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Evaluation of Electricity Consumption and Development of Household Energy Performance Index (EPI): A Case Study of Mumbai Metropolitan Region (MMR)

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Abstract: Electricity demand is the most important aspect in India. The research here was carried out analyze the pattern of electricity consumption in Mumbai Metropolitan Region (MMR). 51 households were surveyed which were the main area of study. The findings showed the average consumption of electricity in MMR region was 399 units or kWh per month. The research also shows that the replacement of all the appliances with the best energy saving technologies available in the market would reduce the average consumption by 46%. A Household Energy Performance Index (HEPI) was formulated which would compare the electricity consumption of households of equal stature.The index was formulated considering 2 important factors of energy consumption i.e. per capita per month consumption and number of people living in the house. The findings of HEPI showed that it can be related to the area of the household and is directly proportional. The area of the houses can then be used to limit the power consumption. The area more than 1000sq.ft. can have HEPI of maximum 0.5. The area of the house between 500-1000 sq.ft should be upto 0.45 and that of houses less than 500sq.ft should have maximum HEPI of 0.4. Classifying the findings of HEPI and area of houses in the 3 main areas of MMR ie. The Mumbai area, Thane and Navi Mumbai it was found that the HEPI was almost equal in spite of great the variation in area of houses in all the 3 areas.

1. INTRODUCTION

The electricity sector in India had an installed capacity of 233.929 GW as of December 2013, the world's fourth largest. Non Renewable Power Plants constitute 87.55% of the installed capacity, and Renewable Power Plants constitute the remaining 12.45% of total installed Capacity.

In December 2011, over 300 million Indian citizens had no access to frequent electricity. Over one third of India's rural population lacked electricity, as did 6% of the urban population. Of those who did have access to electricity in India, the supply was intermittent and unreliable.

In 2010, blackouts and power shedding interrupted irrigation and manufacturing across the country. India's network technical losses is 23.65% in 2013, compared to world average of less than 15%. A high proportion of non-technical losses are caused by illegal tapping of lines, and faulty electric meters that underestimate actual consumption also contribute to reduced payment collection.

Thus inequitable distribution of electricity comes into picture. Hence the one who pays more gets more, This whole scenario of shortage and wastage; profits and losses; rural and urban; investment and supply; needs to be looked into and requires some urgent transformations from the core.

But along with all this there requires some strict laws and legal bindings on all those who have constant supply to electricity and often are the people who's electricity wastage is known to be high. The electricity act 2003 was made by the central government which has its main focus on the electricity generation techniques. But there is no law about the wastage of electricity and the ways to curb them. The following research paper is an attempt to do the same. In it also the issues such as tapping of electric lines, meter based electricity lines, duties and rights of the state government about the same are addressed.

2. METHODOLOGY

A survey of usage electrical appliances used in households, was conducted for 51 households in the Mumbai metropolitan region. The surveys were collected through personal interviews and e-mails.

A spreadsheet model considering the various aspects associated with energy consumption in buildings was prepared.

Considering various energy efficient options available for each type of appliance was analyzed.

A formula for calculating household energy performance index (HEPI) was developed. HEPI was calculated using it.

The survey was taken from various locations from all over MMR. The places from where the survey is taken are marked in the figure 1 with pink dots. We can see that out of the 51 survey that was collected 15 are from Thane and the rest from various locations from all over Mumbai metropolitan region (MMR). The survey conducted on all the above places gave us the data of the hours of usage and the no. of appliances available. The power consumed by each of the appliance in watts was taken from the website of BEST. The product of all the 3 factors gave the wattage consumed by each appliance per day.

Wattage consumed by each appliance per day = no. of appliances* hours of usage* wattage used

Figu. 1: locations of survey in MMR

A Household Energy Performance Index(HEPI) was formulated. The 2 factors that were taken into consideration was the no. of people living in the house and the per capita per month consumption. The arithmetic mean of these 2 dimension indices concludes to a value between 0-1. The values nearing to 0 indicates good performance. As the value deviates from 0 the performance decreases.

Based on current usage and the no. of people living in the household energy performance index were calculated using the formula:

Household Energy Performance Index (HEPI) = $\frac{\left[\left(\frac{x_n-x_1}{x_2-x_1}\right)+\left(\frac{y_n-y_1}{y_2-y_1}\right)\right]}{2}$

Where, x_n- Value of units consumed/person/month.
x_1-min. value of units consumed/person/month.
x_2- max. Value of units consumed/person/month.
y_n- no. of people living in the house.
y_1- min. no. of people living in the house.
y_2- max. no. of people living in the house.

Another data collected in the survey was the area of the house and no. of people living in the house.

3. RESULTS AND DISCUSSIONS.

Table 1: Appliance details and percent reduction in usage

Currently used Appliances used	Appliances replaced withAppliances replaced with	Percent reduction in usage
60W bulb	Replaced with 10W LED	83%
36Wtubelight	Replaced with 18W LED	65%
14W CFL	Replaced with 10WLED	21%
64W fan	Replaced with 40W fan	37%
1 star AC	Replaced with 5 star AC	54%
Electric iron	Replaced with 600W iron	20%
Microwave oven	Replaced with 5 star oven	37%
Washing machine	Replaced with 5 star washing machine	37%
Computer	Replaced with Laptop	66%
No star fridge	Replaced with 5 star fridge	52%

The survey results that we got from use of bulbs was that many of the people have stopped using bulbs and among those who use, use it for very less time so the average per day consumption comes to 639 watts, whereas if it is replaced by 10 watt LED light that gives the same lumens of light the consumption reduces to 107 watts.ie 83% reduction in consumption. Tube lights still is a major consumer in most of

the houses and tends to consume 1437 watts per day; i.e. around 11% of the total monthly consumption. If it is replaced by LED lights of same lumens consumption reduces to 507 watts per day.ie 65% reduction in consumption.

We can see that lately CFL are also much energy saving lights and many of the houses have switched over from conventional tube lights to CFL. The consumption of CFL ranges from 7 to 28 watts so an average wattage of 14 watts had been considered for the calculations. CFL are also known to have mercury vapour and is harmful for the environment. Hence, it is suggested to be replaced with 10w LED lights. The consumption then reduced from 236 W to 169 W i.e. 21% reduction in consumption. Coming over to fans, the most important consumer of electricity; constituting 28% of the average consumption. A normal fan requires 64 watts. Now a day's many energy saving fans are coming into the market that consume just 40 watts. So the consumption reduces from 3.7 units/day to 2.3 units/day i.e. 37% reduction in consumption.

Now talking about air conditioners (AC) India being a tropical country the use of AC in many urban places has become very essential. As far as households are concerned from the taken survey less than 50% of the population own AC. AC have a peculiar property of going into standby mode within sometime of use hence it cannot consume more than certain units of electricity per day. Hence any consumption hours exceeding 2 hours was considered to consume maximum current of that star rated AC. During the survey the star rating of the AC was not examined hence all the AC were considered to have 1 star rating and were suggested to replace it with 5 star AC. And the reduction in consumption was 54%.

Fridge is also a high consumer if electricity in households. It is because of the fact that it runs for 24 hours in all the houses. Considering that the surveyed houses have fridges of no star it is suggested to replace it with 5 star rated fridges. By doing so the consumption reduces from 3.7 units/day to 1.8 units/day i.e. 52% reduction in consumption. The use of electric iron has reduced in urban areas due to the increased availability of laundry services. Most of the households own iron but don't use it, of those who use it do so for very less time. Hence the consumption comes to just 567 watts. There are companies like Panasonic which produce energy saving electric iron which reduces the average consumption to 454 watts i.e. 20% reduction in consumption.

Microwave oven has become an integral part of household cooking. Many of the households do not own it or use it in spite of owning. Still as the use is known to increase its analysis was done. The use of 5star rated microwave instead of no star will give an energy saving of 37%.

Washing machines is another important appliance for laundry that is found in most of the households. It is normally operated for 1 hr every day. If the no star rated washing machines are replaced with 5 star rated ones then the consumption reduces by 37%.

Computer is the most important component of development. It is mostly found in all houses and is used for significant no. of hours. The search for energy saving computers ended in laptops. Laptops are the most efficient substitutes for computers. Hence if all computers are replaced by laptops then the consumption reduces from 456 watts to 152 watts for same usage hours i.e. 66% reduction in consumption.

Now coming over to geyser, mixer, TV and laptop they do not have any energy saving replacements or the options available are not much energy efficient. But their consumptions are comparatively low i.e. 151, 163, and 112 for geyser, mixer and laptop respectively. The only high consumer here is TV which is 514 watts because of the no. of hours used. The units consumed by each house according to the survey and the units that will be consumed if all the appliances are replaced with energy efficient ones are given in the table. On an average there is 46% reduction in units consumed per month.

In figure 2 the blue line indicates the average consumption of the houses by the survey taken and the red line indicates the consumption after replacement by energy saving appliances.

There is a average reduction of 46% if all the appliances are changed to energy saving appliances.

Figure 4: shows the percent consumption of each appliance derived according to the survey. The highest consumers of electricity are fans, fridges consuming 28% and 29% of total electricity respectively. After that AC and lights account to high consumption.

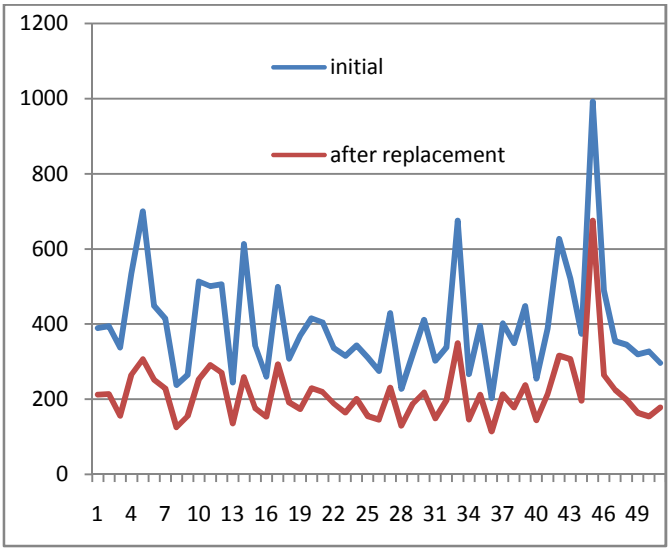

Fig. 2: Chart of reduction in power consumption by the use of energy saving appliances

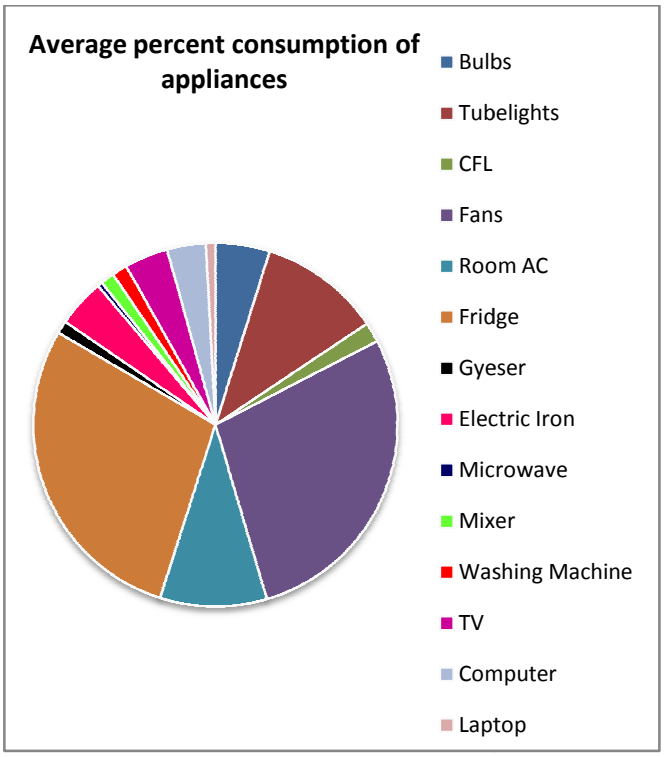

Fig. 3: average percent consumption of appliances

Table 2: average reduction in consumption and costs

	Initial	After replacement
Consumption in units(kWh)	399	215
Cost of electricity bill in Rs	2324	1025

Table 2 shows that on an average decrease in units consumption. There is an decrease of 183 units i.e. 46% reduction. As per the current rates of electricity; average bill decreases from 2324 to 1025 i.e. Rs 1300(approx) reduction in cost.

Using the formula of HEPI, HEPI of all the households were calculated. From the survey data collected the area of the houses were divided 3 main categories i.e. area more than 1000 sq. Ft. area between 500 sq.ft. to 1000 sq.ft., area less than 500 sq.ft. From figure 4 it was found that the HEPI of households increases with increase in the area of the house. In India the debate on the topic of limiting the electricity usage of households according to the area of houses is going on. Hence, if a policy needs to be framed, regarding the limit of electricity according to the area then the HEPI can be given a relaxation of 0.1 more than average. Hence the HEPI limits according to the area will be as shown in table 3.

Table 3: HEPI values of households according to the Area of house

Area of the house	HEPI
Greater than 1000 sq. Ft.	0.5
Between 500 to 1000 sq.ft.	0.430 (can be rounded off to 0.45)
Less than 500 sq. Ft.	0.380 (can be rounded off to 0.4)

The Mumbai metropolitan region mainly consists of 3 parts the ie. The Mumbai city, Thane and Navi The Mumbai metropolitan region mainly consists of 3 parts the i.e. The Mumbai city, Thane and Navi Mumbai. Hence our survey was also divided into these 3 areas.

From figure 5: It was found from the data that the area of houses in Mumbai were the least. People live in very small houses in Mumbai owing to the high population density of the city. Whereas, the area of houses in Thane and Navi Mumbai were found to be comparatively bigger. Both of them being a recently developing area.

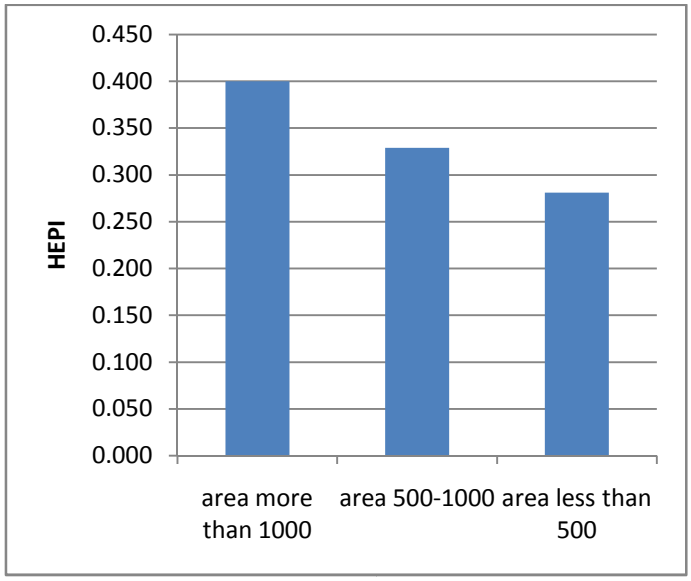

Fig. 4: HEPI of households classified according to Area of house

The figure 6 shows that the HEPI of Mumbai area is the least ie. 0.32. While the HEPI of thane area is higher ie.0.33 and that of Navi Mumbai is still higher ie. 0.34. hence, the HEPI is almost same for all (in the range of 0.30- 0.35) comparing it with the area of the house it can be said that the consumption in Mumbai area is higher as compared to the area of the house they live in. The reason for this could be the people living in this area live in old building and have not updated or maintained the electrical systems. They still depend on old equipments consuming high power and would not be much

aware of the energy saving options or would have been lacking the willingness to opt for the same. The thane area and Navi Mumbai area are recently developed ones. Some of these areas electricity shortage is also experienced. Hence the buildings here would be built with updated electrical technologies and also maintained properly. Due to the service sector population living here the concern about electricity bills also must be a major issue, hence the people here would have been adopting energy saving measures.

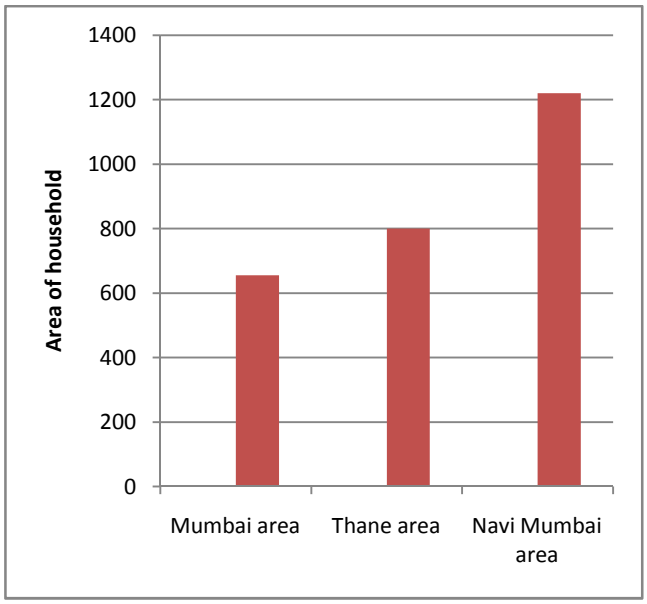

Fig. 5: Area of houses in various parts of MMR

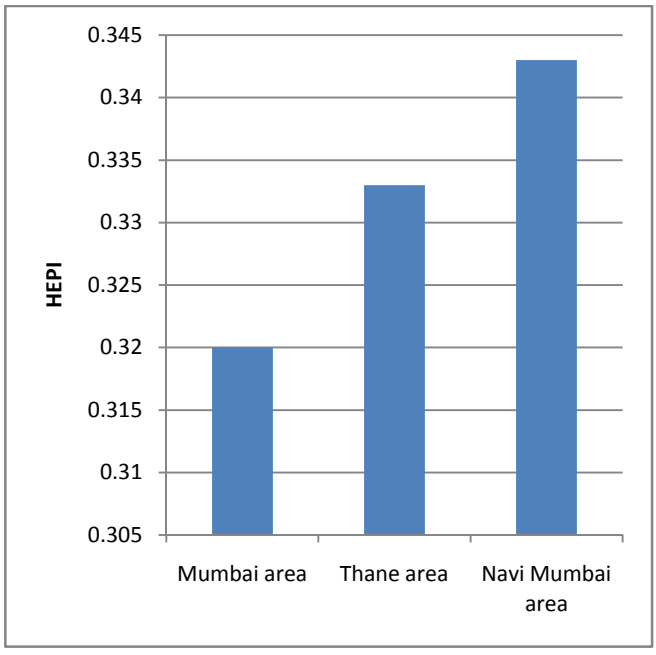

Fig. 6: HEPI of households in different parts of MMR.

4. CONCLUSION

Electricity consumption has become a major component of life in today's world. The major source of generation of electricity is through combustion of fossil fuels. These fossil fuels cause pollution in the environment. Hence, efficient utilization and reduced wastage of electricity is very much essential. Also equitable distribution of electricity is also essential. Conservation of electricity indirectly reduces the pollution levels. Hence it is important to study the various ways of electricity conservation.

The finding of this study shows that if the appliances are replaced with the energy saving components then the consumption reduced by 46% on an average. The maximum reduction was observed for replacing fans and lights with energy saving measures. In order to validate the energy performance of households in a data set household energy performance index (HEPI) was developed.

The HEPI was developed according to the survey data taken by survey hence, can also be applied to any other set of data. More the no. of surveyed data more accurate will be the result. If the surveyed data is reduced then the value will become more n more distorted. But the HEPI of a house will differ according to the survey data. Hence the HEPI of 2 different data sets cannot be compared. Hence, requires further development.

Another fact about houses in city is that the usage of appliances is also high. Hence replacing it with energy efficient appliances will help reduce power consumption without reducing the hours of usage. But frugally using electricity will reduce the consumption further and will be protecting the environment. Hence we can say from the above study that technological innovation like solar power, wind power, energy saving appliances like LED, 5 star rated products can all help in producing and conserving energy. But it is the willingness to adopt them that will help our country become a energy rich economy.

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