

Analysis of the Inadequacies in Existing Practices and Factors Affecting Domestic Energy Demand in Ghana

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Abstract

The economic growth of a country largely has a strong correlation with the availability, reliability and the improved efficiency of energy, which are mostly over simplified. Contrarily, an appreciable reducing in energy demand of a country in general, may prove more difficult than is simply expected due to the rebound effects for actions taken in order to reduce energy demand. Consequently, there are lots of challenges in getting to really understanding complete characteristics and behavior of domestic household electricity consumption; this could be due to the complexity of main energy consumption drivers, the heterogeneity of the residential sector in Ghana and also the absence of reliable data.

Apparently, household behavior, which focuses on the interest and need to practice manageable energy consumption by household occupants, is mostly left out in analyzing the drivers of household energy demand.

In this work, both quantitative and qualitative data on the household energy data was collected and analyzed to deduce the inadequacies in the existing practices and factors that affect domestic energy demand in Ghana. Results indicated that, income level, class of housing, gender of head of household, lack of knowledge on smart grid and meters and demand side management techniques like load shedding and shifting at the residential level greatly influence the domestic energy demand in Ghana.

Key Words: Energy Demand, Smart Grid, Household Behavior, Demand Side Management, energy efficiency.

INTRODUCTION

Improving human welfare, health and rights is increasing at a very fast pace to meet global economic, social and technological advancements due to basic human needs and productivity, thereby increasing demand for Energy and its associated service [1]. This has become necessary owing to the computerization of most aspect of human livelihood.

Domestic energy consumption in Ghana is one of the high energy demand sector, apart from industrial and transport energy use. Achieving the Millennium Development Goals that Ghana has targeted to in 2020 has to do with an increase

in economic growth and also the need for energy supply to meet consumers' demand.

Again, poverty indicators such as illiteracy rate, rural urban migration, life expectancy etc. in developing countries like Ghana do have a match with the inadequacies in energy [35]

Despite the numerous energy supply and generation plants Ghana has, there still exist a huge and worrying gap between energy demand and supply, resulting in slowing down productivity and the countries development as a whole. Even though, Access to energy leads to an improved and better human development in a lot of ways. Yet, 1.3 billion people, making up 10% of the population worldwide, lack access to electricity. Of which 22% emanate from developing countries and proximately the remaining 97% have no access to electricity in sub-Saharan Africa and some developments in Asia [36].

Strategies have been adopted so as to ensure universal accessibility to available and reliable, clean and less expensive energy for the populace of the country.

Aside this, other strategic moves have been initiated by Ghana energy commission to improve on energy services to the poor people and communities, to alleviating poverty. But, the question here is, to what extent has this gone?

Despite all these approaches and strategies, Demand for energy is predicted to always rise due to numerous influential factors, it is therefore very necessary to complement all efforts put in place to improve the standard of living of Ghanaian by researching more into the energy sector, since energy is a driving force for the development of every country.

Although there are several researches into energy demand indicators of residential sector in Ghana, inadequacies in the existing structures and systems of domestic energy demand has not been really tackled, this paper will therefore look at analyzing the system inadequacies and factors affecting domestic energy demand as well as the existing practices of Ghanaian that affect demand.

Background of Study

In Ghana, there still is a challenge for most rural areas to access energy, despite the initiation of rural electrification

projects that was commissioned in 2016 and because it was an election year, the demand for energy has increased causing pressure on the energy distribution and transmission companies due to the quest to convince citizens of campaign promises and other developments. Besides, on-going network expansion works and measures to improve the quality of distribution and transmission services by ECG and NEDCO to further allow the connection of new loads which would subsequently result in an increase in demand in the residential, commercial and industrial sectors.

The major global energy challenges have been grouped into three folds: easy access to energy services for everybody, meeting growing demand by energy supply security and also managing influence of energy to climatic change. Despite the rich energy resources Africa is endowed with, as a continent, there exists an uncontrollable gap between supply and demand. An example is the case of Sub-Saharan Africa that has only 4% of its populace having access to energy out of 13% of the world's population, with about 45% economic growth worldwide in energy since 2000 [36].

Nevertheless, Ghana has available grid power supply of 16,401 GWh which means that, this would only be enough just to improve the economic growth to achieving the targeted 4-4.5% for 2016³⁷. But the estimated transmission grid system peak demand would be between 2,477-2,500 MW, about 8.5% growth over what was projected for 2015.

Prevailing electricity tariff moves Ghana from once among less expensive countries to very expensive grid tariff regimes in Africa³⁸. This is likely to reduce grid power consumption particularly in commercial, services and industries which are the wealth creation sectors with consequential marginal growth of the economy from the expected 3.5-3.9% for 2015 to just around 4% for 2016.

Where is the problem emanating from? How does one control this menace? These and other questions are on the minds of many researchers, and so worth researching.

Statement of Objective

The objective of this study is to analyze the inadequacies of the existing practices and factors (energy reliability) to arrive at demand for domestic energy consumption in Ghana.

Overview of Domestic Energy Consumption in Ghana

Inadequacies in the energy systems and behavioral intentions of consumers have affected energy demand in Ghana, thereby grossly affecting its availability and reliability, and so a high demand for an improvement in energy efficiency. Energy demand is an econometric concept, which demands that improved energy efficiency cannot be achieved in the absence of increasing energy prices and underpinning policies for the attainment of lesser hardships in the systems as well as reduced economic barriers.

But, Even though this conclusion is very necessary and dominant, it still has insufficient suggested policy approaches

and relevant limitations. Among the limitation is the aspect behavioral interventions has to play to encourage the application and awareness of more energy-efficient choices as well as advanced technologies in all aspect of the innovation chain in the energy sector.

However, there has been considerable variation from one country to another when considering the summation of energy demand closely correlating with the total population and income level or poverty level of the populace. What still remain unclear is whether wealth drives energy consumption due to an increase in demand from more goods and services and the ownership of more electrical appliances or whether the availability of energy turns to drive and enhance an increase in wealth due to increased productivity and industrialization, leading to an improved economy.

It is interesting to note that in practice, both mechanisms coexist and are interdependent on each other by strengthening each other within positive feedback loops, with changes in energy improved technology, reliability and availability, income and total population of a country [5].

In Ghana, energy demand at the domestic sector records as the highest energy demand area followed by the transport, industry and agriculture respectively [6]

Information on the total energy demand per sector is examined as clearly shown in Table 1, which can then be applied in the analysis of the implication of energy resource for alternative growth rates, with respect the various sectors.

Literature Review

It is worth noting that, due to the supply deficit of energy in 2015, the generation capacity could not meet the projected peak demand for the year. The projected peak demand for 2016 is therefore a build-up on the projected peak demand for 2015, since this an election year and numerous projected like rural electrification, increasing the existing dependable capacity 2,533 MW to additional dependable capacity of 2533, plus 868 MW, which implies, an additional capacity of 868MW is done[4].

Some of the major energy demand drivers in the country include; higher demand from industrial sector, due to expansion, income, urbanization, service sector improvements especially in communication, banking, schools, hospitals etc. and growing overall population growth (about 2.3 % per annum), with a corresponding power demand grows by about 10 to 15 % along with supply deficit [13], which corresponds to a growth in total power demand of about double its value from 2003 to 2013.

Considering energy demand at the domestic or residential level which is now the leading energy demand sector in the country [4] has a power demand growth shooting –up in overall by about 6.2 % per annum between 2000 and 2010 and an increase by about 15.4 % in 2013 alone.

The Industrial sector ad about 2.2 % power demand growth between 2000 and 2010 and from 2010 to 2013 had about 9.7%, but a decrease in demand to about 1.7% due to

VALCO(Volta Aluminum Company) running on 1 pot line [19].

Therefore, not until a better knowledge and behavior on how various driving factors influence domestic electricity demand is applied to assist in the understanding major developments in the sector to respond to an equally properly manage future demands, by identifying various opportunities to improve on the systems by focusing on selected household and intended policy efforts, the energy sector will still suffer from unabated energy crisis.

For instance most influential information on the impact of class of housing and types, household behaviors on domestic energy demand can provide relevant information as well as guide policy makers and give assistance in the forecasting of the impact of the use of energy efficient appliances and housing types on possible government policy measures in the Ghana.

Ghana's Energy Commission, [20] has also identified drivers of electricity consumption in Ghana being increase in industrial activities, efficiency measures used, up and downstream petroleum mining activities, rapid population growth or urbanization of the four major cities in Ghana etc. and subsequently are the major drivers of energy and its services, causing an increase in residential demand for electricity.

Considering the increment of peak power demand of electricity from 1943 MW in 2012 to about 2061 MW in 2014, [12] Leading to a Corresponding need for an additional generation capacity between 16,398 and 17,350 GWh in order to meet the required energy demand of the country, meaning an additional 4000 to 4200 MW is needed to balance demand currently [12], this is Due to the increasing population projections to rise from about 25million in 2010 to about 40 million by 2030 [21].

The introduction of numerous energy demand forecast models with high precisions, gives an opportunity to electricity utilities for an improved planning, management, operational and distribution processes, and consequently household energy consumption management practices will unveil opportunities one might have to reduce consumption in a whole, going a long way to solving the current energy issues Ghana is battling with.

Previous Works

Reviewed works in the area of energy demand in Ghana, key energy demand drivers and forecasting on the energy demand of a country provided enough guidance into energy demand matters and ways to control, notwithstanding the challenges and gaps in some of the approaches applied are included in the reviews done.

Paul Adjei Kwakwa [25], researched on Energy-growth nexus and demand for energy in Ghana: which reviewed through an empirical studies, the causal relationship between energy and growth, as well as energy demand in Ghana over the years.

Here, four possible outcomes were revealed as expected

results from energy-growth nexus namely, the Growth hypothesis, conservation hypothesis, Feedback hypothesis and neutrality hypothesis.

The studies reached an interesting compromise between the causal relation between energy and growth, giving an outcome attributed to the differences in the source of data for the various reviews, period for study and certainly the methods used. Also, findings is that most of the existing studies in literature made used of electricity for the energy-growth nexus analysis and ignoring the relation between growth and other energy fuels in the country.

The work further indicated that, socioeconomic factors generally affect demand for energy and its services at the micro level, whereas the level at which urbanization , industrialization, policy regime and efficiency of industrial activities were identified to be factors that greatly influence demand for energy and its services at the macro level.

Although the review was empirical, the work never work on very vital areas that need great attention, even though it was suggested as a recommendation for further studies, these areas included, conservation behavior of consumers, the intensity of energy use in the country, awareness of energy efficiency measures and willingness to pay for energy services.

John Bosco Draman et al. in 2013, worked on the End-Use Efficiency of Electricity in Ghana: focusing on the Experience with Policies, Technologies, and Institutions, here, we looked at Ghana's experience in technologies and policies applications which had the aim of improving end-use electrical energy efficiency.

Some of the technologies employed included; appliances, power factor corrections, the lighting system etc. appliances standards and labeling, electricity-saving lamps adoption, policies on economic and financial issues were the key issues the policies contained.

Penetration of these technologies was limited due to a number of market failures, impeding the overall success of the technologies. Unfortunately the part institutions play in influencing consumer behaviors, importers and manufacturers, policy, and prices to achieve an improved penetration of the aforementioned technologies was highly regarded.

In Ghana, according to the Ghana Energy Commission in 2010, electricity efficiency policies are be classified into two major groups, which are known as the mandatory efficiency policies that dealt with standards introduced by government to manage demand for electricity and the market-based efficiency policies which on the other hand, deals with the performance incentives given to consumers for the mode of electricity energy consumption [22].

Brown [23], in his study on Barriers and Market failures, as a basis for clean energy policies, categorized barriers to electricity efficiency into market failures and barriers. The functional imperfections of the market here is the causal element of the market failures, while the diffusion of the policies were responsible for the market barriers.

In 2015, Steve Sorrell argued in his study on the Reducing energy demand by reviewing the issues, approaches and

challenges to achieve improvements in energy efficiency. Despite the method applied to measure factors that reduce energy demand by focusing on an improved energy efficiency, a reduction in demand for energy which could also be achieved from something else either than just improving energy efficiency.

Equating Energy efficiency mathematically as the ratio of useful outputs of a specific system to energy inputs and having in mind that in many cases output of a system m that is most relevant, happen to be an energy service of another form.

Also, measurements of energy services are cumbersome because, it is subjective and dependent on the social context. So therefore there will always be a different definition of energy service due to the distinct understanding based on its dependency and subjectivity, which could subsequently lead to variable judgment on an energy system's efficiency.

So, to claim that 'energy-savings' or 'demand reduction' largely depends on energy efficiency, a reference needs to be specified against data for this measurement, pronouncements and estimations. Where, the assumption made, relevant hypostasis and temporal boundaries need to be specified. Intuitively, the attainment of 'energy savings' does not come that easy, econometric analysis of secondary data is overly relied on, which gives out results that mostly lack resolution and are sensitive to the specification of the model.

In effect, the existing literature is filled with unreliable and questionable claims about future energy savings due to the estimates of historical energy savings pronounced, relating to either specific technologies or policies or even both, he claims.

Challengeable, in the context of Ghana, energy efficiency, consumer behavior, and the application of technologic in the energy sector is researched to be the main indicators of energy demand. Although efficiency has a direct correction with the system in use, awareness for the need of energy efficient appliances will make in great contribution in reducing the energy usage and consequently, managing energy demand.

In conclusion, the researcher recommended that, sociotechnical and energy demand are much closely related because systems that are structured so as to provide energy services such as ironing, heating, lighting etc. are energy-related decisions which happen to be the core insight here. Also, managing energy demand could be improved considering the penetration level of the literature on sociotechnical transitions.

Organization of Paper

This paper has a total of five chapters. **Chapter one** introduces the research topic, states the objective and problem statement as well as the extent of literature on the subject matter. **Chapter two** details the research gaps and chapter three explains the methods used in data collection. **Chapter four** presents results analyses it. **Chapter five** finally, concludes and recommends the research findings

Key Drivers of Household Energy Consumption in Ghana

Demand and supply side drivers are classified as the two main factors that drive energy consumption at the household level in Ghana. Focus of this work, is on the demand side drivers, which include factors such as:

- Population growth rate
- Real Incomes
- salary and wages increment with time
- inefficient electrical appliances
- Access to credit
- Tariffs
- Education

Each of the factors listed contribute to the total demand of energy in Ghana [4].

In a study sponsored by the US government, it was deduced that lack of adequate skills and professional experience have together affected the energy systems and is being blamed for an erratic policy and non-transparent tariff collection regime in semi-urban areas (US Department of State, 2011: 61). Ghana is no exception, due to inadequate skills in the work. The World Bank stresses that, technically, most of the power outages in Ghana are not actually caused by an overload in capacity, but rather, through poor technical maintenance by the ECG (World Bank, 2013: 19).

Bulk of the effect of these challenges is on the demand side, since supply will never meet demand, due to the unavailability of energy and also lack of adequate sensitization on demand side management practices by consumers with the ultimate aim of optimizing energy consumption.

PROBLEM DEFINITION AND SCOPE

The use of energy in Ghanaian homes varies seasonally and is mostly driven by the weather conditions. Even though effects of this variation is minimal seasonally on electricity demand due to Ghana's tropical climatic condition results in minimal variations in daylight and temperature in a season.

With the existence of these two variations the demand for the electricity key services in the country is affected.

Domestic demand for electricity can lead to positive impacts on students' performance in formal educational by improving on lighting systems, on health through reduced indoor air pollution, on efficient process heating and cooling for productivity, and on refrigeration of foods leading to economic productivity of the country.

Existing electrical system of the country comprises of the generation, transmission and distribution companies, working as a team to make sure electricity gets to the end- user, although there are lots of challenges in these sectors a lot of work is on coming to smoothing the process.

Lack of capital due to weak balance sheets by state owned

electrical companies that cannot extend further the availability of power to new consumers has led poor infrastructure in the power systems, which subsequently leads to higher operating costs in the future and lots of infrastructural challenges including expensive emergency maintenance. Electrical demand in Ghana is greatly driven by robust economic growth, rapid urbanization and VALCO's demand limitation. Even though Ghana is fighting the migration of rural people to the cities for better ways of living, it is still a pending issue the county is facing [20].

The introduction of Demand side management techniques plays an important role in an operational efficiency of the power system, by either reducing demand by sensitization consumers on key issues of energy efficiency or the addition of distributed generation in the form of alternate use of other energy sources like solar for residential use.

A distributed energy resources will subsequently cause a reduction in the amount of centralized generation capacity overly depended on, and consequently no need for transmission and distribution facilities.

Despite Ghana energy commission plans to manage the demand side effectively, challenges such lack of funds from donor organization makes the continual awareness to energy efficiency and other demand side management techniques very difficult to penetrate, nevertheless forecast on demand is practice by using LEAP, Time Series Regression etc. depending on the input data.

Penetration and awareness of Passive demand reduction in Ghana's residential energy consumers, which includes the application of energy efficiency programs by improving on the usage of efficient loads that have low energy consumption is better than action active demand reduction technique due to it publicity. The greatest benefit of Energy efficiency is typically because it reduces peak demand in a fairly uniform manner.

On the other hand, Active demand reduction includes the application of programs like demand response and peak-shaving, where commercial consumers and industries are the target groups.

With the Peak-shaving programs, customers are encouraged to carry-out energy intensive activities at off peak hours at what time; total demand on the power system is low. This could equally be applied at the residential levels by encouraging customers at the domestic sector to do laundry with washing machine or iron their clothes in the morning, possibly, when energy demand is lower.

Although, in this regard, total energy consumption is the same, the system still realizes the load shift in demand periods; hence reward the consumer by a significant saving for avoiding systems capacity overload and costs.

Other factors that influences the demand for electricity in the country is the exchange of electricity with other countries which is driven by the two main factors: the need to meet the countries growing demand for electricity at peak hours and the instability of the flow rates and water level of the Volta River.

The trading countries involved in this agreement by

ECOWAS Energy Protocol, signed in 2003 are La Cote d'Ivoire and Togo, who Ghana shares boundaries with. The main aim is to encourage investments in the energy sector, which has proven significant benefits for Ghana. [6]

Suggested solution involves the Strategy plan in designing and implementing demand side management programs, for an improved demand patterns on power supply by making it reliability and availability in Ghana for an improved economy [27].

Dr- Joe Amoako- Tuffour et al. (2015) addressed the question: Why is Ghana still burdened with periodic energy crises? Some of the problems mentioned as the cause of challenges in the supply side included, inappropriate pricing and tariff, setting poor policies and poor management, weak governance and regulatory framework, poor revenue collection and poor institutional coordination [28]

The recommendation made going forward are the ability to improve the power mix of the country by relying the Ghana gas for about 500MW of power to offset the current crisis in 2016 with still a deficit of 5,000MW. Additional the creation of a new power ministries argued to change the style of management is recommended and finally, improving the gas supply to the country by total militancy in the Niger Delta of Nigeria and efficient and normalized functioning of the value chain in the extraction, transmission and delivery power plants [28].

METHODOLOGY

An appropriate research approach based on the research topic was adopted to ensure successful attainment of the project objectives. In this case the mixed/triangulation method was the favorable approach used.

Thus, the research approach employs both qualitative and quantitative research approaches to study a research topic, in this regard; domestic energy demand drivers and system inadequacies. In the absence of extensive research or few works in the study area with regards to Ghana on the set objective, adopting the triangulation method was very important for this research. Hence only limited resources in this study area will be available to complete the questionnaire. A survey was thereby conducted through questionnaires.

Focusing on analytical research, such as this research work, a descriptive approach is used to explain or answer the questions why or how something has happened or happens. Thus, findings and reasons for a particular set of outcomes become key players to explanatory survey. Hence, this research survey was personally done by researcher through questionnaire administrated to respondents.

Research Setting

This research was basically conducted due to indications from the Greater Accra Region of Ghana, with respect to energy demand, setting was chosen due to the higher energy demand and also the fact that it is the capital and has the highest

population due to urbanization as compared to the other administrative regions in Ghana. .

Greater Accra Region is the capital city of Ghana and the smallest of all the ten (10) administrative regions in the country; it has a total land area of 3,245 square kilometers, which represents 1.4% of Ghana's total area

The Greater Accra region is divided into 16 districts in June, 2012. Since politically, the local government system is employed, each District, Metropolitan area is thereby administered by the Chief Executive, representing the central government who also derives authority from an elected presiding member from among the members as Assembly.

Renewable and non-renewable energy consumption and thereby demand in Ghana are majorly driven by productivity growth and income [27] and so this survey targeted the energy demand of different housing and its classes in Ghana, to really get the pattern of consumption and how consumer behavior affects demand.

The Population

Here, the chosen population consisted of the total number of households, estimated to be 450,794, where the population per house is estimated to be 11.1% with an average household size of 3.7.[28], a total of 2.277 million is estimated as the population of Accra [27]

Eligibility Criteria

The Eligibility criteria seeks to specify that characteristics of respondents in the chosen population to be perfect for the study by Politang Hungler, 1999. Here, the eligibility criteria were that the participants had the following;

- ✓ educated
- ✓ member of the household
- ✓ should be an adult
- ✓ should be residence within greater Accra
- ✓ should be connected to national grid of electricity

Sampling Procedure

Using Roasoft software for the calculation of the sampling size, 450,794 household populations corresponded to 261 sampling size [28], at a confidence level of 90%, 5% margin of error and response distribution being 50% and a random sampling method was adopted for questionnaire administering.

It is very important to note that, over reliance on electricity in urban areas in Ghana is great as compared to rural areas, but total population for both urban and rural areas in the greater Accra region was used as the population size, even though rural area's electricity demand is insignificant in this regard.

Data Collection Instrument

The primary source of data was done by research

questionnaire, which was centered on the user behavior towards the use of energy, appliances ownership, energy conservation awareness, knowledge about smart meters and smart grid in Ghana.

Here, the open and closed ended structured questionnaires were used as the primary source of collecting data, with the main aim of ensuring that respondents makes a choice from the closed ended questions as well as give answers in their own words and opinion in the open ended type.

Considering the Response rate of this survey which recorded as high, because of the involvement of the researcher in distribution and collection of questionnaire, aiding respondents to complete questionnaire on time and accurately and partly to aid an understand and respond to questions appropriately, the questionnaire was written in simple English language.

Data Validity and Reliability

The systematic sources of variation are the construct intended and the irrelevant construct because they remain constant for any given individual, accounting for difficulties with data validity. The latter is attributed to accidental factors that arise from the measuring occasion. The random measurement errors are unsystematic and problems associated with reliability are attributed to it.

Data Validity

Data validity could be a mechanism that governs the success of an applied process in data collection by indicating the degree of correlation of the findings to actually happening in a given situation. Therefore, construct validity is the use of instruments that fulfill its purpose to measure variable.

Hence, to ensure content validity, questionnaires were structured in way to produced information about the factors that affect energy demand, types of energy used in Ghanaian homes and user behavior. The researcher also ensured that the external validity of the research by making sure that the right respondents were selected, standard tools were administered, personal administering of questionnaire etc.

Data Reliability

Babbie & Mouton in 2007, described Data Reliability as one that represents a response to distinct approach for the same research, produce the same results over time. Researcher encouraged respondents' privacy and confidentiality by making it clear the need for the research for academic works and nothing else, which greatly contributed to obtaining the information for the study. Reliability therefore, measures the credibility of research findings.

Ethical Considerations

To foster Honesty and integrity in this research work, questionnaires were administered to Respondents after a verbal consent were seek. Nonetheless, participants assured of not bearing any form of risk and participation cost what so ever. Though house numbers of Respondents' were required, names and identities were omitted just to assure participants

of the privacy as well as confidentiality of their response.

In line with this, questionnaires were prepared in order not to infringe on the rights of participants and for that matter any ethical desires. Hence, the covering letter as well as the instructions on questionnaire assured participants of an anonymous nature of the survey.

Data Analysis Procedure

The Dichotomous scales were used in the questionnaire. Again, closed ended questions were differently ranged, due to the type of heterogeneity of the data needed for analysis. Analysis of open ended questions was done accordingly by categorizing data into themes and assigning labels or codes to them.

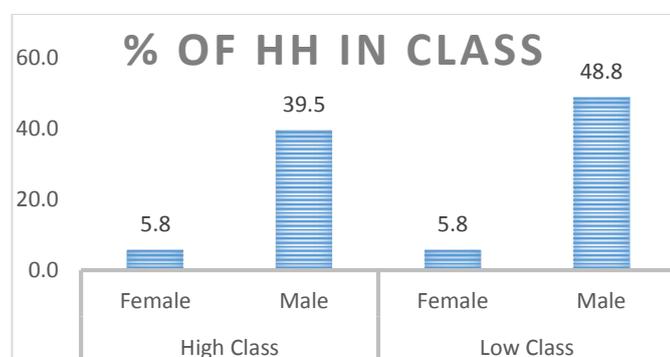
RESULTS AND DISCUSSION

Data collected from survey conducted was first of all recorded in Microsoft excel and presented using the pivotcharts tools. Out of a total of 250 questionnaire administered, 210 respondents were received, with the main reason being lack of trust in the survey and the fact that household heads feels answers to questionnaire are private issues with the fear of future sanctions on the information collected about them.

Due to the close correlation between the inadequacies energy systems and poverty indicators such as rate of illiteracy, economic growth, rapid urbanization etc. in most developing countries and also the heterogeneity of household energy demand because of it numerous drivers that include, building types, household demographics, occupancy, age distributions and income level. This research work depended on these energy drivers and indicators like the household behavior on the use of energy as very important in energy planning, and also the types of housing in Ghana. Below are therefore results obtain for the energy drivers and indicators elaborated earlier.

The indicators are:

Demographic statistic



Source: Field Data Collected

Figure 4.1. Percentage of Gender of Head of Household in Classes

Since the household type has an impact on energy demand, the survey was classified into low class and high class based on the suburb where the household is located in Ghana. In this regard, Percentage of Male and Female Households heads across all residential classes is shown in fig 4.1, which indicates that the percentages of the male gender of head household in each class is higher than female. Research by the World Bank has revealed that the adoption rates and determinants of new cooking technology and use of electricity may differ with regards to gender of the heads of households; some of these determinants include the decision of female head of households to use other source of energy for cooking as compared to the male heads [29]. Apparently, a reflection of the decisions by female heads of households is more closely connected to women's attitude, preferences and welfare. This as a result increased the possibility of female-headed households being responsive and adoptive to various interventions for an improved availability of electricity.

However, the ability of female-headed households to adapt to changes in the availability of energy sources regardless of income and subsequently improving domestic energy demand could possibly be affected by the institutional constraints, legal and cultural issues faced by women. Considering the results of the survey, the number of male heads of household outnumbered the female heads, which indicates that the beneficial attribute of female heads of households is an inadequacy in Ghanaian homes due to the percentage variation of the male and female heads of household.

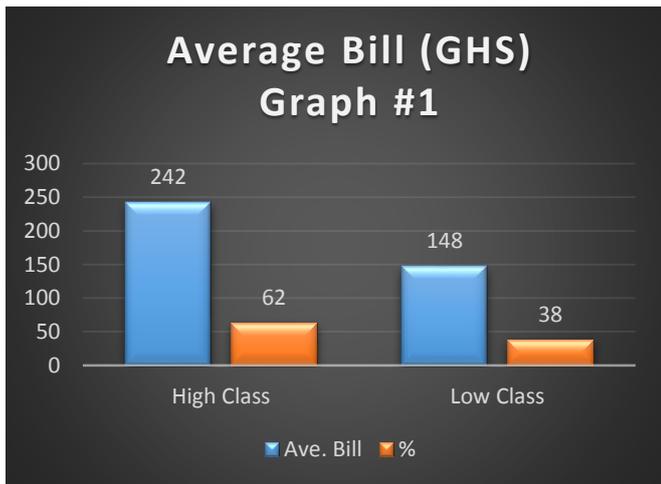
How income affects use of energy

Working on the findings from research conducted by Ismael Ackah, et at. [30] Indicates that the major factor the drive renewable and non-renewable energy consumption in Ghana include population growth, productivity and income. Three graphs were used to explain how income affects use of energy. These include average electricity bill among residential classes, percentage of bill among classes and the monthly income of heads of household.

Caveat: Electricity was the main energy used to analyze this question and other variables due to its dependency and current electricity crisis in Ghana.

Graph #1 in fig 4.2, looked at the average electricity bill among Residential Classes, which suggests that High Class residential areas receive averagely higher light bills and the related proportion in percentage.

The second and third graphs explained the distribution of the 5 income groups in the residential classes, also indicating majority of heads of households in both classes fall within the highest income group. This obviously proves findings of research on the predictor of energy demand in Ghana.

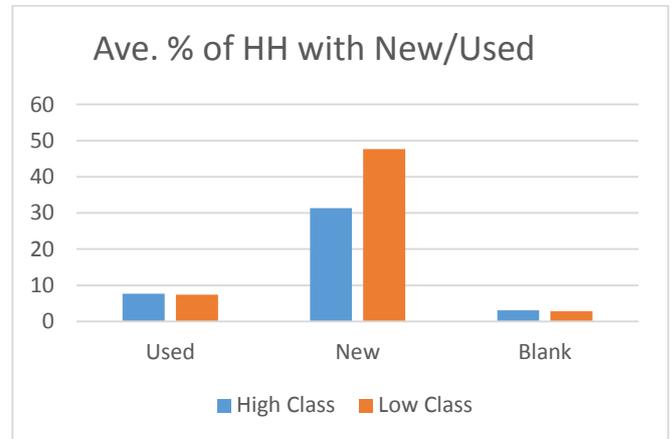


Source: Field Data Collected

Figure 4.2. Effect of Income on Energy Demand

markets.

Fig 4.4 presents the proportion of sampled households using new appliance

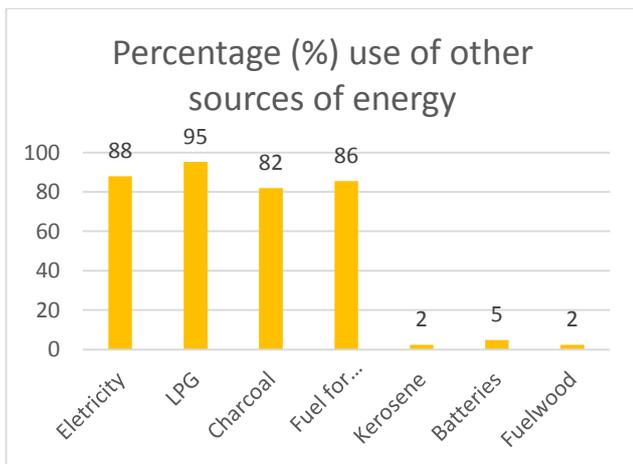


Source: Field Data Collected

Figure 4.4. average percentage of HH using new/used appliances by class

Percentage use of other sources of energy

Data collected on the use of other domestic energy source has been displayed in fig 4.3 by the percentage used of different energy sources among the sampled households



Source: Field Data Collected

Figure 4.3. Percentage Use of Other Sources of Energy

Fig 4.3 represented also suggests that there is an overlap in the usage of energy per HH. This means a household can use more than one source and will be counted under each. The least used are kerosene, batteries and fuelwood. LPG is the highest used in sampled households.

Percentage use of energy efficient appliances

The analysis of this indicator relied on an assumption that all households using New Appliance are considered to be using energy efficient appliance regardless of the number of new appliances in the household. This is because by Ghana Standards Authority, all new appliances must meet the national energy efficiency standard before entering the

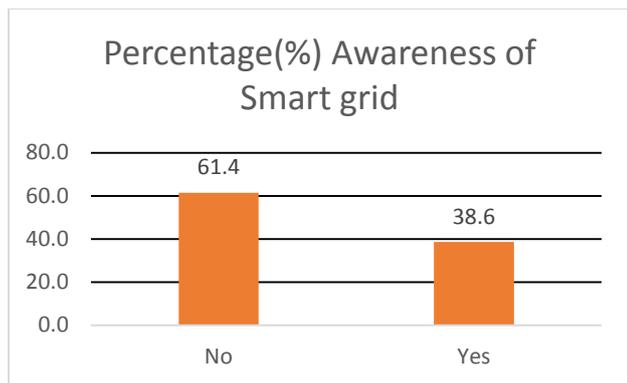
The high percentage of new appliances in sampled household is further supported by the statistics which depicts the households' awareness of the fact that second hand (Used) appliances are not energy efficient. This awareness cuts across households in both the High and Low Class areas. The additional graph displays the average percentage of Household (HH) usage of New and Used appliances.

Awareness about Smart Meters and Grid

Percentage penetration of smart grids and smart meters has helped improved domestic energy demand of many countries due to energy demand management capabilities. Smart grids and meters were introduced to the Ghanaian a few decades ago and there is the need to know the penetration and acceptance level in the country.

Even though a lot of consumers still prefer the use of postpaid billing systems, due to the numerous challenges with the prepaid, which includes over billing. There exist an advantage to this technology, this include its real- time and smartness, making energy demand manageable.

Fig 4.6: displays the percentage of household who are aware Smart grids and meters, obviously, there is still a bottleneck in the awareness level of smart grid and meters, despite their technological advantages.

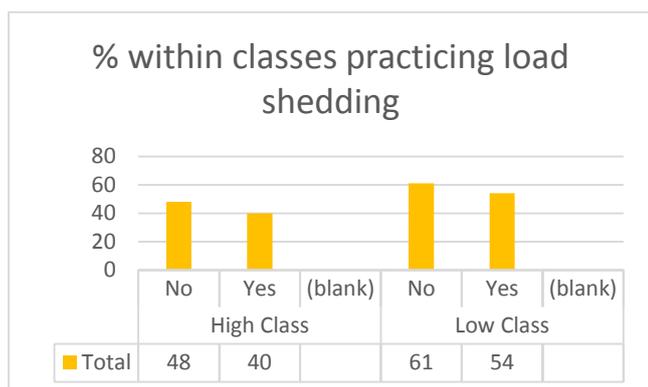


Source: Field Data Collected

Figure 4.5. Percentage Awareness of Smart Grid and Meters

Percentage of Practice of Home Load Shedding and Sifting

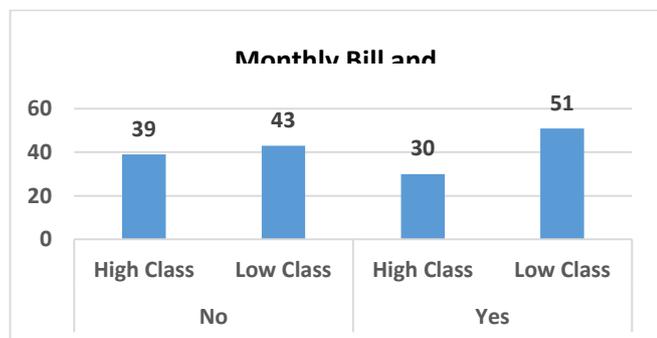
The graph in fig 4.6 seeks to explain the behavioral practice of HH with regards to self-Load shedding. A greater percentage of HHs does not practice load shedding and this is even higher in low class residential areas and also over populated. Also, a smaller percentage doesn't really understand what home load shedding meant.



Source: Field Data Collected

Figure 4.6. Percentage of practice of home load shedding

REFLECTION OF ENERGY CONSUMED ON ELECTRICITY BILLS OR CREDIT PURCHASED.



Source: Field Data Collected

Figure 4.7. energy consumed vs. electricity bills

Considering fig 4.7, the graph clearly indicates that most consumers have challenges with the billing systems and could make customer seeks for other ways of reducing the bills paid for energy consumed.

CONCLUSION

The variation in the residential energy profile for different seasons will be profound when the inadequacies in the existing structures and system that affect the residential energy demand, availability and reliability in the Ghanaian homes is controlled.

It is quite known that the availability and reliability of domestic energy demand cannot be guaranteed due to the energy situation of the country which is highly driven by economic growth. Therefore, energy consumption and generation patterns in the residential environment will play an important role towards switching to Smart Grid applications.

The findings of the research are group into three categories; firstly, findings to unveil the inadequacies in existing structures and practices that affects domestic energy demand, secondly, findings on factors that affect domestic energy demand and lastly, findings on domestic energy demand drivers is the Ghana homes. The following were the findings made from the research conducted:

Findings One: Inadequacies in the existing structures and practices that affect domestic energy demand.

Some of the inadequacies in the existing systems and practices noticed from the survey include:

1. Dominant male heads households in the sampled area, leading to the lack of interventions for an improved accessibility to alternative energy sources, which results in the adoption of other fuels for cooking, apart from electricity.

1. Though, awareness on second – hand product not energy efficient is encouraging, there were still a percentage of the populace who don't have an idea, this possess a great lapse in the awareness creation by the ministry of energy. Again, the percentage use of used appliance in the Ghanaian home is high and could be due to the importation of the used appliances into the country despite all efforts to stop its importation into the Ghanaian market.

2. Inconsistent and inadequate billing and utility control and management systems is a challenge in the energy sector. Consumers always do have a problem with value for money when it comes to the monthly bills they receive and reliable and availability of domestic energy demand. Clearly consumers, most of the time cannot understand the amount of bills received due to its inconsistency and the fact that consumers have less trust in the systems.

3. Despite all known advantages of prepaid metering systems in terms of system control and theft. Most consumers have not switched to it. In most cases,

consumers believe that the system is very much expensive, compared to the traditional postpaid metering system.

Findings Two: factors affecting domestic energy demand in Ghana

4. Some of the factors that affect domestic energy demand from the research conducted include:
 - i. Income
 - ii. Housing type (high class and low class)
 - iii. Educational level
 - iv. Use of Energy Efficient (EE) appliance/ practicing energy conservation. etc.

Other findings: Demand Side Management Systems.

The use of smart grid and smart metering in balancing energy demand and supply has an overwhelming merit, research results in this regard indicated that most domestic consumers have never heard about what smart meters are, not to talk of its beneficial attributes on the conservation of energy.

Another key technique to reduce of energy demand is home load shedding or shifting. Research revealed that, most consumers have never practice it and so off peak and on peak loads are always the same in their home, posing the huge dangers on the demand side and its management.

Research Limitations

Some of the limitations uncounted in the process of data collected include:

1. Refusal of household heads to complete questionnaire, due to the fear of being incriminated.
2. Difficulty in reaching respondents due to their unavailability during work hours.
3. Lack of interest in the study area due to the nature of information needed.

Conclusion

The main objective of this research work is to analyze the inadequacies in the existing practices factors that affect domestic energy demand in Ghana was duly achieved. Conclusions drawn from findings of the research work indicate that the inadequacies in the practices and systems such as, usage of energy inefficient appliances, inconsistent billing for energy consumed, lack of periodic checks and maintenance on energy meter, posing mistrust on the control systems and consequently the billing system.

Again, lack of awareness on key techniques, such as smart meters and home load shedding to manage the demand side of the energy system should be attended to in order to manage

the demand side so as to balance with supply. Finally, the employment of Home energy management systems (HEMS) as a new technology in Ghanaian homes will automatically manage and reduce residential energy use and cost and also make energy reductions through energy efficiency measures more visible and real-time to the customer, and consequently extend Smart Grid applications to the home environment by the use of smart meters.

Recommendations

Based on the finding of this research work, the key recommendations are;

1. Considering the percentage usages of used electrical appliance in Ghanaian homes, it is suggested that, more advertisements on the effect of these appliances to the energy demand, will help in the reduction of its use and thereby improving on the reliability and availability of domestic energy demand.
2. Over reliance on a few energy sources pose a worrying issue on the demand of conventional energy. Though numerous efforts have been made by the government to outline the prospects of renewable energy sources, research has shown that the penetration level is still low due to the cost of installation. Therefore government can substitute the deficit of energy demand by additional supply from renewable energy, despite its intermittent nature, this will go a way to strengthening the demand side management techniques.

Finally, recommendations for further research work include;

3. Extension of the research area to two most highly populated areas in Ghana to confirm findings of this research.
4. Conduct a research on improving the willingness of Ghanaian domestic energy consumers to pay for energy consumed and its services.

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