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Power Consumption Pattern in Residential Buildings: A Case Study

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ABSTRACT: The increasing energy crisis and impact of conventional energy sources on environment will curtail the economic growth of a nation. In meeting the fast growing energy demand and attaining sustainability, the consumer should share the responsibility with the electric utilities. One way of achieving this is by auditing the energy consumption of their respective organisations. In this paper one such audit is conducted on a residential building. Residential sector is one of the largest shareholders and has huge potential in conserving energy. In this paper an analysis is carried out on the energy consumption of a students' hostel. The results obtained are analysed and appropriate suggestions were given to reduce the electrical consumption.

KEYWORDS*:*Consumption, Energy Audit, Illumination, Standby Power.

I.INTRODUCTION

Energy audit is the preliminary step in the process of energy conservation [1]. By conducting an energy audit, the consumer can analyse his energy consumption pattern and can make note of the possibilities that exist in conserving the electricity. Energy conservation has a greater impact on the society in terms of reducing the supply demand gap and minimizing the carbon foot print in addition to the reduction in electricity bills.

Today, domestic sector in India is the second largest in terms of power consumption and accounts to 25% of the total power generated [3]. The increasing usage of electrical appliances in the suburban/rural households at par with urban areas further widens the supply demand gap. If the generation capacity does not meet the demand, it will subsequently burden the economic growth of the nation. Though the majority of the energy consumed in the domestic/residential sector is by the light sources (approximately 30%), there is an urgent need to analyse the power consumption pattern of various other appliances. Sensible usage of electrical appliances has a huge scope in conserving the electricity and eventually minimizing the load shedding.

Replacement of conventional lighting sources to compact fluorescent light bulbs (CFLs) or LEDs will save power consumption and consequently help in reducing the greenhouse gases [2]. The location of these light sources in a room is overlooked in households which generally lead to over illumination and excess power consumption. Another important aspect to be considered in energy conservation is standby power. Standby power also called as vampire power is the power that any equipment consumes when not in use. This power approximates to 4% of total residential electricity consumption and requires an attention during energy audit [3][6].

In this paper the electricity consumption of a students' hostel, is analysed for a period of one month and a load curve is estimated for that building. The residents of the building are interviewed to understand the load consumption pattern and their sensitivity towards energy conservation. This is discussed in detail in the subsequent sections. From the studies carried out, it is observed that the electrical conservation or optimal usage of electricity is generally overlooked and with little initiations from the residents, there can be a huge reduction in the energy consumption. This paper is one such attemptto appraise the situation of energy consumption in residential sector and the initiations to be taken in reducing the power consumption.

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II. LITERATURE SURVEY

Energy Audit is being carried out by various organisations world-wide to estimate their energy consumptionand undertake energy efficiency improvement measures[10]. In the last few years, many industries have made a practice of auditing their energy at regular intervals for managing energy efficiency [11]. The Indian government with the support of United States Agency for International Development (USAID) has developed a Energy Assessment Guide which explains the various procedures to be followed in assessing the energy consumption of a building [12][13]. The Bureau of Energy Efficiency (BEE)has also set few standards to be followed in implementing the energy efficient measures.

Extensive research has been carried out by various agencies till date on different house-hold electrical appliances like refrigerator, lighting, air-conditioners, water pump, washing machines etc. These studies suggest that switching off a refrigerator for 2-3 hours during the peak load of the day, will increase the life time of compressor, in addition to saving in electricity bills. The standby power consumption also called as phantom load is an important parameter in energy conservation. It is the leaking electricity by the appliances when they are not turned on. Many consumers are not aware of this small amount of electricity which leaks from their appliances [14].

III. ENERGY AUDIT OF THE BUILDING

The energy audit on the students' hostel is carried out in four steps. They are
- (a) Preliminary survey of the building
- (b) Accounting of all the appliances in use
- (c) Estimation of energy consumed
- (d) Scope to reduce the energy consumption

As part of the preliminary survey, the residents of the building were interviewed and few interesting facts were found. They are
- (a) The electronic appliances like PCs are not switched off when not in use.
- (b) The students prefer to keep the fans switched on to dry their clothes in the rooms
- (c) Excess illumination is found in the rooms.

The load consumption pattern of the building in a day is as shown in figure 1. The peak demand of the building is estimated to be 950 units per day and where the average load demand hasis found to be 450 units.The load factor of residential buildings is usually low and is observed to be almost constant throughout the month.

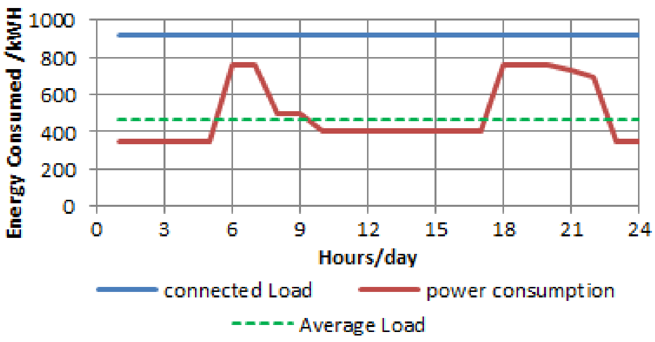

Fig. 1 Power consumption pattern of the building

From the figure 1, it can be inferred that the peak load in a day is much higher than the average power consumption. To meet the supply demand gap and avoid voltage fluctuations the usage of electrical appliances has to be prioritized and if possible the appliances like pump sets, washing machines has to be used during the non-peak duration of the day.

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To analyse further, the hostel building is categorized into four different zones based upon the daily load pattern. They are living rooms, washrooms, common rooms i.e, office space, reading room etc. lastly the public area which includes corridors and gardens.

A. *Living Rooms*

The building has around 150 living rooms accommodating a maximum of 2 students per room. The appliances and the energy consumption per day in the rooms of are shown in table I. It can be noticed that the majority of the power consumption is by PCs and lighting.The leakage power of the various appliances is observed and the leakage electricity is calculated according to the usage of the appliances.

TABLE. I

ENERGY CONSUMPTION OF LIVING ROOM

Appliance	Rating (watts)	Qty	On time (hrs)	Energy Consumed in units (E_c)	Off Time (hrs)		Leakage Power (watts)		Leakage Electricity in units (E_l)	Total consumption in units (E)
					Sleep	OFF	Sleep	OFF		
CFL bulb	11	400	5	22	0	19	0	0	0	22
Incandescent	40	200	1	8	0	23	0	0	0	8
Tube light (T5)	28	150	7	29.4	0	17	0	0	0	29.4
Fan (Ceiling)	100	150	21	315	0	10	0	0	0	210
Monitor	20	235	6	28.2	1	17	1.38	1.13	0.06	28.8
CPU (user type I)	120	65	24	187.2	0	0	21.13	2.84	0	187.2
CPU (user type II)	120	170	18	367.2	2	4	21.13	2.84	0.0536	367.25
Modem	6.25	85	6	3.18	16	2	3.85	3.84	0.06	3.256
Speaker	10	24	2	0.48	1	21	4.12	1.79	0.04	0.52

The total power consumed in a day is the sum of the active energy used and the standby power consumed by the appliances. The total power consumed is calculated by the formula:

$$\text{Total Power Consumed (E)} = \text{Energy Consumed } (E_c) + \text{Leakage Electricity } (E_l)$$

From the table 1, the following are the observations made in reducing the power consumption in the room

Observations

1. *Incandescent lamps replacing with CFLs*

If the incandescent lamps in each room are replaced with CFL bulbs, then the energy saved per day will be 5.8 Units

The energy consumed if all the incandescent lamp is replaced by CFL is 11 x 200 x 1 = 2.2 units. Thus the energy saved is 8 units – 2.2 units = 5.8 units.

The lumen equivalence of various energy sources are as shown in Figure 2.An LED of 5 watts can give a light output of 450 lumens. The same can be achieved by a 13 watts CFL or 40 watts incandescent lamp. Similarly, 800 lumens light output can be achieved by a 8 watts LED or 15 Watts CFL or 60 Watts incandescent lamp. Thus it explains how LED and CFL are effective in reducing the energy costs and increasing the energy efficiency.

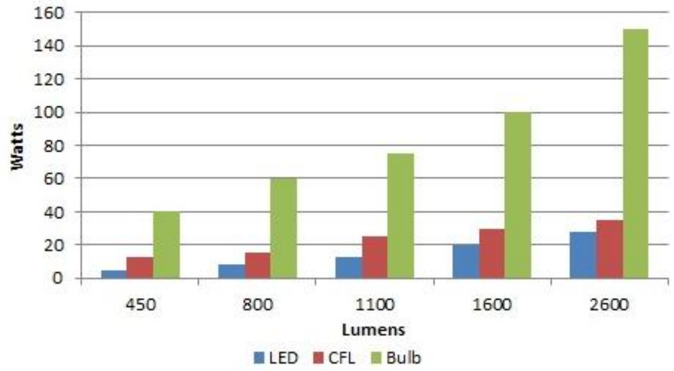

Fig. 2 Lumens equivalence and energy consumed of various light sources [5]

The present tariff for one unit is Rs 3.75/- [4] and the cost of one CFL bulb is Rs. 160/- and that of incandescent lamp is Rs 45/-.

The cost difference between the lamps is Rs. 160 – Rs. 45 = Rs. 115/-

The cost involved in replacement of all the incandescent lamps is 115 x 200 = Rs 23000/-

For the 5.8 units saved per day the savings in the cost is 3.75 x 5.8 = Rs 21.75/-

The payback period for 200 lamps is 23000 / (21.75 x 30) = 33 months

2. *Incandescent lamps and CFLs replacing with LEDs*

To achieve the same 450 lumens of light output, the CFLs and incandescent lamps can be replaced by a 5 W LED, thereby reducing the power consumption much further.

If all the light sources (200 incandescent lamp and 400 CFLs) in the room are replaced by LED, then the probable reduction in the power consumption will be

40W x 200 + 11W x 400 – 5 x 600 = 9400 Watts

i.e for one hour the electricity consumption will reduce by 9.4 units.

3. *Hibernation of Personal computers*

If a computer is put to sleep mode or hibernation mode or suspend mode when not in use, there will be a huge saving in electricity. The power consumed when the PCs is left on and when they are put it into any of the suggested modes is compared as shown in figure 3.

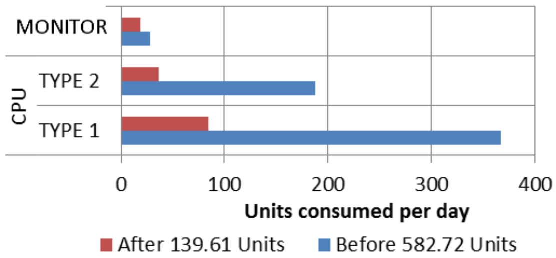

Fig. 3Energy consumption of personal computers

The total energy consumed by the computers before implementing any of the conservation techniques is 582.72 units and after implementing the discussed schemes it will be 139.61 units.

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The energy saved per day is 582.72 units – 139.61 units = 443.11 units.

Assuming the cost per unit is Rs. 4.90, the electricity bill saved per month is Rs. 65,137/-

Rs. 4.90 x 443.11 = Rs.2172.24 / day and Rs. 65,137 /- per month

4. *Appropriate illumination in the room*

The common problem noticed in any residence is that either the illumination is excess or the light in the room is obstructed by furniture like cupboards etc. similar cases are also found in this building and a layout of one such rooms is shown in the figure 4. This room contains four lights placed,one near the door, two lights each placed on study table and one near the bed. The light placed near the door is obstructed by the cupboard and is not effective when used.Thus the lights placed in the room are either very bright leading to glare effect [7] or in one corner of the room obstructed by the cupboard.Instead of four lights placed across the room, a single 40W CFL near the study table will be sufficient for proper lightning. This light also avoids unnecessary glarecaused in the room.

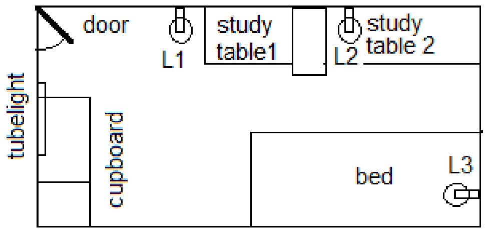

Fig. 4 Top view of the living room

B. *Wash Rooms*

The building has around 16 washrooms and the list of appliances and its ratings are shown in table II.Each wash room has10 CFL lamps and 2 exhaust fans. Common to all these rooms, two geysers, four washing machines and eight blowers to dry clothes are placed.

TABLE.II

APPLIANCES USED IN WASH ROOM

Appliance	Qty	Rating (each)
CFL Bulb	160	11 watts
Exhaust Fan	32	30 watts
Geyser	2	1500 watts
Washing Machine	4	1150 watts
Blower	8	2300 watts

Observation

1. *Illumination in wash rooms*

The illumination in the washroom is measured using a lux meter and found to be in excess as per the standards [5].

Area of washroom = 6.6x 4.5 sq m. = 319.68 sq. Ft

Lumens required in a wash room as per standard is 75 lumens/ sq ft.

Lumen required in the washrooms of the building = 75x 319.68 = 2227.5 lumens.

To achieve this, the number of CFLs required is CFLs required = lumens required /lumens of CFL

The Lumens of 28 Watt CFL= 650 lumens, so CFLs required = 2227.5/650 =3.42

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Hence the minimum number of CFL required in the wash rooms are 4 but 10 CFLs are fixed.

C. *Common Rooms*

The student's hostel has few common rooms used as recreational centres, study rooms, office spaces etc. The list of electrical appliances and the energy consumed in these common rooms is shown in table III.The common rooms have few computers, printers for study and have LCD television andother peripheral devices for entertainment of the students. The common rooms are illuminated by Incandescent lamps, CFL and tube lights. The common rooms are used by the students only for few hours in a day as refreshment. The major energy consuming appliances are the light sources.

TABLE. III

APPLIANCES USED IN COMMON ROOMS

Appliance	Qty	Rating (each)
CFL	3	11 Watts
Tube light (T5)	28	28 Watts
Incandescent	38	40 Watts
Fan (ceiling)	16	100 Watts
Refrigerator	1	100 Watts
Water cooler	1	88 Watts
Induction cooker	1	2000 Watts
Computer	10	140 Watts
Printer	4	360 Watts
Scanner	1	35 Watts
LCD Television	1	130 Watts
DVD player	2	25 Watts
Home theatre	1	156 Watts
Setup box	1	31 Watts
Aquarium	1	1210 Watts

Observation

1. *Incandescent lamps replacing with CFLs*

The energy consumed by incandescent lamps in the common rooms per day is 10.48 units and the energy consumed if these lamps are replaced by CFL is 2.89 units.

Thus, the energy saved per day is 10.48 units – 2.89 units = 7.59 units/ day.

2 *Tube lights replacing with CFLs*

The energy consumed by the tube lights per day in the common areas is 5.4 units and the energy consumed if these lamps are replaced by CFLs is 2.2 units.

Thus the energy saved per day is 5.4 units – 2.2 units = 3.2 units.

D. *Corridor and Garden lighting*

The power supply to the corridors, foyer and the garden are given from the same distribution box. The list of electrical appliances and the energy consumed is shown in table IV. The garden is illuminated by halogen lamps and

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incandescent lamps.The foyer is decorated by CFL lamps and other appliances like water cooler with purifiers are placed in the corridors.

TABLE. IV

APPLIANCES USED IN COMMON ROOMS

Appliance	Qty	Rating (each)
CFL bulb	87	11 watts
Halogen bulb	8	1200 watts
Incandescent lamp	24	40 watts
Fans	4	100 watts
Water cooler	5	775 watts
Water Purifier	5	18 watts
Router	4	20 watts
Shoe polish machine	1	60 watts
PA system	1	400 watts

Observation

1. Similar to other locations of the building, if all the incandescent lamps are replaced by CFL bulbs in the corridors, then the energy saved per day will be 7.68 units – 2.11 units = 5.57 units.

2. In the mid-night, lights in the corridors are needed mainly for security, and not much physical movement is observed in the corridors, the lighting should be designed accordingly.

3. The garden lighting scheme needs to be reorganized since the students were complaining of light trespass in to the rooms.

4. Excessive outdoor lighting (garden lighting) for long hours is to be avoided since it will affect the circadian rhythms of various organisms [8] [9].

Light trespass, Glare and over illumination are the specific types of light pollution. Lighting schemes should be properly taken care while designing a building, so to avoid any adverse effects of light pollution.

IV. CONCLUSION

With rapid increase in supply demand gap and with prevailing constraints in using renewable energy, load shedding and poor quality in power supply is inevitable. The immediate and economical solution can be energy conservation. The results and inference obtained from the analysis carried out on student's hostel will be more or less the same for any other residential building. This work also explains the pressing need of conservative measures to be carried out in the entire residential sector.

REFERENCES

[1] Energy audit by ministry of power (July 2014). Online available at http://www.powermin.nic.in/distribution/energy_audit.htm
[2] Information on Compact Fluorescent light bulbs (CFLs) and mercury November 2010 Online available at www.energystar.gov.
[3] P.AjayDAmal Raj, M. Sudhakaran and P.Philomen D AnadRaj, "Estimation of Standby Power Consumption for Typical Applications", Journal of Engineering Science and Technology Review, Vol 2, no.1, pp 71-75, 2009.
[4] Kerala electricity tariff online available at http://www.old.kerala.gov.in/dept_power/kseb_tariff.htm.
[5] "Code of practice for energy efficiency of lighting installations", Electrical and Mechanical service department, 2005.

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[6] Energy cost of PCs on standby, London: BBC 7. April 2006. Retrieved 2006-08-09
[7] “The Lighting Handbook”, Zumtobel.
[8] Jeanne F Duffy, Charles A. Czeisler, “Effect of light on Human Circadian Physiology”, Sleep Med Clin. , Vol 4, no. 2, pp. 165-177, 2009.
[9] “Light Pollution and Wildlife”, International Dark-Sky Association.
[10] Francis W H Yik, Paul S Sat, H F Yee, Cary W H Chan, “ A detailed energy audit for a commercial office building in Hong Kong”, Hong Kong Institution of Engineers, pp 84-88.
[11] Nilesh R. Kumbhar, Rahul R Joshi, “An Industrial Energy Auditing: Basic Approach”, International Journal of Modern Engineering Research, Vol 2, no 1, pp 313-315.
[12] “Energy Assessment Guide for Commercial Buildings”, USAID ECO-III Project, International Resources Group, 2009.
[13] S Yu, M Evans, A Delgado, “Building Energy Efficiency in India: Compliance Evaluation of Energy Conservation Building Code”, U.S. Department of Energy, March 2014.
[14] Julian Potter, Elizabeth Dawson, Sina Meier, “Are Phantom Loads Haunting your Energy Bill?”, ECS I Case Study, winter 20009.