Energy Audit and Management: To Reduce Power Consumption

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Abstract— Educational Institutions are often unnoticed as a contributor to energy efficiency operations in India and around the world within commercial sector. Energy cost is one of the most manageable costs within an educational institute's budget and can be effectively managed. Resultant cost and energy savings will give long term benefits by reducing energy use within the building and provides a location for reinvestment within the institute. An energy study review of several educational institutions indicates that 10-30 % of energy can be saved. This paper is meant for "Energy Audit and Management of Energy use in Bharati Vidyapeeth College of Fine Arts Pune". It is an effective attempt to achieve improved energy performance. This study aims in highlighting several opportunities in creating and implementing energy management plans within Bharati Vidyapeeth College of Fine Arts, Pune. The energy audit is conducted and strategies of adjusting and improving energy consumption activities are suggested so as to reduce energy consumption and requirements and hence, the cost spent towards energy consumption.

Key words: Energy Audit, Energy Management

I. INTRODUCTION

Power Availability has a multi-faceted role in economic development of a country. Financial strength of a country can be determined by its power consumption. In today's world for the development of a country, energy is very precious. India ranks fifth in total electric power generation. All India installed capacity of power generating stations under various electrical utilities was 288.004 GW as on November 2016. [1] The detailed shares of different types of generating stations are as follows:

- Thermal power plants – 200740.04 MW
- Hydro power plants – 42663.42 MW
- Nuclear power plants– 5780 MW
- Renewable Energy Source – 38821.5 MW

The country's electricity generation capacity has increased in last 25 years by about 220 GW, from about 66 GW in 1991, to 100 GW in 2001, to 185 GW in 2011, to 288 GW in 2016. With industrial demand accounted for 36% of electrical power requirement, domestic use demand accounted for 28%, agricultural demand 21%, commercial demand 9%, rest for the public lighting and other miscellaneous applications. Energy conservation means to reduce energy consumption without making any sacrifice of magnitude or quality. A successful and efficient energy audit and management program begins with energy conservation; which will lead to – demand side management, adequate rating of equipment, using high efficiency equipment's and change in consumption habits and patterns which causes enormous wastages of energy.

A. Audit Phase

[2]An energy audit is an inspection, survey and analysis of energy flow for energy conservation in an industry, process to reduce the amount of energy input into the system without negatively affecting the output.

The energy audit is a wide-ranging energy study which ranges from identifying and selecting major energy problem areas for implications of alternative energy efficient measures. It involves analysing the actual consumption of electrical energy and methods of energy conservation. Energy Audit helps to understand more about the ways electrical energy and fuel are used in any industry and helps in recognizing the areas where energy wastage can occur and where scope for advancement exists.

A walk though audit was conducted initially. The rooms at the college building were surveyed. The connected loads and their wattage were noted. During the visit macro information like number of hours of actual usage of fluorescent light, fan, power points etc. was collected. The main objective was to explore the major areas of conservation. It was found that there was a scope for conducting a General audit and more than 10% of the energy consumed could be saved. The general audit was conducted and measurement of actual energy consumption was recorded .The illumination level was measured and recorded through Lux Meter. Wind speed delivered by fans was recorded through anemometer. Electrical fittings in the rooms like light, fan and ventilation were noted. The measurement was conducted both inside the rooms, in common places like corridors, bathrooms, toilets. Incoming apparent power in the building was recorded by measuring incoming current flowing through the bus bars and their corresponding bus bar voltage was measured and recorded.

II. METHODOLOGY ADOPTED

It was observed that energy efficient measures could be adopted in four categories viz., demand management, ventilation, lighting and water cooler. Consequently, profound analysis of these four categories was carried out.

A. Audit Para

1) Power demand management

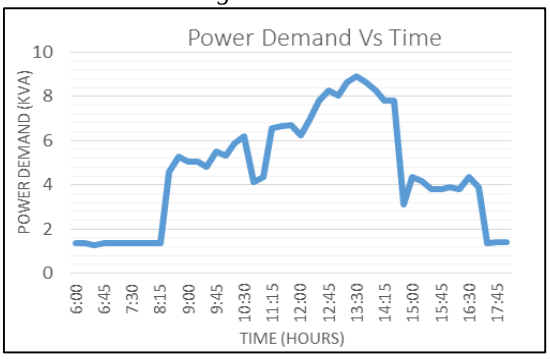

Fig. 1: Power demand vs time

Above Curve shows variation of Power Demand in kVA with time for a single working day of the institute.

We observe Through the Power demand curve that maximum demand, 8.97 KVA is at 1:17 pm in the noon.
Total Load Connected = 19.823 KVA

Demand Factor = Maximum Demand
Total Load Connected
= 8.97/19.823
= 0.452
Maximum Power Demand in the building for a day = 897 KVA
Whereas, power demand at 12:15pm and at 2:30pm = 6.67 KVA.
Thus peak power demand can be efficiently reduced from 8.97 KVA to 6.67 KVA
Reduction in Power Demand = 2.3 KVA

Reduction in power demand charge @ ₹190/KVA
= ₹190*2.3/ month = ₹437/month
Thus to reduce the power demand thereby reducing the demand charges following Steps can be taken.

1) Fourth floor Elementary room, Class room 402 and Foundation room classes can be rescheduled from (12:15 – 2:30) pm to (2:30 – 4:30) pm if possible.
2) Usage of desktop computers can be avoided at this time if possible.

B. Lighting Loads:

Floor	Name of Equipment	Avg. Power (Watt)	No. of Equipment	Operating Hours	Demand Factor	Energy Consumption/ day	Energy Cost/ day @₹8.41/kWh
Ground Floor	Fluorescent Tubes	45.16	19	8	0.452	6.86*0.452=3.10 kw	3.10*8.41= ₹26.10
1st, 2nd, 3rd, 4th Floor	Fluorescent Tubes	45.16	104	6	0.452	28.17*0.452=12.74kw	12.74*8.41= ₹107.2
Corridors and Lobby	Fluorescent Tubes	45.16	29	12	1	15.7*1 =15.7	15.7*8.41= ₹132

Table 1: Distribution of Lamps as Per the Operating Hours, Energy Consumption

1) Selection of Replacement

There are two types of lighting loads on the basis of their operation (1) Fixed lighting loads – Corridor and lobby lamps (2) Variable lighting loads Room lamps. Here 0.452 is the demand factor as obtained earlier from the demand curve.

The Illumination of the lamps was measured and recorded by lux - meter and we observed that the illumination of the lamps 2 meters directly below the lamp and 1 meter above the ground as per the working plane height from the ground ranges from 160 lux to 200 lux at 16:30 Hrs.

Lux ratings of the lamps were found to be ranging from 1800 lux to 2100 lux. Thus every lamp can be conveniently replaced with a pair of LED lamps with wattage of 11 watt each.

For confirmation, we replaced one of the existing lamp with a pair of LED lamps kept 4 feet apart and tested its illumination, which was found to be 200 to 220 lux , 2 Meters below the lamp and 1 meter above the ground at the working.

2) Comparison of Energy consumption and cost between LEDs and Fluorescent lamp

a) Fixed Luminaries

Consumption of power for 1 fluorescent lamp taken on an average is 45.16 W. Energy consumed per day for 29 fixed lights (corridors 6 PM – 6 AM) is 15.7 kWh.

It is found that overrated lamps were used for night lamps. Illumination required for night lamps is 80 lux whereas the received illumination was 150 lux thus only one 11 watt led is sufficient to replace one 45 watt fluorescent lamps.

Energy charges per day=15.7*8.41 = ₹ 132.
Monthly Charge = 132 * 30 = ₹ 3960
Annual Energy Charge = ₹ 47520

Replacing each fluorescent lamps with LED lamps with wattage = 11 watts
Energy saved per lamp = 34 watts
Monthly Energy charge saving = ₹ 2992
Annual Energy saving = 4269.2 kWh
Annual Energy charge savings = ₹ 35904

b) Variable Luminaries

Energy consumed per day for 123 variable luminaries = 35/2.21 = 15.84 kWh.
Energy Charge/day @ ₹8.41 =15.84*8.41
= ₹133.21
Monthly Energy Consumption for 25 working days = 395.95 kWh
Monthly Energy Charge for 25 working days @ ₹8.41 = ₹395.95*8.41 = ₹3330
Annual Energy Consumption for 12 months = 4751.4 kWh
Annual Energy Charge for 12 months @ ₹8.41
= 4751.4*8.41 = ₹39964
Power consumption of a pair of led lamps = 11*2 = 22 watts.
Monthly Energy consumption of 246 LED lamps
= 193.13 kWh
Monthly Energy consumption charge of LEDs
@ ₹8.41= ₹1624.3
Annual energy consumption of LED lamps
= 193.13*12 =2317.6
Annual Energy Charge of LED lamps
= ₹ 19492.68
Annual Energy saving
= 2434.2 kWh
Annual Energy charge saving = ₹ 20472

c) Cost Estimation and Payback Period

Cost for replacing one existing florescent lamp with a pair of LED lamps (11 watt) and its installation = ₹ 240*2 =₹ 480
Cost of (123*2 + 29) LEDs = 240*275 = ₹ 66000
Simple Payback Period = 66000/56376
= 14 months
Audit Observation: The additional cost incurred towards the replacement will be paid back in 13 to 15 month time period. Life of LED is approximately 8 to 10 years.
Hence, it was recommended for replacement.

C. Fans

There are 113 ceiling fans with average power 70 watt each installed in the institute. Distribution of 113 fans on operating hours and energy consumption

Floor	Name of equipment	Avg. Power (Watts)	No. of Equipment	Operating Hours	Diameter	Demand factor	Energy Consumption /day kWh	Energy Cost/day @₹8.41
Ground Floor	Fan	70 W	15	8 Hrs	48 inch	0.452	8.4*0.452= 3.80 kW	₹ 31.95
1st, 2nd 3rd, 4th	fan	70 W	98	6 Hrs	48 inch	0.452	41.16*0.452 =18.62	₹ 156.5

Table 2: Distribution of 113 fans on operating hours and energy consumption

1) Selection of Replacement

Wind speed delivered by the fans was measured and recorded by anemometer. Highest wind speed recorded = 2.1 m/s

Year	2016-2017	2017-2018	2018-2019	2019-2020	2020-2011
Per unit Charge	₹ 8.41	₹ 9.57	₹10.9	₹12.42	₹14.56
Annual Energy Charge	₹ 16164	₹18393	₹20974	₹23877	₹ 27202

Table 3: Yearly database

For 48 inch 4 feet diameter and wind speed 2.1 m/s that is 424.6 feet per second.

Volume of air circulated per minute

= Area under the fan * wind speed = π*(d/2)^2* V

= 5335.9 CFM

Therefore all 113 less efficient ceiling fans with 70 watt power consumption can be conveniently replaced by highly efficient 50 watt fans.

2) Comparison of energy consumption between existing 70 watt fans and highly efficient 50 watt fans.

Consumption of power for each existing fan taken on an average = 70 W.

Energy consumed per day for 113, 70 watt fans= 49.5*0.452 = 22.42 kWh (0.452 = demand factor)

Monthly Energy consumption

= 22.42*25 = 560.5 kWh (for 25 working days)

Monthly Energy Charges@ ₹8.41 = ₹4713.8

Annual Energy Consumption

= 560.5*12 =6726 kWh

Annual Energy Charge = 6726*8.41 = ₹56565

Replacing These 70 Watt fans with highly efficient new 50 Watt fans. Energy saved per Fan = 20 Watt

Annual Energy Consumption for 50 watt fans

= 4804 kWh

Annual Energy Charges for 50 watt fans = ₹16164

3) Estimated per unit cost of upcoming five years and estimated energy for each corresponding years.

Annual Energy savings from April 2016 to April 2017 = 1922 kWh

Annual Energy charge savings from April 2016 to April 2017 = 1922 *8.41= ₹ 16164

Estimated per Unit charges and Energy savings with rise of 13.79 % each year as observed from past five years.

4) Cost Estimation and Payback Period

Cost of replacing one, 50 Watt fan and its installation = ₹ 1200

Purchasing Cost of 113 fans of 50 Watt and their installation = ₹ 135600

Cost of 113 fans of 70 Watt with depreciation factor = 0.3 for initial cost price ₹ 1000 = 300 * 113 = ₹ 33900

5) Compounded Payback Period

= (Purchasing Cost of 113 fans of 50 watt rating - depreciated cost of 113 fans of 70 watt) / Annual Energy saving = (135600 – 33900) / (16164 + 18398 + 20974 + 23877 + 0.81 * 27202) = 4 year 10 months

Audit Observation: The additional cost incurred towards the replacement will be paid back in 4 years 9 months to 5 year time period. Life of FAN is approximately 15 to 20 year.

Hence, it was recommended for replacement

6) Water cooler

A 625 watt water cooler is in operation in the institute for 8.5 hours a day.

While surveying we observed the use of water cooler for hand washing. Continues misuse of chilled water for hand washing leads to more than 20 % energy being wasted in water cooler. Thus a small poster needs to be placed on water cooler indicating the chilled water from water cooler only for drinking, which would reduce more than 50 % of the Energy waste on the water cooler.

Thus 62.5*8.5 =0.53125 kWh of energy can be saved in a day. Annual energy saving @₹ 8.41 = 159.3 kWh

Annual energy cost saving = ₹ 1340.3 (without any investment.

III. Conclusion

A famous sayings is "Energy conserved is Energy Generated". Because the demand of electricity is increasing exponentially with each growing year putting stress on power utilities to meet the growing demand. Thus apart from increasing power generating capacity which would further increase energy cost and hamper the economic development of a country one must go for increasing energy audit to save the electricity at much lower cost. Further there is lack of knowledge about energy efficiency and its offerings among the people. Energy audit studies are only understood as a process of accessing energy flow for industrial buildings which are the major power consumers not the educational institutes and similar commercial buildings.

A. Recommendations

Type of Load	Power Consumption	Annual Energy consumption (kWh)	Recommendation	Power Consumption	Annual Energy Consumption (kWh)	Annual Energy saving s	Annual Energy Charge Savings @₹ 8.41	Payback Period

						(kWh)		
Fluorescent lamps	45 W	4751.4 kWh	Pair Of LED Lamps	11*2=22 W	2317.6 kWh	2434.2 kWh	₹ 20472	14 months
Night lamps (F.T)	45 W	5650.4 kWh	LED Lamps	11 W	1381.2 kWh	4269 kWh	₹ 35904	
Ceiling Fans	70 W	6726 kWh	50W energy efficient fans	50 W	4804.2 kWh	1921.7 kWh	₹ 16164	4 Years 10 months
Water Cooler	625 W	1593.7 kWh	Poster	NIL	NIL	159.3 kWh	₹ 1339.14	NIL
Demand Management	Nil	Nil	Reduction in Peak Power Demand by 2.3 KVA	Nil	Nil	Nil	190*2.3*12 = ₹ 5244	NIL
Summation							₹ 79123.14	2.2 Months

Table 4: Recommendations

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