International Scholars Journals

African Journal of Agribusiness Research Vol. 9 (1), pp. 001-011, January, 2022. Available online at www.internationalscholarsjournals.org © International Scholars Journals



*Full Length Research Paper*

# The welfare costs of electricity outages: A contingent valuation analysis of households in the suburbs of Kampala, Jinja and Entebbe

**Eseza Kateregga**

Makerere University Faculty of Economics and Management, Department of Economic Policy and Planning, P.O. Box 7062 Kampala, Uganda. E-mail: ekateregga@fema.mak.ac.ug.

Accepted 19 October, 2021

**Electricity power outages have been quite rampant in Uganda since the early 1990s.The water hyacinth, faults in the transmission and distribution systems, other generation related faults and the ever increasing demand for electric energy in the face of a given load capacity, are factors that have been responsible for the numerous outages experienced by both commercial and domestic power consumers. Inconveniences that result from such power cuts are likely to differ across consumers depending on the types of consumption requiring power in different time periods. In this study, we use the contingent valuation method to elicit outage costs for electric energy consumers in 3 Ugandan suburbs. We subjected respondents to 8 descriptions of outage scenarios. We used payment cards and open-ended questions to elicit outage costs that accrue from each type of outage. Willingness to pay (WTP) means and medians for each outage type was estimated following the Ayer et al. (1955) estimation procedure and the implied aggregate outage costs calculated. The effects of socio-economic factors on responses from the open-ended questions were explored using Tobit model with sample selection effects. We find that electric energy as the main source of cooking fuel in the household, income and substitution costs were significant determinants of open-ended WTP.**

**Key words:** Willingness to pay, electricity outage costs.

## INTRODUCTION

Uganda has of late discovered some amount of fossil fuel resources in the western region though commercial ex-ploitation is yet to commence. However, it has abundant untapped biomass and hydroelectric power potential. This is enough to meet its own requirements and to ex-port to neighboring countries (Government of Uganda, 1993). However, the principle sources of household ener-gy for the vast majority of the population are fuel, woods and charcoal. Currently, only 12% of the households have access to electricity countrywide, where 9% covers urban and suburban households and 3% rural house-holds. This has severe implications for the rate of defore-station in the country. Electric energy is derived from both diesel driven motors and several mini hydroelectric plants in the west, southwest and North West of the country and the main station located in Jinja on the Victoria Nile.

The demand for electricity is estimated to be growing at 23% per annum (Government of Uganda, 2002). On ave-rage, households consume 100 kWh per month (Uganda Electricity Regulatory Authority, 2006), charged at a rate equivalent to US dollars 0.25 per kWh. The supply capa-city is estimated to be 400 MW. The rapidly growing de-mand for electricity has however continued to create sub-stantial power deficits. This has been further aggravated by the drastic reduction in the water level of Lake Victoria in the recent past. Generation outages have increased, leading to intensified power rationing (load shedding) for the different classes of consumers. The welfare costs re-sulting from electricity outages may be diverse across the different types of consumers.

In this paper we estimate outage costs faced by do-mestic electricity consumers in the suburbs of 3 towns in Uganda.

In the following sections we present a brief review of contingent valuation method literature. Discussions of the survey exercise and the data are presented in section 3. The analyses of WTP means and medians for each of the scenarios subjected to the respondents and the scope tests, are presented in section 4. In section 5 the results from the analysis of the determinants of WTP for each scenario are reported and discussed. In section 6 the aggregation of outage costs over suburbs is conducted. The summary and conclusions of the study are presented in sections 7.

## CVM STUDIES: A LITERATURE SURVEY

The literature on CVM studies is vast. Several studies have shown that the contingent valuation method (CVM) is an important tool for measuring the non-market value of environmental benefits and damage assessment (Boyle and Bishop, 1988; Cameron, 1988; Kanninen, 1993; Holmes and Kramer, 1995). By providing estimates of the Hicksian surplus associated with changes in the provision of environmental goods and services, the CV method enables economists to provide quantitative information to decision makers concerned with environmental policy, regulation and litigation. Structurally the nature of the CVM question format has ranged from open-ended (OE), dichotomous choice (DC), iterative bidding games, rankings and the use of payment cards (Payment card is a card showed to the respondent with several bids printed on it. The respondent is asked if any of the bids is close to her maximum WTP. When committing to her maximum WTP, she does not have to choose any of the bids printed on the card, but may instead state any value that she feels is the worth of the project (Cameron and Englin, 1996; Frykblom, 1997). In the open-ended que-stion format, the respondent is asked to state the maxi-mum willingness to pay (WTP) to secure or forego a given change in the supply or quality of a stipulated good or service (Herriges and Shogren, 1996). In contrast, dichotomous choice formats require that each respondent reveal whether or not he would be willing to pay an amount X to secure the use of the natural resource, public good or for a specified change in the amenity of interest. The sum X is usually fixed by the researcher (Alberini, 1995).

Herriges and Shogren (1996) note that in these dichotomous choice experiments, close-ended questions now dominate the CVM. One advantage of this take- it or leave-it format is that it mimics the decision task that individuals face in everyday market transactions (Carson and Mitchell, 1995; Herriges and Shogren, 1996). Close-ended question formats, particularly those with follow- up questions, have been typically viewed as being easier to respond to and do avoid incentive compatibility problems inherent in open-ended questions (Kanninen, 1993; Herriges and Shogren, 1996). However, Holmes and Kramer (1995) noted that because the method has been rapidly gaining popularity in the economic field, the validity of C-VM based benefit estimates has been a matter of growing concern. A number of issues and criticisms have been raised concerning its applicability in general and in valuation studies in developing countries in particular (Mekonnen, 1998).

Use of payment card subjects the respondent to several bids out of which he has to select the most preferred choice. Some of the studies in which payment cards have been used to elicit WTP include Frykblom (1997) . One of the advantages of the payments cards procedure is that it avoids the starting point problem inherent in the iterative bidding procedure (Mitchell and Carson, 1989). Secondly, unlike in the single and double bounded experiments, payment cards expose several bid alternatives to the respondent. This allows for more flexibility in identifying the interval within which median WTP lies and minimizes the measurement error (Hanemann and Kanninen, 1996). Boyle and Bishop (1988), in their valuation of the scenic beauty along the Wisconsin River, found that WTP estimates from the data derived from iterative bidding procedure and payment cards were comparable, while those derived from the DC format were lower.

However technique comparisons do not yield conclusive results about the size of the estimates of WTP to be expected from each procedure. We thus opted to use payment cards and open-ended follow-up questions in our survey instrument.

## DETERMINATION OF OUTAGE SCENARIO DESCRIPTIONS

In this section we discuss how we determined the outage scenario descriptions included in the survey instrument, the design of the experiment, the sampling and the data. While the incidence of power outages resulting from load shedding is a familiar phenomenon to many of the consumers. The mode in which non-load shedding outages occur has no systematic schedule (Load shedding unrealted outages can occur at any time of the day or evening and the period they last is unpredictable). For this reason in our outage scenario descriptions we first consider the sessions of outages from load shedding. These are outage sessions in the mornings at 7.00 a.m. and evenings at 7.00 p.m., lasting for 4 h. In a bid to compare evening and morning outages we included 1 h and 2 h sessions beginning at 6.00 a.m. and 1 h and 2 h sessions beginning at 6.00 p.m. We also included a 3h afternoon session and 1 for a 12 h day session, in order to explore whether afternoon outages are less costly and whether outage costs really vary with scope.

## THE SURVEY

A sample of 200 households was surveyed from the suburbs of Kampala, Jinja and Entebbe towns. The sample size was however arbitrarily chosen. The number of respondents selected from each of the 3 suburbs was based on the number of households connected to the power grid in each of the 3 zones as presented in the UEB statistical bulletin (May 1999). Load shedding unrelated outages can occur at any time of the day or evening and the period they last is unpredictable, on the basis of these figures, 50% of the respondents were selected from the suburbs of Kampala, 30% from Jinja and 20% from the suburbs of Entebbe. It is worthwhile to note that in each of these 3 zones, there were particular areas that seldom experienced power outages. In Entebbe, these were areas like Nsamizi hill, a big proportion of Bugonga vill-age, Manyago village and others that are connected to the lines supplying power to the airport, Entebbe town and the state house. In Jinja, households connected to the lines supplying Jinja town and the main hospital rarely experience power outages. In Kampala, the city centre, Nakasero, Mulago, Kololo, Naguru and Bugolobi hills, parts of Muyenga hill are seldom subjected to outages. This is because they are either connected to the lines supplying strategic areas like the main hospital, commu-nication equipment, water works or the state house. Due to the structure in which the WTP question was set, seve-ral of the homes we visited in these areas were not willing to join the programme. Many of the respondents here were of the view that the kind of outages they normally experience are rather too brief to warrant a need for back up system (they last for 5 or 10 min at the most and are rare).

Each of the 3 suburbs is divided in zones or divisions comprising of several villages. The Jinja suburbs are Njeru, Mpumudde and Walukuba. The Entebbe suburbs are in Katabi, Kajjansi and Kitooro. The suburbs of Kampala are in the divisions of Nakawa, Kawempe, Makindye and Rubaga. In order to select villages to be included in the sample we first had to delete those that were seldomly subjected to outages. For the remaining villages, each was written on a specific piece of paper, folded and thrown into a container. Then a method of random selection from this container generated the villages to be included in the survey. With regards to the selection of the sampled households in each village, we first randomly selected the lanes (streets) on which to sample and then sampled homes that were placed in odd sequence along the selected lanes. Unfortunately, some of the selected homes were not ready to be interviewed. In response we opted to either sample the opposite or the next home.

In our survey instrument introduction, we first asked respondents questions about their opinion on the reliability of the services of Umeme Uganda Ltd, on the incidence of outages and socio-economic and demographic features. In the WTP elicitation section we begin by giving a vivid description of each outage scenario. Then we present a situation where an alternate power supply line was operated along with the conventional services.

**The service description text is given thus:** Installing a back-up power supply service at your home can eliminate outages of this kind. This service will meet all of your household's electrical needs during this type of outage. You can activate the back-up system with a switch installed in your home. You can turn the back-up system on after an outage has started or leave it on continuously to automatically protect you from outages. The supplier will bill you only when the service provides you backup electricity.

**The question was:** Considering the costs and inconveniences that normally result from this type of outage, which of the following alternatives would you prefer most?

1.) In return for the protection provided by the backup power supply service, you pay a fee each time the backup system supplies power during this type of outage.
2.) You continue to experience outages of this kind about as often as you have in the past and your electricity bill remains the same.

Those who selected option 1 were presented with payment cards out of which they had to select a bid indicating their WTP for the service in each of the defined outage type. In order to screen those who had zero WTP for the service from those who protested the arrangement, follow-up questions as to why they did not want the new service were presented to the respondents who opted for 2. The logic of the traditional utility maximization model suggests that respondents, who consciously reject the contingent market setting, will either not search their preferences or lack the capacity to respond due to education, language barriers and so forth (Harris et al., 1989). Desvousges et al. (1987) suggests that because they fail to search their preferences, such respondents should be classified as protest bidders.

## THE DATA

Of the surveyed households, 28.5% indicated that the power supply firm's performance was not satisfactory and thus was unreliable, 65% were of the opinion that the number of outages they were experiencing was too high. 34% indicated that their mostly used fuel for cooking was electricity, 61.5% use charcoal and fuel wood, 2.5% use gas and 2% use mainly kerosene for cooking. All respondents used electric energy as the main source of lighting. 12.7% of the households indicated that they were running some kind of business at home. The types of businesses include product packaging, brewing, baking, poultry and tailoring.

The number of households who objected to the proposal of subscribing to the back -up system whenever outages occurred at the specified periods (protestors) varied across scenarios, ranging from 7% for scenario A to 12% for scenario E. Scenario E is a 3 h afternoon outage where for a weekday, fewer people would be at home, while scenario A outage is in the early morning hours where more people are assumed to be at home. Thus protest responses were expected to be higher for scenario E.

## WTP ANALYSIS: A NON PARAMETRIC APPROACH

Our analysis was based on the random utility model (RUM) postulate and we employ the non- parametric method of estimating medians and means of WTP for the various scenarios. In the non-parametric approach to the estimation of WTP function parameters, no distributional assumptions are necessary (Kriström, 1990). Kriström (1995) contends that the distribution for the parameters need not be normal. That is, nothing suggests that WTP should be normally distributed in large samples and the WTP functions can take up virtually any shape even in large samples (Kriström, 1995). Like in other referendum data based techniques of measuring consumer surplus, we exploit the assumption that those who reject a bid have a true WTP that is lower than that bid, while those who accept it have WTP values above that bid.

Following the Ayer et al. (1955) parameter estimation approach, we calculate the % yes over the total valid responses and plot these % against bid levels to construct cumulative distribution functions for WTP (or bid curves) for the various scenarios. 2 notable advantages of the Ayer et al. estimator are that, it is robust against misspecification of the WTP distribution and it allows the investigator to explicitly invoke a truncation point such that the probability of obtaining a yes answer for bids outside the design range is zero. Kriström (1993) contends that perhaps the most important advantage of this estimator, in his view, is its transparency and simplicity. As a first step in the non-parametric approach, the bid curves had to be smoothed out in order to impose monotonicity in the cumulative distribution functions of WTP and to ensure consistency with the underlying economic theory. Smoothing out of the survival curves becomes a necessity if the obtained vector of proportions = [ $_1$, $_2$, …. $_n$] is non- decreasing in bids. In such instances where $_{i+1} > _i$ for some i, then the proportions are replaced by [(#yes$_{i+1}$ + #yes$_i$)/(#yes$_i$,+ #no$_i$ +yes$_{i+1}$ + #no$_{i+1}$)], Kriström (lecture notes).

This was accomplished by using a simple pooling algorithm, whenever the % of yes responses increased between 2 or more bid levels for a given bid curve, a weighted average was calculated for those “violation” points and their neighbours until all bid functions decreased steadily from lowest to highest bid. Next, we were faced with 2 confronting tasks of how to determine the y and x axes for the curves. In order to extend the WTP functions to the y-axis, we assumed that for zero cost for the back-up system service all respondents would accept to subscribe. This implies that at the zero cost bid level, the % yes is 100%. Layton and Moeltner (2002) concur with this idea and their argument is that any rational customer is expected to accept an avoidance of outage costs for free. 1 US $ = 1,800 USHS. Domestic connections in Kampala suburbs amounted to 96,665. In Jinja suburbs, the number of connections were 7,592 and for the Entebbe suburbs, the number of connections were 5,909 (UEB Statistical Bulletin November 2004).In economics, local non-satiation is assumed. At price zero therefore, demand tends to infinity.

Next, the x-axis intercept for the curves had to be determined. We used the highest bids as the cut off values for the curves. But it is important to note that a precaution in using the highest bid as cut off is given in the literature (Layton and Moeltner, 2002). This is because it implies that at a bid just a small increment away from this bid, the % yes falls to zero. This may be unrealistic. The median WTP is given by the bid level at which 50% of the households accept the offer and the means are calculated as the areas under the various curves. WTP medians and means have been estimated for each of the suburbs considered and for the aggregate sample. These are shown in Table A1 in the appendix. In addition, the table shows the % of respondents who survived the fifth bid (Bid*) for each scenario and by region and the % of protests per scenario. WTP medians have been found to be lower than means for all scenarios and suburbs, except in two cases; scenario D for Jinja suburbs and scenario E for Entebbe suburbs. The implication here is that although households face inconveniences and thus costs during outages, they are not willing to pay significant amounts to get rid of them. WTP is on the other hand determined by income, thus the bids selected had to reflect this.

Another notable feature is that the WTP mean for Kampala suburbs for a morning outage is higher than that of a corresponding evening outage. But for a 1h session, the WTP mean is higher in the evening scenario. Generally outage costs were found to be higher in the evenings. We do, however, conduct scope tests for the 1 and 2 h, morning and evening outage sessions to test the reliability of our results in the next section.

**Results of the scope tests**

In this section we discuss how we conducted scope tests for outage scenarios A and F and B and G. We conduct scope tests for these 4 scenarios because this is only where we have variations of outage incidences across similar time periods. Several economists have raised the need for a clear distinction between WTP estimates of different size changes in an environmental good or service. For example, Arrow et al. (1993) and Carson et al. (1998) emphasize the need to have WTP estimates that are adequately responsive to the scope of the environmental insult. The consistency and reliability of WTP responses to the predictions of economic theory is thus crucial. As a way of testing the reliability and consistency of CVM estimates, it is recommended that scope tests be conducted.

There are a number of ways in which the tests could be conducted, depending on the circumstances. Diamond and Hausman (1994) show that 1 way of evaluating the reliability of CVM estimates of WTP is to link and compare them to the specific observable properties that economic theory expects them to follow. This is an internal validity test that is quite useful in situations where non-use

**Table 1.** Regression results for scope tests for scenarios A and F.

| Variable | All sample coefficient | Kampala coefficient | Jinja coefficient | Entebbe coefficient |
|---|---|---|---|---|
| Bid | -0.0000197** (-3.65) | -0.0003894*** (-15.92) | -0.0004283*** (-12.08) | -0.0003654***(-10.93) |
| Scenario F | 1.0496104*** (53.55) | 0.7052312*** (38.32) | 0.0721614*** (9.83) | 0.7867138*** (10.12) |
| Log likelihood function | -3074.184 | -1614.094 | -928.554 | -743.7092 |
| σ | 0.5985281 | 1.0142471 | 1.0225438 | 0.9868397 |
| Adj. $R^2$ | 0.90 | 0.92 | 0.93 | 0.91 |
| Observations | 3620 | 1770 | 1040 | 810 |

**, *** represents significance of the parameter at the 10, 5 and 1% respectively. The figures in parentheses are t-statistics.

**Table 2.** Regression results for scope tests for scenarios B and G.

| Variable | All sample coefficient | Kampala coefficient | Jinja coefficient | Entebbe coefficient |
|---|---|---|---|---|
| Bid | -0.0003336*** (-21.93) | -0.0003270*** (-15.26) | -0.0003864*** (-11.90) | -0.0002867*** (-10.23) |
| Scenario G | 0.5801120*** (13.31) | 0.5552754*** (8.91) | 0.7202228***(8.56) | 0.4787398*** (5.40) |
| Log likelihood function | -2895.705 | -1419.169 | -796.423 | -675.609 |
| σ | 1.0805135 | 1.0836256 | 1.0657595 | 1.0863386 |
| Adj. $R^2$ | 0.91 | 0.94 | 0.93 | 0.93 |
| Observations | 3640 | 1780 | 1040 | 820 |

**, *** represents significance of the parameter at the 10, 5 and 1% respectively. The figures the parentheses are t-statistics.

values dominate the responses used to construct monetary measures of economic value (Smith and Osborne, 1996).

We pool observations on responses and bids in outage scenarios A and F and B and G and run regressions with responses (yes or no for each bid) as the dependent variables and the bids and scenario dummies as the explanatory variables. The dummies are coded 1 for the scenarios with longer outage duration. These were scenario F for morning outages and scenario G for evening outages. Results are reported in Table 1 and 2. As a test of the response to the size of the insult, the outage duration, we examine the significance of the coefficients on dummies for the longer outage durations F and G. Regressions were run for the entire sample and for each suburb. The results in all the regressions show that the dummy variables were significant at the 1% level. Thus WTP estimates for the larger duration scenarios were significantly higher than those for the 1 h morning and evening outages for all suburbs.

## Analysis of the determinants of WTP by scenario

In this section, we explore the effects of socio-economic characteristics of the respondents on WTP responses using the Tobit estimation procedure. The descriptive statistics for the variables included in the estimation of the effects of socio-economic factors on the willingness to pay to get rid of power outages are presented in Table 3.

Costs, bids and income are in Uganda shillings. Education brackets were 6. We consider secondary level education as the benchmark for education. This was education bracket 3. We created a dummy for education, which was one if the respondent’s education was 3 and above. Sex of household head is a dummy variable with 1 if head is male. Main fuel for cooking is a dummy, with 1 if main fuel for cooking is electricity.

Whether there was anyone staying home is 1 if there was always some body at home all time. Most inconvenient outage period is dummy variable with 1 if the most inconvenient outage period was in the evening. Whether the household was running a business is 1 if the household is running business at home. Maximum bid refers to the maximum of responses from the open-ended questions. House size is the number of rooms in the house. House ownership is a dummy equal to 1 if the respondents owned their house and 0 otherwise. Period of stay is the number of years spent in the locality.

## Estimation and discussion of results

In this section we discuss the estimation procedure and the results. Though data on WTP responses were obtained through random sampling, screening of observations by eliminating protest responses introduces a question of whether the remaining observations satisfy randomness in the observations. This introduces the sample selection problem that arises when the observed sample is not randomly drawn from the population. As a solution to the selectivity bias problem, Greene (1997) recommends estimation of the model in this case as a Tobit model with an allowance for sample selection to be analyzed. The 2 step Heckman (1979) estimation procedure was used in estimation.

Results from the estimations of the determinants of WTP for the 8 types of outages are presented in Tables 4 and 5.

**Table 3.** Descriptive statistics.

| Variable | Mean | Std. Dev | Min | Max |
|---|---|---|---|---|
| Cost of running substitutes items for evening outages | 1821.60 | 2309.40 | 200.00 | 20000.00 |
| Recent electricity bill | 51507.90 | 91659.50 | 4984.00 | 200000.00 |
| Period of stay in village | 6.68 | 6.23 | 0.25 | 44.00 |
| House ownership | 0.57 | 0.50 | 0 | 1.00 |
| Household size | 6.30 | 3.00 | 1.00 | 14.00 |
| Household income | 2,850,500 | 418,000 | 900,000 | 9,000,000 |
| Education of head | 0.77 | 1.10 | 0 | 1.00 |
| Male household head | 0.30 | 0.50 | 0 | 1.00 |
| Electricity fuel for cooking | 0.35 | 1.00 | 0 | 1.00 |
| Main fuel for lighting | 0.23 | 0.1 | 0 | 1.00 |
| Always someone at home | 0.89 | 0.31 | 0 | 1.00 |
| Most inconvenient outage period | 0.94 | 0.24 | 0 | 1.00 |
| Whether household was running business | 0.13 | 0.33 | 0 | 1.00 |
| Maximum Bid for A | 1232.64 | 836.43 | 0 | 6000.00 |
| Maximum Bid for B | 1657.17 | 1168.77 | 0 | 10000.00 |
| Maximum Bid for C | 2010.71 | 1135.18 | 0 | 8000.00 |
| Maximum Bid for D | 2759.24 | 1522.71 | 0 | 9000.00 |
| Maximum Bid for E | 983.74 | 656.66 | 0 | 5000.00 |
| Maximum Bid for F | 1583.46 | 952.45 | 0 | 8000.00 |
| Maximum Bid for G | 1775.35 | 1161.92 | 0 | 8000.00 |
| Maximum Bid for H | 4431.00 | 2402.81 | 0 | 12500.00 |

**Table 4.** Estimations of the determinants of WTP for scenarios A to D.

| Variable | WTP A Probit | WTP A tobit | WTP B Probit | WTP B tobit | WTP C Probit | WTP C tobit | WTP D Probit | WTP D tobit |
|---|---|---|---|---|---|---|---|---|
| | Coeff. | Coeff. | Coeff. | Coeff. | Coeff. | Coeff. | Coeff. | Coeff. |
| Recent power bill | -0.67* | -0.23 | | 0.10* | | 0.12 | | 0.36** |
| | (-2.61) | (-1.61) | | (1.77) | | (2.10) | | (3.22) |
| Inconveniencing period | | -0.43 | | 0.43* | | -0.50 | | -0.65 |
| | | (0.67) | | (2.27) | | (-0.14) | | (-2.06) |
| Period of stay in the locality | -0.002 | -0.003*** | | -0.0004 | | -0.001 | | -0.01 |
| | (-0.01) | (-4.65) | | (-0.01) | | (-0.10) | | (-0.67) |
| Sex of the household head | | 0.43* | | -0.01 | | -0.01 | | -0.03 |
| | | (1.90) | | (-0.06) | | (-0.16) | | (-0.27) |
| Education of the household head | | 0.16 | | -0.15 | | -0.14* | | 0.06 |
| | | (0.60) | | (-1.30) | | (-1.76) | | (1.24) |
| H/holds running business at home | | -0.11 | | 0.45 | | 0.09 | | 0.03 |
| | | (-0.40) | | (0.66) | | (1.42) | | (1.57) |
| Electricity as main fuel for cooking | 1.28** | 0.70** | | 0.21* | | 0.08** | 0.12 | 0.37* |
| | ( 3.11) | (2.85) | | (1.86) | | (2.48) | (1.03) | (1.83) |
| Costs of substitution | | 0.05 | 0.26* | 0.01 | | -0.04 | 0.65 | 0.14* |
| | | (0.35) | (1.84) | (0.21) | | (-0.05) | (1.89) | (1.80) |
| Home ownership | | 0.30 | | 0.56 | | -0.11 | | 0.03 |
| | | (1.29) | | (0.27) | | (-0.66) | | (0.26) |
| Household with people at home all time | | 0.17 | | 0.15 | 0.44* | 0.49 | 0.56 | 0.41 |
| | | (0.41) | | (0.82) | (1.82) | (0.89) | (0.91) | (1.00) |
| Household income | | 0.24 | | -0.33 | | 0.10* | | 0.15** |
| | | (1.36) | | (-0.52) | | (2.04) | | (2.49) |
| Home size | 1.91* | 1.61*** | -1.28* | -0.03 | -0.86* | -0.89 | -0.80* | -0.51 |
| | (1.71) | (4.03) | (1.78) | (-0.52) | (-1.96) | (-0.57) | (-1.87) | (-1.49) |

**Table 4.** Contd.

| Variable | WTP A Probit | WTP A tobit | WTP B Probit | WTP B tobit | WTP C Probit | WTP C tobit | WTP D Probit | WTP D tobit |
|---|---|---|---|---|---|---|---|---|
| | Coeff. | Coeff. | Coeff. | Coeff. | Coeff. | Coeff. | Coeff. | Coeff. |
| Kampala | | 0.44 | | 0.02 | | -0.08* | | -0.17 |
| | | (1.56) | | (1.78) | | (-1.75) | | (-0.81) |
| Jinja | | -0.30 | | 0.08 | | -0.99 | | -0.22 |
| | | (-1.05) | | (0.62) | | (-0.98) | | (-0.10) |
| Constant | -0.65 | 1.24 | 1.24 | 6.62*** | 1.85 | 8.42*** | -0.65 | 1.24 |
| | (-0.81) | (0.57) | (0.56) | (5.27) | (0.60) | (7.42) | (-0.81) | (0.57) |
| Log likelihood function | -294.34 | | -139.19 | | -151.90 | | -268.19 | |
| σ (1) | 1.15*** | | 0.53*** | | 0.47*** | | 0.78*** | |
| ρ (1,2) | 0.99*** | | 0.98*** | | 0.85*** | | 0.87*** | |

The parameters are marginal effects. ***, **,* indicate significance at 1%, 5% and 10% levels respectively. The figures in the parentheses are t-statistics.

**Table 5.** Estimations of the determinants of WTP for scenarios E to H.

| Variable | WTP E Probit | WTP E tobit | WTP F Probit | WTP F tobit | WTP G Probit | WTP G tobit | WTP H Probit | WTP H tobit |
|---|---|---|---|---|---|---|---|---|
| | Coeff. | Coeff. | Coeff. | Coeff. | Coeff. | Coeff. | Coeff. | Coeff. |
| Recent power bill | | 0.10 | | 0.09 | 0.25 | 0.15* | 0.15 | 0.09* |
| | | (1.20) | | (1.38) | (1.05) | (1.95) | (1.52) | (1.75) |
| Inconveniencing period | | 0.18 | | 0.25 | | 0.003 | | 0.09 |
| | | (0.75) | | (1.26) | | (0.01) | | (0.33) |
| Period of stay in the locality | | -0.001 | 0.01* | -0.001 | | -0.001 | | 0.02 |
| | | (-0.66) | (1.73) | (-1.03) | | (-0.22) | | (0.49) |
| Sex of the household head | | -0.01 | | -0.07 | | 0.04 | | -0.03 |
| | | (-0.32) | | (-0.74) | | (0.34) | | (-0.37) |
| Education of the household head | | -0.04 | | 0.23* | | -0.12 | | -0.03* |
| | | (-1.57) | | (2.15) | | (-1.19) | | (-1.67) |
| H/holds running business at home | | -0.27* | | -0.07 | | -0.31 | | 0.55 |
| | | (-1.74) | | (-0.50) | | (-0.33) | | (0.66) |
| Electricity as main fuel for cooking | | 0.26* | 0.42 | 0.17 | | 0.18* | | 0.88* |
| | | (2.22) | (1.61) | (1.73) | | (1.76) | | (1.87) |
| Costs of substitution | | | | | 0.55* | 0.04 | 0.33* | 0.32 |
| | | | | | (1.96) | (0.55) | (1.91) | (0.56) |
| Home ownership | | -0.80 | | 0.55 | | -0.01 | | 0.03 |
| | | (-0.01) | | (0.54) | | (-0.12) | | (0.45) |
| Household with people at home all time | 0.78* | 0.16 | | -0.16 | | -0.13 | | -0.05 |
| | (1.72) | (0.68) | | (-0.80) | | (-0.58) | | (-0.38) |
| Household income | | 0.03** | | 0.43 | | 0.15* | | 0.11 |
| | | (2.38) | | (1.66) | | (2.25) | | (1.55) |
| Home size | -0.25* | -0.10 | -1.33* | 0.04 | -1.39* | -0.10 | -0.39 | 0.06 |
| | (-1.75) | (-0.49) | (-1.88) | (1.23) | (-1.91) | (1.54) | (-1.59) | (0.46) |
| Kampala | | 0.40** | | 0.01 | | 0.08* | | -0.19* |
| | | (2.86) | | (0.12) | | (1.78) | | (-2.38) |
| Jinja | | 0.22 | | 0.87* | | -0.01 | | -0.18* |
| | | (1.59) | | (1.71) | | (-0.10) | | (-1.90) |
| Constant | 1.99 | 5.82*** | 3.14* | 6.80*** | -3.36 | 6.05*** | -1.92 | 7.37*** |
| | (0.34) | (3.79) | (2.45) | (5.94) | (-1.05) | (4.42) | (-0.56) | (8.23) |
| Log likelihood function | -161.42 | | -132.66 | | -134.84 | | -109.95 | |
| σ (1) | 0.59*** | | 0.50*** | | 0.50*** | | 0.40*** | |
| ρ (1,2) | 0.99 | | 0.98*** | | 0.95*** | | 0.70 | |

The parameters are marginal effects.***, ** ,* indicate significance at 1%, 5% and 10% levels respectively. The figures in the parentheses are t-statistics.

**Table 6.** Aggregated outage cost measures for the entire sample and by suburb.

| Code | Description | Suburb | Total WTP by Suburb (in millions of U shs and US $ equivalent in parenthesis) | Total WTP for the 3 suburbs (in millions of U shs and US $ equivalent in parenthesis) |
|---|---|---|---|---|
| A | Weekday morning | Entebbe | 6.97 (3,872) | 115.60 (64,222) |
| | 7:00 am 1 h | Jinja | 9.87 (5,483) | |
| | | Kampala | 98.76 (54,867) | |
| B | Weekday evening | Entebbe | 9.07 (5,039) | 143.85 (79,917) |
| | 7:00 pm 1h | Jinja | 11.70 (6,500) | |
| | | Kampala | 123.08 (68,378) | |
| C | Weekday morning | Entebbe | 12.41 (6,894) | 195.66 (108,700) |
| | 7:00 am 4 h | Jinja | 14.43 (8,017) | |
| | | Kampala | 168.82 (93,789) | |
| D | Weekday evening | Entebbe | 15.51 (8,617) | 277.95 (154,417) |
| | 7.00 pm 4 h | Jinja | 21.26 (11,811) | |
| | | Kampala | 241.18 (133,989) | |
| E | Weekday afternoon | Entebbe | 7.21 (4,006) | 112.04 (62,245) |
| | 12:00 to 3.00 p.m. | Jinja | 6.07 (3,372) | |
| | 3 h | Kampala | 98.76 (54,867) | |
| F | Weekday morning | Entebbe | 9.16 (5,089) | 136.67 (75,928) |
| | 6:00 a.m. to 8:00 | Jinja | 11.08 (6,156) | |
| | a.m. 2 h | Kampala | 116.43 (64,683) | |
| G | Weekday evening | Entebbe | 10.52 (5,844) | 156.71 (87,061) |
| | 6:00 p.m. to 8:00 | Jinja | 13.13 (7,295) | |
| | p.m. 2 h | Kampala | 133.06 (73,922) | |
| H | Weekday | Entebbe | 24.82 (13,789) | 428.32 (237,956) |
| | 6:00 a.m. to | Jinja | 37.58 (20,878) | |
| | 6:00 p.m. 12 h | Kampala | 365.92 (203,289) | |

In all WTP functions, the parameter estimates for electricity as the main fuel for cooking in the home were signifycant and positive in all scenario equations. This suggested that the costs these households face during outages through substituting for electric energy were higher. The parameters for expenditure on electricity, represented here by the recent bill, were positive and significant in the estimations for scenarios B, C, D, G and H. This indicated that those households whose electricity bills were high were willing to pay more for the backup services. Parameter estimates for the income effect were positive and significant only in functions for scenarios C, D, E and G. Households with higher incomes therefore were willing to pay more for the back -up service. The parameter estimate for home size was positive and significant for outage scenarios A and not significant in other scenarios. This indicates that households, which owned their homes, were willing to pay more for the back-up service for outages that occur at 6:00 a.m., lasting for 1 h. The parameter of the costs of running items used to substitute for electricity during outages was positive and significant for scenario D. This indicated that households, which faced higher costs of substitutes during outages, were willing to pay more for the back-up.

determines whether the problem of sample selection bias arise due to exclusion of protest or invalid responses. In all estimations but E and H, the parameters for were significant at 1%. Thus the exclusion of protest responses would have generated a sample selection bias.

## Outage cost aggregation over suburbs

In practice, a distinction is made between CVM studies that are geared toward benefit-cost analyses and those that aim at natural resource damage assessment. It is recommended that in making valuations for the former, mean WTP be applied, while median WTP is appropriate for the latter. This is because of the differences implied in property rights and the legal requirement to restore all those who were injured to their original position. In our analysis we use WTP medians for the various suburbs and scenarios to calculate the implied costs of outages to domestic consumers in the suburbs of Kampala, Entebbe and Jinja. The details of these costs appear in Table 6. We adopt the median as our measure of welfare costs because of 2 reasons (i) the main objective of the study is to assess the magnitude of the damage to domestic electricity consumers, emerging from outages. According to

## APPENDIX

**Table A1.** WTP means and medians for the 8 scenarios.

| Scenario | | Suburb | Valid OBS | % yes at bid* | Bid* U Shs and US $ equivalent in parenthesis | %protest of valid obs | Median WTP(in U Shs and US $ equivalent in parenthesis) | Mean WTP (in U Shs and US $ equivalent in parenthesis) |
|---|---|---|---|---|---|---|---|---|
| Code | Description | | | | | | | |
| A | Weekday morning | Entebbe | 41 | 60.98 | | 7.31 | 1180.00 (0.66) | 1357.05 (0.75) |
| | 6:00 am | Jinja | 52 | 69.23 | 900.00 (0.50) | 3.85 | 1300.00 (0.72) | 1344.65 (0.75) |
| | 1 hour | Kampala | 89 | 73.33 | | 10.10 | 1187.50 (0.66) | 1397.02 (0.78) |
| | | Total | 181 | 70.17 | | 7.11 | 1222.50 (0.68) | 1349.97 (0.75) |
| B | Weekday evening | Entebbe | 41 | 48.78 | | 7.31 | 1535.00 (0.85) | 1927.99 (1.07) |
| | 6:00 pm | Jinja | 52 | 50.00 | 1500.00 (0.83) | 3.85 | 1541.60 (0.86) | 1578.57 (0.88) |
| | 1hour | Kampala | 89 | 46.07 | | 10.10 | 1480.00 (0.82) | 1679.92 (0.93) |
| | | Total | 182 | 47.80 | | 9.34 | 1518.87 (0.84) | 1728.82 (0.96) |
| C | Weekday morning | Entebbe | 39 | 35.90 | | 12.82 | 2100.00 (1.17) | 2165.70 (1.20) |
| | 7:00 am | Jinja | 51 | 39.22 | 2400.00 (1.33) | 5.88 | 1900.00 (1.06) | 2003.60 (1.11) |
| | 4 hours | Kampala | 90 | 41.11 | | 10.00 | 2030.00 (1.13) | 2004.50 (1.11) |
| | | Total | 180 | 32.76 | | 9.44 | 2010.00 (1.12) | 2057.93 (1.14) |
| D | Weekday evening | Entebbe | 40 | 27.50 | | 10.00 | 2625.00 (1.46) | 3183.50 (1.77) |
| | 7.00 pm | Jinja | 52 | 25.00 | 3600.00 (2.00) | 3.85 | 2800.00 (1.56) | 2630.78 (1.46) |
| | 4 hours | Kampala | 90 | 32.56 | | 10.00 | 2900.00 (1.61) | 3289.60 (1.83) |
| | | Total | 182 | 31.11 | | 8.24 | 2775.00 (1.54) | 3034.63 (1.69) |
| E | Weekday | Entebbe | 39 | 66.67 | | 12.82 | 1220.00 (0.68) | 1201.20 (0.67) |
| | afternoon | Jinja | 52 | 40.39 | 900.00 (0.50) | 3.85 | 800.00 (0.44) | 905.02 (0.50) |
| | 12 noon to 3:00pm | Kampala | 88 | 63.64 | | 12.50 | 1187.50 (0.66) | 1204.64 (0.67) |
| | | Total | 179 | 57.54 | | 10.05 | 1069.10 (0.59) | 1103.62 (0.61) |
| F | Weekday morning | Entebbe | 39 | 51.28 | | 12.82 | 1550.00 (0.86) | 1955.67 (1.09) |
| | 6.00 to 8:00 am | Jinja | 52 | 44.23 | 1500.00 (0.83) | 3.85 | 1460.00 (0.81) | 1523.93 (0.85) |
| | 2 hours | Kampala | 90 | 38.89 | | 10.00 | 1400.00 (0.78) | 2286.58 (1.27) |
| | | Total | 181 | 43.09 | | 8.84 | 1470.00 (0.82) | 1922.06 (1.07) |
| G | Weekday evening | Entebbe | 41 | 48.78 | | 7.31 | 1780.00 (0.99) | 1986.33 (1.10) |
| | 6:00 to8:00 pm | Jinja | 52 | 32.69 | 2500.00 (1.39) | 3.85 | 1730.00 (0.96) | 1862.95 (1.04) |
| | 2 hours | Kampala | 89 | 56.18 | | 11.24 | 1600.00 (0.89) | 1942.07 (1.08) |
| | | Total | 182 | 34.43 | | 8.24 | 1703.30 (0.95) | 1930.45 (1.07) |
| H | Weekday | Entebbe | 40 | 20.51 | | 10.00 | 4200.00 (2.33) | 3931.84 (2.18) |
| | 6:00am to 6:00pm | Jinja | 52 | 17.64 | 4500.00 (2.50) | 3.85 | 4950.00 (2.75) | 4973.45 (2.76) |
| | 12 hours | Kampala | 90 | 17.05 | | 10.00 | 4400.00 (2.44) | 4144.08 (2.30) |
| | | Total | 182 | 19.88 | | 8.24 | 4516.60 (2.51) | 4349.79 (2.42) |

Carson et al. (1998) this justifies our adoption of the median as a welfare measure. (ii) The method used in calculating the means and medians of WTP across outage scenarios (the Ayer et al*.* estimator) is more accurate in estimating the median rather than the mean. And indeed, median estimates by this procedure have been found to be comparable to those from alternative methods (Hanemann and Kanninen, 1996).

On the other hand, by calculating the costs households face as a result of unreliable power supply, we are indeed providing some approximations of their demand for, or the benefits from reliable services. The information on the benefits of reliable services is vital for the power utility, if it is to review the gain from providing reliable services against the outage costs incurred in these suburbs. It is only the utility firm that has the information on the costs of getting rid of outages. Therefore, only the utility firm is able to conduct benefit cost analyses for the different outage scenario.

### Summary and implications

That the inconveniences from outages are associated with positive costs to domestic consumers is a fact that is backed by this study. Costs however vary according to the incidences of outages, particularly with respect to what time of the day (morning or evening) and the time length of the outage. In our survey, close to 90% of the respondents indicated that outages that occur in the evenings were more costly than those in the morning. This is supported by the computed WTP means and medians for the evening outages. Means and medians are relatively higher for outages in the evenings. Further, for all outage scenarios, estimated means were greater than the medians. This suggests that although households incurred costs during outages, few of the sampled homes were willing to pay significant amounts to get rid of inconveniences caused by outages. The interdependence of expenditures on getting rid of the various types of outages may not be ruled out. This could be the effect of the budget constraint. It may also indicate that there is a degree of substitution of activities that require the consumption of electricity during the various outage scenarios considered here. The most significant determinants of the costs of outages for the 8 types of outages were found to be, whether electricity is the main source of cooking energy in the home, household income and the level of the recent electricity bill. The use of electric energy and higher per-capita income, were associated with greater willingness to subscribe to the back-up service during all types of outages (from the Tobit results). The implication here is that households' demand for reliable power supply increases with income per capita. The existence of a significant willingness to pay (monthly expenditure layouts) by domestic consumers for getting rid of power outages serves as an indicator to the electricity generating firm of the existence of a considerable demand for reliable electric energy supply that increases with GDP. This necessitates that power supply steadily increases in line with the ever growing demand for electricity. Whether the provision of more reliable services involves short term strategies like refurbishing the existing equipment or a further expansion of capacity, is a decision the electricity generating firms will have to consider given their other operation goals.

### ACKNOWLEDGEMENTS

I would like to thank Professor Gardner Brown, David Layton, Ståle Navrud, Olof Johansson-Stenman, Per Fredrikson and Thomas Sterner for the useful comments. Financial support from the Swedish international development agency is gratefully acknowledged.

#### REFERENCES

Alberini A (1995). "Optimal Design for Discrete Choice Contigent Valuation: Single Bounded, Double- Bounded and Bivariate Models." J. Environ. Econ. Manage. 28: 287-306.

Arrow K, Sorow R, Portney P, Learner E, Radner R, Schuman H (1993). "Report of NOAA Panel on Contingent Valuations." 58 Fed. Reg. 46.

Ayer M, Ewing HD, Silverman GM (1955). "An Empirical Distribution function for Sampling with Incomplete Information." Annals of Mathematical Statistics 26: 641-647.

Boyle KJ, Bishop RC (1988). "Welfare measurements using contingent valuation: a comparison of techniques." American Agriculture Economics Association 7:20-28.

Boyle KJ, Welsh MP, Bishop RC (1988) "Validation of empirical measures of welfare change: comment." Land Economics 64: 94-98.

Cameron TA (1988) "A New Paradigm for Valuing Non-market Goods Using Referendum Data: Maximum Likelihood by Selected Logistic Regression." J. Environ. Econ. Manage. 15: 355-379.

Cameron TA, Englin J (1996). "Respondent Experience and Contingent Valuation of Environmental Goods." Working Paper No. 752, UCLA Department of Economics. 1

Carson RT (1998). "Sequencing and Valuing Public Goods." J Environ Econ Manage 36: 314-323.

Carson RT, Mitchell RC (1995) " Sequencing and Nesting in Contingent Valuation Surveys." J. Environ. Econ. Manage. 28: 135-269.

Desvousges WH (1987)."Option Price Estimates for Water Quality Improvements: A Contingent Valuation Study for the Monongahela River." J Environ Econ Manage 14: 248-267.

Frykblom P (1997). "Hypothetical Question Modes and Real Willingness to Pay." J. Environ. Econ. Manage. 34: 275-287.

Greene WH (1997). Econometric Analysis. 3rd Ed. Prentice-Hall International (UK) ltd London.

Hanemann WMB, Kanninen (1996). "The Statistical Analysis of Discrete-Response CV Data." California Agricultural Experiment Station, Giannini Foundation of Agricultural Economics. Working paper No.798.

Herriges JA, Shogren JF (1996). "Starting Point Bias in Dichotomous Choice Valuation with Follow up Questions." J. Environ. Econ. Manage. 30:112-131.

Holmes TP, Kramer RA (1995). "An independent Sample Test Yea-saying and Starting Point Bias in Dichotomous Choice Contingent Valuation." J. Environ. Econ. Manage. 29:121-132.

Kanninen B (1993). "Design of Sequential Experiments for Contingent Valuation Studies." J Environ Econ Manage 25: S-1 - S-11.

Kriström B (1990). "A non Parametric Approach to the Estimation of Welfare Measures in discrete Response Valuation Studies." Land Economics 66: 135-139.

Kriström B (1993)."Comparing Continuous and Discrete Contingent Valuation questions." Environmental and Resource Economics 3: 63-71.

Kriström B (1995). ”Spike Models in Contigent Valuation: Theory and Applications.” Working Paper No. 210 SLU-Umeå Sweden.

Layton DK, Moeltner (2002). “A Censored Random Coefficients Model for Pooled Survey Data with Application to the Estimation of Power Outage Costs.” The Review of Economics and Statistics 84: 552 – 561. Little IMD (1957). A Critique of Welfare Economics. New York, NY: Oxford University Press.

Mekonnen A (1998). Rural Energy and Afforestation: Case Studies from Ethiopia. PhD Thesis. Göteborg Universitet. Ministry of Finance and Economic Planning, Uganda, Background to the Budget various issues.

Mitchell RC, Carson R (1989). Using Surveys to Value Public Goods: The Contingent Valuation Method. Resources for the Future Washington D.C. UEB Statistical Bulletin, various issues. UEB Report and Accounts various issues.

Smith VK, Osborne LL (1996). “Do Contingent Valuation Estimates Pass a “Scope” Test? A Meta-analysis.” J. Environ. Econ. Manage. 31: 287-301.

Uganda Electricity Regulatory Authority (2006). “Tariff Determination in the Uganda Electricity Sector”. (Unpublished).

Wang H (1997). “Treatment of Don’t Know Responses in Contingent Valuation Survey: A Random Valuation Model.” J. Environ. Econ. Manage.32:219-232.