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Towards Energy Efficiency in Developing Countries: A Qualitative Model for Understanding Drivers of Domestic Energy Demand and Supply

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Abstract - —
Energy models play an essential role in the current ongoing energy transition processes for better planning and developments. This is needed either for the assessments of policy and market design options or tools for predicting potential developments and required capacity to meet the total demand of electricity and its services. In Ghana, the Integrated Power Sector Master Plan (IPSMP), 2018 is a strategic document for planning, that seek to provide more than just an exercise in revising the inaccuracy in electricity supply-demand predictions. It as well, alongside work on several other projects that can lead to achieving demand and supply balance and moreover plans further to the provision of clear, comprehensive, and coherent control of electricity generation and transmission facilities for future developments in Ghana. According to IPSMP (2018), right implementation and practice of energy efficiency measures could lead to consequent reduction in power demand by nearly 7% in 2030. Factors attributed to this are associated with customers taking economic adoptions to reduce energy prices by deploying energy efficient lighting, industrial motors and air-conditioners. Thus, this qualitative model seeks to focus on drivers of both energy demand and supply in Ghana and additional drivers that influences the existing drivers of household electricity demand and supply in order to reduce consumer costs for electrical power, successively management energy usage and increasing energy efficiency. Here, residential energy demand and supply is explored by classifying types of residence into high and low classes with respect to the income level of tenants. Also, Microsoft excel was used to compel data collected and pivot tables were used for data analysis. Results indicated that main drivers of energy demand are income, population, gender, education, type of household, user behavior etc. On the other hand, energy supply is influenced by energy retail markets, government policy options, obsolete electrical generation system, and inadequate transmission and distribution systems. Generally, this proposed qualitative model is capable of controlling user behavior and other intrinsic factors affecting energy demand and supply to reduce peak energy demand and associated energy supply in developing countries.

Keywords : *Energy policies, quantitative model, DSM, Forecast, Energy efficiency, Cognitive*

INTRODUCTION

Demand for Energy is an econometric concept which postulates that, in the absence of increasing energy prices alongside underpinning policies, an improved energy efficiency cannot be achieved. This is for the attainment of less hardship in the systems as well as reduced economic barriers and increase in energy supply [1]. Even though the attainment of improved energy efficiency is necessary, it still has insufficient suggested policy approaches and limitations. Among these limitations, encouragement in the awareness and application of more energy-efficient choices which is mostly done by the aspect of behavioral interventions as well as the use of advanced technologies in all aspects of the innovation chain in the energy sector [3]. Despite the efforts devoted by researchers such as [4];[6];[8]; [7];[9];[10], in the facet of energy-saving behaviors and energy choices in various Countries, nevertheless, many consumers still indulge in energy-inefficient practices and behaviors. Thus, creating a significant gap in improving energy demand [11], which has resulted in imbalance of the demand and supply of electricity.

There is considerable variation from one Country to another when considering the summation of electricity demand closely correlating with key drivers such as total population and income level or poverty level of the populace. Owing to the fact that energy demand is a derived demand, which is influenced by not the energy itself, but the services it renders to consumers. Thus, a growing population aggravates the demand for general goods and services, spontaneously (World Energy Outlook, 2016). What still remains unclear is determining whether wealth drives energy consumption or vice versa [1]. Interestingly, both mechanisms coexist in practice and turn to be inter-dependent on each other whilst affecting each other positively with changes in reliability, energy improved technology and availability, total population of a Country and income [1][2].

In Ghana, [10] [12] in their studies applied multivariate time series approach to prove the impact of electricity consumption on economic growth in the Country. Though, there was absence of certain useful variables in their analysis, results showed a positive impact of electricity consumption on the economic development. Thus, it is important to know that electricity consumption differs from electricity demand. Such that, the demand is equal to the electricity consumed in addition to the suppressed demand, which is difficult to estimate in Ghana. Hence, causing a challenge in achieving an accurate forecast of the demand of electricity in the Country (Integrated Power System Master Plan for Ghana, 2018).

On the supply- side, the quantity of energy launched on to the market is referred to as energy supplied. According to [13] Ghana's unabated energy situation emanated from the issues with the national grid network ranging from inefficient power plants caused by ageing, lack of patronage for renewable energy as an auxiliary option for peak load management, notwithstanding, the physical deterioration of transmission and distribution lines and the losses caused by these facilities, due to inadequate maintenance, lack of communication facilities, outdated meters used by the Consumers and illegal electricity connections [13]. Approximately, a total of five out of the eleven generation stations that include private power generators are installed for 20 years now and obviously aging of the existing infrastructure caused a lag in the average power generation to daily demand. Hence, affecting the security of the energy value chain [29]. Moreover, 25% of system losses occurred in electricity distribution coupled with lack of end-use demand management of electricity, like homes and schools estimated at about 30% (Sustainable Energy for All and Acceleration Framework Report, 2012). A great reduction in energy supply losses and the use of more efficient energy appliances contribute to effective reduction in the demand for energy in the Country [22].

Despite the numerous developmental merits of availability and reliability of energy as well as the awareness of the use of clean energy and its applications. In 2002, more than 1.6 billion people in developing countries lack access to affordable and reliable energy services [31] and over 80% of the population of Ghana use traditional biomass for cooking and heating [22]. This is caused by the inadequacy of access to affordable, effective, adequate and environmentally sustainable energy services wealthy of improving on economic and human development. According to the International Energy Agency (IEA), 2017 report, 1.1 billion people, clinched to 14% of the global population across the world still lack access to electricity supply. This calls for a critical consideration of the key drivers of electricity supply and demand and the aspect of involving mainstream gender considerations in energy programmes by giving priority to women as well as policy formulation, methodologies, institutions and the design of effective access programmes and best practices to better identify key barriers for improving energy usage (IEA 2017 report; [27]; [12].

Congruently, energy models play an essential role in the current ongoing energy transition processes for better planning and developments. This is either for the assessments of policy and market design options or tools for predicting potential developments and required capacity to meet the total demand of electricity and its

services. The pattern of yearly electricity consumption for various demand sectors and their corresponding Transmission and Distribution (T&D) losses is shown in figure 1. Clearly, the yearly average amount of T&D losses outweighs the yearly demand from the residential and non-residential sectors. This poses a mishap in the system which is greatly attributed to the use of aged and obsolete T&D systems for the transportation of electricity to the end user. Again, the trend of T&D losses from year 2006 to 2016 appears to be consistent throughout the years and thus has a direct relation to the total amount of energy supplied based on demand.

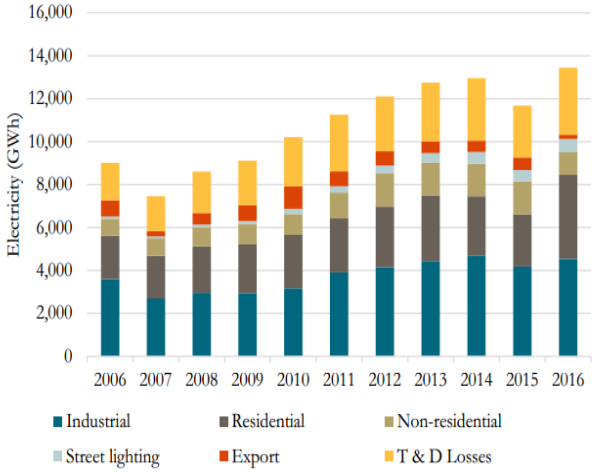

Fig. 1 Pattern of Electricity Consumption for Ghana from 2006 to 2016, [15]

The need for thorough management of electricity demand and consumption at the end-user point, is the focus of most current research studies. This involves adjusting electricity consumption and need to apply the pattern of consumer energy demand to the amount of electricity load needed at a time by the use of Demand Response (DR) options. DR option refers to measures applied to adjust end-user's consumption of electricity by altering the consumption pattern of consumers to suit the rate of change of electricity prices. This could also be achieved by using incentive payments to encourage consumers to reduce the use of electricity by practices like off peak usage of electricity to enhance system reliability at high peak hours (U.S. Department of Energy, 2006). Thus, household's electricity consumers and other large industrial consumers can resort to the DR for cost effective balance of electricity supply, storage and transmission [14];[45]. This research seeks to develop a qualitative model for peak energy demand reduction and consequanrtly managemnet enenrgy supply by considering drivers for both energy demandand supply in Ghana.

1.1 Research problem

According to Ghana Sustainable Energy For All (SE4ALL) Action Plan, Acceleration Framework Report (2012), Demand-Side Management (DSM) and Energy efficiency measures are not adequately practiced. More specifically electricity for refrigeration, lighting, and air conditioning, despite all the potentials associated with the techniques involved in reducing demand growth [22].

1.2 Research objective

The ultimate objective of this study is to develop a qualitative/ interactive model for the understanding the drivers of domestic energy demand and supply.

DETERMINANTS OF ELECTRICITY SUPPLY AND DEMAND IN GHANA

The determinants of energy demand in Ghana include income, dwelling type, education, urbanization, gender, user behavior, technological advancement etc. from the research conducted by [33]. The research conducted by [30], on what factors drive energy consumption in Ghana indicated that productivity growth and income are the major drivers of both the renewable and non-renewable energy consumption in Ghana and efforts should be exerted on investments in productivity of renewable energy type for Ghana in order to exclusively control the nonrenewable energy demands in the Country.

Trends in energy matters of Ghana are increasing in the past decades and research on issues of energy demand is becoming steeper from 2013 onwards in the Country. This is because matters of energy demand and supply has become a national quandary, thus, planning an integrated framework for electricity for an improved power infrastructure and forecast accuracy in alignment with international best practices is warranted [2].

[24], identified some of the drivers of electricity consumption as the existences of up and down stream petroleum activities, industrial activities, efficiency measures se well as urbanization in Ghana etc. which subsequently are considered as the major drivers of energy and its services. This situation has created an impetus for carrying out research in estimating the domestic energy consumption at Ghana.

Considering the increment of peak power demand from 1,943 MW in 2012 to about 2,061 MW in 2014 (Ghana Energy Commission, 2015), which led 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, translating into an additional 4000 to 4200 MW needed to balance demand (Ghana Energy Commission, 2015). This is attributed to the increasing population projections to rise from 25 million in 2010 to 40 million by 2030 (UNICEF, 2014 Generation 2030, Africa). Thus, population is clearly a determinant of the demand of electricity.

Moreover, consumers usually demand energy for its services only. Similarly, businesses need energy to process heat and run large motors. Thus, quantity of energy required by consumers is denoted by $\mathbf{Q_{cd}}$, which is a function of the price of energy **P**. The nonrefundable income **Y** and additional variables like demographic variations, personal preference, weather etc. are denoted by **O.** Consequently, the quantity of electricity needed per household lessens if the price of electricity increases. On the other hand, if the price of alternate sources of electricity lessens comparatively, consumers shall shift away from using appliances that need electricity to alternative appliances that can perform the same task using other sources. This implies that, the price of electrical appliances influences the quantity of power needed. The lesser the price, the more consumers will purchase appliances and vice versa. Accordingly, a general consumer energy demand function can be expressed by putting the ± sign before the income (Y) to indicate whether it is aiding or opposing, in order to determine its effect with respect to time on the demand of electricity [16].

According to [2], right implementation and practice of energy efficiency measures could lead to consequent reduction in power demand by nearly 7% in 2030. Factors attributed to this are associated with customers taking economic adoptions to reduce energy prices by deploying energy efficient lighting, industrial motors and air-conditioners. Thus, a more productive economy is achieved in the presence of increased efficiency to reduce consumer costs for electrical power.

2.0.1 Ghanaian Residential Energy Choices and Appliance Ownership

Beside the industrial sector of energy consumers, the next higher consumption class is residential energy consumers. Energy is applied differentially at the domestic level. Some of the energy types used domestically include electricity, LPG, wood fuel, charcoal etc. which have greatly increased the degree of choices of energy type to adopt and also a substitute in the absence of the other, making life better at the household level (Energy Commission of Ghana, 2016b).

Annually a total of 20 million tonnes of woodfuel is estimated to be consumed, either in the form of firewood or converted to charcoal for use (ECG, 2016b). About 80% of household which represents the majority depend on woodfuels for water heating and cooking as well as industrial, institutional and commercial usage, signifying increasing demand for woodfuel in the Country. There is the likelihood of consuming 25 percent more by 2020 (ECG, 2016b). Figure 2 illustrate the forecast on yield of woodfuel and consumption in tons per year by 2020 (Energy Commission of Ghana, 2016b).

Intuitively, since woodfuel comes from the standing stack, deforestation is going to be on the increase to meet the estimated demand. Considering the consumption of firewood and charcoal by regions in Ghana, households in the Greater Accra region use 18.2% of firewood compared to 68.9% in Northern Region [11]. Even though greater percentage of rural areas used firewood compared to urban areas [11]. 80.1% of urban households used charcoal as compared to 76.15% in rural areas.

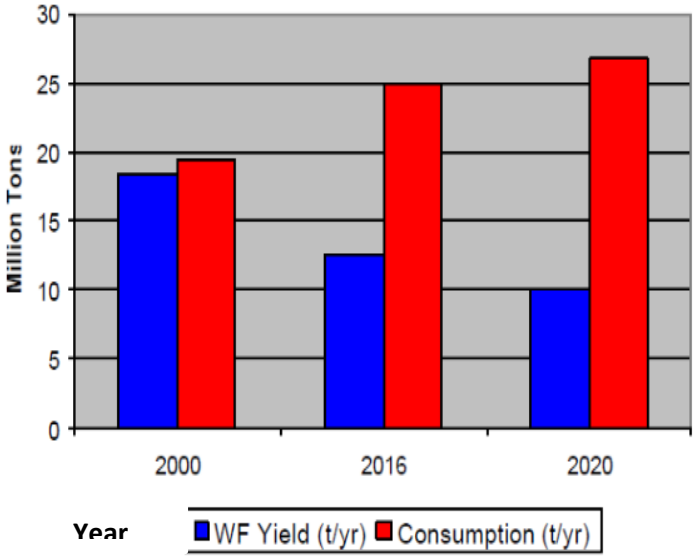

Fig. 2 Woodfuel Production in Ghana (2000-2020), [22]

On the other hand, sample size of 50.6% of households surveyed use LPG for cooking and heating whilst only 23.1 % of rural households depend on LPG. Out of the total number of household surveyed, 85.7% of survey carried out in Accra/ Tema metropolis resorted to the use of LPG for cooking, whilst only 46.3% of households in other regional capitals use LPG [24]. Also, 3% is estimated as demand for charcoal and firewood per annum in the annual growth, electricity is between 6% and 7% per annum, whereas petroleum products are estimated to increase by 5% per annum [24].

Conclusively, the greater Accra region has a higher percentage among all regions in Ghana with respect to the usage of the energy types discussed so far. Thus, demand and supply issues with regards to the capital of Ghana is very imperative and therefore must be given all attention and desire to undertake further research. Finally, the forecasted values of electricity demand and supply for the past decade have differences with the actual values.

[10], reviewed on households energy choice in Ghana, where a critical focus on the household fuel changes in Ghana and the need to know different types of energy fuels used in Ghanaian households and their implications on environmental sustainability. Households in Ghana have a history of reliance on woodfuel and charcoal as their main choice of fuel and so the need to investigate the driven forces to these choices as the way forward to embrace clean energy. Similarly, [18] conducted empirical analysis of household energy choice in Ghana. Here, an investigation of Ghanaian household cooking energy choices and their determinants were investigated by focusing on a nationwide household survey data estimation and analysis performed using probit model.

From results obtained, biomass happened to be the predominant source of energy and cooking fuel for Ghanaian households recorded 89.2% of the population. Thus, the remaining 10.8% represents user of clean energy sources such as kerosene, LPG and electricity for cooking. The findings obtained here also endorsed the energy hierarchy hypothesis that the major determinant of energy choices is the household income. Additionally, demographic and social factors as well as accessibility to energy supplies are referenced to be key determinants of cooking fuel type in Ghana. Recommendations include: the introduction of energy policy measures to intensify the income and poverty reduction programs to boost households' incomes, to elevate majority of their living standards towards the upper rungs of the energy ladder. Thus, an ultimate uplift of usage in modern energy sources such as LPG and electricity in Ghana [9].

Households within the tropical forest zone and savannah zone in Ghana have sample areas for data gathered using same form of questionnaires. Specifically, all semi-structured questionnaires are administered and analyzed using SPSS and STATA.

Determinants for all the energy choices in Ghanaian household are examined and basically the determinant for electricity has the coefficients of income and education recorded negative, which makes it significant for electricity, implying that, with an increase in education and income level of households heads, the less likely it

shall continually rely on electricity only. Mainly because of the intermittent power failures in Ghana, household heads with high income due to employment and earnings shall be compelled to resort to other source of electricity, for example kerosene. This could be caused by household heads getting more informed and enlightenment about other forms of energy for the household through education [10].

Similarly, [51] findings revealed that, lower level of education and income of household heads are the determinants of lack of use of electricity in households. Even though, this work has identified the most used energy types in Ghanaian households as electricity, firewood and charcoal which is same as reported in Ghana Energy Commission (2016b). However, the factors that influence energy choices in Ghana include income, family size or occupancy, employments and education do not include all factors in entirety when considering factors that drive the demand of energy in Ghana. Further, [35] worked on experiments with an agent-based model of domestic energy demand that focused on the domestic energy demand in a community and also social simulator for the household decision making issues on purchase of energy efficient appliances between 2000 and 2046. This experiment was conducted in Scotland, (Aberdeeen and Aberdeenshire) and qualitative data on household finances and equipment as well as energy prices were considered for the study. Input data to the model was time series data of the appliances from the market, energy prices, household income and other external factors that influences the value-strengths. Mechanisms that were in line with value-strength dynamics were hereby emphasized, not forgetting the goal for decisions on the kind of appliances to purchase. Results obtained indicated that economic factors determined the demand for energy. This further endorses research work conducted in Ghana by [33]. However, external factors did not really influence the demand for energy in this research. Thus, to a large extent econometric factors really drive the demand for domestic energy.

2.1 The Existing Drivers to Electricity Generation System

The demand of electricity is the measure of the final power consumption among the end user. On the other hand, electricity load refers to amount of electricity that stabilizes the total amount of electricity generated to the amount drawn from the grid. Thus, the electricity demand equals electricity load if load-shedding, black and brown outs are absent in the system and there is a reliability of power generation to meet demand at all times [19]. To sustain the supply of power to end-users, power generating plants shall be loaded with sufficient energy in order to replenish any losses incurred in the supply process. This implies that, in the prediction of power demand and supply, one must take account of the system losses incurred. In Ghana, even though the system loss is great and assumed to be suppressed demand in the system, it is usually underestimated. Losses arise not only from transmission and distribution system resistances, but also from energy theft which is conducted through illegal connections and usually recorded as meter shortages[20]; [2].

Energy demand reduction in all sectors is approached by different academic disciplines in so many different ways and views. All these aims to establish the reasons why some mechanisms should be more prioritized, in order to attain a reduced energy demand. Thus, an attempt to provide insights as to how the selected mechanisms could more or less be useful to policy makers [1] is warranted. Reducing energy demand has attractive attention all over the world. Some of the strategies adapted by Countries include the identification of energy efficiency as a key driver to the attainment of vision Low-Carbon emission in Europe (European Commission, 2014). The strategy by Sweden to significantly reduce the growth of per capital energy consumption by initiating the Swiss energy strategy 2050, with the aim of decreasing per capital energy consumption of 54% by 2050 (SFOE, 2012). Consequently, the International Energy Agency (IEA) in the world energy outlook has targeted reduced energy consumption as a key focus for an attainment of a reduced CO_2 emission (IEA, 2014a). Clearly, this is a wake-up call to other developing countries to significantly reduce carbon emission by resorting to practices that enable the production of clean, efficient, reliable and affordable modern energy for all by 2030 in line with the Sustainable Development Goal 7.1 (General Economics Division (GED), 2018).

In tackling the reduction in energy demand, it is very essential to consider the main drivers of the demand of energy per sector concern and how it influences demand. Most studies in this area focus on the consumption pattern of consumers and energy profiles to make a prediction of the behavior of consumers and determinants of the demand of energy. However, meagre attention is given to the drivers of consumer's choices and behavioral carters [1].

To express energy demand in applied economic models, it is described as being a function of prices and income only. This means that prices and income level of consumers are the key drivers of energy demand. Other factors are auxiliary effects of these two factors [1]. Theoretically, one can represent an microeconomic

model for consumer choice by first of all considering the customer maximizing utility, denoted by *U* as a function of energy goods, denoted by *e* and other goods, which is denoted by *x* on a condition that total expenditure on energy does not exceed customer's income y for a given vector of energy prices *z* and other prices *p*, which is expressed as;

$$Max_{e,x} \geq 0\ U(e,x),\ s.t.\ z.\ e + p\ x \leq y \qquad \textbf{Eqn. 1}$$

Most econometric models depend on this assumption (consumers are not perfectly aware of all options for changing their energy demand) to estimate the demand of energy by a consumer, where the demand function for energy **e** is equated to a function of energy prices **z**, other prices **p** and the customers' income **y** which can be expressed as $\boldsymbol{e = f(z, p, y)}$ to describe the choice of consumers' energy demand [1]. Thus, the complexity of measuring energy demand is obvious and it is absolutely misleading to simply equate improved energy efficiency with reduced energy demand. Consequently, ignoring these complexities may account a resultant rise in aggregate energy consumption. This could be more challenging to analyze in order to have policies and guidelines to improve on energy efficiency and control the demand of energy in Ghana as well.

2.2 Inadequacies in Existing Practices and Factors that Affect Domestic Electricity Supply and Demand

In recent times, there are thorough examinations of electrical systems worldwide in line with their contribution to environmental issues. These include effects of the continual use of fossil fuel (Zhao, *et al*. 2016), climatic changes and the unabated rising cost for access to electricity because of the investment required for improving on the existing infrastructure, to completely take charge of power delivery during periods of peak demand. The use of energy in Ghanaian homes vary seasonally and mostly driven by the weather conditions (Ghana Energy Commission, 2006). Existence of these weather variations affects the demand for the electricity key services [37]. In spite of this condition, students' performance in formal education can have positive impact due to improvement on lighting systems for reading, efficient process of heating and cooling for productivity, and refrigeration of foods leading to economic productivity of the Country [38]. Essentially, barriers in term of policies formulation, appliance and end-user have root causes due to the inadequacies in the system.

Even though Ghana is fighting the migration of rural urban migration, it is still a pending issue in the Country [24]. Moreover, the introduction of DSM techniques plays an important role in an operational efficiency of the power system. This can be either reducing demand by sensitization of 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. Distributed energy resources can subsequently cause a reduction in the amount of centralized generation capacity overly relied on and consequently no need for transmission and distribution facilities. Thus, losses can be brought to the barest minimum.

Penetration and awareness of passive demand reduction in Ghana's residential energy consumers which include the application of energy efficiency programs by improving on the usage of efficient loads that have low energy consumption is better than acting on active demand reduction technique due to publicity. The greatest benefit of Energy efficiency is typically in the reduction of peak demand in a fairly uniform manner [23].

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. Hence, when the active demand reduction techniques are duly publicized in Ghana, coupled with the already existing passive demand reduction. A corresponding reduction in peak energy demand can be attained consequently.

With the Peak-shaving programs, customers are encouraged to carry-out energy intensive activities at off-peak hours, when the total demand on the power system is low. This could equally be applied at the residential levels by encouraging customers within the sector to do laundry with washing machine or iron their clothes in the morning, possibly, when energy demand is lower. Although, total energy consumption in this regard is the same. However, the system still realizes the load shift in demand period and thereby rewards the consumer by a significant saving for avoiding systems capacity overload and costs (Ghana wholesale power reliability assessment, 2010). Figure 3 illustrates the effects of DSM scheme of peak load per hour.

Demand response schemes often involve load shedding in response to a request by a utility and implemented by the installation of automated control and monitoring systems. In most electrical services for example, residential consumers can manage consumption to a pre-planned load shifting by priority during peak hours

and subsequently reduce cost for electricity.
Though, a measure of the critical hours for energy consumption of the daily demand curve would not be easy in Ghana, due to the flat demand curve, the peak hour can still be deduced by the ratio of average demand to peak demand of the demand curve. This ratio is 80% in Ghana, which indicates that Ghana has a potential opportunity to benefit from DSM programs, despite the expectancy of difficulties and challenges [23].
Figure 3a shows the clipping to the peak demand for energy demand management, if the peak demand curve is realized, the peak hour can easily be deduced and that would promote the Demand Side Management to reduce electricity demand. Also, figure 3b illustrates
The demand curve for electricity conservation. In this case, demand can certainly drop due to the application of energy efficiency measures to promote energy conservation. Figure 3c refers to how the use of electric loads can be shifting from off peak hours, in effect reducing the load at peak hours. Technically, when the three approaches of energy management techniques are applied concurrently, the demand of energy can be reduced. This shall consequently, improve on the GHG emissions in the Country and also promote the use of clean energy to meet the millennium development goal 2030 in parallel.
Another factor that influences the demand for electricity in the Country is the exchange of electricity with other Countries which is driven by two main factor: 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.

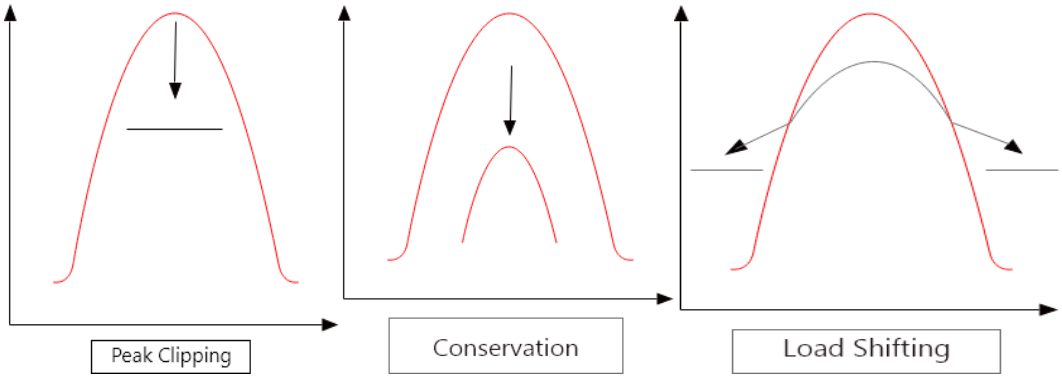

Fig.3 Effects of Demand Side Management Programs, [23]

The trading countries involved in this agreement by ECOWAS Energy Protocol, signed in 2003 are La Cote d'Ivoire and Togo, where Ghana share boundaries. The main aim is to encourage investments in the energy sector, which has proven significant benefits for Ghana (Strategic National Energy Plan 2006–2020).
[25] detailed reasons for his research title: "Why is Ghana still burdened with periodic energy crises?" here, inappropriate pricing and tariff, poor management, weak regulatory framework and governance and setting poor policies were the listed problems as the cause of challenges in the supply side. Again, poor revenue collection and poor institutional coordination were other challenges mentioned [25]. The recommendations include the ability to improve the power mix of the Country by relying on Ghana gas for about 500 MW of power, to offset the crisis in 2016 and still having a deficit of 5,000 MW and an Additional creation of a new power ministries argued to change the style of management. Finally, an improvement in gas supply to the Country by total militancy for improved functioning and overall value chain of power plants [25].

Moreover, most of the households in Ghana are compound houses with a single electricity meter for all residents. Over the years, this practice is a source of suppressed power because the electricity bills are mostly high even though residents are low-income earners. But due to the bulk electricity purchase which eventually places these consumers on high tariffs zones. Thus, customers seek to find other means of reducing cost of electricity, used by engaging in illegal connections of electricity usage (Strategic National Energy Plan 2006 – 2020; Ghana energy commission, 2006).
Nevertheless, numerous decisions concerning the introduction of other power generation options to meet the projected demand, became a matter of emergency because of the over reliance on hydro power.
Generation plant in the Country [39]. Obviously, the installed capacity in Ghana can effortlessly serve the needed demand, but the dependable capacity is always below the expected capacity. Factors causing these include lack of fossil fuel to run the installed machines, urbanization and lack of awareness on Demand Side

Management techniques etc. It should therefore be envisioned that Ghana's primary energy supply is made up of oil, hydro, wood, and natural gas. Hence, the current shortage in power supply prevalent in Ghana originates from inadequate and unreliable fuel (oil) supply for the operation of the thermal power plant, transmission, and distribution losses [9]

Main causes being that, all the state-owned energy companies which operate on high long-run marginal costs, are unable to attract additional capital to expand their operations and consequently leading to inadequate investment in infrastructure and subsequently high operating costs. The overloaded transformer sub-stations, transmission and distribution losses, and transmission bottlenecks are also contributory factors to the frequent power outages in Ghana (Ghana Energy Commission, 2015). Congruently, accuracy in the prediction of the demand and supply of electricity is key for planners to have a schedule arrangement of power distribution. Thus, part of the causes of inadequacies in power demand can be solved if predictions of power demand and supply are conducted with precision.

EXISTING INPUT-OUTPUT DRIVERS AFFECTING SUPPLY AND DEMAND OF ELECTRIC ENERGY DEMAND

This research study portrays evident based and result oriented deductions, which is verifiable with the behavioural and energy choices of Ghanaian households that affect the supply and demand of electrical energy in the residential sector. Thus, structured questionnaire was applied to target Ghanaian household practices and energy choices that affect the supply and demand of electricity at the residential sector as well as the input drivers and causal agents of the supply and demand of electricity in Ghana. Data obtained in this regard is processed with Microsoft excel and pivot tables to analyse the existing drivers and factors affecting the supply and demand electricity at the residential sector. A descriptive approach was used to explain or answer the questions why or how something has happened or happens, whereas findings and reasons for a particular set of outcomes become key players to explanatory survey. Hence, this research survey was personally conducted through questionnaire administrated to respondents.

Thus, both qualitative and quantitative research approaches are applied to eliminate completely or reduce the disadvantages and also gain the advantages of each of the research approaches or both.

3.1 Obtaining the Input Drivers (Methodology I)

Research was conducted in the capital city of Ghana, Accra. Research setting was influenced by the higher energy demand with highest population due to urbanization as compared to the other administrative regions in Ghana. Thus, this survey targeted the energy demand of different housing types and its classes in Ghana, to really get the pattern of consumption and how consumer behavior affects demand of electricity.

The total population of households is estimated to be 450,794, where the population per house is estimated to be 11.1% with an average household size of 3.7 [40]. Also, a total of 2.27 million is estimated as the population of Accra [40]. Moreover, Eligibility criteria was tested to specify that characteristics of respondents is perfect for the study [52] Here, the eligibility criteria were centered on the following: Education, Member of the household, Should be an adult, Should be resident within greater Accra and should be connected to national grid of electricity

Using Roasoft software for the calculation of the sampling size for 450,794 household population corresponded to 261 sampling size [40], at a confidence level of 90% and 5% margin of error and response distribution being 50% and a random sampling method was adopted for administering the questionnaire.

Mathematically, the sample size *n* is given by:

$$n = {}^{Nx}/_{((N1)E^2+x)} \qquad \textbf{Eqn. 2}$$

where, *N* refers to the population size, r is the fraction of responses that have shown interest in survey, *Z*(c/100) refers to the critical value for the level of confidence c and x are given by:

$$x = Z({}^{c}/_{100})^2 r(100r) \qquad \textbf{Eqn. 3}$$

Where, *Z*(c/100) refers to the critical value for the level of confidence c and r is the fraction of responses that have shown interest in survey.

Also, the margin of error *E* is also given by:

$$E = \mathbf{Sqrt}\left[{}^{(Nn)x}/_{n(N1)}\right] \qquad \textbf{Eqn. 4}$$

Where, *N* refers to the population size, n is the sample size and x refers to percentage error.

Data collection for primary source was carried out by using open and close ended structured questionnaires with the main aim of ensuring that respondents make a choice from the close 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 as well as aiding respondents to complete questionnaire on time and accurately. Further, to aid understanding and quick response to questions appropriately, the questionnaire was written in simple English language.

More importantly, distribution of research questionnaires were carried out by researcher. It was distributed randomly to heads of households in several suburbs of Accra, tenants and other relevant workers within one month period because of the numerous assistance needed to complete the questionnaire. Technically the selection of these suburbs of Accra is conducted with respect to the class of households which was determined based on the location of the area. In Ghana, posh and affluent class residential area have different demand patterns for electrical energy as compared to low class residential areas.

Even though, random sampling was employed in administering of questionnaire, the class of residential consumer was also taken into account. Thus, both the high class and low residential areas were covered in this research work.

Out of a total 250 questionnaire administered, 210 respondents were received. The unanswered respondents indicated lack of trust in the survey and the fact that household heads believed that answers to questionnaire are private issues and had the fear of future sanctions on the information collected about them. There is an expected close correlation between the inadequacies in energy systems and poverty indicators such as rate of illiteracy, economic growth, rapid urbanization etc. in most developing countries. There is also a heterogeneity of household energy demand, due to numerous drivers that include occupancy, age, building types, household demographics 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. Existing Input Drivers Analysis for Domestic Electric Energy Demand has been published in [33]

The following were the findings made from the research conducted:

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

i. Dominant male head households, leading to the lack of interventions for application of improved alternative energy sources

ii. Even though, awareness of second–hand product not being energy efficient is great, some percentage of the populace who do not have an idea of this pronouncement. This poses a great lapse in the awareness creation by the Ministry of Energy. Again, importation of used electrical appliance is still on-going. Thus, the percentage of used appliance in the Ghanaian home is high

iii. Inconsistent and inadequate billing, utility control and management systems is a challenge in the energy sector., 39 high class households and 34 low class households claim that, the electricity bills received do not depict the energy consumed. This is because consumers do not understand the amount of bills received due to its inconsistency and this factor leads to loss of consumers' trust in the systems

iv. Despite all known advantages of prepaid metering systems in terms of system control and theft as well as prediction of energy required, 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

v. The Leap Algorithm and its associated methodology used in the forecast of electricity demand in Ghana does not precisely predict the actual demand in the Country due to data input problems which comes along with forecast error margin between -1% and 11%. In order to make informed decisions in the future, an algorithm that is much easier to apply in the precise predicting of electric demand should be used for an improved forecast. This will pave way for a balance between demand and supply of electricity for economic gains.

b. Findings Two: Factors Affecting Domestic Energy Demand in Ghana

Some of the factors that affect domestic energy demand from the research conducted include: Housing type

(high class and low class), Income, Educational level, Use of Energy Efficient (EE) appliance/ practicing energy conservation. Etc.

c. Other Findings: Demand Side Management Systems

The use of Smart Grid and Smart Metering in balancing energy demand and supply has an overwhelming merit. The conducted survey indicated that most domestic consumers have limited knowledge on smart meters and its beneficial attributes on the conservation of energy.

Another key technique to reduce the energy demand is home load shedding or shifting. Research revealed that most consumers have never practiced 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. Decisively, consumer's behavioral management can facilitate a tremendous reduction in the demand of electric energy by controlling the pattern of energy use at what time and planning consumption.

EXISTING INPUT DRIVERS ANALYSIS FOR DOMESTIC ELECTRIC ENERGY SUPPLY (METHODOLOGY II)

Results from survey revealed that existing drivers that affect the supply of electricity in Ghana are as follows:

1. Households Who Practice Hybrid Source of Electricity Supply

A measure of the number of household that have more than one source of electricity is also important for the proposed study. The survey carried out revealed that, most consumers completely rely on the national grid for electricity. About 52% of respondents do not practice the hybrid source of electricity against 48% who have other sources of electricity. This statistics reveal that there is the paradigm shift from the over reliance on one source of energy, just as practiced some years in the past.

2. Consumers Opinion on Ready Availability of Energy in Community

Availability of energy in the research area even though highest responses being positive, the ready availability of energy is still a factor to be addressed. Ghana has very disturbing challenges with regards to a continuous energy supply. Therefore, there is the need to measure and indicate if energy is readily available to consumers. Results obtained in figure 4 indicated that energy is not readily available due to its stochastic behavior, making life unbearable in Ghana. Hence, 80% of the respondents confirmed that energy is not readily available and about 20% endorsing its ready availability.

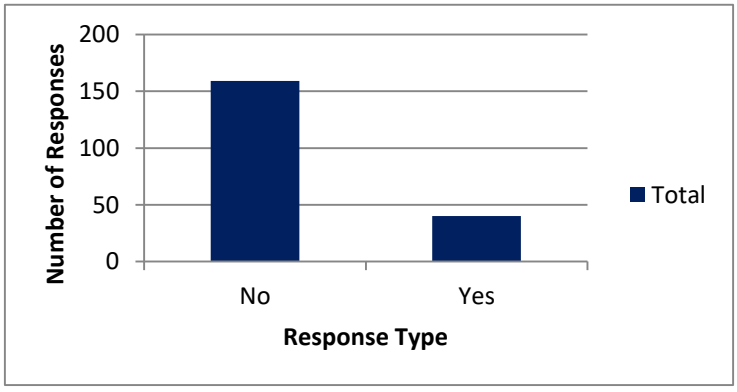

Fig. 4 Ready Availability of Energy

Another area that needs to be looked at, is the quality of the supply of energy and systems adequacies in the supply process that is to measure the reliability of energy supplied. Reliability analyses are most commonly conducted in order to assess the reliability of power systems by applying either the probabilistic or deterministic methodologies. In this case, the probabilistic methods are applied and hence the accessibility. Historical failure in power stability and finally repair rate of components are used to assess the reliability of the entire energy system. Below are the indicators for this test and results obtained for each measurement.

3. Electricity Availability in Number of Hours per Day Electricity Company of Ghana

Results indicated that the highest responses fell within 12hours in the day for availability of electricity. Though some responses indicated more than 2 hours of availability of electricity from national grid on the average, others did not have electricity for less than 12 hours in a day, which translates to the unreliability of

the electricity supply in Ghana.

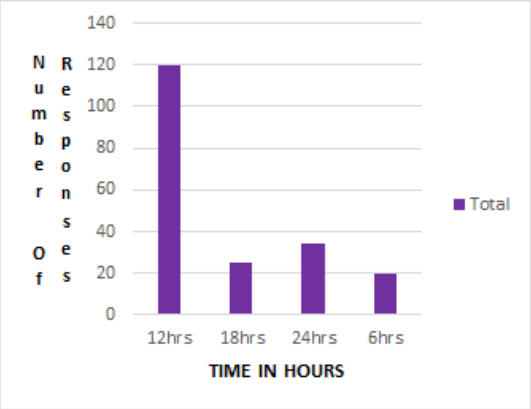

Fig. 5 Average Number of Hours per Day that Electricity is Available

4. Type of Energy Perceive to Pollute the Environment

Survey carried out revealed that wood-fuel records the highest form of energy used in Ghana due to the health hazard in the usage of this type of energy can cause. The proposed research conducted a study on the awareness of respondents with various types of energy that are perceived to be polluting our environments and cause health problems. Responses illustrated in Figure 6 shows that, 58% believe woodfuel and charcoal are pollutants, while LPG and electricity had the lowest responses respectively.

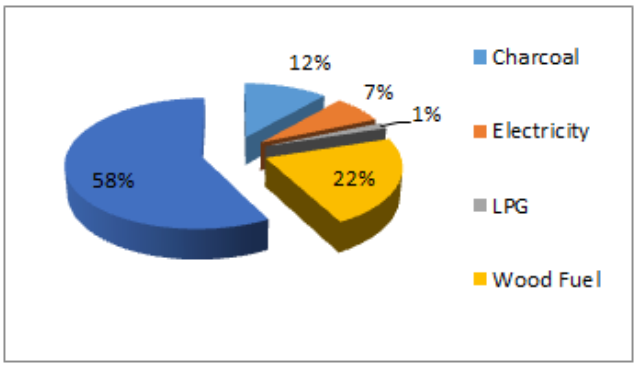

Fig.6 Energy Type that is Inconvenient

Also, question on the types of energy that are convenient for use (Figure 7) revealed that electricity and LPG are the most convenient types of energy by 7% and 1% of inconveniency respectively. Compared to 22% and 12% for woodfuel and charcoal respectively. Yet, even though some responses indicated that solar energy is convenient, there were other multiple choices made by respondents that indicated multiple choice of fuels that are not convenient.

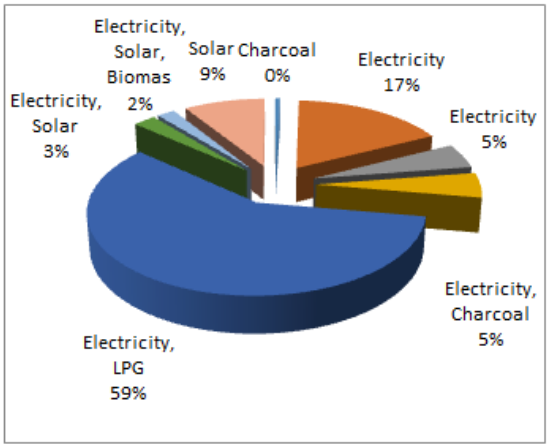

Fig. 7 Most Convenient Energy Type

Knowing the grid characteristics of a Country's electricity systems is very necessary. This is because of the

numerous system challenges including ageing infrastructure, sky-rocketing energy demand trends, the need to improve the security of energy supply and the need to lower carbon emissions and its associate hazards. Researching into this area can facilitate having a knowledge of the status of the grid both presently and future. Smart Grid technologies offer newest technology for developing cleaner energy supply. To meet the above mentioned challenges; measures such as energy efficiency, more affordable and sustainable choice of energy type are recommended. Thus, the following indicators seek to introduce and investigate into the grid characteristics of Ghana both in the present and what customers expect in future.

5. Established Regional Grids and Neighboring Countries

The results of Figure 8 show that, establishment of regional grid presently and in future are the highest choice for respondents. This establishes the fact that, developing regional grids in and among neighboring Countries and also practicing at present are the preferred choice of respondents.

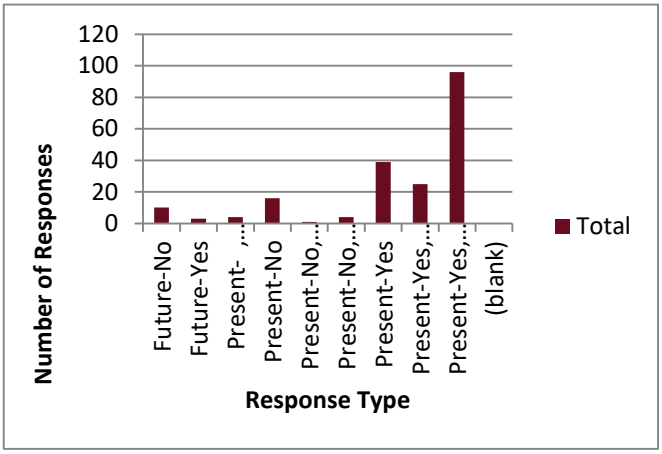

Fig. 8 Established Regional Grids and Neighboring Countries

6. Count of Small Grids

Considering this, respondents prefer in Figure 9 of having small grid both at present and in the future. This indicates that the Country is currently having small grid and aspires to be practiced in the future.

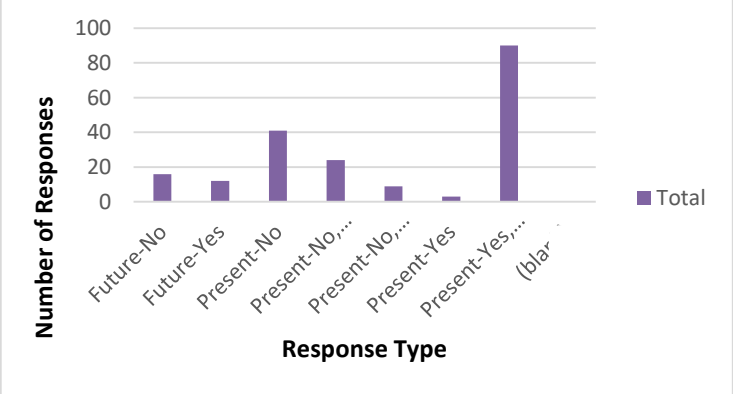

Fig. 9 Count of Small Grids
Source: Field Data Collected

7. Separate Regional Grids within Country

Currently Ghana has separate regional grid and that is helping in the management of transmission and distribution of power to Consumers in all factions. Also respondents (Figure 10) believe that having this continued in the future that greatly help in the management of electrical system.

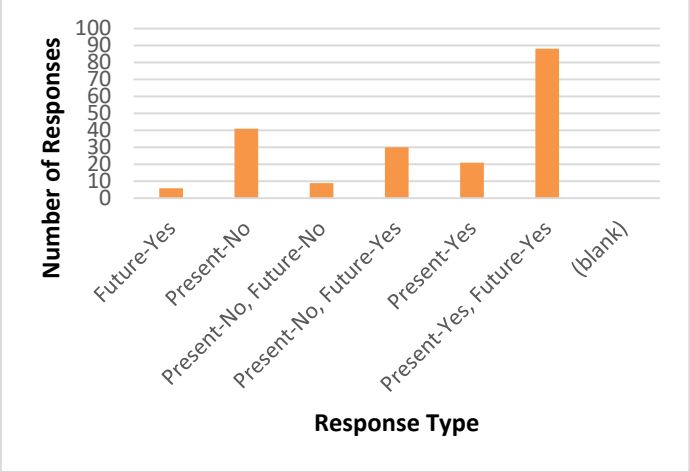

Fig. 10 Distribution of Separate Regional Grids within the Country

Research findings on the drivers and factors that affect domestic electricity supply are:

a. Findings One: On the availability of electricity and LPG in Accra, the following findings were drawn from the data analyzed:

i. Despite the fact that Ghana has set itself a target to attain universal access to electricity by 2020, there exist a small percentage of citizens leaving in the capital city who still do not have access to electricity. From the results obtained about 1% of respondents did not have access to electricity and those corresponded to citizens leaving in new settlement areas in the capital city. Again, the result of the availability of LPG is no way different from that electricity. 99% of respondents have LPG accessible in their communities.

ii. Most domestic consumers are solely relying on electricity from the national grid for electrical services. The percentage distribution of customer for national grid is 97% against 3% that are off grid, which may represent those without electricity at all. Furthermore, a measure of the number of households that have more than one source of electricity, declared that, most consumers completely rely on the national grid for electricity. 52% of respondents do not practice the hybrid source of electricity as against 48% who have other sources of electricity, mainly generators. This means that, more pressure is put on petrol and diesel to run the machine. Even though domestic energy availability had affirmative responses and confirming that in most of the communities in Accra have domestic energy infrastructure, a probe into its ready availability is on the contrary unconstructive. Hence, 80% of respondents are against the ready availability of energy.

b. Factors affecting domestic energy demand in Ghana

Some of the factors that affect domestic energy supply from the research conducted include:

i. Cost of fossil fuel for the electricity
ii. Over reliance on national grid
iii. Technological advancement
iv. Technical -know – how
v. Lack of Small Grids

Awareness on the best energy choices and their merits play a key role in management of the demand in a particular type of energy. It also improves the usage of clean energy. Furthermore, behavioral role of consumers and attitude towards some forms of energy places a huge load on the few supply sources and also makes the attainments of the bridge between energy supply and demand difficult as well as challenging. Therefore, the researcher has assessed on the level of awareness and also the attitude of populace on their energy choices.

i. Results obtained showed that about 58% of respondents believe woodfuel and charcoal causes pollution in our environment while LPG and electricity are perceived to be clean energy, therefore, had the lowest percentage

ii. Electricity and LPG are perceived to be the most convenient types of energy choices in Ghana, followed by solar energy

iii. Though, electricity and LPG are expensive. It causes a lot of counter effects to reduce the cost of energy. The billing software have records of over- billing some customers. Therefore, most consumers engage in illegal electrical connection, making Government find it difficult to retrieve power generation, transmission and distribution costs

4.1 Existing Output Drivers of Domestic Electricity Demand and Supply

The output drivers of domestic electricity demand refers to the external drivers that directly influence the demand and supply of a commodity. In this case, any variable that directly or indirectly affects consumer need for energy and act as a driving force to the supply need of electricity at the household level are highlighted. Some of the output variables that influence demand and supply include:

1. Government policy
2. Gross Domestic product
3. Per capital income
4. Propensity to adopt innovation
5. Transmission and distribution system losses

To emphasize on the identified input and output drivers of domestic electricity demand and supply, critical factors that are probable to influencing the demand and supply of electricity can be identified from the limitations of the existing practices by falling on benchmark practices in other frameworks that have promoted a reduction in demand and supply.

4.2 Identification of Critical Factors in Probable Drivers for Optimal Domestic Electric Energy Supply and Demand

Dealing with an optimal domestic electric energy supply and demand starts by consideration and continuing studies carried out on the factors that affect domestic energy supply and demand. Inadequacies in the supply and demand of domestic energy and additional factors needed to bridge the gap between domestic energy demand and supply in Ghana are also need to be considered. Thus, conclusion and recommendations of these studies were reviewed to facilitate the identification of critical factors and control points that affect domestic energy demand and supply. The review also covered complex interactions between technical and social components that directly or indirectly affect them. This is carried out to bring together incongruent knowledge as to how the conceptual map of all facts can relate in the framework.

There is a paradigm shift in the domestic energy policy that focus on passive and manual management information computing technology for Demand-Side Management from the supply side activities of domestic energy. Also, research paradigms and dimensions of household energy consumption behaviors are categorized into two main research stream namely:

- The behavior–oriented paradigm, which deals with intervention strategies to energy management and analyzed by time, special and user dimensions
- Economic paradigm that deals with demand response of household energy. In this research, both deductive and inductive approaches are applied

The inductive approach has facilitated the interest and motivation directed towards the research for the model or framework design. The prior research studies pertaining to the predictive models were refereed for an insight in the approach of designing a framework with all additional factors unveiled earlier that affect domestic energy demand and supply in Ghana. On the other hand, the deductive approach dealt with finding the causal relationship between all variables in the proposed framework. Thereby, it showed the correlation and covariance between all variables in the model/framework as well. All the factors coming under the purview of inductive and deductive approaches are needed for test to validate the proposed model. In addition, the framework is tested by comparing its results to others for further confirmation of the design. Some of the identified critical drivers of domestic electric energy demand are:

1. Demand Side Management Technique (Home Load Shedding)
2. Propensity to Change
3. Change Management Options
4. Appliance Type(Energy Efficient Appliance)
5. Housing Type(High Class and Low Class)

The Indian Institute of Science, Bangalore conducted a review of the “Development of a Framework Focusing Electricity Consumption Data to Drive Energy Efficiency in the Residential Sector”. The project seeks to demonstrate, driving energy consumption by applying behavioural science. Thus, the consumption pattern,

population, appliance ownership occupancies, billing etc. are gathered from the research conducted [54]. Appliances ownership and usage of energy are the main drivers of residential energy consumption. In non-metro centers in India, apart from energy bill data; no other information is available about the consumer. This information is mostly necessary to enable the utility companies to improve on quality of delivery. Thus, the profile information of consumers is very relevant and should be added to the billing systems. The study was very intensive since research was conducted in whole year. The underlining understanding of the factors that affect electricity peak demand poses a success in addressing peak energy concerns and management.

Another study in this area carried out by [26] reviewed on a "framework for understanding and generating integrated solutions for residential peak energy demand" In this study a model design was proposed for a systematic analysis of the influential factors of domestic energy demand. Different themes were networked by relating them in a way to resultantly influence and associate with electrical appliance usage as well as residential peak energy demands. These themes include technical, social and change management options of the variables involved in this setup. The ultimate goal of the undertaken study was to create awareness and better understanding of the complex nature of peak energy demand at the residential level to end users.

This research had the tendency of facilitating an improved conservation by attaining a reduced peak demand, alongside better policy to have improved outcomes for diverse stakeholders which consequently reduced electricity generation by 2020.

It is recommended that a critical look at the methods that best fit in Country's context, based on the problems and inadequacies in the area of research needed. The research then should focus on for a clear understanding of the challenges and ways to easily address/control these challenges. Such a research study can help solve the issue pertaining to the energy and having a success in the energy system. Similarly, pursuing an in-depth understanding of the effect on factors influencing domestic energy (electricity) demand as well as inadequacies in the existing system. In addition, the study should also consider, how it can positively influence the peak energy demand based on the input and output variables of the factors that are influential in this regard. In considering this, much emphasis must be focused on a comprehending domestic energy usage and complexity in human behaviors to the use of energy. Therefore, the right choice of a model that includes all drivers of domestic electric energy demand and supply can be an innovative step for ensuring the uninterrupted or continuous supply of energy in Ghana. Since research has postulated a relation between energy demand and GDP, an investigation of the causal effects of the two variable contributes to an enhancement of a model for a reduction peak energy demand by considering the probable and existing input and output variables.

4.3 Confirmation of Causal Relations between Drivers of Proposed tQualitative Model

The causal relations between multiple variables from a design framework developed by considering factors affecting the dependent variables of an acquired dataset remains challenging in absence of time series data and also controlled perturbation of experiments. Thus, an accurate tool has to show the causal relations between the various variables in the model. The causal relationships among the multivariate energy demand and supply framework when explored and tested accurately can lead to a better understanding of the drivers in energy demand and supply. Such a framework provides the best direction to tackle energy issue for further research. To handle this, a survey instrument is developed in the form of a framework. It is then possible to test the perceived influence of hypothesized causal relationships amongst all linking variables on independent variable [56]

Shifting our focus to the most recommended tool which include the Structural Equation Modeling (SEM) and the Partial Least Square-SEM (PLS-SEM).These tools which belong to the family of statistical tool and techniques entirely depend on latent variables by accounting errors that may occur. PLS-SEM is a variance-based SEM method, which is referred to as the "most fully developed and general systems" [48], "silver bullet" [49] and more.

It is recommended for usage in most technological areas due to its ability of dealing with both composite and factors findings by modeling latent variables of behavioral research. Thus design of a framework for improved prediction of domestic energy demand in Ghana is attempted by considering the factors affecting demand and supply of energy. Such as:

- Inadequacies in existing practices in the energy systems
- Additional factors to match domestic energy demand and supply
- Attaining a resultant revised peak energy demand for the residential sector
- Additional identified factors to improve on prediction of domestic electricity demand and supply

This research proposes the incorporation of the PLS-SEM model to find the relationship between all the variables in the framework for an informed direction to adopt in the prediction of domestic energy demand and supply in Ghana.

4.4 Theoretical Model

Developing the proposed framework rely solely on the previous studies carried out in the following areas:

i. Determination of factors that affect domestic energy demand and inadequacies in the demand of domestic energy in Ghana
ii. Identification of factors that influence supply and inadequacies in the supply of domestic energy in Ghana
iii. Formulation of the additional factors that would help bridge the gap between domestic energy demand and supply in Ghana

Also, many more literature on the design of framework for the forecast of energy served as bases to make an appropriate proposal in the context of the Ghanaian domestic consumer's behaviors, occupancy, culture etc.
The proposed framework adopted other studies such as: [57], on individual spirit at work and its relationship with employee work attitudes and organizational outcomes: an empirical examination incorporated in Thailand [57] and [26], on a framework for understanding and generating integrated solutions for residential peak energy demand [26], where an outline of the various structures needed for a framework design was empirically conducted with some recommendations and limitations stated referenced the review work conducted by research on these works. Even though proposed framework design is an "add on" and when it comes to the context, definitely the current research is different. Basically the review conducted facilitated the realization of the need to adopt the convincing and empirical studies, even if the area of research is different. It is therefore necessary to emphasize that choice of variables in the proposed model performed in the context of Ghanaian domestic energy drivers with additional factors needed to improve on the current state of the energy system in Ghana considered.

Table 1: Conceptualizing Framework of the Hypothesized Relationship between the Variables

KNOWLEDGE Trust (Billing System) Education User behaviour	**CHANGE MANAGEMENT OPTIONS** Energy Retail Markets Government Policy options	**PROPENSITY TO CHANGE** Change Management Options Household Type Household Demographic
HOUSE Government Policy Options Propensity to Change	**HOME LOAD SHEDDING** Change Management Options Propensity to Change Appliance Type (Energy Efficient Appliances)	**APPLIANCES TYPE** House Propensity to Change

Grouping the factors assumed to affect each other in the proposed framework was conducted for easy understanding of the relations between all variables and also for the various hypothesis to be constructed. To comprehend the proposed framework, one needs to employ self–determination theory and find ways to assume the link each variable has with the other dependent variables in the research work. [50], consider self–determination as the opportunity to satisfy the three intrinsic needs which are competence, autonomy and relatedness.

4.5 Development of the Proposed Qualitative Interactive Model using SmartPLS 3.0

Formation of the structural model to present the proposed conceptual model was conducted by considering the layout of the variables in the proposed model in figure 11. Also, the questionnaire designed for this test had five indicators for each variable in the proposed model. Thus, the construction of the model in SmartPLS was efficient due to the careful choices of indicators for each variable. Moreover, the indicators were exogenous variables, whilst the variables were endogenous variables with regards to the proposed model construct. Furthermore, in developing the proposed model, the field data collated in Microsoft excel was imported in the SmartPLS model. The structural model was built in accordance to the structure of proposed model. Obtaining a blue colored variable, indicate that the model has all variables correlating with the constructs and structural

model tests is carried out for validity of the model constructed.
With this model, both reflective and formative measurement scales are involved. According to [48], whilst the formative measurements deal with uncorrelated measurements, where composite reliability, outer loadings and square root of Average Variance Extracted (AVE) are meaningless, the reflective measurements also deal with indicators that are highly correlated and the causality is directing from the blue-color latent variables to the yellow colored indicators is illustrated in figure 11. Thus, their reliability and validity shall be thoroughly examined [55].
Considering the output of structural model constructs from the SmartPLS, the two numbers seen in the model represent how much the variances of latent variable is explained by the other variables in the conceptual framework. In this case, the numbers in the blue circle represent how much the variance of the latent variables is explained by the other variables in the same construct. Also, numbers on the arrow lines refer to the path coefficients, thus, show the strength of the effect of one variable on the other in the framework. This also helps in ranking the statistical importance of the variables. Apparently, data set of about 1,000 sample size should have a standardized path coefficient of 0.20 so as to be able to demonstrate statistical significance [55]
In this case, all the reflective measurements have more than 0.5 as coefficient values. Latent variables with insignificant indicator are deleted resulting in some of the variables having less than five indicators. This shows that the indicators representing the causal relation between any of two variables are statistically significant and therefore strongly affect the other. So, all values of the path coefficient lesser than 0.40 were deleted from the model for better fit of the framework. For instance, UBK4 in figure 11 has a path coefficient of 0.36, thus, can be deleted from the final model before validating the quality of the variables and indicators in the conceptual model.

Furthermore, focusing on the values in the blue circle in the path model, value in the circle with good values of formative measurements show how much the variances of latent variable is explained by the other variables forming it. Here, it is clear that all reflective measures have no value in the latent variables which indicates how insignificant this value is in reflective measurements. From Figure 11, user behavior, education and trust affect knowledge, also, household demography and type, affect propensity to change. In totality, all these strongly explain why knowledge affects propensity to change at 49.3%. Hence, lower the values the lesser the effect of that particular variable or indicator on the formative measure and so it is an insignificant causal variable. The difference between this model construct and one designed by [26], since it is referred to as the benchmark for the proposed qualitative model for peak energy reduction in the residential level is that, some of variables considered in the proposed model are part of the constructs by [26] accept the relations between the indicator and variables. These indicators applied are factors that affect the demand and supply of domestic electric energy in Ghana. Thus, the choice of variables and indicators were selected in the context of Ghana electricity structural inadequacies. Table 2 is the list of abbreviation in the proposed interactive model construct.

Table 2 List of Indicator Abbreviations and Meaning

ABBREVIATION	VARIABLE RELATIONS
UBK	User Behaviours Affects Knowledge
TK	Trust Affects Knowledge
EK	Education Affects Knowledge
HDP	Household Demographic Affects Propensity to Change
HTP	Household Type Affects Propensity to Change
KP	Knowledge Affect Propensity to Change
CMP	Change Management Affects Propensity to Change
RMC	Energy Retail Markets Drives Change Management Options

PCM	Policy Options Affect Change Management Systems
CMHL	Change Management Options Affects Home Load Shedding
POH	Policy Options Affect The House of a Consumer
PCH	Propensity to Change Affects Customer's House
PHLS	Propensity to Change Encourages Home Load Shedding
HIH	Household Income Influences the House Building
HLP	House or Building Type Drive Appliances
AHLS	Appliances Type Influences Home Load Shedding
HLPD	Home Load Shedding Controls Peak Energy Demand

Referring to the abbreviations used in the proposed model constructs, the following definitions refer to the indicators for the causal relation between two variables in the proposed framework and it is numbered from 1 to 5 to represent the questions pointing at measuring the causal effects of the two variables.

Figure 11 SmartPLS Model Constructs

Determining the fitness of the model has become an expectation to prove a good analysis of the proposed model. Usually bootstrapping is used to check the model fit and other relevant measurement criteria for the factor analysis. With the model fit results, both saturated and estimated values are presented, whilst the saturation refers to the structural model with freely construct correlations and value should be at least 0.08 or below as proposed by [58]. This appears to be more adequate in the proposed model constructs. Basically, the test for model fit rely on deducing the chance of getting a shift in the empirical the model-implied correlation [49]. Essentially, model fit test provides information about what the empirical evidence says about the factor analysis and also how both relate to each other. Thus, a confirmatory factor analysis of the model design is realized. Table 3 illustrates the results of the model fit for the proposed interactive model.

Table 3 Model Fit Results

	Saturated Model	Estimated Model
SRMR	0.09	0.17
d_ULS	12.84	36.75
d_G1	8.89	10.24
d_G2	7.55	8.71
Chi-Square	3,324.25	3,592.73
NFI	0.36	0.31

CONCLUSION AND RECOMMENDATION

In order to understand and generate solutions to domestic peak electricity demand in Ghana, a model to make an improved prediction of domestic peak electricity demand and supply in Ghana is proposed, aiming at conceptualizing a framework to provide more precise forecast values of demand and supply of electricity in Ghana. Thus, a critical factor that can effectively improve on the demand of electricity in the domestic sector is DSM which is introduced in the proposed model as Home Load Shedding (HLS), presenting a technique for DSM at home. Technically, when consumers practice HLS, reduced demand at peak hours can be attained, in effect reducing the peak energy demand from the domestic sector with a corresponding reduction in electricity supply.

It is therefore recommended that a model of this conceptualized framework could be developed showing the effects of the relationship between variables and their contributions in achieving a reduction in peak domestic energy demand. Here, results indicate that knowledge about the DSM is controlled by trust, education as well as user behavior. Also, propensity to change is influenced by change management options, household type and household demographics. Same applies to all the other variables. Thus, with model to show how significant each of these variables have on each other is warranted in order to endorse and verify this proposed factors that affect energy demand and supply and their role in achieving an improved energy efficiency in developing countries.

Difficulty in getting household heads in their various homes to complete survey questionnaires was a great limitation of this research. Reasons was mainly due to household heads fear of being incriminated for disclosing vital information about their energy usage and corresponding bills received, which was in many cases compromised. Findings of factors that affect domestic energy demand from the research conducted include: Housing type (high class and low class), Income, Educational level, Use of Energy Efficient (EE) appliance/ practicing energy conservation. Also, factors that affect domestic energy supply include, cost of fossil fuel for the electricity, over reliance on national grid, technological advancement, technical -know – how and lack of small grids in Ghana. Ready-available of respondents for his study due to fear of arrest because of the type of data the researcher examined has been the limitation of this research work.

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