ENERGY AUDIT: A CASE STUDY OF AN ACADEMIC BUILDING

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Abstract—Energy is very important constraints in all sectors for any country’s economy. The economic development of any country is closely linked with consumption of energy. Coal and gas are conventional sources of energy and available in limited forms. Both this sources are important for electricity generation. It is very necessary to optimize use of natural resources and it is necessary to avoid energy crisis. Energy demand has increased as its consumption is increased so proper energy conservation methodology to be adopted. Energy conservation avoids wasteful use of energy. Energy saving achieved through energy efficiency and conservation also avoids capital investment in fuel, mining, transport, water and land required for power plant, thereby mitigating environmental pollution.

A study of energy audit and conservation is carried out in many different sectors like industrial and agriculture. Academic sector is one of the major energy consuming sectors. This paper has mainly focuses on identification of energy conservation in academic sector. Academic sector consist of many schools, colleges of different field. This paper deals with the energy audit of an engineering college.

Estimation of monthly energy consumption is studied through analysis of electric bills. Energy conservation areas are identified. The purpose of this paper is to carry out energy audit of the institute offering engineering programs. It will help to implement the energy efficient project for improving energy efficiency in academic building.

Index Terms—Energy Audit; Energy Conservation;

I. INTRODUCTION

Energy crisis is one of major problem in exiting world where demand of energy is increasing rapidly. Energy is prime focus due to rapid growth and development of technology. Proper utilization of Energy is one of the major aspects of any developing country. Today the need of energy has increased greatly in order to meet the demand of ever-increasing consumption of it. This energy crisis problem will be solved through Energy conservation and use of energy efficient equipment [1].


This paper is an attempt to carry out energy audit of Government Engineering College Aurangabad. The organization of paper is as follows; Section II describes about layout of institute building Section III discussed about the single line diagram of electrical distribution system in institute. Section IV discussed energy audit methodology. Section V discussed about load survey. Section VI discussed about the replacement techniques. Section VII discussed at the results and conclusion.

II. ABOUT INSTITUTE

Government College of engineering at Aurangabad is one of the oldest engineering colleges in Maharashtra. Initially the institute offered UG programs in three core branches i.e. Civil, Mechanical Electrical with intake capacity 60 students per branch leading to Bachelors degree of Engineering in respective disciplines. Subsequently additional UG programs such as Electronics and Telecommunications, Computer Science and Engineering and Information Technology have been added. Electrical load can be categorizes on layout in lighting, motor and other such as computers, printers.

Aurangabad is situated on latitude of 19° 53’ N and longitude of 75° 23’ E. Figure 1 shows the layout of college building. The Total area covered by the all departments, including library and hostels is 8016.96sqm. As per the latitude and longitude of Aurangabad area, the sunrays availability is high in the summer and moderate in rest of month. As maximum sunrays arises from the north of east side and drop down to south of west.
achieve energy efficiency. It includes monitoring and analysis of different energy consuming equipments and proper action plan to reduce extra energy consumption in the building. Energy auditing of any institute or building can be possible by collecting energy consuming data and analyze those data to find out unnecessary use of energy. Following methodology adopted for energy audit.

A. Data Collection
Data collection is very important step in energy audit. Data collection includes,
2. List of lighting load, fan, computer and air conditioner for each department.
3. Voltage, Current and Power are measured at each feeder.

B. Data Analysis
Data analysis is next important step after data collection. The areas for implementation and energy conservation opportunities are identified.

C. Action Taken
Action taken involved the implementation strategies based on measurement of actual energy consumption. In this methodology different areas of energy consumption are identified.

V. SURVEY OF LOADS
The survey of electrical load is carried out to determine the connected load of institute. The number of quantity of connected load in the institute is measured and presented in table 1. Load is categorizes in different category like lighting, fan, AC and computer.

<table>
<thead>
<tr>
<th>Place</th>
<th>Lighting Load</th>
<th>Fan Load</th>
<th>AC Load</th>
<th>Computer Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>Administrative Zone</td>
<td>29</td>
<td>43</td>
<td>17</td>
<td>31</td>
</tr>
<tr>
<td>Computer Science</td>
<td>178</td>
<td>5</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Electronic Dept</td>
<td>67</td>
<td>11</td>
<td>60</td>
<td>97</td>
</tr>
<tr>
<td>Mechanical Dept</td>
<td>114</td>
<td>52</td>
<td>70</td>
<td>7</td>
</tr>
<tr>
<td>Library</td>
<td>45</td>
<td>32</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>157</td>
<td>78</td>
<td>90</td>
<td>98</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Place</th>
<th>Lighting Load</th>
<th>Fan Load</th>
<th>AC Load</th>
<th>Computer Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applied mechanic Dept</td>
<td>157</td>
<td>78</td>
<td>90</td>
<td>98</td>
</tr>
<tr>
<td>Class room Complex</td>
<td>124</td>
<td>42</td>
<td>92</td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td>923</td>
<td>292</td>
<td>493</td>
<td>108</td>
</tr>
</tbody>
</table>

| Total KW rating | 923 + 923 + 292 + 8 | 5000 | 493 + 493 + 108 | 5877.99 |

| Total KW rating | 480 | 72 | 108 | 22 | 5877.99 | 5877.99 |

| Total KW rating | 480 | 72 | 108 | 22 | 5877.99 | 5877.99 |

**TABLE 1: ELECTRICAL LOAD**

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III. ELECTRICAL DISTRIBUTION SYSTEM

Institute is supplied through 315 KVA Transformer of 11 kV/440V range. The power supply is for academic sector and Hostel is provided through the same transformer. An APFC panel having 200 A, is provided to maintain power factor close to unity. DG set of 115 KVA is used for emergency backup supply for few essential loads of the college buildings. The incoming supply to college is 11 KV which is step down to 440 V by using 315 KVA transformers. This voltage is supplied to each department in college, workshop, library, boys’ hostel and girls’ hostel. Following figure gives the single line diagram.

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IV. ENERGY AUDIT METHODOLOGIES

Energy audit is defined as “the verification, monitoring and analysis of use of energy including submission of technical report containing recommendation for improving energy efficiency with cost benefit analysis and an action plan to reduce energy consumption”. Energy audit is one of the important tools for energy conservation in order to
Table 1 shows the quantity of connected load of institute and their KW rating. From this table energy consumption usage is calculated.

The lighting load consumes 43.959 KW. It includes 923 fluorescent tubelights of 40 watt each. The institute also consists of 392 compact fluorescent lamp of 18 watt each. Maximum portion of institute never get sufficient sunlight during day time so continuous lighting is required during working hours. The complete lighting load in terms of Kwh is calculated for 8 hrs per day. Hence total energy consumption through lighting load is as.

Duration of use of lights in one year excluding Sundays
= 8 hrs*313 days
=2504 hrs
Total energy consumption =43.959*2504 hrs
=110073.336 kWh

Another important load which consumes maximum energy is fan load. The institute consists of 493 fans having 100 watt each. The total fan load consumes 49.31 KW. Although the loading of fan is more than lighting load, still it is less effective in increasing electricity bills since it is not required during winter and rainy season. The complete fan load in terms of Kwh is calculated as

Duration of use of fan in one year excluding Sundays
= 8 hrs*121(Four months of summer) + 4hrs*192 (Rainy and winter months)
=1736 hours
Hence fan load in one year is 49.31*1736 =85602.16 Kwh

Computer and air conditioner load are also plays an important role in energy consumption. The total computer load consumes 27.09 KW. The total numbers of computers are 387 but all the computers are not in running condition during whole day. Only for few hours in a day, that is during practical’s hours and sometime for official work computers are required. The total computer load is calculated as.

Duration of use of computers in one year excluding Sundays
= 4 hrs*313
=1252 hrs
Total energy consumption =27.09*1252
=33916.68 kWh

Air conditioner consumes more energy during summer season only. The total AC load consumes 72 KW. Total numbers of AC’s are 48 having 1.5 KW of each. Total AC load is calculated as .

Duration of use of AC in one year excluding Sundays
= 5 hrs*182
=910 hrs
Total energy consumption =72*910
=65520 kWh

A. Energy Consumption Pattern

The above mentioned methodologies have been applied and similar kind work is carried out for preparing energy audit report of engineering institute. Figure 4 shows the pie chart of connected load in various departments.

Though the lighting load seems to be less compared to other load, energy consumption is more of lighting load. As lighting load consumes maximum amount of energy throughout the year. The energy consumption graph is plotted in figure 4 which shows the percentage of energy consumption by each load in institute.

![Energy Consumption Pattern Pie chart](image)

From the connected load distribution pie chart shown in figure 4, it is clearly observed that load which occupied maximum connected load are lighting load and fan load. Out of this connected load, lighting load can play major role in consumption of energy since lights will be continuously in running condition through the day so analysis of each department is done to calculate the mitigation of lightning load in order to reduce the wasteful energy consumption and also to reduce the electricity bills of college.

VI. ENERGY SAVING TECHNOLOGY

Total connected load distribution consists of 37 % of lighting load. Lighting load plays very important role in energy consumption compared to rest of load. So the focus is mainly given to reduce lighting consumption so that ultimate result will be having less electricity bill. The lighting load of college consists of 923 FTL tubes.

During the data collection and data analysis process it is found that there are following spaces which are having more number of extra lights than required. Table 2 shows the required number and actual number of tubelights for given number of area.

The system under considerations is calculated using the following methodology.

To calculate number of tubelights we consider the number of required lumens for given area.

It is given by the formula.

\[
\text{Lumens} = \frac{\text{Lx}}{\text{area}}
\]

Energy savings/yr = Total energy consumption by
FTL- Total energy consumption by T5

Savings in Rs/yr = Energy savings in KWh \ast \text{cost of one unit}

During the complete survey of all departments and analysis of monthly electricity bills, it is come to know that proper use of existing lightening systems is the major solution for the energy conservation.

**Table 2: Comparison of 40 W and 28 W**

| Sr. no | Types of space | Existing FTL | Total amp | Required T5 | Difference of amp | Savings in watt |
|--------|----------------|--------------|-----------|-------------|--------------------|-----------------
| 1      | Classroom      | 259          | 1746.91   | 158         | 81                 | 228             |
| 2      | Seminar hall   | 108          | 250.6     | 46          | 62                 | 1736            |
| 3      | All types of lab | 201        | 1219      | 132         | 69                 | 1932            |
| 4      | Controller of exam and computer center | 52       | 302.85    | 27          | 25                 | 700             |
| 5      | Hostel        | 204.50       | 23        | 27          | 756               |
| 6      | Departmental library | 40       | 254.09    | 27          | 13                 | 364             |
| 7      | Toilet        | 257          | 8         | 12          | 336               |
| 8      | Mechanical workshop | 54      | 321.6     | 35          | 19                 | 532             |
| 9      | Library       | 57           | 52.0      | 30          | 21                 | 588             |
| 10     | Teacher cell  | 88           | 8         | 8           | 84                |
| 11     | Office        | 51           | 6         | 9           | 522               |
| 12     | T.V.          | 51           | 130       | 13          | 50                 | 840             |
| 13     | T.P.          | 40           | 5         | 8           | 724               |
| Total  | 923           | 5104.11      | 544       | 379         | 10612             |

**B. Replace 40 W tubelight by 28 W T5**

Wattage of existing lamp = 40 watt

Duration of use of lamp in one year excluding Sundays

\[= 8 \text{ hrs} \ast 313\]

= 2504 hrs

Total number of lamps = 923

Total energy consumption = 923 \ast 40 \ast 2504 \text{hrs} = 92447.68 \text{KWh}

Wattage of T5 = 28 watt

Difference in wattage of lamp and T5 = 40 - 28

= 12 watt

Total energy consumption by T5 = 28 \ast 544 \ast 2504 = 38140.928 \text{KWh}

Difference in energy consumption = 92447.68 - 38140.928 = 54306.752 \text{KWh}

**C. Saving in energy bill**

Cost/unit @ Rs 7.65 (1unit=1kwh)

54306.752 kWh \ast 7.65 = 415446.653 Rs/annum

Cost of 40 watt lamp = 50 Rs/lamp

Cost of total 923 tube light = 923 \ast 50 = 46150 Rs

Cost of one 28 watt T5 = 180 Rs

Cost of total 544 T5 = 544 \ast 180 = 97920 Rs

As per as purchasing of T5 bulbs instead of tubelight are concerned, we have to pay 51770 Rs extra. But life of T5 bulb is more than that of tube light also we are saving 38140.928 Rs annually as per above calculation. So in overall we can save money as well energy.

**Table 3: Replacement of FTL to T5**

<table>
<thead>
<tr>
<th>No.</th>
<th>Number of Tubes to be replaced</th>
<th>Average Usage hours/h/day</th>
<th>Power consumption/W</th>
<th>Daily Consumption of Electrical Geyser/Wh/day</th>
<th>Total savings by replacement/ Rs./KWh</th>
<th>Total Rs./quantity/ Rs./quantity</th>
<th>Yearly working days/year</th>
<th>Yearly Savings/ Rs./year</th>
</tr>
</thead>
<tbody>
<tr>
<td>544</td>
<td></td>
<td>8</td>
<td>28</td>
<td>224</td>
<td>8.56</td>
<td>180</td>
<td>313</td>
<td>38140.928</td>
</tr>
</tbody>
</table>

**VII. Results and Discussion**

From the consumption pattern of electricity bill graph shown in figure 5, it is observed that during the year 2013-14 energy consumption is increased linearly from Jan to July and then drop suddenly in August and further it increased from August to December. During this year maximum energy consumption is recorded in the month of July. During the year 2014-15 energy consumption is found maximum in the month of May. The energy consumption in the year 2014-15 is much less compare to year 2013-14 due to replacement of 40 watt fluorescent tubelight by 28 watt T5. The average energy consumption in year 2013-14 is 44322.41 KWh and average energy consumption in the year 2014-15 is 25681.83 KWh. The reduction in average energy consumption during both years is 18640.57 KWh.

**Conclusion**

Energy audit is an effective tool in identifying problems associated with energy management program. A careful audit in any organization will lead to manage energy system in organization at minimum energy cost. In development process to cope with increasing energy demands, energy conservation and
energy audit are two parallel paths.
In this paper we have considered the academic sector for evaluation of energy audit and energy conservation of government engineering college of Aurangabad. Key issues pertaining to the implementation of Energy Conservation proposal and methodology have been discussed in detail. Based on the exhaustive literature survey were presented for energy conservation and energy audit in keeping mind the present Energy scenario and future condition.

We have documented load distribution of institute, based on the pie chart of load we have concluded that lighting load is more energy consuming than other connected load. In this paper we have replaced 40 w FTL by 28w T5 lights. The whole paper concludes that

1. Total Number of units saving in lighting replacement will be 54306.752
2. If we replace FTL by T5 then total savings is 38140.928 Rs annually.
3. The reduction in average energy consumption in electricity bills during 2013-14 and 2014-15 years is 18640.57 KWh.

REFERENCES


