Energy audit and management of a college

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Abstract: Educational Institutions are the major contributors to energy intensive operations in India. Energy cost is one of the problems in the institute's budget. Electricity consumption can be reduced with targeted efforts and by using various energy management methods. Resultant energy saving provides a venue for the reinvestment in the educational institute itself. This paper presents an energy audit of the college site (Amal Jyothi College of Engineering, Kottayam). The review begins by gathering data of all the feeders in the college and the past record of electricity bills. This data is then inspected to realize how much energy is used. The load curve of each feeder in the college along with the power consumption data was obtained. From the above data we noticed that some buildings consume more energy. So, we mainly concentrated on these buildings that are RB (Resource Block), STP (Sewage Treatment Plant), Laundry and Kitchen. The data are obtained using some devices such as power quality and energy analyzer, clamp meter and lux meter. Power quality analyzer technology tracks numerous electrical parameters which include voltage, current, frequency, peak demand, harmonic distortion etc. Lux meter is used to measure the lumens and clamp meter is used to measure the power respectively. After analyses of this readings, we have suggested some of the energy and demand side management that can be implemented in each of this buildings so that energy consumption can be reduced to a minimum level. Time of working of all the buildings was also analyzed along with the data.

Keywords: Energy Audit, Power Quality Analyzer, Clamp meter, Lux meter

I. INTRODUCTION

Energy has been in use by the humanity for several years now and demand has been rising day by day.

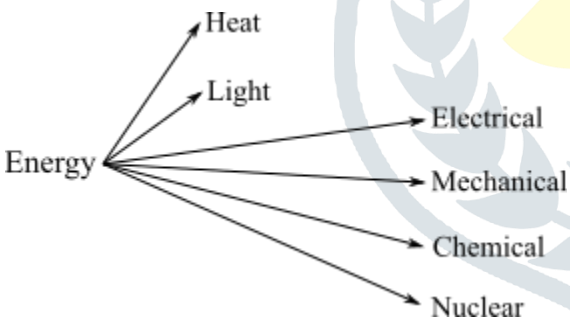

Figure 1: Classification of Energy

Coal and other fossil fuels like Petrol, Diesel, which have taken three million years to form, are likely to deplete near future due to lack of conscious energy use. In the last two hundred years, we have consumed 60% of all resources. For sustainable development, we need to adopt energy efficiency measures. Today, 85% of primary energy comes from non-renewable and fossil sources (coal, oil, etc.). These reserves are continually diminishing with increasing consumption and will not exist for future generations. In this paper we study energy conservation and energy efficiency by how to reduce energy demand to reasonable minimum Cost, recover and re-use heat where possible and also study the use of energy efficient equipment and provide a means to manage use of energy and study how to carry out energy audit.

Energy Audit is the key to a systematic approach for decision-making in the area of energy management. It attempts to balance the total energy inputs with its use and serves to identify all the energy streams in a facility. It quantifies energy usage according to its discrete functions. Energy Audit is the translation of conservation ideas into realities, by lending technically feasible solutions with economic and other organizational considerations within a specified time frame.

II. LITERATURE SURVEY

An **Energy audit** is an inspection survey and an analysis of energy flows for energy conservation in a building. It may include a process or system to reduce the amount of energy input into the system without negatively affecting the output. Lighting constitutes a major portion of electricity consumption in commercial and industrial sector [1].This electricity consumption can only by reduced by detailed study of energy consumption of the selected buildings and by energy management methods. Power Quality Audit allows the transformation of conservation ideas into realities for techno-Economic solution for an organization within a specified time frame [2]. LEED certification helps in the designing for rating new and existing commercial, Institutional and residential buildings [4].Kitchen, Laundry and Sewage Treatment Plant- This buildings are selected for the study of energy consumption patterns and various suggestions are given to provide ways for the energy management in this buildings.

III. ABOUT INSTITUTE

Amal Jyothi College of Engineering is having NAAC accreditation with 'A' grade and to secure the prestigious NBA accreditation for prime departments. The college campus is spread over 60 acres with nearly 1,650,000 square feet. The institute offers 20 courses (B.tech,M.tech and others) and provides hostel facilities with a capacity of 2500 (including boys and girls). The number of students and staffs in college are 3725 and 397 respectively. The campus has its own two 100 kW solar and 1120 kVA power plant.

IV. ELECTRICAL DISTRIBUTION SYSTEM

The 11kV, 3 phase supply is coming to "Amal Jyothi College" from Kerala state Electricity Distribution (KSEB). It is step down to 415V by step down transformer. The power supply is for the academic sector and also the hostel is provided with the same transformer. An APFC panel of 20 kVAr, is provided to maintain power factor close to unity. The incoming supply to college is 11kV which is step down to 415 V by using 500kVA transformers. The DG set provides continuous supply if there is any cutoff from KSEB by any fault or by any reasons. There are 4 DG sets where, 500kVA and 380kVA are connected to the whole campus, 160kVA to kitchen and 82.5kVA to Resource Block section. The central block and P.G block are installed with 50kW solar panel and the 100kW solar panel is equipped on automobile block. The following figure 2 gives the single line diagram.

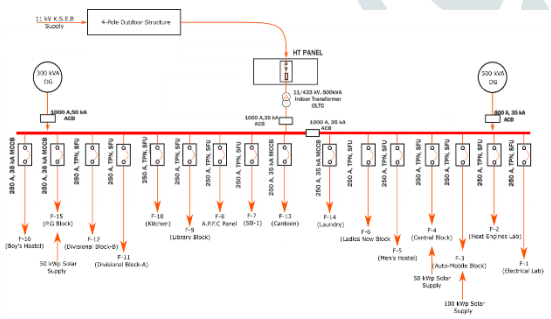

Figure 2: Single line diagram of the electrical distribution of the college

V. METHODOLOGY

The energy audit is defined as "the verification, monitoring, and analysis of the use of energy including submission of technical report containing a recommendation for improving energy efficiency with cost-benefit analysis and an action plan to reduce energy consumption". The energy audit is one of the essential tools for energy conservation so as to accomplish energy efficiency. It includes monitoring and analysis of various energy consuming equipment and convenient action plan to reduce additional energy consumption in the building. Energy auditing of any institute or building can be done by collecting energy-consuming data(electricity bills) and analyze that information to find out unnecessary utilization of energy. Following methodology adopted for an energy audit.

A. Data Collection

Data collection is the very first step in energy audit. Data collection includes

1.Collected data like electricity bills of three years (2016,2017, and 2018).

2. List of lighting load, fan, computer, and air conditioner of Resource Block. 3.List of lighting loads, motor, and other loads in S.T.P, Laundry, and Kitchen.

3. List of lighting loads, motor and other loads in S.T.P, Laundry and Kitchen.

4. Voltage, Current and Power are measured at each feeder.

B. Data Analysis

Data analysis is the next step after data collection. Here we identify the areas for implementation and energy conservation opportunities. Thus finally focus on 4 feeders, which are Resource block, Laundry Sewage treatment plant(S.T.P) and Kitchen. This result is obtained from the energy consumption graph of the campus (includes all feeders).

C. Actions Taken

Actions taken involves the implementation of opportunities based on the measurement of actual energy consumption in each feeder.

VI. RESOURCE BLOCK

The RB(Resource Block) section consumes more power during class-hours and on any events(such as arena(sports tournaments), azure(tech fest), conferences, etc)conducted in the auditorium, basketball court or connected to the RB and UPS supply of 16 kVA is also provided. The survey of the electrical load is carried out to determine the connected load of the block. The measured valve of connected load in the block is measured and presented in table 1. The electrical load can be categorized into lighting, AC and others such as computers, printers.

Name of Load		Quantity Measured
Lighting Load	CFL	26 (11 W), 24 (10 W), 24 (15 W), 29 (18 W), 71 (22 W), 5 (42 W)
	Flurescent Tube	242 (40 W)
	LED	5 (10 W)
FAN Load	Ceiling Fan	163 (60 W)
	Table Fan	16 (60 W)
Other Loads	AC	6 (1.5 Ton), 2 (8.5 Ton), 1 (1 Ton)
	Refrigerator	2 (490 W)
	Computers	35 (200 W)
	Printer	13 (250 W), 5 (1100 W)
	Projector	12 (270 W), 1 (450 W)
	Heater	1 (3kW)
	Audio Loads	2 (800 W), 6 (200 W)
	Air Cooler	2 (185 W)
	UPS	16 kVA*0.895=14.32 kW
	TV	1(110 W), 4(80 W)
Total Load:		103.6 kW

Figure 3: Electrical Load

Power quality analyzer is used for the measurement of power in this building and the below graph is plotted with respect to the measured value.

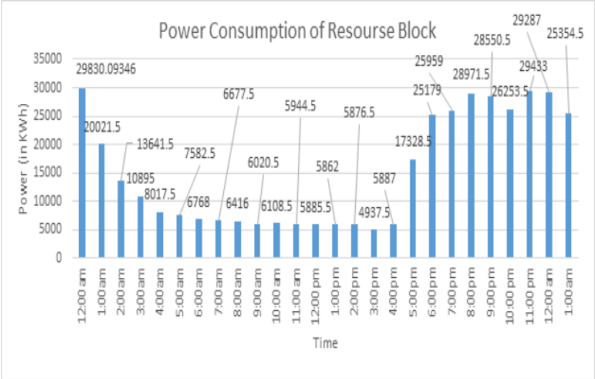

Figure 4: Power Curve plotted for Resource Block

Power consumption graph for the whole college with respect to the measurement taken

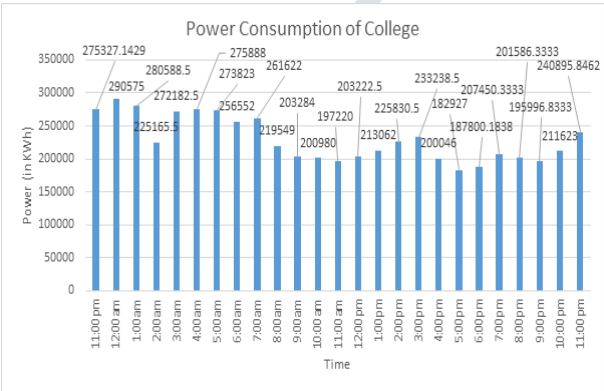

Figure 5: Power Curve plotted for College campus

VII. LAUNDRY

Laundry energy consumption usually depends upon the type and quantity of clothes. Laundry services works in a way to maintain the quality of material required by customers.

In our college, Laundry services start in the morning hours after collecting clothes from both ladies and men hostels. Our Laundry has power loads of 3 washing machines and 3 driers aligned opposite to each other for easy operation. Each motor in washing machine has a connected load of each 1.5 kW motors for washing and extraction. Dryer has two 1.5 kW motor with heat pump and blower motor. The plant has 6 tube lights, 1 fan load, with an elevator with 1.5kW motor. An uniform ironing press with 9 kW heater and 0.37 kW suction motor handles all the uniforms like shirts, pants, overcoat, etc[8]. Other non-uniforms are switched to vacuum table ironing with steam spray. An air compressor with 4 kW motor for pressurising air also used for door operation and extraction for washing machine and dryer as well as for operation of ironing press. The waste water coming out of the plant is passed to S.T.P.

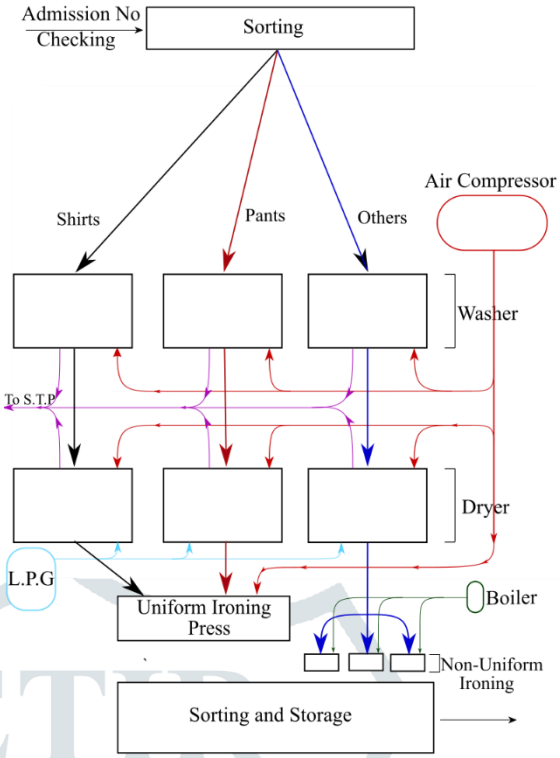

Figure 6: Process Diagram of Laundry

Power quality analyzer and Clamp meter is used for the measurement of power in this building and the below graph is plotted with respect to the measured value.

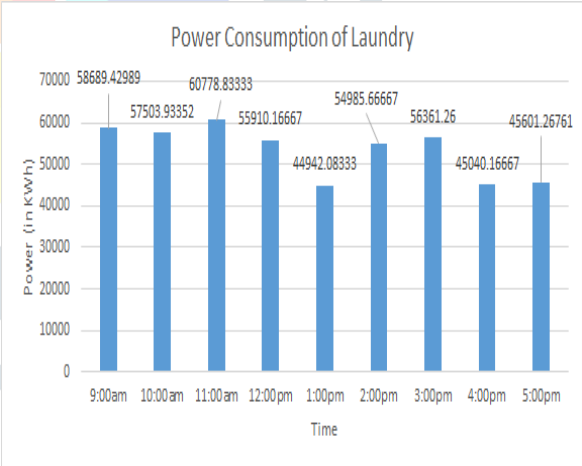

Figure 7: Power Curve plotted for Laundry

VIII. SEWAGE TREATMENT PLANT(STP)

Wastewater treatment is the process of removing contaminants from wastewater and household waste. The physical, chemical and biological process is used to remove contaminants from wastewater. The sewage treatment plant in our college is having the capacity of 6,00,000 litres per day. The processes involved in the treatment are preliminary treatment, primary treatment, secondary treatment and tertiary treatment.

Preliminary treatment consist of separating solid wastes such as sand, organic food materials, debris etc. Treatments such as bar screen, grit chamber and oil grease trap are

used as the wastewater enters first in the treatment plant. During the primary treatment suspended particles are removed and preparing it for the next stage. In secondary treatment both BOD(biological oxygen demand) and COD(chemical oxygen demand) can be reduced by using An-aerobic operation incorporated with SAFF(Submerged An-aerobic Fixed Film Reactor) followed by Aerobic reactor incorporated with MBBR(Moving Bed Biofilm Reactor).In tertiary treatment product water after disinfection and filtration can be collected in a tank can be used for flushing of toilets, for gardening and agricultural purpose.

Power quality analyzer and Clamp meter is used for the measurement of power in this building and the below graph is plotted with respect to the measured value.

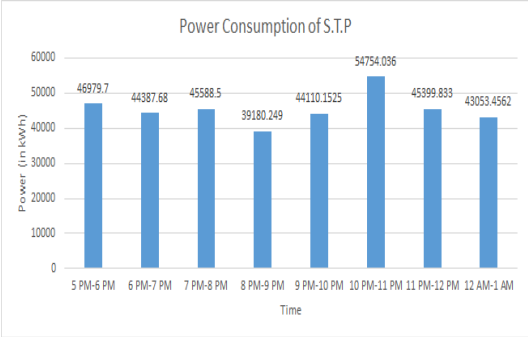

Figure 8: Power Curve plotted for STP

Major connected loads of STP

Connected load	Power rating (kW)
Blower 1	22.5
Blower 2	22.5
Filter feed pump 1	3.75
Filter feed pump 2	3.75
Sludge pump 1	3.75
Sludge pump 2	3.75
Feed pump 1	3.75
Feed pump 2	3.75
Storage pump 1	7.5
Storage pump 2	3.75
Tube (40W)	1.2
Total Load:	79.95 kW

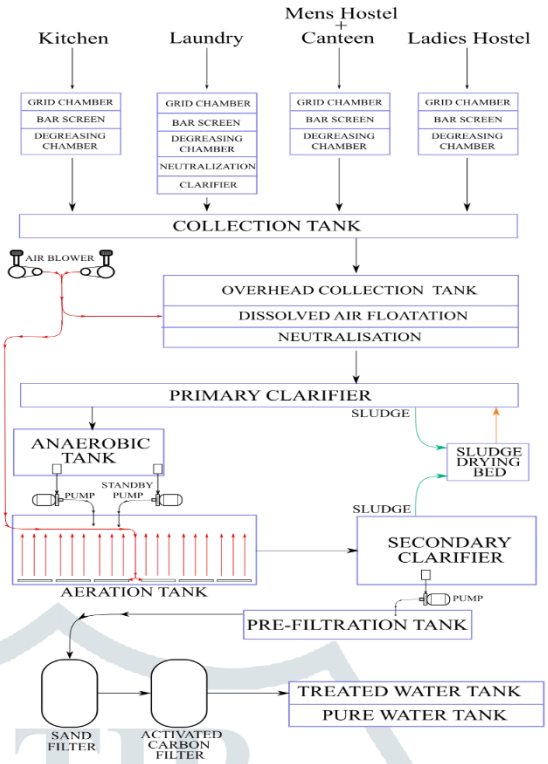

Figure 9: Process Diagram of STP

IX. KITCHEN

Kitchen consume more energy in our campus than any other buildings as the food making process starts early in the morning from 3:30am till 1:00pm in the afternoon. As the campus enhances more than 2300 students, the food making for them is a major part in the day to day program and major energy consumption unit in the campus. From cutting of vegetables to making different dishes are performed by different alternatively aligned machines which have different power ratings. Other than electricity some machines uses energies such as gas, steam from cooking etc. Our study in kitchen reveals that the overall energy can only be reduced by demand side management as devices such as dish washers, vegetables cutters, etc use more power for its working so we decided to select dish washer and provide a method to reduce its energy cost.

Power quality analyzer and Clamp meter is used for the measurement of power in this building and the below graph is plotted with respect to the measured value.

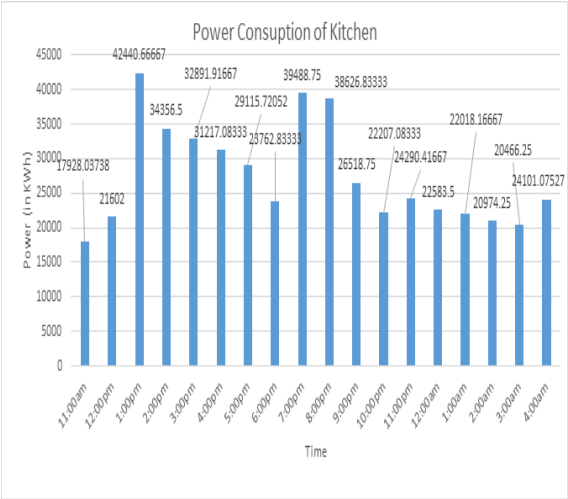

Figure 10: Power Curve plotted for Kitchen

X. DEVICES USED FOR MEASUREMENT

A . Power Quality and Energy Analyzer

The power quality analyzer is a multi-function power analyzer device that measures precisely direct current, alternating current, AC-Voltage, DC-Voltage, the intensity of DC or AC, phase rotation and idle, apparent and effective power. The reading of AC power is considered the real value and has a maximum range of 6000Watts.

Power quality analyzer have many features such as insulated current input, measurement of harmonics, AC and DC current measurement , AC and DC voltage measurement, Frequency measurement, phase rotation measurement. All this data can also be logged and analyze with the delivered PC-software. Power analyzers of the type PCE-PA 6000 can determine the energy in single-phase systems. Power quality analyzer of type PCE-PA 62 allow the energy measurement in symmetrical loaded three-phase systems. Power analyzers of type PCE PA-8000, PCE-360 and PCE-830 support professional power and energy measurements in single and three-phase systems.

Figure 11: Power Quality Analyzer

B. Clamp Meter

Current clamp or **current probe** is an electrical device which uses jaws like opening to allow clamping around an electrical conductor. This allows measurement of the current in a conductor without the need to make physical contact with it and to disconnect it for insertion through the probe. Current clamps are typically used to read the magnitude Of alternating current (AC) and with additional instrumentation. The phase and waveform can also be measured using this meter. Some clamps meters can measure currents of 1000 A and even more. Hall effect and vane type clamps can also measure direct (DC).

A clamp meter measures the vector sum of the currents flowing in all the conductors passing through the probe which depends on the phase relationship of the currents. Only one conductor is normally passed through the probe. In particular if the clamp is closed around a two-conductor cable carrying power to equipment. The same current flows down one conductor and up the other then the meter correctly reads a net current of zero.

C. Lux Meter

A lux meter is an equipment that measures brightness of light falling on an object at a particular area. In other words, it properly gauges the intensity at which brightness appears to the human eye. A lux meter works by making use of a photo cell to capture light. The lux meter the converts this light to an electrical current stream and after measuring this current, the device allows to calculate the lux value of the light which it has captured. Lux meters are used for measuring brightness in lux, fc or cd/m². Some lux meters are equipped with an internal memory or data logger to record and save measurements. The measurements of light intensity with a lux meter is becoming increasingly important in the workplace due to safety concerns. The lux meters with data loggers are highly regarded in the industry due to the devices cosine correction of the angle of incident light. Many lux meters include software for detailed analysis and offer different

interfaces for transferring measured data to a computer.

The Lux meter auditing of all the selected buildings where quiet accurate with respect to the IS 3646(Indian Standard code for recommended illumination) and the buildings with illumination problems where solved by the addition of more LED lights.

RECOMMENDATIONS

A. KITCHEN

The proposed design for dish washer in the kitchen is that the water after cooking (water from washing of vegetables, rice etc.) is allowed to flow into the water tank. This normal water is moved to the flash mixer where the mixing of steam from boiler or from solar heater takes place. There are two two ways for the heating of water. First, the steam from boiler is allowed to pass to the flash mixer, this steam can provide temperature up to 80°c which is the required temperature for the dish washer then the hot water is directly passed into the hot water storage tank.

Second, the temperature provided by the steam can sometime vary as this temperature can sometime only reach up to 70°c so a relay circuit is provided for turning on the solar heater which will latter provide the remaining heat or temperature(10°c) to the water. An electric heater is also provided for the standby purpose incase of any failure from the remaining sources. This proposal is energy efficient as it does not use any electricity for its usage so the dish washing process used now which works fully on electricity can now be reduced which in turn reduce the overall electricity bill in the kitchen.

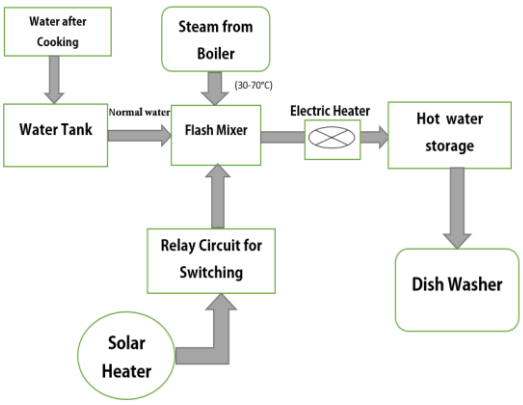

Figure 12: Process diagram for Dish Washer

B. LAUNDRY

Washing machines used now should be reassembled or replaced with other washing machines which can be fully operated with the help of solar energy.

C. SEWAGE TREATMENT PLANT

STP has more CFL lighting loads which should either be replaced by LED lights or the lighting circuit should be reduced to a minimum level as the building has only one occupant (Operator) and the lights are always turned on, which is not required in this building so reduction of lighting loads can reduce the energy bill to a minimum level.

CONCLUSION

Energy audit was conducted in the above buildings to know the energy consumption patterns of the buildings. From the graphs plotted it is seemed that the working process of all the buildings cannot be stopped during the working hours and the energy can only be conserved by implementation of energy management methods. Solar energy is the best optioned method in this buildings as the above mentioned buildings take electricity directly from the KSEB supply. This energy is the best method as it is a non-renewable source of energy and will not cause any problems to the environment. Other implementations in the buildings are discussed in the above chapter.

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