Energy Audit: A Case Study

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Abstract— Energy Audit is the vital to a systematic approach for decision-making in the area of energy management. It endeavor to balance the total energy inputs with its use and serves to identify all the energy streams in a facility. With the advent of energy crisis and exponential hikes in the cost of different forms of energy, Energy Audit will help to understand more about the ways energy and fuel are used in any industry or any HT user area, and help in identifying the where waste can occur and where scope for improvement exists. This paper present the energy audit of Education Institute have 11 different departments with hostel in 9 buildings located in Gujarat. Also perform the one year bill analysis with load calculation in existing area. Corrective measures are given based on detail analysis in every aspect of energy saving. Audit performance gives the most likely areas for improvement for energy savings.Energy Audit is an effective tool in defining and pursuing comprehensive energy management program. In this field also, the basic functions of management like outlining, decision-making, organizing and controlling apply equally as in any other management subject. These functions can be effectively performed based on reliable information, which can be Audit techniques. Perform preliminary as well as detailed energy audit for all the area with all kind of load.

Keywords—Energy Audit; Energy Savings; Energy Efficiency

I. Introduction

Energy is essential input for life comfort. With the increase in use of appliances, transportation and faster industrial growth, the energy resources consumption is increasing with very high demand. The natural resources being less, its import affects lot to the nation budget. The proper management of energy usage can help us in reducing overall consumption with same output. The energy needs to cover various human activities in agricultural, industrial and domestic field rising day by day. There is gap between availability and requirement, and we face power shortage. Many of our villages are still without electricity. Energy gap can be reduced by using efficient equipment and suppressing the wastage. A proper load management can also help in effective utilization. The energy conservation means to curtail the energy consumption without affecting quality and quantity of output by preventing the waste with efficient utilization. These will increase the resources utilization; otherwise it may lead to power shortage, dearth of water and other natural resources. The situation is knocking our door to do needful in this regard at an earliest, which may avoid hardships of generation to come. It is a need of time to create the awareness of the people about the seriousness of energy conservation.

There is wide scope of energy conservation applications in illumination, air conditioner, refrigeration, heat generation and transfer, electric traction, electric drive system, textile industries. More and more equipment is designed and fabricated to have higher efficiency, lower consumption and control leakage, well designed automation and instrumentation scheme can save energy. People must be trained for this battle. It is war against waste. A small step in right direction can help a great selection of appropriate ratings, switching off equipment not require and regular maintenance may have a amazingly. We can also think of electricity generation by the non-conventional resources like solar energy, tidal energy etc. Though the initial cost may be high, aright step in this direction will prove its worth. Necessary incentives are being announce in this regard and ministry of non-conventional energy sources is working and providing guidance in these fields. Energy audit is of a great importance because sometime costlier working thing may prove to be economical looking to their payback period.[1]

The demand side management will provide better utilization of available energy by improving load factor, diversity factor and plant use factor. Another emphasis must be given to subsidies and pilferage. Because of undue conversions the wastage increases to larger extend while power theft has made the consumers free from the worries of their energy bills. This must be prevented by heavy penalties culprits. It is a time to apply check on T & D losses and line outages. The combined effort by electricity authority power supply undertaking and awareness of consumer value will improve the scenario. This is a humble effort to give consideration to cover above topics in this course by experts of respective fields.

"Energy audit" means examination of an electrical installation or electrical apparatus belonging to consumer, for the purpose of verifying whether there is leakage or wastage or inefficient use of an electrical energy, in operating the electrical installation or electrical apparatus.

II.TYPES OF ENERGY AUDIT

The extent and type of Energy Audit should result in gains commensurate with the efforts.

There can be two types of Energy Audit:

1) Preliminary Audit

2) Detailed Audit.

Preliminary Audit is performed in a limited span of time. It focuses upon major energy supply and demands, accounting for at least 70 percent of total energy requirements. The detailed audit goes beyond quantitative estimates to costs and savings. It includes engineering recommendations and well-defined projects with priorities. It accounts for approximately 95% of energy utilized in the plant. A long-range energy plan can be drawn up on basis of data generations and analysis

The two types of audit are compared and shown in Table-1.

Functions	Preliminary Audit	Detailed Audit
Objective	Set priorities for optimizing energy consumption.	a).Quantify energy consumption / Utilization. b). Evolve detailed engineering for Options to reduce energy costs/ Consumption.
Scope	Highlight energy costs and wastages in major equipment / processes.	Formulate a detailed plan on the basis of quantitative and control evaluation.
Duration	2 to 10 days.	1 week to 10 weeks.
Audit frequency	As per requirement.	May be 2 to 3 years in normal cases.
Preparation	a) No pre-audit visit required. b) Detailed questionnaire to be complied before the audit.	One/two pre-audit visits required. In addition to points for preliminary audit, the following points have to be taken care of: i) Advance notice to departmental heads. ii) Arranging for office and secretarial support. iii) Advance tentative schedule iv) Audit kit to be meticulously planned / arranged.
Due date	Within two weeks of completion of fieldwork.	Within 3 months of completion Of field work.

TABLE I. TYPES OF AUDIT COMPARISTIO

III. ROLE OF INSTRUMENTATION

Let us read the saying of Mr. Harsington **"IF YOU CANNOT MEASURE IT, YOU CANNOT CONTROL IT. IF YOU CANNOT CONTROL IT, YOU CANNOT MANAGE IT. IF YOU CANNOT MANAGE IT, YOU CANNOT IMPROVE IT."** [2] True to this, we are able to develop a good number of measuring instruments. I expect improvements in those instruments to study on the spot energy consumption and cut off devices to reduce wastage of energy.

To achieve the perfect monitoring, instrumentation play a major important role. With the help of instrumentation, the goal of monitoring can be achieved. With help of available present status, one can take proper decision for improvement. Today many industries lack of instrumentation due to the following reasons.

i).Quality / life of instruments is not up to the required level.

ii).Cost of the instruments is high/proper instrument is not available.

iii).Unavailability of skill manpower who can operate the instruments.

a. Data Collection

- Basic data covering the overall energy consumption, its cost and production figures for a period of the preceding three use keeping methods.
- Recommendations of overall improvement in efficiency to reduce energy consumption by operational and project giving details to techno economics.
- Suggesting methods of implementations.

b. Billing Data:

From January 2016 to December 2016 light bill data collected and consider following information foe the

analysis. 1) The contract Demand, 2) The Actual Maximum Demand, 3) The Billing MD, 4) The total connected load, 5) The average power factor, 6) The maximum energy consumption, 7) The average energy consumption/month, 8) The total energy bill, 9) The average energy, 10) The cost of unit. Graphical representation of data shown below.

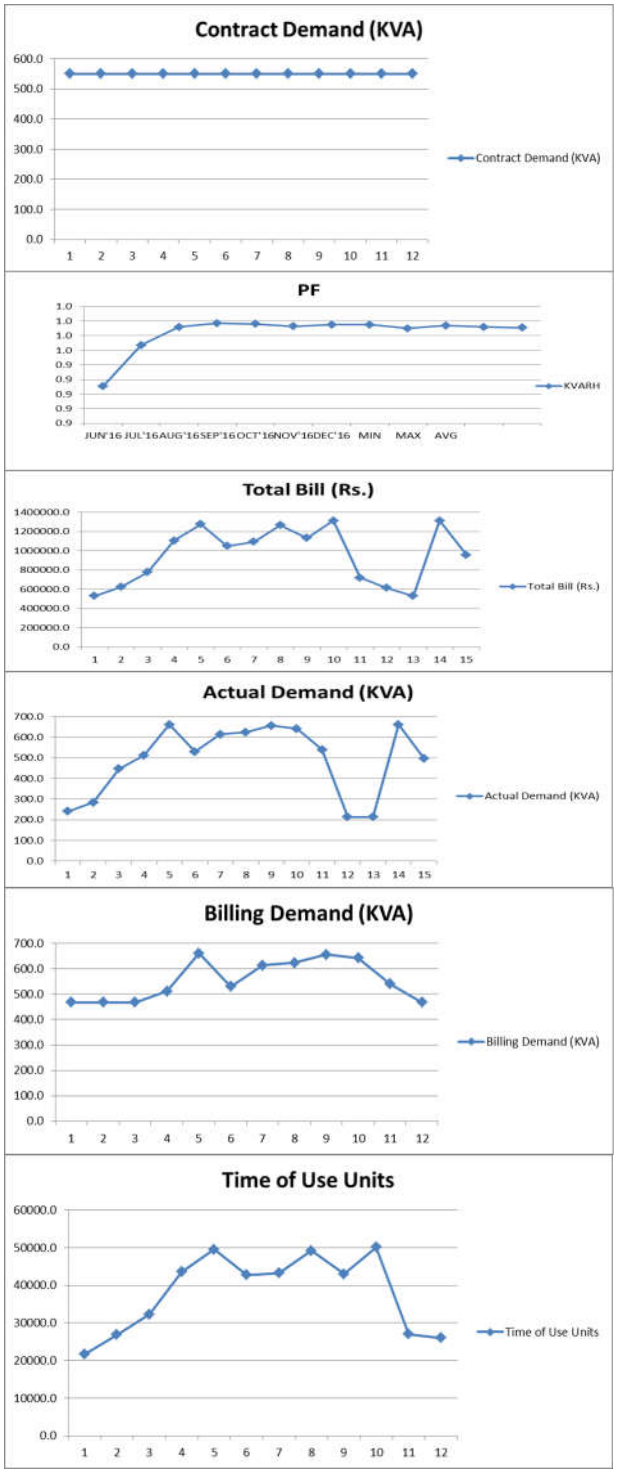

Fig.1. One year billing data

C. Transformer Data

Power transformer is static equipment & having efficiency around 98% & above depending upon the manufacturer's designs and applications.

There are two types of losses in transformer (1) Iron losses, which is assumed to be a constant & (2) Copper losses/ load losses, which is affected by load, loading cycle & load power factor. The maximum efficiency of transformer is generally observed nearly at 50% load & not at 100% load.

Transformer will have maximum efficiency when iron losses = copper losses. That condition or %age loading of the transformer is called optimum loading of the transformer. Losses of the Transformer can be calculated as per following formula.

Total losses = Iron loss+ copper loss (at 100% loading)

OR At part load,

Total losses = Iron loss + (load KVA/rated KVA)^2 x Full load losses

Transformer Efficiency = Output / Output + Losses OR

= Input – Losses / Input

Sr No.	Description	Units	TR1	TR2
1	**Rated KVA**	KVA	400	400
2	**HV VOLTAGE**	KV	11	11
3	**HV CURRENT**	AMP	21	21
4	**LV VOLTAGE**	VOLT	433	433
5	**LV CURRENT**	AMP	533	533
6	**RESISTANCE/PHASE**	OHMS	5.737	5.737
7	**NO LOAD LOSSES**	WATTS	760	760
8	**MAGNETIZING CURRENT**	AMPS	8.25	8.25
9	**LOAD LOSSES**	WATTS	4592	3900
10	**IMPEDENCE**	%	4.82	4.50
11	**HV SIDE TEMP**	^{0}C	50	51
12	**LV SIDE TEMP**	^{0}C	55	55
13	**EFFICIENCY AT U.P.F**	%	98.68	98.52
14	**EFFICIENCY AT 0.8 PF**	%	98.36	97.95

TABLE II. TRANSFORMER DATA

D. Lighting Data

The power consumption in Illumination is comparatively very low in % of entire electricity consumption. It depends on the type of Industries. In industries like textile Industries, pharmaceutical, corporate offices it may be of 5 to 10%. There is significant scope of saving in this area by using energy efficient lighting option, new or retrofit application, controlling voltage level, using daylight option, by

controlling light by sensors etc. In campus different types of lights are in working, florescent tube light 4008, 1340 LED, 63 Programmable light and 1649 CFL

Light output is measured in lumens and the availability of light in a particular area is called illumination, which is measured in lumens/m2 or LUX. The luminance level in the Indian industry, with some rare exceptions, is generally much lower than the recommended levels. Table shows the recommended levels.

Illuminance Data Summary

Average Illuminance (Eave): 212 lx
Maximum Illuminance (Emax): 248 lx at x = 3.82 m, y = 3.82 m
Minimum Illuminance (Emin): 162 lx at x = 0.50 m, y = 0.50 m
Uniformity 1 - Emin / Emax: 0.652 (1: 1.53)
Uniformity 2 - Emin / Eave: 0.762 (1: 1.31)
Total lamp flux: 48800 lm
Total lamp flux per unit area: 762 lm / sq. m
Total electrical power: 600
Total electrical power per unit area: 9.38 W / sq. m

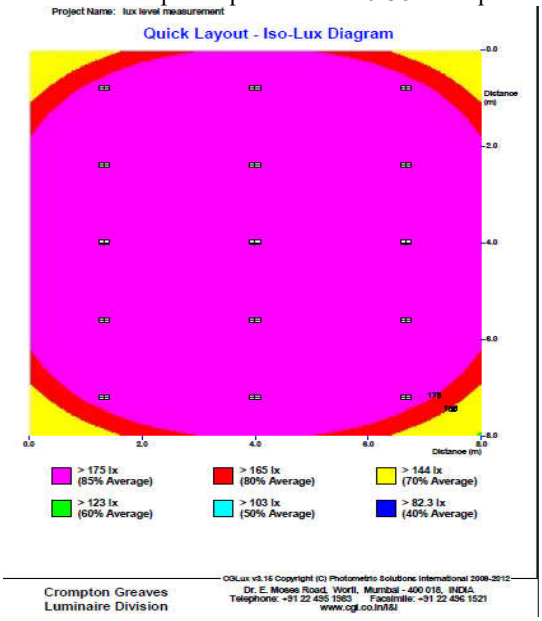

Fig. 2 LUX-Diagram

E. Fans Data

Most people focus on lighting to fix their high electricity bills, but fans consume a lot more than lights. To give a perspective a regular (non BEE star rated) ceiling fan consumes 75 Watts as compared to a regular (most inefficient) tube light that consumes 55 Watts. There are total ___fan in the campus and probably working 5 to 6 hrs per day and tentatively 200 days in a year.

F. Computers and Refrigeration

Computers usually consume 200W-250W including desktop, CPU, printer, etc. They are also included in major consumption equipment's in commercial areas or institutes or universities as more number of computers are used there.

Computers and monitors account for 40%-60% of the energy used by office equipment. Their energy consumption is second only to office lighting.
There are total 2245 computers are in working and tentatively uses are 4hrs per day.

Refrigeration is a process of moving heat from one location to another in controlled conditions. The work of heat transport is traditionally driven by mechanical work, but can also be driven by heat, magnetism, electricity, laser, or other means. Refrigeration has many applications, including, but not limited to: household refrigerators, industrial freezers, cryogenics, and air conditioning. Heat pumps may use the heat output of the refrigeration process, and also may be designed to be reversible, but are otherwise similar to air conditioning units. In the infrastructure have total 22 refrigerators which consume 250 to 550 units per year.

G. AC, PUMPS AND WATER COOLERS

Air conditioner is the process of altering the properties of air (mainly temperature and humidity) to more favorable condition typically with the aim of disturbing air to an occupied space to improve thermal comfort and indoor air quality.
Generally, air conditioning can refer to any form of technology that modifies the condition of air (heating, cooling, and humidification, cleaning ventilation or air movement).
Air conditioners use refrigeration to chill indoor air, taking advantage of a remarkable physical law: When a liquid converts into a gas(in a process called phase conversion),it absorbs heat. Air conditioner exploits this feature of phase conversion to evaporate and condense over and over again in a closed system of coils.
Air conditioners also contain fans that move warm interior over these cold, refrigerant-filed coils.
Total 284 AC working for minimum 4hrs/ day.
And 11pumpus for water supply works 7 to 16 hrs. per day, 27 water coolers which have capacity of 300 Liters each.

So over all consumptions are calculated in the given area is mention in the below table Also represented in graphical terms.

Electrical equipment's	consumption in KWH/year	Use in percentage
LIGHT	280721.04	16.4309439
FAN	257202	15.05434588
AC	301808	17.66518932
PUMPS	208163	12.18403357
COMPUTERS	558250	32.67505147
REFRIGRATORS	8791	0.514547922
WATER COOLERS	93555	5.475887937
TOTAL CONSUMPTION	1708490.04	-

TABLE III. OVERALL CONSUMPTION DATA

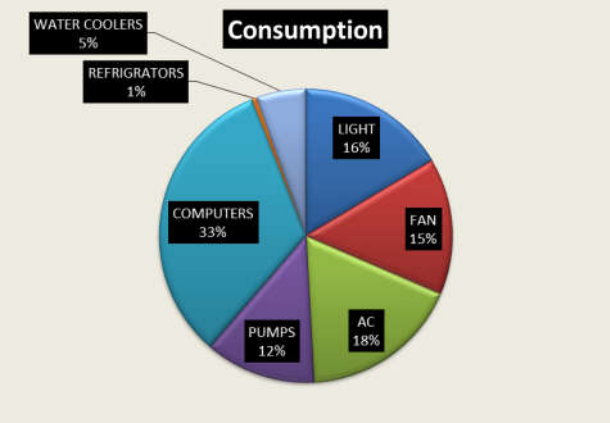

Fig. 3 OVERALL CONSUMPTION DATA CHART

III Energy saving and corrective mesures

The billing data shows that the consumption in that particular month goes above the contract demand and the University pays penalty for those particular months, Consumption during the night hours is very high because of more usage of luminaries in hostel due to which TOU (Time of Use) Units increases.

Observed that the actual demand of the University crosses the contract demand and so it is advisable to increase input power by adding one 500 KVA transformer. According to the IS 1180 contract demand is needed to be increased to stop paying the penalties.

Remedial measures in lightning system (1) Consumption of FTL lights is much more. So it is needed to be replaced with the LEDs. Comparison between FTL and LED is given in the Table __

(2) Voltage stabilizer: By controlling the voltage through stabilizer to 230 V the energy can be saved, which is worked out as under considering secondary voltage 230 volt. In one of the Petrochemical plant, we have observed the lighting voltage at 245 V for 85.3 kW lighting load with 12 hrs average burning. If we reduce the voltage from 245 V to 230 V then almost 14 ~ 20 % power can be saved.

(3) Lux measurement: As shown above lux in a particular room is averagely 210 lumens/m2 .when FTL is used but required lux in a room is 150-200 lumens/m2. This is when replaced with the same number of LEDs required lux level is achieved.

Sr. No.	DESCRIPTION	LUMINAIRE TYPE	
		FTL	LED
1	Lamp Lumen	2440	2160
2	Life	5000	30000
3	No. of fittings	4008	4008
4	Per fitting cost	560	960
5	Total cost (In Rs.)	2244480	3847680
6	Watt including choke loss (W)	40	20
7	Total Consumption (kwh)	160.32	88.176
8	Running hr. / day	5.5	5.5
9	No. of Units / year (kWh)	176352	96993.6
10	Saving in KWH per annum	NA	79358
10	Electricity cost / unit	7.6	7.6
11	Working days / year	200	200
11	Cost / Year (In Rs.)	1340275.2	737151.36
12	Annual saving	603123.60	
13	Pay Back Period (years)	2.658344498	

TABLE IV. EFFICIENT LIGHTNING COMPARISION

From Table III observe that using efficient fans can be much beneficial in decreasing the overall consumption.

Computers should be shut down instead of keeping in sleep mode when there is no long time time usage.

Required instruments should only be kept on. Like if there is no use of printer or modem or such instrument then it's should be kept detach so that power is not consumed.

Fan savings many unit so here I compare fan based on energy efficiency

	FANS USED	REPLACEMENT	
		EFFICIET FANS	SUPER-EFFICIENT FANS
TOTAL	3243	3243	3243
RS/FAN	1500	1600	2600
WATT-HOUR	70	50	35
HOURS/DAY	5.5	5.5	5.5
DAYS/YEAR	200	200	200
UNIT COST	7.6	7.6	7.6
CONSUMPTION COST	1897803.6	1355574	948901.8
FANS COST	4864500	5188800	8431800
ANNUAL SAVINGS	NA	542229.6	948901.8
PAYBACK PERIOD(YEAR)	NA	0.598086124	3.759398496

TABLE V. EFFICIENT FAN COMAPARISION

Savings in Refrigeration

(1) Reducing Need for Refrigeration: Elimination of reduction in the use low temperature fluids or air can result in large energy savings.
(2) Optimize Temperatures: Over specification in temperature settings should be avoided, without jeopardizing process and personnel safety. Specification of –20 deg c in place of –15 deg c can lead to 15 to 20% higher energy consumption. Some industries have achieved significant savings by operating at higher temperatures.
(3) Improve Insulation and Reduce Heat Ingress

Higher energy prices justify better insulation. Domestic refrigerator efficiency has been improved by polyurethane (PUF) insulation. Insulation of valves and pipefittings is also justified. Heat ingress into cold storages and air-conditioned spaces should be reduced by having properly designed doors, air curtains, PVC curtains, use of low emissivity (sun-control) films etc.

(4) Improve Heat Exchanger Design: For the same endues temperatures, use of heat exchanger with larger surface area can result in the refrigerant gas operating at higher temperature in the chiller and lower temperature in the condenser, resulting in the large energy savings. This implies that for chilled water at 8deg.c, larger heat exchanger may result in gas temperature of 3 deg.c, say, instead of 0 deg.c say. Every 1 deg.c higher gas temperature in the chiller or 1 deg.c gas temperature in the condenser reduces the specific energy consumption of the compressor by about 2% to 3%.
(5) Energy Storage: Reduction in maximum kVA demand and peak time energy consumption can be achieved by building in energy storage in the form of ice banks or use of other salts hydrates. This can facilitate the operation of more refrigeration machines during of peak hours, usually night time when ambient conditions are more favorable, and switching of some machines during the plant's peak time.[6]

Remedial Measures For Pumps, water cooler and Ac

(1) Disassemble the pump motor for cleaning the surfaces and make it free from corrosion and burrs
(2) Should be coated with grease and oil
(3) Whole process should be monitored by skilled person
(4) Pumps bearings should be given proper maintenance at least once in 18 months
(5) Defective bearings should be replaced immediately.
(6) Keep the water cooler off whenever not in use.
(7) Don't keep the water cooler in direct sunlight else will consume more power.

(8) If we replace the system with VRV units then compressor size will decrease also it will decrease the consumption.

(9) We can decrease the consumption by adding room temperature controller adjusting the on/off temperature setting.

ENERGY CONSERVATION OPPORTUNITY IN DAY TO DAY LIFE

Switch off the lights whenever it is not required, Maximum use of daylight, Stop frequent opening of refrigerator, Keep the refrigerator at a proper distance (6 inch from the wall), Check the gasket of refrigerator, Don't place hot food inside the refrigerator,Defrost the freeze regularly,Avoid use of less efficient appliances, Minimize the use of dryers especially in summer days,Use light colored wall paint, Use thermostat settings, Use level indicator & automatic controller for overhead tank,Use solar cooker & pressure cooker whenever possible, Clean the carburetor, air filter & fuel filter regularly,Maintain proper air pressure in tire, Avoid sudden acceleration & breaking, Stop the engine at signal.[5]

Time clocks are fitted washing machines, heaters, pumps, compressors etc. the equipment/appliance is switched of automatically after set time and over consumption of electrical energy is avoided. [4]

Insulate roof and walls, close leaks, reduce temperature set points, reduce setting during unoccupied period, shift operating cycle from off peak load duration, use double plastic films on glass panes of windows and curtains in for A. C. rooms.

CONCLUSTION

From the above data observed that the actual demand of the University crosses the contract demand and so it is advisable to increase input power by adding one 500 KVA transformer. The billing data shows that the consumption in that particular month goes above the contract demand and the University pays penalty for those particular months. According to the IS 1180 contract demand is needed to be increased to stop paying the penalties. And we can save energy and reduce billing amount by using saving techniques like AC energy saver, switch off equipment were not in use, regular maintenance. Self-awareness also play major role in energy saving activity.

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