ESTIMATING THE WILLINGNESS TO PAY FOR A RELIABLE ELECTRICITY SUPPLY IN THE TURKISH REPUBLIC OF NORTHERN CYPRUS

by

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A thesis submitted to
The University of Birmingham
for the degree of
DOCTOR OF PHILOSOPHY

Department of Economics

The University of Birmingham

December 2011

Abstract

This dissertation estimates households' willingness to pay (WTP) for an improved electricity service in North Cyprus. Stated WTP is estimated using choice experiments (CE), contingent valuation methods (CVM), and approximated using the averting expenditure (AE) method. These estimates rely on data collected from 350 in-person interviews conducted during the period August 5-22, 2008. Using the Tobit model, an average household's averting expenditures are estimated to be 3.13 YTL/month. In the CVM section, the spike model with varying spike, varying mean, and constant standard error specification results in a median WTP of 23.03 YTL per month and a mean WTP of 29.14 YTL per month. Using CE, compensating variation estimates for eliminating summer and winter outages are calculated using parameter estimates from the mixed logit (ML) model with interactions. The compensating variation is 6.65 YTL per month and 25.83 YTL per month respectively. Among the three valuation methodologies, WTP per hour unserved ranges from 0.13 YTL (0.11 USD) to 1.22 YTL (1.03 USD). In order to avoid the cost of outages, households are willing to incur a 1.5%-13.5% increase in their monthly electricity bill.

Dedication

My grandparents, their children, grandchildren and great-grandchildren learned to live with frequent power outages.

I dedicate this work to the future children of North Cyprus.

I hope they grow up not knowing what it is like to study in candle light.

Acknowledgments

I wish to thank my supervisors at the University of Birmingham, Prof. David Maddison and Prof. Richard Green for their valuable time and effort in making this work the best it could be. I also wish to thank my external supervisor Prof. Glenn P. Jenkins from the Eastern Mediterranean University, North Cyprus, for proposing this very interesting research topic and inspiring me to become a better researcher. I would like to thank my internal examiner Prof. Matthew A. Cole and my external examiner Dr. Ben Groom for their valuable inputs.

A special thanks to Dr. Ekin Birol who helped me in the design of the choice experiment. She took the time to teach me how to use the econometric software NLogit, provided the algorithms to estimate the choice experiment models and who, most importantly, replied to all my emails which were full of questions even when she had no time to scratch her head. I would like to thank Assoc. Prof. Mehmet Balcilar from the Eastern Mediterranean University who introduced me to the econometric software STATA. This research also benefited from very valuable comments from Prof. Trudy Ann Cameron who took the time to respond to my emails in detail and provided very valuable suggestions on the treatment of interval contingent valuation data.

Many thanks to the authors Roy Billinton and Gary Wacker, Fredrick Carlsson and Peter Martinsson, Megha Shukla and Ranjan Bose for providing me with the questionnaires they used in their studies. I also wish to thank Ms. Zalihe Raif, from the State Planning Organization, for her suggestions on the questionnaire and her help in conducting the pilot survey. I am thankful to Mr. Ahmet Dargın, the

Head of the Research and Development department of Kıb-Tek, for his genuine support relating to this research and his willingness to help with anything I required. I would like to express my sincere gratitude to Mr. Mehmet Coşkun, Ministry of Agriculture Fuel Unit Manager. Special thanks to Mr. Özay Öykün, mayor of Yeni Erenköy, for allowing us to hold the focus group session at his premises. I would like to thank all who helped organise the focus group studies and the pilot survey, and assisted in collecting the market data used in the averting expenditures estimation.

Finally, I am grateful to my family and friends who have always supported me and have been very patient with me throughout this research.

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List of Abbreviations

AE	Averting Expenditures
ANOVA	Analysis of Variance
CBA	Cost-Benefit Analysis
CBS	Choice-Based Sampling
CE	Choice Experiment
CV	Compensating Variation
CVM	Contingent Valuation Method
ESRS	Exogenously Stratified Random Sample
EU	European Union
EV	Equivalent Variation
EVI	Extreme Value type I
GDP	Gross Domestic Product
GEV	Generalized Extreme Value
GNP	Gross National Product
GWh	Giga Watt Hour
HEV	Heteroscedastic Extreme Value
IIA	Independence from Irrelevant Alternatives
IID	Independent and Identically Distributed
IV	Inclusive Value
Kıb-Tek	Cyprus Turkish Electricity Authority (*Kıbrıs Türk Elektrik Kurumu* in Turkish)
kV	kilo Volt
KVA	kilo Volt Ampere
kWh	kilo Watt hour

LBM	Lower Bound Mean
LL	Log Likelihood
LPG	Liquefied Petroleum Gas
ML	Mixed Logit
MNL	Multinomial Logit
MNP	Multinomial Probit
MW	Mega Watt
MWTP	Marginal Willingness to Pay
NL	Nested Logit
OLS	Ordinary Least Squares
OMEP	Orthogonal Main Effects Plan
RPL	Random Parameters Logit
RUM	Random Utility Model
SCADA	Supervisory Control and Data Acquisition
S.E.	Standard Error
SPO	State Planning Organization
SRS	Simple Random Sample
TL	Turkish Lira
TRNC	Turkish Republic of Northern Cyrus
UBM	Upper Bound Mean
UK	United Kingdom
UPS	Uninterrupted Power Supply
USD	United States Dollar
VA	Volt Ampere

WTA	Willingness to Accept
WTP	Willingness to Pay
YTL	New Turkish Lira

CHAPTER 1 INTRODUCTION

1.1 Introduction

An adequate and reliable power supply is critical for the economic growth of countries (Kraft and Kraft, 1978; Ferguson et al., 2000; Lee, 2005; Lee, 2006; Wolde-Rufael, 2006; Mehrara, 2007; Lee and Chang, 2008; Apergis and Payne, 2009; Khanna and Rao, 2009). However, one fifth of the world's population still has no electricity. Around 585 million people in the Sub-Sahara, 612 million in South Asia, 186 million in China and East Asia and 31 million in Latin America are without access to electricity (IEA 2010). World electricity demand is expected to double between 2000 and 2030, with higher growth rates in developing countries. In order to meet the growth in electricity demand, China will need to invest around USD 2 trillion, India USD 700 billion, East Asia USD 800 billion and Latin America USD 800 billion (Birol, 2004).

The reliability of a power supply is crucial for small island countries that heavily depend 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 therefore are of great concern to these countries.[1] Several islands in the Caribbean, such as Haiti and the Dominican Republic, Cape Verde in the Atlantic Ocean and North Cyprus in the Mediterranean live with blackouts everyday (World Bank, 2006; Chatterjee, 2008; Clough, 2008; Lober et al., 2008).

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

Often, the reason behind these frequent and long lasting blackouts is lack of investment in electricity generation, transmission and distribution systems.

The adverse effects of power outages are borne mainly by the utility company and its customers. When there is a blackout, the utility company loses the sales revenue and consumers lose the consumer surplus they would have accrued from its consumption. With economic development the cost of power outages likely increases. In India, a 10% power shortage during the 1970s led to a reduction of 0.1% in the average growth rate of per capita income, where a shortage of the same magnitude resulted in a reduction of 0.5% during the 1980s (Akkina 2000). Other studies, that estimate the cost of power outages, show that the cost borne by society is several multiples of the average electricity price charged by the utility company. The Electric Power Research Institute study (1981), estimates the cost of rotating blackouts for Key West, Florida to be around 46 times the average electricity price (which was 0.05 USD /kWh in 1981). Jyoti (1998) estimates the cost of power outages for three different enterprises in Nepal and finds that power failure costs are around 6 times the average electricity price. Willingness to Pay (WTP) figures are therefore a potentially valuable guide for utilities making investment decisions and building system capacity and improving maintenance intended to reduce these power failures.

The objective of this research is to measure WTP for an uninterrupted power supply in North Cyprus. The results can be used by the Government to conduct cost-benefit analysis (CBA) of projects intended to improve electricity reliability:

(a) estimating the peak-load price at which generation capacity meets the peak demand. By setting the peak-price appropriately, the utility company can discourage the consumption in low value uses of electricity at peak hours and hence reduce the demand for system capacity during peak periods;

(b) appraising the option of purchasing additional generation capacity to overcome the shortage of power generation which is one of the main causes of blackouts in North Cyprus.

We approximate the customers' WTP using the averting expenditure (AE) method, their stated WTP using the contingent valuation (CVM) and choice experiment (CE) methods. We then compare the results of the three methods to check the validity of the estimates.[2] Another motivation for using CE is its ability to measure the tradeoffs between the different attributes of electricity supply reliability, and estimate the marginal value of changes in each attribute. This type of multidimensional analysis is possible in the CVM as well, however it is more costly.

The AE method estimates actual expenditures made by people coping with the problem of power outages. Many people in Turkish Republic of Northern Cyprus (TRNC) have invested in diesel or petrol generators, uninterrupted power supply (UPS) systems, or some other device to cope with the frequent and generally unannounced power cuts in North Cyprus. Most of these strategies require initial investments and in addition have operating and maintenance costs throughout their operating life. These coping costs serve to reveal the minimum consumers are willing to pay for an uninterrupted power supply.

[2] According to Hensher et al. (2005), validity is "a significant relationship between the results inferred through estimation and real world behavior."

CVM and CE are survey-based methods used in estimating the economic value of market and nonmarket goods. Respondents are presented with hypothetical scenarios and asked to state directly or indirectly, their WTP. We adopt the payment ladder and the choice modelling approach to measure the WTP for a reliable power supply in North Cyprus. The survey questions were tested using a small pilot group before the full survey was implemented. Professional interviewers conducted face to face interviews on a randomly selected sample of respondents. Employing face to face interview techniques increases the response rate and provides an opportunity to explain better certain hypothetical questions. The data collected by the survey are analysed using econometric models. Finally, we compare the results from the three methods to check the validity of the methods.

This research project is divided into eight chapters, Chapter 1 being the introduction and Chapter 2 a literature review on valuation methodologies for increasing reliability of electricity. In Chapter 3, we will present the main issues in the design of CE, and design the choice sets that will be used in the survey. The questionnaire development and the survey procedure are explained in Chapter 4. Chapters 5, 6 and 7 estimate a household's WTP for electricity reliability in North Cyprus using the AE, CVM, and CE methods respectively. Finally, Chapter 8 includes the conclusions, policy implications, limitations of the current research, and future research challenges.

The purpose of the current chapter is to describe the electricity system in North Cyprus and present a timeline of the events that shaped the current electricity supply system. We look closely at the current situation with respect to generation and transmission capacity, tariff structure, and future investment plans intended to improve the existing service. We provide statistics on the electricity consumption of the residential sector and the number of properties possessing characteristics that may have an impact on electricity usage. In Section 3, we will describe how CBA is used to determine optimal system reliability. Finally in Section 4, we will give an outline of the remainder of the dissertation.

1.2 North Cyprus and the Electricity System

1.2.1 North Cyprus: Timeline of Events that Shaped the Current Electricity System

Cyprus, the third largest island in the Mediterranean (total surface area of 9,250 km^2) after Sicily and Sardinia, lies 65 km from the south coast of Turkey. The climate is characterized by mild winters and hot dry summers.[3] After the war in 1974, the island is divided into two. Turkish Cypriots live in the northern part (surface area of 3,355 km^2) and the Greek Cypriots live in the southern part of the island. The population of the North (TRNC) is 265,100 (25.1% of the total population of Cyprus) and has a Gross Domestic Product (GDP) per capita of USD 13,354 (2009 estimate).[4,5] The GDP is distributed among the sectors as follows: agriculture 6.4%; industry 10.0%; construction 6.5%; trade-tourism 12.8%; transport and communication 12.2%; financial institutions 7.5%; ownership and

[3] The weighted average heating and cooling degree days for Cyprus are 710 and 1091 respectively (Baumert and Selman, 2003).
[4] http://nufussayimi.devplan.org/index-en.html, 2006 census and http://en.wikipedia.org/wiki/Demographics_of_Cyprus#Population
[5] http://devplan.org/Frame-eng.html

dwellings 3.9%; business and personal services 10.8%; public services 22.6%; and import duties 7.3%).[6]

Like most island states, North Cyprus is an energy importer making it highly vulnerable to international oil prices. Many islands are now investing in renewable energy sources to free themselves from their dependence on imported fuel oil (Weisser, 2004; van Alphen et al., 2008). But whilst renewable energy sources can reduce fuel costs of the system, they have problems with intermittency (due to the variability in factors such as the duration of solar radiation, wind speed, water availability, etc.) and their impact on overall system reliability needs to be taken into consideration especially when they comprise a sizeable part of the total system capacity (Billinton and Karki, 2001; Karki and Billinton, 2004; Carrasco et al., 2006).

In North Cyprus indigenous energy resources are solar, wind, and wood. Studies on the potential for renewable energy in North and South Cyprus point to the feasibility of solar and wind power systems on the island (Ibrahim, 1996; Haktanir and Mamedov, 2003; Ilkan et al., 2005; Koroneos et al., 2005; Erdil et al. 2008; Maxoulis and Kalogirou, 2008). Ilkan et al. (2005) carried out the economic analysis of investing in solar and wind power systems in North Cyprus. They did not find having solar and wind systems operating throughout the day to be economically feasible. The residential sector is responsible for most of the peak demand in the evenings, and electric water pumps are one of the major determinants of electricity demand in the summer. These authors therefore recommended wider use of solar systems for water heating and wind turbines for water pumping to reduce peak

[6] Ibid.

demand. According to the authors, even though wind-based systems have higher internal rates of return (IRRs) than solar systems, there are very few locations where the construction of wind farms would be economically viable in North Cyprus. The electricity authority of North Cyprus (Kıb-Tek) is planning to acquire a 5 MW solar and a 5 MW wind power station.[7] The renewable energy law drafted by Kıb-Tek is already approved by the Council of Ministers, however it is still waiting as of April 16, 2011 for approval by the Parliament.

Table 1.1 gives a timeline of major events in the development of the electricity system in North Cyprus starting from 1903 when the first small generator was used (Haktanir and Mamedov, 2003; European Commission, 2006; Kıb-Tek web site[8]).

Table 1. 1 Timeline of Important Events in the Development of the Electricity System in North Cyprus

1903	First small generator -- used to meet only the administrative demand in Nicosia (*Lefkoşa* in Turkish), capital of Cyprus. Followed by a second small generator -- used to meet the medical needs. No power was generated for public use.
1912	After 1912, electricity was served to the public.
1914	Britain annexed Cyprus (after being ruled by the Ottomans since 1878).
1922	Electricity generation, after being included in the British government’s agenda, expanded to other districts of Cyprus. Each district generated their own electricity and the power plants were not connected together.
1952	Centralization of the power plants.
1960	Establishment of the Republic of Cyprus.
1963	Fights between the Greek and Turkish Cypriots led to a physical separation between the two communities. Turkish Cypriots having no power generating plants turned to independent small power generators.

7 http://www.kibtek.com/AB_Projeler/yen_enerji1.htm

8 http://www.kibtek.com/

	The Electricity Office (*Elektrik Dairesi* in Turkish) was established as a state office serving the Turkish Cypriots.
1974	After the war between the Turkish and Greek Cypriots in 1974, Cyprus was divided into two. South Cyprus continued to supply 80-90% of electricity consumed in North Cyprus at no charge due to a mutual agreement. As a result the electricity price in North Cyprus was very low (until 1995). The revenue collected from electricity consumers in the North was mostly used to pay the repair expenses and the salaries of its personnel. Very little went to investments in generating capacity.
1975	Turkish Federated State of Cyprus was declared. Cyprus Turkish Electricity Authority, Kıb-Tek was established. The first power generation plant was built in Dikmen (20 MW gas turbine diesel)
1977	The second 20 MW gas turbine diesel power plant was built at Teknecik.
1977-1981	Because the power supply from the South continued, the power stations were in operation for only half an hour per week for trial purposes.
1982	After a request from the South, the generators were put into operation for two hours a day.
1983	Turkish Republic of Northern Cyprus (TRNC) was declared.
1985	10 MW gas turbine diesel power plant, which was already in use in Turkey, was disassembled and put to operation at Teknecik.
1988	The gas turbine generators were in operation for 16 hours a day, supplying 15% of the consumption in the North.
1994	Electricity supply from South Cyprus was phased out, marking the beginning of a period of power outages. The three gas turbines were operated with full capacity. The first of the two 60 MW steam turbine fuel-oil power plant was built at Teknecik. After being in operation for only two months, a huge explosion in the boiler caused serious damage to the power plant.
1995	The second 60MW steam turbine fuel-oil power plant was built at Teknecik. Kıb-Tek generated 90% of electricity consumed in North Cyprus and increased the price from USD 0.02/kWh to USD 0.06/kWh.
1996	The repair of the first 60 MW steam turbine fuel-oil power plant was completed and put back into operation. On March 17, 1996, South Cyprus terminated supplying electricity to the North. The electricity demand of the North was mostly supplied by the two 60 MW steam turbine fuel-oil power plants and the gas turbine diesel power plants were used for the peak load.
2003	On April 23, 2003, borders open between North and South Cyprus. In September, 2003, a private company, Aksa Enerji Uretim A.S., started generating electricity from its two 17.5 MW capacity fuel oil fired diesel plants at Kalecik and selling its output to Kıb-Tek at a preset price. Aksa's installed capacity at Kalecik has eventually reached 5×17.5 MW. Despite an average growth rate of about 10% in electricity production, the frequency of outages remains high.
2004	On May 1, 2004, South Cyprus joined the European Union (EU).
2006	During January 2006, the Teknecik power plant had technical problems and needed major repairs leading to outages of prolonged duration. For couple weeks electricity was supplied

	by South Cyprus.
2007	For the period of 1997-2008 annual growth in electricity consumption is around 6% due to rapid growth in the construction sector and low electricity tariffs in North Cyprus. 4×17.5 MW diesel plants installed at Teknecik
2008	Kıb-Tek purchased additional 35 MW capacity. Both plants are in Teknecik.
2011	The older gas turbines are phased out. As of January 22, 2011, the 2x17.5 MW units purchased in 2008 have not been used due to insufficient capacity on the transmission lines. On July 11, 2011, the largest power plant in South Cyprus (793 MW) was destroyed by an explosion in an arms depot. Kıb-Tek signed an agreement to sell electricity to South Cyprus.

Outages in North Cyprus date back to 1994. Over the years, population growth (6.0%), increase in the number of foreign students (23.3%) and tourists (19.6%), as well as the exponential growth in the construction sector (26.6%) worsened the power shortage problem in the North.[9] There are now frequent power cuts throughout the year, getting worse during the summer months when the air conditioners are working and during the winter months due to bad weather and more people relying on electricity to heat their homes (Ilkan et al., 2005).

1.2.2 The Electricity System

Kıb-Tek (Cyprus Turkish Electricity Authority -- *Kıbrıs Türk Elektrik Kurumu* in Turkish) is the electricity authority of North Cyprus responsible for the generation, transmission and distribution of electricity in the North. At the end of October 2007, Kıb-Tek employed 648 personnel (up from 592 in 2002). In 2007, Kıb-Tek electricity sales were 955.9 GWh, hence the ratio of sales of electricity per permanent employee was 1.48 GWh (=966.9/646).[10] This ratio was 1.90 GWh per permanent

[9] Annual average growth rates for the period 1979 to 2008. TRNC State Planning Organization, http://devplan.org/Frame-eng.html
[10] Kıb-Tek web site, http://kibtek.com/Santrallar/urt_tuksant97_2008.htm (accessed April 07, 2010)

employee in the electricity authority of South Cyprus.[11] For the same amount of electricity sold there were 143 (or 28%) more permanent employees in Kıb-Tek than in the electricity authority of South Cyprus.[12] In 2007, Enemalta Electricity Division of Malta had electricity sales to permanent employee ratio of 1.56. [13] Hence, compared to Enemalta, Kıb-Tek had 6% more permanent employees.

Total installed capacity in North Cyprus is 362.5 MW (see Table 1.2). The three power stations are Dikmen, Teknecik and Kalecik (see Figure 1.1). The oldest plant is a 20 MW gas turbine diesel plant at Dikmen built in 1975, followed by the 20 MW gas turbine fuel-oil plant at Teknecik which was built in 1977. In 1983 a 10 MW gas turbine fuel-oil plant, and in 1995 and 1996, two 60 MW steam turbine units were added to the capacity at Teknecik. The gas turbines were very expensive to operate with fuel cost of more than 14 US cents/kWh and were therefore initially intended to be used as backup only when the steam turbines needed maintenance. However due to increases in demand, they were in operation most of the time. In 2003, when Kıb-Tek did not have the financing required for additional generation capacity, they entered into a Build-Operate-Transfer contract with a private company, Aksa Enerji Uretim A.S (Aksa Energy Production). Aksa built a 24 million USD power plant at Kalecik with an annual production of 170 million kWh and sold the electricity to Kıb-Tek at 4.27 US cents/kWh. Aksa operated with 30 people and increased the production capacity in North Cyprus by 20%. In 2008, 35 MW capacity was added to the system; however as of January 22,

[11] http://www.eac.com.cy/EN/ourorganization/Pages/Personnel.aspx (accessed April 07, 2010)
[12] 143 = 646 – (955.9/1.90)
[13] http://www.doi.gov.mt/en/press_releases/2009/09/pr1579b.pdf (accessed September 10, 2010), https://www.cia.gov/library/publications/the-world-factbook/geos/mt.html (accessed September 10, 2010)

2011, these 2x17.5 MW units have not been used due to insufficient capacity on the transmission lines. Kıb-Tek's average production costs in 2008 were around 7.55 US cents/kWh.[14]

Table 1. 2 Power Generation Plants and Installed Capacity

Power Generation Plants	Capacity (MW)	
	Installed	Available
Dikmen 20 MW Gas Turbine Diesel, 1975	20	0
Teknecik 20 MW Gas Turbine Diesel, 1977	20	0
Teknecik 10 MW Gas Turbine Diesel, 1985	10	0
Teknecik 60 MW Steam Turbine Fuel-oil, 1994	60	55
Teknecik 60 MW Steam Turbine Fuel-oil, 1995	60	55
Kalecik DG, Aksa Enerji Uretim A.S., 5×17.5 MW, 2003	87.5	85
Teknecik, Diesel, 2007 4×17.5 MW	70	60
Teknecik, Diesel 2008 2×17.5 MW	35	0
Total	362.5	255

Source: Kıb-Tek web site and interview with Kıb-Tek on January 22, 2011
http://www.kibtek.com/Santrallar/Sant2007FalRap.htm

[14] Kıb-Tek web site, http://www.kibtek.com/

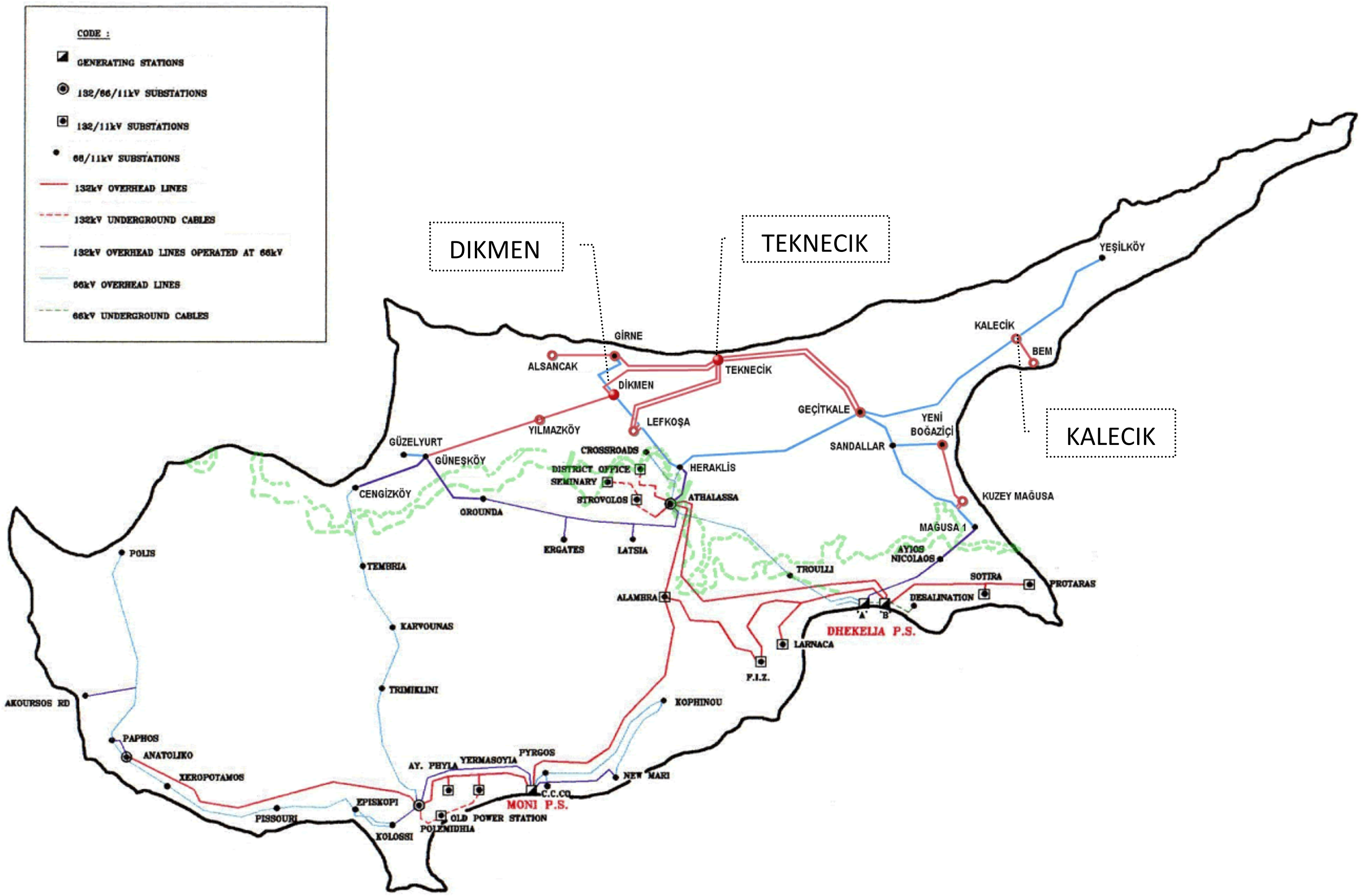

Figure 1. 1 Generating Stations, Substations, Transmission and Distribution Lines in Cyprus

Source: Kıb-Tek web site, http://www.kibtek.com/

The high-tension transmission lines mostly operate at 66 kV. Some of the distribution lines predate the war in 1974 and were used in transporting energy from the South to the North up until 1995. As power plants started to be built in the North, high tension power lines were built by Turkey to transport the energy generated at these power plants. Currently the total length of the transmission lines in North Cyprus is 554km. Kıb-Tek is in the process of upgrading the high-tension transport system from 66kV to 132kV (the system used in South Cyprus) to make future interconnection of the two systems possible. Problems with the transmission and distribution lines are other frequent causes of the outages in North Cyprus. Out of the 309.7 million USD investment made by Kıb-Tek between the years 1975-2001, 87.2% was for additional generation capacity, 3% for transformer stations, and 2.8% for transmission lines. Kıb-Tek is planning on setting up the SCADA system (Supervisory Control and Data Acquisition). This system will enable Kıb-Tek to monitor the distribution lines and the transformer stations from a central location, and respond quickly to problems in the system. Firstly, however, in order for this project to be fully operational, the existing transformer stations must be made compatible with the SCADA system.

Kıb-Tek customers are categorized into thirteen groups and are subject to the tariff rates shown in Table 1.3. The residential sector is divided into five groups by poverty and demand level. In 2008, the households in the poor category paid on average 0.18 YTL/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 for the first 250 kWh, 0.30 YTL/kWh for consumption between 251-500 kWh, 0.32 YTL/kWh for 501-750kWh, and 0.43 YTL/kWh for consumption above 750 kWh.

Table 1. 3 Tariff Rates (2008 Average)

Sector		Tariff (YTL)	
01 Temporary Current		0.70	per kWh
02 Residential (for the first 250 kWh) Poor		0.18	per kWh
02 Residential (0- 250 kWh)		0.24	per kWh
02 Residential (251-500 kWh)		0.30	per kWh
02 Residential (501-750 kWh)		0.32	per kWh
02 Residential (751 kWh and above)		0.43	per kWh
03 Commercial	Single phase	0.35	per kWh
	Multi phase		
04 Commercial	1.Block[15]	0.35	per kWh
	2.Block	0.28	
05 Industrial	Single phase	0.23	per kWh
	Multi phase		
06 Industrial	1.Block	0.20	per KVA
	2.Block	0.18	per KVA
07 Tourism	Single phase	0.23	per kWh
	Multi phase		
08 Tourism	1.Block	0.20	per KVA
	2.Block	0.18	per KVA
09 Water Pumps	Single phase	0.20	per kWh
	Multi phase		
11 Off-peak load	Single phase	0.24	per kWh
12 Defence		0.24	per kWh
13 Government offices	Single phase	0.44	per kWh

Source: Kıb-Tek web site, http://www.kibtek.com/

Adoption of an increasing block tariff structure is common practice among electricity utilities worldwide where the main objectives are to cover the increasing supply cost of additional consumption, encourage conservation, and at the same time subsidize the low income households (Munasinghe 1981b; Munasinghe, 1981c; Whittington, 1992; Boland and Whittington, 1997; Komives et al., 2006; Foster and Yepes, 2006). However, whether the low income households actually benefit from this tariff structure depends on, among other things, their connection and

[15] This tariff applies to commercial and industrial businesses with monthly consumptions higher than 200 kWh. The firm's peak load during the month multiplied by 100 gives the consumption quantity that will be subject to Block 1 rate. The remaining consumption falls in Block 2.

metering status, and on the number of people sharing the same connection. The larger the number of people sharing a connection the higher will be the average price paid per unit consumption, and since this is more likely to be the case with lower income households, they may actually be negatively affected by the increasing block tariff structure (Whittington, 1992; Foster and Yepes, 2006; Komives et al., 2006). As the vast majority of households in North Cyprus are connected and metered, these adverse effects may be less of a concern to Kıb-Tek than the need to promote energy conservation.

During the period covering January to July 2008 fuel oil prices increased by 75% and the Ministry of Finance announced that the electricity prices would be indexed to fuel oil prices and that these increases would be automatically reflected in consumers' electricity bills. On June 10, 2008 electricity prices were increased by 18% from the previous month which resulted in a 50% increase for the whole year from January to June. An additional 15% increase happened in July 2008. The tariffs reached their maximum in August 2008 (see Table 1.4 and Figure 1.2 below).[16]

[16] In August 2008 (main survey period) an average household in North Cyprus paid 0.41 YTL/kWh (0.2323 EUR/kWh). During the second semester of 2008, electricity prices for domestic consumers in Malta and South Cyprus were 0.1463 EUR/kWh (37.0% lower) and 0.1754 EUR/kWh (24.5% lower) respectively. http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nrg_pc_204&lang=en

Table 1. 4 Residential Electricity Tariffs 2008 (YTL/kWh)

	2008 Electricity Tariffs (YTL/kWh)									
Sector	Feb 1	Mar 1	Apr 1	May 1	June 9	July 10	Aug 1	Sept 1	Oct 1	Avg
01 Temporary Current	0.54	0.55	0.56	0.56	0.66	0.76	0.94	0.89	0.82	0.70
02 Residential Poor 0- 250 kWh	0.14	0.14	0.14	0.14	0.17	0.19	0.24	0.24	0.24	0.18
02 Residential 0- 250 kWh	0.17	0.18	0.19	0.19	0.22	0.26	0.32	0.30	0.30	0.24
02 Residential 251-500 kWh	0.21	0.23	0.24	0.24	0.29	0.33	0.41	0.38	0.37	0.30
02 Residential 501-750 kWh	0.23	0.25	0.26	0.26	0.31	0.36	0.44	0.41	0.40	0.32
02 Residential 751 kWh and above	0.31	0.31	0.35	0.35	0.41	0.48	0.59	0.57	0.53	0.43

Source: Kıb-Tek web site, http://www.kibtek.com/

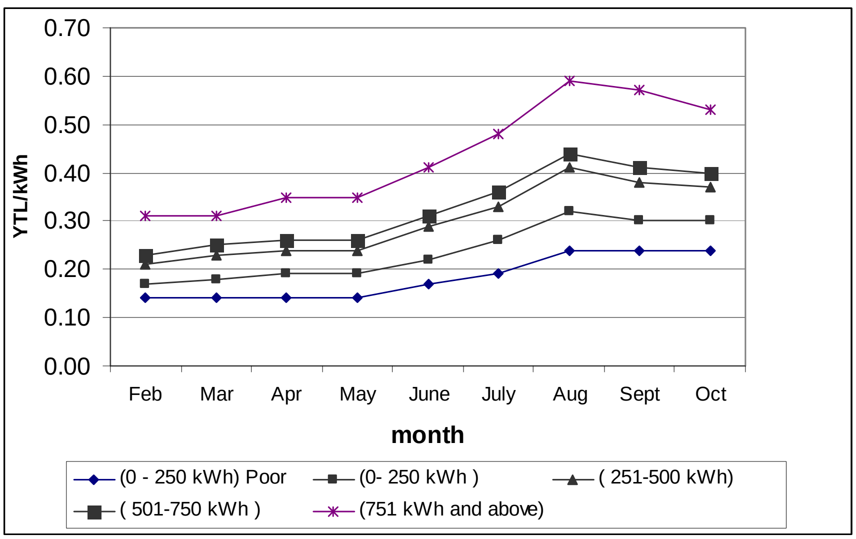

Figure 1. 2 Residential Electricity Tariffs 2008

Source: Kıb-Tek web site, http://www.kibtek.com/

Total electricity required each year is the sum of consumption by the consumers, auxiliary consumption (consumption within the plant), and losses (see Table 1.5). During the 2001-2008, auxiliary consumption has been on average 5.1% of electricity production and the losses 13.6% of electricity production. The residential sector represented 38% of total consumption in 2008 and has grown by an average of 9.3% per annum over the period 2001-2008 (see Figure 1.3).

Table 1. 5 Electricity Consumption 2001-2008 (GWh)

Consumer Groups	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
Temporary Current	15.6	19.2	12.3	14.3	22.3	20.1	26.7	22.2
Residential	205.5	210.2	230.4	265.3	310.1	335.8	360.3	383.1
Commercial I-II	110.1	117.8	107.3	133.7	146.9	138.1	162.1	177.0
Industrial I-II	53.9	58.2	62.3	78.2	78.1	97.6	105.2	91.4
Tourism I-II	45.6	47.9	54.1	61.9	72.4	66.2	95.9	97.3
Water Pumps	53.6	58.6	53.0	57.2	61.5	46.0	49.9	69.9
Street Lights	14.6	15.6	14.9	16.7	20.4	22.2	17.8	23.3
Social Aid	-	-	-	-	-	-	1.8	1.9
Peak Load	0.1	0.1	0.1	0.2	0.1	0.2	0.2	0.2
Defence	93.9	73.9	81.6	78.2	85.9	84.4	87.9	88.2
Government Offices	-	-	-	-	-	44.8	47.8	38.5
Turkish Republic Embassy	-	-	-	-	-	-	0.1	0.1
Diplomat	-	-	-	-	-	-	0.1	0.1
Total	592.9	601.7	616.0	705.7	797.9	855.3	955.9	993.3
Auxiliary Consumption	42.5	43.5	44.9	45.0	43.2	50.1	54.2	54.7
Losses	66.3	65.5	102.6	133.2	157.8	176.2	176.8	177.8
General Total	701.6	710.6	763.5	883.9	998.9	1,081.6	1,186.8	1,225.8

Source: Kıb-Tek web site, http://www.kibtek.com/

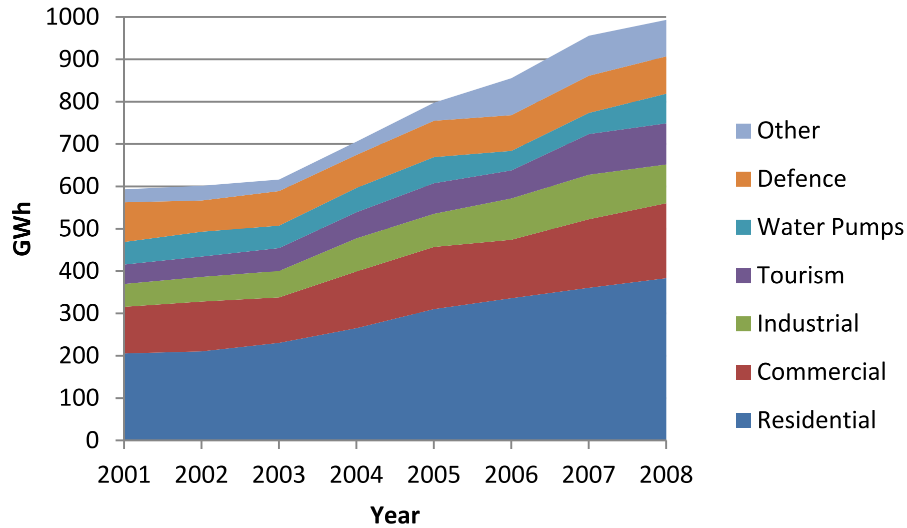

Figure 1. 3 Electricity Consumption 2001-2008 (GWh)

Source: Kıb-Tek web site, http://www.kibtek.com/

From the monthly residential sector consumption figures for the years 2004 and 2008, it is observed that consumption is at its highest in January when electricity is used for space heating by households (see Figure 1.4). Then consumption follows a downward trend and it reaches its low in May and June. These are the months where no space heating/cooling is required. As the weather gets warmer and people start using their air conditioners for space cooling, consumption increases again and reaches its summer maximum around August. Water is very scarce during the summer months and electric water pumps are another major contributor to the pick-up in demand during the summer months. Starting in September it then follows a downward trend until November after which it starts increasing again as the temperature falls.

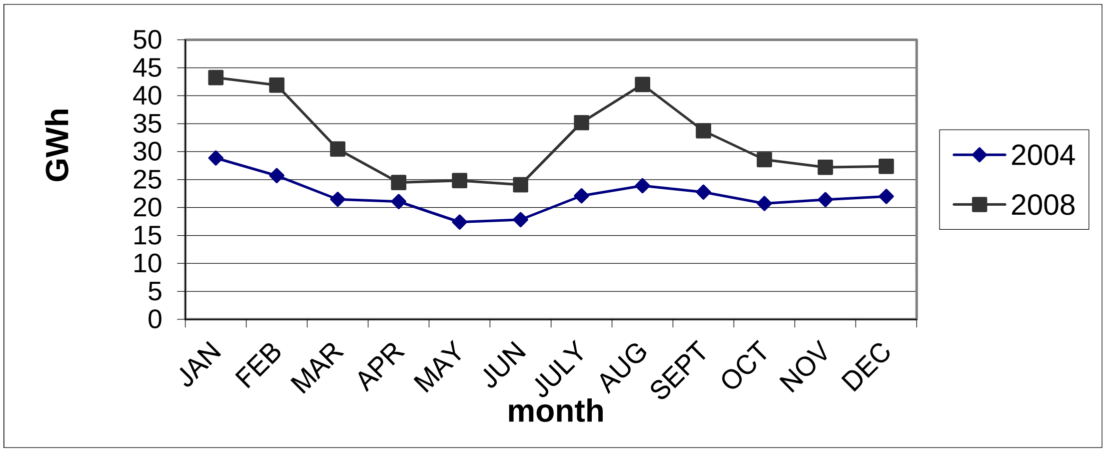

Figure 1. 4 Monthly Consumption – Residential Sector (GWh)

Source: Kıb-Tek web site, http://www.kibtek.com/

From the January 9, 2007 load curve, we observe that the demand is at its lowest at 4-5 am, increases throughout the day and reaches its maximum at around 7 pm (see Figure 1.5). On the other hand the minimum demand on July 30, 2007 was at around 7 am, and reached its maximum earlier at around 3 pm. Comparing the two load curves, it can be observed that the demand at each hour is higher during summer except between 6 pm-9 pm. We can also observe from the figure that between 11 am – 5 pm on January 9, and between 9 am – 4 pm on July 30, the total demand (including unserved energy) exceeded the capacity and there were outages. Time-of-day pricing is relatively uncommon in North Cyprus so users, in general, do not have an incentive to spread their consumption to off-peak hours. However, with funding from the EU, Kıb-Tek is hoping to introduce time-of-day pricing. They are planning on replacing the 132,000 mechanical meters with smart meters. The smart meter system will automatically record consumption, invoice consumers, and monitor timely payment. The non-paying customers will be automatically disconnected and reconnected as soon as the payment is made. The smart meters will not only enable Kıb-Tek to switch to time-of-day pricing, but help save operating costs. The current system has a monthly operating cost (personnel and equipment) of 400,000 YTL, and with the smart meters Kıb-Tek expects a monthly cost reduction of 390,000 YTL. Moreover, as the smart meters are more precise than the mechanic meters in recording the energy consumption, Kıb-Tek anticipates an additional savings of 1,700,000 YTL per month.[17]

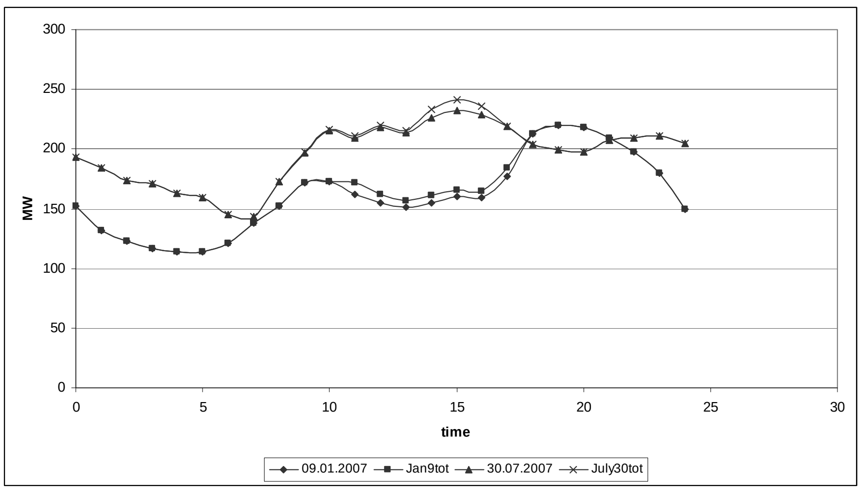

Figure 1. 5 January 9 and July 30, 2007 Load Curves

Source: Kıb-Tek web site, http://www.kibtek.com/

Electricity demand is met mainly by that produced in North Cyprus and partly by the South for a number of villages that are connected to the South Cyprus electricity grid. In 2006, when major breakdowns affected the Teknecik power plant, electricity had to be purchased from the South as well (see Table 1.6). Total electricity demand in 2008 was supplied mostly by the Teknecik steam

[17] http://kibtek.com/AB_Projeler/asayac.htm

turbine plants (56%) and the Kalecik plant (Aksa) (27%). For the remainder diesel and gas turbines had to be used.

Table 1. 6 Electricity Production 2001- 2008 (GWh)

POWER PLANT	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
Teknecik Steam Turbine. S.U.1	338.4	344.9	339.7	321.4	339.1	355.5	321.5	367.8
Teknecik Steam Turbine S.U.2	343.6	343.8	334.0	327.8	337.6	328.3	324.1	322.8
Dikmen Gas Turbine S. TG20	6.1	7.0	12.1	9.1	8.1	6.6	2.5	1.5
Teknecik Gas Turbine S. TG20	11.6	14.3	24.7	8.5	11.3	10.1	1.6	0.6
Teknecik Gas Turbine .S. TG16	2.0	0.7	2.8	1.2	0.0	-	-	-
Kalecik DG	-	-	50.2	215.8	302.8	381.1	443.0	336.3
Teknecik Diesel Generator	-	-	-	-	-	-	94.2	196.7
Total Production TRNC	701.6	710.6	763.5	883.9	998.9	1,081.6	1,186.8	1,225.8
Villages fed from the South	4.9	4.6	5.2	7.9	6.4	5.1	5.4	5.1
Purchases from the South	-	-	-	-	-	40.6	-	-
GENERAL TOTAL	706.5	715.3	768.6	891.8	1,005.3	1,127.3	1,192.3	1,230.9

Source: Kıb-Tek web site, http://www.kibtek.com/

1.2.3 Different Types of Dwellings

According to the 2006 census in North Cyprus, there are 72,624 dwellings with an average household size of 3.17. The majority of households in North Cyprus live in detached houses, multi storey apartments and semi-detached houses (see Table 1.7): 51.6% of households live in detached houses 56.8% of which have one floor only. 22.4% of households live in multi storey apartments (mostly 3-4 storey), and 18.3% live in semi-detached houses of mostly 1-2 floors.

Table 1. 7 Household Building Types

Building Type	Number of floors	Number of dwellings	Building type as % of total dwellings	Number of floors as percent of building type
Total		72624		
Detached house	Total	37508	51.6%	
	1	21303		56.8%
	2	5871		15.7%
	3	68		0.2%
	Not known	10266		27.4%
Semi-detached house	Total	13255	18.3%	
	1	3447		26%
	2	8164		62%
	Not known	1644		12%
Terraced house	Total	3995	5.5%	
	1	1532		38.3%
	2	1909		47.8%
	Not known	554		13.9%
Subsidiary housing	Total	1338	1.8%	
	1	1245		93.0%
	2	63		4.7%
	Not known	30		2.2%
Multi-storey apartment	Total	16244	22.4%	
	1	37		0.2%
	2	1032		6.4%
	3	5987		36.9%
	4	6100		37.6%
	5	1483		9.1%
	6	245		1.5%
	7+	283		1.7%
	Not known	1077		6.6%
Other		210	0.3%	
Not known		74	0.1%	

Source: SPO web-site
http://nufussayimi.devplan.org/index-en.html, 2006 census.

1.8% of dwellings have a private swimming pool and due to the mild winters in Cyprus, only 2.6% of the households equip their dwellings with central heating (see Table 1.8). On the other hand, solar water heating is widely used (71.4% of the dwellings).

Table 1. 8 Swimming Pool, Central Heating, and Solar Water Heating

2006 census	Number of Households	%
Total	72,624	
Swimming Pool		
Swimming pool (private)	1,278	1.8%
Swimming pool (share)	1,016	1.4%
No swimming pool	70,213	96.7%
Swimming pool--don't know	117	0.2%
Central Heating		
Central heating	1,897	2.6%
No central heating	70,441	97.0%
Central heating- don't know	286	0.4%
Solar Water Heating		
Solar water heating	51,889	71.4%
No solar water heating	19,919	27.4%
Solar water heating --don't know	816	1.1%

Source: SPO web-site
http://nufussayimi.devplan.org/index-en.html, 2006 census.

Table 1.9 displays some of the characteristics of dwellings encountered in North Cyprus. 13.89% of the households in North Cyprus own at least one generator, 48.58% own at least one air-conditioner, and 15.95% have at least one fire-place in their home.

Table 1. 9 Household Facilities

Facility	Number of Facilities	Number of Households With The Facility	% of Total Number of Households
Generator	10,234	10,091	13.89%
Air conditioner	62,480	35,280	48.58%
Fireplace	11,935	11,603	15.98%
Computer	33,691	33,691	46.39%
Internet	16,018	15,700	21.62%
Television	102,842	70,960	97.71%
Home telephone	56,157	51,525	70.95%
Mobile telephone	138,405	64,200	88.40%

Source: SPO web-site
http://nufussayimi.devplan.org/index-en.html, 2006 census.

The majority of households use electricity (28.5%), liquefied petroleum gas (LPG) (22.6%), or a combination of the two (17.9%) for space heating (see Table 1.10). Wood is also being used by 17.4% of households. Unfortunately for the mixed categories, the 2006 census data is not detailed enough to know in what proportion each fuel type was used for space heating.

Table 1. 10 Fuel Types Used for Space Heating

Fuel Type Used for Space Heating (2006 census)	Number of Households	%
Total	72,624	
Electricity	20,664	28.5%
Fuel-oil	4,533	6.2%
LPG	16,381	22.6%
Wood	6,271	8.6%
Electricity and fuel-oil	3,242	4.5%
Electricity and LPG	13,022	17.9%
Electricity and wood	2,300	3.2%
Fuel-oil and LPG	376	0.5%
Fuel-oil and wood	318	0.4%

LPG and wood	1,322	1.8%
Electricity, fuel-oil, and LPG	815	1.1%
Electricity, fuel-oil, and wood	407	0.6%
Electricity, LPG, and wood	1,646	2.3%
Fuel-oil, LPG, and wood	59	0.1%
Electricity, fuel-oil, LPG, and wood	338	0.5%
Don't know	930	1.3%

Source: SPO web-site
http://nufussayimi.devplan.org/index-en.html, 2006 census.

1.3 Improved Electricity Services and WTP

Economic CBA has become the preferred approach by many utilities around the world in determining the optimal system capacity and reliability of electricity supply (Munasinghe and Gellerson, 1979; Munasignhe, 1981; Sanghvi, 1983; Billinton et al., 1991; Lawton et al., 2003; Chowdhury et al., 2004; Ortega-Vazquez and Kirschen; 2007; Motamedi et al., 2008; Kang et al., 2009; Sullivan, 2009). This method incorporates the customers' shortage costs as well as the system costs into the decision making, therefore giving a more meaningful and economically efficient result than just setting the reliability depending on some arbitrary maximum value for the probability of an outage. There is a trade-off between the system cost of obtaining greater reliability in electricity supply and the shortage costs experienced by the customers due to unreliability. Higher levels of reliability result in lower shortage costs but require higher levels of investment in system capacity and reliability (see Figure 1.6). CBA helps to determine the economically efficient level of investment in reliability, R_{opt}, where the marginal investment cost in reliability equals the marginal social cost of not undertaking that investment. Determining the optimum level of reliability is the counterpart of determining the optimum level of capacity (Munasinghe, 1981).

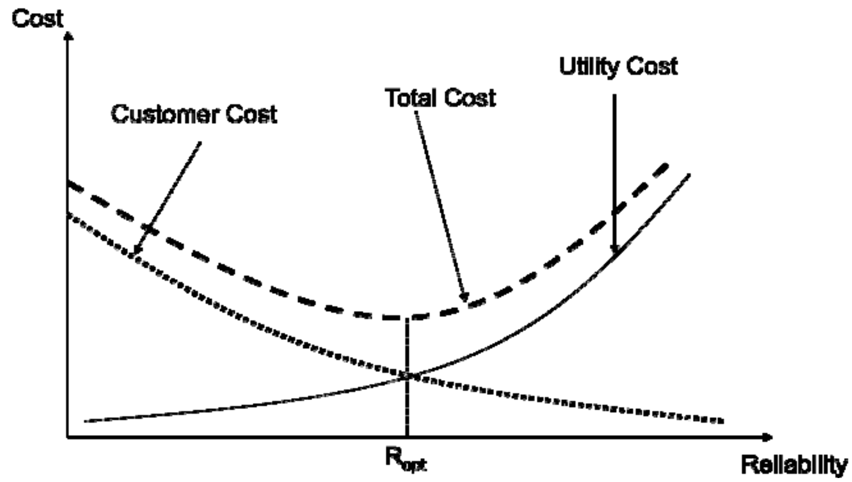

Figure 1. 6 Optimum Reliability

Source: Chowdhury et al., 2004, p2 figure 1.

During certain times of the day, when the capacity of the thermal generating units available in the system is greater than the demand, the decision as to which power stations to run should take into consideration their relative operating costs. In order to minimize the total operating costs, only the most fuel efficient plants should run during these periods. Among other constraints, such as the physical limitations of the equipment, security requirements (e.g. that the generating units, transmission lines, etc., would remain operational after any single failure elsewhere in the system) should be included in the optimization problem. For a review of literature on optimal power flow (the system settings at which the objective cost function is minimized) see: Carpentier, 1979; Burchett et al., 1982; Chowdhury and Rahman, 1990; Huneault and Galiana, 1991; Momoh et al., 1999; Al-Rashidi and El-Hawary, 2009.

To avoid power shortages during periods of high demand, the utility company can choose to invest in a higher reserve capacity, use peak-load pricing or alternatively control the demand for the available supply by load-shedding techniques. Setting a price for a reliable electricity supply is more challenging due to the fact that, unlike water and other regular commodities, electricity cannot be stored in an economical way while its demand varies throughout the day and throughout the year. Teblitz-Sembitzky (1992) noted that power generation is a multi-product industry where the outputs can be indexed by time of use and priority of service, and contrary to a single-product industry, the cost allocation and price setting across different outputs is a complicated task. Electricity generation during peak periods is more costly because less efficient generators are brought online for a short time. Furthermore, it is the growth of demand at the peak that necessitates additional investment in generation capacity. To cover the higher cost of peak-generation, peak-load pricing suggests that off-peak users are charged the marginal operating costs only while the on-peak users pay for the marginal capacity costs in addition to the marginal operating costs (Houthakker, 1951; Steiner, 1957; Hirshleifer, 1958; Boiteux, 1960; Williamson, 1966; Turvey, 1968; Joskow, 1976; Wenders, 1976; Crew et al., 1995).

In North Cyprus, the Government has plans to improve and upgrade the electricity infrastructure. In order to evaluate the economic benefits, the willingness of people to pay for improved electricity services needs to be calculated. There are no prior estimates of WTP for improved service reliability in North Cyprus. Very few such studies have been undertaken elsewhere in the world. There are very few valuation studies of any description in TRNC. The closest study to this one is by Korman (2002), which estimated the WTP for improved water services for Famagusta, North Cyprus.

1.4 Outline of Dissertation

The remainder of the thesis is structured as follows. Chapter 2 contains a literature review of valuation methodologies suitable for estimating household WTP for a more reliable electricity supply. This chapter lays down the theoretical framework for estimating the welfare impact of an improvement in the reliability of supply using the AE, CVM, and CE valuation techniques. We end the chapter with a survey of studies empirically estimating outage costs, including methods used for businesses as well as the residential sector.

Chapter 3 is dedicated to designing the CE. The main issues in CE design such as design objectives, statistical optimality, prior assumptions, cognitive complexity, impact of design on WTP estimates, and inclusion of a status-quo alternative are discussed in detail. We then outline the main steps involved in conducting a CE study. Following these steps, we explain how we selected the attributes and attribute levels included in our CE, and how we constructed the choice sets used first in our pilot study and then in the main study.

Chapter 4 is concerned with the questionnaire development, and the main survey. We explain how questions included in the questionnaire were chosen. We report the results of the pilot survey and explain how the questionnaire and the experimental design were revised following feedback received from the interviewers and the respondents that took part in the pilot study. We discuss the sampling method, sample size, and mode of administration of the main survey. We end the chapter with summary statistics drawn from the main survey.

In Chapter 5, we provide the results of an AE study. First we analyse the summary statistics of a household's averting behaviour, including ownership and usage frequency for a variety of household technologies. The particulars of equipment and the unit prices used in calculation of the AE come from the survey respondents, vendors, and manufacturers. We group respondents based on district, income, outage frequency, and outage duration. Then, we compare group means for the household's perceived service reliability (outage frequency and duration), total monthly AE, and number of averting actions. Household AE are analysed using the Tobit regression model.

Chapter 6 presents the results of a CVM study. After discussing the data and protest responses, we estimate mean WTP and its variance using various nonparametric approaches: the Turnbull lower bound mean, Kriström mean, and upper bound mean. The household's participation in the contingent market is modelled using Probit regression, and WTP is estimated using spike models.

In Chapter 7, we provide the results of the CE study. We explain how the data was handled, discuss the treatment of protest responses, give summary statistics on the choice alternatives, and estimate the utility parameters using three econometric models: the multinomial logit; the mixed logit; and the mixed logit with interactions. We compare these models in terms of fit and provide WTP estimates based on the compensating variation for different service improvement scenarios. Confidence intervals are provided for mean WTP estimates.

Chapter 8 concludes. Here, we compare our WTP estimates from the three methodologies (AE, CVM, and CE). We also compare our estimates with existing WTP estimates found in the literature. We discuss the policy implications of our findings, state the limitations of the current research, and suggest areas for future research.

CHAPTER 2 LITERATURE REVIEW: METHODOLOGIES FOR ESTIMATING THE WTP FOR RELIABLE ELECTRICITY SUPPLY

2.1 Introduction

In Chapter 1, we looked at the unreliability of electricity in less developed and developing countries in general, and discussed some of the reliability problems common to small countries and islands. We described the current electricity problem in North Cyprus, stated the objectives and the methodology of this research. This chapter will discuss the various valuation methodologies for measuring the welfare effects of improvements in the electricity service, and provide the theoretical framework behind each valuation methodology.

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 of interest. Stated preference approach on the other hand relies on survey-based methods and hypothetical scenarios to measure the consumers' WTP for an improvement in the service.

The remainder of this chapter is organised as follows. Section 2 presents the theoretical framework for the welfare impact of a service quality improvement. Section 3 is a discussion of the revealed preference approach, explaining the theoretical framework for the two revealed preference approaches, the direct demand estimation and the AE methods. In Section 4, we describe the stated preference approach, and give the theoretical framework for the two stated preference approaches, the CVM and the CE. Section 5 reviews some of the studies on the welfare impacts of electricity supply reliability improvements.

2.2 Theoretical Framework for the Welfare Impact of a Quality Improvement

When the objective of a project is to increase the quality of a service, we would like to measure the economic welfare impact of that, on the consumers of that service, in units of money income. In the case of an improvement in the reliability of the electricity supply for example, when the reliability is increased from a level of R^0 to R^1, a household's utility increases from U^0 to U^1. How much better off, in monetary terms, the consumer is at the improved reliability level R^1 compared to his initial level R^0 can be measured in two ways (Hanemann, 1991; Silberberg and Suen, 2001).

The first is called the compensating variation (CV), and in the case of an improvement in the quality of service, measures the consumer's maximum WTP for the quality improvement. It is the amount that needs to be taken away from the consumer's income at his new level R^1, to make him as well off at his initial level R^0. In terms of the indirect utility function, this can be represented as:

$$V(p^0, R^0, Y) = V(p^0, R^1, Y - CV)$$

where p^0 is the vector of prices, and Y is the consumer's income. Equivalently, this can be expressed explicitly using the expenditure function:

$$CV = e(p^0, R^0, U^0) - e(p^0, R^1, U^0)$$

where e(.) is the expenditure function, and U^0 is the household's or individual's level of utility with current service reliability of R^0.

The second one is called the equivalent variation (EV), and in the case of an improvement in the quality of service, it measures the consumer's minimum willingness to accept for not having the quality improvement. It is the amount that needs to be given to the consumer at his initial level R^0, to make him as well off as he would have been if the service were to improve to R^1. In terms of the indirect utility function, this can be represented as:

$$V(p^0, R^0, Y + EV) = V(p^0, R^1, Y)$$

Similarly, this can be expressed explicitly using the expenditure function:

$$EV = e(p^0, R^0, U^1) - e(p^0, R^1, U^1)$$

WTP and WTA figures for an improvement in service quality are not in general equal (Willig, 1976; Randall and Stoll, 1980; Hanemann, 1991; Beenstock et al., 1998; Horowitz and McConnell, 2002; Zhao and Kling, 2004; Biel et al., 2006). WTA values for reliability improvements are mostly greater than WTP values, and some of the reasons which explain this discrepancy are income and substitution effects, transaction costs, and existence of loss aversion.

2.3 Revealed Preference Approach

The revealed preference approach includes direct demand estimation, AE (also referred to in literature as coping costs, defensive expenditure, or mitigating behaviour), travel cost, hedonic pricing, and cost of illness methods. Travel cost and cost of illness methods are not used in the evaluation of infrastructure service quality improvements, therefore they will not be discussed here in detail.

2.3.1 Direct Demand Estimation

The theoretically exact measures of the welfare impact of a service improvement on the individual or household are the CV and the EV, and these are measured using the Hicksian demand curves which are difficult to estimate in practice due to their dependence on utility. Willig (1976) shows that the welfare impact of a price change on an individual can be estimated by the consumer's surplus via the Marshallian demand curves, which are observable and hence easier to estimate in practice. This is possible because the partial derivative of the expenditure function with respect to price, $\partial e/\partial p$, can most of the time be approximated by an observable behavioural function, the consumer's demand curve (Bockstael and McConnell, 1999). However, the same does not hold for $\partial e/\partial R$. Randall and Stoll (1980) extend Willig's analysis to include the welfare effects of changes in the amounts of goods/services as well as the changes in prices. One of their findings is that, for goods which are indivisible or lumpy, the welfare gain measured by the CV is smaller in absolute value than that measured by the consumer's surplus which in turn is smaller than the EV measure. Some of the potential CV will be lost because people are required to buy larger volumes of an item than they would prefer to buy at the given price. In order to estimate the welfare impact of a quality change, two additional restrictions on preferences are required: the weak complementarity and the non-essentiality restrictions.

In establishing the weak complementarity restriction, the service quality is viewed as the quality of a privately consumed good/service, for example, the electricity service in our case. The weak complementarity restriction assumes that any changes in the level of quality have no effect on the individual who does not consume any of the private consumption good (Feenberg and Mills, 1980). That is, improvements in the reliability of the electricity service will have no effect on an individual who does not use the electricity service at all.

A good/service is non-essential if there exists a price at which the quantity demanded of the good is zero. This restriction ensures that the demand curve intersects the price axis at this maximum price, also called the choke price, so that the area under the demand curve is finite. Hence, there exists an amount for which the consumer can be compensated for the complete loss of the good/service. For example even though heating and lighting are essential services for an individual, the electricity service used in the production of these services can be considered as non-essential itself, since there are alternative energy sources as a substitute for electricity e.g. wood for heating, oil-paraffin lamps or lanterns for lighting.

To formally explain how the weak complementarity and non-essentiality restrictions allow us to measure the welfare change for changes in service reliability, we will follow the approaches of

Feenberg and Mills (1980) and Bockstael and McConnell (1999), but use our own notation to adapt it to our case of an improvement in the reliability of electricity supply. For an individual who maximizes his utility subject to a budget constraint, and for whom changes in the quality of the service matters, the quality level will enter either his utility function or the constraint, and as a result his indirect utility as well as the expenditure functions will be a function of the level of quality. Let X be a vector of market goods, p their price vector, and Y the individual's income. Among the market goods X consumed by the individual let X_i stand for the electricity service, p_i its price and R the reliability of this electricity service. The consumption and prices of the remaining market goods will be the vectors X_{-i} and p_{-i} respectively. The choke price for X_i, p_i^* is the price at which the quantity demanded for the electricity service is zero. The existence of this choke price follows from the non-essentiality of the electricity service.

The indirect utility function

$$V(p_i, p_{-i}, R, Y)$$

is generated from the consumer's utility maximization problem

$$U(X_i, X_{-i}, R) + \lambda(Y - p_iX_i - p_{-i}X_{-i})$$

Then, using Roy's Theorem, the market demand function for the electricity service, X_i, is derived from the indirect utility function as follows:

$$\frac{\partial V(p_i, p_{-i}, R, Y)/\partial p_i}{\partial V(p_i, p_{-i}, R, Y)/\partial Y} = -X_i(p_i, p_{-i}, R, Y)$$

If the marginal utility of income is denoted as:

$$\partial V(p_i, p_{-i}, R, Y)/\partial Y = \lambda$$

Then the area under the market demand curve for the electricity service with a reliability level of R is:

$$-\int_{p_i^0}^{p_i^*} X_i(p_i, p_{-i}, R, Y)dp_i = \int_{p_i^0}^{p_i^*} \frac{\partial V}{\partial p_i}(p_i, p_{-i}, R, Y).\frac{1}{\lambda}dp_i = \frac{V(p_i^*, p_{-i}^0, R, Y)}{\lambda} - \frac{V(p_i^0, p_{-i}^0, R, Y)}{\lambda}$$

In order to obtain an expression that incorporates the change in electricity service reliability, differentiate both sides with respect to the level of reliability:

$$-\int_{p_i^0}^{p_i^*} \frac{\partial X(p_i, p_{-i}, R, Y)}{\partial R}dp_i = \frac{\partial V(p_i^*, p_{-i}^0, R, Y)}{\partial R}\cdot\frac{1}{\lambda} - \frac{\partial V(p_i^0, p_{-i}^0, R, Y)}{\partial R}\cdot\frac{1}{\lambda}$$

With the weak complementarity restriction, the first terms on the right hand side is taken to be zero, because at the choke-price the quantity consumed by the individual is zero and hence he is indifferent to the changes in the quality level. Therefore, the expression above simplifies to:

$$\int_{p_i^0}^{p_i^*} \frac{\partial X(p_i, p_{-i}, R, Y)}{\partial R}dp_i = \frac{\partial V(p_i^0, p_{-i}^0, R, Y)}{\partial R}\cdot\frac{1}{\lambda}$$

For an improvement in service reliability from R^0 to R^1, integrate both sides with respect to R:

$$\int_{p_i^0}^{p_i^*} X(p_i, p_{-i}, R^1, Y)dp_i - \int_{p_i^0}^{p_i^*} X(p_i, p_{-i}, R^0, Y)dp_i = V(p_i^0, p_{-i}^0, R^1, Y)\cdot\frac{1}{\lambda} - V(p_i^0, p_{-i}^0, R^0, Y)\cdot\frac{1}{\lambda}$$

Note that the first and second terms on the left hand side are the areas under the electricity service market demand curves with and without the reliability improvement respectively. Hence, linking the service reliability to the electricity service and applying the complementarity restriction on the preferences enabled us to use the areas under the market demand curve for the electricity service to derive an expression for the monetary value of a service reliability improvement, provided that there are observable variations in electricity prices and reliability levels.

The direct demand estimation method uses the consumer surplus approach, together with the preference restrictions defined above, in estimating the welfare impact of an improvement in the quality of the electricity supply. Figure 2.1 below demonstrates the consumer surplus for an increase in service reliability.

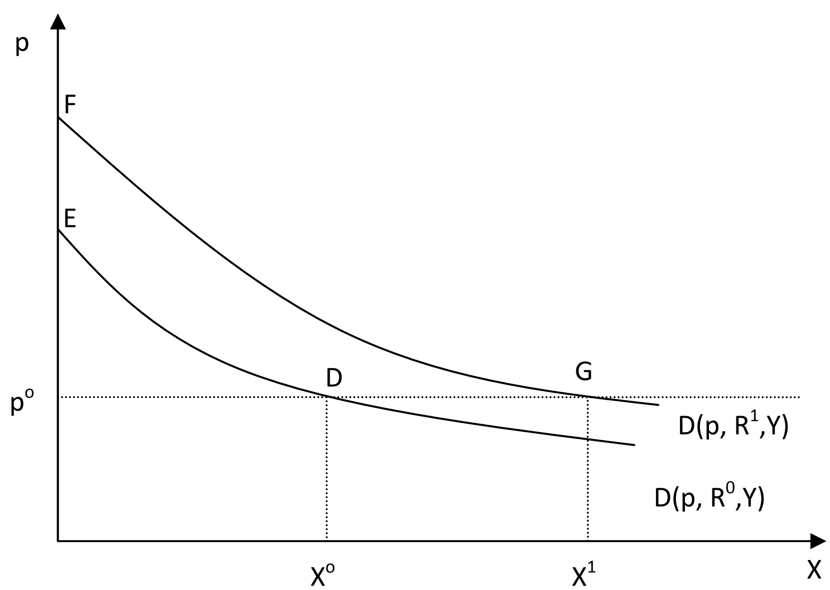

Figure 2. 1 Consumer Surplus of a Service Reliability Change

$D(p, R^0, Y)$ and $D(p, R^1, Y)$ are the market demand curves for the electricity service before and after the improvement in service reliability respectively. An improvement in reliability from R^0 to R^1 shifts the demand for electricity to the right. At the initial reliability level, consumer surplus is the area under the initial demand curve and above the initial price, p^0ED. With the improvement, the final consumer surplus is the area under the final demand curve and above the final price, p^0FG. The change in the two consumer surpluses, p^0FG- p^0ED, is an estimate of the net welfare gain of consumers due to an improvement in the service.

The demand function for electricity can be either estimated econometrically if sufficient data is available or through surveys (Taylor, 1975; Maddigan et al., 1983; Choynowski, 2002; Whittington, 2002; Reiss and White, 2005). Econometric estimation requires sufficient time-series data on electricity sales, the marginal price of electricity sold, electricity supply reliability, and some economic data such as income data, prices of alternate fuels, weather and demographic data (Choynowski 2002). Due to the unavailability of this kind of data, especially in developing countries, this approach is rarely used. In addition to the scarcity of data, other factors that make demand estimation for electricity relatively difficult are the existence of multi-step block pricing, electricity being an input into the production or consumption process, and the necessity to distinguish between the demand for electricity in the long-run and short-run, peak and off-peak, and type of user (Taylor 1975.)[18]

The relevant demand for electricity is the long-run demand, so that the shortage costs are estimated not only by the short-term outage costs (that hold the current stock of electricity dependent

[18] A procedure for estimating the demand for water under increasing block tariffs is presented in Groom et al. (2008).

equipment constant) but the long-term adaptive-response costs as well (e.g. investments in stand-by generators, voltage regulators, etc.) (Sanghvi, 1983). In this case, changes in reliability result in changes in shortage costs (both short- and long-term), therefore a change in the WTP of consumers for electricity, and hence causes a shift in the demand curve. Ignoring these shifts in the demand curve and just considering the benefits from relieving the short-term outage costs will give rise to under investments in electricity infrastructure and hence the optimum reliability will not be achieved. At a given level of consumption, the change in consumers' WTP for electricity due to a change in reliability can be measured by the change in their shortage costs (i.e. change in short-term outage cost plus the change in long-term adaptive response costs).

The preferred functional form for the electricity demand function has been the linear form, due to its simple data requirements (Westley 1984). Two data points suffice to estimate the parameters of the demand equation, and the consumer surplus is calculated by the area of the triangle which is the change in price times the change in quantity divided by two. This may be a close approximation of the welfare change for small changes in price. However, in cases where the supply is currently constrained and reliability is low, the user cost of the current service is most likely much higher than the price that will be charged with the improvements in the service, and a linear approximation will not accurately measure the economic benefits of the incremental electricity consumption (Wilson et al., 2010).

Most of the past empirical work assumed demand functions with constant price elasticity and the price in logarithmic form (Choynowski, 2002). The implication is that there is no upper bound for electricity demand and the demand at a price zero is not defined. To overcome these weaknesses, the author assumes the demand for electricity to be a derived demand with a semi-log functional form that exhibits the expected negative relationship between the price and the quantity of electricity demanded as well as a finite demand at a zero price.

Difficulties arise in estimation of the demand function in situations where the supply is rationed and therefore the consumption data is not a good indicator of how much people are actually willing to consume at the market prices. Another problem is the lack of sufficient variation in the price data where the prices of the services are regulated.[19]

Where data for direct demand estimation is unavailable or very costly to obtain, researchers made use of various other revealed preference valuation methodologies to proxy the direct methods of WTP for a reliable electricity service. It is the AE method that we turn to next.

[19] To overcome these difficulties, Klytchnikova (2006) developed a special case of the direct demand estimation method to estimate the welfare gains from improvements in the service quality of infrastructure services in developing countries where supply is intermittent and uncertain. This switching regression model of direct demand estimation is useful in the estimation of the demand function where households choose among different fuels in their production of home goods and the cost of appliances is not a significant determinant of fuel choices. Azerbaijan is a special case where most appliances are home-made and work with different fuel sources so that households can easily switch from one fuel source to another during an interruption. This approach treats the stock of appliances as constant and therefore is able to estimate the short-run impacts of changes in service quality.

2.3.2 Theoretical Framework for the AE Method and Econometric Analysis

2.3.2.1 Theoretical Framework

The relevant economic approach is the household-production function theory (Becker, 1965; Courant and Porter, 1981; Bartik, 1988; Bockstael and McConnell 1999), where the household's utility is a function of the level of electricity dependent services, other consumption goods/services, and the characteristics of the household. Given the current level of reliability of the network electricity service perceived by the household, the household chooses the minimum AE required to produce its optimum level of electricity dependent services (e.g. heating, cooking, lighting, housekeeping, leisure) that maximizes its utility subject to its income constraint. In other words, each household has a preferred level of electricity dependent services depending on, among other things, its stock of electricity appliances, other consumption goods, and household characteristics. Therefore when the electricity service from the utility company falls below the level required to produce the household's preferred level of services, the household engages in mitigating actions in order to improve the service towards its desired level. Some of these averting behaviours involve using candles, stand-by generators, voltage regulators, UPS, emergency lanterns, and emergency stoves.

Bartik (1988), using reductions in pollution as an example, showed that lower and upper bounds to the exact welfare measures can be developed by using the averting expenditure function and the household choices before and after the pollution level improvement. We will adopt the approach of Bartik (1988), but we will use our notation to show that AE is a lower bound on the welfare measure of the network electricity reliability improvement.

The cost function of producing electricity dependent services, $C_Z(.)$, will be defined as follows:

$$C_Z = C_Z(Z(E, A, R), p_E, p_A, R)$$

where Z(.) is the household's production function of electricity dependent services (e.g. heating, lighting, cooking, leisure, housekeeping), R is the reliability of the service provided by the electricity authority, E is the amount of electricity energy consumed, A is the level of averting behaviour, p_E is the price of network electricity and p_A is the price vector of the averting actions taken. Let Z^* be the optimal level of electricity dependent services for a household confronted by reliability level R^0. Given an increase in reliability from R^0 to R^1, the reduction in the cost of producing the preferred level of services Z^* is given by:

$$C_Z(Z^*, p_E, p_A, R^0) - C_Z(Z^*, p_E, p_A, R^1)$$

The restricted expenditure function will be defined as:

$$e(p, R, U; Z)$$

This is the minimum expenditure required to have utility U when the network's service reliability is R, the prices are p, and the household's preferred level of electricity services is restricted to Z. Then, the savings in expenditures required to achieve Z^*, the optimally chosen level of service given R^0, is given in Bartik (1988) as:

$$e(p, R^0, U^0) - e(p, R^1, U^0; Z^*) = C_Z(Z^*, p_E, p_A, R^0) - C_Z(Z^*, p_{E,} p_A, R^1)$$

Rearranging the equation above

$$e(p,R^0,U^0) = C_Z(Z^*, p_E, p_A, R^0) - C_Z(Z^*, p_{E,} p_A, R^1) + e(p,R^1,U^0;Z^*)$$

And substituting it for $e(p,R^0,U^0)$ in the expression for compensating variation of an improvement in the reliability of the service provided by the utility below

$$CV = e(p,R^0,U^0) - e(p,R^1,U^0)$$

Gives us

$$CV = C_Z(Z^*, p_E, p_A, R^0) - C_Z(Z^*, p_E, p_A, R^1) + e(p,R^1,U^0;Z^*) - e(p,R^1,U^0)$$

The third term is greater than the fourth term, because in the third term utility U^0 is being achieved while constraining electricity service consumption at its previous level of Z^*, even after reliability has increased to R^1. With the reliability level improved to R^1, the previous utility level U^0 could be achieved with fewer expenditures if people were allowed to increase their level of Z. Hence, the CV is equal to savings in the cost of producing Z plus a positive term. Therefore, the cost savings achieved when holding Z constant when R improves will be a lower bound on the welfare measure of the reliability change.[20]

In order to calculate the demand for A we proceed as follows:

[20] The AE approach produces a lower bound on the WTP for improved reliability as it ignores some of the other costs incurred by the household (e.g. the inconvenience of lighting candles, buying and storing fuel for the generator, the noise of the generator, etc.). Generators are more expensive to operate and involve some inconvenience to start; hence they are not used for every outage nor not necessarily for the entire duration of a given outage. Generators are used at critical times, e.g. to watch television when popular football team is playing. Hence generators are not perfect substitutes to the service provided by the utility company and have inconveniences that are not captured in AE.

The household utility maximization problem is:

$\text{Max}_{X,E,A}$ U(X, Z(E, A, R), s) subject to $C_Z(Z, p_E, p_A, R) + p_X X \leq Y$, and

$C_Z(Z, p_E, p_A, R) = \min_{A,E} (p_A A + p_E * E)$ subject to Z = Z(E, A,R)

The solution to the utility maximization problem gives the indirect utility function,

$V = V(p_X, p_E, p_A, Y, R, s)$

Using Roy's theorem, the optimum level of averting actions can be obtained:

$$A = \frac{\partial C_Z}{\partial p_A} = -\frac{\partial V / \partial p_A}{\partial V / \partial Y} = A(p_x, p_E, p_A, R, Z(p_E, p_A, p_X, Y, R, s))$$

2.4 Stated Preference Approach

The stated preference method is a survey-based approach which includes CVM, and CE. Sometimes this is one of the few ways of quantifying the benefits of a good or service that is not purchased in the market. A number of authors, such as Boxall et al. (1996), Maynard (1996), Adamowicz et al. (1998), CIE (2001), Foster and Mourato (2003), Takatsuka (2004), Bateman et al. (2005), Mogas et al. (2005), and Mogas et al. (2006), have conducted a review and made a comparison of CVM and choice modelling methodologies.

2.4.1 CVM

CVM is a survey-based method often used in estimating the economic value of environmental services (Carson 2000). The people are directly asked to state their WTP in the survey. Although widely used in the case of other infrastructure services such as transportation, there are fewer examples where the CVM is used in a 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)

The CVM is used to value a wide range of commodities in the developing countries as well (FAO 2000; Devicienti et al., 2004). Some studies conducted in developing countries using the CVM 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.

2.4.1.1. Potential Problems of the CVM

This method has been commonly criticized for the validity and reliability of its results and the potential errors/biases affecting this validity and reliability (Diamond and Hausman, 1994; Arrow et al., 2001).[21] Venkatachalam (2004) reviewed the developments on the most criticized potential problems of the CVM:

[21] In Hensher et al. (2005) reliability is defined as "the concept that results similar to those from a given sample would be obtained through repeated samples," and validity as "a significant relationship between the results inferred through estimation and real world behavior."

Disparity between WTP and WTA

WTA values have been found to be always greater than WTP values when used for the same good. There are a number of possible reasons causing this disparity, some of which are the income and substitution effects, transaction costs, and existence of loss aversion. The large disparity found between the two measures leads to the conclusion that WTA is not a proper measure of consumer surplus, and WTP should be used in the CVM studies.

Embedding effect

The embedding effect is also called part-whole bias, disaggregation bias, sub-additivity effect, or the scope effect. This is the variation observed in the WTP measure for the same good when valued by itself or as part of a package. There is a small difference in the WTP for a commodity irrespective of its size. The studies that are reported to suffer from the scope bias have been mostly criticized for the flaws in their survey design, improper implementation of the surveys and the sampling procedures, and the clarity of the survey questions.[22] To minimize this bias some of the recommendations made to the researchers are to use various visual aids in describing the scenario to improve the respondents' understanding of the questions, and after describing the different commodity sizes, to ask the respondents to concentrate on the smaller size.

Sequencing effect

The sequencing effect, also called the question order bias, occurs in studies that attempt to measure the WTP for more than one good. The WTP for a particular good depends on the order in which it

---

[22] For a more detailed discussion on the impact of survey design and visible choice set (i.e. the choice set offered to respondents) on scope sensitivity see Bateman et al. (2004). The authors test for the impacts of varying the visible choice set and show that this has a significant impact on the WTP estimates. They also find that, before a choice is made by respondent, advance disclosure of the final choice set offered has a significant impact on scope sensitivity.

is asked in the survey. Some of the factors that give rise to this error are substitution and income effects, as well as the design and administration of the survey. To minimize the sequencing effect, the respondents need to be informed about the complete WTP questions that will be asked, before asking the first one, and be given the opportunity to revise their bids once they are finished with all the valuation questions.

Information effect

The information effect happens when the level of information provided affects the WTP results. Respondents when reminded of substitutes and their income constraints tend to state lower WTP amounts. The effect of the information provided on the respondents' stated WTP depends on their existing level of information about the subject. Additional information provided to the respondents on the quality of their electricity supply, for example, will affect their stated WTP if they possess different levels of information on the quality of the service.

Elicitation effects

The elicitation effect arises when different elicitation formats end in different WTP values. The major elicitation techniques used in CVM surveys are: bidding game (Whittington et al., 1990), payment card (Maddison and Mourato, 2001; O'Garra et al., 2007; Birol et al., 2008), open-ended, dichotomous-choice (single or double-bounded) (Casey et al., 2006).

Bidding game – From a range of predetermined bids, a bid is randomly selected and presented to the respondent for a 'yes' or 'no' answer. Depending on the answer the process is repeated with a higher or lower bid. This continues until the highest response of the respondent is obtained. The advantages of this format are that it creates a market-like situation for the respondent, and gives the maximum WTP value for the good/service. Some of the disadvantages are that this format is not practical for mail surveys; it has relatively higher implementation costs since it requires the presence of an interviewer; and it may be susceptible to starting point bias.

Payment card – The respondent is presented with a range of values and asked to choose his maximum WTP for the good/service. Like the bidding game approach, the payment card format enables the researcher to obtain the maximum willingness value for the good/service. However, it may have range bias and centring bias.

Open-ended elicitation technique – The respondent is directly asked to state his maximum WTP for the good/service. The advantages are that it does not require the presence of an interviewer; does not have any starting point bias; and gives a conservative estimate relative to the bidding game. The problems with this technique are that, it may lead to large number of non-responses if the respondents find it difficult to answer; and it may be vulnerable for strategic bias.

Single-bounded dichotomous choice approach (or take-it-or-leave-it approach) – From a range of predetermined potential maximum WTP bids, a single bid is randomly selected and presented to the respondent for a 'yes' or 'no' answer. This approach reduces non-responses by making it easier for the respondents to answer. It may also minimize the strategic bias due to its incentive compatibility. Some of the potential problems with this approach are that it is not able to elicit the actual WTP values from the respondents; it is vulnerable to starting point bias; and it requires a larger number of observations for econometric analysis.

Double-bounded dichotomous choice approach (or take-it-or-leave-it with follow up) – This starts like the single-bounded dichotomous choice approach, and adds one more bid to the process depending on the answer to the first bid. If the answer to the first one is 'no", then the follow up will be a lower bid, or otherwise a higher bid. The advantages are that it is incentive compatible; elicits the maximum WTP for the good/service; and results in more efficient estimates than the single-bounded format. The disadvantages are that it is susceptible to starting point bias and the yea-saying problem; and requires a larger sample size and more sophisticated econometric techniques.

Different elicitation approaches have different advantages and disadvantages and the choice of an elicitation format depends on the nature of the good being valued, the nature of the statistical approach applied, the nature of the target respondent group, cost of the survey, and so on. The double-bounded dichotomous-choice format, for example, is found to reduce strategic bias due to its incentive compatibility, and to give statistically more efficient results than the single bounded format, however it requires larger sample sizes, sophisticated statistical techniques and is prone to the yea-saying problem.

Hypothetical Bias

The hypothetical bias is the divergence between the true WTP and the stated WTP of the respondent. Most studies find the hypothetical WTP to be higher than the actual WTP. This has been attributed to the level of familiarity of the respondent with the good in question. The hypothetical bias will not be a major problem when the respondents are familiar with the good for which the WTP value is elicited.

Strategic Bias

The strategic bias is the case when respondents act strategically and do not state their true WTP. Their strategic behaviour can be seen in two ways: If they are led to believe that a certain change has already been decided upon, and the survey is to determine the amount they will pay as a result of the change, then they understate their true WTP hoping to pay less for the good in question. On the other hand, if they believe that their stated WTP value will have a positive effect on the acceptance of the proposed change, and they do not see the prospect of them having to pay that amount, then they tend to overstate their true WTP. The strategic bias is minimized by not giving any hints to the respondents in the questionnaires to engage them in strategic behaviour and by choosing incentive compatible elicitation formats like the dichotomous-choice techniques.

Payment Vehicle Bias

The payment vehicle is the element of the CVM survey which provides the context in which payment will be made by the respondent. Some of the different payment vehicles are income taxes, entry fees, changes in utility bills, trust fund payments, and reallocation of taxation funds (Morrison et al., 2000; Kontoleon et al., 2005). Since respondents value the good/service as a package where the payment vehicle is one of the elements, different WTP estimates are expected to result from different payment vehicles. Therefore, the payment vehicle bias arises when the payment vehicle is not understood by the respondent or not used as it was intended by the researcher. In order to avoid bias the payment vehicle should be realistic and appropriate (Morrison et al., 2000). The payment vehicles can be classified into two categories: voluntary vehicles; and coercive vehicles (e.g. taxes, prices, fees, etc.) (Kontoleon et al., 2005). With voluntary contributions the respondents are more likely to engage in free-riding behaviour, and have an incentive to overstate their WTP figures to make sure the good/service is provided. Coercive payment vehicles on the other hand are more incentive compatible, but still prone to the payment vehicle bias if not found realistic or appropriate by the respondents.

Despite the criticisms for the reliability and validity of its results, over the years enough experiments have been conducted using the CVM and a lot of valuable suggestions have been made to minimize the errors/biases that affect the validity and the reliability of the results (Hanemann et al., 1991; Whittington 1998; Arrow et al., 2001; List 2001; Venkatachalam, 2004).

2.4.1.2 Theoretical Framework for the CVM

The underlying economic theory is the random utility theory, and we will explain by adopting the approach of Hanemann (1984) to our case of an improvement in the electricity supply reliability. Suppose the individual is told that the network electricity service reliability will improve from its current level of R^0 to R^1, and the improvement will cost B. The respondent is then asked whether he accepts the payment of the additional cost B to secure the improvement in reliability of the service or not.

Suppose the individual's utility function is given by:

$$U = U(X, Z(E, A, R); s)$$

Z is a vector of services produced by the household that uses electricity, E, as an input e.g. heating, cooking, lighting, leisure activities, housekeeping activities. In cases where the electricity service reliability of the network, R, is below the required minimum to produce the preferred level of electricity dependent services, the household engages in averting behaviour, A, to cope with the loss in network electricity services. X is the vector of all the other goods/services consumed by the household, and s is a vector of the household characteristics. This utility function is known with certainty to the individual; however it is not observable by the researcher. This can be represented as:

$$U_{iq} = V_{iq} + \varepsilon_{iq}$$

Where U_{iq} is individual q's utility from alternative i, V_{iq} is the observable component, and ε_{iq} is the random component. In our case the two alternatives are responding "yes" or "no" to the hypothetical scenario, i.e. the new state with improved reliability or the current state with current level of reliability. Let i =0 represent the alternative where the individual responds "no" to the payment of B, and i = 1 represent the alternative where he responds "yes".

The observable part of the utility function, V_{iq}, of individual q, is given by:

$$V_{iq} = V_{iq}(p_X, p_E, p_A, R, Y; s_q)$$

Where p_X is the price vector for X, p_E is the price of network electricity, p_A is the price vector for the averting actions taken by the household, Y is the individual's income, and s_q is the characteristic vector of individual q.

The individual will accept the payment of amount B if

$$V_{1q}(p_X, p_E, p_A, R^1, Y-B; s_q) + \varepsilon_{1q} \geq V_{0q}(p_X, p_E, p_A, R^0, Y; s_q) + \varepsilon_{0q}$$

or

$$V_{1q}(p_X, p_E, p_A, R^1, Y-B; s_q) - V_{0q}(p_X, p_E, p_A, R^0, Y; s_q) \geq \varepsilon_{0q} - \varepsilon_{1q}$$

The right hand side of this inequality is not observed by the analyst i.e. is a random variable, therefore the individual's response is a random variable and its probability distribution is:

$$P_1 = P(V_{1q}(p_X, p_E, p_A, R^1, Y-B; s_q) + \varepsilon_{1q} \geq V_{0q}(p_X, p_E, p_A, R^0, Y; s_q) + \varepsilon_{0q})$$

or

$$P_1 = P(V_{1q}(p_X, p_E, p_A, R^1, Y-B; s_q) - V_{0q}(p_X, p_E, p_A, R^0, Y; s_q) \geq \varepsilon_{0q} - \varepsilon_{1q})$$

where P_1 is the probability that the individual is willing to pay the stated amount. The probability that the individual is unwilling to pay is then given by:

$$P_0 = 1 - P_1$$

Assume the random errors are independent and identically distributed with a mean of 0. Define $\eta = \varepsilon_{0q} - \varepsilon_{1q}$, and let $F_\eta(.)$ be the cumulative distribution function of η. Then

$P_1 = F_\eta(\Delta V)$, where $\Delta V = V_{1q} - V_{0q}$.

Let WTP^* be the individual's maximum WTP for the service improvement. Then P_1 can be rewritten in terms of WTP^* as:

$$P_1 = P(WTP^* > B) = 1 - G_{WTP*}(B),$$

where $G_{WTP*}(.)$ is the cumulative distribution function of WTP^*.

For econometric estimation, assume WTP^* of alternative *i* has the following form:

$$WTP^*_i = \beta X_i + \omega_i,$$

where X_i are the explanatory variables, β are the coefficients of the explanatory variables, and ω_i are the random errors.

If the ω_i are assumed to have the standard logistic distribution, then the following expression is obtained for P_1:

$$P_1 = \frac{e^{X_i \beta}}{1 + e^{X_i \beta}}$$

When the payment card (payment ladder) elicitation format is used, for each respondent the researcher will observe an interval (with a lower bound B_{li} and upper bound B_{ui}), where the respondent's true WTP lies. For this type of data, Cameron and Huppert (1989) showed that interval regression is the appropriate estimation method. If negative WTP is ruled out and the distribution of WTP is skewed, then a log-normal distribution is frequently assumed:

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

where as above X_i are the explanatory variables, β are the coefficients of the explanatory variables, and ω_i are the random errors distributed normally with mean zero and standard deviation σ. Then, using the approach of Cameron and Huppert (1989), the probability that the natural logarithm of the individual i's true WTP, ln WTP_i, lie in the interval (B_{li}, B_{ui}) is given by:

$$P(\ln B_{li} < \ln WTP_i < \ln B_{ui}) = P(\frac{\ln B_{li} - X_i\beta}{\sigma} < z_i < \frac{\ln B_{ui} - X_i\beta}{\sigma})$$

where z_i has the standard normal distribution. Using the cumulative standard normal distribution, Φ(.), the equation above can be rewritten as:

$$P(\ln B_{li} < \ln WTP_i < \ln B_{ui}) = \Phi(z_{ui}) - \Phi(z_{li})$$

$$z_{li} = \frac{\ln B_{li} - X_i\beta}{\sigma}$$

$$z_{ui} = \frac{\ln B_{ui} - X_i\beta}{\sigma}$$

For a sample of N respondents, the log-likelihood is given as:

$$LL = \sum_{i=1}^{N} \ln[\Phi(z_{ui}) - \Phi(z_{li})]$$

Once this log-likelihood function is maximized and the estimates for β and σ are obtained, then the median and mean WTP are calculated as:

$$median = e^{\beta X_i}$$

$$mean = e^{\beta X_i} . e^{\sigma^2 / 2}$$

The parametric approach to derive the WTP measure requires a distribution assumption (Hanemann, 1984; Bishop and Heberlein, 1979), which may result in inconsistent estimates when the distribution is misspecified. In order to overcome this potential problem, Turnbull (1976) suggested a distribution free lower bound mean estimate. Kriström (1990) proposed another non-parametric approach which results in a higher WTP estimate. According to Kriström (1990), the estimates obtained from this approach are simple to compute and robust against distributional misspecification.

Both models are based on a discrete response survey format where the respondents are asked to give a "yes" or "no" answer to a cost of B. In these models, m different costs are presented to m different samples with each sub-sample i having n_i individuals. Let k_i be the number of people saying "yes" to B_i, then the proportion of yes-answers is given by $p_i = k_i/n_i$. Let p_1 be the proportion of yes-answer for the lowest bid, and p_m for the highest bid, so that the sequence of proportions obtained from a typical survey, is given by $p = (p_1, p_2, \ldots, p_m)$. From this monotonically non-increasing sequence of proportions, using an appropriate rule of interpolation (e.g. linear interpolation), a function of the probability of "yes" is obtained in terms of the bid amount. The Kriström mean WTP is then approximated as the area under this curve.

The Turnbull Lower Bound Mean (LBM) estimate is calculated as (Haab and McConnell, 1997; Vaughan and Rodriguez, 2001; Blaine et al., 2005):

$$LBM(Turnbull) = p_1 B_1 + \sum_{i=2}^{m} p_i (B_i - B_{i-1})$$

The variance of the LBM:

$$Var(LBM) = \sum_{i=1}^{m} \frac{p_i (1 - p_i)(B_i - B_{i-1})^2}{N}$$

2.4.2 Choice Modelling

While CVM gives a single figure for the WTP for a service improvement, choice modelling methods enable us to break down the service improvement of concern into different attributes at different levels and estimate the marginal WTP for each service attribute. The choice modelling approach includes CE (conjoint choice), paired comparison, contingent ranking, and contingent (conjoint) rating methods. In CE consumers are presented with different choice sets where in each one they make a choice between several alternatives and the status quo. In contingent ranking, consumers rank a series of alternatives; in contingent rating from a scale of 1-10, they assign a score to each alternative; and in paired comparisons they score pairs of scenarios on a similar scale (Pearce and Ozdemiroglu, 2002). WTP estimates obtained from the rating method are too large compared to those obtained from the CE method (Louviere 2006). Most importantly, among the four choice modelling methods, only the estimates from the CE method are consistent with welfare economics, therefore we will not describe the other three in more detail here.

2.4.2.1 CE

The use of the CE approach to the valuation of the marginal WTP for the attributes of various assets has its roots in the random utility theory and experimental design (Hanley et al. 1998, Louviere et al. 2000). It is actually a generalization of the discrete choice CVM (dichotomous choice format), and hence the two methods share the common theoretical framework (Hanley et al. 2001). Although CVM is the most widely used stated preference valuation method, CE is increasing in popularity due to its market realism and has been widely used in various valuations in different areas, including health, environment, and infrastructure. Examples include Espino et al. (2006) – analyzing demand for suburban trips; Hensher et al. (2005b) – measuring households' WTP for water service attributes; Hanson et al. (2005) – evaluating preferences for hospital quality in Zambia; Riera and Mogas (2004) - finding the social value of forests. There are fewer studies done in the valuation of electricity services (Beenstock et al., 1998; Goett et al., 2000; KPMG, 2003; Bergmann et al., 2005; Carlsson and Martinsson, 2006b; Carlsson and Martinsson, 2008; Morrison and Nalder, 2009; Abdullah and Mariel, 2010).

2.4.2.2 Theoretical Framework for CE

Louviere et al. (2000) discuss the theory of stated choice methods using a modified Lancaster (1966) and Rosen (1974) approach. In Lancaster's analysis an individual's utility is a function of commodity characteristics, and Rosen extends this for discrete goods. In Louviere and others' modified approach, individuals are assumed to derive utility from the consumption of services delivered by commodities they choose to purchase. These commodities have certain attributes and together produce the desired level of service. However, the actual level of service that can be provided by a commodity is not known to the individual, therefore the consumption of that commodity depends on the expected level of service that will be provided by the commodity instead. In other words, an individual's utility is a function of the expected level of service they will attain when certain attributes of a commodity are grouped together.

The analyst does not observe the consumer's true utility function. Therefore the utility function observed by the analyst is a function of observed as well as unobserved components of the expected levels of services. The utility function observed by the analyst is:

$$U = U((se_o + se_{uo})_1, \ldots, (se_o + se_{uo})_K)$$

where $(se_o + se_{uo})_k$ is the expected amount of k^{th} service for k=1,..,K; se_o is the observed component and se_{uo} is the unobserved component.

The commodities are consumed in the quantities that will produce the utility maximizing levels of services. In a random utility model (RUM) the utility function has a systematic component (from attributes observed by the analyst) and a random component (from attributes unobserved by the analyst). Therefore the utility of the i^{th} alternative for the q^{th} individual can be expressed as:

$$U_{iq} = V_{iq} + \varepsilon_{iq}$$

where the first term on the right hand side is the systematic and the second term is the random component. V_{iq} depends on the attributes of alternative i and the attributes of individual q. It is often assumed that V_{iq}'s are homogenous across the entire population and ε_{iq}'s are independent and identically distributed (IID). The choice model selected for the particular study depends on the assumptions made on the distribution of the random error term.

When faced with a set of possible alternatives, *A*, a utility maximizing individual q will choose alternative i over alternative j if and only if:

$$U_{iq} > U_{jq} \forall j \neq i \in A$$

$$(V_{iq} + \varepsilon_{iq}) > (V_{jq} + \varepsilon_{jq})$$

$$(V_{iq} - V_{jq}) > (\varepsilon_{jq} - \varepsilon_{iq})$$

The right hand side of the inequality is not observed by the analyst, therefore statements about choice outcomes can only be made up to a probability of occurrence, i.e. the probability that $(V_{iq}- V_{jq})>(\varepsilon_{jq} - \varepsilon_{iq})$.

Let *q* be a randomly drawn individual with attributes *s* (e.g. socio-economic background), facing a set of alternatives *A*, and a vector of attributes *x*. Then the RUM states that the probability that an individual *q* will select alternative x_i, given his socio-economic background *s* and the alternative set *A* is:

$$P(x_{iq} \mid s_q, A) = P_{iq} = P[\{\varepsilon(s, x_j) - \varepsilon(s, x_i)\} < \{V(s, x_i) - V(s, x_j)\}] \forall j \neq i$$

Assuming ε is distributed extreme value type I (EVI), the standard multinomial logit (MNL) model is obtained, where the probability of individual *q* choosing alternative *i* is given by:

$$P_{iq} = \frac{e^{\lambda V_{iq}}}{\sum_{j=1}^{J} e^{\lambda V_{jq}}}$$

and λ is a scalar factor given by

$$\lambda = \frac{\pi}{\sqrt{6}\sigma}$$

When the random error terms are IID, the variance of the random error σ is constant across individuals, therefore so is λ. Because λ cannot be estimated separately from the parameters of explanatory variables of V_{jq}, it is often normalized to one.

Assuming V_{jq} to be a linear and additive function of attributes X,

$$V_{jq} = \beta X_{jq}$$

where X_{jq} is the vector of attributes of choice *j* as viewed by individual *q*, and β is the parameter vector to be estimated. Maximum likelihood techniques are used in estimating the parameters of the utility function.

If X consists of K attributes, *p* is the price attribute and the alternative is chosen with certainty, then the marginal WTP for a change in the level of a single attribute *k*, and the WTP for the entire good for changes in levels of all attributes are given by (Lancsar, 2004):

$$MWTP_k = \frac{\partial V / \partial X_k}{-\partial V / \partial p} = \frac{\beta_k}{-\beta_p}$$

$$WTP = \sum_{k=1}^{K} \frac{\beta_k}{-\beta_p} (\Delta X_k)$$

The MNL model is limited by the Independence from Irrelevant Alternatives Axiom (IIA), which states that *the ratio of the probabilities of choosing one alternative over another (given that both alternatives have a non-zero probability of choice) is unaffected by the presence or absence of any additional alternatives in the choice set.* Another limitation of the MNL model is the IID assumption of the error terms. This implies that *cross-substitutions between pairs of alternatives are equal and unaffected by the presence/absence of other alternatives.*

In Chapter 6 of Louviere et al. (2000), alternative models to the MNL that relax the IID assumption are discussed. The authors describe the generalized extreme value (GEV) model and its special case the nested logit (NL) model. The main assumptions of the models of the logit family are that the individuals have homogenous preferences, they act rationally and use all the information to choose the utility maximizing option subject to a budget constraint.

The heteroscedastic extreme value (HEV) models relax the assumption of identically distributed random errors, and the mixed logit (ML) models or the random parameters logit (RPL) models accommodate different covariances of the random errors, as well as the individual-specific effects. Latent class heteroscedastic MNL models include heterogeneity and heteroscedasticity. Multinomial probit (MNP) models totally relax the IID assumption but at the expense of complex estimation requirements. Finally, the authors discuss the multiperiod multinomial probit models as the most general models of all, capable of accommodating assumptions on autoregressivity, correlation between alternatives and time periods, unobserved heterogeneity across individuals, and different variances across alternatives. As the analyst moves from the simple MNL to more complex models mentioned above, there is a trade off between the benefits of adding behavioural realism to the model and the cost of higher sophistication in the statistical techniques required.

Choice models can be parameterized in two different ways (Louviere et al., 2005): either in terms of utility coefficients or in terms of WTP. In the first case, the marginal WTP estimates are obtained by dividing the coefficients of the non-price attributes with the coefficient of the price attribute. In the second case the coefficients are the product of WTP for each attribute and the negative of the price coefficient. In models with fixed coefficients the second approach enables easier calculation of the standard errors, however in models with variable coefficients the choice of parameterization approach is more complex (Louviere et al., 2005)

Being a generalization of the discrete choice CVM, the CE method share the same potential errors/biases, such as the hypothetical bias (Carlsson and Martinsson, 2001; Lusk and Schroeder 2004; Carlsson et al., 2005), scope effects, elicitation effects (Scheufele and Bennett, 2010), order effects (McNair et al., 2010), strategic bias (Louviere et al., 2005; McNair et al., 2010), and framing issues (Rolfe et al., 2002), and whether the CE performs better on any of these problems is being debated (Hanley et al. 2001). Carlsson and Martinsson (2001) tested for hypothetical bias in CE using a cheap talk script, and found that out of the 10 attributes seven had lower marginal WTP estimates on the version with the script. They concluded that, just like the CVM, the CE may also suffer from hypothetical bias.

However, the CE does offer some advantages over the CVM (Boxall et al., 1996; Hanley et al., 2001; Rolfe et al., 2002; Shen, 2005; Mogas et al., 2006). The CE method is able to measure the tradeoffs between the different attributes of the good, and when one of these attributes is price, it estimates the marginal value of changes in each attribute as well. This type of multidimensional analysis is possible in the CVM as well, however it is more costly. In the CVM, respondents are given a hypothetical scenario and their stated WTP relies on the accuracy of the information provided in this scenario. On the other hand, the CE method offers the respondents different choice sets and different alternatives in each choice set, so instead of being questioned in detail on one single scenario, the respondents are given the opportunity to select among different events. The fact that reminders about substitutes and complements improve the accuracy of the WTP measure is explained in the discussion about the potential biases of the CVM above. Since the CE has different choice sets and in each choice set different alternatives, it incorporates the substitutes and complements.

In addition to the common criticisms on potential biases in stated preference methods in general, there are some potential problems with CE methods that need to be considered before it is put into practice (Hanley et al. 2001). Because CE methods measures the marginal value of each attribute, it assumes that the value of the whole good is equal to the sum of the values of its parts, and the validity of this is questioned. Some studies find estimates from the CE method to be significantly higher than those from the CVM (Maynard 1996).

Sensitivity to design, for example, the choice of alternatives, levels, choice sets, is claimed to have an impact on WTP estimates (Hensher et al. 2005a). There is a limit to the amount of information that can be processed by an individual, and when they are presented with different alternatives, with changing levels, learning and fatigue effects may lead to irrational choices. There is also the statistical problem of correlation between the responses given by the same respondent when faced with repeated choice sets (Louviere et al. 2000). These potential problems of the CE method and suggestions to minimize or eliminate them will be discussed in more detail in the next chapter.

2.5 Review of Selected Studies on Empirical Estimation of Outage Costs

2.5.1 Selected Studies that Categorize the Outage Cost Evaluation Methods

There are a lot of 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; Billinton et al., 1991; Lehtonen and Lemstrom, 1995; TERI 2001; Lawton et al., 2003b; Sullivan, 2009). Table 2.1 below shows some of these studies and the way each one categorized the interruption cost evaluation methods.

Billinton et al. (1991) categorize the outage cost evaluation methods into three groups: direct analytical evaluations, case studies of actual blackouts, and customer surveys. The direct analytical evaluations category includes the studies that find a relationship between the use of electricity and the Gross National Product (GNP), or in the case of the residential sector the studies that estimate the impact through wage rate, lost leisure time, and hourly depreciation rates of all electrical appliances in the household that become unavailable because of an outage. The limitation of these measures is that they do not reflect the users' actual needs. The results from case studies of actual blackouts (LaCommare and Eto, 2004) are also limited to a particular incident and cannot be generalized. The customer survey method is favoured by the utilities, due to its advantage of incorporating the customers' needs. The three customer survey methodologies are: WTP method (CVM, CE), direct costing, and indirect costing. The direct costing method is mostly applied to situations where the costs are easy to identify and quantify. In the case of the residential consumers, the direct costing method is not widely used due to the fact that the largest part of the residential outage costs are intangible in nature and arise from inconvenience and activities forgone rather than out-of-pocket expenses, hence are difficult to quantify. The indirect costing approach depends on the availability of substitutes for a reliable electricity supply. To measure the expenditures customers are willing to make to avoid the consequences of an interruption in the electricity supply, the respondents are asked questions on the cost of hypothetical insurance policies, preparatory actions they may take , or they may be asked to rank a set of reliability/rate alternatives.

The various methods of measuring the cost of unreliable electricity are also widely discussed in the literature on optimal reliability assessment (Telson, 1975; Sanghvi, 1983; Burns and Gross, 1990;

Billinton et al., 1991; Tollefson et al., 1994; Gates et al., 1995; Kariuki and Allan, 1996; Billinton and Pandey 1999, Eto et al., 2001; Lawton et al., 2003; Chowdhury, 2004).

Table 2. 1 Selected Studies That Gave A Critical Overview of Outage Cost Methodologies

Study	Methodologies
Sanghvi, 1983	1. Residential sector a. Wage rate method b. Consumer surplus method c. Survey of WTP 2. Industrial sector a. Opportunity cost of resources made idle by an outage b. Production function approach c. Consumer surplus loss
Andersson and Taylor, 1986	1. WTP method 2. Production loss method 3. Opportunity cost of back-up power
Caves et al., 1990	1. Proxy methods a. The cost of back-up generators b. The ratio of output to electricity consumption c. The price of electricity d. The value of production in the home e. The wage rate 2. Survey methods a. Direct cost b. CVM c. Contingent ranking 3. Consumer surplus measures 4. Reliability demand models
Billinton et al., 1991	1. Analytical methods 2. Case studies of blackouts 3. Customer surveys a. CVM b. Direct costing methods c. Indirect costing methods
Lehtonen and Lemstrom, 1995	1. WTP and WTA methods 2. Direct costing methods 3. The price elasticity method 4. Value added by the production

TERI 2001	1. Production loss method 2. Captive generation method 3. WTP method

2.5.2 Methods for Measuring the Cost of Unreliable Electricity: Business Sector

Some of the most widely used methods for measuring the cost of an outage to the business sector are the production loss method (Munasinghe and Gellerson, 1979; Munasinghe, 1981; Pasha et al., 1989; Tishler, 1993; Jyoti, 1998), the captive generation method (Bental and Ravid, 1982; Beenstock, 1991, Matsukawa and Fujii, 1994; Beenstock et al., 1997), the WTP method (Baarsma and Hop, 2009; Morrison and Nalder, 2009), and the direct costing method (Sullivan et al. 1996). Table 2.2 below gives a list of selected empirical studies that estimated the outage cost for the business sector with the methodologies used in each study.

The production loss method measures the value of production which is lost due to an interruption in the power supply. The captive generation method uses the cost of using a stand-by generator as a proxy to the cost of an outage. CVM and CE are the two WTP methods that are used in directly eliciting the consumer's WTP for an improved electricity supply through customer surveys. Another survey method used in estimating the cost of an outage to the business sector is the direct costing method. In this format, the respondents are given different power outage scenarios and are directly asked how much the power outage would cost them. Alternatively, they are given a list of items where the power outage might have a cost impact (e.g. production loss, labour costs, damage to machinery), and are asked to give a figure for each category, and the cost of the outage is calculated as the sum of these items.

Table 2. 2 Selected Empirical Studies on Outage Cost Estimation, Business Sector

Study	Location	Sector	Method
Munasinghe and Gellerson, 1979	Cascavel, Brazil	Industrial	Production loss
Bental and Ravid, 1982	Israel	Industrial	Cost of back-up power generation
Pasha et al., 1989	Pakistan	Industrial	Production loss
Tishler, 1993	Israel	Industrial	Production loss
Matsukawa and Fujii, 1994	Japan	Manufacturing/ Commercial	Cost of back-up systems
Tollefson et al., 1994	Canada	Commercial Industrial	Direct costing Direct costing
Lehtonen and Lemstrom, 1995	Nordic countries	Agricultural Commercial Industrial Public Sector	Direct costing, CVM (WTA), price elasticity Direct costing Direct costing Direct costing
Sullivan et al., 1996	North Carolina, U.S.	Commercial Industrial	Direct costing Direct costing
Beenstock et al., 1997	Israel	Business Public Sector	Cost of back-up generators, and UPS Cost of back-up generators, and UPS
Jyoti, 1998	Nepal	Industrial	Production loss
Goett et al. 2000	U.S.	Commercial Industrial	CE CE
Bose and Shukla, 2001	Gujarat, India	Agricultural Industrial	Cost of alternative fuels (diesel to pump water) Captive generation
TERI 2001	Haryana, and Karnataka, India	Agricultural Industrial	Production loss, Captive generation, CVM(WTP) Production loss, Captive generation, CVM(WTP)
KPMG 2003	South Australia	Business	CE
Lawton et al., 2003	Western U.S.	Commercial Industrial	Direct costing Direct costing
Samdal et al., 2003	Norway	Agricultural Commercial Industrial Public Sector	CVM CVM CVM CVM

Chowdhury et al., 2004	Midwest region, U.S.	Commercial Industrial Company/ Organization	Direct costing Direct costing Direct costing Direct costing
Bose et al., 2006	Karnataka, India	Agricultural Industrial	CVM(WTP), Production loss, Captive generation CVM(WTP), Production loss, Captive generation
Baarsma and Hop, 2009	Netherlands	Business	Conjoint Analysis
Morrison and Nalder, 2009	NSW, Australia	Business	CE

2.5.3 Methods for Measuring the Cost of Unreliable Electricity: Residential Sector

The measurement of the cost of unreliable electricity to consumers in the business sector is more straightforward since they produce an output that has a market value. On the other hand the cost of unreliability to the residential customers is more difficult to measure due 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 him a certain benefit and increases his total utility. A power interruption disrupts this preferred order and results in a reduction of utility enjoyed by the household. This reduction in utility is theoretically equal to the WTP to avoid the costs of the interruption, or equally to the WTA to forgo the benefits from the interrupted activities. In practice, it is measured by survey or market-based methods.

In the wage rate model for estimation of outage costs of residential electricity users, a typical household engages in housekeeping, food preparation and leisure activities at home (Munasinghe, 1980). During an outage, electricity dependent activities are interrupted imposing costs on the user. The magnitude of these costs depends on, among other things, the income level of the household, dependability of the household on electricity, and the substitutability of the electricity dependent activities with those that are independent of electricity. Also, from the consumers' perspective, major determinants of these outage costs are the time-of-occurrence, duration, magnitude, warning time, frequency, persistence, and coverage. In the short-run, when an outage is not expected, a household experiences inconvenience and loss of leisure. As outages become frequent, households take some mitigating measures to reduce their costs from unannounced outages. In the case where outages are persistent, households may switch to alternative sources of power. Therefore, the cost of outage is the loss of housekeeping, food preparation and leisure activities, loss of services from electricity dependent equipment, damage to and reduced life span of motors and equipment due to voltage changes, indirect costs of purchasing standby generators, storage batteries, kerosene lamps, and cost of other mitigating measures, and psychological costs of the disruptions. According to the author, the main outage cost is the loss of leisure during the evening hours, which he estimated in Cascavel, Brazil, to be approximately 1.5 hours occurring at around 19:30-22:30 p.m. And the mean income earning rate for a typical household is an appropriate measure of the marginal leisure loss due to an outage.

This method has the advantage of simple data requirements. However, as the author stated, it may give wrong estimates for the following reasons. First, where workers are not able to work as much as they wish, the wage rate will overestimate the outage cost. This applies to North Cyprus, where a typical working week is 40 hours in most sectors, and where most people employed by the public sector belong to unions which put restrictions on hours worked. Second, in this method, the household income is represented by the wage of the wage-earning member and, therefore, ignores the cost of the outage to the non-wage earning members of the household. Third, in places, like North Cyprus, where outages are frequent, the individual's labour-leisure choice will be affected by the expectation of an outage. Also, in these cases, they may engage in mitigating measures such as back-up generators, voltage regulators to reduce the cost of an outage. Finally, the wage rate method does not take into account the fact that some households might actually enjoy some benefits from the power outage, e.g. an opportunity to have better conversations and closer bonding among the household members.

Most of the studies done on measuring the cost of outages to residential consumers, measured the short-term outage costs using either the wage rate, survey of WTP, or consumer surplus approaches (Sanghvi, 1982). Long-run adaptive costs such as the cost of a backup generator, or a voltage regulator, where present, needs to be added to the short-run outage costs to arrive at the total shortage cost, which is the sum of the observed short-term outage costs plus the long-term adaptive response costs.

The residential survey uses two types of cost evaluation questions: CVM, and indirect method questions (Wacker et al., 1983; Tollefson et al., 1994; Kariuki and Allan, 1996). The indirect reliability worth evaluation asks about the preparatory actions the consumers would take to avoid the costs of an unexpected electricity supply interruption. Because the costs depend on customer and interruption characteristics, in the survey the customers are asked questions on attitudes towards the service provided, the undesirability of certain interruption characteristics (e.g. time of the day, duration, frequency, etc.), as well as the preparatory actions taken to reduce the effect of an outage. In the preparatory actions section, the households are provided with a list of actions and corresponding cost estimates and are asked to choose the ones they might take in preparation for a power failure scenario. The six preparatory actions used in the Canadian survey (Wacker et al., 1983) and the corresponding quoted costs are: make no preparation, purchase and use a candle ($0.25 per hour), an emergency lantern ($0.50 per hour), an emergency stove ($1.50 per hour), purchase or rent and use a small generator ($5.00 per hour), larger generator ($20.00 per hour). The sum of the costs of the chosen actions is a measure of the WTP of a user for alternatives to electricity and is a lower bound for the worth of reliability.

As can be seen in Table 2.3 below, some of the most widely used methods in empirical work in this sector are the wage rate, the consumer surplus method, indirect costing (cost of preparatory actions), and the WTP methods (CVM, CE). Table 2.3 gives a list of studies that measured the cost of an outage to the households and the measurements methods used in each one.

Table 2. 3 Selected Empirical Studies on Outage Cost Estimation, Residential Sector

Study	Location	Method
Munasinghe and Gellerson, 1979	Cascavel, Brazil	Wage rate
Munasinghe, 1980	Cascavel, Brazil	Wage rate

Wacker et al., 1983	Canada	Preparatory action, CVM (WTP, WTA)
Tollefson et al., 1994	Canada	Preparatory action, CVM (WTP, WTA)
Lehtonen and Lemstrom, 1995	Nordic countries	Direct costing, CVM (WTP), price elasticity
Kariuki and Allan, 1996	UK	Preparatory action, CVM
Sullivan et al., 1996	North Carolina, U.S.	CVM (WTP)
Beenstock et al., 1998	Israel	Choice modelling (conjoint analysis), CVM
Billinton and Pandey 1999	Nepal	Preparatory action, CVM(WTP)
Bose and Shukla, 2001	Gujarat, India	Analysis of household income and expenditure
KPMG 2003	South Australia	CE
Lawton et al., 2003	Western U.S.	CVM (WTP)
Samdal et al., 2003	Norway	CVM
Chowdhury et al., 2004	Midwest region, U.S.	CVM (WTP)
Layton and Moeltner, 2005	U.S.	CVM
RIC, 2005	Trinidad & Tobago	CVM
Carlsson and Martinsson, 2006b	Sweden	CE
Klytchnikova 2006	Azerbaijan	Direct demand estimation –switching regression
Carlsson and Martinsson, 2007	Sweden	CVM
Carlsson and Martinsson, 2008	Sweden	CE
Kateregga, 2009	Kampala, Jinja and Entebbe, Uganda	CVM
Abdullah and Mariel, 2010	Kisumu, Kenya	CE
Baarsma and Hop, 2009	Netherlands	Conjoint Analysis

Previously Sanghvi (1982), Andersson and Taylor (1986), and Woo and Pupp (1992) summarized the findings of various residential outage cost studies. We updated these lists with new studies, and converted all estimates to USD in 2008 prices (see Appendix 2.1).[23] Among the studies where the WTP per outage and the duration of the outage were given, we calculated the WTP per hour unserved (see Table 2.4). In this category, the highest WTP figures are found in 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), (see Table 8.2). Within USA, 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), and Wisconsin (0.58-2.49 USD).

Table 2. 4 WTP (USD per hour unserved, in 2008 prices)

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. (1990)	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

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

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

Exchange Rate = (#Domestic Currency/#USD)
Source for GDP Deflators: International Monetary Fund, World Economic Outlook Database, April 2009
Source for Exchange Rates: The central banks of the related countries

Sweden		Carlsson and Martinsson (2006b, 2007, 2008)	0.29-2.86
Nepal		Billinton and Pandey (1999)	0.10-1.15

The dramatic differences in the WTP estimates may be partly attributed to the different valuation methods, econometric models, functional forms, outage attributes, and socio-economic 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 in Townsend (2000) indicated that the WTP are lower in countries where the quality of service continues to remain poor after the price is increased. Finally, the WTP per hour unserved is inversely related to the total outage duration. Keeping everything else constant, the ratio is lower in countries where the total duration is high. The marginal WTP for service reliability declines as total duration increases since people have more time to engage in averting behaviour i.e. there is a concave and monotonically increasing relationship between WTP and total outage duration (Moeltner and Layton, 2002; Layton and Moeltner, 2005; Carlsson and Martinsson, 2007). Given the chronic nature of outages in Nepal, most people have invested in coping measures, and this in addition to lower incomes may be some of the reasons for the lower WTP figures in this country.

CHAPTER 3 CE DESIGN

3.1 Introduction

In Chapter 2, the various methods used in measuring the welfare impact of improvements in the quality of a service were covered, and the theoretical framework for measuring the welfare impact of such a change explained. In this chapter, we will review some of the experimental design issues frequently discussed in the literature, mainly the design objectives, the trade-offs faced by the analyst in trying to satisfy these design objectives, and the statistical efficiency of the design. We will examine the different design strategies in more detail and select the one most appropriate for our purpose. Then using this strategy we will generate the choice sets that will be used in the survey.

Chapter 3 is organised as follows. Section 2 states the design objectives for CE and the properties of an efficient choice design. The impact of choice design on WTP estimates is also discussed. Sections 3 and 4 present the steps of CE design and CE study respectively. Sections 5, 6, and 7 are structured as follows: identification of attributes and attribute levels, selection of a CE design technique, followed by the creation of the choice sets contained in the CE and the revised design after the pilot survey.

3.2 Issues in Design of CE

3.2.1 Design Objectives for CE

In designing the CE, the four important objectives (Louviere et al., 2000) are: identification; precision; cognitive complexity; and market realism.

Identification

The form of the utility function to be estimated needs to be identified. This can be an additive or multiplicative form of the effects of interest, which may include only the main effects or some of the interactions as well.

Precision

The size of the confidence interval of the parameters of the model to be estimated is decided subject to time and budget constraints. Designs with narrower confidence intervals and higher variance efficiency have more precise parameter estimates.

Cognitive Complexity

This involves, among other things, decisions on the number of alternatives in each choice set, and the number of choice sets presented to each individual.

Market Realism

This is the degree to which the decision environment provided by the CE matches the actual decision environment of the respondent in an actual market.

Before moving on to the design of the experiment, the researcher needs first to specify the form of the utility function, determine the number of attributes and the levels for each attribute, then identify the number of alternatives within each choice set and the number of choice sets to be presented to each individual. Once the number of attributes is determined and the number of levels for each attribute is selected, a set of attribute profiles can be generated using a fractional factorial design.

Then, the choice sets are constructed using a design technique (see Louviere et al., 2000 for different design techniques). The goal in this step is the allocation of the alternatives created in the factorial design into choice sets in such a way that a maximum amount of information is extracted from the individuals.

3.2.2 Optimal Statistical Design of CE

The main objective of the optimal statistical design of CE is the achievement of the highest precision possible for the parameter estimates through maximum variance efficiency. The four properties of an efficient choice design (Huber and Zwerina, 1996) are: level balance, orthogonality, minimal level overlap, and utility balance. Level balance requires all attribute levels to occur with equal frequency in the design. Two main effects are orthogonal if the relative frequency of two levels of different attributes occurring jointly is equal to the product of their marginal relative frequencies. Orthogonal designs yield independent parameter estimates, and therefore minimize collinearity. Minimal overlap happens when the probability that an attribute level is repeated in a choice set is minimized. Finally, the utilities are balanced when the utilities from different alternatives in the choice set are as close to each other as possible. Huber and Zwerina (1996) showed that utility-balanced designs can be generated by adding prior parameter assumptions to designs that already possess the other three design principles. However, in practice these four design principles are generally in conflict with each other (Huber and Zwerina, 1996). Trade-offs exists between these four factors and emphasizing some of them at the expense of others may bias the parameter estimates (Viney et al., 2005).

Carlsson and Martinsson (2003) described and compared some of the different design techniques used in creating the CE. One of the designs described is the traditional orthogonal design, where the levels for each attribute vary independently. Another one is the D-optimal design which requires some prior knowledge about the true parameter estimates. Comparing the traditional orthogonal designs and the D-optimal designs with respect to their ability to correctly estimate marginal WTP, Carlsson and Martinsson (2003) found that D-optimal designs with priors result in smaller mean square errors and give parameter estimates with higher precision. However, if the pilot study does not allow for making good prior assumptions on the parameter values, there is uncertainty about the econometric model used in the estimation, and the sample size is not sufficiently large, then shifted designs based on orthogonal fractional factorial designs might be preferred (Ferrini and Scarpa, 2007).

When the utility balance and D-efficiency criteria are applied together, the design will have the most efficient parameter estimates possible. There is a strong positive correlation between utility balance and efficiency of a choice design (Huber and Zwerina, 1996; Golek, 2005). Maximizing utility balance in order to achieve maximum efficiency may however have negative consequences on the individual, such as fatigue effects, inconsistent choices, or disengaging from the task, which may lead to a loss of information due to non-response. Hence once the most efficient design is obtained, with the use of the software used in the analysis, and/or manually, the cumulative utility balance of the choice task can be manipulated, so that the cumulative utility balance is reduced without jeopardizing the efficiency significantly (Golek, 2005).

3.2.3 Prior Assumptions on the Parameter Values

Making assumptions about the parameter values is one of the recommendations in obtaining optimum designs (Sandor and Wedel, 2001; Ferrini and Scarpa, 2007; Scarpa and Rose, 2008). Misspecification of the parameter values has been shown not to have a significant effect on efficient designs (Huber and Zwerina, 1996; Carlsson and Martinsson, 2003). Therefore, even though the exact parameter values may not be known, it is still recommended that prior assumptions on the direction of the parameter effects be made. Golek (2005) compared four different prior assumptions and analysed the effects in their misspecification on the utility balance and efficiency of the design.

The four different prior assumptions studied by Golek (2005) were the zero prior, the equal-spaced prior, the assumption that some attributes are more important than others, and the assumption that the attribute levels are not equally spaced. The zero prior specification assumes that the effect of the different attribute levels and the importance of different attributes are not known in advance. The equal-spaced prior specification assumes that the attribute levels can be ranked according to their relative utility. The levels are assumed to be equally spaced and the attributes to be equally important. In the third prior specification, the assumption is that the rank ordering of the levels and the relative importance of the attributes are known. Finally the last prior assumption, is where in addition to knowing the relative importance of the attribute levels, we also know that they will not be equally spaced. Golek (2005) concludes that designs with the simpler prior assumptions like the equal-spaced prior specification, are more robust to misspecification of the prior.

3.2.4 Cognitive Complexity of the Design

In addition to the efficiency of the CE design, complexity of the design is another factor that may affect the results of the experiment (Swait and Adamowicz, 2001). Some of the criteria used to assess the complexity of a CE are (Swait and Adamowicz, 1996; Alpizar et al., 2001; Golek, 2005): Utility balance, number of tradeoffs, magnitude of tradeoffs, number of attributes, mean standard deviation of attribute levels within each alternative, dispersion of the standard deviation of attribute levels within each alternative, mean standard deviation of attribute levels within each attribute, and the dispersion of the standard deviation of attribute levels within each attribute.

Caussade et al. (2005) assessed the complexity of the design in terms of five design dimensions: the number of alternatives, the number of attributes in each alternative, the number of levels in each attribute, the range of each attribute level, and the number of choice sets presented to each respondent. All five design dimensions were found to affect the error variance; however the two with the highest negative impact were the number of attributes and the number of alternatives. The five design dimensions however were not found to have any systematic effect on the WTP estimates. Carlsson and Martinsson (2006b) also investigated the effects of the number of choice sets and found that it did not have an important effect on the estimates.

Hensher et al. (2005) and Hensher (2006a) challenged the view that design complexity is aligned with the amount of information (number of attributes in each choice set) processed by the individual. Hensher et al. (2005) investigated the effect on WTP estimates of respondents ignoring specific attributes, and found significantly different WTP estimates in the models where specific attributes are ignored. Hensher (2006a) looked at how the number of attributes that are ignored (or not attended to) in a CE varies with the dimensionality of the choice task (number of levels, attribute range, number of alternatives), the number of choice sets per individual, the deviation of the design attribute levels from the base (reference) alternative, the use of adding up attributes where this is feasible, and the socio-economic characteristics of the respondent. He found that the number of attributes ignored is likely to increase as the number of levels of each attribute increases, the range of each attribute narrows, and the number of alternatives decreases.

3.2.5 Impact of Choice Design on Preferences and WTP Estimates

The assumption in most choice models is that respondents behave rationally and always choose the utility maximizing alternative considering the trade-offs between the attributes (Louviere et al., 2000). If individuals do not have predefined preferences and instead form their preferences during the CE or use some heuristic, then their "preferences" may be sensitive to the way in which information is presented to them (Johnson et al., 2000; Louviere et al., 2005; Kjaer et al., 2006; Lancsar and Louviere, 2006). The recommendation of Golek (2005) is that we might be better off designing the choice tasks in a way that participants will not opt to simplifying strategies (heuristics) when answering the choice tasks.

Ryan and Wordsworth (2000) examine the sensitivity of the WTP estimates to the level of attributes, and find that for five of the six attributes included in the experiments the coefficients were not significantly different. However, the mean WTP estimates were significantly different for the four of the five welfare estimates.

Hanley et al. (2005) investigate whether the preferences and the WTP estimates are affected by the choice of which vector of prices to use in the experimental design. They find that individuals exhibit rational behaviour so that the probability of choosing an alternative over the status-quo is higher in the experiment with lower prices, however they do not observe any significant impact of the difference in prices on the WTP estimates.

Kjaer et al. (2006) study the effect the order of the price attribute has on the WTP estimate. They found that when the price attribute is presented to the respondents as the last attribute in the choice set, the WTP estimates are lower compared to the case where the price attribute is placed in the beginning. This implies that there is an ordering effect with respect to the price attribute.

Carlsson and Martinsson (2006b) in addition to the number of choice sets, also investigated the potential effects of the starting point (design of the first choice set), and the levels of the cost attribute on the precision of the marginal WTP estimates. While the design of the first choice set was found not to have an important effect on the estimates, the impact of the level of the cost attribute was significant. This is contrary to the theoretical expectation that in a utility function which is linear in the cost attribute, the difference in the levels of the two alternatives should have an effect, not the scale of the levels.

Lancsar and Louviere (2006) looked into studies that tested for respondents who behaved irrationally, and examined the effect of deleting those responses from the analysis of the CE. They concluded that deleting valid preferences may result in sample selection bias, and/or reduced statistical efficiency, and therefore unless backed by a very strong theory or empirical evidence, they should not be removed from the data set. The authors suggested considering ways of incorporating these data in the models instead. Johnson et al. (2000) found that deleting inconsistent responses had a significant effect on the estimates.

3.2.6 Base or No-Choice Alternative

Including a base alternative or a no-choice alternative in the choice set makes the choice decision more realistic by giving the respondents an alternative choice when the other alternatives in the choice set are not attractive. It also ensures welfare consistent results (Hanley et al., 2001). The respondents may opt for the no-choice alternative due to resistance to change (status-quo bias), fatigue, learning effect, or complexity of the choice task. Beenstock et al. (1998) found that status-quo bias is significant in their study and attribute it to the interviewees' characteristics. The probability of a participant choosing the no-option alternative increases when the task is long causing fatigue effects, or when the choice task is complex. Also the participant who is not familiar with the choice task may choose the no-choice option at the beginning of the task (Johnson et al., 2000). With respect to the learning effect, Rose and Black (2006) suggested including a couple of practice choice sets for respondents to familiarize themselves with the task, and then removing these from the estimation of the model. Alternatively they recommended measuring task response times, noting when it is stable and including only the responses after this point.

Most choice models that incorporate the no-choice option assume the reason behind the selection of the no-choice option to be only the unattractiveness of the other alternatives and do not consider the other reasons. Including the no-choice alternative may make the task more realistic at the expense of information loss and decrease in efficiency of the experiment. Therefore it is important to determine the reasons for the no-choice selection, and minimize the ones that are not due to the unattractiveness of other alternatives. The complexity of the task and the probability of choosing the no-choice alternative are related, hence it is recommended that the participants are not over burdened by choice sets that have high complexity (Dhar, 1997). Golek (2005) also showed that the choice set order within the choice task has an effect on the no-choice selection, and recommended that choice sets with high complexity are not placed late in the choice task.

3.3 Steps of CE Design

The steps in designing the CE are (Ryan and Hughes, 1997; Louviere et al., 2000; Golek, 2005):

Overview of the topic to be studied

The researcher identifies the attributes of interest and their levels, starts developing the prior parameter assumptions, and ranks the alternatives in order of importance to the study.

Consider the target population

The target population is considered with respect to their present knowledge of the study topic, expected degree of engagement in the project being evaluated, and homogeneity.

Select the number of attributes and the number of attribute levels

The attributes to be included in the experiment and their levels are decided.

Select the number of alternatives and the number of choice sets

Keeping the properties of the target population and the reward and delivery systems of the CE (mail, telephone, or in-person) in mind, the number of alternatives and the number of choice sets are selected. At this stage, the decision can be made on whether or not to include a constant alternative.

Select the number of participants

Decision on the sample size is determined among other things by the budget allocated to the study, desired degree of accuracy, delivery system of the experiment and number of no-choice responses expected.

Create several candidate master designs for evaluation

After deciding on the model that will be used in analyzing data and making the prior assumptions for the parameter estimates, with the use of the software several candidate designs are created.

Evaluate and examine the complexity measures for each of the candidate master designs

The complexity of each candidate design is examined by evaluating the utility balance, number of tradeoffs, and magnitude of tradeoffs.

Select the final master design

The final design is selected among the candidate designs based on performance with respect to the complexity measures calculated above.

Allocate choice sets to participants according to complexity measures

The choice sets are grouped and divided among the participants in such a way that each participant faces equal task complexity. The ordering of the choice sets within each task is also considered, so that the choice sets with more complexity are not placed at the beginning of the task. Minimum variability in the parameter estimates and decreased probability of selecting the no-choice alternative are two important considerations.

3.4 Steps in a CE Study

The steps in a CE study as stated by Louviere et al. (2000) are:

Define study objectives

The questions to be answered by the study are decided, and the objectives of the study are defined.

Conduct supporting qualitative study

Using focus groups and/or personal interviews, information about the way consumers think about the product/service is collected.

Develop and pilot the data collection instrument

The CE is designed, and pilot tests of the survey are conducted.

Define sample characteristics

Sampling Strategy

The objectives of the study determine the relevant population from which respondents will be sampled. Then, a sampling strategy is chosen (the method with which the households included in the sample will be chosen from the population). Sampling techniques are classified as non-probability and probability (Champ et al., 2003). In non-probability sampling, each household does not have a known non-zero probability of being included in the sample, and therefore the results from the data cannot be used in making inference to the larger population. In probability sampling, each household has a known non-zero probability of being included in the sample, and the results of sample data analysis can be used in making statistical inference.

The three sampling strategies are choice-based sampling (CBS); simple random samples (SRS) and exogenously stratified random samples (ESRS) (Louviere et al., 2000). The CBS is the preferred method in collecting revealed preference data and it is not used in stated choice studies. It requires that the choice probabilities are known a priori. In the SRS, a random sample is selected from the sampling frame and each sample unit has an equal probability of being included in the sample. With the ESRS, the sampling frame is divided into G mutually exclusive groups, and within each stratum the sample units are randomly chosen. The criteria used in forming the strata can be any of the socio-demographic characteristics of the households, except the observed choice.

Sample size

Because the current sampling theory is not exactly suitable for choice based data, most researchers using choice based data have resorted to rules of thumb in finding the minimum sample size required (Bliemer and Rose, 2005). In estimating the marginal value of attribute levels, the suggested rule of thumb (Orme, 2006) is:

$$\frac{nta}{c} > 500$$

where *n* is the number of respondents, *t* is the number of choice sets given to each respondent, and *a* is the number of alternatives in each choice set (excluding the status-quo or none alternative), and c is the largest number of levels in any attribute for main-effects-only designs or the largest product of levels of attributes when interactions are included. If relationships with socio-economic variables are going to be tested then the sample size calculated with the formula above will need to be doubled (Barton, 2007). On the other hand, a minimum sample of 200 per group is suggested if these groups will be compared, otherwise a minimum of 300 is sufficient for quantitative research (Orme, 2006). When budget is the limiting factor, a minimum of 50 responses per choice will suffice if each respondent is presented with 16 choice sets (Hensher et al., 2005c).

For a sample selected by the SRS method, the minimum sample size to estimate the true choice probability within a percent of the true choice probability p with probability of α is given by (Louviere et al., 2000):

$$n \geq \frac{(1-p)}{rpa^2}\left[\Phi^{-1}\left(1-\frac{\alpha}{2}\right)\right]^2$$

where r is the number of choice sets answered by each respondent, and $\Phi^{-1}(.)$ is the inverse cumulative normal distribution function.

In the case where the sample is selected using the ESRS method, the minimum sample size can be calculated in two ways. The formula above is used to calculate the total sample size which is then divided among the different groups. Alternatively the formula above is used to calculate the size of each group.

Perform data collection

The method in which the survey will be conducted is decided.

Conduct model estimation

The model is estimated using the choice model selected for the study.

Conduct policy analysis

The estimated model is used to answer the questions laid down in the first step.

3.5 Attributes and Attribute Levels

3.5.1 Review of Literature on Attributes Used in Electricity Service Reliability Studies

The utility of the i^{th} alternative for the q^{th} individual is expressed as:

$$U_{iq} = V_{iq} + \varepsilon_{iq}$$

where the first term on the right hand side is the systematic component (from attributes observed by the analyst) and the second term is the random component (from attributes unobserved by the analyst). The systematic component V_{iq} depends on the attributes of alternative i and the characteristics of individual q. Therefore, when an attribute that the users of the electricity service consider important and are willing to pay for is not included in the CE, the model will be misspecified causing the variance of the random component to be higher and reducing the precision of the parameter estimates of the model.

In order to ensure that the important attributes are included in the CE, first we carried out a thorough survey of the literature on cost of power outages to residential customers (see Table 3.1), followed by six focus group interviews held in the five districts, as well as interviews with officials from the electricity authority. As can be seen in Table 3.1, the attributes mostly used in the outage cost literature are outage duration, frequency, timing (season, day of the week, and time of day) and advance notification of the outage. In addition, a price attribute is included to estimate the marginal WTP for a change in the level of an attribute.

Table 3. 1 Outage Attributes Previously Used in the Literature

Study	**Outage Attributes**
Wacker et al., 1983; Kariuki and Allan, 1996	Duration; frequency; season; day of week; time of day
Billinton et al., 1991; Tollefson et al., 1994	Duration; frequency; time of occurrence; complete vs. partial; whether advance warning is given; the nature of the warning; localized vs. widespread outages
Lehtonen and Lemstrom, 1995	Unexpected and planned outages; duration; season; day of the week
Sullivan et al., 1996	Frequency; duration; season; advance notice; time of day
KPMG, 2003	Duration • sustained interruptions (planned and unplanned) • longest interruption • longest planned interruption Frequency • sustained interruptions (planned and unplanned) • momentary interruptions • planned interruptions Quality of supply (voltage fluctuations) Customer service • the ability of utilities to automatically detect that an interruption has occurred without customers ringing to inform them • the performance of utilities' call centres • the accuracy with which estimates can be provided as to when supply will be restored after an interruption has occurred • method of notifying a customer of a planned interruption • notification period for planned interruption Undergrounding Future needs • improve power supply in urban areas, regional areas and rural areas • the party that should pay the cost for augmenting the network when customers connect Cost
Lawton et al., 2003a	Season; hour of day; day of week; duration; warning given; average kW

	usage
Lawton et al., 2003b	Duration; season; time of day; advance notice; day of the week
Layton and Moeltner, 2005	Time of day; duration; instantaneous interruption; duration; number of occurrences
Carlsson and Martinsson, 2007	Duration; planned/unplanned; time of day
Carlsson and Martinsson, 2008	Duration; time of the week (working days and weekends); time of the year -- winter months (November-March) and the rest of the year (April-October); the connection fee to a back-up electricity board
Abdullah and Mariel, 2010	Price; type of provider; number of planned blackouts; duration of outage
Baarsma and Hop, 2009	Frequency of outages; duration of the outage; day of the week; part of the day; season; warning in advance; change in electricity bill

3.5.2 Focus Groups

In conjunction with literature reviews focus group interviews are an essential step in the identification of attributes to be included in the initial design of the CE. Focus groups in CE studies usually consist of 5-10 participants and a facilitator that are brought together to discuss their attitudes, beliefs, and experience on a topic of interest with the goal of revealing the significant attributes they are willing to pay for in a product or service. As a result not only the omission of important attributes from the model is minimized, but the attributes are described in a way that they will be best understood by the respondents in the survey. Due to the small sample size, the data collected from the focus group interviews can only be used in identifying the significant attributes to be included in the initial design of the CE and in making sure that these attributes are phrased in a way that they will be meaningful to the participants. The description of these attributes will be further tested during the pilot study phase of the survey.

Six focus group studies were held in the districts of Lefkoşa, Girne, Gazimağusa, Güzelyurt, and İskele between 31 October, 2007 and 7 November, 2007 (see Table 3.2). The groups were selected to include residential customers from that district. We aimed at having a mix of male and female participants from different age groups and education levels. In each district we contacted several people and asked them to invite other people they knew to participate. For each group around 10 people were invited but on average six were present at the interviews. During these six focus group studies a total of 35 participants (18 female, 17 male) were interviewed from five different districts. Their ages ranged from 21 to 63, and education levels ranged from "no formal education" to PhD.

The meetings in Lefkoşa, Girne, and Güzelyurt took place at one of the participants' homes. The meetings at the two universities took place in offices on campus; and finally the meeting in İskele was held at the municipality building of Yeni Erenköy. The participants were provided with snacks and refreshments to give them the opportunity to get to know each other before the interview. The meetings on average lasted an hour. The participants were first given an introduction regarding the meeting's agenda and then they were asked to fill out a four page questionnaire which included questions on their current electricity service (see Appendix 3.1). Afterwards a group discussion was held on the attributes the participants were willing to pay for in their electricity service. I acted as the facilitator in the discussions, took notes and recorded the conversations for future reference.

Table 3. 2 Focus Group Characteristics

District	Date of Study	No. of Participants	Ages	Education Levels
1. Lefkoşa:	31 October, 2007	6 participants:	36-43	high school-master

		5 Female, 1 Male		
2. Girne (American University faculty)	1 November, 2007	6 participants: all male	28-50	master - PhD
3. İskele	2 November, 2007	7 participants: 2 Female, 5 Male	30-54	primary – university
4. Güzelyurt	3 November, 2007	6 participants: all female	21-56	primary – university
5. Girne	6 November, 2007	5 participants: 3 Female, 2 Male	31-63	no formal education – university
6. Gazimağusa (Eastern Mediterranean University faculty)	7 November, 2007	5 participants: 2 Female, 3 Male	23 – 43	master – PhD

Attributes From the Focus Group Study

The attributes of an electricity service that participants in general believed important and were willing to pay for were frequency of outages, duration of outages, notification of outages, and timing of outages (season, day of the week, time of day). Some other attributes were also mentioned: voltage fluctuations, momentary outages, repair time, under-grounding of power cables, the utility company's ability to answer phones during an outage, and environmentally friendly sources of power. Among the latter group of attributes "voltage fluctuations" was the attribute that was emphasized more than the rest.

Frequency of Outages

The frequency of outages is the number of times an outage occurs on average in a specified period of time. According to the data collected from the focus group questionnaire, unplanned summer outages ranged from "3-4 times a year" to "more than 8 times a month", planned summer outages ranged from "none or no notification" to "3-4 times a month", unplanned winter outages ranged from "1-2 times a year" to "more than 8 times a month", and planned winter outages ranged from 0 to "4-5 times a month" (see Table 3.3). The experience with outages varied with district, and even within the same district.

Table 3. 3 Frequency of Outages – Data from Focus Group Survey

Frequency of outages	**Unplanned**		**Planned**	
	Summer	**Winter**	**Summer**	**Winter**
Never			2 (11.1%)	6 (27.3%)
1-2 times a year		1 (5.3%)	5 (27.8%)	1 (4.5%)
2-3 times a year			1 (5.6%)	
3-4 times a year	1 (5%)			
5-6 times a year				
1-2 times a month	4 (20%)	2 (10.5%)	9 (50%)	11 (50%)
2-3 times a month	3 (15%)	2 (10.5%)		2 (9.1%)
3-4 times a month	2 (10%)	2 (10.5%)	1 (5.6%)	
4-5 times a month	3 (15%)	6 (31.6%)		2 (9.1%)
5-6 times a month				
6-7 times a month	1 (5%)			
7-8 times a month	1 (5%)			
More than 8 times a month	4 (20%)	6 (31.6%)		
Don't know	1 (5%)			
Total	20 (100%)	19 (100%)	18 (100%)	22 (100%)

Duration of Outages

The duration of outages is the number of hours that an outage lasts on average. According to the focus group results, outages on average ranged from 1 hour to "More than 12 hours" (see Table 3.4).

Table 3. 4 Duration of Outages – Data from Focus Group Survey

Duration of outages	Unplanned		Planned	
	Summer	Winter	Summer	Winter
None				4 (16%)

Less than one hour				
1-2 hours	5 (16.1%)	4 (14.3%)	3 (10.7%)	2 (8%)
2-3 hours	14 (45.2%)	8 (28.6%)	6 (21.4%)	4 (16%)
3-4 hours	8 (25.8%)	7 (25.0%)	5 (17.9%)	4 (16%)
4-5 hours	2 (6.5%)	3 (10.7%)	4 (14.3%)	6 (24%)
5-6 hours		2 (7.1%)	3 (10.7%)	1 (4%)
6-7 hours	2 (6.5%)	1 (3.6%)	3 (10.7%)	2 (8%)
7-8 hours			1 (3.6%)	1 (4%)
8-9 hours			2 (7.1%)	1 (4%)
9-10 hours				
10-11 hours		2 (7.1%)		
11-12 hours			1 (3.6%)	
More than 12 hours		1 (3.6%)		
Total	31 (100%)	28 (100%)	28 (100%)	25 (100%)

Season

When comparing the undesirable effects of outages on their households during different times of the year, some participants stated summer, and others winter, outages to be of greater concern. Those that found summer outages had a higher undesirable effect on their households attributed it to the absence of substitutes to electricity in cooling, i.e. there are alternative sources of energy to heating but there are no alternative sources of energy for cooling. The degree of undesirable effects also depended on the duration of the outage. A long outage in summer could be more disruptive since the food in the refrigerator would spoil.

Day of the Week

The participants were asked to compare the degree of undesirable effects of outages on weekdays vs. weekends. Weekend outages were less desirable for those who spend the weekend mostly at home. Also those who work during the week found weekend outages to be more disruptive as they had to get most of the cleaning, laundry, and ironing done at the weekend. For some participants, any day was equally undesirable because of their active lifestyle. Also, for the participants who spend most of their time at home throughout the week, a particular day of the week did not make any difference in the level of outage disruption.

Time of Day

Participants were asked to think about the undesirable effects of outages on their household at different times of the day. Some found weekday outages that took place in the mornings (6am to 9am) and evenings (5pm to midnight) to be more disruptive. In the mornings they prepare to go to work and from 5pm to midnight they are home (want to watch TV, kids do home work, etc.). Some participants stated that being able to watch the 11 pm news on television was important for them, and outages that occur after midnight till morning would be less disruptive. However they did mention that this may not be the case in the summer, when air conditioners are needed in cooling the house and keeping the mosquitoes away at night-time in order to be able to sleep.

Notification

Planned outages are usually notified a day in advance or sometimes on the day of the outage in some newspapers, on radio and TV. However most people are not aware of these either because not enough advanced notice is given, or they do not read or listen to the specific media where the notification is given. So most of the outages they experience are “unplanned” according to the focus group participants. Some said they preferred to receive a written notification in the mail, while others said they can be notified through a text message sent to their mobile telephones, or through the newspapers (if it is published in all of the local newspapers). While some found 1-2 days notice to be enough, others required at least 3-4 days notice to finish the food in their freezers and reschedule other household activities. Longer than a week was not preferred in general because it would be forgotten.

Table 3. 5 Prior Notification for Planned outages – Data from Focus Group Survey

Prior Notification	Preferred
1-2 days	7 (25.9%)
2-3 days	5 (18.5%)
3-4 days	5 (18.5%)
4-5 days	1 (3.7%)
5-6 days	
6 days - 1 week	9 (33.3%)
Total	27 (100%)

Voltage Fluctuations

Voltage fluctuation is the change in the voltage from its acceptable range. When the voltage drops below the acceptable lower limit, then most electrical equipment will not function properly, and in cases when it is above the acceptable higher limit, the electrical equipment may be damaged. Voltage fluctuations were a concern. Participants could notice changes in voltage when their lights dimmed, the oven does not heat up to the desired temperature, washing machines and air conditioners do not work because of lower voltage levels. They mentioned their equipment breaking down: TV, freezers, computers etc. Frequency of voltage fluctuations are difficult to quantify. When asked about the frequency the usual answer is "almost every day".

Other Comments and Concerns of the Focus Group Participants on Their Electricity Service

There is a very negative attitude towards the electricity authority and the Government. Lately, on every month's electricity bill there is a line called "investment contribution". This is around 10% of that month's bill. The Government has recently invested in new generation capacity and is collecting forced contributions from people to pay for it. In the meantime however, power outages continue to happen with the same frequency. So the participants found it hard to believe that payment of an additional amount to their current electricity bill will result in an improvement in their service.

Some feel that they are already being charged a very high price for a low quality service. Participants in general believe that the electricity utility company is overstaffed, and hence a high cost producer of electricity. The participants suggested that the Government should be spending the tax money in better ways instead of collecting additional "investment contributions" from them. They also pointed out that electricity is a public commodity and people have the "right" to have a reliable electricity supply, and it is the Government's duty to provide an electricity service with no interruptions. They think it is unfair that even when they pay their bills regularly they still experience outages and are not compensated for it. On the other hand, when they are late to pay (even after only a couple of days), their service is disconnected immediately.

The total number of alternatives (profiles) in the CE grows exponentially with the number of attributes and the number of attribute levels, and this in turn increases the minimum sample size required or for a given sample size the total number of choice sets that each respondent needs to see in order to have accurate estimates for the parameters. Therefore the attribute levels obtained from the focus group studies need to be grouped together to reduce the number of levels for each attribute (see table 3.6).

Table 3. 6 Attribute Levels (Pilot Study)

Attribute	Number of Levels	Levels
Frequency of outages	4	twice a year 4 times a year once a month 8 times a month
Duration of outages	2	less than 6 hours 6 to 13 hours
Time of outages	2	daytime night-time
Prior notification	2	prior notification no prior notification
Additional Cost	4	5% higher than now 10% higher than now 20% higher than now 30% higher than now

3.6 Experimental Design

Once the number of attributes and the number of attribute levels are determined then an experimental design strategy needs to be selected. In our case we have five attributes, two with four levels, and three with two levels (see Table 3.6). The full factorial would yield 128 profiles ($=4^2 \times 2^3$). The number of profiles grows exponentially with the number of attributes and the number of attribute levels. Since it would be very demanding on the respondents to be presented with so many choice sets as well as very costly to use the full factorial, as a first step in the experimental design process, a fractional factorial with J^* profiles was generated from this full factorial to reduce the number of choice sets used in the experiment (Bunch et al., 1996; Louviere et al., 2000; Hensher et al., 2005c).

A software package like SPSS can be used to generate the experimental design. However, before generating the experimental design the analyst must decide whether a main-effects-only or a main-effects-plus-selected-interactions design is required. An orthogonal main effects plan allows for all main effects to be independently estimated assuming that all interactions are negligible. Considering 70-90% of explained variance originate from the main effects, 5-15% from the two-way interactions, and the remaining from the higher order interactions, an orthogonal main effects plan (OMEP) might be a reasonable design choice if the analyst believes that the interaction terms are insignificant (Louviere et al., 2000).

Using the Orthogonal Design feature in SPSS 15.0, we generated the 32-profile orthogonal fractional factorial plan shown in Table 3.7 below. We are interested in measuring some of the two-way interaction effects as well, therefore in generating the design we used orthogonal coding and we did not assign the columns to the attributes simultaneously. For the four-level attributes, the orthogonal codes used were (-3, -1, 1, 3), and for the two-level attributes they were (-1, 1).

Table 3. 7 Orthogonal Fractional Factorial Plan from SPSS 15.0

Profile	A	B	C	D	E	F
1	1	-1	-1	-1	-3	1
2	-3	1	1	-1	3	-1

3	-1	1	-1	1	-3	-3
4	-1	-1	-1	1	-1	-1
5	1	-1	-1	1	3	-3
6	3	-1	1	-1	-3	-1
7	3	1	1	-1	-1	-3
8	3	-1	1	1	3	3
9	3	-1	-1	1	-1	3
10	-1	-1	1	1	3	-1
11	1	1	1	1	-3	-1
12	-3	-1	-1	-1	-3	-3
13	-1	1	1	1	1	-3
14	1	1	1	-1	3	3
15	-1	-1	-1	-1	1	3
16	-3	-1	1	1	-1	1
17	-3	1	-1	-1	-1	-1
18	-1	1	-1	-1	3	1
19	-3	1	-1	1	1	3
20	1	-1	1	1	-1	-3
21	1	1	-1	-1	-1	3
22	3	1	-1	1	-3	1
23	-3	-1	1	-1	1	-3
24	-3	1	1	1	-3	3
25	-1	1	1	-1	-1	1
26	-3	-1	-1	1	3	1
27	1	-1	1	-1	1	1
28	3	-1	-1	-1	1	-1
29	1	1	-1	1	1	-1
30	3	1	1	1	1	1
31	-1	-1	1	-1	-3	3
32	3	1	-1	-1	3	-3

Attributes A, E, and F consisted of four levels, where B, C, and D had two levels. In addition to the initial five attributes to be used in the CE, we added a sixth attribute with four levels so that we could divide the generated 32-profile orthogonal plan into four blocks. This way each respondent will only see eight of the 32 profiles. We copied the 32-profiles from SPSS to an MS Excel worksheet and calculated all of the possible two-way interactions by multiplying the columns of the two relevant attributes e.g. the columns A and B were multiplied to get the AB interaction (see Table 3.8). In order to determine whether this design would allow the estimation of any two-way interaction terms, using MS Excel we calculated the correlation matrix for the six main effects and the fifteen two-way interactions (see Table 3.9).

Table 3. 8 Two-Way Interactions

Profile	AB	AC	AD	AE	AF	BC	BD	BE	BF	CD	CE	CF	DE	DF	EF
1	-1	-1	-1	-3	1	1	1	3	-1	1	3	-1	3	-1	-3
2	-3	-3	3	-9	3	1	-1	3	-1	-1	3	-1	-3	1	-3
3	-1	1	-1	3	3	-1	1	-3	-3	-1	3	3	-3	-3	9
4	1	1	-1	1	1	1	-1	1	1	-1	1	1	-1	-1	1
5	-1	-1	1	3	-3	1	-1	-3	3	-1	-3	3	3	-3	-9
6	-3	3	-3	-9	-3	-1	1	3	1	-1	-3	-1	3	1	3
7	3	3	-3	-3	-9	1	-1	-1	-3	-1	-1	-3	1	3	3
8	-3	3	3	9	9	-1	-1	-3	-3	1	3	3	3	3	9
9	-3	-3	3	-3	9	1	-1	1	-3	-1	1	-3	-1	3	-3
10	1	-1	-1	-3	1	-1	-1	-3	1	1	3	-1	3	-1	-3
11	1	1	1	-3	-1	1	1	-3	-1	1	-3	-1	-3	-1	3
12	3	3	3	9	9	1	1	3	3	1	3	3	3	3	9
13	-1	-1	-1	-1	3	1	1	1	-3	1	1	-3	1	-3	-3
14	1	1	-1	3	3	1	-1	3	3	-1	3	3	-3	-3	9
15	1	1	1	-1	-3	1	1	-1	-3	1	-1	-3	-1	-3	3
16	3	-3	-3	3	-3	-1	-1	1	-1	1	-1	1	-1	1	-1
17	-3	3	3	3	3	-1	-1	-1	-1	1	1	1	1	1	1
18	-1	1	1	-3	-1	-1	-1	3	1	1	-3	-1	-3	-1	3
19	-3	3	-3	-3	-9	-1	1	1	3	-1	-1	-3	1	3	3
20	-1	1	1	-1	-3	-1	-1	1	3	1	-1	-3	-1	-3	3
21	1	-1	-1	-1	3	-1	-1	-1	3	1	1	-3	1	-3	-3
22	3	-3	3	-9	3	-1	1	-3	1	-1	3	-1	-3	1	-3
23	3	-3	3	-3	9	-1	1	-1	3	-1	1	-3	-1	3	-3
24	-3	-3	-3	9	-9	1	1	-3	3	1	-3	3	-3	3	-9
25	-1	-1	1	1	-1	1	-1	-1	1	-1	-1	1	1	-1	-1
26	3	3	-3	-9	-3	1	-1	-3	-1	-1	-3	-1	3	1	3
27	-1	1	-1	1	1	-1	1	-1	-1	-1	1	1	-1	-1	1
28	-3	-3	-3	3	-3	1	1	-1	1	1	-1	1	-1	1	-1
29	1	-1	1	1	-1	-1	1	1	-1	-1	-1	1	1	-1	-1
30	3	3	3	3	3	1	1	1	1	1	1	1	1	1	1
31	1	-1	1	3	-3	-1	1	3	-3	-1	-3	3	3	-3	-9
32	3	-3	-3	9	-9	-1	-1	3	-3	1	-3	3	-3	3	-9

Table 3. 9 The Correlation Matrix

	A	*B*	*C*	*D*	*E*	*F*	*AB*	*AC*	*AD*	*AE*	*AF*	*BC*	*BD*	*BE*	*BF*	*CD*	*CE*	*CF*	*DE*	*DF*	*EF*
A	1																				
B	0	1																			
C	0	0	1																		
D	0	0	0	1																	
E	0	0	0	0	1																
F	0	0	0	0	0	1															
AB	0	0	0	0	0	-0.2	1														
AC	0	0	0	0	0	0	0	1													
AD	0	0	0	0	0	0	0	0	1												
AE	0	0	0	0	0	0	0	0	0	1											
AF	0	-0.2	0	0	0	0	0	0	0.72	0	1										
BC	0	0	0	0	0	0	0	0	0	0	0	1									
BD	0	0	0	0	-0.45	0	0	0	0	0	0	0	1								
BE	0	0	0	-0.45	0	0	0	0	0	0	0	0	0	1							
BF	-0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	1						
CD	0	0	0	0	0	0	0	0	0	0.4	0	0	0	0	0	1					
CE	0	0	0	0	0	0	0	0	0.4	0	0.72	0	0	0	0	0	1				
CF	0	0	0	0	0	0	0	0	0	0.72	0	0	0	0	0	0	0	1			
DE	0	-0.45	0	0	0	0	0	0.4	0	0	0.09	0	0	0	0	0	0	0	1		
DF	0	0	0	0	0	0	0	0	0	0.09	0	0	0	0	0	0	0	0	0	1	
EF	0	0	0	0	0	0	0	0.72	0.09	0	0.32	0	0	0	0	0	0.36	0	0	0	1

The correlation matrix shows that the two-way interactions AC, AD, AE, BC, CD, CE, CF, DF, and EF are unconfounded with all of the main effects and some of the other two-way interaction effects. Hence, this design will allow the estimation of all of the main effects and some of the two-way interactions.

We assigned the attributes to each of the design columns in such a way that some of the important two-way interactions would be among the measurable ones e.g. frequency-time, duration-time, frequency-notification, and time-notification. "Frequency of outages" was assigned to column A, "duration of outages" to column B, "time of outages" to column C, "prior notification of outages" to column D, and "percentage change in monthly electricity bill" to column E. Column F was used in blocking. The profiles were then sorted by the blocking column (see Table 3.10).

Table 3. 10 Profiles with Attributes Assigned and Sorted Into Four Blocks

profile	Frequency of outages	Duration of outages	Time of outages	Prior notification of outages	Percentage change in monthly electricity bill	Block
3	-1	1	-1	1	-3	-3
5	1	-1	-1	1	3	-3
7	3	1	1	-1	-1	-3
12	-3	-1	-1	-1	-3	-3
13	-1	1	1	1	1	-3
20	1	-1	1	1	-1	-3
23	-3	-1	1	-1	1	-3
32	3	1	-1	-1	3	-3
2	-3	1	1	-1	3	-1
4	-1	-1	-1	1	-1	-1
6	3	-1	1	-1	-3	-1
10	-1	-1	1	1	3	-1
11	1	1	1	1	-3	-1

17	-3	1	-1	-1	-1	-1
28	3	-1	-1	-1	1	-1
29	1	1	-1	1	1	-1
1	1	-1	-1	-1	-3	1
16	-3	-1	1	1	-1	1
18	-1	1	-1	-1	3	1
22	3	1	-1	1	-3	1
25	-1	1	1	-1	-1	1
26	-3	-1	-1	1	3	1
27	1	-1	1	-1	1	1
30	3	1	1	1	1	1
8	3	-1	1	1	3	3
9	3	-1	-1	1	-1	3
14	1	1	1	-1	3	3
15	-1	-1	-1	-1	1	3
19	-3	1	-1	1	1	3
21	1	1	-1	-1	-1	3
24	-3	1	1	1	-3	3
31	-1	-1	1	-1	-3	3

After the J* profiles (i.e. the 32 profiles in our case) have been created, the following steps depend on whether an object-based or an attribute-based strategy is selected (Bunch et al., 1996). While in object based strategies the J^* profiles are assigned to choice sets, in attribute based strategies the J^* profiles form one of the alternatives (usually the first alternative) in the choice sets and the remaining alternatives in the choice set are created from this first alternative using various ways (e.g. shifting, foldover). In shifted designs, the alternatives in a choice set are created using modular arithmetic i.e. adding a generator to the first profile to generate the second alternative, and another generator to create the third alternative and so on. A foldover of the first alternative in the choice set is created by replacing each attribute level with its "*mirror image*" e.g. 0s with 1s, and 1s with 0s for 2-level attributes; 0s with 3s, 1s with 2s, 2s with 1s and 3s with 0s for 4-level attributes (Louviere et al., 2000). Bunch et al. (1996) compare experimental design strategies for CE with generic-attribute

MNL models, and with respect to design efficiency find the shifted designs to perform better than other design strategies.

Statistical efficiency is defined in terms of the information matrix X'X where the columns of the matrix X are the attributes, the rows are the J* profiles, and the elements are the attribute codes of the design (Bunch et al., 1996). D-optimal designs maximize the determinant of the information matrix (Burgess and Street, 2005). For a main-effects-only design, with *m* alternatives in each choice set, *k* attributes in each alternative and l_q levels for attribute *q* (the design can be asymmetric i.e. attributes may have different number of levels), the determinant of the information matrix is maximized when (see Theorem 1, Burgess and Street, 2005):

$$\det(C_{optimal}) = \prod_{q=1}^{k} \left(\frac{2S_q}{m^2 (l_q - 1) \prod_{i=1 i \neq q}^{k} l_i} \right)^{l_q - 1}$$

where S_q is "*the largest number of pairs of profiles that can have different levels for attribute q in a choice set. i.e. S_q is the max number of differences in the levels of attribute q in each choice set*".

$S_q =$	$(m^2-1)/4$	$l_q=2$, m odd
	$m^2/4$	$l_q=2$, m even
	$(m^2-(l_q x^2+2xy+y))/2$	$2<l_q<=m$
	$m(m-1)/2$	$l_q>=m$

and x and y are positive integers that satisfy the equation $m=l_q x+y$ for $0<=y<l_q$.

Using the expression above, we can calculate the S_q for example for attributes with different number of levels, when the number of alternatives in each choice set is 2, 3, and 4 (see Table 3.11).

Table 3. 11 Values of S_q for a Main-Effects-Only design, when m=2, 3, and 4

Number of Levels	S_q, when m=2	S_q, when m=3	S_q, when m=4
2	1	2	4
3	1	3	5
4	1	3	6
5	1	3	6
6	1	3	6
7	1	3	6

Each of the J* profiles of the OMEP becomes the first alternative in the choice sets and the second alternatives can be created by adding:

- 1 (mod 2) to attribute levels of attributes with two levels
- 1, or 2 (mod 3) to attribute levels of attributes with three levels
- 1, 2, or 3 (mod 4) to attribute levels of attributes with four levels

Care must be taken when the number of levels of an attribute is not a prime number, since this may lead to a failure in estimating the main effects of that attribute (Street at al., 2005).

Following the steps of shifting designs suggested above, we made each of the original 32 profiles our first alternative in every choice set (Service A), and created the second alternative (Service B) using modular arithmetic. In order to be able to use modular arithmetic we switched from orthogonal to design coding (see Table 3.12). For the four-level attributes the codes (-3, -1, 1, 3) were replaced with (0, 1, 2, 3) respectively and for the two-level attributes the codes (-1, 1) were replaced with (0, 1) respectively.

Table 3. 12 The Profiles of Service A

Block	profile	Frequency of outages	Duration of outages	Time of outages	Prior notification of outages	Percentage change in monthly electricity bill
0	3	1	1	0	1	0
0	5	2	0	0	1	3
0	7	3	1	1	0	1
0	12	0	0	0	0	0
0	13	1	1	1	1	2
0	20	2	0	1	1	1
0	23	0	0	1	0	2
0	32	3	1	0	0	3
1	2	0	1	1	0	3
1	4	1	0	0	1	1
1	6	3	0	1	0	0
1	10	1	0	1	1	3
1	11	2	1	1	1	0
1	17	0	1	0	0	1
1	28	3	0	0	0	2
1	29	2	1	0	1	2
2	1	2	0	0	0	0
2	16	0	0	1	1	1
2	18	1	1	0	0	3
2	22	3	1	0	1	0
2	25	1	1	1	0	1
2	26	0	0	0	1	3
2	27	2	0	1	0	2
2	30	3	1	1	1	2
3	8	3	0	1	1	3
3	9	3	0	0	1	1
3	14	2	1	1	0	3
3	15	1	0	0	0	2
3	19	0	1	0	1	2
3	21	2	1	0	0	1

3	24	0	1	1	1	0
3	31	1	0	1	0	0

From the profiles of Service A in Table 3.12, the profiles of Service B in Table 3.13 were created as follows:

- 1 (mod 4) was added to the "frequency of outages" column,
- 1 (mod 2) was added to each of the "duration of outages", "time of outages", and "prior notification of outages" columns, and
- 2 (mod 4) was added to the "percentage change in monthly electricity bill" column.

Table 3. 13 The Profiles of Service B

Block	profile	Frequency of outages	Duration of outages	Time of outages	Prior notification of outages	Percentage change in monthly electricity bill
0	3	2	0	1	0	2
0	5	3	1	1	0	1
0	7	0	0	0	1	3
0	12	1	1	1	1	2
0	13	2	0	0	0	0
0	20	3	1	0	0	3
0	23	1	1	0	1	0
0	32	0	0	1	1	1
1	2	1	0	0	1	1
1	4	2	1	1	0	3
1	6	0	1	0	1	2
1	10	2	1	0	0	1
1	11	3	0	0	0	2
1	17	1	0	1	1	3
1	28	0	1	1	1	0
1	29	3	0	1	0	0
2	1	3	1	1	1	2
2	16	1	1	0	0	3
2	18	2	0	1	1	1

2	22	0	0	1	0	2
2	25	2	0	0	1	3
2	26	1	1	1	0	1
2	27	3	1	0	1	0
2	30	0	0	0	0	0
3	8	0	1	0	0	2
3	9	0	1	1	0	3
3	14	3	0	0	1	1
3	15	2	1	1	1	0
3	19	1	0	1	0	0
3	21	3	0	1	1	3
3	24	1	0	0	0	2
3	31	2	1	0	1	2

In terms of the efficiency of design, this design has the desirable properties: orthogonality, level balance, and minimal overlap. This design is orthogonal since we created the set of profiles using the Orthogonal Design feature of SPSS 15.0. Orthogonality can also be seen in the correlation matrix in Table 3.9 above where all of the five main effects of interest are uncorrelated with each other. In addition, this design has level balance: all the levels appear any equal number of times in the profile sets. In order to have level balance we chose the number of levels for each attribute to be a power of two. In the 32-profile plan, each level appears 16 times in case of the two-level attributes, and eight times in case of the four-level attributes. By using modular arithmetic we shifted the levels of Service A to get the levels of Service B, and ensured that within each choice set no attribute level is used twice. Hence this design also has the property of minimal overlap.

The fourth property of design efficiency identified by Huber and Zwerina (1996) is utility balance. The closer the utility from the alternatives in a choice set, the more information is extracted from the respondent. We do not know the utility from the alternatives since we do not have any prior knowledge on the parameter estimates. However we can move in the direction of reducing the utility gap among the alternatives by replacing the dominating alternatives within each choice set. In order to determine the dominating profiles, we followed the methodology used by Carlsson and Martinsson (2008). We summed the codes of each profile of Service A and Service B, and looked at the absolute value of the difference in code-sums between the two alternatives (see Table 3.14).

Table 3. 14 Code-Sum Differences

Block	profile	code sum A	code sum B	Codesum Difference
0	3	3	5	2
0	5	6	6	0
0	7	6	4	2
0	12	0	6	6
0	13	6	2	4
0	20	5	7	2
0	23	3	3	0
0	32	7	3	4
1	2	5	3	2
1	4	3	7	4
1	6	4	4	0
1	10	6	4	2
1	11	5	5	0
1	17	2	6	4
1	28	5	3	2
1	29	6	4	2
2	1	2	8	6
2	16	3	5	2
2	18	5	5	0
2	22	5	3	2
2	25	4	6	2
2	26	4	4	0
2	27	5	5	0
2	30	8	0	8
3	8	8	2	6
3	9	5	5	0
3	14	7	5	2

3	15	3	5	2
3	19	4	2	2
3	21	4	8	4
3	24	3	3	0
3	31	2	6	4

Previously, in coding the attribute levels, we tried to make more precise the attribute levels from "more desirable" to "less desirable" (see Table 3.15). So that the higher the code-sum the less desirable that service will be.

Table 3. 15 Attribute Levels and Their Corresponding Design Codes

code	**Frequency of outages**	**Duration of outages**	**Time of outages**	**Prior notification of outages**	**Percentage change in monthly electricity bill**
0	twice a year	less than 6 hours	daytime	prior notification	5% higher
1	4 times a year	6 to 13 hours	night-time	no prior notification	10% higher
2	once a month				20% higher
3	8 times a month				30% higher

The maximum code-sum difference of nine occurs when an alternative has all the highest levels (3+1+1+1+3=9), and the other alternative has all the lowest levels (0+0+0+0+0=0). We therefore took code-sum differences of above 4 as an indication of dominance. As can be seen from Table 3.14, profiles 1, 8, and 12 of the two alternatives have code-sum differences of six, while profile 30 of the two alternatives have a code-sum difference of eight.

We also checked each choice set to make sure that the outage attribute levels of the two services are consistent with their percentage increases in the bill. This way the respondents are not given a choice set where among the two alternatives the one with poorer service has the higher increase in the bill or vice versa. This would not be realistic and would reduce the credibility of the CE. After these considerations, the "percentage change in monthly bill" level of profiles 1 and 12 of Service A were changed from 0 to 3, and profile 8 was changed from 3 to 0. In service B, the "percentage change in monthly bill" level of profile 30 was changed from 0 to 3, and of profile 21 was changed from 3 to 0. Finally, the design codes were replaced with the corresponding attribute labels and the choice sets were created (see Tables 3.16 and 3.17).

Table 3. 16 Service A

Block	Choice set	profile	Frequency of outages	Duration of outages	Time of outages	Prior notification of outages	Percentage change in monthly electricity bill
0	1	3	4 times a year	6 to 13 hours	daytime	no prior notification	5% higher
0	2	5	once a month	less than 6 hours	daytime	no prior notification	30% higher
0	3	7	8 times a month	6 to 13 hours	night-time	prior notification	10% higher
0	4	12	twice a year	less than 6 hours	daytime	prior notification	30% higher
0	5	13	4 times a year	6 to 13 hours	night-time	no prior notification	20% higher
0	6	20	once a month	less than 6 hours	night-time	no prior notification	10% higher
0	7	23	twice a year	less than 6 hours	night-time	prior notification	20% higher
0	8	32	8 times a month	6 to 13 hours	daytime	prior notification	30% higher
1	1	2	twice a year	6 to 13 hours	night-time	prior notification	30% higher
1	2	4	4 times a year	less than 6 hours	daytime	no prior notification	10% higher
1	3	6	8 times a month	less than 6 hours	night-time	prior notification	5% higher
1	4	10	4 times a year	less than 6 hours	night-time	no prior notification	30% higher
1	5	11	once a month	6 to 13 hours	night-time	no prior notification	5% higher
1	6	17	twice a year	6 to 13 hours	daytime	prior notification	10% higher
1	7	28	8 times a month	less than 6 hours	daytime	prior notification	20% higher
1	8	29	once a month	6 to 13 hours	daytime	no prior notification	20% higher
2	1	1	once a month	less than 6 hours	daytime	prior notification	30% higher
2	2	16	twice a year	less than 6 hours	night-time	no prior notification	10% higher

2	3	18	4 times a year	6 to 13 hours	daytime	prior notification	30% higher
2	4	22	8 times a month	6 to 13 hours	daytime	no prior notification	5% higher
2	5	25	4 times a year	6 to 13 hours	night-time	prior notification	10% higher
2	6	26	twice a year	less than 6 hours	daytime	no prior notification	30% higher
2	7	27	once a month	less than 6 hours	night-time	prior notification	20% higher
2	8	30	8 times a month	6 to 13 hours	night-time	no prior notification	20% higher
3	1	8	8 times a month	less than 6 hours	night-time	no prior notification	5% higher
3	2	9	8 times a month	less than 6 hours	daytime	no prior notification	10% higher
3	3	14	once a month	6 to 13 hours	night-time	prior notification	30% higher
3	4	15	4 times a year	less than 6 hours	daytime	prior notification	20% higher
3	5	19	twice a year	6 to 13 hours	daytime	no prior notification	20% higher
3	6	21	once a month	6 to 13 hours	daytime	prior notification	10% higher
3	7	24	twice a year	6 to 13 hours	night-time	no prior notification	5% higher
3	8	31	4 times a year	less than 6 hours	night-time	prior notification	5% higher

Table 3. 17 Service B

Block	Choice set	profile	Frequency of outages	Duration of outages	Time of outages	Prior notification of outages	Percentage change in monthly electricity bill
0	1	3	once a month	less than 6 hours	night-time	prior notification	20% higher
0	2	5	8 times a month	6 to 13 hours	night-time	prior notification	10% higher
0	3	7	twice a year	less than 6 hours	daytime	no prior notification	30% higher
0	4	12	4 times a year	6 to 13 hours	night-time	no prior notification	10% higher
0	5	13	once a month	less than 6 hours	daytime	prior notification	5% higher
0	6	20	8 times a month	6 to 13 hours	daytime	prior notification	30% higher
0	7	23	4 times a year	6 to 13 hours	daytime	no prior notification	5% higher
0	8	32	twice a year	less than 6 hours	night-time	no prior notification	10% higher
1	1	2	4 times a year	less than 6 hours	daytime	no prior notification	10% higher
1	2	4	once a month	6 to 13 hours	night-time	prior notification	30% higher
1	3	6	twice a year	6 to 13 hours	daytime	no prior notification	20% higher
1	4	10	once a month	6 to 13 hours	daytime	prior notification	10% higher
1	5	11	8 times a month	less than 6 hours	daytime	prior notification	20% higher
1	6	17	4 times a year	less than 6 hours	night-time	no prior notification	30% higher
1	7	28	twice a year	6 to 13 hours	night-time	no prior notification	5% higher
1	8	29	8 times a month	less than 6 hours	night-time	prior notification	5% higher
2	1	1	8 times a month	6 to 13 hours	night-time	no prior notification	10% higher
2	2	16	4 times a year	6 to 13 hours	daytime	prior notification	30% higher
2	3	18	once a month	less than 6 hours	night-time	no prior notification	10% higher
2	4	22	twice a year	less than 6 hours	night-time	prior notification	20% higher
2	5	25	once a month	less than 6 hours	daytime	no prior notification	30% higher
2	6	26	4 times a year	6 to 13 hours	night-time	prior notification	10% higher

2	7	27	8 times a month	6 to 13 hours	daytime	no prior notification	5% higher
2	8	30	twice a year	less than 6 hours	daytime	prior notification	30% higher
3	1	8	twice a year	6 to 13 hours	daytime	prior notification	20% higher
3	2	9	twice a year	6 to 13 hours	night-time	prior notification	30% higher
3	3	14	8 times a month	less than 6 hours	daytime	no prior notification	10% higher
3	4	15	once a month	6 to 13 hours	night-time	no prior notification	5% higher
3	5	19	4 times a year	less than 6 hours	night-time	prior notification	5% higher
3	6	21	8 times a month	less than 6 hours	night-time	no prior notification	5% higher
3	7	24	4 times a year	less than 6 hours	daytime	prior notification	20% higher
3	8	31	once a month	6 to 13 hours	daytime	no prior notification	20% higher

Each respondent will see eight choice sets: four for summer, and four for winter. We created eight different versions: Versions 1-4 consists of the original four blocks and within each block the first four choice sets are assigned to "Summer" and the next four to "Winter". Versions 5-8 reverses the order so that the profiles used in summer are now used in winter (see Table 3.18). This way each of the 32 profiles appears in both seasons e.g. profile 3 belongs to the "Summer" group in version 1 where it is in "Winter" in version 5.

Table 3. 18 CE Versions

Version	Choice set	Season	Profile
1	1	Summer	3
1	2	Summer	5
1	3	Summer	7
1	4	Summer	12
1	5	Winter	13
1	6	Winter	20
1	7	Winter	23
1	8	Winter	32
2	1	Summer	2
2	2	Summer	4
2	3	Summer	6
2	4	Summer	10
2	5	Winter	11
2	6	Winter	17

2	7	Winter	28
2	8	Winter	29
3	1	Summer	1
3	2	Summer	16
3	3	Summer	18
3	4	Summer	22
3	5	Winter	25
3	6	Winter	26
3	7	Winter	27
3	8	Winter	30
4	1	Summer	8
4	2	Summer	9
4	3	Summer	14
4	4	Summer	15
4	5	Winter	19
4	6	Winter	21
4	7	Winter	24
4	8	Winter	31
5	1	Winter	3
5	2	Winter	5
5	3	Winter	7
5	4	Winter	12
5	5	Summer	13
5	6	Summer	20
5	7	Summer	23
5	8	Summer	32
6	1	Winter	2
6	2	Winter	4
6	3	Winter	6
6	4	Winter	10
6	5	Summer	11
6	6	Summer	17
6	7	Summer	28
6	8	Summer	29
7	1	Winter	1
7	2	Winter	16
7	3	Winter	18
7	4	Winter	22
7	5	Summer	25
7	6	Summer	26
7	7	Summer	27
7	8	Summer	30
8	1	Winter	8
8	2	Winter	9

8	3	Winter	14
8	4	Winter	15
8	5	Summer	19
8	6	Summer	21
8	7	Summer	24
8	8	Summer	31

The order in which the respondents see the choice sets may have an impact on the parameter estimates if fatigue or learning effects are present in the CE. In cases of fatigue, the information obtained from choice sets towards the end of the experiment, and in cases of learning effects data obtained from choice sets in the beginning of the experiment may not be of good quality. Instead of giving the respondents additional choice sets to practice and then having to discard these from the final analysis, we have chosen to show first the respondents an example choice set and then present the choice sets to them in different orders. Completely randomizing the order in which the choice sets are presented to each respondent would require too many versions to be created. To keep the administration of the survey manageable but at the same time not to be totally ignorant of order bias, each of the eight blocks is presented in two different orders. This is done by switching the order of "Summer" and "Winter" groups (see Table 3.19): In version 1a, for example, the first four choice sets belongs to the "Summer" group and consists of profiles {3,5,7,12}. The second four choice sets are from the "Winter" group and contains profiles {13, 20, 23, 32}. In version 1b, the order of the two groups is changed and the respondent sees the "Winter" group first followed by the "Summer" group. However, the order of profiles within each group is maintained.

Table 3. 19 CE Versions for Testing Order Bias

Version	SET	SEASON	a	SEASON	b
1	1	Summer	3	Winter	13
1	2	Summer	5	Winter	20
1	3	Summer	7	Winter	23
1	4	Summer	12	Winter	32
1	5	Winter	13	Summer	3
1	6	Winter	20	Summer	5
1	7	Winter	23	Summer	7
1	8	Winter	32	Summer	12
2	1	Summer	2	Winter	11
2	2	Summer	4	Winter	17
2	3	Summer	6	Winter	28
2	4	Summer	10	Winter	29
2	5	Winter	11	Summer	2
2	6	Winter	17	Summer	4
2	7	Winter	28	Summer	6
2	8	Winter	29	Summer	10
3	1	Summer	1	Winter	25
3	2	Summer	16	Winter	26
3	3	Summer	18	Winter	27
3	4	Summer	22	Winter	30
3	5	Winter	25	Summer	1
3	6	Winter	26	Summer	16
3	7	Winter	27	Summer	18
3	8	Winter	30	Summer	22
4	1	Summer	8	Winter	19
4	2	Summer	9	Winter	21
4	3	Summer	14	Winter	24
4	4	Summer	15	Winter	31
4	5	Winter	19	Summer	8
4	6	Winter	21	Summer	9
4	7	Winter	24	Summer	14
4	8	Winter	31	Summer	15

BLOCK	SET	SEASON	a	SEASON	b
5	1	Winter	3	Summer	13
5	2	Winter	5	Summer	20
5	3	Winter	7	Summer	23
5	4	Winter	12	Summer	32
5	5	Summer	13	Winter	3
5	6	Summer	20	Winter	5

5	7	Summer	23	Winter	7
5	8	Summer	32	Winter	12
6	1	Winter	2	Summer	11
6	2	Winter	4	Summer	17
6	3	Winter	6	Summer	28
6	4	Winter	10	Summer	29
6	5	Summer	11	Winter	2
6	6	Summer	17	Winter	4
6	7	Summer	28	Winter	6
6	8	Summer	29	Winter	10
7	1	Winter	1	Summer	25
7	2	Winter	16	Summer	26
7	3	Winter	18	Summer	27
7	4	Winter	22	Summer	30
7	5	Summer	25	Winter	1
7	6	Summer	26	Winter	16
7	7	Summer	27	Winter	18
7	8	Summer	30	Winter	22
8	1	Winter	8	Summer	19
8	2	Winter	9	Summer	21
8	3	Winter	14	Summer	24
8	4	Winter	15	Summer	31
8	5	Summer	19	Winter	8
8	6	Summer	21	Winter	9
8	7	Summer	24	Winter	14
8	8	Summer	31	Winter	15

Finally, to make the choice decision more realistic, to each choice set the "Current Service" option was added (see Table 3.20 for an example of a choice set and Appendix 3.2 for a complete list of choice sets to be used in the pilot survey). This gives the respondents the option of staying with their current service when they do not find the other two alternatives attractive.

Table 3. 20 A Sample Choice Set (Pilot Study)

Power outages during summer (June – August)

v1A Choice set 1 -- Summer

	Service A	Service B	Current Service
Frequency of outages	4 times a year	once a month	Neither
Duration of outages	6 to 13 hours	less than 6 hours	Service A
Time of outages	daytime	night-time	nor
Prior notification of outages	no prior notification	prior notification	Service B:
Percentage change in monthly electricity bill	5% higher	20% higher	I prefer to stay with my current service
Your Choice	[ ]	[ ]	[ ]

3.7 The Revised Design

In March 2008, the questionnaire was tested via personal interviews with 36 respondents from the five districts. After conducting the pilot study, we observed that the levels of the frequency and duration of outages attributes were too high when paired with the percentage change in a monthly electricity bill attribute. For people to be willing to pay for the additional cost, the levels needed to be changed so that the alternatives in the choice sets were improvements over the current service at least with respect to one attribute level. For example when people have outages eight times a month this is hardly considered an improvement by the people and as a result few would be willing to pay any additional amount and still have as many outages. In addition, as respondents will be asked to make choices for summer and winter outages separately, the outage frequency levels need to make sense in terms of seasons as well. The frequency level of "4 times a year" would not be clear enough as to when these outages take place. Do all of them happen in the same season or are spread throughout the year? Similarly, "up to 6 hour" duration would be considered a long outage in the summer since people are concerned about the food in the refrigerator being spoiled. In order to differentiate between short and long outages, the duration levels were changed as well. As a result the attributes levels presented in Table 3.6 were changed as shown in Table 3.21 below.

Table 3. 21 Revised Attribute Levels (Main Survey)

Attribute	Number of Levels	Levels
Frequency of outages	4	once a year once in 3 months once a month twice a month
Duration of outages	2	less than 2 hours 2 to 8 hours
Time of outages	2	daytime night-time
Prior notification	2	prior notification no prior notification
Percentage change in monthly electricity bill	4	5% higher than now 10% higher than now 20% higher than now 30% higher than now

After restudying the correlation matrix in Table 3.9, we also realized that the initial assignment of the columns to the attribute labels would not allow the estimation of one of the most important interactions of interest, the frequency-duration interaction. Hence, the design columns were reassigned as shown in Table 3.22 below.

Table 3. 22 Design Columns Reassigned

Design Column	Attribute
A	Frequency of outages
C	Duration of outages
D	Time of outages
B	Prior notification
E	Percentage change in monthly electricity bill
F	Blocking

The measurable two-way interactions of interest after this reassignment are: frequency-duration, frequency-time, frequency-percentage change in the monthly electricity bill, prior notification-duration, and duration-time. After changing the attribute levels and reassigning the design columns, we went through the steps described in Section 3 of the previous chapter to create the revised choice sets. We checked for dominating alternatives as well as the realism of the choice decision. In Table 3.13 the profiles of Service B were created from the profiles of Service A by adding:

- 1 (mod 4) to the "frequency of outages" column,
- 1 (mod 2) to each of the "duration of outages", "time of outages", and "prior notification of outages" columns, and
- 2 (mod 4) to the "percentage change in the monthly electricity bill" column.

However, for the revised version, we wanted to find the combination of additions that would minimize the total number of dominating alternatives. To find such combination, we calculated the code-sum difference for each combination of modular addition (see Table 3.23).

Table 3. 23 Code-Sum Difference Results for Alternative Modular Additions

No.	Frequency of outages	Duration of outages	Time of outages	Prior notification of outages	Percentage change in monthly electricity bill	% code-sum difference >= 4
	mod 4	mod 2	mod 2	mod 2	mod 2	mod 4
1	1	1	1	1	1	19%
2	1	1	1	1	2	31%
3	1	1	1	1	3	19%
4	2	1	1	1	1	38%
5	2	1	1	1	2	25%
6	2	1	1	1	3	34%
7	3	1	1	1	1	19%
8	3	1	1	1	2	31%
9	3	1	1	1	3	13%

As can be seen from the Table 3.23 above, the last combination where 3(mod 4) is added to the four-level attributes, and 1(mod2) is added to the two-level attributes, generates the least number of dominating alternatives i.e. in 13% of the 32 choice sets the code-sum difference was greater than or equal to 4. The final version of the choice sets are presented in Table 3.24 below and in Appendix 3.3.

Table 3. 24 Final Version of the Choice Sets

			Service A					**Service B**				
Set	Block	profile	Freq.	Dur.	Time	Prior notif.	% change in bill	Freq.	Dur.	Time	Prior notif.	% change in bill
1	0	3	1	0	1	1	0	0	1	0	0	3
2	0	5	2	0	1	0	3	1	1	0	1	2
3	0	7	3	1	0	1	1	2	0	1	0	0
4	0	12	1	0	0	0	0	0	1	1	1	3
5	0	13	1	0	1	1	2	0	1	0	0	1
6	0	20	2	1	1	0	1	1	0	0	1	0
7	0	23	0	1	0	0	2	3	0	1	1	1

8	0	32	3	0	0	1	3	2	1	1	0	2
1	1	2	0	1	0	1	3	3	0	1	0	2
2	1	4	1	0	1	0	1	0	1	0	1	0
3	1	6	3	1	0	0	0	2	0	1	1	3
4	1	10	1	1	1	0	3	0	0	0	1	2
5	1	11	2	1	1	1	0	1	0	0	0	3
6	1	17	0	0	0	1	1	3	1	1	0	0
7	1	28	3	0	0	0	2	2	1	1	1	1
8	1	29	2	0	1	1	2	1	1	0	0	1
1	2	1	2	0	0	0	0	1	1	1	1	3
2	2	16	0	1	1	0	1	3	0	0	1	0
3	2	18	1	0	0	1	3	0	1	1	0	2
4	2	22	3	0	1	1	0	2	1	0	0	3
5	2	25	1	1	0	1	1	0	0	1	0	0
6	2	26	0	0	1	0	3	3	1	0	1	2
7	2	27	2	1	0	0	2	1	0	1	1	1
8	2	30	3	1	1	0	2	2	0	0	1	1
1	3	8	3	1	1	0	3	2	0	0	1	2
2	3	9	3	0	1	0	1	2	1	0	1	0
3	3	14	2	1	0	1	3	1	0	1	0	2
4	3	15	1	0	0	0	2	0	1	1	1	1
5	3	19	0	0	1	1	2	3	1	0	0	1
6	3	21	2	0	0	1	1	1	1	1	0	0
7	3	24	0	1	1	1	0	3	0	0	0	3
8	3	31	1	1	0	0	0	0	0	1	1	3

Service A							
Block	**Set**	**Profile**	**Frequency of Outages**	**Duration of Outages**	**Time of Outages**	**Prior Notification of Outages**	**Percentage Change in Monthly Electricity Bill**
0	1	3	once in 3 months	less than 2 hours	night-time	no prior notification	5% higher
0	2	5	once a month	less than 2 hours	night-time	prior notification	30% higher
0	3	7	twice a month	2 to 8 hours	daytime	no prior notification	10% higher
0	4	12	once in 3 months	less than 2 hours	daytime	prior notification	5% higher
0	5	13	once in 3 months	less than 2 hours	night-time	no prior notification	20% higher
0	6	20	once a month	2 to 8 hours	night-time	prior notification	10% higher
0	7	23	once a year	2 to 8 hours	daytime	prior notification	20% higher
0	8	32	twice a month	less than 2 hours	daytime	no prior notification	30% higher
1	1	2	once a year	2 to 8 hours	daytime	no prior notification	30% higher
1	2	4	once in 3 months	less than 2 hours	night-time	prior notification	10% higher
1	3	6	twice a month	2 to 8 hours	daytime	prior notification	5% higher
1	4	10	once in 3 months	2 to 8 hours	night-time	prior notification	30% higher
1	5	11	once a month	2 to 8 hours	night-time	no prior notification	5% higher
1	6	17	once a year	less than 2 hours	daytime	no prior notification	10% higher

1	7	28	twice a month	less than 2 hours	daytime	prior notification	20% higher
1	8	29	once a month	less than 2 hours	night-time	no prior notification	20% higher
2	1	1	once a month	less than 2 hours	daytime	prior notification	5% higher
2	2	16	once a year	2 to 8 hours	night-time	prior notification	10% higher
2	3	18	once in 3 months	less than 2 hours	daytime	no prior notification	30% higher
2	4	22	twice a month	less than 2 hours	night-time	no prior notification	5% higher
2	5	25	once in 3 months	2 to 8 hours	daytime	no prior notification	10% higher
2	6	26	once a year	less than 2 hours	night-time	prior notification	30% higher
2	7	27	once a month	2 to 8 hours	daytime	prior notification	20% higher
2	8	30	twice a month	2 to 8 hours	night-time	prior notification	20% higher
3	1	8	twice a month	2 to 8 hours	night-time	prior notification	30% higher
3	2	9	twice a month	less than 2 hours	night-time	prior notification	10% higher
3	3	14	once a month	2 to 8 hours	daytime	no prior notification	30% higher
3	4	15	once in 3 months	less than 2 hours	daytime	prior notification	20% higher
3	5	19	once a year	less than 2 hours	night-time	no prior notification	20% higher
3	6	21	once a month	less than 2 hours	daytime	no prior notification	10% higher
3	7	24	once a year	2 to 8 hours	night-time	no prior notification	5% higher
3	8	31	once in 3 months	2 to 8 hours	daytime	prior notification	5% higher

Service B							
Block	**Set**	**Profile**	**Frequency of Outages**	**Duration of Outages**	**Time of Outages**	**Prior Notification of Outages**	**Percentage Change in Monthly Electricity Bill**
0	1	3	once a year	2 to 8 hours	daytime	prior notification	30% higher
0	2	5	once in 3 months	2 to 8 hours	daytime	no prior notification	20% higher
0	3	7	once a month	less than 2 hours	night-time	prior notification	5% higher
0	4	12	once a year	2 to 8 hours	night-time	no prior notification	30% higher
0	5	13	once a year	2 to 8 hours	daytime	prior notification	10% higher
0	6	20	once in 3 months	less than 2 hours	daytime	no prior notification	5% higher
0	7	23	twice a month	less than 2 hours	night-time	no prior notification	10% higher
0	8	32	once a month	2 to 8 hours	night-time	prior notification	20% higher
1	1	2	twice a month	less than 2 hours	night-time	prior notification	20% higher
1	2	4	once a year	2 to 8 hours	daytime	no prior notification	5% higher
1	3	6	once a month	less than 2 hours	night-time	no prior notification	30% higher
1	4	10	once a year	less than 2 hours	daytime	no prior notification	20% higher
1	5	11	once in 3 months	less than 2 hours	daytime	prior notification	30% higher
1	6	17	twice a month	2 to 8 hours	night-time	prior notification	5% higher
1	7	28	once a month	2 to 8 hours	night-	no prior notification	10% higher

					time		
1	8	29	once in 3 months	2 to 8 hours	daytime	prior notification	10% higher
2	1	1	once in 3 months	2 to 8 hours	night-time	no prior notification	30% higher
2	2	16	twice a month	less than 2 hours	daytime	no prior notification	5% higher
2	3	18	once a year	2 to 8 hours	night-time	prior notification	20% higher
2	4	22	once a month	2 to 8 hours	daytime	prior notification	30% higher
2	5	25	once a year	less than 2 hours	night-time	prior notification	5% higher
2	6	26	twice a month	2 to 8 hours	daytime	no prior notification	20% higher
2	7	27	once in 3 months	less than 2 hours	night-time	no prior notification	10% higher
2	8	30	once a month	less than 2 hours	daytime	no prior notification	10% higher
3	1	8	once a month	less than 2 hours	daytime	no prior notification	20% higher
3	2	9	once a month	2 to 8 hours	daytime	no prior notification	5% higher
3	3	14	once in 3 months	less than 2 hours	night-time	prior notification	20% higher
3	4	15	once a year	2 to 8 hours	night-time	no prior notification	10% higher
3	5	19	twice a month	2 to 8 hours	daytime	prior notification	10% higher
3	6	21	once in 3 months	2 to 8 hours	night-time	prior notification	5% higher
3	7	24	twice a month	less than 2 hours	daytime	prior notification	30% higher
3	8	31	once a year	less than 2 hours	night-time	no prior notification	30% higher

CHAPTER 4 QUESTIONNAIRE DEVELOPMENT AND THE SURVEY

4.1 Introduction

In Chapter 3, we reviewed some of the experimental design issues frequently discussed in the literature, examined different experimental design strategies in detail and selected the one most appropriate for our purpose. We then identified the attributes and attribute levels from the results of the focus group and stakeholder interviews. Finally, using the selected design strategy, we created the choice sets contained in the CE.

The present chapter is structured as follows: First we explain the questionnaire development process, and then report the results of the pilot survey starting with the socio-demographics, followed by the estimation results of the CE, CVM, and AE models. Using feedback from the pilot survey and the stakeholder interviews, we then revise the questionnaire. Next we describe the sampling method and the sample size used in the main survey; explain the selection of the survey administration mode; give details of the field procedures; and finally report the summary statistics of the data from the main survey.

4.2 Questionnaire Development

4.2.1 Introduction

In devising the questions included in our questionnaire we benefited from previous questionnaires in the literature used in determining residential electricity customers' outage costs as well as other WTP for service improvement studies: Wacker et al., 1983; Bose and Shukla, 2001; CIE, 2001; Korman, 2002; Moeltner and Layton, 2002; KPMG, 2003; Hensher et al., 2005b; Layton and Moeltner, 2005; RIC, 2005; Carlsson and Martinsson, 2007; and Carlsson and Martinsson, 2008. We organised the questionnaire into five main sections (see Appendix 4.1): Current electricity service; preparatory actions (averting behaviour); WTP for an inverter system (a CVM question); WTP for improved electricity services (CE questions); and household characteristics.[24]

4.2.2 Current Electricity Service

4.2.2.1 Attitudes to the Electricity System

In the first section, we asked attitudinal questions regarding the current electricity service of the respondents. These questions are intended to reveal the respondents' attitudes toward the electricity system overall, as well as load shedding, and tariff variations. In phrasing the attitudinal questions, to limit automatic acceptance, reduce inattention, and encourage respondent engagement, we mostly used interrogative scaling rather than the agreement-with-statement scaling (Falthzik and Jolson, 1974; Haley and Case, 1979; Wong et al., 2003; Swain et al., 2008). For example, instead of phrasing the first question in Section 1A of the questionnaire as "In general, the power supply provided by my electric power company is very poor," and asking the respondents to state their opinion along a 5-point "strongly agree" to "strongly disagree" Likert scale, we let the respondent finish the end of the statement "In general, the power supply provided by my electric power company is …" by choosing from a 5-point "very good" to "very poor" scale.

[24] An inverter system provides reliable electricity supply by storing electricity in batteries when it is available from the utility and converting the current from DC to AC during an outage.

4.2.2.2 Reliability of Supply – Duration and Frequency of Interruptions as Perceived by Respondents

As perceived quality is found to have a positive impact on WTP more (Zeithaml et al., 1996), in addition to the attitudinal questions, we included questions on the duration and frequency of summer and winter interruptions (planned and unplanned) as perceived by the respondents. These data will be used in determining the respondents' current service attribute levels in the CE analysis, and as explanatory variables in the CVM analysis. We also included questions to determine the current notification period as perceived by the respondents and their preferred notification method.

4.2.2.3 Household's Electricity Usage

WTP for a reliable electricity supply among other things is expected to be related to the household's dependence on electricity (Munasinghe, 1980). To determine the level of dependency on electricity we asked questions on the respondents' housing type, size of house in square meters, their monthly electricity consumption (kWh), types of fuel used for space-heating, water-heating, and cooking. We also asked if there is someone at home most of the time, if any household members work from home and if their work at home depends on electricity. We then asked if there are any sickbed residents and whether they use electrical medical equipment at home. At the end of the first section of the questionnaire, we asked questions to find out the time of day when the outages have less impact on the household. Respondents are also asked to state whether frequent short interruptions are worse than one long interruption.

4.2.3 Preparatory Actions

The second section consisted of questions regarding what actions households take in preparation for the outages. The data from this section will be used in calculating households' AE. Respondents are asked to choose from a list of actions their households take in preparation for the failures. The cost per hour of each action will be calculated using market data. The number of hours multiplied by the cost per hour will give us the total cost per year, and the sum of all cost items will give us total AE per year per household.

4.2.4 WTP for an Inverter System: CVM

In Section 3 of the questionnaire, we designed a CVM question where we defined a hypothetical inverter system and using a payment card (payment ladder) format asked the respondents' WTP for the system in order to ensure a reliable power supply without any failures. To secure such a supply without any failures, they will pay their monthly electricity bill and the total monthly cost of the inverter system. 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 chose not to go for the inverter system then in a follow up question they were asked to give their reasons for not choosing the system. The follow up question is intended to separate the protest responses from valid zero values.

4.2.5 WTP for Improved Electricity Services: CE Method

Section 4 of the questionnaire relates to the CE part. After defining the five attributes and their levels, and showing an example of a choice set, respondents were shown the eight choice sets (one at a time) according to the version assigned for them.

4.2.6 Household Characteristics

Finally Section 5 of the questionnaire collected data on household characteristics. Apart from the service attributes, socio-demographic variables help explain the variation in WTP. We will be able to test whether people with certain socio-demographic characteristics (e.g. age, gender, work status, income level, geographic location, education level, etc.) have different WTP values. The demographic data will also be used in checking whether the sample used in our study is a good representation of the population from which it is drawn.

4.3 Pilot Survey

In March 2008, the questionnaire was tested via personal interviews with 36 respondents from the five districts. The results of the pilot survey are summarized below.

4.3.1 Household Characteristics

The majority of the respondents in the pilot study were married, female, TRNC citizens, born in Cyprus, residents of Lefkoşa or Girne, working in public organizations, with a four-year university degree, and a monthly total household income of above 4,000 YTL (see Table 4.1).

Table 4. 1 Household Characteristics

Q5.1	Gender of the respondent	Responses	Percentage
	Male	13	36.1%
	Female	23	63.9%

Q5.3	Do you work?	Responses	Percentage
	Yes	28	77.8%
	No	8	22.2%

Q5.4	What is the legal status of your work?	Responses	Percentage
	Public	20	71.4%
	Private	8	28.6%

Q5.5	What is your status at work?	Responses	Percentage
	Employee (Salary, wages)	25	89.3%
	Employer	2	7.1%
	Self-employed	2	3.6%
	Unpaid family worker	0	0%

Q5.6	What is the reason for not working?	Responses	Percentage
	Retired	1	14.3%
	Student	1	14.3%
	Household duties	5	71.4%
	Looking for a job, couldn't find one	0	0%
	Found a job, waiting to start	0	0%
	Other (please specify)	0	0%

Q5.7	Specify which of the following represent the total monthly income of all the members of your family (YTL) (including yourself)	Responses	Percentage
	Less than 950	1	2.8%
	950-1,250	0	0%
	1,251-1,500	1	2.8%
	1,501-1,750	0	0%
	1,751-2,000	2	5.6%
	2,001-2,250	4	11.1%

	2,251-2,500	0	0%
	2,501-2,750	0	0%
	2,751-3,000	1	2.8%
	3,001-3,250	3	8.3%
	3,251-3,500	2	5.6%
	3,501-4,000	0	0%
	4,001-4,500	6	16.7%
	4,501-5,000	7	19.4%
	More than 5,000	9	25.0%

Q5.8	Marital Status	Responses	Percentage
	Single (never married)	1	2.8%
	Married	34	94.4%
	Divorced/Separated	0	0%
	Widowed	1	2.8%

Q5.10	Which of the following best describes the highest level of formal education you have attained/completed?	Responses	Percentage
	No formal education	1	2.8%
	Primary school	2	5.6%
	Secondary school	2	5.6%
	College/high school	5	13.9%
	Technical school	1	2.8%
	University (2 year)	3	8.3%
	University (4 year bachelor)	14	38.9%
	Post graduate	8	22.2%

Q5.12	Your Place of Birth?	Responses	Percentage
	TRNC	19	52.8%
	South Cyprus	13	36.1%
	Turkey	1	2.8%
	Other country (please specify)	3	8.3%

Q5.13	Your Citizenship?	Responses	Percentage
	TRNC	13	43.3%
	TRNC and other country	15	50.0%
	TR	0	0%
	Other country	2	6.7%

Q5.14	Where do you reside?	Responses	Percentage
	Lefkoşa	12	33.3%
	Gazimağusa	3	8.3%
	Girne	15	41.7%
	Güzelyurt	5	13.9%
	İskele	1	2.8%

4.3.2 Current Electricity Service and Attitudes to the Electricity System

Respondents' attitudes to the current electricity system is summarized in Table 4.2. According to 17% of the respondents, the power supply provided by Kıb-Tek is poor or very poor. 22% think that the number of outages they have at home are high or very high. 47% disagree that their power supply has improved in the last year. 63% find the price of electricity to be high or very high. 33% have low or very low confidence in Kıb-Tek.

44% are not willing to reduce their consumption during the peak hours and 58% do not agree that consumption at peak hours should be charged more. With respect to season, day of the week, and notification status of the outages, the majority of the respondents find outages of all types to be equally disruptive. Outages during 6pm-11pm are regarded as the most disruptive by the respondents.

Table 4. 2 Current Electricity Service and Attitudes to the Electricity System

Q1A.1	In general, the power supply provided by my electric power company is	Responses	Percentage
	very good	0	0%
	good	14	38.9%
	fair	16	44.4%
	poor	5	13.9%

	very poor	1	2.8%

Q1A.2	I think that in general the number of failures of the electrical power to my home is	Responses	Percentage
	very low	0	0%
	low	8	22.2%
	moderate	20	55.6%
	high	7	19.4%
	very high	1	2.8%

Q1A.3	Our power supply has improved in the last year	Responses	Percentage
	strongly agree	0	0%
	agree	13	36.1%
	neither agree or disagree	6	16.7%
	disagree	16	44.4%
	strongly disagree	1	2.8%

Q1A.4	I think that the price of our electricity is	Responses	Percentage
	very low	0	0%
	low	0	0%
	moderate	13	37.1%
	high	14	40.0%
	very high	8	22.9%

Q1A.5	My confidence in our electricity authority is	Responses	Percentage
	very high	0	0%
	high	2	5.6%
	moderate	22	61.1%
	low	9	25.0%
	very low	3	8.3%

Load Shedding

Q1A.6	If during peak periods, the utility company 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?	Responses	Percentage
	Yes	20	55.6%
	No	16	44.4%

User Pays and Tariff Variations

Q1A.7	People who use electricity at peak times should pay more	Responses	Percentage
	strongly agree	1	2.8%
	agree	12	33.3%
	neither agree or disagree	2	5.6%
	disagree	18	50.0%
	strongly disagree	3	8.3%

Preferred Interruption Time for Unplanned and Planned Outages

Unplanned Outages

Q1C.16	When is an unplanned outage of uncertain duration most disruptive for your household? Summer or Winter?	Responses	Percentage
	Summer	9	25.0%
	Winter	13	36.1%
	Both equally disruptive	14	38.9%
	None	0	0%

Q1C.17	When is an unplanned outage of uncertain duration most disruptive for your household? Weekday or Weekend?	Responses	Percentage
	Weekday	8	22.2%
	Weekend	10	27.8%
	Both equally disruptive	18	50.0%
	None	0	0%

Q1C.18	When is an unplanned outage of uncertain duration most disruptive for your household?	Responses	Percentage
	6am to 9am	1	2.9%
	9am to 6pm	2	5.7%
	6pm to 11 pm	21	60.0%
	11pm to 6am	2	5.7%
	All equally disruptive	9	25.7%
	None	0	0%

Planned Outages

Q1C.19	When is a planned outage of certain duration most disruptive for your household? Summer or Winter?	Responses	Percentage
	Summer	7	20.6%
	Winter	9	26.5%
	Both equally disruptive	16	47.1%
	None	2	5.9%

Q1C.20	When is a planned outage of certain duration most disruptive for your household? Weekday or Weekend?	Responses	Percentage
	Weekday	7	20.6%
	Weekend	10	29.4%
	Both equally disruptive	14	41.2%
	None	3	8.8%

Q1C.21	When is a planned outage of certain duration most disruptive for your household?	Responses	Percentage
	6am to 9am	0	0%
	9am to 6pm	4	12.1%
	6pm to 11 pm	16	48.5%
	11pm to 6am	1	3.0%
	All equally disruptive	9	27.3%
	None	3	9.1%

Frequency versus Duration of Unplanned Interruptions

Q1C.22	Frequent short interruptions (30 minutes or less) are worse than one long interruption (more than 30 minutes).	Responses	Percentage
	strongly agree	8	22.2%
	agree	16	44.4%
	neither agree or disagree	6	16.7%
	disagree	6	16.7%
	strongly disagree	0	0%

4.3.3 Preparatory Actions

4.3.3.1 Preparatory Actions Data

In Section 2 of the questionnaire, respondents were asked about the actions their households take in preparation for outages. Out of the 36 respondents who participated in the pilot survey, 34 answered the preparatory actions question. More than half own candles and/or electric lanterns, and 29% have gas lamps. Around 24% own a generator. 20% have gas stoves (see Table 4.3).

Table 4. 3 Preparatory Action Results

Preparatory Action	Number	%
1. No preparation	0	0.0%
2. Candle	19	55.9%
3. Kerosene lamp	2	5.9%
4. Gas lamp	10	29.4%
5. Electric lantern (battery powered)	18	52.9%
6. Emergency kerosene stove	2	5.9%
7. Emergency gas stove	7	20.6%
8. Emergency kerosene heater	1	2.9%
9. Emergency gas heater	0	0.0%
10. Voltage regulator	0	0.0%
11. Surge protector	0	0.0%
12. Small generator	5	14.7%
13. Larger generator	3	8.8%
14. Standby Uninterrupted Power Supply (UPS) system	1	2.9%
15. Car battery connected to an inverter	0	0.0%
16. deep-cycle (lead-acid) battery(ies) connected to an inverter	0	0.0%

4.3.4 CVM Model

4.3.4.1 CVM Data

We use the CVM to elicit WTP for improved electricity supply reliability. The CVM question was in payment ladder (payment card) format (see Appendix 4.1 Section 3). We asked the respondent to consider a hypothetical inverter system that would be capable of running every household appliance at his/her house and as a result the household would never experience an interruption in supply. The respondents were asked whether they would choose such a system. If they said no, then they were further asked to explain the reasons for not going for the inverter system in order to distinguish the protest bids from the true zero WTP bids. The respondents were asked to put a tick next to the highest amount that were sure that they would pay and a cross next to the first amount that they were sure that they would not pay.

Out of the 36 people surveyed, 32 answered the CVM question. Six respondents chose not to go for the inverter system. While three of the latter group did not give an explanation for not going for the system, one stated that electricity was already too expensive, one said in other places municipalities pay for such investments and also her budget was not enough to pay for it, and the other said she did not know anybody using this system before and that she did not have enough information on the advantages and disadvantages. Treating these as protest responses and following the usual practice, we removed these six responses from the CVM analysis (O'Garra et al., 2007; Birol et al., 2008).

Turning to the 26 responses that had a WTP>0, the minimum bid was 10 YTL per month and the maximum was 200 YTL per month. The frequency distribution of the ticks and crosses are given as below (see Table 4.4). 38.5% of the respondents stated a minimum WTP of 50 YTL per month.

Table 4. 4 Number of Ticks and Crosses for the Bids Included in the Payment Ladder

Bid	Lower Bound (tick)	%	Upper Bound (cross)	%
10	1	3.8%	0	0.0%
20	7	26.9%	1	3.8%
30	3	11.5%	5	19.2%
40	1	3.8%	3	11.5%
50	10	38.5%	5	19.2%

70	1	3.8%	3	11.5%
90	0	0.0%	1	3.8%
120	3	11.5%	3	11.5%
150	0	0.0%	1	3.8%
200	0	0.0%	3	11.5%

Even within the remaining 26 records, some of the data for the explanatory variables were missing. In one the average monthly bill, in two the age, and in one the household size were missing. These were replaced with sample averages in order to be able to use all 26 observations in the estimation (Whitehead, 1994). Table 4.5 below presents the summary statistics of the data. Using the formula given in section 2.4.1.2, the LBM(Turnbull) is estimated as 43.08 YTL per month.

Table 4. 5 Summary Statistics

Variable	Definition	Mean	Std. Dev.	Min	Max
frequency	Number of outages in a year	73.79	47.40	14.50	156.25
duration	Average duration of an outage	3.05	1.33	1.00	7.00
totaloutage	Total duration of outages in a year	222.09	171.33	36.00	650.00
floorsize	House floor size	194.16	121.35	90.00	630.00
avgbill	Average monthly electricity bill	219.40	215.44	45.00	1000.00
heating	Percentage of house heating from electricity	0.47	0.35	0.00	1.00
cooking	Percentage of cooking from electricity	0.22	0.18	0.00	0.80
athome	1:Someone at home most of the time	0.50	0.51	0.00	1.00
generator	1: home has a generator	0.27	0.45	0.00	1.00
min	Min bid	46.54	30.98	10.00	120.00
max	Max bid	96.15	108.22	20.00	550.00
gender	1: male	0.35	0.49	0.00	1.00
age	Respondent's age	43.13	12.27	26.00	64.00
income	Average monthly income	4,130.15	1,587.85	1,375.50	6,000.00
hhsize	Household size	3.08	0.80	2.00	4.00

univ	1: has a university degree	0.65	0.49	0.00	1.00

4.3.5 CE

4.3.5.1 CE Data

The CE data was entered in a MS Excel worksheet as shown in Table 4.6 below. The form number of each respondent is entered on column "id". Column "vers" represents the questionnaire version seen by the respondent, "seas" the season (0: summer, 1: winter), "altij" the three alternatives (1: Service A, 2: Service B, and 3: Current Service), "nij" the number of alternatives in a choice set, and "choice" the respondent's selection (1: alternative chosen). The "freq" and "dur" columns have the data for average frequency of outages (per year) and average duration of outages (hours). The frequency and duration data for the current service alternative come from respondents' answers to Section 1B of the questionnaire. Where the current service data were missing, the district averages were used (see Table 4.7). Time and prior announcement data are effects coded. Daytime outages are coded with 1 and night-time outages with -1. In the "ann" column, 1 represents outages with prior notification, and -1 those with no prior notification. Finally "chbill" is the percentage change in the monthly electricity bill.

Table 4. 6 Sample Data Entry for One Respondent

id	vers	seas	altij	nij	choice	freq	dur	time	ann	chbill
1	1	0	1	3	1	4	9.5	1	-1	0.05
1	1	0	2	3	0	12	3	-1	1	0.2
1	1	0	3	3	0	156	2	0	-1	0
1	1	0	1	3	1	12	3	1	-1	0.3
1	1	0	2	3	0	96	9.5	-1	1	0.1
1	1	0	3	3	0	156	2	0	-1	0
1	1	0	1	3	0	96	9.5	-1	1	0.1

1	1	0	2	3	1	2	3	1	-1	0.3
1	1	0	3	3	0	156	2	0	-1	0
1	1	0	1	3	1	2	3	1	1	0.3
1	1	0	2	3	0	4	9.5	-1	-1	0.1
1	1	0	3	3	0	156	2	0	-1	0
1	1	1	1	3	0	4	9.5	-1	-1	0.2
1	1	1	2	3	1	12	3	1	1	0.05
1	1	1	3	3	0	156	2	0	-1	0
1	1	1	1	3	1	12	3	-1	-1	0.1
1	1	1	2	3	0	96	9.5	1	1	0.3
1	1	1	3	3	0	156	2	0	-1	0
1	1	1	1	3	0	2	3	-1	1	0.2
1	1	1	2	3	1	4	9.5	1	-1	0.05
1	1	1	3	3	0	156	2	0	-1	0
1	1	1	1	3	0	96	9.5	1	1	0.3
1	1	1	2	3	1	2	3	-1	-1	0.1
1	1	1	3	3	0	156	2	0	-1	0

Table 4. 7 Sample Averages for Frequency and Duration

District	Frequency (per year)		Duration (hours)	
	Summer	**Winter**	**Summer**	**Winter**
Lefkoşa	73.00	55.00	3.42	2.50
Gazimağusa	50.67	11.00	2.67	2.00
Girne	89.21	86.86	3.14	3.25
Güzelyurt	45.6	48.50	2.3	3.67
İskele	156	156	2	2

4.4 The Revised Questionnaire

The pilot study showed that 37% of the respondents found the questionnaire to be interesting, 32% too long, 7% difficult to understand, 10% educational, and 7% unrealistic/not credible. Considering the feedback from the pilot study, the following changes were made to the questionnaire (see Appendix 4.2):

Introduction

To increase the credibility of the survey, in the introduction section we added the sentence "Along with Birmingham University in the UK, we are conducting a survey to determine your perception of the current reliability of the electricity supply that your household is receiving from your electricity authority". To encourage true responses we added the sentence "There are no right or wrong answers. We are interested in your opinions."

Section 1

The introduction of question 6 in Section 1A was removed since it was found to be too long and confusing, and the question by itself is self explanatory. We added the attitudinal question 8 to determine consumers' expectations about the quality of their service within the next 12 months. The 17.5 MW generator had just arrived and was expected to be in service in September and the second 17.5 MW would be in service by the end of 2008. The Government announced in July 2008 that they would have a complete solution for the electricity problem and "be in a position to sell electricity to the South". AE and WTP for a reliable service will be affected by the expected reliability of the service by the respondents.

Section 1B was rephrased to include all power outages during the past twelve months (June 2007-May 2008). Instead of asking the same questions for summer and winter outages separately, this section was restructured to collect data on the total outages for the whole year and then calculate the outages in each season as a percentage of the total. Question 19 is added as it would be useful for the electricity authority to know the preferred notification method by the customers.

In Section 1C, question 25 and 26 are added to collect data on the number of air conditioners and water pumps owned by the household. These items are two sources of high electricity consumption in the summer months. More choices are added to question 27 to match the payment alternatives offered by the electricity authority. In addition to the questions on fuel types used for heating, and cooking, we added a question on water heating systems. Solar energy is widely used in North Cyprus for water heating at home. Preferred interruption times in questions 18 and 21 were changed to include midnight as part of the night-time as people stated that listening to news before going to sleep was important to them.

Section 2

The table in the preparatory actions section was found to be too detailed and difficult to understand. It was therefore simplified to include the most important fields only.

Section 3

The respondents found it difficult to understand the inverter system as described in the questionnaire. We rephrased it with simpler words. We also added min WTP and max WTP sections in case they chose the last choice of "more than 550YTL".

Section 4

We added question 56 to differentiate protest responses from genuine zero WTP answers.

Section 5

We moved the monthly income question to the end of the questionnaire in order not to create any uneasiness on the respondents' part. We changed the ranges as the minimum wage increased from 950 to 1060 during the carrying out of the main survey. The age categories were increased in question 8 to break up the 25-64 age group into more categories. The question on respondents' opinions on the survey was removed to make the questionnaire shorter.

4.5 Main Survey

4.5.1 Sampling Method and Sample Size

The population of interest in our study is households in North Cyprus. The State Planning Organization (SPO) of North Cyprus maintains a complete list of addresses of all households in North Cyprus and frequently updates this list. However these lists are only used by the SPO themselves and are not made available to private survey firms. The electricity authority of North Cyprus, Kıb-Tek, has a complete list of customers as well, however some of the customers registered as residential may actually be businesses. The main survey will be conducted by a private survey firm in North Cyprus, and since a complete list of Kıb-Tek customers is not available to them, the firm chose to follow a random walk strategy which will be explained below.

Once the sampling frame is determined, then the sampling strategy (the method with which the households included in the sample will be chosen from the population) needs to be selected. Since we intend to make inferences from the sample to all households in North Cyprus, we need to select one of the widely used probability sampling techniques. As also explained in Section 4 of Chapter 3, these are choice-based sampling (CBS); simple random sampling (SRS); and exogenous stratified random sampling (ESRS).

We will choose the ESRS as our sampling strategy, and the sampling frame will be divided into five strata based on the district in which the households reside. Of the 72,624 households in North Cyprus, 32% reside in Lefkoşa, 26% in Gazimağusa, 23% in Girne, 12% in Güzelyurt, and 8% in İskele (2006 Census). These percentages are used in distributing the targeted 340 interviews to each district (see Table 4.8). The budget allocated for the main survey, 2000 GBP, is one of the major determinants of the sample size selected for this study. With this sample size, at 95% confidence interval, the confidence level will be 5.31%.[25]

Table 4. 8 Targeted Number of Interviews in Each District

District	Number of Households	% of Total	Targeted Number of Interviews
Lefkoşa	22,996	32%	108
Gazimağusa	18,541	26%	87
Girne	16,583	23%	78
Güzelyurt	8,608	12%	40
İskele	5,896	8%	28
Total	**72,624**		**340**

[25] Using the minimum sample size formula from Chapter 3,

$$n \geq \frac{p(1-p)}{a^2}\left[\Phi^{-1}\left(1-\frac{\alpha}{2}\right)\right]^2$$

Solving for a when n= 340, p=0.5, and α=5%, gives a=5.31%

Sampling points in each district are allocated based on the list of ballot boxes. According to the latest presidential election in North Cyprus on April 17, 2005, the total number of ballot boxes is 577 (see Table 4.9).[26]

Table 4. 9 Number of Ballot Boxes in Each District

District	Number of Ballot boxes
Lefkoşa	172
Gazimağusa	147
Girne	115
Güzelyurt	76
İskele	67
Total	**577**

Within each district, the number of ballot boxes in each election region is related to the size of that settlement. The 40 ballot boxes (sampling points) used in the survey are randomly selected from the complete list of ballot boxes using the statistical software package SPSS 14.0 (see Table 4.10).

Table 4. 10 Sampling Points Included in the Main Survey

District	Ballot Box	Election Region
Lefkoşa		
	L15	Hamitköy
	L30	Alayköy-Alayköy
	L43	Değirmenlik-Saray Mah
	L57	Gönyeli-Gönyeli Mah
	L63	Gönyeli-Yenikent Mah
	L71	Lefkoşa-Arabahmet Mah
	L98	Lefkoşa-Köşklüçiftlik Mah

[26] http://www.mahkemeler.net

	L126	Lefkoşa-Küçük Kaymakli
	L134	Lefkoşa-Marmara Mah
	L138	Lefkoşa-Ortaköy Mah
	L157	Lefkoşa-Taşkinköy Mah
	L164	Lefkoşa-Yenişehir Mah
Lefkoşa	**Count**	**12**
Gazimağusa		
	M8	Ergenekon
	M10	Görneç
	M49	Gazimağusa-Baykal Mah
	M54	Gazimağusa-Canbulat Mah
	M62	Gazimağusa-Çanakkale Mah
	M73	Gazimağusa-Karakol Mah
	M96	Gazimağusa-Sakarya Mah
	M110	Gazimağusa-Zafer Mah
	M129	Serdarli-Serdarli
Gazimağusa	**Count**	**9**
Girne		
	G32	Ozanköy
	G37	Tepebaşi
	G44	Alsancak-Yayla Mah
	G53	Çatalköy-Çatalköy
	G62	Dikmen-Y.Dikmen Mah
	G69	Girne-Aş.Girne Mah
	G75	Girne-Karakum Mah
	G78	Girne-Karaoğlanoğlu
	G83	Girne-Yukari Girne Mah
Girne	**Count**	**9**
Güzelyurt		
	GZ6	Aydinköy
	GZ29	Güzelyurt-Aş.Bostanci
	GZ35	Güzelyurt-İsmetpaşa Mah
	GZ51	Güzelyurt-Piyale Paşa Mah
	GZ76	Lefke-Yeşilyurt Mah
Güzelyurt	**Count**	**5**
İskele		
	İ12	Çayirova
	İ21	Kumyali
	İ54	İskele-İskele Merkez
	İ61	Mehmetcik-Mehmetcik

	İ67	Yeni Erenköy- Yeni Erenköy
İskele	**Count**	**5**
	Total Count	**40**

4.5.2 Survey Administration Mode

The four most commonly used modes of survey administration are: in-person; telephone; mail; web-based/e-mail; and central facility (Louviere et al., 2000; Champ et al., 2003; Hensher et al., 2005c). The decision on which mode to choose depends among other things on the budget, the complexity of the questionnaire, the time constraint, and the non-response bias. We chose in-person interviews as our mode of survey administration mainly because:

1. Our questionnaire is relatively complex – it includes data collection using three different methodologies (AE, CVM, and CE). In addition, to the best of our knowledge, the CE method has never been tried in North Cyprus before. We feel that interviewer clarification may be needed during the interview.

2. We need to have control over the order of the questions. This is especially important in the CE section where the interviewer needs to introduce the choice sets one after the other to the respondents and remind them to treat each one as an independent decision.

3. We want to prevent the respondents from going back and changing their answers to earlier questions. This is especially important in making sure that the respondents treat each set as independent from the others in the CE section.

4. We want to have control over who in the household answers the questionnaire. We will be interviewing the head of the household.

5. We want to be able to judge the quality of the interview by observing the respondents' body language during the interview.

The in-person interview is one of the most frequently used modes in North Cyprus and therefore the respondents are familiar with this administration mode. The length of our questionnaire and its complexity makes it relatively impractical to use the telephone as the administration mode. According to the 2006 census, of the total 72,624 households in North Cyprus, 71% have at least one home-telephone, 40% have at least one computer, and 22% have internet connection at home. Hence, if telephone or web/e-mail administration modes were used, we would be excluding households who do not have a telephone or internet connection at home. In order to reduce interviewer influence, experienced interviewers will be used and they will be well-trained before the main survey.

4.5.3 Field Procedures

During July 29-August 3, 2008, the questionnaire went through a final revision and was put into the format used in the main survey. On August 4, 2008, a training session was held for the 21 interviewers. In the presence of the supervisors and the interviewers, the fieldwork manager and ourselves went through the questionnaire in detail, explained the sampling strategy, and gave all the other necessary information. The interviewers were given their allocated questionnaires together with their maps and sampling points. On August 5, 2008 they started the interviews.

The starting point at each sampling point (ballot box) was randomly determined and then from that starting point every 3rd dwelling was visited. The head of the household was selected as respondent in each household. The respondent had to be 18 years of age and over, a permanent resident of the dwelling contacted, the only household member interviewed, and interviewed individually without any disturbances or suggestions from anyone else.

The supervisors collected the completed questionnaires each day and checked that the interviewers followed the given instructions, maintained the quality and all went according to schedule. The supervisors also conducted 20% random callbacks to check whether that interview actually took place. The field manager contacted each supervisor on a daily basis to get an update on the survey status. The supervisors sent the questionnaires to the head office once every two days. On August 22, 2008, 350 interviews were completed (see Table 4.11). The data was entered, checked, and then submitted by the survey firm on August 30, 2008.

Table 4. 11 Observed Number of Interviews in Each District

District	Observed Number of Interviews
Lefkoşa	111
Gazimağusa	85
Girne	80
Güzelyurt	46
İskele	28
Total	**350**

The 21 interviewers involved in the survey on their first visit knocked on 505 front doors and completed 268 interviews. In 115 cases no eligible contacts were found. 110 people refused to take part in the survey (10 lack of interest, 88 lack of time, and 12 annoyed), and 12 interviews were interrupted (1 family-matters, 4 not interested, 7 annoyed). The 115 dwellings where no contact could be made during the first visit were revisited, and this time 82 interviews were completed, 4 interrupted (annoyed), and 29 refused to take part-in the survey (4 lack of interest, 17 lack of time, and 8 annoyed). Overall, 620 attempts were made, 505 dwellings were visited, and 350 interviews were completed. The response rate of the survey is high 69% (=350/505) probably due to high interest in the topic. The electricity problem is a topic that is on local news almost every day and a common discussion even during social gatherings in North Cyprus.

4.6 Summary Statistics of the Survey Data

4.6.1 Data

The data was entered in MS Excel. See Table 4.12 for the coding used in data entry.

Table 4. 12 Coding Used in Data Entry

Column	Code
id	whole number 1-350
Q1 - Q5, Q7 - Q8, Q21, Q37, Q47, Q67, Q70, district	whole number 1-5
Q6, Q38	whole number 1-3
Q9.1, Q14-Q18, Q22-26, Q28, Q29, Q53, interview duration	continuous number
Q9.2time	1: per day 2: per week 3: per month 4: per year
Q10-Q13, Q31.1-Q31.5, Q33.1-Q33.3, Q35.1-Q35.4	continuous number 1-100
Q19, Q43, Q46, Q68	whole number 1-6
Q20, Q27, Q55version	whole number 1-8
Q30.1, Q32.1 & Q34.1	1: have 0: don't have
Q30.2, Q32.2, & Q34.2	2: have 0: don't have
Q30.3, Q32.3, & Q34.3	3: have 0: don't have
Q30.4, Q34.4	4: have 0: don't have
Q30.5other	8: don't use anything
Q36, Q39, & Q40	1: yes 2: no
Q41, Q42, Q44, Q45, Q64	whole number 1-4
Q48.1-Q48.16	1: have 2: don't have
Q54	whole number 1-16
Q55.1 - Q55.8	1: Service A 2: Service B 3: Current Service
Q56.1, Q56.2	whole number 1-17
Q57	1: male 2: female
Q58, Q65.1-Q65.8	whole number
Q59	whole number 1-12
Q60	1: yes 2: no
Q61	0: no to Q60 1: public 2: private
Q62	0: no to Q60 otherwise 1-4

Q63	0: 1 to Q60 otherwise 1-5
Q66	whole number 1-9
Q69	whole number 1-13
interviewer	open ended
region	whole number 1-44

The income data was replaced with class midpoints. The last class (6,501 YTL and above) were replaced with 6,501 (Whitehead 2006). The missing data was replaced with region averages. Before the region averages were calculated the outliers were removed. 29 people's perceived frequency of outages were too high – 730 per year and above. These were removed in order not to overestimate the regional averages.

4.6.2 Household Characteristics

The household characteristics of the sample are summarized in Table 4.13 below. 66.3% of the sample consisted of males and the remaining 33.7% were female respondents. Our sample has a higher male percentage compared to the 2006 Census. The interviews were done with the head of the household, and in North Cyprus household heads are more likely to be male than female. The respondents were aged 18 and above. The youngest respondent was aged 18 and the oldest was 79.3. The weighted average age of the sample was 36.7. Using the 2006 census data, the weighted average calculated for ages 18 and above results in 39.1.

53.4% of the respondents were working. This was higher than the 2006 census percentage of 44.1%. Of the 53.4% working, 23.5% work for the public and 76.5% work for a private organization. Of the working respondents, 72.2% were employees, 11.8% were employers, 14.4% were self-employed, and 1.5% were unpaid family workers. The percentage of employers and self-employeds was slightly higher than those of the 2006 census. 46.6% of the respondents were not working. 47.25% of the non-working were students, 27.0% were retired people, and 17.8% were engaged with household duties. The percentage of single respondents, 40.0%, was slightly higher than the census result, 32.3%. The sample contained a higher percentage of students compared to the population and a lower percentage of housewives. The average household size of the sample was 3.28. This was close to the population average of 3.65.

The illiteracy rate in North Cyprus is 3.6%. In our sample, there were no illiterate respondents, and only 0.9% had no formal education. Among the respondents with formal education, 44.1% finished a high school/college, 16.7% finished a primary school, 14.7% graduated from a 4-year university program, and 14.1% completed a technical school. The sample had a lower percentage of primary school graduates since the sample excluded people younger than 18 years old. The sample had a higher percentage of Turkish respondents. 58% of these are employed and 39% are students at universities in North Cyprus.

Overall, the response rate of the survey is high and our sample is representative of the households in North Cyprus. Hence, we will be able to generalize our estimates from this sample to the entire population without having to weight sample observations (Walsh et al., 1984; Loomis, 1987).[27]

Table 4. 13 Household Characteristics

Q57	Gender of the respondent	Responses	Percentage	2006 Census
	Male	232	66.3%	54%
	Female	118	33.7%	46%
	Total	350		

Q58/59	Age Group	Responses	Percentage	2006 Census
	15-19	23	6.6%	8.3%
	20-24	71	20.5%	13.3%
	25-29	47	13.5%	11.2%
	30-34	30	8.6%	8.5%
	35-39	26	7.5%	7.2%
	40-44	34	9.8%	6.9%
	45-49	36	10.4%	5.9%
	50-54	30	8.6%	5.1%
	55-59	21	6.1%	4.3%
	60-64	11	3.2%	3.1%
	65 and over	18	5.2%	7.3%
	Unknown			0.3%
	Total	347		
	Weighted Average Age	36.7		32.10

Q60	Do you work?		Responses	Percentage	2006 Census
	Yes		187	53.4%	44.1%
		Q61. What is the legal status of your work?			
		Public	44	23.5%	

[27] Weighting of sample observations has been applied to correct for low response rates and over/under representation of socio-demographic variables that might have a significant impact on the WTP estimates (DuMouchel and Duncan, 1983; Carson and Mitchell, 1993; Petrolia et al., 2010; and Scarpa and Willis, 2010).

		Private	143	76.5%	
		Q62. What is your status at work?			
		Employee (Salary, wages)	135	72.2%	84.1%
		Employer	22	11.8%	5.3%
		Self-employed	27	14.4%	9.6%
		Unpaid family worker	3	1.6%	0.8%
		Unknown			0.2%
	No		163	46.6%	55.0%
		Q63. What is the reason for not working?			
		Retired	44	27.0%	21.3%
		Student	77	47.2%	32.1%
		Household duties	29	17.8%	31.2%
		Looking for a job, couldn't find one	11	6.7%	
		Found a job, waiting to start	2	1.2%	
		Other (please specify)			12.2%
		Unknown			3.2%
	Unknown				1.0%
	Total		350		

Q64	Marital Status	Responses	Percentage	2006 Census
	Single (never married)	140	40.0%	32.3%
	Married	195	55.7%	59.6%
	Divorced/Separated	6	1.7%	2.9%
	Widowed	9	2.6%	4.2%
	Unknown			1.0%
	Total	350		

Q65	Number of people living in the house. Age Group	Min	Max	Mean	2006 Census
	0-4	0	4	0.15	
	5-14	0	3	0.20	
	15-19	0	4	0.32	
	20-24	0	4	0.69	
	25-34	0	5	0.60	
	35-49	0	5	0.68	

	50-64	0	4	0.52	
	65 and above	0	2	0.11	
	Household Size	1	10	3.28	3.65

Q66	Which of the following best describes the highest level of formal education you have attained/completed?	Responses	Percentage	2006 Census
	Does not know how to read and write (illiterate)	0	0%	3.6%
	knows how to read and write (literate - no formal education)	3	0.9%	8.9%
	Literacy status not specified			0.9%
	Literate – Formal Education		99.1%	86.7%
	Primary school	58	16.7%	33.1%
	Secondary school	33	9.5%	11.3%
	College/high school	153	44.1%	31.1%
	Technical school	49	14.1%	7.5%
	University (2 year)	2	0.6%	2.0%
	University (4 year bachelor)	51	14.7%	12.9%
	Post graduate	1	0.3%	2.1%
	Total	350		

Q67	Place of birth of the respondent	Responses	Percentage	2006 Census
	Cyprus	222	63.4%	81.7%
	Turkey	118	33.7%	15.6%
	Bulgaria	7	2.0%	0.5%
	UK	2	0.6%	1.4%
	Kyrgyzstan	1	0.3%	

Q68	Citizenship of the respondent	Responses	Percentage	2006 Census
	TRNC	235	67.1%	52.6%
	TR	81	23.1%	27.5%
	TRNC-TR	21	6.0%	13.4%
	TRNC-UK	5	1.4%	1.5%
	TRNC-Bulgaria	7	2.0%	
	Kyrgyzstan	1	0.3%	

Q69	Specify which of the following represent the total monthly income of all the members of your family (TL) (including yourself)	Responses	Percentage
	Less than 1,060 YTL	49	15.6%
	1,061-1,500 YTL	63	20.1%
	1,501-2,000 YTL	54	17.2%
	2,001-2,500 YTL	39	12.4%
	2,501-3,000 YTL	40	12.7%
	3,001-3,500 YTL	24	7.6%
	3,501-4,000 YTL	11	3.5%
	4,001-4,500 YTL	10	3.2%
	4,501-5,000 YTL	7	2.2%
	5,001-5,500 YTL	10	3.2%
	5,501-6,000 YTL	2	0.6%
	6,001-6,500 YTL	1	0.3%
	More than 6,501	4	1.3%
	Total	314	

4.6.3 Current Electricity Service and Attitudes to the Electricity System

The respondents' attitudes to the electricity system are summarized in Table 4.14. The power supply provided by the electric power company is perceived as poor or very poor by 32.3% of the respondents. In order for this percentage to be more meaningful, it is important to note that for the 40.3% who perceive to have a fair power supply, the average perceived number of outages per year was 186.1 (or 3.6 per week) and the average perceived total duration of outages in a year was 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 household interviewed. Again it is worth noting that 42.9% of the respondents who stated to have a moderate number of failures in general, have also stated to have 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 the respondents agreed with the statement that their power supply had improved in the last year, 33.1% disagreed with this statement. A very high percentage, 87.1%, of the respondents thought that the price of their electricity is high or very high. Price increases in electricity have been on the news throughout summer 2008, and the electricity authority decided to peg the electricity prices to the fuel oil prices which meant that prices would automatically change every month starting July 2008. 37.4% of the respondents have low or very low confidence in their electricity authority.

If during peak periods, the utility company asked its customers to reduce their electrical consumption for a period of 2 to 4 hours, 42% of the respondents would not be willing to reduce their electrical consumption. 40.6% of the respondents disagree with the statement that people who use electricity at peak times should pay more. This is an important figure to be considered by the electricity authority which is currently considering switching to time-of-day pricing.

38.9% of the respondents do not think that their power supply will improve within the next 12 months. 57.35% of the respondents who disagreed with the statement in Q8 also disagreed with the statement in Q3 that their power supply had improved in the last year.

Table 4. 14 Current Electricity Service and Attitudes to the Electricity System

Q1	In general, the power supply provided by my electric power company is	Responses	Percentage
	very good	5	1.4%
	good	91	26.0%
	fair	141	40.3%
	poor	74	21.1%
	very poor	39	11.1%
	Total	350	

Q2	I think that in general the number of failures of the electrical power to my home is	Responses	Percentage	Average perceived number of failures for each category (from answers to Q9)
	very low	29	8.3%	33.97 times a year (0.7 per week)
	low	78	22.3%	71.97 times a year (1.4 per week)
	moderate	150	42.9%	162.66 times a year (3.1 per week)
	high	64	18.3%	168.43 times a year (3.2 per week)
	very high	29	8.3%	184.43 times a year (3.5 per week)
	Total	350		

Q3	Our power supply has improved in the last year	Responses	Percentage
	strongly agree	21	6.0%
	agree	110	31.4%
	neither agree nor disagree	103	29.4%
	disagree	93	26.6%
	strongly disagree	23	6.6%
	Total	350	

Q4	I think that the price of our electricity is	Responses	Percentage
	very low	3	0.9%
	low	3	0.9%
	moderate	39	11.1%
	high	108	30.9%
	very high	197	56.3%
	Total	350	

Q5	My confidence in our electricity authority is	Responses	Percentage
	very high	5	1.4%
	high	29	8.3%
	moderate	185	52.9%
	low	84	24.0%
	very low	47	13.4%
	Total	350	

Load Shedding

Q6	If during peak periods, the utility company 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?	Responses	Percentage
	Yes	94	26.9%
	No	147	42.0%
	Maybe	109	31.1%
	Total	350	

User Pays and Tariff Variations

Q7	People who use electricity at peak times should pay more	Responses	Percentage
	strongly agree	32	9.1%
	agree	75	21.4%
	neither agree nor disagree	101	28.9%
	disagree	98	28.0%
	strongly disagree	44	12.6%

Q8	Our power supply will improve within the next 12 months	Responses	Percentage
	strongly agree	7	2.0%
	agree	74	21.1%
	neither agree nor disagree	133	38.0%
	disagree	105	30.0%
	strongly disagree	31	8.9%
	Total	350	

As an indicator of attitude towards the current electricity service, for each respondent we can sum up the scores from questions 1-5 and 8. With this scale, a person with a negative attitude can be defined to be one who selected categories 4 or 5 (the last two categories) in each of these questions i.e. having total points of 24-30 (min=4×6 and max=5×6). A person with a positive attitude (i.e. who selected the first two categories) will have between 6-12 points (1×6 for min, and 2×6 for max), and a "neutral" person will have 18 points (3×6). The average total points for the sample is 20.1. This is between "neutral" and "negative".

Reliability of Supply – Duration and Frequency of Interruptions as Perceived by Respondents

An average household had 134.66 outages during the period June 2007-May 2008 (see Table 4.15). 14% of these outages had been notified, 35% happened at night, 39% happened during the previous summer (June-August 2007), and 50% happened during the previous winter (December 2007 – February 2008). The average duration of unannounced outages was 3.8 hours for summer, 4.14 hours for winter, and 3.18 hours for Fall/Spring. The longest interruption during the past twelve months lasted 6.11 hours. When an interruption is planned, on average, households are notified 0.78 days in advance. 54.3% of the respondents preferred to be notified through the media (TV, radio, newspaper, etc.).

Table 4. 15 Duration and Frequency of Interruptions as Perceived by Respondents

Q9	How often did you have power interruptions or blackouts during the past twelve months (June 2007-May 2008)? (Total frequency of outages in a year)						
	Responses	min	max	mean	mode	median	Std. Dev
	347	1.00	7,300.00	134.66	24	36	453.03

Q10	What percentage of these outages that you had during the past twelve months (June 2007-May 2008) was announced?						
	Responses	min	max	mean	mode	median	Std. Dev
	347	0.00	1.00	0.14	0.00	0.00	0.21

Q11	What percentage of these outages that you had during the past twelve months (June 2007-May 2008) happened at night-time?					
	Responses	min	max	mean	mode	median	Std. Dev
	347	0.00	1.00	0.35	0.30	0.30	0.24

Q12	What percentage of these outages that you had during the past twelve months (June 2007-May 2008)happened during the previous summer (June 2007- August 2007)						
	Responses	min	max	mean	mode	median	Std. Dev
	347	0.00	0.90	0.39	0.50	0.40	0.19

Q13	What percentage of these outages that you had during the past twelve months (June 2007-May 2008)happened during the previous winter (December 2007- February 2008)						
	Responses	min	max	mean	mode	median	Std. Dev
	347	0.00	1.00	0.50	0.50	0.50	0.20

Q14	What was the average duration of unplanned power interruptions or blackouts during last summer (June-August 2007)? (hours)						
	Responses	min	max	mean	mode	median	Std. Dev
	348	0.00	50.00	3.80	2.00	3.00	4.17

Q15	What was the average duration of unplanned power interruptions or blackouts during last winter (December 2007-February 2008)?						
	Responses	min	max	mean	mode	median	Std. Dev
	348	0.00	30.00	4.14	2.00	3.00	3.58

Q16	What was the average duration of unplanned power interruptions or blackouts during last fall (September-November, 2007) and spring (March-May, 2008)?						
	Responses	min	max	mean	mode	median	Std. Dev
	348	0.00	20.00	3.18	2.00	2.50	2.54

Q17	How long was the longest unplanned power interruption or blackout that you had during the past twelve months (June 2007-May 2008)?						
	Responses	min	max	mean	mode	median	Std. Dev
	348	0.00	40.00	6.11	6.00	6.00	3.75

Q18	When an interruption is planned, how many days in advance are you notified?						
	Responses	min	max	mean	mode	median	Std. Dev

	347	0.00	9.00	0.78	1.00	1.00	0.81

Q19	When an interruption is planned, by which of the following do you prefer to be notified?	Responses	Percentage
	letter	2	0.6%
	fax	1	0.3%
	media (TV, Radio, Newspaper, etc.)	190	54.3%
	email	5	1.4%
	SMS text message	80	22.9%
	telephone	72	20.6%
	Total	350	

Household's Electricity Usage

57.1 % of the respondents lived in a detached house, and 68.3% had ownership of the dwelling they lived in (see Table 4.16). The average dwelling had a floor-size of 128.01 meter-squared, with 4.74 rooms, 2.62 bedrooms, 1.29 air conditioners, and 0.72 water pumps. 77.4% of the respondents paid for their electrical usage at Kıb-Tek's cash office. An average household pays 220.15 YTL per month for their electricity and consumes 499.43 kWh of electricity (only 27% of the respondents answered the question on kWh consumption).

68.7% of the respondents use electricity and 42.8% use LPG for space heating. The average percentage of heating obtained is 50.14% from electricity, 6.31% from fuel-oil, 29.02% from LPG, and 13.81% from wood. 94.3% of the respondents use LPG for cooking. Percentage of cooking in a typical house is 12.56% from electricity, 84.01% from LPG, and 3.4% from wood. The high usage of LPG for cooking is probably because of the households' experience with the high frequency of outages. 80.2% of the respondents use electricity and 78.2% use solar energy for heating water at home. 43.74% of water heating in the house is from electricity, 45.77% from solar energy, and 10.34% from LPG.

53.7% of the households have someone at home most of the time. 16.3% work from home and 84% of these respondents' work somehow depends on electricity. 1.7% of the households have a sick-bed resident, and 1.7% use electrical medical equipment at home. For planned and unplanned outages, the majority of the respondents find outages at any season, day or time to be equally disruptive. 80.3% of the respondents agree with the statement that frequent short interruptions are worse than one long interruption.

Table 4. 16 Household's Electricity Usage

Q20	Dwelling type	Responses	Percentage	2006 Census
	Detached house	200	57.1%	51.6%
	Semi-detached house	20	5.7%	18.3%
	Terraced house	24	6.9%	5.5%
	Subsidiary house	3	0.9%	1.8%
	Multi-storey apartment or flat	100	28.6%	22.4%
	Other (Specify)	3	0.9%	0.3%
	Unknown			0.1%
	Total	350		

Q21	This house is	Responses	Percentage	2006 Census
	Your own	239	68.3%	61.2%
	Rented	107	30.6%	23.6%
	other	4	1.1%	14.9%
	Unknown			0.3%
	Total	350		

Q22	House floor-size (meter-squared)				
	Responses	min	max	mean	Std. Dev
	346	50.00	400.00	128.01	41.56

Q23	Number of rooms in the house				
	Responses	min	max	mean	Std. Dev
	347	2.00	11.00	4.74	1.58

Q24	Number of bedrooms in the house				
	Responses	min	max	mean	Std. Dev
	347	1.00	5.00	2.62	0.74

Q25	Number of air conditioners in the house				
	Responses	min	max	mean	Std. Dev
	347	0.00	5.00	1.29	1.26

Q26	Number of water pumps in the house				
	Responses	min	max	mean	Std. Dev
	347	0.00	2.00	0.72	0.51

Q27	How is payment made for your electrical usage?	Responses	Percentage
	Kıb-Tek's cashier's office	271	77.4%
	Automatic payment from the bank	56	16.0%
	Mobile cashier's office	3	0.9%
	Included in rent	7	2.0%
	Other (Specify)	1	0.3%
	Do not know	12	3.4%
	Total	350	

Q28	How much does your household currently pay every month for electricity received from the electricity authority?				
	Responses	min	max	mean	Std. Dev
	345	10.00	4,000.00	220.15	337.12

Q29	How much is your average monthly electricity consumption in kWh?				
	Responses	min	max	mean	Std. Dev
	95	30.00	6,000.00	499.43	648.34

Q30	Which of the following fuel types does your household use for heating your house? Please choose one or more of the following fuel types.	Responses	Percentage	2006 Census
	Electricity	239	68.7%	58.4%
	Fuel-oil	34	9.8%	12.2%
	LPG	149	42.8%	40.7%
	Wood	63	18.1%	16.1%
	Other	3	0.3%	
	Unknown			1.3%
	Total	348		

Q31	Percentage of house-heating obtained from this fuel				
		Responses	min	max	mean	Std. Dev
	Electricity	348	0.00	100.00	50.14	42.90
	Fuel-oil	348	0.00	100.00	6.31	20.87
	LPG	348	0.00	100.00	29.02	39.31
	Wood	348	0.00	100.00	13.81	31.62
	Other	348	0.00	100.00	0.43	5.99

Q32	Which of the following fuel types does your household use for cooking? Please choose one or more of the following fuel types.	Responses	Percentage
	Electricity	129	37.0%
	LPG	329	94.3%
	Wood	6	1.7%
	Other	0	
	Total	349	

Q33	Percentage of cooking in your house from this fuel					
		Responses	min	max	mean	Std. Dev
	Electricity	349	0.00	100.00	12.56	25.04
	LPG	349	0.00	100.00	84.01	27.85
	Wood	349	0.00	90.00	3.40	14.36
	Other	349	0.00	10.00	0.03	0.54

Q34	Which of the following water heating systems does your household use? Please choose one or more of the following systems.	Responses	Percentage	2006 Census
	Electricity	279	80.2%	
	Solar energy	272	78.2%	71.4%
	LPG	61	17.5%	

	Wood	1	0.3%	
	Other	1	0.3%	
	Total	348		

Q35	Percentage of water heating in your house from this fuel					
		Responses	min	max	mean	Std. Dev
	Electricity	348	0.00	100.00	43.74	30.90
	Solar energy	348	0.00	100.00	45.77	30.50
	LPG	348	0.00	100.00	10.34	26.39
	Wood	348	0.00	50.00	0.14	2.68

Q36	Is someone at home most of the time?	Responses	Percentage
	Yes	188	53.7%
	No	162	46.3%
	Total	350	

Q37	Does someone in your household work from home?		Responses	Percentage
	Never		293	83.7%
	Rarely		24	6.9%
	Sometimes		20	5.7%
	Very often		3	0.9%
	Always		10	2.9%
	Total		57	
		Q38 Does their work depend on the availability of electricity?		% of Total Responses
		not dependent	9	2.6%
		partially dependent	37	10.6%
		very much dependent	11	3.1%
		Total	57	
	Total		350	

Q39	Does your household have a sick-bed resident?	Responses	Percentage
	Yes	6	1.7%
	No	344	98.3%
	Total	350	

Q40	Does your household use electrical medical equipment at home?	Responses	Percentage
	Yes	7	2.0%
	No	343	98.0%
	Total	350	

Preferred Interruption Time for Unplanned and Planned Outages

Unplanned Outages

Q41	When is an unplanned outage of uncertain duration most disruptive for your household? Summer or Winter?	Responses	Percentage
	Summer	119	34.0%
	Winter	91	26.0%
	Both equally disruptive	140	40.0%
	None	0	0.0%
	Total	350	

Q42	When is an unplanned outage of uncertain duration most disruptive for your household? Weekday or Weekend?	Responses	Percentage
	Weekday	56	16.0%
	Weekend	67	19.1%
	Both equally disruptive	226	64.6%
	None	1	0.3%
	Total	350	

Q43	When is an unplanned outage of uncertain most disruptive for your household?	Responses	Percentage
	6:01am to 9:00am	18	5.1%
	9:01am to 6:00pm	61	17.4%
	6:01pm to 12:00 midnight	122	34.9%
	12:01midnight to 6:00am	10	2.9%
	All equally disruptive	138	39.4%
	None	1	0.3%
	Total	350	

Planned Outages

Q44	When is a planned outage of certain duration most disruptive for your household? Summer or Winter?	Responses	Percentage
	Summer	81	23.1%
	Winter	81	23.1%
	Both equally disruptive	184	52.6%
	None	4	1.1%
	Total	350	

Q45	When is a planned outage of certain duration most disruptive for your household? Weekday or Weekend?	Responses	Percentage
	Weekday	54	15.4%
	Weekend	60	17.1%
	Both equally disruptive	232	66.3%
	None	4	1.1%
	Total	350	

Q46	When is a planned outage of certain duration most disruptive for your household?	Responses	Percentage
	6:01am to 9:00am	18	5.1%
	9:01am to 6:00pm	62	17.7%
	6:01pm to 12:00 midnight	116	33.1%
	12:01midnight to 6:00am	15	4.3%
	All equally disruptive	137	39.1%
	None	2	0.6%
	Total	350	

Frequency versus Duration of Unplanned Interruptions

Q47	Frequent short interruptions (30 minutes or less) are worse than one long interruption (more than 30 minutes).	Responses	Percentage
	strongly agree	120	34.3%
	agree	161	46.0%
	neither agree or disagree	35	10.0%
	disagree	25	7.1%
	strongly disagree	9	2.6%
	Total	350	

CHAPTER 5 RESULTS FROM THE AE STUDY

5.1 Introduction

In Chapter 4, we reported the results of the pilot study and revised the questionnaire accordingly. We described the sampling method, sampling size, the survey administration mode and the field procedures used in the main survey. Finally we presented the summary statistics of the survey data. In this chapter, we estimate households' WTP for electricity service improvements using their AE (a revealed preference approach). Each household has a preferred level of electricity dependent services depending on, among other things, its stock of electricity appliances, other consumption goods, and household characteristics. Therefore when the electricity service from the utility company falls below the level required to produce the household's preferred level of services, the household engages in mitigating actions in order to improve the service towards its desired level. Some of these averting behaviours are using candles, stand-by generators, voltage regulators, UPS, emergency lanterns, and emergency stoves. In Chapter 2, we provided the theoretical framework for AE and showed that the cost savings, achieved when holding household electricity consumption level constant when service improves, will be a lower bound on the welfare measure of the reliability change.

This chapter is organised as follows: In Section 2, we summarize the averting actions the households take in response to the outages in North Cyprus. In Section 3, we provide summary statistics for the ownership and usage of devices associated with averting action. Explanation of how the unit prices of averting actions are obtained in Section 4 is followed by expenditure calculations in Section 5. In Section 6, we compare averting behaviour and expenditures for different groups of households. The households are grouped by district, income level, and perceived service level (outage frequency and duration). Finally in Section 7, the AE are estimated using a Tobit regression.

5.2 Households' Averting Behaviour

In Section 2 of the questionnaire (see Appendix 4.2), respondents were asked about the actions their households take in preparation for service failures. Out of the 350 respondents who participated in the survey, all answered the preparatory actions question and 323 (92.6%) took at least one preparatory action: 49.4% one action only; 32.6% two actions; 8.3% three actions; and 2.0% four actions (see Table 5.1). To cope with the frequent and usually unannounced outages, respondents own/use one or more of the following: candle; kerosene lamp; gas lamp; electric lantern (rechargeable battery powered); emergency kerosene stove; emergency gas stove; emergency kerosene heater; emergency gas heater; voltage regulator; surge protector; generator; uninterrupted power supply (UPS) system; and car battery connected to an inverter. Mainly respondents use candles (55.1%), gas lamps (31.7%), and electric lanterns (23.4%) for lighting during an outage (see Table 5.1).

It can be seen from Table 5.1 that the majority of the averting behaviour is aimed at maintaining the lighting needs of the households (candles and emergency lamps). One explanation for this is that candles are very cheap, easy to store, and require no additional expenditures. On the other hand, households are much less likely to take preventive actions for their cooking and space heating needs during an outage. Outages in North Cyprus have been occurring mainly since 1994, and people, in general, have learned not to depend entirely on electricity for their major household activities such as cooking and space heating. 65% of respondents use non-electric sources for space heating. The percentage of heating obtained from non-electric sources is 49%. The figures are even more striking for cooking and water heating: 95% and 87% of respondents use non-electric sources for cooking and water heating respectively. On average, 95% of cooking and 56% of water heating activities of the household are met by non-electric devices. Mixed solutions are common in North Cyprus where they have an electrical oven and a stove top with gas burners (or a combination of gas and electric burners). Even if the fuel choice cannot be entirely attributed to the unreliability of electricity supply, the high percentage of usage of non-electric sources for cooking, water and space heating means that during an outage these activities are not completely interrupted. [28]

Table 5. 1 Averting Actions Taken by Households

	Total = 350	
Averting Action	**Number**	**%**
No preparation	27	7.7%
Candle	193	55.1%
Emergency Gas lamp	111	31.7%
Electric Lantern (battery powered)	82	23.4%
Emergency Kerosene lamp	43	12.3%
Generator	35	10.0%
Emergency Gas Stove	17	4.9%
Emergency Kerosene Stove	15	4.3%
Emergency Gas Heater	7	2.0%
Standby Uninterrupted Power Supply (UPS) System	7	2.0%
Emergency Kerosene Heater	2	0.6%
Voltage Regulator	2	0.6%
Surge Protector	1	0.3%
Car Battery Connected to an Inverter	1	0.3%

[28] During a phone interview with one of the major electrical appliance vendors in North Cyprus in August, 2009, it was stated that approximately 95% of ovens they sell in North Cyprus are electric, and 95% of stoves they sell are gas. According to the vendor, one of the main reasons for choosing electric over gas is their multi-functionality (availability of different settings). On the other hand, despite their ease in cleaning, electric stoves are still more expensive than gas ones. Also, the heat is better controlled in gas stoves.

Deep-cycle (lead-acid) Battery(ies) Connected to an Inverter	0	0.0%
Number of Actions Taken by Households	**Number**	**%**
0	27	7.7%
1	173	49.4%
2	114	32.6%
3	29	8.3%
4	7	2.0%

5.3 Averting Behaviour: Ownership and Usage Frequency

For each averting action taken by the households, in order to be able to calculate that action's average cost, we asked the households the total number of units they owned, the average number of units they used during an outage, and the total number of hours they used each unit in a year (during outages).[29] Table 5.2 summarizes the averting behaviour related ownership and usage frequency data collected from the respondents. For example, out of the 193 candle users, 43 did not provide the quantity of candles they used at each outage and 83 did not give the number of hours each candle was used. The averages for quantity owned and hours used given that a respondent uses candles are 2.66 candles and 13.54 hours respectively. The missing data were replaced by these averages. We followed the same procedure in the treatment of missing data for the remaining averting behaviours taken by the respondents (see Table 5.2)

[29] In order to be able to calculate expenditures related to outages only (and exclude regular usage of equipment during other times), the usage data (quantity and hours used) were taken on outage basis. This way all operational expenditures can be attributed to the outages.

Table 5. 2 Treatment of Missing Data

		Quantity Owned		Quantity Used per Outage		Total Hours Used per Year	
Preparatory Action	Total	No. Missing	Replace With	No. Missing	Replace With	No. Missing	Replace With
Candle	193	--	--	43	2.66	83	13.54
Kerosene lamp	43	1	1.21	1	1.14	6	17.28
Gas lamp	111	1	1.40	1	1.24	13	22.85
Electric lantern	82	3	1.53	3	1.26	12	120.00
Emergency kerosene stove	15	1	2.00	1	1.46	2	11.62
Emergency gas stove	17	0		0		1	11.13
Emergency Kerosene heater	2	0		0		0	
Emergency gas heater	7	1	1.50	1	1.00	1	18.92

Table 5.3 below gives the summary statistics for the averting behaviour related ownership and usage frequency data collected from the respondents. On average the number of items used per outage for each preparatory action is between 0.97 and 2.67 (the lowest number being for generators and the highest for candles). Usage of each item ranged from 6.0 to 44.4 hours per year.

Table 5. 3 Summary Statistics for Households' Averting Behaviour: Ownership and Usage Frequency

		Quantity Owned			
Averting Behaviour	No. of Households	mean	std. dev.	min	max
candle	193	--	--	--	--
emergency kerosene lamp	43	1.21	0.46	1.00	3.00
emergency gas lamp	111	1.40	0.54	1.00	3.00
electric lantern	82	1.52	0.95	1.00	7.00
emergency kerosene stove	15	2.00	1.20	1.00	4.00
emergency gas stove	17	1.53	0.72	1.00	3.00

emergency kerosene heater	2	1.00	0.00	1.00	1.00
emergency gas heater	7	1.50	0.50	1.00	2.00
voltage regulator	2	1.00	0.00	1.00	1.00
surge protector	1	1.00	0.00	1.00	1.00
generator	35	1.00	0.00	1.00	1.00
ups	7	1.00	0.00	1.00	1.00
car battery connected to an inverter	1	1.00	0.00	1.00	1.00

		Quantity Used per Outage			
Averting Behaviour	No. of Households	mean	std. dev.	min	max
candle	193	2.67	1.44	1.00	10.00
emergency kerosene lamp	43	1.14	0.35	1.00	2.00
emergency gas lamp	111	1.25	0.42	1.00	2.00
electric lantern	82	1.25	0.85	0.00	7.00
emergency kerosene stove	15	1.46	0.99	0.00	3.50
emergency gas stove	17	1.06	0.56	0.00	2.00
emergency kerosene heater	2	1.00	0.00	1.00	1.00
emergency gas heater	7	1.00	0.58	0.00	2.00
voltage regulator	2	1.00	0.00	1.00	1.00
surge protector	1	1.00	0.00	1.00	1.00
generator	35	0.97	0.17	0.00	1.00
ups	7	1.00	0.00	1.00	1.00
car battery connected to an inverter	1	1.00	0.00	1.00	1.00

		Hours Used in a Year			
Averting Behaviour	No. of Households	mean	std. dev.	min	max
candle	193	13.6	8.7	0.8	56.0
emergency kerosene lamp	43	17.3	13.2	2.0	70.0
emergency gas lamp	111	21.7	23.1	0.0	145.0
electric lantern	82	18.4	17.5	0.0	120.0
emergency kerosene stove	15	11.6	10.8	0.0	36.0
emergency gas stove	17	11.1	10.2	0.0	40.0
emergency kerosene heater	2	6.0	5.7	2.0	10.0
emergency gas heater	7	18.9	12.8	0.0	36.0
generator	35	44.4	40.4	0.0	153.6

5.4 Averting Behaviour: Equipment Particulars and Average Unit Prices

In order to calculate a household's total monthly AE, in addition to the ownership and usage data provided by the household, we also need other market and engineering data such as the economic life, fuel consumption rate, and the unit prices for the equipment and other materials used in each action. So that we lessen the burden placed on the respondents and keep the questionnaire at a reasonable length, for the most part we chose to acquire this data from the vendors and manufacturers ourselves.

However, generators, UPS systems, and batteries connected to inverters come in different capacities and therefore have a wider range of prices. For these items therefore, we collected more detailed information from the respondents. The generator question (Appendix 4.3 question 49) asked about: make, capacity, type of fuel, average number of hours run in a month, monthly fuel consumption, monthly expenditure on fuel, capital and installation cost, number of times maintained in year, cost of each maintenance, and contribution of each household if jointly owned. Similarly for the UPS and inverter systems the respondents were asked to provide the equipment characteristics and monthly expenditures in detail (see Appendix 4.3 questions 51).

We present our findings on economic life, fuel consumption, and average market prices (2008 prices) for each item in Table 5.4 below. The missing data for generators, UPS and inverter systems were replaced by these market averages.

Table 5. 4 Engineering and Market Data

Fuel Type	Fuel Prices (2008 average)[30]
Gasoline	2.11 YTL/litre
Diesel	2.08 YTL/litre
Kerosene	1.85 YTL/litre
Butane gas	0.0076 YTL/gram
Electricity	0.30 YTL/kWh

Averting Behaviour	Economic Life (years)	Fuel Consumption	Average Unit Price (YTL, 2008)
candle (2cm diameter, 10cm length)		2.33 candles/hour[31]	0.43
emergency kerosene lamp	10	0.023 litres/hour[32]	
lamp			5.13
glass cover			1.25
1 meter wick			1.00
emergency gas lamp	10	13.92 grams/hour[33]	
stove head			31.57
wick			1.00
gas tube (one time deposit)			8.50
electric lantern	5	0.024 kWh/charging	39.36
emergency kerosene stove	10	0.254 litres/hour[34]	
stove			25.62
wick			1.00
emergency gas stove	10	243.57 grams/hour[35]	
stove head			20.50
gas tube (one time deposit)			8.50
emergency kerosene heater	10	0.254 litres/hour	
heater			33.13
wick			29.00
emergency gas heater	10	115.00 grams/hour[36]	
heater			28.00
gas tube (one time deposit)			8.5
voltage regulator	10		167.63

30 TRNC Ministry of Economy and Energy
31 http://ezinearticles.com/?Emergency-Storage-Quantities-For-Fuel-Related-Items&id=1206062
32 van der Plas, R. (1988), "Domestic lighting", Working Paper WPS 68, Industry and Energy Department, World Bank
33 http://www.emerge-agency.net/files/PowrLit.doc
34 http://www.nitro-pak.com/product_info.php?products_id=637; and http://www.alibaba.com/product-gs/222780006/kerosene_stove.html
35 http://www.theoutdoorworld.com
36 http://www.tradekey.com/product_view/id/106071.htm

surge protector	10		80.55
generator	15		
1 KVA		0.600 litres/hour[37]	466.52
2 KVA		1.051 litres/hour	707.47
3 KVA		1.477 litres/hour	1351.65
4 KVA		1.958 litres/hour	1983.75
5 KVA		2.676 litres/hour	2432.00
ups	5		
600 VA			76.42
650 VA			99.93
1000 VA			135.20
1500 VA			257.44
inverter (connected to car battery)	10		60.32

5.5 AE

The monthly expenditure for each averting action taken by the household is calculated as:

Monthly Expenditure = monthly investment cost + monthly operating cost

+ monthly maintenance costs

Monthly Investment Cost = total investment cost × (monthly opportunity cost of capital

+ monthly depreciation rate)

We assumed an annual opportunity cost of capital of 10% (or monthly 0.8% = $(1+10\%)^{1/12} - 1$), and used the straight line depreciation method to calculate the monthly depreciation rate given each item's economic life. [38] The formula above for calculating the AE is presented in more detail for each averting action in Table 5.5 below. Using the ownership and usage data collected from the

[37] http://www.hepsiburada.com
[38] The average real interest rate on Turkish Lira for the period of 2006-2008 is around 10%. (TRNC Central Bank web site http://www.kktcmb.trnc.net)

respondents, the market and engineering data presented in Table 5.4, and the formulas in Table 5.5, we calculated the monthly AE for each action taken by the households (see Tables 5.5 and 5.6).

Initially 37 respondents said that they used generators during outages. When we examined the data however, the capacities of two of them were too big to be used for residential purposes (22 and 72 kVA). Considering that these households lived in average size houses, these generators were more likely to be used for commercial purposes, so they were not included in generator expenditure estimations. The generator data consists of: make, capacity, type of fuel, average number of hours run in a month, monthly fuel consumption, monthly expenditure on fuel, capital and installation cost, number of times maintained in year, cost of each maintenance, and contribution of each household if jointly owned. Since we collected detailed data on the generator particulars, we were able to guess missing values. For example, in 12 cases, the respondents did not remember the investment cost of the generator but provided us with sufficient details (make, capacity) so that we could replace these missing values with their market averages. 13 respondents did not provide the number of hours the generators were used in a month. From the remaining responses we observed that average generator usage is 25.6% of the total outage duration, and since each household also provided us with their total outage duration, we were able to calculate how many hours they used their generators. Even though the respondents provided us with their monthly fuel expenditures, thinking that these may not be very reliable, we compared these to figures calculated using the fuel consumption rates provided by the manufacturers. Given the generator specifications and the number of hours used, we calculated the monthly consumption for each generator owner. We observed that only six of the observations came close to our calculated figures and on average the respondents overstated their fuel expenditures by a factor of five. Respondents on average use their generators for couple hours a month and consequently do not buy fuel frequently. As a result they may not remember their fuel expenditures precisely. Hence where there was a large discrepancy between the two figures, we chose to use our estimations instead. On average the generators were maintained 1.5 times a year and each maintenance cost was around 113 YTL, so the missing maintenance data was replaced by these figures. After replacing all missing data and deleting the two observations with high capacity values, we found that the 35 generator owners, on average, used their generators 3.7 hours a month and incurred monthly expenditures of 47.17 YTL (12.63 YTL/hour) (see Table 5.7).[39]

We also summarized the households' monthly usage as well as monthly and hourly expenditures for each action in Table 5.7. Except for candles, monthly expenditures consist of fixed (investment cost) and variable components (operating and maintenance costs), and items with higher investment cost and lower usage rate have higher hourly expenditures.

Table 5. 5 AE Formulas and Average Monthly AE by Averting Action (in 2008 prices)

Averting Action	Formula Used in Monthly Averting Expenditure Calculation
candle	(number of candles used (2.7) × hours used per year (13.6) × cost per candle (0.43) / hours per candle (2.33))/12 = 0.55 YTL per month
emergency kerosene lamp	number of lamps owned (1.2) × lamp price (5.13) × (monthly depreciation (0.83%) + monthly opportunity cost of capital (0.80%)) + number of lamps used (1.1) × number of glass covers per year (1.0)× glass cover price (1.25) + (number of lamps used (1.1) × hours used per year (17.3)

[39] An average generator owner's total perceived outage duration is 28 hours per month.

	× fuel consumption per hour (0.023) × fuel price per litre (1.85))/12 + (number of lamps used × amount of wick per lamp per year (1.0) × wick price (1.00))/12 = 0.38 YTL per month[40]
emergency gas lamp	number of lamps owned (1.4) × (price of head (31.57) + one time gas tube deposit (8.50)) × (monthly depreciation (0.83%) + monthly opportunity cost of capital (0.80%)) + (number of lamps used (1.3) × hours used per year (21.7) × fuel consumption per hour (13.92) × fuel price (0.0076))/12 + (number of lamps used (1.3) × quantity of wick used per year (1) × wick price (1.00))/12 = 1.26 YTL per month[41]
electric lantern	Number of lamps owned (1.5) × lamp price (39.36) × (monthly depreciation (1.67%) + monthly opportunity cost of capital (0.80%)) + number of lamps owned (1.5) × number of times charged per year (6) × cost per charging (0.01) = 1.48 YTL per month[42]
emergency kerosene stove	Number of stoves owned (2.0) × stove price (25.62) × (monthly depreciation (0.83%) + monthly opportunity cost of capital (0.80%)) + (number of stoves used (1.5) × hours used per year (11.6) × fuel consumption per hour (0.254) × fuel price (1.85))/12 + (number of stoves used (1.5) × quantity of wick used per year (1.0) × wick price (1.00))/12 = 1.83 YTL per month[43]
emergency gas stove	Number of stoves owned (1.5) × (price of stove head (20.50) + one time gas tube deposit (8.50)) × (monthly depreciation (0.83%) + monthly opportunity cost of capital (0.80%)) + (number of stoves used (1.1) × hours used per year (11.1) × fuel consumption per hour (243.6) × fuel price (0.0076))/12 = 3.08 YTL per month
emergency kerosene heater	Number of heaters owned (1.0) × heater price (33.13) × (monthly depreciation (0.83%) + monthly opportunity cost of capital (0.80%)) + (number of heaters used (1.0) × hours used per year (6.0)

[40] Given the number of hours kerosene lamps are used in a year, averaged around 17 hours, a household will be assumed to use one meter of wick per year, and replace the glass covers once a year.

[41] Given that these lamps are used for approximately 22 hours a year, we assume an annual consumption of one wick per lamp.

[42] In general an electric lantern has two 10 watt fluorescent bulbs and works with 6 volt 4 ampere-hour rechargeable batteries. It takes approximately 19 hours to fully charge the lamp, and then it can be used for around 70 hours. However, when not in use it is recommended that the device be recharged once every two months for more than eight hours in order to extend the battery life. The battery requires 0.024 kWh of energy to become fully charged, and the average electricity price for residential customers is 0.30 YTL/kWh (2008 prices), hence the cost of each charge period is 0.01 YTL. Given that these lamps are used on average for 18 hours during the year, we assumed that they are charged once in two months as recommended by the lamp manufacturers. The 10 Watt fluorescent bulbs last approximately 3000 hours, therefore in our calculations we assumed that they will not be replaced throughout the life of the lamp.

[43] The wick consumption is assumed to be 1 meter per year at 1 YTL per meter.

	× fuel consumption per hour (0.254)× fuel price (1.85))/12 + (number of heaters used (1.0)× quantity of wick used per year (1.0) × wick price (1.00))/12 = 0.86 YTL per month
emergency gas heater	Number of heaters owned (1.5) × (price of heater head (28.00) + one time gas tube deposit (8.5)) × (monthly depreciation (0.83%) + monthly opportunity cost of capital (0.80%)) + (number of heaters used (1.0) × hours used (18.9)× fuel consumption per hour (115.0)× fuel price (0.0076))/12 = 2.32 YTL per month
voltage regulator	Quantity owned (1.0) × voltage regulator price (167.63) × (monthly depreciation (0.83%) + monthly opportunity cost of capital (0.80%)) = 0.23 YTL per month
surge protector	Quantity owned (1.0) × surge protector price (80.55) × (monthly depreciation (0.83%) + monthly opportunity cost of capital (0.80%)) = 0.11 YTL per month
generator	Quantity owned (1.0) × generator price (1,156.26) × (monthly depreciation (0.56%) + monthly opportunity cost of capital (0.80%)) + Quantity used (0.97) × hours used (3.7) × fuel consumption per hour (1.41) × fuel price (2.11) + (number of times maintained per year (1.64) × maintenance cost (123.90))/12 = 47.17 YTL per month[44]
ups	Quantity owned (1.0) × UPS price (365.89) × (monthly depreciation (1.67%) + monthly opportunity cost of capital (0.80%)) = 9.02 YTL per month[45]
Inverter connected to car battery	Quantity owned (1.0) × inverter price (60.32) × (monthly depreciation (0.83%) + monthly opportunity cost of capital (0.80%)) = 0.98 YTL per month

Table 5. 6 Average Monthly AE for Each Averting Behaviour

	Number of Households	Mean (YTL/month)	Std. Deviation	Min	Max
candle	197	0.55	0.49	0.02	3.06
emergency kerosene lamp	43	0.38	0.13	0.28	0.80
emergency gas lamp	111	1.26	0.57	0.74	4.02
electric lantern	82	1.48	0.93	0.97	6.81
emergency kerosene stove	15	1.83	1.65	0.42	6.06
emergency gas stove	17	3.08	3.16	0.47	13.23

[44] A 20% increase in the useful life of generator from 15 to 18 years results in a 2.3% reduction (or 1.1 YTL) in monthly generator expenses.

[45] UPS systems are used by seven respondents in the sample. They provided us with information related to the make, capacity, capital and maintenance expenditures for the equipment.

emergency kerosene heater	2	0.86	0.22	0.70	1.01
emergency gas heater	7	2.32	1.04	0.60	3.80
voltage regulator	2	0.23	0.00	0.23	0.23
surge protector	1	0.11	0	0.11	0.11
generator (overall)	35	47.17	39.48	5.33	174.35
ups	7	9.02	12.46	1.88	36.96
inverter (connected to car battery)	1	0.98	0	0.98	0.98

	Number of Households	Mean (YTL/month)	Std. Deviation	Min	Max
candle	336	0.31	0.46	0	3.06
emergency kerosene lamp	336	0.05	0.13	0	0.80
emergency gas lamp	336	0.41	0.67	0	4.02
electric lantern	336	0.32	0.69	0	3.89
emergency kerosene stove	336	0.08	0.50	0	6.06
emergency gas stove	336	0.15	0.96	0	13.23
emergency kerosene heater	336	0.01	0.07	0	1.01
emergency gas heater	336	0.05	0.36	0	3.80
voltage regulator	336	0.00	0.02	0	0.23
surge protector	336	0.00	0.01	0	0.11
generator	336	4.85	19.12	0	174.35
ups	336	0.18	2.10	0	36.96
inverter (connected to car battery)	336	0.00	0.05	0	0.98
total monthly AE	336	6.40	19.11	0	174.35

Table 5. 7 Average Monthly Usage and Monthly and Hourly Expenditures

Averting Behaviour	**No. of House-holds**	**Average Quantity Owned**	**Average Quantity Used**	**Average Hours Used**	**Average Monthly Exp. YTL/month**	**Average Hourly Exp. YTL/hour**
candle	197		2.7	13.6	0.55	0.18
emergency kerosene lamp	43	1.2	1.1	17.3	0.38	0.23
emergency gas lamp	111	1.4	1.3	21.7	1.26	0.56
electric lantern	82	1.5	1.3	18.4	1.48	0.77
emergency kerosene stove	15	2.0	1.5	11.6	1.83	1.29
emergency gas stove	17	1.5	1.1	11.1	3.08	3.13

emergency kerosene heater	2	1.0	1.0	6.0	0.86	1.72
emergency gas heater	7	1.5	1.0	18.9	2.32	1.47
voltage regulator	2	1.0	1.0		0.23	
surge protector	1	1.0	1.0		0.11	
generator	35	1.0	1.0	3.7	47.17	12.63
ups	7	1.0	1		9.02	
car battery connected to an inverter	1	1.0	1		0.98	

5.6 Comparison of Group Means

In this section, in order to see which groups of households are impacted most heavily by the unreliability of power supply, we compare mean AE for households from different regions, having different income levels, and enjoying different levels of service reliability.

The means were compared using the *One-way ANOVA* feature of SPSS 15.0, which comes with options for descriptive statistics, robust test of homogeneity of variances (Levene's robust test), robust tests of equality of means (Welch test; Brown-Forsythe test), and tests of multiple comparisons (Tamhane's T2; Dunett's T3; Games-Howell; Dunette's C). The one-way ANOVA F test is used in comparing group means when the variances are homogeneous, sample sizes are equal, and the population distribution is normal. Bartlett's test (Bartlett, 1937) and Levene's robust test (Levene, 1960) can be used to test for homogeneity of variances. Levene (1960) showed that Levene's robust test statistic is more robust when the data does not have a normal distribution. When the sample sizes and variances are unequal, then Welch (Welch, 1938) or Brown-Forsythe tests (Brown and Forsythe, 1974) are preferred alternatives to the ANOVA F test. In addition, where the distribution is skewed, Brown-Forsythe is preferred over the Welch test as a test for mean equality

(Clinch and Keselman, 1982). However, if at least one of the groups has zero variance, then the robust tests of equality of means (Welch and Brown-Forsythe tests) cannot be performed. In such cases, we will use the *kwallis* command in STATA 9.2 to perform the non-parametric Kruskal-Wallis test of equality of group means (Kruskal and Wallis, 1952).

The Brown-Forsythe test indicates whether the means of the groups being compared are different. Where the difference is significant, we make use of multiple comparison tests such as Tamhane's T2 (Tamhane, 1979), Dunett's T3 (Dunnett, 1980), Games-Howell (Games and Howell, 1976), and Dunette's C. All of these multiple comparison tests provide for unequal variances and unequal sample sizes; however, we choose the Tamhane's T2 since it is a conservative test (Stoline, 1981; Rafter et al., 2002). In addition, we use the *nptrend* command in STATA 9.2 to carry out the Cuzick's non-parametric test for trend in averting behaviour across ordered groups (Cuzick, 1985).

We compare households' averting behaviour and mean AE for four different groups. The households are grouped by district, monthly income, and perceived service reliability level (outage frequency, outage duration). The *district* group has five levels: Lefkoşa, Gazimağusa, Girne, Güzelyurt, and İskele. The *income* group has five levels as well (in YTL/month): less than or equal to 1060; 1,061-1,500; 1,501-2,000; 2,001-3,000; 3,001 and above. The "*frequency*" group has five levels: less than or equal to 12 outages per year; 12-24; 24-48; 48-96; more than 96 outages per year. Similarly, the "*duration*" group has five levels: less than or equal to 36 hours per year; 36-72; 72-144; 144-288; more than 288 hours per year.

5.6.1 Household's Perceived Service Level

In this section, we examine how households' perceived service reliability (outage frequency and duration) compare across the five districts and income groups.

5.6.1.1 Total Outage Frequency

5.6.1.1.1 Total Outage Frequency by District

Table 5.8 below shows the mean total outage frequency per year by district. The results of hypothesis testing of equality of means are reported for both Kruskal-Wallis and Brown-Forsythe tests. The two tests gave the same results in almost all cases. The overall mean for 336 households is 81.2 outages per year (1.6 outages per week). At 5% significance level, the hypothesis of equal group means can be rejected. The Tamhane's T2 multiple comparison tests revealed that the 5th district İskele differs from the other four districts (the mean difference between the 4th and 5th district is only significant at 10% level). İskele has the highest group mean (270.6 outages per year, or 5.2 outages per week), and its mean total annual outage frequency is significantly different from the means of Lefkoşa (55 outages per year, or 1.1 outages per week), Gazimağusa (66.8 outages per year, or 1.3 outages per week), and Girne (62.3 outages per year, or 1.2 outages per week). The remaining pair-wise differences in group means are not significant at 5% significance level. From our focus group study findings we expected İskele residents to have lower perceived service quality than the others. This result may be attributed to the remoteness of İskele and its inadequate investments in transmission and distribution. Furthermore, infrastructure investments are overall not as well maintained in that part of the country. İskele's poorer electricity service reliability is also evident from having one of the highest generator ownership proportions revealed in the 2006 census: Lefkoşa 11.1%, Gazimağusa 14.0%, Girne 16.9%, Güzelyurt 13.2%, and İskele 17%.

Table 5. 8 Total Outage Frequency by District

	Group Description	Sample Size	Total Frequency (outages per year)		
Levels	District	N	Mean (S.E.)	Min	Max
1	Lefkoşa	109	55.0 (8.0)	1	730
2	Gazimağusa	79	66.8 (12.7)	3	913
3	Girne	76	62.3 (15.5)	0	1,095
4	Güzelyurt	45	88.4 (22.8)	2	730
5	İskele	27	270.6 (60.0)	12	730
Total		336	81.2 (8.3)	0	1,095
Kruskal-Wallis Test of Equality of Means – Significance Level			***		
Brown-Forsythe Test of Equality of Means -- Significance Level			***		
Multiple comparisons (Tamhane's T2)			(1&5)**, (2&5)**, (3&5)**, (4&5)*		
(*) 10% significance level; (**) 5% significance level; (***) 1% significance level two-tailed tests.					

5.6.1.1.2 Total Outage Frequency by Household Income

Table 5.9 shows the mean perceived total frequency by household income. The total outage frequency means of different income groups are not statistically different from the total sample mean of 81.21 outages per year i.e. the perceived number of outages is not sensitive to household's monthly income. The outages are generally unplanned and customers from all income groups in a region have the same outage experience when it occurs.

Table 5. 9 Total Outage Frequency by Household Income

	Group Description	Sample Size	Total Frequency (outages per year)		
Levels	Income (YTL/month)	N	Mean (S.E.)	Min	Max
1	Less than or equal to 1060	45	76.71 (22.01)	1	730
2	1,060-1,500	62	98.11 (23.72)	3	1095
3	1,501-2,000	64	82.61 (16.98)	2	730
4	2,001-3,000	94	79.24 (16.05)	2	913
5	3,001 and above	71	70.66 (15.79)	0	730
Total		336	81.21 (8.31)	0	1095
Kruskal-Wallis Test of Equality of Means – Significance Level			--		
Brown-Forsythe Test of Equality of Means -- Significance Level			--		
Multiple comparisons (Tamhane's T2)			none		
(*) 10% significance level; (**) 5% significance level; (***) 1% significance level two-tailed tests.					

5.6.1.2 Total Outage Duration

5.6.1.2.1 Total Outage Duration by District

Table 5.10 shows the mean total outage duration per year by district. The sample mean for 336 households was 276.8 hours per year (approximately 5.3 hours per week). At 5% significance level, the hypothesis of equal group means can be rejected. İskele's mean (717.6 hours per year, or approximately 13.8 hours per week) was significantly higher than that of Girne (190.5 hours per year, or 3.7 hours per week). The remaining pair-wise differences in group means were not significant at 5% significance level. Once more, this is a result that we expected given İskele's less developed infrastructure. The same result was observed in the pilot study.

Table 5. 10 Total Outage Duration by District

	Group Description	Sample Size	Total Duration (hours per year)		
Levels	District	N	Mean (S.E.)	Min	Max
1	Lefkoşa	109	231.1 (31.3)	3	2,232.0
2	Gazimağusa	79	233.9 (41.1)	5.81	2,737.5
3	Girne	76	190.5 (39.6)	0	2,299.5
4	Güzelyurt	45	343.8 (90.1)	5.3	3,139.0
5	İskele	27	717.6 (166.3)	16.8	2,628.0
Total		336	276.8 (25.4)	0	3,139.0
Kruskal-Wallis Test of Equality of Means – Significance Level			**		
Brown-Forsythe Test of Equality of Means -- Significance Level			***		
Multiple comparisons (Tamhane's T2)			(1&5)*, (2&5)*, (3&5)**		
(*) 10% significance level; (**) 5% significance level; (***) 1% significance level two-tailed tests.					

5.6.1.2.2 Total Outage Duration by Income Group

Table 5.11 shows the mean total duration by household income. The total outage duration means of different income groups were not statistically different from the overall sample mean of 276.8 hours per year, i.e. the perceived duration of outages was not sensitive to a household's monthly income. Outages are mostly unplanned and they are not targeted towards certain groups only. Consequently, households from all income groups equally feel the same level of service reliability.

Table 5. 11 Total Outage Duration by Income Group

	Group Description	Sample Size	Total Duration (hours per year)		
Levels	Income (YTL/month)	N	Mean (S.E.)	Min	Max

1	Less than or equal to 1060	45	276.16 (62.72)	3	1,898
2	1,060-1,500	62	320.87 (67.51)	5.81	2,628
3	1,501-2,000	64	295.67 (58.97)	5.6	2,300
4	2,001-3,000	94	271.15 (52.24)	5.3	3,139
5	3,001 and above	71	229.16 (43.90)	0	1,752
Total		336	276.79 (25.43)	0	3,139
Kruskal-Wallis Test of Equality of Means – Significance Level			--		
Brown-Forsythe Test of Equality of Means -- Significance Level			--		
Multiple comparisons (Tamhane's T2)			none		
(*) 10% significance level; (**) 5% significance level; (***) 1% significance level two-tailed tests.					

5.6.2 Household's Average Total Monthly AE

5.6.2.1 Household's Average Total Monthly AE by District

The total sample average for the monthly AE was 6.40 YTL/month (see Table 5.12). At least one of the district means is different from the total population. Given the 2006 census proportions for generator ownership and the perceived outage frequency and duration means by district, we expected İskele to have the highest mean monthly AE.

Table 5. 12 Household's Average Total Monthly AE by District

	Group Description	Sample Size	Total Monthly AE (YTL/month)		
Levels	District	N	Mean (S.E.)	Min	Max
1	Lefkoşa	109	4.21 (0.88)	0	40.47

2	Gazimağusa	79	3.28 (1.33)	0	88.91
3	Girne	76	5.48 (1.32)	0	59.55
4	Güzelyurt	45	10.10 (4.34)	0	174.35
5	İskele	27	20.81 (8.23)	0	143.61
Total		336	6.40 (1.04)	0	174.35
Kruskal-Wallis Test of Equality of Means – Significance Level			***		
Brown-Forsythe Test of Equality of Means -- Significance Level			**		
Multiple comparisons (Tamhane's T2)			none		
(*) 10% significance level; (**) 5% significance level; (***) 1% significance level two-tailed tests.					

5.6.2.2 Household's Average Total Monthly AE by Income Group

The mean AE for the five income groups are shown in Table 5.13 below. The mean expenditures for the lowest income group are 2.06 YTL/month, and for the two highest income groups were 10.76 YTL/month and 6.82/month respectively. However, the mean differences between the lowest income group and the two highest income groups were significant only at 10% significance level. There is a trend in total monthly AE across the ordered levels of total household income. Household's usage rate of averting devices is likely to increase with income. Also, a high-income household may use a higher number of averting devices and may choose more expensive alternatives such as generators.

Table 5. 13 Household's Average Total Monthly AE by Income Group

	Group Description	Sample Size	Total Monthly AE (YTL/month)		
Levels	Income (YTL/month)	N	Mean (S.E.)	Min	Max
1	Less than or equal	45	2.06	0	41.91

	to 1060		(0.92)		
2	1,060-1,500	62	3.77 (1.57)	0	85.7
3	1,501-2,000	64	5.14 (2.01)	0	105.47
4	2,001-3,000	94	10.76 (3.02)	0	174.35
5	3,001 and above	71	6.82 (1.55)	0	65.65
Total		336	6.40 (1.04)	0	174.35
Kruskal-Wallis Test of Equality of Means – Significance Level			***		
Brown-Forsythe Test of Equality of Means -- Significance Level			**		
Cuzick's Non Parametric Test for Trend -- Significance Level			***		
Multiple comparisons (Tamhane's T2)			(1&4)*, (1&5)*		
(*) 10% significance level; (**) 5% significance level; (***) 1% significance level two-tailed tests.					

5.6.2.3 Household's Average Total Monthly AE by Frequency Group

The nonparametric tests of mean equality and trend show the existence of mean difference and trend. However, according to the more robust mean equality test, the mean expenditures of the frequency groups were not statistically different from the sample mean (see Table 5.14). Experience with frequent outages over a long time causes households to opt for non-electric household devices (e.g. gas stoves, gas space heaters, solar water heaters, etc.) to reduce the cost of frequent electricity outages.

Table 5. 14 Household's Average Total Monthly AE by Frequency Group

	Group Description	Sample Size	Total Monthly AE (YTL/month)		
Levels	Household's perceived total outage frequency per year	N	Mean (S.E.)	Min	Max
1	Less than or equal to 12 times per year	76	6.66 (1.47)	0	66.92
2	12-24 times per year	66	4.87	0	105.47

			(1.81)		
3	24-48 times per year	69	6.13 (2.35)	0	143.61
4	48-96 times per year	58	4.77 (2.12)	0	88.91
5	More than 96 times a year	67	9.29 (3.50)	0	174.35
Total		336	6.40 (1.04)	0	174.35
Kruskal-Wallis Test of Equality of Means – Significance Level			**		
Brown-Forsythe Test of Equality of Means -- Significance Level			--		
Cuzick's Non Parametric Test for Trend -- Significance Level			**		
Multiple comparisons (Tamhane's T2)			--		
(*) 10% significance level; (**) 5% significance level; (***) 1% significance level two-tailed tests.					

5.6.2.4 Household's Average Total Monthly AE by Duration Group

The mean expenditures of the outage duration groups were not statistically different from the sample mean (see Table 5.15). One reason for the insensitivity of the amount of expenditures to the service reliability levels could be the fact that households mostly use candles during outages and candle expenditures does not increase significantly with frequency and duration of outage. Generators are more expensive to operate and involve some inconvenience to start, hence they are not used for every outage nor not necessarily for the entire duration of a given outage. Generators are used at critical times, e.g. to watch television when popular football team is playing. Hence generator use is not expected to be proportional to the overall time span of outages.

Table 5. 15 Household's Average Total Monthly AE by Duration Group

	Group Description	**Sample Size**	**Total Monthly AE (YTL/month)**		
Levels	Household's perceived total outage	N	Mean	Min	Max

	duration per year		(S.E.)		
1	Less than or equal to 36 hours per year	57	6.35 (1.74)	0	66.92
2	36-72 hours per year	60	6.93 (3.04)	0	105.47
3	72-144 hours per year	75	3.89 (1.04)	0	143.61
4	144-288 hours per year	66	6.09 (2.03)	0	88.91
5	More than 288 hours per year	78	5.71 (3.03)	0	174.35
Total		336	6.40 (1.04)	0	174.35
Kruskal-Wallis Test of Equality of Means – Significance Level			*		
Brown-Forsythe Test of Equality of Means -- Significance Level			--		
Cuzick's Non Parametric Test for Trend -- Significance Level			--		
Multiple comparisons (Tamhane's T2)			--		
(*) 10% significance level; (**) 5% significance level; (***) 1% significance level two-tailed tests.					

5.6.3 The Number of Averting Actions

On average during an outage households take 1.5 averting actions. This number was 1.1 in Gazimağusa, and the mean differences between this district and the remaining four districts were statistically significant (Lefkoşa 1.5, Girne 1.6, Güzelyurt 1.8, İskele 1.5) (see Table 5.16). Among the five districts, the sample average for household income in Gazimağusa is the second lowest after İskele.[46] However unlike households in İskele, households in Gazimağusa have lower perceived outage frequency and duration. Lower income coupled with higher perceived service quality may explain the lower number of averting actions undertaken by Gazimağusa households. The number of averting actions taken by a household is sensitive to household's income at a 10% significance level, and the test for trend shows a significant positive association between number of averting actions

[46] Lefkoşa 2,301 YTL/month; Gazimağusa 1,644 YTL/month; Girne 2,685 YTL/month; Güzelyurt 2,582 YTL/month; and İskele 1,535 YTL/month.

and income (see Tables 5.17). The weak sensitivity to income might be due to the fact that the majority of averting behaviour is being aimed at maintaining the lighting needs of the households, and the decision to be made is on the form of averting action not necessarily the number of averting actions.

Table 5. 16 Household's Number of Averting Actions by District

	Group Description	Sample Size	Number of Averting Actions		
Levels	District	N	Mean (S.E.)	Min	Max
1	Lefkoşa	109	1.50 (0.08)	0	4
2	Gazimağusa	79	1.05 (0.09)	0	3
3	Girne	76	1.63 (0.09)	0	4
4	Güzelyurt	45	1.78 (0.13)	0	4
5	İskele	27	1.52 (0.14)	0	3
Total		336	1.46 (0.05)	0	4
Kruskal-Wallis Test of Equality of Means – Significance Level			***		
Brown-Forsythe Test of Equality of Means -- Significance Level			***		
Multiple comparisons (Tamhane's T2)			(1&2)***, (2&3)***, (2&4)***, (2&5)***		
(*) 10% significance level; (**) 5% significance level; (***) 1% significance level two-tailed tests.					

Table 5. 17 Household's Number of Averting Actions by Income Group

	Group Description	Sample Size	Number of Averting Actions		
Levels	Income (YTL/month)	N	Mean (S.E.)	Min	Max
1	Less than or equal to 1060	45	1.31 (0.12)	0	3
2	1,060-1,500	62	1.31 (0.10)	0	4

3	1,501-2,000	64	1.39 (0.10)	0	4
4	2,001-3,000	94	1.55 (0.10)	0	4
5	3,001 and above	71	1.63 (0.10)	0	4
Total		336	1.46 (0.05)	0	4
Kruskal-Wallis Test of Equality of Means – Significance Level			--		
Brown-Forsythe Test of Equality of Means -- Significance Level			*		
Cuzick's Non Parametric Test for Trend -- Significance Level			***		
Multiple comparisons (Tamhane's T2)			none		
(*) 10% significance level; (**) 5% significance level; (***) 1% significance level two-tailed tests.					

The mean number of averting actions of frequency and duration groups were statistically different from their respective sample means (see Table 5.18 and Table 5.19). There does not exist a trend across either group. In the lowest frequency group 1, the average number of averting actions is 1.75 and this is higher than group 2, 3, and 4 averages. The mean of duration group 2 is lower than that of groups 1. As households' experience with outage increases they tend to switch to non-electric household appliances. The high percentage of usage of non-electric sources for cooking, water and space heating means that during outages these activities are not completely interrupted and as a result the household is likely to need less number of averting actions.

Table 5. 18 Household's Number of Averting Actions by Frequency Group

	Group Description	**Sample Size**	**Number of Averting Actions**		
Levels	Household's perceived total outage frequency per year	N	Mean (S.E.)	Min	Max
1	Less than or equal to 12 times per year	76	1.75 (0.11)	0	4
2	12-24 times per year	66	1.38 (0.10)	0	3
3	24-48 times per year	69	1.23	0	4

			(0.10)		
4	48-96 times per year	58	1.31 (0.10)	0	3
5	More than 96 times a year	67	1.58 (0.10)	0	4
Total		336	1.46 (0.05)	0	4
Kruskal-Wallis Test of Equality of Means – Significance Level			***		
Brown-Forsythe Test of Equality of Means -- Significance Level			***		
Cuzick's Non Parametric Test for Trend -- Significance Level			--		
Multiple comparisons (Tamhane's T2)			(1&2)*, (1&3)***, (1&4)**		
(*) 10% significance level; (**) 5% significance level; (***) 1% significance level two-tailed tests.					

Table 5. 19 Household's Number of Averting Actions by Duration Group

	Group Description	Sample Size	Number of Averting Actions		
Levels	Household's perceived total outage duration per year	N	Mean (S.E.)	Min	Max
1	Less than or equal to 36 hours per year	57	1.72 (0.13)	0	4
2	36-72 hours per year	60	1.23 (0.10)	0	3
3	72-144 hours per year	75	1.41 (0.10)	0	4
4	144-288 hours per year	66	1.36 (0.09)	0	4
5	More than 288 hours per year	78	1.58 (0.09)	0	4
Total		336	1.46 (0.05)	0	4
Kruskal-Wallis Test of Equality of Means – Significance Level			**		
Brown-Forsythe Test of Equality of Means -- Significance Level			**		
Cuzick's Non Parametric Test for Trend -- Significance Level			--		
Multiple comparisons (Tamhane's T2)			(1&2)**, (2&5)*		
(*) 10% significance level; (**) 5% significance level; (***) 1% significance level two-tailed tests.					

5.6.4 Household's Averting Behaviour and Expenditures

The main objective of this research is to estimate household's WTP for improvements in electricity service reliability. Therefore including questions that would help us estimate the cost of outages were our main concern when designing the questionnaire. Follow up questions to clarify why an averting action was not undertaken were only included for high expenditures items such as generators, UPS systems, and inverters. Unfortunately, for everything else there were no follow up questions to help us identify the reasons for the different choices of averting behaviour at district level.

Given that lighting is one of households' major concerns during an outage we added up the total number and spend for the four actions (candle, kerosene lamp, gas lamp and electric lantern). In this section, we will compare group means for the averting actions households take for maintaining their lighting needs during an outage. We will also perform mean comparisons for generator ownership and monthly expenditures. The results will reveal if choice of these actions and their monthly expenditures are sensitive to district, income, and perceived service levels. In the sections below we will tabulate and discuss the results for cases where the mean differences are significant at the 5% significance level.

5.6.4.1 Averting Behaviour and Expenditures by District

The mean comparisons for choosing at least one lighting related averting behaviour and expenditures for maintaining the lighting needs of the households by district are summarized in Table 5.20. 85% of households in North Cyprus use at least one of the lighting related behaviours during an outage and have a monthly expenditure of 1.09 YTL. The hypothesis of equal means can be rejected at 5% significance level for the proportion and at 1% significance level for the expenditures.

The proportion of households using at least one lighting related averting action was significantly different when Gazimağusa (75%) was compared with Girne (92%). The expenditures of households was significantly different when Girne (1.66 YTL) was compared with Lefkoşa (0.98 YTL), Gazimağusa (0.66 YTL) and İskele (0.90 YTL). In addition to these, the mean difference in expenditures was also significant when Gazimağusa (0.66 YTL) was compared with Lefkoşa (0.98 YTL) and Güzelyurt (1.27 YTL).

The overall sample average for monthly generator expenses are 10% and 4.85 YTL respectively. The hypotheses of equal means can be rejected for monthly generator expenses. İskele has the highest monthly expenses (19.04 YTL).

Table 5. 20 Averting Behaviour and Expenditures by District

	Group Description	**Sample Size**	**Lighting (Candle+K.Lamp+G.Lamp+E.Lantern)**	
			Proportion of Households	YTL/ month
Levels	District	N	Mean (S.E.)	Mean (S.E.)
1	Lefkoşa	109	0.86 (0.03)	0.98 (0.08)
2	Gazimağusa	79	0.75 (0.05)	0.66 (0.08)
3	Girne	76	0.92 (0.03)	1.66 (0.14)
4	Güzelyurt	45	0.89 (0.05)	1.27 (0.14)
5	İskele	27	0.81 (0.08)	0.90 (0.22)
Total		336	0.85 (0.02)	1.09 (0.06)
Kruskal-Wallis Test of Equality of Means -- Significance Level			**	***

Brown-Forsythe Test of Equality of Means -- Significance Level	**	***
Multiple comparisons (Tamhane's T2)	(2&3)**	(1&2)**, (1&3)***, (2&3)***, (2&4)***, (3&5)*
(*) 10% significance level; (**) 5% significance level; (***) 1% significance level two-tailed tests.		

	Group Description	**Sample Size**	**Generator**	
			Proportion of Households	YTL/month
Levels	District	N	Mean (S.E.)	Mean (S.E.)
1	Lefkoşa	109	0.10 (0.03)	2.59 (0.81)
2	Gazimağusa	79	0.05 (0.02)	2.34 (1.32)
3	Girne	76	0.09 (0.03)	3.31 (1.31)
4	Güzelyurt	45	0.16 (0.05)	8.82 (4.37)
5	İskele	27	0.19 (0.08)	19.04 (8.36)
Total		336	0.10 (0.02)	4.85 (1.04)
Kruskal-Wallis Test of Equality of Means -- Significance Level			--	--
Brown-Forsythe Test of Equality of Means -- Significance Level			--	**
Multiple comparisons (Tamhane's T2)			none	none
(*) 10% significance level; (**) 5% significance level; (***) 1% significance level two-tailed tests.				

5.6.4.2 Averting Behaviour and Expenditures by Income Group

Table 5.21 shows the percentage of households in the five income groups using at least one of the lighting related averting actions and their average monthly expenditures for maintaining their lighting needs. Mean differences were significant for lighting related averting expenditures. The mean expenditures for the lowest income group were 0.87 YTL/month, and the mean difference between this group and the fifth (1.44YTL) income group is statistically significant. There appears to be a trend in lighting expenditures across the income levels.

The overall mean for generator ownership/usage was 10%. When the means of the different income groups were compared, generators were owned/used by 2% of the households in the lowest income group, and this was approximately 8.5 times less than the proportion in group 4 (17%). The remaining combinations of mean differences were not significant at 5% significance level. The overall mean for generator expenditures was 4.85 YTL/month. At the 5% significance level the hypothesis of mean equality for generator expenditures can be rejected, however the difference stemming from mean comparison between group 1 and 4 was only significant at 10% significance level. The mean of group 1 is 0.89 YTL/month whereas that of group 4 was 9.43 YTL/month. The trend test reveals the existence of a trend in generator ownership and expenditures across the income levels. Given generators are among the most expensive averting behaviours available to households in North Cyprus, this result is expected.

Table 5. 21 Averting Behaviour and Expenditures by Income Group

	Group Description	**Sample Size**	**Lighting (Candle+K.Lamp+G.Lamp+E.Lantern)**	
			Proportion of Households	YTL/month
Levels	Income (YTL/month)	N	Mean (S.E.)	Mean (S.E.)
1	Less than or equal to 1060	45	0.80 (0.06)	0.87 (0.15)
2	1,060-1,500	62	0.82 (0.05)	0.97 (0.12)
3	1,501-2,000	64	0.89	1.00

			(0.04)	(0.11)
4	2,001-3,000	94	0.83 (0.04)	1.07 (0.10)
5	3,001 and above	71	0.89 (0.04)	1.44 (0.14)
Total		336	0.85 (0.02)	1.09 (0.06)
Kruskal-Wallis Test of Equality of Means -- Significance Level			--	**
Brown-Forsythe Test of Equality of Means -- Significance Level			--	**
Cuzick's Non Parametric Test for Trend -- Significance Level			--	***
Multiple comparisons (Tamhane's T2)			--	(1&5)*
(*) 10% significance level; (**) 5% significance level; (***) 1% significance level two-tailed tests.				

	Group Description	**Sample Size**	**Generator**	
			Proportion of Households	YTL/month
Levels	Income (YTL/month)	N	Mean (S.E.)	Mean (S.E.)
1	Less than or equal to 1060	45	0.02 (0.02)	0.89 (0.89)
2	1,060-1,500	62	0.05 (0.03)	2.47 (1.57)
3	1,501-2,000	64	0.05 (0.03)	3.14 (1.94)
4	2,001-3,000	94	0.17 (0.04)	9.43 (3.04)
5	3,001 and above	71	0.15 (0.04)	4.91 (1.58)
Total		336	0.10 (0.02)	4.85 (1.04)
Kruskal-Wallis Test of Equality of Means -- Significance Level			***	***
Brown-Forsythe Test of Equality of Means -- Significance Level			***	**
Cuzick's Non Parametric Test for Trend -- Significance Level			***	***
Multiple comparisons (Tamhane's T2)			(1&4)**,(1&5)*, (3&4)*	(1&4)*
(*) 10% significance level; (**) 5% significance level; (***) 1% significance level two-tailed tests.				

5.6.4.3 Averting Behaviour and Expenditures by Frequency Group

Table 5.22, shows the percentage of households in the frequency groups using a lighting related averting action and their average monthly expenditures to maintain their lighting needs. The mean differences across the frequency levels were significant. The percentage of households using at least one of the lighting actions was 75% in group 3 and 94% in the higher frequency group 5. The mean monthly expenditures for lighting were 1.40 YTL and 0.82 YTL for group 1 and 4 respectively. There appears to be a trend in lighting expenditures across the frequency levels. Experience with frequent outages has a learning effect on the households and is expected to decrease the AE incurred by a household.

Table 5. 22 Averting Behaviour and Expenditures by Frequency Group

	Group Description	**Sample Size**	**Lighting (Candle+K.Lamp+G.Lamp+E.Lantern)**	
			Proportion of Households	YTL/month
Levels	Household's perceived total outage frequency per year	N	Mean (S.E.)	Mean (S.E.)
1	Less than or equal to 12 times per year	76	0.88 (0.04)	1.40 (0.13)
2	12-24 times per year	66	0.82 (0.05)	1.03 (0.13)
3	24-48 times per year	69	0.75 (0.05)	1.06 (0.13)
4	48-96 times per year	58	0.84 (0.05)	0.82 (0.10)
5	More than 96 times a year	67	0.94 (0.03)	1.07 (0.12)
Total		336	0.85 (0.02)	1.09 (0.06)
Kruskal-Wallis Test of Equality of Means – Significance Level			**	**
Brown-Forsythe Test of Equality of Means -- Significance Level			**	**
Cuzick's Non Parametric Test for Trend -- Significance Level			--	**
Multiple comparisons (Tamhane's T2)			(3&5)**	(1&4)***

(*) 10% significance level; (**) 5% significance level; (***) 1% significance level two-tailed tests.

5.6.4.4 Averting Behaviour and Expenditures by Duration Group

Table 5.23 shows the percentage of households in the duration groups using a lighting related averting action and their average monthly expenditures to maintain their lighting needs. Their mean monthly expenditures for maintaining the lighting needs in the lowest frequency group 1 (1.51 YTL) were higher than the expenditures in the second (0.82 YTL) and fourth (0.87 YTL) groups. As duration increases households might reduce their use of more expensive alternatives such as kerosene lamps and electric lanterns and replace these with cheaper alternatives such as candles. Also when the outages get too long, people may choose to go to places that have power, or sleep earlier than usual. Eventually instead of resorting to averting actions the households may try to find more permanent solutions such as replacing their electric equipment with nonelectric ones.

Table 5. 23 Averting Behaviour and Expenditures by Duration Group

	Group Description	**Sample Size**	**Lighting (Candle+K.Lamp+G.Lamp+E.Lantern)**	
			Proportion of Households	YTL/month
Levels	Household's perceived total outage duration per year	N	Mean (S.E.)	Mean (S.E.)
1	Less than or equal to 36 hours per year	57	0.91 (0.04)	1.51 (0.17)
2	36-72 hours per year	60	0.75 (0.06)	0.82 (0.12)
3	72-144 hours per year	75	0.80 (0.05)	1.21 (0.12)
4	144-288 hours per year	66	0.85 (0.04)	0.87 (0.10)

5	More than 288 hours per year	78	0.85 (0.02)	1.05 (0.11)
Total		336	0.12 (0.02)	1.09 (0.06)
Kruskal-Wallis Test of Equality of Means -- Significance Level			**	***
Brown-Forsythe Test of Equality of Means -- Significance Level			**	***
Cuzick's Non Parametric Test for Trend -- Significance Level			--	--
Multiple comparisons (Tamhane's T2)			(2&5)*	(1&2)***, (1&4)**
(*) 10% significance level; (**) 5% significance level; (***) 1% significance level two-tailed tests.				

5.7 Tobit Regression

As can be seen in Table 5.1, only 7.7% of the 350 households we interviewed did not take any averting action, and the remaining 92.3% took between one and four actions. In Table 5.7 we have shown that the average monthly expenditures for most averting behaviour, except for owning/using generators, ranged between 0.11 to 9.02 YTL. Monthly AE, excluding generators, on average comprised only 0.1% of a representative household's monthly income (2,253.86 YTL). Therefore engaging in at least one action such as using candles does not have a big impact on the household's budget. On the other hand, average monthly generator expenditures for those households that have them ranged from 24.6 to 150.1 YTL depending on the number of times the generators were maintained, and this is equivalent to 2.2% of an average household's monthly income.

Abdalla (1992), Sukharomana (1998), Korman (2002), Um et al. (2002), and Pattanayak (2005) applied the AE method to measure the WTP of households for improved water services.[47] The

[47] Abdalla (1992) measured the economic cost of ground water contamination to households in Pennsylvania using the averting expenditure method. Sukharomana (1998) measured WTP for water quality improvements in Nebraska using

econometric models used in these studies were: Probit (Um et al., 2002); Heckman two step model (Sukharomana, 1998); OLS regression (Abdalla et al, 1992); and robust regression techniques (robust standard errors regression, robust regression, quantile regression) (Korman, 2002; Pattanayak et al., 2005). We will estimate the amount of households' monthly AE using the Tobit model. The presence of zero observations in our data makes the Tobit model a more appropriate choice then the Heckman two step and OLS models.

Since our data is left-censored at zero (i.e., any potential negative total AE are included in zero observations), we will use a Tobit regression (Tobin, 1958) to model the household's total AE (Jakus, 1994; Um et al., 2002; Cai, 2009).[48]

The latent total monthly AE of each household, $\hat{totalxp_i}$, is specified as an additive function of the explanatory variables:

$$tot\hat{a}lxp_i = \beta X_i + \omega_i$$

where ω_i has a normal distribution with mean 0 and standard deviation σ. The observed $totalxp_i$ of each respondent *i* is modelled as:

$$totalxp_i = tot\hat{a}lxp_i \text{ if } totalxp_i > 0$$

---

both contingent valuation and averting expenditure methods. Korman (2002) estimated the WTP for improved water services in Famagusta, Cyprus, using both contingent valuation and averting expenditure methods. Um et al. (2002) estimated the WTP for improved water quality in Korea using the averting behavior method. Pattanayak (2005) measured the averting expenditures of households in Katmandu, Nepal, in coping with unreliable public water supply.

[48] These authors use the Tobit model in modeling household averting behavior in context of pest control (Jakus, 1994), and drinking water quality control (Um et al., 2002; Cai, 2009).

$totalxp_i = 0$ otherwise

The Tobit regression is estimated using the *tobit* command in STATA 9.2 (see Table 5.24 for the description and summary statistics for the variables used in the regression, Appendix 5.2 for the correlation matrix, and Appendix 5.1 for the regression algorithm).

We expect the household's averting expenditures to depend, among other things, on their historical experience with outages, dependence on electricity, and some socio-demographic factors. Table 5.24 gives definition and summary statistics for the dependent and independent variables used in the Tobit regression.

Table 5. 24 Definition and Summary Statistics for the Variables of Parametric Models

Number of observations = 336					
Variable	Description	Mean	Std. Dev.	Min	Max
totalxp	Monthly AE	6.96	19.83	0.04	174.35
totfreq	Total perceived number of outages during past 12 months (June 2007-May 2008)	81.21	152.25	0	1095
percplan	Percentage of perceived total number of outages during past 12 months (June 2007-May 2008) that are planned	0.14	0.21	0	1
percnite	Percentage of perceived total number of outages during past 12 months (June 2007-May 2008) that are at night	0.35	0.24	0	1
percwint	Percentage of perceived total number of outages during past 12 months (June 2007-May 2008) that are in winter	0.50	0.20	0	1
lntotdur	Log of total perceived outage duration for the past year (hours)	4.78	1.33	0	8.05
avgmaxdur	Longest perceived outage duration during the past year (hours)	6.00	3.58	0	40
dethouse	1 if detached house	0.57	0.50	0	1
florsize	Dwelling floor-size (meter-square)	128.11	41.97	50	400
prcnoeht	Percentage of space heating not obtained from electricity	0.49	0.43	0	1
athome	1 if someone at home most of the time	0.52	0.50	0	1
sickbed	1 if household has sickbed resident	0.01	0.12	0	1
age	Age of the respondent (years)	37.40	14.63	18	79.33
married	1 if respondent is married	0.54	0.50	0	1
haschild4	1 if has a household member less than 4 years old	0.12	0.32	0	1
has65novr	1 if household has someone of age 65 and over	0.07	0.25	0	1

univ	1 if respondent has university education	0.15	0.36	0	1
income	Total monthly income of the household (YTL)	2209.58	1271.66	530	6501
Lefkosa	1 if resident of Lefkoşa	0.32	0.47	0	1
Magusa	1 if resident of Gazimağusa	0.24	0.42	0	1
Girne	1 if resident of Girne	0.23	0.42	0	1
Iskele	1 if resident of İskele	0.08	0.27	0	1

Quality of Service

Experience with frequent outages (*totfreq*) has a learning effect on the households and is expected to decrease household's AE. We expect households to be more likely to take averting action for outages that last for a moderate amount of time (may be up to four hours) than the ones that are longer. It is possible that when the outages get too long, people may choose to go to places that have power, or sleep earlier than usual. When the duration is very long instead of resorting to averting actions the households may try to find more permanent solutions such as replacing their electric equipment with nonelectric ones. Hence, we expect a positive relationship between the AE and the log of total duration (*lntotdur*), but a negative relationship between the AE and average maximum outage duration (*avgmaxdur*).

When experience with planned outages increases, households plan in advance and minimize the number of activities that are interrupted by an outage. Hence we expect *percplan* to have a negative sign. Given most of the averting behaviour is toward maintaining the lighting needs of the household, we expect experience with night-time outages (*percnite*) to have a positive sign. We have no prior expectations for the sign of the variable *percwint*. The sign of *percwint* will depend on whether more household activities are interrupted in winter or summer.

Structural Characteristics of the House

Households with larger houses have larger lighting and space heating needs. Hence we expect *florsize* to have a positive sign. We have no prior expectations for the sign of the variable *dethouse*. Households that live in detached houses may be less worried about having to go up and down the stairs than the households living in apartments. On the other hand, detached houses are not surrounded by other dwellings hence may get colder during the winter, but are easier to cool during the summer. In some cases, households living in apartments may benefit from the averting actions taken by their neighbours (positive externalities), and hence less willing to take actions themselves.

Behaviour of the Household

Having had a long experience in living with outages households often resort to non-electric alternatives for their heating and cooking needs. A household's cooking, space and water heating activities will not be interrupted by an outage if non-electric fuels are being used in the house for these purposes. Hence we expect *prcnoeht* to have a negative sign.

Being at home most of the time is expected to have a positive impact on the AE. The more time a household spends at home a higher number of activities are likely to be interrupted. Having a sickbed resident is likely to increase the necessity to keep more electricity dependent equipment functioning during an outage and hence a positive impact on the AE.

Socioeconomic and Demographic Variables and Regional Dummies

Similarly, having a child of age four or younger is likely to increase the necessity to keep more electricity dependent equipment functioning during an outage and hence a positive impact on the AE. Having an adult of age 65 or older is expected to be negatively related to the AE as they would have fewer activities interrupted. The monthly AE given the household's current usage rate are not a significant portion of a household's income unless they invest in generators. For this reason, we expect a positive relationship between income and the AE, however we do not expect this to be a major determinant of household overall averting behaviour. We have no prior expectations for the signs of the variables *age, married, univ,* and the regional dummies.

336 observations are included in the estimation and the log-likelihood of the full model is -1357.98, with Probability >Chi^2 of 0. The McFadden's pseudo R^2 is 0.021. Table 5.25 below summarizes the Tobit regression results (STATA algorithms in Appendix 5.5). Looking at the significant parameter estimates older and high income households and those that are residents of İskele have higher monthly expenditures than the others. Households that have a child of age 4 and younger and are residents of Gazimağusa have lower monthly AE. İskele residents' higher AE are consistent with their higher generator ownership and lower perceived service reliability level. Similarly Gazimağusa residents' lower AE are consistent with their lower number of averting actions, and higher perceived service reliability. On the other hand, contrary to our prior beliefs, *haschild4* entered negatively. One explanation could be that families with small children do not want to take the risk of some crucial activities being interrupted by an outage and hence have a larger preference for non-electricity dependent devices.

Table 5. 25 Tobit Regression Results

Explanatory Variable	**Coefficient (S.E.)**
Quality of Service	
totfreq	-0.002 (0.010)
percplan	-2.722 (5.219)
percnite	5.436 (5.015)
percwint	-2.161 (5.654)
lntotdur	0.741 (1.128)
avgmaxdur	-0.523 (0.334)
Structural Characteristics of the House	
dethouse	1.691 (2.363)
florsize	0.040 (0.026)
Behaviour of the Household	
prcnoeht	-2.979 (2.819)
athome	1.355 (2.221)
sickbed	5.095 (9.226)
Socioeconomic and Demographic Variables	
age	0.218** (0.109)
married	3.487 (3.032)
haschild4	-7.163** (3.583)
has65novr	-2.741 (5.021)
univ	-2.676 (3.017)
income	0.002** (0.001)
Regional Dummies	
Lefkosa	-4.161 (3.622)

Magusa	-8.449** (3.834)
Girne	-4.641 (3.819)
Iskele	13.970*** (5.016)
_cons	-10.352 (8.048)
/sigma	18.514 (0.747)
Number of observations	336
Pseudo R2	0.021
Monthly Averting Expenditure Estimates (YTL/month)	
Mean	3.13
95% Confidence Interval	1.89 – 4.61
The confidence intervals are bootstrapped confidence intervals using the percentile method (1000 repetitions)	
(*) 10% significance level; (**) 5% significance level; (***) 1% significance level two-tailed tests.	

Using the estimates of coefficients, $\overline{\beta}$, and the average values of the explanatory variables, $\overline{X}$, *totalxp* is calculated for the average household as $\overline{X}.\overline{\beta}$. We need to make an adjustment to $\overline{X}.\overline{\beta}$ to calculate its censored value. The formula for the adjustment is (Tobin, 1958; McDonald and Moffitt, 1980):

$$\text{adjusted totalxp} = \overline{X}.\overline{\beta} * F(z) + \sigma * f(z)$$

σ is the standard error of the regression, z is the normalized index (= $\overline{X}.\overline{\beta}$ /σ), F(z) is the cumulative standard normal distribution function, and f(z) is the standard normal probability density function. After this adjustment, an average household's AE is 3.13 YTL/month (see Table 5.26).

Table 5. 26 Calculation of Mean AE and Confidence Intervals

Explanatory Variable	Coefficient $\bar{\beta}$	Sample Average $\bar{X}$	$\bar{\beta}.\bar{X}$
totfreq	-0.002	81.21	-0.17
percplan	-2.722	0.14	-0.38
percnite	5.436	0.35	1.90
percwint	-2.161	0.50	-1.08
lntotdur	0.741	4.78	3.54
avgmaxdur	-0.523	6.00	-3.14
dethouse	1.691	0.57	0.96
florsize	0.040	128.11	5.17
prcnoeht	-2.979	0.49	-1.47
athome	1.355	0.52	0.71
sickbed	5.095	0.01	0.08
age	0.218	37.40	8.16
married	3.487	0.54	1.90
haschild4	-7.163	0.12	-0.83
has65novr	-2.741	0.07	-0.19
univ	-2.676	0.15	-0.41
income	0.002	2209.58	3.99
lefkosa	-4.161	0.32	-1.35
magusa	-8.449	0.24	-1.99
girne	-4.641	0.23	-1.05
iskele	13.970	0.08	1.12
_cons	-10.352		-10.352
		Total	**5.13**

$\bar{\beta}.\bar{X}$	σ	z $\bar{\beta}.\bar{X}/\sigma$	F(z)	f(z)	bX*F(z)+ σ*f(z)
5.13	18.51	0.28	0.61	0.38	3.13
95% Confidence Intervals:					
3.31		0.18	0.57	0.39	1.89
7.10		0.38	0.65	0.37	4.61
The confidence intervals are bootstrapped confidence intervals using the percentile method (1000 repetitions)					

CHAPTER 6 RESULTS FROM THE CVM STUDY

6.1 Introduction

The objective of this research is to measure the WTP for an uninterrupted power supply in North Cyprus. We opted for estimating the customers' stated WTP using the CE and CVM, their revealed WTP using the AE, and then comparing the results of the three methods to check for the validity of the stated preference methods.[49] In Chapter 5, a typical household's AE estimated using the Tobit model was 3.13 YTL/month.

In Chapter 2, we gave the theoretical framework for the CVM, discussed its different formats and their potential problems. In this chapter, we will cover the results of the CVM study. In Section 2, we will explain how the payment ladder data of the CVM was handled and in Section 3, we will give the results for the non-parametric econometric models estimated. The Turnbull (1976) and Kriström (1990) non-parametric estimates for median and mean WTP will be compared. In Section 4, the household's participation decision will be modelled using Probit regression. In Section 5, the models will be estimated parametrically using Spike models. Finally, in Section 6, we will compare and discuss the WTP estimates from the different approaches used.

[49] In Chapter 2 section 3.2.1, we showed that the cost savings achieved when holding the household's preferred level of electricity services constant when reliability improves, will be a lower bound on the welfare measure of the reliability change.

6.2 Data

The CVM section of the questionnaire consisted of a hypothetical inverter system where using a payment card (payment ladder) format the respondents were asked to state their WTP for the inverter system (see Appendix 4.2 Question 53). 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 were asked to put a tick next to the highest amount they were sure they would pay and a cross next to the first amount they were sure they would not pay. Those not opting for the inverter systems were 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.

Out of the 350 people surveyed, all 350 answered the CVM question. The 140 respondents (40%) that chose not to go for the inverter system were asked a follow up question and gave the reasons shown in Table 6.1. Reasons 10, 11, and 12 are treated as protest responses, because they do not necessarily imply that the households put no value on the hypothetical inverter system. In order to avoid introducing a bias by including invalid zero bids, we followed the usual practice, and removed the 17 protest responses from the CVM analysis (see also Halstead et al., 1992; Whitehead et al., 1993; Jorgensen et al., 1999; O'Garra et al., 2007; and Birol et al., 2008 for a similar treatment of protest responses).

Table 6. 1 Reasons for Not Going for the Inverter System

	Reasons for not going for the inverter system	Number of observations
1	happy with their gas lamp	1
2	have not felt the need for it; use what they have; wait for electricity to	37

	come back, do not want to bother	
3	have a generator, and they are satisfied with it	5
4	do not want extra expenditures	44
5	do not know/have not heard about it	8
6	may think about it if it becomes common	10
7	not interested since they are old	1
8	do not think it is useful	11
9	happy with their current system	3
10	do not believe such a system will be in Cyprus	5
11	the current system needs to be improved, we are already paying enough	5
12	not sure the system will work; it is the Government's duty to provide continuous supply, and do not want to have additional expenditures	7
13	do not have any specific reason	3
	Total	140

We checked the data for inconsistencies in the information provided by the respondents. There were 14 observations that resulted in extremely high total duration (more than 2208 hours =92 days*24 hours/day for summer and 2184 hours =91days*24 hours/day for winter), and four observations where the upper bounds of the WTP intervals reported by the households (the crosses) are greater than their monthly income. These 18 observations were also excluded from our analysis.

Within the remaining 315 observations, 115 (36.5%) were true zero WTP bids and 200 (63.5%) had greater than zero WTP. Table 6.1 shows the frequency for the ticks and the crosses that the respondents provided. The ticks ranged from 10 to 450 YTL and the crosses ranged from 10 to 550 YTL per month (see Table 6.2 and Figure 6.1). The mode for the ticks is 10 YTL, while for the crosses is 30 YTL. 13 respondents put a cross next to the maximum amount on the payment ladder, 550YTL.

Table 6. 2 Number of Ticks and Crosses for the Bids Included in the Payment Ladder

Bid	Lower Bound (tick)	%	Upper Bound (cross)	%
0	115	36.5%	115	36.5%
10	70	22.2%	16	5.1%
20	34	10.8%	30	9.5%
30	30	9.5%	28	8.9%
40	17	5.4%	19	6.0%
50	23	7.3%	28	8.9%
70	9	2.9%	16	5.1%
90	9	2.9%	12	3.8%
120	2	0.6%	15	4.8%
150	2	0.6%	8	2.5%
200	1	0.3%	7	2.2%
250	1	0.3%	2	0.6%
350	0	0.0%	4	1.3%
450	2	0.6%	2	0.6%
550	0	0.0%	13	4.1%

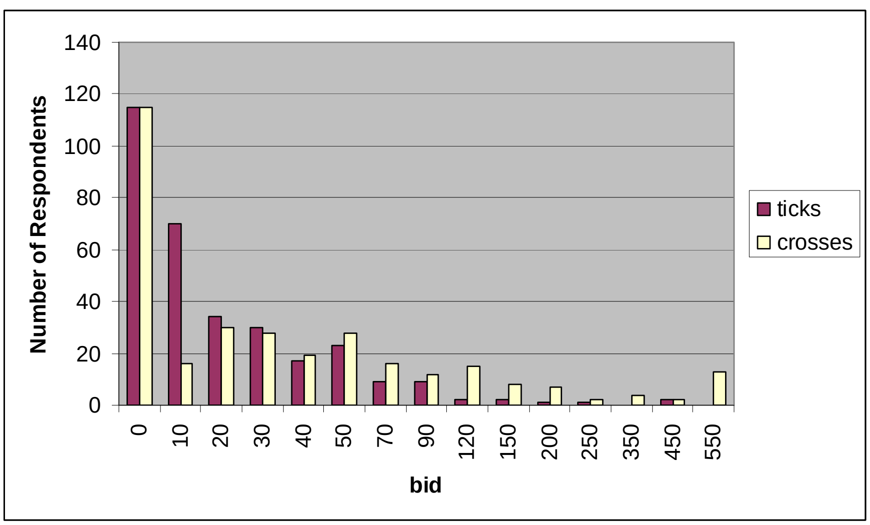

Figure 6. 1 Number of Ticks and Crosses for the Bids Included in the Payment Ladder

6.3 Non-parametric Estimations

The parametric approach to derive the WTP measure requires a distributional assumption, which may result in inconsistent estimates when the distribution is misspecified. In order to overcome this potential problem, Turnbull (1976) suggests a distribution free lower bound mean estimate (see also Chapter 2 Section 4.1.1.). Kriström (1990) proposes another non-parametric approach which results in a higher WTP estimate. According to Kriström (1990), the estimates obtained from this approach are simple to compute and robust against distributional misspecification.

First, for each bid B_i we used the tick data (the lower limits on WTP) to calculate the cumulative number and proportion of "YES" responses p_i (see Table 6.3).

Table 6. 3 Proportion of YES Answer (using the lower limits on WTP)

N = 315			
i	BID (B_i)	Cumulative Number of YES (ticks)	Proportion of YES answer (p_i)
1	10	200	63.49%
2	20	130	41.27%
3	30	96	30.48%
4	40	66	20.95%
5	50	49	15.56%
6	70	26	8.25%
7	90	17	5.40%
8	120	8	2.54%
9	150	6	1.90%
10	200	4	1.27%
11	250	3	0.95%
12	350	2	0.63%
13	450	2	0.63%
14	550	0	0.00%

B_{12} and B_{13} resulted in the same proportion of YES answers ($p_{12}= p_{13}$=0.63%). Therefore following the steps to calculate the Turnbull estimator summarized in Haab and McConnell (1997), we removed B_{13} and pooled responses to B_{13} with B_{12} (see Table 6.4)

Table 6. 4 Proportion of YES Answer after Pooling

N=315			
i	BID (B_i) YTL	Proportion of YES answer (p_i)	Cumulative Probability $\Pi_i = P(WTP \leq B_i) = 1\text{-}p_i$
1	10	63.5%	35.8%
2	20	41.3%	58.0%
3	30	30.5%	69.1%
4	40	21.0%	78.8%
5	50	15.6%	84.7%
6	70	8.3%	91.9%
7	90	5.4%	94.8%
8	120	2.5%	97.4%
9	150	1.9%	98.0%
10	200	1.3%	98.7%
11	250	1.0%	99.0%
12	350	0.6%	99.4%
13	550	0.0%	100%

As can be seen from Table 6.4 and the survivor function in Figure 6.2, p_i, the percentage of the sample who reported a minimum WTP of B_i, decreases with B_i. The median, i.e. the WTP amount at which the cumulative probability Π_i=50%, lies between 10-20 YTL. Using linear interpolation, the lower bound median WTP can be approximated as 16.07 YTL.[50]

[50] Median WTP = 10 + [(50% - 63.5%)(20-10)/(41.3% - 63.5%)] = 16.07 YTL.

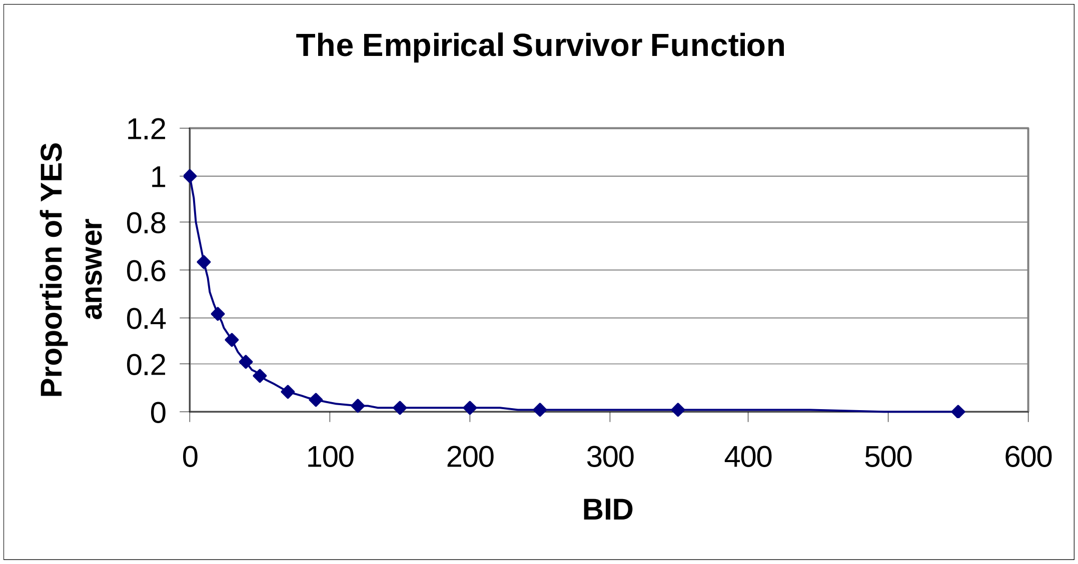

Figure 6. 2 The Empirical Survivor Function

6.3.1 Turnbull Lower Bound Mean

Since we asked the respondents to put a tick next to the highest amount they are sure they would pay and a cross next to the first amount they are sure they would not pay, for each respondent we only observed the interval in which their actual WTP lies. The Turnbull Lower Bound Mean, which uses the lower bound of each interval, is therefore a conservative estimate and is calculated as (Haab and McConnell, 1997; Boman et al., 1999; Vaughan and Rodriguez, 2001; Blaine et al., 2005):

$$LBM(Turnbull) = p_1 B_1 + \sum_{i=2}^{m} p_i (B_i - B_{i-1})$$

The variance of the LBM:

$$Var(LBM) = \sum_{i=1}^{m} \frac{p_i (1 - p_i)(B_i - B_{i-1})^2}{N}$$

where N is the sample size.

Table 6.5 below shows the calculation of the LMB and Var(LBM).

LBM (Turnbull) = 63.5% *10+ 41.3% * (20-10) +…+ 0.6% * (350-250) = 22.98 YTL

Var (LBM) $=[0.64(1-0.64)(10-0)^2 + 0.41(1-0.41)(20-10)^2 +\ldots+ 0.006(1-0.006)(350-250)^2]/315$

$= 0.97$

Standard Deviation (LBM) = $(0.97)^{1/2}$ = 0.99 YTL.

Table 6. 5 Calculation of LBM and Variance of LBM

N=315					LBM	V(lower bound)
	BID (B_i) YTL	Cumulative Number of NO	CDF (NO) ($1- p_i$)	CDF (YES) (p_i)	$p_i *(B_i-B_{i-1})$	$[p_i *(1- p_i)* (B_i-B_{i-1})^2]/N$
0	0		0.0%	100.0%		
1	10	115	36.5%	63.5%	6.35	0.074
2	20	185	58.7%	41.3%	4.13	0.077
3	30	219	69.5%	30.5%	3.05	0.067
4	40	249	79.0%	21.0%	2.10	0.053
5	50	266	84.4%	15.6%	1.56	0.042
6	70	289	91.7%	8.3%	1.65	0.096
7	90	298	94.6%	5.4%	1.08	0.065
8	120	307	97.5%	2.5%	0.76	0.071
9	150	309	98.1%	1.9%	0.57	0.053
10	200	311	98.7%	1.3%	0.63	0.100
11	250	312	99.0%	1.0%	0.48	0.075
12	350	313	99.4%	0.6%	0.63	0.200
13	550	315	100.0%	0.0%	0.00	0.000
				Total	**22.98**	**0.97**

6.3.2 Kriström Mean

The Kriström mean WTP is approximated as the area under the survivor function. Approximating the area under the survivor function as a sum of trapezoids:[51]

Kriström mean = (10-0)*(63.5%+100%)/2 + (20-10)*(41.3%+63.5%)/2+…

+ (550-350)*(0+0.6%)/2 = 29.78 YTL

This approximation assumes that the survivor function is linear within each interval with the lower limit B_l and upper limit B_u. Hence, in calculating the expected WTP, the weight put on that interval is equal to the average of p_l and p_u, where p_l and p_u are the percentages of the sample who reported a minimum WTP of B_l and B_u respectively. As a result, for the same bid interval, the weights used in calculating the Kriström mean were higher than the weights used in the Turnbull LBM. Consequently, the Kriström mean 29.78 YTL was higher than the Turnbull LBM 22.98 YTL.

6.3.3 Upper Bound Mean

Using a similar procedure to the Turnbull Lower Bound Mean calculated above, an Upper Bound Mean can be calculated as (Vaughan and Rodriguez, 2001):

$$UBM = \sum_{i=1}^{m} p_i (B_{i+1} - B_i)$$

UBM = (10-0)*100% + (20-10)*63.5% +…+(550-350)*0.6% = 36.57 YTL

[51] Blaine et al. (2005) uses the following formula to calculate the Kriström mean,

$$= LBM + (1/2)B_0(1-p_0) + \sum_{i=1}^{m}(1/2)\left|p_i - p_{i-1}\right|(B_i - B_{i-1}) + (1/2)p_k(B^* - B_k)$$

As expected from the shape of the survivor function, the median was lower than the mean estimates:

Lower Bound Median (16.1 YTL) < LBM (23.0 YTL) < Kriström Mean (30.0 YTL) < UBM (36.6 YTL).

6.4 Household's Participation Decision – Probit Model

After describing the hypothetical inverter system to the respondents, the respondents chose whether or not to participate in the contingent market. A household's participation decision is modelled as follows:

Let $poswtp_i$ be an independent variable that takes on the value of 1 if the household *i* stated 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_i:

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

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

We expected the household's participation decision to depend, among other things, on their historical experience with outages, dependence on electricity, and some socio-demographic factors. Appendix 6.1 lists all the potential explanatory variables that may be included in vector Z_i with their descriptions and summary statistics. Table 6.6 gives the summary statistics for the dependent and independent variables used in the probit regression.

Table 6. 6 Summary Statistics for Probit Regression Variables

Number of Observations = 315				
	Mean	**Std. Dev.**	**Min**	**Max**
Dependent Variable				
poswtp	0.63	0.48	0	1
Explanatory Variables				
Quality of Service				
totfreq	84.58	156.61	0	1,095
percunpl	0.86	0.21	0	1
percnite	0.35	0.24	0	1
percwint	0.50	0.20	0	1
lntotdur	4.80	1.34	0	8.1
avgnotifn	0.77	0.83	0	9
Structural Characteristics of the House				
dethouse	0.57	0.50	0	1
florsize	126.16	36.49	50	400
Behaviour of the Household				
generator	0.10	0.30	0	1
avert	0.92	0.27	0	1
hasaircon	0.69	0.46	0	1
prcnoeht	0.48	0.43	0	1
wkhmone	0.14	0.35	0	1
Socioeconomic and Demographic Variables				
noadult	2.56	1.13	0	5
nochild	0.67	0.98	0	5
univ	0.15	0.36	0	1
income	2,208.79	1,256.88	530	6,501
nocyborn	0.37	0.48	0	1
Regional Dummies				
Lefkosa	0.34	0.47	0	1
Magusa	0.23	0.42	0	1
Girne	0.22	0.41	0	1
Iskele	0.08	0.27	0	1

Experience with frequent outages has a learning effect on the households and increases the level of preparedness of the households for the 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 are not notified in advance. Households can reduce the negative impact of outages if they are given enough advanced notification. For these reasons, we expected the variables *totfreq*, *percunpl*, and *avgnotifn* to have negative signs. Considering lighting is one of households' major concerns during an outage we expected the variable *percnite* to have a positive sign i.e. households that have a higher rate of historical night-time outages may be more likely to opt for the inverter system. The duration of an outage is positively related to the amount of AE. The higher 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 expected a positive relationship between the probability of participating and log of total outage duration, *lntotdur*.

Having a long experience in living with outages households 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 therefore will be less likely to participate in the CVM market. The variable *avert* shows that the household is not totally carefree with respect to the outages and may be better off with an improved electricity service. Hence we expect this variable to have a positive sign. The households that work at home and their work depends on electricity (*wkhmone*), have air-conditioners (*hasaircon*), have more children (*nochild*), and 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 the households living in apartments. On the other hand, detached houses are not surrounded by other dwellings hence may get colder during the winter, but are easier to cool during the summer. In some cases, households living in apartments may benefit from the averting actions taken by their neighbours (positive externalities), and hence less willing to take actions themselves. Carlsson and Martinsson (2007) found a negative relationship between the probability of a positive WTP and living in a detached house.

Before we ran the probit regression, using cross-tabulated tables (the dependent variable classified by the categorical independent variables), we analysed the frequencies in each cell to make sure there were no empty or small cells as this would create difficulties in running the model.[52] Probit regression was estimated using the *probit* command in STATA 9.2 (see Appendix 6.2). It can be seen from the regression results summarized in Table 6.7 that *percnite*, *percwint*, *florsize*, *avert*, *Lefkosa* and *Iskele* enter with significant coefficients. High income households that experience a higher percentage of night outages, have a longer duration of outages, live in larger houses, participated in at least one type of averting behaviour, have air-conditioners, work from home on work that depends on electricity, have more children, have a university degree, are not born in Cyprus, and are residents of Lefkoşa or İskele, are more likely to participate in the contingent market. Households with higher frequency of outages, higher percentage of unplanned outages, higher percentage of winter outages, more

52 Introduction to SAS. UCLA: Academic Technology Services, Statistical Consulting Group. from http://www.ats.ucla.edu/stat/sas/notes2/ (accessed July 10, 2009).

advanced notification, that live in detached houses, own a generator, obtain a higher percentage of their space heating from non-electric fuels, have more adults, and are from Gazimağusa on the other hand are less likely to go for the inverter system.

Table 6. 7 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)
Behaviour of the Household	
generator	-0.208 (0.283)
avert	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	0.677 e-4 (0.807 e-4)

nocyborn	0.096 (0.203)
Regional Dummies	
Lefkosa	1.093*** (0.277)
Magusa	-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%
The confidence intervals are bootstrapped confidence intervals using the percentile method (1000 repetitions)	
(*) 10% significance level; (**) 5% significance level; (***) 1% significance level two-tailed tests.	

The bootstrapped mean using 1000 repetitions is 64.08% which is close to the sample average of 63.49%. 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.

6.5 Parametric Estimation

While nonparametric approaches are simple to compute and robust against distributional misspecification, making inferences based on parameter estimates using these approaches is difficult (Haab and McConnell, 1998). In this section we will estimate the WTP using a parametric approach. Due to the presence of a large number of zero observations in the data (36.5% of the sample), we need to use a regression model which allows for the inclusion of these zero observations.

Spike Regression Model

An estimation method put into application by several authors in the literature to deal with the presence of a large number of zero observations in the data is the spike model (An and Ayala, 1996; Kriström, 1997; Bosetti and Pearce, 2003; Hu, 2006; McCartney, 2006; Hanley et al., 2009; Hanley et al., 2009b; Hanley et al., 2009c; Yoo and Kwak, 2009). In a spike model, the respondents' decision process consists of two steps. In the first step, the respondents choose whether or not they will participate in the contingent market. In the second step, the respondents that choose to participate in the contingent market decide on how much to pay for the good in the question. Hence the spike model can be considered as an extended version of the Probit model which consists of only the first step of the spike model.

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:

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

Some authors calculate the probability of individual *i* choosing not to participate in the contingent market, p_i^0, separately as the ratio of the 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., 2009). Some 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 H(.):

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

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

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

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

If a standard normal distribution is assumed for G(.) and p_i^0 is specified as a linear function of explanatory variables Z_i, then the log-likelihood for the sample becomes:

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

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

The parameters γ, β, σ can be estimated using maximum likelihood estimation.

The mean WTP for the whole sample is calculated as (Bosetti and Pearce, 2003):

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

Since unlike the Tobit model, the spike model allows us to estimate the participation decision and the WTP amount using different sets of variables (Yoo et al., 2001), we will use the spike model in our econometric estimations. The spike regression also allows us to include true zero observations in the estimation without treating them as if they were from respondents who had a negative WTP. Using the log-likelihood function above where p_i^0 is specified as a linear function of explanatory variables Z_i and G(.) is assumed to have a standard normal distribution, we estimated the following five spike models using TSP 5.0 (see Appendix 6.4 for the TSP algorithms). CVM studies that estimate WTP for service improvements using the interval data format typically choose a log-linear (Moeltner and Layton, 2002; Layton and Moeltner, 2005; Carlsson and Martinsson, 2007) or a linear specification (Whitehead, 2006b; Damigos et al., 2009) for the WTP function. While the median and mean estimates are equal in the linear case, the mean is a function of the variance of the distribution of the error terms in the log-linear case, and the gap between the mean and median increases with this variance (Haab and McConnell, 1997).

The spike, the log of WTP, and the standard error are specified as additive functions of the explanatory variables.

$$p_i^0 = \gamma Z_i$$

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

$$\sigma = \alpha S_i$$

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. Appendix 6.1 lists all the potential explanatory variables that may be included in vectors Z_i, X_i, and S_i with their descriptions and summary statistics. We expect the household's WTP to depend, among other things, on their historical experience with outages, dependence on electricity, and some socio-demographic factors. In addition, the decision of which variables to include in the spike, the standard error, and the mean of the distribution will also depend on the achievement of convergence in the maximum likelihood estimation.

The dependent variables are the logs of the lower ($lnlb_i = \ln(\text{tick value}_i + 0.0001)$) and upper limits ($lnub_i = \ln(\text{cross value}_i)$) specified by the respondent. Since some observations are 0, we used the transformation $\ln(lb_i + 0.0001)$. In cases where the lower and upper limits specified by the respondent were equal, the upper limit of the interval was 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 and mean WTP for the whole sample are calculated as:[53]

E(median WTP)= p^0 .0 + (1- p^0).exp(βX)

E(mean WTP) = p^0 .0 + (1- p^0).exp(βX) .exp($\sigma^2/2$)

6.5.1 Model 1: Constant Spike, Constant Mean, Constant Standard Error

Model 1 is estimated with a constant spike (p_i^0), a constant mean WTP (βX), and a constant standard error of the WTP distribution (σ):

$$p_i^0 = \gamma Z_i = \gamma_0$$

$$\beta X_i = \beta_0$$

$$\sigma = \alpha_0$$

315 observations are included in the estimation and the log-likelihood of the full model is -524.302 (see Table 6.8 below for the regression results).

6.5.2 Model 2: Constant Spike, Varying Mean, Constant Standard Error

Model 2 is estimated with a constant spike (p_i^0), a varying mean WTP (βX), and a constant standard error of the WTP distribution (σ):

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

$$p_i^0 = \gamma Z_i = \gamma_0$$

$$\beta X_i = \beta_0 + \beta_1 percnite + \beta_2 percwint + \beta_3 lntotdur + \beta_4 avgnotifn + \beta_5 dethouse + \beta_6 florsize + \beta_7 act + \beta_8 avgbill + \beta_9 nonecook + \beta_{10} sickbed + \beta_{11} nochild + \beta_{12} noadult + \beta_{13} income + \beta_{14} lefkosa + \beta_{15} magosa + \beta_{16} girne + \beta_{17} iskele$$

$$\sigma = \alpha_0$$

The explanatory variables are (see Appendix 6.1 for descriptive statistics and Appendix 6.3 for the correlation matrix): the percentage of the total number of perceived outages during the past year June 2007-August 2007) that happened at night (*percnite*); the percentage of the total number of perceived outages during the past year June 2007-August 2007) that happened in Winter (*percwint*); log of total perceived outage duration during the past twelve months (*lntotdur*); advance notification (as perceived by respondents) (*avgnotifn*); whether the household resides in a detached-house (*dethouse*); floor-size of the dwelling (*florsize*); whether the household had taken any averting action (*avert*); household's average monthly electricity bill (*avgbill*); whether the household has non electric cooking (*nonecook*); whether the household has a sickbed resident (*sickbed*); number of children (*nochild*); number of adults (*noadult*); total household income (*income*); and regional dummies (*Lefkosa*, *Magusa*, *Girne* and *Iskele*).

It is a common practice in the literature to relate log of WTP with log of the total duration of outages due to the concave and monotonic relationship between the two (Moeltner and Layton, 2002; Layton and Moeltner, 2005; Carlsson and Martinsson, 2007) (also see Chapter 4 Section 3.4.2).

315 observations are included in the estimation and the log-likelihood of the full model is -505.306 (see Table 6.8 below for the regression results).

6.5.3 Model 3: Varying Spike, Constant Mean, Constant Standard Error

Model 3 is estimated with a varying spike (p_i^0), a constant mean WTP (βX), and a constant standard error of the WTP distribution (σ):

$$p_i^0 = \gamma Z_i = \gamma_0 + \gamma_1 percnite + \gamma_2 lefkosa + \gamma_3 girne + \gamma_4 iskele$$

$$\beta X_i = \beta_0$$

$$\sigma = \alpha_0$$

315 observations are included in the estimation and the log-likelihood of the full model is -500.014 (see Table 6.8 below for the regression results). The explanatory variables for the spike equation are the percentage of the total number of perceived outages during the past year June 2007-August 2007) that happened at night (*percnite*), and the regional dummies (*Lefkosa*, *Girne* and *Iskele*).

6.5.4 Model 4: Constant Spike, Constant Mean, Varying Standard Error

Model 4 is estimated with a constant spike (p_i^0), a constant mean WTP (βX), and a varying standard error of the WTP distribution (σ):

$$p_i^0 = \gamma Z_i = \gamma_0$$

$$\beta X_i = \beta_0$$

$$\sigma = \alpha_0 + \alpha_1 avgbill + \alpha_2 nonewatr + \alpha_3 married + \alpha_4 has65nov + \alpha_5 income + \alpha_6 lefkosa + \alpha_7 iskele$$

315 observations are included in the estimation and the log-likelihood of the full model is -503.473 (see Table 6.8 below for the regression results). The explanatory variables for the standard error equation are: whether the household has nonelectric water heating (*nonewatr*); household's average monthly electricity bill (*avgbill*); whether the householder is married (*married*); whether the household has a resident of age 65 and over (*has64nov*); total household income (*income*); and the regional dummies (*Lefkosa, Iskele*).

6.5.5 Model 5: Varying Spike, Varying Mean, Constant Standard Error

Model 5 is estimated with a varying spike (p_i^0), a varying mean WTP (βX), and a constant standard error of the WTP distribution (σ):

$$p_i^0 = \gamma Z_i = \gamma_0 + \gamma_1 percnite + \gamma_2 lefkosa + \gamma_3 girne + \gamma_4 iskele$$

$$\beta X_i = \beta_0 + \beta_1 percnite + \beta_2 percwint + \beta_3 lntotdur + \beta_4 avgnotifn + \beta_5 dethouse + \beta_6 florsize + \beta_7 act + \beta_8 avgbill + \beta_9 nonecook + \beta_{10} sickbed + \beta_{11} nochild + \beta_{12} noadult + \beta_{13} income + \beta_{14} lefkosa + \beta_{15} magosa + \beta_{16} girne + \beta_{17} iskele$$

$$\sigma = \alpha_0$$

315 observations are included in the estimation and the log-likelihood of the full model is -481.019 (see Table 6.8 below for the regression results). The explanatory variables for the spike and WTP equations are the same variables used in the previous models above.

Table 6. 8 Summary of Spike Model Results

	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**
	Constant spike, constant mean, constant SE	Constant spike, varying mean, constant SE	Varying spike, constant mean, constant SE	Constant spike, constant mean, varying SE	Varying spike, varying mean, constant SE
Explanatory Variable	Coefficient (S.E.)	Coefficient (S.E.)	Coefficient (S.E.)	Coefficient (S.E.)	Coefficient (S.E.)
Spike equation, p^0					
const	0.365*** (0.027)	0.365*** (0.027)	0.634*** (0.053)	0.365*** (0.027)	0.634*** (0.053)
Quality of Service					
percnite			-0.207** (0.090)		-0.207** (0.091)
Regional Dummies					
Lefkosa			-0.403*** (0.059)		-0.403*** (0.060)
Girne			-0.180** (0.075)		-0.180** (0.077)
Iskele			-0.292*** (0.101)		-0.292*** (0.102)
WTP equation					
const	3.613*** (0.066)	2.691*** (0.552)	3.613*** (0.066)	3.556*** (0.047)	2.691*** (0.557)
Quality of Service					
percnite		-0.071 (0.268)			-0.071 (0.268)
percwint		-0.278 (0.331)			-0.277 (0.332)
lntotdur		0.078 (0.054)			0.078 (0.054)
avgnotifn		-0.137***			-0.137***

		(0.053)			(0.053)
Structural Characteristics of the House					
dethouse		-0.060 (0.135)			-0.060 (0.138)
florsize		0.001 (0.002)			0.001 (0.002)
Behaviour of the Household					
avert		0.450* (0.263)			0.450* (0.265)
avgbill		0.337e-3** (0.145e-3)			0.337e-3** (0.147e-3)
nonecook		-0.054 (0.283)			-0.054 (0.283)
sickbed		0.816 (0.519)			0.816 (0.520)
Socioeconomic and Demographic Variables					
nochild		-0.091 (0.070)			-0.091 (0.070)
noadult		-0.037 (0.062)			-0.037 (0.062)
income		0.628e-4 (0.511e-4)			0.628e-4 (0.512e-4)
Regional Dummies					
Lefkosa		0.237 (0.201)			0.237 (0.202)
Magusa		0.494** (0.230)			0.494** (0.230)
Girne		0.509*** (0.191)			0.509*** (0.191)
Iskele		0.314 (0.380)			0.315 (0.381)
Standard Error, σ					
const	0.758*** (0.043)	0.686*** (0.043)	0.757*** (0.044)	0.710*** (0.177)	0.686*** (0.043)
Behaviour of the Household					
avgbill				0.001* (0.290e-3)	
nonewatr				-0.318** (0.142)	
Socioeconomic and Demographic Variables					

married				0.193* (0.105)	
has65nov				-0.268 (0.184)	
income				0.116e-3** (0.516e-4)	
Regional Dummies					
Lefkosa				-0.329*** (0.116)	
Iskele				-0.413 ** (0.164)	
Number of observations	315	315	315	315	315
Log likelihood	-524.302	-505.306	-500.014	-503.473	-481.019
Mean and Median WTP (YTL/month, in 2008 Prices)					
Spike, p^0	0.365	0.365	0.364	0.365	0.364
βX	3.613	3.589	3.613	3.556	2.879
σ	0.758	0.686	0.757	0.751	0.686
Median WTP (S.E.) $(1- p^0)\exp(\beta X)$	23.54 (1.838)	22.98 (6.019)	23.60 (1.823)	22.24 (1.406)	23.03 (6.073)
Mean WTP (S.E) $(1- p^0)\exp(\beta X)\exp(\sigma^2/2)$	31.36 (2.239)	29.07 (7.554)	31.44 (2.178)	29.79 (2.038)	29.14 (7.630)
(*) 10% significance level; (**) 5% significance level; (***) 1% significance level two-tailed tests.					

The spike estimates, p^0, ranged between 36.4-36.5% which 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 in Section 4 above. In the spike equation, the parameters with a negative sign imply an increase in the probability for participating in the inverter market for increases in the parameter values. In spike models 3 and 5, where the spike was modelled as a linear function of explanatory variables, it can be seen that the households that experience a higher percentage of night outages, are residents of Lefkoşa, Girne or İskele are more likely to participate in the contingent market.

In the WTP equation, the parameters with a positive sign imply an increase in WTP for increases in the parameter values, where it is the opposite for ones with a negative sign:

Quality of Service

The outage frequency variables *percnite* and *percwint* coefficients enter with negative signs. Households with high perceived frequency of outages learn from their experience with outages and take preparatory actions to reduce the negative impact of outages on their households (referred by Layton and Moeltner, 2005 as the learning-to-cope or preparedness effect). The households with a higher perceived frequency of night outages are willing to pay a lower amount. The higher the frequency of night and winter outages, the more people learn to expect such outages and take preparatory actions such as using candles, substituting electric heating with LPG or wood. Also, the negative sign of *percwint* suggests that the need for cooling in summer outweighs the need for heating in winter. There are more substitutes for methods of space heating than there are for cooling. Most of space cooling in North Cyprus is done using air-conditioners which work with electricity. 69% of the dwellings in our sample have air-conditioners, and an average household owns 1.3 air-conditioners.

The average notification period has a negative impact on household's 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.).[54]

The coefficient of *lntotdur* has the expected positive sign (Layton and Moeltner, 2005).[55] The cost of an outage increases with duration and households are willing to pay more for service improvements. However, the relationship with log of total duration, suggests that this increase in WTP is at a decreasing rate (the longer the outage duration the more time households have to take preparatory actions to avoid the negative impact).

Structural Characteristics of the House

The *dethouse* parameter enters with a negative coefficient. Detached houses, being not surrounded by other buildings, may be easier to cool in summer and the use of air conditioners may not be needed as much as in other dwelling types. Also not having light is not as big a problem as in apartments where people have to use the stairways to go upstairs. The variable *florsize* enters with a positive coefficient. The households that live in larger dwellings are willing to pay a higher amount (Damigos et al., 2009; Kateregga, 2009). One possible explanation for this may be because they need more space heating/cooling. The number of air-conditioners, the dwelling's floor-size, the number of rooms, and the number of bedrooms are positively correlated. During a hot and humid summer day, one has more options of cooling off (e.g. go to the beach, find a place with a breeze, go somewhere

[54] Estimating the model with log of the average advanced notification period did not result in a significant improvement in model fit.
[55] When the model was estimated with totdur instead of lntotdur, the coefficient of totdur was insignificant and the fit of the model was worse.

which has air-conditioning). However, to be able to sleep well on a summer evening, air-conditioners have become a necessity in North Cyprus. They also have another important function, that of keeping the mosquitoes away which is a major problem during summer nights.

Behaviour of Household

The coefficient of *avert* is positive and significant. Households who have taken at least one preparatory action to avoid outages are willing to pay a higher amount than the ones who took no action. The coefficient of *avert* serves as a marker for households who would experience higher costs from an outage. Preparatory actions have a cost and these costs will be saved by the households when the outages are eliminated. The household's average monthly electricity bill and WTP are positively related. This may be because the households with a higher electricity bill are also more dependent on electricity.

Households that obtain some of their cooking from non-electric sources are willing to pay less to avoid outages as their cooking activities are less interrupted during the outage. Households with a sickbed resident are willing to pay more than the others for an improvement in their electricity service. Layton and Moeltner (2005) find the presence of a medical need to enter with a positive sign, but not to have a significant impact on the WTP value.

Socioeconomic and Demographic Variables, and Regional Dummies

WTP is negatively related with the number of children and negatively related with the number of adults in the house. Even though the size of the income coefficient is very small, it has the expected positive sign. Many CVM studies found weak income effects due to the difficulties in measuring household income (e.g. high non-response rate, intentional misrepresentation of respondent's income, failing to include income from all sources)(Alberini, 2004). The likelihood of having a significant income effect has also been related to the sample size and the design choices made in the study (Aiew et al., 2004; Broberg, 2010). The location variables *Lefkosa*, *Magusa*, *Girne*, and *Iskele* enter with positive coefficients.

In the quality of service category, *avgnotifn* enters significantly with a negative sign; in the structural characteristics of the house category, none enters significantly; in the behaviour of the household category, *avgbill* enters significantly with a positive sign (the coefficient is almost zero); in the socio-economic and demographic variables category, none enters significantly; and in the regional dummies category, *Magusa* and *Girne* enter significantly with positive signs. In summary, households that have higher average monthly electricity bills, have a shorter prior notification period, and who are residents of either Gazimağusa or Girne are willing to pay higher amounts in addition to their current monthly electricity bills in order to avoid outages.

The standard error, σ, ranged between 0.686 and 0.758. In the spike model 4, σ was specified as a linear function of independent variables. The standard error is positively associated with *avgbill*, *married*, *income*, and negatively related to *nonewatr*, *has65nov*, *Lefkosa*, and *Iskele*. Only *income*, *nonewater*, *Lefkosa* and *Iskele* enter significantly.

We used the log-likelihood ratio test to compare the goodness of fit of the five models:

-2(LL largest - LL smallest) ~ chi-square

The degrees of freedom for the test is the difference in the number of parameters estimated by the two models. Table 6.9 below shows the log-likelihood ratio test results for the five models estimated. Model 5 statistically improves the LL over all the previous models i.e. the LL of the Model 5 is statistically closer to zero than the other four models.

Table 6. 9 Log-Likelihood Ratio Test for Model Selection

	LL	DF	DF difference	-2LL Function	Chi Critical (5% sig.)
Model 5	-481.019	24.00			
Models Compared					
1 and 5	-524.302	3.00	21	86.566	31.4104
2 and 5	-505.306	20.00	4	48.574	9.48773
3 and 5	-500.014	7.00	17	37.99	27.5871
4 and 5	-503.473	10.00	14	44.908	23.6848

Table 6.10 below, shows the sensitivity of the mean WTP to each variable that enters the WTP equation in Model 5 significantly. The last column in the table shows the percentage change in mean WTP resulting from a 1% change in the variable. A 1% increase in these variables resulted in a 0.1%-0.2 % change in the mean WTP.

Table 6. 10 Sensitivity of Mean WTP to the Significant Variables in the WTP Equation - Model 5

Variable	Sample Mean	Sample Mean	Mean WTP after the	% Change in

		Increased by 1%	Increase YTL/month	Mean WTP
avgnotif	0.77 days	0.78 days	29.11	-0.11%
avgbill	215.20 YTL/month	217.35 YTL/month	29.16	0.07%
Magusa	22.5%	22.8%	29.17	0.11%
Girne	21.6%	21.8%	29.19	0.17%

Table 6.11 below, shows the sensitivity of the spike to each variable that enters the spike equation in Model 5 significantly. The last column in the table shows the percentage change in the spike resulting from a 1% change in the variable. Among the significant variables, the percentage of residents of Lefkosa and the historic percentage of night outages have the most impact on the magnitude of the spike. A 1% increase in these variables resulted in a less than 1% change in the spike.

Table 6. 11 Sensitivity of the Spike to the Significant Variables in the Spike Equation – Model 5

Variable	Sample Mean	Sample Mean Increased by 1%	Spike after the Increase	% Change in Spike
percnite	34.6%	35.0%	36.3%	-0.20%
Lefkosa	34.0%	34.3%	36.2%	-0.38%
Girne	21.6%	21.8%	36.3%	-0.11%
Iskele	7.9%	8.0%	36.3%	-0.06%

6.6 Summary of WTP Estimates

Table 6.12 summarizes the WTP estimates obtained from the non-parametric and parametric approaches used in this chapter. The median WTP estimates of the Lower Bound Turnbull is 16.07 YTL. On the other hand, the median WTP estimates of Spike Models 1, 2, 3, 4, and 5 are 23.54 YTL, 22.98 YTL, 23.60 YTL, 22.24 YTL, and 23.03 YTL respectively. The mean WTP estimates from the spike models fall between the Turbull LBM (22.98 YTL) and the Upper Bound Mean (36.57 YTL) and are closer to the Kriström mean (29.78 YTL). Since the spike models used a log transformation, the median WTP estimates were scaled by exp($\sigma^2/2$). Hence the mean WTP estimates of these models are 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 will report both the median and the mean estimates. Since the spike model 5 has the superiority in model fit over the other four models, we will rely more on the estimates from this model. 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.

Table 6. 12 Comparison of WTP Estimates

N=315	**Median WTP YTL/month in 2008 prices (95% confidence interval)**	**Mean WTP YTL/month in 2008 prices (95% confidence interval)**
Non-Parametric Models		
Lower Bound (Turnbull)	16.07	22.98
Kriström		29.78
Upper Bound		36.57
Parametric Models		
Spike Models		
Model 1	23.54 (19.93-27.14)	31.36 (26.97-35.75)
Model 2	22.98 (11.18-34.78)	29.07 (14.27-43.88)
Model 3	23.60 (20.03-27.17)	31.44 (27.17-35.71)
Model 4	22.24 (19.49-25.00)	29.49 (25.50-33.48)
Model 5	23.03	29.14

	(11.13-34.94)	(14.19-44.09)
Delta method is used in calculating the confidence intervals of the Spike models.		

In this chapter, we explained how the CVM data was handled and gave the results for the parametric and non-parametric econometric models estimated. The non-parametric and parametric estimates for median and mean WTP were compared. A typical household is willing to pay 29.14 YTL per month in addition to its monthly electricity bill for the inverter system in order to avoid outages.

CHAPTER 7 RESULTS FROM THE CE STUDY

7.1 Introduction

In Chapter 5 we reported WTP results estimated using the AE method. An average household's AE estimated using the Tobit model was 3.13 YTL/month. In Chapter 6, we explained how the CVM data was handled and gave the results for the parametric and non-parametric econometric models estimated. The non-parametric and parametric estimates for median and mean WTP were compared. The households' mean WTP to avoid an outage estimated using the CVM data and spike regression was 29.14 YTL per month in addition to their monthly electricity bill.

In this chapter, we will explain how the CE data was handled and give the results for the econometric models estimated: the multinomial logit model; the mixed logit model; and the mixed logit model with interactions.

7.2 Data

All 350 respondents answered the CE section. The sample choice set used in explaining the CE section to the respondents is shown in Figure 7.1. The numbers of respondents for each of the eight different versions used in the questionnaire (see Appendix 3.3) are shown in Table 7.1 below.

ASSUMING THAT THE FOLLOWING TWO SERVICES AND YOUR CURRENT SERVICE WERE THE ONLY CHOICES YOU HAVE, WHICH ONE WOULD YOU PREFER TO BUY?

Power outages during winter (December – February)

	Service A	*Service B*	*Current Service*
Frequency of outages	Once a month	Twice a month	Neither Service A nor Service B: I prefer to stay with my current service
Duration of outages	2-8 hours	Less than 2 hours	
Time of outages	Night-time	Daytime	
Prior notification of outages	No prior notification	Prior notification	
Percentage change in monthly electricity bill of:	20% more	30% more	
Your choice	**[ ]**	**[X]**	**[ ]**

I think Service B is better for me than Service A. Service B has two short interruptions that occur during daytime, where Service A has one longer interruption but it occurs during nighttime. Service A gives me no prior notification where Service B gives me some prior notification. Both services are better than my current service. My choice means that my monthly electricity bill will increase 30%, which is 10 percentage points higher than alternative A. In return for the increase in my electricity bill I will be saving some of the costs caused by my current service.

Figure 7. 1 A Sample Choice Set[56]

Table 7. 1 The Number of Respondents for Each Version

Version	Total	Service	Set1	Set2	Set3	Set4	Set5	Set6	Set7	Set8	Total	Total Sets
1	38	A	12	2	2	10	5	3	4	3	41	304
		B	3	11	13	6	7	11	8	8	67	
		C	23	25	23	22	26	24	26	27	196	
2	45	A	10	5	11	7	9	9	3	10	64	360
		B	12	18	8	13	8	13	17	11	100	
		C	23	22	26	25	28	23	25	24	196	
3	44	A	10	6	3	7	3	6	5	3	43	352
		B	4	8	8	6	14	4	8	10	62	
		C	30	30	33	31	27	34	31	31	247	
4	52	A	11	13	3	11	13	10	17	18	96	416

[56] The sample choice set followed the same format that was used by Carlsson and Martinsson in Sweden in 2004.

		B	5	8	15	11	10	15	7	6	77	
		C	36	31	34	30	29	27	28	28	243	
5	48	A	12	13	6	22	3	15	12	4	87	384
		B	17	7	22	6	21	12	9	14	108	
		C	19	28	20	20	24	21	27	30	189	
6	43	A	3	11	20	3	20	9	12	6	84	344
		B	22	17	9	19	9	17	14	20	127	
		C	18	15	14	21	14	17	17	17	133	
7	40	A	22	13	3	14	7	13	7	7	86	320
		B	3	12	20	8	18	10	15	17	103	
		C	15	15	17	18	15	17	18	16	131	
8	40	A	5	7	0	7	9	7	20	14	69	320
		B	18	19	22	16	13	19	4	6	117	
		C	17	14	18	17	18	14	16	20	134	
Total	350		350	350	350	350	350	350	350	350	2800	2800
		A	85	70	48	81	69	72	80	65	570	20.36%
		B	84	100	117	85	100	101	82	92	761	27.18%
		C	181	180	185	184	181	177	188	193	1469	52.46%
		Total	350	350	350	350	350	350	350	350	2800	

Eight different versions each containing eight choice sets were divided among the 350 respondents as follows: 38 version 1; 45 version 2; 44 version 3; 52 version 4; 48 version 5; 43 version 6; 40 version 7; and 40 version 8. Overall 350 respondents answered a total of 2800 choice sets. From the total 2800 choice occasions, 47.54% of the selected choices were the New Service (20.36% Service A, and 27.18% Service B), and 52.46% the Current Service (Service C).

138 respondents (39.4% of 350) chose the current service on all of the eight choice sets presented to them. The respondents that chose to remain with the current service on all eight occasions were asked a follow-up question to differentiate the protest bids from genuine zero bids. Table 7.2 lists the reasons given by the respondents for staying with the current service on all occasions. The respondents that chose the status-quo on each of the eight choice sets and explained by giving one

of the reasons 1, 4, 6, or 14 (see Table 7.2) were marked as protest bids and were excluded from the econometric analysis (Hanley et al., 2007). Respondents that chose the status-quo because they did not value or could not afford the improvements in the service were marked as non-protest zero WTP bids (genuine zero WTP) and were included in the econometric analysis. Using these criteria, 22 respondents (or 6.3% of the total sample) were marked as protest bids and were excluded from the econometric analysis.

Table 7. 2 Reasons for Choosing the Current Service

	Reason for Choosing the Current Service	Number of observations
1	As the electricity prices go up, not everybody will be able to use electricity and the remaining users will be happy with their service (i.e. the supply will be enough for the remaining few users).	1
2	We are happy with the current service; the current service is good; the current service is not too bad.	50
3	The alternatives in the choice sets are not any different from the current service.	24
4	Chose the current service due to the recent electricity price increases (afraid the prices will increase more).	15
5	We have a generator and are happy with it.	2
6	There should not be any power outages; they need to think of a better solution.	5
7	We do not want additional expenses.	22
8	The percentage increases in monthly electricity bill offered in the alternatives are not favourable.	3
9	The current service is financially better.	7
10	The current service is better than the others.	11
11	The alternatives are not suitable for me.	17
12	Apart from the increases in prices, I am happy with our current service.	4
13	If with Service A or B there will be 0 power outages, I can pay a 5% or 10% increase in monthly bill.	1
14	The current power outages are not reflected in our current bill.	1
15	The electricity bill is included in the rent so we are not aware of electricity prices.	1

17	No specific reason	1

The frequency, duration and percentage change in monthly bill attribute levels were coded as continuous variables, where the time and prior notification of outages attribute levels were effects coded (-1 and 1) (see Table 7.3).[57] The status-quo levels for the attributes were the amounts stated by the respondents in questions 9 through to 18 of the questionnaire.

Table 7. 3 Description and Coding of Variables Used in Econometric Analysis

Variable Name	Description
id	Number of respondent: 1-350
vers	Version seen by the respondent: 1-8
seas	Season specified in the choice set. 1: Winter; 0: Summer
cset	The number of choice set seen by the respondent: 1-8
altij	The alternative in a choice set. 1: A; 2: B; and 3: Current Service
nij	Number of alternatives in each choice set: 3
choice	Alternative selected by the respondent. 1: chosen; 0: not chosen
freq	Frequency of outages (number of outages per year): 1, 4, 12, 24, or status-quo level
dur	Average duration of outages (hours): 1, 5, or status-quo level
time	Time of outages: -1:Daytime; 1:Nighttime
ann	Prior notification of Outages: -1:prior notification; 1: No prior notification
chbill	Percentage change in monthly electricity bill: 0%, 5%, 10%, 20%, 30%
chbilltl	Change in monthly electricity bill in YTL (=respondent's monthly electricity bill * chbill)

After removing the 22 protest bids, the data was checked for any inconsistencies between the percentage increase in the monthly electricity bill chosen by the respondent and the household monthly income. For each alternative chosen, the percentage increase in the bill is multiplied by the

[57] Unlike dummy coding, effects coding avoids the problem of having the base level being confounded with the constant term (Adamowicz et al., 1994; Louviere et al., 2000; Hensher et al., 2005c).

household's monthly electricity bill and the result is compared with the household income. Two respondents chose a percentage increase in the monthly bill that yielded an amount higher than their monthly income. One respondent chose alternatives that resulted in increases in their monthly electricity bill up to 88% of the household income. These three respondents were removed from the econometric analysis as well.

The remaining 325 respondents made a choice on a total of 2,600 choice sets (half of which were for summer and the other half for winter outages). On 1,318 occasions the new services A or B were chosen, and on 1,282 occasions the Current Service (status-quo) was chosen (see Table 7.4). When the respondents opted for one of the new services, in general the alternatives with lower outage frequency levels were preferred over ones with higher levels (around 28%). The duration levels 1 and 5 hours had a very close rate of occurrence (49.77% and 50.23%). While outages with lower duration were more frequently selected in winter (54.04%), the case is reversed for summer outages. With respect to the outage time, the night-time level occurred 52.28% of the time (52.62% in summer, and 51.95% in winter). The frequency of prior notification level was also higher than that of no prior notification (54.77% in summer, 54.64% in winter, and 54.70% in total). The most frequently chosen percentage change in the monthly electricity bill level was the smallest percentage change 5% (32.77% in summer, 38.17% in winter, and 35.51% in total) and the least preferred level was the highest percentage change 30% (15.08% in summer, 14.97% in winter, and 15.02% for the two seasons together).

Where the status-quo alternative was chosen, around 54% of these choice sets had a frequency level of greater than 24 outages per year, around 80% lasted between 1 and 5 hours, around 82% occurred during the daytime, and all of them had no prior notification given.

Table 7. 4 Distribution of Alternatives and Alternative Levels Chosen

	Summer		Winter		Summer and Winter	
Alternatives						
A	285	21.92%	276	21.23%	561	21.58%
B	365	28.08%	392	30.15%	757	29.12%
C	650	50.00%	632	48.62%	1282	49.31%
Total	1300		1300		2600	
A and B	650		668		1318	
Frequency (outages per year)						
1	183	28.15%	186	27.84%	369	28.00%
4	173	26.62%	167	25.00%	340	25.80%
12	154	23.69%	179	26.80%	333	25.27%
24	140	21.54%	136	20.36%	276	20.94%
Duration (hours)						
1	295	45.38%	361	54.04%	656	49.77%
5	355	54.62%	307	45.96%	662	50.23%
Time						
Daytime	308	47.38%	321	48.05%	629	47.72%
Night-time	342	52.62%	347	51.95%	689	52.28%
Prior Notification						
yes	356	54.77%	365	54.64%	721	54.70%
no	294	45.23%	303	45.36%	597	45.30%
%Change in Monthly Electricity Bill						
5%	213	32.77%	255	38.17%	468	35.51%
10%	185	28.46%	145	21.71%	330	25.04%
20%	154	23.69%	168	25.15%	322	24.43%
30%	98	15.08%	100	14.97%	198	15.02%

	Summer		Winter		Summer and Winter	
Current Service	650		632		1282	
Frequency (outages per year)						
freq<=1	1	0.15%	4	0.63%	5	0.39%
1<freq<=4	33	5.08%	26	4.11%	59	4.60%
4<freq<=12	134	20.62%	126	19.94%	260	20.28%
12<freq<=24	135	20.77%	137	21.68%	272	21.22%
24<freq	347	53.38%	339	53.64%	686	53.51%
	650		632		1282	
Duration(hours)						
dur<=1	23	3.54%	32	5.06%	55	4.29%
1<dur<=5	547	84.15%	472	74.68%	1019	79.49%
5<dur	80	12.31%	128	20.25%	208	16.22%
	650		632		1282	
Time						
Daytime	539	82.92%	510	80.70%	1049	81.83%
Night-time	111	17.08%	122	19.30%	233	18.17%
	650		632		1282	
Prior Notification						
yes	0	0%	0	0%	0	0%
no	650	100%	632	100%	1282	100%

The cost attribute in the CE was expressed as a percentage increase in the monthly electricity bill. However since the data exists on respondents' monthly electricity bill, for each chosen alternative we are able to calculate the increase in the monthly electricity bill in YTL as well. Table 7.5 gives the distribution of increases in the monthly electricity bill the respondents opted for in the CE. Approximately half of the time the status-quo alternative was selected with zero change in the bill. 30% of the remainder lie between 0 and 20 YTL, and 20% is distributed between 20 and 120 YTL, after which there are fewer occurrences in each range. The overall average monthly increase in the electricity bill is 15.83 YTL. Within the non-status quo alternatives chosen (i.e. given that A or B is chosen), the average monthly increase in the electricity bill is 31.23 YTL.

Table 7. 5 Change in Monthly Electricity Bill in YTL

Change in Monthly Electricity Bill (YTL)	Summer		Winter		Summer and Winter	
0	650	50.00%	632	48.62%	1282	49.31%
0-10	192	14.77%	214	16.46%	406	15.62%
10-20	181	13.92%	171	13.15%	352	13.54%
20-30	101	7.77%	93	7.15%	194	7.46%
30-40	49	3.77%	55	4.23%	104	4.00%
40-50	37	2.85%	57	4.38%	94	3.62%
50-70	42	3.23%	32	2.46%	74	2.85%
70-90	22	1.69%	17	1.31%	39	1.50%
90-120	9	0.69%	14	1.08%	23	0.88%
120-150	3	0.23%	6	0.46%	9	0.35%
150-200	4	0.31%	2	0.15%	6	0.23%
200-250	3	0.23%	2	0.15%	5	0.19%
250-350	0	0.00%	0	0.00%	0	0.00%
350-450	4	0.31%	2	0.15%	6	0.23%
450-550	0	0.00%	0	0.00%	0	0.00%
more than 550	3	0.23%	3	0.23%	6	0.23%
	1300		1300		2600	

7.3 The Multinomial Logit model (Conditional Logit Model)

In Chapter 2 Section 4.2.2, within the random utility framework, the utility of the i^{th} alternative for the q^{th} individual was expressed as systematic and random components:

$$U_{iq} = V_{iq} + \varepsilon_{iq}$$

The systematic component, V_{iq}, depends on the attributes of alternative *i* and the attributes of individual *q*.

The standard multinomial logit (MNL) model assumes that the random component ε is distributed extreme value type I (EVI), and the probability of individual *q* choosing alternative *i* is then given by:

$$P_{iq} = \frac{e^{\lambda V_{iq}}}{\sum_{j=1}^{J} e^{\lambda V_{jq}}}$$

and λ is a scalar factor given by

$$\lambda = \frac{\pi}{\sqrt{6}\sigma}$$

λ is constant when the random error terms are IID, and the variance of the random error σ is constant across individuals. Since λ cannot be estimated separately from the parameters of explanatory variables of V_{jq}, it is often normalized to one.

Assume V_{jq} to be a linear and additive function of attributes X,

$$V_{jq} = \beta X_{jq}$$

where X_{jq} is the vector of attributes of choice *j* as viewed by individual *q*, and β is the parameter vector to be estimated. Maximum likelihood techniques are used in estimating the parameters of the utility function.

The econometric software package LIMDEP 9.0 NLOGIT 4.0 was used to estimate four MNL models with linear specification for the parameters, and linear and logarithmic specifications for the attributes (see Table 7.6 for the model specifications and Appendix 7.1 for the NLogit Algorithms). In order to determine the goodness of fit of an estimated model, it needs to be compared to a base model (a constant-only model). The LL-ratio test is used to compare the LL of the estimated model to the LL of the corresponding base model. The formula for the test is:

-2(LL base model – LL estimated model) ~ chi-square

The degrees of freedom (d.f.) for the test is the difference in the number of parameters estimated by the two models. For model 1 (winter data) for example,

-2LL = -2(-1363.62– (-1346.98)) = 33.264

At 95% significance level, the critical value of chi-square with d.f. 5 (= 6 – 1) is 11.0705. Since the value of -2LL function, 33.264, is greater than this chi-critical, the null hypothesis that the estimated model is not better than the base model can be rejected. The LL-ratio was calculated for all of the four models and compared with their respective constants only models, and for all models and data sets the null hypothesis was rejected.

The pseudo-R-squares can be calculated for all models as:

Pseudo R-square= (LL base model – LL estimated model)/ (LL base model)

For model 1 (winter data) for example,

Pseudo R-square = 1-(-1346.98/-1363.62)= 0.0122

Table 7. 6 Alternative MNL Model Specifications

		Summer		Winter		Pooled	
No	Model Specification	LL	Pseudo R^2	LL	Pseudo R^2	LL	Pseudo R^2
	Constant Only Model	-1351.64		-1363.62		-2715.50	
1	*U(1,2)=asc+Bfreq*freq+Bdur*dur+ Btime*time+Bann*ann+Bchbill*chbilltl*	-1345.83	0.00	-1346.98	0.01	-2700.17	0.01
2	*U(1,2)=asc+Bfreq*freq+Bdur*dur+ Btime*time+Bann*ann+Blbill*lbill*	-1336.53	0.01	-1332.05	0.02	-2676.1	0.01
3	*U(1,2)=asc+Blfreq*lfreq+Bdur*dur+ Btime*time+Bann*ann+Blbill*lbill*	-1328.45	0.02	-1326.44	0.03	-2662.14	0.02
4	*U(1,2)=asc+Blfreq*lfreq+Bldur*ldur+ Btime*time+Bann*ann+Blbill*lbill*	-1327.97	0.02	-1330.04	0.02	-2663.76	0.02

From Table 7.6 it can be seen that the following additive utility function with the attributes frequency (*lfreq*) and change in monthly bill (*lbill*) in natural logarithmic, and duration (*dur*), time (*time*) and prior notification (*ann*) in linear specification, resulted in the highest value of the log-likelihood function:

$$V=\beta_{asc}+ \beta_{lfreq}*lfreq+ \beta_{dur}*dur+ \beta_{time}*time+ \beta_{ann}*ann+ \beta_{lbill}*lbill$$

The results of the MNL models estimated using summer, winter and pooled data sets are presented in Table 7.7.

Table 7. 7 MNL Estimates for Summer, Winter, and Pooled Data Sets

Attribute	**Summer**	**Winter**	**Pooled**
	Coefficient (S.E)		
ASC	-0.277 (0.191)	-0.006 (0.188)	-0.145 (0.133)
BLFREQ	-0.128*** (0.032)	-0.110*** (0.032)	-0.120*** (0.022)
BDUR	0.006 (0.011)	-0.053*** (0.013)	-0.019** (0.008)
BTIME	0.063 (0.035)	0.076** (0.035)	0.071*** (0.025)

BANN	-0.106*** (0.040)	-0.118*** (0.040)	-0.112*** (0.028)
BLBILL	-0.258*** (0.056)	-0.349*** (0.056)	-0.300*** (0.039)
Number of Observations	1300	1300	2600
Log-likelihood	-1328.45	-1326.44	-2662.14
Pseudo R-square	0.02	0.03	0.02
(*) 10% significance level; (**) 5% significance level; (***) 1% significance level two-tailed tests. Pseudo R-square =(LL base model – LL estimated model)/(LL base model)			

We tested for the equality of parameter estimates between the summer and winter models using the log-likelihood ratio test:

$$-2LL = -2(LL_{pooled} - (LL_{summer} + LL_{winter})) =$$

$$= -2(-2662.14 - (-1328.45 -1326.44)) = 14.504$$

The calculated -2LL value (14.504) is greater than the critical chi-square value (12.5916 at 6 d.f., 5% significance level). Therefore the null hypothesis of parameter equality between the summer and winter data sources can be rejected.

The constant term is negative and insignificant for all data sets. The pseudo R-squares are low, however most of the parameters are significant and have the expected sign: For summer data, the parameters *lfreq*, *ann*, and *lbill* are negative and significant at the 1% significance level; and for winter data, all parameters are negative and significant at 1% significance level except the parameter for time which is positive and significant at 5% significance level.

The marginal WTP for a change in the level of a single attribute k, is

$$MWTP_k = \frac{\partial V / \partial X_k}{-\partial V / \partial p}$$

where p is the price attribute (the change in the monthly electricity bill in YTL in our case, *chbilltl*). The MWTP for the effects coded binary attributes is (Hu et al., 2004)

$$MWTP_k = 2\frac{\partial V / \partial X_k}{-\partial V / \partial p}$$

Since the frequency and change in bill attributes enter the utility function in natural logarithmic form, their MWTPs are calculated as follows:

Given that,

$V=\beta_{asc}+ \beta_{lfreq}*lfreq+ \beta_{dur}*dur+ \beta_{time}*time+ \beta_{ann}*ann+ \beta_{lbill}*lbill$

and *lfreq* and *lbill* are specified as[58]

lfreq = ln(freq+1)

lbill = ln(chbilltl+1)

then

$$MWTP_{freq} = \frac{\partial V / \partial freq}{-\partial V / \partial chbilltl} = \frac{\beta_{lfreq}(\frac{1}{freq+1})}{-\beta_{lbill}(\frac{1}{chbilltl+1})} = \frac{\beta_{lfreq}}{-\beta_{lbill}} \frac{(chbilltl+1)}{(freq+1)}$$

[58] Due to the presence of zero observations in frequency, duration and change in monthly bill data, we added the value of 1 before taking their natural logs to avoid having ln(0) (Moeltner and Layton, 2002)

$$MWTP_{dur} = \frac{\partial V / \partial dur}{-\partial V / \partial chbilltl} = \frac{\beta_{dur}}{-\beta_{lbill}(\frac{1}{chbilltl+1})} = \frac{\beta_{dur}}{-\beta_{lbill}}(chbilltl+1)$$

The time and prior notification are effects coded binary attributes, and their MWTPs are calculated as follows:

$$MWTP_{time} = 2\frac{\partial V / \partial time}{-\partial V / \partial chbilltl} = 2\frac{\beta_{time}}{-\beta_{lbill}(\frac{1}{chbilltl+1})} = 2\frac{\beta_{time}}{-\beta_{lbill}}(chbilltl+1)$$

$$MWTP_{ann} = 2\frac{\partial V / \partial ann}{-\partial V / \partial chbilltl} = 2\frac{\beta_{ann}}{-\beta_{lbill}(\frac{1}{chbilltl+1})} = 2\frac{\beta_{ann}}{-\beta_{lbill}}(chbilltl+1)$$

When the attributes are linearly specified, the WTP for the entire good for changes in levels of all attributes are given by (Lancsar and Savage, 2004):

$$WTP = \sum_{k=1}^{K} \frac{\beta_k}{-\beta_p}(\Delta X_k)$$

In our models the change in the monthly electricity bill amount is specified in natural logarithmic form i.e. lbill = ln(chbilltl+1), therefore the welfare impact of a service improvement on an average respondent will be calculated as follows:

A representative respondent's utility with the current service, V^0, is

$$V^0 = \beta_{lfreq}*lfreq^0 + \beta_{dur}*dur^0 + \beta_{time}*time^0 + \beta_{ann}*ann^0 + \beta_{lbill}*lbill^0$$

Since $lbill^0 = \ln(chbilltl^0 + 1)$, and the change in the monthly electricity bill amount for the current service is zero, i.e. $chbilltl^0 = 0$, then V^0 simplifies to

$$V^0 = \beta_{lfreq}*lfreq^0 + \beta_{dur}*dur^0 + \beta_{time}*time^0 + \beta_{ann}*ann^0$$

After the service improvement but with no change in the monthly electricity bill, the respondent's utility becomes

$$V^1|_{chbilltl=0} = \beta_{asc} + \beta_{lfreq}*lfreq^1 + \beta_{dur}*dur^1 + \beta_{time}*time^1 + \beta_{ann}*ann^1$$

The change in utility due to the service improvement (keeping the electricity bill constant) is therefore

$$V^1|_{chbilltl=0} - V^0$$

The compensating variation (CV) is the increase in the monthly bill amount that will keep the respondent at its current utility level. So with this increase in the bill,

$$lbill^1 = \ln(chbilltl^0 + 1 + CV)$$

$$= \ln(1 + CV)$$

and the representative respondent's utility with service improvement and an increase in the monthly bill becomes

$$V^1 = \beta_{asc} + \beta_{lfreq}*lfreq^1 + \beta_{dur}*dur^1 + \beta_{time}*time^1 + \beta_{ann}*ann^1 + \beta_{lbill}*lbill^1$$

$$= V^1|_{chbilltl=0} + \beta_{lbill}*lbill^1$$

$$= V^1|_{chbilltl=0} + \beta_{lbill}*\ln(1 + CV)$$

From the definition of compensating variation

$$V^1 - V^0 = 0$$

$[V^1|_{chbilltl=0} + \beta_{lbill}*\ln(1+CV)] - V^0 = 0$

Solving the above equation for CV, gives the expression we used in calculating the welfare impact of a service improvement on an average respondent:

$$\ln(1+CV) = (\frac{1}{\beta_{lbill}}\left[V^0 - V^1|_{chbilltl=0}\right])$$

$$CV = \exp(\frac{1}{\beta_{lbill}}\left[V^0 - V^1|_{chbilltl=0}\right]) - 1$$

The MNL model is limited by the IIA and the IID assumption of the error terms (see also Chapter 2). We tested the IIA assumption using the Hausman test (see Appendices 5.2, and 5.3). The p-values for the tests (for summer and winter) are all smaller than 0.05, hence the null hypothesis (violation of IIA does not occur) is rejected and we need to consider a less restrictive model specification. Other limitations of the MNL are that heterogeneity in the preferences of the respondents and correlation in the error terms across respondents' choices are not allowed. The heterogeneity in the preferences limitation may partly be dealt with by introducing interactions of socio-economic variables, however since the IIA assumption is violated and the MNL results can therefore be biased and unreliable (Hensher et al., 2005c), we will move to an estimation of a less restrictive model: the mixed logit.

7.4 The Mixed Logit Model

The mixed logit (ML), also called the random-parameters (RPL), random-coefficients, error-components, hybrid, or mixed multinomial logit, is a less restrictive model than the MNL in that it does not require the IIA property and allows for heterogeneity in preferences i.e. the coefficient of each attribute varies randomly across respondents (Revelt and Kenneth, 1998).

The utility that each respondent *q* obtains from alternative *j* in choice situation c:

$$U_{jcq} = \beta_q X_{jcq} + \varepsilon_{jcq}$$

where

$$\beta_q = b + \eta_q$$

then

$$U_{jcq} = bX_{jcq} + \eta_q X_{jcq} + \varepsilon_{jcq}$$

Unlike the homogenous parameters of the MNL model, the vector of coefficients β_q is respondent-specific and is randomly distributed with a density function $f(\beta_q | \theta)$, where θ is the parameters of the distribution. In the expression for β_q, *b* is the population mean, and η_q is the random term representing the deviation of each respondent's taste from the population mean.

With the unobserved error term ε_{jcq} distributed IID extreme value and independent of the coefficients β_q and the attributes X_{jcq}, the conditional probability that individual *q* chooses alternative *i* in choice situation *c* given β_q is standard logit (Revelt and Kenneth, 1998):

$$P_{icq|\beta_q} = \frac{e^{\lambda \beta_q X_{icq}}}{\sum_{j=1}^{J} e^{\lambda \beta_q X_{jcq}}}$$

If the respondent is presented with a total of C choice situations, the probability of the respondent's sequence of choices S_q conditional on β_q will be the product of conditional probabilities for each choice situation:

$$P_{S_q|\beta_q} = \prod_{c=1}^{C} P_{icq|\beta_q}$$

Since β_q is not observed by the researcher, it is integrated out to get an expression for the unconditional probability:

$$P_{icq} = \int P_{icq|\beta_q} f(\beta_q \mid \theta) d\beta_q$$

The integral is estimated by simulated maximum likelihood where values of β_q are randomly drawn from a specified distribution.

Using LIMDEP 9.0 NLOGIT 4.0, different ML models were estimated with the attributes entering the utility function in logarithmic and linear specifications. We started estimating models with all attributes except price being normally distributed. Goett et al. (2000) choose a fixed parameter for the price attribute to avoid the difficulty of having the distribution of WTP for an attribute being the ratio of two distributions. In addition, while a normal distribution for the price coefficient allows for positive values, a log-normal distribution allows values close to zero resulting in exceptionally high WTP measures. The choice of normal distribution for the non-price coefficients implies that some households may be positively impacted while others may be negatively impacted by a change in the attribute level. Considering some households might actually enjoy some benefits from the power outage, e.g. an opportunity to have better conversations and closer bonding among the household members, we specified the coefficients of all non-price attributes to be normally distributed.[59]

Then those attributes with insignificant standard deviations for their distributions were respecified as nonrandom parameters in the utility function.[60] The following additive utility function with the attributes frequency (*lfreq*), and change in the monthly bill (*lbill*) in logarithmic, and duration (*dur*), time (*time*) and prior notification (*ann*) in linear specification, resulted in the highest value of the log-likelihood function (see Table 7.8 for parameter estimates and Appendix 7.4 for NLogit algorithms) . Frequency and duration attributes are specified as random parameters in the utility function:[61][62]

$$V = asc+(Blfreq+\eta_{lfreq,q})*lfreq+(Bdur+\eta_{dur,q})*dur+Btime*time+Bann*ann+Blbill*lbill$$

Table 7. 8 ML Results for Summer, Winter, and Pooled Data

	SUMMER		WINTER		POOLED	
Variable	Coefficient (S.E.)	Derived s.d. of parameter distributions (S.E)	Coefficient (S.E.)	Derived s.d. of parameter distributions (S.E)	Coefficient (S.E.)	Derived s.d. of parameter distributions (S.E)
Random parameters in utility functions						

[59] Abdullah and Mariel (2010) carry out tests for the distributions of the random parameters and as a result specify frequency of outage to have a triangular distribution and duration of outage to have a lognormal distribution.

[60] The duration attribute is kept as normally distributed even though the standard deviation for its distribution is insignificant because respecifying it as nonrandom had negligible impact on the LL, and parameter and CV estimates. This way, all three models are compared on the same basis.

[61] The fact that the parameter for duration centered on a positive value for the summer data is unexpected and difficult to explain. A possible explanation can be that some households might actually enjoy some benefits from the power outage in summer, e.g. an opportunity to have better conversations and closer bonding among the household members. On the other hand, for winter and pooled data sets duration entered significantly and with a negative sign as expected.

[62] Using the parameter estimates:

V_{summer}= -0.417 + (-0.163 + 0.300*N)*lfreq + (0.026 + 0.284*N)*dur + 0.079*time -0.134*ann -0.291*lbill, where N has a standard normal distribution.

BLFREQ	-0.163*** (0.041)	0.300** (0.132)	-0.122*** (0.042)	0.492*** (0.133)	-0.149*** (0.029)	0.384*** (0.091)
BDUR	0.026 (0.021)	0.284*** (0.072)	-0.067*** (0.015)	0.003 (0.045)	-0.023* (0.013)	0.175*** (0.049)
Nonrandom parameters in utility functions						
ASC	-0.417* (0.231)		0.152 (0.214)		0.096 (0.155)	
BTIME	0.079* (0.042)		0.065* (0.038)		0.073*** (0.028)	
BANN	-0.134*** (0.049)		-0.145*** (0.043)		-0.139*** (0.032)	
BLBILL	-0.291*** (0.067)		-0.423*** (0.067)		-0.361*** (0.048)	
Number of observations	1300		1300		2600	
Log-likelihood	-1321.161		-1321.902		-2652.801	
McFadden Pseudo R-squared	0.075		0.074		.071	
(*) 10% significance level; (**) 5% significance level; (***) 1% significance level two-tailed tests.						

We tested for the equality of parameter estimates between the summer and winter models using the log-likelihood ratio test:

$$-2LL = -2(-2652.801 - (-1321.161 - 1321.902)) = 19.476$$

The calculated -2LL value (19.476) is greater than the critical chi-square value (15.5073 at 8 d.f., 5% significance level). Therefore, like the MNL model, the null hypothesis of parameter equality between the summer and winter data sources can be rejected.

For the summer data, frequency (*lfreq*), prior notification (*ann*), and change in bill (*lbill*) attributes are significant and enter the utility function with a negative sign. The standard deviation of the distributions for *lfreq* and *dur* are both significant indicating the presence of unobserved heterogeneity in the preferences for the two attributes i.e. *lfreq* might enter positively and duration might enter negatively into some individual's utility function.

For the winter data, frequency (*lfreq*), duration (*dur*), prior notification (*ann*), and change in bill (*lbill*) attributes are significant and enter the utility function with a negative sign. Frequency attribute is specified as a random parameter in the utility function. The standard deviation of the distributions for *lfreq* is significant indicating the presence of unobserved heterogeneity in the preferences for this attribute i.e. some individuals might derive positive utility from this attribute.

Using the estimated utility parameters and the CV formula given in Section 3, we calculated the welfare impact of a service improvement on an average respondent under different scenarios: outages of 1-hour duration with two different outage frequency levels (once a year and zero) happening with or without prior notification and at different times of the day (daytime and night-time) and season of the year (summer and winter) (see Table 7.9). The current service attribute levels are the sample averages. The welfare impact measured in YTL, is the increase in the monthly electricity bill required to keep the average respondent at his/her current utility level.

Table 7. 9 Welfare Estimates for an Average Respondent Using the ML Model

Current Service Attribute Levels	**SUMMER**	**WINTER**
outage frequency (per year)	54.2	54.2
outage duration (hours)	3.82	4.13

time (-1: daytime; 1:nighttime)	-1	-1
ann (-1:prior notification; 1:no prior notification)	1	1
change in monthly electricity bill (YTL)	0	0

	Welfare Impact (increase in the monthly electricity bill, YTL)	
	FREQUENCY	
Duration: 1hour	**Once a year**	**Zero**
SUMMER		
no prior notification		5.95
daytime	0.19	
night-time	1.05	
with prior notification		
daytime	1.99	
night-time	4.16	
WINTER		
no prior notification		22.86
daytime	5.15	
night-time	7.38	
with prior notification		
daytime	11.22	
night-time	15.66	

The welfare impacts are higher in winter. The maximum impact of 22.86 YTL happens if winter outages are eliminated. This is approximately equivalent to a 10.6% increase in the household's monthly electricity bill.

Mixed Logit Model with Interactions

The ML model allows for heterogeneity by allowing the model parameters to vary randomly over respondents. However, it does not explain the sources of this heterogeneity (Boxall and Adamowicz, 2002). To explain the sources of heterogeneity we included interactions with socio-economic variables (Revelt and Kenneth, 1998). Initially we estimated models with all potential interactions and one by one removed them and kept the significant interactions only (Birol and Villalba., 2006) (see Tables 7.10-11 for parameter estimates and Appendix 7.5 NLogit algorithms). The frequency attribute interacted significantly with the respondent's age, detached-house, and log of income. The duration attribute interacted significantly with non-electric heating.

Table 7. 10 ML with Interactions Results – Summer Data

Variable	Coefficient (S.E.)	Derived standard deviations of parameter distributions
Random parameters in utility functions		
BLFREQ	-0.129** (0.057)	0.453*** (0.151)
BDUR	0.109*** (0.032)	0.199** (0.094)
Nonrandom parameters in utility functions		
ASC	-0.359 (0.237)	
BTIME	0.072* (0.041)	
BANN	-0.139*** (0.047)	
BLBILL	-0.301*** (0.068)	
BFAGE Frequency*age	0.000143*** (.435D-04)	
BDNEH Duration*non-electric heating	-0.144*** (0.039)	
BFDH Frequency*detached-house	-0.004*** (0.001)	
BFLI Frequency*lnincome	-0.001** (0.0003)	
Number of observations	1300	
Log-likelihood	-1296.506	
McFadden Pseudo R-squared	0.092	
(*) 10% significance level; (**) 5% significance level; (***) 1% significance level two-tailed tests.		

The frequency attribute is significant and enters the utility function with a negative sign. However, the standard deviation of this parameter's distribution is also significant, therefore some individuals may have a positive utility from this. The duration attribute is significant and has a positive sign. Similarly, the significant standard deviation of its distribution means that there might be some individuals who derive negative utility from outage duration. Prior notification and change in the monthly bill are both significant and negative. High income households, those that live in detached houses, and younger respondents derive less utility from high outage frequency. Households with non-electric heating prefer outages with a shorter duration.

Table 7. 11 ML with Interactions Results – Winter Data

Variable	Coefficient (S.E.)	Derived standard deviations of parameter distributions
Random parameters in utility functions		
BLFREQ	-0.123** (0.057)	0.577*** (0.162)
Nonrandom parameters in utility functions		
ASC	0.166 (0.225)	
BDUR	-0.077*** (0.016)	
BTIME	0.065* 0.039	
BANN	-0.159*** (0.045)	
BLBILL	-0.441*** (0.071)	
BFAGE Frequency*age	0.0002*** (.515D-04)	
BFU Frequency*university	0.004** (0.002)	
BFG Frequency*generator	-0.004*** (0.001)	
BFW	0.005*	

Frequency*work home depends on electricity	(0.002)	
BFNEC Frequency*non-electric cooking	-0.007** (0.003)	
BFDH Frequency*detached house	-0.004** (0.002)	
Number of observations	1288	
Log-likelihood	-1281.422	
McFadden Pseudo R-squared	0.094	
(*) 10% significance level; (**) 5% significance level; (***) 1% significance level two-tailed tests.		

Similar to the findings for summer, the parameter of the frequency attribute is negative and significant and so is its standard deviation. Hence, some individuals may derive positive utility from this attribute. Also, the parameters of *ann*, *lbill*, *fage*, and *fdh* have the same sign as the summer estimates. This time the parameter of duration enters the utility function negatively as a nonrandom parameter. Households that own a generator and have non-electric cooking, and respondents that do not have a university degree prefer lower frequencies. It may be because people who own generators and non-electric sources of cooking are also the ones more inconvenienced by frequent outages.

Using the *Wald* command in NLOGIT 4.0, we calculated the marginal WTP estimates and standard errors for the attributes (see Table 7.12 for results and Appendices 7.5 and 7.6 for the NLOGIT algorithms).

Table 7. 12 Marginal WTP Estimates for the Electricity Service Attributes

		SUMMER	WINTER
Service Attribute	MWTP Function	MWTP (S.E)	MWTP (S.E)
Alternative Specific Constant	asc1/Blbill	1.193	-0.376

		(1.015)	(0.459)
Frequency	Bfreq/Blbill	0.428** (0.218)	0.280** (0.140)
Duration	Bdur/Blbill	-0.361*** (0.133)	0.174*** (0.040)
Time	2*(Btime/Blbill)	-0.480* (0.292)	-0.293 (0.186)
Prior Notification	2*(Bann/Blbill)	0.928*** (0.359)	0.723*** (0.217)

Using the CV formula given in Section 3, we calculated the welfare impact of a service improvement on an average respondent under the same scenarios and the current service levels (see Table 7.13). Here as well, the maximum impact of 25.83 YTL happens if winter outages are eliminated. This is approximately equivalent to 12.0% increase in an average household's monthly electricity bill.

Table 7. 13 Welfare Estimates for an Average Respondent --ML model With Interactions

	Welfare Impact (increase in the monthly electricity bill, YTL)	
	FREQUENCY	
Duration: 1hour	**Once a year**	**Zero**
SUMMER		
no prior notification		6.65
daytime	0.46	
night-time	1.35	
with prior notification		
daytime	2.68	
night-time	4.95	
WINTER		
no prior notification		25.83
daytime	5.71	
night-time	8.00	
with prior notification		
daytime	12.83	
night-time	17.54	

7.6 Comparison of MNL, ML, and ML with Interactions Results

We used the log-likelihood ratio test to compare the goodness of fit of the four models:

-2(LL largest - LL smallest) ~ chi-square

The degrees of freedom for the test is the difference in the number of parameters estimated by the two models. Table 7.14 below shows the log-likelihood ratio test results for the four models estimated. We started our analysis with the MNL model. However, as the IIA assumption was violated, we moved to less restrictive model specifications. As it can be seen from Table 7.14, for both seasons, the ML with interactions models improve the LL over the MNL and ML respectively i.e. the LL of the ML model with interactions is statistically closer to zero than the other two models.

Table 7. 14 Log-Likelihood Ratio Test for Model Selection

Models Compared	LL	D.F.	D.F. difference	-2LL Function	Chi Critical (5% sig.)
SUMMER					
MNL vs. ML					
MNL	-1327.97	6			
ML	-1321.161	6	0	13.618	
ML vs. ML with interactions					
ML	-1321.161	8			
ML with Interactions	-1296.506	12	4	49.31	9.48773
WINTER					
MNL vs. ML					
MNL	-1330.04	6			
ML	-1321.492	6	0	17.096	
ML vs. ML with interactions					
ML	-1321.492	8			
ML with Interactions	-1281.422	13	5	80.14	11.0705

Table 7.15 summarizes our CV estimates for the two scenarios: once a year, one hour, planned and night-time outage; and zero outage. Among the two models, for the first scenario, the CV estimates ranged between 4.16 - 4.95 YTL per month, and 15.66 – 17.54 YTL per month for a summer and a winter outage respectively. The CV estimates for the zero outage scenario ranged between 5.95-6.65 YTL per month, and 22.86 -25.83 YTL per month for summer and winter seasons respectively. Since ML model with interactions has the superiority in model fit over the ML model, we will rely more on the estimates from this model. A typical household is willing to pay 6.65 YTL per month and 25.83 YTL per month in addition to its current monthly electricity bill in order to eliminate summer and winter outages respectively.

Table 7. 15 Comparison of CV Estimates

	Outage Scenario: once a year, one hour, planned, night-time		Outage Scenario: Zero Outage	
	WTP (YTL)	% of Monthly Bill	WTP (YTL)	% of Monthly Bill
Summer				
ML	4.16	1.9%	5.95	2.8%
ML with Interactions	4.95	2.3%	6.65	3.1%
Winter				
ML	15.66	7.3%	22.86	10.6%
ML with Interactions	17.54	8.2%	25.83	12.0%

The confidence intervals for the WTP measures have been calculated in the literature using various methods: the delta method (Greene, 2003); the Fieller method (Fieller, 1954); the Krinsky Robb method (Krinsky and Robb, 1986); and the bootstrap method (Efron and Tibshirani, 1993). Hole (2007) describes the estimation procedures for the four different approaches and compares the measured WTP confidence intervals. He finds the results from all four methods to be similar and nearly accurate.

As explained in detail by Hole (2007), in the delta method, the variance of mean WTP is calculated using a first-order Taylor expansion and then the confidence interval for WTP is estimated using the equation

$$W\hat{T}P \pm z_{\alpha/2}\sqrt{\text{var}(W\hat{T}P)}$$

where $W\hat{T}P$ is the mean value of WTP, and $z_{\alpha/2}$ is the positive critical value for the standard normal distribution when the confidence level is (1-α). The author emphasizes that the main assumption of the delta method is that the WTP has a normal distribution, and this may hold approximately when the sample size is large and the standard error of the coefficient for the price attribute is relatively small compared to its coefficient estimate i.e. in our case S.E.(β_{lbill})/(β_{lbill}) is small.

The Fieller method on the other hand does not require the assumption that the WTP is normally distributed and hence will result in more accurate confidence intervals in cases where the distribution of WTP is not symmetric (Hole, 2007). The Krinsky Robb (or the parametric bootstrap method) and bootstrap methods use simulations to build a distribution for WTP, after which the lower and upper bounds for the confidence interval for WTP can be calculated by first sorting the simulated WTP estimates and then according to the confidence level chosen marking the lower and upper percentiles e.g. the 26th and 975th WTP observations will be the lower and upper bounds when the simulation is run 1000 times and the confidence level is 95%. According to Hole (2007), while both the Krinsky Robb and bootstrap methods do not require the symmetry of WTP distribution assumption, bootstrap has the additional advantage of not requiring any assumptions on the distribution of coefficients. As a result, bootstrap performs better with small sample sizes. Application of the Krinsky Robb parametric bootstrapping method to calculation of the confidence intervals in recent CE studies can be found in Meyerhoff et al. (2007) and Kragt and Bernett (2009). The non-parametric bootstrapping method on the other hand was applied in CE studies in Choi (2009) and Kataria (2009).

We used the delta method to calculate the confidence intervals for the CV measured by the Mixed Logit model with interactions. With the *Wald* command in NLOGIT 4.0, we estimated the compensating variations and their standard error for the two scenarios given in Table 7.16 below (see Appendices 7.6 for the NLOGIT algorithms).

Table 7. 16 Confidence Intervals for CV Estimates – Delta Method

Outage Scenario		95% Confidence Interval	
Once a Year, 1hr, Night-time, Announced	CV (S.E.)	Lower Bound (YTL/month)	Upper Bound (YTL/month)
SUMMER	4.95 (3.62)	-2.15[a]	12.06
WINTER	17.54 (6.44)	4.91	30.17
Zero Outage			
SUMMER	6.65 (5.34)	-3.81[b]	17.12
WINTER	25.83 (11.45)	3.38	48.27

a. 8.6% of households had negative valuation
b. 10.6% of households had negative valuation

CHAPTER 8 CONCLUSION AND POLICY IMPLICATIONS

8.1 Introduction

The outages in North Cyprus date back to 1994. Since then population growth, the increase in the number of foreign students and tourists as well as the exponential growth in the construction sector has worsened the power shortage problem in the North. There are frequent power cuts throughout the year. The Government has plans to improve and upgrade the electricity infrastructure. To allocate scarce public funds efficiently however, a careful CBA needs to be conducted. As long as the economic benefits are greater than the economic costs, there will be an increase in the welfare of the people living in North Cyprus. In order to evaluate economic benefits, WTP of the people for improved electricity services must be estimated. In this research, households' WTP for improved electricity services is estimated for North Cyprus using the CE, CVM, and AE method (which provides a lower bound on WTP for improved reliability). The data used comes from 350 in-person interviews conducted during the period August 5-22, 2008.

This research makes a number of contributions to the literature. This is the first study that compares households' WTP for reliable electricity derived from three different valuation methods. Second, it is the first and only study in North Cyprus collecting information on the extent of the problem of unreliability of supply. Third, it is the first and only CE study completed to date in North Cyprus. Fourth, it is the first and only study in North Cyprus that measures households' WTP for reliable electricity. It is also one of the few CE studies that attempt to measure the cost of outages in a country with a high actual outage frequency.

The remainder of this chapter is organised as follows. In Section 2, we will compare our WTP results from application of the three methodologies. Then in Section 3, we will compare our WTP results with the findings of other outage cost studies in the literature. Section 4 discusses the policy implications of our findings, Section 5 states the limitations of the current research, and finally Section 6 presents the future research challenges.

8.2 Comparison of WTP Estimates: CE, CV, and AE

Previously in Chapters 5, 6, and 7, we estimated the mean WTPs for particular policies using the AE, CVM, and CE data respectively. In the AE section the respondents were asked about the actions their households take in preparation for the failures. To cope with the frequent and usually unannounced outages, the respondents own/use one or more of the following: candle; kerosene lamp; gas lamp; electric lantern (rechargeable battery powered); emergency kerosene stove; emergency gas stove; emergency kerosene heater; emergency gas heater; voltage regulator; surge protector; generator; uninterrupted power supply (UPS) system; and car battery connected to an inverter. 92.3% of the respondents took between one to four actions. An average household's AE estimated using the Tobit model was 3.13 YTL/month.

The CVM section of the questionnaire consisted of a hypothetical inverter system where using a payment ladder format the respondents were asked to state their WTP for the inverter system which would guarantee uninterrupted power supplies. The nonparametric Turnbull lower bound mean was calculated to be 22.98 YTL. The mean and median WTP were also estimated parametrically using spike models. The spike model with varying spike, varying mean, and constant standard error specification enjoyed the best fit and resulted in a median WTP of 23.03 YTL per month and a mean WTP of 29.14 YTL per month. In other words an average household is willing to pay 29.14 YTL per month in addition to its monthly electricity bill simply in order to avoid outages.

In the CE section, each choice set consisted of three alternatives (two improved services and the current service) and each alternative had five attributes. The attributes of an electricity service included in the CE were frequency of outages, duration of outages, notification of outages, and timing of outages (season, time of day). Approximately half of the time the respondents chose the status-quo alternative with no change in their monthly electricity bill. Compensating variation estimates for a zero outage scenario were calculated using the parameter estimates from the ML model with interactions and they were 6.65 YTL per month for summer and 25.83 YTL per month for winter.

The mean WTP estimate derived from AE is the lowest, the mean WTP estimate from the CVM is the highest, and the mean WTP estimates from the CE lie somewhere between the AE and CVM figures (see Table 8.1).[63] The AE approach produces a lower bound on the WTP for improved reliability as it ignores some of the other costs incurred by the household (e.g. the inconvenience of lighting candles, buying and storing fuel for the generator, the noise of the generator, etc.). Our WTP estimates from CVM and AE are for outages in general while the CE valued in addition the attributes of the outage (e.g. season, duration, frequency, time, and prior notification status). The WTP estimate for winter derived from the CE is closer to that from CVM.

[63] The average of WTP for eliminating summer and winter outages is 16.24 YTL/month (=(6.65+25.83)/2)

Average total outage per year of the sample was 287.6 hours a year (or 24.0 hours a month). Dividing monthly WTP estimates in Table 8.1 by the average total outage per month, we calculate WTP per hour unserved.[64] The WTP per hour unserved ranges from 0.13 YTL (0.11 USD) to 1.22 YTL (1.03 USD). In order to avoid the cost of outages, households are willing to incur a 1.5%-13.5% increase in their monthly electricity bill.

Table 8. 1 Summary of WTP Results: CE, CVM and AE

Method	WTP[c] YTL/month (USD) in 2008 prices	95% Confidence Interval YTL/month (USD) in 2008 prices	% of Monthly Bill	WTP YTL per hour unserved (USD) in 2008 prices
CVM	29.14 (24.79)	14.19-44.09[d] (12.07-37.50)	13.5%	1.22 (1.03)
AE	3.13 (2.66)	1.89-4.61[e] (1.61-3.92)	1.5%	0.13 (0.11)
CE				
Summer[a]	6.65 (5.66)	-3.81-17.12[g] (-3.24-14.16)	3.1%	0.28 (0.24)
Winter[b]	25.83 (21.97)	3.38-48.27[g] (2.87-41.06)	12.0%	1.08 (0.92)

a. Status quo levels for summer outages: 54.2 times per year, 3.82 hours, unplanned, daytime
b. Status quo levels for winter outages: 54.2 times per year, 4.13 hours, unplanned, daytime
c. The WTP is obtained using the entire sample.
d. The confidence intervals are obtained using the classical statistical method.
e. The confidence intervals are bootstrapped confidence intervals using the percentile method (1000 repetitions)
g. The confidence intervals are obtained using the delta method.

If $E(WTP_i)$ and $E(WTP_j)$ are the two mean WTP measures derived from different valuation methodologies, and the distributions of WTP_i and WTP_j are approximately normal, then the classical

[64] This is the average total perceived outage duration per year. Since in the CVM and AE approaches we did not specify the outage attributes (season, timing, prior notification), in order to have a common denominator for all the approaches we are using the total outage duration.

statistical method can be used to test if the means of these distributions differ to a statistically significant extent (Desvouges et al., 1992). If the distributions have the same variance (σ^2) and sample size (n), the test statistic Z has a standard normal distribution and is calculated as:

$$Z = \frac{E(WTP_i) - E(WTP_j)}{\sqrt{\frac{2\sigma^2}{n}}}$$

The non-overlapping confidence interval technique compares the confidence intervals for WTPs at the chosen α% level (Park et al., 1991). If these (1- α)% confidence intervals do not overlap, then the differences in mean WTP are significantly different from zero. Unlike the classical statistical method above, this approach does not require the normality assumption.

The convolutions approach is another method used to compare the mean WTP estimates from different estimation methodologies (Poe et al., 1994; Loomis et al., 1997; Mogas et al., 2005; Goldberg and Rosen, 2007; Yoshida and Kanai, 2007). Poe et al. (2001) describe a repeated sampling approach that can be applied to compare independent WTP distributions. For each WTP distribution, when calculating their confidence intervals using the nonparametric bootstrap technique a matrix of 1000 elements is also obtained. For the comparison between the two distributions WTP_{CV} and WTP_{CE}, for example, first WTP_{CE} is randomly ordered 100 times and 100 different WTP_{CEi} vectors are created, where i= 1,2,..,100. Then $WTP_{CV} - WTP_{CEi}$ is calculated for each randomly ordered vector WTP_{CEi}. For each of the 100 vector of differences created, the ratio of number of negative differences to the total number of differences is calculated. Finally, the average of this ratio is calculated. If this proportion is greater than 0.95 then it can be concluded that the difference between the two WTP measures is significantly different from zero at the 5% significance level.

In our case, the 95% confidence intervals for mean WTP derived from the three different valuation methodologies overlap (see Table 8.1). Therefore, using the non-overlapping confidence interval method, we cannot conclude that the differences in mean WTP are significantly different from zero. The mean WTP using the AE method is lower than the mean WTP derived from the CE and CVM methods. This is an expected result as the AE approach provides a lower bound on WTP for improved reliability. However the higher variation in the WTP estimates from the three approaches resulted in wider confidence intervals.

8.3 Comparison with Other WTP Findings in the Literature

Sanghvi (1982), Andersson and Taylor (1986), and Woo and Pupp (1992) summarize the findings of various residential outage cost studies. In Chapter 2 Section 5.3, we updated these with new studies, as well as converting all estimates to USD in 2008 prices (see Appendix 2.1). Among the studies where the WTP per outage and the duration of the outage were given, we calculated the WTP per hour unserved. In this category, the highest WTP figures were 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), (see Table 8.2). 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), and Wisconsin (0.58-2.49 USD). Our estimates of WTP in North Cyprus are in the range of 0.11-1.03 USD. The higher bound of 1.03 USD is not within the WTP range of Brazil; however it is included in the WTP ranges of the remaining countries.

Table 8. 2 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. (1990)	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 (2006b, 2007, 2008)	0.29-2.86
Nepal		Billinton and Pandey (1999)	0.10-1.15
North Cyprus		Ozbafli (2011)	0.11-1.03

The differences in the WTP estimates may be attributed to the different valuation methods, econometric models, functional forms, outage attributes, and socio-economic 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 in Townsend (2000) indicate that the WTP is lower in countries where the quality of service continues to remain poor after the price is increased.[65] Given the chronic nature of outages in Nepal,

[65] 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 being automatically added to everybody's bill in order to cover for Kıb-Tek's investments in generation capacity. These may partly explain the lower WTP figures in North Cyprus.

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.

8.4 Policy Implications

Our estimates of the WTP for electricity reliability can be used to evaluate the feasibility of alternative ways of improving the electricity reliability:

(a) estimating the peak-load price at which the generation capacity meets the peak demand. By setting the peak-price appropriately, the utility company can discourage high use of electricity at peak hours and control the demand;

(b) appraising the option of purchasing additional generation capacity to overcome the shortage of power generation which is one of the main causes of blackouts in North Cyprus.

Before introducing any changes to the existing system, Kıb-Tek needs to take into account the attitudes of its customers. Particularly, the attitudes of the residential sector are important since they comprise one third of the customer base.[66] Our results show that, the power supply provided by the electric power company is perceived as poor or very poor by 32% of the respondents, and the number of supply failures is judged high or very high for 27% of the households interviewed. Approximately one third of the respondents disagreed 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

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

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. And a significant proportion of households, 37%, have low or very low confidence in their electricity authority. When appraising the option of purchasing additional generation capacity to overcome the shortage of power generation, and considering an increase in tariffs to cover for the investment costs involved, in order to have more consumers in favour of the project these negative attitudes towards the quality of service provided, the level of prices, and the level of confidence towards the electricity authority needs to be considered.

In the CE study, approximately 40% of the respondents chose the current service on all of the eight choice sets presented to them, and around 6% of the total sample consisted of protest bids. In the CVM study, 40% of the sample chose not to go for the inverter system and approximately 5% of the observations were protest bids. In the AE study we found that approximately 93% of the respondents took at least one preparatory action, and that the majority of the averting behaviour was for the lighting needs of the households (candles and emergency lamps) which resulted in relatively lower coping costs.[67] The electricity authority needs to be aware of the fact that a high percentage of the residential customers are not willing to pay anything beyond the relatively high rate they are now paying for an improvement in the service. However, if a system of peak and off-peak pricing were implemented then it is likely that consumption patterns would respond hence improving the overall reliability of the service.

[67] However, the quality of outcome is lower than some more expensive options, such as using a generator.

Table 8.3 below gives the total annual economic benefits of improved electricity services for residential customers in North Cyprus. These figures range from 6.64 million USD to 12.7 million USD depending on the valuation method used in estimating WTP. The total investment costs that Kıb-Tek would need to incur to achieve a given reliability level will among other things depend on the condition of the existing power stations as well as the transmission and the distribution system. Investing in additional generation capacity may not solve the outage problem if the transmission and distribution capacity is not adequate or well maintained. If we assume an investment cost per MW of capacity of USD 1 million and other fixed operating and maintenance costs of USD 10 million for a combined cycle generation plant, taking the economic cost of capital (discount rate) to be 10% and the economic life of the plant to be 25 years, the most conservative measure (AE method) of 2.78 million USD for the residential sector justifies an investment in additional generation capacity of approximately 15 MW.[68, 69]

Table 8. 3 Total Annual Economic Benefits of Improved Electricity Services for the Residential Consumers in North Cyprus (in 2008 prices)

Number of Households: 87,150 (2008 estimate)[a]		
Method	WTP (million YTL)	WTP (million USD)
CE		
Summer	3.48	2.96

[68] Lazard, (June 2008). *"Levelized Cost of Energy Analysis — Version 2.0"*, retrieved on March 2009, http://www.narucmeetings.org/Presentations/2008 EMP Levelized Cost of Energy – Master June 2008 (2).pdf

Boyce P., M. (2001), Handbook for Cogeneration and Combined Cycle Power Plants, American Society of Mechanical Engineers, (P.35).

[69] The annualized investment and other fixed costs for additional generation are set equal to 6.64 million USD. The annuity is calculated using the PMT function in MS Excel. The total investment and other fixed costs that solves the equality 2.78 = PMT(10%,25, x) is 25 million USD. Given that other fixed costs are 10 million USD, then the investment cost is 15 million USD. At 1 million USD per MW, this implies an investment in additional generation capacity of 15 MW.

Winter	13.51	11.49
Total	16.98	14.45
CVM	30.47	25.92
AE	3.27	2.78
a. We assumed a growth rate of 20% in the number of households,[70] and used the 2006 census estimate to calculate the number of households in 2008 to be approximately 87,150 (=72,624*1.2)		

The CE study findings revealed that frequency, duration, prior notification, and price are the important attributes valued by the customers. The time attribute did not enter significantly in the models estimated. For planned and unplanned outages, the majority of the respondents stated that they found outages at any season, day and time to be equally disruptive. 80% of the respondents agreed with the statement that frequent short interruptions were worse than one long interruption. In the case of planned outages, approximately half of the respondents surveyed preferred to be notified through the media (TV, radio, newspaper, etc.). These findings show that customers are willing to pay for improvements in the service that includes reducing the frequency and duration of outages and giving prior notification.

8.5 Limitations of the Current Research

Despite our efforts to limit potential problems, some may still remain in our study. In this section these limitations and their possible impacts on the results are discussed.

The order in which the respondents see the choice sets may have an impact on the parameter estimates if fatigue is present in the CE. As a result, the information obtained from choice sets

[70] This takes into account the high growth rate in the construction sector, and the unfinished dwellings that were not counted in the 2006 census but were occupied in 2008.

towards the end of the experiment may not be of good quality. Completely randomizing the order in which the choice sets are presented to each respondent would require too many versions to be created. Initially, to keep the administration of the survey manageable but at the same time not to be totally ignorant of order bias, for each of the eight versions we had in our original design, we created another version by switching the order of "Summer" and "Winter" groups i.e. in one version, four summer choice sets were followed by four winter sets, while in the other version the respondents were given the winter sets first. The order of the choice sets within the seasons was kept unchanged. This resulted in 16 different versions. Before implementation of the main survey, and after a discussion with the survey firm, we came to the conclusion that eight versions was the maximum number feasible. Consequently, we were not able to test for fatigue effects in this study.

The budget allocated for the main survey, 2000 GBP, was the major determinant of the sample size selected for this study. The sample size of 350 is not small, but a larger sample size would have allowed for more complex CE designs including interaction effects. A larger sample size would have also allowed better inference-testing and comparisons to be made at the district level. Our survey collected data on numerous potential explanatory variables, some of which might have entered our regression equations in a statistically significant manner if we had had a larger sample size.

In the CE we estimated two less restrictive models: the mixed logit, and the mixed logit with interactions. There are other models that could have been used, e.g. the nested logit model (McFadden, 1981), the latent class model (Wedel and Kamakura, 2000), and the covariance heterogeneity model (Bhat, 1997). It is possible that some of these other models could have provided additional insights into households' behaviour. We were able to estimate reasonable nested logit, latent class and covariance heterogeneity specifications but the WTP estimates derived from these models were implausibly high. In our CVM and AE models the income coefficient was almost zero and statistically insignificant. Hence we could not estimate the income elasticity for WTP with a satisfactory degree of precision. Many CVM studies have found weak income effects perhaps due to the difficulties in measuring household income (e.g. high non-response rate, intentional misrepresentation of the respondent's income, failing to include income from all sources)(Alberini, 2004). The likelihood of encountering a significant income effect is also related to the sample size and the design choices made in the study (Aiew et al., 2004; Broberg, 2010).

The calculation of the welfare impact of alternative improved services is limited by the boundaries of the attribute levels used in the CE design (Guikema, 2005; Hanley et al., 2006). The frequency of outages in the design ranged from once a year to 24 times a year. Because zero outage is not within this range, we extrapolated our results to outside the range in order to calculate the welfare impact of eliminating outages altogether and make the CE and CVM estimates directly comparable. Guikema (2005) points out that outside the attribute range respondents' preferences may be different. Hence our CE estimates for the zero-outage scenario may have been over/under estimated.

In order to calculate a household's total monthly AE, in addition to the ownership and usage data provided by the household, we needed other market and engineering data such as the economic life, fuel consumption rate, and the unit prices for the equipment and other materials used in each action.

To lessen the burden placed on respondents and keep the questionnaire at a reasonable length, for the most part we chose to acquire these data from the vendors and manufacturers ourselves.

8.6 Future Research Challenges

We estimated the WTP of residential electricity consumers in North Cyprus for service reliability. Kıb-Tek has six other types of consumers (commercial, industrial, tourism, agriculture, defence, and Government) and in order to calculate the total economic benefits of improving the service reliability these need to be taken into consideration.[71, 72]

By setting the peak-price appropriately, the utility company can discourage high use of electricity at peak hours and control the demand. However, before introducing such a pricing system, its impact on consumers' consumption patterns needs to be studied. 41% of respondents in our study disagreed with the statement that people who use electricity at peak times should pay more. Nevertheless, what is more important to deteremine is whether they would actually use less electricity at these times if they were charged more. Several authors studied the demand response of electricity consumers and empirically estimated price elasticities of demand for electricity (Caves and Christensen, 1980; Faruqui and Malko, 1983; Heberlein and Warriner, 1983; Lijesen, 2007; Filippini, 2010).

[71] See chapter 2 section 5.2 for a discussion of some of the most widely used methods for measuring the cost of an outage to the business sector and a list of empirical studies on outage cost estimation.

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

Given the current level of reliability of the network electricity service perceived by the household, the household chooses the minimum AE required to produce his optimum level of electricity dependent services (e.g. heating, cooking, lighting, housekeeping, leisure) that maximizes his utility subject to his income constraint. We based our analysis on households' perceived value of service reliability rather than the actual service levels. The compensating variations for summer in our CE study, for example, were calculated for reducing the number of outages from the household's stated level of approximately 54 times in summer to zero. It would be very useful for the utility company if the ratio of actual to perceived service levels were available. Using these ratios the amount of actual reduction in the number of outages that would correspond to the perceived level which the customer is willing to pay for (i.e. 54 outages in summer) could be estimated (KPMG, 2003). Once the proposed SCADA system becomes operational, more detailed data will be available on the electricity system in general, and that will make possible the comparison of perceived and actual service levels.

APPENDICES

Appendix 2.1 WTP Findings in the Literature – Residential (in USD, 2008 Prices)

Summarized in Sanghvi (1982)

Study	Country	Method	US$ per kWh unserved
Lolander (1948)	Sweden		1.24-2.08
Sheppard/Electricity Council (1967)	UK	Wage Rate	2.56
Swedish Joint Committee for the Electricity Council (1969)	Sweden	Cost of interrupted household activities	2.41-4.81
Lundgerg, Jomier, Orson (1972)	UK	Wage Rate	3.79-11.40
Lundgerg, Jomier, Orson (1972)	Sweden	Survey	3.17
Jaramillo and Skokonic (1973)	Chile	Annuitized value of household appliances made idle	0.93
Turner/New Zealand Electricity (1977)	New Zealand	Wage Rate	1.43

Study	Country	Method	Duration	US$ per kWh unserved
Finnish Power Producers Council (1979)	Finland	Survey of WTP	2 minute	21.04
			15 minute	5.88
			1 hour	2.94
			4 hour	1.93
			10 hour	1.55
Ontario Hydro (1980)	Canada	Survey of WTP to avoid outage	1 minute	1.46
			20 minute	0.37
			1 hour	0.12
			4 hour	0.05
			8 hour	0.02
Faucett (1979)	Key West, Florida	Survey of WTP following a series of outages over a several week period		0.10-0.12
Systems Control (1980) Jacksonville, Florida, USA		Survey of WTP		0.00

Summarized in Andersson and Taylor (1986)

Study	Country	Method	US$ per kWh unserved

Swedish Joint Committee for the Electricity Council (1969)	Sweden	cost of interrupted household activities	2.34
			9.37
			33.97
Energy Systems Reasearch Group (1980)	Sweden	cost of interrupted household activities	0.47
			2.53
			29.28

Summarized in Woo and Pupp (1992)

Study/ Country	Method	Season,Time of Day, Frequency, Duration, Notification	US$/ outage	US$ per hour unserved	US$ per kWh unserved
Munasinghe (1980) Cascavel, Brazil	Wage Rate	Evening, 1 hour, unannounced	4.77	4.77	2.70-4.15
Sanghvi (1983) Wisconsin, USA	Consumer Surplus	Summer,12 noon, 1 hour, unannounced	0.58	0.58	0.26
		Summer, 12 noon, 2 hour, unannounced	1.17	0.58	0.28
		Summer, 12 noon, 4 hour, unannounced	2.56	0.64	0.33
		Summer, 12 noon, 12 hour, unannounced	30.03	2.49	1.20
		Summer, 8 a.m., 1 hour, unannounced	0.58	0.58	0.36
		Summer, 8 a.m., 2 hour, unannounced	1.20	0.59	0.37
		Summer, 8 a.m., 4 hour, unannounced	2.87	0.72	0.44
		Summer, 8 a.m., 8 hour, unannounced	8.49	1.06	0.62
		Summer, 4 p.m., 1 hour, unannounced	1.22	1.22	0.48
		Summer, 4 p.m., 2 hour, unannounced	3.19	1.61	0.50
		Summer, 4 p.m., 4 hour, unannounced	7.08	1.78	0.59
		Summer, 4 p.m., 8 hour, unannounced	11.33	1.40	0.58
Wacker, Wojczynski, and Billinton (1983) Canada	direct cost	Winter, evening, monthly, 1 hour, unannounced	2.45	2.45	
	direct cost	Winter, evening, monthly, 4 hour, unannounced	24.67	6.16	
	direct cost	Winter, evening, weekly, 4 hour, unannounced	38.15	9.54	
	WTP	Winter, evening, monthly, 4 hour, unannounced	11.00	2.75	
	WTP	Winter, evening, weekly, 4 hour, unannounced	16.74	4.18	
	WTP	Winter, evening, daily, 1 hour, unannounced	16.76	16.76	
	WTA	Winter, evening, monthly, 4 hour, unannounced	22.87	5.71	
Doane, Hartman, and Woo (1988) California, USA	Direct Cost	Winter, evening, 1 hour, unannounced	18.93	18.93	25.23
	Direct Cost	Winter, evening, 4 hour, unannounced	35.06	8.77	9.47

	Direct Cost	Winter, morning, 4 hour, unannounced	21.27	5.31	6.75
	Direct Cost	Winter, morning, 12 hour, unannounced	71.41	5.95	7.28
	Direct Cost	Summer, afternoon, 1 hour, unannounced	6.45	6.45	8.59
	Direct Cost	Summer, afternoon, 4 hour, unannounced	23.94	5.55	7.48
	Direct Cost	Summer, afternoon, 12 hour, unannounced	66.96	5.58	6.69
	Direct Cost	Summer, afternoon, 1 hour, announced	4.91	4.91	6.55
	Direct Cost	Summer, afternoon, 5 hour, unannounced	4.46	0.90	
	Direct Cost	Any time, momentary, unannounced	2.93		
	WTP	Winter, evening, 1 hour, unannounced	5.19	5.19	6.92
	WTP	Winter, evening, 4 hour, unannounced	8.42	2.12	2.28
	WTP	Winter, morning, 4 hour, unannounced	5.27	1.32	1.67
	WTP	Winter, morning, 12 hour, unannounced	15.91	1.32	1.62
	WTP	Summer, afternoon, 1 hour, unannounced	2.88	2.88	3.83
	WTP	Summer, afternoon, 4 hour, unannounced	6.34	1.59	1.99
	WTP	Summer, afternoon, 12 hour, unannounced	1.29	1.28	1.53
	WTP	Summer, afternoon, 1 hour, announced	1.73	1.73	2.29
Goett, McFadden, and Woo (1988) California, USA	WTP	Winter, morning, once, 1 hour, unannounced	33.29	33.29	42.29
	WTA	Winter, morning, once, 4 hour, unannounced	147.14	57.99	93.43
	WTA	Winter, morning, twice, 4 hour, unannounced	0.00	30.08	38.18
	WTA	Winter, morning, 4 times, 1 hour, unannounced	33.29	33.29	42.29
	WTA	Winter, morning, 4 times, 4 hour, unannounced	123.52	8.82	11.22
Doane, Hartman, and Woo (1988) California, USA	WTP	Twice, 1 hour, unannounced	70.16	17.53	25.11
	WTA	5 times, 2 hour, unannounced	19.98	9.99	14.31
	WTA	5 times, 4 hour, unannounced	70.16	10.02	7.18
	WTA	15 times, 2 hour, unannounced	19.98	9.99	14.31
	WTA	15 times, 4 hour, unannounced	28.33	6.30	9.02
Keane, MacDonald, and Woo (1988) California, USA	WTP	Summer, afternoon, once, 4 hour, unannounced	28.72	7.18	2.87
Doane et al. (1990) New York, USA	WTP	Summer, 8 a.m., 1 hour, unannounced	6.90	6.90	8.42
	WTP	Summer, 8 a.m., 4 hour, unannounced	9.97	2.49	2.95
	WTP	Summer, 8 a.m., 8 hour, unannounced	15.57	1.95	2.34
	WTP	Summer, 2 p.m., 1 hour, unannounced	5.53	5.53	6.83
	WTP	Summer, 2 p.m., 4 hour, unannounced	7.60	1.90	2.28
	WTP	Summer, 2 p.m., 8 hour, unannounced	11.42	1.43	1.51
	WTP	Summer, 2 p.m., 1 hour, 1 hour	5.53	5.53	6.83

		notification			
	WTP	Summer, 2 p.m., 4 hour, 1 hour notification	7.60	1.90	2.28
	WTP	Summer, 2 p.m., 1 hour, 4 hour notification	5.53	5.53	6.83
	WTP	Summer, 2 p.m., 4 hour, 4 hour notification	7.60	1.90	2.28
	WTP	Summer, 6 p.m., 1 hour, unannounced	6.03	6.03	5.80
	WTP	Summer, 6 p.m., 4 hour, unannounced	8.34	2.09	1.99
	WTP	Winter, 8 a.m., 1 hour, unannounced	10.46	10.46	11.13
	WTP	Winter, 8 a.m., 4 hour, unannounced	13.96	3.49	3.58
	WTP	Winter, 8 a.m., 8 hour, unannounced	20.85	2.60	2.70
	WTP	Winter, 2 p.m., 1 hour, unannounced	9.52	9.52	10.24
	WTP	Winter, 2 p.m., 4 hour, unannounced	12.54	3.13	3.23
	WTP	Winter, 2 p.m., 8 hour, unannounced	18.79	2.35	2.15
	WTP	Winter, 6 p.m., 1 hour, unannounced	11.38	11.38	9.47
	WTP	Winter, 6 p.m., 4 hour, unannounced	15.19	3.80	3.13
	WTP	Winter, 6 p.m., 1 hour, 1 hour notification	11.11	11.11	9.26
	WTP	Winter, 6 p.m., 1 hour, 4 hour notification	10.29	10.29	8.57
	WTP	Winter, 6 p.m., 4 hour, 1 hour notification	14.80	3.71	3.05
	WTP	Winter, 6 p.m., 4 hour, 4 hour notification	13.57	3.40	2.81
Tollefson et al. (1994)					
Country	Method	Season,Time of Day, Frequency, Duration, Notification	US$/ outage	US$ per hour unserved	US$ per kWh (annual energy consumed)
Canada	Preparatory Actions (Direct Cost)	Winter, monthly, 20 minute	0.29		0.0000187
	Preparatory Actions (Direct Cost)	Winter, monthly, 1 hour	1.70		0.0001082
	Preparatory Actions (Direct Cost)	Winter, monthly, 4 hour	18.72		0.0012017
	Preparatory Actions (Direct Cost)	Winter, yearly, 8 hour	39.83		0.0026519
	Preparatory Actions (Direct Cost)	Winter, yearly, 24 hour	181.22		0.0120949
	Preparatory Actions (Direct Cost)	Winter, yearly, 48 hour	445.94		0.0294308
	Preparatory Actions (Direct	Summer, monthly, 4 hour	6.69		0.0004340

	Cost)				
	Preparatory Actions (Direct Cost)	Summer, yearly, 48 hour	226.89		0.0152662
	Preparatory Actions (Direct Cost)	Summer, twice a year, 24 hour	220.87		0.0149564

Sullivan et al. (1996)

Country	Method	Season,Time of Day, Frequency, Duration, Notification	US$/ outage	US$ per hour unserved	US$ per kWh unserved
North Carolina, USA	mail survey, using WTP measures with high control and low control variations	Generation outage: Summer, afternoon, 1 hour, 1 hour notification	6.96		2.66
		Transmission or Distribution outage: Summer, afternoon, 1 hour, unannounced	7.64		2.93

Beenstock et al. (1998)

Country	Method	Season,Time of Day	US$ per kWh unserved
Israel	Conjoint	Winter, Morning/midday	13.38
	Conjoint	Winter, Afternoon/evening	17.74
	Conjoint	Spring/Autumn, Morning/midday	4.51
	Conjoint	Spring/ Autumn, afternoon / evening	4.84
	Conjoint	Summer, Morning / midday	9.27
	Conjoint	Summer, Afternoon /evening	7.58
	CVM	Winter, morning	2.26-3.31
	CVM	Winter, Midday	3.47-5.48
	CVM	Winter, Evening	3.39-4.35
	CVM	Spring/ Autumn morning	3.22-3.22
	CVM	Spring/ Autumn, midday	4.84-5.80
	CVM	Spring / Autumn, evening	5.48-5.72

Billinton and Pandey (1999)

Country	Method	Frequency, Duration	US$/ outage	US$ per kWh (annual energy consumed)
Nepal	Preparatory Action	20 minute	0.05	0.0000240
	Preparatory Action	1 hour	0.26	0.0001266
	Preparatory Action	4 hours	1.35	0.0006625
	Preparatory Action	8 hours	2.75	0.0013606
	Preparatory Action	24 hours	9.88	0.0048826
	Preparatory Action	48 hours	21.30	0.0104824
	WTP survey	Monthly, 4 hours	0.41	0.0001950
	WTP survey	Weekly, 4 hours	0.56	0.0002686
	WTP survey	Daily, 4 hours	0.92	0.0004369

	WTP survey	30 minute	0.06	0.0000320
	WTA survey	Weekly, 4 hours	3.24	0.0157900
	WTA survey	Daily, 4 hours	4.60	0.0224315

KPMG(2003)

Country	Method		US$/ outage
South Australia	WTP, choice modelling		
	Attributes	status quo	
	reduction in the frequency of interruptions of 1 perceived interruption per annum	2.38 /yr	2.62
	reduction in the perceived duration of interruptions of 1 hour per annum	95.7 min/year	1.94
	reduction in the duration of the perceived longest interruption of 1 hour	95.7 min	3.30
	reduction in the number of momentary interruptions by one per annum	8.44 /yr	0.19
	reduction in the number of planned interruptions by one per annum	0.31/yr	0.87
	reduction in the duration of the longest planned interruption by one hour	86.2 min	1.65
	reduction by one in the number of equipment changes per annum	109.39 /yr	0.19
	value relative to ETSA Utilities not being able to automatically detect interruptions		23.90
	call centre performance		
	wait <30 secs		5.73
	wait 30 secs - 2mins		0.00
	wait 2-10 mins		-15.83
	wait 10-20mins		-21.76
	not get through		-42.74
	SMS text message		-105.01
	Recorded message		6.02
	value of 1 a hour improvement in the accuracy of the restoration time		2.04
	information about planned interruptions		
	method of notification		
	letter		3.11
	media		-3.11
	fax		1.75
	email		3.01
	SMS		0.10
	phone		-2.23

	WTP to increase the notification period from 4 to 30 days		-0.19
	Value of undergrounding		46.04
	WTP to improve the power supply in urban areas		40.70
	WTP to improve the power supply in remote areas		58.67
	WTP to improve the power supply in rural areas		33.61
	costs of augmenting the distribution network for new customers to be		
	shared between the customer connected and everyone else		-2.82
	shared by everyone		-1.26
		Total	40.51

Lawton et al (2003)

Country	Method	Season,Time of Day, Frequency, Duration, Notification	US$/ outage
Western USA		SEASON	
	WTP	All	8.11
		Winter	9.68
		Summer	7.68
	WTA	All	12.36
		Winter	18.07
		Summer	11.10
		DAY	
	WTP	All days	8.11
		Weekday	8.06
		Weekend	9.06
	WTA	All days	12.36
		Weekday	12.31
		Weekend	12.73
REGIONS			
All Regions	WTP		8.11
Northwest	WTP		8.93
Southwest	WTP		8.25
Southeast	WTP		8.42
West	WTP		2.66
All Regions	WTA		12.36
Northwest	WTA		15.82
Southwest	WTA		
Southeast	WTA		11.00
West	WTA		
HOME OWNERSHIP			
All	WTP		8.11
Own	WTP		8.14

Rent	WTP		7.70
Other	WTP		11.15
All	WTA		12.27
Own	WTA		12.17
Rent	WTA		12.60
Other	WTA		14.39
			Predicted Outage cost
		Summer, afternoon, 1 hour	3.41
		Summer, afternoon, 8 hour	8.46
		Winter, afternoon, 1 hour	3.88
		Winter, afternoon, 8 hour	9.78

Chowdhury et al. (2004)

Country	Method	Season,Time of Day, Frequency, Duration, Notification	US$/ outage	US$ per hour unserved	US$ per kWh (annual energy consumed)
Midwest region, USA	CVM (WTP)				0.62
		20 minute	0.74		
		1 hour	2.24		
		4 hour	8.95		
		8 hour	17.91		
		Yearly, 30 minute	0.66		
		Yearly, 1 hour	1.32		
		Yearly, 4 hour	5.28		
		Yearly, 8 hour	10.55		
		Monthly, 30 minute	1.12		
		Monthly, 1 hour	2.24		
		Monthly, 4 hour	8.95		
		Monthly, 8 hour	17.91		
		Weekly, 30 minute	1.52		
		Weekly, 1 hour	3.03		
		Weekly, 4 hour	12.15		
		Weekly, 8 hour	24.29		

Layton et al.(2005)

Country	Method	Season,Time of Day, Frequency, Duration, Notification	US$/ outage	US$ per hour unserved	US$ per kWh unserved
USA	CVM WTP	Winter, evening, 1 hour, unannounced	17.07		6.78
		Winter, evening, 4 hour, unannounced	31.94		3.38
		Winter, evening, 8 hour, unannounced	43.77		2.91
		Winter, evening, 12 hour, unannounced	52.68		2.61

Carlsson and Martinsson (2006b)

Country	Method	Season,Time of Day, Frequency, Duration, Notification	US$/ outage		
Sweden	CE		MWTP Base Version		
		April – October, weekday, 4 hour, unannounced	1.66		
		April – October, weekday, 8 hour, unannounced	2.97		
		April – October, weekday, 24 hour, unannounced	7.83		
		April – October, weekend, 4 hour, unannounced	1.99		
		April – October, weekend, 8 hour, unannounced	4.51		
		April – October, weekend, 24 hour, unannounced	10.10		
		November – March, weekday, 4 hour, unannounced	1.21		
		November – March, weekday, 8 hour, unannounced	2.74		
		November – March, weekday, 24 hour, unannounced	10.25		
		November – March, weekend, 4 hour, unannounced	2.99		
		November – March, weekend, 8 hour, unannounced	5.31		
		November – March, weekend, 24 hour, unannounced	13.69		
			MWTP Scope Version		
		April – October, weekday, 4 hour, unannounced	1.18		
		April – October, weekday, 8 hour, unannounced	6.35		
		April – October, weekday, 24 hour, unannounced	11.81		
		April – October, weekend, 4 hour, unannounced	4.96		
		April – October, weekend, 8 hour, unannounced	10.60		
		April – October, weekend, 24 hour, unannounced	15.11		
		November – March, weekday, 4 hour, unannounced	2.79		
		November – March, weekday, 8 hour, unannounced	8.18		
		November – March, weekday, 24 hour, unannounced	19.56		
		November – March, weekend, 4 hour, unannounced	9.06		
		November – March, weekend, 8 hour, unannounced	9.77		
		November – March, weekend, 24 hour, unannounced	20.82		

Klytchnikova (2006)

Country	Method	Season,Time of Day, Frequency, Duration, Notification	US$/ outage		
Azerbaijan	Direct demand estimation – switching regression		total compensation variation per year		
		Scenario			
		50% price increase	-0.87		
		quality improvement to perfect reliability	7.38		
		50% price increase and quality improvement to perfect reliability	5.44		
		100% price increase and 50% quality improvement	-0.16		

Carlsson and Martinsson (2007)					
Study/Country	Method	Season,Time of Day, Frequency, Duration, Notification	US$/ outage	US$ per hour unserved	US$ per kW
Carlsson and Martinsson (2007) Sweden	CVM	January, Evening 6 pm, 1 hour, announced	1.05	1.05	0.50
		January, Evening 6 pm, 4 hour, announced	4.73	1.18	2.26
		January, Evening 6 pm, 8 hour, announced	14.04	1.75	6.65
		January, Evening 6 pm, 24 hour, announced	31.47	1.31	14.97
		January, Evening 6 pm, 1 hour, unannounced	1.64	1.64	0.75
		January, Evening 6 pm, 4 hour, unannounced	6.21	1.55	2.96
		January, Evening 6 pm, 8 hour, announced	17.97	2.25	8.63
		January, Evening 6 pm, 24 hour, unannounced	37.08	1.55	17.63
		January, Evening 6 pm, between 2 and 6 hours, unannounced	11.44	2.86	5.47
Svenska Elverksforeninge n (1994) Sweden		1 hour, announced			0.1995385
		4 hour, announced			0.6983846
		8 hour, announced			2.8600513
		24 hour, announced			na
		1 hour, unannounced			0.4489615
		4 hour, unannounced			1.7127052
		8 hour, unannounced			4.8055514
		24 hour, unannounced			na
		Between 2 and 6 hours, unannounced			na

Carlsson and Martinsson (2008)					
Country	Method	Season,Time of Day, Frequency, Duration, Notification	US$/ outage		
Sweden	CE		MWTP		
		April – October, weekday, 4 hour, unannounced	1.78		
		April – October, weekday, 8 hour, unannounced	4.38		
		April – October, weekday, 24 hour, unannounced	12.83		
		April – October, weekend, 4 hour, unannounced	3.33		

		April – October, weekend, 8 hour, unannounced	6.67		
		April – October, weekend, 24 hour, unannounced	17.45		
		November – March, weekday, 4 hour, unannounced	1.23		
		November – March, weekday, 8 hour, unannounced	3.50		
		November – March, weekday, 24 hour, unannounced	15.86		
		November – March, weekend, 4 hour, unannounced	4.89		
		November – March, weekend, 8 hour, unannounced	7.92		
		November – March, weekend, 24 hour, unannounced	20.76		

Appendix 3.1 Focus Group Handouts

Date:

Home Address: District:

1. Gender of the respondent

    1. Male [ ] 2. Female [ ]

2. How old are you?

    Age________ Year of birth: ________

3. Occupation:___________________

4. Marital Status

    [ ] 1. Single (never married)
    [ ] 2. Married
    [ ] 3. Divorced/Separated
    [ ] 4. Widowed

5. Which of the following best describes the highest level of formal education you have attained/completed?

    [ ] 1. No formal education
    [ ] 2. Primary school
    [ ] 3. Secondary school
    [ ] 4. College/high school
    [ ] 5. Technical school
    [ ] 6. University (2 year)
    [ ] 7. University (4 year bachelor)
    [ ] 8. Post graduate

Preparatory actions

6. Which of the following actions your household takes in preparations for the failures? Please choose one or more of the following actions.

Preparatory Action

[ ] 1. No preparation

[ ] 2. Candle

[ ] 3. Kerosene lamp

[ ] 4. Gas lamp

[ ] 5. Electric lantern(battery powered)

[ ] 6. Emergency kerosene stove

[ ] 7. Emergency gas stove

[ ] 8. Emergency kerosene heater

[ ] 9. Emergency gas heater

[ ] 10. Small generator

[ ] 11. Larger generator

[ ] 12. Standby Uninterrupted Power Supply (UPS) system

[ ] 13. Car battery connected to an inverter

[ ] 14. deep-cycle (lead-acid) battery(ies) connected to an inverter

[ ] 15. Other (Specify)

7. How much does your household currently pay every month for electricity received from the electricity authority?________________YTL

Unplanned power interruptions: ***Summer***

1. How often do you have unplanned power interruptions or blackouts in summer?

2. What is the average duration of unplanned power interruptions or blackouts in summer?

3. How long is the longest unplanned power interruption or blackout that you have in summer?

Unplanned power interruptions: ***Winter***

4. How often do you have unplanned power interruptions or blackouts in winter?

5. What is the average duration of unplanned power interruptions or blackouts in winter?

6. How long is the longest unplanned power interruption or blackout that you have at least once a year?

General

7. How many of the unplanned failures you experienced in a month caused a problem or were disruptive?

______

Planned power interruptions: ***Summer***

8. How often do you have planned power interruptions or blackouts (day/week/month/year) in summer?

9. What is the average duration of planned power interruptions or blackouts in summer?

10. How long is the longest planned power interruption or blackout that you have in summer?

Planned power interruptions: ***Winter***

11. How often do you have planned power interruptions or blackouts (day/week/month/year) in winter?

12. What is the average duration of planned power interruptions or blackouts in winter?

13. How long is the longest planned power interruption or blackout that you have at least once a year?

General

14. When an interruption is planned, how many days in advance are you notified?

_______days in advance

15. When an interruption is planned, how long in advance you prefer to be notified

_______days in advance

For each question below, assume that you *did not* know prior to the failure when it would occur or how long it would last. Please using a scale of 1 to 5, evaluate how undesirable each of the following unplanned outages at the given times would be to you or your household:

1: no undesirable effect

2: low undesirable effect

3: moderate undesirable effect

4: high undesirable effect

5: extremely undesirable effect

Unplanned outages						
How much would your household be affected by the following outages		Circle the number which indicates your rating				
Summer Weekday (Monday-Friday)						
1.	6am to 9am	1	2	3	4	5
2.	9am to 3pm	1	2	3	4	5

3.	3pm to 6pm	1	2	3	4	5
4.	6pm to 11 pm	1	2	3	4	5
5.	11pm to 6am	1	2	3	4	5
Summer Weekend (Saturday-Sunday)						
6.	6am to 9am	1	2	3	4	5
7.	9am to 3pm	1	2	3	4	5
8.	3pm to 6pm	1	2	3	4	5
9.	6pm to 11 pm	1	2	3	4	5
10.	11pm to 6am	1	2	3	4	5
Winter Weekday (Monday-Friday)						
11.	6am to 9am	1	2	3	4	5
12.	9am to 3pm	1	2	3	4	5
13.	3pm to 6pm	1	2	3	4	5
14.	6pm to 11 pm	1	2	3	4	5
15.	11pm to 6am	1	2	3	4	5
Winter Weekend (Saturday-Sunday)						
16.	6am to 9am	1	2	3	4	5
17.	9am to 3pm	1	2	3	4	5
18.	3pm to 6pm	1	2	3	4	5
19.	6pm to 11 pm	1	2	3	4	5
20.	11pm to 6am	1	2	3	4	5

For each question below, assume that you *were notified* when the failure would occur and how long it would last. Please using a scale of 1 to 5, evaluate how undesirable each of the following planned outages at the given times would be to you or your household:

1: no undesirable effect

2: low undesirable effect

3: moderate undesirable effect

4: high undesirable effect

5: extremely undesirable effect

Planned outages						
How much would your household be affected by the following planned outages		Circle the number which indicates your rating				
Summer Weekday (Monday-Friday)						
1.	6am to 9am	1	2	3	4	5
2.	9am to 3pm	1	2	3	4	5
3.	3pm to 6pm	1	2	3	4	5
4.	6pm to 11 pm	1	2	3	4	5
5.	11pm to 6am	1	2	3	4	5
Summer Weekend (Saturday-Sunday)						
6.	6am to 9am	1	2	3	4	5
7.	9am to 3pm	1	2	3	4	5
8.	3pm to 6pm	1	2	3	4	5
9.	6pm to 11 pm	1	2	3	4	5
10.	11pm to 6am	1	2	3	4	5
Winter Weekday (Monday-Friday)						
11.	6am to 9am	1	2	3	4	5
12.	9am to 3pm	1	2	3	4	5
13.	3pm to 6pm	1	2	3	4	5
14.	6pm to 11 pm	1	2	3	4	5
15.	11pm to 6am	1	2	3	4	5
Winter Weekend (Saturday-Sunday)						
16.	6am to 9am	1	2	3	4	5
17.	9am to 3pm	1	2	3	4	5
18.	3pm to 6pm	1	2	3	4	5
19.	6pm to 11 pm	1	2	3	4	5
20.	11pm to 6am	1	2	3	4	5

Appendix 3.2 Choice Sets – Pilot Study

			Service A					Service B				
Block	**set**	**profile**	**Freq.**	**Duration**	**Time**	**Prior notif.**	**% bill**	**Freq.**	**Duration**	**Time**	**Prior notif.**	**% bill**
0	1	3	4 times a year	6 to 13 hours	daytime	no prior notification	5% higher	once a month	less than 6 hours	night-time	prior notification	20% higher
0	2	5	once a month	less than 6 hours	daytime	no prior notification	30% higher	8 times a month	6 to 13 hours	night-time	prior notification	10% higher
0	3	7	8 times a month	6 to 13 hours	night-time	prior notification	10% higher	twice a year	less than 6 hours	daytime	no prior notification	30% higher
0	4	12	twice a year	less than 6 hours	daytime	prior notification	30% higher	4 times a year	6 to 13 hours	night-time	no prior notification	10% higher
0	5	13	4 times a year	6 to 13 hours	night-time	no prior notification	20% higher	once a month	less than 6 hours	daytime	prior notification	5% higher
0	6	20	once a month	less than 6 hours	night-time	no prior notification	10% higher	8 times a month	6 to 13 hours	daytime	prior notification	30% higher
0	7	23	twice a year	less than 6 hours	night-time	prior notification	20% higher	4 times a year	6 to 13 hours	daytime	no prior notification	5% higher
0	8	32	8 times a month	6 to 13 hours	daytime	prior notification	30% higher	twice a year	less than 6 hours	night-time	no prior notification	10% higher
1	1	2	twice a year	6 to 13 hours	night-time	prior notification	30% higher	4 times a year	less than 6 hours	daytime	no prior notification	10% higher
1	2	4	4 times a year	less than 6 hours	daytime	no prior notification	10% higher	once a month	6 to 13 hours	night-time	prior notification	30% higher
1	3	6	8 times a month	less than 6 hours	night-time	prior notification	5% higher	twice a year	6 to 13 hours	daytime	no prior notification	20% higher
1	4	10	4 times a year	less than 6 hours	night-time	no prior notification	30% higher	once a month	6 to 13 hours	daytime	prior notification	10% higher
1	5	11	once a month	6 to 13 hours	night-time	no prior notification	5% higher	8 times a month	less than 6 hours	daytime	prior notification	20% higher
1	6	17	twice a year	6 to 13 hours	daytime	prior notification	10% higher	4 times a year	less than 6 hours	night-time	no prior notification	30% higher
1	7	28	8 times a month	less than 6 hours	daytime	prior notification	20% higher	twice a year	6 to 13 hours	night-time	no prior notification	5% higher
1	8	29	once a month	6 to 13 hours	daytime	no prior notification	20% higher	8 times a month	less than 6 hours	night-time	prior notification	5% higher
2	1	1	once a month	less than 6 hours	daytime	prior notification	30% higher	8 times a month	6 to 13 hours	night-time	no prior notification	10% higher
2	2	16	twice a year	less than 6 hours	night-time	no prior notification	10% higher	4 times a year	6 to 13 hours	daytime	prior notification	30% higher

2	3	18	4 times a year	6 to 13 hours	daytime	prior notification	30% higher	once a month	less than 6 hours	night-time	no prior notification	10% higher
2	4	22	8 times a month	6 to 13 hours	daytime	no prior notification	5% higher	twice a year	less than 6 hours	night-time	prior notification	20% higher
2	5	25	4 times a year	6 to 13 hours	night-time	prior notification	10% higher	once a month	less than 6 hours	daytime	no prior notification	30% higher
2	6	26	twice a year	less than 6 hours	daytime	no prior notification	30% higher	4 times a year	6 to 13 hours	night-time	prior notification	10% higher
2	7	27	once a month	less than 6 hours	night-time	prior notification	20% higher	8 times a month	6 to 13 hours	daytime	no prior notification	5% higher
2	8	30	8 times a month	6 to 13 hours	night-time	no prior notification	20% higher	twice a year	less than 6 hours	daytime	prior notification	30% higher
3	1	8	8 times a month	less than 6 hours	night-time	no prior notification	5% higher	twice a year	6 to 13 hours	daytime	prior notification	20% higher
3	2	9	8 times a month	less than 6 hours	daytime	no prior notification	10% higher	twice a year	6 to 13 hours	night-time	prior notification	30% higher
3	3	14	once a month	6 to 13 hours	night-time	prior notification	30% higher	8 times a month	less than 6 hours	daytime	no prior notification	10% higher
3	4	15	4 times a year	less than 6 hours	daytime	prior notification	20% higher	once a month	6 to 13 hours	night-time	no prior notification	5% higher
3	5	19	twice a year	6 to 13 hours	daytime	no prior notification	20% higher	4 times a year	less than 6 hours	night-time	prior notification	5% higher
3	6	21	once a month	6 to 13 hours	daytime	prior notification	10% higher	8 times a month	less than 6 hours	night-time	no prior notification	5% higher
3	7	24	twice a year	6 to 13 hours	night-time	no prior notification	5% higher	4 times a year	less than 6 hours	daytime	prior notification	20% higher
3	8	31	4 times a year	less than 6 hours	night-time	prior notification	5% higher	once a month	6 to 13 hours	daytime	no prior notification	20% higher

Appendix 3.3 Revised Choice Sets

			Service A					Service B				
Block	set	profile	Freq.	Duration	Time	Prior notif.	% bill	Freq.	Duration	Time	Prior notif.	% bill
0	1	3	once in 3 months	less than 2 hours	night-time	no prior notification	5% higher	once a year	2 to 8 hours	daytime	prior notification	30% higher
0	2	5	once a month	less than 2 hours	night-time	prior notification	30% higher	once in 3 months	2 to 8 hours	daytime	no prior notification	20% higher
0	3	7	twice a month	2 to 8 hours	daytime	no prior notification	10% higher	once a month	less than 2 hours	night-time	prior notification	5% higher
0	4	12	once in 3 months	less than 2 hours	daytime	prior notification	5% higher	once a year	2 to 8 hours	night-time	no prior notification	30% higher
0	5	13	once in 3 months	less than 2 hours	night-time	no prior notification	20% higher	once a year	2 to 8 hours	daytime	prior notification	10% higher
0	6	20	once a month	2 to 8 hours	night-time	prior notification	10% higher	once in 3 months	less than 2 hours	daytime	no prior notification	5% higher
0	7	23	once a year	2 to 8 hours	daytime	prior notification	20% higher	twice a month	less than 2 hours	night-time	no prior notification	10% higher
0	8	32	twice a month	less than 2 hours	daytime	no prior notification	30% higher	once a month	2 to 8 hours	night-time	prior notification	20% higher
1	1	2	once a year	2 to 8 hours	daytime	no prior notification	30% higher	twice a month	less than 2 hours	night-time	prior notification	20% higher
1	2	4	once in 3 months	less than 2 hours	night-time	prior notification	10% higher	once a year	2 to 8 hours	daytime	no prior notification	5% higher
1	3	6	twice a month	2 to 8 hours	daytime	prior notification	5% higher	once a month	less than 2 hours	night-time	no prior notification	30% higher
1	4	10	once in 3 months	2 to 8 hours	night-time	prior notification	30% higher	once a year	less than 2 hours	daytime	no prior notification	20% higher
1	5	11	once a month	2 to 8 hours	night-time	no prior notification	5% higher	once in 3 months	less than 2 hours	daytime	prior notification	30% higher
1	6	17	once a year	less than 2 hours	daytime	no prior notification	10% higher	twice a month	2 to 8 hours	night-time	prior notification	5% higher
1	7	28	twice a month	less than 2 hours	daytime	prior notification	20% higher	once a month	2 to 8 hours	night-time	no prior notification	10% higher
1	8	29	once a month	less than 2 hours	night-time	no prior notification	20% higher	once in 3 months	2 to 8 hours	daytime	prior notification	10% higher
2	1	1	once a	less than 2	daytime	prior	5%	once in 3	2 to 8 hours	night-	no prior	30%

			month	hours		notification	higher	months		time	notification	higher
2	2	16	once a year	2 to 8 hours	night-time	prior notification	10% higher	twice a month	less than 2 hours	daytime	no prior notification	5% higher
2	3	18	once in 3 months	less than 2 hours	daytime	no prior notification	30% higher	once a year	2 to 8 hours	night-time	prior notification	20% higher
2	4	22	twice a month	less than 2 hours	night-time	no prior notification	5% higher	once a month	2 to 8 hours	daytime	prior notification	30% higher
2	5	25	once in 3 months	2 to 8 hours	daytime	no prior notification	10% higher	once a year	less than 2 hours	night-time	prior notification	5% higher
2	6	26	once a year	less than 2 hours	night-time	prior notification	30% higher	twice a month	2 to 8 hours	daytime	no prior notification	20% higher
2	7	27	once a month	2 to 8 hours	daytime	prior notification	20% higher	once in 3 months	less than 2 hours	night-time	no prior notification	10% higher
2	8	30	twice a month	2 to 8 hours	night-time	prior notification	20% higher	once a month	less than 2 hours	daytime	no prior notification	10% higher
3	1	8	twice a month	2 to 8 hours	night-time	prior notification	30% higher	once a month	less than 2 hours	daytime	no prior notification	20% higher
3	2	9	twice a month	less than 2 hours	night-time	prior notification	10% higher	once a month	2 to 8 hours	daytime	no prior notification	5% higher
3	3	14	once a month	2 to 8 hours	daytime	no prior notification	30% higher	once in 3 months	less than 2 hours	night-time	prior notification	20% higher
3	4	15	once in 3 months	less than 2 hours	daytime	prior notification	20% higher	once a year	2 to 8 hours	night-time	no prior notification	10% higher
3	5	19	once a year	less than 2 hours	night-time	no prior notification	20% higher	twice a month	2 to 8 hours	daytime	prior notification	10% higher
3	6	21	once a month	less than 2 hours	daytime	no prior notification	10% higher	once in 3 months	2 to 8 hours	night-time	prior notification	5% higher
3	7	24	once a year	2 to 8 hours	night-time	no prior notification	5% higher	twice a month	less than 2 hours	daytime	prior notification	30% higher
3	8	31	once in 3 months	2 to 8 hours	daytime	prior notification	5% higher	once a year	less than 2 hours	night-time	no prior notification	30% higher

Appendix 4.1 Questionnaire used in the Pilot Survey

SURVEY FOR ELECTRICITY SUPPLY IMPROVEMENTS IN NORTH CYPRUS

Date: ________________	Form No:
Address:	District: ________________
Time started: ________________	Time ended: ________________

Introduction

We are conducting a survey to determine your perception of the current reliability of electricity supply that your household is receiving from your electricity authority. We will also ask you questions regarding types of activities your household uses to avoid, if any, problems related with the existing electricity service. The results can be used by the Government in their evaluations of alternative electricity improvement projects, as well as in setting the appropriate tariff that reflect opportunity costs once the best alternatives are chosen. Your answers to this questionnaire will be completely confidential.

When the term POWER FAILURE (or OUTAGE/INTERRUPTION/BLACKOUT) is used in this survey booklet, it means a complete interruption of electricity for a period lasting a few seconds, minutes, hours, or even days.

In your answers, please consider the needs of all members of your household.

FORM 1:

Section 1: Current electricity service

Section 1A: Attitudes to the electricity system

For electricity system overall

What is your opinion on the following matters? Check the answer which best describes your opinion for each of the following.

1. In general, the power supply provided by my electric power company is

[ ] 1. very good [ ] 2. good [ ] 3. fair [ ] 4. poor [ ] 5. very poor

2. I think that in general the number of failures of the electrical power to my home is

[ ] 1. very low [ ] 2. low [ ] 3. moderate [ ] 4. high [ ] 5. very high

3. Our power supply has improved in the last year

[ ] 1. strongly agree [ ] 2. agree [ ] 3. neither agree or disagree [ ] 4. disagree [ ] 5. strongly disagree

4. I think that the price of our electricity is

[ ] 1. very low [ ] 2. low [ ] 3. moderate [ ] 4. high [ ] 5. very high

5. My confidence in our electricity authority is

[ ] 1. very high [ ] 2. high [ ] 3. moderate [ ] 4. low [ ] 5. very low

Suppose that the total requirement of all of your electricity authority's customers was nearing the company's maximum capacity to produce electricity. In order to ensure that the customers' requirement does not rise above the company's maximum capacity, some options are possible. Some of these: all electricity users are asked to reduce the amount of electricity they are using for a period of time; electricity consumption at peak periods is charged a higher price; some of the users will experience a temporary outage, etc.

Load shedding

6. If during peak periods, the utility company 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?	[ ] 1. Yes [ ] 2. No

User pays and tariff variations

7. People who use electricity at peak times should pay more

[ ] 1. strongly agree [ ] 2. agree [ ] 3. neither agree or disagree [ ] 4. disagree [ ] 5. strongly disagree

Section 1B: Reliability of Supply – Duration and Frequency of Interruptions as Perceived by Respondents

Unplanned power interruptions (no prior notification):	*Summer*
1. How often do you have unplanned power interruptions or blackouts (day/week/month/year) in summer?	_______per(day/week/month/year)
2. What is the average duration of unplanned power interruptions or blackouts in summer?	_______hours
3. How long is the longest unplanned power interruption or blackout that you have in summer?	_______hours
Unplanned power interruptions:	*Winter*
4. How often do you have unplanned power interruptions or blackouts (day/week/month/year) in winter?	_______per(day/week/month/year)
5. What is the average duration of unplanned power interruptions or blackouts in winter?	_______hours
6. How long is the longest unplanned power interruption or blackout that you have at least once a year?	_______hours

Planned power interruptions:	*Summer*
7. How often do you have planned power interruptions or blackouts (day/week/month/year) in summer?	_______per(day/week/month/year)
8. What is the average duration of planned power interruptions or blackouts in summer?	_______hours
9. How long is the longest planned power interruption or blackout that you have in summer?	_______hours
Planned power interruptions:	*Winter*
10. How often do you have planned power interruptions or blackouts (day/week/month/year) in winter?	_______per(day/week/month/year)
11. What is the average duration of planned power interruptions or blackouts in winter?	_______hours
12. How long is the longest planned power interruption or blackout that you have at least once a year?	_______hours
General	

13. When an interruption is planned, how many days in advance are you notified?	______days in advance

Section 1C: Household's electricity usage

<table>
<tr><td colspan="2">1. Dwelling type (Type of housing)</td><td rowspan="4">2. This house is
[ ] 1. Your own
[ ] 2. Rented
[ ] 3. Other (Specify) _____</td><td rowspan="4">3. House floorsize: __________meter-square

4. Number of bedrooms in the house: _____

5. Number of bathrooms in the house:_____</td></tr>
<tr><td>[ ] 1. Detached house</td><td>[ ] 4. Subsidiary house</td></tr>
<tr><td>[ ] 2. Semi-detached house</td><td>[ ] 5. Multi-storey apartment or flat</td></tr>
<tr><td>[ ] 3. Row house</td><td>[ ] 6. Other (Specify) _____</td></tr>
</table>

<table>
<tr><td>6. How is payment made for your electrical usage?</td><td colspan="3">7. How much does your household currently pay every month for electricity received from the electricity authority?</td></tr>
<tr><td>Payment Type</td><td>Monthly total bill (YTL)</td><td>Monthly consumption (kWh)</td><td></td></tr>
<tr><td>[ ]1. Invoice from Kıb-Tek</td><td rowspan="3">1.</td><td rowspan="3">2.</td><td rowspan="3">3. [ ] do not know</td></tr>
<tr><td>[ ]2. included in rent</td></tr>
<tr><td>[ ]3. Other (Specify)</td></tr>
</table>

<table>
<tr><td colspan="2">8. Which of the following fuel types your household uses for heating your house? Please choose one or more of the following fuel types.</td><td colspan="2">9. Which of the following fuel types your household uses for cooking? Please choose one or more of the following fuel types.</td></tr>
<tr><td>Fuel Type</td><td>Percentage of house-heating obtained from this fuel</td><td>Fuel Type</td><td>Percentage of cooking in your house from this fuel</td></tr>
<tr><td>[ ] 1. Electricity</td><td></td><td>[ ] 1. Electricity</td><td></td></tr>
<tr><td>[ ] 2. Fuel-oil</td><td></td><td></td><td></td></tr>
</table>

[ ] 3. LPG		[ ] 2. LPG	
[ ] 4. Wood		[ ] 3. Wood	
[ ] 5. Other (Specify) ________		[ ] 4. Other (Specify) ________	

10. Is someone at home most of the time?	11. Does someone in your household work from home:	12. Does their work depend on the availability of electricity?
[ ] 1. Yes [ ] 2. No	[ ] 1. never→go to question 13 [ ] 2. occasionally [ ] 3. sometimes [ ] 4. very often [ ] 5. always	[ ] 1. not dependent [ ] 2. partially dependent [ ] 3. very much dependent

13. Does your household have sickbed resident?	14. Does your household use electrical medical equipment at home?
[ ]1. Yes [ ]2. No	[ ]1. Yes [ ]2. No

15. This question asks you to rate the undesirable effects of a power failure. Suppose a power failure lasting 1 to 4 hours occurred. Starting with the most important what kinds of activities does an electricity cut prevent your household from undertaking?

Activity	Order No.	**Activity**	Order No.
1. Kitchen appliances not useable	[ ]	8. Loss of use or damage to equipment that is particularly sensitive to power failures. (e.g. computers, digital clocks)	[ ]
2. Clothes care (washing machine, iron, etc.) or home cleaning appliances not useable	[ ]	9. Elevator not functioning	[ ]
3. Hobby and leisure equipment not useable	[ ]	10. Can't work from home	[ ]
4. Fear of crime (e.g. due to street or apartment	[ ]	11. Other effects	

hallway lighting not working)		11.1	[ ]
5. Fear of accidents in home	[ ]	11.2	[ ]
6. Discomfort (e.g. due to change in home temperature)	[ ]	11.3	[ ]
7. Loss of lighting (This may overlap with some of the above effects)	[ ]	11.4	[ ]

Preferred interruption time for *unplanned and planned* outages

The undesirable effects of power failures may depend on the season, the day of the week and the time of day when the failure occurs,

as well as whether they are planned or unplanned. This question asks you to state when an outage would be most disruptive for your household.

UNPLANNED OUTAGES

16. When is an unplanned outage of uncertain duration most disruptive for your household? Summer or Winter?

[ ]1. Summer [ ]2. Winter

[ ]3. Both equally disruptive [ ]4. None

17. When is an unplanned outage of uncertain duration most disruptive for your household? Weekday or Weekend?

1. Weekday [ ] 2. Weekend [ ]

3. Both equally disruptive[ ] 4. None [ ]

18. When is an unplanned outage of uncertain most disruptive for your household?

[ ] 1.	6am to 9am	[ ] 4.	11pm to 6am
[ ] 2.	9am to 6pm	[ ] 5.	All equally disruptive

PLANNED OUTAGES

19. When is a planned outage of certain duration most disruptive for your household? Summer or Winter?

[ ]1. Summer [ ]2. Winter

[ ]3. Both equally disruptive [ ]4. None

20. When is a planned outage of certain duration most disruptive for your household? Weekday or Weekend?

1. Weekday [ ] 2. Weekend [ ]

3. Both equally disruptive[ ] 4. None [ ]

21. When is a planned outage of certain duration most disruptive for your household?

[ ] 1.	6am to 9am	[ ] 4.	11pm to 6am
[ ] 2.	9am to 6pm	[ ] 5.	All equally disruptive
[ ] 3.	6pm to 11 pm	[ ] 6.	none

[ ] 3.	6pm to 11 pm	[ ] 6.	none		

Frequency versus duration of *unplanned* interruptions

22. Frequent short interruptions (30 minutes or less) are worse than one long interruption (more than 30 minutes).

[ ] 1. strongly agree [ ] 2. agree [ ] 3. neither agree or disagree [ ] 4. disagree [ ] 5. strongly disagree

Section 2: Preparatory actions

1. Which of the following actions your household takes in preparations for the failures? Please choose one or more of the following actions.

Preparatory Action	Make	Year purchased	Capacity / Size	Price paid per unit (capital and installation)	Expected life of equipment	Monthly Operating Expense per unit	Number of times each unit is maintained in a year	Payment for each maintenance (Per unit)	Number owned	Average number used in a month	Average number of hours used in a month
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
[] 1. No preparation	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
[] 2. Candle	NA	NA	NA		------hours	NA	NA	NA	NA		
[] 3. Kerosene lamp											
[] 4. Gas lamp											
[] 5. Electric lantern (battery powered)											
[] 6. Emergency kerosene stove											

[] 7. Emergency gas stove											
[] 8. Emergency kerosene heater											
[] 9. Emergency gas heater											
[] 10. Voltage regulator											
[] 11. Surge protector											
[] 12. Small generator						Details will be taken in question 2					
[] 13. Larger generator						Details will be taken in question 2					
[] 14. Standby Uninterrupted Power Supply (UPS) system						Details will be taken in question 4					
[] 15. Car battery connected to an inverter						Details will be taken in question 4					
[] 16. deep-cycle (lead-acid) battery(ies) connected to an inverter						Details will be taken in question 4					
[] 17. Other (Specify)											

If own/share generator(s) is one of the preparatory actions your household takes in preparation for the failures, please answer question 2, otherwise question 3.

2. Particulars of generator(s)

Parameters		Generator 1	Generator 2
Make	1		
Year installed	2		
Capacity	3		
Type of fuel	4		
Average number of hours run in a month	5		
Monthly fuel consumed (litres)	6		
Monthly expenditure on fuel (YTL)	7		
Capital & installation cost (YTL)	8		
Expected life of the generator	9		
Number of times maintained in a year	10		
Cost of each maintenance (YTL)	11		

If own/share invertor(s) is one of the preparatory actions your household takes in preparation for the failures, please answer question 4, otherwise question 5.

4. Particulars of inverters/UPS

Parameters		Inverter 1	Inverter 2
Make	1		
Year installed	2		
Capacity	3		
Anticipated life of the inverter	4		
Life of the batteries	5		
Number of continuous hours the inverter can be used with one recharge	6		
Capital & installation cost (YTL)	7		
Cost of batteries (YTL)	8		
Number of times maintained in a year	9		
Cost of each maintenance (YTL)	10		
Number of bulbs connected	11		
Number of fans connected	12		

If jointly owned, how much was your initial contribution? (YTL)	12		

3. What are the reasons for not going for generator(s)? Please elaborate.

____

____

Maximum connected load	13		

5. What are the reasons for not going for inverter(s)? Please elaborate.

____

____

Section 3: Willingness to pay for an inverter system

1. An inverter is a device connected to a battery and is used to convert 12-volt power into 240-volt power. Suppose that an inverter system has become available which would provide a reliable electric power supply without any failures. With the inverter system the household will never again experience an interruption in supply, and the inverter system will be capable of running every household appliance at your house. 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.

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	[]

If you chose not to go for the inverter system please go to question 2 of this section, otherwise go to section 4.

2. What are the reasons for not going for this inverter system? Please elaborate.

____

____

Section 4: Willingness to pay for improved electricity services

We will now ask some questions regarding your household's willingness to avoid power outages. Your electricity service will be defined by the following characteristics and the levels each characteristic may take:

1. Frequency of outages: This refers to the average number of outages in a certain time period. You will be presented with four frequencies: once a month, twice a month, 4 times a month, and 8 times a month.

2. Duration of outages: This shows how long on average an outage lasts. You will be presented with two durations: less than 6 hours, and 6-13 hours.

3. Time of outages: This is the time of occurrence of the outage. You will be presented with two times: daytime, and night-time. Daytime refers to the time of day where there is enough daylight and one does not need to turn the lights on.

4. Prior notification of outages: Outages will happen either with prior notification or without prior notification. With prior notification you will be notified of an outage at least one day prior to its occurrence.

5. Percentage change in monthly electricity bill: This is the percentage change from your current average monthly electricity bill you will need to pay for the chosen alternative. You will be presented with four levels: 10%, 20%, 30%, and 40%.

In order to provide improved electricity services, the Government has to make major capital investments and cover maintenance costs of the new project. The level of investment and maintenance costs required to provide a service depends on the levels chosen for each of the attributes defined above. The Government will pay for this investment and maintenance costs by collecting money from the electricity users. For example, reducing the number of outages requires higher investment and maintenance costs and as a result the tariff charged to the users will also be higher.

We will show you 8 choice-sets one by one. In each choice set you will be presented with two electricity service alternatives. For each alternative we will state the frequency, duration, time, the prior notification status of power outages, and the percentage change in monthly electricity bill. These characteristics are identical throughout the choice sets however their levels will change. The time of the year may impact on your experience of the power outages. We will therefore show 4 choice-sets for power outages during winter and 4 choice-sets for summer months.

An example of a choice set is shown below. For each set we want you to state which alternative you think is best for you and your household. Note that your choice will not affect anything other than the frequency of power outages, the duration of outages, the time of outages, prior notification of outages and your monthly electricity bill, everything else remains as it is today.

ASSUMING THAT THE FOLLOWING TWO SERVICES AND YOUR CURRENT SERVICE WERE THE ONLY CHOICES YOU HAVE, WHICH ONE WOULD YOU PREFER TO BUY?

Power outages during winter (December – February)

	Service A	*Service B*	*Current Service*
Frequency of outages	Once a month	Two times a month	Neither Service A nor Service B: I prefer to stay with my current service
Duration of outages	6-13 hours	Less than 6 hours	
Time of outages	night-time	daytime	
Prior notification of outages	No prior notification	Prior notification	
Percentage change in monthly electricity bill of:	20%	30%	
Your choice	**[ ]**	**[X]**	**[ ]**

In winter, I think Service B is better for me than Service A. Service B has two short interruptions that occur during daytime, where Service A has one longer interruption but it occurs during nighttime. Service A gives me no prior notification where Service B gives me some prior notification. Both services are better than my current service. My choice means that my monthly electricity bill will increase 30%, which is 10 percentage points higher than alternative

We will ask you to state your choice in all questions that follow.

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.

1. Do you have any questions so far?

1. Yes [ ] →Repeat scenario 2. No [ ] →Continue

Go to the choice sets and show the respondent 8 choice sets according to the version assigned for him/her. Make sure that the consumer understands that each card represents a new decision, independent of the other. After the 8 choice sets are over, proceed with the rest of the survey.

Section 5: Household characteristics

1. Gender of the respondent [ ] 1. Male [ ] 2. Female	2. How old are you? Year of birth: ________ Month: ________

3. Do you work?

[ ] 1. Yes →go to question 4 [ ] 2. No →go to question 6

4. What is the legal status of your work?

[ ] 1. Public [ ] 2. Private

5. What is your status at work?

[ ]1. Employee (Salary, wages)	[ ]3. Self-employed
[ ]2. Employer	[ ]4. Unpaid family worker

→Go to question 7

6. What is the reason for not working?

[ ]1. Retired	[ ]3. Household duties	[ ]5. Found a job, waiting to start
[ ]2. Student	[ ]4. Looking for a job, couldn't find one	[ ]6. Other (please specify)

7. Specify which of the following represent the total monthly income of all the members of your family (TL) (including yourself)

[ ] 1.	Less than 950	[ ] 6.	2,001-2,250	[ ] 11.	3,251-3,500
[ ] 2.	950-1,250	[ ] 7.	2,251-2,500	[ ] 12.	3,501-4,000
[ ] 3.	1,251-1,500	[ ] 8.	2,501-2,750	[ ] 13.	4,001-4,500
[ ] 4.	1,501-1,750	[ ] 9.	2,751-3,000	[ ] 14.	4,501-5,000
[ ] 5.	1,751-2,000	[ ] 10.	3,001-3,250	[ ] 15.	More than 5,000

8. Marital Status

[ ] 1. Single (never married) [ ] 3. Divorced/Separated

[ ] 2. Married [ ] 4. Widowed

9. Number of people living in the house, and its distribution with respect to age category and gender

Age category	1. Total	2. Number of Females	3. Number of Males	Age category	1. Total	2. Number of Females	3. Number o
1. [ ] 0-4				4. [ ] 20-24			
2. [ ] 5-14				5. [ ] 25-64			
3. [ ] 15-19				6. [ ] 65 and above			

10. Which of the following best describes the highest level of formal education you have attained/completed?

[ ] 1. No formal education
[ ] 2. Primary school
[ ] 3. Secondary school
[ ] 4. College/high school
[ ] 5. Technical school
[ ] 6. University (2 year)
[ ] 7. University (4 year bachelor)
[ ] 8. Post graduate

If "no formal education" continue to question 11, otherwise go to question 12.

11. Do you know how to read and write?

[ ] 1. Yes [ ] 2. No

12. Your Place of Birth?

[ ] 1. TRNC
[ ] 2. South Cyprus
[ ] 3. Turkey
[ ] 4. Other country (please specify) _______

13. Your Citizenship ?

[ ] 1.TRNC
[ ] 2. TRNC and other country ________
[ ] 3. TR
[ ] 4. Other country ________

14. Where do you reside?

1. TRNC →	2. Abroad (please specify) ________
[ ] 1. Lefkoşa [ ] 2. Gazimağusa [ ] 3. Girne [ ] 4. Güzelyurt [ ] 5. İskele	

15. Finally: overall, what did you think of this questionnaire?

Interesting	[ ] 1
Too long	[ ] 2
Difficult to understand	[ ] 3

Educational	[ ] 4
Unrealistic/not redible	[ ] 5
Other (specify)	[ ] 6

THANK YOU FOR PARTICIPATING IN THIS SURVEY

Appendix 4.2 Revised Questionnaire

FIELD SURVEY FOR

ELECTRICITY SUPPLY IMPROVEMENTS IN KYRENIA MUNICIPALITY

With Birmingham University in UK, we are conducting a survey to determine your perception of the current reliability of electricity supply that your household is receiving from your electricity authority. We will also ask you questions regarding types of activities your household uses to avoid, if any, problems related with the existing electricity service. The results can be used by the Government in their evaluations of alternative electricity improvement projects, as well as in setting the appropriate tariff once the best alternatives are chosen. Your answers to this questionnaire will be completely confidential. There are no right and wrong answers. We are interested in your opinions.

When the term POWER FAILURE (or OUTAGE/INTERRUPTION/BLACKOUT) is used in this survey booklet, it means a complete interruption of electricity for a period lasting a few seconds, minutes, hours, or even days.

In your answers, please consider the needs of all members of your household.

Section 1: Current electricity service

Section 1A: Attitudes to the electricity system

For electricity system overall

What is your opinion on the following matters? Check the answer which best describes your opinion for each of the following.

1. In general, the power supply provided by my electric power company is

1	2	3	4	5
very good	good	fair	poor	very poor

2. I think that in general the number of failures of the electrical power to my home is

1	2	3	4	5
very low	low	moderate	high	very high

3. Our power supply has improved in the last year

1	2	3	4	5
strongly agree	agree	neither agree nor disagree (Neutral)	disagree	strongly disagree

4. I think that the price of our electricity is

1	2	3	4	5
very low	low	moderate	high	very high

5. My confidence in our electricity authority is

1	2	3	4	5
very high	high	moderate	low	very low

Load shedding

6. If during peak periods, the utility company 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?

1	2	3
Yes	No	Maybe

User pays and tariff variations

7. People who use electricity at peak times should pay more

1	2	3	4	5
strongly agree	agree	neither agree nor disagree (Neutral)	disagree	strongly disagree

8. Our power supply will improve within the next 12 months.

1	2	3	4	5
strongly agree	agree	neither agree nor disagree (Neutral)	disagree	strongly disagree

Section 1B: Reliability of Supply – Duration and Frequency of Interruptions as Perceived by Respondents

Power interruptions (past twelve months June 2007-May 2008):	
9. How often did you have power interruptions or blackouts (day/week/month/year) during the past twelve months (June 2007-May 2008)?	______ per(day/week/month/year)
10. What percentage of these outages that you had during the past twelve months (June 2007-May 2008)was announced?	________%
11. What percentage of these outages that you had during the past twelve months (June 2007-May 2008)happened at night-time?	________%
12. What percentage of these outages that you had during the past twelve months (June 2007-May 2008)happened during the past summer (June 2007- August 2007)	________%
13. What percentage of these outages that you had during the past twelve months (June 2007-May 2008)happened during the past winter (December 2007- February 2008)	________%

14. What was the average duration of **unplanned** power interruptions or blackouts during last summer (June-August 2007)?	_____ hours
15. What was the average duration of **unplanned** power interruptions or blackouts during last winter (December 2007-February 2008)?	_______ hours
16. What was the average duration of **unplanned** power interruptions or blackouts during last fall (September-November, 2007) and spring (March-May, 2008)?	_______ hours
17. How long was the longest unplanned power interruption or blackout that you had during the past twelve months (June 2007-May 2008)?	_______ hours
18. When an interruption is planned, how many days in advance are you notified?	_______ days in advance

19. When an interruption is planned, by which of the following do you prefer to be notified?

1	2	3	4	5	6
Letter	Fax	Media (TV, Radio, Newspaper etc)	Email	SMS text message	Telephone

Section 1C: Household's electricity usage

20. Dwelling type (Type of housing)

1	2	3	4	5	6
Detached house	Semi-detached house	Row house	Subsidiary house	Multi-storey apartment or flat	Other (Specify)

21. This house is

1	2	3
Your own	Rented	Other (Specify)

22. House floorsize	23. Number of rooms in the house	24. Number of bedrooms in the house	25. Number of air conditioners in the house	26. Number of water pumps in the house
meter-square				

27. How is payment made for your electrical usage?

Payment Type	

Kıb-Tek's cashier's office	1
Automatic payment from the bank	2
Mobile cashier's office	3
Included in rent	4
Other (Specify)	5
Do not know	6

28. How much does your household currently pay every month for electricity received from the electricity authority?..
29. How much is your average monthly electricity consumption in kWh?.......................................

30. Which of the following fuel types your household uses for heating your house? Please choose one or more of the following fuel types.	31. Percentage of house-heating obtained from this fuel	32. Which of the following fuel types your household uses for cooking? Please choose one or more of the following fuel types.	33. Percentage of cooking in your house from this fuel	34. Which of the following water heating systems your household uses? Please choose one or more of the following systems.	35. Percentage of water-heating obtained from this system
Fuel Type	**% Use**	**Fuel Type**	**% Use**	**Fuel Type**	**% Use**
[] 1. Electricity	[]1. %	[] 1. Electricity	[]1. %	[] 1. Electricity	[]1. %
[] 2. Fuel-oil	[]2. %			[] 2. Solar energy	[]2. %
[] 3. LPG	[]3. %	[] 2. LPG	[]2. %	[] 3. LPG	[]3. %
[] 4. Wood	[]4. %	[] 3. Wood	[]3. %	[] 4. Wood	[]4. %
[] 5. Other (Specify) _________	[]5. %	[] 4. Other (Specify) _________	[]4. %	[] 5. Other (Specify) _________	[]5. %

36. Is someone at home most of the time?

Yes	1
No	2

37. Does someone in your household work from home?

Never	1	Go to question 39
Rarely	2	Continue from question 38
Sometimes	3	Continue from question 38
Very often	4	Continue from question 38
Always	5	Continue from question 38

38. Does their work depend on the availability of electricity?

1	2	3
not dependent	partially dependent	very much dependent

39. Does your household have sickbed resident?

1	2
Yes	No

40. Does your household use electrical medical equipment at home?

1	2
Yes	No

Preferred interruption time for *unplanned and planned* outages

The undesirable effects of power failures may depend on the season, the day of the week and the time of day when the failure occurs, as well as whether they are planned or unplanned. This question asks you to state when an outage would be most disruptive for your household.

UNPLANNED OUTAGES

41. When is an unplanned outage of uncertain duration most disruptive for your household? Summer or Winter?

1	2	3	4
Summer	Winter	Both equally disruptive	None

42. When is an unplanned outage of uncertain duration most disruptive for your household? Weekday or Weekend?

1	2	3	4
Weekday	Weekend	Both equally disruptive	None

43. When is an unplanned outage of uncertain most disruptive for your household?

1	2	3	4	5	6
6:01am to 9:00am	9:01am to 6:00pm	6:01pm to 12:00 midnight	12:01midnight to 6:00am	All equally disruptive	None

PLANNED OUTAGES

44. When is a planned outage of certain duration most disruptive for your household? Summer or Winter?

1	2	3	4

Summer	Winter	Both equally disruptive	None

45. When is a planned outage of certain duration most disruptive for your household? Weekday or Weekend?

1	2	3	4
Weekday	Weekend	Both equally disruptive	None

46. When is a planned outage of certain duration most disruptive for your household?

1	2	3	4	5	6
6:01am to 9:00am	9:01am to 6:00pm	6:01pm to 12:00 midnight	12:01midnight to 6:00am	All equally disruptive	None

Frequency versus duration of *unplanned* interruptions

47. Frequent short interruptions (30 minutes or less) are worse than one long interruption (more than 30 minutes). e.g. four 30 minute interruptions in a day are worse than one 2 hour interruption.

1	2	3	4	5
strongly agree	agree	neither agree nor disagree (Neutral)	disagree	strongly disagree

Section 2: Preparatory actions

48. Which of the following actions your household takes in preparations for the failures? Please choose one or more of the following actions.

		Number owned	Average number used during an outage	Average number of hours used per unit in a year
Candle	1			
Kerosene lamp	2			
Gas lamp	3			
Electric lantern (battery powered)	4			
Emergency kerosene stove	5			
Emergency gas stove	6			
Emergency kerosene heater	7			

Emergency gas heater	8			
Voltage regulator	9			
Surge protector	10			
Generator	11	Details in Question 49		
Standby Uninterrupted Power Supply (UPS system)	12	Details in Question 51		
Car battery connected to an inverter	13			
Deep-cycle (lead-acid) battery(ies) connected to an inverter	14	Details in Question 51		
Other (Specify)	15			
No preparation	16			

If you do not own/share generator(s) please ***continue to question 50***.

49. Particulars of generator(s)

Parameters		Generator 1	Generator 2
Make	**1**		
Capacity	**2**		
Type of fuel	**3**		
Average number of hours run in a month	**4**		
Monthly fuel consumed (litres)	**5**		
Monthly expenditure on fuel (YTL)	**6**		
Capital & installation cost (YTL)	**7**		
Number of times maintained in a year	**8**		
Cost of each maintenance (YTL)	**9**		
If jointly owned, how much was your initial contribution? (YTL)	**10**		

50. What are the reasons for not going for generator(s)? Please elaborate.……………………………………………………………………………………………
……
………………………………………………………………..

If you do not own/share inverter(s) please ***continue to question 52***.

51. Particulars of Inverters/UPSs

Parameters		Inverter 1	Inverter 2
Make	**1**		
Capacity	**2**		
Number of continuous hours the inverter can be used with one recharge	**3**		
Capital & installation cost (YTL)	**4**		
Cost of batteries (YTL)	**5**		
Number of times maintained in a year	**6**		
Cost of each maintenance (YTL)	**7**		
Number of bulbs connected	**8**		
Number of fans connected	**9**		
Maximum connected load	**10**		

52. What are the reasons for not going for inverter(s)? Please elaborate………………………………………………………………………………………..
………
………………………………………………………………..

Section 3: 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.

53. Would you choose the inverter system if its total monthly costs (monthly rental and running costs) were...

		Total monthly cost		
	1.	Would not go for the inverter system	[ ]	Continue from Question 54
put a tick next to the highest amount you are sure	2.	10 YTL per month	[ ]	
	3.	20 YTL per month	[ ]	

that you would pay and a cross next to the first amount that you are sure that you would not pay	4.	30 YTL per month	[ ]	**GO TO SECTION 4**
	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	[ ]	

54. What are the reasons for not going for this inverter system

Section 4: Willingness to pay for improved electricity services

We will now ask some questions regarding your household's willingness to pay to avoid power outages. Your electricity service will be defined by the following characteristics and the levels each characteristic may take:

1. Frequency of outages: This refers to the average number of outages in a certain time period. You will be presented with four frequencies: once a year, once in 3 months, once a month, and twice a month.

2. Duration of outages: This shows how long on average an outage lasts. You will be presented with two durations: less than 2 hours, and 2-8 hours.

3. Time of outages: This is the time of occurrence of the outage. You will be presented with two times: daytime, and night-time. Daytime refers to the time of day where there is enough daylight and one does not need to turn the lights on to read.

4. Prior notification of outages: Outages will happen either with prior notification or without prior notification. With prior notification you will be notified of an outage at least one day prior to its occurrence.

5. Percentage change in monthly electricity bill: This is the percentage change from your current average monthly electricity bill you will need to pay for the chosen alternative. You will be presented with four levels: +5%, +10%, +20%, and +30%.

In order to provide improved electricity services, the Government has to make major capital investments and cover maintenance costs of the new project. The level of investment and maintenance costs required to provide a service depends on the levels chosen for each of the attributes defined above. The Government will pay for this investment and maintenance costs by collecting money from the electricity users. For example, reducing the number of outages requires higher investment and maintenance costs and as a result the tariff charged to the users will also be higher.

We will show you 8 choice-sets one by one. In each choice set you will be presented with two electricity service alternatives. For each alternative we will state the frequency, duration, time, the prior notification status of power outages, and the percentage change in monthly electricity bill. These characteristics are identical throughout the choice sets however their levels will change. The time of the year may impact on your experience of the power outages. We will therefore show 4 choice-sets for power outages during winter and 4 choice-sets for summer months.

An example of a choice set is shown below. For each set we want you to state which alternative you think is best for you and your household. Note that your choice will not affect anything other than the frequency of power outages, the duration of outages, the time of outages, prior notification of outages and your monthly electricity bill, everything else remains as it is today.

ASSUMING THAT THE FOLLOWING TWO SERVICES AND YOUR CURRENT SERVICE WERE THE ONLY CHOICES YOU HAVE, WHICH ONE WOULD YOU PREFER TO BUY?

Power outages during winter (December – February)

	Service A	*Service B*	*Current Service*
Frequency of outages	Once a month	Two times a month	Neither Service A nor Service B: I prefer to stay with my current service
Duration of outages	2-8 hours	Less than 2 hours	
Time of outages	Night-time	Daytime	
Prior notification of outages	No prior notification	Prior notification	
Percentage change in monthly electricity bill of:	20% more	30% more	
Your choice	**[ ]**	**[X]**	**[ ]**

I think Service B is better for me than Service A. Service B has two short interruptions that occur during daytime, where Service A has one longer interruption but it occurs during nighttime. Service A gives me no prior notification where Service B gives me some prior notification. Both services are better than my current service. My choice means that my monthly electricity bill will increase 30%, which is 10 percentage points higher than alternative A. In return for the increase in my electricity bill I will be saving some of the costs caused by my current service.

Go to the choice sets and show the respondent 8 choice sets according to the version assigned for him/her. Make sure that the consumer understands that each card represents a new decision, independent of the other. After the 8 choice sets are over, if in all choice sets "the current service" is chosen then ask question 56, and proceed with the rest of the survey.

55. Please state your preferred choice for each occasion. 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.

	A	**B**	**Current**	
1. SET	**[ ]**	**[ ]**	**[ ]**	VERSION…………
2. SET	**[ ]**	**[ ]**	**[ ]**	
3. SET	**[ ]**	**[ ]**	**[ ]**	
4. SET	**[ ]**	**[ ]**	**[ ]**	
5. SET	**[ ]**	**[ ]**	**[ ]**	
6. SET	**[ ]**	**[ ]**	**[ ]**	
7. SET	**[ ]**	**[ ]**	**[ ]**	
8. SET	**[ ]**	**[ ]**	**[ ]**	

56. What are the reasons for preferring to stay with your current service? Please specify.

Section 5: Household characteristics

57. Gender of the respondent	Male	1	Female	2

58. Year of birth		59. Month of birth	

60. Do you work?

Yes	1	Go to Question 61
No	2	Continue from Question 63

61. What is the legal status of your work?	Public	1	Private	2

62. What is your status at work?

1	2	3	4
Employee (Salary, wages)	Employer	Self-employed	Unpaid family worker

→**continue from Question 64**

63. What is the reason for not working?

1	2	3	4	5	6
Retired	Student	Household duties	Looking for a job, couldn't find one	Found a job, waiting to start	Other (please specify)

64. Marital Status

1	2	3	4
Single (never married)	Married	Divorced/Separated	Widowed

65. Number of people living in the house, and its distribution with respect to age category and gender

Age category	1. Total	2. Number of Females	3. Number of Males	Age category	1. Total	2. Number of Females	3. Number of Males
0-4				25-34			
5-14				35-49			
15-19				50-64			
20-24				65 and above			

66. Which of the following best describes the highest level of formal education you have attained/completed?

1	2	3	4	5	6	6	7	8

Does not know how to read and write	knows how to read and write	Primary school	Secondary school	College/ high school	Technical school	University (2 year)	University (4 year bachelor)	Post graduate

67. Place of Birth of the respondent	
68. Citizenship of the respondent	

69. Specify which of the following represent the total monthly after-tax income of your household (YTL) including labour income, government transfers and interest on investments etc.?

Less than 1,060 YTL	1	3,001-3500 YTL	6	5,501-6,000 YTL	11
1,061-1,500 YTL	2	3,501-4,000 YTL	7	6,001-6,500 YTL	12
1,501-2,000 YTL	3	4,001-4,500 YTL	8	More than 6501YTL	
2,001-2,500 YTL	4	4,501-5,000 YTL	9		
2,501-3,000 YTL	5	5,001-5,500 YTL	10		

THANK YOU FOR PARTICIPATING IN THIS SURVEY

Section 6: post interview (for interviewer only)

---

70. Please rate the quality of the interview based on the concentration of the person to be interviewed, attentiveness to the questions, and number of questions answered:

1	2	3	4	5
very poor	poor	fair	good	very good

Name of interviewer..
Date...................................
Time started..
Duration of the interview...........................

Appendix 5.1 STATA 9.2 Algorithms – Averting Expenditures

Tobit Regression

```
tobit totalxp totfreq percplan percnite percwint lntotdur avgmaxdur dethouse florsize prcnoeht athome
sickbed age  married haschild4 has65novr univ income lefkosa magusa girne iskele, ll
```

Bootstrapped confidence intervals

```
set seed 1
bs " tobit totalxp totfreq percplan percnite percwint lntotdur avgmaxdur dethouse florsize prcnoeht athome
sickbed age  married haschild4 has65novr univ income lefkosa magusa girne iskele, ll " "((
37.3997023809524*_b[age] + 0.116071428571429*_b[haschild4]+ 2209.58175595238*_b[income] +
0.235119047619048*_b[magusa]+ 0.0803571428571429*_b[iskele]))", reps(1000)
```

Appendix 5.2 Correlation Matrix for Variables used in Tobit Regression

	Tot freq	Perc plan	Perc nite	Perc wint	Lntot dur	Avg maxdur	Det house	Flor size	Prc noeht	At home	Sick bed
totfreq	1										
percplan	0.05	1									
percnite	0.06	0.01	1								
percwint	0.16	-0.04	0.27	1							
lntotdur	0.65	0.03	0.25	0.27	1						
avgmaxdur	-0.01	0.01	0.20	0.10	0.18	1					
dethouse	0.13	-0.06	0.05	-0.03	0.12	0.14	1				
florsize	0.00	-0.10	0.08	0.08	-0.04	0.01	0.11	1			
prcnoeht	0.10	0.04	0.05	-0.06	-0.02	0.00	0.31	0.08	1		
athome	0.11	-0.10	0.17	-0.03	0.07	0.06	0.04	-0.07	0.05	1	
sickbed	-0.04	0.04	0.00	-0.03	-0.06	-0.05	0.06	-0.02	0.07	0.12	1
age	0.10	-0.01	-0.01	-0.03	-0.04	0.00	0.20	0.05	0.39	0.16	0.06
married	0.07	-0.02	0.01	-0.07	-0.04	0.04	0.19	0.08	0.30	0.12	0.01
haschild4	-0.04	-0.02	-0.02	-0.07	-0.02	-0.01	0.00	0.13	0.08	0.01	-0.04
has65novr	0.21	0.03	0.04	0.08	0.05	-0.06	0.12	-0.02	0.25	0.09	0.26
univ	0.04	-0.06	0.04	0.01	0.05	-0.08	-0.06	0.07	-0.07	0.07	0.02
income	-0.04	0.00	0.07	-0.04	-0.08	-0.13	-0.09	0.17	0.09	-0.07	-0.02
lefkosa	-0.12	0.16	0.09	0.05	0.00	-0.01	-0.24	0.01	-0.17	0.02	-0.03
magosa	-0.05	-0.10	-0.12	-0.10	0.00	0.18	0.06	-0.09	-0.05	0.08	0.05
girne	-0.07	-0.14	0.16	0.02	-0.11	-0.15	-0.04	-0.01	0.11	-0.01	0.05
iskele	0.37	0.16	-0.09	0.10	0.20	-0.01	0.21	0.01	0.15	-0.09	-0.04
	age	married	Has child4	Has 65novr	univ	income	lefkosa	magosa	girne	iskele	
age	1										
married	0.64	1									
haschild4	0.01	0.24	1								
has65novr	0.44	0.11	-0.10	1							
univ	-0.10	-0.11	0.00	-0.02	1						
income	0.06	0.16	0.05	-0.06	0.19	1					
lefkosa	-0.20	-0.18	-0.07	-0.11	0.04	0.05	1				
magosa	0.08	0.18	0.02	-0.07	-0.04	-0.25	-0.38	1			
girne	-0.02	-0.06	-0.11	-0.01	0.03	0.20	-0.37	-0.30	1		
iskele	0.02	-0.02	0.00	0.18	-0.09	-0.16	-0.20	-0.16	-0.16	1.00	

Appendix 6.1 Explanatory Variables Used in Model Estimation

N = 315					
Variable	**Description**	**Mean**	**Std. Dev.**	**Min**	**Max**
generator	1: has generator 0: no	0.10	0.30	0	1
avert	1: at least one preparatory action 0: otherwise	0.92	0.27	0	1
totfreq	Total perceived number of outages during past 12 months (June 2007-May 2008)	84.58	156.61	0	1095
percplan	Percentage of perceived total number of outages during past 12 months (June 2007-May 2008) that are planned	0.14	0.21	0	1
percunpl	Percentage of perceived total number of outages during past 12 months (June 2007-May 2008) that are unplanned	0.86	0.21	0	1
plndfreq	Total perceived number of planned outages during past 12 months (June 2007-May 2008)	13.20	37.92	0	255.5
unplfreq	Total perceived number of unplanned outages during past 12 months (June 2007-May 2008)	71.37	129.34	0	876
percnite	Percentage of perceived total number of outages during past 12 months (June 2007-May 2008) that are at night	0.35	0.24	0	1
nightfreq	Total perceived number of night outages during past 12 months (June 2007-May 2008)	31.48	72.75	0	766.5
percsumm	Percentage of perceived total number of outages during past 12 months (June 2007-May 2008) that are in summer	0.39	0.19	0	0.9
percwint	Percentage of perceived total number of outages during past 12 months (June 2007-May 2008) that are in winter	0.50	0.20	0	1
summfreq	Total perceived number of outages during the past	31.93	57.49	0	438

	summer (June 2007- August 2007)				
wintfreq	Total perceived number of outages during the past winter (December 2007- February 2008)	47.32	102.43	0	985.5
avgsumdur	Average perceived duration of perceived summer outages (hours)	3.83	4.34	0	50
totsumdur	Total perceived outage duration for the past summer (hours)	102.24	186.78	0	1512
lnsumdur	Log of total perceived outage duration for the past summer (hours)	3.68	1.44	0	7.32
avgwintdur	Average perceived duration of perceived winter outages (hours)	3.99	3.37	0	27.5
totwinterdur	Total perceived outage duration for the past summer (hours)	164.65	321.76	0	2075.94
lnwintdur	Log of total perceived outage duration for the past winter (hours)	4.03	1.54	0	7.64
avgdur		3.65	2.81	0	23.33
totdur	Total perceived outage duration for the past year (hours)	287.53	479.06	0	3139
lntotdur	Log of total perceived outage duration for the past year (hours)	4.80	1.34	0	8.05
avgmaxdur	Longest perceived outage duration during the past year (hours)	5.95	3.63	0	40
avgnotifn	Advance notification (as perceived by respondents) (days)	0.77	0.83	0	9
dethouse	1: detached house 0: otherwise	0.57	0.50	0	1
owndweln	1: owns their dwelling 0: otherwise	0.67	0.47	0	1
florsize	Dwelling floor-size (meter-square)	126.16	36.49	50	400
rooms	Number of rooms	4.70	1.57	2	11
bedrms	Number of bedrooms	2.60	0.73	1	5

aircons	Number of air-conditioners in the dwelling	1.32	1.24	0	5
wtrpmps	Number of water pumps in the dwelling	0.71	0.51	0	2
hasaircon	1: Has air-conditioner 0: does not have	0.69	0.46	0	1
haswtrpmp	1: has water-pump 0: does not have	0.69	0.46	0	1
nocashier	1: does not pay at Kıb-Tek's cashier's office 0: otherwise	0.23	0.42	0	1
avgbill	Average monthly electricity bill (YTL)	215.20	343.27	10	4000
lnavgbill	Log of average monthly electricity bill	5.03	0.72	2.30	8.29
noneheat	1: has non-electric space heating 0: does not have	0.63	0.48	0	1
prcnoeht	Percentage of space heating not obtained from electricity	0.48	0.43	0	1
nonecook	1: has non-electric cooking 0: does not have	0.95	0.22	0	1
prcnoeck	Percentage of cooking not obtained from electricity	0.87	0.25	0	1
nonewatr	1: has non-electric water heating 0: does not have	0.86	0.34	0	1
prcnoewt	Percentage of water heating not obtained from electricity	0.55	0.31	0	1
athome	1: someone at home most of the time 0: no	0.52	0.50	0	1
wkhome	1: work from home 0: no	0.04	0.19	0	1
wkhmone	1: work at home depend on availability of electricity 0: no	0.14	0.35	0	1
sickbed	1: has sickbed resident 0: no	0.02	0.13	0	1
medequip	1: use electrical medical equipment at home 2: no	0.02	0.14	0	1
freqovrdur	1: frequent and short outages are worse than one long outage	0.80	0.40	0	1

	0: otherwise				
minwtp	lower bound of the interval marked by the respondent on the payment ladder	23.62	45.67	0	450
maxwtp	upper bound of the interval marked by the respondent on the payment ladder	64.48	121.48	0	550
midwtp	Midpoint of minwtp and maxwtp	44.05	76.40	0	500
lb	lower bound of the interval marked by the respondent on the payment ladder after entering zero bids as "."	37.20	52.75	10	450
ub	upper bound of the interval marked by the respondent on the payment ladder	64.48	121.48	0	550
Llb1	Log of (lb+1)	3.25	0.80	2.40	6.11
lnminwtp	Log of the lower bound of the interval marked by the respondent on the payment ladder	2.06	1.69	0	6.11
lnmaxwtp	Log of the upper bound of the interval marked by the respondent on the payment ladder	2.56	2.11	0	6.31
lnmidwtp		2.39	1.96	0	6.22
gender	1: male 0: female	0.64	0.48	0	1
age	Age of the respondent (years)	36.97	14.75	18	79.33
employed	1: respondent works 0: does not work	0.53	0.50	0	1
public	1: respondent works for a public organization 0: otherwise	0.13	0.34	0	1
married	1: respondent is married 0: otherwise	0.53	0.50	0	1
hhsize	Household size	3.23	1.39	1	10
haschild4	1: has a household member less than 4 years old 0: otherwise	0.11	0.31	0	1
has65novr	1: Household has someone of age 65 and over 0:otherwise	0.07	0.26	0	1
noadult	Number of household members who are older than	2.56	1.13	0	5

	19 years old				
nochild	Number of household members who are 19 years of age or younger	0.67	0.98	0	5
univ	1: respondent has university education 0: otherwise	0.15	0.36	0	1
cyborn		0.63	0.48	0	1
nocyborn	1: respondent is not born in Cyprus 0: otherwise	0.37	0.48	0	1
income	Total monthly income of the household (YTL)	2208.79	1256.88	530	6501
	Log of total monthly income				
lefkosa	1: resident of Lefkoşa 0: otherwise	0.34	0.47	0	1
magusa	1: resident of Gazimağusa 0: otherwise	0.23	0.42	0	1
girne	1: resident of Girne 0: otherwise	0.22	0.41	0	1
gyurt	1: resident of Güzelyurt 0: otherwise	0.14	0.35	0	1
iskele	1: resident of İskele 0: otherwise	0.08	0.27	0	1
poswtp	1: WTP >0 0: otherwise	0.63	0.48	0	1
abnogen		0.88	0.32	0	1

Appendix 6.2 STATA 9.2 Algorithms

Probit Regression:

probit poswtp totfreq percunpl percnite percwint lntotdur avgnotifn dethouse florsize generator avert hasaircon prcnoeht wkhmone noadult nochild univ income nocyborn lefkosa magusa girne iskele

set seed 1

bs " probit poswtp generator avert totfreq percunpl percnite percwint lntotdur avgnotifn dethouse florsize prcnoeht wkhmone noadult nochild income lefkosa magusa girne iskele hasaircon univ nocyborn**" "**(norm(0.920634921*_b[avert]+0.3460428 *_b[percnite]+ 0.5008192*_b[percwint]+ 126.1606*_b[florsize]+ 0.3396825 *_b[lefkosa]+ 0.0793651 *_b[iskele]+_b[_cons]))**", reps(1000)**

Appendix 6.3 Correlation Matrix of Explanatory Variables Used in Spike Regression

	llb1	lnmaxwtp	avert	percnite	percwint	lntotdur	dethouse	florsize	haswtrpmp	nonecook
llb1	1									
lnmaxwtp	0.67	1.00								
avert	0.07	0.10	1.00							
percnite	0.05	-0.06	-0.01	1.00						
percwint	-0.02	-0.07	0.07	0.35	1.00					
lntotdur	0.10	0.10	0.00	0.23	0.27	1.00				
dethouse	0.01	0.12	0.06	0.00	-0.09	0.11	1.00			
florsize	0.08	0.00	-0.08	0.06	0.06	0.01	0.18	1.00		
haswtrpmp	0.12	0.06	-0.03	0.10	-0.10	-0.06	-0.06	0.09	1.00	
nonecook	0.02	0.01	0.02	-0.09	0.01	-0.07	-0.01	0.03	0.05	1.00
generator	0.21	0.19	0.08	0.04	-0.04	0.01	0.08	0.16	0.10	0.10
sickbed	0.15	0.13	0.03	-0.01	-0.03	-0.08	0.07	-0.03	0.08	0.04
noadult	0.00	-0.07	-0.01	0.19	-0.11	-0.03	0.06	0.13	0.17	-0.06
income	0.09	0.09	0.15	0.02	-0.06	-0.13	0.01	0.13	0.18	0.17
lefkosa	-0.09	-0.17	0.02	0.13	0.09	-0.07	-0.24	-0.04	0.18	-0.24
girne	0.21	0.17	0.06	0.08	-0.02	-0.10	-0.08	0.00	0.03	0.06
iskele	0.00	0.09	-0.01	-0.14	0.10	0.20	0.27	0.06	-0.22	0.09
	generator	sickbed	noadult	income	lefkosa	girne	iskele			
generator	1.00									
sickbed	0.18	1.00								
noadult	0.01	0.02	1.00							
income	0.19	0.01	0.23	1.00						
lefkosa	-0.06	-0.06	0.14	-0.04	1.00					
girne	-0.07	0.10	-0.01	0.22	-0.47	1.00				
iskele	0.17	-0.04	-0.23	-0.15	-0.28	-0.16	1.00			

Appendix 6.4 Spike Model TSP Algorithms for Models 1-5

Model 1

```
? model1 constant spike, constant mean, constant std error
FREQ N;
SMPL 1 315;
LOAD(FILE=SpikeVar.txt)
hasgen avert totfreq percplan plndfreq percunpl unplfreq
percnite nitefreq percsumm percwint percrest
summfreq wintfreq sumdur totsdur lnsumdur wintdur
totwdur lnwdur totrdur avgdur     totdur lntotdur   maxdur
avgnotif dethouse florsize rooms bedrms aircons
wtrpmps hasairc haswtrp avgbill lnavgbil noneheat prcnoeht
nonecook prcnoeck nonewatr prcnoewt athome wkhome
wkhmone sickbed medequip minwtp maxwtp gender age employed
public   married  hhsize   haschld4 has65nov noadult
nochild univ cyborn nocyborn income
lefkosa  magusa girne gyurt iskele poswtp;

genr maxwtp=log(maxwtp);
genr minwtp=log(minwtp+0.0001);
param delta0 0.36 beta0 4 s 3;
const beta1 beta2 beta3 beta4 beta5 beta6 beta7 beta8 beta9 beta10 beta11 beta12
beta13 beta14 beta15 beta16 beta17;

frml eq1 logl=
 (1-poswtp)*log(e)+
 poswtp*log((1-e))+
 poswtp*log((cnorm((maxwtp-y)/s)-cnorm((minwtp-y)/s)))
 ;
frml eq2 y = beta0 + beta1*percnite
+ beta2*percwint + beta3*lntotdur + beta4*avgnotif
+ beta5*dethouse + beta6*florsize + beta7*avert + beta8*avgbill + beta9*nonecook
+ beta10*sickbed + beta11*nochild + beta12*noadult + beta13*income
+ beta14*lefkosa + beta15*magusa + beta16*girne + beta17*iskele
;

frml eq3 e = delta0
;
eqsub eq1 eq2 eq3;
ml(maxit=200) eq1;
smpl 1 315;
ml(maxit=200) eq1;
frml median1
((exp(beta0))*(1-delta0))
;
analyz median1;
frml wtp1
((exp(beta0))*(exp((s*s)/2))*(1-delta0))
;
analyz wtp1;
end;
```

Model 2

```
? model 2 constant spike, varying mean, const std error
FREQ N;
SMPL 1 315;
LOAD(FILE=SpikeVar.txt)
hasgen avert totfreq percplan plndfreq percunpl unplfreq
percnite nitefreq percsumm percwint percrest
summfreq wintfreq sumdur totsdur lnsumdur wintdur
totwdur lnwdur totrdur avgdur      totdur lntotdur    maxdur
avgnotif dethouse florsize rooms bedrms aircons
wtrpmps hasairc haswtrp avgbill lnavgbil noneheat prcnoeht
nonecook prcnoeck nonewatr prcnoewt athome wkhome
wkhmone sickbed medequip minwtp maxwtp gender   age employed
public   married  hhsize   haschld4 has65nov noadult
nochild univ cyborn nocyborn income
lefkosa   magusa girne gyurt iskele poswtp;
genr maxwtp=log(maxwtp);
genr minwtp=log(minwtp+0.0001);
param delta0 0.36 beta0 4 s 3;
const beta1 beta2 beta3 beta4 beta5 beta6 beta7 beta8 beta9 beta10 beta11 beta12
beta13 beta14 beta15 beta16 beta17;
frml eq1 logl=
 (1-poswtp)*log(e)+
 poswtp*log((1-e))+
 poswtp*log((cnorm((maxwtp-y)/s)-cnorm((minwtp-y)/s)))
 ;
frml eq2 y = beta0 + beta1*percnite
+ beta2*percwint + beta3*lntotdur + beta4*avgnotif
+ beta5*dethouse + beta6*florsize + beta7*avert + beta8*avgbill + beta9*nonecook
+ beta10*sickbed + beta11*nochild + beta12*noadult + beta13*income
+ beta14*lefkosa + beta15*magusa + beta16*girne + beta17*iskele
;
frml eq3 e = delta0;
eqsub eq1 eq2 eq3;
ml(maxit=100) eq1;
param beta1 beta2 beta3 beta4 beta5 beta6 beta7 beta8 beta9 beta10 beta11
beta12 beta13 beta14 beta15 beta16 beta17   ;
ml(maxit=100) eq1;
smpl 1 315;
ml(maxit=100) eq1;
frml median2
((exp(beta0+0.7728836*beta4+215.1971*beta8
+0.2253968*beta15+0.215873*beta16))*(1-delta0));
analyz median2;
frml wtp2
((exp(beta0+0.7728836*beta4+215.1971*beta8
+0.2253968*beta15+0.215873*beta16))*(exp((s*s)/2))*(1-delta0));
analyz wtp2;
end;
```

Model 3

```
? model3 varying spike constant mean constant std error
FREQ N;
SMPL 1 315;
LOAD(FILE=SpikeVar.txt)
hasgen avert totfreq percplan plndfreq percunpl unplfreq
percnite nitefreq percsumm percwint percrest
summfreq wintfreq sumdur totsdur lnsumdur wintdur
totwdur lnwdur totrdur avgdur     totdur lntotdur   maxdur
avgnotif dethouse florsize rooms bedrms aircons
wtrpmps hasairc haswtrp avgbill lnavgbil noneheat prcnoeht
nonecook prcnoeck nonewatr prcnoewt athome wkhome
wkhmone sickbed medequip minwtp maxwtp gender  age employed
public   married  hhsize   haschld4 has65nov noadult
nochild univ cyborn nocyborn income
lefkosa  magusa girne gyurt iskele poswtp;
genr maxwtp=log(maxwtp);
genr minwtp=log(minwtp+0.0001);
param delta0 0.36 beta0 4 s 3;
const beta1 beta2 beta3 beta4 beta5 beta6 beta7 beta8 beta9 beta10 beta11 beta12
beta13 beta14 beta15 beta16 beta17
delta1 delta2 delta3 delta5 ;
frml eq1 logl=
 (1-poswtp)*log(e)+
 poswtp*log((1-e))+
 poswtp*log((cnorm((maxwtp-y)/s)-cnorm((minwtp-y)/s)))
 ;
frml eq2 y = beta0 + beta1*percnite
+ beta2*percwint + beta3*lntotdur + beta4*avgnotif
+ beta5*dethouse + beta6*florsize + beta7*avert + beta8*avgbill + beta9*nonecook
+ beta10*sickbed + beta11*nochild + beta12*noadult + beta13*income
+ beta14*lefkosa + beta15*magusa + beta16*girne + beta17*iskele
;
frml eq3 e = delta0 + delta1*lefkosa+ delta2*girne + delta3*iskele
+ delta5*percnite
;
eqsub eq1 eq2 eq3;
ml(maxit=200) eq1;
param delta1 delta2 delta3 delta5 ;
ml(maxit=200) eq1;
smpl 1 315;
ml(maxit=100) eq1;
frml median3
((exp(beta0))*(1-(delta0+delta1*0.3397+delta2*0.2159
+delta3*0.0794+delta5*0.3460428)));
analyz median3;
frml wtp3
((exp(beta0))*(exp((s*s)/2))*(1-(delta0+delta1*0.3397+delta2*0.2159
+delta3*0.0794+delta5*0.3460428)));
analyz wtp3;
end;
```

Model 4

```
? model 4 constant spike, constant mean, varying std error
FREQ N;
SMPL 1 315;
LOAD(FILE=SpikeVar.txt)
hasgen avert totfreq percplan plndfreq percunpl unplfreq
percnite nitefreq percsumm percwint percrest
summfreq wintfreq sumdur totsdur lnsumdur wintdur
totwdur lnwdur totrdur avgdur      totdur lntotdur   maxdur
avgnotif dethouse florsize rooms bedrms aircons
wtrpmps hasairc haswtrp avgbill lnavgbil noneheat prcnoeht
nonecook prcnoeck nonewatr prcnoewt athome wkhome
wkhmone sickbed medequip minwtp maxwtp gender   age employed
public   married  hhsize   haschld4 has65nov noadult
nochild univ cyborn nocyborn income
lefkosa   magusa girne gyurt iskele poswtp;
genr maxwtp=log(maxwtp);
genr minwtp=log(minwtp+0.0001);
param delta0 0.36 beta0 4 alpha0 3;
const beta1 beta2 beta3 beta4 beta5 beta6 beta7 beta8 beta9 beta10 beta11 beta12
beta13 beta14 beta15 beta16 beta17
alpha1 alpha3 alpha4 alpha5 alpha6 alpha9 alpha10;
frml eq1 logl= (1-poswtp)*log(e)+ poswtp*log((1-e))+
 poswtp*log((cnorm((maxwtp-y)/s)-cnorm((minwtp-y)/s))) ;
frml eq2 y = beta0 + beta1*percnite
+ beta2*percwint + beta3*lntotdur + beta4*avgnotif
+ beta5*dethouse + beta6*florsize + beta7*avert + beta8*avgbill + beta9*nonecook
+ beta10*sickbed + beta11*nochild + beta12*noadult + beta13*income
+ beta14*lefkosa + beta15*magusa + beta16*girne + beta17*iskele;
frml eq3 e = delta0;
frml eq4 s = alpha0 +alpha1*lefkosa
+ alpha3*married + alpha4*avgbill
+ alpha5*nonewatr + alpha6*has65nov
+alpha9*income +alpha10*iskele;
eqsub eq1 eq2 eq3 eq4;
ml(maxit=200) eq1;
param  alpha1 alpha3 alpha4 alpha5 alpha6 alpha9 alpha10;
ml(maxit=200) eq1;
smpl 1 315;
ml(maxit=100) eq1;
frml median4
((exp(beta0))*(1-delta0));
analyz median4;
frml wtp4
((exp(beta0))*(exp(((alpha0+alpha1*0.3396825+alpha5*0.8634921
+alpha9*2208.793+alpha10*0.0793651)*
(alpha0+alpha1*0.3396825+alpha5*0.8634921+alpha9*2208.793
+alpha10*0.0793651))/2))*(1-delta0));
analyz wtp4;
end;
```

Model 5

```
? model 5 varying spike, varying mean, const std error
FREQ N;
SMPL 1 315;
LOAD(FILE=SpikeVar.txt)
hasgen avert totfreq percplan plndfreq percunpl unplfreq
percnite nitefreq percsumm percwint percrest
summfreq wintfreq sumdur totsdur lnsumdur wintdur
totwdur lnwdur totrdur avgdur      totdur lntotdur    maxdur
avgnotif dethouse florsize rooms bedrms aircons
wtrpmps hasairc haswtrp avgbill lnavgbil noneheat prcnoeht
nonecook prcnoeck nonewatr prcnoewt athome wkhome
wkhmone sickbed medequip minwtp maxwtp gender   age employed
public    married   hhsize   haschld4 has65nov noadult
nochild univ cyborn nocyborn income
lefkosa   magusa girne gyurt iskele poswtp;
genr maxwtp=log(maxwtp);
genr minwtp=log(minwtp+0.0001);
param delta0 0.36 beta0 4 s 3;
const beta1 beta2 beta3 beta4 beta5 beta6 beta7 beta8 beta9 beta10 beta11 beta12
beta13 beta14 beta15 beta16 beta17 delta1 delta2 delta3 delta5 ;
frml eq1 logl=
 (1-poswtp)*log(e)+
 poswtp*log((1-e))+
 poswtp*log((cnorm((maxwtp-y)/s)-cnorm((minwtp-y)/s))) ;
frml eq2 y = beta0 + beta1*percnite
+ beta2*percwint + beta3*lntotdur + beta4*avgnotif
+ beta5*dethouse + beta6*florsize + beta7*avert + beta8*avgbill + beta9*nonecook
+ beta10*sickbed + beta11*nochild + beta12*noadult + beta13*income
+ beta14*lefkosa + beta15*magusa + beta16*girne + beta17*iskele;
frml eq3 e = delta0 + delta1*lefkosa + delta2*girne + delta3*iskele + delta5*percnite;
eqsub eq1 eq2 eq3;
ml(maxit=100) eq1;
param beta1 beta2 beta3 beta4 beta5 beta6 beta7 beta8 beta9 beta10 beta11
beta12 beta13 beta14 beta15 beta16 beta17 delta1 delta2 delta3 delta5 ;
ml(maxit=100) eq1;
smpl 1 315;
ml(maxit=100) eq1;
frml median5
((exp(beta0+0.7728836*beta4+215.1971*beta8
+0.2253968*beta15+0.215873*beta16))
*(1-(delta0+delta1*0.3397+delta2*0.2159
+delta3*0.0794+delta5*0.3460428)));
analyz median5;
frml wtp5
((exp(beta0+0.7728836*beta4+215.1971*beta8
+0.2253968*beta15+0.215873*beta16))*
(exp((s*s)/2))*(1-(delta0+delta1*0.3397+delta2*0.2159
+delta3*0.0794+delta5*0.3460428)));
analyz wtp5;
end;
```

Appendix 7.1 LIMDEP 9.0 NLOGIT 4.0 Algorithms: MNL Alternative Model Specifications

Constants Only Model

```
RESET;
READ;File=C:\CESummerData_08_12_12.xls
   ;Nvar=41;Nobs=4513;Format=xls ;Names $
REJECT; CHOICE<-10$
NLOGIT
   ;Lhs=Choice
   ;Choices= 1,2,3
   ;Model:
   U(1,2)=asc $
```

Model 1: U(1,2)=asc+Bfreq*freq+Bdur*dur+Btime*time+Bann*ann+Bchbill*chbilltl

```
RESET;
READ;File=C:\CESummerData_08_12_12.xls
   ;Nvar=41;Nobs=4513;Format=xls ;Names $
REJECT; CHOICE<-10$
NLOGIT
   ;Lhs=Choice
   ;Choices= 1,2,3
   ;Model:
   U(1,2)=asc+Bfreq*freq+Bdur*dur+Btime*time+Bann*ann+Bchbill*chbilltl/
   U(3)=Bfreq*freq+Bdur*dur+Btime*time+Bann*ann+Bchbill*chbilltl $
```

Model 2: U(1,2)=asc+Bfreq*freq+Bdur*dur+Btime*time+Bann*ann+Blbill*lbill

```
RESET;
READ;File=C:\CESummerData_08_12_12.xls
   ;Nvar=41;Nobs=4513;Format=xls ;Names $
REJECT; CHOICE<-10$
create; lbill=log(chbilltl+1)$
NLOGIT
   ;Lhs=Choice
   ;Choices= 1,2,3
   ;Model:
   U(1,2)=asc+Bfreq*freq+Bdur*dur+Btime*time+Bann*ann+Blbill*lbill/
   U(3)=Bfreq*freq+Bdur*dur+Btime*time+Bann*ann+Blbill*lbill $
```

Model 3: U(1,2)=asc+Blfreq*lfreq+Bdur*dur+Btime*time+Bann*ann+Blbill*lbill

```
RESET;
READ;File=C:\CESummerData_08_12_12.xls
    ;Nvar=41;Nobs=4513;Format=xls ;Names $
REJECT; CHOICE<-10$
create; lfreq=log(freq+1)$
create; lbill=log(chbilltl+1)$
NLOGIT
    ;Lhs=Choice
    ;Choices= 1,2,3
    ;Model:
    U(1,2)=asc+Blfreq*lfreq+Bdur*dur+Btime*time+Bann*ann+Blbill*lbill/
    U(3)=Blfreq*lfreq+Bdur*dur+Btime*time+Bann*ann+Blbill*lbill $
```

Model 4: U(1,2)=asc+Blfreq*lfreq+Bldur*ldur+Btime*time+Bann*ann+Blbill*lbill

```
RESET;
READ;File=C:\CESummerData_08_12_12.xls
    ;Nvar=41;Nobs=4513;Format=xls ;Names $
REJECT; CHOICE<-10$
 create; lfreq=log(freq+1)$
create; ldur=log(dur+1)$
 create; lbill=log(chbilltl+1)$
NLOGIT
    ;Lhs=Choice
    ;Choices= 1,2,3
    ;Model:
    U(1,2)=asc+Blfreq*lfreq+Bldur*ldur+Btime*time+Bann*ann+Blbill*lbill/
    U(3)=Blfreq*lfreq+Bldur*ldur+Btime*time+Bann*ann+Blbill*lbill $
```

Appendix 7.2 Hausman Test for IIA – Summer Data

```
RESET;
READ;File=C:\CESummerData_08_12_12.xls
   ;Nvar=41;Nobs=4513;Format=xls ;Names $
REJECT; CHOICE<-10$
create; lfreq=log(freq+1)$
create; lbill=log(chbilltl+1)$
NLOGIT
   ;;Lhs=Choice
   ;Choices= 1,2,3
   ;Model:
   U(1,2)=asc+Blfreq*lfreq+Bdur*dur+Btime*time+Bann*ann+Blbill*lbill/
   U(3)=Blfreq*lfreq+Bdur*dur+Btime*time+Bann*ann+Blbill*lbill $
NLOGIT
                  ;Ias=1
                  ;Lhs=Choice
   ;Choices= 1,2,3
   ;Model:
   U(1,2)=asc+Blfreq*lfreq+Bdur*dur+Btime*time+Bann*ann+Blbill*lbill/
   U(3)=Blfreq*lfreq+Bdur*dur+Btime*time+Bann*ann+Blbill*lbill $
+--------------------------------------------+
| Hausman test for IIA. Excluded choices are  |
| 1                                           |
| ChiSqrd[ 6] =  17.1021, Pr(C>c) =  .008915  |
+--------------------------------------------+


NLOGIT
   ;Lhs=Choice
   ;Choices= 1,2,3
   ;Model:
   U(1,2)=asc+Blfreq*lfreq+Bdur*dur+Btime*time+Bann*ann+Blbill*lbill/
   U(3)=Blfreq*lfreq+Bdur*dur+Btime*time+Bann*ann+Blbill*lbill $
 NLOGIT
                  ;Ias=2
                  ;Lhs=Choice
   ;Choices= 1,2,3
   ;Model:
   U(1,2)=asc+Blfreq*lfreq+Bdur*dur+Btime*time+Bann*ann+Blbill*lbill/
   U(3)=Blfreq*lfreq+Bdur*dur+Btime*time+Bann*ann+Blbill*lbill $

+--------------------------------------------+
| Hausman test for IIA. Excluded choices are  |
| 2                                           |
```

```
| ChiSqrd[ 6] =  16.7667, Pr(C>c) =  .010180  |
+---------------------------------------------+

NLOGIT
   ;Lhs=Choice
   ;Choices= 1,2,3
   ;Model:
   U(1,2)=asc+Blfreq*lfreq+Bdur*dur+Btime*time+Bann*ann+Blbill*lbill/
   U(3)=Blfreq*lfreq+Bdur*dur+Btime*time+Bann*ann+Blbill*lbill $
 NLOGIT
                    ;Ias=3
                    ;Lhs=Choice
   ;;Lhs=Choice
   ;Choices= 1,2,3
   ;Model:
   U(1,2)=asc+Blfreq*lfreq+Bdur*dur+Btime*time+Bann*ann+Blbill*lbill/
   U(3)=Blfreq*lfreq+Bdur*dur+Btime*time+Bann*ann+Blbill*lbill $
+---------------------------------------------+
| Could not carry Hausman test for IIA.       |
| Difference matrix is not positive definite. |
+---------------------------------------------+
 STOP$
```

Appendix 7.3 Hausman Test for IIA – Winter Data

```
RESET;
 READ;File=C:\CEWinterData_08_12_12.xls
   ;Nvar=41;Nobs=4513;Format=xls ;Names $
 REJECT; CHOICE<-10$
create; lfreq=log(freq+1)$
create; lbill=log(chbilltl+1)$
NLOGIT
   ;;Lhs=Choice
   ;Choices= 1,2,3
   ;Model:
   U(1,2)=asc+Blfreq*lfreq+Bdur*dur+Btime*time+Bann*ann+Blbill*lbill/
   U(3)=Blfreq*lfreq+Bdur*dur+Btime*time+Bann*ann+Blbill*lbill $
 NLOGIT
                    ;Ias=1
                    ;Lhs=Choice
   ;Choices= 1,2,3
   ;Model:
   U(1,2)=asc+Blfreq*lfreq+Bdur*dur+Btime*time+Bann*ann+Blbill*lbill/
   U(3)=Blfreq*lfreq+Bdur*dur+Btime*time+Bann*ann+Blbill*lbill $
+--------------------------------------------+
| Hausman test for IIA. Excluded choices are  |
| 1                                           |
| ChiSqrd[ 6] =  74.6417, Pr(C>c) =  .000000  |
+--------------------------------------------+

 NLOGIT
   ;Lhs=Choice
   ;Choices= 1,2,3
   ;Model:
   U(1,2)=asc+Blfreq*lfreq+Bdur*dur+Btime*time+Bann*ann+Blbill*lbill/
   U(3)=Blfreq*lfreq+Bdur*dur+Btime*time+Bann*ann+Blbill*lbill $
 NLOGIT
                    ;Ias=2
                    ;Lhs=Choice
   ;Choices= 1,2,3
   ;Model:
   U(1,2)=asc+Blfreq*lfreq+Bdur*dur+Btime*time+Bann*ann+Blbill*lbill/
   U(3)=Blfreq*lfreq+Bdur*dur+Btime*time+Bann*ann+Blbill*lbill $
+--------------------------------------------+
| Hausman test for IIA. Excluded choices are  |
| 2                          |
| ChiSqrd[ 6] =  32.3482, Pr(C>c) =  .000014  |
+--------------------------------------------+
```

```
NLOGIT
   ;Lhs=Choice
   ;Choices= 1,2,3
   ;Model:
   U(1,2)=asc+Blfreq*lfreq+Bdur*dur+Btime*time+Bann*ann+Blbill*lbill/
   U(3)=Blfreq*lfreq+Bdur*dur+Btime*time+Bann*ann+Blbill*lbill $


NLOGIT
                        ;Ias=3
                        ;Lhs=Choice
   ;;Lhs=Choice
   ;Choices= 1,2,3
   ;Model:
   U(1,2)=asc+Blfreq*lfreq+Bdur*dur+Btime*time+Bann*ann+Blbill*lbill/
   U(3)=Blfreq*lfreq+Bdur*dur+Btime*time+Bann*ann+Blbill*lbill $
+--------------------------------------------+
| Could not carry Hausman test for IIA.       |
| Difference matrix is not positive definite. |
+--------------------------------------------+
 STOP$
```

Appendix 7.4 Mixed Logit Model NLogit 4.0 Algorithm

```
RESET;
READ;File=C:\CESummerData_08_12_12.xls
   ;Nvar=41;Nobs=4513;Format=xls ;Names $
REJECT; CHOICE<-10$
create; lfreq=log(freq+1)$
create; lbill=log(chbilltl+1)$
DISCRETE CHOICE 1
                    ;Lhs=Choice
   ;Choices= 1, 2, 3
   ;RPL =freq, dur, time, ann
   ;Pts=500
   ;Fcn=Blfreq(N),Bdur(N)
   ;Model:
   U(1,2)=asc+Blfreq*lfreq+Bdur*dur+Btime*time+Bann*ann+Blbill*lbill/
   U(3)=Blfreq*lfreq+Bdur*dur+Btime*time+Bann*ann+Blbill*lbill $
```

Appendix 7.5 Mixed Logit Model with Interactions NLogit 4.0 Algorithm

```
RESET;
READ;File=C:\CESummerData_08_12_12.xls
   ;Nvar=41;Nobs=4513;Format=xls ;Names $
REJECT; CHOICE<-10$
create; lfreq=log(freq+1)$
create; lbill=log(chbilltl+1)$
create; FAGE=(freq*Age)$
create; DAGE=(dur*Age)$
create; FU=(freq*univ)$
create; DU=(dur*univ)$
create; FHS=(freq*HHSize)$
create; DHS=(dur*HHSize)$
create; FG=(freq*hasgen)$
create; DG=(dur*hasgen)$
create; FN=(freq*negattit)$
create; DN=(dur*negattit)$
create; FW=(freq*wkhmOnE)$
create; DW=(dur*wkhmOnE)$
create; FNEW=(freq*nonEwatr)$
create; DNEW=(dur*nonEwatr)$
create; FNEC=(freq*nonECook)$
create; DNEC=(dur*nonECook)$
create; FNEH=(freq*nonEHeat)$
create; DNEH=(dur*nonEHeat)$
create; FDH=(freq*dethouse)$
create; DDH=(dur*dethouse)$
create; FLI=(freq*lnincome)$
create; DLI=(dur*lnincome)$
create; FM=(freq*gender)$
create; DM=(dur*gender)$
NLOGIT
   ;Lhs=Choice
   ;Choices= 1,2,3
   ;RPL
   ;Pts=500
   ;Fcn=Blfreq(N),Bdur(N)
   ;Model:
   U(1,2)=asc+Blfreq*lfreq+Bdur*dur+Btime*time+Bann*ann+Blbill*lbill
   +BFAGE*FAGE+BDNEH*DNEH+BFDH*FDH+BFLI*FLI/
   U(3)=Blfreq*lfreq+Bdur*dur+Btime*time+Bann*ann+Blbill*lbill
   +BFAGE*FAGE+BDNEH*DNEH+BFDH*FDH+BFLI*FLI$
```

Appendix 7.6 Compensating Variation Confidence Interval NLogit Algorithm – Mixed Logit Model with Interactions, Summer Data

```
RESET;
READ;File=C:\CESummerData_08_12_12.xls
     ;Nvar=41;Nobs=4513;Format=xls ;Names $
REJECT; CHOICE<-10$

create; lfreq=log(freq+1)$
create; lbill=log(chbilltl+1)$
create; FAGE=(freq*Age)$
create; DAGE=(dur*Age)$
create; FU=(freq*univ)$
create; DU=(dur*univ)$
create; FHS=(freq*HHSize)$
create; DHS=(dur*HHSize)$
create; FG=(freq*hasgen)$
create; DG=(dur*hasgen)$
create; FN=(freq*negattit)$
create; DN=(dur*negattit)$
create; FW=(freq*wkhmOnE)$
create; DW=(dur*wkhmOnE)$
create; FNEW=(freq*nonEwatr)$
create; DNEW=(dur*nonEwatr)$
create; FNEC=(freq*nonECook)$
create; DNEC=(dur*nonECook)$
create; FNEH=(freq*nonEHeat)$
create; DNEH=(dur*nonEHeat)$
create; FDH=(freq*dethouse)$
create; DDH=(dur*dethouse)$
create; FLI=(freq*lnincome)$
create; DLI=(dur*lnincome)$
create; FM=(freq*gender)$
create; DM=(dur*gender)$

NLOGIT
      ;Lhs=Choice
      ;Choices= 1,2,3
      ;RPL
      ;Pts=500
      ;Fcn=Blfreq(N),Bdur(N)
      ;Model:

   U(1,2)=asc+Blfreq*lfreq+Bdur*dur+Btime*time+Bann*ann+Blbill*lbill
```

```
+BFAGE*FAGE+BDNEH*DNEH+BFDH*FDH+BFLI*FLI/

   U(3)=Blfreq*lfreq+Bdur*dur+Btime*time+Bann*ann+Blbill*lbill
+BFAGE*FAGE+BDNEH*DNEH+BFDH*FDH+BFLI*FLI$

WALD
; Fn1 = asc/Blbill
; Fn2 = Blfreq/Blbill
; Fn3 = Bdur/Blbill
; Fn4 = 2*(Btime/Blbill)
; Fn5 = 2*(Bann/Blbill)
; Fn6 = Blfreq*4.010963+Bdur*3.816-Btime+Bann
+BFAGE*54.2*37.885+BDNEH*3.816*0.649+BFDH*54.2*0.575+BFLI*54.2*7.712
; Fn7 = Blfreq*0.693147+Bdur+Btime-Bann
+BFAGE*37.885+BDNEH*0.649+BFDH*0.575+BFLI*7.712+ASC
; Fn8 =Btime-Bann+ASC
; Fn9 = (exp(-(Fn7-Fn6)/Blbill)-1)
; Fn10= (exp(-(Fn8-Fn6)/Blbill)-1)$
```

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