THE WILLINGNESS TO PAY BY HOUSEHOLDS FOR IMPROVED RELIABILITY OF ELECTRICITY SERVICE

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ABSTRACT

This research examines households' willingness to pay (WTP) for an improved electricity service. Households' WTP is estimated using the contingent valuation (CV) method on data from 350 in-person interviews in North Cyprus. In order to avoid the cost of outages, households are willing to incur a 13.5% increase in their monthly electricity bill. A cost–benefit analysis (CBA) indicates that the annualized economic benefits of improved reliability of the electricity service would be approximately USD 37.8 million for the residential sector alone. This figure is more than enough to finance the investments needed to completely eradicate any electricity outages. In addition, the fuel savings from substituting the generation of the new plants for the old plants would yield about USD 44.6 million per year in fuel savings. Hence, a change from the current low-reliability policy to one of providing a high-quality service would yield an economic net present value to the residents of North Cyprus of over 2.5 times the investment costs or USD 226 million within five years.

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1. Introduction

The reliability of a power supply is crucial for small island countries that depend heavily on tourism for their economic prosperity. Power outages, especially in the summer months when air conditioners are in almost continuous use, can have a deleterious effect on the tourism sector and are therefore of great concern to these countries.[1] Cape Verde in the Atlantic Ocean, North Cyprus in the Mediterranean, and several islands in the Caribbean, such as the Dominican Republic, live with almost daily blackouts (World Bank, 2006; Clough, 2008). Often the reason behind these frequent interruptions in electric supply is the lack of a coherent policy and investment planning framework to ensure that adequate and timely investments are being made in the electricity generation, transmission and distribution systems.

This study reports on an evaluation of willingness to pay (WTP) for electricity reliability in North Cyprus, using the contingent valuation (CV) method. The economy of North Cyprus relies heavily on tourism and universities for its economic well-being. The results of this study are key inputs for decision making by regulators and the public electric utility in their recommendations for funding of electricity reliability improvement projects.

Economic cost–benefit analysis (CBA) has become the approach preferred by many utilities around the world in determining the optimal system capacity and reliability of electricity supply (Munasinghe and Gellerson, 1979; Sanghvi, 1983; Chowdhury et al., 2004; Sullivan, 2009). This method incorporates into the decision making the customers' evaluation of the costs of shortages, which is reflected by the magnitude of the customers' WTP. Given the system's costs for enhanced reliability, it is the size of the consumer's WTP for electricity reliability that will determine the optimal policy rules for maintaining alternative levels of reliability of service.

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[1] When the term 'power outage' (or failure/interruption/blackout) is used in this paper, it refers to a complete interruption of electricity for a period lasting a few seconds or longer.

1.1 North Cyprus and the Electricity System

Cyprus, the third largest island in the Mediterranean, is characterized by mild winters and hot, dry summers. North Cyprus has a population of 265,100 (25.1% of the total population of Cyprus) and a gross domestic product (GDP) per capita of USD 13,354 (2009 estimate).[2,3] Its principal industries are tourism and the six international universities it hosts.

In 2014 the total installed electricity generation capacity in North Cyprus was 376 MW(Kib-Tek, 2014)[4]. The system has suffered from both insufficient generation capacity and some of the generation plants have been kept in service longer than their planned life, hence causing frequent outages. Electricity outages have been chronic for two decades, largely as a result of the lack of a firm policy or set of regulations making electricity reliability a policy priority. Over this period an increase in the number of foreign students and tourists has worsened the power shortage problem.[5] There are power cuts throughout the year, becoming worse during the summer months when the air conditioners and water pumps are working, and during the winter months when more people rely on electricity to heat their homes (Ilkan et al., 2005).

The reason that has officially been given for the failure to maintain reliability is a lack of funds or unwillingness on the part of consumers to pay sufficient amounts for the electricity they consume to enable the public utility to have a policy for maintaining adequate generation reserves and a strong transmission and distribution system. There has been a lack of information on how costly this dysfunctional policy environment has been for the residents of North Cyprus. The purpose of this study is to fill this information gap and to inform policy makers of

[2] http://nufussayimi.devplan.org/index-en.html, 2006 census and http://en.wikipedia.org/wiki/Demographics_of_Cyprus#Population
[3] http://devplan.org/Frame-eng.html
[4] Kib-Tek (Cyprus Turkish Electricity Authority – Kibris Türk Elektrik Kurumu in Turkish) is the electricity authority of North Cyprus that is responsible for the generation, transmission and distribution of electricity in the north.
[5] Annual average growth rates for the period 1979–2008. TRNC State Planning Organization, http://devplan.org/Frame-eng.html

consumers' WTP for improved reliability of electricity supply, provided the electric utility is able to deliver such a service.

Very few studies have been undertaken elsewhere in the world to estimate the WTP for improved electricity service reliability. Setting a price for a reliable electricity supply is challenging owing to the fact that electricity cannot be stored in an economical way while its demand varies throughout the day and year. Teblitz-Sembitzky (1992) noted that power generation is a multi-product industry in which the outputs can be indexed by time of use and priority of service, and in contrast with a single-product industry, the cost allocation and price setting across different outputs is analytically challenging.

2.0 Methods

There are many studies that survey the outage cost evaluation literature and categorize the interruption impact evaluation methods into various groups (Sanghvi, 1982; Andersson and Taylor, 1986; Caves et al., 1990; Lehtonen and Lemstrom, 1995; TERI, 2001; Lawton et al., 2003; Sullivan, 2009). The various methods of measuring the cost of unreliable electricity have also been widely discussed in the literature on optimal reliability assessment (Telson, 1975; Sanghvi, 1983; Tollefson et al., 1994; Billinton and Pandey 1999; Chowdhury et al., 2004). Zachariadis and Poullikkas (2012) have undertaken three alternative approaches to the measurement of the economic cost a major one time outage that took place in South Cyprus in 2011.

Measuring the cost of unreliable electricity to consumers in the business sector is relatively straightforward, since these consumers produce an output that has a market value. Measuring the cost of unreliability to residential customers is more difficult owing to the intangible nature of the main losses. The models used for residential users are based on utility maximization subject to an income constraint (Sanghvi, 1982). Each household has a preferred order in which it performs certain activities in a day, each of which brings a certain benefit and increases the household's total utility. A power interruption disrupts this preferred order and results in a reduction in the utility enjoyed by the household. This reduction in utility expressed in monetary values is theoretically equal to the WTP to avoid the costs of the interruption, or alternatively, to the WTA (willingness to accept) the forgoing of benefits from the interrupted activities. In practice, it is measured by survey or market-based methods.

Valuation methodologies for WTP are generally studied under two main categories: revealed and stated preference. The revealed preference approach measures the WTP for a service using actual expenditure data on marketed goods related to the service concerned. The stated preference approach relies on survey-based methods and hypothetical scenarios to measure the consumers' WTP for an improvement in the service. The stated preference method includes the contingent valuation (CV) method and the choice modeling method. Sometimes this is one of the few ways of quantifying the benefits of a good or service that is not purchased in the market.

CV is a survey-based method often used in estimating the economic value of environmental services (Carson, 2000). Individuals are asked directly to state their WTP in a survey. Although widely used in the case of other infrastructure services such as transportation, there are fewer examples in which CV has been used in the valuation of electricity service improvements (Farhar, 1999; Rehn, 2003; Wiser, 2003; Atkinson et al., 2004; Layton and Moeltner, 2005; Carlsson and Martinsson, 2006; Carlsson and Martinsson, 2007; Kateregga, 2009).[6]

2.1 Survey

The residential sector in North Cyprus is responsible for about 38% of total consumption and grew by an average of 9.3% per annum over the period 2001–2013. Our study is focused on the WTP of residential households for improved electricity reliability.

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[6] CV is also used to value a wide range of commodities in developing countries (FAO, 2000; Devicienti et al., 2004). Some of the studies conducted in developing countries using CV are: Alberini et al. (1997) – valuation of health effects of air pollution; Altaf and Hughes (1994) – measuring the demand for improved urban sanitation services; Whittington et al. (1990); and Montes de Oca and Bateman (2006) – estimating the WTP for water services.

In devising the questions for our study we have benefited from previous questionnaires in the literature that were used to determine residential electricity customers' outage costs, as well as other studies on WTP for service improvement (Wacker et al., 1983; Bose and Shukla, 2001; CIE, 2001; Korman, 2002; Moeltner and Layton, 2002; KPMG, 2003; Hensher et al., 2005a; Layton and Moeltner, 2005; RIC, 2005; Carlsson and Martinsson, 2007; Carlsson and Martinsson, 2008). We ask attitudinal questions regarding the respondents' current electricity service. These questions are intended to reveal the respondents' attitudes towards the electricity system overall, as well as information on load shedding, and on tariff variations. As perceived quality has been found to have positive impact on WTP (Zeithaml et al., 1996), in addition to the attitudinal questions we include questions on the duration and frequency of summer and winter interruptions (planned and unplanned) as perceived by the respondents. WTP for a reliable electricity supply is expected to be related, among other things, to the household's dependence on electricity (Munasinghe, 1980). Hence, we also ask questions to determine the level of dependency on electricity.

We design a CV question in which we define a hypothetical inverter system, and using a payment card (payment ladder) format ask about respondents' WTP for the system in order to ensure a reliable power supply without any failures (see Table 1). To secure a reliable electricity power supply without any failures, they would pay their monthly electricity bill and the total monthly cost of the inverter system. The respondents are asked to put a tick next to the highest amount they are sure that they would pay and a cross next to the first amount that they are sure that they would not pay. If they choose not to go for the inverter system then in a follow-up question they are asked to give their reasons for not choosing the system. The follow-up question is intended to separate the protest responses from the valid zero values. We test the questionnaire via personal interviews with 36 respondents from the five districts.

Table 1. Willingness to Pay for an Inverter System

Suppose that an inverter system has become available which would provide a reliable electric power supply without any failures. In this system the batteries are charged by electricity. As soon as the electricity supply is interrupted, the 12-volt power stored in the batteries are automatically converted into 240-volt and the house has continuous power. The inverter system will be capable of running every household appliance at your house and the household will never again experience an interruption in supply. This system will be so efficient that there will be no additional expenditure on electricity compared to a situation in which there is no power cut.
For a reliable electricity power supply without any failures you will pay your monthly electricity bill and the total monthly cost of the inverter system.
Note: Every household has different electricity needs and financial resources. Please respond to the questions on the basis of your own needs and finances. You should also consider whether your family has more important things to spend its money on.
Would you choose the inverter system if its total monthly costs (monthly rental and running costs) were...

		Total monthly cost	
Put a tick next to the highest amount you are sure that you would pay and a cross next to the first amount that you are sure that you would not pay	1.	Would not go for the inverter system	[ ]
	2.	10 YTL per month	[ ]
	3.	20 YTL per month	[ ]
	4.	30 YTL per month	[ ]
	5.	40 YTL per month	[ ]
	6.	50 YTL per month	[ ]
	7.	70 YTL per month	[ ]
	8.	90 YTL per month	[ ]
	9.	120 YTL per month	[ ]
	10.	150 YTL per month	[ ]
	11.	200 YTL per month	[ ]
	12.	250 YTL per month	[ ]
	13.	350 YTL per month	[ ]
	14.	450 YTL per month	[ ]
	15.	550 YTL per month	[ ]
	16.	More than 550 YTL per month Min WTP _________YTL per month Max WTP _________YTL per month	[ ]

Of the 72,624 households in North Cyprus, 32% are in Lefkosa, 26% in Gazimagusa, 23% in Girne, 12% in Guzelyurt, and 8% in Iskele (2006 Census). These percentages are used to determine how many of the targeted 350 in-person interviews should take place in each district. Overall, 505 dwellings are visited, with the head of the household selected as the respondent in each case. All 350 interviews were completed in August 2008 (Lefkosa 111, Gazimagusa 85, Girne 80, Guzelyurt 46, Iskele 28). The response rate for the survey is high, at 69% (=350/505), probably owing to the high level of interest in the issue. The electricity problem was on the local news almost every day and is a common subject for discussion, even in social gatherings.

3. Results

3.1 Household Characteristics of the Sample

The household characteristics of the sample are summarized in Table 2. As can be seen, 66.3% of the sample is male. The weighted average age of the sample is 36.7 and the average household size is 3.28.

Table 2. Household Characteristics

N=350	Male	Mean age (years)	Employed	Married	Household Size	University
Sample	66.3%	36.7	53.4%	55.7%	3.28	15.6%
2006 Census	54.0%	32.1	44.1%	59.6%	3.65	15.2%

The respondents' attitudes to the electricity system are summarized in Table 3. The power supply provided by the electric power company is perceived as poor or very poor by 32.3% of respondents. In order for this percentage to be more meaningful, it is important to note that for the 40.3% who perceive that they had a fair power supply, the average perceived number of outages per year is 186.1 (or 3.6 per week) and the average perceived total duration of outages in a year is 696.6 hours (i.e. around 8% of the year, or 13.4 hours per week). The perceived number of failures is high or very high for 26.6% of the households interviewed. Again, it is worth noting that 42.9% of respondents who say they had a moderate number of failures in general also stated that they had on average 162.66 failures per year (or 3.1 per week). This is not very different from the average of the "high" category, 168.43 failures a year (or 3.2 per week). While 37.4% of respondents agree with the statement that their power supply has improved in the past year, 33.1% disagree with this statement.

A very high proportion of respondents (87.1%) think that the price of their electricity is high or very high.[7] Price increases in electricity were on the news throughout the summer of 2008; the

[7] The residential sector is divided into five groups by income and demand level. In 2008, the households in the poor category paid on average 0.18 YTL/kWh (0.15 USD/kWh) for the first 250 kWh/month. An increasing block tariff is used for the residential sector, where regular residential customers paid on average 0.24 YTL/kWh (0.20 USD/kWh) for the first 250 kWh, 0.30 YTL/kWh (0.26 USD/kWh) for 251–500 kWh, 0.32 YTL/kWh (0.27 USD/kWh) for 501–750 kWh, and 0.43 YTL/kWh (0.37 USD/kWh) for consumption above 750 kWh.

power authority decided to peg electricity prices to the fuel oil prices, which meant that prices would automatically change every month starting in July 2008. Our survey finds that 37.4% of the respondents have low or very low confidence in their electricity authority. If, during peak periods, the utility asked its customers to reduce their electrical consumption for a period of 2 to 4 hours, 58% of respondents indicate that they may be willing to do this.

Table 3. Current Electricity Service and Attitudes to the Electricity System

N=350	Very Good	Good	Fair	Poor	Very Poor
In general, the power supply provided by my electric power company is...	1.4%	26.0%	40.3%	21.1%	11.1%
	Very Low	Low	Moderate	High	Very High
I think that in general the number of failures of the electrical power to my home is...	8.3%	22.3%	42.9%	18.3%	8.3%
I think that the price of our electricity is...	0.9%	0.9%	11.1%	30.9%	56.3%
My confidence in our electricity authority is...	13.4%	24.0%	52.9%	8.3%	1.4%
	Strongly Agree	Agree	Neither Agree Nor Disagree	Disagree	Strongly Disagree
Our power supply has improved in the last year.	6.0%	31.4%	29.4%	26.6%	6.6%
Our power supply will improve within the next 12 months.	2.0%	21.1%	38.0%	30.0%	8.9%
If during peak periods, the utility asked its customers to reduce their electrical consumption for a period of 2 to 4 hours, would your household be willing to reduce its electrical consumption?			Yes 26.9%	No 42.0%	Maybe 31.1%

3.2 Econometric analysis

All 350 individuals surveyed answered the contingent valuation question: 115 are true zero WTP bids and 200 have WTP greater than zero. The ticks range from 10 to 450 YTL and the crosses from 10 to 550 YTL per month (see Figure 1). The mode for the ticks is 10 YTL, and for the crosses 30 YTL. Thirteen respondents put a cross next to the maximum amount on the payment ladder, 550 YTL. Table 4 gives the description for the variables used in parametric estimation.

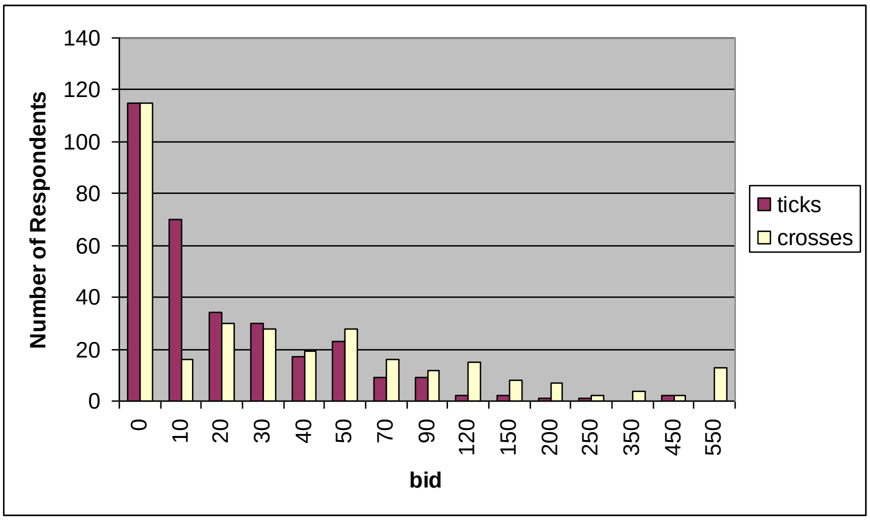

Figure 1. Number of Ticks and Crosses for the Bids Included in the Payment Ladder

Table 4. Description of Regression Variables

Variable	Description		Variable	Description
poswtp	1: WTP >0; 0: otherwise			
	Quality of Service			*Socioeconomic and Demographic Variables*
totfreq	Total perceived number of outages during past 12 months (June 2007–May 2008)		noadult	Number of household members who are older than 19 years
percunpl	Percentage of perceived total number of outages during past 12 months (June 2007–May 2008) that are unplanned		nochild	Number of household members who are 19 years of age or younger
percnite	Percentage of perceived total number of outages during past 12 months (June 2007–May 2008) that are at night		univ	1: respondent has university education; 0: otherwise
percwint	Percentage of perceived total number of outages during past 12 months (June 2007–May 2008) that are in winter		income	Total monthly income of the household (YTL)
lntotdur	Log of total perceived outage duration for the past year (hours)		nocyborn	1: respondent was not born in Cyprus; 0: otherwise
avgnotifn	Advanced notification (as perceived by respondents) (days)			
	Behavior of the Household			*Structural Characteristics of the House*
avgbill	Average monthly electricity bill (YTL)		dethouse	1: detached house; 0: otherwise
generator	1: has generator; 0: no		florsize	Dwelling floor-size (meter-square)
act	1: at least one preparatory action; 0: otherwise			*Regional Dummies*
hasaircon	1: has air conditioner; 0: does not have		lefkosa	1: resident of Lefkosa; 0: otherwise
prcnoeht	Percentage of space heating not obtained from electricity		gazimagusa	1: resident of Gazimagusa; 0: otherwise
nonecook	1: has non-electric cooking; 0: does not have		girne	1: resident of Girne; 0: otherwise
wkhmone	1: work at home depends on availability of electricity; 0: no		iskele	1: resident of Iskele; 0: otherwise
sickbed	1: has sickbed resident; 0: no			

3.2.1 Household's participation decision – probit model

After the hypothetical inverter system had been described to respondents, they were asked to choose whether or not to participate in the contingent market. A household's participation decision is modeled as follows:

Let $poswtp_i$ be an independent variable that takes on the value of 1 if the household i states a positive WTP amount, and zero otherwise. The household i's participation decision will be assumed to be a linear function of a vector of explanatory variables Z:

$$poswtp_i = \gamma Z_i + \upsilon_i$$

The coefficients γ of the participation model are estimated using a probit regression.

We expect a respondent's participation decision to depend, among other things, on their household's historical experience with outages, dependence on electricity, and some sociodemographic factors. Experience with frequent outages has a learning effect on households, and increases their level of preparedness for outages. Households that are already well prepared for outages may be indifferent towards the inverter system. The level of preparedness is higher if the majority of outages occur without advanced notification. Households can reduce the negative impact of outages if they are given enough advanced warning. For these reasons, we expect the variables *totfreq*, *percunpl*, and *avgnotifn* to have negative signs. As lighting is one of households' major concerns during an outage we expect the variable *percnite* to have a positive sign, i.e. households that have a higher rate of historical nighttime outages may be more likely to opt for the inverter system. The duration of an outage is positively related to the amount of averting expenditures. The longer the duration, the higher will be the coping costs of the household, and the more they may be willing to participate in the inverter market to avoid these coping costs. Hence, we expect a positive relationship between the probability of participating and log of total outage duration, *lntotdur*.

Households that have had long experience in living with outages may resort to non-electric alternatives for their space-heating needs. A household's space-heating activities will not be interrupted by an outage if non-electric fuels are being used in the house for these purposes. A household that has already invested in a generator may be indifferent towards the new inverter system. These households will therefore be less likely to participate in the contingent valuation market. The variable *act* shows that the household is not totally unconcerned about the outages and may be better off with an improved electricity service. Hence, we expect this variable to have a positive sign. Households that work at home and whose work depends on electricity (*wkhmone*), those who have air conditioners (*hasaircon*), those who have more children (*nochild*), and those who have a university degree (*univ*) are also expected to be more likely to enter the market. We expect a positive relationship between household income and the participation decision.

We have no prior expectations for the signs of the variables *percwint, dethouse, noadult*, and *nocyborn*. The sign of *percwint* will depend on how households view summer versus winter outages. Households that live in detached houses may be less worried about having to go up and down the stairs than households living in apartments. On the other hand, detached houses are not surrounded by other dwellings, and hence may get colder during the winter, but be easier to cool during the summer. In some cases, households living in apartments may benefit from the averting actions taken by their neighbors (positive externalities), and hence be less willing to take actions themselves.

Before running the probit regression we analyze the dependent variable and the categorical independent variables to make sure there are no empty or small cells, as this would create difficulties in running the model.[8] As can be seen from the regression results summarized in Table 5, *percnite*, *percwint*, *florsize*, *act*, *Lefkosa* and *Iskele* enter with significant coefficients. High-

[8] Introduction to SAS. UCLA: Academic Technology Services, Statistical Consulting Group, from http://www.ats.ucla.edu/stat/sas/notes2/ (accessed July 10, 2009). The probit regression was estimated using the probit command in STATA 9.2.

income households that experience a higher percentage of night outages, have a longer duration of outages, live in larger houses, have participated in at least one type of averting behavior, have air conditioners, work from home on work that depends on electricity, have more children, have a university degree, were not born in Cyprus, and are residents of Lefkosa or Iskele are more likely to participate in the contingent market. Households with a higher frequency of outages, a higher percentage of unplanned outages, a higher percentage of winter outages, or more advanced notification, and those that live in detached houses, own a generator, obtain a higher percentage of their space heating from non-electric fuels, have more adults, or are from Gazimagusa are less likely to choose the inverter system.

Table 5. Probit Regression Results – Participation Decision

Explanatory Variable	Coefficient (S.E.)
Quality of Service	
Totfreq	−0.001 (0.001)
Percunpl	−0.594 (0.461)
Percnite	1.042*** (0.404)
Percwint	−1.318*** (0.469)
Lntotdur	0.157* (0.089)
Avgnotifn	−0.109 (0.100)
Structural Characteristics of the House	
dethouse	−0.356* (0.196)
florsize	0.009*** (0.003)
Behavior of the Household	
generator	−0.208 (0.283)
act	0.741** (0.336)
hasaircon	0.147 (0.191)
prcnoeht	−0.206 (0.219)
wkhmone	0.307 (0.255)
Socioeconomic and Demographic Variables	
noadult	−0.091 (0.079)
nochild	0.165* (0.094)
univ	0.127 (0.245)
income	0.000 (0.000)
nocyborn	0.096 (0.203)
Regional Dummies	
Lefkosa	1.093*** (0.277)
Gazimagusa	−0.007 (0.280)
Girne	0.478* (0.290)
Iskele	0.982*** (0.382)
_cons	−1.632** (0.818)
Number of observations	315
Pseudo R-squared	0.212
Mean (S.E.)	64% (22%)
95% Confidence Interval	19%–97%

Note: The confidence intervals are bootstrapped confidence intervals using the percentile method (1,000 repetitions).
*10% significance level; **5% significance level; ***1% significance level two-tailed tests.

The bootstrapped mean using 1,000 repetitions is 64.08%, which is close to the sample average of 63.49%. Some 64% of households in North Cyprus are willing to participate in the contingent market and pay a positive amount in addition to their monthly electricity bill.

3.2.2 Spike Model

Several authors in the literature have used the spike model to deal with the presence of a large number of zero observations in the data (An and Ayala, 1996; Kriström, 1997; Bosetti and Pearce, 2003; Hu, 2006; McCartney, 2006; Hanley et al., 2009a, 2009b, 2009c; Yoo and Kwak, 2009). In a spike model, the respondents' decision process consists of two steps. In the first step, respondents choose whether or not they will participate in the contingent market. In the second step, the respondents who have chosen to participate in the contingent market decide how much to pay for the good in the question.

Let T_i be an independent variable that takes on the value of 1 if the individual i chooses to participate in the contingent market, and zero otherwise. Let p_i^0 be the probability of individual i choosing not to participate in the contingent market. Let $F(.)$ be the cumulative distribution function of WTP such that:

$$F(.) = \begin{cases} 0 \; if \; WTP_i < 0 \\ p_i^0 if \; WTP_i = 0 \\ G(.) if \; WTP_i > 0 \end{cases}$$

where $G(.)$ is a continuous and increasing function such that:

$$G(.) = \begin{cases} 0 \; if \; WTP_i = 0 \\ 1 \; as \; WTP_i \to \infty \end{cases}$$

The log-likelihood for the sample is given by:

$$\ln L = \sum_{i=1}^{N} (1 - T_i) \ln p_i^0 + T_i \ln(1 - p_i^0) + T_i \ln(\left[\mathrm{G}(\frac{cross_i - \beta X_i}{\sigma}) - \mathrm{G}(\frac{tick_i - \beta X_i}{\sigma}) \right]$$

Some authors have calculated the probability of individual i choosing not to participate in the contingent market, p_i^0, separately as the ratio of number of respondents who said no to the participation question to the total number of valid responses (Bosetti and Pearce, 2003; Broberg and Brännlund, 2008; Hanley et al., 2009a). Some have adopt the endogenous spike model approach where p_i^0 can have a distribution and be jointly estimated with the other utility parameters in the model (An and Ayala, 1996; Hu, 2006). In the endogenous spike model, the p_i^0 will be assumed to be a function of a vector of explanatory variables Z_i and to have a distribution of $\mathrm{H}(.)$:

$$p_i^0 = \mathrm{H}(\gamma Z_i)$$

Substituting this into the log-likelihood equation for the sample above, we have:

$$\ln L = \sum_{i=1}^{N} (1 - T_i) \ln \mathrm{H}(\gamma Z_i) + T_i \ln(1 - \mathrm{H}(\gamma Z_i))$$

$$+ T_i \ln(\left[\mathrm{G}(\frac{cross_i - \beta X_i}{\sigma}) - \mathrm{G}(\frac{tick_i - \beta X_i}{\sigma})\right]$$

If a standard normal distribution is assumed for $\mathrm{H}(.)$ and p_i^0 is specified as a linear function of explanatory variables Z, then the log-likelihood for the sample becomes:

$$\ln L = \sum_{i=1}^{N} (1 - T_i) \ln(\gamma Z_i) + T_i \ln(1 - \ln(\gamma Z_i))$$

$$+ T_i \ln(\left[\Phi(\frac{cross_i - \beta X_i}{\sigma}) - \Phi(\frac{tick_i - \beta X_i}{\sigma})\right]$$

The parameters γ, β, and σ can be estimated using maximum likelihood estimation. The mean WTP for the whole sample is calculated as follows (Bosetti and Pearce, 2003):

$$E(WTP) = p^0.0 + (1 - p^0).\beta X$$

Using the log-likelihood function above, where p_i^0 is specified as a linear function of explanatory variable Z, and $G(.)$ is assumed to have a standard normal distribution, we estimate the spike model with varying spike, and varying mean using TSP 5.0 (see Table 6).

The log of WTP is specified as an additive function of the explanatory variables.

$$\log WTP_i = \beta X_i + \omega_i$$

where ω_i has a normal distribution with mean 0 and standard deviation σ. The respondent's unobserved true WTP is assumed to lie within the lower and upper limits specified by the respondent. The dependent variables are the logs of the lower ($\ln lb_i = \ln(\textit{tick value}_i + 0.0001)$ and upper limits ($\ln ub_i = \ln(\textit{cross value}_i)$) specified by the respondent. Since some observations are 0, we use the transformation $\ln(lb_i + 0.0001)$. In cases where the lower and upper limits specified by the respondent are equal, the upper limit of the interval is set to the next bid level on the payment ladder, i.e. the zero observations were entered as (*tick value* = 0, *cross value* = 10). The median[9] and mean WTP for the whole sample are calculated as:

$$E(\text{median } WTP) = p^0.0 + (1 - p^0).\exp(\beta X)$$

$$E(\text{mean } WTP) = p^0.0 + (1 - p^0).\exp(\beta X).\exp(\sigma^2/2)$$

[9] Since we use a log transformation, the median WTP will be scaled by $\exp(\sigma^2/2)$ (Stynes et al., 1986).

Table 6. Summary of Spike Model Results

Explanatory Variable	Coefficient (S.E.)
Spike equation, p^0	
const	0.634*** (0.053)
Quality of Service	
percnite	−0.207** (0.091)
Regional Dummies	
Lefkosa	−0.403*** (0.060)
Girne	−0.180** (0.077)
Iskele	−0.292*** (0.102)
WTP equation	
const	2.691*** (0.557)
Quality of Service	
percnite	−0.071 (0.268)
percwint	−0.277 (0.332)
lntotdur	0.078 (0.054)
avgnotifn	−0.137*** (0.053)
Structural Characteristics of the House	
dethouse	−0.060 (0.138)
florsize	0.001 (0.002)
Behavior of the Household	
avert	0.450* (0.265)
avgbill	0.337e−3** (0.147e−3)
nonecook	−0.054 (0.283)
sickbed	0.816 (0.520)
Socioeconomic and Demographic Variables	
nochild	−0.091 (0.070)
noadult	−0.037 (0.062)
income	0.628e−4 (0.512e−4)
Regional Dummies	
Lefkosa	0.237 (0.202)
Gazimagusa	0.494** (0.230)
Girne	0.509*** (0.191)
Iskele	0.315 (0.381)
Mean and Median WTP (YTL/month, in 2008 Prices)	
Spike, p^0	0.364
βX	2.879
σ	0.686
Median WTP (S.E.) $(1-p^0)\exp(\beta X)$	23.03 (6.073)
Mean WTP (S.E.) $(1-p^0)\exp(\beta X)\exp(\sigma^2/2)$	29.14 (7.630)

Note: *10% significance level; **5% significance level; ***1% significance level two-tailed tests.

The spike estimate, p^0, is 36.4%. This is very close to the proportion of zero bids in the sample (115/315=36.5%) as well as the results of the probit regression above. The households that experience a higher percentage of night outages and those who are residents of Lefkosa, Girne or Iskele are more likely to participate in the contingent market.

In the quality of service category, *avgnotif* enters significantly with a negative sign. The average notification period has a negative impact on households' WTP. The more advanced notice they are given, the more time they will have to prepare for outages and avoid or reduce their negative impacts (e.g. consume the perishable foods in the refrigerator, reschedule some of the electricity-dependent activities such as washing and ironing, etc.). In the 'structural characteristics of the house' category, none enters significantly; in the 'behavior of the household' category, *avgbill* enters significantly with a positive sign (the coefficient is almost zero); in the 'socioeconomic and demographic variables' category, none enters significantly; and in the 'regional dummies' category, *Gazimagusa* and *Girne* enter significantly with positive signs. In summary, households that have higher average monthly electricity bills, have more experience with planned outages, or are residents of either Gazimagusa or Girne are willing to pay higher amounts in addition to their current monthly electricity bills in order to avoid outages.

Since the spike model uses a log transformation, the median WTP estimate is scaled by $\exp(\sigma^2/2)$. Hence, the WTP estimate is positively related with the standard error of the regression. The higher the standard error, the higher will be the mean WTP (Haab and McConnell, 1997). In a log-linear specification, the median, which is not scaled by this factor, will be more reliably estimated (Hanemann, 1984). However, for the purposes of CBA the mean WTP is the preferred measure (Johansson et al., 1989; Smith et al., 1999; Vaughhan et al., 1999; Atkinson et al., 2008); hence, we report both the median and the mean estimates. A typical household's median and mean WTP for the inverter system are 23.03 YTL per month and 29.14 YTL per month respectively.

4. Discussion

This research makes a number of contributions to the literature. It is one of the few CV studies that attempts to measure the cost of outages in a country with a high actual outage frequency. The spike model with varying spike and varying mean results in a median WTP of 23.03 YTL (19.59 USD) per month and a mean WTP of 29.14 YTL (24.79 USD) per month, i.e. an average household is willing to pay 29.14 YTL (24.79 USD) per month expressed in 2008 prices in addition to its monthly electricity bill in order to avoid the outages. This is equivalent to a 13.5% increase in the monthly electricity bill. The average total duration of outages for the sample is around 287.6 hours a year (or 24.0 hours a month). Hence, by dividing the monthly WTP figure by the average total outage duration per month, we calculate the WTP per hour unserved to be 1.22 YTL (1.03 USD).

Sanghvi (1982), Andersson and Taylor (1986), and Woo and Pupp (1992) summarize the findings of various residential outage cost studies. From the studies in which the WTP per outage and the duration of the outage are given, we calculate the WTP per hour unserved (in 2008 prices[10]) (see Table 7). In this category, the highest WTP figures are found in the USA (0.58–57.99 USD), followed by Canada (0.88–16.76 USD), Brazil (4.77 USD), Sweden (0.29–2.86 USD), and Nepal (0.10–1.15 USD). Within the USA, the highest outage costs occurred in California (0.90–57.99 USD), followed by New York (1.43–11.38 USD), North Carolina (6.96–7.64 USD), the Midwest region (1.32–3.04 USD), and Wisconsin (0.58–2.49 USD). Our estimate of WTP in North Cyprus is 1.03 USD per hour unserved. This is not within the WTP range of Brazil; however, it falls within the WTP ranges of the remaining countries.

[10] The prices in domestic currency of a country in any year t (P_t^d) are converted to 2008 prices in USD (P_{2008}^{USD}) using the following formula:

$$P_{2008}^{USD} = P_t^d \times \left(\frac{GDPDeflator_{2008}^d}{GDPDeflator_t^d}\right) \times ExchangeRate_{2008} ExchangeRate = (\#DomesticCurrency)/\#USD$$

Source for GDP Deflators: International Monetary Fund, World Economic Outlook Database, April 2009; source for Exchange Rates: central banks of the relavant countries.

Table 7. WTP (USD per hour unserved)

Country	State	Study	WTP USD per Hour Unserved in 2008 Prices
USA		Layton and Moeltner (2005)	0.58–57.99
	California	Doane et al. (1988), Goett et al. (1988), Keane et al. (1988)	0.90–57.99
	New York	Doane et al. (1989)	1.43–11.38
	North Carolina	Sullivan et al. (1996)	6.96–7.64
	Midwest Region	Chowdhury et al. (2004)	1.32–3.04
	Wisconsin	Sanghvi (1983)	0.58–2.49
Canada		Wacker et al. (1983), Tollefson et al. (1994)	0.88–16.76
Brazil		Munasinghe (1980)	4.77
Sweden		Carlsson and Martinsson (2006, 2007, 2008)	0.29–2.86
Nepal		Billinton and Pandey (1999)	0.10–1.15
North Cyprus		Ozbafli (2012)	1.03

The differences in the WTP estimates may be attributed to the different valuation methods, econometric models, functional forms, outage attributes, and socioeconomic and demographic variables included in the econometric estimations. The level of confidence in the electricity authority might also explain the differences in the WTP figures (Abdullah and Mariel, 2010). The findings reported by Townsend (2000) indicate that the WTP is lower in countries where the quality of service continues to remain poor after the price is increased.[11] Given the chronic nature of outages in Nepal and North Cyprus, most people have invested in coping measures, and this may be one of the reasons for the lower WTP figures in these countries.

Before introducing any changes to the existing system, Kıb-Tek needs to take into account the attitudes of its customers. In particular, the attitudes of the residential sector are important since this comprises one third of the customer base.[12] Our results show that the power supply provided by the electric power company is perceived as poor or very poor by 32% of the

[11] In 2008 the electricity prices increased in North Cyprus while the quality of service deteriorated. At the same time the electricity bills included a line called "investment contribution." This was approximately 10% of the monthly bill, and it was automatically added to all bills in order to cover for Kıb-Tek's investments in generation capacity. These factors may partly explain the lower WTP figures in North Cyprus.

[12] Since our study excludes the other customer groups, we do not have a measure of their attitudes towards the electricity service. However, the other sectors are also adversely affected by the frequent outages (World Bank, 2006). Many firms and hotels have their own generators to cope with the unreliable electricity supply.

respondents, and the number of supply failures is judged to be high or very high by 27% of the households interviewed. Approximately one third of the respondents disagree with the statement that their power supply had improved in the last year, and 39% of the respondents do not think that their power supply will improve within the next 12 months. A very high percentage of the respondents (87%) think that the price of their electricity is high or very high. A significant proportion of households, 37%, have low or very low confidence in their electricity authority. These negative attitudes towards the quality of service provided, the level of prices, and the level of confidence towards the electricity authority need to be considered when appraising the option of purchasing additional generation capacity to overcome the shortage of power generation, and when considering an increase in tariffs to cover the investment costs involved, if more consumers are to be in favour of the project.

In the CV study, 40% of the sample chose not to go for the inverter system and approximately 5% of the observations were protest bids. The electricity authority needs to be aware of the fact that a high percentage of residential customers are not willing to pay anything beyond the relatively high rate they are now paying for an improvement in the service.

4.1 Cost Benefit Analysis of Improved Reliability

The estimates of the WTP for electricity reliability can be used to evaluate the feasibility of alternative policies of improving electricity reliability by appraising the option of purchasing additional generation capacity to overcome the main causes of blackouts in North Cyprus, the shortage of power generation.

Using the estimated values for the WTP for improved reliability, a CBA can be undertaken for making additional investments to improve the generation capacity reserve of the system.

The situation of electricity reliability in 2014 has changed very little from the situation was in 2008. The source of problem with outages is primarily one of inadequate and obsolescent generation capacity that is subject to frequent breakdowns. In the 12 months from September 2013 to September 2014, there have been 166 outages almost all caused by generation failures or inadequate generation capacity during the hours of peak demand (Kib-Tek, 2014).

Given the estimated WTP in 2008 prices, these values are adjusted for inflation to bring them into 2014 prices and then converted into USD by the current exchange rate to find the monthly WTP values. The 2014 value of the WTP is estimated to be 21.02 USD per month per household. The number of metered households in North Cyprus in 2014 is 150,000 (Kib-Tek, 2014). Hence, the total annual economic benefits of improved electricity services for residential consumers in North Cyprus as measured by their willingness to pay would be USD 37.8 million (= 150,000*21.02 USD/month*12).

The total investment costs that Kib-Tek would need to incur to achieve a given reliability level will depend, among other things, on the condition of the existing power stations as well as the transmission and distribution system. Substantial investments have been made over the past decade to strengthen the transmission and distribution system. At the same time the state of the generation plants deteriorated.

At the present time, the public utility, Kib-Tek, has generation capacity that includes two 60 MW steam turbine generators that are fully depreciated and are also very inefficient in the utilization of fuel. They use on average 300 gr of HFO per Kwh of electricity generated. The utility also has 105 MW of relatively new diesel generators that are used as peaking plants. These plants are much more efficient and use only an average of 190 gr of HFO per KWh. Supplementing to the generation capacity of Kib-Tek is a private generator, Aksa Enerji, that has a power purchase agreement (PPA) to supply 120 MW of electricity with 6 diesel plants (Aksa Enerji, 2014). The PPA compensates Aksa for the fuel consumption of the plants that is based on a rate of 216 gr of HFO per KWh generated. Many of the Aksa's plants are also near the end of their useful life.

In order to rectify the problem of lack of the reliability, the utility needs to invest in seven new diesel generation plants of 17.5 MW capacity of each to replace the electricity now generated by the two steam turbine plants. In addition, two new diesel plants should be purchased to meet the growing demand for electricity in the economy and to maintain a reliable service for the near future. The cost of each of the new diesel plants is approximately 550,000 USD per MW for a total of USD 9.6 million (including installation costs)[13]. For nine plants, the total upfront capital cost would amount to USD 86.6 million in 2014 prices. In the analysis below a real rate of discount of 10 percent is used.

At the moment, the value of the fuel and operating savings from substituting the diesel generation plants for the inefficient steam turbine generation will be set aside and we will simply compare the present value of the capital cost of the new generation capacity with the annual willingness to pay of households for electricity reliability of USD 37.8 million. If this investment that would eliminate the incidence of electricity outages, we find that the value of the households' willingness to pay would be sufficient in just three years to more than covering the initial capital costs of the additional generation capacity. If this increase in capacity could eliminate the electricity outages for a period of five years, the NPV of the investment from the consumers' perspective of improving reliability of supply would be USD 56.8 million[14].

Let us consider the financial and economic benefits of this investment from the point of view of the public utility(Kib-Tek). The investment in the nine new plants would yield substantial fuel savings from the replacement of both the steam turbines and the diesel plants of the private generator (Aksa). Accordingly, it is assumed that the system would be run so as to manage total generation costs. The steam turbines would be retired and the Aksa's generation would be shifted to generate only during the peak demand periods. The steam turbines have a marginal

[13] Based on the actual cost charged to Kib-Tek buy generators in 2014.
[14] The benefits of only few years are included in this analysis because it is estimated by Kib-Tek that the steam turbines plants will be completely inoperative in five years and hence the replacement of these plants will be forced on the supplier by that point in time.

running cost (fuel and variable operating and maintenance costs) of 0.194 USD per KWh under the assumption of a HFO cost of USD 650 per tonne. The new diesel plants that would replace them have a marginal running cost of 0.1178 USD per KWh. Simply generating the same GWh of electricity by the new diesel generator plants as was generated by the steam turbine generators would save Kib-Tek USD 36.6 million annually of fuel costs. In addition with the purchase of the more efficient diesel generation capacity there would be further savings of Aksa plants where shifted their current generation of 700 GWh per year to peak generation of only 37.9 GWh and while the difference in total generation would be made up with the increased generation Kib-Tek's more efficient plants. This results in a further fuel saving of the difference between the fuel cost of Aksa's diesel plants (0.1300 USD per KWh) and the new diesel plants (0.1178 USD per KWh). The annual amount of this fuel savings would equal to USD 8 million. Consequently, the total annual benefits of fuel savings by investing in the new plants and optimizing the dispatch of the system would add up to an annual saving of USD 44.6 million in 2014 prices. These estimates are also carried out under the assumption that the price of HFO would remain at USD 650 per tonne.

The next step in the analysis is the consideration of both the benefits from the households' willingness to pay and the fuel savings accruing to Kib-Tek in order to compare them with the present value of the capital cost of the new generation capacity. Benefiting from USD 82.5 million of annual benefits, the present value would pay back the initial investment cost of the nine new plants in two years. Moreover, in a five-year period, the NPV of this investment would be USD 226 million.

5. Conclusion and Policy Implications

Northern Cyprus is a typical of many developing countries in Africa and Asia where the public electric utility is severely capital rationed due to the political polarization of maintaining electricity actual rates below the long-run cost of generation plus transmission and distribution.

The consequence of this practice is a deterioration of the reliability of the service that imposes costs and inconvenience on electricity consumers. In addition, over time it causes an increase in the cost of electricity generation due to the deterioration in the efficiency of the existing generation plants. The existing plants should have been replaced by more efficient new plants much easier.

At the present time, there is an alignment of interests between the consumers and the public utility in North Cyprus. The public utility can actually improve its cash flows position by replacing the depreciated thermal plants with the efficient diesel generators. At the same time, the consumers would benefit immediately from the increased reliability of supply. In the longer run, consumers will actually be able to enjoy lower electricity tariffs as the costs of generation are decreased.

The constraint that still remains is the upfront capital financing constraint of new generation capacity. Yet, the return to such investment from both the point of view of consumers satisfaction and from the overall economy point of view is extremely high.

In the past, the government of North Cyprus tried to relax their financing constraint turning to an independent private power producer (Aksa) to supply the capital to increase the generation capacity in the system.

The results of this experiment has not been entirely positive. Instead of supplying new efficient generators the IPP moved used equipment to Northern Cyprus that were both fuel inefficient, unreliable. They also heavily polluted the air of the most historical and attractive town (Kyrenia) in Northern Cyprus. The largest proportion of the generation outages in 2014 have been traced to failures of the Aksa plants and equipment (Kib-Tek, 2014).

This points back to the weakness of the policies and management of the electricity sector that had allowed both the public electric utility as well as the private IPP to provide a deteriorating quality of service. As the survey results of this study show, resident customers are very aware of the poor management of the sector and have a very low confidence in the electricity authority.

Due to the short time political goals, the default policy of the government over the past 20 years was to allow the reliability of the electricity service to deteriorate rather than to maintain electricity tariffs at a level that would adequately finance the needed investment and maintenance. The results of this study show that this has been a misguided policy in that consumers are now willing to pay an amount that would be much greater than the economic costs required to improve the quality of service so as to obtain relief from the current situation. In addition, the cost savings by the utility through reducing fuel costs would more than pay for the badly needed new generation capacity.

Unfortunately, these short sighted electricity pricing policy are not unique to Northern Cyprus. Such policies have led to a deterioration of both the reliability of service and the fuel efficiency of generation across much of Africa (Foster and Steinbuks, 2009) to the point where the costs imposed on both consumers and the electricity sector can no longer be rationalized as a consequence of a policy that is creating benefits to any stakeholder in the system.

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