

Assessment of Average Household Utility Consumption in Khulna City of Bangladesh

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Abstract. Utilities mean useful features, or something useful to the home such as electricity, gas, water, cable and telephone etc. Study of utility consumption is a driving force to build a sustainable household facility management by monitoring and controlling the rate of consumption. The principal objective of this study is to determine the average monthly household utility such as electricity, water and gas consumption at Khulna city which is the third biggest city in Bangladesh. A field survey was conducted for collecting utility consumption data from household. Households from four major residential area of Khulna city were audited to collect utility consumption data. Three types of utility such as electricity, water, gas were the scope of this research. From the surveyed it has been found that the average consumption of electricity is 234 KWh/month for 3 rooms flat, 281 KWh/month for 4 rooms flat and 340 KWh/month for 5 rooms flat type. Similarly, the average consumption of water is 16900 Ltrs/month for 3 rooms flat, 18200 Ltrs/month for 4 rooms flat and 22500 Ltrs/month for five rooms flat type. Likewise, the average gas consumption is 8.5 kg/month for 3 rooms flat, 14.5 kg/month for 4 room flat and 15 kg/month for 5 rooms flat type. The findings of this study would assist all sorts of stakeholders to monitor and control the utility consumption behavior to develop a sustainable facility management system. Most importantly; however, it would increase the awareness of Khulna's people about the misuse of utilities and indirectly protects the environment.

Keywords: Household, Consumption, Khulna city, Utility, sustainable.

1. Introduction

Utilities such as water, electricity and gas are essential elements that play a significant role in social and economic development of a country. Energy in the form of electricity is used in building to operate equipment for the safety, efficiency and comfort. Such equipment includes emergency systems, air-conditioning, lighting, transportation, office systems and other appliances (Fels 1986). Building is responsible for around 40 % of total energy consumption globally (Barua, Hossain et al. 2017) and this amount increased to 47 % in Bangladesh (Alam, Islam et al. 2014). China's energy consumption increased by 5.6% annually. The national total primary energy consumption of buildings was 18.8% in 2006, and the percent is estimated to rise to 25%~30% by 2020 in China (Jiang and Wu 2010). Residential and commercial buildings account for two-thirds of the electricity used in the US, 36 percent of US greenhouse gasses, 9 percent of world greenhouse emissions, and 12 percent of US fresh water consumption (Petersen, Shunturov et al. 2007). Results show the average energy consumption per residential house are 64.2 kWh/m²/year in Mentiri area, 55.7 kWh/m²/year in Panaga and 47.8 kWh/m²/year in Meragang area, respectively in Brunei Darussalam (Shabunko, Lim et al. 2016). Likewise, Building and Construction Authority (BCA) in Singapore shows that the energy consumptions in building about 57% of the whole electricity consumption in Singapore (Dong, Lee et al. 2005). Energy cost, carbon dioxide (CO₂) and green house gas (GHG) are directly linked with magnitude of energy consumption. Therefore, it is very much important to establish an effective and efficient strategy to manage the energy consumption (Waheed, Oni et al. 2012).

A comprehensive review of 38 studies of household energy use conducted over the last 25 years in Europe and the US concluded that information feedback on rates of consumption provided to building occupants can increase awareness and motivate decreased energy use (Darby 2001).

Water and gas are also used in a large amount in residential buildings. Water is mainly used as a cooking, drinking, bathing, washing etc. Gas is used as cooking foods.

The baseline model is a key to secure and verify savings from energy programs(Dong, Lee et al. 2005). It has found that baseline building energy consumption is one of the important elements for energy performance contracting and measurement and verification protocol (MVP) (Dong, Cao et al. 2005). Fumo et al. have created a methodology that estimates the hourly building energy consumption based on the building utility bills(Fumo, Mago et al. 2010). By establishing the baseline for buildings, the measured energy savings from retrofits in buildings is determined as the difference of energy consumption of buildings between the predicted by a baseline model and the observed, according the International Performance Measurement and Verification Protocol(Committee 2001). Kisoock et al. made a regression methodology to measure energy use in commercial buildings(Kisoock 2008) but in most practical cases, utility bill data are used because they are widely available and inexpensive to obtain and process(Reddy, Saman et al. 1997). The zone wise supply of electricity in Bangladesh per day provided in table 1.

Table 1. Statistics of zone wise electricity supply in Bangladesh

Zone wise electricity supply (MW)								
Dhaka	Chittagon	Comilla	Mymensingh	Sylhet	Rangpur	Rajshahi	Khulna	Barisal
3782	1047	882	581	379	396	874	903	180

Source: Power Grid Company of Bangladesh (PGCB)

Few researches have been conducted on assessment of household energy utilization in building(Dong, Lee et al. 2005; Waheed, Oni et al. 2012).However, previous studies was only in-terms of building energy utilization. Therefore, it

would be interesting to conduct a holistic investigation on building utility such as electricity, water and gas in Khulna city area of Bangladesh. In this paper, an attempt has been taken to assess the average utility (electricity, water & gas) consumption on the basis of different flat type. Household from four biggest residential area of Khulna city area has been surveyed where the data about three major utilities such as electricity, water and gas were considered. The outcome of this research would be used to monitor and control the utility consumption that will lead to build sustainable tomorrow.

2. Methodology

In this research, a field investigation was conducted in Khulna city area of Bangladesh to assess the utility consumption trend. During this investigation, a questionnaire survey form was prepared. The surveyed residential home was classified on the basis of number of rooms such as 3 room flat type, 4 room flat type and 5 room flat types.

2.1 Selection of Study Area

Khulna, the third largest city of Bangladesh, is located in the southern part of the country and is situated below the tropic of cancer, around the intersection of latitude 22.49N and longitude 89.34E. The area of Khulna city is 47 square km with a population 1.5 million (corporation 2018). It has the large residential area and consume large amount of utilities such as electricity, water, gas etc. Energy has become a crucial topic because the development system is based on the use of energy. With regards to investigate the utility consumption, a field survey was conducted in Khulna city area. The selected study sites for RUCA were Nirala Residential Area (NRA), Mujgunni Residential Area (MRA), Sonadanga Residential Area (SRA) and Khalipur Residential Area (KRA) of Khulna city in Bangladesh (Figure 1).

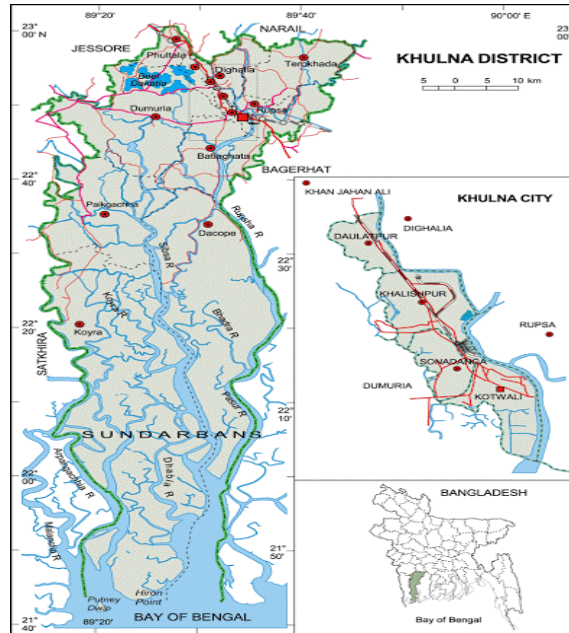


Figure 1. Location of study areas in Khulna city of Bangladesh.

2.2 Field Survey in the Selected Area

The Residential Utility Consumption (RUC) level has been developed in residential area (RA) form. This study was performed using a questionnaire survey in Khulna city area of Bangladesh. The scope of the survey was covered three major utilities such as electricity, water and gas. The field survey was conducted in March, April & May of 2017 and covered interviewed of 40 nos of residential flat. All surveyed residential flat were categories as 3 room, 4 room and 5 room flat type. The data was collected by interviewing representative of each flat, making questionnaires, talking with the owners which were considered as primary data source. During survey information regarding appliances such as air conditioning (AC), Rice cooker, Oven, Iron machine, Refrigerator and induction cooker has been considered. The survey also considered consumption of water in Liters and gas in kg as well. From this, the average monthly utility consumption was found on the basis of flat type.

The information about electricity consumption was determined from prepaid meter that has been installed at every individual residential unit. Currently in Khulna city there have no pipeline gas supply and because of that the amount of gas used was determined from no of gas cylinder used for a month that means how much kilogram (kg) of gas used every month? Moreover, currently the main source of water supply in Khulna city is underground water. There was no metering system for the measurement of water in Khulna city. As a result, following method was used to estimate the amount of water consumed per month for a particular flat type:

Let, the capacity of water in a overhead tank = Q Litters

No. of overhead tank water used per day = N

So, the amount of water used per month = Q x N x 30 Litters

3. Result and Discussion

The utility consumption of a home depends on many factors such as numbers of family members, no and type of home appliances such as rice cooker, blending machine, fan, electric sewing machine, water heater, washing machine, microven, iron machine Refrigerator etc. Some other heavy electricity consumer like Air conditioning. However, the findings of this study according to flat type have been presented in table 1, 2 & 3.

Table 2. Utility consumption for 3 rooms flat type

Flat No	Family members	No. of ANC	No. of Rice Cooker	No. of Oven	No. of Iron Machine	No. of Refrigerator	No. of Induction	Electricity (KWh/month)	Water (Ltrs/month)	Gas (kg/month)
1	5	0	1	0	0	1	0	210	22000	6
2	4	0	1	0	0	1	1	194	20000	4
3	4	0	1	1	1	1	1	280	18000	6
4	4	0	1	1	0	2	0	320	19000	12
5	3	0	1	0	1	1	0	194	15000	8

6	5	0	1	1	1	1	1	270	19500	7
7	4	0	1	0	1	1	0	175	17000	6
8	4	0	1	0	1	1	0	200	17500	8
9	3	0	1	0	0	1	0	199	14500	5
10	4	2	1	1	1	1	0	322	19000	12
11	4	0	1	1	1	1	0	270	20500	5
12	4	1	1	1	1	2	1	315	18500	14
13	1	0	1	1	1	1	0	145	4200	6
14	3	0	1	0	1	0	0	155	13500	14
15	3	0	1	1	1	1	0	220	14000	10
16	4	1	1	1	1	1	1	290	17500	13
Average								234	16900	8.5

Table 3. Utility consumption for 4 rooms flat type

Flat No	Family members	No. of AC	No. of Rice Cooker	No. of Oven	No. of Iron Machine	No. of Refrigerator	No. of Induction cooker	Electricity (KWh/month)	Water (Ltrs/month)	Gas (kg/month)
1	4	0	1	1	1	1	1	350	19500	13
2	4	0	1	2	1	1	0	220	20000	12
3	5	1	1	1	1	1	0	350	21500	14
4	4	0	1	0	1	1	1	301	19000	24
5	4	1	0	0	1	2	1	340	18000	18
6	3	1	1	1	1	1	0	230	13500	10
7	5	1	1	1	1	1	0	320	21000	15
8	4	0	0	0	1	1	0	205	16000	14
9	4	0	0	2	2	2	0	260	15500	15
10	3	0	0	1	1	1	0	194	12000	11
11	5	2	1	1	1	1	0	410	21000	14
12	4	0	1	1	1	1	0	220	18000	12
13	5	1	1	0	1	1	1	330	20500	16
Average								281	18200	14.5

Table 4. Utility consumption for 5 rooms flat type

Flat No	Family members	No. of AC	No. of Rice	No. of .	No. of Iron	No. of Refrigerator	No. of Induction	Electricity (KWh/month)	Water (Ltrs/month)	Gas (kg/month)
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	A C	Coo ker	Ov en	Mach ine		cooke r				
1	4	2	1	1	1	1	1	460	16800	18
2	6	1	0	1	1	3	1	380	24500	12
3	5	1	1	1	1	1	1	360	20800	15
4	6	0	1	0	0	2	0	280	25000	14
5	4	1	1	1	1	1	1	370	16500	14
6	8	1	1	1	2	2	0	298	32500	16
7	6	0	1	0	0	1	1	310	23000	13
8	7	1	1	1	2	1	0	300	29500	15
9	5	0	0	0	1	2	1	360	21500	14
10	5	0	1	0	1	2	0	290	19500	10
11	4	3	1	1	1	3	1	1150	17600	24
							Avera ge	340	22500	15

3.1 Household Electricity Consumption

Figure 2 shows the electricity consumption for 3 rooms, 4 rooms and 5 rooms flat type respectively. From the figure 2(a) it has been found that, surveyed flat no. 13-consumed minimum amount of electricity which is around 145 KWh/month and flat no. 10-consumed maximum amount of electricity which is around 322 KWh/month. However, the average electricity consumption for 3 rooms flat type is 234 KWh/month. Flat no.10 of 4 room flat type consumed minimum amount of electricity which is around 194 KWh/month and flat no. 11- consumed maximum amount of electricity which is around 410 KWh/month. However, the average electricity consumption for 4 rooms flat type is 281 KWh/month (figure 2a). Similarly, from figure 2(c) it has been found that flat no. 4 of 5 room flat type consumed minimum amount of electricity which is around 280 KWh/month and flat no. 11-consumed maximum amount of electricity which is around 1150 KWh/month. And, the average electricity consumption for 5 rooms flat type is 340 KWh/month.

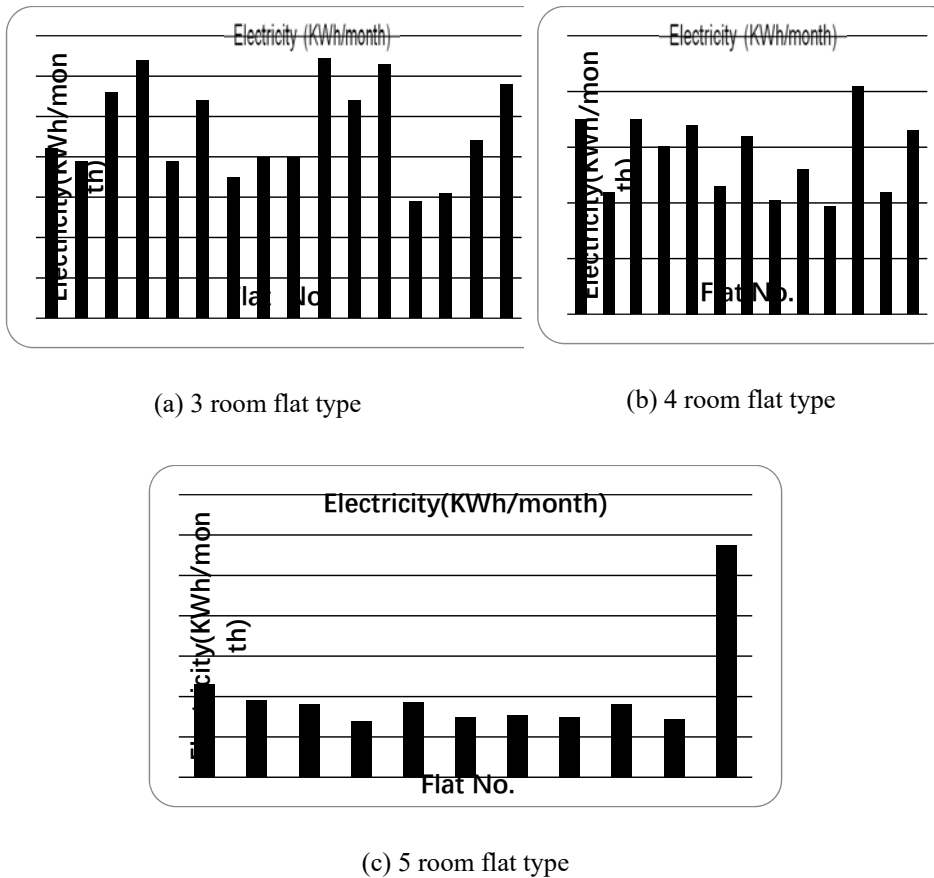
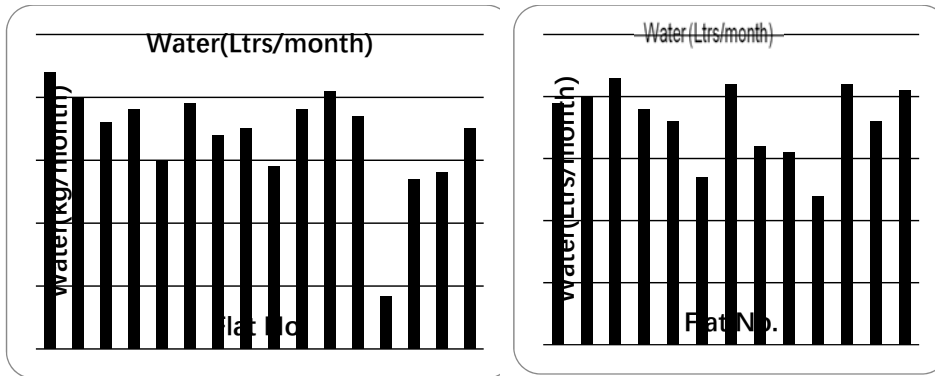


Figure 2. Consumption of electricity for different flat type

3.2 Household Water Consumption

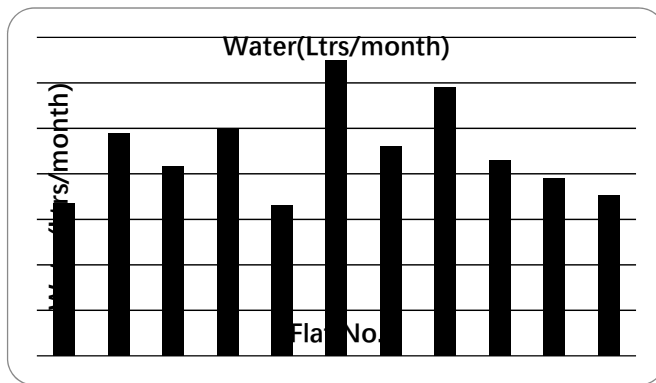
Figure 3 shows the water consumption for 3 rooms, 4 rooms and 5 rooms flat type. It has been found from the figure 4(a) that, surveyed flat no. 13 of 3 room flat type consumed minimum amount of water which is around 4200 Ltrs / month and flat no.1- consumed maximum amount of water which is around 22000 Ltrs / month. However, the average water consumption for 3 rooms flat type is 16900 Ltrs/month. 4 room flat type consumed minimum amount of water which is around 12000 Ltrs/month (flat no 10) and flat no. 3-consumed maximum amount of water which is around 21500 Ltrs/month. However, the average water

consumption for 4 rooms flat type is 18200 Ltrs/month. Similarly, in 5 room flat type, flat no. 5-consumed minimum amount of water which is around 16500 Ltrs/month and flat no. 6-consumed maximum amount of water which is around 32500 Ltrs/month. However, the average water consumption for 5 rooms flat type is 22500 Ltrs/month.



(a) 3 room flat type

(b) 4 room flat type



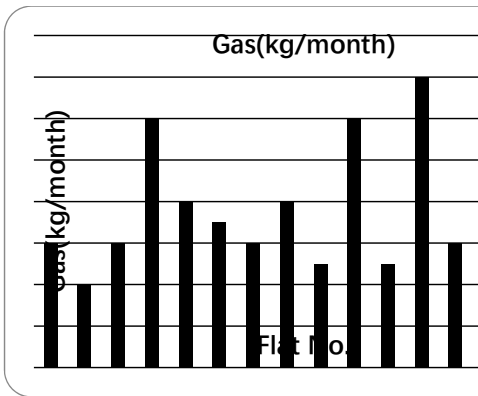
(c) 5 room flat type

Figure 3. Consumption of water for different flat type.

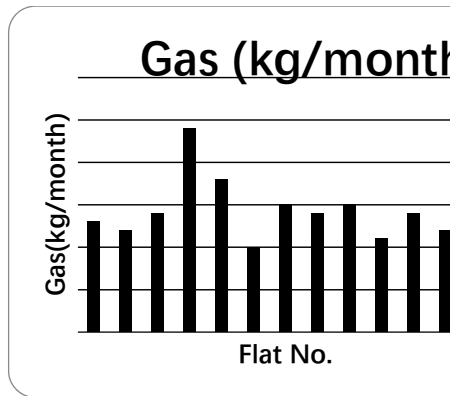
3.3 Household Gas Consumption

Figure 4 shows the gas consumption for 3 rooms, 4 rooms and 5 rooms flat type. From the survey result it has been found that flat no. 3-consumed minimum

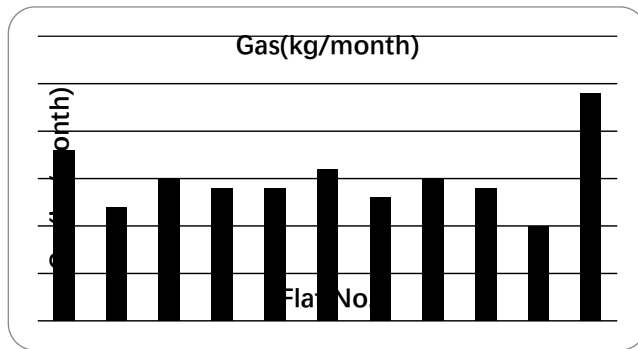
amount of gas which is around 4 kg/month and flat no.12 &14 consumed maximum amount of gas which is around 14 kg/month (figure 4-a). However, the average gas consumption for 3 rooms flat type is 8.5 kg/month. For 4 rooms flat type it has been found that flat no. 6 consumed minimum amount of gas which is around 10 kg/month and flat no. 4-consumed maximum amount of gas which is around 24 kg/month (figure 4-b). However, the average gas consumption for 4 rooms flat type is 14.5 kg/month. Similarly, for 5 room flat type 10 no. flat consumed minimum amount of gas which is around 10 kg/month and flat no 11-consumed maximum amount of gas which is around 24 kg/month (figure 4-c). However, the average gas consumption for 5 rooms flat type is 15 kg/month.



(a) 3 room flat type



(b) 4 room flat type



(c) 5 room flat type

Figure 4. Consumption of gas for different flat type

4. Implication of This Study

The world is moving toward sustainable development. According to Singapore based green mark rating system BCA green mark allocate 56 % of point for energy and 9% of point allocated for water efficiency. Similarly, according to LEED V4, 34 % point allocation for energy and 11% point for water. Therefore, it can be said that building utility specially electricity and water plays a significant role for green building. In order to build-up awareness within the residents regarding efficient and effective utility consumption, the outcome of this study would play a significant role. Similar study has been conducted in Singapore where Public Utility Board (PUB) provides statistics of utility consumption with monthly utility bill with compare to national average.

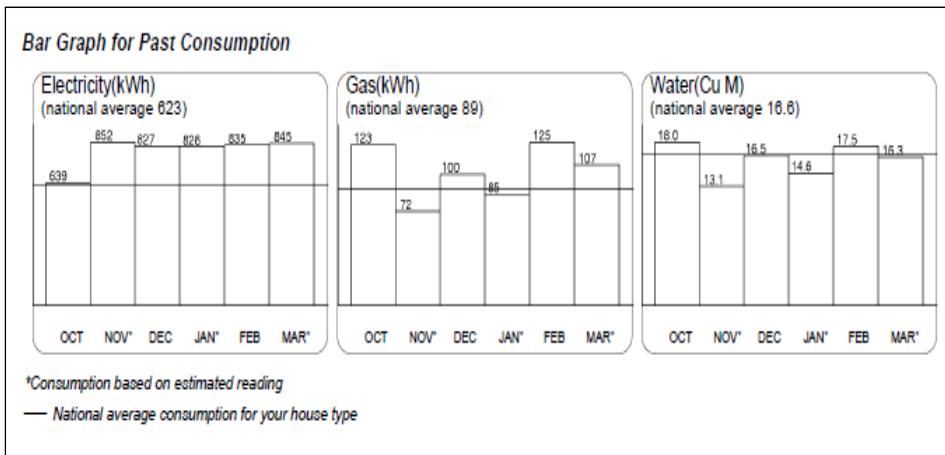


Figure 5. Energy Consumption Trend (source PUB Singapore)

Therefore, this study would assist to achieve sustainable utility management by measuring, monitoring & controlling of utility utilization. The research finding will also provided awareness to the resident on utility consumption level.

5. Conclusion

Effective and efficient consumption of utility is a global demand at the moment. To understand the present scenario of the household utility consumption in Khulna city of Bangladesh, this study have been conducted for residential buildings of Khulna in summer season of 2017. Three months utilities consumption from four residential areas in Khulna were collected. The major findings of this study are given below:

- Average electricity utilization was 234, 281 & 340 KWh/month for 3 rooms, 4 rooms and 5 rooms respectively.
- Average water used was 16900, 18200 and 22500 Ltrs/month for 3 rooms, 4 rooms & 5 rooms respectively.
- And average gas consumption was 8.5, 14.5 & 15 kg/month for 3 rooms, 4 rooms and 5 rooms respectively.

This study revealed that overall utility consumption amount among the residents of Khulna city is not so high. However, extensive public motivation would reduce the amount of utility consumption. Electricity supplier could include the average utility consumption statistic with monthly bill according to the flat type and that would be act as a motivational guideline for the resident. When people become aware about using the utilities according to statistic, the misuse of utilities will be decreasing. So, the negative impact of using over utilities will be reduced from the environment.

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