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Assessing the total economic value of electricity in Ghana

A step toward energising economic growth

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ASSESSING THE TOTAL ECONOMIC VALUE OF ELECTRICITY IN GHANA: A STEP TOWARD ENERGIZING ECONOMIC GROWTH

A REPORT PRESENTED TO INTERNATIONAL GROWTH CENTRE (IGC) FOR PROJECT NUMBER 1-VCE-VGHA-VXXXX-33402

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LIST OF ABBREVIATIONS

ABBREVIATION	FULL NAME
GW	GIGAWATT
KWh	KILLOWAT HOUR
NDPC	NATIONAL DEVELOPMENT PLANNING COMMISSION
GDP	GROSS DOMESTIC PRODUCT
WTP	WILLINGNESS TO PAY
CVM	CONTINGENT VALUATION METHOD
OECD	ORGANIZATION FOR ECONOMIC-COOPERATION AND DEVELOPMENT
IEA	INTERNATIONAL ENERGY AGENCY
DSM	DEMAND SIDE MANAGEMENT
LCP	LEAST COST PRICING
NOAA	U.S. NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
MOP	MINISTRY OF POWER
EC	ENERGY COMMISSION
PURC	PUBLIC UTILITY REGULATORY COMMISSION
VRA	VOLTA RIVER AUTHORITY
GRIDCo	GHANA GRID COMPANY (GRIDCO), ELECTRICITY COMPANY OF GHANA LIMITED
NEDCo	NORTHERN ELECTRICITY DEPARTMENT COMPANY
ECG	ELECTRICITY COMPANY OF GHANA
EPC	ENCLAVE POWER COMPANY

EXECUTIVE SUMMARY

This report describes and analyzes the results of a large Contingent valuation survey conducted in Ghana to assess the total economic value of electricity in Ghana. The assessment was geared toward energizing economic growth, since the severe energy crisis Ghana went through had led to a loss of 5.6% of GDP in a period when economic growth was less than 5%.

The study also responds to issues raised by the Ghana Energy Commission (through its Director for Technical Regulation) at the IGC Energy and Growth Conference in London on November, 12, 2015, presented on Ghana's energy sector. He stated among other things that the Commission needed to know the ability and willingness to pay for a unit of power in Ghana to help the Commission advice government on appropriate tariff rates.

Over 3000 households selected through probability sampling procedure responded to the questionnaire countrywide. They responded to questions on their current perception of the electricity situation in their localities, their expenditures in response to electricity shortages, their assessment of the value of electricity and their willingness to pay for reliable 24 hour electricity supply.

The report describes several tests that were conducted to check the reliability of respondents' answers to the valuation questions. The findings show that Contingent Valuation studies can be successfully carried in a developing country to assess the value of electricity reliably. The report also shows how the results can be used to help Ghana out of its electricity crisis.

All households were not willing to pay more than they were currently paying for electricity. The total economic value for a kilowatt-hour of electricity was 1.18 Ghana cedis (that is US$0.27 at US$1 = 4.40 Ghana cedis). This value was only 64.5% of the current subsidized end user tariff charged by the ECG. Without the subsidy, the value is only 47% of the end user tariff.

The study shows that, the current tariffs exact about 11% of households' incomes, while households are able to pay only 8% of their incomes for electricity. Thus, electricity tariffs as they stand are not affordable to Ghanaian households. The study further reveals that Ghanaians demand for electricity is more for non-use value purposes than for use-value purposes. This means that households do not regard electricity as a means for wealth creation. This concept has the tendency to dampen further efforts to improve the provision of electricity particularly if the only way is by means of higher tariffs.

Ghana's electricity sector has huge potential for development, to ease the country's energy difficulties and help Ghanaians launch a modern and more determined approach towards production and wealth creation. There is however a low level equilibrium trap impeding Ghana's effort towards enjoying the fruits of development through the use of reliable and affordable electricity. Demand side management of electricity supported by bold and decisive public policy towards efficiency will be needed to get out of the trap to energize economic growth and development in Ghana.

1. NTRODUCTION

Electricity has for several decades been a major aid in the creation of the wealth of nations. Its availability and efficient management to a large extent defines the welfare of communities. This has made the losses associated with inefficiently managing electricity in developing countries a source of concern globally. The concern has been manifested in the variety of policies and funding provided to ensure the efficient management and use of electricity, which, when handled appropriately would provide benefits not only in developing countries but also on a global scale.

Sub-Saharan Africa has been of particular interest, since its lack of access to electricity afflicts about 620 million people. This has limited economic opportunities and created health and environmental risks, reducing the quality of life and human capital development (Sy and Coplay, 2017).

Even though electricity has the potential to transform economic and social wellbeing, it appears to be one of the most mismanaged resources in Africa. It is common knowledge that people do not misuse what they consider to be of great value. If, however, the value of a resource is unknown, the likelihood exists that it may be undervalued and subsequently misallocated. This has probably been the plight of electricity in Africa, which remains largely mismanaged and misallocated.

The availability of resources to generate and sustain economic growth in most natural resource rich African countries, from evidence over several decades, has depended to a large extent on the availability of electricity. This is because most capital goods which drive economic growth and development in these countries have been obtained through the conversion of natural resources through extraction and trade, which require stable and adequate electricity. However, Africa’s electricity markets remain largely distorted and plagued with inefficiencies and resource misallocation.

The fact that well-structured markets mostly do not exist for electricity in Africa brings to the fore the importance of public interventions that in turn require accurate valuation to design socially optimal policies to correct the situation. The expected future progress for the African continent for instance, to a large extent appears embedded in how efficiently and equitably electricity can be managed and distributed, being a prime driving force for productivity improvements in all sectors of the economy. Without electricity, health clinics struggle to provide basic services, children are unable to get a proper education, and businesses cannot grow and thrive in today’s global economy. Even when there is electricity, the quality of supply is often poor. A majority of countries in Africa are still experiencing frequent power shortages. Yeboah (2017) reports that a World Bank’s assessment showed that 32 out of the 48 nations on the African continent are in energy crisis.

Electricity generation capacity has been around 100 gigawatts (GW)—one-third of India's, with a similar population—and an average annual per capita consumption of about 500 kilowatt-hours (kWh), one-fifth of the global average. Close to two-thirds of Africa's population–largely rural and poor—are left out of the service delivery paradigm, with adverse consequences on socioeconomic welfare and economic productivity. This reality is at odds with the rising aspirations of the international community and national governments to reach every consumer with reliable, affordable, and sustainable energy solutions by 2030 (World Bank, 2017).

Valuing electricity in Africa will provide appropriate facts on the extent of damage the current crisis is causing, as well as what can be gained if the situation is fixed sustainably, so as to inform policy on the extent of solutions needed and the quantum of resources required. Unfortunately, no economic value exists in the literature for electricity in Sub-Saharan Africa. Therefore accurate valuation should be considered a non-negotiable activity if sufficient growth and development is to be realized through electricity.

Quantifying the actual willingness to pay for high-quality service is quite difficult in practice, but the actual effects on households are potentially quite large however, making much of their work and leisure time more efficient. Similarly, the effects on production are also significant. It can be used as a direct input in production or to increase the efficiency of the current human and capital inputs already being utilised (or both).

Additionally, increasing the reliability of electricity allows producers to stop the use of other makeshift measures, such as costly diesel-based generators. The willingness to pay for the current electricity services appears to remain low in many developing countries however.

What remains to be investigated is not only how to improve these services, but also if improving them will raise the willingness to pay sufficiently to profitably sustain that quality of service (Greenstone, 2014)

This project assesses the total economic value of electricity in Ghana, a coastal West African country which started using electricity commercially in 1914 (ISSER, 2005). Ghana's experience with electricity provides lessons for Africa, evidenced by the fact that lack of adequate and uninterrupted electricity has been the major binding constraint to the accelerated economic growth and development of the Ghanaian economy (NDPC, 2014).

2. BACKGROUND OF THE STUDY

Ghana's economy has suffered from inadequate electricity generation, transmission and distribution resulting in chronic power outages, which have had negative effects on economic growth and development. With a current annual growth in electricity peak "demand" of about 10%, the country needs to meet the existing deficit and go the extra mile to create additional supply due to the annual growth in peak "demand". This will require private sector participation in electricity supply due to the enormity of the required investment particularly in infrastructure and skills. However, private sector will only participate if there is enough motivation through profits. Thus tariffs will need to be economic and be based on sustainable willingness and ability to pay.

The country's electricity sector, beset with high inefficiencies resulted in frequent and prolonged power outages, disrupting productive activities in all sectors of the economy. This state of affairs earned the Ghanaian term "Dumsor" a place in the 9th edition of the Oxford Advanced Learner's dictionary, which explains the term as "persistent, irregular and unpredictable electric power outages". These culminated in a loss of 5.6% of GDP in Ghana (NDPC, 2014).

In recent times, there have been serious disagreements between government and organized labour and consumer unions over tariff increases. The issue of pricing electricity has assumed serious social, political and economic dimensions in Ghana's economy, which could further serve as an additional drag on economic growth and development. Policy makers believe consumers must pay higher tariffs to end the energy crisis and to also provide the needed resources for a sustainable electricity supply. Some consumers argue that there have been series of tariff increases in the past, yet the crisis had still persisted, hence their reluctance to pay. Other consumers believe they simply cannot pay higher tariffs, even though an analysis of their ability to pay has not been scientifically determined. The value Ghanaians assign to electricity will to a large extent determine their willingness to pay (WTP) higher tariffs for electricity.

In June 2017, Ghana's energy minister Boakye Agyarko, addressing the maiden Ghana Energy Summit in Accra, summed the outcome of almost one decade long experimented solutions by saying that the implementation of all the over 30 power purchase agreements which Ghana had to embark on to ease its energy crisis was going to cost the country annual extra capacity charges of nearly US$700 million (Appiah-Adjei, 2017). Among the reforms the minister has proposed are a review of the over 30 power purchase agreements, placing a moratorium on others and refinancing of energy sector debts (Yeboah, 2017).

In 2015, the performance of the electricity subsector in Ghana was weak, with negative growth of the order of -10.2 percent. The considerable reduction in output of the subsector in 2015 was largely due to severe EI Nino weather effect, which considerably reduced the output of the hydroelectric dams due to the reduced volumes of water in their catchment areas. For example, due to the reduced volume of water, only three of the six turbines at the Akosombo Dam were fully operational in 2015, resulting in a shortfall of about 450 MW in electricity production (ISSER, 2016).

The government of Ghana undertook various measures to address the power challenges that confronted the industrial sector and the economy as a whole. A new Power Minister was appointed, who pledged to end the power crisis by the end of 2015. This pledge was largely achieved, with improvement in the energy production situation by the end of 2015 (ISSER, 2016). During the year, work was completed on the 110 MW TICO expansion and also the 220 MW Kpone Thermal Power Project. The 360 MW Sunon Asogli expansion project was partially completed by the end of the year. The Volta River Authority (VRA) expanded its plant (49.5 MW) by adding 38 MW (Government of Ghana, 2015). Also, an emergency offshore generation plant assembled in Turkey arrived in Ghana during the fourth quarter of 2015. The rush for emergency power systems shows how desperate the situation was for Ghana.

2.1 Trend in end user tariff

The Energy Commission of Ghana has argued that prevailing electricity tariff moves Ghana from once among less expensive countries to very expensive grid tariff regimes in Africa. This is based on the classification where low or less expensive tariffs are 2-9 US cents/kWh; medium expensive tariff: 10-15 cents/kWh; high or very expensive: 18-25 US cents/kWh and 26-35 US cents/kWh being the most expensive. This they feared was likely to reduce grid power consumption particularly in commercial, services and industries customers which are the wealth creation sectors with consequential marginal growth of the economy.

Most heavy industries including the mines would require on the average tariff less than 6 US cents per kWh to stay competitive with similar products imported. Light industries could go as high as 10 US cents per kWh to survive. Thus for current energy tariffs for industries ranging from 18 – 26 US cents per kWh, excluding service charges means they are on the very high-side.

For non-residential or Commerce/service customers, with a tariff range of 26-43 US cents per kWh for initial consumption of 300 kWh in a month, it would be cheaper running own diesel alternative if available, except for convenience. Running a back-up generator at the current retail diesel price in the country would produce electricity at an average cost of 27 US cents per kWh. As if some service sector consumers have already realised it, they are switching to their backup gensets (Energy Commission, 2016).

Figure 1 shows a rising trend in end user tariff which the Ghana Energy Commission has confirmed moves Ghana from the low tariff to the very high tariff regime, creating uncertain consequences for firms and the economy as a whole. Such a trend may not be in line with economic sustainability of the electricity sector.

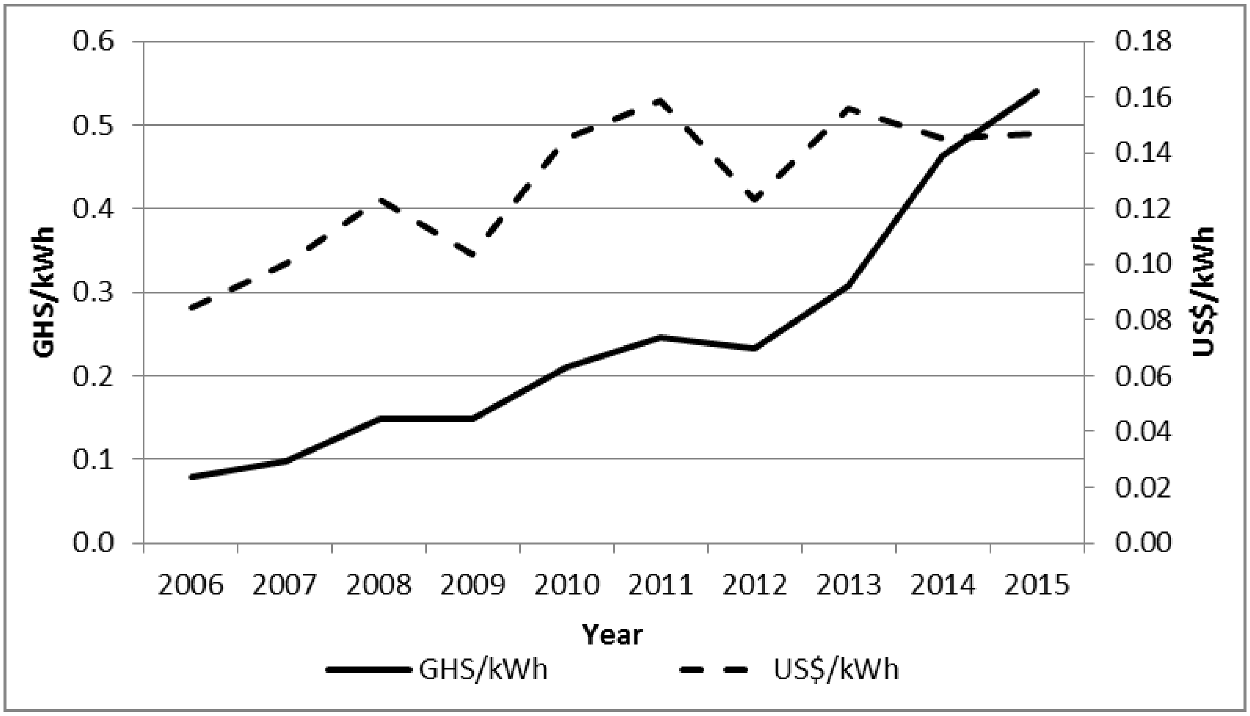

Figure 1 Trend in end user tariff

. Source: Energy Commission, Ghana (2016)

While some development planners trace the cause of Ghana’s decade old energy crisis to lack of proper planning, others believe climate change has been largely responsible, denying Ghana cheap hydro power and throwing all its plans regarding electricity out of gear.

Irrespective of the immediate cause of Ghana’s current energy predicaments, if the root cause of the problems had been identified much earlier, it could have been prevented or even managed better than it was, when it occurred. One certain fact about electricity and any other resource is that if its value is not known, it tends to be abused, misused, mismanaged and misallocated.

If Ghanaians had known exactly what the value of electricity was and that its absence for a while could trigger a 5.6% GDP loss in one year, the right planning measures would probably have been put in place to forestall the bitter loss and disruption of livelihoods caused by the crisis.

The World Bank (2013) observed that the recent crisis were due to misguided and inappropriate policies which failed to learn from a major, avoidable crisis in 2006/7, which at that time cost the country about 1% of GDP. Thus the power sector clearly has become a major drag on Ghana’s economic growth and development for more than one decade. The way out would be to take steps to energize economic growth and development through injecting sustainable electricity into the economy. One extremely important step is to provide accurate and relevant facts and analysis to inform policy, consumers and producers, of the real economic value of electricity for the growth and welfare of households and the nation as a whole.

2.2 Institutional framework for electricity in Ghana

Ghana's electricity sector is manned by seven public institutions. These institutions are supported by a few Independent Power Producers (IPPs) whose main role is generation of electricity. The public institutions are the Ministry of Power (MOP), Energy Commission (EC), Public Utility Regulatory Commission (PURC), Volta River Authority (VRA), Ghana Grid Company (GridCo), Electricity Company of Ghana Limited (ECG) and the Northern Electricity Department Company (NEDCo), a subsidiary of the VRA. The Ghana Energy Foundation is a private-public sector partnership to promote energy efficiency and conservation countrywide. Table 1 shows the various functions performed by the institutions.

Table 1: Major Institutions in Ghana's Electricity Sector

INSTITUTION	MAIN FUNCTION
Ministry of Power	Government mouthpiece and responsible for energy policy formulation
Energy Commission	Energy Policy Advisory, planning, technical regulation & monitoring
PURC	Electricity Tariff Regulation
VRA	Electricity Generation
GridCo	Electricity Transmission
ECG	Electricity Distribution (Southern Sector)
NED	Electricity Distribution (Northern Sector)
Energy Foundation	Promotion of energy efficiency and conservation
IPPs	Electricity Generation

Source: Electricity Company of Ghana, 2017

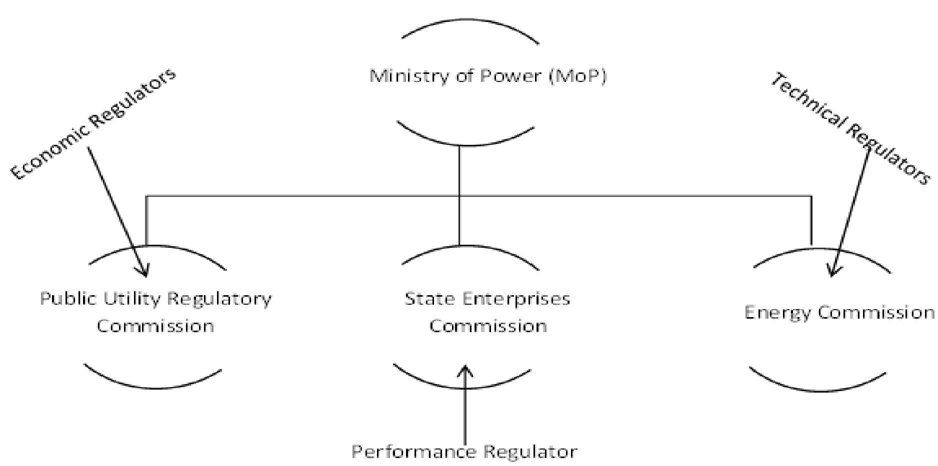

Figure 2: Relationships among institutions in Ghana's electricity sector
Source: Electricity Company of Ghana, 2017

Electricity Generation

Generation is the first arm of the power chain in Ghana. Volta River Authority (VRA) is the major power generation company, solely owned by the Government of Ghana and established in 1961 by an Act of Parliament.

Table 2: Installed capacity of electricity in Ghana

Generation Facility	Installed Capacity (MW)
Akosombo Hydroelectric Power Plant	1020
Kpong Hydroelectric Power Plant	160
Takoradi Thermal Power Station (T1)	330
Takoradi Thermal Power Station (T3)	132
Takoradi International Company (TICO/T2)	220
Tema Thermal 1 Power Plant	110
Tema Thermal 2 Power Plant	50
Mines Reserve Power Plant	80
Solar Power Plant	2.5
Sunon-Asogli Power Plant (SAPP)*	200
CENIT*	126
Bui Hydroelectric Power Plant	400
Karpower*	225
Ameri*	250
BXC Solar PV Plant	20

*Independent Power Producers

Source: Ghana Wholesale Electricity Market Bulletin by Energy Commission (Feb 2016 edition)

VRA combines hydro, thermal and solar plants to generate electricity for supply to the local and export markets. Due to the energy sector reform, there are also other generation companies that are privately owned known as the Independent Power Producers. Notable among them are Ameri, Karpower, Sunon-Asogli and CENIT.

Electricity Transmission

Transmission is the second arm of the Power Chain in Ghana. GRIDCo owns and operates the transmission grid mainly at 161kV with a total length of about 5,100 km. The other transmission voltages are 69kV, 225kV, and 330kV. These lines carry power from various generating stations to over fifty-four (54) substations owned by GridCo. At these substations, the power is stepped down to lower voltages including 34.5kV and 11kV for the major bulk customers which include the distribution companies namely: Electricity Company of Ghana (ECG), Northern Electricity Distribution Company (NEDCo) and Enclave Power Company (EPC).

Electricity Distribution

Distribution is the last and final arm of the Power Chain in Ghana. The Electricity Company of Ghana (ECG) is the major distribution company with over 70% market share. It is responsible for distribution of power in six administrative Regions in Ghana namely Greater Accra, Western, Ashanti, Central, Volta and Eastern Regions.

The Northern Electricity Distribution Company (NEDCo) was established under the Volta River Authority (VRA), to take the responsibility of electricity power distribution in Northern part of Ghana. There is a third distribution company, Enclave Power Company, the only private owned distribution company, which is mainly responsible for the industries in the Free Zone Enclave of Ghana in Tema. The distribution companies receive power at 34.5kV from GridCo. And step it down to 11kV to industrial customers and step it further down to 440/230Volts to commercial and residential customers.

Seven out of every ten households is connected to the national electricity grid while about a quarter of households rely on torch or flashlight for lighting (24.3). Electricity is the main source of lighting for 88.6 percent of urban households, with 93.1 percent of the households in Accra (GAMA) having access. In the rural areas, less than 50 percent of households have electricity as the main source of lighting. The use of wood or charcoal is still very popular among households. About three-quarters of households depend on wood or charcoal for cooking while less than one-quarter use LPG (22.3%). In the urban areas, 43.6 percent of households use charcoal while 35.8 percent use gas (GSS, 2014).

Though access to electricity for households continues to increase, the power generation capacity remains constrained. Though government introduced measures to address the power supply challenges through some emergency programmes, the long-term risk of power outage persists (NDPC, 2017). Thus the call to develop a sustainable power supply system which permanently resolves the currently vulnerable power set up is more relevant than ever before.

This study assesses the total economic value assigned by households to electricity in Ghana, which is theoretically proportional to their willingness to pay for electricity. Such a value has not been available to guide policy makers on the extent to which tariffs can be raised in order not to make consumers worse off. The less value people assign to electricity, the less WTP that can be harnessed for economic growth. The study employed the Contingent Valuation Method (CV) to elicit WTP responses from 3100 household heads through a bidding game approach in rural and urban Ghana. It also ascertained the factors that determine the willingness and ability to pay for electricity in Ghana. Finally, the study derived demand and total revenue curves for electricity in Ghana through analysis toward private sector delivery of electricity.

3. AIM AND OBJECTIVES

The study aims to determine a monetary value for a unit of electricity in Ghana, a value which the Energy Commission has said was not available yet, prior to this study. It also seeks to identify the most relevant factors that determine the value Ghanaians place on electricity. Finally, it also seeks to provide a guide on how far governments can go, using tariff increases as a means of obtaining more resources to drive economic growth.

Thus the study sought to create knowledge which will strengthen policy decisions toward economic growth and development in Ghana and other developing countries going through energy deficit and management difficulties like Ghana. Following the above, the study hypothesizes that there exists a significant relationship between electricity tariffs and the total economic value of electricity in Ghana.

4. RESEARCH QUESTIONS

The main research questions that the study sought to answer were the following:

1. What is the total economic value of a unit of electricity in Ghana?
2. What factors determine the total economic value of electricity in Ghana?
3. What is the relationship between the total economic value per unit of electricity and the tariff?
4. Are households able to pay a tariff equivalent to the total economic value?
5. What is the net welfare gain for paying tariffs higher than the current one?
6. To what extent can electricity tariffs be increased so as not to make the poor worse-off?

Through answering these questions, the study provided a monetary value for a unit of electricity in Ghana, a value which the Energy Commission had said was not available before the commencement of the study. It also identified the most relevant factors that determine the value Ghanaians place on electricity. Finally, the study also provided a guide on how far governments can go, using tariff increases as a means of obtaining more resources to drive economic growth.

5. RELEVANCE OF STUDY

To grow an economy sustainably, adequate modern energy is required. However, the energy crisis across several developing countries including Ghana, attest to the fact that economic growth and development in these countries would suffer setbacks due to inadequate provision of modern energy, particularly electricity.

One main reason given by some policy makers in Ghana is that consumers are not paying economic tariffs to enable utility providers increase electricity generation and also improve on transmission and distribution systems. However, there is the possibility that most electricity consumers in Ghana do not value the resource adequately and therefore are not willing to pay beyond the value they perceive to be deriving from it.

Knowing the total economic value of electricity in Ghana would be helpful to inform policy makers whether demand for electricity in Ghana could generate enough revenue to sustain electricity supply for economic growth and development. Also, a knowledge of the factors which determine total economic value of electricity could inform policy on how to provide the electricity needs of Ghanaians for sustainable development.

In addition, understanding the value that consumers place on accessible and reliable electricity is critical to the formulation and prioritization of policy. Under conditions of limited resources, time, and capabilities, it is necessary for policymakers to ensure that their policies generate gains that are greatest for the long-term growth of the country. Therefore, it is essential to obtain an idea of the value of reliable, high-quality electricity services across regions and consumer groups in order to both determine (i) what public and private costs would result in net social gains for communities, and (ii) which of these groups would receive the largest social gains from improvements in the quality of their electricity supply (Greenstone, 2014).

6. REVIEW OF RELATED LITERATURE

6.1 The Concept of Economic Value

Economic valuation of electricity is based on human preferences, which emanate from the satisfaction a resource would provide the person doing the valuation. Failure to value electricity will imply it being assigned a default value of zero in computations designed to guide policy. A value of zero justifies wastage and misallocation of electricity as a resource. Economic valuation of electricity is a way to demonstrate the value of electricity to society, to justify the inefficiencies of misallocating electricity, since it makes no economic sense to waste what is valuable.

Valuing electricity does not only help in quantifying benefits gained by having it or lost by not having it. It also provides a basis for decision making on how much can be expended to provide electricity and by what means, for every economy. In addition, economic valuation can be a basis for legal actions and judgments relating to electricity's worth, where compensation would have to be paid. Trade-offs, which far exceed gains to be obtained from electricity could easily be identified and avoided, if the economic value to be gained is known. Thus countries may not go for emergency electricity at whatever cost based on their knowledge of the value, which could be lost, compared to what would be gained from electricity. In the same vein countries could invest heavily in sustainable access to electricity if they find the value to be gained exceeds the value of the investment to be made. A lack of knowledge of the economic value of electricity thus leaves policy makers to making guesses, which end up creating huge costs for society.

6.2 Types of economic value

The types of economic value to be gained from electricity are use values and non-use values. Use values refer to willingness to pay to make use of electricity. Such uses may be direct, e.g. extractive uses, or indirect, e.g. a measure of the level of progress. If one used one of one's senses to experience the resource - sight, sound, touch, taste, or smell—then one would have used the resource. Some of these uses are called passive-use values or non-consumptive use values if the resource is not actually used up (consumed) in the process of experiencing it (Tietenberg and Lewis, 2013).

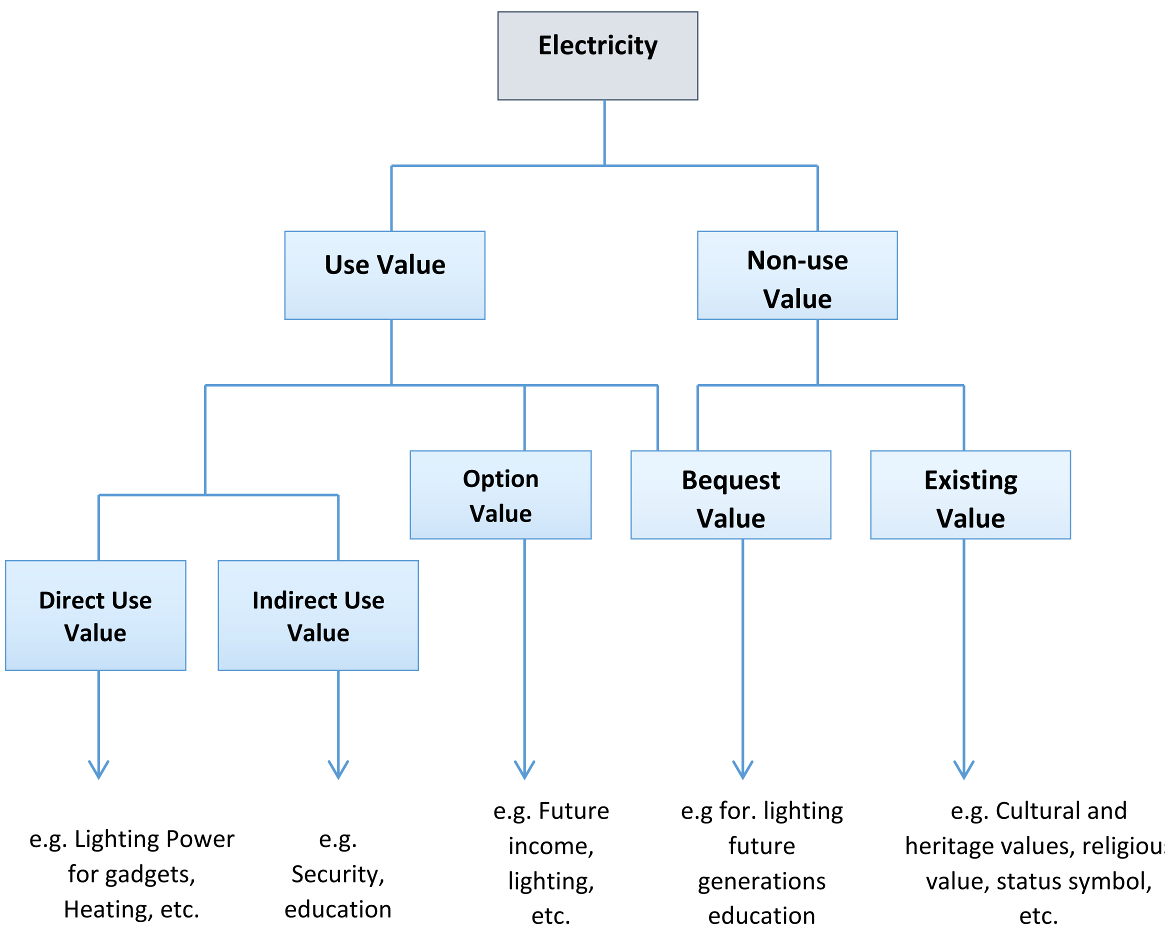

Figure 3: Types of economic value of electricity

Use values may also contain option values; willingness to pay to conserve the option of future use even though no use is made of the resource now. Such options may be retained for one's own use or for another generation. Non-use values relate to willingness to pay which is independent of any use made of electricity now or any use in the future. Non-use values reveal the multi-faceted nature of the motivations for electrification projects, e.g. being driven by concerns about future generations, etc. Since nonuse values are derived from motivations other than personal use, they are obviously less tangible than use values. Total willingness to pay estimated without nonuse values, however, will be less than the minimum amount that would be required to compensate individuals if they are deprived of electricity (Tietenberg and Lewis, 2013). Some of these values, illustrated in Figure 3 are classified in Table 3.

The sum of use and non-use values gives total economic value. It is this value that is lost if people are deprived of electricity. Total economic value can then be estimated by summing individual use and non-use values, or by seeking some all-encompassing willingness to pay for electricity generally.

Table 3: Components of the Total Economic Value of Electricity

Use Value	**Non-use Value**
• Light	• Electricity as object of intrinsic value, as bequests, as a responsibility (stewardship)
• Power for gadgets	• Cultural and heritage values
• Jobs	• Religious values
• Output of goods and services	• Status symbol
• Heating	
• Cooling	
• Security	
• Health	
• Education	
• Recreation/Entertainment	
• Agriculture	
• Communication	

The taxonomy of economic values presented above aims at covering the whole range of benefits electricity has on the individuals' utility/welfare, and it is rooted in the disciplinary definition of value developed in neo-classical economics (Norton and Noonan, 2007). According to it "an entity has economic value only if people consider it desirable and are willing to pay for it" (Chee, 2004). This implies an individualistic approach to the concept of value. Such an approach assumes stable individual preferences, expressed by well-informed and selfish "rational economic agents" that act in order to maximize their personal utility under given income and time constrains (Hanley and Spash 1993, Farber et al. 2002). Thus, this standpoint captures solely "individual based values" (Farber et al. 2002). This perspective is not problematic, since electricity valued has features of private goods, namely (Farber et al. 2002), it being individually consumed and its consumption occuring without generating externalities (Tesileanu, 2008).

6.3 Economic Value and price

Value is different from price. One could know the price of everything but the value of nothing. While price is determined by forces of demand and supply, value is determined by the "worth" (function) of a resource and how useful it is (the role it plays) in determining the welfare of its owners. While a price exists for a unit of electricity in Ghana, the value of that same unit of electricity is not known to policy makers (Ghana Energy Commission, 2016), rendering the efforts at efficient allocation of electricity very costly guess work, to a large extent. Such a situation normally leads to inefficiency and consequently resource misallocation. This is because for a socially efficient electricity allocation, electricity must be used in its highest valued uses as against its least valued uses. Thus for socially efficient electricity allocation, households and firms must be in a position to determine their value for electricity so as not to make decisions whose trade-offs would result in welfare loss and resource wastage.

It is also worth noting that "economic" is different from "financial" or "commercial". Any function, which contributes to human welfare is deemed to be an economic function, and the flow of such services may or may not have a cash flow associated with it (Pearce, N.d.).

In dealing with electricity, functions with associated cash flows are made to appear more 'real' than those without such cash flows. There is thus "misplaced concreteness" and decisions are likely to be biased in favor of cash flows related functions creating "asymmetry of value". Thus there might be the tendency to undervalue educational uses of electricity in favor of other uses, which could generate immediate cash.

Also, market forces do not determine the value of electricity in developing countries because of direct government interference, making the price signal distorted. It is worth noting that allowing market forces alone to operate to solve the issue will not work since market prices themselves fail to reflect full social costs. Nonetheless, getting government underpricing of electricity corrected is a very important step toward the solution.

Market prices in many cases form the basis of individual decisions, but may be an inappropriate measure of the marginal costs and benefits to society of electricity. There are a number of cases where prices are implicit rather than explicit in exchanges; where policy results in non-market changes, and where market imperfections, unemployed resources, taxes, subsidies and constraints on use exist. In such cases, market prices are not a measure of the social opportunity cost of benefits forgone to society (Garrod and Willis, 1999). Under such conditions, economic value becomes the most correct choice toward household electricity allocation decision making, which is the basis for household demand for electricity.

6.4 Electricity Demand

Taylor (1975) suggests that electricity demand contains a number of features that are singularly difficult to model. Being difficult however, does not mean it is impossible. One such feature of great importance is the existence of multistep block pricing of electricity. An appreciation of these features is essential for understanding the structure of electricity demand.

The classical theory of consumer behaviour holds that a consumer maximizes utility functions defined over n goods constrained by their incomes. This generates a demand function of the form

$$q = f(x, p_1, p_2, \ldots., p_n),$$

where q represents the quantity the consumer is willing and able to purchase of a good, x represents the consumer's income and $p_1, p_2, \ldots., p_n$ the prices of the n goods.

Such a demand function is considered theoretically plausible, and with regard to electricity, it is worth noting that most "demand" functions derived in literature on electricity are not theoretically plausible. The explanation for such a gap in literature has been that the demand for electricity has usually been estimated in isolation or else in conjunction with the demand for its close substitutes (Taylor, 1975). Such an approach may not compel economists to ascertain whether their demand functions satisfy the Sluskey symmetry conditions for a complete system of demand functions.

Another explanation is that electricity consumers do not face a single price, they have face a price schedule instead, which sells electricity in blocks at a decreasing marginal price. Beginning from Hauthakker's (1951) revelations, Bunchana (1966), Gabor (1966) and Oi (1971) have discussed the theoretical implications of block tariffs which have gone unnoticed in the econometric literature (Taylor 1975). The existence of the price schedule has implications for the demand function and the consumer's equilibrium.

6.5 Non-analytical derivation of electricity demand

While the presence of a single price provides a linear budget constraint, the price schedule for electricity provides a nonlinear budget constraint. The consequences of non-linear budget constraints for electricity consumers are varied, the most crucial being that, the equilibrium of the consumer can be derived using mathematical programming but not differential calculus. The implication is that even though the demand functions and Engel curves exist, they cannot be obtained as closed from expressions by solving first-order conditions for utility maximization. Thus, the demand functions for electricity cannot be derived analytically (Taylor, 1975). Again the demand function will be multi-valued where there occurs a price configuration at which the budget constraint has multiple tangencies along the same indifference curve.

Taylor (1975) also explains that the non-analytical nature of the demand for electricity function due to block pricing though a valid issue against econometric estimation of demand for electricity, is more theoretical than practical. However, if theory is a simplification of the real world situation, then it is crucial that demand for electricity functions are correctly estimated even if outside the traditional econometric way.

The difficulty of specifying a demand for electricity function which is theoretically plausible led to a compromise on what demand for electricity really is. Many studies which set out to estimate demand for electricity end up estimating electricity consumption. However, it is an economic theory reality that demand is not the same as consumption. This misplaced identity has led to the use of electricity consumption functions in place of electricity demand functions. This has had serious consequences on demand and its responses for policy, particularly in developing countries. While this may not be a big problem for high income economies where stability in the electricity sector is highly guaranteed, it can be very destabilizing for developing countries where very high growth rates in electricity consumption occur annually.

Turvey and Anderson (1977) point out that for efficient resource allocation, it is the actual resources used or saved by consumer decisions that are important. Substituting consumption for demand rules out the ability to track the income and substituting effects of electricity price changes, to aid in policy decisions. The estimation of demand for electricity in this report is done from first principles, where demand for electricity is correctly interpreted as the marginal willingness to pay for a unit of electricity at various prices over some period of time, for the sake of theoretical plausibility and correct policy application.

6.6 Misplaced Terminology

A clash of terminology has created substantial confusion about the demand for electricity. What energy engineers refer to as electricity "demand" is actually not what economists mean by demand. The economist typically or traditionally defines demand for electricity as the quantity of electricity that a consumer is willing and able to purchase at a given price over some period of time, holding all other things equal. In economics demand is a flow quantity not a stock. It is not what is consumed or purchased but what consumers are "willing and able" to purchase, the constraint being their income as far as the price/tariff is concerned.

The relevance of demand response becomes very strong here and hence the need to ascertain how much consumers are willing and able to pay for electricity since that becomes the driving force behind demand. Thus the demand curve becomes the marginal willingness to pay curve for the individual consumers, while the market demand is the horizontal summation of the individual/household demand curves. Theoretically therefore, the demand for electricity curve must be a downward sloping curve, showing a relationship between marginal willingness to pay for a unit of electricity and the quantity of electricity over some specified period of time.

The electricity engineering definition of “demand” for electricity rightly distinguishes it from consumption of electricity. The difference, according to electrical engineers is said to be vital for choices in reducing energy cost. This explanation shows that the engineer’s “demand for electricity” is a purely supply side definition, which contradicts economic principles. The simple differentiation between electricity “demand” (measured in kW) and consumption (measured in kWh) as held by electrical engineers is provided in the lighting example below.

One 50 watt light bulb burning for 20 hours consumes 1,000 watt-hours or 1 kWh of electricity. While it is on, it requires or “demands” 50 watts or 0.05 kW from the utility provider. Thus the utility provider must have 0.05kW ready whenever the customer turns the lamp on.

Similarly, ten 50-watt light bulbs burning for 2 hours consume 1,000 watt-hours or 1 kWh. This means the utility provider must be ready to provide ten times as much capacity in response to the “demand” of the 10 light bulbs operating all at once.

Here, it is worth noting that even though in both cases the consumption is 1 kWh, the “demand” (kW) is different for both, the second consumer has a higher requirement from the utility provider than the first consumer. It is this requirement which the electrical engineer calls “demand for electricity”. If both of these consumers are billed based on their consumption only, both will receive the same bill for 1 kWh of electricity.

Defining demand the engineer’s way excludes demand response since it does not consider the price effect of the demand for electricity. In such a situation, the engineer’s upward sloping “demand curves” for electricity which are common in literature could be acceptable. However, these curves are simply consumption trends, since they show electricity consumption by years – a complete distortion of the concept and application of demand.

Following these consumption trend graphs, policy makers in developing countries have tried in vain to address the real issues of electricity demand. Without demand response, real issues about demand side management of electricity, which are fundamental for the development of the electricity sector of developing countries cannot be appreciated and thus taken into account for policy purposes.

6.7 Specification of the Demand Equation

The avoidance of costly policy errors by electric utilities and their regulators depends critically on reliable estimates of demand equations parameters, particularly price elasticities. In response to this need, econometric studies of residential electricity demand have proliferated in recent years. Common to these studies is the problem that electricity has typically been sold according to a “multi-step block pricing” schedule, under which marginal price a step function, usually declining, of quantity is purchased (Henson, 1983).

In his important survey paper, Taylor (1975) noted the specification and estimation difficulties raised by the multi-step block pricing structure for electricity. Specification is complicated by the dependence of quantity demanded on the entire vectors of marginal prices and block boundaries rather than on a single price. As a solution, Taylor showed (in a suggestion later modified by Nordin (1976) that the rate schedule can be characterized locally by simple summary variables. However, as Taylor also pointed out, estimation is still complicated by possible correlation of these summary variables with the error term in the equation, particularly if these price variables are calculated at ex post observed, rather than at predetermined, consumption levels (Henson, 1983).

Households do not receive utility from the consumption of energy per se, but use it as an input into the production of various household services. The demand for electricity can thus be viewed as derived from the demand for each of the end-use activities into which it is an input. If the production technologies for the services are non-joint and exhibit constant returns to scale, then the households' total demand for electricity can be viewed as additive across end-uses (Dubin, 1982). Letting qi be the demand for electricity for activity j, the total electricity demand for a typical household can be written as

$$q = \sum_{j} d_j q_j + u = \sum_{j} d_j f_j\left(p, X_j; \beta_j\right) + u$$

Where q_j a dummy variable indicating use of electricity in activity is $j, p\ and\ X_j$ are vectors of prices and other explanatory variables relevant to activity j, respectively, and $B_j$is a vector of parameters (Henson, 1983).

6.8 Demand Response

Improving the ability of electricity demand to respond to wholesale prices will reduce the total costs of meeting demand reliably and can reduce the level and volatility of prices during critical periods. Despite the growing interest in short-run demand response (DR), recent analyses and proposals contain remarkably little discussion of the basic economic principles involved. This has led to fundamental and important economic errors, common where DR is concerned (Ruff, 2002).

Demand response refers to a set of strategies which can be used in competitive electricity markets to increase the participation of the demand-side, or end-use customers, in setting prices and clearing the market. When customers are exposed in some way to real-time prices, they may respond by a) shifting the time of day at which they demand power to an off-peak period, and/or b) reducing their total or peak requirement through energy efficiency measures or self-generation. A possibility exists that some may choose not to respond at all and pay the market price for electricity instead. The extent to which they respond, the profile of demand in the market will be smoothed which, in turn, feeds back into prices, clipping the peaks significantly and, to a lesser degree, lowering average prices. The net effect of the demand response is to ease system constraints and to generate security and economic benefits for the market as a whole (IEA, 2003).

6.9 Developments in demand response for electricity management

Until the 1970s, price was usually ignored in forecasting electricity demand even in the long run. Then some economists explained that regulated prices below the costs of incremental supplies give consumers too little incentive to conserve electricity and make it unprofitable to expand supply. Thus for an electricity utility firm tasked mainly to supply, consumers' incentives and full-cost-recovery prices can be reduced by paying for demand reductions. This would work if the payments do not exceed the difference between marginal costs and retail prices, since they could be regarded as "price corrections" rather than subsidies. The demand reductions to be paid for must be known and this will have to come from estimating the demand function, which is price related (Ruff, 2002).

Electricity demand grew in the 1970s despite increases in electricity prices. Utilities rapidly added generating capacity. Then, in the early 1980s, world oil prices collapsed and deregulated natural gas made a comeback as electricity prices continued increasing to cover the costs of the new capacity. Electricity demand growth slowed below expectations, creating excess capacity that led to even more rate increases and, in some cases, cost disallowances that created financial problems for utilities.

In the early and mid-1990s, the increasing divergence between high regulated retail utility rates and low incremental wholesale costs created pressure for competition in electricity. These events showed conclusively that electricity demand is strongly affected by prices and that ignoring this reality will lead to costly mistakes. This notwithstanding, most developing countries forecast electricity demand without considering prices as critical explanatory variables.

The OECD/IEA carried out a study which considered the proposition that the demand side is not actively participating in the price-setting process in many liberalised markets, whether due to on-going price regulation, poor incentive structures or the relative immaturity of the market players and institutions. The study argued that this has contributed to a number of the problems seen in liberalised markets – blackouts, system failures, excessive price volatility and suggestions of market manipulation – all of which have had wider economic and social consequences for member country governments, in addition to generating some spectacular corporate failures (IEA, 2003).

6.10 Toward efficient allocation of electricity

In efficient markets, prices are formed through complex interactions between buyers and sellers: the demand – and supply-sides of the market. In today's liberalised electricity markets, most buyers do not participate actively in the price-setting process. As a result, prices fail to play their normal role of balancing natural swings in supply and demand, leading to excessive instability.

Demand response presents a viable alternative to traditional supply-side remedies in constrained wholesale markets. It offers a highly-flexible and naturally-distributed resource to network operators, and reduces the need for investment in peak supply capacity. Critically, demand response enhances security, particularly on constrained networks (IEA, 2003).

Concentration on the supply-side of the market and the abuse of market power continue to trouble the efficient operation of many liberalized electricity markets. Most competition models in electricity markets overlook the potential contribution of increased demand response to this problem. Yet market power abuses can be reduced either by reducing concentration on the supply-side of the market (e.g. by requiring divestiture by dominant firms of some of their generating plant) or by increasing the elasticity of demand relative to price – and this is what demand response does. In fact, doubling the price elasticity of demand would have the same impact on prices as halving the concentration on the supply-side, yet the former may be considerably easier to achieve (IEA, 2003).

Economic efficiency in competitive electricity markets requires that customers are offered a variety of pricing options, to efficiently reflect variations in cost and value. Significant economic gains can be realised with relatively small amounts of response – in some cases, wholesale prices could be reduced by up to 50% with as little as a 5% demand response capability. Most importantly, demand response offers real financial savings for electricity users. It has been estimated, for example, that incorporating demand response into the United States market, with dynamic pricing, would lead to savings of between $10 billion to $15 billion per year (IEA, 2003). These benefits however can be quantified to influence policy only when an accurate demand for electricity function is estimated. One of the main reasons why Ghana has not been able to quantify demand response benefits is the reliance on "demand" estimates which have not been consumer sensitive.

6.11 The Economic Theory of Contingent Valuation

Contingent Valuation (CV) uses surveys to measure an economic concept of value. The goal of a CV study is to measure an individual's monetary value for some item. In valuing a single item q, where the individual or household is a consumer, it is usual to assume the individual has a utility function defined over the quantities of various market commodities, denoted by the vector x, and q, $u(x, q)$. Corresponding to this direct utility function, an indirect utility function can be obtained as, $v(p, q, y)$, where p is the vector of the prices of the market commodities and y is the person's income. The conventional assumption that $u(x, q)$ is increasing and quasi-concave in x is made, which implies that $v(p, q, y)$ satisfies the standard properties with respect to p and y. If the consumer regards q as a "good," $u(x, q)$ and $v(p, q, y)$ will both be increasing in q.

Valuing an economic resource like electricity implies a contrast between two situations – a situation with the item, and one without it. What is being valued is usually regarded as a change in q. Specifically, suppose that q changes from q^0 to q^1; the person's utility thus changes from $u^0 \equiv v(p, q^0, y)$ to $u^1 \equiv v(p, q^1, y)$. If the consumer regards this change as an improvement, $u^1 > u^0$.

The value of the change to the consumer in monetary terms is represented by the Hicksian measure, the compensating variation in income C which satisfies

$$v(p, q^1, y - C) = v(p, q^0, y)$$

If the change is regarded as an improvement, $C > 0$; in this case, C measures the individuals' maximum WTP to secure the change.

CV uses a survey to measure people's WTP for the change in q. The utility theoretic model of consumer preference outlined above provides the framework for interpreting the CV responses. The derivation typically involves a statistical analysis of the survey responses. In the framework of statistical modeling, it is conventional to treat the survey responses as the realization of a random variable. It is necessary, therefore, to recast the deterministic model of WTP outlined above into a stochastic model that can generate a probability distribution for the survey responses. These involve the WTP distribution; and the survey response probability distribution based on the assumption of a utility maximizing response to the survey question. The WTP cumulative distribution function denoted $G_C(x)$; for a given individual, specifies the probability that the individual's WTP for item in question is less than x

$$G_C(x) \equiv \Pr(C < x),$$

where the compensating variation in income C is now viewed as a random variable.

With respect to the closed-ended, single-bound discrete choice question format: the respondent is asked: "Would you vote to support the change from q^0 to q^1 if it would cost you \$$A$?" Suppose the response is 'yes'. This means that for this individual, his value of C is some amount more than A. In terms of the underlying WTP distribution, the probability of obtaining a 'yes' response is given by

$$\Pr(\text{Response to closed-ended question is 'yes'}) = \Pr(C \geq A) \equiv 1 - G_C(A).$$

With the open-ended format, the response directly reveals the respondent's value of C. With the closed-ended format, it does not reveal the exact value of C but it does provide an interval in which C must lie. In both cases, however, a link exists between the WTP distribution and the response probability distribution (Carson and Hanemann, 2005).

6.12 Empirical Review

Since the pioneer work of Houthakker (1951), vast literature on modelling the residential demand for electricity and examining its determinants has been published. Donatos and Mergos (1991); Burney (1995); Silk and Joutz (1997); Filippini (1999); Lariviere and Lafrance (1999); Christian and Michael (2000); García-Cerruti (2000); Miller (2002); Lin (2003); Holtedahl and Joutz (2004), Hondroyiannis (2004); Narayan et al. (2007); Mohammadi (2009) and Alberini and Filippini (2011) are some of the studies. Most of these works have estimated both the short-run and the long-run residential demand for electricity using aggregate data and applying different methodologies.

Also, prior to Davis' work in the early 1960s, only the Ciracy-Wantrup (1952) and Audience Research study for the National Park Service (1958) had been documented as literature on CV. The growth in CV studies from then increased steadily to about 450 by 1994. By the end of 2000, CV studies in the literature had risen to the range of 400 to 450 papers per year. Geographically, CV studies had been conducted in twenty-nine out of thirty OECD member countries. CV studies had also been conducted in 80 developing countries (Carson and Hanemann, 2005). Work on contingent valuation now typically comprises the largest single group of papers at major environmental economics conferences and in several of the leading journals in the field. Carson (in press) provides a bibliography spanning fifty years with over six thousand CV papers and studies from over one hundred countries.

CV research on household electricity are also gaining grounds in the literature, even though most of these studies have been conducted in developed economies. Thus most of the theoretical and empirical issues in literature would need to be investigated for developing countries particularly due to the differences in levels of development, sophistication and above all social and cultural characteristics. Some recent studies in developing countries which have relevance for household electricity are reviewed briefly.

Agostini et al. (2014) studied the demand for residential electricity in Chile using data from the National Survey of Socioeconomic Characterization (CASEN, 2006), being innovative over previous studies by using disaggregated data per household as previous studies had used aggregated data (Benavente et al. (2005) and Marshall (2010)). Their results were consistent with some previous studies, showing a price elasticity between -0.38 and -0.40 for residential consumption of electricity.

Fullerton et al. (2015) analyzed residential electricity demand in Arkansas. The analysis was carried out within a dynamic framework that employs a long-run co-integrating equation and a short-run error correction equation. Explanatory variables utilized include real median household income, a statewide average real residential electricity price, and a statewide real residential natural gas price. The estimated equations indicated that changes in median household income positively impact electricity demand. Over the long-run, as consumers buy new appliances, entertainment equipment, and larger houses, increased lighting, heating, and cooling requirements are likely to occur. Thus, rising incomes will likely exert pressure to increase electricity generation capacity in some areas of Arkansas.

The empirical analysis of residential demand for electricity of Blazquez et al. (2012) was conducted in Spain. For this purpose, a dynamic partial adjustment model was estimated. Aggregated data for the period 2000-2008 and 47 Spanish provinces were used in the estimation. The paper used aggregate data in two ways. First, by analyzing the impact of weather on electricity demand, using different climate variables for it. Secondly, by providing Spanish policy makers with new values on the price and income elasticities. The empirical results show relatively low short and long run price and income elasticities. Therefore, an increase in electricity prices will have a modest impact on the residential electricity demand. It is then clear that in order to limit the growth rate of electricity consumption, policy makers should introduce higher energy efficiency standards for electrical appliances.

Lee et al. (2016) used the CV method in an experimental study to derive a demand curve for rural electrification in Kenya. Respondents were first asked whether they would accept a randomly assigned, hypothetical price—ranging from $0 to $853—for a grid connection. The study showed that rural electrification may reduce welfare in Kenya.

Berry et al. (2015) demonstrated the use of the Becker-DeGroot-Marschak mechanism alongside the take-it-or-leave-it elicitation procedure to study the willingness-to-pay for and impacts of household water filters in 15 villages in rural northern Ghana. Though a study on water, the methodological issues were closely associated with those of this study, which also conducted a CV study in Northern Ghana as one of the sampled zones.

Academic research on the total economic value of electricity is not common, particularly for developing countries and most especially Ghana. Most of the few CV studies available limited themselves to assessing the willingness to pay for improvements in the provision of electricity, which was typically analyzed not with the ultimate aim of obtaining the total economic value of electricity, thereby missing the essential elements required to obtain total economic value. Typical among these are the works of Taale and Kyeremeh (2015), Twerefou (2014), Quartey (2011) and Amoah (2016).

Taale and Kyeremeh (2015) carried out a CV study with the Tobit regression technique to investigate the factors influencing households' willingness to pay for improved electricity services in Ghana.

Twerefou (2014) assessed households' willingness to pay for improved electricity supply as well as the factors that influence willingness to pay through a contingent valuation survey in Ghana.

Quartey (2011) assessed the demand for energy and economic welfare in Ghana using the CV methodology. The assessment showed the extent to which the 2007 power crisis in Ghana affected the welfare of households.

In his thesis, Amoah (2016) undertakes a cost & benefit analysis of electricity in a developing country (Ghana). He estimates and tests the reliability of WTP estimates by discussing the WTP and WTA divergence/convergence test using both parametric and non-parametric approaches. The thesis contributes to an assessment of the welfare impact of electricity outages and provides an estimate of the household willingness to pay (WTP) for a 24hour service of electricity supply in the Greater Accra Region of Ghana.

While none of these studies aimed at total economic value, their sample sizes were much smaller than that of this study. Again, each of these earlier studies used an analytical estimation for WTP which practically is not able to capture the bloc pricing of electricity as discussed in the theoretical literature. While this study uses the largest, most comprehensive and inclusive sample so far available in the literature on Ghana, it also goes beyond the computation of willingness to pay to estimate total economic value and makes provision for the derivation of a theoretically plausible demand for electricity function which has been overlooked by most studies on the subject matter. Underestimating the effect of theoretically non-plausible demand for electricity functions for developing countries, which typically have large annual changes in electricity demand, can be a major source of destabilization in the electricity sector. Such effects may however not be felt in developed economies due to the marginal changes in demand for electricity in these economies.

6.13 Methodological review of CV

Value estimates for non-marketed goods can be obtained by either estimating preference parameters as "revealed" through behavior related to some aspect of the goods or using "stated" information concerning preferences for the goods. In the environmental economics literature the stated preference approach, known as "contingent valuation," presents "valuation" of the good from preference information. The respondent's value of the non-marketed good is "contingent" on the details of the "constructed market" for the good offered through the survey.

For goods that exist in the market, a person's WTP is directly revealed through their purchase decision. However, several categories of goods and services are not traded in the market, such as public goods and utility service attributes. Stated preference approaches, such as contingent valuation surveys, are the main mechanisms through which valuations for these non-market goods can be revealed. In contrast to observed purchase decisions, stated preference approaches reveal only behavioural intentions rather than actual behavior (Akcura, 2013).

Stated preference techniques are used extensively in the valuation of utility attributes because there is no market mechanism through which a consumer can reveal their preference for an improvement in utility services. Instead, utility companies, as well as policy-makers, rely on stated preference surveys to elicit a valuation from the respondent for a proposed change in service levels (Akcura, 2013).

CV surveys differ from other surveys on public policy issues in many ways. One difference is that a major portion of the survey is devoted to a description of the non-marketed good of interest. Also, the elicitation of preference for the good is more extensive and nuanced than in a typical opinion survey. Moreover, it involves the elicitation of monetary (Hicksian) measure of welfare: maximum willingness-to-pay (WTP) to obtain a desired good not currently possessed.

Even though economists have largely focused on market prices as the indicator of economic value, earlier writers such as Clark (1915) and Hines (1951) clearly saw that much of an individual's utility was driven by unpaid costs and uncollected benefits and that "market prices" did not exist for many of the more interesting quantities to economists(Carson and Hanemann, 2005).

Following the Exxon oil spill, the U.S. National Oceanic and Atmospheric Administration (NOAA) convened a Blue Ribbon Panel co-chaired by two Nobel Prize winners (Arrow et al. (1993)) to consider whether passive use values should be included in natural resource damage assessment and whether they could reliably be measured by contingent valuation. After extensive hearings and detailed review of a large volume of evidence, the Panel concluded that passive use values should be included in natural resource damage assessment and that "CV studies can produce estimates reliable enough to be the starting point for a judicial or administrative determination of natural resource damages-including lost passive-use value." The report was followed by a set of guidelines for carrying out reliable CV studies.

6.14 Application of CV in developing countries

The NOAA panel report legitimized the use of contingent valuation for estimating passive-use (non-consumptive use) and use values, and also set some guidelines that reliable studies should follow. The cost of completing an "acceptable" contingent valuation study could well be so high that they will only be useful for large incidents, those for which the damages are high enough to justify their use. Yet, due to the paucity of other techniques, the failure to use contingent valuation may, by default, result in passive-use values of zero, which is not a very appealing alternative (Tietenberg and Lewis, 2013).

Whittington (2002) examines the reasons why so many contingent valuation studies in developing countries are unhelpful. Poorly designed or rapidly implemented surveys could result in costly policy mistakes on topics that are very important in the developing world. The current push for cheaper, quicker studies is risky and researchers need to be very cautious (Tietenberg and Lewis, 2013). This caution means that every CV study would have to adhere strictly to the rules, particularly as specified by the NOAA report.

Eftec (2006) provide an overview of some general issues relating to the application of CV. In relation to application of CV in developing countries, Whittington (1992) suggests that the reasons contributing to the low quality of many CV studies in developing countries include: poor administration and execution of studies; poorly crafted scenarios; and the lack of testing of the researcher's key assumptions about the way local people think about the non-marketed good in question. In a later critique, Whittington (1998) highlights some identified key lessons, which include: Enumerator training, Language issues, Misleading responses to questions, Setting referendum prices and Administration issues.

Other methodological issues include the fact that some countries have no monetary economy, or are in transition towards one. This causes problems since respondents may have less understanding / experience of the relative monetary value of goods and services, and thus will have difficulties in expressing WTP values for non-marketed goods. A number of researchers have attempted to overcome this issue by asking respondents to express their preferences in other terms. For example, Shyamsundar and Kramer (1996) asked respondents how many bowls of rice they would be prepared to accept as compensation for the loss of access to forest lands annexed to a national park in Madagascar.

The majority of CV surveys conducted in developing countries have used a dichotomous choice WTP elicitation format, with one or more follow-up questions (in some cases, with an added final open-ended question). Whittington *et al.* (1990) argue that this "bidding game" approach is well understood and accepted by respondents in developing countries, who, unlike the counterparts in the United States or Western European countries, are used to negotiating over the price of items they purchase on a regular market. These conclusions clearly differ from the NOAA panel's recommendations that suggest a 'referendum' elicitation format.

This point was probably missed by the NOAA panel because they did not consider issues specifically relating to developing countries. This truth about the appropriateness of the "bidding game" in developing countries would complement the NOAA guidelines in cases involving valuation in developing countries. This study also used the bidding game for the very reason given by Whittington (1990).

Hadker *et al.* (1997) suggest that protest zero responses relating to government provision of environmental goods may be a significant problem in developing countries.

Whittington *et al*. (1992) and Cook et al. (2011) have explored the influence of incorporating 'time to think' into contingent valuation surveys. They used split-sample experiments, in which one sample was given a 'standard' CV protocol, while the second allowed respondents 'time to think' about their values, i.e. they were asked to go home, discuss matters with family members and neighbours before answering the WTP question. The results indicated that those respondents who had had 'time to think' reported systematically lower WTP amounts. The researchers ruled out strategic considerations as the reason for these findings, and concluded that giving respondents 'time to think' resulted in WTP bids of superior quality.

What is considered superior here might be subject to the researchers' ultimate goal. Non income earners' influence on bids will definitely send them down, since they are not in a good position to exercise effective demand for the good in question. Urama and Hodge (2006) conclusions that participatory education significantly improved respondent's perception of the problem and the precision of their WTP could mean that respondents did not have the requisite information about the good and should probably not have been asked to value the good.

Given the above observations, it would appear that many of the methodological issues associated with applying CV in developing countries stem from the assumption that people in developing countries think in the same way as western researchers. Clearly this is not the case, so finding ways that more appropriately consider the context in which these methods are used is important. The use of local researchers and enumerators is therefore considered fundamental to ensuring that local nuances are taken into account.

Whittington (1998) argues that it can be easier to administer high quality contingent valuation surveys in some developing countries than in developed countries. He suggests that response rates are typically very high in developing countries, and respondents are often quite receptive to listening and considering the questions posed. He also argues that interviewers are relatively inexpensive, and that this allows the CV researchers to use larger sample sizes and conduct more elaborate split-sample experiments. However, CV studies require analysts and enumerators that are fairly well-endowed with appropriate skills and experience. Therefore considerable effort needs to be undertaken to train local researchers.

In terms of administering CV studies, most studies in developing countries have relied on in-person interviews conducted by local enumerators, who usually need training by an international team (Alberini & Cooper, 2000). There are practical reasons for the use of in-person interview: the literacy levels in some developing countries are often too low to permit mail or self-administered surveys; telephones are often not available (especially in rural areas), and local enumerators are relatively cheap to hire.

The absence of recent / reliable official population statistics in some developing countries can cause problems for developing a rigorous sampling frame (Hadker *et al.*, 1997). Further, this causes problems for comparing the respondents in the sample with those of the population of the area from which the sample was drawn (Whittington, 1998).

CVM is considered to be capable of providing useful and meaningful results for policy. In particular, CVM can assess both use and non-use values and therefore provides a full assessment of the total economic value of electricity. Most other approaches are incapable of assessing non-use values and will therefore underestimate total economic value (Nijkamp *et al.*, 2006).

7. METHODOLOGY

7.1 The Research Design

The main source of data for this study was a survey conducted in sampled communities from the three main geographic zones of Ghana. The fieldwork for the study was made up of the design and implementation of a nationwide household survey with the main aim of estimating the total economic value of electricity in Ghana. To achieve the above-stated objective, a participatory approach that involves interactions with household heads was adopted. This entailed the use of quantitative methods to generate and analyze data.

To begin with, a draft household survey questionnaire was developed by the principal investigators. With a clear knowledge of the electricity issues already in the public domain, as well as events that had unfolded in Ghana due to severe electricity crisis, the investigators carefully crafted the questionnaire to avoid all irrational emotions that could lead to undesirable responses. A pretest of the questionnaire was carried out to ascertain whether respondents would understand the questions and provide the expected responses. This helped to modify aspects of the questionnaire which respondents were not clear with. A pilot survey was then conducted during the training sessions of the research assistants and interviewers at Ejisu, a district of the Ashanti Region in Ghana. Results from the pilot survey showed that the questionnaires were set to elicit accurate responses from respondents. The pilot also served as a practical session for the research assistants and interviewers.

The final version of the questionnaire used for the survey is presented in Appendix A. The questionnaire was made up of four parts. The first part captured demographic characteristics of the household and the household head as well as some socioeconomic characteristics. The second part concerned the characteristics of electricity supply to the household and their assessment of its reliability, as well as the bill paid monthly and how much they spent to provide alternative lighting to the household each time the power went off. The third part was on the household valuation of electricity through the willingness to pay question. This part first of all presented the market description, after which the willingness to pay bidding game was carried out. The fourth part covers the type of value of electricity for which the respondent had expressed willingness to pay as well as electricity conservation issues.

Eight interviewers administered questionnaire in each of the zones over a total period of two weeks for each zone. The research assistants and interviewers were teaching assistants from the Department of Economics of the Kwame Nkrumah University of Science and Technology, Kumasi, Ghana. These were selected based on their high level experience in data collection for their undergraduate projects as well as a good understanding of the survey methodology that the research entailed. The group was taken through a four day training session receiving instruction on CV data collection culminating in their going out for a trial session in a pilot survey. Each participant was assessed and found to be excellent for the task. The data collection commenced in October, 2016 and ended in June 2017.

Environmental Economic methodology describes six phases in the practical application of the CV study, which estimates the monetary value of the change in welfare resulting from the change in allocation of electricity. These are the market description, elicitation, calculation, estimation, aggregation and validation phases.

7.2 Market Description

A hypothetical market was set up for the provision of a 24-hour supply of easily and quickly accessible electricity to communities in suburbs of Ghana that either had electricity power outages or limited access to electricity in the description phase of the research. The hypothetical market explained the services that could be made available and at what price.

The payment mechanism, modalities of delivering the service, its quality and reliability were also discussed with respondents to make the market scenario complete. These were presented in the elicitation scenario. The survey used questionnaire that started by describing the problem and the change envisioned - the provision of a 24-hour supply of electricity to consumers' homes through the national grid by private operators. Payment for the commodity would be made through a pre-paid meter principle or arrangement.

The iterative bidding game technique was used to elicit responses from respondents. The question asked for the iterative bidding game was, "suppose you are supplied with a 24-hour daily service of electricity in your home each time you need it, how much would you be willing to pay for one day's worth of it?" If the respondent's answer was yes to the bid of 2 Ghana cedis per day, then the question was repeated with a higher bid of 2.50, if the answer was no, the question was repeated with a lower bid of 1.50. This continued until the respondent's maximum WTP was reached.

7.3 Sample Selection

The country was first divided into three zones, the Northern Zone, the Middle Zone and the Southern Zone. Regions from each zone were selected based on probability sampling. The selected Northern Zone consists of the Upper West Region and the Northern Region, the Middle Zone consists of the Ashanti Region while the Southern Zone consists of the Greater Accra Region.

The study sampled districts from the zones using official lists of districts in each region. The sampling was done using the sample function in R (Becker et al., 1988). A list of all districts within the selected regions was collated from the 2010 Population Census data and the Ghana Living Standards Survey (Round 6) Report from the Ghana Statistical Service. From this list a sample of districts was randomly selected without replacement, proportional to the zonal population of the zones using the sample function. For each sampled district, the names of the top 20 most populated communities were obtained from the Ghana Statistical Service 2010 Census data. Using the most populated communities, one community was randomly sampled using the "sample function in R". However from the Kumasi Metropolitan Area, the number of communities sampled were more than one given the massive populations and concentration of several sub-metropolitan areas which in reality were "districts" in their own rights. This principle was also used in Accra and Tamale.

7.4 Sample Size

The choice of sample size in a Contingent Valuation survey determines the precision of the sample statistics used as estimates of population parameters such as mean WTP. In general, the larger the sample the smaller the variation in mean WTP as measured by the standard error, and described in confidence intervals (Garrod and Willis, 2000).

Mitchell and Carson (1989) devised a system to determine an appropriate sample size for Open Ended Contingent Valuation questions which relies on the researcher's choice of an acceptable deviation between "true" WTP, either 90% or 95% of the time. The smaller the value of X, the larger the sample size required to achieve it. Mitchell and Carson state that for most applications an initial estimate of overall precision given by a coefficient of determination of 2 is advisable. For this level of precision a sample of over 6000 would be required to ensure that estimated WTP deviated from "true" WTP by within 5 percent 95 percent of the time.

Alternatively, if it was acceptable that estimated WTP could deviate up to 20% of "true" WTP 90% of the time, then a usable sample of only 286 is required. Mitchell and Carson argue that, for applications which seek to evaluate policy, the sample size should be at least 600. This study, being policy oriented follows this accepted recommendation and makes some room for non-response by using a sample size of 3100 households. At the given level of accuracy this would ensure an estimate of WTP within 10% of the "true" WTP 95% of the time.

Table 4 presents the sampled districts and the various communities. The table also presents the sample sizes from each community as well as the percentage each community carries.

Table 4: Sample Distribution

Regions	Districts	Community	Sample Size	Percentage Of Sample
Middle Zone	Adansi North	Aboabo	45	1.45
	Kwabre East	Adwumam	46	1.48
	Kumasi Metropolitan	Ahinsan	157	5.06
	Kumasi Metropolitan	Alaba	23	0.74
	Kumasi Metropolitan	Atonsu	90	2.90
	Kumasi Metropolitan	Ayigya	22	0.71
	Kumasi Metropolitan	Bantama	80	2.58
	Kumasi Metropolitan	Kwadaso	131	4.23
	Kumasi Metropolitan	Old Tafo	33	1.06
	Kumasi Metropolitan	Ashtown	101	3.26
	Adansi Northdistrict	Anhwiaso	35	1.13
	Asokore Mampong	Asawasi	29	0.94
	Offinso North	Asempaneye	41	1.32
	Sekyere East	Asokore	69	2.23
	Adansi South	Ataase	25	0.81
	Afigya Kwabre	Buoho	27	0.87
	Atwima Kwanwoma	Foase	41	1.32
	Atwima Nwabiagya	Maakro	103	3.32
	Obuasi Municipal	Odumase	37	1.19
	Offinso South Municipal	Offinso	95	3.06
	Bekwai Municipal	Senfi	29	0.94
Southern Zone	Accra Metropolitan	Abossey Okai	158	5.10
	Accra Metropolitan	Achimota	274	8.84
	Ga Central	Anyaa	161	5.19
	Adenta Municipal	Ashiyie	22	0.71
	Adenta Municipal	Frafraha	18	0.58
	Accra Metropolitan	Kokomlemle	192	6.19
	Tema Metropolitan	Tema Com.	23	0.74
	Lekma	Teshie Nu	20	0.65
Northern Zone	Nanumba South	Baduli	30	0.97
	Karaga	Bagli	12	0.39
	Tamale Metropolitan	Bomahigu	31	1.00
	Tamale Metropolitan	Gumbihini	39	1.26
	East Mamprusi	Jawani	24	0.77
	Tamale Metropolitan	Lamashegu	194	6.26
	Wa Municipal	Limanyili	41	1.32
	Kpandai	Loloto	21	0.68
	Tamale Metropolitan	Nachimbaya	30	0.97
	Tolon	Nayilifon	40	1.29
	Tamale Metropolitan	Tishigu	174	5.61

	Tamale Metropolitan	Zogbeli	117	3.77
	Wa West	Bamahu	22	0.71
	Wa East	Bulenga	15	0.48
	Wa Municipal	Dawko	20	0.65
	Wa Municipal	Doreamon	16	0.52
	Tatale Sangule	Jayondo	8	0.26
	Yendi Municipal	Maabambol	11	0.35
	Nadawli-Funisi	Mangu	25	0.81
	Nadowli	Nadowli	26	0.84
	Bole	Nyoli	11	0.35
	Wa Municipal	Wa	66	2.13

Figure 4 shows the locations of many of the communities sampled and the transmission gridlines of GRIDCO.

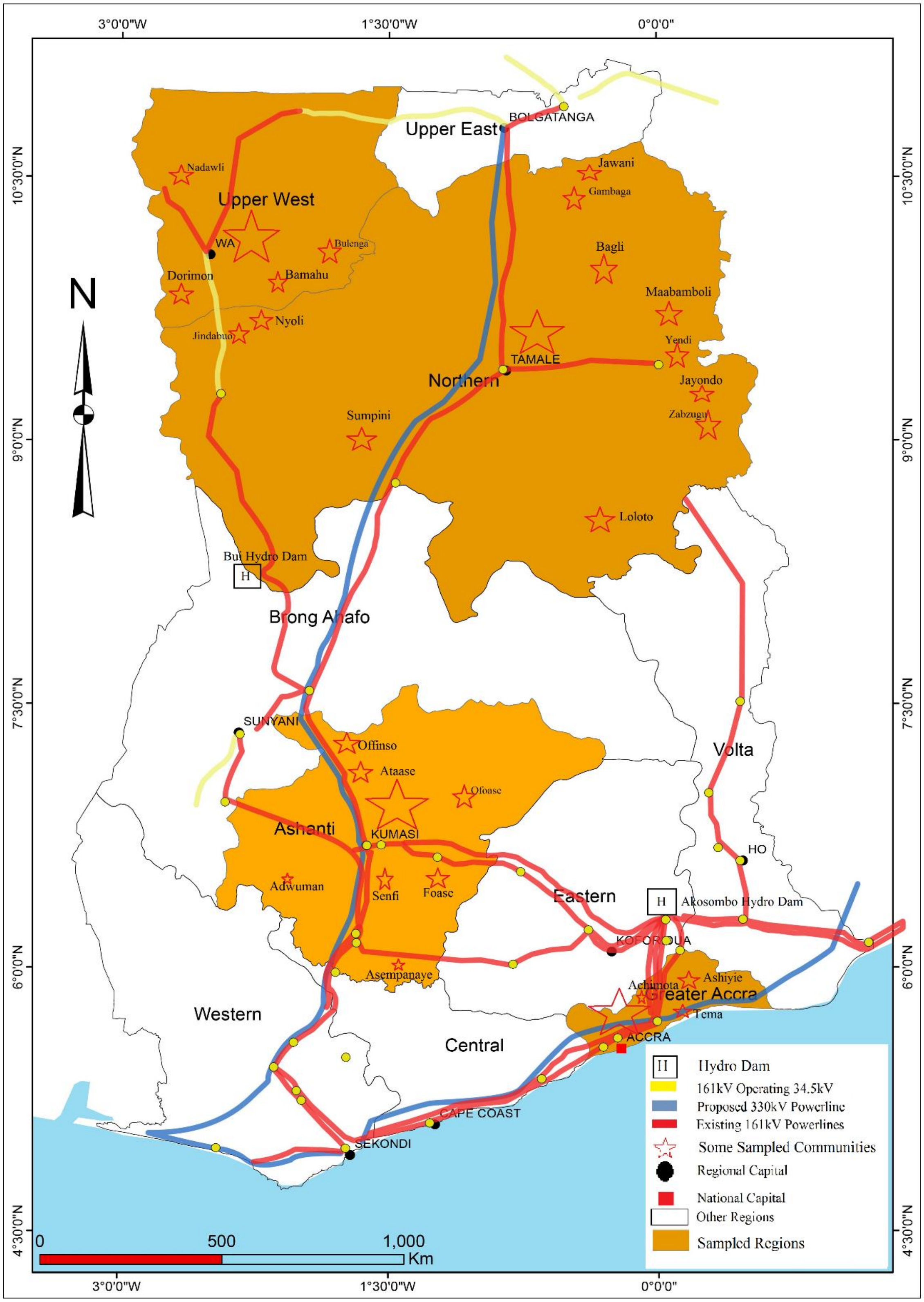

Figure 4 Map of Ghana showing sampled regions, some sampled communities and main transmission lines

7.5 The Estimation Models

To ensure theoretical plausibility for the derived demand for electricity function, the study purposefully avoided an analytical derivation of the demand for electricity. Instead, it used a derivation from first principles where the marginal willingness to pay was determined by computing the total maximum cumulative values demanded at various WTP bids. Here, all WTP tariffs were taken into account from the various block tariffs from which electricity consumers' tariffs are billed by their respective utility companies. The upper boundary of the cumulative values plotted against the WTP bids becomes the marginal WTP curve, while the area under this curve is the maximum WTP for electricity over the specified period of time.

The determinants of the demand for electricity were however determined through the normal econometric procedure using the model below:

$$\begin{aligned} WTP_i = {} & \beta_0 + \beta_1 Gender_i + \beta_2 Age_i + \beta_3 Dep_{Sc}hool_i + \beta_4 Income_i + \beta_5 Income_{SQ_i} \\ & + \beta_6 Availability_i + \beta_7 Affordability_i + \beta_8 CPO_i \\ & + \beta_9 Service\_Ratings_i + \beta_{10} Education_i + \beta_{11} Usage_i \\ & + \beta_{12} Lighting_{Need_i} + \beta_{13} Commercial_i + \beta_{14} Consumption_i \\ & + \beta_{15} Consumption\_SQ_i + \beta_{16} RFEC_i + \beta_{17} Value\_Type_i + \mu_i \end{aligned}$$

The selected variables were based on economic theory, previous studies, as well as knowledge of factors which stakeholders in the electricity sector of Ghana were practically confronted with while making decisions on electricity allocation. It has been reported, with varying degrees of consensus, in many studies globally, that willingness to pay for reliable electricity service depends on several factors including age, gender, education, family size and composition, house ownership, household income, value orientation, political party affiliation, monthly electricity bill, and access to information on power outages (Hobman and Frederiks, 2014; Shi, Zhou & Kristrom, 2013; Zoric & Hrovatin, 2012; Hansla, 2011; Kotchen & Moore, 2007; Rowlands, Scott & Parker, 2003; Zarnikau, 2003; Bergstrom, Stoll & Randall, 1989). The next section defines the variables in the estimation model for the determinants of reliable electricity demand in Ghana, used by this study.

7.6 Variable definition

Gender was a dummy variable coded 1 if respondent was male and 0 if female. In the questionnaire, respondents were asked to select between the two options of male and female. The variable gender is expected to have a positive effect on willingness to pay. This is because males in Ghana were better resourced than females and as a result, they were expected to be willing to pay higher rates than females.

Age measures respondents' ages in years. The study targeted household heads, thus respondents below the age of 18 deemed to be minors, were excluded from answering the questionnaire. Only those 18 years and above answered the questionnaire. The variable Age in the regression results was expected to influence willingness to pay positively. This is because, it was expected that older people would have had enough knowledge about the usefulness of electricity and also acquired more money and so would be willing to pay more than younger people at least up to the end of their working age.

Dependents in School: The number of dependents of the household heads in school was one of the independent variables. Respondents were asked to state the number of dependents they had who were still in school. This was count data as it ranged from zero to early twenties. The number of dependents in school was expected to negatively influence willingness (WTP) to pay for electricity. This is because more dependents in school means higher opportunity cost of spending too much on electricity. Those who spend more on educating their dependents could generally have less available for spending on electricity.

Income: Income refers to the monthly income of a household head. It was measured in Ghana cedis. Respondents were asked to indicate how much they earned as income on average a month. This value represents a households economic capability and it was expected to have a positive influence on household willingness to pay (WTP) for electricity. For respondents who did not earn monthly income due to their occupations, incomes were elicited in kind and later converted to money income at the market value of the products offered as payment.

Consumption: This measures household monthly consumption of electricity measured in kilowatt hours (kWh). This was computed from tariff data from the Electricity Company of Ghana (ECG). The tariff paid by a respondent at the end of the month is dependent on their kWh consumption of electricity. Using expenditure on electricity per month, one could compute the kWh of electricity consumed based on the ECG consumption and bills chart of 2016. For example, a household with monthly EUT of 17.66 Ghana cedis must have consumed about 50 kWh of electricity. Consumption was expected to positively influence willingness to pay. This is because households that consume more kilowatt hours of electricity per period should be willing to pay more than households that consumer less kilowatt hours of electricity over the same period.

Affordability: Affordability refers to a dummy variable that was coded 1 if the respondent thought the amount they pay each month for electricity was affordable and 0 if otherwise. Affordability was expected to have a positive influence on household willingness to pay. This is because those who find their monthly electricity consumption expenditure affordable should be economically well endowed compared to those who find it not affordable. As a result, those who find it affordable should be willing to pay more than those who find it not affordable.

Cost of Power Outage (CPO): CPO represents the amount households spend on lighting when there was power outage. Without electricity, how much do households spend to provide lighting? They were asked to indicate the amount in Ghana cedis, which they spent each day when there was power outage. CPO was expected to positively influence WTP.

Those who spend high amounts to provide lighting when there is power outage should be willing to pay more for electricity especially if the higher prices would come with supply reliability.

Service Rating: Respondents were asked to rate the performance of their primary electricity distributor (ECG for those in the Southern and Middle zones and NEDCO for those in the Northern zone) on a scale of 1 to 5. The expected sign of this variable is positive. This is because a highly rated service was expected to attract satisfaction and hence higher payment from consumers.

Education measures the highest number of years of schooling that respondents have had. For example, someone who's highest level of education is primary school had six (6) years of schooling, a Junior High School graduate would have had nine (9) years of school, a Senior High School graduate would have had 12 years of schooling. The variable Education was expected to positively influence WTP. This was because other things being equal, a highly educated household head should be able to afford to pay more than less educated household heads.

Usage: Usage is a variable created to serve as a measure of the extent of respondents' use of electricity. A number of household appliances were listed and households were asked to tick as many as they used in their houses. Usage is a count of how many appliances that a particular household uses. Usage was expected have a positive association with WTP. This is because a household that uses many appliances should be willing to pay more for electricity than a household that has fewer appliances.

Lighting Needs: Households were asked to indicate how many light bulbs they used in their household. They were also asked about the average wattage of these bulbs. The interviewers calculated the average wattage of the bulbs on site by inspecting the bulbs. The product of the number of bulbs and the average wattage indicates how much electricity was required by the household for lighting. It was expected to have a positive association with household WTP.

Commercial: Commercial is a dummy variable that was coded 1 if the respondents used electricity at home for any commercial purpose and 0 otherwise. This variable is expected to positively correlate with household WTP. This is because households that have commercial usage of electricity at home have benefits beyond households that do not use electricity at home for commercial purposes. Therefore using electricity commercially at home should be willing to pay more than those who do not do so.

Availability: Availability shows the extent to which consumers could be assured of electricity supply in a day. Respondents were asked to indicate how available electric power has been in their area by taking into account the number of hours of electricity they had enjoyed each day. Power availability is expected to associate positively with household WTP for electricity. This is because reliable electricity supply confers many advantages, which households should be willing to pay to for.

Willingness to Pay (WTP): Willingness to Pay is the dependent variable in the regression model. It was measured using the bidding game method. It indicates the amount households were willing to pay for a 24 hour supply of reliable electricity. It was measured in Ghana cedis.

Reason for practicing energy conservation (RFEC): Reason for practicing energy conservation was a dummy variable that was coded 1 if the reason respondent cited for conserving electricity was toward cost reduction and 0 otherwise. In the questionnaire, respondents were asked to cite the reasons why they conserve electricity using an open ended question. Their responses were then classified into groups and then coded into a dummy variable. If the reason cited was related to electric bill reduction, RFEC was coded 1 but if the reason cited was not related to cost reduction, RFEC was coded 0.

Value Type (VT): Respondents were asked to cite the reasons why they had valued electricity through their WTP bids. Four reasons were provided, two were related to the use value of electricity and the other two related to non-use values of electricity. If a respondent rated the use values higher than the non-use value reason, the dummy variable (VT) was coded 1 and if the non-use value reasons were rated higher than the use value reasons, VT was coded 0. The coefficient of this variable was expected to have a positive sign to indicate that, households that valued the direct benefit of electricity more should be willing to pay more than households that valued the non-use values of electricity more.

7.7 Data Collection Procedure

Following the initial exchange of greetings as tradition demands, and identification of a household head who was willing to respond to the questionnaire, the participant information leaflet was read and explained to the prospective respondent. This was followed by asking for the consent of the prospective respondent to participate in the survey. Thereafter, they were asked to fill and sign or thumbprint the relevant portions of the consent letter (in the presence of a witness where the respondent was non-literate in English) to signify consent on the part of the prospective respondent. A copy of the signed consent letter was then given to the prospective respondent prior to administering the questionnaire.

The questionnaire was administered face-to-face by the trained interviewers. Communities were inspected and apportioned using noticeable landmarks based on the number of interviewers. Each interviewer interviewed households within their allocated sections. The interviewers visited the first house in their allocated area, afterwards they visited every fourth house. The study targeted household heads as the primary respondents to the questionnaire. As a result, the first thing the interviewers did after greeting and introducing themselves was enquiring who the household head was. In cases where there was no one at home or the heads declined to participate in the study, the interviewer moved to the next house in line.

As part of the initial training, interviewers translated the questionnaire into the various local languages of the sampled areas. In the Northern Region, Dagbani, Hausa and English were used while in the Ashanti Region, Twi and English were used. In the Greater Accra Region, English, Twi and Ga were used while in the Upper West Region Waale, Dagaari and English were used. The interviewers translated the questions on the questionnaire in the order in which they appeared on the questionnaire, in the languages used through discussions during the training session for the most appropriate translations to ensure consistency in questions posed. The interviewers were chosen purposefully because of their ability to speak the languages common in the sampled regions. The administration of questionnaire lasted about 30 minutes in each case. In a day, an interviewer administered on average 20 questionnaires.

7.8 Ensuring Reliability of CV Procedure

The study was conducted with the strictest adherence to the NOAA guidelines in addition to some more current suggested procedures in literature, particularly suitable to ensure reliability in developing country CV studies. The steps outlined in Table 5 were specifically followed as prescribed in the NOAA guidelines.

Table 5 Reliability Checks for NOAA guidelines for survey

Survey Guidelines		Status
I.	General	
a.	Sample Size and Type	Satisfied
b.	Minimize Non-Response	Satisfied
c.	Personal Interview	Satisfied
d.	Pretesting for interviewer Effects	Satisfied
e.	Reporting	Satisfied
f.	Careful Pretesting of CV Questionnaire	Satisfied
II.	Value Elicitation Survey	
a.	Conservative Design	Satisfied
b.	Elicitation Format	Modified
c.	Accurate Description of market scenario	Satisfied
d.	Pretesting of Photographs	Not Applicable
e.	Reminder of Undamaged Substitutes Commodities	Not Applicable
f.	Adequate Time Lapse from Electricity Crisis	Satisfied
g.	Temporal Averaging	Satisfied
h.	No Answer Option (Would-not-pay)	Satisfied
i.	Yes/No Follow-ups	Satisfied
j.	Cross Tabulations	Satisfied
k.	Checks on Understanding and Acceptance	Satisfied

The source for the guidelines: NOAA Panel report; Arrow et al (1993).

7.9 Data Processing

Collected data was cross checked to reject answered questionnaire which had responses which were outliers, showed inconsistencies or not fully answered; these were just 1.8 percent of the number of questionnaire administered. These were identified using scatter plots and boxplots. The next step was to correct for missing values. The percentage of observations that had a maximum of 2 missing values was 4.3 percent. After these were done, the number of observations remaining was 3100. To impute missing values, the study used the missForest function from the missForest package in R.

MissForest is a nonparametric imputation method for basically any kind of data. It uses a random forest trained on the observed values of a data matrix to predict the missing values. It can be used to impute continuous and/or categorical data including complex interactions and non-linear relations. The method is based on the publication Stekhoven and Bühlmann (2012). The algorithm is based on random forest (Breiman [2001]) and is dependent on its R implementation randomForest by Andy Liaw and Matthew Wiener.

8. ANALYSIS

The information obtained from the CV survey was analysed in three ways: (a) by examining the frequency distribution of responses to the WTP questions; (b) by looking at cross-tabulations between WTP responses and socio-economic characteristics of the respondents; and (c) using multivariate statistical techniques to estimate a function that relates the respondent’s answers to their socioeconomic characteristics. Table 6 provides a descriptive summary of the continuous variables.

Table 6 Descriptive summary of selected continuous variables

VARIABLE	Observations	Mean	Std. Dev.	Min	Max
AGE	3,100	39.08	11.92	17	90
DEP_SCHOOL	3100	2.31	1.89	0	22
INCOME	3100	662.66	605.91	10	6000
AVAILABILITY	3100	2.27	0.74	1	5
TARIFF	3100	73.24	69.96	5	800
CPO	3100	2.18	4.83	0	70
BULBS	3100	3.26	2.50	1	30
WATTAGE	3100	17.40	11.39	7	250
EDUCATION	3100	9.53	4.33	0	20
AV_CONSUMPTION	3100	58.25	66.16	7	1000

The purpose of all three types of analysis was to determine whether respondent’s answers were consistent with theory and common sense (this increases one’s confidence in the accuracy and reliability of the information gathered); and to establish statistical relationships or models that can be used to aggregate responses to the overall population under study.

Table 7: Descriptive summary of categorical variables

Variable	Category	Frequency	Percentage
Gender	Female	1,375	44.35
	Male	1,725	55.65
Affordability	No	2,326	75.03
	Yes	774	24.97

8.1 Frequency distribution of WTP responses

Respondents' answers to the WTP questions yield a data set of individual WTP 'point estimates'. Answers to yes/no questions (bidding games) place each respondent's WTP in an interval defined by the last value accepted and the last value rejected. This information can be used in two ways: (a) to predict the distribution of WTP responses in the total population, and (b) to predict the WTP for the good or service at a specified price. The frequency distributions are presented in Table 8 and Table 9.

Table 8 Frequency Distribution of WTP bids

Interval for WTP Bid	Ghana		Middle Zone		Southern Zone		Northern Zone	
	Data (Sample)	Frequency Distribution (%)	Data (Sample)	Frequency Distribution (%)	Data (Sample)	Frequency Distribution (%)	Data (Sample)	Frequency Distribution (%)
0-0.5	499	16.1	268	21.29	63	7.26	168	17.27
0.5-1	659	21.26	307	24.38	153	17.63	199	20.45
1-1.5	405	13.06	146	11.6	74	8.53	185	19.01
1.5-2	749	24.16	285	22.64	255	29.38	209	21.48
2-2.5	200	6.45	59	4.69	55	6.34	86	8.84
2.5-3	248	8	81	6.43	109	12.56	58	5.96
3-3.5	63	2.03	15	1.19	23	2.65	25	2.57
3.5-4	90	2.9	35	2.78	46	5.3	9	0.92
4-4.5	9	0.29	1	0.08	7	0.81	1	0.1
4.5-5	132	4.26	45	3.57	66	7.6	21	2.16
5-5.5	2	0.06	3	0.24	6	0.69	2	0.21
5.5-6	13	0.42	2	0.16	4	0.46	4	0.41
6.5-7	9	0.29	-	-	-	-	3	0.31
7.0-10	22	0.71	12	0.95	7	0.81	3	0.31
Total	**3,100**	**100**	**1,259**	**100**	**868**	**100**	**973**	**100**

From Table 8, the modal willingness to pay for a daily supply of 24-hour reliable electricity supply falls within the tariff range of 1.5 to 2 Ghana cedis. The southern zone and the northern zone of Ghana have modal WTP ranges equal to that of the country while the middle zone has a lower modal WTP range of 0.5 to 1 Ghana cedis.

Table 9: Frequency distribution of domestic use of electricity

Electricity Uses	Frequency	Percentage Frequency distribution
Light	3100	100
Television	2716	87.6
Fan	2543	82.0
Ironing	1868	60.3
Fridge	1764	56.9
Cooking	276	8.9
Ratio	164	5.3
Hair Dryer	65	2.1
Washing machine	61	2.0
Air Conditioner	55	1.8

From Table 9, all households used electricity for lighting purposes in their homes. The next highest use was for television viewing (87.6%) followed by use for powering fans (82%). The next most important uses were for ironing (60.3%) and for powering refrigerators (56.9%). The remaining uses had less than 10% of households using electricity for those purposes. These uses of electricity show that households used electricity mostly for highly domestic purposes.

8.2 Cross-tabulations of WTP responses with socioeconomic characteristics

Cross tabulations can be used to determine whether different groups of people in the sample gave different responses to the valuation question(s). This addresses the question of who is willing to pay the most (and the least) for the good or service, and why. For example, with WTP bids grouped based on the value of respondents' income, the expectation is for WTP to increase with income. When cross tabulation of WTP bids and socioeconomic or attitudinal information reveals the effects one would hypothesize based on demand theory and common sense, then the analyst has greater confidence in the quality of data and greater insights into the factors that may determine an individual's willingness to pay.

Table 10 Cross tabulation of WTP and Socioeconomic characteristics of households

Variables	Categories	Frequency (%)	Mean WTP
Age Group	Less than 25	6.94	1.779
	25 – 35	32.29	1.819
	35 – 45	34.13	1.989
	45 – 55	15.87	1.793
	55 – 65	6.52	1.636
	65 – 75	3.23	1.768
	75 – 90	1.03	1.278
Commercial	Non-commercial	87.09	1.838
	Commercial	12.1	1.935
Consumption Group	1 – 50	7.19	1.004

	50 – 150	67.81	1.655
	150 – 300	18.74	2.458
	300 – 600	5.71	2.961
	600 and above	0.55	4.549
Education Level	No Formal Education	11.29	1.514
	Primary Education	9.19	1.658
	Junior Secondary Education	28.90	1.660
	Secondary Level Education	32.55	1.948
	Tertiary (Diploma)	16.10	2.208
	Tertiary (University)	1.97	2.868
Gender	Female	44.35	1.739
	Male	55.65	1.937
Income Group	Less than 100	3.81	1.350
	100 – 500	39.58	1.577
	500 – 1000	9.48	1.956
	1000 – 1500	5.03	2.513
	1500 – 2000	1.61	2.987
	2000 – 2500	0.29	2.591
	2500 – 3000	1.10	3.232
	3000 – 4000	0.42	3.398
	4000 – 5000	38.42	2.571
	5000 – 6000	0.26	1.468
Reason	Avoid Wastage	2.77	1.814
	For Future Generations	3.52	1.893
	Prevent Fire Outbreak	9.58	1.519
	Protect Appliances	3.16	2.012
	Reduce Bill	76.52	1.854
	Saving Energy	4.45	2.341
Regions	Ashanti Region	40.61	1.681
	Greater Accra Region	28.00	2.287
	Northern Region	24.29	1.687
	Upper West Region	7.10	1.639
Service Ratings	Very Good	3.90	1.932
	Good	29.45	1.637
	Moderately Good	27.90	1.978
	Poor	22.61	1.915
	Very Poor	16.13	1.896
Value Type	Use Value	28.55	1.877
	Non-Use value	71.45	1.838
Water Bill Group	Less than 10	25.13	1.510
	10 – 50	57.00	1.839
	50 – 100	12.77	2.328
	100 – 200	3.580	2.381
	200 and Above	1.000	2.815
Saving Group	Less than 50	49.19	1.615
	50 – 100	19.06	1.760
	100 – 150	11.19	2.030
	150 and above	20.55	2.393

From the cross tabulation, WTP increases with income, savings and type of use electricity is put to, households which use electricity for commercial purposes were willing to pay higher tariffs than those who used it for only domestic purposes. Also, people with higher education were willing to pay more than those with lower levels of education. Households with higher levels of electricity consumption were also willing to pay more than those with lower levels of electricity consumption.

With respect to age, WTP increased with age up to 45 years and the declined after 45 years. Males were willing to pay higher than females, while households in the Greater Accra Region were willing to pay the highest, followed by those in the Northern Region, then the Ashanti Region, with those in the Upper-West Region willing to pay the least.

8.3 Multivariate analysis of the determinants of WTP responses

Multivariate analysis can provide better information and greater insight into the factors that affect WTP responses than simple cross tabulations. The general approach is to estimate a valuation function that relates the hypothesized determinants with the WTP responses. The decision on what determinants of WTP should be included in the valuation function is typically based on consumer demand theory. The results of such analysis can indicate that the WTP estimates are systematically related to the variables suggested by economic theory.

8.3.1 Regression Diagnostics Result

A number of post regression estimations were carried out to ascertain the ones which provided the best estimates. Table 11 presents the multicollinearity test.

Table 11 Multicollinearity Test

Variable	**VIF of Initial Model**		**VIF of Correctly Specified Model**	
	VIF	1/VIF	VIF	1/VIF
Consumption (kWh)	1.39	0.717974	7.43	0.134526
Consumption Squared (kWh2)			6.28	0.159299
Usage	1.34	0.747477	1.44	0.696634
Education	1.32	0.760399	1.33	0.752994
Income	1.25	0.797437	5.39	0.185471
Income Squared			4.71	0.212465
Lighting Needs	1.2	0.831517	1.21	0.828111
Service Rating	1.18	0.850749	1.18	0.850066
Age	1.16	0.864519	1.16	0.863254
Availabilty	1.14	0.875855	1.14	0.875801
Dep_School	1.14	0.878632	1.14	0.875789
CPO	1.13	0.884476	1.13	0.881317
Affordability	1.1	0.906309	1.14	0.878605
Gender	1.08	0.927605	1.08	0.927128
Commercial	1.02	0.979136	1.02	0.978774
RFEC	1.02	0.98338	1.02	0.981933
Value Type	1.02	0.984426	1.02	0.984305
Mean VIF	**1.17**		**2.28**	

Table 11 presents the Variance Inflation factor (VIF) of the independent variables in the initial model and the correctly specified model. The rule of thumb is that, a VIF of above 10 is a sign of serious collinearity problem. Multicollinearity is when the explanatory variables are highly correlated that, it becomes difficult to isolate the effect of one variable. It results in the inflation of the standard errors, which in turn make the coefficients insignificant. From the VIF results, this study has no problems with multicollinearity.

Heteroskedasticity Test

The study used the "imtest", which tests the null hypothesis that the variance of the residuals is homogenous. Therefore, if the p-value is very small, we would have to reject the null hypothesis and accept the alternative hypothesis that the variance is not homogenous. This is the case in this study. The null hypothesis is that the variance of the error terms were homogeneous – constant. This is required for the OLS estimates to be BLUE. Only after the rejection of the null can we say there is heteroskedasticity problem.

Table 12 presents the test for heteroskedasticity. Given the estimated chi-square statistic of 420.89 with its p-value of 0.0000, the null hypothesis is therefore rejected. This means the data had violated the homoskedasticity assumption. Also reported was the "hettest" for heterskedasticity result. The estimated chi-square statistic was 496.28 with a p-value of 0.000, which confirms the results of the "imtest". The two tests confirmed the problem of heteroskedasticity.

Table 12 Constant Variance Test Results

Tests	**Source**	**Chi-squared Statistic**	**Degrees of freedom**	**P-value**
IMTEST	Heteroskedasticity	420.89	165	0.0000
	Skewness	66.36	17	0.0000
	Kurtosis	22.05	1	0.0000
	Total	509.29	183	0.0000
HETTEST		**496.28**		**0.0000**

To correct for heteroskedasticity, the study used the robust standard error methods. The idea is that, heteroskedasticity affects the standard errors of the estimated, not the estimate themselves, as a result, the robust standard errors adjust the problematic standard errors to account for the non-constant variables. This was accomplished using the robust command in Stata after the regression. The final regression results therefore used the robust standard errors rather than the normal standard errors.

Specification Test

Another diagnostic test performed was the specification tests. A model specification error can occur when one or more relevant variables are omitted from the model or one or more irrelevant variables are included in the model. If relevant variables are omitted from the model, the common variance they share with included variables may be wrongly attributed to those variables, and the error term is inflated. On the other hand, if irrelevant variables are included in the model, the common variance they share with included variables may be wrongly attributed to them. Model specification errors can substantially affect the estimate of regression coefficients.

The first test used was the linktest in stata. The linktest command performs a model specification link test for single-equation models. linktest is based on the idea that if a regression is properly specified, one should not be able to find any additional independent variables that are significant except by chance. linktest creates two new variables, the variable of prediction, _hat, and the variable of squared prediction, _hatsq. The model is then refit using these two variables as predictors. _hat should be significant since it is the predicted value. On the other hand, _hatsq shouldn't, because if our model is specified correctly, the squared predictions should not have much explanatory power.

Table 13 presents the linktest results of the regression model. From the results, the coefficient of _hatsq of -0.0866571 was statistically significant and it leads to the rejection of the null hypothesis that the model is specified correctly. This means the model has a miss-specification problem. The study also used the ovtest command in Stata to test for specification bias in the model. The ovtest command performs another test of regression model specification. It performs a regression specification error test (RESET) for omitted variables. The idea behind ovtest is very similar to linktest. It also creates new variables based on the predictors and refits the model using those new variables to see if any of them would be significant. From the results, the estimated $F(3, 3082)$ was 7.54 and a p-value of 0.0001, which is less than 0.05. The null hypothesis of the ovtest is that, the model has no missing variable. A rejection of this hypothesis implies there is omission variable problem. Given that the p-value is less than 0.05, the null hypothesis has therefore been rejected confirming the results from the linktest. This is a specification error in the model.

Table 13 Model specification Test Results

		Initial Model		**Final Model**	
LINKTEST	WTP	Coefficient	P-value	Coefficient	P-value
	_hat	1.324353	0.0000	0.9132926	0.0000
	_hatsq	-0.0687677	0.0030	0.0199563	0.4620
	_cons	-0.3336175	0.0090	0.0825743	0.5180
OVTEST		**F-statistic**	**P-value**	**F-statistic**	**P-value**
		4.3	0.0049	0.5	0.6822

To correct for the specification error, the square of income and consumption were included in the regression model and the test performed again. Table 13 also presents the linktest result of the new regression model (Final Model). Both the linktest and ovtest results showed no specification problem since the p-values of the linktest and the ovtest were higher than 0.05. The null hypothesis of a correctly specified model could not be rejected. The resulting regression results are presented in Table 14-17 below. The tables present the final OLS regression results after correcting for heteroskedasticity and testing for specification bais.

8.3.2 Regression Results

Tables 14-16 present the results of multivariate models of WTP bids for electricity in Ghana. Each table includes the results for 2 different models. Results are presented for the three estimators namely; OLS, Interval Regression and Ordered Probit. For each of these estimators, two versions of model were reported: (1) one which uses the complete list of independent variables as potential determines of WTP and (2) one which uses a more restricted list of independent variables. This approach was used to show how sensitive the model results were to changes in model specification.

Overall, the multivariate results are remarkably robust. The results presented in Tables 14-16 show conclusively that the WTP information obtained from the Contingent Valuation survey for valuing electricity in Ghana is systematically related to the socioeconomic characteristics of the households and the respondents in ways suggested by the consumer demand theory and prior expectations. This is true regardless of the source of WTP information, the estimation used, or the exact model specification.

The OLS Estimation

Tables14 presents the final OLS regression results after heteroskedasticity and specification biases had been corrected. The estimated F-statistic was 44.71 with a p-value of $0.000 < 0.05$. The significance of the F-statistic indicates the overall significance as it shows that at least one of the independent variables had statistically significant influence on WTP. The coefficient of determination was 0.2505, which meant about 25.05 percent of the variations in WTP could be explained by the model. While it is generally true that much of the variation in the WTP bids cannot be explained by the model, the reported R^2 is quite high for cross sectional CV surveys and compare very favourably with results of CV studies conducted in many developed countries (Whittington, 1992). Mitchell and Carson (1989) suggest that a CV study which has an R^2 of less than 0.15 might be deemed unreliable. The study thus satisfies the Mitchell and Carson requirement for a reliable CV study.

Interval Regression Analysis

The interval regression required two dependent variables, the lower pounds of the intervals first and then the upper bounds of the interval. The study created the lower bounds by subtracting 0.5 from each respondent’s willingness to pay except in the cases where doing so would lead to a negative lower bound. In that case the value of zero was used as the lower bounds. On the other hand, the upper bounds of the interval were created by adding 0.5 Ghana cedis to the stated willingness to pay of each respondent. The interval was constructed such that, the difference between the lower and upper bounds of each respondent was 1 Ghana cedi. The interval regression was estimated using the intreg command in Stata.

Ordered Probit Regression

To estimate the ordered probit regression, the dependent variable (WTP) was converted into ranked variables. First, all respondents with WTP of zero were grouped as one and coded 0, next, those with WTP higher than zero but less than 2 were also grouped and coded 1, then 2 – 3 were coded 2, 3 – 4 were coded 3 and 4 – 5 were coded 4 and finally those with WTP above 5 were coded 5. It should be noted that, the numbers used to represent each category does not really matter, only the rank order matters. The ordered probit regression model was estimated using the oprobit command in Stata.

The Likelihood Ratio (LR) Chi-Square test that at least one of the predictors' regression coefficient is not equal to zero in the model was conducted. The number in the parenthesis indicates the degrees of freedom of the Chi-Square distribution used to test the LR Chi-Square statistic and is defined by the number of predictors in the model. From the results, the Likelihood Ratio (LR) was 881.6. The p-value is the probability of getting a LR test statistic as extreme as, or more so, than the observed under the null hypothesis; the null hypothesis is that all of the regression coefficients in the model are equal to zero. In other words, this is the probability of obtaining this chi-square statistic (31.56) if there is in fact no effect of the predictor variables. To determine significance this p-value is compared to the alpha level, which for this study is 0.05.Since the p-value is higher than 0.05, it means at least one of the coefficients of the explanatory variables was not zero.

The coefficients of the ordered probit regression are ordered log-odds. Standard interpretation of the ordered probit coefficient is that for a one-unit increase in the predictor, the response variable level is expected to change by its respective regression coefficient in the ordered log-odds scale while the other variables in the model are held constant. Interpretation of the ordered probit estimates is not dependent on the ancillary parameters; the ancillary parameters are used to differentiate the adjacent levels of the response variable (Bruin 2006).

The consistency of the regression results from the different regressions namely OLS, Interval regression and ordered probit regression is an indicator of the robustness in the results and to a large extent attests to its reliability. The different regression results consistently showed that, Age, Income, Availability, Affordability, CPO, Usage, Lighting needs and consumption were statistically significant determinants of WTP for electricity at the 5% level of significance. Apart from Age which had a negative influence on WTP, all the other statistically significant variables influenced WTP positively. Also consistent were the results for the variables which were not statistically significant determinants of WTP for electricity at the 5% level of significance. These were Gender, Number of dependents in school, Service rating, Education, Commercial, RFEC and Water. Savings behavior was significant in only the interval regression but not in the OLS and Ordered Probit regressions.

Table 14 Multiple regression results (OLS)

	Models with All Explanatory Variables			Models with only Significant Explanatory Variables		
WTP	Coefficients	Robust Std. Error	P-value	Coefficients	Robust Std. Error	P-value
Constant	0.077	0.148	0.6010			
Gender	0.083	0.045	0.0640			
Age	-0.008	0.002	0.0000			
Dependents in School	-0.017	0.013	0.1820			
Income	4.47E-04	9.57E-05	0.0000	-0.008	0.002	0.0000
Income Squared	-8.74E-08	1.89E-08	0.0000	4.72E-04	9.07E-05	0.0000
Availability	0.121	0.034	0.0000	-8.51E-08	1.93E-08	0.0000
Affordability	0.408	0.055	0.0000	0.119	0.033	0.0000
CPO	0.025	0.007	0.0000	0.417	0.055	0.0000
Service Ratings	0.01	0.02	0.6310	0.025	0.006	0.0000
Education	-0.005	0.005	0.3960			
Usage	0.11	0.018	0.0000			
Lighting Needs	0.002	0.001	0.0000	0.112	0.017	0.0000
Commercial	-0.006	0.07	0.9340	0.002	0	0.0000
Consumption	0.008	0.001	0.0000			
Consumption Squared	-6.57E-06	1.68E-06	0.0000	0.008	0.001	0.0000
RFEC	-0.022	0.053	0.6790	-6.37E-06	1.67E-06	0.0000
Water	7.73E-05	2.72E-04	0.7760			
Savings	2.81E-04	1.76E-04	0.1100			
Observations			3100			3100
F(18, 3081)			41.96			73.81
Prob > F			0.000			0.0000
R-squared			0.2515			0.2486
Root MSE			1.1980			1.1986

Table 15 Interval Regression Results

Variables	Model with all Explanatory Variables			Model with only Significant Variables		
	Coefficients	Std. Err.	P-value	Coefficients	Std. Err.	P-value
Gender	0.023	0.042	0.5930			
Age	-0.007	0.002	0.0000	-0.007	0.002	0.0000
Dependents in School	-0.014	0.011	0.2080			
Income	3.504E-04	7.800E-05	0.0000	3.384E-04	7.660E-05	0.0000
Availability	0.113	0.029	0.0000	0.123	0.028	0.0000
Affordability	0.436	0.050	0.0000	0.439	0.049	0.0000
CPO	0.019	0.004	0.0000	0.018	0.004	0.0000
Service Rating	0.019	0.019	0.3200			
Education	-0.001	0.005	0.9200			
Usage	0.106	0.017	0.0000	0.108	0.016	0.0000
Lighting Needs	0.001	3.231E-04	0.0010	0.001	3.158E-04	0.0010
Commercial	0.022	0.059	0.7050			
Consumption (kWh)	0.008	0.001	0.0000	0.008	0.001	0.0000
RFEC	-0.035	0.048	0.4660			
Income Square	-7.410E-08	1.860E-08	0.0000	-7.270E-08	1.850E-08	0.0000
Consumption Square	-8.560E-06	1.000E-06	0.0000	-8.470E-06	9.980E-07	0.0000
Value Type	0.036	0.045	0.4250			
Water	-4.980E-05	2.666E-04	0.8520			
Savings	3.188E-04	1.368E-04	0.0200	3.367E-04	1.361E-04	0.0130
Observations			3100.0000			3100
LR $chi^2(19)$			809.2900			804.9
Prob > chi^2			0.0000			0.000
Pseudo R^2			0.1015			0.1009

Table 16 Ordered probit regressing results

Variables	**Model with all Explanatory Variables**			**Models with only Significant Variables**		
	Coefficient	Std. Err.	P-value	Coefficient	Std. Err.	P-value
Intercept	0.119	0.141	0.4000	0.150	0.120	0.2110
Gender	0.083	0.045	0.0620			
Age	-0.007	0.002	0.0000	-0.008	0.002	0.0000
Dependents in School	-0.015	0.012	0.2020			
Income	4.329E-04	8.330E-05	0.0000	4.569E-04	8.030E-05	0.0000
Availability	0.121	0.031	0.0000	0.119	0.029	0.0000
Affordability	0.396	0.052	0.0000	0.407	0.052	0.0000
CPO	0.025	0.005	0.0000	0.026	0.005	0.0000
Service Rating	0.010	0.020	0.6260			
Education	-0.005	0.006	0.3890			
Usage	0.106	0.018	0.0000	0.107	0.017	0.0000
Lighting Needs	0.002	3.533E-04	0.0000	0.002	3.462E-04	0.0000
Commercial	-0.007	0.062	0.9120			
Consumption (kWh)	0.008	0.001	0.0000	0.007	0.001	0.0000
RFEC	-0.032	0.051	0.5300			
Income Square	-8.350E-08	2.000E-08	0.0000	-8.120E-08	1.990E-08	0.0000
Consumption Square	-6.300E-06	1.090E-06	0.0000	-6.110E-06	1.080E-06	0.0000
Value Type	0.027	0.047	0.5700			
Water	7.840E-05	2.760E-04	0.7760			
Savings	2.763E-04	1.486E-04	0.0630			
/lnsigma	0.137	0.013	0.0000	0.139	0.013	0.0000
Sigma	1.147	0.015		1.149	0.015	1.1197
Observations			3100			3100
LR Chi2(19)			891.9			881.6
Prob > Chi2			0.000			0.000

8.4 Computation of total economic value of electricity

8.4.1 Calculating benefits

The frequency distribution of WTP bids can be used in electricity project analysis in two ways: (1) to estimate the total WTP for electricity, and (b) to roughly estimate revenue from providing electricity at a specified price. Total willingness to pay is the total economic benefit of electricity; revenue is the financial return that can be expected by the entity providing reliable 24-hour supply of electricity at a price.

8.4.2 Estimating total WTP

From Table 17, the Total maximum WTP of the respondents for electricity can be calculated by multiplying the frequency distribution of the sample by the total population of households with access to electricity in Ghana (3509901), to get the estimated population in each WTP interval (column 2). Then, by assuming that the midpoint of each WTP interval is the mean WTP (column 3), the population can be multiplied by this mean to estimate total willingness to pay (column 4). Total WTP for reliable 24-hour supply of electricity is 5,782,562.41 Ghana cedis per day in Ghana. Graphically, this is represented as the area under the electricity demand curve in Figure 5. For the Southern, Middle and Northern Zones the TWTP values were 1,876,837.23; 1,260,845.55 and 220,294.02 Ghana cedis respectively per day for a 24-hour reliable supply of electricity. Tables 18-20 show the zonal computations of TWTP. From these TWTP values, the mean WTP per day for 24- hour reliable electricity in Ghana would be 1.6475 Ghana cedis.

Table 17 Total WTP for Electricity (Ghana)

Frequency Distribution (%) (1)	**Total Population (2)**	**WTP Midpoint (Ghana Cedis) (3)**	**Total WTP (Ghana Cedis) (4)**	**Cumulative Population (5)**
16.1	565094	0.25	141273.53	3509550
21.26	746205	0.75	559653.76	2944456
13.06	458393	1.25	572991.39	2198251
24.16	847992	1.75	1483986.27	1739858
6.45	226389	2.25	509374.43	891866
8	280792	2.75	772178.29	665477
2.03	71251	3.25	231565.74	384685
2.9	101787	3.75	381701.77	313434
0.29	10179	4.25	43259.53	211647
4.26	149522	4.75	710228.53	201468
0.06	2106	5.25	11056.19	51947
0.42	14742	5.75	84764.12	49841
0.29	10179	6.75	68706.32	35099
0.71	24920	8.5	211822.54	24920
100	**3509901**		**5782562.41**	

Using an average annual per capita electricity consumption of about 500 kilowatt-hours (World Bank, 2017), the daily average consumption becomes 1.4 kilowatt-hours. Thus if a household willing to pay 1.6475 Ghana cedis consumes 1.4 kilowatt- hours on the average, then the household will be willing to pay 1.18 Ghana cedis for 1 kilowatt-hour of electricity proportionately. Thus, the mean maximum WTP for 1 kilowatt-hour of electricity is 1.18 Ghana cedis

Table 18 Total WTP for Electricity (Middle Zone)

Frequency Distribution (%)	Total Population	WTP Midpoint (Ghana Cedis)	Total WTP (Ghana Cedis)	Cumulative Population
21.29	181267	0.25	45316.79	851419
24.38	207576	0.75	155682.02	670152
11.6	98765	1.25	123455.80	462576
22.64	192761	1.75	337332.33	363811
4.69	39932	2.25	89846.02	171050
6.43	54746	2.75	150552.22	131119
1.19	10132	3.25	32928.64	76372
2.78	23669	3.75	88760.46	66240
0.08	681	4.25	2894.83	42571
3.57	30396	4.75	144379.43	41890
0.24	2043	5.75	11749.59	11494
0.16	1362	6.75	9195.33	9451
0.95	8088	8.5	68752.11	8088
100	**851419**		**1260845.55**	

Table 19 Total WTP for Electricity (Southern Zone)

Frequency Distribution (%)	Total Population	WTP Midpoint (Ghana Cedis)	Total WTP (Ghana Cedis)	Cumulative Population
7.26	65538	0.25	16384.50	902908
17.63	159151	0.75	119363.08	837370
8.53	77003	1.25	96253.27	678219
29.38	265221	1.75	464137.11	601216
6.34	57233	2.25	128774.01	335995
12.56	113383	2.75	311801.92	278762
2.65	23922	3.25	77747.37	165380
5.3	47845	3.75	179417.00	141457
0.81	7312	4.25	31076.38	93613
7.6	68607	4.75	325884.46	86301
0.69	6229	5.75	35815.70	17693
0.46	4153	6.75	28029.67	11465
0.81	7312	8.5	62152.76	7312
100	**902727**		**1876837.23**	

.
This mean WTP is only 64.5 percent of the current end user tariff of the Electricity Company of Ghana (ECG) for consuming 1 kilowatt-hour of electricity, which is 1.83 Ghana cedis. This ECG tariff includes a subsidy of 0.66 Ghana cedis. Without the subsidy, the mean WTP will be only 47.4 percent of the end user tariff of 2.49 Ghana cedis. This shows a great disparity between the value households put on 1 kilowatt-hour of electricity and the end-user tariffs they have to pay. Therefore, current end user tariffs are far higher than the real value households attach to one unit of electricity in Ghana.

Table 20 Total WTP for Electricity (Northern Zone)

Frequency Distribution (%)	**Total Populating**	**WTP Midpoint (Ghana Cedis)**	**Total WTP (Ghana Cedis)**	**Cumulative Population**
17.27	25712	0.25	6428.11	148885
20.45	30447	0.75	22835.24	123173
19.01	28303	1.25	35378.81	92726
21.48	31981	1.75	55965.88	64423
8.84	13161	2.25	29613.23	32442
5.96	8874	2.75	24402.26	19281
2.57	3826	3.25	12435.62	10407
0.92	1370	3.75	5136.53	6581
0.1	149	4.25	632.76	5211
2.16	3216	4.75	15275.60	5062
0.21	313	5.25	1641.46	1846
0.41	610	5.75	3509.96	1534
0.31	462	6.75	3115.42	923
0.31	462	8.5	3923.12	462
100	**148885**		**220294.02**	

Plotting the cumulative populations (column 5) against their respective WTP midpoints (column 3) gives the demand curve for electricity. This is also known as the marginal willingness to pay curve. These demand curves are illustrated in Figure 5. The area under each demand curve represents the maximum TWTP for a 24-hour supply of reliable electricity within the area the curve represents, which are shown in the corresponding tables above.

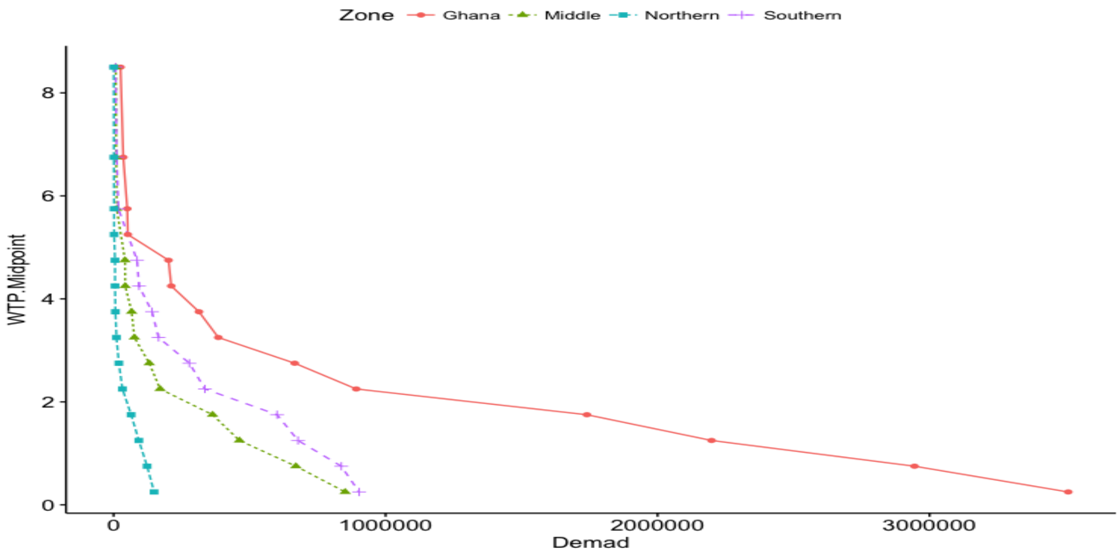

Figure 5 Demand for electricity in Ghana

8.4.3 Value Type

The survey asked respondents to provide reasons why they expressed the WTP they did. These reasons captured both use and non-use values. The cross-tabulation shows breakdown of the reasons why respondents expressed their WTP. It is clear that 71.45% of respondents indicated their valuation was for non-use value purposes. This has implications for the use of electricity. It means that the current generation of households regards electricity not as an aid to production but for other social purposes. This however did not affect the WTP since it was not statistically significant.

8.5 Elasticity Estimation

8.5.1 Willingness to Pay Elasticity of Demand

The WTP values of the 3100 observations were sorted from lowest to highest, and then the cumulative percentage for each observation was computed starting from the minimum WTP at 0. At zero WTP, all households demand electricity. From the cumulative percentages, the study computed the number of households willing to purchase their daily electricity needs at their WTP values. The study then estimated a regression model with the specification:

$$WTP = \beta_0 + \beta_1 Q + \beta_2 Q^2 + \beta_3 Q^3 + \mu_i$$

where μ_i is the error term and Q represents the number of households. The results are shown in Tables 21-24 for Ghana as well as the various zones.

From the results, all the independent variables were very significant. The results also implied that, the relationship between WTP and Q might not be linear as Q^2 and Q^3 were both very significant. The equation for WTP can be written as

$$WTP = 5.7657 - 8.1923Q + 5.2102Q^2 - 1.1411Q^3$$

To estimate the Willingness to pay Elasticity, the formula below was used.

$$WTP_{Elasticity} = \frac{1}{\partial WTP/\partial Q} \times \frac{WTP}{Q}$$

Because the estimated demand function was not linear, the slope coefficient was not constant but rather varied depending on the values of Q. From the regression results, the slope was estimated to be:

$$\frac{\partial WTP}{\partial Q} = -8.1923 + 2(5.2102) \times Q + 3(-1.1411) \times Q^2$$

So, the elasticity expression became:

$$WTP_{Elasticity} = \frac{1}{-8.1923 + 2(5.2102) \times Q + 3(-1.1411) \times Q^2} \times \frac{WTP}{Q}$$

Using the predicted WTP values and their corresponding Q values, WTP elasticity was estimated and the results presented in Table 18(A-D). It should also be noted that, because WTP is in the numerator of the Elasticity formula, elasticity was zero for those with zero WTP.

Table 21 Ghana

WTP Range	**Elasticity**	**Interpretation**
Less than 0.1	-0.0012	Inelastic
0.11 - 0.3	-0.0217	Inelastic
0.31 - 0.5	-0.0512	Inelastic
0.51 - 0.8	-0.1144	Inelastic
0.81 -1.0	-0.2407	Inelastic
1.0 - 1.19	-0.5873	Inelastic
1.2	-1.0039	Unitary Elastic
1.21 - 2.0	6.0966	Elastic
2.0 - 3.0	-1.3633	Elastic
3.1 - 4.0	-1.9584	Elastic
4.1 - 5.0	-3.9284	Elastic
5.1 and above	-34.8369	Elastic

Table 22 WTP Elasticity (Middle Zone)

WTP Group	Elasticity	Interpretation
Less than 0.1	-0.0065	Inelastic
0.1 - 0.3	-0.0295	Inelastic
0.3 - 0.5	-0.0717	Inelastic
0.5 - 0.8	-0.1750	Inelastic
0.8 - 1.0	-0.4634	Inelastic
1.0 - 1.073	-0.8585	Inelastic
1.0374	-1.0071	Unitary Elastic
1.04 - 2.0	-2.3034	Elastic
2.0 - 3.5	-1.3912	Elastic
3.5 - 4.5	-2.8725	Elastic
4.5 - 5.5	-9.7861	Elastic
5.5 and above	-94.7866	Elastic

Table 23 Southern Zone

WTP Group	Elasticity	Interpretation
Less than 0.1	-0.0051	Inelastic
0.1 - 0.3	-0.0209	Inelastic
0.3 - 0.5	-0.0473	Inelastic
0.5 - 0.8	-0.0944	Inelastic
0.8 - 1.0	-0.1620	Inelastic
1.0 - 1.55	-0.5076	Inelastic
1.553	-1.0070	Unitary Elastic
1.6 - 2.0	-2.1772	Elastic
2.0 - 3.5	-1.5150	Elastic
3.5 - 4.5	-2.1894	Elastic
4.5 - 5.5	-4.1629	Elastic
5.5 and above	-27.9769	Elastic

Table 24 Northern Zone

WTP Group	Elasticity	Interpretation
Less than 0.1	-0.0015	Inelastic
0.1 - 0.3	-0.0064	Inelastic
0.3 - 0.5	-0.0137	Inelastic
0.5 - 0.8	-0.0256	Inelastic
0.8 - 1.0	-0.0419	Inelastic
1.0 - 2.497	-0.2833	Inelastic
2.498	-1.0043	Unitary Elastic
2.5 - 3.5	-1.6090	Elastic
3.5 - 4.5	-5.1875	Elastic
4.5 - 5.5	-46.2322	Elastic

Thus for Ghana, it was realized through the elasticity computations that the WTP elasticity for electricity demand was inelastic for lower WTP values up to 1.19 Ghana cedis, becoming unitary elastic at 1.2 Ghana cedis and after that becoming elastic. Realizing that the point of unitary elasticity is just 0.02 Ghana cedis more than the mean WTP for a unit of electricity, there will be no room for the utility companies to increase tariffs, since their tariffs for 1 kilowatt-hour of electricity exceeds 1.2 Ghana cedis. As a matter of fact the tariffs as they stand currently have exceeded the point of unitary elasticity and entered the area of elastic WTP for electricity. This demonstrates the need to employ demand side management, since demand response will be crucial in getting utility companies to attract tariffs from households. Only a supply side approach will certainly be ineffective.

With respect to the zonal effects, it is worth noting that both the Middle and Southern Zones have fallen within the elastic WTP region. Only the Northern Zone has some room for further tariff increases based on the maximum willingness to pay.

8.5.2 Income Elasticity of WTP

Income Elasticity of WTP: This is the percentage change in WTP due to some unit percentage change in household income. It indicates how responsive household WTP for electricity is to changes in household income. It was computed as:

$$\text{Income}_{\text{WTP}} = \frac{\partial \text{WTP}}{\partial \text{Income}} \times \frac{\text{Income}}{\text{WTP}}$$

Where $\frac{\partial \text{WTP}}{\partial \text{Income}}$ is obtained from a regression model between WTP as dependent variable and income and income squared as the independent variables. This gives the regression model as:

$$\text{WTP} = \beta_0 + \beta_1 \text{Income} + \beta_2 \text{Income}^2$$

The slope of $\frac{\partial \text{WTP}}{\partial \text{Income}}$ was computed as $\beta_1 + 2 \times \beta_2 \text{Income}$ and as a result, the income elasticity formula became:

$$\text{Income}_{\text{WTP}} = \beta_1 + 2 \times \beta_2 \text{Income} \times \frac{\text{Income}}{\text{WTP}}$$

Separate regression models were estimated for all the zones and the β_1 and β_2 coefficients were used in computing the corresponding income elasticity reported in Table 25. Using the Income and WTP data and the coefficients from each zonal model, the elasticity in Table 25 were estimated.

Table 25 Mean Income Elasticity over WTP range (upper boundaries not included)

WTP Group	Ashanti	Greater Accra	Northern Region	Upper West	Northern Zone	All Zones
Up to 0.5	1.0736	1.2816	0.6831	0.8687	0.7531	1.4131
0.5 - 1.5	0.3877	0.3488	0.4011	0.4235	0.4196	0.6319
1.5 - 2.5	0.2210	0.2018	0.2727	0.3527	0.2938	0.4065
2.5 - 3.5	0.1404	0.1453	0.1899	0.2849	0.2118	0.3547
3.5 - 4.5	0.1283	0.1169	0.2023	0.1631	0.1972	0.2652
4.5 - 5.5	0.1203	0.0927	0.0833	0.2229	0.1213	0.2422
5.5 - 6.5	0.0898	0.0392	-0.0352	0.2431	0.0285	0.3408
6.5 - 7.5	0.1157	0.0763	NA	0.1507	0.1289	0.1965
7.5 - 8.5	0.0943	NA	NA	NA	NA	0.1507
8.5 - 9.5	NA	NA	NA	NA	NA	NA
9.5 - 10.5	0.0461	0.0542	0.0710	NA	0.0769	0.1379

Note: the NA in Table 19 indicates that the zone does not have WTP observations within the said range. For example, for the WTP range of 8.5 to 9.5, none of the respondents from Ashanti Region cited WTP within that range. As a result, there was no computed elasticity hence the NA. Given that the WTP is in the denominator of the income elasticity formula, the elasticity results for those with zero WTP were undefined. As a result, the elasticity result above consists of WTP for only respondents with WTP higher than 0.

The results of income elasticity of WTP show that a 24-hour supply of reliable electricity is a necessity for all the zones individually as well as for all the regions. This is shown by the fact that income elasticity of WTP is income inelastic, since the elasticities are positive and less than one, except in the case of the lowest WTP range. For the WTP range of 0 to 0.5 Ghana cedis, the WTP for electricity shows that it is a luxury. This will certainly is welcoming news for policy, to use electricity subsidy to get them out of their low income status, since electricity in this age must not be considered as a luxury except there is serious ignorance as to what it stands for.

8.6 Household Income, Mean WTP and End User Tariffs

Establishing the factual issues about the ability of households to pay for electricity required an assessment of the proportions of their incomes they were willing to pay for electricity on a monthly basis compared to what they were actually paying as end user tariffs. This would also provide an input for demand management of electricity based on demand response analysis. With respect to the total sample, household heads were willing to pay on average 8% of their incomes per month for electricity while their monthly end user tariffs were on average 11% of their monthly incomes. Thus households were already paying on average 3% more of their incomes than they would be willing to pay. This trend is consistent with all the zones as Tables 27-29 show. Thus, if the British standard of energy poverty being payments beyond 10% of incomes for energy holds, then Ghanaian households are energy poor in terms of end user electricity tariffs. Hence it no surprise that they are willing to pay much lower than the end user tariffs they currently pay.

Table 26 WTP and EUT at proportions of households' income

Number of Uses	Mean Household Income	Household Size	End User Tariff (EUT)	Mean WTP (Monthly)	Income per Head	EUT/Mean Household Income (%)	WTP/Mean Household Income (%)
1	324.98	5.86	30.26	30.80	55.47	9.31	9.48
2	374.09	5.52	46.96	35.89	67.73	12.55	9.59
3	475.65	5.19	53.22	43.03	91.59	11.19	9.05
4	628.27	5.08	69.10	56.16	123.60	11.00	8.94
5	781.79	5.22	88.68	64.44	149.63	11.34	8.24
6	961.00	5.17	93.15	67.96	185.81	9.69	7.07
7	1075.63	4.76	121.06	77.76	225.84	11.25	7.23
8	1403.68	4.77	163.77	96.85	294.10	11.67	6.90

Table 27 Middle Zone

Number of Uses	Mean Household Income	WTP (Ghana Cedis)	Household Size	EUT	Income per Head	WTP as % of Household Income	EUT as % of Household Income
1	347.1	26.8	4.7	27.8	74.6	7.7	8.0
2	394.7	37.6	5.3	52.2	75.0	9.5	13.2
3	525.5	42.6	4.7	54.8	112.1	8.1	10.4
4	580.7	51.7	4.3	73.8	135.2	8.9	12.7
5	782.0	60.9	4.7	93.4	165.8	7.8	11.9
6	873.7	60.4	4.0	84.7	216.5	6.9	9.7
7	616.7	53.5	4.6	104.7	134.3	8.7	17.0
8	1472.7	74.3	4.7	184.2	311.5	5.0	12.5

Table 28 Northern Zone

Number of Uses	Mean Household Income	WTP (Ghana Cedis)	Household Size	EUT	Income per Head	WTP as % of Household Income	EUT as % of Household Income
1	271.8	33.7	7.7	29.4	35.5	12.4	10.8
2	298.2	30.3	6.5	35.3	45.8	10.1	11.9
3	370.2	42.7	6.2	46.4	59.7	11.5	12.5
4	584.8	53.0	7.3	59.5	80.7	9.1	10.2
5	702.2	56.5	6.5	65.8	107.3	8.0	9.4
6	849.9	71.1	6.2	89.2	137.8	8.4	10.5
7	1516.7	95.0	6.8	125.3	222.0	6.3	8.3

Table 29 Southern Zone

Number of Uses	Mean Household Income	WTP (Monthly)	Household Size	EUT	Income per Head	WTP as % of Household Income	EUT as % of Household Income
1	488.8	43.9	3.8	55.8	128.6	9.0	11.4
2	488.4	43.7	4.0	55.6	122.1	9.0	11.4
3	618.9	44.8	3.9	66.4	159.5	7.2	10.7
4	746.7	66.4	4.1	71.5	181.2	8.9	9.6
5	833.9	73.0	4.8	99.2	172.4	8.8	11.9
6	1264.4	72.7	5.0	111.0	252.9	5.8	8.8
7	1287.5	89.6	4.6	129.8	277.2	7.0	10.1
8	1428.1	125.4	4.8	149.7	297.5	8.8	10.5

9.0 Expected Revenue

The frequency distribution of WTP bids can be used to provide a rough estimate of the revenue that might be expected from providing electricity at a specified price. This is done by first predicting the total number of individuals that would be willing to pay for electricity at a specified price and then multiplying this by the price. Estimating total revenue is very important, because it allows the electricity utility to determine how many connections it can afford to provide to the community. Expected revenue is calculated by predicting the percentage of households using electricity at different tariffs. From Table 30 it can be seen that if 0.25 Ghana cedis per day is charged for each household's use, the electricity utility can expect 3,509,901 households to subscribe to the service and revenues of 877,475.30 Ghana cedis per day will be earned. If a price of 0.75 Ghana cedis is charged, only 2,944,807 households will subscribe to the service and revenues will be 2,208,605.40 Ghana cedis. The range of revenues at different prices presented in Tables 30 to 33 is represented graphically in Figure 6 for Ghana and the zones.

From table 30, the WTP, which yields the highest revenue per day, is 1.75 Ghana cedis. This generates a revenue of 3,045,365.90 Ghana cedis per day for the utility provider. This means that investors would use this WTP as a guide to determine their revenue if they decide to invest in supplying 24 hour service of reliable electricity. It is worth noting that the WTP which gives the highest revenue is lower than current tariff per unit of electricity but higher than the mean maximum WTP.

Thus investors will need to invest in demand side management practices to be able to raise enough revenue to make profit if indeed the current cost structure of electricity supply is the optimum. The other alternative will be to go for better technology, which is able to cut cost such that the tariff will be enough to meet the expectation of investors.

With respect to the Zonal revenues, the data in Table 31-33 show that the tariff which gives the highest revenue for the Southern and Middle Zones is 1.75, while the Northern Zone has a lower tariff of 1.25 giving the highest revenue. Thus a uniform tariff for investors for the whole country could be injurious to those who may want to operate in the Northern Zone.

Table 30 Calculating Expected Revenue (Ghana)

Frequency Distribution (%)	Percentage of households connected	Households connecting at different prices	WTP Midpoint (Ghana Cedis)	Expected Revenue (Ghana Cedis)
16.1	100.00	3509901	0.25	877475.3
21.26	83.90	2944807	0.75	2208605.4
13.06	62.64	2198602	1.25	2748252.7
24.16	49.58	1740209	1.75	3045365.9
6.45	25.42	892217	2.25	2007488.1
8	18.97	665828	2.75	1831027.8
2.03	10.97	385036	3.25	1251367.6
2.9	8.94	313785	3.75	1176694.4
0.29	6.04	211998	4.25	900991.7
4.26	5.75	201819	4.75	958641.8
0.06	1.49	52298	5.25	274562.0
0.42	1.43	50192	5.75	288601.6
0.29	1.01	35450	6.75	239287.5
0.72	0.72	25271	8.5	214806.0

Table 31 Calculating Expected Revenue (Middle Zone)

Frequency Distribution (%)	Percentage of households connected	Households connecting at different prices	WTP Midpoint (Ghana Cedis)	Expected Revenue (Ghana Cedis)
21.29	100	851419	0.25	212854.82
24.38	78.71	670152	0.75	502614.10
11.6	54.33	462576	1.25	578220.13
22.64	42.73	363811	1.75	636670.06
4.69	20.09	171050	2.25	384862.81
6.43	15.4	131119	2.75	360576.07
1.19	8.97	76372	3.25	248210.01
2.78	7.78	66240	3.75	248401.58
0.08	5	42571	4.25	180926.60
3.57	4.92	41890	4.75	198976.69
0.24	1.35	11494	5.75	66091.42
0.16	1.11	9451	6.75	63792.59
0.95	0.95	8088	8.5	68752.11

Table 32 Calculating Expected Revenue (Southern Zone)

Frequency Distribution (%)	Percentage of households connected	Households connecting at different prices	WTP Midpoint (Ghana Cedis)	Expected Revenue (Ghana Cedis)
7.26	100	902727	0.25	225681.76
17.63	92.74	837189	0.75	627891.80
8.53	75.11	678038	1.25	847547.86
29.38	66.58	601036	1.75	1051812.42
6.34	37.2	335814	2.25	755582.54
12.56	30.86	278582	2.75	766099.31
2.65	18.3	165199	3.25	536896.91
5.3	15.65	141277	3.75	529787.94
0.81	10.35	93432	4.25	397087.06
7.6	9.54	86120	4.75	409070.76
0.69	1.94	17513	5.75	100699.20
0.46	1.25	11284	6.75	76167.59
0.81	0.79	7132	8.5	60618.12

Table 33 Calculating Expected Revenue (Northern Zone)

Frequency Distribution (%)	Percentage of households connected	Households connecting at different prices	WTP Midpoint (Ghana Cedis	Expected Revenue (Ghana Cedis)
17.27	100	148885	0.25	37221.26
20.45	82.73	123173	0.75	92379.44
19.01	62.28	92726	1.25	115907.00
21.48	43.27	64423	1.75	112739.47
8.84	21.79	32442	2.25	72994.61
5.96	12.95	19281	2.75	53021.68
2.57	6.99	10407	3.25	33822.96
0.92	4.42	6581	3.75	24677.69
0.1	3.5	5211	4.25	22146.65
2.16	3.4	5062	4.75	24044.93
0.21	1.24	1846	5.25	9692.42
0.41	1.03	1534	5.75	8817.72
0.31	0.62	923	6.75	6230.84
0.31	0.31	462	8.5	3923.12

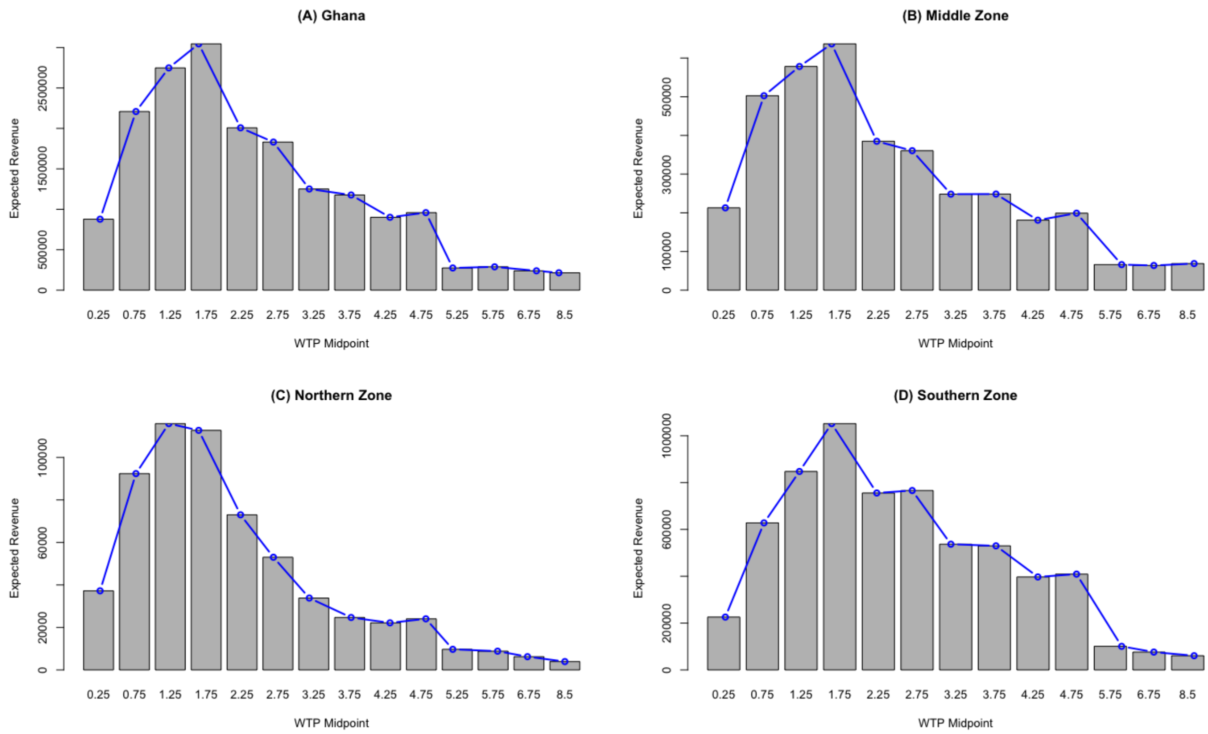

Figure 6: Expected Revenue Curves

10. ANALYSIS FOR ZERO BID TARIFFS

Out of the 3100 respondents, 90 representing 2.9 percent had WTP amount of zero Ghana cedis. Thus they were not willing to pay any amount for electricity. The reasons they cited are illustrated in Figure 7 below.

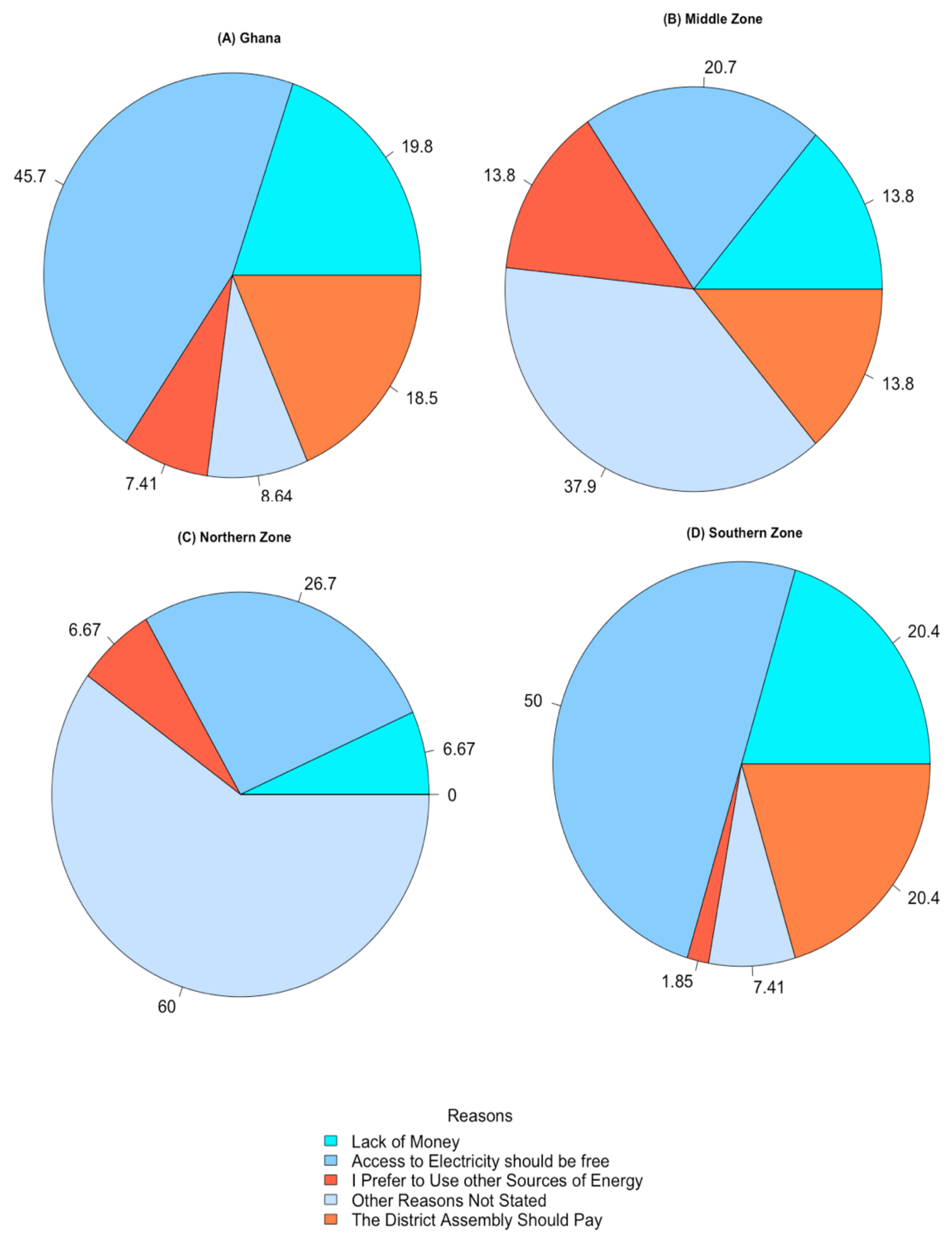

Figure 7 Zero bid reasons (by percentages of respondents)

The importance of ascertaining the reasons for zero bids is to ascertain why some households were not in a position to place value on electricity. This could expose protest bids and non-protest bids. From Figure 7, for all Ghana, 19.8 % of households who had WTP of zero indicated their not valuing electricity stemmed from their lack of the means to pay. The remaining reasons were basically protest bids trying to imply that the responsibility of providing electricity was the role of government or some other institution.

To confirm protest bids apart from using the reasons assigned for non-payment, such respondents were given the option of providing community service in place of payment. Household heads who were not willing to pay for monetary reasons offered to work on average for 10 days for their communities to have the opportunity to use electricity. Those who were not willing to pay for non-monetary reasons were willing to work for their communities on average for about 4 days. In all about 20.4% of those not willing to pay were also not willing to offer community service to have the opportunity to benefit from electricity. It is worth noting that 18.5% of zero WTP bid households preferred other alternatives to state provided electricity. Further details of the zero bid households are provided in Tables 34 to 37.

Table 34 Income distribution of household with zero bid

Income Group (Ghana cedis)	Frequency	Percent (%)
Less than 100	16	17.78
101 – 300	28	31.11
301 – 600	19	21.11
601 – 1000	19	21.11
Above 1000	8	8.89
Total	**90**	**100**

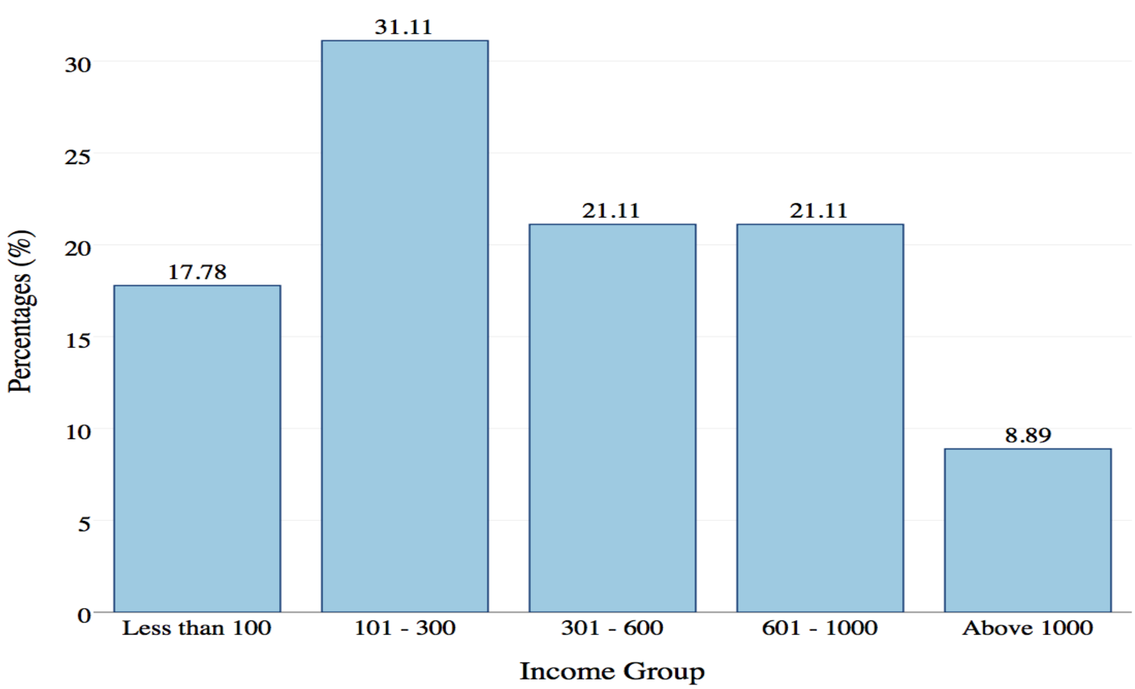

Figure 8: Income distribution of those with zero bid

Table 35 Reasons for zero bid and average number of days of work

Reasons for Zero Bid	Average Number of Days of work
Monetary	10.13
Non-monetary	4.955

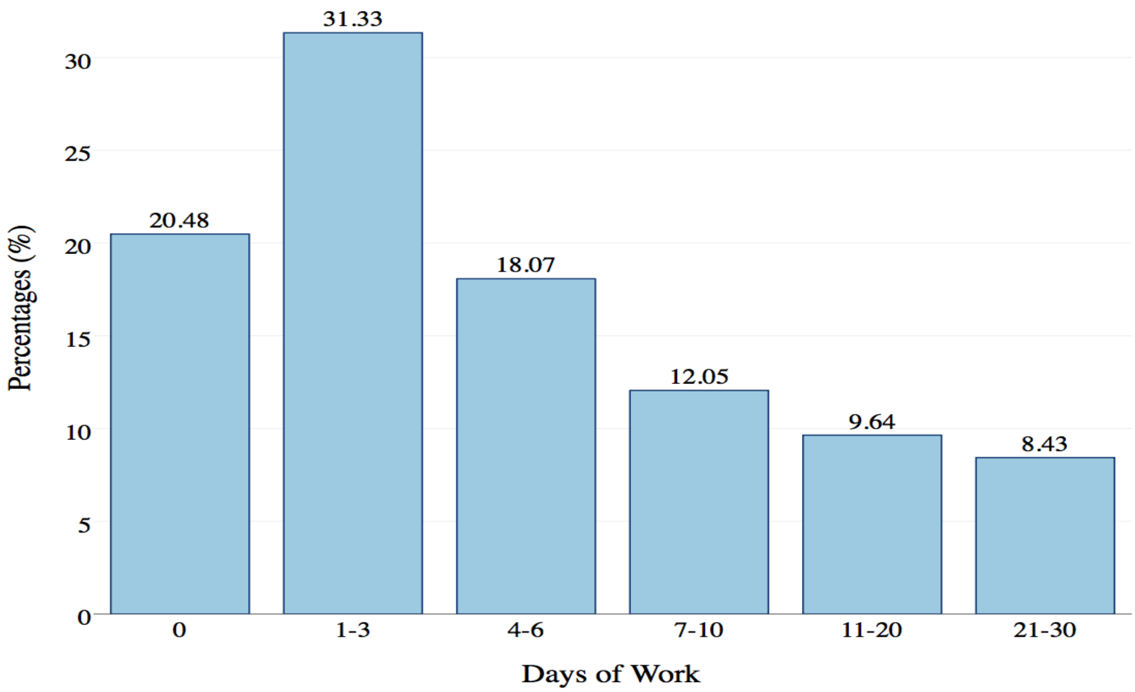

Figure 9 Distribution of days of work for those with zero bid

Table 36 Zonal Income distribution of those with zero bid

Zones	Income Group	Freq.	Percent
Middle	Less than 100	2	8.33
	101 – 300	6	25
	301 – 600	9	37.5
	601 – 1000	5	20.83
	Above 1000	2	8.33
Northern	Less than 100	13	25
	101 – 300	20	38.46
	301 – 600	8	15.38
	601 - 1000	9	17.31
	Above 1000	2	3.85
Southern	Less than 100	1	7.14
	101 – 300	2	14.29
	301 – 600	2	14.29
	601 - 1000	5	35.71
	Above 1000	4	28.57

Table 37 Zonal distribution of those with zero bids based on number of days

Zones	Days Group	Freq.	Percent
Middle	0	9	47.37
	1-3	3	15.79
	4-6	2	10.53
	7-10	0	0.00
	11-20	3	15.79
	21-30	2	10.53
Northern	0	1	1.92
	1-3	22	42.31
	4—6	12	23.08
	7-10	5	9.62
	11-20	7	13.46
	21-30	5	9.62
Southern	0	7	58.33
	1—3	1	8.33
	4—6	1	8.33
	7--10	2	16.67
	11--20	1	8.33
	21-30	0	0.00

11. COMMUNITIES WITHOUT LIGHT

From the cross tabulation of results in Table 38, WTP increases with income, savings, and education. Households with higher incomes were willing to pay more than households with lower incomes. WTP increased with levels of education up to the secondary level, it however fell slightly at the tertiary level relative to the secondary level. With age, WTP at age 18 to 35 was higher than WTP at ages above 34, which suggests that, younger household heads were willing to pay higher than the relatively older household heads. The WTP for male household heads was slightly higher than the WTP for female household heads.

Table 38 Descriptive Summary (CWL)

Variables	Categories	Frequency (%)	Average WTP
Age	18 - 25	10.43	1.49
	25 - 35	22.7	1.88
	35 - 45	26.38	1.39
	45 - 55	15.34	1.22
	55 - 65	17.18	0.78
	65 and Above	7.98	0.97
Occupation	Non-Farmers	30.67	1.35
	Farmer	69.33	1.34
Gender	Female	31.29	1.05
	Male	68.71	1.48
Savings Group	Less than 50	82.82	1.25
	50 - 100	8.59	1.57
	100 - 200	3.07	1.3
	200 - 400	3.68	3.08
	400 and Above	1.84	1.17
Water Bill Group	Less than 3	92.02	1.34
	3-10	7.36	1.5
Income Group	Less than 100	22.7	1.1
	100 - 400	53.37	1.23
	400 - 600	15.34	1.56
	600 - 800	4.29	2.14
	800 and above	4.29	2.5
Education	No formal Education	38.04	1.1
	Primary Level	9.2	1.1
	JHS Level	32.52	1.66
	Secondary Level	15.95	1.45
	Tertiary Level	4.29	1.21
Number of Dependents in school	No Dependents	17.18	1.45
	1-3	50.92	1.29
	3-6	26.99	1.43
	6+	4.91	1.06

Constructed from Geo-Map Consult Data (2016)

11.1 Regression Diagnostics

Table 39 Multicollinearity Test (CWL)

VARIABLE	VIF	1/VIF
INCOME_SQ	6.31	0.158422
INCOME	4.78	0.209059
SAVINGS	4.28	0.23356
AGE	1.41	0.710017
EDUCATION	1.4	0.714362
SOURCE	1.16	0.864659
DEP_SCHOOL	1.12	0.896226
GENDER	1.11	0.89989
WATER_BILL	1.05	0.949866
MEAN VIF	**2.51**	

Table 39 presents the variance inflation factor of the explanatory variables. From the results, all the variables has VIF less than 10, which according to the rule of thumb mean the level of correlation between the variables should not results in multicollinearity.

Table 40 Constant variance test (CWL)

Source	Chi-Square Statistic	df	P-VALUE
IMTEST	85.26	51	0.0019
HETTEST	**53.48**		**0.0000**

Table 40 presents the tests for heteroskedasticity. The null hypothesis of both tests is that, the variance of the errors terms is constant. The p-values of both tests are less than 0.05, which meant a rejection of the null hypothesis. This also implies that the models have issues with heteroskedasticity. This was corrected using the robust standard errors.

Table 41: Specification Bias Test (CWL)

LINKTEST	WTP	Coefficient	Std. Err.	t	P-value
	_cons	0.2525414	0.4390269	0.58	0.566
	_hat	0.5896462	0.6386095	0.92	0.357
	_hatsq	0.1454113	0.21988	0.66	0.509
OVTEST		**1.34**			**0.2629**

Table 41 presents the specification test. In the LINKTEST, the significance of the _hatsq variable implies specification problems. If the p-value of the ovtest is less than 0.05, it indicates an incorrectly specified model. From the results, the _hatsq coefficient was not statistically significant. This means the model is correctly specified. In the ovtest, the p-value is also less than 0.2629, which confirms the results from the LINKTEST.

Table 42 Multiple Regression Results (Ghana)

VARIABLES	REGRESSION WITH ALL EXPLANATORY VARIABLES			REGRESSION WITH ONLY SIGNIFICANT VARIABLES		
	Coefficient	Robust SE	P-value	Coefficient	Robust SE	P-value
INTERCEPT	1.4891	0.3668	0.0000	1.4936	0.284	0.0000
GENDER	0.3779	0.1403	0.0080	0.3554	0.1401	0.0120
AGE	-0.0205	0.0057	0.0000	-0.0192	0.005	0.0000
DEP_SCHOOL	0.0043	0.0347	0.9030			
EDUCATION	-0.0125	0.015	0.4080			
INCOME	0.0017	0.0005	0.0000	0.0017	0.0005	0.0010
INCOME_SQ	-5.32E-07	2.32E-07	0.0230	-4.55E-07	1.22E-07	0.0000
WATER_BILL	-0.0004	0.0086	0.9670			
SAVINGS	0.0008	0.0021	0.6840			
SOURCE	0.2829	0.2198	0.2000			
OBS		=	163		=	163
F(9, 153)		=	4.88		=	8.14
PROB > F		=	0.0000		=	0.0000
R-SQUARED		=	0.2147		=	0.1950
ROOT MSE		=	0.9866		=	0.9830

Constructed from Geo-Map Consult Data (2016)

Tables 42 to 44 present regression results for two models – one with all explanatory variables and the other with only significant variables, for three sets of regressions. These are the OLS, the interval regression and the ordered Logit regression. In the case of the OLS regression, the F-statistic was 4.88 with p-value of 0.0000 < 0.05. From the results, the estimated R-squared was 0.2147 in the full model. The result implies that 21.47 percent of the variation in WTP is explained by the model, meeting the Mitchel and Carson (1989) requirement for reliability.

Table 43 Interval Regression Results

	REGRESSION WITH ALL EXPLANATORY VARIABLES			REGRESSION WITH ONLY SIGNIFICANT VARIABLES		
	Coefficients	SE	P-value	Coefficients	SE	P-value
INTERCEPT	1.4828	0.3528	0.0000	1.5048	0.2863	0.0000
GENDER	0.3743	0.1703	0.0280	0.3441	0.1655	0.0380
AGE	-0.0203	0.0059	0.0010	-0.0189	0.0051	0.0000
DEP_SCHOOL	0.0034	0.0382	0.9300			
EDUCATION	-0.0124	0.0178	0.4860			
INCOME	0.0017	0.0004	0.0000	0.0017	0.0004	0.0000
INCOME_SQ	-5.33E-07	1.49E-07	0.0000	-4.50E-07	1.25E-07	0.0000
WATER_BILL	0.0082	0.0189	0.6640			
SAVINGS	0.0009	0.0011	0.4370			
SOURCE	0.284	0.18	0.1150			
/LNSIGMA	-0.0919	0.0597	0.1240	-0.0780	0.0596	0.1900
SIGMA	0.9122	0.0545	0.8114	0.9250	0.0551	0.8230
OBSERVATIONS			163.00			163.00
F(9, 153)			38.340			34.240
P-VALUE			0.0000			0.0000

Constructed from Geo-Map Consult Data (2016)

Table 43 presents the interval regression results for the model with the full set of explanatory variables and one with only significant variables. From the results, gender, age, income and Income Squared all significantly influence WTP, with the effects of age and income squared being negative. The results from the interval regression are consistent with those from the normal OLS regression and the odered Logit regression in Table 42 and 44 repectively. Thus Education, Number of dependents in School, Savings, Water bill payments and Source of lighting did not significantly influence willingness to pay for electricity in communities without light.

Table 44 Ordered Logit

	REGRESSION WITH ALL EXPLANATORY VARIABLES			**REGRESSION WITH ONLY SIGNIFICANT VARIABLES**		
WTP_ORDERED	Odds Ratio	Std. Err.	P-Value	Odds Ratio	Std. Err.	P-Value
GENDER	2.0879	0.6864	0.0250	2.1378	0.6747	0.0160
AGE	0.9529	0.0118	0.0000	0.9564	0.0103	0.0000
DEP_SCHOOL	1.0328	0.0754	0.6590			
EDUCATION	0.8495	0.2967	0.6400			
INCOME	1.0032	0.0009	0.0000	1.0031	0.0008	0.0000
INCOME_SQ	1.0000	0.0000	0.0020	1.0000	0.0000	0.0000
WATER_BILL	1.0079	0.0403	0.8440			
SAVINGS	1.0010	0.0022	0.6680			
SOURCE	1.4505	0.5189	0.2980			
/cut1	-1.6758	0.7353		-1.6298	0.5847	
/cut2	-0.0927	0.7149		-0.0569	0.5618	
/cut3	0.6455	0.7204		0.6719	0.5670	
/cut4	1.9139	0.7526		1.9275	0.6089	
/cut5	2.4803	0.7793		2.4914	0.6421	
Observations			163.00			163.0
LR Chi2(9)			42.730			40.98
P-value			0.0000			0.0000
Pseudo R2			0.0832			0.0798

Constructed from Geo-Map Consult Data (2016)

11.2 Willingness to Pay

Table 45 presents the distribution of the households' willingness to pay. From the results, the modal WTP is within the WTP group of 0.5 Ghana cedis to 1.5 Ghana cedis.

Total WTP for reliable 24-hour supply of electricity to the communities without electricity was estimated at 3,064,247.12 Ghana cedis per day. Graphically, the total WTP is depicted as the area under the demand curve in Figure 10.

From the TWTP and total household numbers, the mean WTP per day for 24-hour reliable electricity would be 1.5656 Ghana Cedis while the mean per day for 24-hour reliable electricity to households with electricity access was estimated at 1.6475. Thus, the mean WTP for communities without light was 4.07% lower than that of those with light. This implies the existing tariff would be beyond the reach of communities without light if they were connected to the national electricity grid.

Table 46 presents the computation of total WTP as well as the cumulative population of households. A plot of the cumulative population against the WTP midpoints is presented in Figure 10 as the demand curve.

Table 47 presents the computation of expected revenue for households without electricity. From the result, the WTP value that maximizes expected revenue is around 1.0 Ghana cedi. This value is lower than the value from households with electricity, which was 1.75. This result again indicates that, uniform pricing of electricity in Ghana may not be efficient. The implication here is that investors in areas without electricity will have to charge lower tariffs than those with electricity. A graph of the relationship between WTP midpoint and expected revenue is illustrated in Figure 11.

Table 45 Frequency distribution base on WTP Group

Interval for WTP Bid	Data (Sample)	Frequency Distribution (%)
0-0.5	9	5.52
0.5-1.5	91	55.83
1.5-2.5	47	28.83
2.5-3.5	6	3.68
3.5-10	10	6.13
Total	**163**	**100**

Constructed from Geo-Map Consult Data (2016)

Table 46 Total WTP Computation (Ghana)

Frequency Distribution (%)	Total Population	WTP Midpoint (Ghana Cedis)	Total WTP for Electricity (Ghana Cedis	Cumulative Population
5.52	108039	0.25	27009.843	1957039
55.83	1092724	1	1092724.301	1849000
28.83	564271	2	1128541.701	756276
3.68	72026	3	216078.744	192005
6.13	119979	5	599892.5275	119979
100	**1957235**		**3064247.116**	

Constructed from Geo-Map Consult Data (2016)

Table 47: Computation of Expected Revenue

Frequency Distribution (%)	Percentage of households connected	Households connecting at different prices	WTP Midpoint (Ghana Cedis)	Expected Revenue (Ghana Cedis)
5.52	100	1957235	0.25	489309
55.83	94.48	1849196	1	1849196
28.83	38.65	756471	2	1512943
3.68	9.82	192200	3	576601
6.13	6.14	120174	5	600871

Constructed from Geo-Map Consult Data (2016)

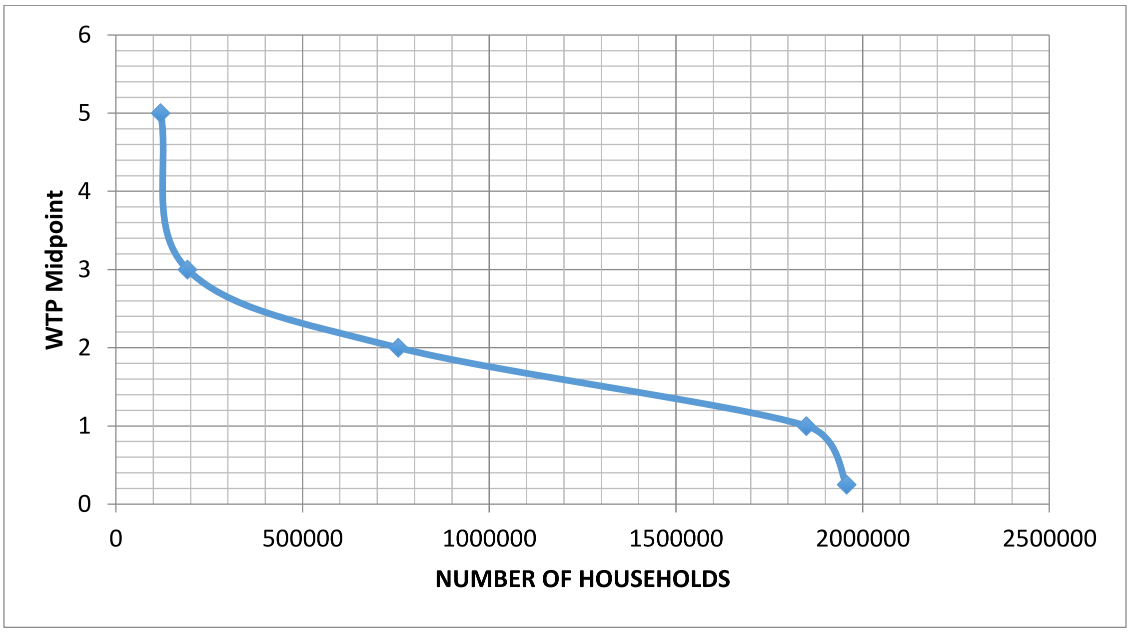

Figure 10: Demand for electricity Curve for communities without light
Source: Constructed from Geo-Map Consult Data (2016)

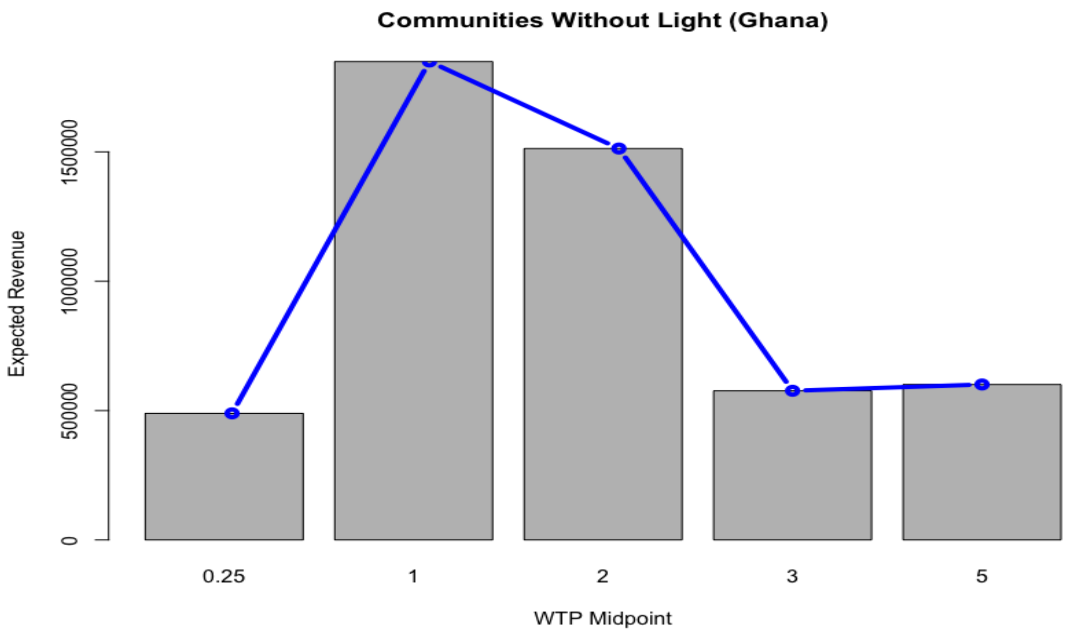

Figure 11 Expected Revenue Curve (CWL)
Source: Constructed from Geo-Map Consult Data (2016)

Table 48 Household income and mean WTP for electricity

Income Group	Mean Household Income (Ghana Cedis)	Mean Household Size	Monthly Mean WTP (Ghana Cedis)	Monthly Income per Head (Ghana Cedis)	WTP as % of Income
Less than 100	66.27	6.78	32.92	9.77	49.67
100 - 300	219.95	7.32	34.32	30.04	15.60
300 - 600	433.67	7.79	45.46	55.68	10.48
600 - 1000	840.92	5.92	69.23	141.97	8.23
Above 1000	2600.00	4.00	45.00	650.00	1.73

From Table 48, respondents with less than 100 Ghana cedis income were willing to pay over 49% of their incomes for electricity. This percentage decreased consistently with increasing income. Thus, people with higher incomes in areas without electricity are willing to pay far less of their incomes for electricity than those with lower income. This may mean that households with higher incomes in communities without lights already have an alternative way of meeting their electricity needs. The proportions of incomes to be paid by those without light exceed the less than 10% requirement to guarantee freedom from energy poverty. The proportion of their incomes households without light were willing to pay was on average 17%. Therefore the WTP values suggest the provision of electricity to these communities on the same terms as those with electricity would create more energy poverty in these communities.

11. POLICY IMPLICATIONS AND RECOMMENDATIONS

The information obtained from households' WTP and value types could be used to improve planning for and allocation of electricity in many ways. One way is to try to compare the WTP values to the cost of providing electricity so as to ascertain how to bridge the gap if need be. From the study, it was realized that the maximum WTP was lower than the current tariff, even when a subsidy of 0.66 Ghana cedis is paid by government. This shows that, the value attached to electricity by households is not high enough to warrant the supply of electricity by utility providers if profits are to be expected by these utility companies. However, due to the fact that electricity is a necessity for economic growth and general human welfare, it will be necessary for government to find a way of subsidizing electricity for those who really cannot afford it.

Cost of supplying electricity

The cost build up for supplying electricity in Ghana has been a cause for concern. While utility companies have been advocating for higher tariffs to meet their cost of operation, households have always be on the defensive against higher tariffs. The question is whether it is the true cost of production, which is high, or that not enough tariffs are being charged. To answer the issue of tariffs, the study shows that based on the value placed on electricity, households are being over charged for electricity. This suggests that the problem may be coming from the supply side. The cost build up has increased dramatically over the past decade. This is due to the fact that cheaper hydroelectric power which allowed a kilowatt-hour to be sold cheaply was no longer available due to low levels of water in the Akosombo/Kpong and Bui dams. Thus the more expensive option – thermal generation has to be used. This has led to astronomical increase in the cost of producing 1kWh of electricity. Here, the cost of fuel to run the thermal plants is a factor as well as inflationary trend and above all exchange rage depreciation in Ghana. For 2016, about US$1.18 billion was needed to purchase fuel to run the country's many thermal plants (Energy Commission, 2016).

In addition, the cost of borrowing to finance electricity projects in the sector at very high interest rates as well as the cost of emergency power plants have been on the high side. The losses due to over aged equipment as well as inefficiency all contribute to raise the cost of production beyond what the ordinary Ghanaian can bear. The World Bank (2013) notes that Ghana's transmission system concentrated in the Southern part of the country is relatively old. These were constructed in the 1970s and have since seen very little improvement. Also, about half of the country's 161-Kilovolts-transmission infrastructure was constructed in the 1960s, and long past its recommended retirement age.

There is certainly a mismatch between the cost build up increase and the income increase that households receive. Therefore it is logical that at some point in time the cost will exceed what the household can bear. This appears to be the point being expressed by the WTP value elicited from households. Under such circumstances, it is clear to observe the low level equilibrium trap in which the electricity sector of Ghana lies. If tariffs keep going up, households will get worse off since the values they attach to electricity will continue to be unaffordable.

Thus, to be realistic enough to give households value for money, the cost of production will have to come down. First, losses will have to be checked, old systems replaced and macroeconomic indicators watched and brought under control – inflation, exchange rate, depreciation, cost of borrowing. This is a very difficult thing to do, particularly in the short to medium term. The easiest solutions however, come from the demand side, a solution option that has been ignored by authorities for over two decades.

In addition, the external cost of running thermal plants has high implications for human health and environmental system health in the country. Given the revelation from the elasticity computations, utility providers will not be in the position to use tariff increases to obtained more resources to provide electricity on a sustainable basis. Thus policy should be looking at alternative sources of electricity, which are relatively cheaper than the current thermal source. Renewable energy sources, most of which stand alone and may not need to go through the entire national grid should be seriously explored since some of the ones available to Ghana are generally cost competitive and eventually more sustainable.

Demand Side Management

Allowing demand response to play a significant role in electricity allocation can get Ghana out of the low level equilibrium trap it finds itself in as far as electricity is concerned. The diagram below explains the issue. Prior to Ghana's electricity crisis, there was sufficient supply of hydroelectricity to power households and the economy as a whole. From the diagram we position Ghana at S_N on the supply side. So the supply of electricity at the time of sufficiency was S_N. During this period the demand for electricity in Ghana was D^0, which was not determined due to purely supply side management. Then came the crisis leading to the shortage and moving Ghana from S_N to S_E supply, the shortage of about 1000MW in the crisis therefore was $Q_NQ_E^0$ given that demand still stayed at D^0. This was actually the situation. When things were normal the tariff was P_N but due to the shortage, suddenly, prices for electricity went high up to $P_N + \Delta P$ which is the difference between the price in good times plus the change (ΔP). Here, the price paid was also made up of loss of output and man hours, the health risks and damage due to persistent and chronic power outages called "Dumsor" in Ghana.

What the Government decided to do was to still try to supply electricity at the high price $P_N + \Delta P$. All the emergency arrangements were to ensure that Ghana continued to supply electricity at the high cost which created the price $P_N + \Delta P$. This is what Ghana up to today is doing. This has contributed to distort the Ghanaian economy leading to the loss of 5.6% of GDP, with the country still counting the cost. This is the supply side management, which is asking people to continue to pay higher tariffs relative to the maximum WTP.

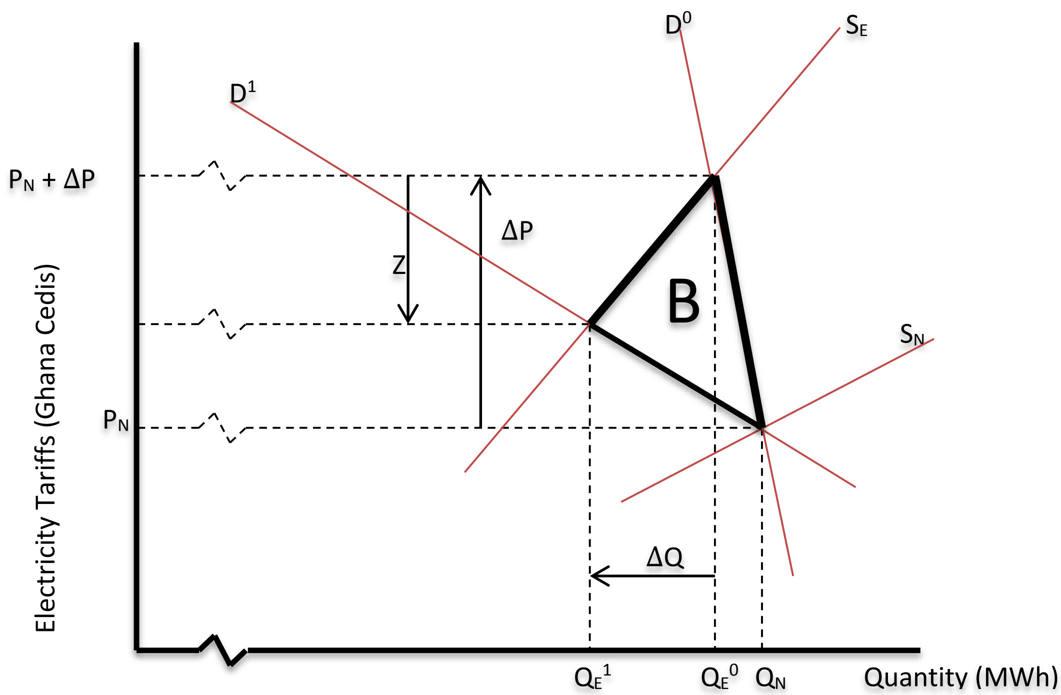

Figure 12: Benefits of demand side management of electricity in Ghana

If Ghana heeds to the call for demand side management, what Ghana will be doing will be to attempt to move the demand curve, which is highly inelastic, from D^0 to D^1, thereby reducing the elasticity of demand for electricity.

When this happens, the shortage will not be gone overnight, but the pressure on the utility companies, government, households and the economy as a whole would have gone down, to provide enough space to sort things out. The new demand curve D^1 would bring prices (tariffs) down by Z. The New Supply would be $Q_E^{1.}$ Note that Ghana would not have gone in for any emergency power badge yet. No extra cost but pressures are down. This brings net economic gains equivalent to the area B (Ruff, 2002).

Since this study has made great strides in the determination of the needed demand function, it remains a challenge to the Energy Commission of Ghana to advice government on quantifying the expected gains and setting the agenda to achieve it. It will be too costly to continue to wait for another peak "Dumsor", which if Ghana delays could surely come. The current brief relief is for such pragmatic demand side management steps to be put in place to restore economic progress back to the Ghanaian economy. Ghana will surely need to energize economic growth through demand side management of electricity.

Perceived Value of Electricity

The WTP value elicited was clearly an expression of the perceived value of electricity by Ghanaians. The relatively low value and the fact that about 70% of Ghana's households demand electricity primarily for non-use value purposes shows that most Ghanaians are not well-informed about the benefits of electricity. If electricity is for leisure and pleasure, then Ghana could be heading for a major output crisis even with a generation capacity of 5000MW.

There should be massive education to raise the awareness of Ghanaians on the benefits they could derive from electricity (i.e. Use value). Electricity is not primarily for pleasure but for work, after which, pleasure could be guaranteed. This to a large extent could raise future WTP and create more room for expansion in electricity infrastructure.

Electricity Subsidies

The CV values showed that income elasticity for electricity was greater than 1 for the bid group 0 – 0.5 Ghana cedis. Thus for these people, electricity is a luxury. The alternative for such people would be to fall back on the use of local sources of lighting, most of which have been shown to have serious health implications. These alternatives also carry high security risks since most of them are open fires. The education of the children of such groups of people will be highly impeded since they would not be in the position to study effectively at home. Thus, the development potential of a critical mass of the Ghanaian society will be compromised if government does not reach out to such people to offer the needed help though subsidies for electricity.

Holistic Pricing Policy

The difference in tariff published by the PURC and the ECG for instance does not create the impression that the welfare of consumers in taken into account in the tariff setting decision. While the PURC's tariffs appear to be lower, they do not include the taxes, levies and subsidies, which eventually determine what consumers really pay. Such a policy disturbs the welfare effect of tariffs, giving the impression that rates are affordable and therefore consumers should be able to pay from the policy regulators but coming out to be unaffordable from the distributor's end. It is worth noting that while the PURC published a tariff of 0.34 Ghana cedis, the ECG's bill based on the tariff was 1.83 Ghana cedis for consuming 1 kilowatt-hour of electricity. This leaves no room for any more tariff adjustment for improvements in the system.

To create room out of the relatively low WTP, government should withdraw all the taxes and charges to allow households to pay only the PURC rate. This will make electricity affordable and create enough room for IPPs to acquire more resources through higher tariffs to develop the sector through demand management. These levies are payments for streetlights, national electrification levy, and service charges. It is worth noting that the service charge of at least 2.13 Ghana cedis is far higher than the approved tariff of 0.34 Ghana cedis. The service charge therefore appears to be the cause of the problem.

This means, based on the PURC approved charges, tariffs are affordable and the electricity sector can comfortably expand to provide better services. The difference between the PURC approved rate (0.34 Ghana cedis) and the WTP of 1.18 Ghana cedis shows that PURC rates are lower than the total economic value placed by households on a unit of electricity by 0.84 Ghana cedis. This means if ECG charges were removed, the WTP will exceed the tariff by 71.2%. Thus the PURC tariff is only 29.8% of what households are willing to pay for one unit of electricity.

Any distributor of electricity must be willing to shed up to 63% of the service charges, otherwise in the event of competition, that distributor will lose out. With the charges removed, tariffs can be increased by at most 0.84 Ghana cedis per unit of electricity which is 247% increase, to reach the total economic value.

Thus, a lot of potential exists in Ghana's electricity sector, but there is a hitch from the distribution end, creating the low level equilibrium trap. Bold and decisive policy response is therefore required from state authorities to save what is left in Ghana's electricity sector.

12. SUMMARY AND CONCLUSIONS

Ghana's economy has suffered from inadequate electricity generation resulting in chronic power outages, which have had negative effects on economic growth. The National Development Planning Commission reported a loss of 5.6% of Gross Domestic Product (GDP) as a result of the crisis (NDPC, 2014). With a current annual growth in electricity requirement of about 10%, the country needs to meet the existing deficit and go the extra mile to create additional supply due to the annual requirement growth. This will need private sector participation in electricity supply and management. However, private sector will only participate if there is motivation through profits. Thus tariffs will need to be economic and be based on sustainable willingness and ability to pay.

In recent times, there have been serious disagreements between government and organized labour unions over tariff increases. The issue of pricing electricity has assumed serious social, political and economic dimensions in Ghana's economy, which could serve as a drag on economic growth and development. Policy makers believe consumers must pay higher tariffs to end the current energy difficulties. Some consumers argue that there have been series of tariff increases in the past, yet much of the problem still persists, hence their reluctance to pay. Other consumers believed they simply could not pay higher tariffs, even though an analysis of their ability to pay had not been scientifically determined. The value Ghanaians assign to electricity will to a large extent determine their willingness to pay (WTP) higher tariffs for electricity.

This study sought to assess the total economic value assigned to electricity in Ghana, which is theoretically equal to the area under the electricity demand curve. Such a value had not been available to guide policy makers on the extent to which tarrifs could be raised in order not to make consumer's worse off. The less value people assign to electricity, the less WTP that can be harnessed for economic growth through tariffs. The study employed the Contingent Valuation Method (CV) to elicit WTP responses from 3100 household heads through a bidding game approach in rural and urban Ghana, initially divided into three zones to capture all the characteristic features of electricity demand from all parts of the country. It also ascertained the factors that determine the willingness and ability to pay for electricity in Ghana. Finally, the study derived a theoretically plausible demand for electricity curve for Ghana and a total revenue schedule for electricity in Ghana through analysis toward private sector delivery of electricity.

The main research questions that the study sought to answer were the following:

1. What is the total economic value of a unit of electricity in Ghana?

2. What factors determine the total economic value of electricity in Ghana?

3. What is the relationship between the total economic value per unit of electricity and the tariff ?

4. Are households able to pay a tariff equivalent to the total economic value?

5. What is the net welfare gain for paying tariffs higher than the current one ?

6. To what extent can electricity tariffs be increased so as not to make the poor worse-off?

The study found that the total economic value of 1 kilowatt-hour of electricity in Ghana was 1.18 Ghana cedis. For commuities without access to electricity the value was much lower. This total economic value mainly composed of non-use value as against use value, 71.45% of respondents indicated their valuation was for non-use value purposes. This has implications for the use of electricity. It means that the current generation of households regards electricity not as an aid to production but for social and cultural purposes. This however did not affect their willingness to pay for electricity since it was not statistically significant.

The results showed that several factors, most of which are supported by economic consumer theory determined the demand for electricity in Ghana. The consistency of the regression results from the different regressions namely OLS, Interval regression and ordered probit regression was an indicator of the robustness of the results and to a large extent attested to its reliability. The different regression results consistently showed that, Age, Income, Availability, Affordability, CPO, Usage, Lighting needs and consumption were statistically significant determinants of the demand for electricity at the 5% level of significance. Apart from Age which had a negative influence on demand for electricity, all the other statistically significant variables influenced demand for positively. Also consistent were the results for the variables which were not statistically significant determinants of demand for electricity at the 5% level of significance. These were Gender, Number of dependents in school, Service rating, Education, Commercial, RFEC and Water. Savings behavior was significant in only the interval regression but not in the OLS and Ordered Probit regressions.

The study also found that household heads were willing to pay on average 8% of their incomes per month for electricity while their monthly end user tariffs were on average 11% of their monthly incomes. Thus households were already paying on average 3% more of their incomes than they would be willing to pay. This trend is consistent in all the zones. Thus, if the British standard of energy poverty being payments beyond 10% of incomes for energy holds, then Ghanaian households are energy poor in terms of end user electricity tariffs. Hence it no surprise that they are willing to pay much lower than the end user tariffs they currently pay.

In addition, the study established that the WTP which yields the highest revenue per day, was 1.75 Ghana cedis. This generates a revenue of 3,045,365.90 Ghana cedis per day for the utility provider. This means that investors would use this WTP as a guide to determine their revenue if they decide to invest in supplying 24 hour service of reliable electricity. It is worth noting that the WTP which gives the highest revenue is lower than current tariff per unit of electricity but higher than the mean maximum WTP.

Thus investors will need to invest in demand side management practices to be able to raise enough revenue to make profit if indeed the current cost structure of electricity supply is the optimum. The other alternative will be to go for better technology, which is able to cut cost such that the tariff will be enough to meet the expectation of investors.

The study found through elasticity computations that the WTP elasticity for electricity demand was inelastic for lower WTP values up to 1.19 Ghana cedis, becoming unitary elastic at 1.2 Ghana cedis and after that becoming elastic. Realizing that the point of unitary elasticity was just 0.02 Ghana cedis more than the mean WTP for a unit of electricity, there will be no room for the utility companies to increase tariffs, since their tariffs for 1 kilowatt-hour of electricity exceeds 1.2 Ghana cedis. As a matter of fact the tariffs as they stand currently have exceeded the point of unitary elasticity and entered the area of elastic WTP for electricity. This demonstrates the need to employ demand side management, since demand response will be crucial in getting utility companies to attract tariffs from households. Only a supply side approach will certainly be ineffective.
With respect to the zonal effects, it is worth noting that both the Middle and Southern Zones have fallen within the elastic WTP region. Only the Northern Zone has some room for further tariff increases based on the maximum willingness to pay.

The results of income elasticity of WTP show that a 24-hour supply of reliable electricity is a necessity for all the zones individually as well as for all the regions. This is shown by the fact that income elasticity of WTP is income inelastic, since the elasticities are positive and less than one, except in the case of the lowest WTP range. For the WTP range of 0 to 0.5 Ghana cedis, the WTP for electricity shows that it is a luxury. This will certainly be welcoming news for policy, to use electricity subsidy to get them out of their low income status, since electricity in this age must not be considered as a luxury, except where there is serious ignorance as to what it stands for.

Ghana's electricity sector has huge potential for development, to ease the country's energy difficulties and help Ghanaians launch a modern and more determined approach towards production and wealth creation. There is however a low level equilibrium trap impeding Ghana's effort towards enjoying the fruits of development through the use of reliable and affordable electricity. Demand side management of electricity supported by bold and decisive public policy towards efficiency will be needed to get out of the trap to energize economic growth and development in Ghana.

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APPENDIXES

APPENDIX A : QUESTIONNAIRE

KNUST – DEPARTMENT OF ECONOMICS
RESEARCH ON: ASSESSING THE TOTAL ECONOMIC VALUE OF ELECTRICITY IN GHANA: A STEP TOWARD ENERGIZING ECONOMIC GROWTH
QUESTIONNAIRE

Introductory Statement and Payment Conditions:

This research is to clarify issues and give understanding about the values and preferences people place on electricity. Some of the questions may involve issues you have never focused on, so take your time, and where you are not sure about anything, please feel free to say so. Your responses will be confidential. They will be regarded as opinions and hence there are no right or wrong answers. Honest answers will go a long way to provide a means of assessing the best way to handle the issues that have to do with the provision of electricity in Ghana.

Date of Interview …………………………………………… Identification Code ………………………………………………………

Location: ……..

1. Gender: Male [ ] Female [ ]
2. Occupation ………..
3. Age: ……………………………………………………………..
4. Marital Status: Married [ ] Single [ ] Widowed [ ] Divorced [ ]
5. Number of immediate dependents: ………………………………………………………………………………………………..
6. Number of dependents in school: …………………………………………………………………………………………………..
7. Number of people in your household: …………………………………………………………………………………………….
8. Highest of Education: ……
9. Monthly Income: ………
10. What do you use electricity for in your home?
    Light for household [ ] Washing machine [ ] Fan [ ] Fridge [ ]
    Hair Drying [ ] Air conditioner [ ] Cooking [ ] Ironing [ ] TV [ ]
    Other(s) ………..
11. How important is electricity to your household?
    Very important [ ] Fairly important [ ] fairly unimportant [ ] Not important [ ]

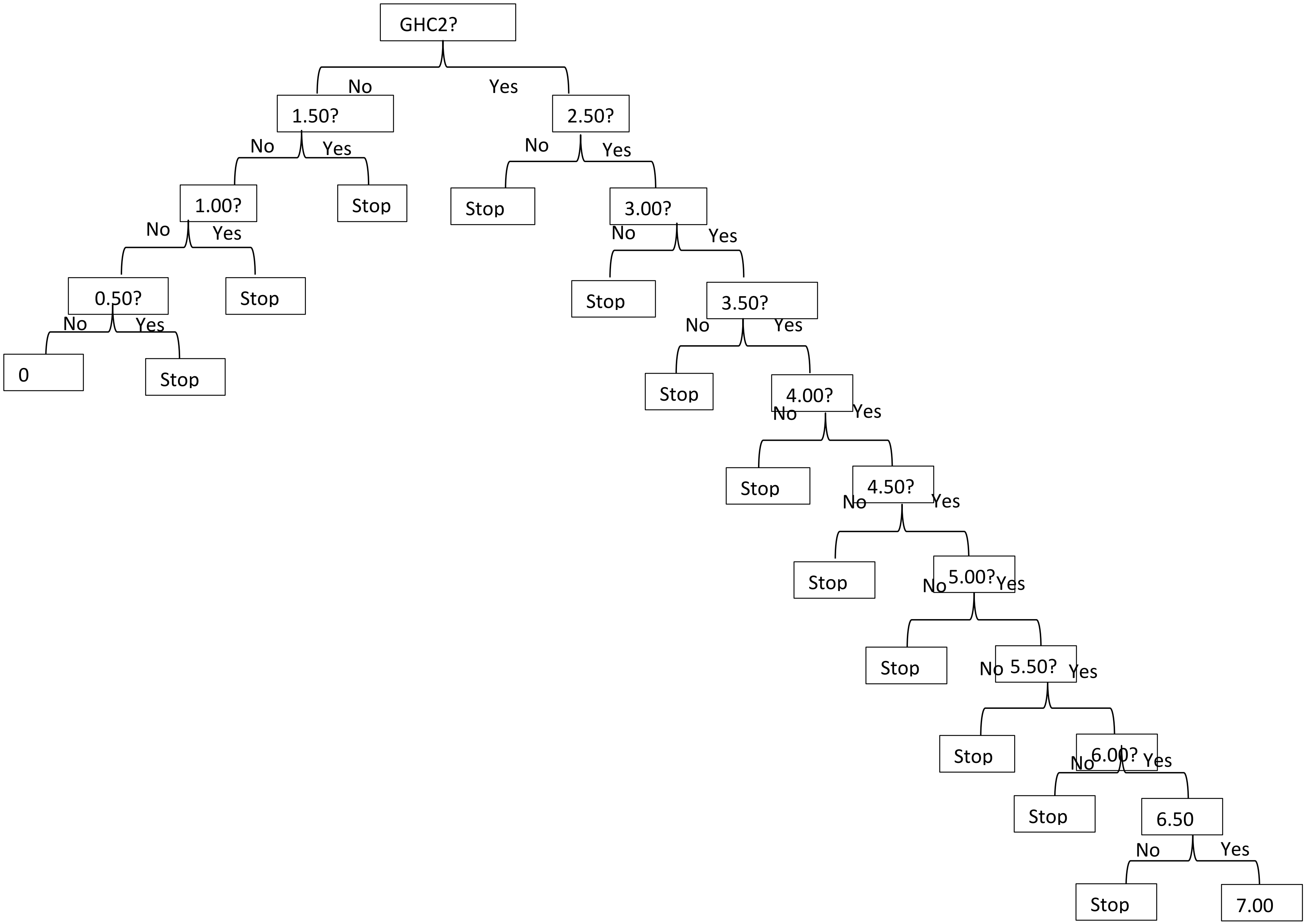
12. (a) What benefits do you derive from electricity? ……………………………………………………....................
………
………
………
………
………
………………………………………………….
(b) Do you really lose anything in a day when you do not have electricity? Yes [ ] No [ ]
If Yes, what do you lose?
……………………………………………………………………………………………………...
………
………..……….
…………………….………………………………………………………………………………………………….
…………………………………..
13. Check the following characteristics of your current electricity supply
Always available [ ] Available most of the time [ ] Available some of the time [ ]
Not available most of the time [ ] Scarcely Available [ ]
14. (a) How much electricity bill do you pay each month?
……………………………………………………………
(b) Are your bills affordable? Yes [ ] No [ ]
15. How much do you spend in a day to provide light for your household when there is power outage?
……..
16. What are the sources of light you use when there is power outage? ……………….....................
17. (a) Would you be better off if you had 24 hour power supply each day without interruptions?
………
…………...
(b) In what way? ………………………………………………………………………………………………………...
………
…………...……….
……………………….

18. How does the power crisis affect you? ………………………………………………………………………..
....
....
19. How would you describe the services currently provided by ECG/VRA to you (e.g. Response to calls to repair faults, billing system, purchase of units, etc.)?
Very good [ ] Good [ ] moderately good [ ] Poor [ ] Very poor [ ]

BIDDING GAME

The purpose of this survey is to assess the viability of providing electricity for this community. The Energy Commission of Ghana has realized the importance of providing electricity to communities that have no access to reliable electricity. However, due to the huge expenditure required, which government alone cannot afford to bear because of the numerous services it has to render to the populace, e.g. road construction, building schools and hospitals, etc., it has become necessary to ask some private organizations to participate in the provision of electricity with their own money and resources. This implies that the private firms will expect some profit for their investments. These firms would supply electricity to your community 24 hours a day. Each consumer would be expected to pay for the electricity they consume to an agent of the private firm who would be posted at the community to collect payments on daily or weekly basis.

20. Suppose you are supplied with a 24-hour daily service of reliable electricity in your home each time you need it, how much would you be willing to pay for one day's worth of it?


GHC2?
No
Yes
1.50?
2.50?
No
Yes
No
Yes
1.00?
Stop
Stop
3.00?
No
Yes
No
Yes
0.50?
Stop
Stop
3.50?
No
Yes
No
Yes
0
Stop
Stop
4.00?
No
Yes
Stop
4.50?
No
Yes
Stop
5.00?
No
Yes
Stop
5.50?
No
Yes
Stop
6.00?
No
Yes
Stop
6.50
No
Yes
Stop
7.00

21. (For those who make zero bid)
Could you please explain why you are not willing to pay any money for electricity to be supplied by a private firm?
[ ] Access to electricity should be free
[ ] Lack of money
[ ] the district assembly should pay
[ ] I prefer to use other sources of energy
[ ] Other (please specify) …………………………………………………………………………………………………
22. Suppose you are given the option to work for your community, for example, on the farm or on a construction project to pay for the amount of electricity you would use in a month when connected to the grid. For how many days would you work? …………………………………………………..
23. To what extent is your willingness to pay for electricity influenced by the following considerations?

		Very Much	Moderately	Not at all
i.	Electricity for children and future generation	[ ]	[ ]	[ ]
ii.	Electricity as a status symbol for community	[ ]	[ ]	[ ]
iii.	Electricity for security	[ ]	[ ]	[ ]
iv.	Electricity as a necessity for socio-economic development	[ ]	[ ]	[ ]

24. Do you try to conserve electricity? Yes [ ] No [ ]
25. How do you do it? ……..
………
…………..
26. Why would you need to conserve electricity? ………………………………………………………………………………
………
………
………………………..
27. How many bulbs do you use in your household? ……………………………………………………………………………
28. What is the wattage of each bulb you use? ………………………………………………………………………………..
29. How much do you spend on water in one month? ....
30. How much do you save in one month? ....

Thank you for your time and attention

APPENDIX B: REGRESSION RESULTS USED IN ELASTICITY CALCULATION

GHANA

WTP	Coefficient	Std. Error	t	P-value
Intercept	5.7657	0.0327	176.06	0.0000
Q	-8.1923	0.1094	-74.88	0.0000
Q^2	5.2102	0.0981	53.12	0.0000
Q^3	-1.1411	0.0249	-45.87	0.0000
Observations				3100
F-statistic				8464.95
P-value				0.0000
R^2				0.8913

Ashanti

WTP	Coefficient	Std. Error	t	P-value
Intercept	5.680973	0.0594587	95.54	0.000
Q	-19.58928	0.4566748	-42.9	0.000
Q2	28.58934	0.9413296	30.37	0.000
Q3	-14.153	0.549005	-25.78	0.000
Observations				1259
F-statistic				2530.17
Prob > F				0.000
R-squared				8578

Greater Accra

WTP	Coefficient	Std. Error	t	P-value
Intercept	6.427447	0.056384	113.99	0.000
Q	-20.96044	0.4702315	-44.57	0.000
Q2	32.66534	1.052555	31.03	0.000
Q3	-17.8577	0.666692	-26.79	0.000
Observations		=		868
F(3, 864)		=		5304.46
Prob > F		=		0.000
R-squared		=		0.9215
Root MSE		=		0.4135

Northern Zone

WTP	Coefficient	Std. Error	t	P-value
Intercept	4.901704	0.053238	92.07	0.000
Q	-40.66877	1.074782	-37.84	0.000
Q^2	159.8272	5.8235	27.45	0.000
Q^3	-218.2318	8.928502	-24.44	0.000
Observations		=		973
F-statistic		=		3349.38
Prob > F		=		0.000
R-squared		=		0.8769
Root MSE		=		0.41356

Ashanti Region:

WTP	Coefficient	Std. Error	t	P-value
Intercept	1.1149	0.0727	15.34	0.000
Income	0.0011	0.0001	8.5	0.000
$(Income)^2$	-1.87E-07	3.41E-08	-5.48	0.000
Observations		=		1,259
$F(2, 1256)$		=		28.42
Prob > F		=		0.000
R-squared		=		0.0661

Greater Accra:

WTP	Coefficient	Std. Error	t	P-value
Intercept	1.75464	0.1070224	16.4	0.000
Income	0.0007737	0.0001592	4.86	0.000
$(Income)^2$	-1.01E-07	3.90E-08	-2.6	0.010
Observations		=		868
$F(2, 865)$		=		16.38
Prob > F		=		0.000
R-squared		=		0.0432

Northern Zone

WTP	Coefficient	Std. Error	t	P-value
Intercept	1.03688	0.0691613	14.99	0.000
Income	0.0013596	0.000142	9.57	0.000
$(Income)^2$	-1.99E-07	4.19E-08	-4.74	0.000
Observations		=		973
$F(2, 970)$		=		44.59
Prob > F		=		0.000
R-squared		=		0.1267

APPENDIX C LIST OF PARTICIPANTS

ROLE	NAMES
PRINCIPAL INVESTIGATOR	DR. JONATHAN D. QUARTEY
CO-INVESTIGATOR	WISDOM D. AMETORWOTIA
RESEARCH ASSITANTS 1	EMMANUEL OTOO
RESEARCH ASSISTANT 2	FELIX BOAKYE-YADOM
INTERVIEWERS 1	IRENE ATADANA
INTERVIEWERS 2	AHMED HADI
INTERVIEWERS 3	AHMED MASHUD
INTERVIEWERS 4	CLEMENT ASAANA
INTERVIEWERS 5	SIMON BLEMADZIE

APPENDIX D: Institutions visited and individuals interviewed

- Energy Commission of Ghana
  - ✓ Director, Technical Regulation (Dr. N.D.K Asante)
- PURC (Regional Complaints Manager) (Mr. Edward Boduah) Kumasi
  - ✓ Principal Engineer (Electrical) Accra (Mr. Fiasorgbor Nutifafa Kodzo)
- TUC (Regional Industrial Public Relations Officer at the Public Utility Workers Union of the TUC, Ashanti Region) Mr. Jones Owusu Afriyie
- National Development Planning Commission (NDPC)
  - ✓ Principal Planning Analyst (Mr. Nelson Winfred)
- ABANTU for Development
  - ✓ Executive Director (Dr. Rose Mensah-Kutin)
- Multigoldlink Limited, Kumasi
  - ✓ General Manager for Operations (Mr. Joshua Sarpong Kumankuma)
- Electricity Company of Ghana (ECG)
  - ✓ Personnel Officer (
- Ghana Grid Company Limited (GRIDCo)
  - ✓ Project Engineer, Tema (Mr. Ebenezer Wilberforce Oakley)
- Volta River Authority (VRA)

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