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Improved Electricity Supply: What Factors Determine How Much Domestic Customers are willing to Pay in Tamale Urban and Peri-Urban Areas?

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Authors' contributions

This work was carried out in collaboration between all authors. Author DSE designed the study and wrote the protocol. The background and the literature were written by author DT. Author FNM wrote the methodology and did the analysis. All authors read and approved the final manuscript.

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ABSTRACT

The paper estimates households' willingness to pay (WTP) for improved supply of electricity in Tamale Urban and Peri-Urban Communities. A contingent valuation method (CVM) was used to determine the stated WTP amount and its determinants. The results from the CVM indicate that households are willing to pay an additional amount of Gh¢0.2232 (US$0.0698) for 1kWh of improved electricity. From the double-logarithmic econometric model results, education, residential ownership status, age of household head, household size, household's monthly income, monthly blackout duration and monthly electricity bill are factors that significantly influence the WTP amount for uninterrupted supply of electricity. It is therefore important for the electricity service providers in the study area to improve their services and increase the electricity tariff by Gh¢0.2232 (US$0.0698) per kWh since domestic customers are willing to pay such amount for quality services. Private organisations which have the capacity to provide reliable supply of electricity should capitalise on the poor services provided by Volta River Authority of Northern Electricity Department Corporation (VRA-NEDCo) and supply reliable electricity so as to enjoy the higher tariff that households are

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willing to pay. Also, it is recommended that social intervention programmes which aim at increasing the level of household incomes should be implemented to help them increase their WTP amount.

Keywords: Contingent valuation method; electricity; willingness to accept and willingness to pay.

1. INTRODUCTION

Energy serves as one of the most important commodity globally and Ghana is not an exception. The supply and demand dynamics of energy is manifested in global economies. Besides, energy serves as a driver for sustainable social and economic development because it powers all sectors of an economy spanning from transportation, health, industry to households. As indicated by [1], the practical demonstration of the linkage between energy and economic development can be traced to the global economic crisis which hit non-oil producing economies in 1975 when the Arab oil producing countries decided to reduce the production of oil. It is worth noting that many countries suffer in one form or the other when there is short supply of crude oil by the Oil Producing and Exporting Countries (OPEC).

Over the years, both developing and advanced economies have engaged in various reforms and diversification strategies to power their economies. Key components of these reforms are policies geared towards increasing quality, reliable and affordable power supply to meet the increasing demand of their expanding economies. These have led to huge exploitation and investment in different alternatives for energy production. Developed economies like UK, USA, and China have been successful in producing energy from renewable sources, nuclear, and coal apart from the traditional hydro sources.

Electricity has been a major component of energy demand in Ghana and its inadequacy in recent times has led to significant losses in both industrial and domestic sector. It is however no doubt that, there is a direct linkage between energy supply and economic development implying energy is a driver of economic activities. [2] concluded from his research that “there exists a unidirectional causality running from economic growth to electricity consumption”. The Ghana energy ministry indicates that, electricity has been the dominant modern energy used in the industrial and service sector accounting for 69% of modern energy used in the two (2) sectors of the national economy.

Choynowski [3] explained that, access to electricity is the function of availability and affordability, and that demand for electricity is a derived demand since electricity is an input into the production of services from a stock of electricity consuming- equipment’s in the household. In terms of consumer pricing of utilities, electricity for instance is mostly subsidized in most countries. Electricity as an essential commodity in Ghana is provided by the central government at a subsidized rate.

The electricity tariff increased by 78.9% on 26September 2013, which was later, reduced to 59.2% by the government after the outcry of Ghanaians. With this decision, government would be spending GH¢400 million per annum as subsidy. Meanwhile, government already owe Volta River Authority an accumulated amount of GH¢509million. In spite of the recent increase in electricity tariff, the average cost of generating, transmitting and supply of electricity is still above the tariff charged. Also, irrespective of this increase in tariff, domestic customers are still experiencing intermittent power outages which are affectionately called *dumsordumsor* in Ghana. International Monetary Fund (IMF) and World Bank have urged government to scrap the subsidies since poor people are not benefiting as most of them do not have access to electricity. Rather, government should spent resources in pro-poor social interventions.

Twerefou [4] noted that there has been perpetual outcry for the service providers to improve service delivery. It is estimated that about half of the electricity is consumed in our residential homes. Electricity is commonly used in domestic homes for lighting, powering television, powering radio, conditioning, refrigeration, ironing, cooking, powering of computers, charging of mobile phones etc. The electrical appliances of many domestic customers have unduly been damaged because of intermittent power outages and low voltages. There is one school of thought which argues that customers are intentionally made to pay the price of not paying for the full cost of electricity tariff through deliberate intermittent power interruptions by service providers. Many households of late are calling for privatisation of electricity service providing companies on the condition that it will ensure an improved electricity supply. One then need to establish the fact that significant numbers of households are willing to pay higher tariff for improved supply of electricity and the willingness to pay (WTP) amount is high enough to cover the cost of electricity generating, transmission and supply. Another important concern is what are the factors that influence a household's WTP amount?

A research which aims at investigating amount of money domestic consumers are willing to pay for improved electricity supply will go a long way to help policy makers design policies which aim at improving service that are provided. Also, the factors that influence household's WTP amount need to be identified so that private investors and government can implement programmes to increase the WTP amount [4].

2. LITERATURE REVIEW

2.1 The Concept of Contingent Valuation

The concept used in conducting any research has its genesis. The Contingent Valuation Method (CVM) was first proposed and used in 1947 by Siegfried von Ciriacy-Wantrup, a German Environmental and Resource Economist. Irrespective of the vital role played by Siegfried von Ciriacy-Wantrup in pioneering the development of CVM, it was not practically used until 1963. [5] practically used CVM to estimate the value that hunters and tourists place on marine wood. [6] asserted that it was Davis practical application of CVM that resulted in its breakthrough in academia.

The CVM involves the use of field survey to elicit market valuation of non-market goods base on the theory of utility maximisation. Non-market goods are difficult to price. Meanwhile, with the evolution of CVM, economists are able to assign monetary values for non-market goods. There are two approaches to assigning prices to goods. These are stated preference approach and revealed preference approach. Even though, both approaches use utility maximisation theory, the stated preference approach uses willingness to pay to value a good. On the other hand, the revealed preference approach uses the real monetary values that people actually commit in using, or accessing any resource [7]. With CVM, an individual is asked to state how much money he/she would be willing to pay to maintain or increase the level of satisfaction in enjoying from the use of an environmental resource or any non-market good. Also, in another instance an individual can be asked to state the amount of money he/she would be willing to accept as a compensation for the loss of the whole resource or the loss in quantity or quality of part of the resource. This latest valuation method is called willingness to accept (WTA).

2.2 Assumptions underlying the use of CVM

As CVM uses theory of utility maximisation, there is the need to outline the assumptions underpinning the use of this method. The value that an individual place on a non-market good is opined on the decisions he/she makes. In making decisions, the rationality assumption is very crucial. Also, utility is assumed to be cardinal and hence individuals can assign monetary value to any change in quality or quantity of a non-market good. Lastly, it is assumed that the respondents have well knowledge on the value of the good under valuation.

2.3 Economic Valuation

According to [8], every resource has both use and non-use values. The use values can easily be valuated but this is not the same as non-use values. Meanwhile, the implicit value of non-use value is not zero. For instance, it is possible for one to actually assign monetary value to the fact that he/she has light but not black out. Some people may not loose in monetary terms when there is black out but they may lose some satisfaction of not enjoying light. Therefore, electricity has both use and non-use values. It is possible for one to use both revealed and stated preference approaches in determining the use values of a good. With non-use value, one can only use stated preference approach and this involves the construction of a hypothetical market. As indicated in Fig. 1, choice modelling and CVM is used to estimate use and non-use values of resources through the construction of a hypothetical market [9]. Based on revealed preference approach (which uses real market prices), travel cost method, hedonic pricing method, averting expenditure approach and market pricing methods are developed.
Meanwhile, [4] grouped valuation methods into two namely pecuniary and non-pecuniary methods. The pecuniary method assigns monetary value to resources whilst non-

pecuniary valuation method does not assign monetary value to resources. From Fig. 1, it can be concluded that CVM can be used to find the use and the non-use value of a resource. As such, [4] categorically asserted that this is a major merit of CVM over other methods.

3. METHODOLOGY

3.1 Theoretical Concept

The theoretical concept of WTP and WTA is linked to Hicksian measurement of Compensating Variation (CV) and Equivalent Variation (EV). Assuming an individual is supplied a certain quantity of electricity due to inability of the electricity company to provide the desirable need of the individual. This quantity of electricity supplied in a month is denoted Q_E^0 (quantity of electricity consumed due to frequent power outages and low current). Assuming there is improvement in the supply of electricity, thus the individual is now supplied Q_E^1 kWh per month and this is the quantity that provides full satisfaction to the individual due to uninterrupted power supply. From Fig. 2, IC_1 and IC_2 are indifference curves which show the relationships between quantity of electricity and income. The indifference curve IC_2 has a higher utility (U_2) than the indifference curve IC_1 with a utility of U_1. As far as the individual remain on any point along an indifference curve, he/she would enjoy a constant utility (welfare) irrespective of the quantity of electricity supply. A movement from

IC_1 to IC_2 represents an improvement in welfare and vice versa.

With an energy consumption of Q_E^0, an individual pays electricity bill which is equivalent to income Y_0 and at this level the individual enjoys a lower utility U_1 at point *A*. An improvement in the supply of electricity makes the individual to consume Q_E^1 with constant income Y_0 but at a higher utility U_2 at point *D.* The increase in utility as a result of the increase in the quantity of electricity consumption is the same as the increase in utility as result of the increase in income implying the interval AB and CD are equal. Technically, AB is the maximum amount an individual would be willing to pay to enjoy Q_E^1 at constant level of income, Y_0. The amount AB is called equivalent surplus or WTP which is a change in income that is equivalent to a change in energy consumed. The amount CD is called compensating surplus or WTA since it indicates the amount of money that need to be used to compensate an individual for a reduction in utility from U_2 *to* U_1 as a result of the decrease in the quantity of electricity supplied. In reality, WTP and WTA amounts are not equal [10-12]. [13] ascribed income effects, substitution effects, transaction costs and loss of aversion as the main cause of the discrepancies.

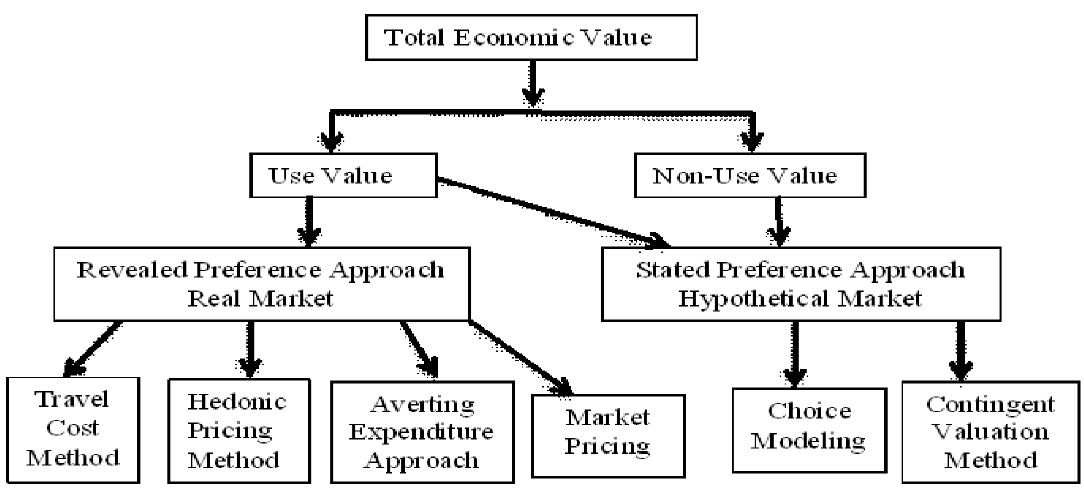

Fig. 1. Economic valuation methods
Source: [7]

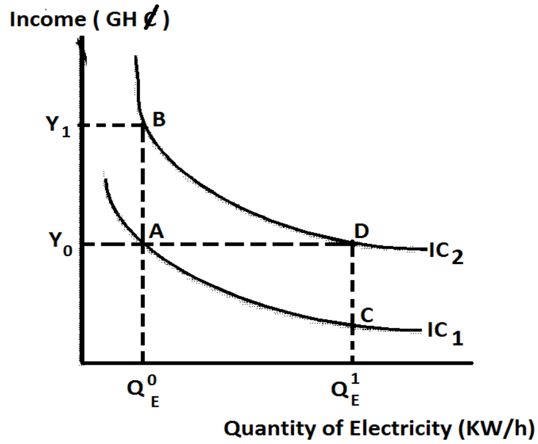

Fig. 2. Indifference curves for electricity supply

3.2 Theoretical Framework for WTP

The expenditure function has been used to derive WTP for resources. [14] have criticised that this analysis is difficult and laborious for empirical studies since utility levels cannot easily be measured. Therefore, [15] used indirect utility function to derive WTP for safe drinking water in Vietnam. This is derived from the theory of consumer behaviour. When there is unreliable supply of electricity the well behaved indirect utility function of a household is given as:

$$V = V\left(P,\quad Q_E^0,\quad Y_0\right) \qquad (1)$$

Where *P* is the exogenous price vector.

When the individual household is willing to pay Gh¢*w* for improvement in the supply of electricity by *E*kWh of energy, the indirect utility function becomes:

$$V^1 = V^1\left(P,\quad Q_E^0 + E,\quad Y_0 - w\right) \qquad (2)$$

With the assumption of equilibrium market conditions, the two equations are equivalent and can be written as:

$$V\left(P,\quad Q_E^0,\quad Y_0\right) \approx V^1\left(P,\quad Q_E^0 + E,\quad Y_0 - w\right) \qquad (3)$$

It is assumed that the improvement in the quality of electricity supply and the change in income due to the demand for quality service are very small. This implies that the first order approximation of $V^1 = V^1\left(P,\quad Q_E^0 + E,\quad Y_0 - w\right)$ is given as:

$$V^1\left(P,\ Q_E^0 + E,\ Y_0 - w\right) = V\left(P, Q_E^0, Y_0\right) + \frac{\partial V\left(P, Q_E^0, Y_0\right)}{\partial Q_E^0}E - \frac{\partial V\left(P,\ Q_E^0,\ Y_0\right)}{\partial Y_0}w \qquad (4)$$

Addition of equations (3) and (4) gives:

$$0 = \frac{\partial V\left(P,\ Q_E^0,\ Y_0\right)}{\partial Q_E^0}E - \frac{\partial V\left(P,\ Q_E^0,\ Y_0\right)}{\partial Y_0}w \qquad (5)$$

Making *w* the subject gives the WTP bids.

$$WTP = w = \frac{\partial V\left(P,\ Q_E^0,\ Y_0\right) / \partial Q_E^0}{\partial V\left(P,\ Q_E^0,\ Y_0\right) / \partial Y_0}E \qquad (6)$$

Where $\frac{\partial V\left(P,\ Q_E^0,\ Y_0\right)}{\partial Q_E^0}$ is the marginal utility for improvement in electricity supply. So, when a household has no marginal utility for improvement in electricity supply, it implies that the left hand side of equation (6) will be zero making the WTP zero. Household with zero marginal utility for improvement in electricity supply are those whose utility do not change in response to the improvement in the supply of electricity.

Also, $\frac{\partial V\left(P,\ Q_E^0,\ Y_0\right)}{\partial Y_0}$ is a measure of the marginal utility for money. People with large marginal utility for money will have zero WTP. This is because such people are very poor and will not use the increase in their income to pay for reliable electricity supply but rather they will commit those funds into buying basic necessities of life such as food, water and clothing.

Taking the natural log of equation (6) gives:

$$\ln WTP = \ln\left[\frac{\partial V\left(P,\ Q_E^0,\ Y_0\right)}{\partial Q_E^0}\right] - \ln\left[\frac{\partial V\left(P,\ Q_E^0,\ Y_0\right)}{\partial Y_0}\right] + \ln E \qquad (7)$$

Equation (7) implies that WTP depends on marginal utility for improvement in electricity supply, marginal utility for money as well as the quality of service provided.

3.3 Empirical Model for WTP

Considering the fact that WTP in this research is measured as a continuous variable, a multivariate regression either semi-logarithmic or double logarithmic or linear can be used to identify the determinants of WTP for uninterrupted electricity supply. It can also be used to determine the magnitude of their effects on WTP for uninterrupted electricity supply. The amount consumers are willing to pay depends on certain socio-economic characteristics and electricity attributes. Due to the fact that the amount of energy consumed is proportional to the electricity bill charged and easy access of information, the researchers used monthly electricity bill instead of the quantity of energy consumed. The empirical model for factors that affect WTP for uninterrupted electricity supply can be derived from equation (7) above.

Following [15,16], a modified multivariate empirical regression model is stated as:

$$\ln WTP_i = \beta_0 + \beta_1 Sex_i + \beta_2 MStat_i + \beta_3 Edu_i + \beta_4 RS_i + \beta_5 Gen_i + \beta_6 Avt_i + \beta_7 \ln(Ag_i) + \beta_8 \ln(HHS_i) + \beta_9 \ln(Inc_i) + \beta_{10} \ln(BR_i) + \beta_{11} \ln(BOD_i) + \beta_{12} \ln(Sat_i) + \beta_{13} \ln(Bil_i) + \varepsilon_i \text{..........(8)}$$

The above model was subjected to econometric analysis. The double logarithmic results were tested for multicollinearity and autocorrelation. The Variance Inflation Factor and the Breusch-Pagan/Cook-Weisberg test were used to check respectively whether or not multicollinearity and heteroscedasticity exist. Also, the value of R-squared adjusted was used to determine the goodness of fit of the model. A summary of how the explanatory variables were measured and the *apriori* expectations are presented in Table 1.

3.4 Data Collection and Sampling

As noted by [4], improved (uninterrupted) electricity supply is unavailable in Ghana and hence one need to value the provision of such service by developing a hypothetical market. This research collected data on the households' stated WTP bid for improve provision of electricity. Households' socio-economic characteristics were collected and analysed to determine factors that influence WTP bids. Multistage sampling technique was employed. Firstly, the study area, urban and peri-urban Tamale Metropolis was purposively selected due to cluster of population and the diversity in the socio-economic characteristics of the people. Also, people who are connected to the national electricity grid were purposively selected. This was done to make sure that the respondents understand the hypothetical make that is created for the survey. Systematic sampling technique was used to select the respondent households. Every 10th house was selected and the household was interviewed. If there are more than one household in the house, only one is interviewed. A semi-structured questionnaire was used for the data collection. The interview was face-to-face.

The researchers created a hypothetical market for the improved electricity supply. This improved electricity supply includes constant supply of 220volts of electricity which is safe for any domestic electrical gadgets. It was also assumed that the improved electricity supply will be provided irrespective of their response. Both open ended and closed ended questions were asked. The number of households interviewed is 310 but 293 questionnaires were used for the analysis. This is because only 17 respondents indicated that they are not willing to pay for any improvement in electricity supply. Therefore, using 17 respondents who are not willing to pay against 293 respondents who are willing to for choice modelling will be biased.

3.5 Study Area

The Tamale Metropolis is one of the six Metropolitan Assemblies in the country and the only Metropolis in the three Northern Regions of Ghana. It shares boundaries with five districts namely the Savelugu- Nanton to the North, Yendi Municipal Assembly to the East, Central Gonja to the South West, East Ganja to the South and Tolon-Kumbungu to the West. The Metropolis has a total estimated land size of 750 km sq which is about 13% of the total land area of the Northern Region. There are a total of 197 communities in the Metropolis of which 33 are urban communities whilst others are peri-urban communities. All the communities in the Metropolis are connected to the national grid of electricity.

4. RESULTS AND DISCUSSION

4.1 Descriptive Statistics

Table 2 in appendix 1 shows the means, the standard deviations, the minimum and maximum values of the continuous variables used in the WTP model. It is shown in the table that the maximum and the minimum monthly WTP amount are Gh¢100.00 and Gh¢2.00 respectively. Averagely, each household is willing to pay Gh¢12.89 monthly to enjoy improved supply of electricity. Also, each household averagely experienced two days, six hours of blackout duration of electricity in the study area. The frequency distribution of discrete variables used in the model is represented in Table 3 of appendix 2. Averagely, the amount of money that households in Tamale urban and peri-urban areas are willing to pay per 1kilowatt-hour of energy just in the bid to enjoy uninterrupted supply of electricity is Gh¢0.2232 (US$0.0698).

4.2 Determinants of WTP

Table 4 shows the empirical results of the factors influencing the amounts households are willing to pay for improved electricity supply. The explanatory variables are indicated in the first column whilst the elasticities and marginal WTP amounts are represented in the second and the last column respectively. The Variance Inflation Factor (VIF) mean value of 1.44 is far less than10 implying that there is no statistical significant multicollinearity among the regressors. Also, Breusch-Pagan/Cook-Weisberg test was used to check whether or not heteroskedasticity exist. From the test, the Chi-Sqaure value of 0.08 with the probability value of 0.7760 suggests that the null hypothesis of constant variance is accepted. This means that heteroskedasticity is absent and hence the variance of the error term is constant or homoskedastic. It is also clear from Table 4 that the adjusted R-Sq is 0.7747 implying 77.47% of the variations in regressand (WTP amount) are explained by the explanatory variables. It is important to note that the F-statistic (144.21) is significant at 1% meaning that the regressors jointly and significantly affect the WTP amount for reliable electricity supply in Tamale urban and peri-urban areas.

From the table, education, residential ownership status, age of household head, household size, monthly household income, monthly blackout duration and monthly electricity bill are the factors that significantly affect the WTP amount for uninterrupted supply of electricity. Meanwhile, sex, marital status, whether or not a household has a generator, whether or not a household adopts any averting actions to minimise the effects of frequent power outages, the number of bedrooms in the house and the level of satisfaction about the services provided by the electricity company do not statistically influence how much one is willing to pay. Out of the seven significant explanatory variables mentioned above, only education that does not meet the *a priori* expectation.

Table 1. Description, measurement and a priori expectations of explanatory variables

Variable	Description	Measurement	A priori expectation
Sex	Sex	Female = 0, Male = 1	+
MStat	Marital status	Not married = 0, Married = 1	-/+
Edu	Education	Not educated = 0, Educated = 1	+
RS	Residential status	Tenant = 0, owned a house = 1	+
Gen	Generator ownership	Do not owned a generator = 0, Owned a generator = 1	+
Avt	Whether the respondent use some gadgets in averting the effects of blackout or not	No = 0, Yes = 1	+
Ag	Age	Years	-
HHS	Household size	Number of people who feed from the same pot	-
Inc	Household monthly income	GH¢	+
BR	Number of bed rooms	Counting numbers	
BOD	Number of blackout hours per month	Hours	+
Sat	Level of satisfaction for reliability of electricity supply	1 = Very dissatisfied 2 = Dissatisfied 3 = Indifferent 4 = Satisfied 5 = Very satisfied	+
Bil	Monthly electricity bill	GH¢	+

Table 4. Results of double logarithmic model for WTP amount

Variable	Coefficients (elasticity)	Standard error	P-value	Marginal effects (Marginal WTP)
Sex	0.0068	0.0118	0.563	0.0238
MStat	–0.0112	0.0145	0.438	–0.0359
Edu	–0.0376	0.0190	0.048**	–0.1009
RS	0.0288	0.0076	0.000***	0.1799
Gen	–0.0019	0.0036	0.594	–0.0337
Avt	0.0140	0.0174	0.423	0.0393
lnAg	–0.2947	0.1639	0.072*	–0.1719
lnHHS	–0.0783	0.0206	0.000***	–0.1278
lnInc	1.8128	0.1311	0.000***	0.5832
lnBR	0.0170	0.0137	0.215	0.0412
lnBOD	0.2575	0.05373	0.000***	0.1452
lnSat	–0.0487	0.0334	0.144	–0.0805
lnBil	0.3580	0.0565	0.000***	0.2430
Cons	–2.1384	0.3851	0.000	

Dependent Variable: lnWTP.
Obs = 293 *R-Sq = 0.7847* *Adj R-Sq = 0.7747*
Mean VIF = 1.44 *F(13, 279) =144.21* *Prob>F = 0.0000*
Breusch-Pagan/Cook-Weisberg test for heteroskedasticity: H0 : Constant variance
Chi ^{2} (1) = 0.08 *Prob>Chi^2 = 0.7760*

* p=0.1; ** p=0.05; *** p=0.01

Residential ownership status is statistically significant at 1% and conforms to the *a priori* expectation. The marginal effect value of 0.1799 implies that those who have their own houses are willing to pay Gh¢0.1799 more for improvement in the supply of electricity than those who do not have personal houses. Electricit=in general provides lighting system in the night and this is a security measure. People with their own houses may be more security conscious about the properties in the houses than tenants and will be ready to pay higher amount of money for better electricity services. Also, considering the current economic situations in Ghana, a household which has its own house is considered relatively rich and have the means to pay more for reliable supply of electricity.

Age of house head is lowly significant at 10% and meets the *a priori* expectation. The negative sign indicates that young respondents are willing to pay higher amount of money just to enjoy uninterrupted or improved supply of electricity. Considering the marginal effects of -0.1719, a decrease in the age of the household head by one year holding other factors constant will increase the WTP amount by Gh¢0.1719. This revelation is premised on virtue of the fact that younger generation tend to use electricity more for charging phones, powering computers, studies etc. In our current dispensation, the younger generation especially those who are still doing some form of studies are so tuned to the internet and other electrical appliances that they appear to have higher WTP amount than the elderly people.

Household size is indispensable when it comes to modelling of WTP for improved supply of electricity. It is observed from Table 4 that household size is highly significant at 1% and conforms to the expected direction of the effects. It can be interpreted that the larger the household size, the smaller the amount the household is willing to pay for reliable supply of electricity. An increase in the household size by one person decreases the WTP amount by Gh¢0.1278 *ceteris paribus*. This disclosure is a confirmation of what [4] observed. In his studies, he observed that as the household size increases, the probability of the household paying higher amount decreases. People with large household sizes tend to spend greater amount of money on electricity bill considering their energy consumption level and this discourages them from wanting to pay an additional amount just to enjoy better services. Meanwhile, [4] explained that families with large household size substitute expenditure on WTP amount for reliable supply of electricity on household necessities.

Also, there is 99% confident level that household monthly income statistically and significantly affects the WTP amount for reliable supply of electricity. The direction of the effects makes economic sense. Households with higher monthly income have higher WTP amount than those with lower monthly income holding other factors constant. It can be predicted that an increase in the household monthly income by Gh¢1.00 will lead to an increase in the WTP amount for improved electricity supply by Gh¢0.5832. This means that households are ready to spend more than half of the increase in their monthly income on electricity just to get improvement in the services provided by VRA. This revelation was confirmed by [17,13,4]. Household monthly income has the highest magnitude of the effects. This is because households with higher monthly incomes have higher marginal utility for reliable supply of electricity. On the other hand, households with low monthly income are relatively poor and hence have low or sometimes zero marginal utility for improvement in the supply of electricity. The latter households will rather use larger proportion of the increase in their monthly income on necessities of life thus water, food and shelter.

Monthly hours of blackout has a significant effect on the WTP amount for improved supply of electricity. There is 99% confident level from this research that the amount that the respondents are willing to pay for reliable supply of electricity is determined by but not limited to the monthly blackout durations (hours) experienced. As a respondent experiences more hours of power outages in a month, he/she is ready to pay higher amount for enjoyment of improved electricity supply. It is revealed that if the duration of power outages increases by 1hour, the WTP amount for reliable supply of electricity supply will increase by Gh¢0.1452 or Ghp14.52 ceteris paribus. This is because, the more power outages a household experiences, the more desperate the household is in paying higher amount just to make him/her enjoy better services. [12] confirmed this by noting that the duration of an outage is positively related to the amount of averting expenditure on power outage.

From Table 4, there is statistical significant effect of the amount of money a household pay as monthly electricity bill on the WTP amount. Households who pay higher monthly electricity bills are willing to pay an additional amount of money so as to enjoy improved supply of electricity. The quantity of energy consumed (Kilowatt per hour) by a household has a positive increasing rate to the electricity bill. The presence of multicolinearity between quantity of energy consumed and the electricity bill made the researchers to exclude the former from the model. We can infer from the table that as a household's electricity bill increases by Gh¢1.00, the amount that the household is willing to pay for reliable supply of electricity in a month increases by Gh¢0.2430.

5. CONCLUSION AND POLICY RECOMMENDATIONS

The intermittent power outages (affectionately called *dumsor-dumsor* in Ghana) have come to stay and many households are calling for the improvement in the electricity supply. This study used CVM for the estimation of how much consumers are willing to pay monthly for the reliable and quality electricity supply to their residential facilities. It also identified the determinants of household monthly WTP amount. Averagely, the amount of money that households in Tamale urban and peri-urban communities are willing to pay per 1kWh of energy for uninterrupted electricity supply is Gh¢0.2232 (US$0.0698).

From the econometric results, education, residential ownership status, age of household head, household size, household's monthly income, monthly blackout duration and the monthly electricity bill are factors that significantly influence the WTP amount for uninterrupted electricity supply.

It is important for the electricity service providers in the study area to improve their services and increase the electricity tariff by Gh¢0.2232 (US$0.0698) per kWh since their domestic customers are willing to pay such an amount for quality services. Private organisations which have the capacity to provide reliable supply of electricity should capitalise on the poor services provided by VRA-NEDCo and supply reliable electricity so as to enjoy the higher tariff that households are willing to pay. Also, it is recommended that social intervention programmes which aim at increasing the level of household incomes should be implemented to help them increase their WTP amount. Additionally, both the youths and the adults should be educated to reduce their family size since the larger the household size the smaller the amount one is willing to pay for reliable electricity supply.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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APPENDICES

Appendix 1

Table 2. Summary statistics of continuous variables used in the model

Variables	Mean	Standard Deviation	Minimum	Maximum
WTP amount (Gh₵)	12.89	12.57	2.00	100.00
Ag (years)	37.40	9.83	21.00	79.00
1.HHS (numbers)	4.61	3.40	1.00	17.00
Inc (Gh₵)	1,033.81	846.74	98.00	4600.00
BR (numbers)	3.09	2.30	1.00	12.00
BOD (hours)	63.05	67.20	3.00	560.00
Sat (numbers)	3.88	1.15	1.00	5.00
Bil (Gh₵)	32.50	26.95	5.00	190.00
Energy Consumed (KW/h)	57.72	31.65	5.00	210.00

Number of observations = 293
Mean monthly WTP per Kilowatt-hour = Gh₵0.2232
Exchange rate used: US$1.00 = Gh₵3.20

Appendix 2

Table 3. Frequency distribution of discrete variables used in the model

Variables	Frequency	Percentage
Sex:		
Male	178	60.75
Female	115	39.25
Marital Status:		
Married	188	64.16
Single	105	35.84
Education:		
Educated	180	61.43
Not educated	113	38.57
Residential Status:		
House owner	121	41.30
Not house owner	172	58.70
Generator ownership:		
Owned a generator	106	36.18
Do not owned a generator	187	63.82
Averting:		
Avert	182	62.12
Do not avert	111	37.88

Number of observations = 293

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