3% of households are connected to the national electricity grid with about 5% of the households using kerosene for indoor lighting.

Lessons learned from theories that underpin energy access planning (viz. the energy ladder and household agricultural model) seem to elucidate the consensus that access to modern energy services is crucial in communities' sustainable poverty reduction and development. Due to this, the GoG and her DPs have introduced several policies, programmes and

projects in the national development frameworks (GPRS I, GPRS II and GSGDA, volume one) and national energy documents (SNEP, NEP and EPRAP) aimed at improving households' access to energy services. The policies do not only emphasise the need for increased access to energy services, but also gives equal attention to the improvement of the end-use equipment. For instance, the GoG's SHEP, REP, Appolonia Biogas Project, and the UNDP's "LPG Substitution for Wood Fuel" and "Improving Supply Chain for LPG access in the Tamale Metropolis of Northern Ghana" projects all aim to improve households and other users' access to reliable and efficient energy sources.

Vital as the literature on the typologies of energy used by rural and urban households is, specific information on the quantities of the various energy resources, households' expenditure on them and the en-use equipment has not been addressed in the literature. This specific information is the pre-requisite of effective energy access planning in Ghana. Additionally, most of the statistics presented in the literature are estimates whose methodology is unknown to the reviewers and thus may not be reliable for large-scale planning due to high risk. In response to these, the survey was intended to obtain energy access data to fill the gaps and validate available energy access data on rural and urban areas in Ghana.

CHAPTER THREE

RESEARCH METHODOLOGY

3.0 Introduction

This chapter explains the methods employed to elicit the responses to the research questions. The methodology starts with the research framework and continues with the research approach, study population, method of determining the sample size and the sampling techniques used to select the respondents for the study. The chapter also explains the methods used to collect and analyse data for the study. Finally, a synoptic profile of the forest agro-climatic zone was presented in the chapter.

3.1 Research Approach

A survey research approach was adopted because it allows researchers to quantify and generalise research findings to an entire population if the sample is appropriately determined and selected. Errors are minimised in a survey research where standardised structured questionnaires are used (The Health Communication Unit, 1999). The survey research was considered to be most appropriate research approach to provide the required quantitative descriptions of the typology of energy services available to households in the Ashanti region and so it was thus used to gather data on households' access to the available energy resources in the region. Household data were gathered using structured and predefined questionnaire. Sampling was used in selecting households for the survey. This was to enable the sample to be used to generalise for the entire population.

3.2 Key Variables of the Research and Unit of Analysis

Using variables as key elements of a research problem helps to move the research from conceptual level to empirical level (Kumepkor, 2002). Based on these, the research's variables are presented in Table 3.1.

The unit of analysis was households in the Ashanti region heads of families responded to the survey, despite the fact that they gave data about other family individuals. Without the households heads, the next senior individual in the family unit was cross-examined; however, follow-ups were made to validate responses such as incomes and expenditures.

Table 3.1: Research Variables, Definitions and Relevance

Variable	Definition/Indicators	Relevance
Quantities of different energy types used by households;	▪ Measured in KWh if the energy type considered is electricity or kilogram if woodfuel, charcoal, sawdust or LPG. ▪ Measured in litres if the energy type is kerosene, petrol, diesel or any energy in liquid form. ▪ Measured in numbers if the energy type is dry cell.	To determine the per capita quantities of different energy types used by the households by locality.
Household ▪ income	The household monthly income in ▪ Ghana cedis. Household monthly incomes per decile.	To determine the number of households in each income decile group using the identified energy.
Per capita expenditures on different types of energy	▪ Household monthly expenditure on the various energy forms identified from the survey.	To determine the price per Mega Joule (MJ) of the different types of energy used by households.
Cooking stove by ▪ type	Identified by the type of cooking stove and the fuel it uses.	To determine the number of Households using different cooking stove types and their cooking location.

Source; Authors' construct, August, 2015

3.3 Sampling Procedure

Premised on the general objective of addressing data gaps on energy access in rural and urban areas in Ghana, the researcher selected communities that represent the different facets of Ghanaian communities in the Ashanti region. Three strata of communities,

namely *large towns, small-medium towns and rural communities* selected from the Ashanti region (forest agro-ecological zone) were used for the purpose of this study.

3.3.1 Stratification of the Kumasi Metropolitan Area

The Kumasi Metropolitan Assembly (KMA) uses a combination of housing types, land values and available infrastructure as the indicators for the classification of communities into high income, medium income and low income zones. Accordingly, high income residential areas of the city are characterised by well-developed infrastructural facilities such as motorable roads with good drainage systems, telephone, electricity and water (Johan *et al.,* 2003; KMA, 2006). The waste collection method used in the high income suburbs of the city is the door-to-door service. Serviced lands in the high income residential areas in the city are valued between US$150,000-200,000. By this, the residents in the high income residential suburbs are believed to be high income earners (see KMA, 2006; Babalola, 2010). The high income suburbs in the Kumasi Metropolis are indicated in Appendix 1.

Relative to the high income residential areas, the medium income residential areas have higher population densities arising out of the occupation of houses (mostly compound) by multiple households. These localities are characterised by averagely developed infrastructure (see Appendix 1 for the list of medium income suburbs in the metropolis).

Even though there are traces of poverty in all areas of the metropolis, it is more pronounced in the peri-urban and slum communities classified as low-income communities. Common features of these low income communities are inadequate facilities/opportunities, poor housing, poor road network, poor environmental sanitation and relatively low incomes (KMA, 2006). The low income communities in the Kumasi Metropolis are indicated in Appendix 1.

3.3.2 Selection of the Study Communities

Following the stratification of the suburbs in the Metropolis according to incomes levels and access to physical infrastructure (as indicated in Appendix 1), the researcher adopted the simple random sampling procedure for the selection of one community from each stratum. A total of three communities were selected from the Metropolis for the study. The selected communities were Ahinsan Estate (high income suburb), Gyinyase (medium income suburb) and Dompoase (low income suburb) from the Kumasi Metropolis (refer to Table 3.2).

For the purposes of triangulation, the small-medium sized town was selected from the list of small-to-medium sized towns used by the Energy Commission in their *"Energy Use in Ghana"* survey. The small-to-medium sized town selected was Kumawu from the Ashanti Region, (refer to Table 3.2).

The researcher selected a community with population less than 5,000 people from the region (refer to Table 3.2). Accessibility to this rural community was a major factor for the selection of the rural community. Only one rural community was selected for the purpose of this survey. The rural community selected was Wonoo in the Ashanti Region.

Table 3.2: Surveyed Communities

Region	Large Towns	Small-Medium Size Town	Rural Community
Ashanti	Ahinsan Estate (high income suburb) Gyinyase (medium income suburb) Dompoase (low income suburb)	Kumawu	Wonoo

Source; Authors' Construct, August, 2015

3.3.3 Determination of the Sample Size from the Frame

A major limitation for the determination of the sample size was the lack of up-to-date population census data (actual data) on some study communities. The preliminary results

of the 2010 Population and Housing Census which covered only the characteristics (total population, land area, population density, sex ratio, etc) of the region could not be used for the determination of the population sizes of the study communities because of the lack of details of the demographic characteristics of some surveyed communities. The researcher thus used historical data (2000) for the estimation of the 2010 populations for those study communities. The researcher first computed the inter-censal (2000-2010) growth rates (2.7%) for each community based upon which their 2015 projected populations were estimated with an inter-censal (2010-2015) growth rate of 2.5% according to the Ghana Statistical services (2012).

The main assumption for the population projection was that the estimated inter-censal growth rates would remain unchanged for the period between 2010 and 2015. Also assuming an unchanged household size, the total projected population for each community was divided by the average household size to derive the total household population for each community. The total number of households for each community was then summed up to determine the sample frame. The researcher then adopted a mathematical model from Miller and Brewer (2003) to determine the sample sizes for each of the zones at 90% confidence level (refer to Appendix 2). A total of 60, 30 and 10 households were interviewed in the large towns, small-medium town and rural community, respectively, as indicated in Table 3.3. The researcher proportionately allocated the sample sizes among the selected communities based on the population of households in each community as presented in Table 3.3.

Table 3.3: Determination of Sample Sizes by urban and rural areas

City/Town	District / Mun. /	Projected Population	Average Household	Number of Households	Sample Size

	Metro.	(2015)	Size	(2015)	
		Large /Towns			
Ahinsan Estate	KMA	8,977	3.9	2,302	20
Gyinyase	KMA	15,681	4.0	3,920	30
Dompoase	KMA	4,567	4.0	1,142	10
Sub-total				**7,364**	**60**
		Small-to-Medium Town			
Kumawu	Kumawu	15,099	4.2	3,595	30
Sub-total				**3,595**	**30**
		Rural Community			
Wonoo	Kumawu	1,094	4.3	254	10
Sub-total				**254**	**10**
Overall Total				**11,213**	**100**

Source; Ghana Statistical Service, 2012 (2010 Population and Housing Census)

3.3.4 Selection of Sampling Units in the Study Communities

The researcher used the systematic sampling technique for the selection of units from the study communities. Firstly, the numbers of the houses in the communities were used as the starting point. After the calculation of the sampling interval for each community, the first house was selected randomly. The other houses were selected through the application of the "K^{th}" approach

3.3.5 Response Rate

The survey obtained an almost 100% response rate. The direct interface methodology adopted by the study accounts for the high response rate. None of the questionnaires was

disposed of as incorrect yet not every question in the instruments were replied by or were pertinent to every household. Subsequently, responsiveness to questions in the instrument varied from person to person thus reactions to particular questions did not as a matter of course signify 100 in some cases. This high response rate underscores the reliability of the survey's findings.

3.4 Sources of Data and Methods of Data Collection

The study used both secondary and primary sources of data to answer the research questions. The secondary information was obtained through a desk study while the primary data were gathered through interviews with the use of structured questionnaires.

3.4.1 Secondary Sources of Information

The secondary information that was obtained through desk study includes the meanings and characteristics rural and urban areas of Ghana, role of energy in national development and typology of energy services available to urban and rural households. The information obtained from the secondary sources includes the energy access policies and programmes in Ghana, the theoretical underpinning of energy access policies, programmes and projects and the characteristics of the forest agro-climatic zones.

3.4.2 Primary Sources of Information

Primary data were gathered through a systematic process of questionnaire design through pre-testing to questionnaire administration.

3.4.2.1 Questionnaire Design

The researcher designed a household questionnaire to draw the necessary responses from the households (refer to Appendix 3). The questionnaire gathered information on household characteristics, income and expenditure, energy usage and cost, end-use equipment and home-based enterprises.

3.4.2.2 Pilot Testing of Questionnaires

The researcher tested the household questionnaires in three communities within the Kumasi Metropolis. The researcher administered the questionnaires with Twi[2] as the medium of communication. As part of the pre-testing, the researcher observed the time taken to administer each instrument, the responsiveness of participants and any challenges experienced in understanding and interpreting the questions in the instruments. The results of the pilot testing helped to fine-tune the instruments before a second pre-test was undertaken. The essence of carrying out the second pre-testing was to ensure that all the relevant feedbacks received from the supervisor during the first pre-testing were incorporated in the final instrument and to ensure improvement in the quality of questionnaires.

3.4.3 Design of Data Entry Template

Census Processing System (CSPro) was used for the analysis of the survey data. The researcher was trained in the use of the software. The software provides a framework meant for the design of templates which is used to meet the specific requirements of the user, unlike others which are generally limited and inflexible. The topics covered in the training included data collection, data entry, data consolidation, data storage, data management and data delivery. The researcher was trained in the process of the template design and the input of data into the software. The researcher was educated on how the wrong data gathered from the survey could negatively impact the outcomes of the project. The researcher first identified the core questions in the instrument that should be addressed

[2] Twi is the language for the Akans, the largest ethnic group in Ghana. Twi is most spoken language in Ghana.

carefully to ensure that the importance of designing the template is not compromised with other questions of less importance.

3.4.3.1 Enumeration and Period of Enumeration

Having quality assured the household questionnaires through the pilot testing; the researcher gathered the required data from the 5 communities selected from the Ashanti region (forest agro-ecological zone). A total of 100 household questionnaires were administered (refer to Table 3.3) in 30 days in the region.

3.5 Method of Data Analysis

The quantitative data collected from household heads were synthesised with the use of CSPro. Descriptive statistics such as the measures of central tendency, percentages and frequency distribution tables were used to analyse the household data. These descriptive statistics used for the data analysis were generated with the aid of the statistical package, STATA.

3.6 Characteristics of the Forest Agro-climatic Zone

This section of the chapter provides an overview of the forest agro-climatic region selected for the study. The intent is to situate the study areas in a regional context for better appreciation of the study areas.

Ghana's forest ecological zone constitutes 10% of the total land area of the country covering a total land area of about 135,670 km^2. The forest zone is floristically divided into rain forest (covering 750,000 hectares) and semi-deciduous forest (covering 740,000 hectares) (Statistics, Research and Information Directorate (SRID), 2001). The forest zone extends to the Ashanti, Brong-Ahafo, Western, Eastern and some areas of the Volta Region.

The forest zone has an even tree canopy of 30-40 metres while emergent may attain 60 metres. Canopy trees may be deciduous in the dry season but the under storey shrubs and trees are evergreen throughout the year. The zone is characterised by high rain forests interspersed with patches of mangrove forest with a large expanse of high tropical forest and semi-deciduous forests (Oppong-Anane, 2001). The growth of the vegetation is supported by favourable climatic conditions.

The forest ecological zone in Ghana is characterised by a high temperature between 2627ºC coupled with a double maxima rainfall pattern from April – July and from September – November. The zone has a high heavy rainfall that ranges from 1500–2200mm, which is well distributed throughout the year in the zone and thus promotes very rapid plant growth such as cocoa, oil palm, coffee, rubber, maize, plantain, cocoyam and cassava (Oppong-Anane, 2001).

About 30% of the total population in Ghana is found within the forest ecological zone. This is attributed to the fact that in Ghana, majority of the economically active population (i.e. 15 – 64 years) is found in the agricultural sector (mainly crop farming) which thrives best in the forest ecological zone (MoFA, 1990).

CHAPTER FOUR

DATA ANALYSIS

4.1 Introduction

The chapter first analysis households' economic characteristics with emphasis income levels expressed in deciles. The chapter also identifies the different types of energy used by the households in the Ashanti region. The quantities of each of the energy types used by households are correlated with their income levels expressed in deciles. The objective for the correlations is to identify any possible relationship between household income levels and the types and quantities of energy they consume. The type of end-use equipment used for cooking and their cooking location of the identified energy types are also discussed in the chapter. Finally, the chapter examines the sourcing profile of wood fuels (charcoal and firewood).

4.1.1 Households' Annual Incomes, Locality

The analysis of household income included the earnings of all household members. This information was provided by heads of household in consultation with the other income earning members of the household in the data collection process.

The analysis of household incomes revealed a mean annual income of GH¢7,355.70 which was about two times lower than the national annual household mean income of GH¢16,644.59 (Ghana Statistical Service, 2014). Further analysis of the survey results revealed that about 94% of the households earned less than the national annual household mean income. Specifically, households whose earnings placed them within the last decile groupings, earned more than the national annual mean household income of GH¢16,644.59 as indicated in Table 4.1.

Table 4.1: Mean Annual Income of households in Deciles grouping

Deciles	Range (GH¢)	Mean income in Deciles (GH¢)
1	0 -504	15.30
2	505 – 2,280	1,536.27
3	2,281 – 3,360	2,772.50
4	3,361 – 4, 488	3,900.66
5	4,489 – 5,502	5,050.09
6	5,603 – 6,792	6,112.91
7	6,793 – 8,400	7,637.82
8	8,401 – 10,800	9,778.65
9	10,801 – 15,600	12,882.25
10	15,601+	32,419.00
Mean	**-**	**7,355.70**

Source: Field Survey, August, 2015

The survey disclosed that households in the large towns were the highest income earners as they earned the highest category of incomes (i.e. from decile groups 6-10). Households in the large towns within the sixth decile income group earned 0.48% and 2.94% higher than the households within the small-medium towns and rural communities, respectively. The disparity increased with increasing decile groupings. This claim is elucidated with a comparative analysis of the households' earnings from the seventh to tenth income deciles. The survey results revealed that households in the large towns within the seventh income decile earned 0.79% and 4.87% higher than the counterparts within the small-medium towns and rural communities, respectively.

Table 4.2: Household Annual Income in Deciles by Locality

	Range (GH¢)									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Locality	0 -504	505 – 2,280	2,281 – 3,360	3,361 – 4, 488	4,489 – 5,502	5,603 – 6,792	6,793 – 8,400	8,401 – 10,800	10,801 – 15,600	15,601+
Gyenyase	7.11	1,539.91	2827.36	3,899.22	5,066.54	6,142.08	7,697.51	9,681.63	13,023.83	36,420
Ahinsan Estate	0	1,146.40	2,400.00	0.0	4,800	5,760	0.0	10,395	12,000	36,911.21
Dompoase	0	1,603.2	2,733.33	3,800.00	5,010	6,260	7,524	9,450	12,760	18,386.40
Large towns (mean)	**7.11**	**1,429.84**	**7,960.69**	**3,849.61**	**4,958.85**	**6,054.03**	**7,610.76**	**9,842.21**	**12,594.61**	**30,572.54**
Kumawu	31.74	1,591.79	2717.73	3884.271	5051.77	6024.86	7550.08	9268	11636.55	22,788.03
Small-medium towns (mean)	**31.74**	**1,591.79**	**2,717.73**	**3,884.271**	**5,051.77**	**6,024.86**	**7,550.08**	**9,268**	**11,636.55**	**22,788.03**
Wonoo	54	1,384.9	2904	4005	4800	5875.96	7240	0.0	0.0	0.0
Rural (mean)	**54**	**1,384.9**	**2,904**	**4,005**	**4,800**	**5,875.96**	**7,240**	**0.0**	**0.0**	**0.0**

Source: Field Survey, August, 2015

Households in the large towns whose earnings put them in the eighth, ninth and tenth income deciles earned about 5.8%, 7.6% and 25.5% higher than their counterparts within the same income deciles in the small-medium sized towns, respectively. However, there was no rural households presented within the eighth, ninth and tenth income deciles.

Table 4.2 further indicates that the highest income earners (i.e. within the last decile) were in Ahinsan Estate. The survey results showed that the average annual income of the household that earned within the tenth decile in Ahinsan Estate was about GH¢36,911.21 per annum. Furthermore, within the tenth decile, the earnings of the residents at Gyenyase (the middle income suburb in Kumasi) tallied well with the earnings of the households within the same decile at Ahinsan Estate (the high income suburb in Kumasi).

The survey data underscored the claim that Ahinsan Estate is a highest income suburb within Kumasi, as indicated in Table 4.3. The survey results shown in table 4.3 indicates that the mean household annual income was highest in Ahinsan Estate, GH¢17,142.28 and least in Wonoo, GH¢4,768.67.

Table 4.3: Mean Annual Household Income by Locality

Locality	Mean Annual Income (GH¢)	Rank
Gyenyase	8,182.44	2nd
Ahinsan Estate	17,142.28	1st
Dompoase	6,346,92	3rd
Kumawu	5,753.72	4th
Wonoo	4,768.67	5th

Source: Field Survey, August, 2015

4.2 Typology of Energy used for Lighting by Households

The survey identified that grid-connected electricity and dry cell batteries were the main sources of energy for lighting at the household level. This section of the report details the

proportion of households that used the various energy forms for lighting, the quantity they consumed and the corresponding expenditure incurred for using them.

4.2.1 Grid-Connected Electricity

The survey results indicate that about 81% of the households had access to grid-connected electricity in their dwellings as compared to an estimate by the Ministry of Energy and petroleum which suggest that about 76% of Ghanaians have access to electricity as at the last quarter of 2014 (Ministry of Energy and Petroleum, 2014). Table 4.4 depicts that the proportion of households that had access to grid-connected electricity was highest in the Ahinsan Estate (30%) and least in Wonoo (3%). The study results showed that there was universal (100%) access to grid electricity in the high income suburb of Ahinsan Estate in the Ashanti Region.

An average of 19% of the households was without access to grid-connected electricity. Majority (14%) of these households were in Kumawu and Wonoo communities (see Table 4.4). The major reasons why these households were not connected to the grid even though their dwellings were within coverage were household's limited income to afford electricity connection (75%) and disconnection for failure to pay electricity bills (25%) especially in Kumawu. The survey results also indicated that all the households without grid connection expressed their desire for grid electricity. About 60% of them believed that diesel/petrol and dry cell batteries were more expensive than electricity from the national grid. About 30% of the households were of the opinion that electricity from the national grid was clean and easy to use relative to the other energy forms (dry cells and diesel/petrol). The remaining 10% needed grid electricity for entertainment purposes (viz. Watch television and listen to radio programmes) dry cell could not provide and petrol/diesel would provide at higher cost.

Table 4.4: Proportion of Households with Access to Grid Electricity, by Locality Locality

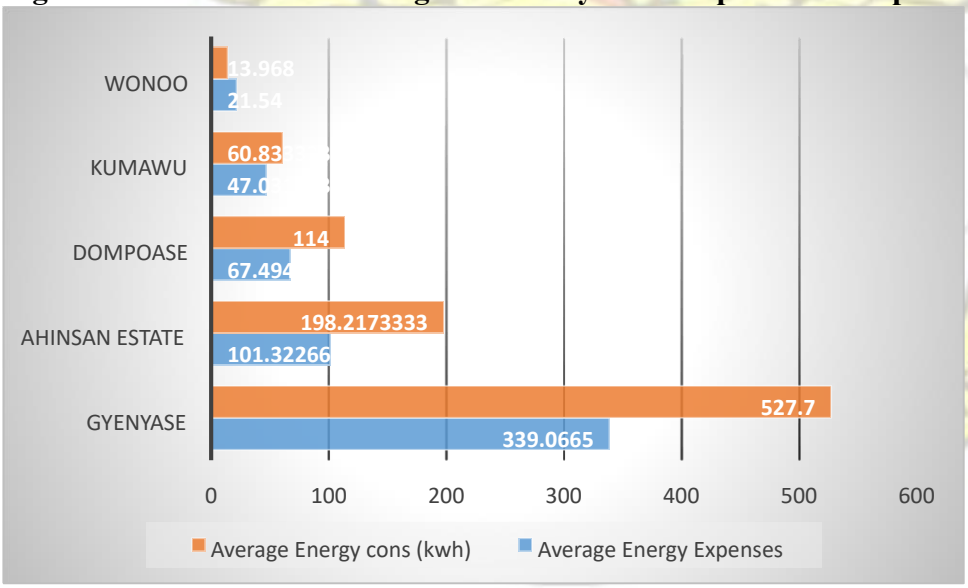
Electricity	Access	Total % Access	%	No Access	%		
All Households	***81***	***81***	***19***	***19***	***100***	***100***
Gyenyase	20	20	0	0	30	30
Ahinsan Estate	30	30	0	0	30	30
Dompoase	5	5	5	5	10	10
Kumawu	23	23	7	7	30	30
Wonoo	3	3	7	7	10	10

Source: Field Survey, August, 2015

4.2.1.1 Household Electricity Consumption and Expenditure Levels

It emerged from the analysis of the survey data that households paid an average of GH¢121.22 for the consumption of an average of 196.052 KWh of electricity per month. Figure 4.1 indicates that the expenses on electricity were highest in the Gyenyase where households consumed an average of 527.7 KWh of electricity per month.

Figure 4.1: Households' Average Electricity Consumption and Expenditure Level



Source: Field Survey, August, 2015

Ghana's electricity tariff structure shows a four-tier band. The first category, also referred to as the "lifeline tariff category", represents consumers that consume between 0 and 50 KWh of electricity per month. In the second category (residential category) are consumers that use between 51 and 300 units of electricity per month. In the third and fourth categories are consumers whose monthly electricity consumption levels are 300 and 600 KWh, and over 600 KWh of electricity, respectively. Per the consumption levels of the households as expressed in Figure 4.1 and Table 4.5, all the households fitted perfectly within the residential band and thus paid 6 Ghana Pesewas (Gp) per KWh consumed.

Table 4.5: Cross-tabulation between Quantity of Electricity Consumed and Household Income Levels

Deciles	Range(GH¢)	Quantity (KWh) per decile group
1	0 -504	79.65
2	505 – 2,280	74.33
3	2,281 – 3,360	73.04
4	3,361 – 4, 488	130.11
5	4,489 – 5,502	130.03
6	5,603 – 6,792	86.17
7	6,793 – 8,400	111.91
8	8,401 – 10,800	127.38
9	10,801 – 15,600	165.34
10	15,601+	137.65

Source: Field Survey, August, 2015

The outcome of a cross-tabulation between household income levels and quantity of electricity they consumed further elucidated the finding that all the households were within the residential tariff band (i.e. consumed between 51-300KWh). The quantity of electricity they consumed however increased with increased income levels. In a linear regression analysis, it emerged that income levels affected electricity consumption positively. Regressing quantity of electricity consumed (y) over income (x) in the Ashanti Region: the study identified that $y = 36.2 + 0.1122x$. Thus a unit increase in income level would

cause electricity consumption to increase by 0.1122KWh (refer to table 4.6). The product moment correlation coefficient (r) computed to be 84.4% revealed a positive relationship between income levels and quantity of electricity consumed. The subsequent correlation coefficient (r^2) of 71% also affirmed the positive correlation between income levels and quantity of electricity consumed in the Ashanti Region.

Table 4.6: Regression summary between quantity of energy consumed (kWh) and level of income

Energy consumption	coefficient	Std error	t P>*t* (kwh)
Income	.1122104	.0071903	15.61	0.000
constant	36.21769	15.19198	2.38	0.019

Number of obs = 100, F(1, 98) = 243.54, Prob > F = 0.0000, R-squared = 0.7131
Adj R-squared = 0.7101, product moment correlation coefficient (r) = 0.8444

Source: Field source, August, 2015

4.2.2 Frequency Distribution of Dry Cell Battery Users

As indicated in Table 4.7, about 95% of the households used dry cell batteries at the domestic level. While Ahinsan Estate (30%) ranked first in terms of the proportion of households that used dry cell batteries, Kumawu was ranked second (27%) and Gyenyase third (20%), respectively (refer to Table 4.7).

Table 4.7: Proportion of Households that Used Dry Cell Batteries, by Locality

Locality	Utilisation of Dry Cell at the Domestic				Total	% level
	Use	%	Do not Use	%		
All households	***95***	***95***	***5***	***5***	***100***	***100.00***
Gyenyase	20	20	0	0	20	20
Ahinsan Estate	30	30	0	0	30	30
Dompoase	8	8	2	2	10	10
Kumawu	27	27	3	3	30	30
Wonoo	10	10	0	0	10	10

Source: Field Survey, August, 2015

It emerged that households used dry cell batteries for lighting purposes and for operating their radio sets. The survey results pointed out that 81.1% of the households used dry cell batteries to operate their remote controls of their electrical appliances while 34.7%, 14.7% and 41.1% used dry cells for lighting, operating their radio sets and in wall-clocks respectively (refer to Table 4.8).

Table 4.8: Main Uses of Dry Cell Batteries

Locality	Uses of Dry Cell Batteries								Total	
	Radio Sets		Lighting		Wall clocks		Remote control		Number	%
	N	%	N	%	N	%	N	%	N	%
All households	**14**	**14.7**	**33**	**34.7**	**39**	**41.1**	**77**	**81.1**	***95***	***100.0***
Gyenyase	0	0	2	2.1	18	18.9	20	21.1	20	*21.05*
Ahinsan Estate	6	6.3	12	12.6	17	17.9	29	30.5	30	*31.58*
Dompoase	0	0	7	7.4	3	3.2	7	7.4	8	*8.42*
Kumawu	3	3.16	10	10.5	1	1.1	18	18.9	27	*28.42*
Wonoo	5	5.26	2	2.1	0	0	3	3.16	10	*10.53*

Source: Field Survey, August, 2015

4.3 Typology of Energy Used for Cooking

This section of the report analyses households' cooking fuels. The survey results revealed that households used LPG, charcoal, and wood fuel for cooking at the domestic level.

4.3.1 Frequency Distribution of LPG Users

The survey data revealed that an average of 61% of the households used LPG for cooking at the domestic level. A further analysis of the proportions of households that used LPG as cooking fuel per community revealed that, Ahinsan Estate had the highest proportion (49.2%) of households that used LPG as cooking fuel. This community was the high income suburb selected from the large towns for the study. Also 32.8%, 9.8% and 8.2% of the households in Gyenyase, Kumawu and Dompoase, respectively used LPG for cooking. The use of LPG as a household cooking fuel was highest (90.2%) in the large towns but none of the households in the rural communities used LPG for cooking at home as indicated in Table 4.9.

Table 4.9: Proportion of Households Using LPG by Locality Locality Utilisation of LPG at the Domestic level

	Use	%	Do not Use	%	Total	%
All households	***49***	***49***	***51***	***51***	***100***	***100.00***
Gyenyase	20	20	0	0	20	20
Ahinsan Estate	30	30	0	0	30	30
Dompoase	5	5	5	5	10	10
Kumawu	6	6	24	24	30	30
Wonoo	0	0	10	10	10	10

Source: Field Survey, August, 2015

Table 4.10 further indicates that the use of LPG declined as the size of the communities reduced. Thus, the urban households were more inclined to use LPG than the rural households; a finding

which conforms to the national situation (i.e. the rural areas are the least users of LPG). This claim is further buttressed by the finding that none of the households at Wonoo were using LPG for cooking at home.

Table 4.10: Proportion of Households Using LPG, by Ranking

Communities	Proportion of Household using LPG	Rank/Position
Gyenyase	20	2nd
Ahinsan Estate	30	1st
Dompoase	5	4th
Kumawu	6	3rd
Wonoo	0	5th

Source: Field Survey, August, 2015

The exception to the claim that LPG contributed insignificantly to rural household energy consumption mix, however, is Kumawu which had about 20% of its households using LPG as cooking fuel and was subsequently ranked 3rd among the 5 communities surveyed. Kumawu's role as a commuting town could offer an explanation to the high use of LPG as cooking fuel.

Despite the high proportions of households using LPG in the region, only 47.9% used them as their main primary sources of energy for cooking. Table 4.10 indicates that the households that used LPG as their main primary cooking fuel were domiciled in Ahinsan Estate which had been identified as the high income suburb in the large towns. Even in this affluent area, charcoal was used as a complementary source of cooking fuel because of the erratic supply of LPG in Ghana.

4.3.2 Household Expenditure on LPG and Quantity by Income Deciles

A cross-tabulation between income levels expressed in deciles and users of LPG revealed that households' income levels influenced the quantity of LPG they used. As indicated in

Table 4.11, there was no income decile group of the households that used 2kg, 3kg, 19kg and 45kg of LPG. However, about 67% of the households that used 15kg of LPG earned between the 6th and 10 deciles. The survey results also indicate that the proportion of the households that used 12.5kg of LPG earned between 5th and 7th deciles per annum.

Table 4.11: Cross-tabulation between Households' Income and Quantity of LPG used

Income Decile (GH₵)	Quantity of LPG														Total	
	2kg		3kg		6kg		12.5kg		15kg		19kg		45kg			
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
0 – 504	0	0	0	0	0	0	0	0	2	4.65	0	0	0	0	2	4.08
505 – 2,280	0	0	0	0	1	50	0	0	3	6.98	0	0	0	0	4	8.16
2,281 – 3,360	0	0	0	0	1	50	0	0	2	4.65	0	0	0	0	3	6.12
3,361 – 4, 488	0	0	0	0	0	0	0	0	3	6.98	0	0	0	0	3	6.12
4,489 – 5,502	0	0	0	0	0	0	1	25	4	9.30	0	0	0	0	5	10.20
5,603 – 6,792	0	0	0	0	0	0	2	50	3	6.98	0	0	0	0	5	10.20
6,793 – 8,400	0	0	0	0	0	0	1	25	5	11.63	0	0	0	0	6	12.24
8,401 – 0,800	0	0	0	0	0	0	0	0	4	9.30	0	0	0	0	4	8.16
10,801–15,600	0	0	0	0	0	0	0	0	7	16.28	0	0	0	0	7	14.29
15,601+	0	0	0	0	0	0	0	0	10	23.26	0	0	0	0	10	20.41
Total	**0**	**0**	**0**	**0**	**2**	**100**	**4**	**100**	**43**	**100**	**0**	**0**	**0**	**0**	**49**	**100**

Source: Field Survey, August, 2015

The study employed the product moment correlation coefficient (r) and the coefficient of correlation (r^2) to determine the nature and extent of relationship between income levels and quantity of LPG used at the household level. It emerged that household income level was inversely related to the use of 6kg of LPG and thus a percentage increase in income levels were likely to reduce the usage rate of 6kg of LPG by 0.02% (see Table 4.12).

Conversely, income level was a major factor accounting for the use of LPG in quantities of 12.5kg and 15kg (see Table 4.12). The survey results indicated that income level has a positive correlation with the use of 12.5kg – 15kg of LPG. A percentage change in income level (in decile) is likely to increase the usage rate of 12.5Kg by 66.79%, and 15kg by

77.08%.

Table 4.12: Relationship between Income levels and Quantity of LGP used

Quantity	Product Moment Correlation Coefficient (r)	Coefficient of Determination (r^2*100)
2kg	0	0
3kg	0	0
6kg	-0.01	0.02
12.5kg	0.82	66.79
15kg	0.88	77.08
19kg	0	0
45kg	0	0

Source: Field Survey, August, 2015

4.3.3 Frequency Distribution of Charcoal Users

It emerged from the analysis of the survey data that about 90% of the household used charcoal as cooking fuel at the domestic level. Table 4.13 indicates that the proportion of charcoal-using households in Gyenyase was 13%, Ahinsan Estate (30%), Dompoase (10%), Kumawu (28%), and Wonoo (9%). The proportion of households in large towns using charcoal is higher than the national urban average of 43.6% (Ghana Statistical Service, 2014).

Table 4.13: Proportion of Households that Used Charcoal, by Locality Locality Utilisation of Charcoal at the Domestic Total % level

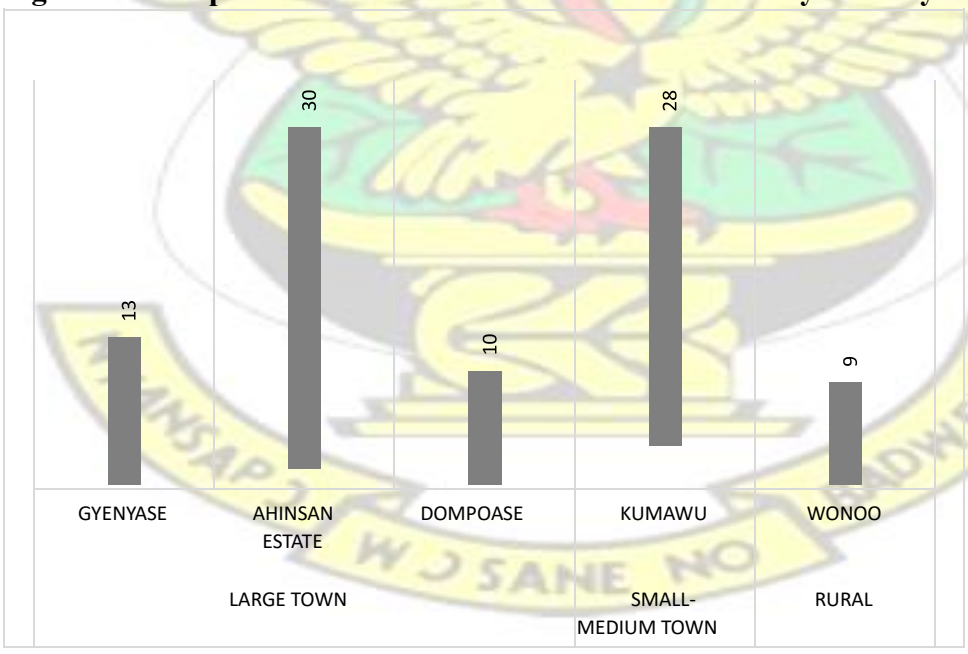
	Use	%	Do not Use	%		
All households	***90***	***90***	***10***	***10***	***100***	***100.00***
Gyenyase	13	13	7	7	20	20
Ahinsan Estate	30	30	0	0	30	30
Dompoase	10	10	0	0	10	10
Kumawu	28	28	2	2	30	30
Wonoo	9	9	1	1	10	10

Source: Field Survey, August, 2015

A further examination of the survey results revealed that 27% of the households used charcoal as their primary source of energy for cooking. The rest used LPG (47%) and wood fuel (22%) as their primary source of energy for cooking and occasionally used charcoal.

Figure 4.2 indicates that the use of charcoal as cooking fuel was high across the five different categories of communities selected for the study. The survey results revealed that an average of 53% and 28% of the households within the large towns and small-mediumsized town used charcoal as cooking fuel. The proportion of households in the rural areas using charcoal is relatively low (9%). Wonoo had the least proportion of households that used charcoal for cooking. This is explained by the availability of wood fuel sources which were often in abundance in the natural forest and were extracted from the natural forest without cost.

Figure 4.2: Proportion of Households that Used charcoal by Locality



Source: Field Survey, August, 2015

4.3.3.1 Quantity of Charcoal Used by Households

The survey results revealed that households consumed an average of 235.15kg of charcoal per annum. Table 4.15, however, indicates that the quantities of charcoal consumed by households varied from locality to locality and income deciles. Subsequently, the mean quantity of charcoal consumed in the small-medium towns was 254.2kg per annum; which was 6.2% and 18.8% higher than the mean quantities consumed by households in the large towns (238.4kg) and rural town (206.38kg), respectively.

Table 4.14: Cross-tabulation between Incomes and Charcoal Consumption Levels in Decile

Deciles	Range(GH₵)	Quantity (kg) per decile group
1	0 -504	108.774
2	505 – 2,280	118.166
3	2,281 – 3,360	152.162
4	3,361 – 4, 488	184.89
5	4,489 – 5,502	182.768
6	5,603 – 6,792	336.266
7	6,793 – 8,400	396.612
8	8,401 – 10,800	279.316
9	10,801 – 15,600	346.506
10	15,601+	246.058
Mean	**-**	**235.15**

Source: Field Survey, August, 2015

The small-medium's proximity to the charcoal producing areas accounted for the highest quantities of charcoal consumed by households. The survey results indicated that while 1.4kg of charcoal was sold for 50 Ghana Pesewas (Gp) in Wonoo, the same amount could buy 1.2kg and 1.1kg of charcoal in Kumawu and large towns, respectively. Households within the seventh decile were the highest consumers of charcoal using an average of 396.61kg per annum while the first decile income earners were the least consumers of charcoal. They used an average of 108.77kg of charcoal per annum (see Table 4.14).

Table 4.15: Cross-tabulation between Incomes and Charcoal Consumption Levels (kg) in decile, by Locality

Income Deciles	Gyenyase	Ahinsan Estate	Dompoase	Kumawu	Wonoo
0 -504	102.35	0.0	138.4	147.12	156
505 – 2,280	112.85	168	0.0	124.48	185.5
2,281 – 3,360	193.37	0.0	178.8	153.12	235.52
3,361 –4, 488	280.89	0.0	200	175.56	268
4,489 – 5,502	359.38	0.0	360.5	193.96	0.0
5,603 – 6,792	344.61	328	382.8	203.92	422
6,793 – 8,400	445.47	0.0	416.57	324.22	796.8
8,401 –10,800	227.32	543.75	293.4	332.11	0.0
10,801 –5,600	502.37	288	500	442.16	0.0
15,601+	330.36	158.6	296	445.33	0.0
Mean	289.89	148.64	276.65	254.20	206.38

Source: Field Survey, August, 2015

4.3.3.2 Source Profile of Charcoal

The survey results revealed that the predominant source of household charcoal was retailers which accounted for about 95% of the responses. An average of 2% of the household obtained their charcoal supply from distribution trucks while about 1% of them produced the charcoal themselves from wood extracted from their own farms and the natural forest.

Table 4.16: Source Profiles of Charcoal by Locality

Communities	Local Retailer / Market / Agent		Distribution Truck		Own Farm		Others		Tota	
	F	%	F	%	F	%	F	%	F	%
All households	***95***	***95***	***2***	***2***	***1***	***1***	***2***	***2***	***100***	***100***
Gyenyase	12	12	1	1	0	0	0	0	13	100
Ahinsan Estate	30	30	0	0	0	0	0	0	30	100
Dompoase	10	10	0	0	0	0	0	0	10	100
Kumawu	27	27	1	1	0	0	0	0	28	100
Wonoo	6	6	0	0	1	1	2	2	9	100

Source: Field Survey, August, 2015

Except Wonoo where 1% of the households produced the charcoal themselves, none of the households in the other four communities in the Ashanti Region were producers of the charcoal they used. The survey results indicated that that about 68% of the households used the traditional coal pot as the end-use equipment for charcoal conversion. The remaining 32% used improved cook-stoves *(*such as *Gyapa)*. The use of the traditional coal pot is widespread and was not limited to any particular locality. Despite their efficiency, Ottu-Danquah (2010) argues that the improved cook stoves are expensive relative to the traditional coal pots. Households, thus, prefer to buy the inefficient stoves that are manufactured by several blacksmiths in all localities (TEC/ESMAP, 2010).

4.3.4 Frequency Distribution of Firewood Users

It emerged from the analysis of the survey data that about 28% of the household used firewood as cooking fuel at the domestic level. Among the five communities in the forestagro-climatic zone studied, Kumawu (small-medium-sized town) had the highest proportion of households (18%) that used wood fuel for cooking (refer to Table 4.17). The average number of households using wood fuel in Wonoo (rural community) was 10%.

Furthermore, the proportion of households that used firewood relative to overall households in each community was dominant in the Wonoo (100%), a finding which overtook the Ghana Statistical Service's (2014) observation that about 74.8% of rural households use firewood.

Table 4.17: Proportion of Households Using Firewood by Locality Locality Utilisation of Firewood at the Domestic Total % Level

	Use	%	Do not Use	%		
All households	**28**	**28**	**72**	**72**	**100**	**100.00**
Gyenyase	0	0	20	20	20	20
Ahinsan Estate	0	0	30	30	30	30
Dompoase	0	0	10	10	10	10
Kumawu	18	18	12	12	30	30
Wonoo	10	10	0	0	10	10

Source: Field Survey, August, 2015

Table 4.17 further supports the claim that wood fuel use was inversely proportional to the economic status of the communities. That is, wood fuel was more common as cooking fuel in the rural community (Wonoo) than the large towns (Gyenyase, Ahinsan Estate and Dompoase), where none of the households used firewood for cooking.

4.3.4.1 Wood Fuel Sourcing Profile

The survey results revealed that about 89.3% of the households that used wood fuel for cooking obtained them from their own farms and /or forest. The proportion was highest in the small-medium town where about 53.6% of the households obtained firewood from the natural forest as indicated in Table 4.18. The dense forest cover of the Region provides a good opportunity for households to acquire their wood fuel from the natural forest.

However, proportion of households that obtained wood fuel from the natural forest relative to overall household that used firewood in each community was higher in Wonoo (100%) than Kumawu (83.3%). In general, the natural forest provided the wood fuel needs of majority of the rural households. Table 4.18 indicates that 10.7% of the household that used wood fuel as cooking fuel obtained them from local retailers. All the wood fuel users in the two localities used for the study used the traditional three-stoned stove as the enduse equipment for conversion wood fuel to heat energy.

Table 4.18: Wood Fuel Sourcing Profile by Locality

Communities	Nearby Agent		Local Retailer/Market		Distribution Truck		Own farm/forest	
	N	%	N	%	N	%	N	%
All households	***0***	***0***	***3***	***10.7***	***0***	***0***	***25***	***89.3***
Gyenyase	0	0	0	0	0	0	0	0
Ahinsan Estate	0	0	0	0	0	0	0	0
Dompoase	0	0	0	0	0	0	0	0
Kumawu	0	0	3	10.7	0	0	15	53.6
Wonoo	0	0	0	0	0	0	10	35.7

Source: Field Survey, August, 2015

4.4 Contribution of the various Energy Forms to Energy-Consumption-Mix

4.4.1 Household Energy for Lighting

The survey results indicate that grid-electricity accounted for about 93% of the total energy-mix for lighting. The contribution of grid electricity to household energy for lighting was highest in highest in the Ahinsan Estate (30%) and least in Wonoo (7%). Furthermore, the households in the large towns depended largely on grid electricity for lighting relative to the other localities. Grid electricity contributed about 98.3% of the total

lighting energy needs of the residents in the large towns as against 90% and 70% in the medium-sized towns and rural communities, respectively.

It emerged that household's use of dry cell batteries for lighting purposes was about 5% of total primary energy for lighting. Dry cell batteries contributed about 30% of the total lighting energy needs of the residents in the rural community as against 6.67% in the medium-sized town and none in large towns, respectively.

Also, the survey results indicate that solar accounted for about 2% of the total energy-mix for lighting. Solar contributed about 1.6% of the total lighting energy needs of the residents in the large towns as against 3.3% in the medium-sized town and none in rural community, respectively.

Table 4.19: Household Primary Energy for Lighting, by Locality

Communities	Grid		Solar		Dry cell		Total	
	N	%	N	%	N	%	N	%
All households	***93***	***93***	***2***	***2***	***5***	***5***	***100***	***100.00***
Gyenyase	20	20	0	0	0	0	20	20
Ahinsan Estate	30	30	0	0	0	0	30	30
Dompoase	9	9	1	1	0	0	10	10
Kumawu	27	27	1	1	2	2	30	30
Wonoo	7	7	0	0	3	3	3	10

Source: Field Survey, August, 2015

4.4.2 Household Energy for Cooking

As presented in Table 4.20, LPG was the highest contributor to household primary cooking fuel mix. About 47.9% of the households used LPG as their main source of cooking fuel as against 29.6% for charcoal and 22.4% for firewood. The use of LPG as primary cooking fuel as identified in the large and small-medium-sized towns accounting for 93.6% and

6.4% respectively. Critical analysis of the proportion of rural dwellers that used LPG as primary cooking fuel disclosed that none of the households in the Wonoo community used LPG as primary cooking fuel (refer to Table 4.20).

As indicated in Table 4.20, charcoal's contribution to household primary cooking fuel-mix was highest in the large towns (55.2%) as against 44.8% and none for the small-mediumsized towns and rural communities, respectively.

Firewood accounted for about 22.4% of the household's total primary cooking energymix. Further analysis of the survey data revealed that, all the households in Wonoo used firewood as their main source of cooking fuel. In the small-medium-sized towns, however, only 40% used wood fuel as their primary source of energy. None of the households in Gyenyase, Ahinsan Estates and Dompoase used wood fuel as their main source of cooking fuel. However, 2% of the surveyed households did not use any primary energy fuel source for cooking as they buy food from outside.

Table 4.20: Household Primary Energy for Cooking, by Locality

Locality	**Charcoal**		**Firewood**		**LPG**		**Total**	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
All households	**29**	**29.6**	**22**	**22.4**	**47**	**47.9**	***98***	***100***
Gyenyase	8	8.2	0	0	12	12.2	20	*20.4*
Ahinsan Estate	0	0	0	0	30	30.6	30	*30.6*
Dompoase	8	8.2	0	0	2	2	10	*10.2*
Kumawu	13	13.2	12	12.2	3	3.1	28	*28.6*
Wonoo	0	0	10	10.2	0	0	10	*10.2*

Source: Field Survey, August, 2015

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This section of the report presents the summary of findings with regards to access and use of various energy forms within the selected communities in the Ashanti region. Also it includes the conclusions made on the basis of the survey objectives and also the recommendations made to address identified issues regarding households' access to energy.

5.2 Summary of findings

A key finding from the survey was that households paid an average of GH¢121.22 for the consumption of an average of 196.052 KWh of electricity per month. The households, thus, fitted perfectly within the residential band and thus paid 6 Ghana Pesewas (Gp) per KWh consumed. The quantity of electricity households consumed increased with increasing income levels. The study identified that unit increase in income level would cause electricity consumption to increase by 0.1122KWh in the Ashanti Region.

The study identified that majority (20.41%) of the households within the 10th income decile (GH¢15,601+) consume the largest quantities of LPG of varying sizes. The survey data further indicated that the least (4.08%) proportion of households that use LPG were within the 1st income deciles (0 – GH¢505). Again, a significant (55.1%) proportion of the households that used LPG were within the 7th – 10th income deciles. It emerged that household income level was inversely related to the use of 6kg of LPG and thus a percentage increase in income levels were likely to reduce the usage rate of 6kg of LPG by 0.02%. Conversely, income level was a major factor accounting for the use of LPG in

quantities of 12.kg and above (see Table 4.12). The survey results indicated that income level has a positive correlation with the use of 12.5kg – 15kg of LPG. A percentage change in income level (in decile) is likely to increase the usage rate of 12.5Kg by 66.79%, and 15kg by 77.08%.

The survey results indicated that 1.4kg of charcoal was sold for 50Gp in Wonoo. However, 50Gp worth of charcoal weighed differently in the other towns. In Kumawu, 50Gp worth of charcoal weighed an average of 1.2kg as against 1.1kg in the large towns. Households within the seventh decile were the highest consumers of charcoal using an average of 396.61kg per annum while the first decile income earners were the least consumers of charcoal. They used an average of 108.77kg of charcoal per annum (see Table 4.14).

The survey results indicated that about 81% of the households had access to grid-connected electricity in their dwellings. Table 4.4 depicts that the proportion of households that had access to grid-connected electricity was highest in the Ahinsan Estate (30%) and least in Wonoo (3%). The study results showed that there was universal (100%) access to grid electricity in the high income suburb of Ahinsan Estate in the Ashanti Region.

The survey also depicted that about 95% of the households used dry cell batteries at the domestic level. While Ahinsan Estate (30%) ranked first in terms of the proportion of households that used dry cell batteries, Kumawu was ranked second (27%) and Gyenyase third (20%), respectively (refer to Table 4.7).

The survey data revealed that an average of 61% of the households used LPG for cooking at the domestic level. A further analysis of the proportions of households that used LPG as cooking fuel per community revealed that, Ahinsan Estate had the highest proportion (49.2%) of households that used LPG as cooking fuel. This community was the high

income suburb selected from the large towns for the study. Also 32.8%, 9.8% and 8.2% of the households in Gyenyase, Kumawu and Dompoase, respectively used LPG for cooking.

The use of LPG as a household cooking fuel was highest (90.2%) in the large towns but none of the households in the rural communities used LPG for cooking at home as indicated in Table 4.9.

The survey identified that about 90% of the households used charcoal as cooking fuel. . Table 4.13 indicates that the proportion of charcoal-using households in Gyenyase was 13%, Ahinsan Estate (30%), Dompoase (10%), Kumawu (28%), and Wonoo (9%). The proportion of households in large towns using charcoal is higher than the national urban average of 43.6% (Ghana Statistical Service, 2014).

It also emerged from the analysis of the survey data that about 28% of the household used firewood as cooking fuel at the domestic level. Among the five communities in the forestagro-climatic zone studied, Kumawu (small-medium-sized town) had the highest proportion of households (18%) that used wood fuel for cooking (refer to Table 4.17). The average number of households using wood fuel in Wonoo (rural community) was 10%. Furthermore, the proportion of households that used firewood relative to overall households in each community was dominant in the Wonoo (100%), a finding which overtook the Ghana Statistical Service's (2014) observation that about 74.8% of rural households use firewood.

5.2.1 Contribution of the various Energy Forms to Energy-Consumption-Mix The survey results indicate that grid-electricity accounted for about 93% of the total energy-mix for lighting. The contribution of grid electricity to household energy for lighting was highest in highest in the Ahinsan Estate (30%) and least in Wonoo (7%). Furthermore, the

households in the large towns depended largely on grid electricity for lighting relative to the other localities. Grid electricity contributed about 98.3% of the total lighting energy needs of the residents in the large towns as against 90% and 70% in the medium-sized towns and rural communities, respectively.

It emerged that household's use of dry cell batteries for lighting purposes was about 5% of total primary energy for lighting. Dry cell batteries contributed about 30% of the total lighting energy needs of the residents in the rural community as against 6.67% in the medium-sized town and none in large towns, respectively.

Also, the survey results indicate that solar accounted for about 2% of the total energy-mix for lighting. Solar contributed about 1.6% of the total lighting energy needs of the residents in the large towns as against 3.3% in the medium-sized town and none in rural community, respectively.

As presented in Table 4.20, LPG was the highest contributor to household primary cooking fuel mix. About 47.9% of the households used LPG as their main source of cooking fuel as against 29.6% for charcoal and 22.4% for firewood. The use of LPG as primary cooking fuel as identified in the large and small-medium-sized towns accounting for 93.6% and 6.4% respectively. Critical analysis of the proportion of rural dwellers that used LPG as primary cooking fuel disclosed that none of the households in the Wonoo community used LPG as primary cooking fuel.

However, charcoal's contribution to household primary cooking fuel-mix was highest in the large towns 55.2% as against 44.8% for the small-medium-sized towns and none for rural communities, respectively.

Finally, the survey results showed that firewood accounted for about 22.4% of the household's total primary cooking energy-mix. Further analysis of the survey data revealed that, all the households in Wonoo used firewood as their main source of cooking fuel. In the small-medium-sized towns, however, only 40% used wood fuel as their primary source of energy. However, none of the households in Gyenyase, Ahinsan Estates and Dompoase used wood fuel as their main source of cooking fuel.

5.2.2 Types of Cooking Stoves and Location

The survey identified that about 68% of the households who used charcoal used the traditional coal-pot as the end-use equipment. The remaining 32% used improved cook stoves as the end-use equipment. The survey results also indicated all the households that used wood fuel converted with the traditional three-stoned stove. LPG users predominantly used 6kg, 12.5kg and 15kg capacity cylinders.

5.2.3 Biomass Sourcing Profile

The survey results revealed that the predominant source of household charcoal was retailers which accounted for about 95% of the responses. An average of 2% of the household obtained their charcoal supply from distribution trucks while about 1% of them produced the charcoal themselves from wood extracted from their own farms and the natural forest.

The survey results revealed that about 89.3% of the households that used wood fuel for cooking obtained them from their own farms and / or forest. The proportion was highest in the small-medium town where about 53.6% of the households obtained firewood from the natural forest as indicated in Table 4.18. However, proportion of households that obtained wood fuel from the natural forest relative to overall household that used firewood in each community was higher in Wonoo (100%) than Kumawu (83.3%).

5.3 Conclusion

The research was a household survey designed to address gaps in data on energy access for rural and urban areas in Ghana. The findings from the survey revealed and addressed differences that influenced access and use of various energy forms within the selected communities in the Ashanti region. The per capita quantities of the various energy forms, incomes and expenditures of households were studied. The number of households in each income/expenditure decile group using the various energy forms and the price per MJ of the different types of energy used by households in the surveyed communities were also studied vis-a-vis addressing the energy gaps that exist. However, based on the objectives of the study, the following conclusions have been drawn;

- The majority (20.41%) of the households within the 10th income decile (GH¢15,601+) consume the largest quantities of LPG of varying sizes. The least (4.08%) proportion of households that use LPG were within the 1st income deciles (0 – GH¢505). Again, a significant (55.1%) proportion of the households that used LPG were within the 7th – 10th income deciles. The survey results indicate that about 81% of the households had access to grid-connected electricity in their dwellings. The proportion of households that had access to grid-connected electricity was highest in Ahinsan Estate (30%) and least in Wonoo (3%). The study results showed that there was universal (100%) access to grid electricity in the high income suburb of Ahinsan Estate in the Ashanti Region.
- Households paid an average of GH¢121.22 for the consumption of an average of 196.052 KWh of electricity per month. The second category (residential category)

is consumers that use between 51 and 300 units of electricity per month. The households fitted perfectly within the residential band and thus paid 6 Ghana Pesewas (Gp) per KWh consumed. The quantity of electricity they consumed however increased with increased income levels.

- The survey results revealed that households consumed an average of 235.15kg of charcoal per annum. Quantities of charcoal consumed by households varied from locality to locality and income deciles. The mean quantity of charcoal in the smallmedium towns was 254.2kg per annum; which was 6.2% and 18.8% higher than the mean quantities consumed by households in the large towns (238.4kg) and rural town (206.38kg), respectively. The survey results indicated that 1.4kg of charcoal was sold for 50Gp in rural community. However, 50Gp worth of charcoal weighed differently in the other towns. In small-medium town, 50Gp worth of charcoal weighed an average of 1.2kg as against 1.1kg in the large towns.
- The survey results revealed that about 89.3% of the households used wood fuel for cooking obtained them from their own farms and /or forest. The proportion of households that used firewood relative to overall households in each community was dominant in the Wonoo (100%), a finding which overtook the Ghana Statistical Service's (2014) observation that about 74.8% of rural households use firewood.
- The survey identified that about 68% of the households who used charcoal used the traditional coal-pot as the end-use equipment. The remaining 32% of households used improved cook stoves as the end-use equipment. The survey results also indicated all the households that used wood fuel converted with the traditional three-stoned stove. LPG users predominantly used 6kg, 12.5kg and 15kg capacity cylinders. Households in the rural communities were mostly using

the traditional coal pots and the traditional three-stoned stove simply because of its affordability, availability and accessibility to the energy source particularly charcoal and fuel wood.

5.4 Recommendations

5.4.1 The Deployment of Modern Energy to Households

The UNDP's 'LPG Substitution for Woodfuel', 'Household Energy for cooking', and 'Improving the Supply Chains for LPG Access in the Tamale Metropolis' and other projects should be expanded to cover households in all the localities. Amidst climate changes and the health ramifications from the use of traditional fuels, the UNDP and other Development Partners as well as the Government of Ghana should endeavour to encourage household to use these modern energy forms.

The Government of Ghana could increase the proportions of households using LPG as their main source of fuel if the erratic supply of LPG is addressed. Households in the rural areas who, for the distant location to the nearest electric poll are not connected to the national electricity grid, should be assisted to obtain supply. The implication is that the Ministry of Energy and Electricity Company of Ghana should use households as their units of analysis in expanding electricity coverage rather than communities.

Other modern and safe sources of electricity could be promoted as standby sources of electricity instead of diesel/petrol which has adverse health and environmental ramifications.

5.4.2 Deployment of Improve-cook stoves

The traditional cook-stoves and coal pots must make way for the use of improved cookstoves to make best use of the energy from burning fuels and minimize the health risk

on the users and environment. The Government of Ghana must thus create an enabling environment for the manufacturers of the improved cook-stoves. The enabling environment could be tax rebates and subsidies in order to minimise the cost of the stoves. Additionally, institutions such as the Ministry of Energy, The Energy Center and the private sector must be engaged to develop more efficient and affordable energy conversion equipment which increases productivity while minimising fuel consumption.

The promotion of improved cook stoves for family units ought to be initiated by the National Board for Small Scale Industries (NBSSI) which has the mandate to perform such functions in the country to identify, train and manufacture improve cook stoves once researchers are able to design appropriate technology for that. The Ghana Regional Appropriate Technology Service (GRATIS) should get on board to assist in the development of skills of artisans in improve cook stove production. This could also be an avenue for decent employment since the cook stoves would serve not only the needs of the households but also the entire urban and rural populace.

5.4.3 Proposals for Future Research

Underpinned by the diversity of the various types of localities in Ghana, future surveys should have an expanded scope to cover all the 10 administrative regions and remote offgrid communities. Communities with the influence area of cities (Kumasi, Accra, etc.) may be exhibiting peri-urban status whose characteristics may be similar to the urban communities. The results may be biased for example, the proportion of households that used LPG as cooking fuel was higher in Kumawu (6%) than Dompoase (5%). This implies that there are diversity in the various type of communities in Ghana which future survey should identify and stratify.

The survey approach could be complemented with other qualitative approaches in order to have an in-depth understanding of the factors affecting energy access and utilisation from the actors' perspectives.

Future surveys should be mindful of the working hours of household heads and members in order to plan for effective data collection and analysis. The study's interference with the working hours of the respondents protracted the survey period and thus distorted the project's milestone.

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APPENDICES

Appendix 1: Stratifying the Large Towns by Income Levels

Metropolis	High Income Suburbs	Medium Income Suburbs	Low Income Suburbs
Kumasi	Suburbs such as Nhyiaeso, Danyame, Ahodwo, Asokwa, Adiebeba, New Suame, New Asafo, Ahinsan Estate and Gyenyaase New site.	Ashanti New Town, Bohyen, Mbrom, Dadiesoaba, Duako Abrampong, Asokwa, Suntreso, Amakom, Atonsu S-Line, Gyenyaase Town.	Apatrapa, Dompoase, Nyankyerenease, Kokoben, Asawase, Aboabo No. 1 & 2, Dichemso Old Town, and Moshie Zongo, Dakwadwom, Sawaba, Yalwa (near Asem), Daban, Kaase, Sokoban, Nsenie, Anwomaso. Anloga and Ayigya Zongo.

Source; Kumasi Metropolitan Assembly, 2006

Appendix 2: Determination of the Sample Size

Formula:

$$n = \frac{n}{1 + N(\alpha_2)}$$

Where n is the sample size; n is the sample frame (number of households in each community);

N is the total number of households and α is the margin of error.

APPENDIX 3: HOUSEHOLD QUESTIONNAIRE

ADDRESSING GAPS ON ENERGY ACCESS IN RURAL AND URBAN AREAS

IN GHANA

HOUSEHOLD SURVEY QUESTIONNAIRE

Questionnaire Number: ..... Name of Region: .....

Name of Community: ..... House Number: .....

Name of Enumerator: ..... Date of Interview: ...../...../.....

Time Started: ..... Time Ended: .....

Data Entered by: ..... Date: .....

Instructions:

1. ***All interviewees should be well informed about the objective of the survey and their approval sought before the interview commences. They should be made aware of the duration for the administration of the questionnaire to give them an idea of the required time needed to complete the instrument.***

2. ***Head of household should be interviewed. Only in his/her absence should the next of kin be interviewed. The next of kin should be well-placed to provide the required answers, otherwise, the enumerator should hold on till he/she meets the head of household.***

3. ***Please CIRCLE/TICK the appropriate responses where options are provided. Where there are no options, you are required to ensure clarity of expression. The handwritten statements/answers must be legible.***

A.	PROFILE OF HOUSEHOLD HEAD *Please, circle the appropriate responses*	
1.	Respondent's relationship with head of household.	a. Head of household 1 b. Spouse 2 c. Daughter/son 3 d. Daughter/son –in-law 4 e. Parent 5 f. Parent –in-law 6 g. Other (specify)..... 7
Questions 2 – 7 refer to household head		
2.	Age of household head.	..... years old
3.	Sex of household head.	a. Male 1 b. Female 2
4.	Were you/was he/she born and raised here?	a. Yes 1 b. No 2 c. Don't Know 3
5.	If No, what is your/his/her hometown (include region)?	**Hometown** **Region**.....
6.	Household head's highest educational level attained.	a. None/no formal education 1 b. Primary 2 c. JHS/JSS/Middle School 3 d. SHS/ Technical 4 e. Vocational 5 f. Tertiary 6 g. Other (specify) 7
7.	Marital status of head of household.	a. Married 1 b. Single 2 c. Widower/widow 3 d. Separated 4 e. Divorced 5 f. Cohabiting 6

		g. Other (specify)..... 7
8.	Size of household ***(a household refers to a group of people who eat from the same pot and share the same housekeeping arrangements).***	....
9.	Type of household (question 9 is based on the response in question 8. Don't ask the respondent again).	a. Single household 1 b. Multiple household 2
10.	How many households live in this house?	

	(Note that this question is not the same as questions 8 and 46)	.....

B.	**HOUSEHOLD INCOME**						
11.	What is the total income of the household? ***(Please, indicate whether the household earnings are daily/weekly/ monthly/seasonal (e.g. GH¢10/day)) and make sure the incomes are recorded appropriately.*** ***If recorded on seasonal basis e.g. agricultural income(s), please indicate the number of months in a season and the number of season(s) in a year (see subsection c1).***						
	TYPE OF INCOME AND BENEFITS	**Member 1**	**Member 2**	**Member 3**	**Member 4**	**Member 5**	**Member 6**
A	***WAGE INCOME*** ***(a wage is a compensation, usually financial, received by workers in exchange for their labour e.g. labourer on a farm (typically known as by-day, a labourer in a construction firm paid daily for output, etc).*** ***(a salary is periodic payment from an employer to an employee, which may be specified in an employment contract. E.g. teacher, medical doctor, attendant at a public bathhouse who is paid every month, etc).***						
a1	Salaries and wages						
a2	Other (specify) ……..						
a3	***SUB TOTAL***						
B	***TRANSFER PAYMENTS***						

b1	Remittances (specify e.g. from son, daughter, etc). 1. 2. 3.						
b2	Disability benefits						
b3	Insurance (e.g. old age, disability, etc)						
b4	Monetary allowance and gifts						
b5	Pension						

b6	Other benefit(s) (specify)						
b7	***SUB TOTAL***						
	HOUSEHOLD INCOME FROM BUSINESS ACTIVITIES						
C	**HOUSEHOLD AGRICULTURAL INCOME** **(*Please enquire about the number of seasons in a year as well as the number of months in a season, if seasonal incomes are reported.***						
c1	How many season(s) in a year do you earn this income? ***Circle the appropriate response.***	a. One b. Two c. Three d. Other.....	a. One b. Two c. Three d. Other.....	a. One b. Two c. Three d. Other.....	a. One b. Two c. Three d. Other.....	a. One b. Two c. Three d. Other.....	a. One b. Two c. Three d. Other.
c2	If more than one, how many months are in a season?						
	EARNINGS						
C3	Cropping / crop farming						
c4	Animal rearing (e.g. livestock, etc)						
c5	Fishing						
c6	Fish Farming						
c7	Hunting						
c8	Gathering (e.g. shea nut, mangoes, etc)						

c9	Other (specify).....						
c10	***SUB TOTAL***						
D	***HOUSEHOLD NON-FARM SELF EMPLOYMENT*** ***(Please indicate if the household's earnings are daily/weekly/ monthly (e.g. GH¢10 per day))***						
d1	Artisans (e.g. carpentry, masonry, coal pot and head pan manufacturing, blacksmithing, etc)						
d2	Baking						
d3	Communication centres/space-to-space						
d4	Dressmaking						
d5	Drinking bar (including VC 10 or blue kiosk, pito, palm wine, etc)						
d6	Driving (i.e. selfemployed driver) ***Note: if he is employed by another person or company as a driver then he may be a salaried worker. Probe and record the response appropriately.***						
d7	Fish and meat mongering						
d8	Food vending/chop bars						
d9	Groundnut paste production						
d10	Hair salon (including barbering shops)						
d11	Head portage (kayaye)						

d12	Herbal medicine (including herbalists) preparation						
d13	Internet cafe operation						
d14	Kenkey production						
d15	Palm oil/kernel oil production						
d16	Printing and photocopying						
d17	Public bathhouse						
d18	Repairs (electrical appliances, etc)						
d19	Scrap metal collection and sale						
d20	Trading (wholesaling and retailing)						
d21	Video centre/video game operation						
d22	Other business activities (specify)						
d23	***SUB-TOTAL***						
E	***OTHER INCOME SOURCES***						
e1	Income from rent of property ***(please estimate monthly amount if lump sum is received).***						
e2	Rent of other assets (e.g. pushing trucks, wheel barrows, generators, canopies, chairs, cars, etc).						

e3	Interest on savings and loans						
e4	Reward and prize						
e5	Other (specify)						
e6	***SUB TOTAL***						
TOTAL (a3+b7+c10+d23+e6)							
OVERALL TOTAL (for all income earners of the household)							

C.	**HOUSEHOLD EXPENDITURE**				
12.	What is the total household expenditure? ***(Please indicate when daily expenses are reported e.g. on food)***	**TOTAL GH₵ (please record the expenditure in the appropriate cell)**			
A	**<u>LAST MONTH</u> WHAT WAS THE TOTAL HOUSEHOLD EXPENSES ON:**	**Daily**	**Weekly**	**Monthly**	**Other specify .....**
a1	Food: *(note that food expenditure includes expenses on meat, fish and sea food, milk, cheese and eggs; oils and fat; vegetables; sugar, jam, honey and chocolate, etc.)* ***Please, your diligence is required here as the expenses on some of the food items would be reported on daily, weekly or monthly.***				
a2	Household expenses on water (includes drinking water).				
a3	Household expenditure on personal hygiene – e.g. soap, detergent, shampoo, pomade, barbering, etc.				
a4	Expenses on telephone calls (including cell phone usage).				
a5	Expenses on transportation.				

a6	Expenses on household energy. **Reconcile the responses here with the expenses on the various energy forms indicated in sections F, H, I, J, K, L and M.**				
a7	Recreation activities, entertainment, cultural services. E.g. funerals, out-dooring, video shows, etc.				
a8	Tobacco (cigarette) and alcohol.				
a9	Rent.				
a10	Hotel/guest house.				
a11	Miscellaneous (tooth paste and brush, comb and ear rings, etc).				
a12	Newspapers, books and stationery.				
a13	Insurance.				
a14	Other (specify)				

a15	***SUB-TOTAL***				
B	**OVER THE <u>LAST MONTH</u> WHAT WAS THE TOTAL HOUSEHOLD EXPENSES ON:**	**TOTAL GH¢**			
b1	Health care: ***Please, indicate the number of household members who have registered under the NHIS .....and exclude the <u>registration and renewal</u> fees from the heath care expenses.***				
b2	Education of household members (include school uniforms, foot wears, school fees, textbooks, etc). ***(Ensure that this question is answered if the household has children or members in school).***				
b3	Transfer expenditures (remittances and gifts to other family members, etc.).				
b4	Clothing and footwear for household members.				

b5	Home maintenance and repair.			
b6	Other (specify)			
b7	**SUB-TOTAL**			

C	**OVER THE LAST *12* MONTHS WHAT WAS THE TOTAL HOUSEHOLD SPENDING ON:**	**TOTAL GH¢**	
		Annu	**Monthly (convert to a monthly account by asking the number of times the item is**
c1	Furniture & furnishings, carpets and floor coverings.		
c2	Household electrical appliances.		
c3	Glassware, tableware and household cooking utensils.		
c4	Home maintenance and repair (painting, patching of leaking roofs, replacement of worn-out parts, etc).		
c5	Tools and equipment for household garden.		
c6	Taxes (TV licenses and property taxes).		
c7	Contributions to self-help projects.		
c8	Other (specify).....		
c9	***SUB TOTAL***		
c1 0	***GRAND TOTAL (a15 + b7 + c9)*** ***Note: Make sure that the records of household expenses have the same period of measurement (preferably on monthly***		

	D TENURE AND TYPE OF DWELLING		
	Please, circle the appropriate responses		
13.	Type of dwelling occupied by household.	a. Wooden shack	1
		b. Corrugated aluminium	2
		c. Compound house	3
		d. Semi-detached	4
		e. Detached	5
		f. Hut	6
		g. Other (specify).....	7

14.	Does your household own this dwelling?	a. Yes..... 1 b. No..... 2
15.	If no, do you pay rent for your dwelling?	a. Yes..... 1 b. No..... 2
16.	If you pay rent, how much do you pay per month?	GH¢ .....per month ***(Use this answer to check the expenditure on rent provided under household expenditure).***
17.	From whom does your household rent this dwelling?	a. Private individual/family living in the same area ……..... 1 b. Private individual/family living elsewhere ..... 2 c. Metropolitan/Municipal/District Assembly..... 3 d. Other (specify)..... 4

18. Does your dwelling have the following housing facilities?

Use the codes Yes.....1 and No .....2 to answer question 18

	Facility	**Yes ..... 1 No.....2**	**Number of rooms used**
	Sleeping room (e.g. chamber)		
	Sitting room (hall)		
	Bathroom		

	Kitchen		
	Toilet		
	Store room		
	Garage		
	Other (specify)..... ..		

19.	If your house does not have the following facilities, where does your household usually use.....? **(Tick (√) as appropriate)**				
	Ownership / Facilities	**Communal (public)**	**Private (e.g. owned by neighbour)**	**Open space**	**Other (specify)**
	Sleeping room				
	Sitting room (hall)				
	Kitchen				
	Bathroom				
	Toilet				
	Store room				
	Garage				
	Store room				
	Other (specify).....				
20.	Do you pay for using any of the above facilities?		Yes..... 1 No..... 2		
21.	If yes, how much **(in GH¢)** do you pay per **day/week/month** for using the facilities? ***(Please, indicate the period, e.g. 50p per <u>week</u> for using bathroom).***		Facility — Amount (GH¢) a. Kitchen ..... per..... b. Toilet ..... per..... c. Bathroom ..... per..... d. Store room ..... per..... e. Other (specify) ..... per.....		
22.	If no, why don't you pay?				
E.	**ENERGY USAGE BY THE HOUSEHOLD** Types of energy used at the household level and purposes for which they are used.				

23.	What is your main source of energy for lighting at home?	a. Grid 1 b. Solar 2 c. Wind 3 d. Kerosene 4 e. LPG 5 f. Diesel/petrol 6 g. Other (specify)..... 7
24.	What is your main source of energy for cooking at home?	a. Grid 1 b. Solar 2 c. Wind 3 d. Kerosene 4 e. LPG 5 f. Charcoal 6 g. Firewood 7 h. Dung 8 i. Biomass (saw dust, etc) 9 j. Other (specify)..... 10

25. What do you use the following fuels for if you use them at the domestic level? ***(Please tick* (√) *as appropriate)***

Fuels	**Lighting**	**Cooking**	**Heating**	**Washing**	**Cooling**	**Automobile (e.g. in cars, etc)**	**Other (specify)**
Fossil fuels							
LPG							
Kerosene							
Petrol/diesel (e.g. in a generator)							
Electricity							
From the grid							
Solar PV							

	Traditional fuel							
	Firewood							
	Charcoal							
	Biomass (saw dust, palm kernel shell, etc)							
	Dung							
	Other energy forms							
	Candle							
	Dry cell batteries							
	Wet cell batteries							
	Biogas							
	Other (specify)							

26. How much do you spend on the quantity of energy by type mentioned in question 39 per day/week/month?
(Please specify whether it is day, week or month).

Remember to use the accompanying scale to weigh samples of charcoal, firewood, dung, etc used by households and record the mean weight.

Energy type	**Quantity** (e.g. 1 beer bottle (600ml) of kerosene for lighting)	**Price** e.g. GH¢2	**Duration** (For how long does it last?) e.g. 1 week
Lighting			
LPG			
Electricity grid(mains)			

	Diesel/petrol (e.g. to power a generator)			
	Kerosene (for lantern, kerosene lamp, etc.)			

	Solar			
	Dry cell batteries (e.g. for flash light)			
	Wet cell (car) batteries			
	Candle			
	Other (specify).....			
	Cooking			
	Charcoal			
	Firewood			
	LPG			
	Biogas			
	Kerosene			
	Biomass (saw dust, palm nut shell, corn cobs, etc)			
	Dung			
	Other (specify).....			
	Running Automobile (e.g. in cars, etc)			
	Petrol/Diesel			
	LPG			
	Other (specify.....			
	Other Services (e.g. cooling, heating, etc)			
	Charcoal			
	Electricity			
	Solar			
	Firewood			
	LPG			

	Kerosene			
	Biomass (saw dust, etc)			
	Other (specify).....			

27.	What is the alternative form of energy used by the household? For:	a. lighting..... b. cooking.....
28.	Are these alternative forms of energy readily available?	**Alternative for lighting** a. Yes..... 1 b. No..... 2 **Alternative for cooking** a. Yes..... 1 b. No..... 2
29.	If yes/no, please explain.	
30.	Are you willing to pay for better alternative forms of energy for lighting?	a. Yes..... 1 b. No..... 2
31.	If yes/no, please explain.	
32.	Are you willing to pay for better alternative forms of energy for cooking?	a. Yes..... 1 b. No..... 2
33.	If yes/no, please explain your reason.	

34.	Which energy types do you prefer for domestic activities and why? ***(Please rank from A –B where A is the more preferred energy type).*** **Codes for the Energy type:** Electricity-1; LPG-2; Charcoal-3; Firewood-4; Biomass (eg: sawdust)-5; Kerosene-6; Solar-7; Battery-8; Candles-9; Dung-10, Diesel/Petrol-11, Other (specify)..... 12 ***Note that the intent of this question is not to identify the current energy forms used by the households but what they prefer to use for not only the under-listed purposes but also other purposes. Their preferred energy types may however be the same as the ones they are currently using for their domestic activities.***

	End use	Ranking		Reason
		A	B	
	Lighting			
	Cooking			
	Heating (e.g. water)			
	Ironing			
	Cooling/refrigeration			
	Other (specify).....			

35. How do you get the fuel used by the household?
(Only for those who use traditional fuel such as charcoal, Biomass (saw dust), wood fuel, etc). (More than one response is allowed.)

a. Purchased 1
b. Collected freely..... 2
c. Other (specify)..... 3

36. Who performs the activity in question 35?

Please use the following codes to answer question 36.
(Self - 1; Wife – 2; Husband - 3; Boys - 4; Girls - 5;
Other family member (specify)..... 6).
Tick (√) as appropriate.)

Energy type	Purchased by:					Collected freely by:						Other (specify).....								
	1	2	3	4	5	6		1	2	3	4	5	6		1	2	3	4	5	6
Charcoal																				
Saw dust																				
Wood fuel																				
Dung																				
Other (specify)....																				

37. What disadvantages can you associate with the **traditional form(s)** of energy used by the household?
Please tick (√) as appropriate

	Disadvantage(s)	Charcoal	Biomass (e.g. Saw dust)	Firewood	Dung	Other (specify) ....
	None					
	Harmful					
	Expensive / unaffordable					
	Unavailable					
	Time wasting					
	Other (specify)					

F.	ELECTRICITY AS A SOURCE OF HOUSEHOLD ENERGY	
38.	Do you have electricity in your house?	a. Yes.....1 b. No.....2
	If the household does not have electricity in the house skip questions 39 -57, to 58.	
39.	What is your main source of electricity?	a. Grid (Mains)..... 1 b. Generator..... 2 c. Solar..... 3 d. Batteries (dry/wet cell)... 4 e. LPG..... 5 f. Other (specify)..... 6
40.	If your source of electricity is the "grid-main", who connected your household?	a. ECG..... 1 b. Private individual..... 2 c. Self..... 3 d. Unwilling to tell..... 4 e. Don't know..... 5 f. Other (specify)..... 6
41.	Were you in this house when the electricity connection was done?	a. Yes.....1 b. No.....2
42.	If yes, how much was paid for the electricity connection? (***NB: in some cases, households in compound houses and some localities contributed to get the connection especially from ECG. In instances like this record the total amount paid by <u>all households</u> as well as <u>each household</u>.***	**Amount (GH₵)** .....,.....
43.	Does your home have an electricity meter?	a. Yes.....1 b. No.....2
44.	If the home has an electricity meter, what is the type?	a. Pre-paid meter.....1 b. Regular meter.....2

45.	Please, indicate your electricity meter's name, accounts and geo code.	***Meter name:*** ..... ***Account:*** ..... ***Geo code:*** .....
46.	How many households are connected to the electricity meter? **NB: in some cases, *households outside the house may be connected to the meter, please probe and add the total number if such is the cases***	**.....**
47.	If the household does not have its own meter (but shares a meter with other households), how many households outside this dwelling are connected to the electricity meter?	**.....**

48. If the household has its own electricity meter, what were the quantities of electricity consumed in the last three months and how much did you pay? **(Please, request for the electricity bill to answer this question).**

You should record the "total this month" only.

Month	1. Last Month	2. Two months ago	3. Three months ago
Units (KWh)			
Cost (GH₵) (total this month)			

49. If the household does not have its own electricity meter (but shares a common meter with other households), how much did you pay as electricity bill in the last three month?

Month	1. Last Month	2. Two months ago	3. Three months ago
Cost (GH₵)			

50.	If the household does not have its own meter (but shares a meter with other households), how is the money you pay determined?	a. Fixed charge or flat rate determined by ECG ..... …… 1 b. Fixed charge or flat rate determined by landlord..... 2 c. Point-based rate agreed upon by all households sharing the common meter ..... 3 d. Other (specify) 4
51.	If the household does not have its own meter (but shares a meter with other households), whom do you pay the money to?	

52.	If you do not pay for the electricity you consume, why?	a. I don't need to pay because I did my own connection….. 1 b. I don't know where to pay the bills…… 2 c. Nobody comes to me for bills …… 3 d. Other (specify) …..... 4
53.	Do you have a standby source of energy for lighting?	a. Yes ..... 1 b. No 2
54.	If yes, please identify the standby sources	a. Generator 1 b. Solar (including solar torches) 2 c. Kerosene wick lamps 3 d. Rechargeable lamps 4 e. Candle 5 f. Dry cell flashlights 6 g. Other (specify) 7
55.	How many hours (on the average) do you use this standby source of energy for lighting in a month?	.....
56.	What type of fuel/energy is used in the standby source?	a. None 1 b. Diesel 2 c. Petrol 3 d. Kerosene 4 e. Solar 5 f. Dry /wet cell batteries 6 g. Other (specify) 7
57.	How much do you spend (on the average) per month on fuel/energy used in the standby source?	GH¢.....
	Answer questions 58 to 62 if the household has no electricity connection	

58.	Why is your house not connected?	a. Distance from grid..... 1 b. Can't afford ..... 2 c. Disconnected ..... 3 d. Not needed..... 4 e. Other (specify)..... 5
59.	Would you like to have electricity?	a. Yes..... 1 b. No..... 2
60.	If yes/no, please explain.	
61.	Have you ever applied for electricity connection from the utility company (ECG)?	a. Yes.....1 b. No.....2
62.	If yes/no, please explain (why you still don't have connection if Yes and why you have never applied for connection, if No).	

G.	**HOUSEHOLD ELECTRICAL APPLIANCES**									
63.	Which of the following household electrical appliances do you own?									
	Appliance	Tick (√) if available	Brand new	Number of brand new appliances used	Number of hours used in a day	Year acquired	Second hand	Number of second hand appliances in use by the household	Number of hours used in a day	Year acquired
	a. Television (s)									
	b. Refrigerator(s) and freezer(s)									
	c. Air conditioner(s)									
	d. Electric bulbs: *Incandescent* *Compact Fluorescent* *Fluorescent:*									

	e. Radio set(s)									
	f. Stabiliser (s)									
	g. Uninterrupted Power Supply (UPS)									
	h. Computer(s)									
	i. Blender(s)									
	j. Sound system(s)									

	k. Amplifier(s)									
	l. DVD player(s)									
	m. Electric immersion heater(s)									
	n. Electric oven(s)									
	o. Electric stove(s)									
	p. Washing machine (s)									
	q. Electrical sewing machine (s)									
	r. Rice cooker(s)									

	s. Pressing iron(s)									
	t. Electric fans(s)									
	u. Electric cooker(s)									
	v. Microwave oven(s)									
	w. Electric oven(s)									
	x. Bread toaster(s)									
	y. Deep fryer(s)									
	z. Other(s) (specify).....									
	aa. Other(s) (specify).....									

H.	**KEROSENE USE AND SUPPLY**	
64.	Does your household use kerosene?	a. Yes..... 1 b. No..... 2
65.	If no, why don't you use kerosene in your house? ***(Multiple responses are permitted).***	a. Dangerous to use ..... 1 b. Expensive/unaffordable...2 c. Not available.....3 d. Harmful (health).....4 e. Not needed ..... 5 f. Other (specify) 6
	Please answer the following questions if the household uses kerosene, otherwise skip to 75.	
66.	Where do you get your supply of kerosene?	a. Nearby Filling Station... 1 b. Local Retailer..... 2 c. Distribution truck ..... 3 d. Other (specify)…..... 4

67.	In what quantities does your household usually purchase kerosene? ***(measure size of measuring container)***	a. ½ bottle (300 ml)..... 1 b. 1 bottle (600 ml)..... 2 c. 1 gallon (4.5 litres)..... 3 d. Jerry can (20 litres) ..... 4 e. Other (specify)..... 5
68.	What is the price per the quantity (see Q67) used by the household?	GH¢..... per..... Refer to question 26
69.	How much does the household spend on kerosene per week/month?	GH¢..... per..... Refer to question 26
70.	Does your household use kerosene for the following purposes?	a. To start wood fuel/charcoal. Yes...1 No...2 b. Lamp lighting Yes...1 No...2 c. Cooking Yes...1 No...2 d. Home business Yes...1 No...2 e. Other (specify)..... Yes...1 No...2

71.	**End use equipment**	**Tick (√) if available**	**Brand new**	**Year the brand new equipment was/were acquired**	**Number of hours brand new equipment is/are used in a day**	**Second hand**	**Year the second-hand equipment was/were acquired**	**Numbe r of hours secondhand equipm ent is/are used in a day**
	Simple wick							
	Hurricane lantern							
	Kerosene stove							
	Other (specify)							

72.	Is kerosene always available in the market?	a. Yes.....1 b. No.....2

73.	If yes/no, please explain.	

74.	What does the household use when kerosene is not available? (**Please, tick** (√) **as appropriate).**				
	Energy Type	**Lighting**	**Starting fire**	**Cooking**	**Other (specify e.g. Water heating)**
	Polythene bags				
	Dried fibre				
	Corn husks				
	Firewood				
	LPG				
	Electricity				
	Biomass residue (saw dusts, corn cobs, etc				
	Dung				
	Batteries (dry cells and car batteries)				
	Other (specify).....				

I.	**BATTERIES SUPPLY AND USAGE**	
75.	Does your household use batteries?	a. Yes.....1 b. No.....2
76.	If no why?	a. Dangerous to use..... 1 b. Expensive/unaffordable... 2 c. Not available..... 3 d. Harmful (health)..... 4 e. Not needed..... 5 f. Other (specify) 6
	If No, skip to question 82	
77.	What type of battery does your household use?	a. Dry cells ..... 1 b. Car batteries..... 2 c. Other (specify) 3

78.	Purposes for which batteries are used	Quantity(in pairs)	Duration	Amount (GH¢)
	Radio			
	Flashlight			
	Lighting			
	Clock			
	Remote control			
	Other (specify).....			

79.	Where do you get the dry cell batteries from?	a. Nearby Agent ..... 1 b. Local retailer ..... 2 c. Local market ..... 3 d. Other (specify)…..... 4
80.	Is battery always available in the market?	a. Yes....1 b. No.....2
81.	If yes/no, please explain.	

J.	**CANDLES SUPPLY AND USAGE**	
82.	Does your household use candles	a. Yes.....1 b. No.....2
83.	If no why?	a. Dangerous to use..... 1 b. Expensive/unaffordable... 2 c. Not available..... 3 d. Harmful (health)..... 4 e. Not needed..... 5 f. Other (specify) 6

If No, skip to question 88

84. On the average, what quantity of candle do you use per period and how much does it cost the household? Refer to question 26

Purpose for which candle is used	Quantity (no. of pieces)	Price (GH¢)	Duration
Illumination			
Starting fire			
Religious			

	Other (specify)			
85.	In the absence of candles what alternative does the household use?		.....	
86.	Is candle always available in the market?		a. Yes.....1 b. No.....2	
87.	If yes/no, please explain.			
K	**LPG SUPPLY AND USE**			
88.	Does your household use LPG?		a. Yes.....1 b. No.....2	
89.	If no why?		a. Dangerous to use ..... 1 b. Expensive/unaffordable... 2 c. Not available ..... 3 d. Harmful (health) .....4 e. Not needed..... 5 f. Other (specify) 6	
(Please answer the following questions if the household uses LPG. Otherwise skip to 103).				
90.	What does your household use LPG for?		a. Cooking 1 b. Lighting 2	

	Multiple responses are allowed	c. Automobile 3 d. Other (specify) 4
91.	What size of gas cylinder/tank does your household usually use at home?	a. 2Kg..... 1 b. 3Kg.....2 c. 6Kg..... 3 d. 12.5Kg..... 4 e. 15Kg..... 5 Refer to question 26 f. 19Kg..... 6 g. 45Kg..... 7 h. Other (specify)..... 8
92.	What is the price of LPG per cylinder (mentioned above)?	a. 2 kg GH¢..... b. 3 kg GH¢..... c. 6 Kg GH¢..... d. 12.5 Kg GH¢..... e. 15Kg GH¢..... f. 19Kg GH¢..... g. 45Kg GH¢..... h. Other (specify) GH¢.....
93.	LPG end use equipment used at the household level.	

End use equipment	Type	Price (GH¢)	Number	State of equipment at time of purchase		No. of years used
				Brand new	Second-hand	
Stove						
Cylinder size						
LPG Lamp						
Other (specify)						

94.	How many days/weeks/months does one cylinder of LPG (mentioned above) last? ***(Please indicate the appropriate period, e.g. 5 days).***	..... days/weeks/month
95.	Where do you get your supply of LPG from?	a. Nearby LPG filling station..... 1 b. Local LPG Distribution truck..... 2 c. Other (specify)……..... 3
96.	Are you happy with the use of LPG at the household level?	a. Yes.....1 b. No.....2
97.	Please explain your answer in question 96.	

98.	Are you willing to replace the system (LPG stove and cylinder) when it is obsolete?	a. LPG Stove Yes.....1 No.....2 b. Cylinder Yes.....1 No.....2
99.	Please explain why you will or will not replace the system (stove and cylinder).	LPG Stove..... Cylinder.....
100.	In the absence of LPG what alternative does the household use?	.....
101.	Is LPG always available in the market?	a. Yes.....1 b. No.....2
102.	If yes/no, please explain.	
L.	**CHARCOAL USE AND SUPPLY**	
103.	Does your household use charcoal?	a. Yes.....1 b. No.....2
104.	If no, why?	a. Expensive/unaffordable.....1 b. Not available/difficult to get..... 2 c. Harmful (health)..... 3 d. Difficult to use in the wet season. 4 e. Not needed..... 5 f. Other (specify)..... 6
	If No, skip to question 114	
105.	What does your household use charcoal for?	a. Cooking..... 1 b. Heating..... 2 c. Other (specify) 3
106.	Where do you get your supply of Charcoal?	a. Nearby Agent..... 1 b. Local Retailer/market..... 2 c. Local Distribution truck .. 3 d. Own farm..... 4 e. Other (specify) …… 5
107.	What quantity of charcoal does your household use per day/week/month for cooking?	.....kg Per.....Refer to question 26
108.	How much does your household usually spend per day/week/ month on charcoal for cooking?	GH¢..... Per..... Refer to question 26

109.	In percentage terms, what proportion of cooking fuel is from charcoal?	.....%

110.	Is charcoal always available in the market?	a. Yes .....1 b. No 2
111.	If yes/no, please explain.	
112.	What charcoal conversion equipment do you use in your household?	a. Traditional Cook Stove..... 1 b. Car Rim Stove..... 2 c. Improved Cook Stove..... 3 d. Box Iron..... 4 e. Other (Specify)..... 5
113.	In the absence of charcoal what alternative does the household use?	.....
M.	**FIREWOOD USE AND SUPPLY**	
114.	Does your household use wood fuel?	a. Yes .....1 b. No 2
115.	If no why?	a. Harmful (health) ..... 1 b. Expensive/unaffordable.....2 c. Not available/difficult to get..... 3 d. Difficult to use in the wet season... 4 e. Not efficient to use..... 5 f. Not needed..... 6 g. Other (specify) 7
Please answer the following questions if the household uses firewood (Otherwise skip to 124).		
116.	What does your household use firewood for?	a. Cooking..... 1 b. Heating..... 2 c. Other (specify) 3
117.	Where do you get your supply of wood fuel?	a. Nearby Agent..... 1 b. Local Retailer/Local market.... 2 c. Local Distribution truck.. 3 d. Other (specify)……..... 4
118.	How much does your household spend per day/week/month on wood fuel for cooking? (Please, indicate as appropriate, e.g. *90 pesewas per week*).	GH¢..... Refer to question 26

119.	In percentage terms, what proportion of cooking fuel is from wood fuel?	.....%
120.	In percentage terms, what proportion of wood fuel used for cooking in the home is: a. Bought by the household	.....% .....%
	b. Collected by household members (free) c. Other (specify)	.....%
121.	What firewood conversion equipment do you use in your household?	a. Three Stoned Stove..... 1 b. Car Rim Stove..... 2 c. Other (Specify)..... 3
122.	Is firewood always available in the market?	a. Yes .....1 b. No 2
123.	If yes/no, please explain.	

N.	HOME-BASED ENTERPRISE *Please answer the following questions if the household has a home-based enterprise else skip to 140.*	
124.	What is the Home-based enterprise's core business?	
125.	How long have you been working in this enterprise?	..... years
126.	Is the enterprise registered with the appropriate authorities?	a. Yes.....1 b. No…….2
127.	If Yes, list authority registered under.	
128.	If No, explain why the business is not registered?	
129.	Do you pay toll/tax to the city authorities	a. Yes.....1 b. No…….2
130.	If yes, how much do you pay?	GH₵.....
131.	What type of activities is the enterprise into?	a. Service based ..... 1 b. Manufacturing/ production based ..... 2 c. Commercial/trading. ..... 3 d. Other (specify)..... 4
132.	If into manufacturing, please answer the following:	

	Type of Items Manufactured	**No. of items produced (daily/weekly/monthly)**	**No. of items sold daily/weekly/Monthly**

133.	How much do you sell each of your products?		
	Product(s)	**Unit price (GH₵)**	**Total (GH₵)**

134.	If into service enterprise, how many people do you serve in a day (averagely)?				
135.	How many employees does the enterprise have?				……employees
136.	Who are your customers/clients?				
137.	What is the peak and lean hours/seasons of your enterprise?				a. Peak season …… b. Lean season ……
138.	On the average how much income do you make?				a. Per day…… b. Per week…… c. Per month……...
139.	What energy types do you use for your business?				
	Energy Type	**Lighting**	**Starting fire**	**Cooking**	**Other (specify e.g. Water heating)**
	Polythene bags				
	Dried fibre				
	Corn husks				
	Firewood				
	Charcoal				
	LPG				
	Electricity				
	Biomass residue (saw dusts, corn cobs, etc				
	Batteries (dry cells and car batteries)				
	Other (specify).....				

140. Time Ended: _____

THANK YOU FOR YOUR TIME Appendix 4: Income Distribution among the Household Interviewed

Decile Grouping	Range (GH¢)	NO.	%	% Cumulative Frequency	Mean Income	%	% Cumulative Mean Income
1	0 -504	2	2	2	15.30	0.02	0.02
2	505 – 2,280	15	15	17	1,536.27	1.87	1.89
3	2,281 – 3,360	12	12	29	2,772.50	3.38	5.27
4	3,361 – 4, 488	10	10	39	3,900.66	4.75	10.02
5	4,489 – 5,502	12	12	41	5,050.09	6.15	16.17
6	5,603 – 6,792	10	10	51	6,112.91	7.44	23.61
7	6,793 – 8,400	14	14	65	7,637.82	9.30	32.91
8	8,401 – 10,800	11	11	76	9,778.65	11.91	44.82
9	10,801 – 15,600	8	8	94	12,882.25	15.69	60.51
10	15,601+	6	6	100	32,419.00	39.48	100
Total		**100**	**100**		**82,105.45**	**100**	

Source: Field Survey, August, 2015