Power Wastage Audit and Recommendation of Conservation Measures at University Library

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Abstract Energy plays a important role in all day to day activities, especially those that are energy intensive. An Energy audit plays a major role in reduction of new power generation. It can help us to determine the energy wasting deficiencies in homes, firms, factories, industries and can show exactly how to address these problems. A detailed study to establish and investigate optimal utilization of lighting for specific department has been carried out in this work. The energy audit of University library has been executed with formulated procedure and proposed recommendation. The suggested implementation can improve the energy efficiency of library and thereby reducing the energy wastage.

Keywords Consumption · Energy audit · Illumination · Lighting · Lux

1 Introduction

Energy is critical, directly or indirectly, in the entire process of evolution, growth and survival of all living beings. Power availability plays a major role in economic development of the country. Energy is high priced in the today's world. India ranks third in the world total energy consumption [1]. All India installed capacity of electric power generating power stations is 278,734 MW till 30th October 2015 [2]. The detail break up share of different type of generating stations is follow: Hydro power plants—15.2 %, thermal power plants—69.7 %, nuclear power plants—2.1 %, renewable energy source—13.1 %. India's electricity generation touched the

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1 trillion units mark during 2014–15 this is for the first time in the history, showing a growth of 8.4 % over the previous year. Since 1991–95, the compounded annual growth rate of electricity generation has been around 5–6.6 %. The contribution of thermal sector was significant i.e. 20,830 MW (92 % of the total) but still 11 laces thousand people have no electricity. Where in an indication of growing appetite for electricity in a country like India with huge population, there has always been an appetite for electricity. According to Central Electricity Authority, the country's power usage were pitched up to 1010 kilowatt-hour (kWh) in 2014-15, compared with 957 kWh in 2013–14 and 914.41 kWh in 2012–13, according to the Central Electricity Authority (CEA), India's apex power sector planning body. Conservation of energy means reduction in energy consumption with less usage of power resources.

There are different ways of meeting generation and demand Generation of Power, Saving of Energy. We are going with Energy Audit for saving energy rather than generating power. We spend most of our time in buildings—homes, schools, offices, stores and libraries. But most people hardly notice details about the buildings, such as how they are designed, how many lights and fans are there in the building, whether they are used efficiently or not, how they are maintained. The details have shown a strong effect on how comfortable a building is and how much it costs to operate. Energy Audit provides the platform to analyze the building, determine wastage and to provide suitable recommendation. An Energy audit is used to determine pattern of energy use; and to enhance energy efficiency in the system. A study say that energy auditing and conservation in India can minimize the operation and production cost of Rs. 1750 Crore per year as a continuation of the statistics of this data the industrial sector and save installation equivalent to 5200 MV.

2 Audit Review

Different authors presented review papers related to library which are coming in the next section. This paper [3] shows the prefatory study of energy audit that has been done in UMP library. Energy audit has been done within 7 days time frame. In this study, energy consumption data has been recorded over a period of time by installing a data logger at the library main switch board. Programmed capacitor bank is installed at main switch board to improve the power factor, reduce the current consumption, voltage drop and electrical energy losses for actual implementation of energy efficiency. From the analysis, it was found that the level of energy efficiency in building is inversely proportionate to the energy losses that occur; the higher the loss, the lower the efficiency. The main objective of this audit is to propose energy efficiency method to reduce energy consumption with techniques and calculations.

The paper [4] presents the Energy Audit that has been done in the State Library of Tasmania, on 15 May 2008. The building energy consumption and GHG inventory for the period May 2007 to April 2008 was calculated from the energy usage and information provided by Department of Education Monthly Electricity Consumption of the library along with electricity index is studied. The HVAC system is controlled by a microprocessor based BMS system. High efficiency hot water storage heaters has been installed which replaced old normal hot water storage heaters. Occupancy sensors are installed in the toilets and Multi stack heat pumps replaced old boiler system. This paper [5] presents on a model and formulation for library load management on electricity consumption. Lighting is an essential service in all the libraries. Innovation and continuous improvement in the field of lighting has to be carried out on basic necessity basis. Energy plays a vital role in the socio-economic development and human welfare of a country but in present scenario most of the common people are waiting energy by different methods. 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 [6–11]. This work is the pilot study-2 of Vision 10 MW. This study covers the waste audit analysis and recommendation for the University library in the first stage. In the second stage, detailed power audit is conducted in the university library and the suitable recommendation for savings of energy is recommended for implementation.

3 Data Observation

Data observation and calculations are discussed in this section. This work executed with our own procedure to start and end the audit process. The basic structure of the data analysis and observation were taken on the basis of the reference taken from this paper

- Layout sketch for existing system
- Theoretical lux level is calculated by using the formula
- Practical lux level is calculated by using lux meter depending on the room index value
- Live practical lux value is calculated
- The constraints for designing optimal lighting is identified
- Present issues related to lighting system is found
- Design of proposed optimal design of lighting, fan, flux etc. is made
- Proposed layout lux level is studied
- Investment cost analysis
- Saving benefit analysis (Fig. 1)

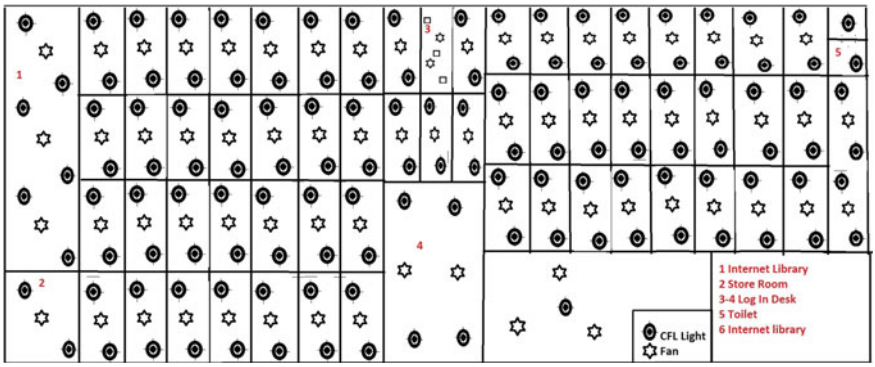
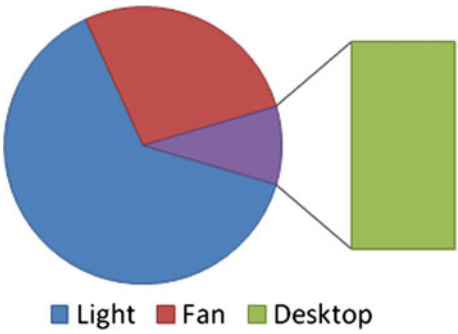


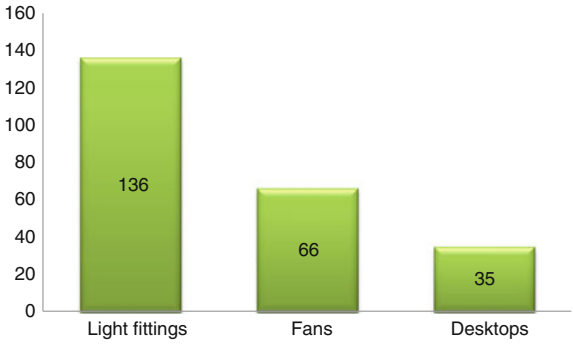
Fig. 1 Layout sketch of the library

Fig. 2 Daily unit consumption on the university library



Power Utilization Analysis: The usage of power across the library is presented in the pi-chart. It shows that the lighting occupies 75 % of the library (Fig. 2). The representation of total number of equipments used is shown in Fig. 3 .

Fig. 3 Number of equipment fitted



3.1 Index Level Calculation

Theoretical lux level and Room Index calculation [12–14] for the given area is calculated using the specified formula given by Installed lux = total no. of fitting * no. of lamps per fittings * L.D.L output of each lamp

Lux Level − LHS side of the library = 1074.34 lx/m^2
Lux Level − RHS side of the library = 1075.26 lx/m^2
Lux level − Central portion of the library = 1279.56 lx/m^2

Room Index: Room Index is given by Room Index = length * width/Mounting height * (length + width).

But here for this library we need to find the room index of both LHS and RHS side as width of both side is different.

Room index of LHS side = 4
Room index of RHS side = 4.9
Room index of central room = 1.17
Room index of main central = 2.37 (Table 1)

ILER (Installed Load Efficiency Ratio) Calculation: The procedure to calculate ILER is presented below in steps

Step 1:- Measure the floor area of the interior
Step 2:- Calculate the room index
Step 3:- Determine total circuits watts of installation
Step 4:- Calculate watt per m^2
Step 5:- Ascertain the average maintained illuminate
Step 6:- Divide Step 5 by 4 to calculate actual lux/watt/m^2
Step 7:- Obtain target lux/w/m^2
Step 8:- Calculate ILER (Divide step 6 by 7)

The calculated value of ILER in all the area are presented below

Lux level required = 53
ILER = 0.28 (LHS)
ILER = 0.28 (RHS)
ILER = 0.37 (Counter room)
ILER = 0.5 (Central room) (Table 2)

Table 1 Room index calculation

Room index value	No. of measurements
Below one	9
Between (1–2)	16
Between (2–3)	25
Above 3	36

Table 2 ILER assessment

ILER	Assessment
0.75 or over	Satisfactory or good
0.51–0.74	Review suggested
0.5 or less	Urgent action required

Table 3 Power wastage sample data

Timing	Day 1	Day 2	Day 3	Day 4
10–12 A.M.	10 fittings, 3 fans	10 fittings, 4 fans	14 fittings, 4 fans	8 fittings
12–2 P.M.	25 fittings, 14 fans, 2 desktop (sleep mode)	17 fittings, 20 fans, 3 desktop (sleep mode)	15 fittings, 18 fans (3 desktop sleep mode)	20 fittings, 15 fans
2–4 P.M.	16 fittings, 14 fans, 2 desktop (sleep mode)	15 fittings, 10 fans, 2 desktop (sleep mode)	14 fittings, 12 fans (2 desktop sleep mode)	10 fittings, 6 fans (4 desktops sleep mode)
4–6 P.M.	30 fittings, 14 fans, 3 Desktop (sleep mode)	28 fittings, 5 fans	30 fittings, 8 fans	20 fittings, 5 fans

With reference to the ILER ratio of all the rooms, it indicates that urgent action is needed for LHS, RHS and counter room. There is a review suggested for central room. This will help us to identify guarantee for strong recommendation.

3.2 Wastage Audit

The power wastage in the library is audited for the period of 1 month. The average analysis for 4 days is presented in the Table 3 (Fig. 4).

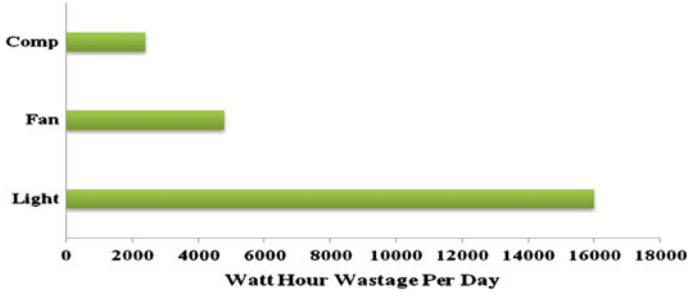


Fig. 4 Watt hour wastage

4 Recommendation

The recommendations which are give after a audit can be take as a best suggestion for the betterment of energy saving, especially the best suggestion you choose the better result you get. Mostly recommendations are based on the average of both particle and theoretical value. Auditing provide clear and reliable information on potential investment and saving the electricity in long term benefits, by calculating net present values cash flow and the resulting discounted saving over time. This enhances considerably the quality and value of the recommendations.

4.1 Recommendation Without Investment

According to the layout of the library, we have recommended some of the best saving tips by which electrical energy can be saved and tariff without an investment by proper utilization and also reduce tariff in their bills. These are the important tips to save energy in library.

- Unplug and switch off the entire electric device of appliance that is not in used to reduce no—load losses.
- Clean the fittings regularly at least once in a week as a heavy cost of dust can block 50 % of light output.
- Remove the cut covering used in the fitting by plain glass. It also reduce the amount of light output
- Clean the fan blades regularly as heavy coat of dust in fan blades reduces motor efficiency and output. The light control may consist of a row of switches at the main circulation desk provided that single switch is
- Connected to every single fitting. Adjustable window covering can be provided so that direct sunlight does not reach the stack or other sensitive materials.

With reference to the Fig. 5 indicated that the library can save above 300 units per month, if they maintain proper switching procedure.

4.2 Recommendation with Rearrangement

Calculations of No. of fittings required

$$N = E^{*} A/F^{*} UF^{*} LLF$$

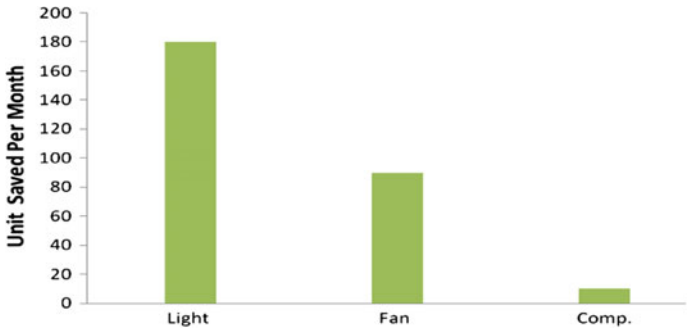


Fig. 5 Wastage audit saving graph

where,

E = lux level required on working plane
A = Area of the room
F = Total flux (lumens) from all the lamps in one fittings
UF = utilization factor
N = 500 * 1040.48/2800 * 3 * 0.75 * 0.63 = 131 fittings

So total 131 fittings are required in the library

Total 136 fittings are available in the library; Hence 5 fittings are extra in the library.
Unit used per day = 127.3

4.3 Recommendation with Investments

The lighting design is reworked for fixing of LED lighting and the proposed layout is shown in Fig. 6. It represented by 120 number of light fitting, which are 16 light set reductions when compared with the existing system (Fig. 7).

No. of LED light required (Type 15 W square LED) = 120 Fitting * 2 set light = 240
Unit consumed by 240 LEDs = 3600 watts = 28.8 units/day (Average 8 h/day)
Unit consumed/month = 720 unit/month (Figs. 8 and 9)

Money invested in buying total LED = Rs 80,000
Money Saved/month by using LED in the place of CFL = Rs 12,652
Money will be repaid in approx. 2 years

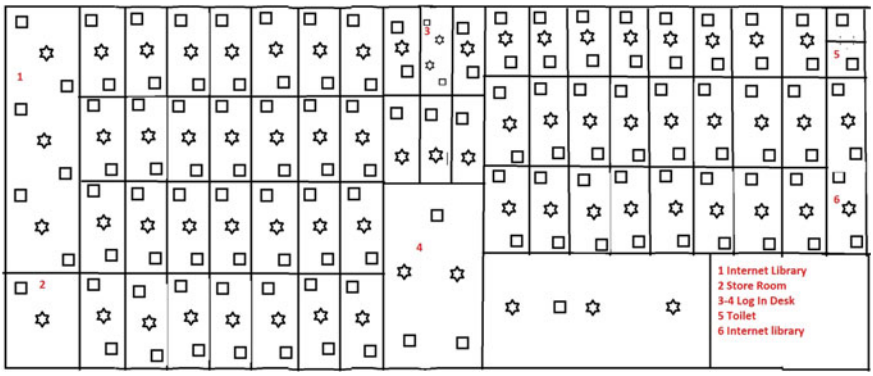


Fig. 6 Proposed layout with rearrangement

Fig. 7 Saving graph on the monthly and yearly basis

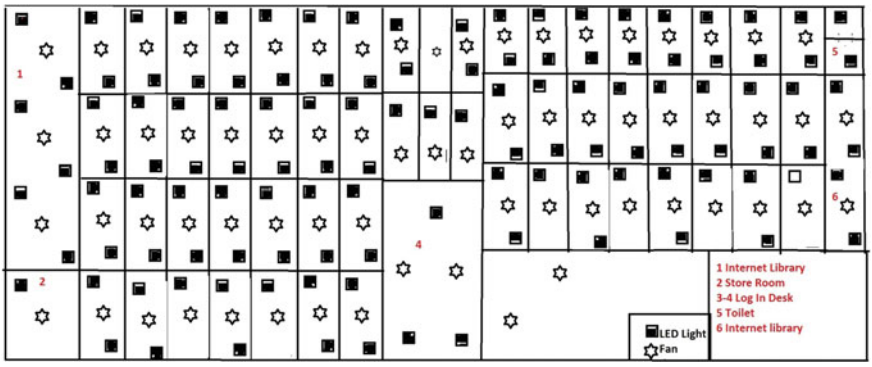


Fig. 8 Proposed lighting recommendation layout for the university library

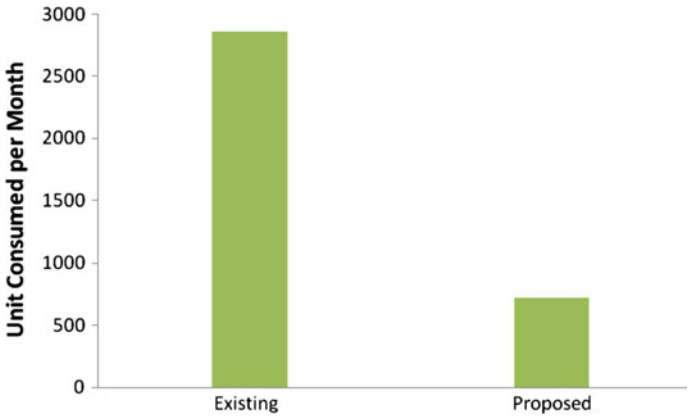


Fig. 9 Comparison of unit saved after proposed system

Recommendation with On-Grid Solar The study on the library states that the daily usage of library from 9 a.m. to 8 p.m. The study also reveals that the average number of light used per day in the library is 90–100. It is recommended to implement on-grid solar connected system to glow all the 100 LED light from 10 a.m. to 5 p.m.

Total watts required = 100 * 15 = 1500 watts
The number of solar panel required = 12
Total cost of solar panel and control equipment = 12 * Rs 14,700 = Rs 176,400
The unit saved per day by solar implementation = 20 unit (Fig. 10)

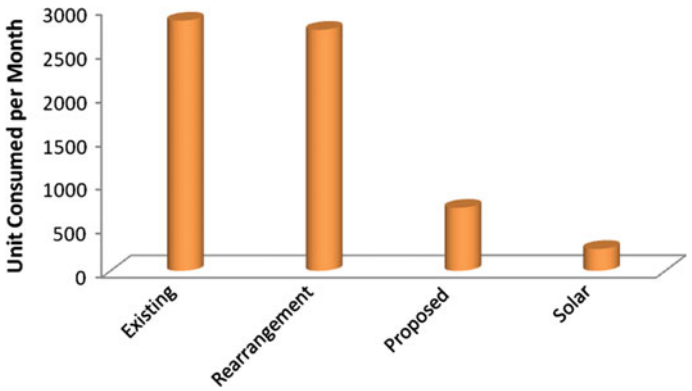


Fig. 10 Comparison of unit saved after proposed solar system

5 Conclusion

The Energy audit wastage analysis and implementation of conservation measures at University Library has been successfully completed and suggested the recommendation for implementation. The wastage audit recommendation was implemented immediately in the library. The proposed layout for lighting is agreed for implementation from June 2016. The estimated savings in the library is 55 %.

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