Effect of different factors on the electricity consumption and electricity usage intensity (EUI) of residential buildings in Pakistan

Efecto de diferentes factores sobre el consumo de electricidad y la intensidad de uso de la electricidad (EUI) en los edificios residenciales en Pakistán

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Abstract
Buildings consume one-third of final energy consumption in the world and are graded as the largest sources of carbon dioxide (CO_2) emissions. Buildings energy consumption is driven by numerous factors that have direct or indirect effects on it. Identification of such factors could help building designers and architectures in introducing energy efficient designs of various types of buildings. Such studies are indispensable for countries such as Pakistan where a very limited research has been published in this area. This study attempts to fill this knowledge gap by investigating the effect of numerous factors on the residential electricity consumption and further, aims to establish an electricity usage intensity (EUI) value for the residential sector of Pakistan. Data were collected from 523 dwellings through site surveys and interviews with residents. Effect of 48 different variables, (five socioeconomic variables, 14 dwelling variables, 22 variables from electric appliances details, five demographic variables and two variables from renewable energy sources) was investigated on the residential buildings annual electricity consumption using SPSS software. It was found that 17 out of 48 variables have significant linear relationship with annual electricity consumption. Further, through a multivariate analysis, it was found that annual electricity usage intensity (EUI) for Pakistan's residential buildings is 24kWh/m^2. Finally, this EUI value is compared with the same of two major South Asian countries. It is observed that mean EUI of Pakistan is almost similar to that of India, i.e. 24kWh/m^2 whereas Bangladesh has a higher value of mean EUI, i.e. 32kWh/m^2.

Keywords: Electricity consumption, EUI, buildings, Pakistan.

Resumen
Los edificios consumen un tercio del consumo final de energía en el mundo y están clasificados como las mayores fuentes de emisiones de dióxido de carbono (CO2). El consumo de energía en los edificios se debe a numerosos factores que tienen efectos directos o indirectos. La identificación de tales factores podría ayudar a los diseñadores y arquitecturas de edificios a introducir diseños de eficiencia energética de varios tipos de edificios. Tales estudios son indispensables para países como Pakistán, donde se ha publicado una investigación muy limitada en esta área. Este estudio intenta llenar este vacío de conocimiento al investigar el efecto de numerosos factores en el consumo de electricidad residencial y, además, tiene como objetivo establecer un valor de intensidad de uso de electricidad (EUI) para el sector residencial de Pakistán. Se recolectaron datos de 523 viviendas a través de encuestas de sitio y entrevistas con residentes. El efecto de 48 variables diferentes (cinco variables socioeconómicas, 14 variables de vivienda, 22 variables de detalles de electrodomésticos, cinco variables demográficas y dos de fuentes de energía renovables) se investigó sobre el consumo anual de electricidad de los edificios residenciales utilizando el software SPSS. Se encontró que 17 de las 48 variables tienen una relación lineal significativa

con el consumo anual de electricidad. Además, a través de un análisis multivariado, se encontró que la intensidad anual del uso de electricidad (EUI) para los edificios residenciales de Pakistán es de 24kWh / m^2. Finalmente, este valor de EUI se compara con el mismo de dos de los principales países del sur de Asia. Se observa que la media de la EUI de Pakistán es casi similar a la de la India, es decir, 24kWh / m^2, mientras que Bangladesh tiene un valor más alto de la media de la EUI, es decir, 32kWh / m^2.

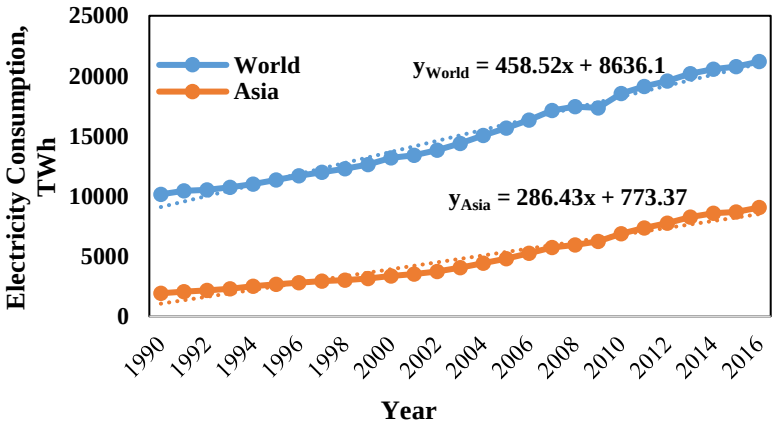
Palabras clave: Consumo de electricidad, EUI, edificios, Pakistán.

Introduction

Electricity is a major energy source for every nation and plays a vital role towards the economic development (Amber, Aslam & Hussain, 2015). In the era of globalization, rapidly expanding reliance of nations on energy show that it will be one of the most concerning issues of mankind in the following century (Stern, 1993). Buildings consume one-third of final energy consumption of the world and are graded as the largest sources of carbon dioxide (CO_2) emissions. Building sector is one of the major energy consuming sector having a share of 40% worldwide (Domínguez, Alonso, Morán, Prada, & Fuertes, 2015). Building sector of the United Kingdom, Europe and USA consumes about 43, 40, 40%, respectively (United Nations, 2013; Ghedamsi, Settou, Gouareh, Khamouli, Saifi, & Recioui, 2015). Building sector can be further be categorized as, residential and non-residential buildings. The residential sector is a major user of energy. Energy consumption trend in the residential sector of the World and of Asia is shown in Figure 1 for the period 1990-2016.

It is apparent from Figure 1 that residential sector electricity consumption has increased linearly (4%/year) over the period of 1990-2016 (Enerdata, 2018). Energy usage in residential sector increases with an increase in population, improvement in standard of living, urbanization and migration to large cities (Ghedamsi, Settou, Gouareh, Khamouli, Saifi, Recioui, & Dokkar, 2016). Figure 1 also demonstrates that residential energy consumption in the Asian region of the world is following the trend of world's total energy consumption. This linear increase in the residential energy consumption shows that the Asian countries would require sufficient energy resources to meet their future energy demands. Buildings sector of Pakistan consumes nearly 55% of country's total electricity annual basis (HDIP, 2015). Sector wise electricity consumption of Pakistan (Nasir, Tariq & Arif, 2008) is presented in Figure 2. It is apparent that the building sector is the highest electricity consuming sector in Pakistan whereas the industrial sector is the second highest electricity consuming sector with an annual electricity consumption share of 28.4%. Pakistan's per capita electricity consumption is 438.26 kWh which is 3.4, 7, 17 and 87% of USA, Europe, China and India's per capita electricity consumption, respectively (Nation Master, 2018).

Figure 1. The trend of energy consumption in residential sector from 1990-2016 (Enerdata, 2018).



The trend of electricity consumption in residential sector of Pakistan from year 2009-10 to year 2014-15 is shown in Figure 3. It is apparent that the electricity usage in residential sector of Pakistan remained fairly constant from 2009-10 to 2012-13. After 2012-13, the electricity consumption has started increasing (Government of Pakistan, Ministry of Finance, 2006). Punjab province has the highest share with Sindh, KPK and Baluchistan provinces at the 2nd, 3rd and 4th place. From the current trend it is expected that the electricity consumption will be increased 39% by 2025 compared to 2015.

Literature review

Different countries have different cultures and climate and therefore, it is very important to individually investigate the effect of different types of factors on buildings energy consumption. Table 1 explains the work of the researchers and their use of different statistical techniques to determine the variables having significant impact on the energy consumption in buildings sector.

Figure 2. Sector wise electricity consumption of Pakistan (HDIP, 2015).

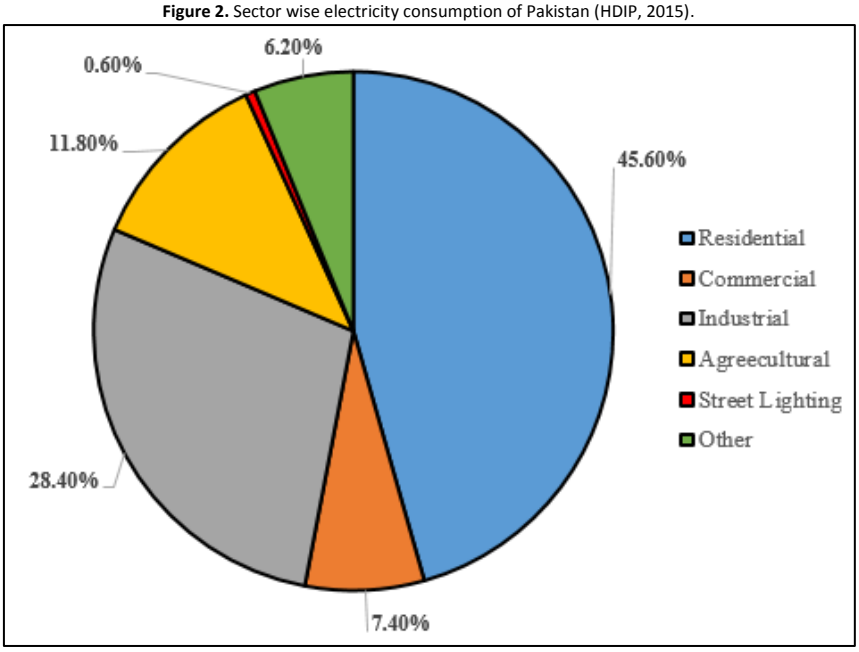
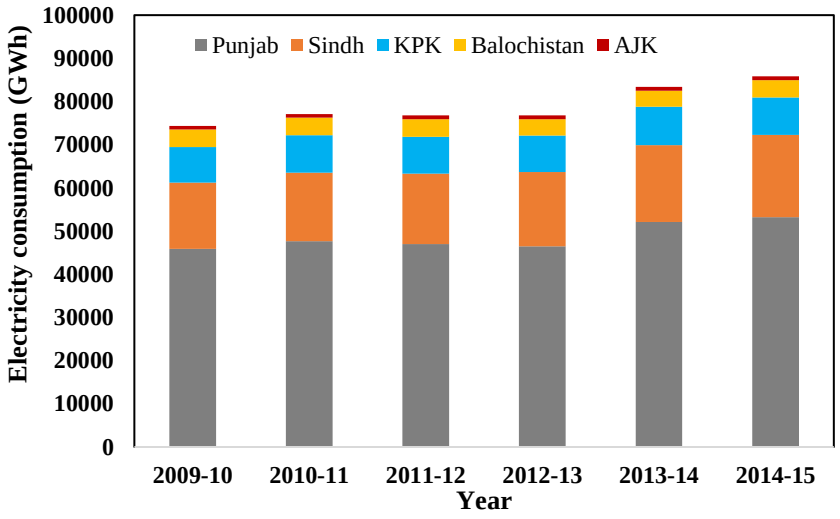


Figure 3. Electricity usage trend in residential sector of different provinces of Pakistan (HDIP, 2015).



On the basis of above literature review the variables effecting the electricity consumption can be divided into four major categories, i.e. dwelling variables, socio-economic variables, electric appliances variables and demographic variables. The variables having significant impact on the annual residential electricity consumption are categorized below.

Dwelling variables

It is observed that the use of double pan window and south facing orientation can reduce the electricity consumption (Kavousian, Rajagopal, & Fischer, 2013). The size of home (Baker & Rylatt, 2008; William & Gomez, 2016; Huebner, Shipworth, Hamilton, Chalabi & Oreszczyn, 2016), number of bedrooms (Baker & Rylatt, 2008; Jones, Fuertes, & Lomas, 2015), building orientation (Abanda & Bayers, 2016), age of building (Jones, Fuertes, & Lomas, 2015) and type of home (Durkman & Jackson, 2008) have also significant positive impact on the annual electricity consumption of the home. Also the single family detached homes consume more than 75% of the residential electricity.

Table 1. Published studies on the benchmarking of buildings energy consumption.

Author (s)	Country	Sample size (No.)	Investigated variable categories	Significant variables	Method
Kavousian, Rajagopal, & Fischer, 2013	USA	1,628	Weather and location, Dwelling variables, Appliances variables, occupancy and occupants, behavioral factors	Size of home, type of house, refrigerators, entertainment devices and water heaters and Age of occupants	Regression
Baker & Rylatt, 2008	UK	148	Dwelling Appliances Socio-demographic	No. of bedrooms, No. of part time servants	Cluster analysis, Multiple Regression
Tso & Yao, 2003	Hong Kong	1,500	Dwelling, Appliances, demographic, ,economic	Size of the home, Air conditioners, washing machine dryers, cooling fans, ventilation fans, number of occupants, income	Multiple Regression
William & Gomez, 2016	USA	426,305	Dwelling, Fuel type (electricity, natural gas, both)	Size of home, Fuel type	Linear Regression, Multiple Regression, Multivariate adaptive regression
Abanda & Bayers, 2016			Building orientation	45 degrees from north as worst and 180 degrees from north (south facing) best orientation.	Emerging BIM (building information modelling)
Sanquist, Orr, Shui, & Bittner, 2012	USA	2,165	Lifestyle, house hold income, weather and behavioral factors connected with utilization of electric appliances	40% difference in electricity consumption due to five lifestyle factors, social and behavioral examples connected with use of PC, TV, cooling and Clothing.	Factor analysis, Multiple regression
Jones, Fuertes, & Lomas, 2015		Comparative study	socio-economic, dwelling and appliances variables	Dwelling age, no. of rooms, no. of bedrooms, total floor area, level of detachment, Ownership of PC, TV, refrigerator, dishwasher, tumble dryer, washing machine, range hood, electric heater, Increased household income, disposable income, number of occupants and age of occupants.	Comparative study
Huebner, Shipworth, Hamilton, Chalabi & Oreszczyn, 2016	UK	845	Dwelling, socio-demographic and appliances variables	Size of home, type of home, no. of children's, Presence of disable person, employment status, no. of bulbs, freezers, TV, tumble dryer, dishwasher, longer lightening hours	Multiple Regression
Shabunko, Lim, Brahim & Mathew, 2014	Brunei Darussalam	256	Type of building material, No. of windows and windows orientation, HVAC appliances, Floor area	Floor area	Ordinary least square (OLS), Support Vector Machines (SVM), Engineering Modelling (EM)
Durkman & Jackson, 2008	UK	7,000	Socio-economic variables, Dwelling variables	Income, type of home, location and house hold composition	Local area resource analysis (LARA), Cluster Analysis

Socio-Economic Variables

The resident's income have a significant impact on the electricity consumption (Amber, Aslam & Hussain, 2015; Tso & Yao, 2003; Durkman & Jackson, 2008). For an annual increase of US $27000 in the income of the resident, the 350kWh increase in the electricity consumption is seen in Japan (Genjo, Tanabe, Matsumoto, Hasegawa, & Yoshino, 2005). Also the social lifestyle and comfort level of the residents have a strong impact on annual electricity consumption (Sanquist, Orr, Shui, & Bittner, 2012).

Appliances variables

The relationship of appliances and energy consumption is discussed in many studies (Kavousian, Rajagopal, & Fischer, 2013; Tso & Yao, 2003; Jones, Fuertes, & Lomas, 2015; IEA, 2008; Huebner, Shipworth, Hamilton, Chalabi & Oreszczyn, 2016). The entertainment devices, refrigerators, high utilization appliances (Kavousian, Rajagopal, & Fischer, 2013; Jones, Fuertes, & Lomas, 2015), air conditioners, cooling ventilation fans, washing machine dryers, lightening and cooking appliances (Tso & Yao, 2003), water heating appliances (IEA, 2008), freezers, tumble dryers, washing machines (Huebner, Shipworth, Hamilton, Chalabi & Oreszczyn, 2016) and building maintenance appliances (Jones, Fuertes, & Lomas, 2015) have significant positive effect on the annual residential electricity consumption. The use of efficient lights and appliances can result in the reduction of annual electricity consumption (Kavousian, Rajagopal, & Fischer, 2013).

Demographic Variables

It is observed that the number of residents (Kavousian, Rajagopal, & Fischer, 2013; Tso & Yao, 2003) and the age of the residents (Kavousian, Rajagopal, & Fischer, 2013; Baker & Rylatt, 2008) have significant impact on the annual residential electricity consumption. Homes with two person consume 19% more electricity per week then the home with one occupant (Leahy & Lyons, 2010) also in India the two-family member home consumes 23% less electricity then the five-family member home (Tiwari, 2000).

Methodology

The data used for this study were collected from the residential sector by surveys and interviews. Three techniques for data collection were used. First of all a comprehensive questionnaire was developed in Microsoft Excel 2013 on the basis of literature review and primary surveys. Primary surveys were done do identify more independent variables which may affect the annual electricity consumption. The questionnaire was then sent to the employees of Mirpur University of science and technology via e-mail with the help of Network and Telecommunication Centre (NTC). Unfortunately out of 600 only eight employees responded. Therefore, printed questionnaires were used for door to door data collection survey. Data related to different social, dwelling and appliances factors and annual electricity consumption were collected whereas electricity consumption data were collected in the form of past one year electricity bills. The data from 600 homes were collected.

In response, 77 questionnaires (13%) received were found to be incomplete and with some vague data. Such data was excluded on the basis of the following reasons:

- Fix electricity consumption throughout the year, i.e. no variability in electricity consumption; and,
- Questionnaires with missing details.

Out of 600 data questionnaires 25 (4%) were excluded due to fix electricity consumption throughout the year. 32 (5%) data questionnaires were excluded due to missing details and 20 (3%) due to missing floor area details respectively. 523 (87%) respondents returned completed questionnaire. In next sections, different datasets received as part of questionnaires are explained.

Independent variables

Variables used for data collection and regression analysis are discussed in this section. Tables 2, 3, 4 and 5 show the selected variables from dwelling, demographic, socio-economic and appliances categories respectively, their data source, reason of selection and their frequencies.

Table 2. Dwelling variables.

Variable	Variable description	Reference	Data source	Categories N (Frequency), Mean*(M)*, Standard Deviation *(SD)*
x_1	City	Durkman & Jackson (2008)	Site Visit	Mirpur (N: 356) Muzaffarabad (N: 167)
x_2	Province			AJK (N: 523)
x_3	Type of home	Jones, Fuertes, & Lomas, 2015; EIA, 2015; Huebner, Shipworth, Hamilton, Chalabi & Oreszczyn, 2016	Site Visit	Single storey (N=320) Multi-storey (N=191) Flat (N= 9) Residential Plaza (N= 3)
x_4	No. of stories	Huebner, Shipworth, Hamilton, Chalabi & Oreszczyn, 2016	Residents interview	Single storey building (N= 319) Double storey building (N= 147) Three storey building (N= 43) Four storey building (N= 13) Five storey building (N= 01)
x_5	At which floor do you live	Jones, Fuertes, & Lomas, 2015	Residents interview	Ground floor (N= 63) First floor (N= 27) Second floor (N= 24) Third floor (N= 3) Multiple floors (N= 3) All floors (N= 403)
x_6	Building age	Jones, Fuertes, & Lomas, 2015; Huebner, Shipworth, Hamilton, Chalabi & Oreszczyn, 2016	Residents interview	*M=14.94, SD=8.82*
x_7	Type of ceiling	Huebner, Shipworth, Hamilton, Chalabi &	Residents interview	Standard (N= 517), False (N= 6)
x_8	Material used for walls	Oreszczyn, 2016		Bricks (N= 338), PCC Concrete blocks without steel (N: 185)
x_9	Material used for roof	Primary Surveys	Residents interview	Lanter (N= 520),Corrugated Metal sheets (N= 3)
x_{10}	Sides of home directly exposed to sun	Abanda & Bayers, 2016	Site Visit	*M=3.30, SD=0.84*
x_{11}	No. of windows in each room	Kavousian, Rajagopal, & Fischer, 2013; Huebner, Shipworth, Hamilton, Chalabi & Oreszczyn, 2016	Residents interview	*M=2.66, SD=0.87*
x_{12}	Living in this house since	Primary Surveys	Residents interview	*M=18.65, SD=88.59*
x_{13}	Building Ownership	Huebner, Shipworth, Hamilton, Chalabi & Oreszczyn, 2016	Residents interview	Own (N= 373), Rented (N= 150)
x_{14}	Total floor area	Baker & Rylatt, 2008; William & Gomez, 2016; Huebner, Shipworth, Hamilton, Chalabi & Oreszczyn, 2016	Residents interview	*M=96.97, SD=22.13*

Table 3. Demographic variables.

Variable	Variable description	Reference	Data source	Categories N (Frequency)
x_{15}	No. of residents above 15 years	Tso & Yao, 2003; Jones, Fuertes, & Lomas, 2015	Resident's interview	1 (0), 2 (26), 3 (122), 4 (150), 5 (124), 6 (57), 7 (30), 8 (10), 9 (03)
x_{16}	No. of residents below15 years	Tso & Yao, 2003; Jones, Fuertes, & Lomas, 2015	Resident's interview	1 (80), 2 (53), 3 (86), 4 (87), 5 (39), 6 (15), 7 (05), 8 (0), 9 (0)
x_{17}	No. of working residents	Primary survey	Resident's interview	1 (115), 2 (235), 3 (124), 4 (37), 5 (08),

Table 4. Socio-economic Variables.

Variable Abbreviation	Variable	Reference	Data source	Categories N (Frequency)
x_{18}	How would you grade your family socially	Primary Survey	Resident's interview	Casually social (372), Highly social (151)
x_{19}	Total family income/month	Jones, Fuertes, & Lomas, 2015; Shabunko, Lim, Brahim & Mathew, 2014	Resident's interview	0-10k (2), 11k-50k (13), 50k-100k (110), 101k-150k (27), above 150k (16), No response (355)
x_{20}	Are you a local resident of the area?	Primary Survey	Resident's interview	Yes (416), No (107)
x_{21}	Average no. of week family remain away	Primary Survey	Resident's interview	0 (416),1-4 (78), 5-8 (17), 9-12 (12)
x_{22}	No. of cars/ vehicles	Ghedamsi, R., Settou, N., Gouareh, A., Khamouli, A., Saifi, N., Recioui, B., & Dokkar, 2016	Resident's interview	0 (91),1 (287), 2 (127), 3 (16), 4 (2),
x_{23}	No. of full time servants	Ghedamsi, R., Settou, N., Gouareh, A., Khamouli, A., Saifi, N., Recioui, B., & Dokkar, 2016	Resident's interview	0 (473),1 (48), 2 (1), 3 (0), 4 (1),
x_{24}	No of hours part time servant works at your home	Primary Survey	Resident's interview	0 (242),1 (07), 2 (63), 3 (93), 4 (64), 5 (35), 6 (14), 7 (05)

Table 5. Appliances Variables.

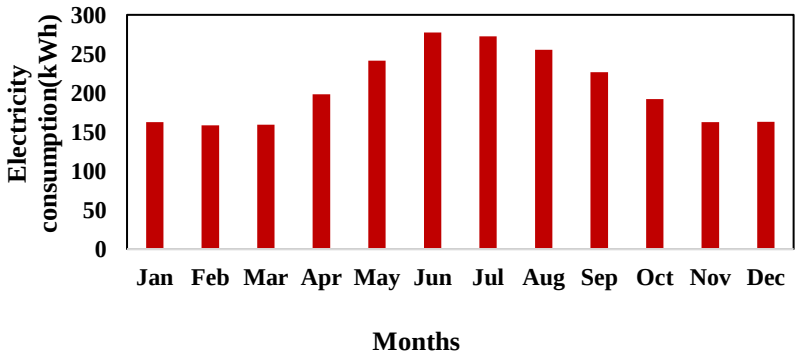
Variable	Variable description	Reference	Data source	Categories Frequency (N), Mean*(M)*, Standard Deviation *(SD)*
x_{25}	Total number of ceiling fans	Nation Master, 2018	Resident's interview	1 (0), 2 (02), 3 (28), 4 (70), 5 (128), 6 (120), 7 (91), 8 (44), 9 (24), 10 (09), 11 (05), 12 (02)
x_{26}	Number of pedestal fans	Nation Master, 2018	Resident's interview	0 (364),1 (122), 2 (30), 3 (5), 6 (2)
x_{27}	Average no. of lights in each room	Nation Master, 2018; Jones, Fuertes, & Lomas, 2015	Resident's interview	1 (26),2 (398), 3 (89)
x_{28}	Type of lights installed	Jones, Fuertes, & Lomas, 2015	Resident's interview	Mixed (424), Energy Saver (85), Tube light (14), LEDs (0)
x_{29}	No. of AC installed	Tso & Yao, 2003;	Resident's interview	0 (332), 1 (106), 2 (69), 3 (16)
x_{30}	No. of Electric geysers	Tso & Yao, 2003	Resident's interview	0 (179), 1 (245), 2 (95), 3 (04)
x_{31}	No. of room coolers		Resident's interview	0 (241), 1 (181), 2 (98), 3 (03)
x_{32}	No. of Fridges	HDIP, 2015; Jones, Fuertes, & Lomas, 2015	Resident's interview	0 (08), 1 (477), 2 (44), 3 (01)
x_{33}	No. of electric heaters	HDIP, 2015	Resident's interview	0 (298), 1 (173), 2 (51), 3 (01)
x_{34}	No. of TVs	HDIP, 2015	Resident's interview	0 (04), 1 (218), 2 (257), 3 (37), 4 (07)

x_{35}	No. of computers	HDIP, 2015	Resident's interview	0 (80), 1 (242), 2 (158), 3 (33), 4 (09), 5 (01)
x_{36}	No. of Electric Cookers	Nation Master; Tso & Yao, 2003	Resident's interview	0 (372), 1 (150), 2 (01)
x_{37}	Do you have UPS	Primary survey	Resident's interview	Yes (259), No (264)
x_{38}	Size of Uninterrupted Power Supply	Primary survey	Resident's interview	*M=540.73, SD=587.81*
x_{39}	No of Washing machines	Tso & Yao, 2003; Jones, Fuertes, & Lomas, 2015	Resident's interview	0 (06), 1 (506), 2 (11)
x_{40}	Number of washing machine dryer	Nation Master; Tso & Yao, 2003	Resident's interview	0 (166), 1 (354), 2 (01), 4 (02)
x_{41}	No of water dispenser	Primary survey	Resident's interview	0 (422), 1 (101),
x_{42}	Number of vacuum cleaner	Tso & Yao, 2003	Resident's interview	0 (324), 1 (198), 2 (01)
x_{43}	Number of water Pump Motors	Tso & Yao, 2003	Resident's interview	0 (177), 1 (346)
x_{44}	No of electric Irons	Primary survey	Resident's interview	0 (02), 1 (283), 2 (232), 3 (06)
x_{45}	No. of Microwave Oven	Jones, Fuertes, & Lomas, 2015	Resident's interview	0 (207), 1 (299), 2 (15), 3 (02)
x_{46}	Generator	Primary survey	Resident's interview	*M=28.11, SD=204.11*
x_{50}	Do you have Solar Panels installed at your home	Primary survey	Resident's interview	Yes (29), No (494)
x_{51}	Do you have solar geysers installed at your home	Primary survey	Resident's interview	Yes (11), No (512)
x_{52}	Is electricity meter shared?	Primary survey	Resident's interview	Yes (0), No (523)

Dependent variable

The annual electricity consumption in kilowatt hours (kWh) is the dependent variable, the data of the dependent variable were collected from the residents in the form of electricity bills. The data having the constant electricity consumption throughout the year were excluded. The mean of the annual electricity consumption is 2468.88 kWh and the standard deviation is 8.25. The trend of average monthly electricity consumption in all 523 throughout the year is shown in Figure 4.

Figure 4. Average Monthly Electricity Consumption Profile of a domestic building in Pakistan.



The trend clearly shows high electricity consumption during summer months. This is mainly because of cooling load. In winter, electricity consumption trend remains consistent.

Multiple regression analysis

When multiple predictors are used to predict the dependent variable's value, multiple regression is employed. A number of researchers have employed MRA in their studies to establish relationship among dependent and independent variables. While performing MR analysis, it is important to check whether there are any two or more than two independent variables collinear to each other. One method of checking co-linearity among variables is the Pearson Correlation Coefficient and is usually denoted by R. Two variables are strongly collinear if R=>0.6 and vice versa. Another check that helps in identifying the significant variables is t-stat check. In MR analysis, variables having t-stat values =>1.96 or p-values <=0.05 are considered significant and vice versa. SPSS software provides a detailed analysis showing R, t-stat and p-values.

Results

To observe the effect of independent variables on annual electricity consumption (Y) MR analysis was performed using SPSS software. Model fitness, R^2 change, Pearson correlation and confidence interval 95% were observed. The co-linearity was observed between independent variables using Pearson correlation. Sixteen independent variables were found collinear, and some of these were dropped after observing their low t-state value. 17 variables were found significant and strong predictors. These variables are and their significance is demonstrated through t-stat values and p-values as shown in Table 6.

Table 6. Model summary of Final MR Analysis.

Description of Variable	Variable	B	t-stat value	Significance
	(Constant)	-295.308	-1.713	0.87
No. of windows in each room	x_{11}	81.657	2.971	.003
No. of residents above 15 years	x_{15}	61.743	3.304	.001
No. of cars/ vehicles	x_{22}	81.821	2.222	.027
Total number of ceiling fans	x_{25}	87.004	5.016	.000
Number of pedestal fans	x_{26}	175.236	5.063	.000
Number of lights in each room	x_{27}	182.215	8.313	.000
No. of AC installed	x_{29}	347.336	10.551	.000
No. of Electric geysers	x_{30}	87.343	2.226	.026
No. Of electric heaters	x_{33}	76.971	1.959	.051
No. Of TVs	x_{34}	160.926	4.309	.000
No. of computers	x_{35}	125.343	4.334	.000
No. of Electric Cookers	x_{36}	-197.615	-3.350	.001
No of Washing machines	x_{39}	283.140	2.147	.032
No of water dispenser	x_{41}	215.825	3.477	.001
Number of vacuum cleaner	x_{42}	166.044	3.087	.002
No. of Microwave Oven	x_{45}	184.216	3.863	.000
Solar Panels installed at home	x_{50}	-372.500	-3.697	.000

Electricity Usage Intensity (EUI)

The mean and median values of the EUI (kWh/m^2) are shown in Figure 5 whereas the mean and median values of EUI (kWh/resident) are presented in Figure 6. Due to the skewed nature of the data distribution, the median values of EUI have been selected for the benchmarking purpose. The median values of EUI are 24 kWh/m^2 and 349 kWh/resident respectively and therefore, these values have been selected as the benchmarks for the electricity consumption in the domestic buildings of Pakistan. The values of EUI (kWh/m^2) were compared with same of Bangladesh and India. The EUI of Bangladesh residential sector is 32 kWh/m^2, 13% more electricity than EUI of Pakistan (Ahsan, Soebator & Williamson, 2014) whereas for India it ranges between 12-36 kWh/m^2 (GBPN, 2014).

Figure 5. Mean and median of EUI (kWh/m²).

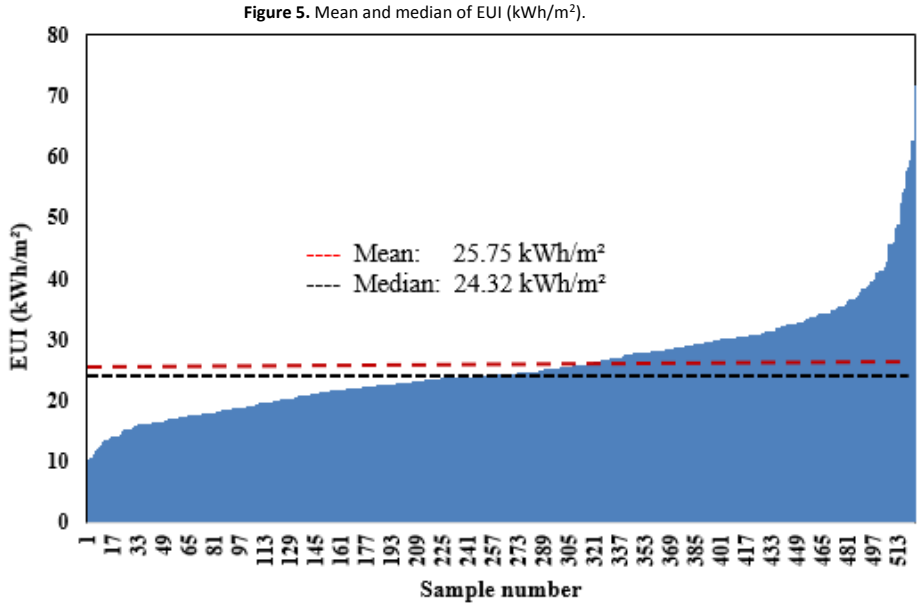
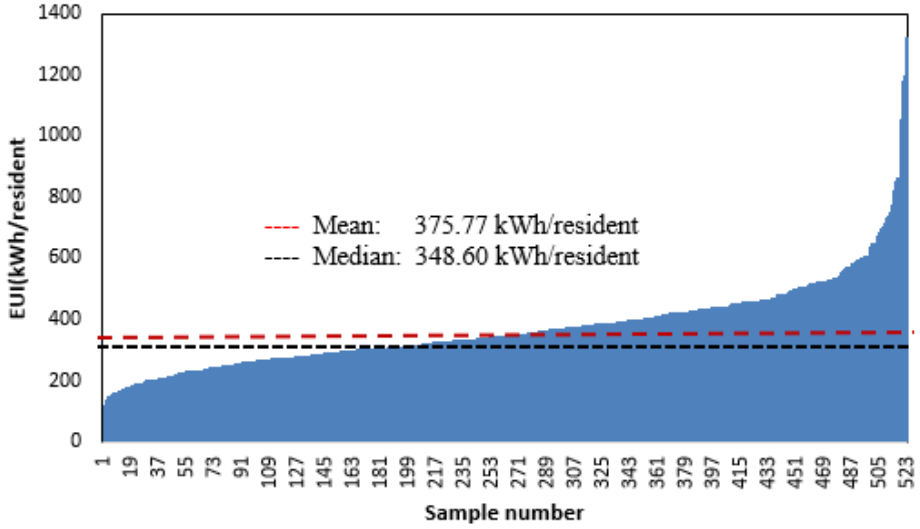


Figure 6. Mean and median of EUI (kWh/resident).



Conclusions

The aim of this study was to observe the impact of dwelling, socio-economic, demographic and appliances variables on annual electricity consumption of residential sector in Pakistan and to establish a EUI value. With the help of multiple regression analysis the impacts of above stated variables were found.

- It has been found that 17 variables have significant impact on annual electricity consumption.
- 15 variables (one from dwelling category, one from socio-economic, one from demographic and 12 variables from appliances category) have significant positive impact on annual electricity consumption. The variables with positive impact are, No. of windows in each room, No. of residents above 15 years, No. of cars/ vehicles, Total number of ceiling fans, Number of pedestal fans, Number of lights in each room, No. of AC installed, No. of Electric geysers, No. of electric heaters, No. of TVs, No. of computers, No of Washing machines, No of water dispensers, Number of vacuum cleaner, and No. of Microwave Ovens.
- Two variables, i.e. No. of Electric Cookers and No. of Solar Panels installed at home have significant negative impact on electricity consumption.
- Further through a univariate analysis, it has been found that annual EUI values are 24kWh/m^2 and 349kWh/resident.

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