Research article

Households' preference for reliable electricity: evidence from Hosanna and Durame towns of Southern Ethiopia

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ABSTRACT

The reliable and renewable Electricity services have a substantial contribution to the environment, economy, and social cohesion. Nevertheless, in developing countries like Ethiopia, electricity services are irregular and unreliable. The study aims to analyze households' preference for reliable electricity services using primary data collected from 210 sample households in Hosanna and Durame towns of Southern Ethiopia. The households' preferences were analyzed using the choice experiment valuation technique. The study used both Conditional and Mixed Logit models to estimate the mean and marginal Willingness to Pay (WTP) for the attributes. The result suggests that households are willing to pay 230.84 ETB ($8.34), 229.34 ETB ($8.2), 2230 ETB ($8.3), and 230 ETB ($8.26) per month for improvement scenario one, two, three and four respectively in addition to the current monthly charge. Hence, the government should heavily invest in improving electricity transmission and distribution capacity besides upscaling the generation capacity.

1. Introduction

Renewable energy is a key factor for sustainable development and poverty alleviation. It plays an important role in all development challenges that the world faces currently (The World Bank Annual Report, 2017). Moreover, access to modern energy services such as green electricity plays vital roles in creating employment, increasing trade, supporting value-adding activities, facilitating the accumulation of “surpluses” or savings that will enhance nutrition and health, improve housing conditions, facilitate access to education, and in sum contributing to overcoming poverty (Karekezi et al., 2012).

As the population increases and people's standard of living improved, the demand for modern and renewable energy raises. Nevertheless, Developing countries are far behind in expanding access to modern energy. Energy poverty is overwhelmingly concentrated in Sub-Saharan Africa. 609 million people or six out of ten do not have access to electricity in Sub-Sahara Africa compared to 32 percent or 343 million people in South Asia (State of electricity access report, 2017). In Ethiopia, over 50 million people, or four out of ten do not have access to electricity (MoWIE, NEP 2, 2019).

However, having access is not a guarantee to serve the requirements of households, schools, health centers, and native enterprises; electricity must be available at the proper time with a reliable supply. Outages have become a characteristic feature of most economies in Africa in general and Ethiopia in particular. Households and firms endure several hours of day and night without access to power (Rocket Medea, 2020).

A long and frequent power interruption, force households to maintain alternative sources of energy like fuel wood, charcoal, generator, and kerosene for cooking as well as lighting purposes. These sorts of energy are costlier compared to electricity. Hence, it increases the economic burden on the household budget (Gartner and Stamps, 2014).

To solve the problem, the Ethiopian government has been investing a huge amount of resources to expand and improve electricity service. In addition, the government aimed to attract new investors into the energy sector (Energypedia, 2020). However, the consumers are unable to get uninterrupted and good-quality services yet. Hence, it is difficult for the government to finance the sector and realize significant improvement; the stakeholders should take part to enhance government revenue via increasing tariffs. Accordingly, this study intends to address the problems by examining consumer preference for improved electricity services. Putting a value on such environmental goods or services advocates responsibility and precaution when striving for economic development and growth (Quah and Tan, 2019). Valuation of electricity services is important for prioritizing investments that modernize the electric grid to meet national, regional, or state energy and climate objectives (Voisin et al., 2016). Furthermore, without understanding the demand for
reliable electricity, it is impossible to make socially feasible investment
decisions, target the effective policies for sustained supply of electricity
and so far improve the welfare of vulnerable groups (De Nooij et al.,
2007).

Limited studies have been conducted concerning energy valuation or
Willingness to Pay (WTP) for reliable electricity services in developing
countries in general and Ethiopia in particular. Among them, Entele
(2020), Joshua et al. (2020), Siyaranamual et al. (2019), Wakjira (2016),
Gunatilake et al. (2012) and etc. However, none of these studies estimate
the extra cost incurred by households during the power interruptions.
They are mainly focused on estimating WTP for electricity service.
Moreover, among the conducted studies, some of them were used the
contingent valuation method and this method composed of various
shortcomings: it provides less information since it doesn't allow for
estimating the implicit price or mean WTP for the different attributes
(Iloyos, 2010). Second, Contingent Valuation (CV) aggravates ethical
protesting (Hanley et al., 2001, p. 451). CV cannot give the chance to
elicit a deeper understanding of the trade-offs between different attri-
butes (Admowicz et al., 1998).

Thus, this study aims to investigate households’ preference for unin-
terrupted electricity services using the Choice Experiment (CE) method
and hence filled the identified gap by estimating the cost of power in-
terruptions in addition to analysing households’ WTP for reliable elec-
tricity services through survey data which was collected using structured
questioner. The result from this study is important for Ethiopian electric
power to spot the worth that folks attach to electricity service attributes
for creating investment decisions, building system capacity, and
improving maintenance intended to scale back these power failures. This
study aims to answer the following research questions. (1) How much
outage costs are incurred by the households due to power interruption?
(2) Does the households mean WTP varies across various improvement
scenarios? (3) Does the marginal WTP vary across electricity service at-
tributes? The rest of the paper is structured as follows: Section 2 presents
a brief overview of the Ethiopian energy sector, section 3 outlines a
Review of empirical studies on electricity service, section 4 discusses the
research methodology and data, and section 5 presents the study results,
section 6 outlines Discussion and interpretation, section 7 notes conclu-
sions and policy implications.

2. A brief overview of the Ethiopian energy sector

Besides its ambitious plans to realize a climate-resilient develop-
ment by 2025, Ethiopia is among the lowest rates of access to modern
energy services, whereby the energy supply is predicated on biomass with
a share of 85% in primary biomass (wood, agricultural residues),
3% derived biomass (charcoal, ethanol), 9% petroleum, 1% coal and a
couple of electricity with primitive cooking stoves (Ministry of Water,
Irrigation and Electricity, 2019). The overreliance on traditional
fuelwood use has contributed to drastic forest cover loss and had
negative public health and welfare consequences (Guta, 2014) (see
Figure 1).

Ethiopia features a final energy consumption of around 40,000
GigaWatt hours (GWh), whereof 42% are consumed by domestic appli-
cances, 36% by industry, 22% services, and 10% get exported (Ministry of
Water, Irrigation and Electricity, 2019). The produced electricity of 9000
GWh is especially generated by hydro energy (96%) followed by wind
energy (4%). In contrast, the main share of energy supply for transport
is imported in sort of petroleum (International Energy Agency, 2014).

The estimated energy consumption is 2.1 kg of wood fuel equivalent
per person per day. As of the projection made by the Employee and
Family Assistance Program (EFAP) for the year 2008, the supply of fuel
woods was 9.8 million cubic meters compared to the demand which is
74.9 million cubic meters (showing a deficit of 65 million m³ of wood).
The projection made by EFAP for the year 2020 indicated that the
demand will reach 100 million against a supply projection of seven million
envisaging a deficit of 92.3 million (Bekele, 2001). The energy demand is
predicted to rise by a rate of 10–14% per annum till 2037 due to its fast
economic process (EEPC, 2013).

Today only 44% of the country’s population have access to electricity
of which 33% are connected to the grid and 11% are served with off-grid
mainly solar lanterns/home system (MoWIE, NEP 2, 2019). This share is
increasing thanks to an extension of the national grid on one hand, and an
increasing number of Stand-alone-systems and Mini-grids on the opposite
hand (World Bank, 2020). The price of electricity in Ethiopia is 0.009
USD or 0.349 ETB per KWh for households and 0.022 USD or 0.816 ETB
for businesses which incorporates all components of the electricity bill
such as the value of power, distribution, and taxes. This price is lower
compared to the world average price of electricity (0.14 USD per KWh
for households and 0.12 USD for businesses) during the same period (Global
Petrol Prices, 2020).

Ethiopian Electric Utility (EEU) charges a minimum of 500 ETB
(36.6€) as a connection fee. The fee can go up to 100 USD. The quantity is
usually recovered through the customer’s bill over a 24-month or a long
period. The fee includes wiring to the house and the installation of an
electrical meter (Energypedia, 2020).

3. Review of empirical studies on electricity service

Entele (2020) analyzes rural households’ preferences and WTP for
gridline and photovoltaic electricity service connection using contingent
valuation and a bivariate probit model. The result from this study indi-
cates that, among the two sources of renewable electricity services,
households preferred grid lines to solar electricity services regardless of
the payment scheme. However, the study focuses only on assessing rural
households’ preference for grid and PV (photovoltaic solar) electricity.
For instance, the study failed to consider urban households and the
reliability of the service as far as the quality of the service plays a vital
role in achieving sustainable development goals. Siyaranamual et al. (2019)
have used the CE method and two esti-
mation models: mixed logit and latent class logit to explore the value that
the consumers place on electricity service attributes. The study used four
electricity service attributes: frequency of outage per year; hydropower
for electricity generation; rural electrification; and monthly electricity

Figure 1. A photograph of a Woman baking staple bread in Southern Nation Nationalities and Peoples Region (SNNPR), on three-stone fire during the outage. Source: Wakjira, 2018.)
The result from this study indicates that to reduce the outage duration (2 h/year), the respondents have WTP between $0.17 per kWh which is 24–35% higher than the current electricity bill. Business firms have a higher WTP which is almost 50% more per kWh than households.

Abdullah and Mariel (2010) of Kenya used CE valuation techniques and the attributes like price, type of distribution provider, number of planned blackouts, and duration of the outage. The result from the MXL model indicated that consumers have the highest WTP (61.87 Kenyan Shilling) for the duration of the outage. Moreover, different socio-economic and demographic characteristics may reveal that there are heterogeneities in preferences. However, they failed to include important attributes like the time of outages.

Wakjira (2016) of Ethiopia estimates households’ WTP for reliable electricity using the CE valuation method. The estimated result indicated that respondents have willing to pay 19 cents per KWH for reducing the frequency of outages and 13 cents for reducing unannounced outages that occurred during nighttime. This study only used four attributes including cost attributes and it only focused on estimating households’ WTP for reliable electricity service. But this study failed to estimate the extra cost incurred by households that resulted from power interruptions.

Markus (2009) investigates household and business consumers’ preferences for reliable electricity services using the CE valuation method. The result from the probit model indicates that all attributes were statistically significant. Both households and business consumers have willing to pay above their current electricity bill to reduce the frequency and duration of outages from the current level. Regarding the timing of an interruption, business customers prefer power interruption on weekends and during the night when their business is usually closed, whereas households prefer interruptions during the week.

Ozbafl and Jenkins (2016) estimates WTP using the CE valuation method. The result from the mixed logit model indicates that compensating variations are 6.65 Turkish Lira (YTL) or 5.66USD per month for summer and 25.83 YTL or 21.97 USD per month for the winter. Furthermore, households have willing to pay 3.6% and 13.9% for summer and winter respectively in addition to their monthly electricity bill to avoid the cost of outages.

Murakami et al. (2015) explores consumers’ WTP for nuclear and renewable electricity compared to fossil fuels using a CE valuation method based on an online survey in Japan and four USA states. The result confirms that both USA and Japanese consumers have willing to pay $0.31 and $0.26 per month respectively for 1% decrease in greenhouse gas emissions and willing to pay $0.71 and $0.31 per month for 1% increase in the use of renewable source energy. Both consumers have a negative preference for an increase in nuclear power.

Sagiebel and Rommel (2014) investigates domestic consumers’ WTP for reliable electricity using survey data collected from 798 urban households in Hyderabad, India. To identify heterogeneity in preferences and variance scale, they had used a scale-adjusted latent class model. The result indicates domestic users have a lower WTP for electricity quality and renewable energy.

Tweresfou (2014) of Ghana estimates households’ WTP for reliable electricity supply using the CV method. Results confirm that on average, households have willing to pay 0.2734 for a kilowatt-hour in addition to their current electricity bill. Furthermore, household income, sex, size, and education significantly influence households’ WTP.

Kim et al. (2019) of Korea investigate residential consumers’ WTP to avoid power outages using the CV method. The results indicate that the mean monthly WTP of households averages KRW 1522 (USD 1.41) which is equivalent to KRW 360.7 billion (USD 335.3 million) when converted into annual and national values.

Gunati lake et al. (2012) investigates households’ WTP for electricity service attributes using a CE in Madhya Pradesh, India. Results indicate that consumers have a higher WTP for improvement scenarios. Among the attributes, respondents have the highest WTP for hours of supply, and WTP declines significantly with reduced hours of supply.

Ma et al. (2015) intend to determine variation in WTP using a meta-regression analysis. The results revealed that respondents have higher WTP for solar generic renewable energy sources relative to wind, hydro, or biomass.

4. The research methodology and data

4.1. The study site description

Hosanna and Durame towns are the administrative centers of the Hadiyya and Kembata Tamboro Zone respectively. Fortunately, they are located in the SNNPR (Southern Nation Nationalities and Peoples Region). Hosanna has a latitude and longitude of 7°33′N 37°51′E with an elevation of 2177 m above sea level whereas Durame town has a latitude and longitude of 7°14′N 37°53′E with an elevation of 2101 m above sea level respectively. Based on the population projection made by the Central Statistical Authority (CSA) in 2015, the total population of the Hosanna and Durame towns are 89,300 and 46,800 respectively in the year 2011. The Main Food Crops in these sites are Enset and wheat (Southern Nation, Nationalities and People's Region Ethiopia Livelihood Profiles, 2006). More than 80% of urban households in SNNPR (320,000 households) use open fire for non-Injera cooking. Moreover for baking Injera, bread, and other cooking purposes, urban households of SNNPR consumed 6.92 Kilograms of wood equivalent (Kgwe) per day per household which is equivalent to 1.65 kg per day per capita (Household energy baseline survey in SNNPR GIZ, 2011). In this region, the annual deforestation rate is 1.6% which is the highest compared to the national deforestation rate of 1.1% (see Figure 2).

This implies that there is high demand for biomass fuels in the region (Household energy baseline survey in SNNPR GIZ, 2011).

4.2. The choice experiment design and pre-test

The CE is a family of stated preference elicitation techniques in which respondents are presented with different alternatives defined by many attributes or characteristics. Moreover, in CE, respondents are asked to choose the most preferred among aset of alternatives by comparing various levels of attributes in different alternatives which are presented in a choice set (Alpizar and Bennett, 2001). Despite the cognitive complexity that the respondent faces in the CE, in this study we used the CE method as it has several advantages relative to CV: CE methods are more informative due to multiple choices provided for the respondents, and it reduces response problems (‘yes-saying’, protest bids and strategic bidding), and it helps to estimate the Marginal values of goods/services (Bateman and Jones, 2003; Hanley et al., 1998; Boxall et al., 1996).

According to Bateman and Jones (2003), four steps are needed to conduct a CE study and hence, the study followed all of the stated steps. The first and second stages in designing the CE survey are identifying the attributes of the electricity services and their levels which influence the household’s decision. As the first and second steps in designing the survey, we undertake Focus Group Discussions (FGDs) with 12 households (6 from each town) and semi-structured in-depth interviews with 18 expert key informants which have purposively selected from Ethiopian Electric power (EEP) head office, Hosanna and Durame towns EEU (Ethiopian Electric Utility) district staffs as well as local NGOs. In addition, the researchers reviewed various energy-related articles. Accordingly, FGDs participants were willing to pay as little as 120 ETB to 300 ETB per monthly, mainly to reduce unannounced outage that
occurs during the nighttime. The participants also stated that the average number of outages occurring per month is 120 with an average duration of 180 h per month. Based on the information gathered from FGDs participants, energy-related literature, the key informants, and local NGOs, we selected five attributes and their levels as follows: Time of outages, Frequency of outages, Duration of outages, notification of outage, and additional cost as presented in Table 1 below.

The third and the fourth steps are experimental design and construction of choice sets: Having established relevant attributes and their levels, an experimental design strategy needs to be selected and presented to individuals. Accordingly, for this study, the full factorial design yields 83 alternatives ($3^4 + 2^1$). Thus, it is very costly to use the full factorial design. Therefore, we used a fold-over design method and generated six choice sets that have 18 choices which satisfy Orthogonality (Louviere et al., 2000). A fold over design is one of the techniques used by Carlson and Martinsson (2003) to create the choice experiment. It is the mirror image of the traditional orthogonal design (See Table 2).

4.3. Design and development of questioner

Based on the finding from the pre-test (FGD and Key informant interview), the draft questionnaires were prepared and reviewed by the Wachemo university college of Business and Economics research committee. For instance, some refinement was made by incorporating the committees’ comments. After incorporating the feedback from pre-questioner and our college research committee comments we have prepared the final questioners which were presented in five sections. The first section is the introduction part and it consists of information like the purpose of the study, informed consent, survey dates, and others. The second section includes socio-economic questions like income, educational status, sex, age, family size, monthly expenditure, occupation, and marital status. The third section constitutes questions related to the perception and preference of households corresponding to the current price, current service quality, additional expenses incurred due to outages, perceived benefit of electricity, etc. The fourth section is the choice set questions designed to elicit the WTP of consumers for improved electricity services. Respondents were asked to choose the most preferred among a set of alternatives by comparing various levels of attributes in different alternatives which are presented in a choice set (Alpizar and

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Table 1. The key attributes and the attribute levels for improved electricity services.

| Attributes          | Definition                                                                 | Levels                                                                 |
|---------------------|---------------------------------------------------------------------------|-----------------------------------------------------------------------|
| Time of outages     | The time of occurrence of the outage                                       | 3 (Daytime, Night-time, and midnight time)                             |
| Frequency of outages| The average number of outages per month                                   | 3 (1, 3 and 5)                                                        |
| Duration of outages | The length of outages in hours.                                           | 3 (1, 2 and 3)                                                        |
| Notification of outages| Informing the consumer before the outage                                      | 2 (no prior notification, prior notification during blackout)         |
| Additional costs    | The cost that is added to the per monthly electricity bill                | 3 (20, 40 and 80 ETB)                                                 |

Table 2. A sample of choice set that was provided for the respondents.

| Attributes          | Service A                | Service B                | Current services                                                                 |
|---------------------|--------------------------|--------------------------|----------------------------------------------------------------------------------|
| Time of outages     | Mid-night time           | Night-time               | Neither Service A nor Service B: I prefer to stay with my current service       |
| Frequency of outages| Outage three times a month | Outage ones a month     |                                                                                  |
| Duration of outages | Outage for 2 h           | Outage for 3 h           |                                                                                  |
| Notification of outages| No prior notification            | Notification during blackouts |                                                                                  |
| Additional costs    | 80 ETB                   | 40 ETB                   |                                                                                  |
Bennett, 2001). Section five is the follow-up questions for those respondents who choose the status quo option also known as the ‘business-as-usual’ position, as it does not vary across the choice sets (Mogas et al., 2006). The administration and execution of stated preference interviews is a key step (Whittington, 2002). Therefore, to minimize the bias, we hired one field supervisor and six professional enumerators and then trained them about the research questionnaires to slickly approach the respondents and conduct the survey. Finally, the data was collected using a face-to-face interview scheme. In the course of the data collection, each respondent was asked to indicate their consent by their signature and all of them ascertained their decisions by their signature as they have had any questions answered and have received a copy of the form to keep with themselves. The other critical concern during data collection was the ethical issue. Hence, the prepared questionnaires were evaluated by the research and ethical review board of Wachemo University and then acquired approval from the board. Lastly, the survey was conducted from Mid-March to Mid-April 2018 across Hosanna and Durame towns of Southern Ethiopia.

4.4. Sample selection and sample size

The survey questionnaires were developed and presented in English and then translated into the local languages Amharic, and Hadiyya. Then Professional enumerators were carefully screened and trained to collect households’ WTP for reliable electricity services by employing multistage sampling techniques. In the first stage, two towns (Hosanna town from the Hadiyya zone and Durame town from the Kembata Tambaro zone) were purposively selected for having the majority of households connected to the grid and using electricity other than fuels compared to the others. In the second stage, 3 kebeles (small district administrative units in Ethiopia) were randomly selected from each town as there is no significant difference among these kebeles in terms of their electricity consumption based on the information obtained from the EEU Hosanna and Durame districts. Random sampling is preferred because each element in the population has an equal chance of being selected and so far reduces a selection bias. However, in this study, we couldn’t test the existence of any bias since data on non-respondents, which is necessary to conduct the tests, were not available. Finally, 394 sample households were randomly selected using the proportional sampling technique. To select sample size from the total population, Yamane’s (1967) sample size determination formula was used assuming a 95% confidence interval and 0.05 precision levels. Based on the population projection made by the Central Statistical Authority (CSA) in 2015, the total population of the Hosanna and Durame towns are 16,707 and 8433 households respectively in the year 2011. Therefore, the total populations of these towns are 25,140.

\[
n = \frac{N}{1 + Ne^2} = \frac{25,140}{1 + 25,140(0.05)} \approx 394
\]

Where,
- \(n\) = number of respondents.
- \(N\) = population size.
- \(e\) = sampling error/level of precision.

The total sample size of respondents based on the above sample size determination is 394 households. Then based on the proportion of households in each town we selected 262 and 132 respondents from Hosanna and Durame towns respectively.

4.5. Data analysis techniques

In this study, the CLM (Conditional Logit Model) is presented and compared with the Mixed Logit Model (MXL) to estimate households’ mean WTP and marginal WTP for electricity service attributes. The difference between the two models is illustrated with an analysis of the choice for electricity service attributes. According to McFadden (1973), Conditional Logit Model is appropriate when the choice among alternatives is modelled as a function of the characteristics of the alternatives rather than the characteristics of the individual assuming independence from Irrelevant Alternatives (IIA). Implied that, the odds ratio between two alternatives does not change by the inclusion or exclusion of any other alternative. Therefore, the probability that household will choose the service attribute is given by:

\[
Pr(Y_i = j) = \frac{\exp(x_i \beta_j)}{\sum_{j=1}^{J} \exp(x_i \beta_j)}
\]

An obvious theoretical way to handle the IIA property is to allow the unobserved part of the utility function to follow: a multivariate normal distribution, allowing the residuals to be correlated with each other and estimate the model with nested logit, multinomial probit, and mixed logit model. The Mixed Logit Model allows the coefficient of observed variables to vary randomly with a specific probabilistic distribution across individuals (Yang, 2005). According to Brownstone and Train (1999), the Mixed Logit Model in a cross-sectional setting can be modeled as presented in equation (2) below. Where coefficient of observable variable \(x_i\) is and is respondent characteristic and hence represents the respondent’s preference.

\[
P_i(\eta_j) = \frac{\exp(\beta_j x_i + \eta_i)}{\sum_{j=1}^{J} \exp(\beta_j x_i + \eta_i)}
\]

Once we estimated the coefficients from the two models, we calculated the implicit price (MWTP) for each attribute using the formula given by Hanemann (1984), Parson and Kealy (1992) as presented in Eq. (3) below.

\[
MWTP = \beta_b / \beta_M
\]

Where \(\beta_b\) represents the coefficient of non-marketed attributes and \(\beta_M\) shows the coefficient of the cost attribute.

5. Results

5.1. Descriptive statistics

Of the total of 394 respondents, 85 (21.57%) responded to only two choice questions, 52 (13.2%) responded to three choice questions and 45(11.42%) refused to tell their income levels. Therefore, we drop them from the analysis. As a result, our sample size was reduced to 210 households, yielding 3780 observations (Each respondent answered six choice sets and each choice set has three alternatives: option A, option B, and the status quo option). Of 210 households, 25 respondents choose the status quo or current alternative. Before empirical analysis, the data was first coded and entered in the wide-format then converted into the long format for statistical analysis using the reshape command. Finally, we used STATA software version 16 to estimate both conditional and Mixed logit models. Descriptive statistics of the findings are presented in Table 3 below. The respondents’ age ranged from 21 and 83 years, with a mean age of 46 years. Males (57%) were dominant compared to females. About 57% of the female respondents has formal education. The average family size is 4.4 which is much higher compared to the average family size of the urban household in the SNNPR 3.9 (CSA, 2014–2017). The average income of the sampled respondents was 10,250.7 ETB (Ethiopian Birr) per month or 266.5USD which is higher compared to the average income at the national level of 8900 ETB (Salary explorer, 2020). Because, households in these Zones have been received high remittances (Feyisa, 2011). The monthly expenditure by households ranged from 3000 ETB to 15,000 ETB. Farming is the dominant form (67%) of employment. Majority of the respondents (68%) reported that they are willing to engage in the
Table 3. Summary of variables used in the models.

| Variable          | Description                         | Mean       | Std. dev  | Min  | Max  | obs |
|-------------------|-------------------------------------|------------|-----------|------|------|-----|
| Age of HH         | The age of HH's head                | 45.98      | 17.59     | 21   | 83   | 210 |
| Male HH           | 1 if head of HH is male             | .576       | .496      | 0    | 1    | 210 |
| Education         | 1 if head of HH has formal education| .567       | .497      | 0    | 1    | 210 |
| Family size       | Total no of the family for HH head  | 4.39       | 2.239     | 1    | 10   | 210 |
| Income of HH      | Total per monthly income of HH head | 10,250.7   | 6504.4    | 1500 | 16,000 | 210 |
| Monthly exp       | monthly expenditure by HH head      | 8758.2     | 1024.1    | 1000 | 15,000 | 210 |
| Occupation        | 1 if head of HH is farmer           | .67        | .32       | 0    | 1    | 210 |
| No of livestock   | Total no of livestock owned by HH   | 3.018      | 4.99      | 0    | 20   | 210 |
| Interest in business | 1 if HH head has willing to engage in business | .681 | .348 | 0 | 1 | 210 |
| Owns house        | 1 if HH head owns house             | .493       | .523      | 0    | 1    | 210 |
| Bank account      | 1 if HH head had bank account       | .619       | .345      | 0    | 1    | 210 |
| Marital status    | 1 if HH head is married             | .641       | .213      | 0    | 1    | 210 |

Source: Survey result, 2018.

The staff of the EEU Hosanna district responded: “the town encounters frequent power failures and sometimes significant blackouts which stay for a week or more. Hence, for this town, electricity has been generated from the Gilgel Gibe dam and this river has experienced heavy sedimentation over the years which resulted in frequent power interruptions in the region. In addition, power interruption has arisen due to low-quality equipment that was used by the company”.

5.2. Econometric analysis

The study used Conditional and Mixed logit models to determine the right attributes. The CLM was used as the first step (as presented in Table 4) because this model is appropriate when the researcher's interest is to analyse the effect of characteristics of alternatives on individual choices (McFadden, 1973). However, the CLM is effective if and only if the assumption of Independence of Irrelevant Alternatives (IIA) holds. This assumption states that the inclusion or removal of one alternative doesn't affect the relative probabilities of choosing other alternatives. The existence of the IIA can be tested using: the estimation of the nested logit model, regression-based statistics by McFadden (1973) and Small (1994); a nonparametric test by Zheng (2008), and the Haussmann test which was formulated by Hausman and McFadden (1984). This paper used the Hausmann test due to its simplicity and by far the most frequently used test. For instance, the independence and irrelevance of alternatives were tested as shown in Table 5, using Stata version 16. However, the test results of IIA or Prob > chi2(0.000) are significant at a 5% significance level. A significant test result suggests that the alternatives are cross-correlated, and hence the IIA assumption is violated (Hensher et al., 2005). When the IIA is violated, the CLM is biased. This is why the Mixed logit model was computed as the second step in determining the right attributes since it relaxes the IIA assumption and allows for heterogeneity when the random parameter varies with the distribution. To evaluate the validity of MXL, the likelihood ratio (for the overall joint test) was used. For instance, the goodness of fit using the log-likelihood in Table 6 (–271.95) point out high improvements in
Table 4. Estimates from the CLM.

| Choice                        | Coef.  | Std.Err | Z     | p>|z| | 95% CI             | Interval |
|-------------------------------|--------|---------|-------|-----|-----------------|---------|
| Additional cost               | −1.004 | .141    | −7.11 | 0.00 | −1.28           | −.727   |
| Frequency 3                   | −.657  | .177    | −3.71 | 0.00 | −1.004          | −.309   |
| Frequency 5                   | −.579  | .201    | −2.88 | 0.00 | −.974           | −.185   |
| Duration 2                    | −2.475 | .161    | −15.36| 0.00 | −2.79           | −2.16   |
| Duration 3                    | −5.138 | .294    | −17.45| 0.00 | −5.71           | −4.56   |
| Night time outage             | −.652  | .174    | −3.75 | 0.00 | −1.079          | −.311   |
| Status-quo                    | 7.48   | .448    | 16.71 | 0.00 | 8.36            | 9.59    |
| LR chi2                       | 2822.70|         |       |      |                 |         |
| Prob > chi2                   | 0.00   |         |       |      |                 |         |
| Pseudo R2                     | 0.68   |         |       |      |                 |         |
| Log-likelihood                | −652.73|         |       |      |                 |         |
| Number of observation         | 3780   |         |       |      |                 |         |
| Number of respondents         | 210    |         |       |      |                 |         |

Source: Survey result, 2018.

Random Probability Model (RPM) relative to the CLM (−652.73) as shown in Table 4.

Using the output of the MXL model, the implicit price for each attribute (MWTP), Mean willingness to pay, and aggregate Mean WTP were estimated. Implicit price is the ratio of the coefficient of non-marketed attributes to the coefficient of the cost attribute. The result of implicit price was presented in Table 7.

Mean WTP represents the amount of money that individuals are willing to compensate to acquire improved electricity services. It can be calculated as: where \( V_0 \) and \( V_1 \) represent utility from status quo service and the utility from improved service respectively and indicate the coefficient of cost attribute. Furthermore, Mean WTP (CS) measures welfare changes associated with improved electricity service away from the “status-quo” scenario (current situation) as indicated in Table 8. The mean and the marginal WTP are computed only for those attributes which are statistically significant like frequency 3, frequency 5, duration 2, duration 3, and night-time outage. For further clarification, the Status-quo scenario (Current service) implies frequency (120 outages per month), duration (180 h per month), and the outage that occur every time, improvement scenario 1 implies improvement of outage from the current service to 3 times per month for 2 h and night time outage, improvement scenario 2 implies improvement of outage from the current service to 5 times per month for 2 h and night time outage, improvement scenario 3 implies the improvement of outage from the current service to 3 times per month for 3 h and night time outage and improvement scenario 4 implies the improvement of outage from the current service to 5 times per month for 3 h and night time outage.

Aggregate mean WTP is calculated by multiplying the mean willingness to pay by the total number of households in each town (see Table 9).

5.3. Welfare analysis

5.3.1. Marginal willingness to pay (MWTP)

5.3.2. Consumer surplus (mean WTP)

5.3.3. The estimated aggregate mean WTP for each improvement scenario

5.4. The result from the follow-up question

6. Discussion and interpretation

Table 4 presents the CLM outputs. Of eleven attributes, the coefficient of frequency (ones per month), duration of the outage (one hour per month), prior notification, mid-night outage, and daytime outage are insignificant and hence we drop them from the model. The remaining attributes are negatively and significantly related to individual utility. The coefficients of frequency 3, frequency 5, Duration 2, Duration 3 Nighttime outage and additional cost are negative as expected, implying that households’ WTP for improved electricity service increases with a decrease in the frequency of outage, duration of the outage, night time outage and additional costs. This result supports the finding of Abdullah and Mariel (2010) in which cost, frequency of outages, and duration of outages are significant and have the expected negative signs, and Wakjira (2016) in which frequency of outage, time of outage (nighttime outage) and additional cost are significant and negative. Table 6 shows the estimates from the MXL. Similar to the previous CLM, the coefficients of frequency 3, frequency 5, Duration 2, Duration 3 Nighttime outage and additional cost are statistically significant and negative. Nevertheless, in MXL the standard deviation is positive and significant at 1% for duration 3 and monetary attributes and at a 10% level of significance for frequency 5, night-time outage, and the status quo attributes. The significant standard deviation implies that there is considerable heterogeneity in sample households’ preferences. In addition, an increment in log-likelihood from (−652.73) in CLM to -271.95 in MXL implies that there is an improvement in the overall fit of the MXL model.

Once the parameter estimates have been obtained, a WTP welfare measure for policy change that affects the environmental good/service can be derived (Bateman et al., 2002). The MWTP is the ratio of the coefficient of non-monetary attribute to the coefficient of the cost attribute (Train, 2009). Table 7 presents the MWTP result with their respective confidence interval. The result indicates that the households’ are willing to pay about 88 ($0.0167) and 86 cents ($0.0163) per kWh for the reduction of frequency of outages to five times and three times per month respectively, 85 cents for reducing unannounced outages that occurred during the nighttime, 70 ($0.0133) and 56 ($0.0106) cents to reduce the duration of the outage to three and 2 h per month.

Table 5. The Hausmann test for IIA assumption.

| Coefficients (b) (B) Fe (b)−(B) Difference sqrt(diag(V_b−V_B)) S.E. |
|-----------------|-----------------|-----------------|-----------------|-----------------|
| Frequency 3     | .9953           | .1786           | .8167           | .308            |
| Frequency 5     | 1.2138          | .393            | .8207           | .379            |
| Duration 2      | −.322           | −2.214          | 1.89            | .288            |
| Duration 3      | −2.922          | −6.014          | 3.091           | .371            |
| Night time outage | −.300         | −.332           | .032            | .328            |
| chi2(6)         | (b−B)/[(V_b−V_B)(−1)](b−B) 177.80 |
| Prob > chi2     | 0.0000          |                 |                 |                 |

Source: Author’s computation, 2018.
Table 6. The estimates from the MXL model.

| Choice                  | Coef.  | Std.Err | Z     | p>|z| | 95% Conf Interval |
|-------------------------|--------|---------|-------|------|-----------------|
| Mean                    |        |         |       |      |                 |
| Additional cost         | -1.27  | .224    | -5.35 | 0.000| -1.63, -.759    |
| Frequency 3             | -1.073 | .264    | -4.01 | 0.000| -1.58, -.543    |
| Frequency 5             | -.772  | .303    | -2.79 | 0.010| -1.44, -.252    |
| Duration 2              | -3.27  | .278    | -11.42| 0.000| -3.72, -2.63    |
| Duration 3              | -16.64 | 2.42    | -6.03 | 0.000| -19.38, -9.86   |
| Night time outage       | -1.09  | .266    | -4.26 | 0.000| -1.65, -.611    |
| Status quo              | -10.68 | .982    | -10.40| 0.000| -12.13, -8.288  |
| SD                      | 1.005  | .172    | 5.83  | 0.000| .668, 1.344     |
| Frequency 5             | .054   | .275    | -.60  | 0.857| -.704, .374     |
| Frequency 5             | -.699  | .402    | -.29  | 0.065| -.906, .673     |
| Duration 2              | .141   | .276    | -11.42| 0.618| -.182, .901     |
| Duration 3              | 7.570  | 1.196   | 5.52  | 0.000| 4.264, 8.96     |
| Night time outage       | .649   | .551    | 0.34  | 0.091| .267, .393      |
| Status quo              | 1.880  | .403    | 2.38  | 0.006| 1.752, 1.96     |
| LR ch2                  | 109.81 | 0.000   |       |      |                 |
| Prob > ch2              | -.271  | 9.0     |       |      |                 |
| Number of observations  | 3780   |         |       |      |                 |
| Number of respondents   | 210    |         |       |      |                 |

Source: Survey, 2018.

Table 7. The estimates of MWTP.

| Scenarios               | MWTP   | Std.err | p-value | 95% confidence interval |
|-------------------------|--------|---------|---------|-------------------------|
| Frequency 3             | .8603  | .2304   | 0.000   | .291, .389              |
| Frequency 5             | .884   | .239    | 0.011   | .073, .136              |
| Duration 2              | .560   | .423    | 0.000   | .389, .731              |
| Duration 3              | .702   | .3145   | 0.000   | .189, .860              |
| Night time outage       | .857   | .260    | 0.001   | .368, .534              |

Source: survey, 2018.

Table 8. The estimates of compensating surplus.

| Improvement scenario   | Electricity service attributes | Compensating surplus |
|------------------------|---------------------------------|----------------------|
| Frequency of outage    | Duration of outage per monthly  | Time of Outage       |
|                        | 3 times per month               | The outage that occurs during the nighttime | 230.8 | .834 |
| 1                      | 3 times per month               | Outage for 2 h per month | 229.3 | .82 |
| 2                      | 5 times per month               | Outage that occurs during the nighttime | 220.3 | .83 |
| 3                      | 3 times per month               | Outage that occurs during the nighttime | 230.8 | .826 |

Source: Survey, 2018.

Table 9. The estimates of social welfare per monthly and annually.

| Scenarios               | Total monthly WTP for two towns households in birr (US$) | Total annual WTP for two towns households in birr (US$) |
|-------------------------|--------------------------------------------------------|--------------------------------------------------------|
| Improvement scenario    |                                                       |                                                       |
| 1                       | 5,803,317.6 (110,263.03)                                | 69,639,811.2 (1,323,156.4)                             |
| Improvement scenario    | 5,765,607.6 (109,546.5)                                 | 69,187,291.2 (1,314,358.5)                             |
| 2                       | 5,782,200 (109,861.8)                                   | 69,386,400 (1,318,341.6)                               |
| Improvement scenario    | 5,745,998.4 (109,173.9)                                 | 68,951,980.8 (1,310,087.6)                             |

Source: Survey, 2018.

Table 10. Reason for choosing the status quo option.

| Reason for choosing the status quo | Number of households | Percentage (%) |
|-----------------------------------|----------------------|-----------------|
| The current service is not too bad| 1                    | 4               |
| The alternatives in the choice sets are not much different from the current service. | 3 | 12 |
| Afraid of the price increment | 10                   | 40              |
| The current service is financially better | 5 | 20 |
| Others                           | 4                    | 16              |
| No specific reason               | 2                    | 8               |
| Total                            | 25                   | 100             |

Source: Survey, 2018.

respectively. This result is much lower compared to the finding of Siyaranamual et al. (2019), in which respondents are WTP between 1.18$ and 14.49$ per month to reduce the outage duration to 2 h/year.

Table 8 indicates welfare gains to the consumers due to an improvement from the status quo options. The result indicates that the mean WTP is 230.84 ETB or $8.34 per month for improvement scenario one, 229.34 ETB or $8.2 for improvement scenario two, 230 ETB or $8.3 for improvement scenario three, and 228.56 ETB or $8.26 for improvement scenario four. The mean WTP is slightly higher compared to the finding of the previous studies: According to Taale and Kyeremeh (2016), on average, Ghananian households were prepared to pay GH¢ 6.8 or $2.04 more in addition to the mean monthly electricity bill. For Kim et al. (2019) of Korea the mean monthly WTP of households averages KRW 1522 (USD 1.41). According to Ozba and Jenkins (2016), consumers are WTP 6.65 YTL (Turkish lira) or 5.66USD per month for summer and 25.83 YTL or 21.97 USD per month for winter. The higher mean WTP in Ethiopia may be attributed to high power interruption and hence high costs of power interruption relative to the above-stated countries. As presented in Table 9 above, the total mean WTP per month for improvement scenario one, two, three and four are 5.8 million ETB ($110,263.03), 5.76 million ($109,546.5), 5.78 million ETB ($109,861.8) and 5.74 million ETB ($109,173.9) respectively. This is much lower compared to the finding of Entele (2020) of Ethiopia in which the total monthly instalment payment scheme for grid line and Solar PV electricity services are 12.65 million ETB ($459,822.5) and 11.51 million ETB ($418,350.5) respectively. This may be attributed to higher connection costs relative to the cost of improving the quality of existing services.

For those who choose the current services (status quo) option, the reason for protesting is identified and presented in Table 10. For instance, of the total protests, (40%) of them chooses the status quo scenario due to being afraid of the price increment followed by the financial betterment of the current service.
7. Conclusions and policy implications

This study intends to analyze the preference of households for uninterrupted electricity services based on representative households’ survey data collected from 210 Residential households in Hosanna and Durame towns of Southern Ethiopia in 2018. Each respondent is presented with a choice set and each choice set has three alternatives including the status quo attribute. Each alternative has five attributes including the cost attribute. These are Time of outages, Frequency of outages, Duration of outages, notification of outages, and additional costs. Of these attributes, four of them are presented with three levels and one with two levels.

We used the CLM and MXL model to analyse households’ preference for reliable electricity services. The result from both models indicates that the coefficient of frequency (ones per month), duration of the outage (one hour per month), prior notification, mid-night outage, and daytime outage are statistically insignificant hence we drop them from our model. The remaining attributes are negatively and significantly related to individual utility. The coefficient of frequency 3, frequency 5, Duration 2, Duration 3 Night-time outage and additional costs are negative as expected, implying that households’ WTP for improved electricity service increases with a decrease in the frequency of outage, duration of the outage, night time outage and additional costs. However, the goodness of fit using the log-likelihood indicates that there are high improvements in RPM than in the CLM model. The MWTP for each attribute was estimated. Hence, respondents are WTP 88 and 86 cents per kWh for reducing the frequency of outages from current to five times and three times per month respectively. Respondents also WTP 85 cents for reducing unannounced outages that occurred during the nighttime, 70 and 56 cents to reduce the duration of outages from the current to three and 2 h per month respectively. Thus, to improve the reliability of electricity services, the priority should be given to reducing the frequency of outages followed by choosing the favourable time of the outage, and then the duration of the outage. We also estimated the MWTP for each service attributes. Accordingly, the MWTP is 230.84 ETB per month for improvement scenario 1, 229.34 ETB for improvement scenario 2, 230 ETB for improvement scenario 3, and 228.56 ETB for improvement scenario 4 in addition to the current monthly charge.

The total per monthly mean WTP for improvement scenario one, two, three and four are 5.8 million ETB ($110,263.03), 5.76 million ETB ($109,546.5), 5.78 million ETB ($109,861.8) and 5.74 million ETB ($109,173.9) respectively. This result is important for Ethiopian electric power to spot the worth that people attach to improved electricity service for creating investment decisions, building system capacity, and improving maintenance intended to scale back these power failures.

The clean and uninterrupted electricity service is expected to enhance people’s standard of living as it is important for running the business in addition to lighting and cooking. Improving the quality of electric supply is important for a sustainable energy transition from the use of traditional fuels to modern energy services in developing countries like Ethiopia. Nevertheless, as obtained from in-depth interviews with Ethiopian Electric power (EEP) head office, and staff of EEU Hosanna and Durame districts, most of the power failure happens in the course of distribution from the national grid to the end-users due to the low-quality equipment used by the company.

About 65% of respondents stated that they suffered from damage to appliances or equipment resulting from abnormal power release. In addition, more than 83% of respondents stated that they have incurred costs on purchasing alternative fuels such as fuelwood, charcoal, kerosene lamp, candle, and battery for cooking and lighting purposes when there is no light. Therefore, it is recommended that in addition to improving the energy generation capacity the government should also invest in electric transmission and distribution capacity with aim of reducing power failure through increasing electricity tariffs with improvement in services as a community is willing to pay for it. In general, this study is limited to assessing the preference of residential consumers from two zones towns only. However, consumer preference may vary from place to place and among various groups of consumers. Thus capturing preference heterogeneity at the consumer level is essential to offer a menu of improvement structures grounded on the types of the consumers. Therefore, future studies have to consider the preferences of business firms by up scaling the case studies. Further studies are also recommended to make the cost-benefit analysis on reliable and clean energy improvement projects as it eases the evaluation of investment feasibility for service improvement.

Declarations

Author contribution statement

Toleshi Wakjira & Teshome Kefale: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

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References

Abdullah, S., Mariel, P., 2010. Choice experiment study on the willingness to pay to improve electricity services. Energy Pol. 38 (8), 4570–4581.

Admovicwicz, W.L., Hanley, N., Wright, R.E., 1998. Using choice experiments to value the environment. Environ. Resour. Econ. 11 (3–4), 413–428.

Alpizar, Bennett, 2001. a.b. Using Choice Experiments for Non-Market Valuation, Working Papers in Economics no. 52. Department of Economics, Goteborg University.

Batemani, I.J., Jones, A.P., 2003. Comparing conventional with multi-level modeling approaches to meta-analysis: expectation consistency in UK woodland recreation values. Land Econ. 79 (2), 235–256.

Batemani, I., Caron, R., Day, B., Hanemann, M., Hanley, N., Hett, T., Jones-Lee, M., Loones, G., Mourato, S., Ozdemiroglu, Pearce, D.W., Sugden, R., Swanson, J., 2002. A Manual: Economic Valuation with Stated Preference Techniques. Edward Elgar Publishing, Massachusetts.

Boxall, P.C., Adamowicz, W.L., Swait, J., Williams, M., Louviere, J.J., 1996. A comparison of stated preference methods for environmental valuation. Ecol. Econ. 18, 243–253.

Bekele, Million, June 2001. Forestry Outlook Studies Africa. http://www.fao.org/3/ABS-62053.htm.

Brownstone, D., Train, K., 1999. Forecasting new product penetration with flexible substitution patterns. J. Econom. 89, 109–129.

Carlson, Martinsson, 2003. Using choice experiments for non-market valuation. Economic 3 (8), 83–110.

Central Statistical Agency, 2015. Population Projection of Ethiopia at All Regions at Town Level for 2014–2017. http://www.csa.gov.et. Central Statistics Agency (Ethiopia). Population Projection of Ethiopia from All Regions at Wereda Level for 2014-2017 (in English and Amharic). Archived from the original on 2015-10-17. Retrieved 2016-08-25. www.csa.gov.et.

De Nooij, M., Koopmans, C., Bijvoet, C., 2007. The value of supply security: the costs of power interruptions: economic input for damage reduction and investment in networks. Energy Econ. 29 (2), 277–295.

Energypedia, 2020. Ethiopia Energy Situation. http://www.iea.org/atais/webGraphs/EthIOPIA4A4.pdf.

Entele, R.R., 2020. Analysis of households’ willingness to pay for a renewable source of electricity service connection: evidence from a double-bounded dichotomous choice survey in rural Ethiopia. Heliyon 6 (2020), e03322.

Ethiopian Electric Power Corporation, 2013. ETH Energy Master Plan. Feyisa, D., 2011. Ethiopian Brief. https://www.mideq.org/en/resources-index-page/ethio-pia-brief.
