What Inspires Energy Crises at the Micro Level: Empirical Evidence from Energy Consumption Pattern of Urban Households from Sindh

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Abstract

The present study uses the Conditional Demand Model to determine household electricity demand by end use electricity consumption, and uses Logistic regression to analyze economic and social characteristics of households as determinants of prevailing electricity crises. The study uses cross-section data collected through household energy survey from all five districts of the Karachi. The results from the estimation of Conditional Demand Model show that electricity demand in urban households is determined by the end uses of electricity consumption and varies also by gender of the head of household. The estimates of Logit Model show that households who could afford alternative arrangements during load shedding are less affected than households who cannot make such provisions. The study suggests for the role of demand side management by promoting local investment in the production of energy-efficient appliances, motivating electricity conservation at the household level and legislation against power theft to address the problem of electricity shortfall.

Keywords: Logit Model; Electricity End Use Consumption; Conditional Demand Model.

***JEL classification*:** C25; C51; D12

1. Introduction

With urbanization and modernization of the economy, the use of modern electrical appliances has increased manifold in Pakistan. Presently, household share in the electricity usage comprises 46.5 percent which is the highest among other users, i.e., industrial 27.5, agriculture 11.6, commercial 7.5 and government has a share of 6.2 percent only [Economic Survey, 2012-13]. The household electricity use has also increased by 28.8 percent from 1993-94 to 2011-12 due to increase in number of electricity consumers (increased by 20.8 percent between 2007-08 and 2012-13), village electrification—8995 more villages electrified from June 2012 to March 2013, increase in per capita incomes specially of urban households[1], women participation in labor force—has grown by 4.7% and 6.57% in the whole country and in urban areas respectively between 2007-08 and 2012-13, globalization—Pakistan indexed at 51.68 in 2013 by the globalization index[2], and the availability of locally made and smuggled cheap modern electric appliances [Economic Survey, 2012-13]. The electricity supply and demand gap has widened over time and turned to alarming proportions in March 2012, when it increased to 57754 GWh from 56930 GWh in 2011-12, showing increase by 1.4 percent from the corresponding period 2011-12 [Economic Survey, 2012-13]. This accelerated electricity shortfall coupled with poor supply side management has resulted in the frequent breakdown of power and long hours of electricity load shedding.

Karachi is the largest city of Pakistan and the fourth largest urban center of the world. It is located at the elevation of 65 meters above the sea level. It has the largest population comprising locals, internal migrants and even external migrants especially from Bangladesh and Afghanistan. Karachi is administratively divided into five districts, eighteen towns and six cantonments, and city management

[1] Urban household has been benefiting from the services sector growth concentrated mainly in urban areas and has been around 7 to 8 percent in the last five years[Economic Survey 2011-2012]

[2] New globalization index or KOF measures three main dimensions of globalization; economic, political and social.

is run by provincial, local and military officials .Karachi Electric Corporation or (KESC)[3] is responsible for supplying electricity to entire Karachi including its suburbs and some parts of Baluchistan. Presently, households in all five districts of Karachi are facing acute shortage of electricity due to huge demand and supply gap in power generation, malfunctioning in power generation and distribution and poorly managed transmission lines by the KESC. The demand for electricity in Karachi increased to 2500 MW in 2013 and crossed 2700 MW in the peak of summer Jun 2013 (KESC, 2013) which resulted in the load shedding of up to 14 hours daily. The magnitude of the suffering resulting from electricity power outages differ by district, income groups and gender.

With this background, the present study focuses on the following two issues: First, the demand for electricity is a derived demand as household makes use of electricity for cooking, washing, cooling, refrigerating, ironing etc. Therefore, the electricity demand in the metropolitan city like Karachi needs to be decomposed into different end uses for which electricity is mainly purchased by households. Variables which are important in relation to explaining both total electricity consumption and different end uses have also been analyzed to explore heterogeneity in electricity consumption. For this purpose the conditional demand analysis model (CDM) has been applied. This is a multivariate econometric technique which combines the information of household's total electricity consumption, household specific information about electricity pricing, weather and detailed household survey data on energy appliance stock. The model yields robust end-use estimates for energy consumption of different appliances.

Second, the economic and social impacts of the electricity crises on the urban households and their coping strategies have been analyzed. The household perceptions about the extent of power crises in the last five years and its main contributors have also been explored. For this, the logistic regression is used which is a superior technique over the linear probability model in the presence of binary dependent variable and with unknown form of heterogeneity.

It is pertinent to point out two main limitations of the study: first, it is confined to only urban households of Karachi which limits the scope of the study as cities in other provinces are facing a rather more severe situation emanating from the persistent electricity shortfall. Second, the data collected on electricity consumption in kWh may not be as accurately reported by households as needed for this kind of study. It is mainly due to the high prevalence of electricity theft, illegal connection, average and over billing and absence of end use meters in Karachi.

The remaining article is organized in five sections. Section 2 discusses the method of data collection and brief summary of personal characteristics of households selected. Section 3 presents a review of literature on the electricity demand with special reference to Pakistan. Section 4 discusses the background of household appliance specific demand, analytical framework, econometric model,

[3] KESC is presently a private limited company established in 1913 under the Indian companies act of 1882.It was privatized in 2005 .it is also only vertically integrated company that supplies electricity to Karachi and some parts of Baluchistan.

estimation and results. Section 5 presents the micro level implications of electricity crises for urban households of Sindh with various demographic and economic characteristics, and discusses various factors motivating the electricity crises at household level. The last Section 6 concludes the study.

2. Data Collection

The household level information on appliances specific electricity demand, economic and social implications of electricity cries were collected for three months by the household energy survey conducted in all five districts of Karachi in the last week of May 2013[4]. The simple random sampling technique was used and 2500 households of various income groups, asset ownership, localities and characteristics were selected. A well-structured questionnaire was formed and emailed to more educated households and on spot interviews were also conducted from comparatively less internet oriented households. In total 2333 filled questionnaire was received of which 110 questionnaires were found with duplicate cases or repeated information. Similarly around 220 forms were found with less than 50% responses and with responses missing on electricity billing, income, expenditures and assets. Only 2001 questionnaires found with 99.8 % response rate have been used in this study. The questionnaire consisted of 5 structured sections, i.e., personal information, electric and gas appliance ownership, household income and expenditures, job type and experience, electric and gas billing of the last three months, electric and gas load shedding and perceptions about electricity crises .The number and percentage of the households interviewed in all five districts are given in Table 1.

Table1 Total and Percentage of Households Surveyed by District

District	Household interviewed	Percentage of Household interviewed	Male headed households	Female headed households
Central	637	31.85	551	86
East	623	31.15	535	88
South	188	9.40	172	16
West	231	11.55	208	23
Malir	321	15.05	287	34
Total	2000	100	1,753	247

All information was collected at the household level. The head of the household was the main respondent, except in few cases where elder son or daughter participated on behalf of the head. The data collected on job types revealed that 56.40 % head of the household or interviewed individuals own private jobs whereas only 5.35 percent were retirees or unemployed. Only 16.70 percent were found in government jobs while 21.50% had their own business. The survey revealed that around 93% female heads were employed at the time of the interview, and about 65 percent was employed by the private sector. This showed that almost all women interviewed are working women. The data show

[4] the information on electricity consumption in kWh ,electricity expenditures and prices were collected for March, April and May 2013 and on all other variables for May 2013.The Household Energy survey was conducted by the students of Adv. Economics Statistics , Department of Economics, University of Karachi under the supervision of the course in charge Lubna Naz (author) .

that illiterate heads of the household interviewed were only 1.20 percent. Above 36 percent of the household heads were graduate with 33 percent female graduates, and more than 31 percent of the heads had post-graduate qualification. About 86 percent of male heads and 55 percent of the female heads were married, 25 percent of the female heads were widowed or divorced, and only 1.2 percent of the male heads were widower or divorcee. This implies that a large bulk of the data has been obtained from families living with dependents. It is also established by the one person and two people's families which are only 2.55% and 7.80 % of the entire data set.

3. Review of Studies

In Pakistan, the literature on the demand for electricity can be categorized into three groups. Fist group relates to studies estimating the demand for electricity and its determinants consistent with economic theory[5] .The studies include: Siddiqui (1999, 2004), Aqeel & Butt (2001), Khan & Qayyum (2008), Khan and Usman (2009), Tariq et al. (2009), Jamil and Ahmad (2010) and Shahbaz and Feridun (2011)[6]. Almost all studies used electricity consumption as dependent variable, and electricity prices and real per capita income as explanatory variables .These studies differ in the use of econometric technique, sample period , other explanatory variables and decomposition of electricity demand (dependent variable) into commercial, industrial and household[7]. The findings are mostly consistent with economic theory[8] except a few studies[9] which contradict with the theory.

Second group relates to research conducted more recently with reference to causes and consequences of energy and electricity shortages in Pakistan. These studies are addition to the literature as electricity crises gained ground in 2007-08 and reached at peak in 2011 when electricity shortfall exceeded 40 percent of national demand (FODP, 2010). The studies include: FODP (2010), Malik (2010), Asif (2011) Trimble, et al. (2011), Nasir & Rehman (2011), Alhadad (2012), Qasim & Kotani (2013) and GOP (2013). The research revealed that rapid growth in electricity demand, inadequate generation capacity, lack of alternative energy sources, inconsistent power policy, issues in governance and circular debt have been some of the main reasons for the long-standing problem of electricity shortages .Similarly the most commonly noted consequences are fiscal burdening (as 7.6 percent of total government revenue used for power subsidy in 2007/8), decline in economic growth, poor performance of industrial and commercial sectors, mounting external deficit due to oil imports and decline in employment.

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[5] Utility maximization approach was used to derive electricity demand and time series econometric techniques i.e. Cointegration, Autoregressive and Distributed Lag model, Granger Causality etc. were used for estimation of electricity demand.

[6] See table at the end of section-3 for detail

[7] Aqeel and Butt(2001) analyzed relationship among different sources of energy and economic growth , Siddiqui(2004) analyzed the relationship between commercial sector electricity demand and economic growth and Jamil and Ahmad(2010)analyzed electricity demand at various disaggregation i.e. sectors level

[8] Electricity demand is price inelastic and income elastic in long run[Jamil and Ahmad 2010],Electricity demand is price and income inelastic[Khan & Usman,2009]

[9] Electricity demand is price and income elastic in the short and long run [Khan and Qayyum,2009]

A third set of studies relates to the implications of electricity crises on the industrial output, employment and output supply order, and decline in commercial activity. In this regard, two important studies have been undertaken by Pasha(2010) and Siddiqui, et al (2011) .The former has calculated the losses attributed to the commercial sector from persistent power outages and the latter focused on calculating the real cost of electricity shortages in the industrial sector of Punjab . The findings showed a decline in commercial activity, industrial output, delay in supply orders and employment due to electricity shortfall.

The studies by Iqbal (1983) and Saleem (1992) may be considered as exceptions of earlier studies as the two studies significantly departed in methodology from the earlier work in Pakistan. The former estimated fuel demand function conditioned on the stock of energy using appliances and their rate of use and the latter used cross-sectional data from Karachi on electricity demand to find the probability of electricity shortage and predict the average and the peak electricity demand in 2000[10].Recently, Chaudhry (2010) analyzed the impact of appliance ownership under different tiers of electricity tariff on residential electricity consumption in Punjab. The findings showed a positive relationship between income and electricity demand, and appliance ownership and electricity demand under different tiers of electricity tariff.

There is no dearth of literature of electricity demand based on end use electricity consumption. The studies may be distinguished by the use of two main approaches; the first approach is called a Conditional Demand model or CDM and the second approach is known as Engineering Model. The early studies ,for example, Parti and Parti (1980),Aigner et al. (1984) , Lafrance and Perron (1994), Fiebig and Steel(1994) and Bartels and Fiebig(2000) were based on the former approach of electricity demand which combines household's total electricity consumption in kWh, household specific information about electricity prices , weather and detailed household survey data on energy appliance stock and demographic and economic characteristics of the household to model electricity demand at household level. The analyses differed in the sample period as some of the studies used many periods[11] to determine the causes of changes in the pattern of electricity consumption. The studies based on Conditional demand model justified its use over engineering model due to the theoretical underpinning of the latter which restricts the ability of the researcher to adjust the electricity demand model for regional differences in income, prices, energy consuming behavior and household size.

Recent studies , for example, Hsiao et al (1998) , Larsen and Nesbakken (2004)[12], Reiss and White (2005), Firth et al (2008), Yun and Steemers (2011) used the latter approach which is an improvement on the former in that it uses directly metered data on electricity consumption for

[10] See detail in table at the end of section-3

[11] Lafrance and Perron (1994), Fiebig and Steel(1994) ,Bartels and Fiebig(2000) and Larsen and Nesbakken (2004).

[12] Larsen and Nesbakken (2004) compared results from conditional demand model and engineering model.

specific appliances by households to yield more robust results. However the studies based on this approach demands on the use of end use electricity meters by the households which imposes significant cost on the household and hence are difficult to be used in developing countries.

The present study contributes to the existing literature by specifying and estimating end use based electricity demand for the largest group of urban households in Pakistan. For this, the study used Conditional Demand Model[13]. Moreover, the study investigates into the economic and social implications of prevailing electricity crises for urban household by using statistical analysis and Logistic Regression.

4.1 Modeling Household Electricity Consumption

This paper applies Conditional Demand Model or CDM[14] on the household energy survey data[15] collected in May, 2013 from Karachi. The data set provides detailed information on household energy consumption, electricity prices and energy expenditures, household ownership of energy using appliances, income, gender, marital status, job type, number of dependents in the household, dwelling type, education level of the head, working household members, district of residence and size of the family unit. The basic econometric specification of the CDM is given by

$$xij = \delta j + \sum_{m=1}^{M} \rho jm\left(Cim - \overline{Cjm}\right) + \mu ij \text{.....................(4.1)}$$

Where x_{ij} is end use electricity consumption for appliance j (j=1,2,…………K) of household i (xi, i=1, N) per period , C_{im} (m=1, 2, M) are economic and demographic variables relating to household for example age, household size, income, electricity prices, etc., $\overline{C_{jm}}$ is the mean value of these variables for households possessing appliance j. μ_{ij} is a stochastic error term. The parameter δ_j gives the mean value of electricity for end use j provided that the household characteristics (Cim) relevant to end use j are equal for all households or $\rho_{jm} = 0 \;\; \forall m$. Household characteristics vary across households. The second term on the right hand side of Equation (4.1) represents an adjustment in the end use electricity consumption for appliance j due to the impact of economic and demographic characteristics of the household. The Equation 4.1 can be estimated by the Ordinary Least Square, given the data has been collected on electricity consumption through end use meters. For this article, the data on household electricity consumption in kWh has not been obtained from end use meters; hence the basic CDM specified in Equation (4.1) cannot be estimated.

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13 It is multivariate econometric technique ,see section-4 for detail

14 Conditional demand model is used due to unavailability of directly metered data on end use consumption of electricity in Karachi.

15 This study uses sample of 2000 households for estimation after data cleaning.

Authors	Period of Study	Variables /Objectives	Methodology	Results
Iqbal ,.M (1983)	1960-1981 Annual data	Household fuel consumption & Household Gas and Electric appliances and temperature	Ordinary Least Square	Income and price elasticity of Fuel found consistent with Economic Theory.
Burney & Akhtar (1990)		Household expenditure on energy, household size, income ,age etc.	Ordinary Least Square	More rural household fuel expenditure than urban & low fuel price Elasticities (price inelastic fuel demand)
Saleem.,C (1992)	2000	Household electricity consumption, weather ,household characteristics	Ordinary Least Square	The changes in electricity demand are subjected to weather conditions.
Aqeel & Butt(2001)	1956-1996	Per capita Energy Consumption and per capita GDP.	Johnson cointegration ,Hsaio version of Granger Causality	Economic growth causes demand for electricity not vice versa ,no causality between Gas consumption and economic growth
Siddiqui (2004)	1971-2003	Commercial Sector Electricity consumption and per capita GDP.	Hsaio Granger Causality , ARDL	Lack of uniformity in the impact of all components of energy demand on Economic Growth, only Electricity and some petroleum products has high impact on Economic Growth.
Khan & Qayyum (2008)	1972-2007	Electricity Consumption, Electricity Prices and Real Per Capita Income.	Johnson cointegration	Long run Positive Relationship between Household Electricity Demand and and elastic income and price electricity demand.
Tariq etal (2009)	1979-2006	Electricity Consumption, Electricity Prices, Temperature, Real GDP.	Johnson cointegration	Significant unitary income Demand Elasticity in the Long run and Short run ,low Price Elasticity of Electricity.
Jamil & Ahmad(2010)	1960-2008	Electricity Consumption, Electricity Prices and Income at Aggregate and Sectoral levels.	Johnson cointegration	Growth in GDP causes Electricity Demand & Growth in output in Commercial, Manufacturing and Agriculture Sectors tend to increase EC.
Atif & Siddiqui (2010)	1971-2007	Electricity Consumption and Per Capita Real GDP.	Granger causality & Autoregressive Distributed Lag Model (ARDL)	Unidirectional Causality From Electricity Consumption to Economic Growth.

Authors	Study Period	Variables /Objectives	Methodology	Results
Chadury,.T (2010)	2003 /04	Household Electricity Consumption, Income, electricity prices and electric Appliance.	Endogenous Switching Model for Electricity Demand under different tariff tiers ,Probit Model	Positive Impact of Adjustment in Tariff Tiers on Revenue Collection From Electricity, Positive Relationship Between Income and Electricity Demand.
Chaudary, A (2010)	Panel data (66 countries,1991-2009)	Electricity Consumption, Electricity Prices and Real GDP	Panel Data Models; Fixed Effects and Pooled Regression	Positive Income Elasticity Of Electricity ,Negative Impact Of Electricity Prices on Manufacturing Sector
Malik,.A (2010)		Detailed Analysis of the Causes and Consequences of the Electricity Shortage in Pakistan.	Statistical Analysis	Poor Governance has been determined as a main factor contributing in present crises.
Siddiqui (2011)	1971-1997	Determinants of Energy Demand & Revenue Generating Impact of Changes in Energy Prices.	Estimated Electricity Price Elasticity from Earlier studies were used	Negative Price Elasticity of Energy and Positive Income Elasticity.
Alter & Syed(2011)	1970-2010	Electricity prices ,real GDP, number of Electricity Consumers & Electric Appliances	Johnson cointegration	Long run relationship between Electricity Consumption and Prices.
Shahbaz(2011)	1971-2009	Real GDP per capita, real domestic private sector credit, electricity consumption	ARDL	Long run cointegration among financial development, electricity consumption, labor and Economic Growth.
Shabaz & Feridun (2011)	1971-2008	Electricity Consumption and Per Capita Real GDP.	Autoregressive Distributed Lag Model or ARDL	Economic growth causes Demand for Electricity and not vice versa.
Alhadad .,Z (2012)		Introduced integrated Energy Planning & Policy information as tool to resolve Energy Crises	Analytical Approach used	Usefulness of IEP (integrated Energy planning) is emphasized.
Pasha etal(2010)		Impact of Electricity short fall on Industrial Sector.	Analytical and Statistical Analysis	Power Shortage in Industrial Sector alone has attributed in the loss to Economy over 2.5 percent of GDP.
Javed & Awan (2012)	1971-2008	Real per capita GDP and Electricity Consumption.	Engle and Granger Two Step Procedure.	Unidirectional causality from Electricity Consumption to Economic Growth; Electricity Shortages limits Economic Growth.
Ali ,Iqbal & Sharif (2013)	1990-2010	Electricity Consumption and Maximum Temperature Index.	ARIMA Time Series Forecast Model for temperature Index	Positive Impact of Maximum Mean temperature and Socio Economic Factors on Electricity Demand.

However, the electricity consumption in kWh can be gathered over all end uses in Equation (4.1) that gives total electricity consumption in kWh of household i as xi . As all households do not possess all types of modern electric appliance, it is impossible to specify all end uses. To account for this fact, dummy variable, D_{ij} , is used to value one if household i possess appliance j and value zero if the household does not possess appliance j. Of a total of J possible end uses, S is interpreted as electricity end uses that can be estimated separately, i.e. j=1, 2... ,S,...,J and S<J. The econometric specification of the household conditional electricity demand is

$$x_i \equiv \sum_{j=1}^{S} x_{ij} D_{ij} \equiv \sum_{j=1}^{J} x_{ij} D_{ij} + \sum_{j=S+1}^{J} x_{ij} D_{ij} = \sum_{j=1}^{J} \delta_{ij} D_{ij} + \sum_{j=S+1}^{S} \delta_{ij} D_{ij} + \sum_{j=1}^{J}\sum_{m=1}^{M} \rho_{jm} \left(C_{im} - \overline{C_{jm}}\right) D_{ij} + \mu_i \text{.........(4.2)}$$

Where, u_i is a stochastic error term and $u_i \approx$ NID (0, 1), which is given as

$$\sum_{j=1}^{J} \varepsilon_{ij} D_{ij} = u_i \text{...(4.3)}$$

The third term on the right hand side of the Equation (4.2) denotes economic and demographic variables as C_{im} and their mean values as $\overline{C_{jm}}$. These variables are included as interaction with appliance variables to adjust electricity consumption for appliance j. For instance, the interaction between lighting and household size captures the effect that electricity consumption by lighting varies by household size . The interactions are computed as deviations from average values of different household demographic and economic characteristic for the households possessing the appliance for example $\overline{C_{jm}} = \frac{1}{H_j} \sum_{i=1}^{N} C_{im} D_{ij}$. The first term in Equation (4.2), $\sum_{j=S+1}^{S} \delta_{ij} D_{ij}$, is unspecified electricity consumption which is assumed in this model not to vary between households, $\sum_{j=S+1}^{S} \delta_{ij} D_{ij} = x_0$, whereas interactions are also applied to all j because unspecified end use electricity consumption may depend on demographic and economic condition just like specified end use electricity consumption. However, it is assumed that the coefficients for the appliance dummies and interactions are not varying across households. The final specification of the econometric model to be estimated is thus

$$x_i = x_0 + \sum_{j=1}^{S} \delta_{ij} D_{ij} + \sum_{j=1}^{J}\sum_{m=1}^{M} \rho_{jm} \left(C_{im} - \overline{C_{jm}}\right) D_{ij} + \mu_i \text{ .... (4.4)}$$

Where x_i is total electricity consumption in kWh per month conditional on the possession of appliances D_{ij} which takes the value one if household i possess the electric appliance j and zero if household i does not possess the appliance j, x_0 is unspecified electricity consumption for households and δ_{ij} is the coefficient of the mean electricity consumption of appliances j held by the household i and for which D_{ij} has value equal to one. To compute estimates of the mean electricity consumption for different appliances of the average household, the estimates of mean electricity consumption for each appliance are multiplied by the proportion of the households possessing the appliance. The coefficient ρ_{jm} represents consistency between interactions $(C_{im} - \overline{C_{jm}})D_{ij}$ and electricity consumption x_i, C_{im} ($m=1,2,3\ldots\ldots.M$) represents economic and demographic characteristics of households relating to end use consumption of electricity for example income, age, household size, type of family unit, type of dwelling, educational and marital status of the head of households and electricity price, $\overline{C_{jm}}$ is the mean value of the household demographic and economic characteristics.

All variables on the right hand side in the Equation (4.4) are assumed to be exogenous. It is because of the data set used in this model is cross-sectional collected in summer[16]; therefore, it is assumed that no change occurs in the stock of electricity-using equipment during the survey months. However, the households may change their stock of energy-using equipment as well as other characteristics over time. The Equation (4.4) is estimated by Ordinary Least Square or OLS[17]. The study uses total electricity consumption in kWh as dependent variable and stock of household electric appliances as main explanatory variable, other variables include income[18], age and gender of the head of the household, household size, type of family unit, type of dwelling, no of days with temperature[19] <35^{C} , education and marital status of the head of households and household saving behavior.

4.2 Calculation of End Use Electricity Model

The expected end use electricity consumption for household i of appliance k is obtained from the equation (4.4) as

$$E(x_{ik}) = \delta_k D_{ik} + \sum_{m=1}^{M} \rho_{km} \left(C_{im} - \overline{C_{km}}\right) D_{ik} \ldots\ldots\ldots\ldots\ldots.(4.5).$$

E is expectation operator. The coefficient δ_k represents the difference in electricity consumption in kWh between households that have appliance k, $D_{ik} = 1$ or $\delta_k + \sum_{m=1}^{M} \rho_{km} \left(C_{im} - \overline{C_{km}}\right)$ and zero for

[16] The data was collected in May 2013 but comprises information on electricity consumption in kWh and electricity expenditure for the month of March and April & May 2013.

[17] Ordinary Least square is Classical linear regression based on certain assumption i.e. homoskedasticity, normality, linearity, exogenity and no multicolinearity

[18] Real total expenditures are used as proxy of income (due to discrepancy between income and expenditures reported) and income quintiles have been computed. Real expenditures were computed by deflating total expenditure by the official General CPI for the month of May 2013(gives real expenditure for the base year 2007-08) from Pakistan Bureau of Statistics www.pbs.gov.pk

[19] The information on daily weather was obtained from www.pmd.org.gov for March, April and May2013.

those that do not have appliance, $D_{ik} = 0$ .The average electricity consumption for end use k is computed as

$$\hat{x}_k = \hat{\delta}_k \overline{D_k} + \sum_{m=1}^{M} \hat{\rho}_k \left(C_{im} - \overline{C_{km}}\right)\overline{D}_k \text{ ...... (4.6)}$$

Equation 4.6 represents estimated parameters. Where $\overline{D}_k = \frac{1}{N}\sum_{i=1}^{N} D_{ik}$ is the mean value of the dummy variable for appliance D_{ik} possessed by the surveyed household. The average electricity consumption relating to appliance k is calculated as average electricity consumption for households that possess appliance k times the share of households the appliance owned after making corrections for interaction variables. The final estimated equation is

$$x^p = \hat{x}_0 + \sum_{j=1}^{S} \hat{\delta}_k \overline{D_k} \text{ .... (4.7)}$$

Where $\hat{x}_0$ is unspecified estimated electricity consumption, x^p is predicted mean end use electricity consumption whereas mean actual electricity consumption are also computed for all households in the survey as $\overline{x} = \frac{1}{N}\sum_{i=1}^{N} x_i$ .The share for electricity consumption of appliance k in total electricity consumption is computed as

$$apl_k = \frac{x_k^p}{\overline{x}} \text{ .... (4.8)}$$

x_k^p is the mean electricity consumption for the appliance k and $\overline{x}$ is the average of the total electricity consumption. Finally, the share of unspecified electricity consumption is calculated as follows

$$S_{un} = 1 - \sum_{j=1}^{k} S_j = \frac{\hat{x}_0}{\overline{x}} \text{ .... (4.9)}$$

S_j is specified electricity consumption for appliance j, where j=1,2,…..k and S_{un} is the share of unspecified electricity consumption in total electricity which is calculated as residual end use after making adjustment for all specified end use electricity consumption.

4.3 Empirical Findings

This paper uses data from the household energy survey conducted during the last week of May 2013 in Karachi. The Section 3 of the questionnaire provides three months, March-May 2013, record of electricity consumption in kWh and expenditures on electricity and gas, household level information on dwelling type, ownership of modern electrical appliances, gas appliances and vehicles owned by the households during the month of May 2013. The data on weather has been collected from the weather reports of the Pakistan meteorological department[20] .

[20] www.pmd.gov.pk

Table-3 provides summary statistics for gas, electrical appliance ownership and household characteristics for all households and by gender for the survey month. The data show that almost all households had cell phone, television, iron, washing machine, refrigerator, gas stove and lighting in Karachi. However, a small proportion of households surveyed possessed air cooler, air conditioners, microwave oven and geysers. Analysis of appliances ownership by income groups[21] provides reason for this disparity in the ownership of high energy using equipment as those in the high strata of income or above 50 percent of the mean income of the all households surveyed had 79% of the high energy using appliances like air conditioners, geysers and microwave ovens. The data also reveals that household on average consumed 688 kWh of electricity per month or 2076 kWh of electricity per quarter[22].

The data from the daily weather reports show that recorded temperature in 27 days out of 92 days during March-May 2013 remained more than 40^0C in Karachi. The Columns 2 and 3 of the Table- 3 presents differences in the ownership of the stock of energy using appliances by gender of the head of the household. The study finds no gendered difference in the pattern of the ownership of TV, electric water extracting motor, iron, gas stove and geysers. However, the data show statistically significant differences in the ownership of specific electrical appliances like air conditioner, desktop, dryer, number of lighting points, washing machine and deep freezer between male and female headed households. Energy saving behavior as female headed households are more inclined towards energy conservation than male headed households. Figure-1 displays appliance ownership for all households and Figure-2 presents differences in the stock of modern appliances by gender.

Table-4 reports results from the estimation of Conditional Demand Model (CDM) specified in Equation 4.4. The model is estimated using OLS. The dependent variable is average electricity consumption in kWh from March to May 2013. Table 4 shows estimated electricity use for different appliance variables. Only equipment that is significant at least at 10 percent level is included in the estimations. The second column shows the variables' estimated effects on electricity consumption. The third column shows the standard errors from the estimation. The lower section of the Table- 4 represents results from interaction variables and their standard errors. The estimates of most of the appliances are statistically significant at 5 percent and only deep freezer, microwave oven and dryer are significant at 10 percent and 1 percent.

[21] Real total expenditures are used as proxy of income (due to discrepancy between income and expenditures reported) and income quintiles have been computed, results for income quintiles are not reported in table-3.
[22] For March ,April and May 2013

Table- 3 Descriptive Statistics of Household Energy Survey 2013

Variables	All	Male	Female
Electricity consumption (kWh in 2nd quarter)	2076	1998	1950
Electrical appliance variables (0 or 1)			
Cell phone	0.99	0.99n/s	1.00n/s
Microwave oven	0.37	0.38n/s	0.34n/s
Television	0.98	0.97n/s	0.97n/s
Electric Water extracting motor	0.66	0.67*	0.56*
Dryer	0.38	0.37*	0.48*
Desktop	0.74	0.73***	0.78**
Washing machine	0.91	0.91**	0.97**
Iron	0.99	0.97	0.97
Refrigerator	0.93	0.93	0.98
Air cooler	0.24	0.21*	0.29*
Air conditioner	0.43	0.44*	0.39*
Electricity price (per kWh)	12.83	12.88	12.83
Gas stove	0.89	0.93	0.92
Gas heater	0.34	0.71**	0.83**
Geezer	0.59	0.58	0.63
Deep freezer	0.23	0.24*	0.27*
Tube lights	0.99	0.99	1.00
No of lighting points>10	0.42	0.82*	0.89*
Other variables (interactions)			
Age of the head of household	43.9	44.40	40.37
Household size	4.5	4.5	4.0
Household income			
Married head(0 or 1)	0.82	0.86	0.55
Energy saving household (0 or 1)	0.74	0.74*	0.79*
Two person household	.078	0.07	0.10
Flat ownership(0 or 1)	0.54	0.59*	0.66*
Single person household (0 or 1)	.025	0.03	0.01
At least 1 person over age 60 (0 or 1)	0.17	0.17	0.12
Dependency	0.23	0.22	0.19
Education of the head of households			
No education (0 or 1)	0.012	0.011	0.016
Matric (0 or 1)	0.14	0.14	0.10
Inter (0 or 1)	0.18	0.18	0.14
Graduation (0 or 1)	0.36	0.36	0.33
Post-graduation (0 or 1)	0.22	0.20	0.31
Diploma (0 or 1)	0.45	0.04	0.05
Primary (0 or 1)	0.036	0.036	0.034
No of days temperature>40	27	27	27
Job status of the head			
Private	0.56	0.55	0.65
Government	0.16	0.17	0.14
Own business	0.21	0.23	0.12
Retirees/unemployed	0.05	0.05	0.06

Note: *, **, *** implies significance levels at 5%, 1% and 10% respectively.

Figure-1 Average Energy Appliances Holding by Households

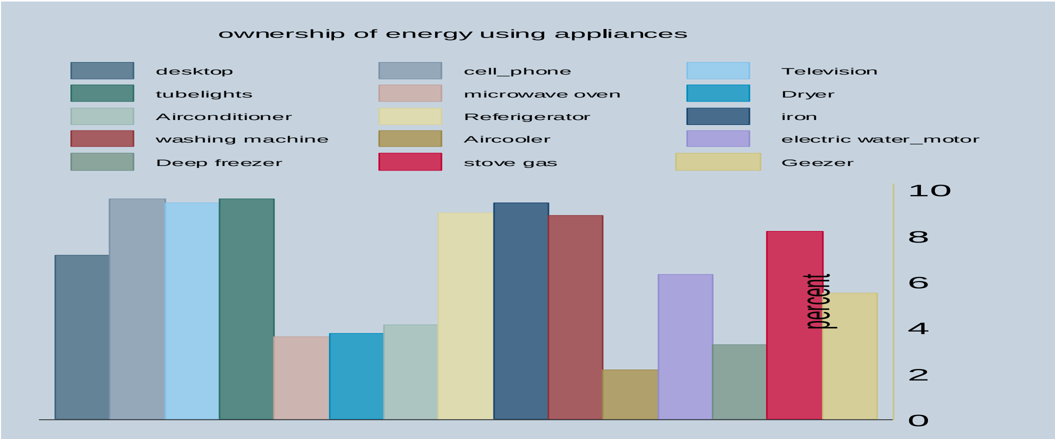
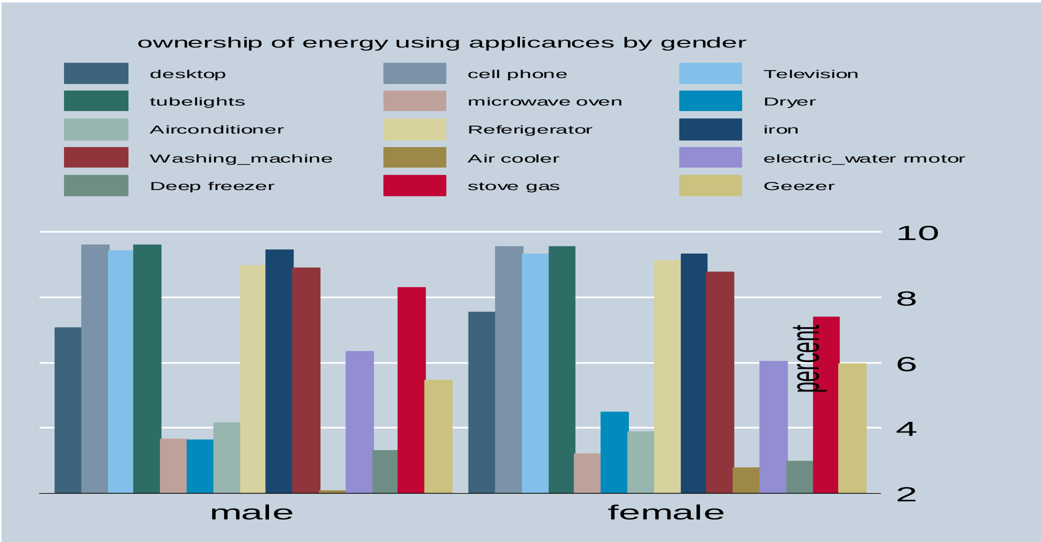


Figure-2 Average Energy Appliances Holding by Gender



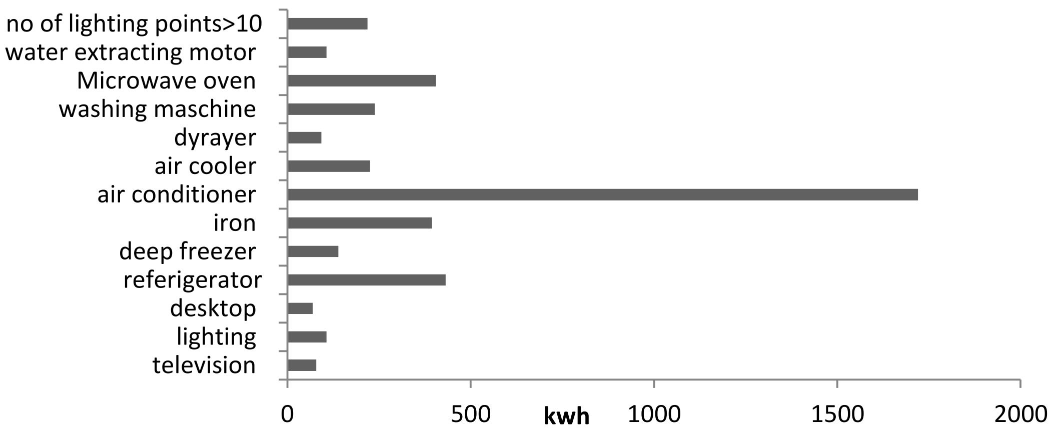
The quarterly estimate of electricity demand by air conditioner is 1720 kWh as 42 percent household possess air conditioners for cooling, this gives only 722 kWh for this cooling electric equipment for the average household. As almost all of the households surveyed own iron and washing machine, this gives estimates for households having iron and washing machine 386 kWh and 220 kWh respectively. The estimate of electricity consumption for more than 10 lighting points is greater than the electricity estimate of lighting, it indicates that larger family size or dwelling size or both affects the consumption of lighting as only 42 percent use more than 10 lighting spots and 88 percent of these households belong to larger dwelling size and larger household size (house residents and not apartment residents). The estimate of electricity consumption of microwave oven is 406 kWh which is even higher than washing machine and air cooler but only 37 percent households own microwave, this gives electricity estimate for households having this equipment is 150 kWh.

Table -4 Estimated Electricity Consumption (kWh per quarter- 2013)

Variables [a]	Coefficient [23]	S/E	Mean-value	Assets ownership
Intercept	172(2.20)*	78.21	000	000
Television	79 (2.51)*	31.24	77	0.97
lighting	107(4.2)*	25.76	106	0.99
Desktop	69(2.09)*	33.03	56	0.74
Refrigerator	432(4.7)*	91.19	402	0.93
Deep freezer	139(2.7)***	51.24	46	0.34
Iron	394(3.7)*	105.08	386	0.98
Air conditioner	1720(51.60)*	33.33	739	0.42
Air cooler	226(6.2)**	36.30	50	0.24
Dryer	93(2.9)**	32.68	36	0.38
Washing machine	239(4.6)*	51.79	220	0.92
Microwave oven	406(8.2)**	49.18	150	0.37
Water extracting motor	107(3.5)*	30.87	71	0.66
No of lighting spots>10	219(4.91)*	44.26	92	0.42

Interaction Variables [b]		**Coefficient**	**S/E**
High income*air conditioner		443(4.6)*	96.01
Household size*deep freezer		241(4.7)**	51.12
Household size*lighting		-191(-3.5)**	54.20
Single person household*fridge		288(3.8)*	74.78
Two person household*water motor		-126(2.06)*	60.08
Non Heating degree days *AC		-42 (2.07)*	20.21
Married head*microwave		49 (2.36)*	20.70
Female headed households*air cooler		167.37(3.9)*	42.57
Type of dwelling*lighting		- 92(2.2)*	41.63
R^2	0.41		
F-value	316.52(0.000)		
N-obs	2000		

Figure-3 Mean Electricity Consumption Estimates in kWh per quarter for different appliances



[23] Note :electricity estimates reported in table -4 are based on robust regression (corrected for hetrosediasticty in variance),estimation has been carried out in stata;11

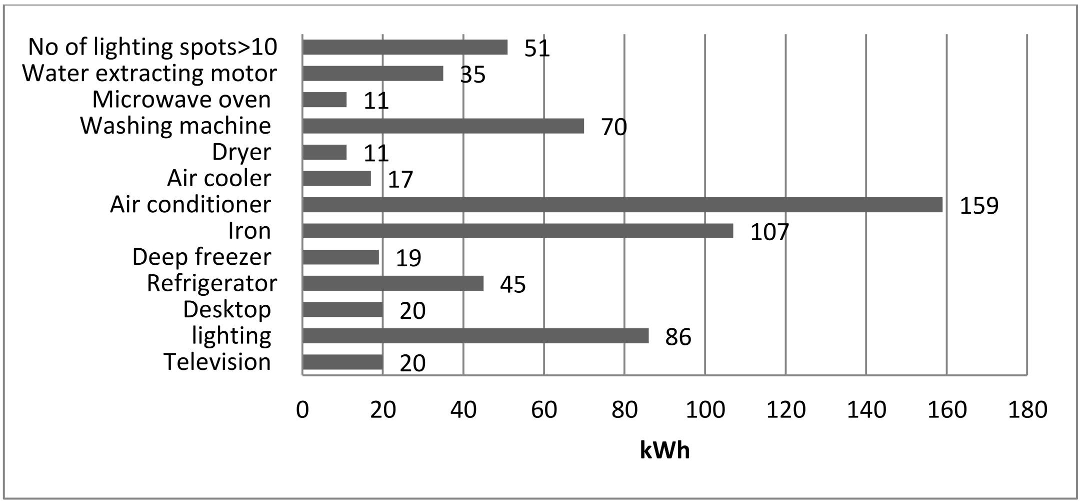
Table-5 presents results for end use electricity consumption in kWh for the preceding survey month (April 2013).The electricity estimates for air conditioner, washing machine and iron show similar pattern of consumption as reported for these equipment for a quarter in Table 4. The electricity estimates of lighting spots are higher than lighting but it is vice versa for household size—as those using more than 10 lighting points in the data set belong to larger family size and dwelling. Figure 4 displays the mean value of electricity estimates for households from Table-5.

Table-5: Estimated Electricity Consumption in kWh, April 2013

Variable	Coefficient	Standard error	Mean-value	Assets ownership
Intercept	63	10.11		
Television	21*	9.8	20	97.80%
lighting	86*	17.48	86	99.14%
Desktop	26*	11.58	20	74.10%
Refrigerator	49*	20.20	45	93.35%
Deep freezer	56*	16.97	19	33.90%
Iron	110*	35.26	107	97.90%
Air conditioner	374**	11.03	159	42.90%
Air cooler	72***	18.89	17	24.45%
Dryer	27**	11.21	11	38.80%
Washing machine	76	18.79	70	92.20%
Microwave oven	29**	10.64	11	37.50%
Water extracting motor	54	13.44	35	66.01%
No of lighting spots>10	122*	19.78	51	42.01%
R^2_adj	0.46			
F-value	304.02(0.00)			
N-obs	2000			

Note: *, **, *** implies 5%, 1% and 10% significance respectively.

Figure-4: Mean Electricity Estimates for Different Appliances in kWh for April 2013



5. Economic and Social Implications of Electricity the Crises

Up till 2004-05, Pakistan witnessed surplus electricity due to satisfactory performance of WAPDA and KESC. The transitory gaps between demand and supply in early 1990s were overcome by power reforms in the energy sector. These efforts yielded surplus power as the actual load growth was much less than the projected. However, the energy policy was focused on power generation through thermal projects resulting in more share of thermal in the overall generation mix [Malik, 2012].

On the other hand, the expansion of Pakistan's economy generated manifold increase in the demand for electricity. From 4 percent annual moderate growth rate in 1990, it reached 10 percent in 2007-08. According to one estimate for every 1 percent of GDP growth in Pakistan an increase of 1.25 percent in electricity supply is required [Merril Lynch, 2007]. Thus a GDP growth of 7 percent (as in 2002-07) required an increase of 8.8 percent in electricity supply. However, in that period the installed capacity grew at the rate of only 2 percent which led to the beginning of present electricity crises. The gap between demand and supply has grown to the level of 5000 MW at many points during the year 2011, and in May 2011 the electricity shortfall surpassed 7000 MW. This widening demand supply gap has resulted in the regular load shedding of eight to ten hours in urban areas and eighteen to twenty hours in rural areas [FODP, 2010].

Karachi Electric Supply Corporation (KESC) is the only power supplier to the largest city of Pakistan. It had installed capacity at 1400MW while demand for electricity reached at 2500MW in 2013. The huge gap between demand and supply turned to alarming proportion during summer (April to July) in Karachi which resulted in regular announced and unannounced load shedding of 8 to 11 hours. The household energy survey was conducted in May 2013 to determine the extent of crises and its implications on the largest group of urban households in Pakistan. The information was collected on the duration of load shedding in between 9am to 4pm (day time) and 10pm to 8am (night time), perceptions about the increase in the magnitude of the crises in the last five years, role of government, implications on work and daily targets, energy saving behavior, use of electricity alternatives during power outages, electricity theft, illegal connection, street crimes in load shedding, damages to electric appliances for volatility in voltage and reaction of the household to electricity crises. The electricity crises affected are households who have suffered from any load shedding during March, April and May 2013.

Table-6 presents the distribution of the electricity crises affected households by district and by gender. The data reveals that almost all (96.7 percent) households are affected by the electricity crises and only 3.3 percent reports not affected. The badly hit districts were the Central and the East and least affected was the South. The distribution of the data on monthly income[24] across districts showed that about 56 percent of the households in the bottom strata or lowest 20 percent income earners reside in the district east and the central. Hence more than half of the population affected by electricity crises in these districts comprises relatively poor households.

[24] Real expenditures were used as proxy for income of the surveyed household and income deciles were also computed.

Table-6 : Electricity Crises Affected household by District

Districts	Crises affected household	Male headed (crises affected household)	Female headed (crises affected household)
Central	31.80	31.40	34.68
East	29.88	29.38	33.58
West	11.65	12.01	8.99
South	8.56	8.71	7.43
Malir	14.81	15.23	11.74
Total	96.70	96.73	96.42

Another important finding from the household energy survey is that households are not only electricity crises affected but also suffer from losses to their electrical appliances. It is due to high or low volatility in voltage, for which electric theft by adjacent neighborhood may be held responsible with KESC, as people's attempt to get electricity from main transmission lines illegally or through "Kunda" during load shedding causes significant drop in electricity voltage. The paper defines worst affected household as one who has suffered from load shedding and damages to electric appliances in the last three months. Table 7 displays district wise distribution of the worst affected households. It also shows the data on electric theft by the adjacent community of the worst affected households interviewed.

Table-7: Worst Affected Households from Electricity Crises and Electricity theft by District

District	Worst affected household	Electric theft in neighborhood of worst affected
Central	22.45	17.20
East	20.58	15.43
West	8.47	6.60
South	5.49	3.70
Malir	10.20	7.09
Total	67.19	50.03

About 1340 households of the surveyed are worst affected. Again a good proportion of the worst affected households live in the Central and East implying the severity of the electricity crises in these two districts. The data on electric theft in the neighborhood shows that problem of electricity theft is also rampant in the Central and the East following Malir .It is also established by the KESC which reports that central and district east has the highest rate of late electricity payment and electricity theft[25].

5.1 Implications of Electricity Crises

The electricity crises has affected all types of individuals such as working, non-working, students, aged household members, housewives and children. The magnitude of impact varies from person to person. Table 8 presents implications, perceptions and households' reaction over prevailing electricity crises. The work impact of load shedding varies by job as the worst affected are private employees

[25] www.kesc.com.pk

which are 42.07 percent following own business 16.29 percent, government 13.60 percent and retirees or unemployed 3.79 percent. The variable "Daily Targets" combines the responses of the interviewed households on three important missed daily tasks i.e. Like reaching office in time, pick and drop of children to school and meeting with the doctor's appointment .The Households whose these three tasks are badly affected are 62.50 percent whereas 11.01 percent households report that they could not accomplish the third task only.

Electricity load shedding has adverse impact on the family budgets as 68.01 percent household reported increase in the expenditure on electricity alternatives such as ups, generator from the last year. Similarly, prolonged load shedding has also resulted into diseases like depression, behavior disorder and Narcolepsy[26] in the population. Especially the working age males and females are severely affected as 45.03 percent households (working heads) reports increase in medical expenditures due to the persistent problem of load shedding and sleeplessness. The proportion of the household members who could not perform well in their exams—as matric and intermediate exams are held during the months of April and May in Karachi, are 60.12 percent of the total.

Table-8: Implications, Perceptions and Reaction of Electricity Crises Affected Households

Variables	All households	Male headed households	Female headed households
Implications			
Work impact	73.13	88.59	11.41
Daily targets	62.50	84.53	15.47
Impact on study	60.12	54.01	8.11
Increase in expenditures on alternatives	51.02	58.52	41.06
Increase in medical expenditure	45.03	47.01	55.99
Participation in ceremonies	77.06	46.06	53.94
Electricity theft by neighborhood	68.65	86.93	13.07
Street crimes	55.52	86.62	13.38
Voting behavior in 2013 general elections	77.69	88.11	11.89
Perceptions			
Magnitude of the crises in last five years	89.15	89.43	10.57
Role of the last government	87.83	87.65	12.35
Increase in electricity prices	89.16	78.01	21.99
Electricity crises on Election manifesto ,2013	34.01	31.22	2.85
Reaction			
Passive	78.47	82.16	17.84
Protest in media	13.50	87.82	12.18
Protest in streets	16.63	93.01	6.99

The load shedding specially during the night time has contributed in the perpetration of street crimes in Karachi as darkness provides opportunity to criminals to commit crime without exposing their identity. The data reveals that 55.52 percent of the households agree with this opinion. However the female headed households are less vocal in reporting the impact on electricity theft and street crimes

[26] Severe kind of sleep disorder. Households were asked to report sleep disorders and their visit to hospital for treatment due to load shedding in past three months,26 percent of the working households reported severe sleep disorder.

than male headed households as 86.93 percent of the male headed households perceived an increase in electricity theft due to load shedding, while only 13 percent females consider load shedding responsible for it. Similarly, 88 percent male headed households find load shedding as an important factor in shaping their opinions for voting in the 2013 general elections, whereas only 12 percent females reported that political opinion was influenced by the load shedding. This shows that despite the high proportion of highly qualified females (surveyed heads) which are more than 60 percent of the female headed households and women work participation (77 percent), females' political opinion was not significantly affected.

The data collected on the perceptions about the electricity crises and its determinants revealed that 31 percent of the households viewed increase in the problem by multiple times in the last five years, 46.60 percent found increase, and only 9.25 percent opinioned no change in the situation over the last five years. Over 88 percent of the households held past governments responsible for this—as no effective role was played by the previous governments to attract investment in the energy sector of Pakistan. Pasha (2010) and Asif (2011) have also established that a decline in the share of power sector in public sector programmes to an extent of less than 3 percent and the failure on the part of previous governments to timely react to the situation have led the country into a severe electricity crisis. About 89 percent of surveyed households held increase in the electricity prices as a reason for multiplying the problem of load shedding as more people have resorted to electric theft. Finally, the households were asked to report their reaction in the last two months against load shedding, the majority of the households (78 percent) did not complain against crises at any forum. However, 16 percent of the heads of households reported participating by themselves or any of their family members in the street protests against the power outages.

5.3 Coping Strategies

Households vary in capabilities in resorting to coping strategies in the event of any economic crises due to differences in economic and demographic characteristics. The data collected from the household energy survey reveals that the households having income above the mean have more chances to avoid electricity crises by using electricity alternatives—as 59 percent of high income group resorts to UPS and 82 percent use generators during load shedding. Similarly, 91.7% households headed by male could afford generators more frequently as they can arrange fuel (oil or gas). They can also afford maintenance conveniently than female headed households (see Figure 6). Figure-5 displays use of electricity alternatives during load shedding by all households. About 40 percent of the households—82 percent of which are below the average level of income, cannot afford any alternative arrangement during electricity load shedding and hence bear the brunt of load shedding. Figure-6 shows that only 7.48 percent of the households can afford both UPS and generators.

Figure-5: Use of Electricity Alternatives during Load Shedding by All Households

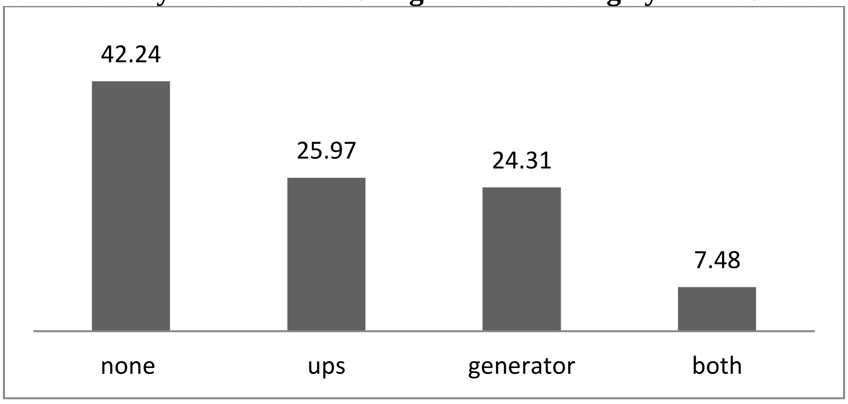
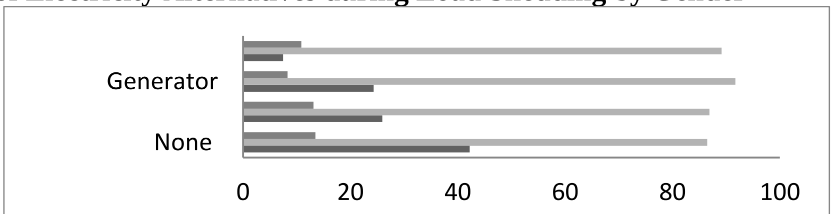


Figure-6: Use of Electricity Alternatives during Load Shedding by Gender



	None	Ups	Generator	Both
Female headed	13.51	13.12	8.29	10.83
Male headed	86.49	86.88	91.7	89.17
All	42.24	25.97	24.31	7.48

5.4 Determinants of Electricity Crises

The model estimated in this section is based on the data collected during the month of May 2013 from households on the important variables which could affect the extent of sufferings from electricity crises. The variables include real income[27] (total expenditure used as proxy for income), marital status, working age household members, job type, and number of dependents in the household, electricity expenditure, neighbor's electricity theft, location of the household's residence (district), energy economizing behaviors, and electricity prices[28].

***5.4.1Modeling Determinants of Electricity Crises*:** The present study defines shock affected household[29] as a binary variable (0 or 1) which assumes the value 1 ($Y_i = 1$) if the household has suffered from any electricity load shedding in the specified period (week prior to interview

27 Sum of food and nonfood expenditure converted in to real total expenditure by dividing the nominal total expenditure computed from household energy survey by the consumer price index for May 2013 .

28 Most of the electricity consumers (50 percent of the data) consume 300-700 units/kWh per month and hence pay 12.83 per kWh.

29 The data from household energy survey show that 96.7 % households suffer from 4 to 11 hours of load shedding in Karachi during March to May 2013.

conducted) and zero ($Y_i = 0$) if the household has not suffered from any power interruption .The econometric specification may be given by the standard linear model as

$$Y_i = \alpha_0 + \sum_{j=11}^{k} \beta Z_i + \varepsilon_i ....(5.1)$$

The Equation (5.1) assumes that $\varepsilon \approx N(0,\sigma^2)$, other assumptions underlying equation (5.1) are exogenity, linearity and no multicolinearity. If all these assumption continue to hold, the estimated model (known as LPM, linear probability model) gives unbiased estimates of β .Since the dependent variable is a binary variable (residuals cannot be normally distributed) and the model uses cross sectional data(hetrosediasticity cannot be ruled out)[30]. The better way to model this data is to assume that the variables ($z_{1............}z_k$) influence the probability that $Y_i = 1$ through some appropriate form of linear function in Equation (5.1), the simplest function that could be of this type is the Logit function Which assumes that

$$P(Y = 1|z_i.......z_k) = \frac{\exp(\alpha + \sum_{j=1}^{k} \beta_j Z_j)}{1 + \exp(\alpha + \sum_{j=1}^{k} \beta_j Z_j)} ....(5.2)$$

In Equation (5.2), P_i shows the probability of getting affected by the electricity crises (defined in terms of load shedding). Under this specification, the probability of not getting affected from electricity breakdown is written as

$$P(Y = 0|z_i.......z_k) = 1 - \frac{\exp(\alpha + \sum_{j=1}^{k} \beta_j Z_j)}{1 + \exp(\alpha + \sum_{j=1}^{k} \beta_j Z_j)} = \frac{1}{1 + \exp(\alpha + \sum_{j=1}^{k} \beta_j Z_j)} ....(5.3)$$

For the estimation of the parameters from the data set ($y_i, z_{1i}.........z_{ki}$) and $i = 1,2...........n$, it is assumed that all or n samples are independent, the joint probability of the observed values ($y_1.........y_i$) is

$$P(y_1.............y_n) = \Pi_{i=1}^{n} P(Y_i = y_i | z_{1i}...........z_{ki}).................(5.4)$$

Now by substituting Equation (5.2) and Equation (5.3) in place of each parameter on the right hand side of equation (5.4), the probability can be given as an explicit function of the known parameters ($\alpha\ , \beta_1........\beta_k$). The resulting function is likelihood function for ($\alpha\ , \beta_1........\beta_k$) given ($y_1.........y_i$), that can be given by

$$L(\alpha, \beta_1........\beta_k | y_1........y_n) = \Pi_{i=1}^{n} \left\{ \left[\frac{\exp(\alpha + \sum_{j=1}^{k} \beta_j Z_j}{1 + \exp(\alpha + \sum_{j=1}^{k} \beta_j Z_j} \right]^{yi} \left[\frac{\exp(\alpha + \sum_{j=1}^{k} \beta_j Z_j}{1 + \exp \sum_{j=1}^{k} \beta_j Z_j} \right]^{1-y_i} \right. \quad (5.5)$$

[30] See Jefrey M. Wooldridge, Econometric Analysis of Cross Section and Panel Data, The MIT, Cambridge, Massachusetts London, England

When $y_i = 1$ it follows that $1 - y_i = 0$ and the term in brackets reduces to Equation (5.2). Conversely, when $y_i = 0$ it follows that $y_i = 1$ and the term in brackets then reduces to Equation (5.3). The parameters obtained from the estimation of the Equation (5.5) will be maximum likehood estimates of $\alpha\ , \beta_1 .... \beta_k$ for the logistic regression .The results of the estimation of the Equation (5.5) are reported in sub-section 5.4.2.

5.4.2: Results of the Logit Model Given Above**:** The results are given in Table-9 of only those variables which are significant. Variables like dwelling type, government role, real per capita income, assets (iron, washing machine & electric water motor), protest through media, household members with age above 60, marital status and job types were finally excluded from the model for being statistically insignificant. The 2nd column gives log odd ratios (coefficients) and the 3rd column presents odd ratios. The log odds with negative sign such as electricity expenditures, protest in streets, coping strategies and energy saving imply negative relationship between log odd ratios and the probability of getting affected by the electricity load shedding. The odds ratio (0.27) for gender suffering from electricity crises implies that males are only 0.27 times the odds of females to suffer from the electricity crises. It can also be established from the ability to use alternative arrangements during load shedding by gender, see Figure 6. Households who have air conditioners have odds 1.95 times of the odds of households who do not use air-conditioning. The odds of district central (only statistically significant district found) implies that households who live in the district central have odds of suffering from electricity crises twice the odds of those households who live in other districts .The odds of suffering from electricity crises are 0.22 given household resorts to alternative arrangements during load shedding compared to households with no such arrangements. Similarly the odds for street protest is 0.46 implying that households have odds of 0.46 of getting disposed to electricity crises given they come out on the street and protest compared to households who remained passive.

Table-9: Estimates of the Determinants of Electricity Crises at Household Level

Variables	Coefficient	Odd ratios	S/E
Intercept	-2.92		1.39
District (central)	0.71	2.03	0.32
Working Age households	0.24	1.27	0.11
Electricity expenditure	-0.63	0.53	0.28
Number of dependents	0.46	1.58	0.18
Damages to electric appliances	1.50	4.48	0.21
Electricity theft	0.53	1.69	0.26
Protest in streets	-0.76	0.46	0.35
Coping strategies	-1.21	0.22	0.34
Energy saving	-0.73	0.48	0.19
Number of household members	1.19	3.28	0.45
Ownership of air conditioner	0.67	1.95	0.32
Gender	-1.3	0.27	0.19
Log like hood	-255.66		
LR Chi2(12)	76.29		
Probability >Chi2	0.00		
No of obs	2000		

Note: all coefficients are significant at 5%

6. Conclusion

This article analyses the information collected from the energy survey of household from all five districts of Karachi in 2013 .The findings of the study suggest that demand for electricity depends on the holdings of electric modern appliances which have become necessity rather than fashion due to increasing female participation in labor force in urban areas .Other households' economic and social characteristics are also important in determining the electricity consumption through end use demand like family and dwelling size, number of dependents, age of household members, income, energy saving behavior and marital status of the head of the household. Similar factors also determine the magnitude of the suffering from electricity crises also. On top of that, the prevalence of illegal connections and power theft have compounded the impact of household suffering by causing damages to transmission lines which resulted in low or high voltage problem for those who are not involved in such theft .

The calculation of losses incurred in terms of work loss, studies, income, assets and health at the household level is sufficient to raise concerns about the significance of the neglected areas in government energy policies. Given the findings of the study, it may be suggested that the need of the hour is to focus on demand side management and for that investment in the production of energy efficient appliances should be encouraged through economic policies. Households should be motivated through media campaign (electronic and social media can be used for this purpose specially) to use all means to conserve energy at the household level. The most important is the need for the legislation of the law which regard power theft (tampering with meter or transmission lines) a criminal offense or such act of crime should be considered as unbailable like that enforced in India where "2003 Electricity Act" has reduced power losses to 40 percent from power theft in New Delhi.

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