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ENERGY AUDIT OF AN ENGINEERING COLLEGE IN KERALA

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ABSTRACT

The primary purpose of Energy Audit is to reduce the energy costs and improve the energy efficiency. In this comprehensive study, various factors such as energy consumption trends, connected loads, and energy layout were meticulously analyzed through a detailed audit conducted at Govt. Model Engineering College in Kochi. Furthermore, a cost benefit analysis was performed, giving insightful recommendations on more efficient approaches to reduce energy consumption and associated costs. Identification of the other issues at college which were causing the decline in energy efficiency was a key outcome of this study. The data and information collected from this study is documented.

KEYWORDS: ***Energy Audit, Energy efficiency***

INTRODUCTION

According to Bureau of Energy Efficiency (BEE), Energy Audit means the verification, monitoring and analysis of use of energy including submission of technical report containing recommendations for improving energy efficiency with the cost benefit analysis and an action plan to reduce energy consumption. By conducting energy audits, it is easy for us to identify where the energy is being used inefficiently and cost-effective solutions can be implemented to reduce the energy waste. It also contributes to environmental sustainability.

In a country like India there's a growing demand for energy, but there are only limited energy sources to meet this demand. One of the answers to this problem is energy conservation. Energy conservation is the act of reducing wasteful energy consumption. This can be achieved by efficient and judicious use of energy. Increased energy efficiency is also an important way to meet the shortfall in the energy supply.

The main vision of this audit is to make the institution Govt. Model Engineering College energy efficient by identifying the energy wastage areas and balancing the loads. The Energy audit at the college was done several years ago after which there have been several add-ons to the system. Hence this audit is highly necessary for Govt. Model Engineering College.

Gousia Sultana's [3] mentioned in her paper on energy audit conducted at Nandi Institute of Technology that the energy needs of the college will increase as the institute is planning to start new two branches which requires installation of heavy machineries and because of this it is necessary to reduce energy consumption. As per the recommendations put forward by her, the energy consumption was expected to reduce by 41.66%.

Several energy audits have been conducted in technical institutions such as audit done by Takshila Bhandari's [1] at Govt College of Engineering, Aurangabad, and Chikku Abraham's [2] audit in the IIT Bombay campus, focusing on reducing energy consumption and increasing the energy efficiency.

Our audit is done in three phases – pre audit, audit, and post audit. It focuses on improvement in energy efficiency, equipment management, cost effective strategies for long-term energy and cost savings.

PROBLEM STATEMENT

With an average consumption of 18,000 units, Govt. Model Engineering college spends around 1.5 to 2 lakhs per month on electricity bill. Even though we have solar panels of capacity 30 kW installed at college, the electricity bill seems to be increasing. Also, the college is making a new building that will have 2 floors and more than 12 classrooms. In this scenario, we are expecting the current bill to raise at least by 30,000 to 40,000 rupees. The only way to reduce the energy consumption and thereby the electricity bill is to use the energy efficiently and to make more use of the renewable energy sources.

OBJECTIVE

Our goal is to help the college by doing cost benefit analysis and coming up with a plan to help the college reduce electricity bill by 20-40% even after the addition of the new building. Since heavy machineries are operated at the college, increasing the solar panel capacity can also be very beneficial.

RESEARCH METHODOLOGY USED

There are two types of energy audits: Preliminary Audit and Detailed Audit. We are use the Detailed Audit in this study as it is proved to be the more efficient one. There are three phases in the detailed audit:

a. Pre – Audit
   In this phase, initial site visit and the preparation required for the detailed audit was done.

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- Analysed the major energy consumption data with the relevant personnel, obtaining site drawings - building layout, electricity distribution etc.
- Collected macro data on the major energy consuming centers.

b. Audit

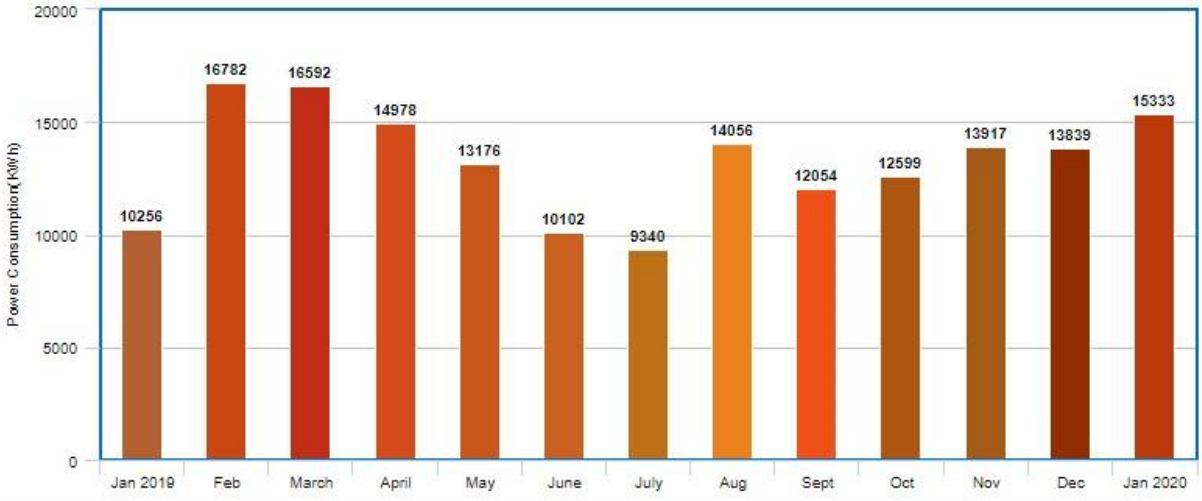
- Analysis of the energy consumption pattern connected load, energy waste centers, and utilization of renewable sources based on the data collected in the pre – audit phase.
- Preparation of process flow charts, all service utility system diagram (Single line power distribution diagram).
- Recorded the annual energy bill and energy consumption pattern.
- 24-hours power monitoring (Maximum Demand, PF, KWh etc).

c. Post - Audit

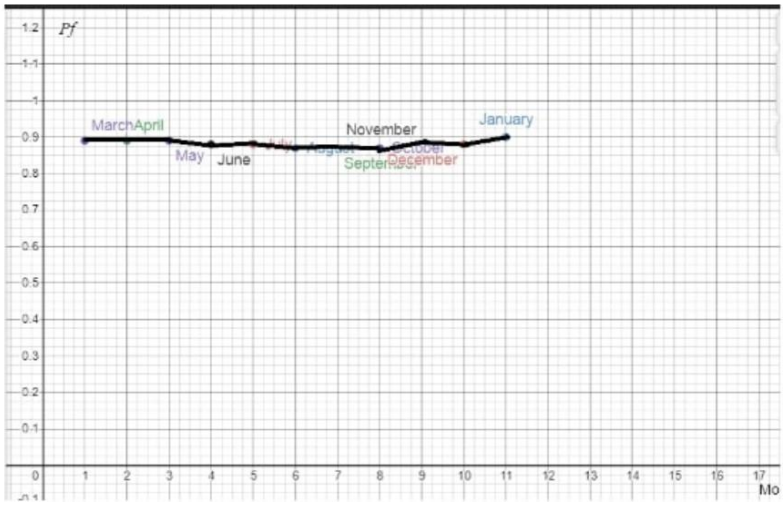
- Documentation of the collected data.
- A cost-benefit analysis was conducted to evaluate the feasibility, cost-effectiveness, and priority of energy conservation options for implementation. There solutions were prioritized based on if they were short term or long term.
- Small issues affecting the energy efficiency were identified and recommendations were given to solve them.

ENERGY SCENARIO

Model Engineering College is a High Tension consumer. It takes supply from Kerala State Electric Board's (KSEB) 11 KV line and the college also has solar panels generating around 30 KW. We have an indoor substation with 11KV/433 KVA transformer and gets an auxiliary supply from a 50 KVA Generator set with a control panel. The total load connected is 360 KW.



Graph 1: Energy Consumption from January 2019 to January 2020



Graph 2: Power Factor Trend

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Connected Load

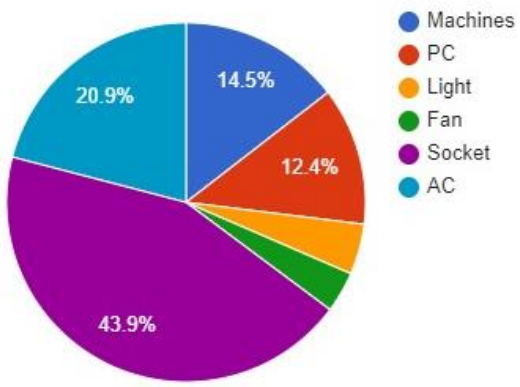
From the floor plan, college layout was made which is as follows:

- Number of Floors: 5
- Number of rooms: 46
- Number of labs: 18

The quantity of the load connected, and the power consumed is depicted in table 1. The loads are categorized into light, fan, AC, PC, Sockets and Machines.

Type of Load	Number of appliances	Power Consumption per appliance (in W)	Total power consumed (in W)
Light – FTL	513	40	20520
Light– LED	85	18	1530
Fan	298	60	17880
Air Conditioners (AC)	29	3500	101500
Personal Computers (PC)	241	250	60250
Socket	1450	60	87000
Power Sockets	252	500	126000
Machines	-	-	70586

Table1: Load connected and the total power consumption.



Graph 3: Load Distribution Chart

COST BENEFIT ANALYSIS

Replacing electronic ballast FTLs with LED Tubes

Replacing the Electronic ballast FTLs with LED tubes will result in an annual saving of 65,730 Rupees. Capital cost recovery time for replacing FTLs is 3.12 years.

Total number of electronic ballast FTLs	513
Average power of FTL	40 W
Average power of LED	18 W
Power saved per LED	22 W
Total power saving	11286 W
Average use of LEDs per year	260 x 4 = 1040 hours
Energy saving per year	11.286 kW x 1040 h = 11737.44 kWh
Savings (in rupees) per year	11737.44 x 5.6 = 65729.664 Rupees
Cost of replacing 1 FTL	400 Rupees
Capital investment (in rupees)	513 x 400 = 205200 Rupees
Simple payback period	3.12 years

Table 2: Replacing FTLs with LED Tubes

Replacing CRT Monitors with LED Monitors

It is evident that CRT monitors consume greater power than LCD monitors. Thus replacing the existing CRT monitors with LCD monitors will result in a total power saving of about 270 W per computer.

There are 3 CRT computers at Model Engineering College.

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Power Saved = 270*3 = 810 W.

Power Factor Improvement

From the previous electricity bills collected (January, 2019 to January, 2020), it is found that average power consumption is 18000 kWh and average power factor being 0.88. A penalty should be given if the power factor is below 0.9. Therefore, it is important to improve the power factor.

Apparent power: 63.016 kVA.

Correction of power factor from 0.88 to 0.95.

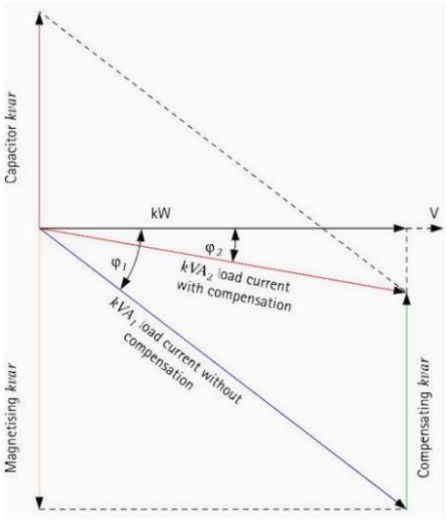

Fig1: Power Factor correction from θ1 to θ2

Cos θ1 = 0.9
θ1 = 25.842
tanθ1 = 0.484
cosθ2 = 0.98
θ2 = 11.478
tanθ2 = 0.203
kVAR of capacitor = KW x (tan θ 1 - tan θ2) = 63.016 x (0.484 - 0.203) = 17.7

According to KSEB Ltd, Incentive for Power factor above 0.95 is 0.25 percent of the energy charges for each 0.01 unit increase from 0.95 pf. Installation of capacitor banks can help in improving the power factor and thus saving the annual penalty. Moreover, the payback period is about 7 months, which indicates that the economic benefit from such installation is quite fast.

Average energy charge	1,50,000 rupees per month
Pf incentives earned per month	150000 x 0.005 x 3 = 2250 rupees
Annual incentives	27000 Rupees
Penalty paid last year(from previous bills)	24880 Rupees
Annual cost saved	27000 + 24880 = 51880 Rupees
Cost of 2 units of 10 kVAR capacitor bank	6890 x 2 = 13780 Rupees
Additional charges	15000 Rupees
Total cost of installation	28780 Rupees
Simple payback period	0.55 years (approx 7 months)

Table 3: Power Factor Improvement

Extension of rooftop solar panel to meet college's energy requirements

Additional installation of 70 kW solar panels can greatly satisfy the college's net energy demand thereby making it self-sufficient. Though it's installation involves a huge investment, massive saving on the amount spent as the monthly electricity bill can be done.

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Average energy charge	1,50,000 rupees per month (approx. 18,00,000 rupees annually)
Net energy requirement	100 kW
Present installed capacity	30 kW
Additional installation required	70 kW
Solar panels	234 x 18000 = 42,12,000 Rupees
Associated charges	60,00,000 Rupees
Net investment	1,02,12,000 Rupees
Simple payback period	5.67 years

Table 4: Extension of Solar Panel.

Other Recommendations

- Tripping issues in CC1 (Computer Center) and Media Hall:
  This might be primarily due to circuit overload. It can be resolved by redistribution of electrical devices and keeping them off of the same circuit. From the Single Line Diagram, it is noted that Media Hall comes under LSB (specifically under SMBD-2). Due to the additional installation of electronic equipment like ACs in the Media Hall, the circuit is overloaded when the adjacent Biomedical Lab is functioning.
- Wires were found out to be old and some were burnt out:
  Replacement of wires should be done, otherwise it might affect the other wires and the equipment connected to it as well. Finding the reason for the burning out of wires and taking proper actions to resolve the same would prevent such situations.
- Meters in generator room were not working:
  Proper repair and maintenance of the existing meters. Replacement of faulty ones with modern metering equipment. For example, the ammeter and voltmeter attached to the MSB, and Control Panel are not functioning.
- Extension boards were used in the Computer Science and Applied Science Departments for connecting PCs and Laptops:
  When using an extension cord, we must check the Amps required to power the needed devices, equipment, or tool against the extension cord's rating. We should select the correct gauge wire and cord length to meet the electrical demands. For example, 25 feet for 1-13 A.
- Efficiency of generator has deteriorated to less than 50 percent:
  Maintenance of the existing equipment and proper testing of its efficiency. Using a buffer generator set for load sharing.

CONCLUSION

Energy audit was very necessary in Govt. Model Engineering College as there's are a lot of changes that can be made in this colleges which can significantly reduce the electricity consumption and can reduce the electricity bill by 20 to 40%. The payback period of the money spent on these changes is also very less. The energy consumption trend and the connected loads are explained in detail along with the cost benefit analysis and some other recommendations to improve the energy efficiency. The conclusion of the whole paper:

- More than 65,000 can be saved per year by replacing FTLs by LED Tubes.
- Around 57,000 can be saved by installing capacitor bank to improve the power factor. We will be able to save on penalty for power factor falling below 0.9 and incentives will be received if power factor is kept above 0.95.
- A solar panel of capacity 30 KW is already installed on the rooftop of college. By increasing the capacity by 70 KW, a large amount can be saved on the electricity bill, and it is better for the environment.
- There are many minor issues at college that is left unnoticed. It is causing energy leak and low efficiency.

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