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Energy Conservative Measures by Energy Audit and Load Management

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Abstract

The use of Electrical Energy is exponentially increasing both in domestic and industrial sectors. The per capita consumption of Electrical Energy is taken now a day as an index of country's growth. Unfortunately, the sources of electrical energy particularly conventional sources are depleting and hence the gap between the supply and the demand is continuously increasing. To manage this gap the usual method adopted by the supplier of electrical energy is random load shedding which doesn't take the consumer's interest. This has created a renewed awareness about the economic advantage of energy conservation. Recently, the concept of energy audit and load management has emerged and is being applied throughout the world. The fundamental concept of Energy audit and Load management is to bring both supplier and consumer together across the table and discuss the use of available electrical energy for maximum benefit and minimum inconvenience and loss for both. This paper presents the result of Energy Audit and Load Management during the peak hour and feasible Energy Conservative measures applied to a Professional Technical Institution. This deals with energy monitoring and finding out the feasible energy conservative measures like improvement of power factor, staggering of lab timings and proper load balancing will not only increase the reliability of the electric supply, considerable amount of savings in electricity bills.

1. Introduction

Energy is the basic necessity for the development of our country. Among all the available forms of energy electricity is most flexible form of energy needed for all types of activities. Electricity is most becoming an unavoidable form of energy and unsubstitutable form of energy in recent times. The growth rate of country is measured in terms of per capita consumption of electrical energy. Because of the above reasons the demand for electricity is continuously increasing while the generation is limited by so many constraints. Thus a time has come to utilize the available energy efficiently, optimally for the mutual benefits of consumer and supplier [1, 2]. The unbalanced load distribution on 3 phases causes increase in maximum demand (KVA rating). As a result of which the customer has to pay the penalty charges, which are incurred. In this paper concentrated on electricity charges per month. For this purpose a Technical Institution (KLE Society's College of Engg. & Tech, Belgaum) is considered as it has both state electricity supply & centralized captive generation to the tune of 62.5 KVA.

2. Energy Audit

Energy audit attempts to balance total input energy with its use. There is no particular method that can be readily used for conducting energy audit in institution / industry. What works in one institution may not be suitable for other institutions. In such a situation, energy audit must direct and control the energy management programme leading the overall economy of the system.

2.1 Classification of Energy Audit

The type of energy audit to be performed mainly depends on two factors, functions and type of institution/ industry and depth to which final audit is needed. Basically, energy auditing is classified into two categories: [i] Preliminary Audit [ii] Detailed Audit

[i] Preliminary Audit

Preliminary Audit is performed in a limited time span. It mainly deals with better operating practices, better utilization, avoidance of waste and modifications in the productions in the production schedules. Preliminary Audit is mainly focused on major energy supplies and demands, accounting for at least 70% of the total energy requirement. These are low cost measures. Preliminary audit involves

- Power factor improvement
- Preventive maintenance
- Energy conservation in lighting
- Economic operation of distribution transformers
- Training program

[ii] Detailed Audit

Detailed audit includes engineering recommendations and well-defined projects. It generally includes long-term measures such as new technology, new equipment, new control logic and major modifications of plant. This requires large investment and savings are normally huge. This study needs to be carried out for a process or a unit or a system. Data about energy input, energy output, energy consumption, energy flow and distribution, losses, efficiency & temperatures etc. are necessary for a detailed audit.

3. Load Management

It is the concept of changing the consumer's electricity use pattern. The scope of load management and implementation of programs whose objective is to actually shape the daily load profile of consumers so as to result in better overall capacity utilization and lower the costs.

4. Case Study: Details of the KLE Distribution System

K.L.E. Society's College of Engineering & Technology Belgaum, Karnataka has 10 UG courses and 5 PG courses. The college distribution belongs to HT consumer category with the transformer capacity 250 KVA, 11 KV Δ / 433 V Y (Oil immersed Natural Air-Cooled) 3 phase transformer (Step-Down). A centralized diesel generator set of capacity 62.5 KVA.

The distribution has **3** feeders supplying different departments viz.

I Feeder--- Feeding Main College Building.

II Feeder--- Feeding College Boys Hostel.

III Feeder--- Feeding College Ladies Hostel.

Table – I gives the Type of Load distributed in the college.

Table – I

Type	%	Connected Load in KW
Computers	13.56%	65.40
Motors	34.00%	164.06
Lighting Load	17.10%	82.36
Remaining Load	33.70%	162.11

Load Consumption (Peak) Variation in the days of a week is shown in Fig.1

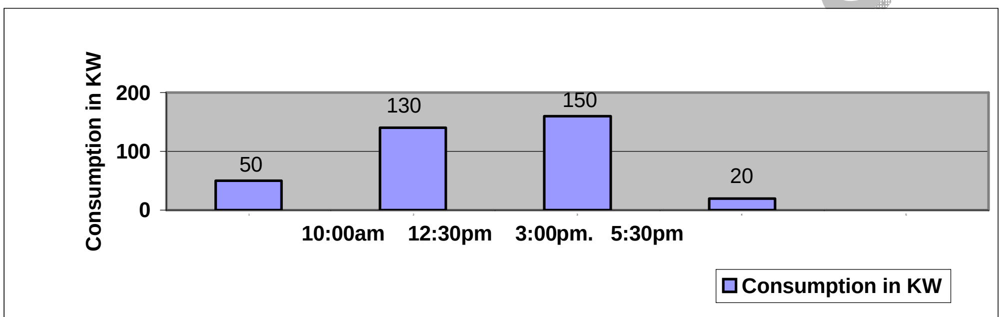

Fig. 1. Load Variation in the days of a week

4.1 Energy Audit of Institution

The energy audit involves the following steps:

i) Survey of all connected load.
ii) Measurement of hourly load both at the control room and at the selected location during peak hours.
iii) Analysis of peak hour load measurements.
iv) Analysis of previous electricity bills.
v) Remedial steps to minimize the electricity charges.

Steps 1 & 2 belong to data collection to understand the trend of the existing energy consumption. Steps 3 & 4 fall under data analysis category. Step 5 belongs to suggestive measures for the Institution. Fig.1 shows the variation of load consumption in the days of a week. From the data it is clear that all the laboratories were working during peak hours between 11.30 AM & 3.30 PM. causing lot of unbalance in the distribution system. The effect of this unbalance is the oscillating neutral (Neutral shifts). This is because of the presence of this harmonic currents in the network which are co-phasal in nature and these third harmonic currents makes the neutral to oscillate at frequency of 2ω[5].

The reason for this unbalanced load is mainly due to the usage of single phase UPS and air conditioning facility. As a result the maximum demand (MD) indicator was crossing the contract demand of 100 KW. The usual value recorded by the MD meter was greater than 100 KW with maximum value recorded being 150 KW, resulting in high maximum demand penalty. This motivates the need for Energy audit, Load management and to implement Energy Conservation Measures to minimize the electricity charges.

5. Conservative Measures

From the monitoring survey conduction for the months from March to June (Odd Semester), it has been seen that the allotted load to the college is 100 KW where as the load consumed by the college is about 150 KW during peak hours. Also observed was that there was unbalanced distribution of loads on the 3 phases due to which the KVA rating increases as a result of which the institute has to pay the penalty charges which are incurred. The main observation done was low power factor than the desired p.f. i.e. 0.90 as per the KPTCL (Karnataka Power Transmission Corporation Limited) standards.

5.1 Some of the feasible conservative measures

[i] Improvement of power factor.
[ii] Switching off of lighting loads during the daytime.
[iii] Staggering of the lab timings.
[iv] Meters for individual Departments.
[v] Balancing of 3 phase currents.
[vi] Solar panels in the Girls Hostel.
[vii] Change in the wiring system.

[i] Improvement of power factor

If we improve power factor we can reduce the penalty charges, which are incurred. The power factor improvement is very important for both consumers as well as generating stations.

a) Consumers

A consumer has to pay electricity charges for his maximum demand in KVA plus the units consumed. If the consumer improves the power factor, then there is a reduction in his maximum KVA demand and consequently there will be annual saving due to maximum demand charges. Although power factor improvement involves extra annual expenditure on account of p.f. correction equipment, yet improvement to a proper power factor value results in the net annual saving for the consumer.

b) Generating Stations

A generating station is as much concerned with the power factor improvement as the consumer. The generators in a power station are rated in KVA but the useful output depends on the kW output. As station output is KW = KVA x cosϕ, therefore, the number of units supplied by it depends upon the power factor. The greater the power factor of the generating station, the higher is the KWH it delivers to the system. This leads to the conclusion that improved power factor increases the earning capacity of the power station.The value to which the power factor should be improved so as to have maximum net annual saving is known as the **most economical power factor.**

c) Calculations for power factor (P.F.) correction

Consider an inductive load taking a lagging current I at a p. f. (Cosϕ_1). In order to improve power factor of such a circuit, the remedy is to connect such equipment in parallel with the load, which takes a leading reactive component and partly cancels the lagging reactive component of the load. The capacitor put across the load for the purpose takes a current Ic, which leads the supply voltage by 90°. The current Ic partly cancels the lagging reactive component of the load current as shown in Fig.2

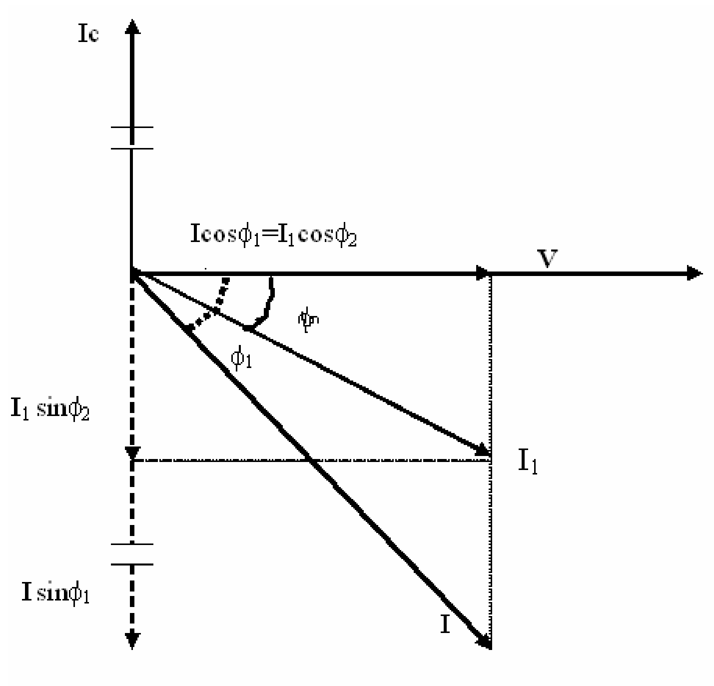

Fig.2

The resultant circuit current becomes $\mathbf{I}_1$ and its angle of lag is ϕ_2. $\phi_2 < \phi_1$.
The power factor $\cos\phi_2$ is more than the previous power factor $\cos\phi_1$.
After p.f. correction, the lagging reactive component of the load is reduced to $I_1\sin\phi_2$.

$I_1\sin\phi_2 = I\sin\phi_1 - Ic$. or $Ic = I\sin\phi_1 + I_1\sin\phi_2$.

Hence, capacitance of capacitor to improve the p.f. from cos ϕ_1 to cos ϕ_2,

$C = (Ic / \omega V)$.

The power factor correction can also be illustrated from the power triangle shown in Fig.3.

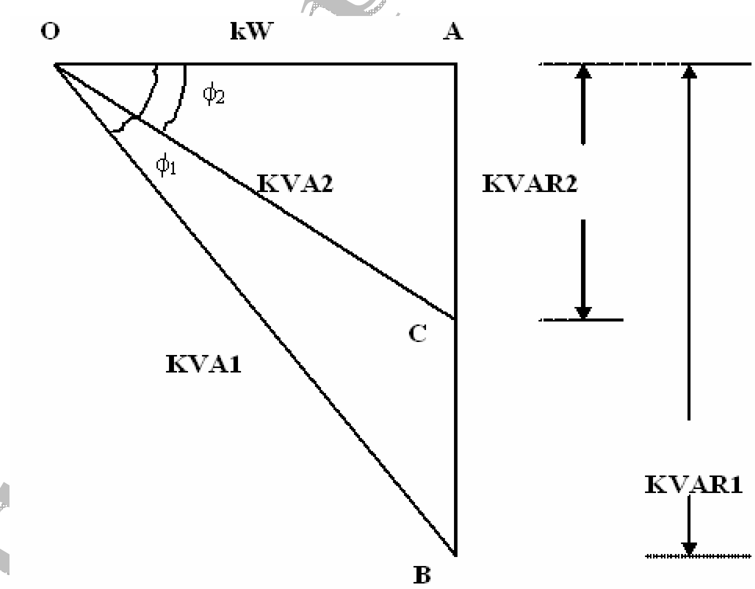

Fig.3

Leading KVAR supplied by the p.f. Correction equipment

= BC = AB – AC = KVAR1 – kVAR2

= OA ($\tan\phi_1$ - $\tan\phi_2$) = KW ($\tan\phi_1$ - $\tan\phi_2$).

Knowing the leading KVAR supplied by the p.f. Correction equipment, the desired results can be obtained.

d) Calculation saving/year by power factor correction of the institution

Present p.f. = 0.8 =$\cos\phi_1$
Improved p.f. =0.95 =$\cos\phi_2$
Rs.200 /kVA is the maximum demand.
Rs.150 / kVAR for the capacitor bank.
At p.f. $\text{Cos}\phi_1$ =0.8, KVA1 = 125 kVA.
At p.f. $\text{Cos}\phi_2$ = 0.95, KVA2 = 105.26 kVA.
Savings on maximum demand charges
= 200 x (KVA1 – KVA2)
= 200 x (125 – 105.26) = Rs.3948.
Reactive power at $\text{Cos}\phi_1$ = kVAR1 = 75 kVAR.
Reactive power at $\text{Cos}\phi_2$ = kVAR2 = 32.86 kVAR.
$\therefore$ Leading KVAR that should be supplied by the capacitor bank
= 42.14 kVAR.
There is 10% depreciation on the capacitor bank.
$\therefore$ Cost of power factor correction = (150 x 10%) x 42.14 =Rs. 632.12.
$\therefore$ Total savings per month = Rs. 3316.
$\therefore$ Total savings per year = Rs. 3316 x 12 = Rs. 39,792/-

[ii] Lighting loads

The lighting loads are generally taken to be 17% of the total load. In the institution, as seen during the survey, the lights were seen to be switched on even during the day. This is not needed for at least early part of the working day hours, from 10 AM to 4 PM. This can be the duration when the lights of the classrooms can be switched off.

[iii] Staggering of the lab timings

The heavy electric loads are used in the labs of the Mechanical, Civil and Electrical & Electronics Departments. Remaining departments such as the Departments of C.S.E., E&C, Biomedical & Telecommunication, Chemical Engg, MCA and MBA have mainly electronic loads, which do not consume appreciable power as compared to the former three Departments mentioned earlier.

For the former three departments, considerable energy is consumed during the labs. If the lab timings could be staggered, some peak load situations could be avoided. This can be taken care while setting up the timetable for various departments; the Electrical Maintenance Department is called upon to seek proper advise as to the different loading situations in the labs of the Mechanical, Civil and Electrical & Electronics Departments.

[iv] Meters for individual departments

If separate meters could be installed for major load sites like the Workshop, Electrical Machines lab, Civil Engg. Department and Mechanical Engg. Department, the sub-metering can be of use in keeping a track of the energy being consumed. Thus, measures could be adopted to avoid situations of heavy or peak loads.

[v] Balancing of three phase currents

This is one of the most effective measures that could be adopted to keep the electricity tariff at a minimum. In the survey, it has been seen that of all the three phases, the R-phase has the maximum current, while the Y-phase and the B-phase have nearly equal currents, but both are far apart from the R-phase when it comes to the current being carried by them. The high current in the R-phase causes unbalancing of the three-phase system of the College. To make an effective change in the existing system and to make the system balanced, the loads in different phases can be studied and then distributed to other of the three phases for effective loading of the phases.

[vi] Solar panels in the Girls' hostel

As seen during the energy survey, the Girls' Hostel was seen to have a higher rating of the currents in the three phases. This could be attributed to the water heaters or electric geysers employed in the hostel. If they could be replaced by Solar Heating Panels as are used in the Boys' Hostel, considerable amount of electrical energy could be saved.

[vii] Changes in the wiring system

If the wiring could be so done that each of the three phases has equal number of various different loads like tube-lights, fans, induction motor, etc. then the phase unbalancing could be eliminated to a higher level. The existing system is not arranged as said above. This measure, if applied, needs a high initial investment, but in the longer run it is going to be advantageous and fruitful because it can very effectively minimize the penalty levied in the electricity charges.

6. Conclusion

From the monitoring survey conduction for the month of March to June, it has been seen that the allotted load to the institution is 100 KW, where as the load consumed by the institution is about 150 KW. Also observed was that there is unbalanced distribution of loads on the 3 phases due to which the KVA rating increases as a result of which the Institute has to pay the penalty charges which are incurred. The main observation done was low power factor than the desired power factor i.e. 0.90 as per the Karnataka Power Transmission Corporation Ltd., (KPTCL) Standards. If power factor correction is implemented, total savings per year approximately Rs.40,000 & if the stagger the peak load, the total savings per year approximately Rs.1, 00,000. Combined more than 1.4 lakhs can be saved for the institution. In addition to this, energy can be conserve during the peak hours and hence increase the reliability of the electric supply & considerable amount of savings in electricity charges.

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