Illumination Level Study and Energy Assessment Analysis at University Office

Regu Narayanan, Ashok Kumar, Chandru Mahto, Omshivam and L. Ramesh

Abstract The power consumers of the modern world start to think about the concept of "Right appliance to the Right usage". Nationally now there is an unbridgeable gap between electricity generation capacity and the ever raising demand. The electrical energy audit is paving the way to conserve electrical energy by the way of analyzing and adopting the standards without any major investments. Energy saving of up to 80 % can be achieved by modernizing our lighting system by installing an intelligent light management system with day light triggered dimming function and occupancy sensors. By professionally restructuring the process flow cycle, lighting system, etc. more beneficial results can be achieved in industrial establishments too. Indeed electric power is precious energy which involves the generation, transmission and distribution of energy to the consumer via cumbersome process. So the question of monitoring its usage is affirmative on every single unit. Nowadays an audit in electric sector has become a mandatory requirement especially for large consumers. In the proposed project the audit was conducted in university office in prime two stages. The first stage dealt with wastage audit and second with detailed electrical energy audit. The necessary recommendation is suggested for optimal savings of energy in university office.

Keywords Consumption · Energy audit · Illumination · Lighting · Lux

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1 Introduction

The development of economy of any country is fundamentally based on the capacity of generation of electricity via non conventional and conventional methods. The need of electrical energy audit and conservation of energy can be understood if one can just imagine the consequences of the whole world slipped to black out or even brown out of energy flow. No one could enlist the losses faced under these circumstances. One can appreciate the job of optimizing the energy consumption but that will be a challenging work in the endeavor as the cost of energy is in ascending trend although inevitable addition of new equipment will increase the total energy consumption as the consumer's demand is generally in ascending trend [1]. Optimization, beneficial utilization and improving consumption pattern by interfacing with electronic sub systems are the areas where exists a huge possibility of revamping the present status also use of some energy efficient appliances can be recommended against the existing system. In the present system huge possibility is there for saving energy through new generation and energy efficient equipments. This paper progressed through the analysis and review of existing audit research papers, collection of real data for the present audit through proposed procedure, suitable recommendations and conclusion of the present work. In connection to the energy conservation, audit and management, the views of the selected researchers are presented in the next section.

2 Audit Review

This section featured with selected work on audit done by existing researchers. Singh [2] outlined 'electrical energy audit' outcome of an industrial class load. According to his work the new generation innovation and tremendous improvement in the field of lighting has given rise to number of energy saving opportunities. According to him lighting is an area which has major scope of saving energy while conducting audit. According to his recommendation, electronics chokes can be used in place of electromagnetic chokes. They can be replaced one by one, when they became defective. metal halide lamp can be used in place of halogen and mercury lamps. The indicating lamps were recommended to be replaced in a phased manner to LED when existing lamps became defective. The tubes are not required during day and should be switched off and better arrangement for the use of natural daylight should be availed. The Right way to achieve energy efficiency is to start planning at the design stage, use of modern efficient lamp, luminaries and gears are also important apart from good practice. An industrial unit has been undertaken as a case study, as they are the major consumers of the power. After case study the author has provided data in the paper which shows the different ways of saving energy by incorporating certain changes and installation in the present structure can make the present system more energy efficient. The author has also out lined that an

energy auditor should see all possibilities available in and around the proposed area. Energy conservation and exploring new methods to reduce the demand and to save more energy can fulfill the growing industrial demand in future. The author has also advocated that the implementation of suggestion of energy audit can improve efficiency and thus reduces the wastage.

Pramanik [3] working in the electrical engineering department, Kalyani Government Engineering College also conducted energy audit with similar audit recommendations. In his work he presented very simple ideas on energy conservation. In order to verify the ideas described in his paper, a room size ($25' \times 30'$) belongs to the faculty members of the Electrical Engineering has been considered as a case study. He envisaged that, the modern society is strongly based on the energy for their economic development. Production and supply of goods and energy consumption, exercising strong effect environmentally in local and global level which requires equitable balance between the energy usage for the development of social welfare and the environmental preservation. The misuse of energy and lavish handling may lead to negative environmental impacts. The author has also stressed the need of the energy management which is indeed the need of the hour. The conventional resources beyond our limits, might have been exhausted within some decades. The paper has explored solutions for the energy reduction. The author has recommended using energy efficient appliances and implementation of microcontroller based system, along with power electronics which can reduce the energy consumption. With these microcontroller based system included in the control system of air conditioner, the percentage saving in energy could have proven better.

Ahuja [4] along with his team conducted electrical energy audit in the IIT Roorkee Campus and data collected during May–June‘09. They have conducted audit to find the new opportunities to improve the energy efficiency of the campus. The audit was not only done to identify the energy consumption pattern but also to find most energy efficient appliances. Moreover, some daily practices relating to common appliances have been provided which help them in reducing the energy consumption. The report gives a detailed information regarding the energy consumption pattern of the academic area, central facilities and bhawans, based on actual survey and detailed analysis during the audit. The work comprises the area wise consumption traced, using suitable equipments. The ELEKTRA software was used for their audit purpose. The report compiles a list of possible actions to conserve and efficiently access the available scarce resources and identifying to save the potentials. The author has looked forward towards optimization for adoption of set of mission for the authorities, students and staff should follow the recommendation in the best possible way. The report is based on certain generalizations and approximations wherever they found it necessary.

To create energy awareness to the general public, Dr. M.G.R Educational and Research Institute, University Chennai has taken initiative called ‘MGR Vision 10 MW’ under leadership of Dr. L. Ramesh to save 10 MW in 10 years. In this pilot audit study-1 was conducted by the team of members in the year 2015 at

various residential houses and industries. The outcomes of the studies are published in indexed conferences and Journals [5–10].

This work is the pilot study-1 of Vision 10 MW. This study covers the waste audit analysis and recommendation for the University office in the first stage. In the second stage, detailed power audit is conducted in the university office and the suitable recommendation for saving of energy is recommended for implementation.

3 Data Observation

The first phase of an energy audit started with site inspection work. The measurements in all aspects have been taken for reckoning actual value of prevailing luminous intensity level of the office. In this paper the details of possible technical viability are analyzed and scope of saving both energy and cost has been done through auditing in the university office. The theoretical level of illumination required as per the standards which studied against the actual level. Every appliance has been subjected to audit and aggregate load details were prepared. The room index for every partition was calculated and LUX levels were recorded. The analysis of energy wastage in the university office was also done on the merits of data collected by visiting different timing over the span of a week. The data collected revealed the possibility of energy saving in the office envelope of total area of approximately 225 m^2. This paper projects with energy audit recommendations in the later part.

The steps involved [11] in the execution of electrical energy audit are as below.

- The preliminary study in the prospective area
- Wastage audit
- Theoretical lux level calculation for the proposed area
- Practical lux level calculation
- Constraints for optimal lighting
- Addressing present issues in lighting
- Proposed layout
- Recommendation part on cost analysis and saving benefits.

3.1 Preliminary Study About the Prospective Area

The following layout shows the university office and the way of spread of lighting system. The load details with respect to room tabulated. The office was subjected to electrical energy audit and solutions devised. The overall area was divided into various segments named from A to K (Fig. 1).

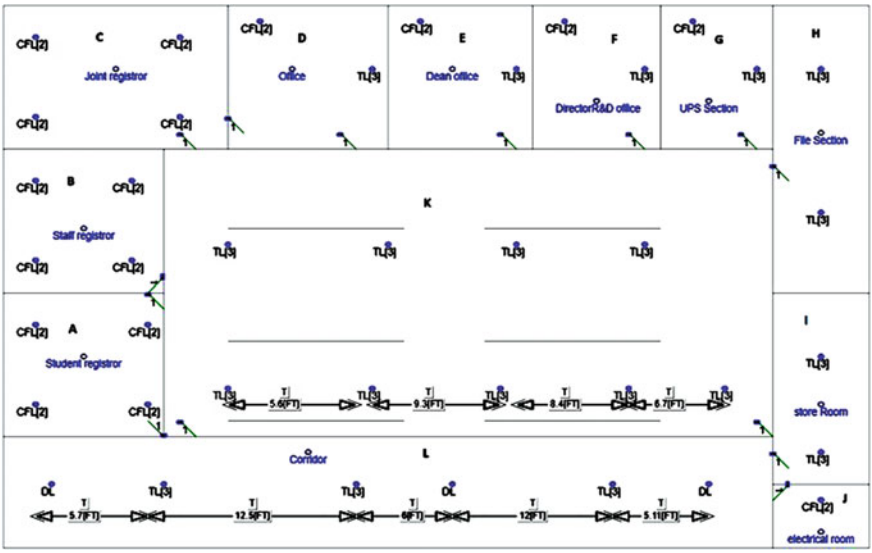

Fig. 1 Layout of the existing area

Here mainly seating arrangement for most of the staff is in 'K' segment. The prospective auditable area was calculated both in sq. feet and square meters. The total area of the office comprises of 2470 sq. feets with a staff strength of 40. Out of that the major area is covered by the area "K" which is around 903 sq. feets. "A" is of 121 sq. feets, "B" is of 110 sq. feets, "C" is of 130 sq. feets, "D" is of 100 sq. feets, "E" is of 110 sq. feets, "F" is of 120 sq. feets, "G" is of 80 sq. feets, "H" is of 264 sq. feets, "I" is of 121 sq. feets, "J" is of 33 sq. feets, "L" is of 378 sq. feets.

3.2 Wastage Audit

This step is to ascertain the scope of the possible saving of energy during the working hours of office. As to acquire reliable data, periodical visits have been paid in different time slots and observed the nature of load running waste and accounted its ratings. The computed consumption also worked out. An independent enquiry also conducted without revealing the purpose among the staff to ascertain their style of functioning with energy equipments and also collected the factors influencing the wastage of energy particularly in respect of the operation of Photostat, personal computers etc. The average pattern of energy running waste is tabulated below (Table 1 and Fig. 2)

Table 1 Wastage assessment with time

Time	Fans	Lights	Rating in Watts
9:15–10:15 A.M.	3	10	1260
10:30–11:15 A.M.	2	12	1416
11:15–12:15 P.M.	2	10	1200
12:15–1:15 P.M.	3	12	1476
01:30–2:30 P.M.	2	11	1308
02:30–4:00 P.M.	1	10	1140
04:00–05:00 P.M.	2	10	1200
05:00–06:00 P.M.	2	8	984

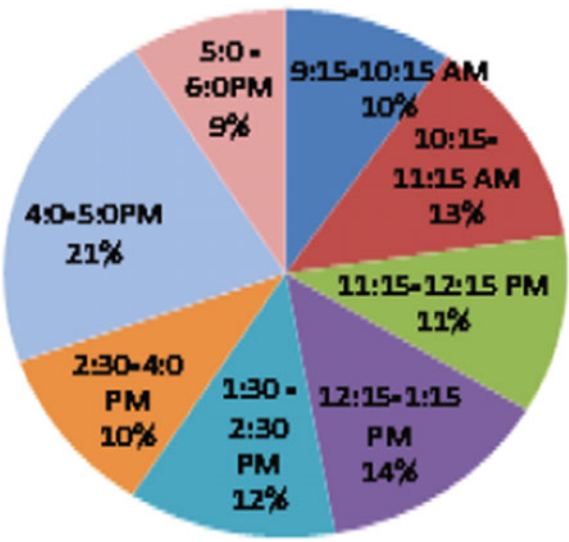

Fig. 2 Energy wastage percentage assessment

The graphical representation of the wastage audit with the data collected from the university office has shown. From the table it can be vividly seen that the maximum wastage occurs during 9.15–10.15 h, in the morning which is being because of the college work starts from 9:30 but the equipments are switched on by 9:00 h and there is only one person who is switching on and off all the lights and fans regularly. Considerable wastage occurs during 12:30 to 1:30 which is lunch time, while most of the equipments left in switched on state but less staff were found in the office. So here it can be seen that just due to unawareness and ignorance precious energy is being wasted which can be minimized by taking proper care. It is estimated that, by the way of effective utilization around 10 kWh per day can be saved which roughly works out to the figure of 3000 kWh units per annum. If the cost per unit is Rs 7 then estimated saving of Rs 21000 per annum which reminds the proverb 'Little drop makes an ocean'. Already the office enclave is air-conditioned fully; hence under normal conditions fans are not necessary.

Table 2 Aggregate connected load

S. no.	Description	Total nos.	Wastage	Total load
1	CFL fitting	16	36	576
2	Sq. fitting	19	108	2052
3	Doom fitting	3	120	360
4	Photostat machine	1	300	300
5	Ceiling fan	20	60	1200
6	Split A/c machine	3	2500	7500
7	Desk top computers	8	250	2000
8	Water purifier	1	300	300
9	UPS system 1 7.5 KVA	1	7.5 KVA	–
	Total load			14.288 KW

But considering extra ordinary occurrence in the event of air-conditioning failure, the usage of fans can be opted. However such a view point was not taken into account in this audit study for calculation of saving aspect. The team suggesting to keep the fans in off, when office enclave in air conditioned mode. Then the estimated saving will be higher.

Connected Load

The table given below shows the total connected load of the office. From the graph shown it can be easily depicts that the max energy consumption is due to the UPS, The lightning on a whole adds a total load of 3 KW in addition with fans, computers the minimum consumption by the printers (Table 2).

3.3 Lux Level Calculation

In fact it was conducted by adopting two methodologies.

1. Measurement of actual level of lux at the center of the every working surface and tabulated. The lux level is measured at every working table. Among these measurements it was noticed that the lux measurement level was below the required value in a8 and b5 working Table.
2. Measurement carried out in each cabin and hall, corridor etc. as per the calculated room Index and analyzed.

The available luminous intensity level of the corridor is more than the prescribed level. The illumination level of the office is non–uniform which can be improved by the way of installing distributed illumination using, single fixture or using louvers.

Room index According to the bureau of energy efficiency, 'room index' is the number that describes the ratio factor of the room length, width and height.

$$\text{Room index} = (\text{L} \times \text{W})/(\text{Hm}(\text{L} \times \text{W}))$$

L = length of the room, W = width of room, Hm = mounting height.

It doesn't matters whether the dimensions are in meters or not, but the unit should be same for all. The minimum number of measurement point can be ascertained from the table shown below (Table 3).

As per the Code of practice [12] of interior illumination – IS 3646-1 (1992) room index is required to get the numbers of reading required to measure the theoretical lux level of the proposed area. Using the above facts the required numbers of reading are taken and tabulated as shown above. Measurement carried out in each cabin and hall, corridor etc. as per the calculated room index and analyzed. Lux level measured at every working table. In such measurement it was noticed that the lux measurement level was below the stipulated value in a8 and b5 table. Hence both the seat may be rearranged accordingly.

The available luminous intensity level of the corridor is more than the prescribed level. The illumination level of the office is not uniform which can be eliminated by intelligent lighting system.

Constraints for Optimal Lighting

The wall with brown wooden coverage even though appears good is not supporting for effective lighting spread due to more rate of diffusion and not supporting gross illumination. The lights are provided above the two fans in 'K' segment may be

Table 3 Room index calculation

Segment	Description	Prescribed level of lux. (advocated value)	Room index	Meas. Reqd.
A	Room	100–200	0.50	9
B	Room	100–200	0.48	9
C	Room	100–200	0.51	9
D	Room	100–200	0.45	9
E	Room	100–200	0.48	9
F	Room	100–200	0.50	9
G	Room	100–200	0.40	9
H	Room	100–200	0.69	9
I	Room	100–200	0.50	9
J	Room	40–60	0.21	9
K	Office	100–200	1.28	16
L	Corridor	50–75	0.56	9

Table 4 Practical lux level

Segment	Area	Lux level measured at working surface					
A	Room	104					
B	Room	101					
C	Room	132					
D	Room	250					
E	Room	233					
F	Room	205					
G	Room	214					
H	Room	140					
I	Room	198					
J	Room	255					
K	Office hall	a1	124	b1	125	c1	176
		a2	122	b2	141	c2	160
		a3	142	b3	127	c3	160
		a4	129	b4	106	c4	138
		a5	115	b5	95	c5	150
		a6	135	b6	110	c6	155
		a7	110	b7	127	c7	164
		a8	92	b8	150	c8	155
L	Corridor	No working table					

rearranged to improve shadowing effect which will be quiet annoying. In spite of its technological merits in all aspects, it seems impractical to suggest all lighting fittings by light emitting diode lamps owing to the initial high cost (Table 4).

4 Recommendation

Recommendation is an act of suggestion or proposal as to the best of course of action, especially one put forward by an authority's body [13]. Basically there is two modes of recommendations namely without investment and with investment.

Proposed Layout

Instead of recommending all lamps to be replaced by the present modern technology energy star rated LED lamps which possess long span of life up to 50,000 h and environmental friendly, but due to the factor of cost, it is suggested the first phase of conversion for k segment, the main staff working area and for the corridor as shown replacing 36 × 3 (108 W) fluorescent fitting by 24 × 3 (72 W). By these replacement, the luminous level will be more over same with lesser involvement of cost. The system of LED can also provided with presently available electronic control gear. The use of modern concept of lightning including the use of daylight offers up to 75 % potential to save energy (Fig. 3).

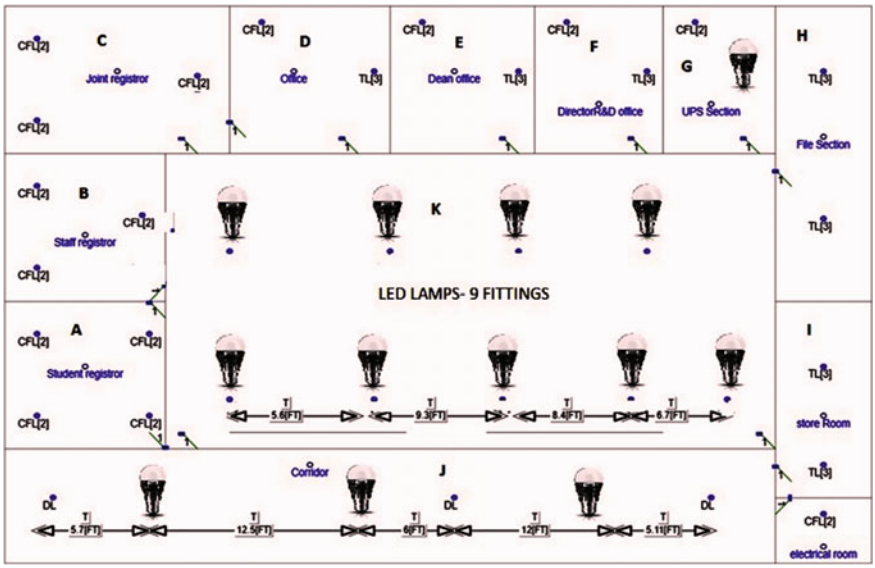

Fig. 3 Proposed lighting design

4.1 Recommendation Without Investment

1. **Wastage Recommendation**: The wastage audit reveals the fact that the practice should be imparted that when leaving working table, everyone should be bound to switch off the lights and fans. There is considerable saving in long run. In this audit, there will be estimated saving of 3000 kWh per annum which is roughly saving of Rs 21,000 per annum. Briefly to say that
   - All the equipment should be switched off when not in use.
   - Fans should be switched off when the AC is ON. It is advocated to keep a slogan display on energy conservation in every one's view with a advice of keeping fans off when air condition system is operative.
   - Usage of minimum lights in the segment C, D, E, F, G during day time because of sunlight availability (Fig. 4).
2. **Rearrangement Recommendation**: It is seen that two lights are connected above the fans in segment 'K' and should be rearranged to improve illumination and avoiding possible rotational shading while the fan is rotating.
   (a) Matching the proper lamp type to the respective work task, consistent with color, brightness control and other requirements.
   (b) Establishing adequate light level without compromising objective and safety.
   (c) The decorating lighting fitting (TL-3nos.) of 120 W in the corridor normally recommended to be kept off, except on special occasions.

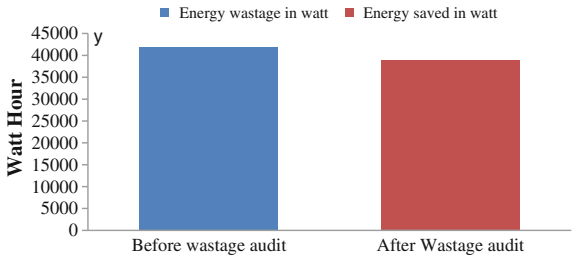

Fig. 4 Wastage audit saving analysis

3. **Recommendation with PC and Photostat Machine**: According to the survey of the wastage audit conducted by the energy audit team, it is noticed that, most of the system and the Photostat machines are left in the sleep mode. Hence, energy is wastage in the form of no load loss. So the additional energy saved is used to shut down the unit when there will be no work with it for longer period. The computer systems, printers and Photostat machine are used effectively for 6 h in a day in the university office and left 2 h in sleep mode as observed in audit study then the energy loss will be more than 80 units per month.

Audit Observation: The energy saving per annum by avoiding sleep mode in PC and Photostat machine is 960 units.

4.2 Recommendation with Investment

1. **Recommendation with LED light**: In any energy audit report, if it fails to envisage to adopt modern efficient system at least at its preliminary level in the area of the audit, then the suggestions and directives are not up to the present technological yard stick. Hence it is recommended to replace the existing 9 florescent lamp fitting of 108 W into 72 W in 'K' segment and 1 number in 'G' segment. These lamps are environment friendly as it does not possess mercury and it will be energy efficient. The life of the star rated LED lamps will be more than 50,000 h. By this replacement using LED lamps, estimated energy saving will be 1290 kWh per year. Considering the cost implication for conversion to LED lamps apparently thrice of other fittings, first phase of conversion is suggested only for main staff working segment (Fig. 5).

The given chart stresses that if we properly switch on and off the lights and avoid using lights during day time will save the load of 1124 W without any investment.

Audit Observation: Cost equivalent of 1290 unit per annum can be saved by the LED lamp replacement.

2. **Recommendation with Fan**: The energy audit team found that the fan installed in the in office is not star rated. Available fan is consuming 60 W. It is recommended for replacement with energy efficient star rated fan which will be

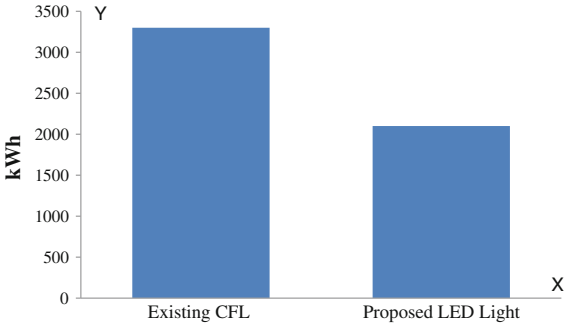

Fig. 5 Saving with lights

available for 50 W per fan. If the fans are replaced by star rated fans in a pace manner the savings in that aspect will be:

$$\text{Difference in watt} = 10\,\text{watt}$$
$$\text{Saving} = 700\,\text{kwh per annum}$$

Audit Observation: From the above data analysis, the possible saving of 700 units per annum is achieved by replacing old fans by new energy efficient fans.

3. **Recommendation with PC and Xerox machine**: The graph shown below gives the quantum of saving if the staff not preferred the sleep mode in personal computers and Photostat machine (Fig. 6).

Audit Observation: From the above data analysis, the possible saving of 900 units per annum is benefited, if the operator of PCs and Photostat machines are not preferring sleep mode (Figs. 7 and 8).

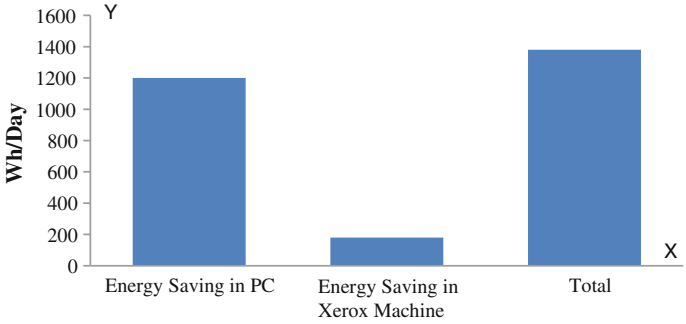

Fig. 6 Energy saved with PC and Xerox machine

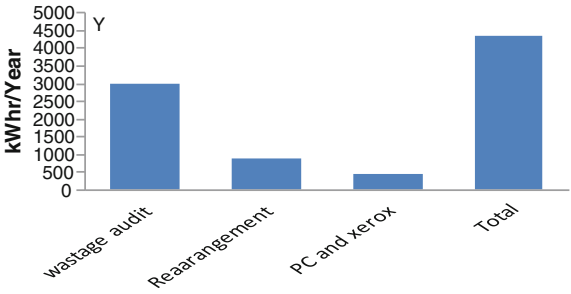

Fig. 7 Energy saved with PC and Xerox machine

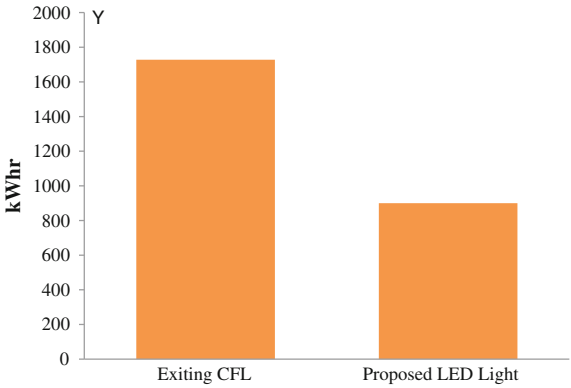

Fig. 8 CFL and LED comparison

5 Conclusion

A famous quote "Energy saved is Energy generated". This shows that apart from increasing the generation capacity with investment, one must go for the energy audit to save the electricity at lower cost. The outcome result of the work shows the possibility of energy savings in the University Office. The wastage and electrical energy audit was conducted in the University office. The wastage audit recommendation was implemented in the office from Jan 2016. The suggested other recommendation also agreed to implement within 6 months of time span.

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