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Energy Audit: A Case Study on Buildings

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ABSTRACT

In any firm efficient usage of energy plays a major role in order to reduce energy consumption. Efficiency in usage of energy can be achieved through energy auditing process. This process helps to optimize the cost related to energy consumption and also plays a major role in saving environment from getting polluted. Energy auditing process involves analyzing the existing system, its energy consumption pattern and finally suggesting conservation measures possible to reduce energy consumption. In this paper an attempt is made to analyze the energy consumption pattern in hostels of an educational institution. A detailed auditing process has been done on all hostels to find out the areas of inefficiency and measures to save energy have been suggested. To find out the feasibility of the energy conservation measures, Financial and carbon emission reduction analysis has been done.

Keywords: Energy audit, Energy conservation measures, Hostels, Financial and Carbon emission reduction analysis

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INTRODUCTION

The increasing demand for power has led to considerable fossil fuels burning which has in turn had an adverse impact on environment. In this situation, efficient use of energy and its conservation is of great importance. As per energy conservation act 2001, it is estimated that approximately 25,000 MW can be saved by implementing energy saving measures throughout India. Effective utilization of energy reduces the need for creation of fresh capacity by 2 to 2.5 times. Such energy saving measures can be implemented at the cost of less than one-fifth the cost of fresh capacity. Therefore, energy efficiency plays a major part in saving energy and also reducing the fossil fuel consumption.

Energy audit can be performed at three levels depending on the time, budget constraints, the building envelope, and client requirements. The energy audits levels defined by the ASHRAE 100-2006 standards are as follows: level 1, "walk-through analysis"; level 2, "energy survey and analysis"; and level 3, "detailed analysis of capital intensive modifications [1]. In state of Kuwait ,audit report on educational building has shown that over 50% of total energy can be saved after implementing energy conservation measures[1].energy audit will be started with a review of historical data use followed by data analysis and implementation of energy conservation measures to save energy[2].A case study on Wanchai Government Office Tower has shown that more than 10% of energy costs can be reduced after implementation of energy conservation measures[2].So many studies have been done on hotels in various countries in order to assess the energy performance of the hotels[3][4][5][6][7].For assessing energy performance of hotels, it was found that energy utility index based on unit floor area is not sufficient. So in order to adequately assess energy performance, it was suggested to separate a hotel building into two parts: guest floors and non-guest floors and perform energy performance evaluation for the two parts separately [3]

The feasibility of energy saving options can be determined through cost benefit analysis and net present value (NPV) [8]. Cost benefit analysis give results in terms of years whereas NPV gives positive and negative values. An energy saving option can be considered economically convenient if the NPV is positive [8].

In this paper, the main aim is to study and conduct energy auditing process for all boys hostel buildings in an educational institution. At present there are 7 boys hostel in the educational institution. There are total 1261 resident rooms with current strength of 3746. The energy auditing process was conducted at all boy's hostel buildings in order to identify the major areas of inefficiency and suggestions has been given to save energy.

ENERGY AUDIT METHODOLOGY

The term Energy audit can be defined as the process to identify energy management opportunities (EMO) and suggesting measures to improve inefficient areas. Its result mainly depends on the resources being allocated by top management. This process involves collection of building information, analysis of collected information, identification of energy management opportunities, Financial and carbon emission reduction analysis, recommendations and finally compilation of report.

Energy audit of hostel buildings was done in three stages:

1. This is a preliminary auditing stage where basic information about the buildings (no. of equipment's installed, no. of operating hours on daily basis and monthly basis, water usage data, number of students in hostels) have been collected.
2. This is a detailed auditing stage where details about power consumption of every equipment, defective equipment's to be replaced, survey about the usage of various loads by students in hostels, per capita power consumption, per capita water consumption have been taken and analyzed.
3. This is a final stage where categorization of various loads, financial and carbon emission reduction analysis, suggestion of various measures to save energy (power and water) have been done.

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Data collection:

Monthly wise electricity consumption pattern of all hostels in 2014 is shown in fig. 1. The total annual power consumption of all hostel building is 1612 MWh with average per capita power consumption of 479 KWh. The annual power consumption pattern of different hostel buildings and average per capita power consumption in each hostel are shown in fig. 2 and fig. 3 respectively.

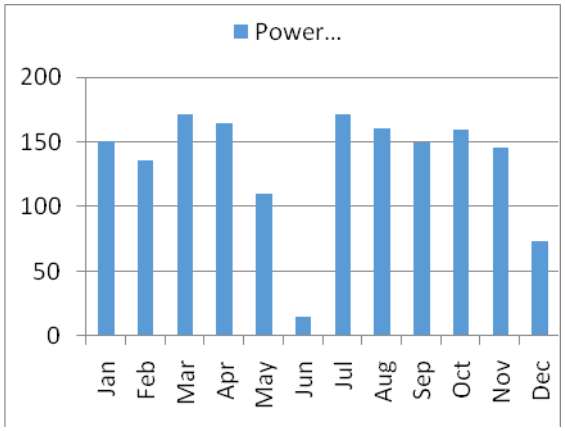

Fig 1: Monthly wise Power consumption pattern of all hostels in 2014

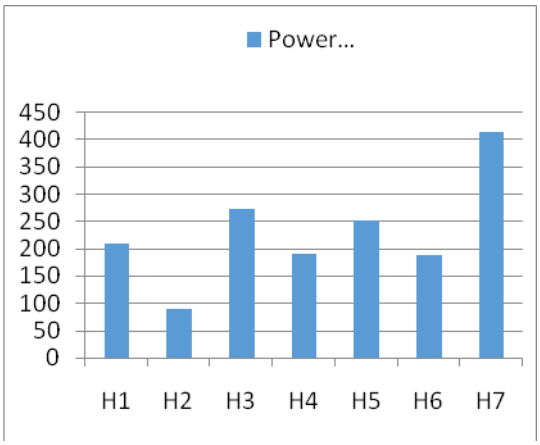

Fig 2: Annual Power consumption pattern in different hostels

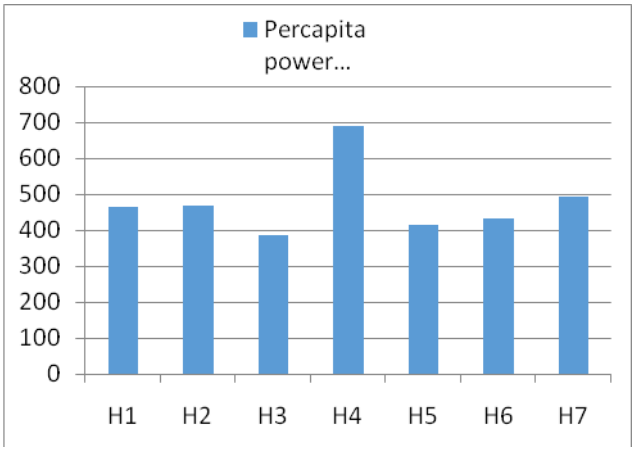

Fig 3: Annual per capita power consumption pattern in different hostels

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From fig. 3 it is observed that there is a variation in per capita power consumption pattern in different hostel buildings. This variation mainly depends on number of users in hostel and efficiency of equipment's installed. In these seven hostels, hostel no (2,3,5,6) are very old when compared to hostel no (1,4,7).

This audit shows that electrical energy is used mainly for lighting, fan cooling, water cooling, laptops and other equipment's (heaters, cookers etc.) in hostel buildings as shown in fig. 4

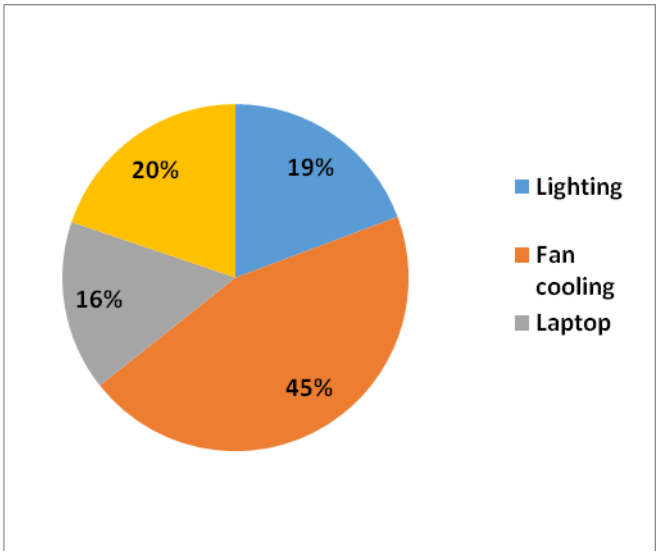

Fig 4: Yearly energy utilization for various loads in all Hostels

From fig. 4 it is observed that major portion of electrical energy is used for the purpose of fan cooling followed by other loads (heaters, cookers etc.), lighting and laptops.

Audit of lighting load:

The lighting system used in hostel buildings consists of Incandescent bulbs, Compact fluorescent lights(CFL), T12, T8 4ft and T8 2ft electronic fluorescent tube lights(FTL) of rating 60W, 11W, 40W, 36W and 18W respectively. It is found that there is excess lighting in bathrooms when compared to its necessity. So there is a scope to save more lighting energy in case of bathrooms

Table I: Details Of Lighting Load

Type of lighting	No.	Rated power(W)
T8 FTL (4ft)	1389	36W
T8 FTL (2ft)	358	18W
T12 FTL (4ft)	1538	40W
CFL's	792	11W
Incandescent bulbs	256	60W

Audit of fan and water cooling load:

From the audit it is found that the major part of consumption of power from the total power supply to hostels is taken for fan cooling. The fans used in all hostels are of the same type (1200mm). There is so much scope to save energy in case of water coolers as there are 24 old coolers(575W) out of 27 coolers.

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Table 2: Details Of Fan And Water Cooling Loads

Type of load	No	Rated power(W)
Ceiling fan(1200mm)	2197	60W
Old water coolers	24	575W
New water coolers	3	390W

Audit of Laptops and other equipment loads:

After taking the survey of 50 rooms it is found that approximately 65% of the students are using laptops, 7% of the students are using kettles, cookers and 5% of the students are using heaters.

Table 3: Details Of Gadgets And Laptop Loads

Type of load	No	Rated power	Approximate operation hrs/day
Laptops	65% of total strength	60W	6-7
Kettles, Cookers	7% of total strength	2000W	0.5
Heaters	5% of total strength	1500W	2 in winter 1 in summer

Audit of heating load:

In these hostels, no heating equipment's are there to heat water during winter season. Because of this, students are using immersion rods to heat water which in turn consumes more power due to its faulty design. Even though usage of this type of equipment's in hostels is strictly restricted, students are using these equipment's because of lack of proper checking in hostels. So there is a chance to save more energy in this situation by reducing its usage

Audit of water load:

There are 3746 students residing in these seven hostels. Approximately 80% of the total water supply is from truck water suppliers and the remaining 20% is from Kaveri water. Monthly wise total water supply and approximate usage of water (135 LPCD) are shown in fig. 5.

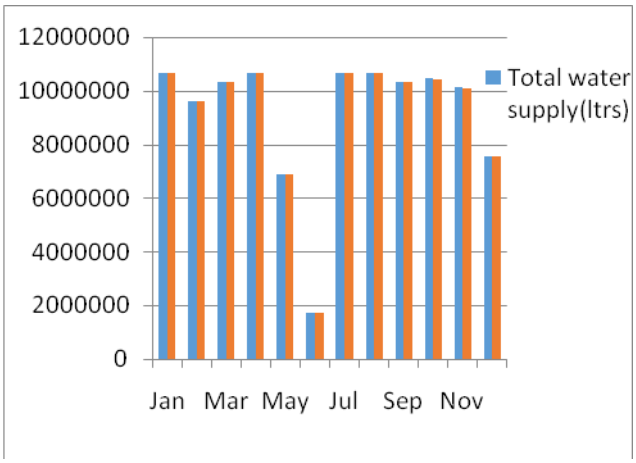

Fig 5: Monthly wise total water supply and approximate water consumption

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From fig. 5 it is observed that there is some variation between total water supply and approximate water consumption in every month. This variation indicates wastage of water occurring every month. The water consumption data was calculated by taking per capita standard water consumption of 135LPCD into consideration.

- Annual water supply to the hostels - 109664200ltrs
- Annual water consumption - 109594072ltrs
- Annual wastage of water - 70128ltrs
- Cost of 1 liter of water in this region - Rs 0.059
- Annual wastage of money -Rs4137
-

So there is a chance to reduce the wastage of water by adapting some energy management opportunities.

RECOMMENDATIONS

After collecting and analyzing data, energy saving recommendations are proposed by taking cost of implementation and energy savings into consideration. The possible energy saving recommendations are discussed and analyzed in this section.

Recommendation for lighting load:

There is more scope to save energy in case of lighting load. To achieve this, energy saving measures are proposed to all the seven hostels. The energy saving measures are (1) replacement of T12 40W FTL with T5 28W FTL bulbs in all rooms and corridors except bathrooms and T12 40W (4ft), T8 36WFTL(4ft) with T5 18W FTL(2ft) in all bathrooms (2) replacement ofT8 36W FTL with LED 18W bulbs in all rooms except bathrooms, verandahs and stairs (3) replacement of electromagnetic ballasts with electronic ballasts (4) installing lighting control system in all the hostels

1. Out of seven hostels, four hostels are old which are equipped with old T12 40W FTL bulbs in all rooms, corridors and bathrooms. Replacement of these bulbs in rooms and corridors with T5 28W FTL will save more energy. Bathrooms of all hostels are having excess lighting for its necessity. This excess lighting can be reduced by replacing T12 40W (4ft) and T8 36W FTL (4ft) with T5 18W FTL(2ft) in all bathrooms. These replacement details are shown in table IV
2. By replacing T8 36W FTL with LED 18W bulbs in all hostel rooms, drastic amount of energy will be saved. But the cost invested for the LED bulbs will be very high (financially won't get accepted). Details of this measure is shown in table IV
3. In old hostels, bulbs are fitted with old electromagnetic(EM) ballasts which uses a power of 14W while getting started whereas the new electronic ballasts uses only 3W power to start. So replacing EM ballasts with electronic ballasts saves more power. It is shown clearly in table IV

Table 4: Energy Saving Measures In Lighting Load

Energy saving measures	No.	Annual energy savings (KWH)	Annual cost savings (INR)	Investment costs (INR)	Payback period (years)
Replacing T12 40W with T5 28W (in rooms and corridors) and T8 36W(4ft),T8 40W(4ft) with 2ft T5 18W bulbs(in bathrooms)	2270	91800	734400	684700	0.93
Replacing T8 36W FTL with LED 18W bulbs in all hostel rooms	2435	188668	1509344	3165500	2.09
Replacing EM ballasts with electronic ballasts	1538	26307	210456	192250	0.91

4. By using lighting control system (occupancy sensors, day light harvesting sensors), approximately 30%-40% of the lighting power consumption can be reduced. But the cost involved in installing it will be very high. So it is not preferable to install in hostels until there is some subsidy given by Indian government.

Recommendation for Laptops and other equipment loads:

By implementing energy conservation awareness programs, it is possible to reduce energy consumption by laptops and other equipment loads. So much of energy is wasted due to usage of cookers and illegal heating equipment's in hostels. The power consumption of cookers and heaters are very high due to its faulty design. This wastage of energy can be reduced by conducting frequent checking in hostels and imposition of fines on its usage

Recommendation for fan and water cooling load:

At present there are 2197 fans in all hostel buildings. The fans used in all the hostels are 60W 700 mm type. But there are less energy consuming fans like Usha 43W and orient 48W available in market. When compared to their energy savings, the cost of investment for these fans is very high which in turn have more payback periods. So recommending this measure will not be financially accepted.

There are 24 old water coolers(575W) out of 27 coolers in all the hostels. By replacing these 24 old coolers with new 390W coolers, there is a chance to save more energy. The details regarding the replacement of coolers are as follows

- Total number of coolers to be replaced – 24
- Total annual energy savings after replacement of old coolers with new 390W coolers - 23828 KWh
- Cost of one 390W cooler- Rs 23000
- Total cost for 24 coolers 390W -Rs 552000
- Unit energy cost Rs/KWh - Rs 8
- Total annual money savings - Rs 190624
- Payback period - 2.89 yrs

Recommendation for heating load:

In these 7 hostels with 3746 residents, there is no heating equipment available to heat water during winter season. Because of this, the students are using some illegal equipment's like immersion rods to heat water which consumes very high energy. Usage of solar water heating equipment'swill be an efficient way to save energy in case of heating loads. To achieve this flat plate collector of 500 liters per day capacity is recommended. The details of this recommendation is as follows

- Cost of one FPC (500ltrs) - Rs 102000
- Averageper capita hot water required - 25ltrs
- Number of residents - 3746
- Total hot water required/day- 93650 ltrs
- Power required to heat 25ltrs water - 1.25 KWh
- Duration of winter season in Tamilnadu - 50 days
- Annual energy consumption - 234125 KWh
- Annual total cost - Rs 1873000
- No. of FPC's required Hot water required per day/capacity of FPC
  -93650/500 = 187
- Total cost for FPC's - Rs 19074000
- A subsidy of 70% will be given by government for solar heaters
- Total cost after subsidy - Rs 5722200
- Payback period - 5722200/1873000
  = 3 yrs.

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Recommendation for water load:

The wastage of water can be done during its supply to the hostels, storage and usage. Approximately 20% of water wastage is done due to trucks with damaged carriers, 10% ofwastage due to leakage of taps, 2% of wastage due to overflowing of water in tanks and more than 50% of water wastage is by the students. The recommendations to save water are as follows

- Replacement of damaged trucks
- Implementing awareness programs among the students about the usage and scarcity of water in this area
- Efficient management in storage and supply of water which reduces the wastage of water due to overflow and leakage
- Installation of Low Flow Faucet Aerators to the water taps in wash basins
-

Details of water taps(wash basins) in all the hostels are as follows

- Total water taps(wash basins) - 711
- Approximately 10% of total taps are having Low Flow Faucet Aerators
- Total taps in wash basins to be replaced - 640
- Total annual water supply - 109664200 ltrs
  - Approximately 5% of water can be saved annually-2193284ltrs
- Total amount saved annually - Rs129403
  - Cost of one tap with Low Flow Faucet Aerator - Rs. 350
- Total cost of investment - Rs224000
- Payback period - 1.73yrs

FINANCIAL AND CARBON EMISSION REDUCTION ANALYSIS

There are so many tools available to do financial analysis of the project. But among those tools, payback period is the best tool to analyze the project financially and give quick results.

Payback period =Total investment/Annual cost savings [9]

Carbon emission reduction analysis is also important to find out the amount of carbon emission reduced after implementing the project. The annual CO_2emission can be calculated by the given formula as follows

Annual CO_2 emission = Annual KWh * Conversion factor [10]

Where conversion factor value is $1.25*10^{-3}$which is taken from BP statical review of world energy 2010. Details of all energy saving measures are listed in table V

Table 5: Financial And Carbon Emission Analysis To Implement Energy Saving Measures

Items	Quantity	Units
Annual power consumption	1846990	KWh
Proposed power consumption	1490930	KWh
Annual power savings	356060	KWh
Annual CO_2emission in	2308	tCO_2

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existing system		
Annual CO_2 emission in proposed system	1863	tCO_2
Amount of carbon emission reduced	445	tCO_2
Cost of implementing energy saving measures	7375150	INR
Annual money savings in power	2848480	INR
Annual money savings in water	129403	INR
Total money savings	2977883	INR
Payback period	2.47	years

The energy saving measures are mainly dependent on financial status of the organization and its payback period. In this case the replacement of T12 40W with T5 28W (in rooms and corridors) and T8 36W(4ft), T8 40W(4ft) with 2ft T5 18W bulbs(in bathrooms) are recommended as the energy savings are more and payback period is less. But in case of LED replacement, even though it saves more energy the cost related to its installation is more. So this replacement is not strongly recommended. After implementing energy saving measures, the annual per capita power consumption has reduced to 419 KWh

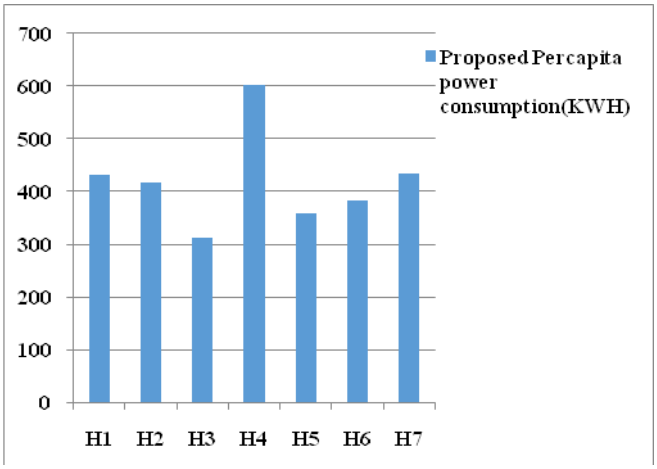

Fig 6: Proposed annual percapitapower consumption in different hostels

CONCLUSIONS

Energy audit plays a major role in saving energy which in turn reduces the rate of depletion of fossil fuels. From the audit done on hostel buildings it is observed that there is a good scope to save energy. By applying above recommendations, the average annual power savings of 356MWh can be achieved which will be about 19% of total annual power consumption. After application of proposed recommendations, the carbon emission has been reduced to 445 tCO_2. \Approximately Rs 29 lakhs has been saved annually after implementation of proposed recommendations. So energy audit plays an important part in protecting environment by reducing carbon emission and at the same time saves more money. From the above case study, it is found that there is a great chance to save energy in hostel buildings.

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REFERENCES

[1] Ali Alajmi,2012, Energy audit of an educational building in a hot summer climate –A Case Study, Energy and Buildings 47 (2012) 122–130

[2] H.K. Wong and C.K. Lee, 2001, Application of Energy Audit in Buildings and a Case Study, IEE 2nd International Conference on Advances in Power System Control, Operation and Management.

[3] Shi-Ming Deng and John Burnett, 2000, A study of energy performance of hotel buildings in Hong Kong, Energy and Buildings 31(2000). 7–12

[4] SemihOnut and SelinSoner, 2006, Energy efficiency assessment for the Antalya Region hotels in Turkey, Energy and Buildings 38 (2006) 964–971

[5] Rajagopalan et.al, 2009, A study on energy performance of hotel buildings in Singapore, Energy and Buildings 41 (2009) 1319–1324.

[6] AbdelhakKhemiria and Mohamed Hassairi, 2005, Development of energy efficiency improvement in the Tunisian hotel sector: a case study, Renewable Energy 30 (2005) 903–911

[7] Nasser Ayoub et.al, 2014, Energy consumption and conservation practicesin Qatar—A case study of a hotel building, Energy and Buildings 84(2014) 55–69

[8] Umberto Desideri and Stefaniaprioretti, 2002, Analysis of energy consumption in the high schools of central Italy, Energy and Buildings,34(2002)1003-1016.

[9] Wayne C. Turner, Steve Doty, Energy Management Handbook, 6th edition, The Fairmont Press, 2006, pp. 9-69

[10] Bureau of Energy Efficiency, Ministry of Power, Government of India, "Energy Conservation Building Code User Guide", USAID ECO-III Project, July 2009.