Energy Auditing and Management: A Case Study to Improve Energy Efficiency and Setting Benchmarking

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***Abstract*— The paper presents a detailed study of energy auditing of the building to improve its overall energy efficiency. Recorded data of energy consumption of each floor in a building are used to diagnose the weak points of the building energy-usage system and then a detailed energy audit study is carried out. The energy audit of the energy usage focuses mainly on the equipment consumption i.e fans, lighting system, air conditioning system, water pumping system and electronic equipment etc. Based on energy audit results on the total energy consumption of the building for particular time duration the location of equipment and their ratings are the two leading factors for the change of the total energy consumption. Also, for the different time slot the total energy consumption of the equipment varies significantly in summer and winter as well. Therefore, in this paper a comparative study of power demand, equipment cost and their size as well as make has been demonstrated for a sample building.**

***Keywords*— Energy Auditing, Energy Conservation, Power Demand, Recommended Standards, Benchmarking.**

I. Introduction

Building owners in India are facing significant challenges with the rising energy cost and decreasing availability and reliability of energy supply. Rising operating budgets are directly attributable to increasing energy costs for lighting, air conditioning and building services. But unlike many other operational costs, energy costs are controllable. Building energy assessment can assist building owners to learn more about their facilities energy use and take steps to effectively manage the energy use for long term savings.

The first step towards reducing energy consumption is becoming familiar with current energy use and learning how to make existing process more energy efficient. By undertaking an energy assessment/audit, a building owner can identify energy intensive systems and greatest potential for energy savings. All levels of building energy assessment provide the owner with a baseline of their facilities to set performance targets i.e. benchmarking and determine future course of action.

To institutionalize energy efficiency in the country, the Government of India enacted the Energy Conservation Act in 2001. Under the EC Act 2001, the government of India established Bureau of Energy Efficiency (BEE) in March 2002, a statutory authority under the Ministry of Power (MOP) to enact energy efficiency policies through various regulatory and promotional measures. BEE developed energy efficiency plans which focus on various thrust areas including Energy Efficiency in Commercial Buildings, Energy Conservation Building Code and conduction of Energy Auditors cum Energy Managers certification Program.

BEE launched its first energy efficiency program for existing buildings in 2002. Sample studies conducted in a few selected government buildings in Delhi under the program, have identified energy savings potential of about 30% on average. In the on-going next phase, 17 more buildings in Delhi have been audited. Similar initiatives are being considered for public and private buildings in the state by the authorities as well as the building owners [1]. In the past energy auditing had completed at IIT Bombay campus in 2008. The IIT Bombay electricity bill for the year 2007 was Rs. 10.2 crores. Through energy auditing they save around Rs. 1.75/- crores i.e. 17% of the electricity bill in 2007[2].

II. Energy Audit: A Case Study

The energy audit of a building is a study of building to determine how and where energy is used and to identify methods for energy savings [2]. The primary objective of Energy Audit is to determine ways to reduce energy consumption per unit of product output or to lower operating costs. Energy Audit provides a "bench-mark" i.e. reference point for managing energy in the organization and also provides the basis for planning a more effective use of energy throughout the organization.

Energy Audit can be classified into following two types

i) Preliminary Audit
ii) Detailed Audit

Preliminary Audit is quick exercise to:

- Establish energy consumption in the building.
- Estimate the scope for saving.
- Identify the most likely (and the easiest areas of attention).
- Identify immediate improvements/savings.
- Set a 'reference point'
- Identify areas for more detailed study
- Preliminary energy audit uses existing, or easily obtained data.

A comprehensive audit provides a detailed energy project implementation plan for a facility, since it evaluates all major energy using systems. This type of audit offers the most accurate estimate of energy saving and cost.

Detailed energy auditing is carried out in three phases as described in [3]:

Phase I -Pre Audit Phase
Phase II -Audit Phase
Phase III -Post Audit Phase

For the studied case, the next section described the energy requirements of the building having five floors. The data is then collected about ratings and locations of equipments such as fans, lights, air conditioning, computers etc. The collected data is arranged floor-wise and the percentage loading of different loads is considered for a particular time period.

III. Energy Requirements of Sample Case

A building under case study is having four floors and equipped with all the necessary requirements. Tables-I shows floor-wise distribution of peak power consumption of various loads.

TABLE I
FANS LOAD

Floor	Name of the company									
	CG	B	P	U	SK	MMI	EW	KW	HW	LC
G	32	2	12	15	0	0	0	0	2	5055
I	47	4	8	0	0	0	1	0	0	4695
II	50	10	7	0	2	0	1	0	0	5485
III	57	8	3	1	7	2	0	0	0	6105
IV	0	0	0	0	0	0	0	20	0	1000
T	186	24	30	16	9	2	2	20	2	22340

TABLE II
LIGHT LOAD

Floor	Fluorescent Tube				CFL		Bulb		TL	
	P	O	S	B	H	C	P	S	W	LC
G	6	10	7	1	45	5	1	7	9	3995
I	9	2	13	0	17	0	0	11	28	5150
II	17	2	7	0	20	5	0	10	8	3635
III	19	2	4	0	9	5	13	11	4	3290
IV	18	0	0	0	0	0	0	0	0	990
T	69	16	31	1	93	15	4	39	49	17060

TABLE III
COMPUTERS LOAD

Floor	Desktop						CPU			
	CP	HP	SMR	SMT	HCL	VNT	HP	P3	P4	LC
G	36	14	2	2	2	1	36	5	16	4665
I	66	5	0	3	0	0	66	0	8	4210
II	12	31	1	1	0	0	12	1	32	5205
III	2	0	7	1	0	0	2	7	1	1285
IV	0	0	0	1	0	0	0	0	1	180
T	116	50	10	8	2	1	116	13	58	15545

TABLE IV
AIR CONDITIONING SYSTEMS LOAD

Floor	Window AC					Split AC	
	VV+	S	A	OID	DK	LG	LC
G	2	0	0	0	1	1	7964
I	2	0	0	1	0	0	6000
II	0	0	1	1	0	0	4000
III	0	1	0	0	0	0	1950
IV	0	0	0	0	0	0	0
T	4	1	1	2	1	1	19914

TABLE V
WATER PUMP, WATER COOLER,
R.O. SYSTEM AND REFRIGERATOR LOAD

Floor	Water Pump	Water Cooler	RO System	Refri-gerator	
	KKDS 338+	Kirl-oskar	Voy-ager	Whirlpool Shakti	LC
G	0	1	1	1	1750
I	0	0	0	0	0
II	0	1	0	0	1600
III	0	0	0	0	0
IV	4	0	0	0	14800
T	4	2	1	1	18150

TABLE VI
FLOOR-WISE DISTRIBUTION AND POWER CONSUMPTION OF PRINTERS, XEROX MACHINES AND UPS

Floor	Printer		Photocopy	UPS	
	HPL	HPD	R	Alpha -1000	LC
G	9	2	1	0	3980
I	0	0	0	0	0
II	1	0	0	0	315
III	0	0	0	1	1200
IV	0	0	0	0	0
T	10	2	1	1	5495

Table [I-VI] shows the number of power equipments, power rating and total power consumption floor-wise. From the data collected it can be noticed that the power consumption for each equipment or devices is not same for different makes. Further the lighting load, fans and the air conditioning system is not uniform at each floor, and hence the huge scope for reduction of power consumption is there at number of floors. The peak power consumption of various loads floor-wise is given below:

Ground Floor = 27049W
First Floor = 20055W
Second Floor = 20240W
Third Floor = 13830W
Top Floor = 18590W

Total Energy Consumption = 99764W

The loads were segregated based on the end usage as fans, air conditioning system, lighting, computers and other loads. Quantification, types and necessary measurements were carried out and the details are given as shown in Fig. 1. It can be noticed that the total fans load is 22.4%, computer power load is 15.6%, lighting load is 17.1%, air-conditioning load is 20% and the other like water pump, water coolers etc. is 23.6% of the total connected load requirement. Though, the operating load is not always equal to the connected load. This is because the some loads are required to be operated in morning or in evening hours only like water pump etc. The power load mostly in operation during working hours comprises of more than 75% of the total consumption and this can be easily released from the pie chart.

The sample building is divided in five sections floor-wise like ground floor (G), First Floor (I) etc. The floor-wise section consists of number of room of different size having unique power demands. Therefore, a sample room of dense energy intensity is selected for further energy evaluation to show the effective results. Further, the quantification of the power consuming devices will help in finding the most sensible area for improving energy efficiency.

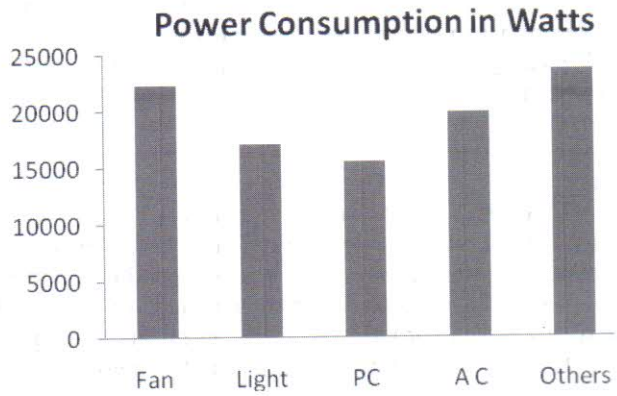

Fig.1. Power Consumption in Different Loads

IV. TEST RESULT AND DISCUSSIONS

A. Energy Evaluation of sample room

The relevant data about location, rating and number of equipment in the room have been collected and tabulated as shown below in Table-VII.

TABLE VII
POWER EQUIPMENTS IN SAMPLE ROOM WITH RATING

S. No.	Item/ Make	Qty	Power Rating	LC
1	Fans			
	Usha	11	85	935
	Havells	2	50	100
2	Lighting			
	CFL			
	Halonix	7	20	140
	Fluorescent Light			
	Small	60	20	1200
	Large	2+1	55+ 65	175
3	Printers			
	HP Laser	5	315	1575
4	Monitor			
	Compaq	14	30	420
	Samtron	2	95	190
	HP	5	50	250
	Samtel	2	90	180
	HCL	2	95	190
	Vintron	1	95	95
5	CPU			
	HPDX2009	14	15	210
	P3	5	50	250
	P4	7	90	630
	Total Loading Capacity			6540

Fig. 2 shows the exact location of the each power consuming equipment and devices in the sample room taken in to consideration. The floor area of the sample room is 13.3m X 8.6m. The total peak load power or the connected load is 6600W. Further the operating hours of each device