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Assessment and optimization of Electrical Energy Utilization

Ms Trupti Nandikolmath[*], Dr M R Shivakumar[**]
[*]*Research Scholar, Jain (Deemed to be University)*
***Principal, SRS Institute of Technology*

ABSTRACT
An energy audit is a tool is used to determine the usage of energy and help in identifying the different methods of saving energy. Reduction in usage of energy or improvement in energy efficiency of building can conserve energy and some of the environmental problems like green house effect, depletion of ozone layer can be reduced. In this work, energy utilization pattern and its effectiveness at a premier institution is being studied. Energy utilization pattern helps in collecting information about the equipments and analyzing the flow of energy across the institution. This process includes measurement of efficiencies of both light and heavy loads. The data collected from these measurements is evaluated and analyzed. Based on the evaluation and analysis, recommendations are proposed to the existing system to improve its efficiency. The recommendations proposed are commercially viable solutions. Payback period is calculated for the proposed recommendations.
Keywords: energy audit, energy utilization pattern, energy efficiency, payback period

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I. INTRODUCTION

Electrical energy is one off basic necessity of life. But, nowadays it is becoming a scarce commodity and also expensive. With the increase in population, the individual life expectancy is increasing day by day which is causing shortage of electrical energy. In future there will be more problems due to energy deficit. To meet these energy demands the supply should increase. As there is lot of dependency on non renewable energy sources, with these sources getting depleted, it is very difficult to increase the supply. Hence there arises need for energy conservation. Energy conservation is a deliberate practice or an attempt to save energy without spending additional resources. One of the ways of effectively utilizing the available electrical energy and conserving it is through an energy management tool called energy audit. Energy audit helps in energy conservation through it simple means and specific ways.

Energy audit is an in-depth study of a facility to determine how and where energy being used or converted from one form to another, to identify opportunities to reduce energy usage, to evaluate the economics and technical practicability of implementing these reductions and to formulate prioritized recommendations for implementing process improvements to save energy. It is instrumental in coping with the situation of variation in energy cost availability, reliability of energy supply, decision on appropriate energy mix, decision on using improved energy conservation equipments, instrumentations and technology. Energy audit helps in optimization of energy resources and its cost, also suggests recommendations to improve the energy efficiency. Energy efficiency is achieved when energy intensity is reduced without effecting the output or consumption. Energy efficiency is an integral part of energy conservation.

Energy audit is an important tool which has to be carried out at every organization and domestic level to save and utilize energy effectively. This paper deals with energy audit of the institution, and required recommendations proposed along with the payback period. This paper also gives an idea about the importance of energy audit. The main objective of the energy audit will facilitate options of alternative ways of saving energy, making it cost effective as well. This process will help the institution in optimizing the cost effective and contribute to sustainable development and also protection of the environment. Auditing will provide results of the building performance and the alternatives suggested in the audit which will help optimize its performance further. The audit will help the institution to bridge the gap between energy shortage and consumption by realizing the lighting requirements, efficiencies of various equipments as well.

II. AUDIT METHODOLOGY

The overall auditing process is divided into three steps: preliminary audit, detailed audit and post audit.

Step 1: Preliminary audit

This audit includes collection of previous data i.e. electricity bills and analysis of the energy bills collected. From the previous electricity bills obtained the following graphs were plotted. One graph was with respect to the maximum demand and the other with respect to power factor as shown in figure 1 and 2. From the bills it was found that the contract demand from BESCOM was 300 kVA and if the contract demand was exceeded a liable penalty would be charged. 225 kVA which is 75% of contract demand is the base value for which the demand charges have to be paid at the rate of Rs 190/ kVA. The first slab rate for each unit is Rs 6.50. It was also observed that if the power- factor is not maintained at 0.9 a penalty is charged at 0.25% of the total bill.

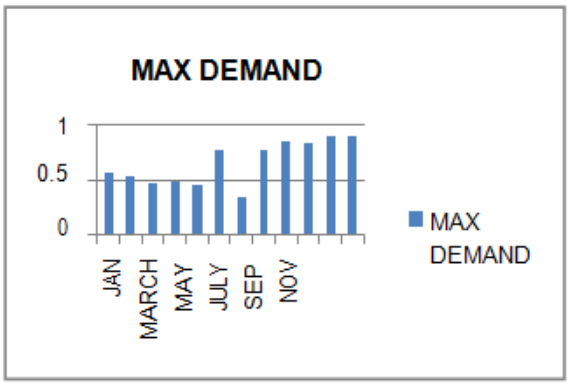

Figure 1: Graph showing max demand of 12 months

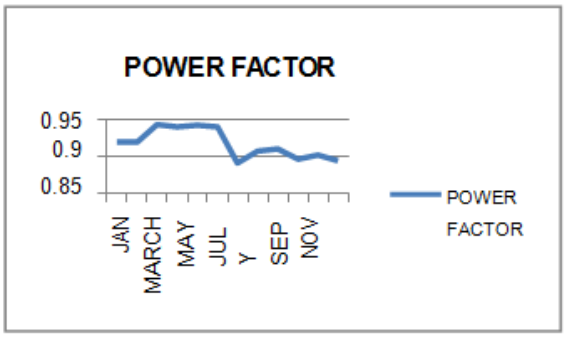

Figure 2: Graph showing power factor of 12 months

Step 2: Detailed audit

This audit was carried out floor wise and the total power consumed, KWH was calculated. The following parameters were calculated:

Total Power = no of apparatus * power consumed by each apparatus
Energy per year (KWh) = (Total Power * no of hrs per year)/ 1000
Average energy = energy per year/ 12

The average energy calculated must match the readings of energy consumption (KWh) mentioned in the electricity bill. The number of hours has been calculated based on the data provided by the particular in-charge. Floor wise consumption pattern of the major load is plotted as shown in figure 3.

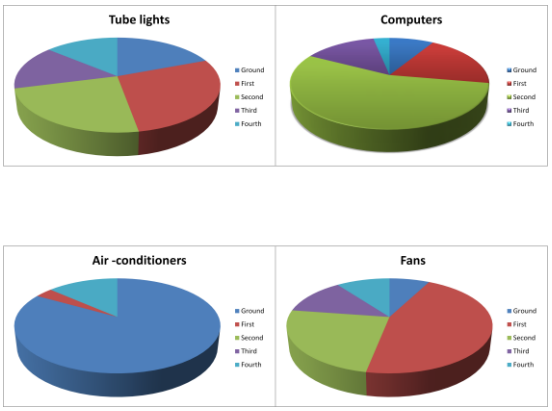

Figure 3: Pie chart of energy consumption pattern

Step 3: Post audit

The final phase of audit is the post energy audit which would comprise of recommendations and payback period. The concentration would be on the following recommendations:

Harmonic study: harmonic test is carried out at the substation. Voltage and current values are noted using a clamp meter. The waveforms of both current and voltage are observed on CRO. These waveforms are studied and analyzed. To minimize the input current distortion, power factor correction is performed for the current to be in phase with the voltage. Power factor correction will reduce the harmonic distortion. Reduction of harmonic distortion will have the following advantages:

- Improvement in the power quality
- Reduction in power losses
- The harmonics flowing through the neutral line and disrupting the other devices connected to the line sometimes is avoided.

PV cells: PV cells should be installed at the topmost floor of the building of the institution i.e. terrace region. Considerable amount of energy i.e., solar energy will be generated which can be used to generate electrical energy. Government of India provides subsidy if power is generated using renewable source of energy. Some amount of

power can be pumped back to the grid during excess load i.e. peak load. PV cell calculations are as shown below:

- The energy consumption in Kw-hr per day of the fourth floor = 75.57
- Now considering the energy lost system factor is 1.3, the total energy consumption = 98.241kW-hr
- The peak watt produced depends on the size of the PV module and climate of site location. Assuming panel generation factor to be 2 for India. The total watt peak rating needed = 98.241/ 2 = 49.120
- The no of PV panels required = total watt peak rating/ rated output peak of PV module = 49.120 * 10^3/ 4000 (with efficiency of 16% and area of 320 sq.ft) = 12.28
- Approximating it to 13, now calculating payback period assuming the total energy consumed by fourth floor in a year is 30000 kW-hr and each PV module costing Rs 1,00,000. And the cost of each kW-hr is Rs.6.30. Therefore the annual electricity bill of fourth floor is Rs.1, 95,000. Therefore the payback period is = 6.67 years (1,95,000 * 6.67 = 13,00,650) .The one lakh per panel includes the installation and maintenance of inverter and battery. The life span of each PV module is roughly 25 years.

Alternative lighting: LED's can be used as alternative lighting in institutional building as well as hostel building. Compared to compact fluorescent lamps and incandescent lamps, LED's have more advantages. The following table shows the comparison between different lighting systems.

Parameters	LED	CFL	Incandescent Lamp
			
Life	50,000 Hrs.	10,000 Hrs.	1500 Hrs.
Power consumption for same light output	6 - 8 Watt	12 - 15 Watt	60 Watt
Units per year	29 KWH/yr.	55 KWH/yr.	219 KWH/yr.

Light Output	 Light Emitting Diodes (LEDs)	 Incandescent Light Bulbs	 Compact Fluorescents (CFLs)
Lumens	Watts	Watts	Watts
450	4-5	40	9-13
800	6-8	60	13-15
1,100	9-13	75	18-25
1,600	16-20	100	23-30
2,600	25-28	150	30-55

Table 1: Comparison between LED, CFL and incandescent lamps

Check on the earth potential and neutral point: The neutral current was zero indicating system is healthy. The earth resistance is measured using Meggar's test.

I. Energy auditing equipments used for the study

1. Clamp meters: These meters are testing instrument that will measure current on live conductor without circuit interruption as shown in figure 4. While measuring current using ordinary multimeter, the wiring is cut and the instrument is connected to the circuit under test as shown in figure 5.

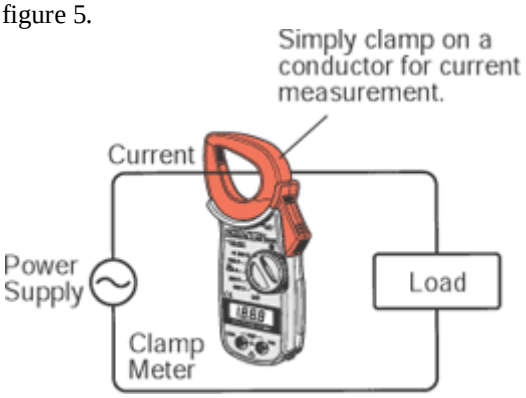

Figure 4: Current measurement using clamp meter

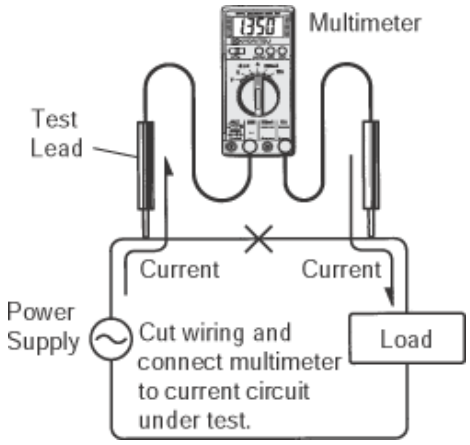

Figure 5: Current measurement using ordinary multimeter

2. Energy meter: It's a measuring device which records the energy consumed over a specific period of time as shown in figure 6. It is measured in terms of units. It was used to measure the energy of various equipments in different labs.

Figure 6: Portable digital energy meter

Software used
Microsoft Excel is used for various tabulations obtained from pre and post audit details.

III. CONCLUSION

Energy, labor and material are the top three operating expenses of any organization. From the three top most expenses, energy is the potential cost saving in each of the components. Thus energy management function constitutes a strategic area for cost reduction. Electrical energy is the most expensive energy and most important form of purchased energy. For this reason, the available energy must be utilized efficiently and operated economically. Electrical energy is flexible hence it has more advantages compared to fossil fuels. Conserving electricity will increase cost savings. Larger organizations and industries will consume large amount of power. Hence it is important to use energy efficient systems. Energy audit throws light on different electrical wastages and how a building can be made self sufficient using solar or wind or hybrid.

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