Technical Journal, University of Engineering and Technology (UET) Taxila, Pakistan *Vol. 26 No. 4-2021*
ISSN:1813-1786 (Print) 2313-7770 (Online)

Impacts of Socio-Economic Factors and Elements of Urban Form on Domestic Electricity Consumption: a Case Study of Islamabad

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Abstract- The global energy scarcity and exceptional increase in energy consumption pushed energy optimization in the ambit of inevitable tasks. Meanwhile, the ambience of urban life is reliant on energy availability. Energy crisis of the 1970s gave rise to the energy conservation principles but the idea of regulating domestic electricity demand through socio economic and urban form elements gained popularity in the early 2000s. Pakistan has 39% urban population while urbanization rate in Pakistan is 2.81% which means cities are expanding faster and will claim more energy in future. The country is facing an electricity shortage hence beside production, optimum regulation of electricity demand is imperative. This research investigates the socio-economic features and urban form elements with respect to their effects on domestic electricity demand in the context of Islamabad, Pakistan. Four residential areas of Islamabad are selected as the case study. Income level, household size, house ownership is taken as socio economic characteristics. Street pattern, land cover, house size, no of storey, basement, tree plantation, open to sky area are taken as elements of urban form. Electricity billing data is collected from the electric supply company, IESCO and a questionnaire survey is conducted in four residential areas of case study. Satellite imagery is obtained through Google earth and plans are downloaded from the official website of CDA. A total of 200 households are surveyed. The data is coded and analyzed in SPSS, therefore, multivariate analysis techniques including correlation and regression analysis are employed. Moreover, electricity consumption is largely dependent on the micro elements of urban form including open to sky area, tree plantation, basement and house size. The paper intends to highlight major trends of electricity consumption. The key findings of this study show that two of the socio-economic features including income and household size significantly affect electricity consumption. This research concludes that significant reduction in electricity demand is possible through socio economic and urban form changes. It is recommended to ensure basement provision in the buildings, maximize open area, promote tree plantation, incorporate natural ventilation and minimize household size for reduction in electricity consumption.

Keywords- Energy Scarcity, Urbanization, Energy Conservation, Urban Form, socio economic, Multivariate analysis techniques

I. INTRODUCTION

In the late 1920s alarms related to energy resources depletion started beeping, but these were responded merely through conservation strategies till the 1970s. In 1970 the energy crises pushed planners to pay attention towards energy efficiency at building and neighborhood level. Subsequently, many design and planning principles emerged regarding the optimum association of urban development and energy usage in the 1970s but most of these concepts remained unimplemented. Once again, the energy and economic crunch in the last few decades brought our focus to this subject [1]. Globally The major green-house gas emissions and total (60%-80%) energy usage is done in cities, due to the ever-increasing urbanization. Energy crisis is a global concern and more attention is being paid to energy safety, energy equity and energy sustainability. Cities have almost two-thirds share in the primary energy consumption around the globe and by the year 2050 half of the world will be urbanized in terms of population. It is imperative to take demand side measures to maintain balance between energy supply and its demand [2]. Modern urban planning methods are particularly needed to get advantage from energy efficiency measures. Urban form may play an essential role in reducing energy consumption to optimum level. Currently, less work is conducted on this subject and a significant research gap exists in this direction. Reducing domestic energy consumption through elementary improvements in urban form. domestic electricity consumption is affected by urban form elements are studied in the context of Islamabad, Pakistan. Islamabad has a diverse climate with variant five seasons. June is the hottest month with an average temperature 38 °C (100.4 °F). Four residential areas of Islamabad are selected as the case study. Both the micro and macro level elements of urban form are incorporated in this study. Macro level elements include street pattern, land composition and topography. The micro level elements include demographic, housing characteristics and environmental characteristics. Demographic characteristics are represented by household size, household type and household income. Housing characteristics are represented by house size, no of storey, basement provision, no of rooms, house age and house ownership. The percentage of open to sky area and no plants in house are considered as environmental characteristics. Domestic energy consumption is represented through electricity bills and occupant behavior. To conduct this study, both the primary and secondary source data is acquired from the case study and relevant departments i.e. CDA, IESCO. Descriptive and correlation analysis techniques are employed to generate results. Electricity billing detail and a questionnaire survey from the residents of the case study area is collected. The major trends of electricity consumption are highlighted. Considering these trends, this research concludes that micro level elements of urban form remarkably affects the domestic energy consumption and suggests improvements that can play a vital role for optimum regulation of domestic electricity demand. Thus, it may enable city planners to understand their role in minimizing domestic energy demand. The findings of this study are expected to generate base for the future research in the field of domestic energy efficiency and is expected to recommend the improvement in bylaws/rules regulating development.

Today, European cities claim about 70% of the overall primary energy consumption, and this share is likely to swell to 75% by 2030. Buildings demand higher energy in developed countries as compared to industry and transportation sector, like in London city it is 2.2 times higher than transportation sector [3]. Considering these facts, more insistent efforts are required to regulate domestic energy consumption. Over the last few decades, world-wide urban form emerged as a factor that potentially influences domestic energy consumption and many studies are conducted on the usefulness of urban form elements as a tool to regulate consumption of energy. Since 2000 there is an increasing trend of studying the urban form and its impacts on energy consumption throughout the world. Urban planners propose multiple solutions for energy efficiency including going vertical through compact development and green construction technologies. Some of the formerly conducted popular research studies are briefly discussed in the under given paragraphs, in which researchers investigated the cities of the United States and computed the association of urban form and domestic electricity usage. They concluded that compact development is associated with least domestic energy consumption. [4] investigated the mutual dependence of energy consumption on urban form elements and found out that housing characteristics are notably influencing the domestic energy consumption and calculated the association of urban geometry of cities with their energy consumption. He considered façade distance, its orientation, specific angles and sky line as variables. The association was found positive and the study concluded reliance of energy consumption upon the geometry of cities. Cities are expanding faster and will claim more energy in the coming years. Meanwhile Pakistan is facing an energy shortage. Hence, optimum regulation of energy demand is imperative. Along with the construction of new dams, there is another facet to deal with this issue.

Urban form tissues are combined together with urban elements, like street patterns, open spaces, buildings and different block types in the formation of a city on both macro and micro levels [5]. The urban form is a combination of macro & micro level elements of the urban system. Urban form represents the relation between the outdoor spaces and buildings, which exist in a given landscape/soil. The outdoor space and buildings may be then analyzed as elements in their relationship with other urban elements [6].

The idea of regulating domestic energy demand through urban form elements gained popularity in the early 2000s. Many studies are conducted on this subject in different parts of the world. In 2008, Ewing & Rong in the major cities of the United States studied the relationship between urban form and residential energy. Their study indicated that compact development is correlated with lower residential energy consumption and implications of urban form elements on energy consumption found dwelling characteristics have remarkable effects on domestic energy consumption. Rising income level and households energy consumption level and choices depends upon the energy price scenarios [7]. Situational factor and behavioral intentions correlate the energy saving and energy consumption patterns in China [8]. Residential energy consumption effect climate change and it also depends upon the economic conditions of the household & the energy prices. It is heterogeneous in both urban and rural areas of China [9]. Space heating and cooking are the main energy intensive demands in rural areas and is related to living standards, socioeconomic levels, air pollution and health [10]. Household energy consumption and fuel choices in southern Ethiopia depends upon the socioeconomic level, qualification of the household members and access to road and distance to the market [11].

Pakistan has 39% urban population while urbanization rate in Pakistan is 2.81% which means cities are expanding faster and will claim more energy in the coming years. Meanwhile Pakistan is facing an energy shortage. Hence, optimum regulation of energy demand is imperative [12].

This research studies the impact of urban form elements on domestic electricity consumption in the context of Islamabad, Pakistan. Both the micro and macro level elements of urban form are incorporated in this study. Macro level elements include street pattern, percentage green area and topography and micro level elements include Demographic and housing characteristics. Domestic energy consumption is represented through electricity bills.

II. LITERATURE REVIEW

The alarms of energy concerns first started beeping in the 1920s. The energy crises in 1970 brought this subject into mainstream attention worldwide which resulted in significant research work in the field of energy efficiency. Researchers contributed various design and planning principles to link urban development and energy usage in the best efficient manner including societies like the Village Home in Davis, California. In the late 2000s the energy and economic crisis reawakened our attention to this subject. City planners are now exploring the multi- scale factors of domestic electricity consumption.

Danish Ministry of Energy published research results carried out among 1500 houses in Denmark, on electricity saving in the domestic sector. Using a multiple regression analysis, the study assessed the effect of number of children and adults, dwelling size, household income and stock of electrical appliances on annual electricity consumption. The results discovered that 64% of electricity consumption can be ascribed to the number of people in the house, appliance consumption and the total floor area [13]. A study conducted in Australian cities are highlighted the fact that compact city form consumes less residential energy per capita than the scattered outskirts [14]. In another research socioeconomic parameters, climatic and weather conditions, dwelling characteristics, occupant number, dwelling size and type of heating and cooling in it determines the energy consumption levels in Greece. Technological development, socioeconomic parameters and contemporary ways of living determine the energy consumption patterns [15].

Total number of rooms, dwelling type, tenure type and number of electricity appliances effect the annual energy consumption in households [16].

Another study in Malaysia also reveals that the family size, income level, number of rooms and technological development are the factors that determines the energy consumption in Malaysian households [17]

Compared the household energy use between urban fringe suburbs and inner-city neighborhoods of Adelaide, Southern Australia [18]. The statistical analysis pointed out that the delivered energy use was largely affected by the urban form factors including location, number of shared walls, dwelling structure, and the site area with the variations in the household's use of operational energy were explained by the physical features in contrast. This study concluded that there is a regular impact of physical and socio-economic characteristics on domestic energy usage. M. Murshed and M. Ishak investigated that increase in economical growth, technological advancement and overall socio-economic conditions correlated the energy consumption and choice of energy usage from renewable energy resources to renewable energy resources in Bangladesh [19].

Studied the energy usage of buildings in urban context. The study indicated that urban buildings consume at least twice the energy of urban transport. The urban form is a significant determinant of energy use. The study reviewed urban and regional energy modeling and identified the research gap that there are no energy models with sensitivity to urban form. The study adopted different assessment methods at the scale of city and neighborhood [20]. In Iran household and neighborhood level study was conducted based on primary survey, ordinary linear regression analysis depicted that physical feature like building height, parcel size and setback width played significant roles in explaining the variances exist in energy use level. The results of study confirmed the role of high-density development in reducing energy consumption. However, no substantial association was found between energy consumption and other features of urban form including building age, materials used in buildings and the type of Facades [21].

A study indicated that increasing urban density and reducing the sizes of units and lots can subsidize energy use for residential neighborhoods. The researcher proposed energy-related incentives/ regulations for community design and municipal tree-planting programs to reduce the domestic energy demand [22].

The research studies on the subject of energy conserving principles observed a gradual shift from traditional rigid energy conserving layouts to the multi- factor comprehensive designs of domestic electricity consumption. The studies conducted in early 2000 incorporated the demographic and social elements as a significant factor to the trend of energy consumption and proposed conservation measures. The contemporary studies indicated that urban density and physical interventions at building scale are also a factor of energy consumption [23]

III. RESEARCH METHODOLOGY

Both the descriptive and exploratory research methods are employed. The energy impact of Macro level urban form elements is described through descriptive research while exploratory research is applied to explore the impact of micro level urban form elements on the domestic electricity consumption. Data is collected through both sources primary and secondary including responses from households through questionnaires. Secondary data covers relevant research papers, Billing data and departmental documents. The research is conducted in three consecutive stages i.e. conceptualization, data collection and data analysis.

IV. DESCRIPTION OF THE STUDY AREA

The capital city Islamabad having 540 meters elevation is located at the northern edge of the Pothohar Plateau and at the foot of the Margalla Hills. July is the wet month with extreme rainfall. G-11, Tele Garden, Wapda Town and Commoners Town has an area of 906 square km or (350 Sq mi). It has a population of 2 million. The city is administered by the Capital Development Authority (CDA). There are eight basic zones in the city. Fragments of four selected areas are studied including sector G-11/3, B-17, F-17, a Commoners town. These areas lie at different locations of the capital city.

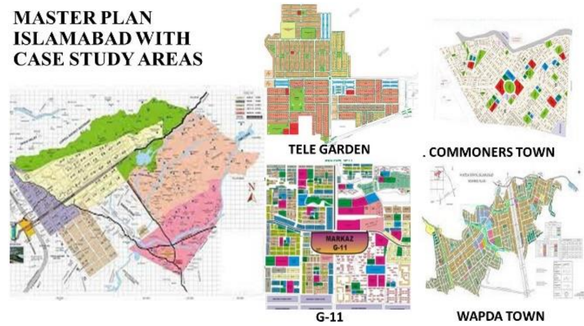


Figure 1: Case Study Areas

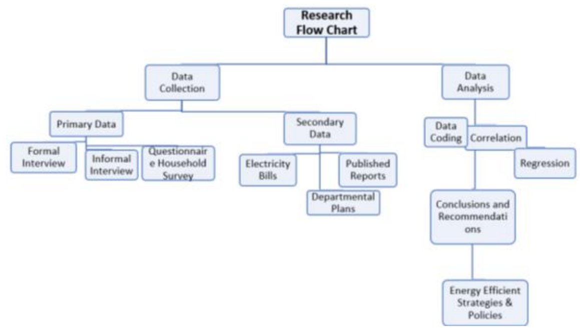


Figure 2: Flow Chart Diagram of Research

The definition of urban form and classification of its elements are studied through the literature. Articles related to the definition and elements of urban form, energy impact of urban form determinants of residential energy consumption and strategies for regulating domestic electricity consumption through urban form features are also studied.

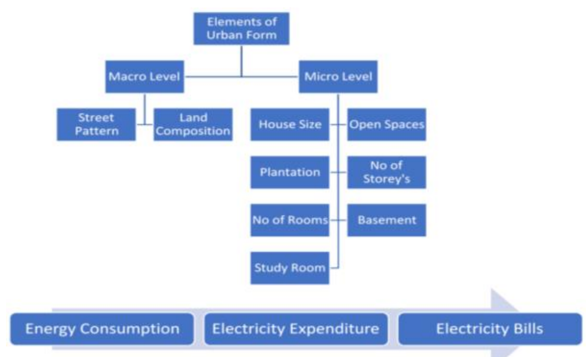
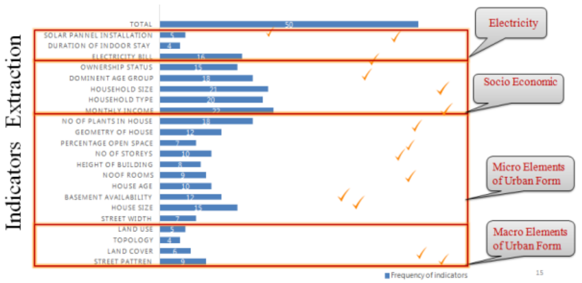


Figure 3: Elements of Urban form and Energy Consumption

V. DATA COLLECTION

The total no of households in the selected four areas are roughly estimated about 2000 units as per CDA. The 10% sample size is selected for the survey. Almost 200 households were sampled for the data collection. Questionnaire survey was conducted from four selected areas in an even manner with 50 questionnaires from each area. Random sampling technique was employed to collect primary data from each of the four selected areas.

Table: 1



The individual variable and its indicator source are given in the below table.

Table: 2

Selection of Variables		
Dimension	**Variables**	**Indicator Source**
Urban Form (Macro level)	Street pattern Land composition	*Downs A, 1994* *TBR, 2009*
Urban Form (Micro level)	House size Basement Opens pace percentage No of floors No of rooms Plantation	*Mc Loughlin et al., 2012* *O' Doherty et al., 2008*
Socio economic	Income Household type Household size House ownership status	*Zhou & Teng, 2013* *Bartusch et al., 2012* *Sardiano, 2007* *Chen et al., 2013*
Electricity consumption	Average monthly bill Solar panel installation	*Yekang Ko, 2013*

VI. DATA ANALYSIS

The primary data collected from questionnaire survey and secondary data gathered from Islamabad electricity supply company IESCO is organized and processed in a statistical package for social sciences SPSS. Multivariate analysis is employed. The cross-tabulation technique, correlation analysis and regression analysis are conducted to generate results. The descriptive statistics and the model outcomes are explained with reference to the findings of formerly conducted research studies.

Urban Form Elements

Table: 3

G-11		Commoners Town	
Frequent Household Type (Joint)	46%	Frequent Household Type (Joint)	54.4%
Average Household size	4.34	Average Household size	4.%
Average Monthly Income	96000	Average Monthly Income	65000
Frequent House Size (10 Marla)	68%	Frequent House Size (10 Marla)	70%
Basement Availability	36%	Basement Availability	35%
Multi Floor Houses	79%	Multi Floor Houses	30%
Average Number of Bed Rooms per House	4.5	Average Number of Bed Rooms per House	3.5
Condition of House (Prevailing)	78%	Condition of House (Prevailing)	85%
House with big plants	61%	House with big plants	76%
Frequent Open Area in a House (20%)	72%	Frequent Open Area in a House (20%)	70%
Maximum electricity Consuming Activity (Air Conditioning)	60%	Maximum electricity Consuming Activity (Air Conditioning)	68%
Willingness to Install solar Panels	41%	Willingness to Install solar Panels	40%
WAPDA TOWN		**Tele Garden**	
Frequent Household Type (Joint)	55%	Frequent Household Type (Joint)	50%
Average Household size	3.0	Average Household size	3.94
Average Monthly Income	70000	Average Monthly Income	67860
Frequent House Size (10 Marla)	47%	Frequent House Size (10 Marla)	45%
Basement Availability	30%	Basement Availability	35%
Multi Floor Houses	68%	Multi Floor Houses	87%
Average Number of Bed Rooms per House	4	Average Number of Bed Rooms per House	4
Condition of House (Prevailing)	56%	Condition of House (Prevailing, Good)	73%
House with big plants	65%	House with big plants	80%
Frequent Open Area in a House (20%)	43%	Frequent Open Area in a House (20%)	44%
Maximum Light consuming Activity (Light, Fans)	67%	Maximum Light consuming Activity (Light, Fans)	68%
Willingness to Install solar Panels	21%	Willingness to Install solar Panels	29%

The area wise breakdown of house size shows that maximum ten Marla house size is the most frequent in nearly all areas while the least found is one kanal. A trend of house size is observed in WAPDA Town and Commoners Town as compared to G-11 and Tele Garden. A low tendency of basement provision in houses is observed in all areas. However, the least number of basements are found in Multi Garden. The minimum ratio of single to multiple floors of houses in the case of Tele Garden shows that it has a maximum number of multistory buildings and each house has four bedrooms on average. However, majority of single storey houses are observed in Commoners Town with least average of bedrooms i.e.

3.38. A moderate blend of single and multistory buildings is found in WAPDA Town with an average of 4.14 bedrooms per house. Three quarter houses are more than single storey in G-11 having maximum no of bedrooms on an average exceeding 4.5 bed rooms.
The house condition, ownership states and age of building shows remarkable variations. Majority of houses in G-11 and Tele Garden are found in normal condition. However, a balanced distribution of houses is observed regarding good and normal conditions in case of WAPDA Town and Commoners town. Only one house out of the complete sample is noted in poor condition. The age of house is highest in case of G-11 and that is closely followed by Commoners Town. However, the average age of houses drops remarkably in case of Tele Garden and WAPDA Town as compared to G-11. The result shows that the maximum number of houses in WAPDA Town lack plantation. The houses in Tele Garden have a maximum plantation. A mixed trend of plantation is observed in case of G-11 while limited plantation is observed in case of Commoners Town. Houses in nearly all the areas are properly ventilated. However, the percentage of open space in Commoners Town is observed a bit lesser compared to other areas.

Table:4

URBAN FORM ELEMENTS				
	FREQUENCY (G-11)	**FREQUENCY (TELE GARDEN)**	**FREQUENCY (WAPDA TOWN)**	**FREQUENCY (COMMONERS TOWN)**
House Size				
3 Marla	1	7	3	8
5 Marla	4	14	19	35
6 Marla	2	1	1	0
8 Marla	7	8	2	1
10 Marla	34	20	21	6
12 Marla	2	0	2	0
Basement				
Exists	17	19	16	19
Doesn't Exist	33	31	34	31
Single / Multi Floor Ratio	(0.25)	(0.190)	(0.66)	(1.77)
Average No of Bed Rooms	4.58	4.0	4.14	3.38
No of Big Plants				
0	17	11	20	11
1	17	10	16	31
2	15	19	11	10
3	1	9	2	0
4	0	1	1	0
Open Area in House				
15%	1	7	2	7
20%	12	20	22	33
25%	36	22	24	10

The residents of houses in G-11 consider air-conditioning as the maximum energy consuming activity while the same is considered as least energy consuming activity by the residents of Commoners Town. A trend of high usage of Air conditioners is also observed among the G-11 residents. However maximum usage of fans & lights is observed in case of Commoners Town. None of the houses in the complete sample is found with installation of solar panels. The residents of Commoners town and Tele Garden are more inclined towards installation of solar panels in future. The least willingness to install solar panel is observed in the case of G-11.
To identify the correlation of socio economic, physical, environmental and behavioral characteristics with the electricity expenditure correlations analysis is employed on a total no of fifteen variables. Data set collected against each variable represents 200 respondents. The results suggest that 24 out of 105 correlations were statistically significant with a p value greater than 0.5.
A total of 68 correlations are found positive while the rest of correlations are negative out of a total 105 correlations. Some of the vital values of correlation are discussed below in the matrix shown below. More attention is being paid on energy sustainability, safety and equity in order to cope with energy crises globally and to maintain imperative measures for energy efficient methods to cope with the difference between demand and supply. Urban form can play a significant role in energy efficient housing.

Socio Economic Characteristics

The area wise distribution of household type shows that the overall tendency of the nucleus family unit is higher compared to single or joint systems in all areas. A higher trend of joint families is observed in G-11 & Tele Garden F-17 while in WAPDA Town B-17 & Commoners Town the single household type is frequently found. The distribution of household size reflects that G-11 has the maximum household size and is followed by Tele Garden. The minimum household size is found in the case of Commoners Town which is slightly lower than the household size of Multi Garden.

Table:5

Socio Economic Features				
	Frequency (G-11)	**Frequency (Tele garden)**	**Frequency (WAPDA town)**	**Frequency (Commoners Town)**
Household Type				
Single	9	7	5	8
Nucleus	23	5	2	7
Joint	18	8	[illegible]	
Dominant Age Group				
Youngster	10	1	[illegible]	
Mature	33	1	7	8
Elder	7	8	7	7
Average Household Size	4.34	3.94	3.68	4.1
Average Monthly Income Rs	94,120	67,860	68,820	64,780

Electricity Expenditure and Socio-Economic Features
Majority of formerly conducted studies endorsed that demographic characteristics create significant impacts on residential electricity consumption. The socio-economic features upon which correlation analysis is computed are household size, household type, income group, average lifespan of family members and dominant age group. Through the correlation analysis, this study reveals that energy consumption keeps a high relationship with the demographic attributes. The electricity expenditure is strongly correlated with the majority of pre-selected characteristics in a positive manner.

Table: 6

Electricity Consumption Behavior				
	Frequency (G-11)	**Frequency (Tele garden)**	**Frequency (WAPDA town)**	**Frequency (COMMONERS TOWN)**
Max Electricity Consuming Activity				
Food prep& Preserve	4	11	2	0
Washing & Cleaning	8	13	1	3
Air Conditioning	29	16	20	14
Lighting & Fans	9	10	27	33
Frequently used Electrical Appliance				
Fridge, Freezer, Microwave	4	10	2	0
TV, LCDs, Radio	0	1	0	0
Water Pump, Cloth Cleaner,	29	16	20	14
Air Conditioner, Split Unit	8	13		3
Bulbs, Fans	9	10	27	33
Solar Panel Installed				
Yes	0	0	0	0
No	50	50	50	50
Willingness to Install Solar				
Panel				
Yes	9	10	7	16
No	41	40	43	34

Income appeared to be a big influencer of electricity expenditure as per results. A strong positive correlation exists among monthly income and electricity bills which reflects that the electricity demand of rich domestic units is much more than those falling in lower income groups. It also points towards affordability and energy behavior of different income groups. A possible explanation for this trend could be the high living standard and comfort priority of high-income groups. The rich households are normally composed of a larger number of occupants inclusive of servants and live in big houses. It shows that the high-income group is less inclined to compromise comfort living and hence consumes more electricity as compared to the low-income group. Similar findings have been reported by in their research to predict electricity consumption using household income and other explainable variables [24]. Another study on the energy-saving features and determinants of ownership conducted by J.O. Doherty in context Ireland regards income as a leading factor in determining the electricity expenditure [25]. Mcloughlin stated that the variable of disposable income has a substantial impact on consumption of energy [26].
The domestic energy use and household size are significantly correlated in a positive manner. It indicates that joint family households consume more electricity compared to nucleus and single households. With the increase in dwelling occupants, the concurrent usage of electrical devices also increases that increases the electricity demand. In a study conducted to determine the multiple causes of electricity demand in the context of Mumbai, (Tiwari in 2000) claimed that electricity expenditure is correlated with the household size and recognized that families with 5 members consume 23% more electricity than two-member families [27].
The higher or lower life span of residents of a house doesn't affect the electricity expenditure to much extent as average life expectancy has very weak positive correlation with average electricity bill with a P value of 0.114 only. This result might be explained by analyzing the correlation of life span with household size which is quite weak and insignificant. It shows that longer or smaller life span does not necessarily cause rapid change in the number of residents and resultantly energy expenditure remains unaffected. The statistics shows that electricity expenditure is very weakly correlated with the dominant age group and this correlation is statistically insignificant. This finding is in concurrence with the former studies of similar nature. Bedir calculated the determinants of energy demand in Dutch houses and reported that family composition in terms of age has no influence on electricity demand [28]. Some researchers also found no significant correlation among dominant age groups and electricity expenditure while investigating the equity implications of social and engineering determinants on domestic electricity usage [29]. However, some researchers believe that the presence of teenagers as the dominant group affects electricity consumption

[30]. F. Bartiaux in 2005 while studying the influence of Socio-political factors on household energy usage reported the significant impact of teenage group on electricity usage.

A significant adverse correlation exists between house ownership status and electricity expenditure. The electricity expenditure of privately owned housing units is more than the rented units. One logical explanation of this outcome might be financial. Ownership is something associated with wealth and it is predominantly observed that the size of houses on rent are lesser than owned houses. It is a common observation that lower income families are more engaged in rented housing so they prefer electricity conservation measures because of financial constraints [31]. (Yohanis, Y.G., Mondol, J.D., Wright, A., Norton, B, 2008) established a significant correlation between ownership of houses and domestic electricity usage in the context of Northern Ireland. In a comparison between rented and owned homes by (Wyatt in 2013) found out that owned homes have high electricity demand. The findings show low domestic electricity consumption in newer houses [32]. A moderately negative correlation prevails among house age and electricity consumption with a value of 0.36 statistically significant. It is because of the heat loss due to poor insulation as older houses contain outdated insulation techniques. (D. Wiesmann in Energy Policy) studied residential electricity consumption in Portugal and reported that new houses have less electricity demand because of improved insulation facilities [33].

VII. Results & Discussion

A total of 200 households are surveyed. The majority of respondents are found to be male by gender and the head of household. The trend of private sector occupation is dominantly observed in all the four selected areas. The respondents from different age groups are surveyed while the majority of respondent's age lies above 35 years. The figure 6.0 below shows the detailed profile of respondents.

The house size is ten Marla and five Marla while the least found is one kanal (i.e. 4500 sqft). A trend of smaller house size is observed in curved linear and fragmented liners as compared to grid iron and linear street patterns. A low tendency of basement provision in houses is observed in all types of street patterns. However, the least number of basements is found in the curve linear pattern. The age of the house is highest in case of grid iron and that is closely followed by fragmented linear. However, the average age of houses drops remarkably in case of linear and curve linear patterns as compared to grid iron & fragmented linear pattern.

The residents of houses in grid iron pattern consider air-conditioning as the maximum energy consuming activity while the same is considered as least energy consuming activity by the residents of fragmented street pattern. A trend of high usage of Air conditioners is also observed among the grid iron pattern residents. However maximum usage of fans & lights is observed in case of fragmented linear patterns. None of the houses in the complete sample is found with installation of solar panels. The residents of fragmented linear and linear street patterns are more inclined towards installation of solar panels in future. The least willingness to install solar panels is observed in case of grid iron pattern.

The minimum ratio of single to multiple floors of houses in case of linear pattern shows that it has a maximum number of multistory buildings and each house has four bedrooms on an average. However, the majority of single storey houses are observed in a fragmented linear pattern with least average of bedrooms i.e. 3.38. A moderate blend of single and multistory buildings is found in a curvilinear pattern with an average of 4.14 bedrooms per house. Three quarter houses are more than single storey in grid iron pattern.

Respondent's Profile

Respondents	No of questionnaires
Govt Job	52
Private Job	96
Business	42
Others	10
Total	200

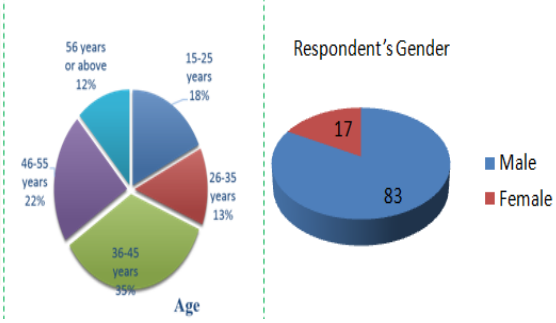


Figure: 4 The detailed profile of case study areas

Electricity Expenditure and Urban Form Elements

The impact of house size on electricity expenditure is generally linked to its requirement for space conditioning. The correlation is statistically significant with a value of 0.554.

A statistically significant, +ve correlation between electricity usage and size of house is detected. The electricity demand of a house is positively dependent upon its size because more area requires space conditioning in bigger houses. Moreover, it might be due to a common assumption that bigger residential units imply a larger number of residents and thus, the electricity demand for air-conditioning, cooking and cleaning is higher. Another justification for this result is that bigger houses have a greater number of rooms as compared to smaller houses. No of rooms and energy expenditure are positively correlated with a value of 0.530 and highly significant statistically. It implies that due to more no of rooms, more electrical appliances are used in bigger houses which elevate the electricity expenditure in comparison with small houses. This result is in line with the previous studies [34]. Nielsen in (1993) reported that if the floor area of a housing unit increases by 1%, it will elevate the electricity demand by 0.61% in the context of Denmark. While studying the domestic electricity consumption in the context of Indiana, (M. Filippini in 2004) recognized that electricity consumption rose 0.2% with an addition of 1% floor area of the household [35].

The number of floors in a house and its electricity expenditure are found to be positively correlated with high statistical significance as per results. This effect can be explained by the effect of number of floors on space cooling. The houses with multiple floors protect the ground floor from heat & sunlight exposure which is likely to reduce its cooling demand. Moreover, the common pattern of shifting from upstairs to ground floor in summer and vice versa in winters might also be a positive contributor towards reduction of electricity expenditure. The correlation matrix shows that the presence of a basement in a house is moderately correlated to energy expenditure with a high statistical significance. It implies that due to underground nature basements provide best shelter from the exposure of extreme weather and their demand for space cooling is low. Hence it is cognitive to assume that residents of houses with a basement avail this facility in summer due to which their energy expenditure drops. (P. Ferreira in 2005), endorsed the positive effect of the basement on reduction of space cooling expenditure [36].

The number of big plants and percentage of open area in houses are found to have moderate correlation with the electricity expenditure with high statistical significance. The results show that the percentage of open space in a house has r =0.526 and p= 5 and is correlated with energy expenditure. This effect might be explained through the space conditioning demand of floor area. More the floor area of the house, the more will be its cooling demand. Furthermore, the natural ventilation of houses through more open space is likely to reduce the expenditure incurred on mechanical ventilation.

The number of plants in the house is negatively correlated with energy expenditure with a high level of statistical significance. Houses with greater numbers of big plants are likely to have less electricity expenditure. The results show that the number big plants in the house has r = (0.441) and p= 5 and is correlated with energy expenditure. The rationale behind this finding is the eco-friendly nature of plants and their positive effect on the surrounding area. The plants in house produce a cooling effect which lowers the demand of space cooling. R. Haas in , 1998) also reported that plants have a significant effect on the cooling demand of houses depicted 23.96% energy saving in hot season and reported an energy saving of up to 23.96% in the hottest month by vindication of heat gain in indoor spaces as a tactic to decrease cooling demand through the optimum placing of plantation [37]. CDD is a localized term, depending upon the geographical region, difference in construction technology, insulation, orientation, building usage, sun exposure and orientation of the building relative to other. It helps to identify the total cost of projected energy consumption, where the temperature is above 65 degrees. (HDD) A heating degree day is a measurement required to enumerate the energy demand to heat a building when average temperature of the building is below 65-degree Fahrenheit, to maintain the average building temperature up to 70-degree Fahrenheit.

Macro Elements of Urban Form

The street pattern of four different areas of Islamabad is examined through satellite imagery. The area of G-11 with its rigorous grid iron pattern has a central and very compact urban occupation. It shows an extremely regular alignment of blocks with a proportionate more building height. Such street geometry leads to restricted natural ventilation. When narrow streets with high building height are parallel to the wind direction, a straight wind tunnel (street canyon) increases wind speed. High wind speed exposes buildings to the same air pressure on both sides, thus reducing the natural ventilation of the buildings. The street pattern in Multi garden, B-17 is predominantly curved linear. More circulation space and clear vista is observed at turning points due to chamfering of lot. It allows more natural ventilation which may reduce load on mechanical ventilation.

The Commoners Town area shows fragmented linear street patterns having higher percentage of open space compared to build form which results in scattered development with varied heights. It may enhance the ventilation of buildings. The Tele-Garden F-17 consisted of a linear street pattern which enabled a continuous regular development in this area with most houses of large size and less number of floors. It may increase the cooling demand.

Figure 5

The land cover of four selected areas is analyzed according to major broad categories including built space and green space (vegetation). The information on land cover is captured through maps and satellite imagery. The vegetation cover is found maximum in Commoners Town with least built-up area. Relatively higher vegetation is observed in-tele garden compared to multi garden. The G-11 contains least area under vegetation while its built up area is maximum. Vegetation reduces space conditioning energy demand in several ways: directing solar access, evaporation transpiration, natural ventilation, regulating urban heat island effect. It implies that areas with more vegetation cover are likely to have less electricity expenditure on space cooling.

Correlation Analysis

To identify the correlation of socio economic and urban form elements with the electricity expenditure correlations analysis employed on the results suggest that 24 out of 105 correlations were statistically significant with a p value greater than 0.5. A total of 68 correlations are found positive while the rest of correlations are negative out of total 105 correlations and some of the results are discussed below:

Table:7

Table: Correlation Matrix

	AMEE	THH	SHH	MI	ALSFM	DAFM	SHM	TF	UF/BH	TBH	SSH	OSH	AHY	PCH	TBPH	OA	MECH	FUEAH	WIHF	TSP
AMEE		.63**	.58**	.88**	.114	.095	.554**	.44**	-.363**	.530**	-.093	-.234**	.360**	.275**	-.441**	.526**	-.416**	-.639**	.226**	-.399**
THH			.68**	.65**	.15*	.121	.47**	.501**	-.11	.51**	.03	-.360**	.167*	.246**	-.163*	.427**	-.390**	-.516**	.226**	-.307**
SHH				.59**	.13	-.006	.50**	.42**	-.11	.561**	.116	-.234**	.169*	.126	-.180*	.451**	-.266**	-.403**	.236**	-.063
MI					.14*	.090	.602**	.522**	-.251**	.624**	.016	-.32**	.283**	.213**	-.418**	.589**	-.406**	-.649**	.286**	-.318**
ALSFM						-.030	.101	.141*	-.06	.150*	.09	-.076	.031	.069	.006	.099	-.134	-.138	-.090	-.094
DAFM							.022	-.021	-.073	-.06	-.179*	.061	.103	.015	-.098	.07	-.049	-.089	-.074	.08
SHM								.64**	-.011	.8**	.234**	-.301**	.133	.287**	-.155*	.931**	-.345**	-.452**	.095	-.427**
TF									.046	.796**	.225**	-.35**	.104	.306**	-.121	.610**	-.401**	-.430**	.089	-.370**
UF/BH										.051	.488**	-.094	-.053	-.141*	.271**	.018	.114	.288**	-.142*	.014
TBH											.313**	-.353**	.145*	.229**	-.199**	.750**	-.331**	-.434**	.110	-.304**
SSH												-.228**	.107	-.089	.27**	.230**	-.029	.047	-.003	-.096
OSH													.024	.204**	.095	-.302**	.21**	.249**	-.064	.219**
AHY														.320**	-.07	.113	-.03	-.066	.040	-.23**
PCH															-.052	.241**	-.2**	-.209**	.014	-.231**
TBPH																-.224**	.015	.245**	-.066	-.082
OA																	-.279**	-.390**	.040	-.38**
MECH																		.820**	-.128	.413**
FUEAH																			-.250**	.37**
WIHF																				.11
TSP																				

Notes: This table shows the correlation among all the variables. * and ** shows the significance level at 1% and 5%. The total number of observations are 200. AMEE = Average Monthly Expenditures of 3 Years, THE = Type of Household, SHH = Size of Household, MI = Monthly Income, ALSFM = Average Life Spam of Family Member, DAFM = Dominant Age Group Among Family Member, SHHM = Size of Home in Marla's TF = Total No. of Floors, UF/BH = Underground Facility/Basement in House, TBH = Total No. of Bedrooms in House, SSH = Separate Study Room in House, OSH = Ownership Status, AHY = Age of House in Years, PCH = Physical Condition of House, TBPH = Total No. of Big Plants in House, OA = Open Area MECH

In order to study the correlation between variables, correlation analysis is performed and a matrix is generated representing the r value of each correlation. The significance level of correlations is assessed through the correlation coefficient scale as shown below. The r values above 0.8 reflect strong correlation, values below 0.5 show weak correlation and the moderate correlation exists if r value falls in the range 0.5-0.8.

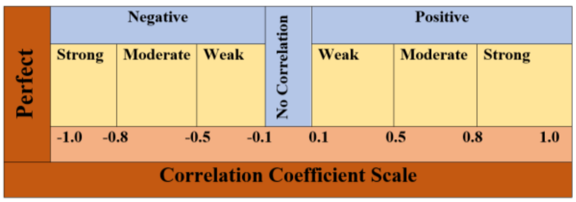


Figure 6: The correlation Coefficient Scale

Regression Analysis
Regression analysis is more decisive in studies where cause and effect relationships are desirable. On the other hand, it is different from correlation analysis in the sense that correlation analysis can only tell the relationship among two variables. However, regression analysis not only describes the relation between two variables, it also shows the direction of variables i.e. cause and effect. We have data from 200 households. Regression analysis is employed to develop a model for predicting changes in energy consumption from eight predictor variables. The dependent variable is average monthly electricity expenditure of 3 years. Prior to conducting the regression analysis, the data normality test is executed to generate the normality curve and to know the distribution of our data set.

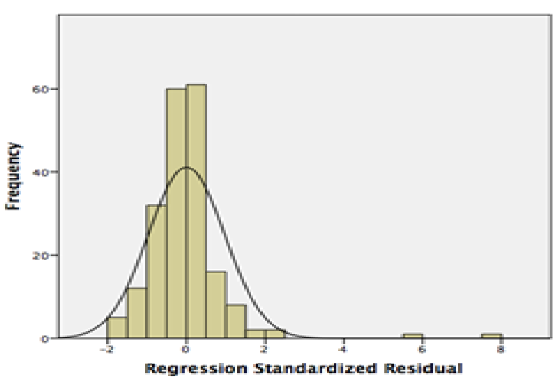


Figure 7: The histogram of regression

The graph depicts that the normal distribution range is between -3 and +3. Standard deviation value is 0.969 which lies in the middle of range and shows that the data is normally distributed. The dependent variable is continuous. This is an assumption in regression analysis is the residual from the regression should be normally distributed with mean of zero and constant variance. The graph shows that the regression analysis is suitable for this data set and results are likely to be conclusive.

Table:8

Model Summery			
R	R Square	Adjusted R Sq	Std. Error of the Estimate
.740[a]	.548	.519	2213.34794

Dependent Variable: Average Monthly Energy Expenditure of 3 years

Predictors: (Constant), Total No of Big Plants in House, Physical Condition of House, Basement in House, Age of house, Separate Study room, Open Area %age, Total Number of Floors, Total Number of Bedrooms, Size of House.

The R square value is about 54.8% which shows the variations in energy consumption explained by the independent variables. However, simple R square values might be misleading because this value is not adjusted for the inclusion of more variables. It is quite possible that the simple R square may increase by including irrelevant or redundant variables in the model. To resolve this issue the adjusted R square is a more reliable statistic. The adjusted R square value shows that 51.9% variations in energy consumption are explained by the dependent variables. This means that a momentous portion of the energy use is well described by the independent variables. Moreover, since our data is cross sectional which varies across households therefore, normally the R square values are not that high. The F- statistic shows the overall fit of the model. Df shows the degree of freedom

Table: 9

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Regression	1111540152.860	12	92628346.072	18.908	.000b
Residual	916096001.806	187	4898909.101		
Total	2027636154.667	199			

Basic descriptive statistics and regression coefficients are shown in the below table. Each of the predictor variables has a significant ($p < 0.1$) zero-order correlation with energy consumption. The eight-predictor model was able to account for 54.8% of the variance in electricity consumption. Diagnostic tests show that the regression model is statistically good. The F-statistics shows 18.908 with corresponding P-Values of 0.00. It shows that the overall model is statistically stable and good. Moreover, the adjusted R-square value is .519. It implies that 51.9% of the variations in average energy consumption are explained by the independent variables.

Table: 10

Regression Model						
		B	**Std. Error**	**Beta**	**T**	**Sig.**
Constant	**A**	3253.0	2048.0		1.589	.114
Size of House	**SH**	30.0	150.0	.027	-.201	.841
Physical Condition of House	**HC**	510.0	386.0	.080	1.321	.188
Age of house	**HA**	349.00	103.00	.2	3.387	.001
Total Number of Floors	**TF**	1575.0	538.0	-.3	-3.0	.004
Basement in House	**BH**	-1726.0	3934.0	-.3	-4.385	.000
Total Number of Bedrooms	**TB**	749.0	275.0	.301	3.0	.007
Study room	**SR**	4778	487.0	.063	.982	.33
Open Area %age	**OA**	40	113.020	.041	.350	.73
Total No of Plants	**TP**	-717.0	195.0	-.210	-4.0	.000

Whereas:
t = T- Statistics,
β =*Beta Coefficient of independent variable*
Sig = Percentage of doubt.

Based on this analysis, we have recommended that the electricity consumption is closely related to urban form elements. Hence, they require to be optimized to minimize the electricity demand. Six out of eight predictor variables affect electricity consumption in a positive manner while two variables have negative impact on energy consumption. For example, the Size of a house positively affects the electricity consumption. The results are statistically significant at 1% level. The coefficient value is 0.027. It implies that as the size of a house increases by 1 unit, it will lead to an increase in electricity consumption by .02 units. Moreover, the larger the size of the household the more the energy consumption would be. This is quite logical as the demand for energy increases with an increase in the number of members in the house.

The results indicate that there is a linear association between physical condition of the house and average energy expenditures. It is found that better the physical condition of a house is, greater are the expenditures on energy. However, the results are not statistically significant as the p-values exceed the standard limit of 10%. So, it asserts that although there is a positive relationship between the physical condition of the house and energy expenditures, this relationship is not very important.

The age of the house has a statistically significant relationship with average energy expenditure. It implies that as the house gets older it will lead to an increase in average energy expenditures. Alternatively, consumers will spend more as the age of the house increases. This relationship is stronger statistically as the T-Stats are 3.387. The average energy expenditure is negatively related to the number of floors in a house. Intuitively, there should be a positive association among these two. However, results show the contrary. It is observed that as the number of floors increases the energy expenditures decreases. Again, this relationship is significant at 1% level.

Consistent with the above results regarding number of floors, it is also observed that there is a negative relationship between houses in which basement facilities are available and energy expenditures. This is logical since basements are normally less warm therefore appliances such as fans and air conditions are randomly used, it leads to reduce the cost of energy. This relationship is also statistically very strong.

Next, we test the impact of the number of rooms in a house on average energy consumption. It is found that there is a direct relationship between these two variables. It shows that people will consume more energy as the number of rooms increases. These results are significant at 1% level. It is also explored how the energy expenditures are affected if there is a separate room allocated for study purposes in the house. Although, results show that houses in which separate rooms are allocated for study purpose increases the energy expenditures, but these results are uncertain as the statistical association is weak.

In equation 1 the dependent variable is energy consumption denoted by Eci. Where i is for the household which ranges from 1 to 200. The right-hand side of the regression shows the independent variables. Intercept is donated by α which captures the average energy consumption of the household if all other factors are held constant. Betas are the coefficients to be estimated using the ordinary least squares method. Moreover, beta shows the sensitivity between the dependent and independent variables. The error term is donated by Eci. In this model we test the following hypotheses.

H1: A momentous relationship between energy consumption and size of house.
H2: A significant relationship among energy consumption and age of house.
H3: A significant relationship between energy consumption and the number of floors in the house.
H4: A significant relationship among energy consumption and the house basement
H7: A significant relationship between energy consumption and no of bedrooms in the house.
H8: A momentous relationship between energy consumption and big plants in the house.

Equation 1

Model Equation
$Eci = \alpha + \beta i(SH)i + \beta i(HA)\ i + \beta i(TF)i + \beta i(BH)i + \beta i(TB)i + \beta i(TP)I + Ei$

Whereas: SH represents size of house, HA represents house age, TF represents total number of floors, BH represents basement in house, TB stand for total number of bedrooms, TP represents total number of big plants., α is constant, β *is beta coefficient of independent variable and Ei is the error term.*

This study concludes that micro elements of urban form have a significant influence over the domestic electricity consumption.
This research concludes that the macro level elements of urban form also influence the energy consumption in a slighter way.

VIII. CONCLUSION

This study concludes that the social class of residents (inclusive of Income level, house ownership status, electrical appliances ownership) affects the socio-economic features and elements of urban form, both of which are prime factors of electricity expenditure. Air conditioning is the prime electricity consuming activity among the mediocre group while the poor group uses fans for the same purpose with additional cooling effect of trees. All the social class rated cleanliness related electrical appliances at a low rate. The poor group has at least number of rooms in a house with only a few houses having more than five rooms. Majority of houses have three rooms per house. Moderate number of rooms are observed in the case of the mediocre group with maximum houses having five rooms while a trend of maximum number of rooms up to eight rooms exist among the rich. These trends are possibly due to the differences in living style and financial well-being of residents. The mediocre households are abundant in Grid iron pattern with majority of double storey houses which is closely followed by curve linear pattern. Fragmented linear accommodates majority of poor households with a mixed trend of single and double storey houses. In addition, Grid iron also accommodates the rich with all the houses having more than storey. On the whole, among all social classes the trend of basement provision is low. The mediocre is already at the moderate level of electricity consumption with a moderate number of rooms and a blend of multi storey buildings while the potential of reduction in electricity consumption is high in the rich class.
It is concluded that the social class and energy expenditures increase with an increase in the size of the household. As it is obviously bigger the size of the household more would be the energy expenditures. It implies that smaller families consume less energy and have less expenditure.

IX. RECOMMENDATIONS

The research output suggest that micro elements of house form, micro elements and household socioeconomic characteristics can be utilized in decreasing the electric consumption. Basement provision provide well insulated environment tend to reduce energy consumption overall.
Incorporated more open to sky area in the building design is also recommended as an electricity demand reduction measure as with proper geometry it enables natural ventilation and reduces the per square foot area of space cooling. It is also recommended to keep the number of rooms proportionate to the occupants and avoid any unnecessary rooms in the house design as each additional room adds lighting, cooling and other electrical appliances into the electricity consumption list. The regulatory body should incorporate Height zoning strictly in the building by laws.
It is highly recommended to pay special focus on the planting of trees suitable to the local climate and maximize the number of trees inside the house along the boundary wall, natural cooling environment effect noticeable reduction in mechanical cooling demand. It is recommended to plant maximum trees on the north side and avoid planting on the southern side as both the rise and set positions of sun are displaced towards the north in the mid-summer towards south in winter hence it will reduce sun exposure during summer and allow maximum sunlight in the winter season. Municipal tree plantation programs at household level should be encouraged.

Policy formulation for reduction in household size. Less number of occupants will require less electricity. Overcrowding of housing stock should be avoided by curtailing haphazard urban rural migration on the analogy of Chinese urban migration policy. Based upon the electricity demand implication of macro level urban form elements, it is recommended to promote curvilinear pattern as it enhances natural ventilation. The development authorities should encourage the developers of housing schemes to adopt curvilinear layout by introducing tax concession policy.

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