Performance Analysis of Loads in Hospital

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Abstract:

In this paper we have conducted a review of different loads such as HVAC, lighting & pump which is installed in AVBR hospital, Sawangi by carrying out detailed energy audit in hospital premises with its proper methodology specified as per Bureau of Energy efficiency (BEE) and it is being recommended that efficient devices should be installed in hospital campus and within the premises to reduce overall energy consumption of HVAC, lighting & pump .On the other hand proper handling of HVAC system, for improving better performance of HVAC, proper mounting of lights & their uniform flux distribution in each room of hospital has also suggested. Along with these efficient pump characteristics studied and proper recommendation given so as to improve the performance of the pump in the hospital .Thereby our objective is to achieve energy conservation through replacing and arranging earlier system by some new efficient one and proper recommendation given so as to improve the performance of complete system and also an important parameter for energy saving in the buildings sector is the high efficiency of the energy infrastructures, which requires excellent quality of the relevant equipment installed, as well as the compliance with all the requirements set by the legislation.

Keywords: Bureau of Energy efficiency (BEE), Efficient Operator, Energy Audit, Energy consumption of HVAC, Energy Conservation, Efficient Lighting, Efficient pump characteristics.

INTRODUCTION

In many countries, hospitals are large energy consumers. In order to evaluate energy saving possibilities in such facilities an energy audit was conducted in a hospital campus. The audit objective was to provide background for similar applications in all hospital facilities. The ever-increasing energy costs and environmental concerns make paramount the rational use of energy and the energy conservation acts. Governmental and generally state-owned buildings, especially the old ones are good for conducting energy audits and proposing energy conservation opportunities. Electrical energy consumption is more in private hospitals as compared to government hospital. So it is essential to find out those reasons which are responsible for high energy consumption. So here we have carried out study of energy consumption & conservation in hospital HVAC, lighting & pump load on the basis of practical implementation of energy audit in **"AVBRH Sawangi (Meghe)"**, Wardha (M.S).

HVAC is an important loading on power system, along with pump & other loads; it constitutes 50% energy consumption out of total energy consumption. But mostly we have seen this energy consumption is not used efficiently as Watt consumption is more and maintenance of HVAC system is not done regularly.

HVAC will recommend different types of air conditioner system for different application. The air conditioner system to be use which depends upon a factors including how long the area is to be cooled, the total heat generated inside the enclosed area, etc. Even though maintenance of HVAC was good solution earlier but nowadays proper handling is adopted by most of commercial institutions and therefore we have suggested whole procedure used for carrying out energy audit has given following with its different studied and analyzed aspect. Pumping & Lighting is an important loading on power system, but mostly we have seen in lighting that energy consumption is not used efficiently as lumen / watt consumption is more and luminous efficiency is less in terms of wattage. Even though fixture of CFL lighting was good solution earlier but nowadays LED lighting is being adopted by most of commercial institutions and therefore we have suggested replacement of earlier lighting with an energy efficient lighting to achieve energy conservation by using lighting system efficiently.

Whereas in case of pump energy audit, pump efficiency was calculated by collecting data, in this efficiency found very low with respect to head along with the flow capacity in liter/minute and thus concluded that due to selection of improper rating i.e. either overrating or underrating of pump, the pump efficiency get lowered and pump should always operate at its full rated capacity so that the maximum output can be obtained and ultimately the efficiency of the pump will increase. Whole procedure used for carrying out energy audit of hospital lighting loads & pumping loads, with its calculation, data observations, solution & suggestions has been given below .whole analysis & case study of this paper is carried out as per rules framed by BEE.

Major Electricity End-Users and Energy saving potential in Hospitals:

One of the main building types with a great potential to apply measures of energy saving is the hospitals. Below, some of the most important reasons why hospitals consume lot of energy and some simple ways to reduce their energy consumption are mentioned.

HVAC System:

In large and centrally air-conditioned hospitals, HVAC systems may consume 40% of total electricity consumption.

Air Conditioning and Ventilation system in hospitals is required for:

•Maintaining the requisite indoor temperature, air distribution and humidity levels for thermal comfort.

•Maintaining indoor air quality, particularly in areas requiring prevention of infection.

The big size of the rooms that have to be cooled makes the cooling of hospitals a very energy-consuming process. However, as temperature has to be stable and patients must feel comfortable, most hospitals have a central cooling system, which helps controlling electricity consumption by adjusting the desired temperature and the humidity at the central cooling system. However, thermal insulation improvement and the adequate maintenance of the system can reduce significantly the needs for cooling.

Lighting:

Lighting is a major electricity consumer next only to HVAC systems. Requirement of lights in a hospital varies widely depending upon the activity, time of day and the occupancy level. The complexity can be well understood from the simple fact that National Building Code (NBC) 2005 recommends illuminance level varying from one lux for night lighting in some areas to 750 lux in

operation theaters for general requirements. At times, special lights are used with illuminance of 10,000- 50,000 lux in operation theaters.
Lighting is a sector with great energy saving potential. At the places that have to be lightened 24 hours a day, high performance lamps can be used. Besides, some type of lamps that are put outdoors, consume lot of reactive load; as a result their performance is reduced. This issue can be addressed with the local use of capacitors for power factor correction. These could result in a 50% reduction in energy consumption.

Water Pumps:

Water is consumed in different sections of the hospitals for various requirements. In most hospitals, water pumping systems may account for 5-15% of total electricity consumption and offer scope for reducing energy consumption.

Electricity consumption:

Electricity consumption is very high in hospitals due to the continuous operation, the large rooms, the medical equipment and the electric motors. Bying equipment with low energy consumption, replacing old motors with new ones and local use of capacitors for power factor correction help to the reduction of energy consumption.

Energy saving measures can play a significant role for lowering energy consumption and energy costs, as well as for environmental protection. Energy consumption is responsible for CO2 emissions to the atmosphere that contributes to the "greenhouse effect".
- An important parameter for energy saving in the buildings sector is the high efficiency of the energy infrastructures, which requires excellent quality of the relevant equipment installed, as well as the compliance with all the requirements set by the legislation.

Energy Consumption Profile of AVBRH:

In AVBR Hospital, lighting and pump contributes about 32% (20% lighting + 12% Pump Load) of the total energy consumed in the hospitals. Lighting load includes tube lights, lamps, bulbs, TV, computer, fans, and UPS inverter charging of dc batteries for mobiles & laptops and pumping loads .On the other hand loads like HVACs, Cooking, Office equipments, Special equipments, refrigeration contributes the rest 68% of the total energy consumed. Energy saving opportunities are identified based on the share of each sector contributes.

METHODOLOGY

A. HVAC

The methodology adopted focuses on understanding the present energy baseline that identifies energy saving opportunities and achievability to implement the potential energy saving measures. In order to identify the energy saving opportunities, the energy use pattern has to be analyzed. Though energy audit targets the active energy consumption and power factor improvement this gives special prominence to reduce maximum power demand.
In all over process we used instrument for energy audit such as identification and quantification of energy necessitates measurements. The equipment which is used for identification and quantification are as follow.

Digital Temperature and Humidity Meter

It is used for the measurement of temperature and relative humidity of interior area, which contain the temperature and relative humidity sensor in the plastic box picture. It has to just put in the room and it shows the result. The upper reading shows temperature and lower shows humidity meter.

Digital Flow Meter

It is used for measurement of flow of AC, cooler, etc. It contains the fan gauge which is connected to the digital meter. When we keep meter in front of the low of AC's it shows the speed of the air at output of the AC's or coolers.

Table 1: Air Conditioner

Location	Type	Tonne	No of AC	Flow m/s	Vent Temp	Room temp	Rh
Seminar Hall	Split	1610W	1	3.6	23.68	31.6	36%
Blood Bank TTDRoom	Window	2500 W	1	3.3	16.6	29.8	54%
Dialysis Room(Door Open)	Centralize	8740W	1			28.6	57%

Observation:

- 197.75 tones of Packaged Air conditioners and 159 Window and Split AC are installed.
- Total approximate tonnage is around 525 TR.
- Total loading due to Air Conditioners is 630 kW.
- Total Energy Consumed by Air Conditioners is 367 kWhr
- Most Window and Split Air Conditioners are ill maintained.
- Doors at most rooms are left open, thereby increasing the load on the AC.
- Centralized AC's / Package AC's / Laminar AC's have no local operators, and hence they work in total in-efficient manner: Example, in the Ortho Building, First floor, two 7.5 ton AC are in parallel, supplying to the same duct. One AC was sending cold air at 7.5 degree C, whereas the other AC was working at 18 degree C. This was creating a high temperature of return air, and hence both the AC's did not get cut off.
- Water logging and high humidity was noticed in most Centralized AC rooms. This causes water condensation in the duct, and consequently dripping in the rooms.
- Excepting for few AC's, most of the AC compressors work for all the time, this causes high power consumption and frequent breakdown of AC.

Remedies:

- They need to be regularly maintained.
- At each location / room / ward, there should be a person responsible for running of the AC and Coolers. He / She will observe the working of the equipments, and shut them off.
- Install a Temperature / Humidity display in each Ward / ICU for the local operator to control the AC/ Coolers.
- In case the AC / Coolers are not working, then the Electrical Maintenance Department should be notified. They will follow up with the Outsource team, who will repair it and take consent of the local operator.

- 4 Data loggers for temperature / humidity control should be purchased which can log readings every 1 minute and sends the output in Excel graph through the USB port. This can be used both for pin pointing to the outsource agency, and keep a check on the local operator. This data logger can store data for more than 20 days at a stretch, and battery life is more than 3 years.

B. Lightning

Our target is to find out the net electrical energy consumption from different lighting loads (tube lights, lamps, bulbs, TV, computer, fans, and UPS inverter) connected in each & every room of hospital, this is done by carrying out an energy audit, this energy audit is for finding out average Lux, ILER (Installed load efficacy ratio) & lighting efficiency of overall room.
For example, suppose auditor has to do energy audit of a single room, then his aim should be as per information given below:

To calculate average Lux: - To know Room lux level (readings of 3 or 5 places) lux level readings can be taken by Lux meter). And then he will calculate average lux by taking average of no of readings .
To calculate Room Index:-To know overall size of room by taking length, width & height (length, width & height can be taken by digital distance meter)\
To calculate ILER (Installed load efficiency ratio):- therefore to find out actual lux/W/m^2 and to find out Target lux /W/m^2 depends upon Light Power per square meter and this is depends upon Average wattage reading of room.

Observations:

Table 2: Lightning

Room	Size L	Size W	Size H	Lux avg.	ILER
Main Building	10	11	11	35	0.02
Old Bulding	45	39	9	50	0.02
ENT Building	11	10	10	39	0.02
Ground floor Dental-OPD	13	9	9	47	0.03
Ortho Building	16	10	12	81	0.07
Ground floor HOD Cabin	10	13	10	125	0.07

Avg. LUX		
		Very Low Lux levels
		Lux Level are Border Line
		Good Lux Levels.

- Lighting load is not very high. Only around 80 KW
- However, the Lux levels are very poor at most places, which need immediate attention.
- Lux levels are to be improved immediately, and average Lux of 100 needs to be maintained for a comfortable work place ambience.

- Where ILER is below 0.5, lights have to be re-positioned, so that the Lux levels are maintained with less power consumption. All the locations where ILER is below 0.5 signify in-efficient lighting. At least 77% of the rooms fall under this category.
- Day lighting is also not effectively used in the wards.

Remedies:

- Installation of energy efficient fluorescent lamps in place of conventional fluorescent lamps
- Installation of LED panel indicator lamps in place of filament lamps.
- Installation of high frequency (HF) electronic ballasts in place of conventional magnetic ballasts.
- Use of high efficiency light sources for reducing the energy consumption for lighting.
- Solar Lighting Systems are providing to be a viable option because it involves no moving parts, low maintenance, and are simple to operate.
- More use of natural light during day time.

C. Pumps

During audit, we have collected all the electrical as well as mechanical data with the help of measuring instruments and then we have analyzed the obtained data to calculate the efficiency of the pump. For the measurement of the flow of the water through the pipe, we use digital flow meter. While measuring the flow of water, we have to select a straight pipe having maximum length by which accurate readings can be obtained. Then we have to set the ultrasonic transducer in such a manner that maximum ultrasonic wave transmitted by the transmitter can be received by the receiving transducer. The position and distance between the transducers is also important, hence transducer should always set at maximum signal strength.
For the flow, we have to insert an internal diameter of the pipe in the flow meter which can be calculated from the outer diameter and the thickness of the particular pipe by simple way i.e.
(Inner diameter=Outer diameter-thickness)

From the data collected, Input and Output Energy can be found out for the calculation of the efficiency. The Input is calculated as

$$Pi = \sqrt{3} \times V \times I \times 0.8$$

$$P_o = \frac{\rho * q * g * h}{3.6 * 10\text{^}5}$$

Where,

ρ= flow of liquid, q=density of liquid, g=gravity, h=Head of the Pump

$$\text{Efficiency} = \frac{P_o}{P_i}$$

Table 3: Pump

PUMP	GYNEC	Behind CVTS submersible	Behind CVTS submersible	ORTHO	MIDC
Velocity FPS	2.54	8.18	4.40	5.20	9.87
Flow LPM	68	401	296	424	403
Flow CuM /Hr	4.08	24.08	17.75	25.45	24.19
Pipe Outer Dia	2.00	2.50	3.00	3.00	2.50
Pipe Inner Dia	1.70	2.30	2.70	2.80	2.10
Pipe Thickness	0.15	0.10	0.15	0.10	0.20
Head Ft	70.00	51.00	51.00	47.70	3.50
Head M	21.34	15.54	15.54	14.54	1.07
Time	0.51	0.68	0.69	0.61	0.57
Efficiency %	9.97	29.66	61.56	37.90	1.67

Observations and Remedies:

- As per the website of the pump manufacturer's, these pumps are for high head, i.e. head above 25 meters. However, we are using it on low heads
- Only one pump (Behind CVTS) has acceptable efficiency.
- MIDC Pump is the least efficient since the head is very low, and the pump used is not designed for this head. We need low head high flow pump.
- The pump in GYNEC department needs to be checked. The output flow is very low.
- Pumps are also running dry, or overflowing. Need to install dry run protection, and tank overflow protection. This will cost less than Rs. 7500/- per pump.

Graph performance:

Here we have carried out a detailed energy audit in AVBRH, especially of hospital premises with its systematic methodology. The following are some observations that have been observed:

i. **Percentage Load Distribution of system:**

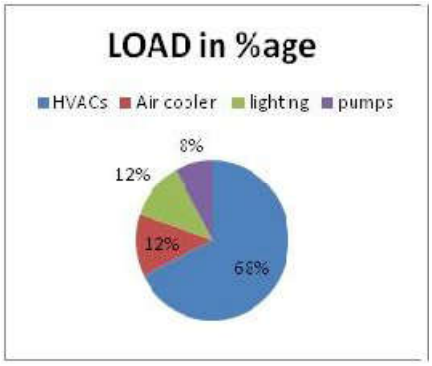

Figure 1. Load Distribution in percentage

ii. Power Factor:

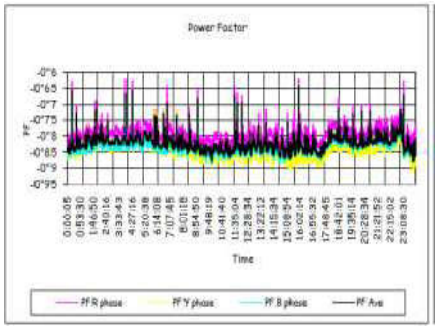

Figure 2. Power Factor

We observed that power factor is extremely poor in night hours. It goes up to 0.7 and then it improved in working hours in the day. The different power factor on different phases is shown in the graph. The power factor of R phase is extremely poor during noon period of time and it fluctuating from 0.85 to 0.7. That would dangerous for the system. And power factor on Y and B phase are quite similar and it's fluctuating from 0.8 to 0.88 that is acceptable for the system. Main thing is that we observed that the capacitor bank not worked properly. It can be improved to 0.85.

iii. Active Power

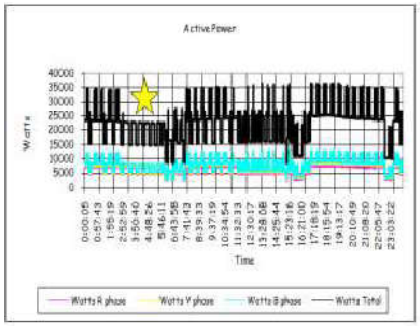

Figure 3. Active Power

Here constant load of 25Kw at starting interval. In which it shows active power on R, Y and B phases. On B phase we can see 13Kw during time 2:223pm and goes down to 7.5Kw at 2:46pm to 4:03pm, again sudden falls down to 2Kw. And again rose up to 11Kw as shown in the above graph. In first graph Star check point shows acceptable active power and in another graph star check point shows which is not acceptable yet for the system. This shows that the load on B phase higher than other two phases and total active power is 35Kw on time 14:23pm. This is constant for two hours.

iv. Reactive Power:

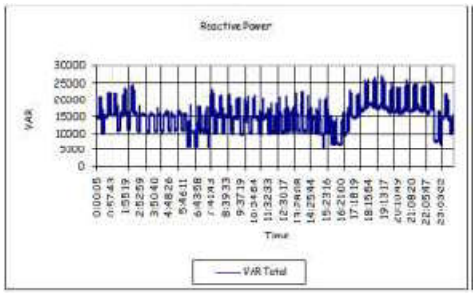

Figure 4. Reactive Power

Above graph shows the reactive power is varying during 2:23pm to 2:46pm between ranges of 15 kVAr to 23 kVAr and suddenly falls down to 2.5 kVAr and then constant for 7.5 kVAr till 3:03pm. It raised up to 23 kVAr and continuously fluctuating between ranges of 15 kVAr to 24KVAr. Relative compensation of 15KVAr can be given.

CONCLUSION

Conducting an energy audit is one of the main objectives in identifying the potential areas of the unit for energy conservation. A simple and minor change in the system can conserve energy and bring down the utility of energy to a greater extent and also various solutions have been suggested to authority of hospital for using energy in efficient way instead of wasting energy into excessive consumption and therefore our objectives of energy conservations is fulfilled. It is also reported that the audit was aimed at conservation of energy in Hospital only. If energy audit for the entire institute is conducted the quantitative energy conservation will be more.

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