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AN INVESTIGATION INTO ELECTRICITY CONSUMPTION: A HOUSEHOLD LEVEL STUDY

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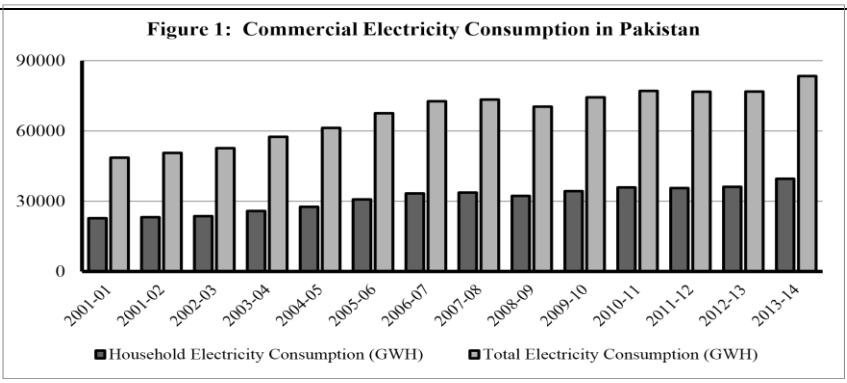
ABSTRACT

Electricity is one of the key sources and has a vital role in the economic development of a country large number of industrial units are hosed on electricity and it is the chief source of energy for households. The improvement in technology had increased the demand for electricity many folds and consequently, its shortfall is observed. It is alarming that the shortfall is increasing over time. The present study is based on the empirical analysis of electricity consumption at the household level. The main objective of this study is to explore the household determinants of electricity consumption. In this regard, we analyzed the effect of temperature, hoe size, members, income, region, and price of electricity on its consumption. The study is based on the latest available micro data set of the Household Integrated and Economic Survey (HIES 2013-2014) comprising of 17,989 households. Two models are estimated in this study. In the first model, we used OLS to find out the average effect of different explanatory variables on electricity consumption; the result shows the positive effect of household size, house size, and number of air conditioners and refrigerators on electricity consumption, while it shows the negative effect of the average price of electricity and temperature on electricity consumption. In the second model, we compare the consumption pattern of household electricity among different groups using the Multinomial Logit Model. The result showed that house size, household income, and month dummy have a positive effect on electricity consumption, while household size, average monthly temperature, and heating degree days show a negative impact on electricity consumption. The interesting phenomenon is that the increase in the average price of electricity leads to an increase in the consumption of electricity in higher-income groups relative to low-income groups.

1. INTRODUCTION

Electricity is one of the most important sources of energy. Nowadays life is almost impossible without electricity (Bernat and Desideri, 2018; Quaschning, 2019). Electricity is considered as the backbone of industrial and agricultural development, as most of the industrial and agricultural units are operated with electricity. The need of electricity for households is much unavoidable, as they by-large do not have alternative options. The situation is too alarming in Pakistan where load shedding (at household level) is observed from 6 to 8 hours a day (Naseem et al., 2020; Butt et al., 2021). This indicates a huge shortfall in supply of electricity. Figure 1 summarizes the pattern of household electricity consumption in Pakistan.



Source: Economic Survey (2013-14)

During the last 13 years, the total electricity consumption (commercial) has increased 71.7 percent. This increase is 73.7 percent for households indicating that household consumption is growing more rapidly. The statistics further reveal that on average 46 percent of the total electricity is consumed by households. Since households are the major consumers of electricity, therefore it will be worthwhile to analyze the household level determinants of electricity consumption. The present study is an attempt to explore the determinants of electricity consumption for households.

After independence, Pakistan had an overall electricity generating capacity of 60 MW and it increased in 1959 from 60 (Mega Watt) MW to 119 MW after the establishment of (the Water and Power Development Authority) WAPDA (Sibtain et al., 2021; Zhang et al., 2023). To strengthen the economy and power sector WAPDA started new projects of thermal and hydel power for the generation of electricity. After five years of hard work and consistency, WAPDA increased the electricity generating capacity from 119 MW to 638 MW. The electricity crisis started in the 1980s. To overcome or remove the gap between demand and supply, the government initiated a few steps and built a Mangla dam which raised the electricity generating capacity to 1331 MW.

A large number of studies (Ali et al. 2021; Sharma et al., 2019; Imran et al.2019; Zi et al.2021; Abbasi et al., 2021) are conducted to examine the pattern and determinants of electricity consumption by households. However, most of the studies are confined to developed economies. In this regard studies by (Chunekar, A. and Sreenivas, (2019); Ali et al., 2019; Sharma et al.2019; Imran et al.,2019) are important. A few studies (Jan et al., 2012; Abbasi et al., 2021; Idrees et al.,2013; Hussain et al.,2016) are conducted in Pakistan to estimate the demand for electricity using aggregate and sector-wise data at the national level as well as household, commercial, industry and agriculture sector. The consumption of electricity does not depend on the price of electricity alone.

Different socio and economic variables also affect the consumption of electricity like the income of the household, the number of people living in a house, own price of electricity, electric appliances, and most important the climate of the country. In a country like Pakistan climate is not the same in all the regions, and electricity consumption varies with the change in the temperature. An increase in temperature during summer months or hot day cause a rise in the usage of electric appliances like air conditioner and air cooler for cooling purpose. There are different sources of energy like oil, firewood, kerosene oil, gas, and electricity, out of this electricity is much more important and it has no close substitute. For the last 20 years, Pakistan is facing the problem of load shedding and electricity crisis, and trying to eliminate the gap between demand and supply of electricity. An increase in frequent load shedding and electricity shortage directly affect the industrial, commercial, services, and household sector, but normally industries and commercial sectors are considered to be stable and use alternative/substitute for electricity like generators, but in the household sector, most of the household doesn't have the purchasing power to afford generators and other substitutes for electricity.

The empirical analysis of electricity consumption/demand has always been a great issue

for the researcher. This issue gained much popularity during the last few decades and especially in countries like Pakistan which are facing a huge shortfall in electricity. In this regard earlier literature on electricity consumption can be broadly classified into two groups. First at an aggregate level and Second at the disaggregate level. Most of the studies are conducted at the aggregate level to find the determinants of electricity consumption.

The prime objective of the present study is to explore the household determinants of electricity consumption and analyze the effect of temperature on electricity consumption.

- First to analyze the average effect of different explanatory variables on household electricity consumption.
- Second we shall divide the household into five groups (based on the consumption of electricity) and compare the difference across groups.

With the passage of time demand for electricity increases due to rapid development, and modernization. 20 years back the demand for electricity in the household sector was not so high, but nowadays it is increasing day by day because of the latest machinery and technology used by households. Unfortunately, the supply of electricity is not increasing, due to which there is a gap between demand and supply. So there is a need for a micro-level study in which the determinants of household electricity consumption like household size, house size, temperature, and another socio-economic variable will be discussed.

2. DATA SOURCE AND PERIOD OF ANALYSIS

The prime data used in the present study is the Household Integrated Economic Survey (HIES) for the year 2013-2014 conducted by the Pakistan Bureau of Statistics, Statistics Division, and Government of Pakistan. The survey is being conducted with different time intervals comprising a detailed micro-level data set containing information on age, gender, education, health status, house size, and members. The HIES data is collected through a questionnaire. The questionnaire is designed in such a way as to obtain information at the household and individual levels. The questionnaire consists of different sections and each section provides specific information about households and household members. The detail of the sections questionnaires is given in Appendix A. The HIES of 2013-14 contains information on 17,989 households comprising 1, 19,018 individuals. HIES contains detailed information on all required variables except temperature. The data on temperature is collected from Pakistan Metrological Department (PMD).

3. ANALYTICAL FRAMEWORK AND ECONOMETRIC MODELS

We shall carry out two types of analysis; *first,* the quantity of electricity demanded will be regressed on different variables. In the *second* part of our analysis, we shall divide the household into five groups (based on the consumption of electricity) and compare the difference across groups.

3.1 METHODOLOGY EMPIRICAL ANALYSIS OF HOUSEHOLD ELECTRICITY CONSUMPTION

The prime objective of the present study is to explore the role of household characteristics and socioeconomic variables on the consumption of electricity, i.e., how household income and other characteristics affect the decision of electricity consumption. In this regard, we shall carry out two types of analysis. First, we shall consider the exact units of electricity consumption as the dependent variable. This will enable us to know how each explanatory on average affects household electricity consumption. In the second part of our analysis, we shall divide households into four groups. The grouping will be based on the units of consumption. The purpose is to compare the behavior of these groups. A detailed discussion is presented below:

3.1.1. Considering Exact Unit of Electricity Consumption as Dependent Variable

The dependent variable in our model is household electricity consumption. As we know that consumption of electricity does not depend on temperature alone, control variables like household income, house size, household size, and the average price of electricity are also very important in determining the consumption of electricity. A huge review of the literature suggests a number of factors that determine the demand for electricity. The energy demand is a function of several factors such as Household income, household size, house

size, electric appliances, price of electricity available technology, the structure of the economy, and temperature (Brounen et al.,2012; Fumo et al.,2015;Hu et al.,2017;Singh et al.2018). In HIES data we have information available on total the spending of households' electricity consumption, from total spending, we calculate exact the quantity of electricity consumed. We analyze our model by incorporating temperature variables three ways: heating degree day (HDD), average monthly temperature (AVT) and month dummy (MD). The residential demand for electricity is quite different from commercial or industrial demand sectors. Following Xiao *et.al.*(2007), Zarnikau (2003) and Idrees *et.al* (2012) we formulated following model:

$$logE_i = \beta_0+\beta_1 PE_i + \beta_2 HY_i+\beta_3 HHS_i+\beta_4 HS_i+\beta_5 TEMP_i+\beta_6 AC_i+\beta_7 REF_i+ \beta_8 REG_i+ \mu_i \quad (3.1)$$

Where,

E_i = Electricity consumption by *ith* household, measured in KWU

PE_i = Average unit price of electricity for *ith* household. It is obtained by dividing total expenditures on electricity with the quantity consumed.

HY_i = Monthly income of *ith* household. It is measured in '000' rupees.

HHS_i = Household size. It is expressed as number of members in *ith* household.

HS_i = House size. It is measured in terms of number of rooms in *ith* household.

$TEMP_i$ = A variable capturing temperature. It is measured in following three ways heating degree days (HDD), average monthly temperature (AVT) and month dummy (MD).

AC_i = Number of Air Conditioner owned by *ith* household.

REF_i= Number of refrigerator and freezer owned by *ith* household.

REG_i = Dummy variable for region. It is '1' for rural area and 0 for otherwise.

In the log-linear model coefficient explains the proportionate change in the dependent variable due to a one-unit change in the explanatory variable. In these analyses, we will get the average mean effect of each variable. For instance, the coefficient of HY_i would give the average proportionate change in electricity consumption for *ith* household due to one unit (one thousand) change in the average monthly income of the household. This information is quite useful but fails to explain the difference in the behavior of bulk users (of electricity) and small users. Therefore, we shall carry out another analysis to explore the difference in the attitude of bulk and small consumers.

3.2.2. Considering Groups of Electricity Consumption

Groups	Electricity Consumption (KWU)	Proportion of Households
1	0 – 40	31.5percent
2	40.001 – 80	14.9percent
3	80.001 – 120	16.8percent
4	120.001 – 160	12.4percent
5	More than 160	24.4percent

The purpose of the previous model was to estimate the average effect of each variable on household demand for electricity. For comparative analysis, based on the consumption of electricity we shall divide households into five consumption groups. The grouping is summarized in Table 4.1. **Table 4.1. Household Grouping with Respect To Electricity Consumption**

In this case the dependent variable shall take the form of categorical variable (1,2,3,4,5) and it can be estimated through Multinomial Logit model, because the dependent variable has more than two groupings. This analysis will enable us to study the relative difference in behavior of households across groups regarding the role of explanatory variables in determining electricity consumption.

We shall repeat our analysis by incorporating Heating Degree Days (HDD), Average temperature (AVT), and Monthly Dummy (MD) in the model one by one for overall Pakistan and compare the consumption pattern of four groups with the reference group. In this regard equation 4.1 will be re-estimated by considering the dependent variable with values 1 to 5. As the dependent variable has numerical values ranging from 1 to 5, therefore we shall estimate Mlogit Model. Now we shall explain the Multinomial Logit Model.

3.2.3 MULTINOMIAL LOGIT MODEL

The multinomial logit regression (MLOGIT) model is an extension of the logistic regression model, generally proposed by Nerlove and Press

(1972) for the estimation of unordered choices. It is commonly used to forecast the probabilities of a categorical dependent variable based on an explanatory variable. Like the logistic regression model [(Ordered logit (Ologit), Generalized logit model (GOLOGIT)], the Multinomial logistic regression model also use a maximum likelihood (ML) estimator to predict the probabilities of categorical variable. The multinomial regression model is based on the assumption of independence of irrelevant alternatives, concluding that the choice of one class or group is not associated/connected to another group or class. In the present study we defined our model as follow:

$$logE_i = \beta_0 + \beta PE_i + \beta_2 HY_i + \beta_3 HHS_i + \beta_4 HS_i + \beta_5 TEMP_i + \beta_8 REG_i + \varepsilon_i \quad \textbf{(3.2)}$$

To compare the electricity consumption between different groups we use the Multinomial logit model because, on the dependent side, we have a categorical variable, and if we apply OLS then it gives us biased results. If the dummy variable is in a continuous form on the dependent side it can be estimated through OLS, but if the dummy variable is in discrete form (0,1) then it can be estimated through the logit-Probit method. But here we have dummy variables in categories (*1, 2, 3, 4, 5*), so we use the Multinomial logit model instead of logit-Probit model.

4. RESULTS & DISCUSSION

4.1 RESULTS OF LOG-LINEAR MODEL

In this section we will discuss the result of log-linear model obtained from using Ordinary Least Square (OLS). In the first model we shall explain the result for overall Pakistan including heating degree days. HDD refers to a situation during the days' temperature is above 34°c. In the Second model we shall discuss the result incorporating average monthly temperature (AVT) as a proxy variable for temperature, while in third table we shall explain the result after replacement of HDD and AVT with month dummy (MD). The results are presented in Table 4.1.

Table 4.1 Results of Log-Linear Model

Variables	Model: 1 (with Heating Degree Days)		Model: 2 (with Average Temperature)		Model: 3 (with Monthly Dummy)	
	Coefficients	t-stat	Coefficients	t-stat	Coefficients	t-stat
C	1.904447	189.87	1.896853	156.07	1.8958	190.02
Household Size	0.0109	13.04	0.0109	13.04	0.0109	13.04
House size	0.0399	18.10	0.0405	18.45	0.0405	18.45
Price of Electricity	-0.0420	-49.96	-0.0420	-49.90	-0.0420	-49.90
Household Income	0.0042	9.87	0.0042	9.88	0.0042	9.87
Heating degree days	-0.0008	-3.65	----	----	----	----
Average Temperature	----	----	-0.0000	-0.07	----	----
Month dummy	----	----	----	----	0.0011	0.21
Air conditioner	0.0855	10.63	0.0847	10.52	0.0847	10.53
Refrigerator	0.2473	44.36	0.2475	44.33	0.2476	44.38
Region	0.2089	37.22	0.2070	36.86	0.2070	37.02

Source: Author own calculation

The sign of all the explanatory variable are statistically significant and have positive impact on electricity consumption, while coefficient of heating degree day and month dummy have

significant effect on electricity consumption in all the three model, except average monthly temperature. In all the three models the coefficient of household size (HHS) is statistically significant and positive its means that if the HHS or number of person living in house increase it have positive effect on electricity consumption, its value is 0.0109 tells us that if the HHS size increase by one-unit or household/members increase by one-person it will lead to an increase of electricity consumption by 1.09 percent. The results are in line with those of other research (Yalcintas and Kaya, 2017; Sovacool et al., 2018; Moser et al., 2018), demonstrating that, an essential consideration for assessing residential power usage is "household size (HHS)". This is thus since the quantity of electricity used and household size are strongly correlated. Larger Household size houses use much more electricity. In contrast, Huang (2019) and Yang et al., (2020) argued that smaller households' utilize more power on an individual's level as a consequence of the decline of scale economies, as a result, the coefficients value of household size is strongly positive, indicating that adding a new family member potentially lead to a substantial rise in the quantity of power consumed overall.

The variable house size (HS) is positive and have significant impact on electricity consumption in all three model, while magnitude of House size is different in all models. In the model 1 the variable House size has value of 0.0399 indicates that if the HS increases or increase in one room will cause the electricity consumption to rise by 3.99 percent. In model 2 and 3 the House size is highly significant and have positive value shows positive impact on consumption of electricity, its value is 0.0405 explain that increase in House size cause to rise the electricity consumption by 4.05 percent.

The coefficient of Price of electricity (PE) has a negative value in all three models and it is statistically significant and shows negative effect on electricity consumption. In all the three models the coefficient PE has value of -0.0420 indicates that if the price of electricity rises by one-unit electricity consumption decrease by 4.20 percent. Similarly, other scholars (Gasealahwe 2020; Wang and Yang (2019) uncovered a negative association between energy consumption and prices with in domestic sector. The variable household income / Per capita income is statistically significant and has positive sign in all the three models, indicates that if the income of the household increases its purchasing power increases and its consume more goods and services as compared too previous. The household income or per capita income has a value of 0.0042 tell us that if the household income or per capita income increases by one thousand rupees it will lead to rises the electricity consumption by 0.42 percent. In model 1 coefficient of heating degree days is highly significant but have negative impact on electricity consumption. The coefficient heating degree days is -0.0008 indicates that increase in one more heating degree days will lead to decrease the consumption of electricity by 0.08 percent.

The difference between three models is that we replace Heating degree days (HDD) with average monthly temperature (AVT) and month dummy (MD). The replacement of HDD with AVT and MD effect the sign and magnitude of the coefficient in both model. However, the interpretation for both coefficients AVT and MD are different. In Second model the coefficient AVT is statistically insignificant and have negative value shows adverse effect on electricity consumption. The coefficient of AVT is -0.0000 tell us that if the average monthly temperature increases by 0.1°c than there will be no effect on electricity consumption. While in third model coefficient of Month dummy is 0.0011 states that in the summer month the household consumption for electricity increases by 0.11 percent as compared to winter months. The coefficient AC is positive and statistically significant in all models showing significant and positive impact on consumption of electricity. In first model the coefficient AC is 0.0855 states that if air conditioner increases by one unit or number of air-conditioner owned by household increases by one it will lead to increase the electricity consumption by 8.55 percent. In second model the coefficient of AC is 0.0847 tell us that increase in one unit of Air conditioner will lead to increase the consumption of electricity by 8.47 percent. As compared to first and second model the coefficient of AC is positive in third model also showing that increase in one unit of AC will lead to rise the consumption of electricity by 8.47 percent.

The coefficient of refrigerator has positive sign and highly significant effect on electricity consumption, while the magnitude is almost same in all three models. In First model the coefficient

refrigerator has 0.2473 value tells us that if the ownership or usage of refrigerator by household increase by one unit its causes 24.73 percent rise in electricity consumption, while in Second and third model refrigerator have value 0.2475 shows that increase in one unit of refrigerator or if the usage of refrigerator increases by household it will result in 24.75percent rise the electricity consumption. The coefficient region is statically significant in all models. In the first model the coefficient region is 0.2089 showing that the household living in urban areas can consume 20.89 percent more electricity as compared to household living in rural areas. As compared to first model in second or third model the coefficient region is highly significant and have value of 0.2017 respectively tells that the household living in urban areas he can consume 20.17 percent more electricity as compared to household living in rural areas. Similar to this, several studies (Zhou and Teng, 2013; Wang et al., 2021; Wang et al., 2017) found that urban residents use more electricity than rural residents.

4.2 RESULTS OF MULTINOMIAL LOGIT MODEL

In this section we will discuss the result of multinomial logit model. In the first model we shall explain the result for overall Pakistan including heating degree days. HDD refers to a situation during the days' temperature is above 34°c. In the Second model, we shall discuss the result incorporating average monthly temperature (AVT) as a proxy variable for temperature, while in third table we shall explain the result after replacement of HDD and AVT with month dummy (MD). Results of Multinomial model are presented in Table 4.2.

Table 4.2. Result of Multinomial Logit Model

Variables	Model: 1 (with Heating Degree Days)		Model: 2 (with Average Temperature)		Model: 3 (with Monthly Dummy)	
	Coefficients	Z value	coefficients	Z value	Coefficients	Z value
	Base category: Group 1					
2 Constant	-2.1365	-21.92	-2.3142	-19.42	-2.238641	-23.22
Household size	-0.0088	-0.94	-0.0103	-1.11	-0.0100905	-1.08
House size	0.2611	10.04	0.2727	10.52	0.2722327	10.5
Price of Electricity	0.0960	11.64	0.0965	11.71	0.0963865	11.7
Household Income	0.0718	5.62	0.0698	5.48	0.0697455	5.47
Heating degree days	-0.0103	-4.51	------	------	------	------
Average Temperature	------	------	0.0038	1.16	------	------
Month dummy	------	------	------	------	0.025881	0.51
Region	1.0734	16.61	1.0456	16.22	1.052178	16.35
3 Constant	-2.5836	-27.44	-2.6984	-23.46	-2.740268	-29.36
Household size	0.0253	2.84	0.0238	2.68	0.0238057	2.67
House size	0.4247	17.40	0.4378	18.00	0.4385433	18.03
Price of Electricity	0.0550	6.84	0.0555	6.91	0.0548662	6.82
Household Income	0.1242	10.47	0.1223	10.34	0.1216538	10.27
Heating degree days	-0.0129	-5.73	------	------	------	------
Average Temperature	------	------	-0.00009	-0.03	------	------
Month dummy	------	------	------	------	0.1316372	2.63
Region	1.6095	26.42	1.58148	26.04	1.586348	26.16
4 Constant	-4.1736	-35.75	-4.27983	-31.06	-4.356033	-37.48
Household size	0.0691	7.13	.067916	7.02	0.0677495	7
House size	0.5236	20.08	.5401807	20.79	0.5406631	20.81

Price of Electricity	0.1128	10.62	.112657	10.63	0.1122326	10.58
Household Income	0.1730	14.38	.171085	14.26	0.170698	14.22
Heating degree days	-0.0184	-7.05	------	------	------	------
Average Temperature	------	------	-.00237	-0.66	------	------
Month dummy	------	------	------	------	0.0858728	1.5
Region	2.0503	31.51	2.01386	31.06	2.01379	31.12
5 Constant	-5.9834	-48.66	-6.000993	-42.91	-6.076608	-49.61
Household size	0.1143	13.06	.1131167	12.93	0.1129818	12.92
House size	0.7015	29.74	.726809	30.33	0.7266936	30.33
Price of Electricity	0.2376	21.57	.23824	21.64	0.2379836	21.62
Household Income	0.2276	20.05	.225953	19.96	0.2257004	19.93
Heating degree days	-0.0109	-4.68	------	------	------	------
Average Temperature	------	------	-.00396	42.10	------	------
Month dummy	------	------	------	------	-0.0169085	-0.32
Region	2.5704	42.27	2.55302	38.04	2.546632	42.11

Source: Author own calculation

The result for the above model states that in four groups all the variables are statistically significant and have positive impact on electricity consumption except household size/members in first group, while the variable HDD is statistically significant but has a negative effect on electricity consumption.

In the second group household size is statistically insignificant and has a negative value indicating negative effect on electricity consumption. The coefficient HHS is -0.0075 tells that if the number of person living in house increase by one person, or if the variable household size increase by one-unit, the multinomial log odds for electricity consumption of second group relative to first group would be expected to decrease by 0.0075 units, while holding all other coefficients in the model constant. As compared to Second model the coefficient household size is -0.0103 indicates that if the household size/members increase by one person the multinomial log odds for electricity consumption of second group relative to first group would be expected to decrease by 0.0103 units, keeping all other variables constant, While in third model the coefficient household size is 0.0100 tells that if the household size increases increase by one person the multinomial log odds for electricity consumption being in second group relative to first group is expected to decrease by 0.100 units, keeping other things constant.

The coefficient house size is highly significant and have positive value indicating positive effect on electricity consumption in all the three model. In first model the variable house size is 0.2611 indicates that if the house size increase by one room the multinomial log odd for electricity consumption being in second group relative to first group is expected to increase by 0.2611 units, keeping all things constant. While in second and third model the coefficient house size has value of 0.2727 and 0.2722 indicates that if the house size increases by one room it will result in increase in 0.2727 and 0.2722 units in electricity consumption for second group relative to first group, keeping all coefficient constant.

The coefficient of price of electricity is statistically significant and has a positive effect on electricity consumption, if the coefficient price of electricity increases by one-unit the multinomial log odds of electricity consumption for second group relative to first group would be expected to increase by 0.0960 units. While in second and third model the variable price of electricity is 0.0965 and 0.0963 tells that increase in one-unit price of electricity will result in 0.0965 and 0.0963 units increase in electricity consumption in second group relative to first group keeping all variables in the model constant.

The coefficient of household income or per capita income is statistically significant and positive effect on consumption for electricity in all three model. The coefficient of household income or per capita income is 0.0718 tells that if the household income or per capita income increase by one thousand rupees, the multinomial log odds for electricity consumption in second group relative to first group would be expected to increase by 0.718 units, while in second and third model the variable

household income or per capita income is 0.0698 and 0.0697 respectively indicates that if the household income or per capita income increases by one thousand rupees the multinomial log odd for electricity being in second group relative to first group would be expected to increase by 0.0698 and 0.0967 units, keeping all things constant.

The coefficient heating degree has value of -0.0103 in first model indicates that increase in one more heating degree days will result in 0.0103 units decrease in consumption for electricity in second group relative to first group, keeping all other factors constant. These statistics contradict with those of Aktemur (2018), who reported that as the amount of cooling and heating degree days' rises, power consumption rises, and when the amount of both cooling and heating degrees days reduces, power consumption decreases. In second and third model replacement of heating degree days with average temperature and month dummy results in difference in sign and magnitude of the coefficients. In second model the coefficient average temperature is 0.0038 tells that increase in average monthly temperature will result in 0.0038 units increase in consumption for electricity in second group relative to first group. Whereas in third model the coefficient month dummy has value of 0.0258 show that in summer months the consumption of electricity increases in second group relative to first group, holding all other variables constant.

The variable region is highly significant in all the three model and have positive effect on consumption for electricity. The coefficient of region is 1.0734 shows that if the household living in urban areas he can consume 1.0734 more-unit consumption for electricity in second group relative to first group. In second model the coefficient region is 1.045 tells that if the household living in urban areas, the multinomial log odds for electricity consumption for second group relative to first group would be expected to increase by 1.045 unit, holding all factors constant. While in third model the coefficient region is 1.052 indicates that if the household living in urban areas, the log odds for electricity consumption would expected to increase by 1.052 unit in second group relative to first group as compared to rural areas.

Moving from second group to fifth group the magnitude of the coefficient household size increases indicates that electricity consumption increases with increase in the household size. The coefficient of household size is 0.1143 tells that in rich families or bulk user of electricity increase in family size will lead to increase the electricity consumption in fifth group relative to first group in first model, while in second and third model the variable household size is 0.1131 and 0.1129 tells that if the household size increases by one room, the multinomial log odds for electricity consumption in fifth group relative to first group would expected to increase by 0.1131 and 0.1129 unit, holding other things constant. The magnitude of the coefficient house size also increases while moving from second group to fifth group. The coefficient of house size is 0.7150 tells that if the house increases by one room, it will lead to increase consumption of electricity by 0.7150 units in fifth group relative to first group. In second model the coefficient house size is 0.7268 shows that if the house size increase by one room, the log odds of electricity consumption for fifth group relative to first group would be expected to increase by 0.7268 units. While in third model the coefficient house size indicates that increase in house size or number of room will result in rise in electricity consumption by 0.7266 units in fifth group relative to first group holding all factors constant.

In first model moving from second group to fifth group the magnitude of the coefficient price of electricity is increasing indicates that in higher income groups the price of electricity does not affect the consumption pattern of household, thus the coefficient price of electricity have minor impact on electricity consumption. The coefficient price of electricity has value of 0.2376, 0.2382, and 0.2379 in group five for all the three model, indicates that if the price of electricity increases by one unit, the multinomial log odds of electricity consumption for fifth group relative to first group would be expected to increase by 0.2736, 0.2382 and 0.2379 units respectively in all three models. Same is the case for household income moving from second group to fifth group an increase in household income in higher groups will result in more use of electricity consumption in fifth group as compared to first group. While heating degree day, average monthly temperature and month dummy coefficient have negative sign but magnitude of the coefficient decreases while moving from second group to fifth group indicating

little impact on consumption for electricity. The magnitude of the variable region increases, while moving from second group to fifth group indicates higher impact on electricity consumption. It means that the household living in urban areas can consume more electricity as compared to rural areas in fifth group relative to first group, keeping all things constant. Now we shall explain results in the form of relative risk ratio, which are easily interpretable. The results are presented in Table 4.3.

The Table 4.4 shows the result of relative risk ratio of the multinomial logit regression model for the household consumption for electricity. The coefficient household size shows that it significantly affects the electricity consumption pattern in second group relative to first group. The relative risk ratio coefficient of household size is 0.9912, shows that if the household size or members increases by one person, keeping other variables constant, the relative risk or relative probability of consumption of electricity for second group to first group would be increased by 0.99 percent. This situation may happen because as compared with base group the consumption of electricity and household per capita income is high in second group, so the effect of increase in members is more as compared to first group. While in second and third model the coefficient household size is of 0.989 indicates that with an increase in household size or increase in one member, holding other things constant the relative probability of electricity consumption within group 2 relative to group 1 increase by 0.99 percent. Moving from second group to fifth group the magnitude of the coefficient household size is increasing showing more impact on electricity consumption. It is because in higher income household they consume high voltage electric appliances as compared to low income groups, so the effect of household size is much more than lower income groups.

Table 4.4. Results of Multinomial Logit Model in Relative Risk Ratios

Variables	Model: 1 (with Heating Degree Days)		Model: 2 (with Average Temp.)		Model: 3 (with Monthly Dummy)	
	RRR	Z value	RRR	Z value	RRR	Z value
1	Base category					
2 Constant	0.1180	-21.92	0.0988	-19.42	0.1066	-23.22
Household size	0.9912	-0.94	0.9896	-1.11	0.9899	-1.08
House size	1.2984	10.04	1.3135	10.52	1.3128	10.5
Price of Electricity	1.1007	11.64	1.1013	11.71	1.1011	11.7
Household Income	1.0744	5.62	1.0723	5.48	1.0722	5.47
Heating degree days	0.9897	-4.51	-----	-----	-----	-----
Average Temperature	-----	-----	1.0038	1.16	-----	-----
Month dummy	-----	-----	-----	-----	1.0262	0.51
Region	2.9254	16.61	2.8453	16.22	2.8638	16.35
3 Constant	0.0754	-27.44	0.0673	-23.46	0.0645	-29.36
Household size	1.0256	2.84	1.0241	2.68	1.0240	2.67
House size	1.5292	17.40	1.5493	18	1.5504	18.03
Price of Electricity	1.0566	6.84	1.0570	6.91	1.0563	6.82
Household Income	1.1322	10.47	1.1301	10.34	1.1293	10.27
Heating degree days	0.9870	-5.73	-----	-----	-----	-----
Average Temperature	-----	-----	0.9999	-0.03	-----	-----
Month dummy	-----	-----	-----	-----	1.1406	2.63
Region	5.0007	26.42	4.8621	26.04	4.8858	26.16
4 Constant	0.0153	-35.75	0.0138	-31.06	0.0128	-37.48
Household size	1.0715	7.13	1.0702	7.02	1.0700	7

House size	1.6882	20.08	1.7163	20.79	1.7171	20.81
Price of Electricity	1.1195	10.62	1.1192	10.63	1.1187	10.58
Household Income	1.1888	14.38	1.1865	14.26	1.1861	14.22
Heating degree days	0.9817	-7.05	-----	-----	-----	-----
Average Temperature	-----	-----	0.9976	-0.66	-----	-----
Month dummy	-----	-----	-----	-----	1.0896	1.5
Region	7.7706	31.51	7.4922	31.06	7.4916	31.12
5 Constant	0.0025	-48.66	0.0024	-42.91	0.0022	-49.61
Household size	1.1211	13.06	1.1197	12.93	1.1196	12.92
House size	2.0443	29.74	2.0684	30.33	2.0682	30.33
Price of Electricity	1.2682	21.57	1.2690	21.64	1.2686	21.62
Household Income	1.2557	20.05	1.2535	19.96	1.2532	19.93
Heating degree days	0.9891	-4.68	-----	-----	-----	-----
Average Temperature	-----	-----	0.9960	-1.2	-----	-----
Month dummy	-----	-----	-----	-----	0.9832	-0.32
Region	13.0718	42.27	12.8458	42.1	12.7640	42.11

Source: Author own calculation

The variable house size is highly significant and have positive impact on electricity consumption in all three models. The coefficient house size has value of 1.298, 1.313 and 1.312 in three model indicates that an increase in house size or if the house size increase by one room, the relative probability of electricity consumption within group 2 relative to group 1 increase by 1.298, 1.313 and 1.312 percent respectively. Moving from second group to fifth group the magnitude of the coefficient is increasing, showing high impact of house size on electricity consumption.

If the coefficient price of electricity increases by one unit, the relative probability of electricity consumption within group 2 relative to group 1 increase by 1.1007 percent, holding all variables constant. While in group 5 the coefficient price of electricity is 1.268 tells that if the price of electricity increases by one unit, the relative chance of electricity consumption within group 5 comparative to group 1 increase by 1.268 percent.

The coefficient household income is highly significant and positive effect on electricity consumption in all three models. If the variable household income or per capita income by one thousand rupees, the relative probability of electricity consumption for second group to first group would be expected to increase by 1.0774 percent. While in second and third model the if the coefficient household income or per capita income increases by one thousand rupees the relative risk for group 2 to group 1 of electricity consumption increase by 1.072 percent. Moving from group 2 to group 5 the magnitude of variable household income increase its means that in higher income groups the electricity consumption is more as compared to low income groups. Relative probability of household income or per capita income for group 5 to group 1 indicates that with an increase in household income or per capita income in thousand rupees' relative chance of electricity consumption for group 5 to group 1 will increase by 1.211 percent, holding all variables constant.

The coefficient heating degree days is highly significant and positive impact on electricity consumption. If the coefficient heating degree increases or more heating degree will result in relative increase in electricity consumption within group 2 to group 1. Moving from group 2 to group 5 the magnitude of the coefficient heating degree days' increase, it might be because in higher income groups or households with bulk user of electricity is more affected by heating days or hot days, thus in group 5 the variable heating degree days is 0.9891 tells that increase in one more heating degree day, relative probability of electricity consumption within group 5 to group 1 would be expected to increase by 0.989 percent. If the variable average monthly temperature increases, the relative probability of electricity consumption within group 2 to group 1 would be expected to increase by 1.0038 percent. As compared to group 5 the coefficient average monthly temperature tells that with an increase in average monthly temperature, the relative chance

of electricity consumption within group 5 relative to group 1 increase by 0.9969 percent. The coefficient of month dummy is 1.0262 shows that in summer months the consumption of electricity increases by 1.0262 percent in group 2 relative to group 1, keeping other things constant. While in group 5 the variable month dummy is 0.9832 indicate that in summer months the consumption of electricity increases by 0.9832 percent in group 5 relative to group 1 as compared to winter months.

The coefficient of region is 2.9524 tells that the relative chance of electricity consumption for household living in urban areas compared to rural areas would be expected to increase by 2.9254 percent. While in model 2 and model 3 the variable region has value of 2.845 and 2.863 tell that the relative risk of consumption of electricity for household living in urban areas compared to rural areas increased by 2.845 and 2.863 percent in group 2 relative to group 1. In group 5 the magnitude of the variable region is high as compared to other groups indicates that the household living in urban areas consume more electricity as compared to household living in rural areas in group 5 relative to group 1 in all three model.

5 CONCLUSION

Nowadays electricity is an unavoidable energy source, it has a vital role in the economic development of any country. In specific it is indispensable for households, as they rarely have close substitute of electricity. Like other countries of the world the demand for electricity at household level has increased substantially in Pakistan also. For instance, the household electricity has increased by 4 times during last 25 years; moreover, the share of household electricity consumption had increased from 30percent in 1988-89 to 47percent in 2013-14 (Economic Survey, various issues). On the other hand, supply of electricity had not increased with the required pace and as a result there is a huge shortfall of electricity. This shortfall is continuously increasing leading to long hours of load shedding.

The present study estimated two model to analyze the effect of different explanatory variables on the electricity consumption using cross sectional household data. In first model we examined the relationship between different explanatory variables by using simple OLS model and found the average effect of explanatory variables on dependent variable. Unlike the findings of Eiswerth et.al.(1998), Zhou and Teng (2013), Idrees et.al.(2013), our results showed significantly positive effect of household size, house size, number of air conditioner and refrigerator on electricity consumption. While negative effect of price electricity, heating degree days and average temperature on consumption for electricity. In Second model we compare the consumption pattern of household electricity among different groups using multinomial logit model. The grouping was based on per capita electricity consumption and we constructed five groups. The result of multinomial logit indicated that for Group 2 house size, household income, and month dummy have positive effect on electricity consumption. The household size, heating degree days and average monthly temperature had negative effect on consumption for electricity. Moving from Group 2 to lower last group (with reference to base group) the magnitude of coefficient increases, show that effect of all variables is much stronger for bulk users. The interesting phenomenon is that increase in the price of electricity lead to increase the consumption of electricity in higher income groups relative to low income groups. A possible reason could be that high voltage appliances like Air conditioner, refrigerator and freezer are used by high income groups only. Similarly, electric appliances had positive effect on electricity consumption, while the dummy variable of region indicated that the household living in urban areas consume more electricity as compared to the household living in rural areas of Pakistan.

The present study presented a comprehensive analysis of household demand for electricity. It is a significant contribution to literature and a reasonable effort under the given limitations. The following are the data limitations of the present study:

- Household Integrated Economic Survey gives information about electricity consumption, not demand. As demand could be higher than consumption.
- Another limitation is regarding the exact house size. The only available information is a number of rooms, which is not the true measure of house size.

- The voltage (size) of electric appliances like air conditioners and refrigerator is also not given; we considered all air conditioners of the same voltage. The same assumption was made for refrigerators.

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Appendix A

- Section 1-part A include Household roster file containing detail information on gender, age, marital status and household status (relation to head).
- Section 1-part B include employment and income file containing detail information on employment status (self-employed, employer and employee), earning from different sources and pension etc.
- Section 2-part A and B is the education file contain information on education, last school attended, highest class completed, what type of school attended (private, government, deeni madrasa, NGO, foundation and trust), total spending of household on school/institution and enrollment status.
- Section 3-part A and B contain information on health facilities, immunization, consultation for the treatment of malaria and tuberculosis.
- Section 4-part A, B and C contain information on the pregnancy, maternity history of female and family planning.
- Section 4-part D, E and F contain information on women power for decision making, pre and post-natal care.
- Section 5 contain detail information on house size, occupancy status (self-hired, not self-hired) and availability of natural gas, water and electricity.
- Section 6 contain information on household monthly expenditure on durable and non-durable goods and services.
- Section 7 contained information on consumption items owned and sold by household during a year. It includes appliances like refrigerator, AC, T.V, car and motor vehicle etc.
- Section 8 contain detail information on income received from zakat, usher, and remittances.

Section 9-part A and B contain information on land (agriculture and nonagricultural land) and building owned by household.