Determinants of Household's Demand for Electricity in District Peshawar

Naeem Ur Rehman, Khattak and Tariq, Muhammad and Khan, Jangraiz

University of Peshawar, University of Peshawar, University of Peshawar

2010

Determinants of Household's Demand for Electricity in District Peshawar

Naeem Ur Rehman Khattak[1], Muhammad Tariq[2] and Jangraiz Khan[3]

ABSTRACT

The main purpose of this study is to explore the role of economic and non-economic factors in the determination of household's demand for electricity in district Peshawar. Primary data was collected for this purpose from 200 households of City Rural Division during November-December 2009. Multinomial logistic model was used to derive estimates. The study concluded that income, number of rooms, price of electricity, weather and education are important determinants of household demand for electricity in district Peshawar. However, the study suggested that a provincial level study in this regard will be more helpful for government in understanding the real pattern of domestic demand for electricity.

Key Words: Household's Demand for Electricity, Multinomial Logistic Model, City Rural Division

[1] Prof. Dr Naeem Ur Rehman Khattak, Dean, Faculty of Social Sciences, University of Peshawar. Naeemurrehman2001@yahoo.com
[2] Muhammad Tariq, Ph.D Scholar, Department of Economics, University of Peshawar Tariq_noor82@hotmail.com
[3] Jangraiz khan, Ph.D Scholar, Department of Economics, University of Peshawar economist95@hotmail.com

1. INTRODUCTION

Access to reliable, affordable and environment friendly energy services are the basic rights of every human under international law and policy (Stephen, 2006). Demand for energy services has been increased enormously with development of human lives over time. Electricity, natural gas and fuel oil are the main sources of energy, which facilitate human lives. With technological development, the usage of electricity increased manifold. The shortage of electricity brings life to a standstill. It is generally considered that demand for electricity at household (HH) level is mainly determined by economic factors i.e. income, prices of electricity etc. However, the role of structural and behavioural factors such as weather, lifestyles of household (HH), stock of appliances and number of rooms also cannot be ignored (Filippini & Pachauri, 2002; Halicioglu, 2007; Franco & Sanstad, 2008).

At household level people demand electricity for services, such as lighting, powering, heating, cooling, and cooking, which are produced by using electric appliances. Therefore, the use of electric appliances and its stock are major determinants of demand for residential electricity. The consumers' use of electrical appliances depends on their income, price of electricity, housing unit structure, number of family members and weather.

In Pakistan, electricity is produced by two major sources hydro and thermo power. Water and Power Development Authority (WAPDA) and Pakistan Electric and Power Company (PEPCO) are responsible for the provision of electricity in the country. WAPDA is concerned with the schemes and plans for the generation, transmission and distribution of electricity, whereas, the distribution of electricity to domestic, commercial, industrial and agricultural sector is the responsibility of PEPCO. It supplies electricity through its nine Distribution Companies (DISCOs) i.e. Lahore Electric Supply Company (LESCO), Gujranwala Electric Power Company (GEPCO), Faisalabad Electric Supply Company (FESCO), Islamabad Electric Supply Company (IESCO), Multan Electric Power Company (MEPCO), Peshawar Electric Power Company (PESCO), Hyderabad Electric Supply Company (HESCO), Quetta Electric Supply Company (QESCO), Tribal Electric Supply Company (TESCO) to all sectors in the country.

Electricity is mostly used for domestic, commercial, agriculture and industrial purposes in Pakistan. Despite it's per unit price hike, household's demand for electricity is growing day by day. The HH sector is the largest consumer of electricity in the Pakistan with a share of 42.2% of electricity, whereas the industrial and agriculture sectors shares are 25.2% and 13.3% respectively (Economic Survey of Pakistan,2008-09).

1.1 Research Motive of the Study

The major purpose of this study is to explore the factors that determine HH's demand for electricity consumption in district Peshawar. This study will provide a better understanding to the government regarding the present structure of domestic consumers' electricity consumption in the study area. The following research question has been asked to analyze the issue.

What are the determinants of HH demand for electricity? Do economic, structural and behavioural factors play any role in its demand determination?

1.2 Scope of the Study

This study is confined to City Rural Division of district Peshawar. Primary data was collected from HHs of the study area to find the determinants of their demand for electricity. As the pattern of HH's consumption of electricity, their conditions and characteristics are different in various areas of NWFP. So the present study cannot be generalized for the whole province.

1.3 Research Hypotheses

The purpose of this study was to find-out the factors that determine HH's demand for electricity in district Peshawar. Based on the objectives of the study the following hypotheses were developed:

1. Income, price of electricity and education have significant impact on household demand for electricity.
2. Weather does play its role in determination of household monthly electricity consumption.

2. LITERATURE REVIEW

Several studies have been conducted in both developed and developing countries to measure HH's demand for electricity by using micro and macro level data. The details of some of studies are as follows:

Amusa *et al* (2009) analyzed the determinants of aggregate demand for electricity in South Aftrica by using bounds testing approach in an autoregressive distributed lag framework during the period 1960 to 2007. The results showed that demand for electricity was greatly affected by changes in income. However, the study found that changes in price of electricity had no effect on the demand for electricity. The study suggested that any policy of the government for bringing changes in price of electricity depends on the factors affect the demand for electricity. The study further mentioned that the government should focus on these factors while bringing any change in the price of electricity in South Africa.

Athukorala and Wilson (2009) used unit root, Error Correction and Cointegration to find the short and long run determinants of HH's demand for electricity in Sri Lanka during the period 1960-2007. The results showed that demand for electricity in the long run increases due to increase in HH's income. The study concluded that increase in HH income in the future should also be included in policies regarding the production of electricity because focusing only on current per capita consumption and population growth may give wrong estimates of HHs demand for electricity. Louw *et al* (2008) conducted a study in two low income rural areas of Africa and concluded that income, wood fuel usage and appliances stock were the main factors influencing HH electricity consumption in Africa.

Ziramba (2008) investigated the determinants of HH demand for electricity in South Africa by using bound testing approach and concluded that the demand for electricity was largely affected by HH income. However, the study found that there was no effect of changes in price of electricity on its demand.

Al-Salman (2007) used a two level approach for analyzing the factors of HH demand for energy in Kuwait. The study found that rise in prices reduced demand for energy.

Carcedo and Otero (2005) checked the impact of weather on demand for electricity in Spain. The study used Smooth Transition, Threshold Regression and Switching

Regressions models and concluded that weather played strong role in changing electricity demand in Spain.

Holtedahl and Joutz (2004) analyzed the HH demand for electricity in Taiwan. The main variables of the study were HH income, population growth, electricity price and urbanization and weather. The Error Correction Model was applied to separate both the short and long run effects of these variables on HH demand for electricity. The study concluded that in the long run demand for electricity increased with increase in income where the price effect was negative and inelastic. However, the effects of price and income were smaller in short run as compared to long run. Furthermore, weather and urbanization also influenced demand for electricity in both short and long run. Psiloglou *et al* (2009), confirmed this result by making a comparative analysis of the determinants of electricity demand in HH and commercial sectors for London and Athens and reached the same conclusion that social, economic and demographic factors play a key role in demand for electricity. Hondroyiannis (2004) examined the factors which brought changes in aggregate demand for electricity in Greece for both short and long run periods. The study concluded that in the long run real income, price level and weather played an important role in HH demand for electricity. However, in the short run changes in demand for electricity was affected only by weather condition. The study recommended that HH demand for electricity in future will remain stable in Greece. Erdogdu (2007) also concluded that income and price influence electricity demand in Turkey.

Halvorsen and Larsen (2001) analyzed the factors behind increased HH electricity demand in Norway by using annual consumer expenditure data. According to results, increase in number of HHs, average consumption of electricity per HH, stock of appliances, income and number of rooms were the main determinants responsible for the rise in HH demand for electricity.

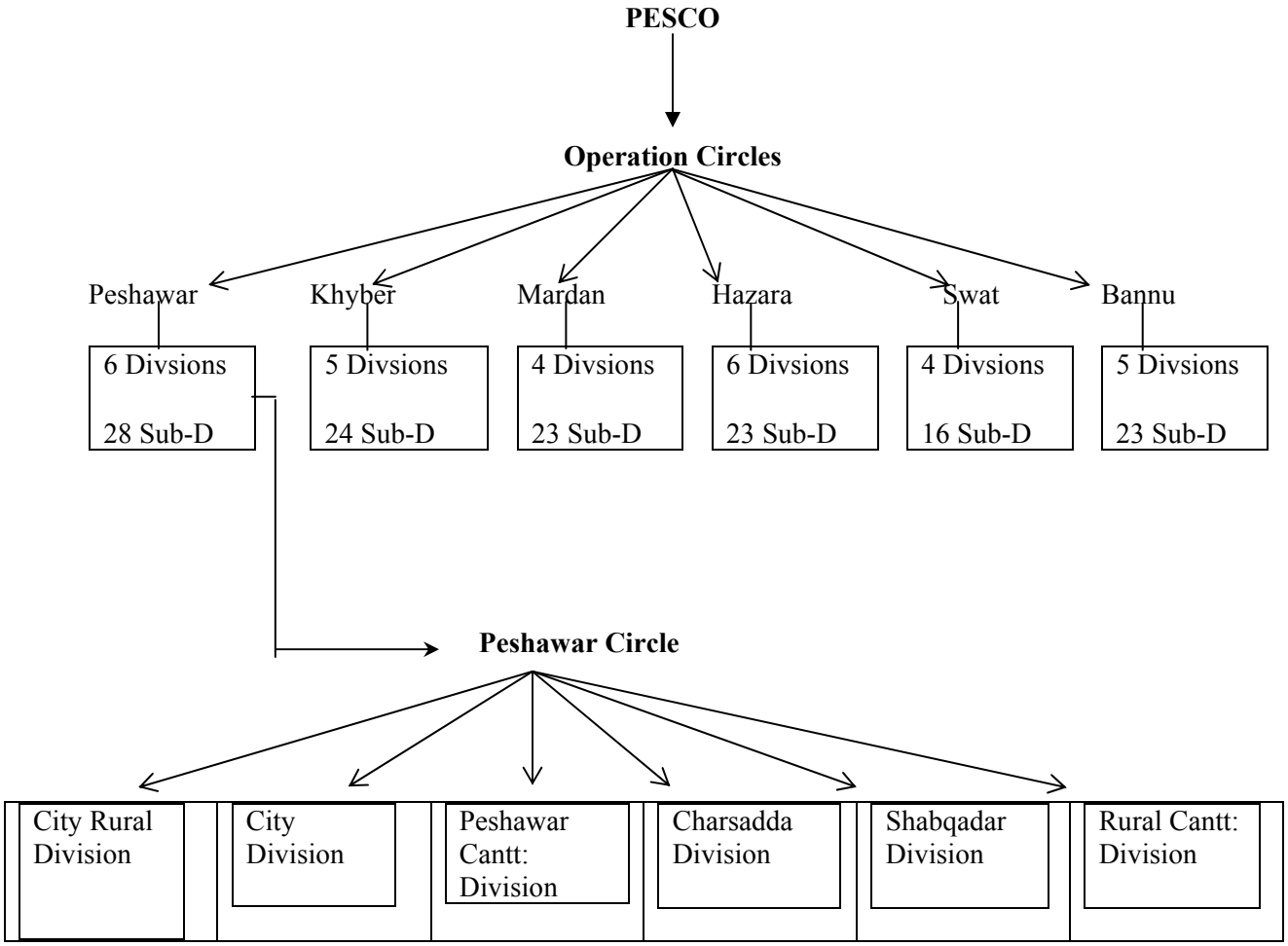
Meddigan et al. (1983) mentioned that HH demand for electricity in rural areas depends on sources of energy used by HHs and price of electricity itself.

After a detailed literature review, it is concluded that both economic and non-economic factors influence domestic consumers demand for electricity. The present study is different from the previous work due to sample selection procedure and in use of

multinomial logistic model as an econometric technique. Moreover, education is used as explanatory variables which will be a valuable contribution to the literature.

3. ORGANIZATIONAL STRUCTURE OF ELECTRICITY SUPPLY IN DISTRICT PESHAWAR

Peshawar Electric Supply Company (PESCO) performs the function of electricity distribution and provision to all districts of NWFP. The Chief Executive Officer (CEO) is the administrative head of the department. Other staff members including Chief Engineer Operations, Manager Operations, Deputy Manager Operations, Assistant Manager Operations, work under CEO. PESCO supplies electricity through its six Distribution Operation Circles. The following schedule provides details of the same.



(Source: PESCO & City Rural Division)

The study area is all the five sub-divisions of City Rural Division namely Nishtaraabad, Chankani, Hashtnagri, Rehman Baba and Lala. There are 48533 domestic

consumers in the City Rural Division out of which 1350 domestic consumers are in Nishtar Abad division, 11295 in Chamkani, 5226 in Hashtnagri, 10654 in Rehman Baba and 20008 in Lala division respectively. PESCO supply electricity to City Rural division through five Grid Stations i.e Peshawar Fort, Rehman Baba, Dalazak Road, City Grid and Shahi Bagh.

4. MATERIALS AND METHODS

4.1 Data

The present study used primary data collected from all sub-divisions of City Rural Division during the period November-December 2009. A questionnaire was developed which consisted of all important variables relevant to the study objectives. It was discussed with the experts and pre-tested in the field through a pilot study. A sample size of 200 HHs was selected from all sub-divisions of City Rural Division through proportional sampling method by using the following formula.

$$n_i = N_i \cdot n / N$$

Where,

n_i = Stands for number of HHs selected from the i^{th} sub-vision

N_i =Total number of all HHs in the i^{th} sub-division

n = Total sample size

N = Total Population

Secondary data showing the organizational structure and distribution of electricity in the study area was collected from PESCO office and City Rural Division of district Peshawar.

4.2 Methodology

Household's demand for electricity depends on the utility they derive from its consumption in form of the use of electric appliances. A modified form of general utility function based on the demand model used by Louw et al, for Africa (2008) is adopted which is as follows.

$$U = f(e, x)$$

Subject to constraint

$$Y = p_e q_e + p_x q_x$$

Where e is the electricity and x is a vector of all other goods and services consumed by the HH, Y is the income of HH, p_e is the per unit price of electricity, q_e shows the units of electricity, p_x is the price and q_x is the quantity of all other goods and services consumed by HH.

For maximization of HH utility the following Lagrangian Multiplier function is used.

$$\phi = u(e, x) - \lambda (p_e q_e + p_x q_x - Y)$$

Differentiating with respect to q_e, q_x and λ we have

$$\partial\phi/\partial q_e = \partial u/\partial q_e - \lambda p_e = 0$$

$$\partial\phi/\partial q_x = \partial u/\partial q_x - \lambda p_x = 0$$

$$\partial\phi/\partial\lambda = 0 - (p_e q_e + p_x q_x - Y)$$

$$\partial\phi/\partial\lambda = 0$$

Simplifying the above equations we obtained

$$\partial u/\partial q_e = \lambda p_e$$

$$\partial u/\partial q_x = \lambda p_x$$

Where

$$\partial u/\partial q_e = mu_e \;\&\; \partial u/\partial q_x = mu_x$$

So we have

$$mu_e / p_e = mu_x / p_x$$

Lagrrangian Multiplier function satisfies the first order condition. This helps us in the derivation of the following HH demand function for electricity by using Marshallian Demand function.

$$e = f(p_e, Y)$$

4.3 Model for Estimation

To measure HH's demand for electricity, their monthly electricity consumption (MEC) in Rupees is taken as a dependent variable. Multinomial Logistic Model is applied to estimate the effects of explanatory variables on HH's MEC which is categorized in four different groups. Category 1 represent those HHs whose MEC is within the range of Rs. 1-1000. Where categories 2, 3 and 4 stands for those HHs whose MEC is within the

ranges of Rs. 1001- 2000, Rs. 2001-3000 and Rs. 3001 & above respectively. HH income, education, price of electricity, number of rooms and a dummy variable for weather were taken as explanatory variables.

In demand, price plays a key role. To know the impact of rising prices of electricity on HH's demand for electricity, price is taken as a dummy variable in which 1 stands for, that rising prices of electricity affect HH's MEC and 0 depicts no effect.

Income is another important variable affecting HH demand for electricity. Income was divided into four quartiles in which Q_1 stands for those HH whose monthly income is up to 10000. Similarly Q_2, Q_3 and Q_4 represent those HH whose income levels are Rs. 10001-20000, Rs. 20001-30000 and Rs. 30001 & above respectively by keeping Q_1 is a base category. The third variable included in the model is HH level of education. Among the HH members the highest level of education is used as a proxy for its measurement. To know the impact of various levels of education on household MEC, education is divided into four categories i.e. primary, metric, graduate and post graduate. Primary is kept as a base category among all levels of education. Education is used in sense of awareness. It is assumed that HHs with highest level of education save more electricity. Number of rooms is also an important determinant of HH's MEC. A rise in number of rooms increases HH's MEC and vice versa. To find-out the impact of change in weather on HHs electricity consumption weather is included in the model. Weather is used as a dummy variable in which 1 depicts that in summer HHs increase the consumption of electricity and 0 for no increase.

The Model used to find out the determinants of HH demand for electricity is :

$$MEC = a_0 + a_1Ep + a_2Inc + a_3\ Edu + a_4\ Nr + a_5We + ui$$

Where,

MEC = Household Monthly Electricity Consumption

Ep = Effect of Rising Prices of Electricity on HH Electricity Consumption.

Inc = Household Income

Edu = Household Education

Nr = Number of Rooms

We = Weather

4.4 Results and Discussion

4.4.1 Estimation Results

Results obtained from Multinomial Logistic Model by taking **MEC** is a dependent variable are as under:

Table 2

Estimated Parameters of MEC

Dependent Variable HH Monthly Electricity Consumption

Category 1: MEC (Rs. 1-1000)

Independent Variables

	Coefficient	SE	z	P>|z|
Effect of Rising Prices (EP)	-0.9094844***	0.4887984	-1.86	0.063
2nd Income Quartile (Q2)	2.433073**	1.156941	2.10	0.035
3rd Income Quartile (Q3)	0 .7201541	1.065628	0.68	0.499
4th Income Quartile (Q4)	1.313565	1.169764	1.12	0.261
Metric (Highest Level of HH Education)	2.171577**	1.040892	2.09	0.037
Graduation (Highest Level of HH Education)	3.389441*	1.151709	2.94	0.003
Post-graduation (Highest Level of HH Education)	2.398301**	1.025339	2.34	0.019
Number of Rooms (Nr)	0.2885796***	0.158623	1.82	0.069
Weather (We)	1.194966**	0.5221577	2.29	0.022
Category 2: MEC (Rs. 1001-2000)				
Effect of Rising Prices (EP)	0.1221152	0.4909006	0.25	0.804
2nd Income Quartile (Q2)	2.65984**	1.179833	2.25	0.024
3rd Income Quartile (Q3)	0.3644551	1.090515	0.33	0.738
4th Income Quartile (Q4)	0.8246546	1.088723	0.76	0.449
Metric (Highest Level of HH Education)	2.567264**	1.041462	2.47	0.014
Graduation (Highest Level of HH Education)	3.049233*	1.164787	2.62	0.009
Post-graduation (Highest Level of HH Education)	2.58544**	1.030083	2.51	0.021
Number of Rooms (Nr)	0.241524	0.1592621	1.52	0.129
Weather (We)	1.176288**	0.5276604	2.23	0.026
Category 3: MEC (Rs. 2001-3000)				
Effect of Rising Prices (EP)	0.7108629	0.5672979	1.25	0.210
2nd Income Quartile (Q2)	2.141068***	1.241074	1.73	0.084
3rd Income Quartile (Q3)	1.391335	1.142349	1.22	0.223
4th Income Quartile (Q4)	2.186554***	1.198235	1.82	0.068
Metric (Highest Level of HH Education)	2.640406**	1.11305	2.37	0.018
Graduation (Highest Level of HH Education)	3.893186*	1.220125	3.19	0.001
Post-graduation (Highest Level of HH Education)	3.164014 *	1.082436	2.92	0.003
Number of Rooms (Nr)	0.3526182**	0.1752085	2.01	0.044
Weather (We)	0.6373347	0.5836954	1.09	0.275
Category 4: MEC (Rs. 3001 & Above)				
Effect of Rising Prices (EP)	2.102127	2.24463	0.94	0.349
2nd Income Quartile (Q2)	5.340367**	2.56006	2.09	0.037
3rd Income Quartile (Q3)	6.095708**	2.673673	2.28	0.023
4th Income Quartile (Q4)	2.379944	2.133666	1.12	0.265
Metric (Highest Level of HH Education)	2.882814	2.539253	1.14	0.256

Graduation (Highest Level of HH Education)	2.360819	2.76028	0.86	0.392
Post-graduation (Highest Level of HH Education)	3.266685	2.488545	1.31	0.189
Number of Rooms (Nr)	1.056645**	0.4476658	2.36	0.018
Weather (We)	0.2311067	2.025986	0.11	0.909

Number of obs	200
LR chi2 (48)	90.36
Prob > chi2	0.0002
Log likelihood	-241.9514

*, **, ***, Indicates Significance at 1 %, 5% and 10% Level of Significance

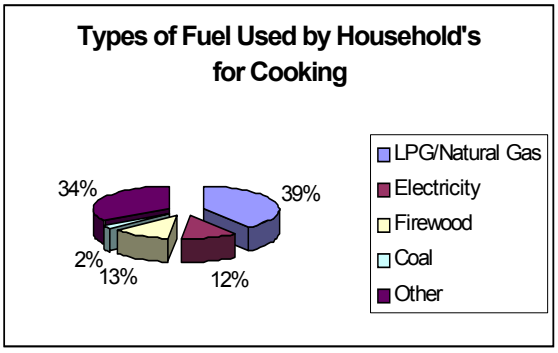
In order to find-out HH's demand for electricity, Multinomial Logistic Model was used. The results were derived by using statistical packages SPSS & Stata. The regression results indicate that income, education, price of electricity, number of rooms and weather have significant impact on HH's demand for electricity. According to the results, price remained significant for category 1 with negative sign. It showed that as the MEC level of these HHs are low any rise in price of electricity will result in reduction of their demand for electricity. However, for all other categories it turned out insignificant. Income is also an important determinant of HH's demand for electricity. The results obtained show that income positively affects HH's demand for electricity. With the increase in income, HHs increase the use of electric appliances which in turn raise their monthly electricity consumption and vice versa. The electricty demand of HHs of 2nd income quartile increases with increase in their income irrespective of MEC category. However, the 3rd income quartile is significant only for category 4 and 4th income quartile is significant for only category 3.

The study used education in the sense of awareness. Education at different levels for all categories of MEC remained significant but with positive sign. The positive sign indicates that an increase in the HH's education level may raise their standard of living, resultantly increasing their MEC level. Similarly, number of rooms also positively influence HH's demand for electricity for almost all MEC categories. Weather also remained significant for HHs of category 1 & 2 but insignificant for category 3 & 4. It is clear that as the MEC level of these HHs is already very high so they do not care for change in weather.

Types of fuel and appliances used by the consumers are some other important

variables which also influence HH's monthly electricity consumption apart from major variables of the study. Different types of fuel i.e. firewood, coal and gas are mostly used for cooking. However, with the passage of time people also started the use of electricity for fuel purposes. One reason for this is the electric devices, which made cooking easier for people in comparison with other sources. HHs were asked about the usage of different fuels to know the people tendency towards the use of electricity for cooking.

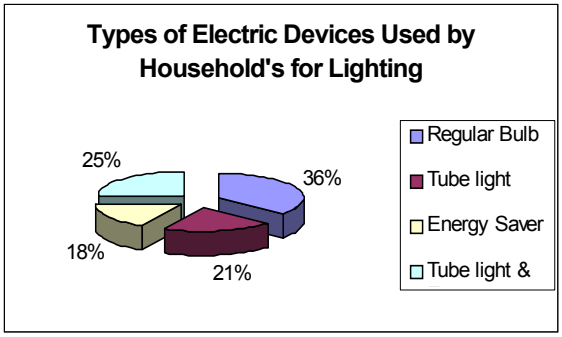
Figure. 1



Source: Field Survey

Figure.1 shows that 39% HHs use gas for cooking, 12% electricity, 13 % firewood, 2% coal and 34% other types of fuel. This shows that the use of electricity as a fuel is also an important determinant of HH's MEC. Different types of electric devices used by HHs affect their demand for electricity. HHs were asked, what type of electric devices they generally use for lighting.

Figure. 2



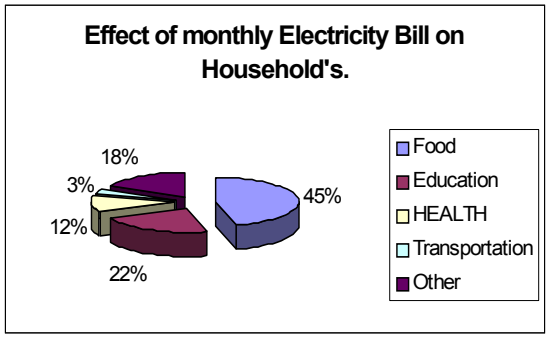
Source: Field Survey

Figure. 2 shows that 36% use regular light bulbs, 21 % tube lights, 18% energy savers

and 25 % tube lights & energy savers. The main reasons of differences among HH's choice of different electric lights are income, locality and other expenses.

HHs were also asked about the type of their expenditure mostly affected by electricity charges. 45% HHs mentioned food items, 22% education, 12% health, 3% transportation and 18% other things which is given in figure. 3.

Figure. 3



Source: Field Survey

COCLUSION

This study investigated the role of economic and non-economic factors in the determination of HH's demand for electricity in district Peshawar. The results revealed that residential demand for electricity is mostly affected by income, education level of HH, number of rooms and the change of weather. The price of electricity also affects the electricity demand but only for the consumers having comparatively lower monthly electricity consumption. However, it is suggested that a provincial level study will be more beneficial to get clear estimates of residential demand for electricity. This study will be helpful for government in understanding the future trend and pattern of residential demand for electricity in Peshawar

REFERENCES

Al- Salman, M. H. (2007). HH demand for energy in Kuwait. *J. King Saud Univ*, Vol. 19, pp. 51-60.

Amusa, H., Amusa, K., & Mabugu, R. (2009). Aggregate demand for electricity in South Africa: An analysis using the bounds testing approach to Cointegration. *Energy Policy* 37, pp. 4167-4175.

Athukorala, P. P. A. W., & Wilson, C. (2009). Estimating short and long-term residential demand for electricity: New evidence from Sri Lanka. *Energy Economics* xxx, ENEECO, 01814.

Carcedo J. M., & Otero , J. V. (2005) Modelling the non-linear response of Spanish electricity demand to temperature variations. *Energy Economics* 27, pp. 477– 494

Erdogdu, E., (2007). Electricity demand analysis using cointegration and ARIMA modelling: A case study of Turkey. *Energy Policy* 35 pp. 1129–114.

Filippini, M., & Pachauri, S. (2002). Elasticities of electricity demand in urban Indian HHs *CEPE*, Working Paper No. 16.

Franco, G., & Sanstad, A. H. (2008). Climate change and electricity demand in California. Climatic Change 87, (Suppl 1) S139–S151.

Government of Pakistan, Economic Survey of Pakistan (2008-09), Economic Advisors Wing, Ministry of Finance, Islamabad.

Halicioglu, F. (2007). Residential electricity demand dynamics in Turkey. *Energy Economics* 29, pp.199-210.

Halvorsen, B., & Larsen, B. M. (2001). Norwegian residential electricity demand: A microeconomic assessment of the growth from 1976 to 1993. *Energy Policy* 29, pp. 227-236.

Holtedahl, P., & Joutz, F. L. (2004), Residential electricity demand in Taiwan. *Energy Economics* 26, pp. 201-224.

Hondroyiannis, G. (2004). Estimating residential demand for electricity in Greece. *Energy Policy* 26, pp. 319– 334.

http://www.pepco.gov.pk/

http://www.pesco.gov.pk/area_of_operation_t.asp

Louwa, K., Conradie, B., Howells, M., & Dekenah, M. (2008). Determinants of electricity demand for newly electrified low-income African HHs. *Energy Policy* 36, pp. 2812– 2818.

Maddigan, R. J., Chern, W. S., & Rizy, C. G. (1983). Rural residential demand for electricity. *Land Economics*, Vol. 59, pp. 150-162.

Psiloglou, B.E., Giannakopoulos, C., Majithia, S., & Petrakis, M. (2009). Factors affecting electricity demand in Athens, Greece and London, UK: A comparative assessment. *Energy* 34, pp.1855–1863.

Tully, S. (2006). The human right to access electricity. *The Electricity Journal*, Vol.19, Issue 3.

Ziamba, E., (2008). The demand for residential electricity in South Africa. *Energy Policy* 36, pp. 3460-3466.