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**Fuel Demand Elasticities for Energy and Environmental Policies: Evidence from Household Data in Pakistan**

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**Abstract**
Energy can be considered as condition for both financial growth and a higher set of living. Due to increase in demand of electricity Pakistan is facing many problems of energy. An incorporated plan is required to enhance the efficiency of energy. This study has investigated the most thoughtful economic problem of this era. Today electricity and gas have a great impact on economic life of any person. No one can deny the importance of these natural resources. I have tried my best to find out the weaknesses in these two dimensions and want to highlight the lack of interest of our government in the welfare of humans according to these resources. A middle income person always used the low appliances in their household budget. But our elite class always uses a big part of these resources in their luxuries and in hustle bustle of life. The analysis is based on the cross sectional data for about 16341 households covering the period 2010-2011. Ordinary Least Square and Tobit is used for electricity demand function estimation. From this research I have concluded that prices play a significant role in these resources of demand, but income shows insignificant effect.

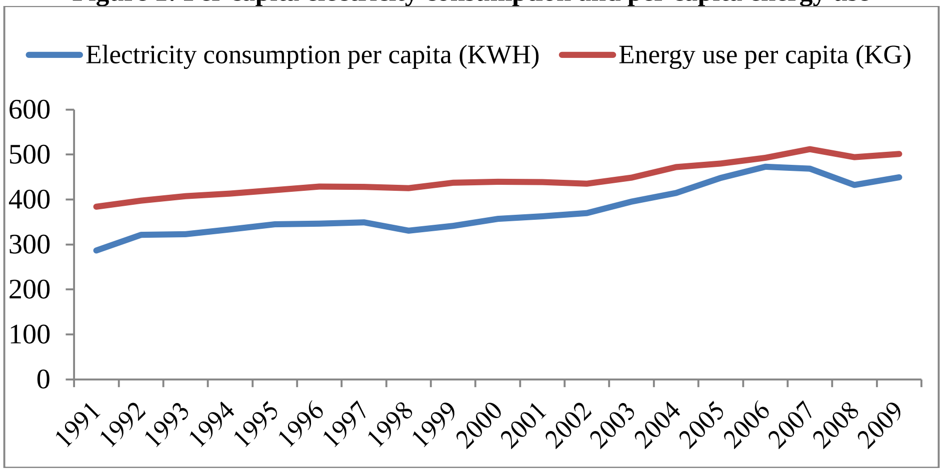
**Keywords:** energy, household, OLS
**JEL Codes:** O13, D10

## I. Introduction

Energy is considered most influential resource for economic development. Energy plays an important role for the welfare of households in developed and as well as in developing countries. Energy is used in household sector for the purpose of cooking, heating and lighting. Around the globe main energy sources are electricity, oil and natural gas where demand for oil and gas is 60 percent. In Pakistan, share of household electricity consumption is 43.1 percent which is high among other sectors. While electricity consumption in other sectors like industry, agriculture and commercial accounting 26.27 percent, 10.83 percent and 6.29 percent respectively Afia (2012). Energy is a major driver of economic growth but sustainable growth is only possible with the efficient utilization of energy. To achieve desired economic growth rate, economies should insure persistent supplies of energy Alam (2006). Literature suggests two opinions over the importance of energy in the production process. First claims that energy is more important than labor and capital as energy is directly related to the well-being of economies in all over the world. Second, macroeconomic theories consider other factors more important than energy Stem and Cleveland (2004). In spite of the undisputed consensus over the importance of energy, excessive use of energy raises environmental issues i.e. high carbon emissions. This relationship is used to policy implications. Economists are working to find out the relationship between energy consumption and economic activities of developed and under developing countries but final results have not been found. The study by Kraft and Kraft (1978) found the linear relationship between energy consumption and economic growth in United States. No relationship has been founded between energy consumption and economic growth Erol and Yu (1987).

Following figure shows the trends of per capita electricity consumption and per capita energy consumption in Pakistan. There is an increasing trend of per capita energy consumption in Pakistan because of increasing per capita income. Now a day's energy has become the basic need of human life. In Pakistan energy demand is increasing along with a sharp rise in its prices. Per capita energy demand has been increased because of high use of energy intensive products.

**Figure 1: Per capita electricity consumption and per capita energy use**

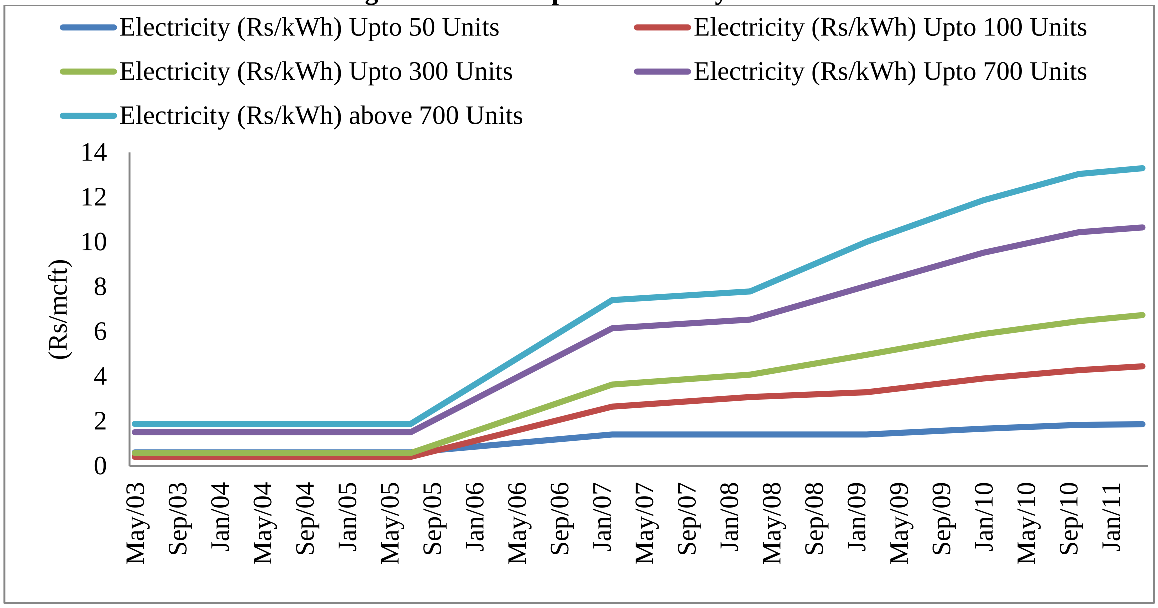



***(Source; World Bank Development Indicator)***

From 1991-2001, there was an increasing trend of per capita income in energy consumption. In 2006 there is a Sharp rise in energy consumption. Trend of energy consumption is increasing time by time. Because of increase in fuel prices the electricity prices have also been increased. Gas and electricity were subsidized but now subsidies have been reduced and cost of capital increased in Pakistan. The government is the sole authority to set the prices of energy. There is a gap between the demand and supply of energy consumption. Pakistan being a under developing economy there is a need of balance in demand and supply of energy consumption with high growth of population. Due to increasing demand of energy there is a question mark about the energy production in future. Globally, oil and natural gas are major energy production sources after fuel usage. The gap between energy demand and supply is increasing day by day due to inadequate domestic sources. In Pakistan 35 percent energy is produced by oil.

Prices of electricity in commercial sector are higher as compared to household sector. Energy prices have been increased time by time. Following figure shows the electricity prices trend from 2003-07.

**Figure 2: Per unit price electricity use in Pakistan**




***(Source; economic survey of Pakistan)***

There is a rise in per unit electricity price. After 2005 electricity price increased sharply. Due to reduction in electricity subsidies energy prices are increasing along time. The lower line shows that there is less increase in electricity prices because of targeted subsidies. The power market of Pakistan is operating on a "Single Buyer Model". Because of legal constraints, no consumer can be charged at a higher rate than that determined by NEPRA (National Electric Power Regulatory Authority). Central power Purchasing Agency (CPPA) collects electricity from all GENCOs, IPPs, WAPDA Hydro and other producers and sells it to DISCOs in proportion to their demand. In Fiscal Year 2011, the total capability of the power system other than KESC during the peak demand period was about 13,000-14,000 MWs compared to the peak demand of about 18,500 MW, resulting in power deficit of about 4,500-5,500 MW. The average cost of electricity sold was Rs9.05/KWh where average revenue billed to customer, excluding taxes and levies, was 7.05 Rs/KWh necessitating a large subsidy.

Energy prices are set in such a way that shows the shortage of the commodity and marginal willingness to pay. Price elasticities can be used to show the response of the consumers. It also is used to determine the willing of consumer they purchased alternate for the goods when prices increase. A consumer with fixed budget has three responses to the price change in short run. First include consumer can buy substitutes of the goods. Second, consumer can reduce the amount of commodity when alternate goods are not available. Lastly, by reducing expenses on other goods then consumer can buy the same quantity of the good. Household sector use natural gas and electricity in cooking, lightning, washing, etc. Due to sharply increase in electricity prices people are moving from electricity to natural gas. Increasing electricity prices are inversely related to household's welfare. Fuel demand elasticities are used to examine the effect of increase in energy prices on different sectors. In this context, this study contributes to the existing literature in two ways;First of all, we estimate price and income elasticities for electricity at the household level. Secondly, different studies focus on analyzing the elasticities of electricity demand with respect to electricity prices and income at the national level but we also estimate these elasticities in Pakistan between the rural and urban areas.

## II. Literature Review

In this part, we highlight previous studies that are occurred in different countries. Mostly economists are estimated income and price elasticities of energy in different regions. But they cannot found final results and mostly studies are under estimation. But we participate in literature on the bases of these topics with rural and urban areas. Akhter.et al. (1990) investigated the pattern of households' expenditure on fuel consumption in Pakistan. This study used data of household income and expenditure survey (1984-85). For this analysis Extended Linear Expenditure System was used. Two stage budgeting process was also used in this analysis. Results indicated that marginal propensity to consume fuel is low in Pakistan. With an increase of one rupee in per capita income, expenditure expenditures on fuel consumption increase by 2.4 percent. With an increase in fuel prices by100 percent household saving decrease by 24percent and 17 percent in urban and rural areas respectively.

Graham et al. (2000) reviewed the international research on fuel price changes and magnitude of income and price elasticities in London. Co integration technique was applied to get the elasticity estimates. Their result showed that there is a difference between long run and short run fuel demand. In long run price elasticities falls between -0.6to -0.8 and in short run, it lies between -0.2 to 0.3. The long run income elasticity of fuel demand fall from1.1 to 1.3, while in short run, it lies between 0.35 and 0.55. Results also found that demand for automobiles depends upon income. Filippini and Pachauri (2004) estimated seasonalprice and income elasticities of electricity demand in urban area in India. The study used primary data at micro level which was collected from 30,000 Indian households for the period 1993-1994. Study estimated electricity demand functions using monthly data for the winter, summer and monsoon through OLS. Results of this study conclude that elasticity demand is inelastic in all three seasons. The estimated price elasticity for winter, monsoon, and summer is -0.42, -0.51 and -0.29 respectively. Reiss and White (2005) estimated a model of residential electricity demand using a representative sample of 1307 Californian households and applied nonlinear least square technique. Results of this study revealed that income effect were insignificant and price elasticity of electricity consumption was -0.4. Olivia and Gibson (2008) estimated the marginal social cost of indirect taxes and subsidies on five energy source such as electricity, kerosene, LGP, gasoline and lubricant oil. For analysis of demand system of five sources, budget survey data from 29,000 Indonesian households was employed. Marginal social cost of price change for each item is calculated with the combination of price elasticities, tax and subsidy rates. The results suggested that Gasoline and Kerosene, subsidies are reducing even if there are high levels of inequality. Gundimeda and Kohlin (2008) estimated the income and price elasticities of household demand for different kinds of fuels in urban and rural households in India. The study used the linear approximate almost ideal system (LA-AIDS) with micro data of more than 100,000 household samples across India. For this analysis two stage budgeting process is used. Empirical results show that household size is negatively correlated with the probability of adopting electricity and LPG. However, this implies that households are affected by higher fuel and wood prices. Increased fuel costs lead to adaptation of inferior fuels and reducing their fuel consumption. Eltony (1993) used household data for estimating the behavioral foundations that give rise to price elasticities of demand for fuel. He used a panel data of household between 1969 and 1988 for gasoline consumption. The short run price elasticities of gasoline were at -0.31 and the long term elasticity was around -0.1. Using aggregate data, Espey (1996) found a fuel price elasticity of fuel economy of -0.2 and income elasticity was not significantly different from zero. This study also concluded that price elasticities do not appear to be decreasing over time or with increasing fuel prices. In long run, it should be noted that there are also changes in population density, lifestyles and other factors but they are not readily willing to measurement.

Craigwell and Mitchell (2009) used survey data of a sample of 130 Barbadian customers and estimated an electricity demand function. This research examined nonlinear pricing structure due to the absence of data for the electricity demand for individual appliances. They estimated a censored regression model using Hickman's two step approach. This study indicated that the price elasticities of demand for particular appliances varied significantly with households with higher price elasticity for the households that use solar heating water compared to the households that use electric water heating. The income elasticity for households with solar heating was found to be negative. Sultan (2010) applied ARDL approach to co-integration to estimate long run and short run characteristics of gasoline demand in transport sector in Mauritius. For this study, data from National Income Accounts from the Central Statistics Office was applied. Results found that gasoline demand per capita income and real income are integrated of order 1. The long run income elasticity of gasoline demand was 0.77 while price elasticity was found to be 0.4. Similarly, in short run income and price elasticity were estimated to be 0.37 and -0.21 respectively. Jamasb and Meier (2010) explored the link between households' energy demand and income with the help of using panel data from UK households from 1991-2007 in Britain. Hausman test are employed for statistically purpose. Results of this study indicated that low income households are more affecting to electricity price changes and less responsive to gas price changes than higher income. Higher gas prices, lower the electricity consumption among the poor but no effect on higher income people. Chaudhry (2010) estimated the price elasticity of electricity demand in Pakistan using panel data from 63 firms from 1998-2008. A fixes effect model is estimated for all 402 firms over 4 different years. This study suggested price elasticity of demand for electricity across all firms is -0.57.

Chauudhry (2010) applied GMM and Maximum likelihood technique to estimate residential electricity demand in Pakistan's Punjab. This study used data from the Punjab Multan Cluster Survey (MICS) of 2003-2004, collected between September and December 2003 by the Punjab Bureau of Statistics. Statistically found that electricity demand and tariff rank depends upon positively on income and appliances ownership. Both are increased with planned projects for increasing supply, and minimizing the impact on poverty. Bekhet and Othman (2011) investigated and estimated the price and income elasticity of electricity consumption and then compared the level of sensitivity of demand for electricity in the rural and urban areas in Malaysia. This study used Gas price as proxy variable for measuring the level of sensitivity. Annual time series data for the 1980-2009 periods were utilized in this study. The nonlinear model was employed for estimation. The results found that electricity is necessity good for Malaysian people and its consumption is greater in urban areas as compared to rural areas. More electricity consumed in urban areas because many facilities are provided. Bemstein and Madlener (2011) analyzed long and short run residential natural gas demand elasticities with regard to real disposable income and real gas price. The analysis was based on time series information for the period 1980-2008. This study gathered data on residential natural gas consumption and price, net disposable income, and heating degree days for as many OECD countries as possible. Autoregressive Distributed Lag (ARDL) was used for estimating long run demand elasticities. Error correction framework was employed for the speed of adjustment to long run equilibrium and short run elasticities for individual countries. Heating degree days were used as control variable for checking the weather effect on natural gas. The estimated result indicated that on average the short run elasticities are approximately half in magnitude compared to their long run counterparts. The income elasticities are 0.94 and 0.45 and price elasticities are -0.51 and -0.24 in the long run and short run respectively.

**III. Theoretical Background**

In electricity demand studies it is traditional Roland et al., 2009 and Filippini and Pachauri (2004) to assume that the household demand for energy is the derived demand. Therefore, a general household utility function incorporating the household electricity demand would generally take the form of

$$U=u(X\ \{E, A, I\}\ N, T) \quad (1)$$
$$M<PxX+PyY$$

Where X is the energy services consumed by the household, E is energy; A represents the stock of appliances needing energy for operation, I means other fuel consumed by the household, Ndenotes the goods and services are consumed by household, T represent the taste and preferences of the household, M is the income of household, Px is the price of energy services and Py are the prices of goods and services consumed. With household maximizing household utility being the objective, the Lagrange given below can be formed:

$$£=u(X, \{E, A, I\}, N, T)-\lambda\ (PxX+PyY-M) \quad (2)$$
$$\frac{\partial £}{\partial x} = u(E,A,I),N,T - \lambda Px$$
$$\lambda Px = u\ (E, A, F), Y, Z$$
$$\lambda = u\ (E, A, I), N, T/Px$$
$$\frac{\partial £}{\partial Y} = u[X(E,A,I),T] - \lambda Py$$
$$\lambda Py=u[X\ (E, A, I), T]$$
$$\lambda=u[X\ (E, A, I), T]/Py$$
$$\lambda=u\ (E, A, Y), N, T/Px=u[X\ (E, A, I), T]/Py$$
$$Px/Py= u\ (E, A, I), N, T/u[X\ (E, A, I), T]$$
$$Y/X= Px/Py$$
$$Y=Px/Py.X$$
$$\frac{\partial £}{\partial \lambda} = PxX + PyY - M$$
$$M =PxX+PyY$$
$$M=PxX+Py\ (Px/Py.X)$$
$$M=PxX+PxX$$
$$M= 2PxX$$
$$X=M/2Px$$
$$Y =Px/Py.X$$
$$Y =Px/Py.M/2Px$$
$$Y=M/2Py$$

These equation represent the X, Y positively relate with income and negatively related with prices of both commodities of X and Y.
Electricity demand function from this Langrange function is

X=X(Px,M,T,ε)

In the demand function, to represents the household preferences for the decision of fuel consumption. The error expression ε is used to the equation for evaluation principle.
Therefore, the household utility function can be written as:

U=U(N (E, KS), T; D, J) (3)

Where N is the combined energy commodity, E is energy; KS is the capital stock of existing appliances, Y shows the income of households, while D and J represent geographic and demographic characteristics which determine the household preferences.

Following household production theory, the optimal output demand functions for E and KS can be written as:

E=E ($p_e$, $p_{ks}$, Y; D, J) (4)
KS=KS ($p_e$, $p_{ks}$, Y; D, J) (5)

Where$p_e$ is the price electricity, $p_{ks}$is the price of electric appliances and Y is the income. Equations (4) and (5) reflect the long run behavior of households. This model is fixed in nature that it assumes an immediate adjustment to new equilibrium values when prices or income change. It is assumed that household can change both their rate of utilization and their stock of appliances immediately. In this study we use a single equation approach in modeling the residential demand for energy for overall sample, rural households and the urban households. We suggest that the demand for electricity depends on the price of electricity, income and some demographic and geographic variables. Because of lack of data on electrical appliances we were not able to estimate equation (5).

The empirical model based on equation (2) results can be represented by the following demand function:
X=E(Pe.,Pg,Y,Ref.,Frez.,AC,Cool,Fan,Geyser,Washing,Stove,Micro,Heater,TV,PC,HS,AD (6)
Where

X= Residential energy consumption demand
Pe=Electricity price in rupees
Pg= Gas price in rupees
Y=Household personal income
Ref = Refrigerator
Frez=Freezer
AC = Air conditioner
Cool= Air coolar
Micro=Micro wave
VC= Vacum cleaner
PC = Personal Computer
HS= Number of household member living in the household
AD= Covered area of residence in square feet

We follow the demand function of Filippini and Pachauri (2004) “Elasticity of Electricity Demand in Urban Indian” for estimation purposes.
The energy demand of household is a function of the energy price, the price of substitutes (gas price) household income, and some demographic and geographic characteristics (the household size, the residence size, the household resides) and the household income. Since block prices apply for electricity market in Pakistan, we use ratio of the electricity block price paid to the average electricity price in Pakistan. We used this ratio instead of the actual price paid by the consumers in Pakistan because Chaudhry (2010) indicates that we can get positive price elasticity if the actual block prices are used for the estimation purposes.

Since electricity is not the only energy source for a household, electricity demand can also be affected by the prices of other alternative fuels. Therefore, we include the price of natural gas in the estimation of the demand function. These are also included in the model to testing hypothesis of whether these fuels are complementary or substitutes for electricity.

Cross sectional data on appliance prices are not available. However, appliance prices faced by household can, apart from minor regional variations, be regarded as constant. Therefore, they may be excluded from the model without causing bias in estimation Halvorsen (1975). The variables number of household member living in the household (DHHS) and dwelling size (AD), are included in the model to check the wealth effects on energy consumption. The regional dummy variables have been included in the model to take account of the impact of regional characteristics such as weather, urbanization. There is no clear consensus in the literature on functional form that is best suited for estimating household electricity demand. Most studies have been used single equation specification either in a linear or a logarithmic form. The double logarithmic form is appropriate functional form for answering question about income and price elasticities. The major advantage is that the estimated coefficient amount of elasticities, which are assumed to be constant Filippini and Pachauri (2004).

The equation to be estimated for each province is

$$lnX = \alpha_0 + \alpha_1 \ lnX + \alpha_2 \ pklnPg + \alpha_3 ylnY + \alpha_4 \text{Ref.} + \alpha_5 \text{Freez.} + \alpha_6 \text{AC} + \alpha_7 \text{Cool} + \alpha_8 \text{Fan} + \alpha_9 \text{Geyser} + \alpha_{10} \text{Washing} + \alpha_{11} \text{Stove} + \alpha_{12} \text{Micro} + \alpha_{13} \text{Heater} + \alpha_{14} \text{TV} + \alpha_{15} \text{PC} + \alpha_{16} dlnAD$$

For estimation baseline estimation, ordinary least square (OLS) method has been applied. A limitation this approach is that when the variable is censored, OLS provide inconsistent estimates of the parameters. It means that, the coefficients from the analysis will not necessarily approach the true population parameters as the sample size increases. To overcome this problem, we also estimate the models with Tobit model.

The Tobit model, also called **censored regression model**. "A model for a dependent variable that takes on the value zero with positive probability but is takes on the roughly continuously distributed over strictly positive values" (Wooldridge 4th Edition).

It is also called **limited dependent variable regression model** because of the restriction put on the values taken by the regressed.

Statistically, we express the Tobit model as

$Y_i = \beta_0 + \beta_1 X_I + \mu_i$ if R.H.S > 0
= 0

otherwise

OLS estimates of the parameter obtained from the subset of observations will be biased as well as inconsistent.

This consists of two-step estimating procedure.

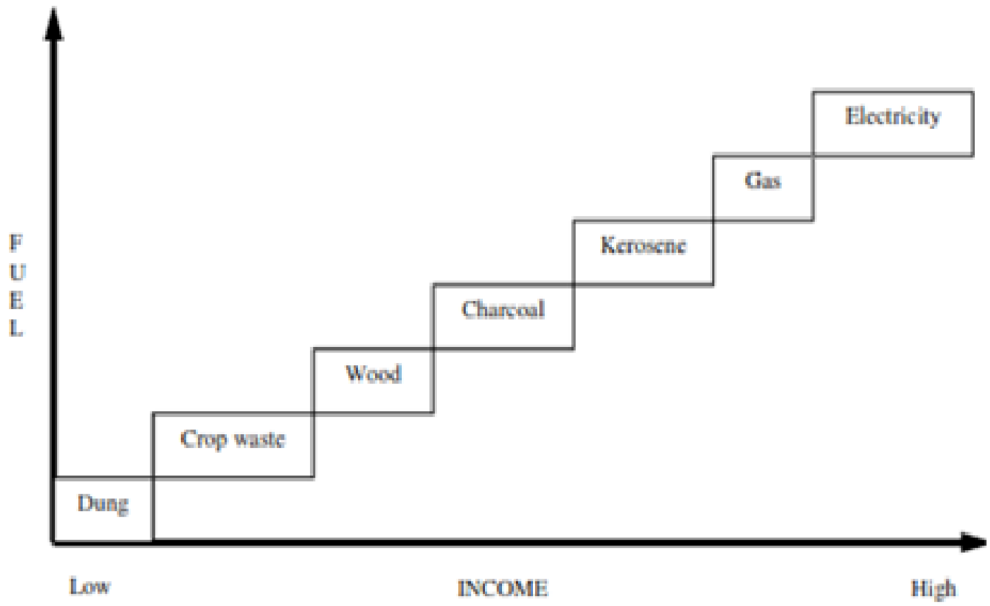
1. In first step, we estimate the probability of consumer owing a house.
2. We estimate the model (1) by adding to it a variable.

**IV. Model and Data**

The choices of fuel by household depends on own price, the prices of the related fuels, appliances used, the efficiency of the fuels and household characteristics. As stated earlier, the energy ladder hypothesis explains the movement of energy consumption from traditional sources to more complicated sources along creative steps with the improvement in the economic status of households. The energy ladder is presented in below graph (Maser et al., 2000).

The basic assumption of the model is that households are making a number of fuel choices in an order of increasing technological sophistication. Biomass fuels occupy the bottom of the list while electricity, that is much cleaner, lies at the top. It is assumed that energy transition occurs from the bottom to the top with increasing socio-economic status of household either through a rise in income or a fall in prices Hosier and Dowd (1987).

**Figure 8: Energy Transition**




It explain the theory partly, showing when income increases households not only consume more goods but also shift to higher quality goods.

The major source of energy consumed at the household level in Pakistan is firewood, electricity and gas. Firewood occupies the bottom step of the ladder while electricity is at the top. It is assumed that with the improvement in economic status of households, they would shift toward modern fuels.

**IV. I. Data**

The empirical electricity demand data employed in this study is taken from the HIES (Household Integrated Economic Survey). The survey data was collected during 2010-2011 on 1180 urban and rural PSU's with 16341 respondent households. For this analysis 6589 urban households and 9751 rural households are included in the estimation. According to household survey 2010-11 total budget share of fuel consumption was 7.06 percent in urban areas and 8.01 percent in rural areas.

Descriptive statistics for the variables employed in this study are shown in Table 02.

**Table 2: Descriptive Statistics**

| variables | Observation | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| income | 16341 | 184251.7 | 198804.3 | 0 | 6467500 |
| ref1 | 15731 | 0.376 | 0.496 | 0 | 4 |
| frez1 | 15731 | 0.028 | 0.171 | 0 | 3 |
| ac1 | 15731 | 0.071 | 0.335 | 0 | 6 |
| cool1 | 15731 | 0.075 | 0.295 | 0 | 5 |
| fan1 | 15731 | 2.422 | 1.779 | 0 | 20 |
| geyser1 | 15731 | 0.062 | 0.267 | 0 | 6 |
| washing1 | 15731 | 0.489 | 0.542 | 0 | 4 |
| stove1 | 15731 | 0.426 | 0.523 | 0 | 3 |
| micro1 | 15731 | 0.028 | 0.167 | 0 | 2 |

| | | | | | |
|---|---|---|---|---|---|
| heater1 | 15731 | 0.115 | 0.435 | 0 | 6 |
| tv1 | 15731 | 0.569 | 0.459 | 0 | 6 |
| vc1 | 15731 | 0.011 | 0.107 | 0 | 3 |
| pc1 | 15731 | 1.071 | 1.008 | 0 | 12 |
| Rooms | 16341 | 2.409 | 1.345 | 1 | 18 |
| Hhs | 16341 | 6.681 | 3.057 | 1 | 38 |
| el_ex1 | 16341 | 738.347 | 1032.996 | 0 | 20000 |
| gas_ex1 | 16341 | 193.425 | 379.044 | 0 | 12000 |
| p_elec | 16341 | 4.837 | 1.338 | 1.87 | 8.78 |
| p_gas | 16341 | 6.251 | 3.517 | 3.55 | 17.75 |

In descriptive statistics, we collect data from 16341 households and their income is 16341. All other variables collected form 15731 households. We also check the prices scenario of electricity and gas from 16341 households. We also calculate the minimum and maximum values of all these variables which explains, one household that have minimum and maximum appliances. One household have only minimum one and maximum 18 rooms. The price of gas is higher as compared to electricity.

## V. Estimation and Results

### V.I. Electricity Demand Function

Table 3 present the estimated electricity demand function for Pakistan using ordinary least square (OLS) as well as the Tobit model.

**Table 3: Tobit and OLS estimates**

| | Electricity Demand Function | | | | | |
|---|---|---|---|---|---|---|
| | Completesample | | Rural Household | | Urban Household | |
| | Coefficient and Std. Err. | | Coefficient and Std. Err. | | Coefficient and Std. Err. | |
| | Tobit | OLS | Tobit | OLS | Tobit | OLS |
| Lpe | -5.66 | -5.345 | -5.776 | -5.35 | -5.363 | -5.234 |
| | [0.019] | [0.016] | [0.027] | [0.021] | [0.029] | [0.027] |
| Lpg | 0.0582 | 0.065 | 0.0103 | 0.015 | 0.112 | 0.112 |
| | [0.014] | [0.014] | [0.027] | [0.023] | [0.015] | [0.015] |
| Lincome | 0.001 | 0.001 | -0.0001 | 0.0004 | 0.005 | 0.005 |
| | [0.001] | [0.002] | [0.003] | [0.002] | [0.002] | [0.002] |
| ref1 | 0.027 | 0.044 | 0.008 | 0.035 | 0.045 | 0.05 |
| | [0.014] | [0.013] | [0.023] | [0.02] | [0.002] | [0.014] |
| washing1 | 0.021 | 0.022 | 0.004 | 0.009 | 0.027 | 0.028 |
| | [0.013] | [0.012] | [0.021] | [0.018] | [0.015] | [0.015] |
| fan1 | 0.043 | 0.041 | 0.064 | 0.059 | 0.02 | 0.021 |
| | [0.004] | [0.004] | [0.006] | [0.005] | [0.015] | [0.004] |
| tv1 | 0.039 | 0.038 | 0.049 | 0.046 | 0.005 | 0.006 |
| | [0.012] | [0.011] | [0.018] | [0.016] | [0.004] | [0.014] |
| pc1 | -0.002 | 0.001 | -0.009 | -0.004 | 0.006 | 0.007 |
| | [0.006] | [0.006] | [0.011] | [0.009] | [0.006] | [0.006] |
| stove1 | -0.024 | -0.018 | -0.03 | -0.019 | -0.006 | -0.004 |
| | [0.015] | [0.014] | [0.027] | [0.024] | [0.015] | [0.015] |
| heater1 | -0.013 | -0.017 | 0.082 | 0.054 | -0.019 | -0.019 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | [0.014] | [0.013] | [0.036] | [0.031] | [0.012] | [0.012] |
| geyser1 | -0.034 | -0.006 | -0.04 | -0.026 | 0.041 | 0.049 |
| | [0.022] | [0.02] | [0.057] | [0.051] | [0.02] | [0.019] |
| Hhs | 0.001 | 0.002 | -0.005 | -0.003 | 0.009 | 0.009 |
| | [0.002] | [0.002] | [0.002] | [0.002] | [0.002] | [0.002] |
| Punjab | 0.186 | 0.179 | 0.254 | 0.222 | 0.101 | 0.113 |
| | [0.017] | [0.016] | [0.027] | [0.023] | [0.021] | [0.02] |
| Sindh | 0.049 | 0.042 | 0.075 | 0.048 | 0.016 | 0.024 |
| | [0.018] | [0.017] | [0.028] | [0.024] | [0.022] | [0.021] |
| Kpk | 0.173 | 0.153 | 0.256 | 0.207 | 0.062 | 0.068 |
| | [0.019] | [0.018] | [0.029] | [0.026] | [0.024] | [0.023] |
| Urban | 0.059 | 0.057 | _ | _ | _ | _ |
| | [0.013] | [0.012] | _ | _ | _ | _ |
| Cons | 9.296 | 9.113 | 9.291 | 9.047 | 9.215 | 9.128 |
| | [0.037] | [0.034] | 0.057 | 0.049 | 0.045 | 0.043 |
| Pseudo $R^2$ | 0.547 | _ | 0.5174 | _ | 0.5889 | _ |
| R-saqured | _ | 0.9113 | _ | 0.9102 | _ | 0.8848 |
| Adj R-saqured | _ | 0.9112 | _ | 0.9101 | _ | 0.8846 |

**V.II. Complete Sample**

The results from both techniques are similar. Electricity demand is derived demand and depends upon the usage of stock of electric goods and capital stock. Thus on that basis, electric appliances appear to be an important influencing factor of electricity consumption and express positive linkage with it. The model is able to account for large proportion of the cross sectional variation in electricity consumption. Therefore, we conclude from our equation that the 1percent increase in electricity price per slap as a ratio to the average electricity price[1] results in a reduction in electricity demand by 0.566 percent and 0.534 percent respectively by Tobit and OLS model respectively for the overall sample from HIES. The change in prices of gas will also affect the electricity demand by 0.0582 to 0.065. As expected, the estimates for income show that electricity is a necessity. We can expect energy demand to increase with economic development of the country. The Tobit and OLS analyses value of income coefficient concludes that elasticity of electricity demand with respect to income in case of Pakistan is inelastic. These effects may have been captured by choices of appliances rather than utilization and agree Parti and Parti (1980) and Dubin and McFadden (1984). Income elasticity of demand ranges between 0.001-0.001 across all the specifications. With one percent change in stock of pc, stove, heater and geyser is associated with -0.002 to 0.001, -0.024 to -0.018, -0.013 to -0.017, -0.034 to -0.006 percent change in electricity demand in Pakistan by Tobit and OLS respectively. But the other independent variables (Refrigerator, Washing, Fan and TV) show positive effect on electricity demand in Pakistan. In Pakistan, the Province of Punjab more affects the electricity demand as compared to Sindh and Kpk.

**V.III. Rural Households**

In rural areas, one percent increase in the electricity price per slap as a ratio to the average electricity price is negatively affected the electricity demand by -5.776 to -5.35 percent. One percent increase in price of gas is associated with 0.0103 to 0.015 percent increase in the electricity demand. In rural areas, the Tobit and OLS analyses value of income coefficient concludes that elasticity of electricity demand with respect to income in case of Pakistan is inelastic. Some other independent variables show positively effects on electricity demand such as refrigerator 0.008 to 0.035, washing 0.004 to 0.009 fan 0.064 to 0.059, and TV 0.049 to 0.046 by Tobit and OLS respectively. And other variables i.e., PC, stove, heater, geyser and household size also negatively affected to the

[1] Prices expenditure = prices per slab/ prices average

electricity demand. In Kpk rural household more consumed electricity 0.256 to 0.207 percent as compared to other provinces.

**V.IV. Urban Households**

Similar price elasticity estimates prevail in urban areas, one percent increase in price of electricity is associated with a -5.363 to -5.234 percent decrease in the electricity demand respectively. But in urban areas, the price of gas affect more change in demand as compare to rural and over the Pakistan situation. The one percent change in prices of gas will increase demand between 0.016-0.29 percent. In contrast, demand of electricity is complementary to gas, that is, a rise in the gas price expenditure results a slight fall in electricity demand. With one percent change in the stove and heater is associated with -0.006to -0.004 and -0.019 to -0.019 percent change in electricity demand in Pakistan. But the stock of pc, geyser, refrigerator washing, fan and TV show positive effect on electricity demand by a 0.006 to 0.007,0.041 to 0.049, 0.045 to 0.05, 0.027 to 0.028, 0.02 to 0.021 and 0.005 to 0.006 percent respectively Tobit and OLS. The household size has positive impacts on electricity demand by 0.009-0.009, but demand of electricity is income inelastic. In Punjab urban areas electricity demand is affected by 0.101 to 0.113 percent. But Sindh and Kpk household urban areas are less affected to demand of electricity. Our results are significant according to previous studies. Prices effect is significant but sensitive and income effect is insignificant on electricity demand. The household size is also positive impact on electricity demand.

**VI. Conclusions**

Energy is the sustenance of nation. The economic train and wheels of all sectors need energy to move toward. But in Pakistan, due to lack of power supply all sectors perform badly. In this study we analyzed the electricity demand elasticities at household level in Pakistan. This survey uses household level data for 2010-2011. The HIES data provide a rich source of information for estimating electricity demand in Pakistan. For the determination of prices and income eleasticities between different regions OLS and Tobit regression models are applied. The prime aim of the analysis is to estimate income and price elasticities at the household level and across regions. The Variables used in the analysis include own price of electricity, price of substitute, income and variables relating to demographic and geographic characteristics of households, for different regions of Pakistan. The models also provide estimates of income, cross price and own price eleasticities of electricity demand for rural and urban Pakistan. As expected, the estimates for income elasticities show that electricity is necessity. The analysis shows that demand is income inelastic in all regions. However, household size has positive impact on electricity demand in Pakistan. Electricity is found to be price elastic in all models. However, the fairly low value of income electricity confirms that with economic development of country, we can expect to reach higher level of electricity demand at the household level. The cross price elasticities between fuels show that electricity is substitute to gas. If the price of electricity increases, then people prefer to use gas appliances in households. If people decrease the more usage of luxuries, then we overcome the electricity deficiency. People prefer to more substitutes of all appliances due to higher prices of electricity then demand of electricity can fulfill. Government must provide the facility of Gas to all rural areas as substitution. They must utilize raw resources with the help of modern technology.

Govt. should build a number of DAMS such as KALABAG DAM, BHASHA DAM etc. and produce cheap electricity for domestic needs.

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