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Energy audit: Case study of an Institute

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ABSTRACT

India's economy is affected immensely by the consumption of energy. Excessive use of fossil fuels for the generation of energy not only increases emission of greenhouse gases but it also increases the cost of energy. In this project we highlight that Energy Audit is a continuous process to minimize the losses occurring at consumer end. By suggesting an alternative energy source, the thesis of this project, provides an opportunity to reduce carbon footprints, become energy efficient and in turn support capital investment.

Keywords— *Energy audit, Energy conservation*

1. INTRODUCTION

The College of Engineering was established in 2009. It has a vast infrastructure and significantly huge electrical system. It is an accepted fact that it spends a large amount of financial resources on providing uninterrupted energy throughout the campus. Execution of audit on this campus has given us a brief knowledge of total installed load and consumption pattern. Thus, providing energy saving opportunities. The college is located in Maharashtra. Power to this area is supplied by MSEDCL.

2. INSTITUTE

2.1 Architecture

The College is divided into 4 blocks i.e. A, B, C, D block. These four blocks have different metering panels for separate load panels. The load in each floor is varying and has its own power supply from the main node.

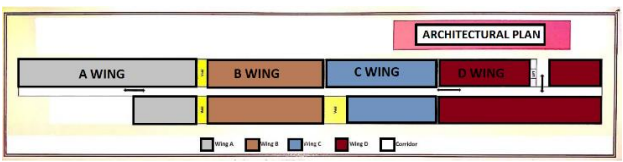

Fig. 1: Architectural Plan

2.2 Distribution System

MSEDCL supplies 22kV HT supply to the college which further is stepped down to 415V by 1000 kVA transformer. This 415 V is distributed to the main node of the engineering building. An APFC with a rating of 340kVAR is installed to maintain the P.F close to unity. In case of power failure there is an emergency backup DG set which provides electricity to the engineering building. The supply to the engineering building is from the main node which then distributes power to A, B, C& D block. All the blocks have their independent power meters.

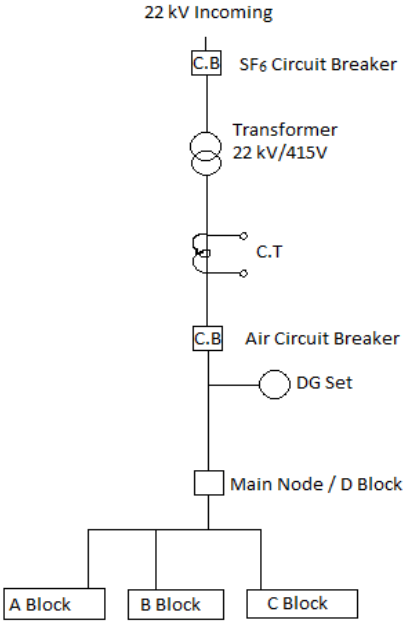

Fig. 2: Single Line Diagram

3. METHODOLOGY

3.1 Data Collection

3.1.1 Load Survey: The total installed capacity has been audited from Sept. 2019 to Jan. 2020 which provides profound insights of the demand load. This further gave us the knowledge of the total connected load on the four wings of the building. The categorization of load is done, which gives us in-depth knowledge of types of load. The entire connected load of the building is 258.45 kW comprising of loads like light, fan, AC, Computer, Cooler as well as 3phase load.

Table 1: Connected Equipment

Room	A Block	B Block	C Block	D Block	Total no. equipment
CFL Bulb (15 W)	468	422	340	10	1240
LED Bulb (10 W)	3	0	0	35	38
CFL Light TL (40 W)	138	496	466	453	1553
LED Light TL (20 W)	35	113	77	200	425
Fan (60 W)	184	226	184	223	817
PC (110 W)	5	138	106	376	625
Printer (80 W)	3	10	6	24	43
Projector (150 W)	0	1	0	9	10
AC (1250 W)	1	9	6	20	36
Exhaust Fan (40 W)	0	6	2	0	8
Water Cooler (750 W)	0	1	5	0	6

Total number of connected equipment of institute is shown in Table I. The illumination in the institute is covered by sunlight as well as lighting equipment. The total light fittings are **3256** which comprises of CFL Bulb, LED Bulb, CFL TL and LED TL. Another major type of load is Computer there are 19 labs, HOD cabins and other rooms constituting of **625** Computers. These labs and rooms are equipped with a total of 36 Air conditioners. There are also printers in the computer labs and xerox rooms where they are used occasionally at the time of need.

There is a total of 6 water coolers used daily by the students. The 6 exhaust fans in chemistry labs are only used at the time of any practicals. Total of 10 projectors are only used when there is any guest lecture or presentations scheduled.

3.2 Data Analysis

3.2.1 Load Wise Consumption: Load wise consumption is the total connected load multiplied with the no. of hours the loads are on for in a month. Hence, showing the monthly consumption of the load in kWh. This consumption gives us a generic idea of the load pattern of the college.

Table 2: Connected Load

Room	A Block (in W)	B Block (in W)	C Block (in W)	D Block (in W)	Total connected load (in W)
CFL Bulb (15 W)	7020	6330	5100	150	18600
LED Bulb(10 W)	30	0	0	350	380
CFL Light TL (40 W)	5520	19840	18640	18120	62120
LED Light TL (20 W)	700	2260	1540	4000	8500
Fan (60 W)	11040	13560	11040	13380	49020
PC (110 W)	550	15180	11660	41360	68750
Printer (80 W)	240	800	480	1920	3440
Projector (150 W)	0	150	0	1350	1500
AC (1250 W)	1250	11250	7500	25000	45000
Exhaust Fan (40 W)	0	240	80	0	320
Water Cooler (750 W)	0	750	3750	0	4500
Connected Load (kW)	26.350	69.610	56.040	105.630	257.630

We have come across some loads which are seasonal, as we all know that the engineering course is based on semester pattern. So, for each semester there are different experiment which requires different machine in that case the other machines are in off condition. Likewise, the demand keeps varying. The power consumption also varies because during non-academic days like holidays, exam preparation, vacation the power consumption is very less.

Loads are segregated wing wise which have their own power supply from the main node. Also, the consumption of the loads is taken according to the operation time. The total connected light load including CFL and LED (bulbs and tube lights) is18600+380+62120+8500 = 89600Wi.e. 89.6kW which is multiplied by 7 hrs daily in a month excluding Sundays and Saturdays. There are total of 25 days excluding Saturdays and Sundays. So, for total consumption in a month:89.6*25*7= 15680 kWh.

The total fans in the college are817with rating of 60W.These fans contribute a major amount of the bill. The total fan load is 49020W i.e. 49.02kW. These fans are not on for7hrsstraight in the whole month. The consumption calculations are shown below accordingly:

At summer season (31 days i.e. for months of summer) – no. of hours the fan is on is 7hrs = 49.02*7*25 = 8578.5 kWh

At winter and rainy season (31 days i.e. rainy and winter months) – no. of hours the fan is on is 4 hrs = 49.02*4*25= 4902 kWh

The total ACs in the college is36 which has a rating of 1250 W. The total AC load connected in the building is 45000 W i.e. 45kW.ACs being seasonal are used on high temp. days which consume more electricity. The calculations for the ACs are done same as that of fans. The total consumption for the same is: At summer season (25 days i.e. four months of summer) – no. of hours the AC is on is 5 hrs = 45*5*25 = 5,625 kWh

At winter and rainy season (192 days i.e. rainy and winter months) – no. of hours the AC is on is 2 hrs = 45*2*25= 2,250 kWh

There is a total of 625 computers in the whole college which contribute a major amount of bill if used for 7 hrs straight. The total connected computer load in the college is 68750 W i.e. 68.75 kW. Since the computer loads are on only at the time of need. So, the total consumption of the computer in whole year excluding Sundays is= 68.75*4*25 = 6,875 kWh

The projectors are another aspect of smart education which has connected load of 1500 W i.e. 1.5 kW in the building. It being a very small load and an occasional load is counted in no. of hours i.e. only 7 hrs in a month (in avg.). 1.5*7 = 10.5kWh

There is a total of 6 water coolers. The total connected load of the water cooler is 4500 W i.e. 4.5 kW.The water cooler being on for 7hrs. So, the total consumption of the cooler is = 4.5*7*25=787.5 kWh

3.2.2 Block Wise Consumption: Energy consumed per wing in the table below is calculated by the given equation.

*Formula - No. of Equipment (from TABLE I) * Ratings (from TABLE II) * Hours of Usage =

Daily Consumption.

*Formula - Daily Consumption * 25

Monthly Consumption

Table 3: Block Wise Consumption

Room	A Block (in Wh)	B Block (in Wh)	C Block (in Wh)	D Block (in Wh)
CFL Bulb (15 W)	49140	44310	35700	1050
LED Bulb (10 W)	210	0	0	2450
CFL Light TL (40 W)	38640	138880	130480	126840
LED Light TL (20 W)	4900	15820	10780	28000
Fan (60 W)	77280	94920	77280	93660
PC (110 W)	2750	75900	58300	206800
Printer (80 W)	480	1600	960	3840
Projector (150 W)	0	150	0	1350
AC (1250 W)	6250	56250	37500	125000
Exhaust Fan (40 W)	0	480	160	0
Water Cooler (750 W)	0	5250	26250	0
Daily Consumption in kWh	179.65	433.56	377.41	588.99
Monthly Consumption in kWh	4491.25	10839	9435.25	14724.75

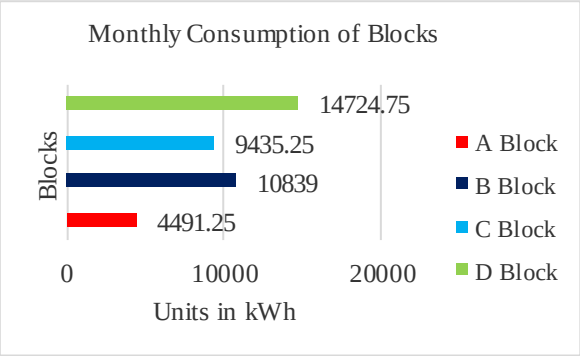

Fig. 3: Graph of Monthly Consumption

4. SOLUTIONS

4.1 Providing Alternate Energy Source as Solar PV Installation

Observing the massive consumption of engineering campus, installing renewable energy source can prove to be a substantial solution to support financial management and conserve environment by reducing use of conventional power from grid.

- Subsidy can be claimed depending on the type of building. Commercial set ups can claim depreciation cost, 40% for the first two years and 20% for the remaining year.
- Per Kw energy to be generated requires 100sqft of area.
- One solar panel on an average produces 320W.
- 1kW of solar plant generates 135 units (i.e. 4.5hrs x 30 days)

Block	Load (W)	(kW)	Consumption [calculated] (kWhr)
A Block	26350	26.35	179.65x 25(days) = 4491.25

As per availability of rooftop area, solar energy can be generated equivalent to the consumption of A block.

- In case of A block, no. of units required to supply load monthly is 4491.25 kWh.
- Therefore, capacity of solar power plant required in kW = 4491.25/135 = 33.26 kW
- To find out area required to install 33.26kW of solar plant =33.26 x 100 = 3326sqft
- Further, No. of panels required = 33260/320 = 103.9 equals approx. 104 panels.
- Cost involved:Panels + inverter + ACDB + DCDB + wiring.
- Per watt cost for solar energy is Rs.27, =27 x 33260= 8,98,020/- (panel cost)
- Payback period: Depreciation cost - Can claim 40% for first two years and 20% for third year.
- Therefore, 40% of 8,98,020 = 3,59,208/- (1st year)
- 8,98,020 – 3,59,208 = 5,38,812/-
- 40% of 5,38,812 = 2,15,524/- (2nd year)
- 5,38,812 - 2,15,524 = 3,23,288/-
- 20% of 323288 = 64,657/- (3rd year)
- Total depreciation cost recovered out of 8,98,020 will be 6,39,389/-

4.2 Replacement of 40 W CFL TL with 20 W LED TL

- Total No. of CFL Tube lights in Campus =1553
- CFL Tube Light average power = 40 W.
- LED Tube Light average power = 20 W.
- Difference in power saved per Tube Light = (40-20) W =20 W.
- Total Power saving = 1553*20W = 31060W= 31.0 kW.
- Average Use of Tube Light per year = 270*7h=1890h.
- Energy saved per year = 31.0 kW *1890h = 58590 kWh.
- Per year saving = 58590*9.5=Rs 556605
- LED tube light average cost = Rs. 450/piece
- Total Cost of Replacing all Conventional tube lights = 1553*450 = Rs.698850.
- Payback time = Rs698850/556605= 1.3yrs.

So, the payback time required for replacing all CFL Tube lights of the campus with LED Tube lights is around 1.3 year.

4.3 Replacement of 15 W CFL Bulb with 10 W LED Bulb

- Conventional Bulb average power = 15 W.
- Total No. Of conventional bulb in campus = 1240
- Difference in power saved per Bulb = (15-10) W = 5 W
- Total power saving = 1240 * 5W = 6200W = 6.2 kW
- Average Use of Bulb per year = 270*7h =1890h.
- Energy saved per year =6.2*1890kWh=11718kWh
- Per year savings = 11718*9.5 = Rs.111321
- LED bulb average cost = Rs 34 /piece
- Total cost of replacement of all conventional bulb = 1240 * 34 =Rs 42160
- Payback time = 42160/111321 = 0.4 yrs.

So, the payback time required for replacing all CFL bulbs of the campus with LED bulbs is around 0.4 years.

4.4 Use of Motion Sensors in Corridors

- Total number of tube lights in a corridor = 209
- Tube lights average power = 20 W
- Total motion sensors = 64
- Energy consumption reduced by use of motion sensor = 2 h
- Per year energy saved in corridor = (209*20*2*270)/1000 = 2257.2 kWh.
- Per year saving in Rs = 2257.2x9.5 = Rs. 21,443.4
- Motion sensor approx. cost = Rs. 450.
- Total cost of installing motion sensors in a corridor = 64*450 = Rs. 28800
- Capital Cost Recovery Time = (28800/21443.4) = 1.34 yrs.

4.5 Use of Motion Sensors in Washrooms

- Total number of tube lights in a Washroom = 84

- Tube lights average power = 20 W
- Motion sensors = 84
- Energy consumption reduced by use of motion sensor = 2 h
- Per year energy saved in corridor = (84*20*2*270)/1000 = 907.2 kWh.
- Per year saving in Rs = 907.2*9.5 = Rs. 8618.4
- Motion sensor approx. cost = Rs. 450.
- Total cost of installing motion sensors in a corridor = 84*450 = Rs. 37,800
- Capital Cost Recovery Time = (37800/8618.4) = 4.38 yrs.

5. CONCLUSION

Comprehensive attempt to improve energy management of college campus has been made by adapting energy audit methodology. This paper provides brief solutions, to significantly reduce energy consumption of the building. By implementing the solutions that are suggested, the institution can save financial resources as well as contribute towards energy conservation.

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