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An Assessment of Electricity Tariff Reforms in Karachi City: The City of Light

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Providing reliable access to electricity to every citizen is a responsibility of the government, which is also considered an imperative condition for improving the life of every household in a country. This study thus aims to find the electricity accessibility as well as affordability condition of the households of Karachi. To collect in-depth electricity information at the household level, this study surveys Karachi city through a questionnaire design. The study surveyed 467 randomly selected households from 18 towns in Karachi. The accessibility and affordability indicators of electricity have been examined using descriptive analysis. Findings from the survey data reveal that although tariff rates are still subsidised for lower consumption households, additional charges such as government charges, TVL fees, fuel adjustment charges, etc., constitute a significant proportion of total electricity bills. The study also recognises households' cognitive and behavioural aspects of energy use by incorporating these modules in the survey questionnaire. Hence, numerous viable policy options are recommended in the study to successfully implement reforms without compromising the social aspects.

Keywords: Karachi; Electricity, Household, Tariff Reforms

1. INTRODUCTION

Access to quality electricity is a prerequisite for a better standard of living, which ultimately leads to social and economic development in a country. A huge literature on household electricity consumption shows that poor quality and lack of access to electricity adversely affect households' welfare (Chakravorty, et al. 2014; Samad & Zhang, 2016, 2017). Additionally, studies conducted by Dinkelman, 2011; Khandker, et al. 2012; Lipscomb, et al. 2013; and Banerjee, et al. 2015 have also evaluated the households' welfare effects of electricity consumption. Moreover, the UNDP's *Sustainable Development Goals (SDGs-17)* linkup the energy-related goals (SDG-7) with human welfare such as SDG-13 (action on climate change), SDG-3 (ensuring healthy lives) & SDG-11(building sustainable cities & communities) and targeted to ensure access to affordable, reliable and modern energy for all by the end of 2030.

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Access to more efficient and reliable energy sources is also an important issue that needs to be addressed. According to the World Energy Outlook (2016) statistics, at least 51 million people in Pakistan, representing 27 percent of the total population, live without access to electricity. In its annual State of the Industry Report, the National Electric Power Regulatory Authority concludes that approximately 20 percent of all villages (32,889 out of 161,969) are not connected to the grid. Even those households that are statistically connected experience blackouts daily. It is estimated that more than 144 million people across the country do not have reliable access to electricity. A survey revealed that rural households in Punjab spent about 9 percent of their total household income on fuel and lighting. However, poor households are forced to invest up to 25 percent of their monthly income in fuel, kerosene oil, and batteries due to the dysfunctional market.

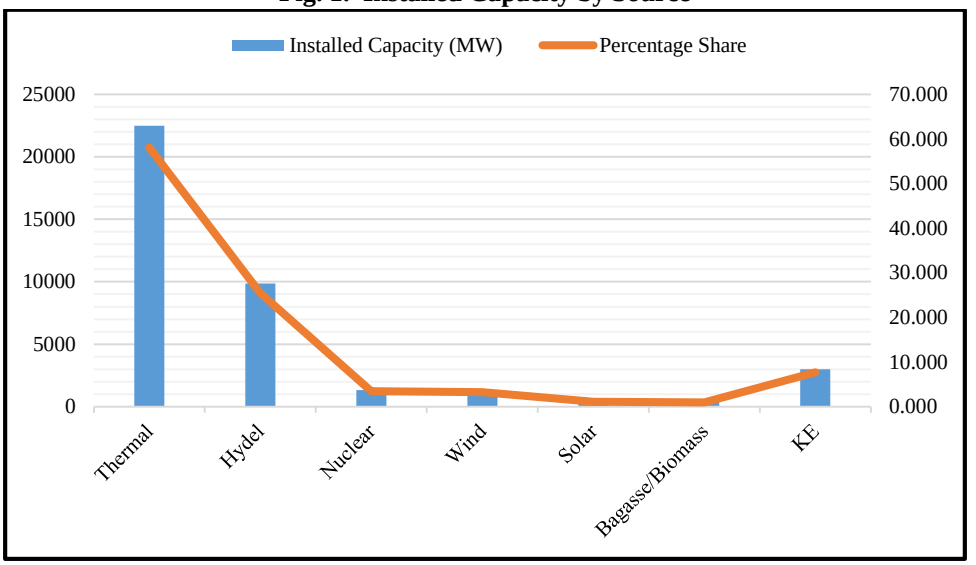
Considering the above facts, the current study is an attempt to assess the households' accessibility and affordability of electricity in Karachi city. For this purpose, the study collects an in-depth survey through a questionnaire. A random sample of 457 households from 18 towns of Karachi has been selected to examine the households' accessibility and affordability–measured by households' electricity consumption and expenditures respectively. Additionally, the study also evaluates the households' cognitive and behavioural aspects of energy particularly related to electricity consumption. The assessment of the study is based on a descriptive analysis of households' average consumption and expenditures across different slabs of the K-electric. Furthermore, the study constructs households' literacy, behaviour, and satisfaction indices across 18 towns of Karachi using linear combinations of various indicators selected from the questionnaire. Thus the overall findings of the study reveal that lower consumption households of Karachi still pay a higher amount of electricity bills consisting of electricity unit expenditures, and other charges such as government, TVL fees, and fuel adjustment charges. However, the unexpected rise in electricity prices resulting from a reduction in subsidies could aggravate anger among individuals and obstruct the implementation and completion of the government's reform programmes.

The rest of the study is organised as follows: The next section presents a brief introduction to the electric power sector of Pakistan. Section 3 presents the sampling methodology and sample size of each town drawn for the study. Section 4 discusses the findings of the survey. However, the last section concludes the study and provides policy implications.

1.1. Brief Introduction to the Electric Power Sector of Pakistan

In Pakistan, electricity is generated and supplied by both the public and private sectors. The major sources of power generating plants are Hydro, Thermal, Nuclear, and Renewable (wind, solar & biomass). Figure 1 presents the total installed capacity of electricity and its share in each power plant. Further, the figure also shows the share of K-Electric. The figure depicts that the Thermal power plant possesses the highest share (58 percent) of total installed capacity followed by Hydro and KE.

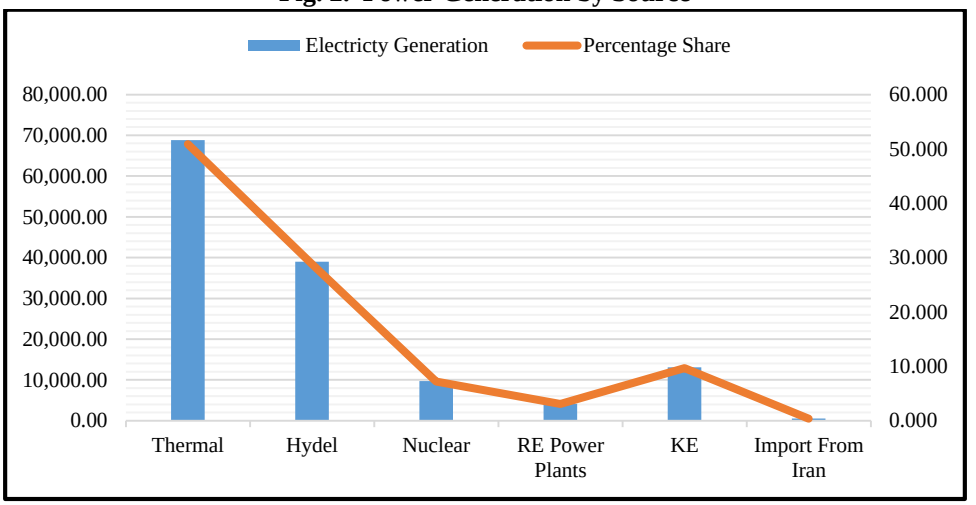
Fig. 1. Installed Capacity by Source



Source: Authors' illustration based on GENCOs/WAPDA/IPPs/DISCOs/KE.

However, Figure 2 below displays the total electricity generation and its share by source in FY 2019-20. It can be depicted from the figure that along with public/private suppliers, Pakistan also imports electricity from Iran. The total electricity generation in Pakistan during the FY 2019-20 was reported as 135, 259.39 GWh. The following figure depicts that the share of Thermal power plants in the country's total electricity generation remains highest (51 percent) followed by Hydro power generation plants with 29 percent of the total electricity generation of the country. Though the private sector i.e. KE contributes around 10 percent to the country's electricity generation.

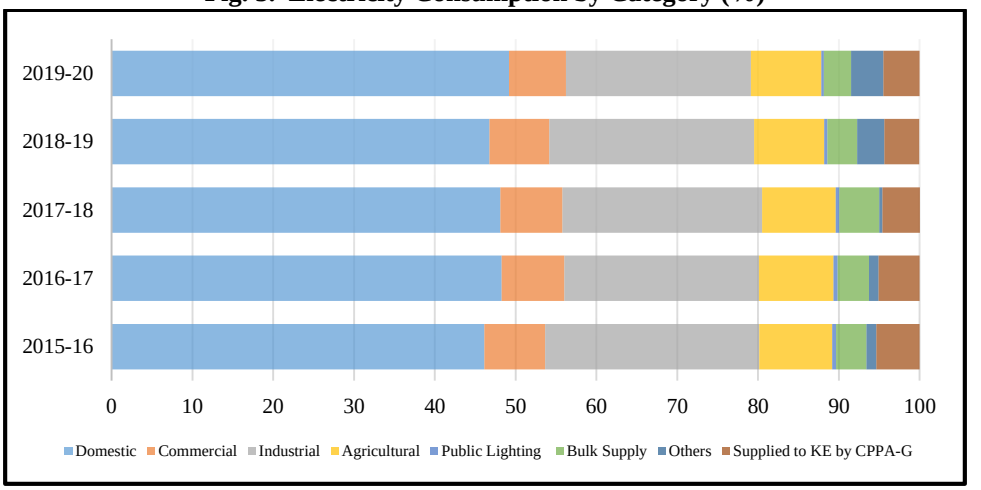
Fig. 2. Power Generation by Source



Source: Authors' illustration based on GENCOs/WAPDA/IPPs/DISCOs/KE

Figure 3 below presents the share of electricity consumption by category for 2015-16 to 2019-20. The figure depicts that the pattern of consumption (electricity) for each category is almost the same over the years. However, the domestic users (households) are the major consumer of electricity followed by the industrial sector and agricultural sector of the economy.

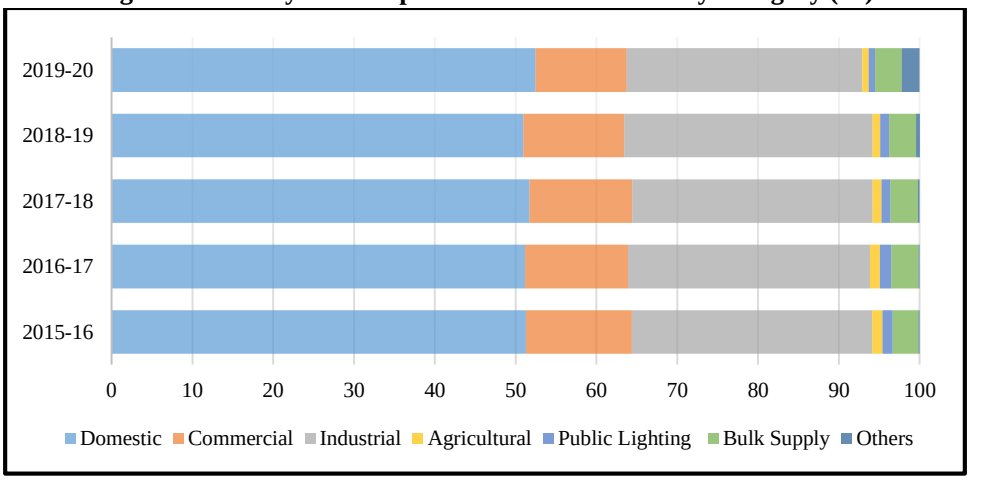
Fig. 3. Electricity Consumption by Category (%)



Source: Authors' illustration based on DISCOs/KE.

However, Figure 4 below displays the trend and share of consumption of electricity supplied by KE in Pakistan. The figure depicts a similar pattern of consumption for each sector over the period. Domestic and industrial users are the major consumers of electricity.

Fig. 4. Electricity Consumption of K-Electric Area by Category (%)



Source: Authors' illustration based on DISCOs/KE.

2. METHODOLOGY

This section of the study provides the sampling technique of the survey and discusses the c of household level questionnaire module used to collect the data. A pre-test was conducted in two districts of Karachi namely district East and Central. The sampling design and survey details are as follows:

Sampling Design and Survey Details

The table below provides the details of the households sample selected from each town in Karachi. To reach an appropriate household sample, different combinations of confidence interval and specification errors were considered for statistical validity and representativeness. Given the above, the sample size with a 95 percent confidence interval and less than 10 percent specification error was considered appropriate. The following formula was used, which yielded an optimal sample size of around 455 households:

Optimal Sample Size = Z^2 [p (1-p)]/e^2 (for known population)

Where,

Z = Specification of confidence coefficient.
p = Estimated Proportions of the population (based on 2005 and projected population for 2020).
e = Specification error.

The sample size was determined according to the proportion of the population. Furthermore, the town-wise estimated population was extracted from the 2017 census provided by the Pakistan Bureau of Statistics.

Table 1

Household Sample

S. No.	Town Name	Total Population	Proposed Sample	Actual Sample Used
1	Baldia	616,721	20	20
2	Bin Qasim	480,855	15	15
3	Gadab	439,675	14	13
4	Gulberg	688,581	22	21
5	Gulshan-e-Iqbal	949,351	29	40
6	Jamshed	1,114,138	34	37
7	Kaemari	583,641	19	19
8	Korangi	829,813	26	26
9	Landhi	1,012,393	31	32
10	Liaqatabad	985,576	30	34
11	Lyari	923,177	29	30
12	Malir	604,766	19	20
13	New Karachi	1,038,863	32	34
14	North Nazimabad	753,423	24	21
15	Orangi	1,098,858	34	35
16	Saddar	935,565	29	30
17	SITE	709,944	22	23
18	Shah Faisal	509,916	16	17
	City Total	14,275,256	445	467

Source: Authors' calculations based on Pakistan Bureau of Statistics.

2.1. Household Questionnaire Description

To gather household-level information, the study has designed a comprehensive questionnaire based on multiple policy dimensions: affordability, accessibility, reliability, and sustainability which directly affect household welfare. The questionnaire consists of 12 sections that are given as follows:

Section 1: Household Composition & Demographic Information

This section discusses the basic household-level information such as relationship with the head, gender, age, marital status, and migration status.

Section 2: Current Education Status

This section of the questionnaire presents the educational status of all the household members: literacy, current enrolment, and completed years of education.

Section 3A & 3B: Employment & Other Sources of Employment

Section 3A discusses the employment details such as employment status, nature of work, industry, occupation, and income of the households. However, section 3B presents the details of employment from other sources.

Section 4: Housing Characteristics of Households

This section provides the household's characteristics related to their houses such as nature, the total area of the plot, the number of rooms, the material used for floor, roof, and walls, and the main fuel used for cooking, heating & lighting.

Section 5: Housing Expenditure

This section displays the information on a household's expenditure on the consumption of daily use basic items such as food & beverages, Clothing &footwear, utility charges, health and education expenses, etc.

Section 6: Household Electrical Appliances & Item

Section 6 of the questionnaire gives information related to the number of electrical appliances owned and how many hours these appliances are used by the households.

Section 7: Electricity Source of Lighting (Grid)

This section obtains the electricity (Grid) connection information such as units consumed, tariff structure, and expenditure born by the household.

Section 8: Electricity Source of Lighting (Off Grid)

Section 8 of the questionnaire provides information related to off-grid sources of lighting such as solar, UPS, generators, Dry Cell, and batteries. The information is based on the mode of purchase, fixed and fuel costs, etc.

Section 9: Natural Gas as a Source of Heating and Cooking

This section gathers information related to natural gas as the source of heating and cooking. It includes variables such as gas connection, unit consumed, expenditure, and, tariff structure of the household.

Section 10: Heating and Cooking (Other Sources)

Section 10 is based on other sources of heating and cooking such as electricity, LPG, Kerosene, and, other sources. Further, it provides related variables such as the presence of these sources, mode of payment to purchase, and amount paid on these sources.

Section 11: Electricity Outages/Load Shedding

This section provides information related to electricity outages and load shedding such as season & reason for outages, hours of power breakdown, and how frequently households experience power outages.

Section 12: Energy Literacy

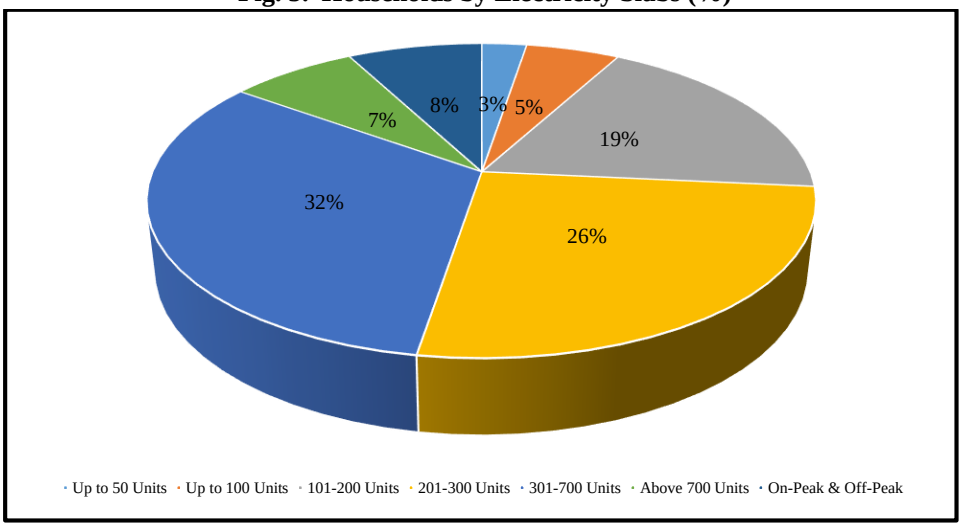
This section is completely based on energy literacy that is to what extent households are energy literate. It includes the best guess estimate of 1 KWh, increases in per unit rates in peak hours, which item consumes more electricity, etc.

3. FINDINGS OF THE SURVEY

This section of the study discusses the findings, which are based on a descriptive analysis of the household-level primary data of Karachi city. The descriptive analysis presents the consumption, expenditure, and change in the recent increase in electricity tariff by electricity consumption slabs. The analysis also provides information on energy literacy, consumers' satisfaction, and, household behaviour regarding electricity use.

Figure 5 above illustrates the percentage of households in each consumption slab. The figure depicts that most of the households were middle-slab consumers, i.e., 32 percent in the 5^{th} slab (301-700), 26 percent of households in the 4^{th} slab (201-300), and 19 percent in the third slab. As argued by Walker, et al. (2014), survey results validate that the lifeline tariff slab is nearly ineffective in Pakistan as a meager 2.57 percent of households were lifeline consumers consuming less than 50 units per month. The Proportion of households consuming in the lowest and highest slabs was also relatively low, whereas the ToU tariff applies to households having sanctioned load equal to or greater than 5 kWh. Hence, according to the survey results, only 8 percent of households fell under this category.

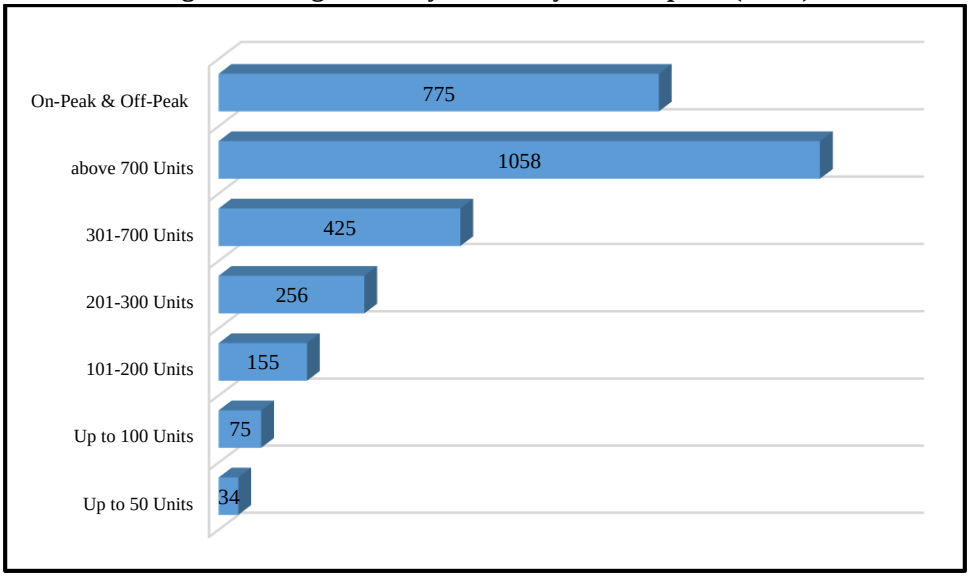
Fig. 5. Households by Electricity Slabs (%)



Source: Authors' illustration based on a primary survey of Karachi.

Figure 6 portrays the average electricity consumption in units by electricity slabs. The figure depicts that on average, the highest units of electricity (1058) were consumed by only 7 percent of households. Following this, on average, about 775 units of electricity per month were consumed by only 8 percent of households that belong to the ToU category. However, the highest proportion of households in Karachi, i.e. 32 percent, on average, consume only 425 units of electricity per month. This is followed by an average consumption of 256 units by 26 percent of households.

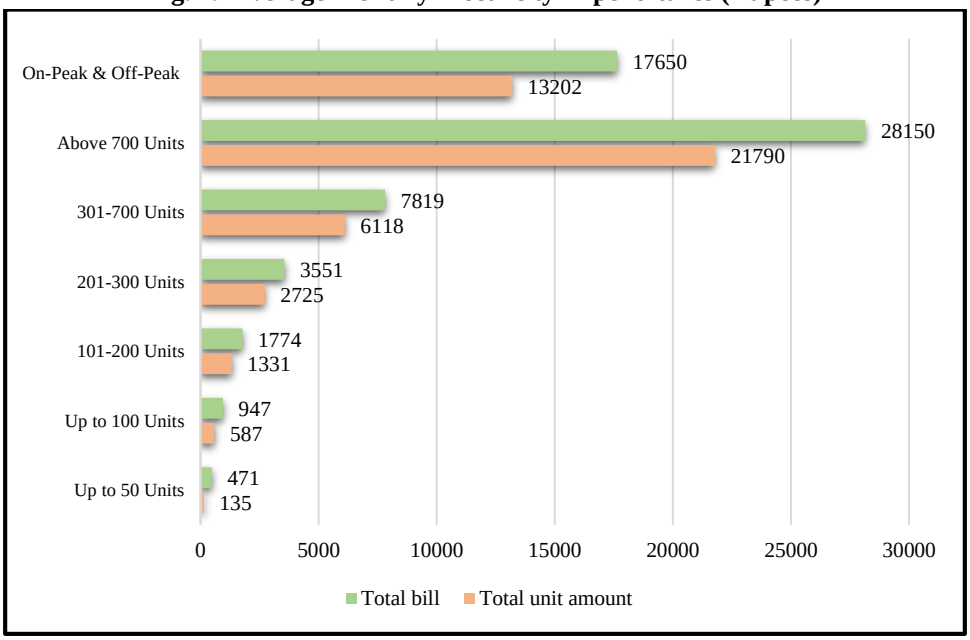
Fig. 6. Average Monthly Electricity Consumption (Units)



Source: Authors' illustration based on a primary survey of Karachi.

Figure 7 illustrates the average expenditures on electricity by households in Karachi. The smaller bar in each slab represents the consumption expenditure of units (kWh), while the bigger bar shows the total amount of the electricity bill inclusive of government charges, fuel adjustment charges, etc. The figure depicts that, on average, households that consumed more than 700 kWh per month paid about three times more than the households that ended up consuming just below 700 kWh. Similarly, the difference in the expenditure between households that consumed in the fourth (201-300 units) and fifth slabs (300- 700units) was about two times. Another significant feature of Figure 7 is that the government charges and other charges such as the TVL fees, fuel adjustment charges, etc., constituted a significant proportion of total bills. Figure 17 shows the disaggregation of total billing components for each slab.

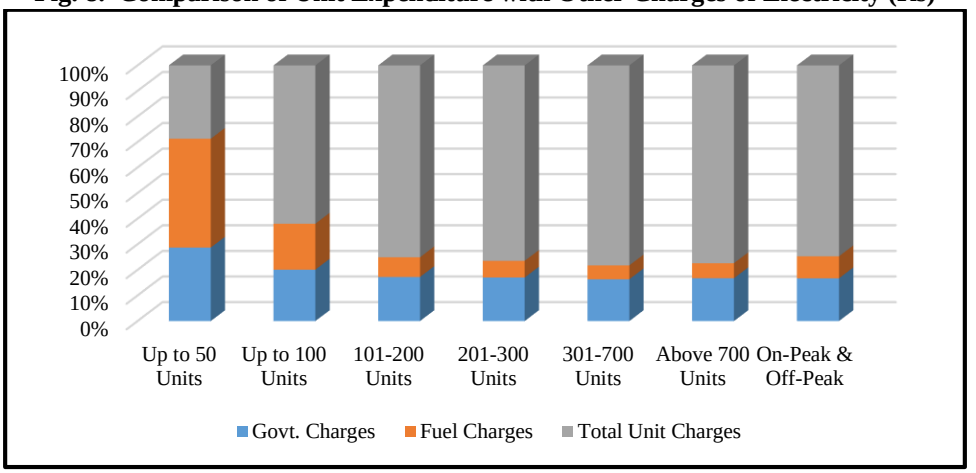
Fig. 7. Average Monthly Electricity Expenditures (Rupees)



Source: Authors' illustration based on a primary survey of Karachi.

Figure 8 presents the comparison of electricity unit charges with other charges of electricity that the households are bound to pay with an electricity bill. These charges consist of government charges and fuel adjustment charges, imposed by the K-Electric. The figure shows that the proportion of total units' charges was highest, followed by government charges and fuel adjustment charges for electricity. The most significant information detected from this graph is that the fuel adjustment charges for the lifeline slab were more than the total amount spent on units consumed, whereas government charges also constituted a significant proportion. This information reveals that, on the one hand, the lifeline slab is supposed to be the most protected and subsidised but, on the other hand, various additional charges significantly increase the total electricity bill. Conclusively, it can be depicted from the figure that households bear an extra burden in the form of these charges.

Fig. 8. Comparison of Unit Expenditure with Other Charges of Electricity (Rs)

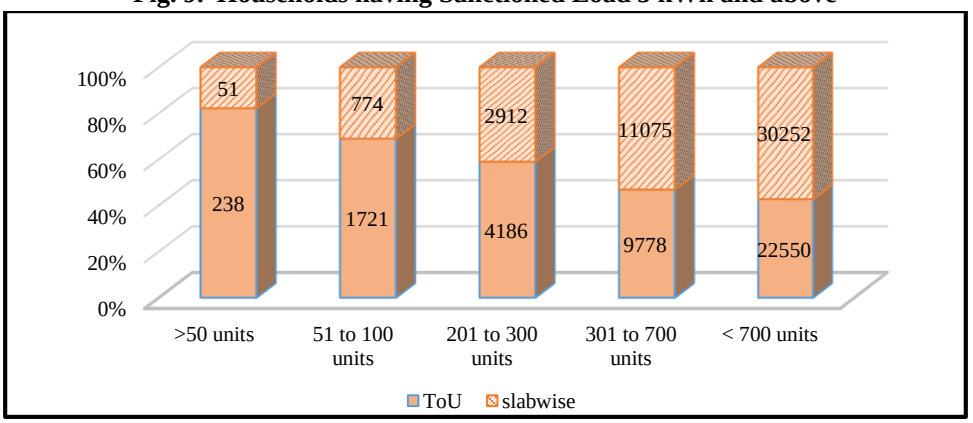


Source: Authors' illustration based on a primary survey of Karachi.

Another foremost reform in the tariff structure is the implementation of the time of use (ToU) metering arrangement. According to this reform, all the new and existing customers having sanctioned loads of 5 kWh and above have installed ToU meters and are, therefore, billed based on the peak and off-peak tariff structure.

Figure 9 shows the electricity expenditure of households having sanctioned loads greater than 5. The amount in rupees mentioned in the bars is the unit consumption amount (government and other charges are not included). This figure is constructed for comparison purposes as the rate of peak hours are charged at the highest rates irrespective of the number of units consumed. In the figure, each bar is divided into two, where the solid part represents the actual expenditure of these households based on the ToU tariff structure and the textured part is constructed on the basis that if these households were billed under the slab-wise tariff structure. The figure reveals that households consuming less than 300 kWh units, on average, were worse off under this new reform. Such households were bound to pay more than two times.

Fig. 9. Households having Sanctioned Load 5 kWh and above



Source: Authors' illustration based on a primary survey of Karachi.

Impact of Recent Increase in Tariff

Table 2 below provides the impact of the recent increase in electricity tariff rates on household expenditures. For each three consumption slabs, from 1 to 300 kWh units, tariff rates were increased at a flat rate of Rs. 1.61, while for all the higher slabs tariff was revised at a flat rate of Rs. 3.33.

Table 2
Electricity Expenditure Before and After the Tariff Increase

Slabs Category	Electricity Units Expenditures (Before Tariff Increase)	Electricity Units Expenditures (After Tariff Increase)	Percentage Change
Up to 50 Units	135.35	135.35	00
Up to 100 Units	587.31	699.38	19.08
101-200 Units	1331.38	1581.60	18.79
201-300 Units	2724.99	3107.18	14.03
301-700 Units	6117.94	7022.17	14.78
Above 700 Units	21790.36	25572.70	17.36
On-Peak & Off-Peak	13201.52	15769.42	19.45

Source: Authors' calculations based on Primary data of Karachi.

In Table 2, the percentage increase in electricity expenditures is calculated by keeping the units consumed constant and applying new rates to calculate the expenditures after the increase in tariffs. It shows that expenditures increased by more than 14 percent for all the slabs. The highest percentage increase was recorded for households having sanctioned load of 5 or above. The impact of the recent tariff revision was also substantial on lower consumption households.

Energy Literacy and Behaviour

Considering all the above issues in electricity management and affordability, it is imperative to educate the general public about sustainable energy consumption habits. Considering it an essential instrument, this study included these important modules in the energy survey that we carried out for this study to understand the cognitive and behavioural aspects of household energy use. Including these aspects in the policy, the design will enable individuals to make appropriate choices in energy use as well.

Various indices were calculated from the literacy, behaviour, and satisfaction modules in the energy questionnaire. Each index was calculated by linear combinations of various indicators.[1]

[1] The list of the indicators for each index is provided in Annexure.

Table 3 shows the energy literacy index computed by employing various energy literacy indicators, given in the questionnaire. The index given below measures the extent to which households in Karachi are energy literate. The values of the index range from 0 (energy illiterate) to 1 (energy literate).

Table 3 shows that residents of not a single town in Karachi were literate enough in the tariff structure, tariff rates, and other aspects of energy. However, residents of Liaquatabad, Jamshed town, Malir town, Gulshan-e-Iqbal town, and Saddar town were relatively more informed.

Table 3

Energy Literacy Index

Town	Mean
Baldia	0.300
Bin Qasim	0.244
Gadab	0.397
Gulberg	0.325
Gulshan-e- Iqbal	0.413
Jamshed	0.455
Kaemari	0.211
Korangi	0.314
Landhi	0.260
Liaqatabad	0.461
Lyari	0.328
Malir	0.425
New Karachi	0.294
North Nazimabad	0.381
Orangi	0.167
Saddar	0.411
Site	0.210
Shah Faisal	0.382

Source: Authors' calculations based on Primary data of Karachi.

Table 4 shows the index that measures the households' behaviour or habits regarding the use of electricity in their daily lives. The index value ranges from 0 to 1, where 0 indicates households having irresponsible behaviour regarding energy utilisation and the index value of 1 indicates good habits of households.

The table shows that the households' behaviour regarding electricity use was moderate (indicated by the dark blue color) in Malir, Lyari, and Gadab. Index values show that citizens' behaviour towards energy use could be improved by educating them. This could help the policymaker in achieving the aim of efficient energy use and conservation of energy resources.

Table 4

Energy Behavioural Index

Town	Mean
Baldia	0.375
Bin Qasim	0.05
Gadab	0.538
Gulberg	0.405
Gulshan-e- Iqbal	0.406
Jamshed	0.223
Kaemari	0.434
Korangi	0.077
Landhi	0.117
Liaqatabad	0.147
Lyari	0.500
Malir	0.675
New Karachi	0.419
North Nazimabad	0.369
Orangi	0.414
Saddar	0.342
Site	0.348
Shah Faisal	0.441

Source: Authors' calculations based on Primary data of Karachi.

Table 5 shows the satisfaction index that measures households' level of satisfaction with K-Electric services. The index was measured using indicators based on power outages asked in the questionnaire. The average value of the index for each town ranges from 0 (extremely unsatisfied) to 1 (totally satisfied). The darker shade in the table shows a relatively higher level of satisfaction compared to the lighter shade which represents lower levels of satisfaction. The index value for each town is around 0.5, which shows a moderate level of satisfaction across households.

Table 5

Satisfaction Index

Town	Mean
Baldia	0.523
Bin Qasim	0.440
Gadab	0.530
Gulberg	0.536
Gulshan-e-Iqbal	0.534
Jamshed	0.502
Kaemari	0.524
Korangi	0.538
Landhi	0.533
Liaqatabad	0.484
Lyari	0.423
Malir	0.477
New Karachi	0.500
North Nazimabad	0.512
Orangi	0.434
Saddar	0.518
Site	0.559
Shah Faisal	0.515

Source: Authors' calculations based on Primary data of Karachi.

4. CONCLUSION AND POLICY IMPLICATION

Over the past few years, the Government of Pakistan has initiated electricity tariff reforms that directly impact household welfare in the country. As a result of these reforms, the government has started curtailing the electricity subsidies, gradually increasing end-consumer electricity prices. However, changing the policy to raise the subsidised electricity tariff decreases the affordability for a consumer and impacts the overall welfare of a household, which is believed to increase energy poverty in Pakistan.

The findings of the study are based on a descriptive analysis of consumption, expenditures, and changes in the recent increase in electricity tariff on household welfare in Karachi city. The first important conclusion drawn from this section is that the government charges and other charges, such as the TVL fees, fuel adjustment charges, etc., constitute a significant proportion of total electricity bills. Secondly, the fuel adjustment charges for the lifeline slab were more than the total amount spent on units consumed, whereas government charges also constituted a significant proportion. Results revealed that households bore an extra burden in the form of these charges. The third important finding was related to the households having sanctioned load of 5 kWh or above. It was found that households consuming less than 300 kWh units, on average, were worse off under the ToU tariff structure. This finding shows that although electricity charges are still subsidised for low-consumption households, the proportion of additional costs should also be curtailed to diminish the adverse effects on the poor.

This study considers that educating the general public about sustainable energy consumption habits is imperative. Considering this as an essential instrument, this study encompassed these crucial modules in the energy survey to understand households' cognitive and behavioural aspects of energy use. Including these aspects in policy, the design will enable individuals to make appropriate choices in energy use. Results show that the general public of Karachi was not informed about the current electricity sector reforms. Similarly, efficiency in end-use also needs to be improved. In this regard, literacy programmes at high-school levels or through advertisements on social media could be initiated. In the past, public service messages for saving electricity were communicated through television advertisements. The same policy should be continued to make individuals energy literate. Energy-efficient appliances should also be promoted to improve electricity affordability, particularly among middle and high-income households. Without any government interference, households can respond to a rise in price either by switching towards more energy-efficient appliances or adopting habits of efficient electricity utilisation. These kinds of efficiency programmes will bring sustainable changes to society. These measures are believed to provide a buffer against the adverse impact of price increases, particularly on middle- and higher-income households. The existing literature on Pakistan also points toward the importance of institutional and end-use efficiencies, including efficiency in production, distribution, and consumption.

Analysis of this study shows that the government is determined to gradually phase out electricity subsidies at a high pace. In this regard, it is recommended to publicise the upcoming rise in price among the general public as not all the individuals in the country are literate enough to anticipate the impact. However, unexpected rises in price aggravate anger among individuals and could obstruct these reform processes' smooth implementation and completion.

ANNEXURE

Box A: Indicators Used for Energy Indices

✓	**Indicators used for Satisfaction Index**
	1. Did you experience power/Load shedding outages in 2020-21?
	2. At what frequency do the load shedding/outages occur?
	3. On average, how many hours does the power breakdown lasts?
	4. How do you rate your customer service phone experience?
	5. How do you rate K-electric restoration response to your outage(s)?
	6. Do any occupants require utility service for medical reasons such as refrigeration for medicine or any critical medical equipment?
	7. Does the load shedding effect Educational activities of household members?
✓	**Indicators used for Perception Index**
	1. Running only full loads when using the washing machine
	2. Using AC at 26^0C
	3. Completely switch off electronic devices (no stand by)
	4. Do you extinguish fire right after cooking
✓	**Indicators used for Literacy Index**
	1. How much do you think 1 Kilowatt hour (kWh) currently costs? Please indicate your best guess without checking your bill or other resources.
	2. Do you know, how much per unit rates of electricity increase during the peak hours?
	3. How much do you think it costs in terms of electricity unit to run a fan for an hour?
	4. In the following, which item consumes more energy in terms of rupees?
	5. In the following, which item consumes more electricity? Q12_5
	6. In the following, which item consumes more electricity? Q12_6

Source: Authors' illustration.

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