International Innovative Research Journal of Engineering and Technology
ISSN: 2456-1983 Vol: 4 No: 2 December 2018

Application of Energy Conservation Techniques in Industries and Institution

Wong Seng Yue
Centre for the Initiation of Talent & Industrial Training, Universiti Malaya, 50603 Kuala Lumpur, Malaysia

Abstract: Power saving is essential nowadays because of growing electricity demand is more than the generation due to large consumers like industries, factories, electric vehicles, etc. This paper gives the clear understanding of energy conservation techniques. This paper describes the possible energy conservation techniques to be implemented in the industries. Energy and cost savings are the very important factors for industries. There are many energy conservation techniques available for reducing electricity consumption in industries like Energy efficient motors, Split capacitor based Automatic Power Factor Correction (SCBAPFC), Harmonic compensators. Energy efficient motors consumes less electricity, reduced core & copper losses, improved power factor and last longer than other motors of the same size. Maintaining power factor above 0.8 is necessary to avoid penalty charges in industries. SCBAPFC maintains the power factor near unity, reduces the line conductor losses, increases the supply line load ability limit. Harmonic compensator provides required harmonic current to the non linear loads without affecting the source. In KAYCEE PLASTO PACK, RIYA OIL PRODUCTS, DHARMA RATHINA TEXTILES, industries and In Kamaraj College of Engineering & Technology (KCET) D-Block Power System Simulation (PSS) Lab the energy audit was conducted and the area of energy leakages, possible energy saving loads was identified. For the issues, possible energy saving methods with additional cost and without additional cost was implemented. Thus 30-40% of electricity consumption is reduced.

Keywords: Energy Conservation; SCBAPFC; Power Factor; Harmonics

1. INTRODUCTION

Availability of power has an important role in the economic development of a country. In India, the gap between the electricity demand and generation capacity is high. As to reduce the gap between the demand and generation capacity energy should be managed. An energy audit is an inspection, survey and analysis of energy flows, for energy conservation in a building, industries and process to reduce the amount of energy input into the system without negatively affecting the outputs. An Energy audit is the first step for conservation of electrical energy in industries and other organizations.

KAYCEE PLASTO PACK plastic cans manufacturing industry, RIYA OIL PRODUCTS industry, DHARMA RATHINA TEXTILES spinning industry, evinced interest in availing the services of KCET students, for conducting an preliminary energy audit and consultancy service at all production units. The methodology adopted for conducting the preliminary energy audit and solution for energy conservation at following steps.

- Analysis of previous year EB bill, consuming equipment, capacities of the major equipment
- Measurement of operating parameters for various equipments to estimate their operating efficiency.
- Identifying the possible energy saving loads.
- Suggesting the suitable energy saving methods (with and without additional cost).
- Suggesting the suitable cost saving methods (with and without additional cost).
- Report was given based on energy audit and energy conservation techniques as suggestions like Energy efficient motors for drives, Harmonics compensators, SCBAPFC, Fixed Capacitor, Timer Relay and LED lighting system were given to the KAYCEE PLASTO PACK, RIYA OIL PRODUCTS, DHARMA RATHINA TEXTILES industry personnel.

2. ENERGY CONSERVATION TECHNIQUES

The electricity demand is more than the production and so the conservation of electrical energy is essential to maintain

the balanced power supply. The various energy conservation and power factor improvement techniques are replacement of conventional motor by Energy Efficient Motor, usage of Timer Relay for continuously operating load, usage LED Lamp instead of fluorescent lamp and filament lamp, Automatic Power Factor Correction (APFC), Fixed Capacitor, Split Capacitor based APFC.

A. Automatic Power Factor Correction (APFC):

The APFC is one of the methods used for the power factor improvement and generally it is connected at the source side to supply reactive power to the load. The voltage and current measurements are taken from the load. The magnitude, phase angle of both voltage and current are calculated from the separate blocks. Figure 1 shows the block diagram of APFC.

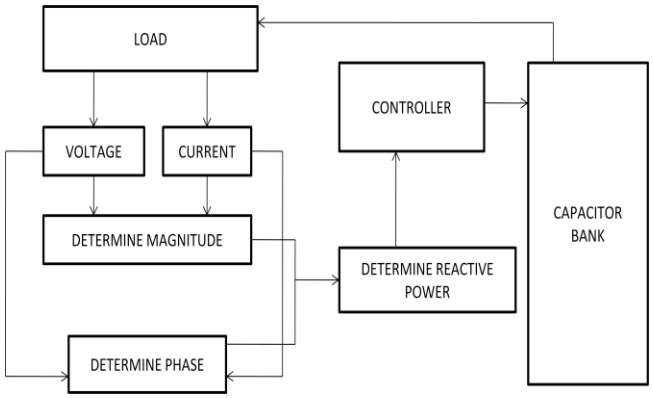

Figure 1. APFC

The APFC is used for both continuously operating loads and intermittent loads with increased line conductor losses. The required reactive power for the load is determined by the reactive power calculator and fed to the controller. The controller switches on the corresponding capacitors from the capacitor bank and then the reactive power is supplied to the load from the capacitor. The controller may be a PIC microcontroller, ATMEGA microcontroller, 8051 microcontroller etc.

B. Fixed Capacitor

The fixed capacitor is mostly used for continuously operating loads. A fixed capacitor is constructed in such manner that it possesses a fixed value of capacitance which cannot be adjusted. A fixed capacitor is one of the conventional methods used for compensating reactive power required for the load. Figure 2 shows the block diagram of fixed capacitor.

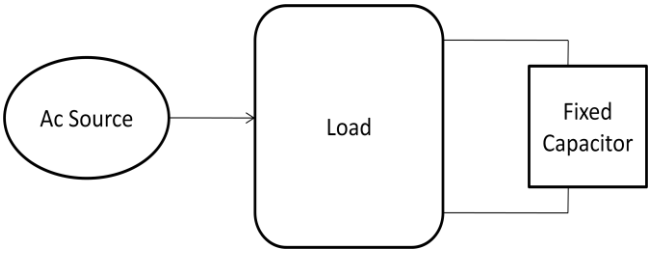

Figure 2. Fixed Capacitor

The fixed capacitor is connected at the terminals of the load to reduce the line conductor losses. It provides the reactive power required by the load and improves the power factor.

C. LED Lamp

An LED lamp is an electric bulb that produces light using light emitting diodes (LEDs). LED lamps have more lifespan and higher electrical efficiency than incandescent lamps, fluorescent lamps. Figure 3 shows the block diagram of LED lamp. The 230Volts AC source is given to the rectifier circuit. It converts the ac supply to 12Volts dc supply.

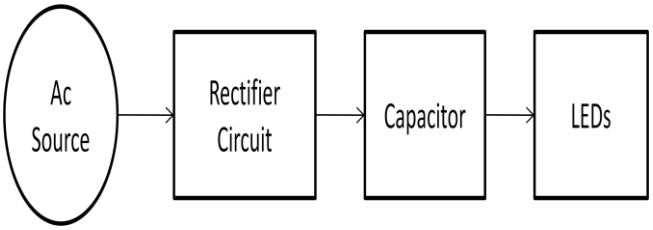

Figure 3. LED Lamp

A capacitor is connected across the rectifier circuit which provides required voltage to the LEDs when the output of the rectifier circuit goes below 12Volts. The LEDs are connected across the capacitor and gives the light output. The LED lamp consumes less amount of power than any other lamps.

D. Split Capacitor based APFC

The split capacitor based APFC is used for continuously operating loads and intermittent loads with reduced line

conductor losses. The split capacitor based APFC is the new and efficient method used for improvement of power factor. Figure 4 shows the block diagram of split capacitor based APFC.

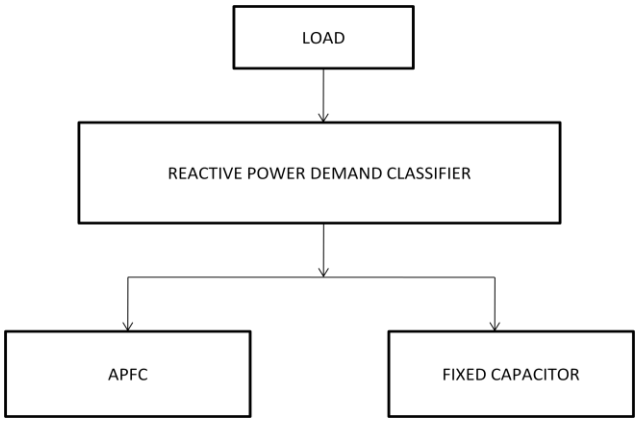

Figure 4. Split Capacitor based APFC

The split capacitor based APFC is the combination of fixed capacitor and APFC. Here the load reactive power demand is classified based on load and correspondingly the reactive power is supplied to the load either by the APFC or by both APFC and fixed capacitor. In split capacitor based APFC, the fixed capacitor is connected at the terminals of the continuously operating load to reduce the line conductor losses, 90% of reactive power is supplied by the fixed capacitor and 10% is supplied by the APFC. For intermittent loads the reactive power is supplied only by the APFC. It maintains the power factor near unity, has high efficiency, minimizes harmonic current, reduces the losses, protects the electrical equipments, improves the lifetime of the electrical equipments.

E. Energy Efficient Motor

Energy efficient motor is the induction motor which is mostly used for all applications in most of the industries. Energy efficient motor has large copper cross sectional area in its winding than the conventional induction motor which reduces the copper losses.

It has longer stator and rotor cores than the conventional induction motor which results in effective flux utilization. It has the better lamination for core and so eddy current losses will be reduced. It has an improved power factor rating compared to a conventional induction motor.

F. Timer Relay

The timer is used to switch the load automatically by adjusting the ON time and OFF time which results in reduced power consumption by the load. The timer consists of a relay, adjustable time setting (ON & OFF Time). Figure 5 shows the block diagram of timer relay.

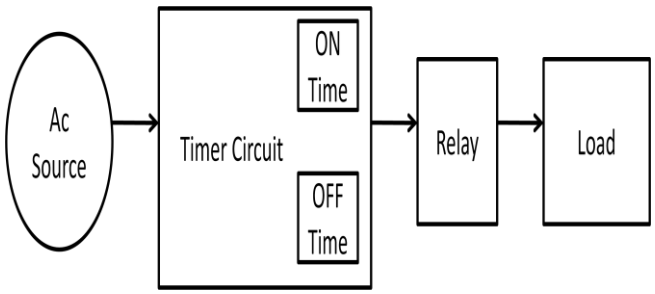

Figure 5. Timer Relay

The Ac power supply is given to the timer circuit and it has the adjustable ON and OFF time that varies from seconds to hours. The timer circuit is then connected to the relay. Based on the output from the timer the relay will operate. The relay acts as a switch for the load. For continuously operating load the timer can be connected and the power consumption can be reduced.

3. TECHNIQUES ADOPTED/SUGGESTED IN VARIOUS INDUSTRIES

The energy audit was conducted in institution/various industries and the possible energy saving methods were implemented and the same discussed below.

A. Energy Conservation Work at Kaycee Plasto Pack Industry Using Fixed Capacitor, Voltage Stabilizer, Split Capacitor Based Apfc, Electronic Choke, Led Lamp, Harmonic Conditioner

(a)Fixed Capacitor:

In Kaycee plasto pack industry the reactive power compensation (KVAR Rating) for some motors is not proper. Industrial thumb rule for reactive power compensation is 1/3rd of the motor horse power rating. For example 5HP-2KVAR should be installed. Installing proper KVAR rating for motor improves the power factor, reduces the reactive power loss and improves the efficiency of the motor.

(b)Voltage Stabilizer

The voltage stabilizer gives the constant and required output voltage for particular application. In Kaycee plasto pack industry there are many motors which are loaded less than the rated loading. The current drawn is less than rated current, full voltage is provided which leads to more core losses even though they are not loaded fully. It is necessary to reduce the voltage using stabilizer to reduce the core losses. If the rated current of the motor is 38Amps but it is consuming maximum of 30Amps on the maximum load with supply of 420V it introduces more losses due to increased iron loss. By using voltage stabilizer if the voltage is reduced to 405V, iron loss decreases leads to lower power consumption. There are many fluorescent lamps in the Kaycee plasto pack industry. The maximum light intensity of the fluorescent obtained in 205 volts itself. Figure 6 shows the graphical representation of voltage optimization in fluorescent lamp.

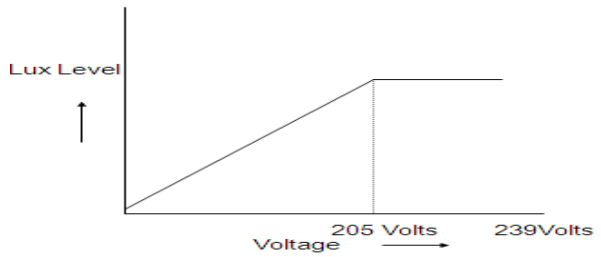

Figure 6. Voltage Optimization in Fluorescent Lamp

The voltage can be stabilized to 210 volts and fed to the fluorescent lamps to reduce the power consumption. 15% reduction in voltage leads to 15% reduction in power consumption.

(c) Split Capacitor based APFC

The split capacitor based APFC is one of the efficient methods to improve the power factor and to supply required power based on the type of load.

Existing System

The conventional APFC is connected at the source side which has the drawback of additional line conductor loss when it supplies the reactive current to the continuously operating load. Here the APFC supplies three loads with one continuously operating load and other two are intermittent loads. Figure 7 shows the block diagram of existing APFC system.

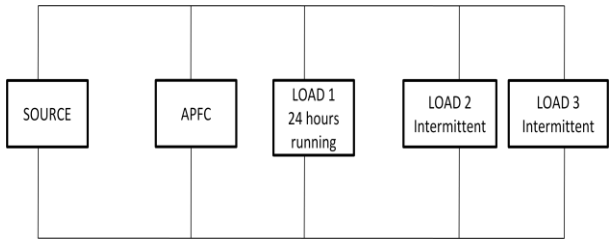

Figure 7. Existing APFC System

The APFC can improve the power factor but the line conductor loss is the only drawback. For intermittent loads APFC will be very efficient.

Proposed System

In the proposed system of SCBAPFC the loads are same but the fixed capacitor is connected at the terminals of the continuously operating load to reduce the line conductor losses. Figure 8 shows the block diagram of proposed SCBAPFC system.

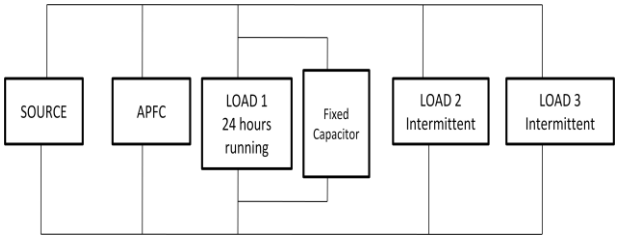

Figure 8. Proposed SCBAPFC System

Here the fixed capacitor supplies 90% of reactive power to the continuously operating load and only 10% of reactive power is supplied by the APFC. Hence the line conductor losses will be reduced.

(d) Electronic Choke

The copper chokes and aluminium chokes are used in fluorescent lamps in the kaycee plasto pack industry which produces I^2R loss which results in more power consumption. The electronics choke can be used instead of copper and aluminium chokes to reduce the power consumption. Additionally the electronics choke has good life time.

(e) LED Lamp

A light-emitting diode (LED) is a two-lead semiconductor light source. It is a p-n junction diode that emits light when a suitable voltage is applied to the leads, electrons are able to

recombine with the holes within the device, releasing energy in the form of photons. The conventional lamps like filament, fluorescent lamp consumes more power and dissipates more amount of heat. LED lamp consumes very less amount of power than other conventional lamps. LED lamp has a very good lifetime, the efficiency of the higher than other lamps.

(f) Harmonic Filter/Conditioner

Harmonics is one of the major power quality problems occurring in most of the industries. It occurs mostly due to electronic loads. The current THD% (Total harmonics distortion) is high in the drives of the kaycee plasto pack industry. TNEB standard for harmonics is VTHD = 5% and ITHD = 8%. The occurrence of harmonics produces additional core and copper loss which leads to more power consumption. Proper harmonics conditioner or low/high pass filter can be used to reduce the particular order of harmonics which is mostly occurring. Particularly third order harmonics mostly occur in drives.

B. Energy Conservation Work at Riya Oil Products Using Fixed Capacitor, Modern Star Delta Starter

(a) Fixed Capacitor

Existing System

In Riya oil products industry the average power factor is less than 0.8, average penalty charges for 10 month is Rs.3387. Table 1 shows the electricity bill of the oil industry for 10 months.

Table 1. Electricity Bill of Riya Oil products

DATE	CONSUMED UNIT	POWER FACTOR	PENALITY CHARGES (Rs.)
20.01.2018	3920	0.78	1742.44
20.11.2017	3910	0.79	1489.71
21.09.2017	3530	0.67	6052.18
21.07.2017	4610	0.51	14929.49
23.05.2017	3160	0.59	7825.74
24.03.2017	550	0.5	1833.56
AVERAGE			**Rs.3387**

The TNEB standard for power factor in industries must be greater than or equal to 0.8. If Power factor is maintained below 0.8, penalty charges will be taken into total bill amount. Installing proper KVAR rating of capacitor will maintain the power factor above 0.8 and avoids penalty charges.

Proposed System

Proper KVAR rating of capacitor **(**say 5kvar for 15HP motor) will compensate the losses due to reactive power in induction motors. In Riya oil products the capacitor rating of groundnut grinding machine is not properly installed. In name plate details it is given as 6 KVAR but the calculated KVAR rating is 1.35 KVAR only.

The capacitor current is measured using the clamp meter and the current required for 1KVAR is determined with the help of measured current of another 6KVAR capacitor. The ratio of measured capacitor current and the current required for 1KVAR gives the actual KVAR rating of the capacitor. **In**dustrial thumb rule for 5HP motor is 2kvar. So installing a proper capacitor (say 5 KVAR) for 15HP motor is essential to maintain the power factor above 0.8 and to avoid the penalty charges. Cost savings per year will be Rs.9678.

(c) Modern Star Delta Starter

Existing System

Star Delta starter is used to reduce the inrush (starting) current of the induction motor. The motor runs as star connected (Phase voltage is 0.577 times the line voltage) motor during starting and changed to delta connection when motor achieves the 70% of the rated speed and to develop the required load torque. In Riya oil industry the star delta starter does not support delta to star conversion.

Proposed System

In Riya oil industry the 15HP motor is not loaded fully and it is loaded like a 10HP motor. The core loss is same for both loadings of the motor since it depends on the voltage. Hence it is necessary to bring the motor back to star connection to reduce the core losses. The core loss in star is reduced by three times the core loss occurring in delta connection.

C. Energy Conservation Work at Dharma Rathina Textiles Industry Using Timer Relay

In Dharma rathina textiles industry the Over Head Cleaner (OHC) is used to separate the cotton dust from the spindles by blowing the air. The three phase induction motor is used in OHC. Totally there are 18 OHC motors in Dharma rathina textiles. Table 2 shows the specifications of OHC Motor.

Table 2. Specifications of OHC Motor

Name Plate Details: OHC Motor	
Motor Type	Induction Motor
Rated Voltage	440V
Rated Current	20A
Power Rating	2HP
Kilowatts Rating	1.5 kW
Connection	Delta

(a) Existing System of Over Head Cleaner Motor

The power is supplied continuously to the three phase induction motor in over head cleaner by the ac source during operating condition. Figure 9 shows the block diagram of existing system of over head cleaner motor.

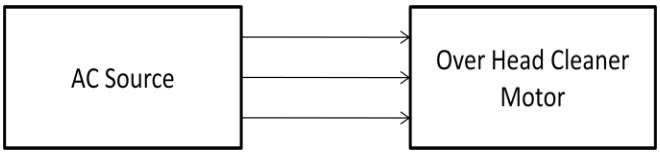

Figure 9. Existing System of Over Head Cleaner Motor

The power consumption will be more by the over head cleaner motor when it is operated continuously for 24 hours. Hence the modification can be made to reduce the power consumption.

(b) Proposed System of Over Head Cleaner Motor

In the proposed system a timer relay is connected between the ac source and over head cleaner motor. Figure 10 shows the block diagram of proposed system of over head cleaner motor.

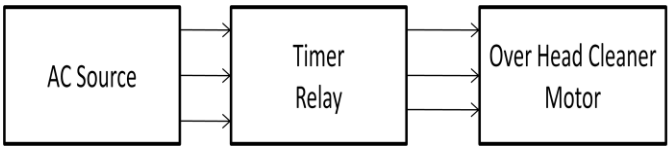

Figure 10. Proposed System of Over Head Cleaner Motor

The timer relay is connected at the source side in which we can specify the ON time and OFF time. The time setting is available from seconds to hours and the timer runs continuously throughout when the power supply is provided. The timer automatically calculates the time duration for the specified ON time and OFF time. Here the timer relay acts as a control circuit for the over head cleaner motor and to reduce the power consumption.

D. Energy Conservation Work at Kamaraj College of Engineering and Technology Block D Power System Simulation Lab Using Timer Relay

In Power System Simulation (PSS) lab there are two cassette type air conditioners. The air conditioner is a large power consuming load. The indoor unit of the cassette type air conditioner is mounted on the ceiling and the outdoor unit consists of a compressor, a fan which is mounted outside as similar to the split type air conditioner.

(a) Existing System of Air Conditioner KCET - D-BLOCK PSS LAB

The power is supplied continuously to the air conditioner by the ac source during operating condition. Figure 11 shows the block diagram of existing system of air conditioner.

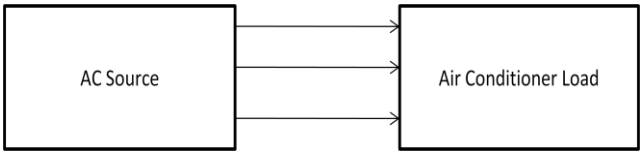

Figure 11. Existing System of Air Conditioner

The power consumption will be more by the air conditioner load when it is operated continuously since the air conditioner load is a large power consuming load. Hence the modification can be made to reduce the power consumption.

(b) Proposed System of Air Conditioner KCET D-BLOCK PSS LAB

In the proposed system a timer relay is connected between the ac source and air conditioner. Figure 12 shows the block diagram of proposed system of air conditioner. The timer relay is connected at the outdoor unit in which we can specify the ON time and OFF time.
The time setting is available in seconds to hours and the timer runs continuously throughout when the power supply is provided.

International Innovative Research Journal of Engineering and Technology
ISSN: 2456-1983 Vol: 4 No: 2 December 2018

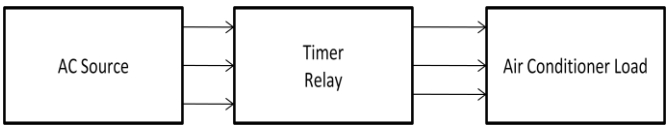

Figure 12. Proposed System of Air Conditioner

The timer automatically calculates the time duration for the specified ON time and OFF time. Here the timer relay acts as a control circuit for the air conditioner load and to reduce the power consumption.

4. RESULTS AND DISCUSSION

In Kaycee plasto pack industry the fixed capacitor of proper KVAR rating is installed for all motors. The outcome achieved in Kaycee plasto pack industry is shown in below table 3.

Table 3. Outcome Achieved In Kaycee Plasto Pack

SL. NO.	Problem	Solution	Power factor Improvement	Unit Savings Per Month
1.	Reactive power compensation is not proper for many motors	Install totally 25KVAR Capacitor	0.83 to 0.91	200 Units

The cost of 25KVAR capacitor is Rs.8000 and the payback period for the investment is 6 months. Some other energy conservation techniques like voltage optimization, SCBAPFC, energy efficient copper chokes were suggested and the expected outcome is shown in below table.

Table 4. Expected Outcome in Kaycee Plasto Pack

SL.No	Problem	Solution	Units Saving per month
1.	Reactive power loss is high	Install Split Capacitor based APFC (Rs. 50000.00 for 40kvar)	600 Units
2.	230V is supplied for fluorescent lamps	Voltage can be reduced to 210V through voltage stabilizers for lighting loads.	55 Units
3.	Conventional Copper chokes in fluorescent lamps	Use energy efficient copper chokes (35*200=Rs.7000)	10W/lamp is saved. 105 Units
TOTAL UNITS SAVINGS PER MONTH			**760 Units**

In Riya oil products industry 4KVAR fixed capacitor is installed to groundnut grinding machine and the outcome achieved is shown in below table 5.

Table 5. Outcome Achieved In Riya Oil Products

SL. NO.	Problem	Solution	Power Factor Improvement	Cost Savings Per Year
1.	Reactive power compensation is not enough	Install 4kvar capacitor to groundnut grinding machine	0.78 to 0.92	Rs.9688

The cost of 4KVAR capacitor is Rs.1280 and the payback period for the investment is 2 months.

The timer relay is suggested in over head cleaner motor. In the timer relay the time specified for ON condition is 5 minutes and for OFF condition is 5 minutes. Based on the above timings the over head cleaner motor electric energy consumption is analyzed for the two operating modes such as with and without timer. The total energy savings and cost savings of over head cleaner motor is discussed below.

Load Duty = 24 Hours

Energy Savings in18 OHC motor for 2 hours = 27kWhr
Energy Savings per Day = 1.5*12 = 324kWhr
Cost Savings per Month = Rs.52,682
Cost Savings per Year = Rs.6,32,188
Cost of Timer = 18* 850 = Rs.15,300
Payback period for total cost of timer = 10 days
The timer relay is used in air conditioning system of KCET D-BLOCK PSS LAB as discussed above. In the timer relay the time specified for ON condition is 2 minutes 30 seconds and for OFF condition is 4 minutes 30 seconds. Based on the above timings the air conditioner operation is analyzed. The energy meter reading of air conditioner is shown in table 6 and it was taken every half an hour for the two operating modes such as with and without timer.
Date: 04/01/2018 & 06/01/2018

Table 6. Energy Meter Reading of A/C

Time Duration (AM/PM)	Units Consumed without Timer (KWhr)	Units Consumed with Timer (KWhr)
10.30 – 11.00 AM	2.7	1.7
11.00 – 11.30 AM	2.6	1.8
11.30 -12.00 PM	2.7	1.6
12.00 – 12.30 PM	2.8	1.8
Total Units	**10.8 units**	**6.9 units**

The unit consumed with timer is 6.9 units, without timer is 10.8 units. The total energy savings and cost savings of air conditioner is discussed below.
Load Duty = 2 Hours
Energy Savings per Day = 3.9kWhr
Energy Savings per Month = 85.8kWhr
Cost Savings per Month = Rs.634
Cost Savings per Year = Rs.6974
Cost of Timer = Rs.1700
Payback period for total cost of timer = 4 months
The electric energy consumption of air conditioner is reduced up to 35% of total electricity consumption.
The table 7 shows the overall outcome achieved in industries/institution.

Table 7. Overall Outcome Achieved in Industries and Institution

SL. NO.	**Name of the Institution/Industry**	**Technique Adopted**	**Outcome**
1.	Kaycee Plasto Pack	Installed totally 25KVAR Capacitor	**Improvement in Power factor from 0.84 to 0.91 and** Energy savings per month is **200kWhr,** cost savings per year is **Rs.16,680**
2.	Riya Oil Products	Installed 4kvar fixed capacitor	**Improvement in Power factor from 0.78 to 0.92 and** Cost savings per year is **Rs.9,678**
3.	Dharma Rathina Textiles	Timer Relay	Expected energy savings per month is **52,682kWhr** and **c**ost savings per year is **Rs.6,32,188.**
4.	Kamaraj College of Engineering and Technology D-BLOCK PSS LAB	Timer Relay	Energy savings per month is **85.8kWhr**, Cost Savings per year is Rs.**6684.**

Thus by implementing the energy conservation techniques electric energy consumption is reduced up to 30-40% in industries/institution.

5. CONCLUSION

Electricity demand is increased due to the usage of drives in factories, industries etc. Energy audit is an inspection, survey, analysis of energy flows for conservation of energy. Some of the energy conservation techniques are energy efficient motor, fixed capacitor, timer relay, Split capacitor based APFC, Efficient lighting system. Fixed capacitor is installed in KAYCEE PLASTO PACK, RIYA OIL PRODUCTS industry and cost savings per year is Rs.16,680, Rs.9678. The timer relay is suggested for OHC motor in DHARMA RATHINA TEXTILES and expected cost savings per year is Rs.6,32,188. The timer relay is implemented in air conditioning system of KCET D-Block PSS Lab and 35% of electrical energy is conserved, cost savings per year is Rs.6684.

REFERENCES

[1] W. Lee, R. Kenarangui, "Energy management for motors, systems, and electrical equipment, " IEEE Transactions on Industry Applications; vol. 38, no. 2, March/April 2002, pp. 602-607.

[2] J. Gomes, D. Coelho and M. Valdez, .Energy audit in a school building technology, professional and artistic school of Pombal., IEEE Conference Publications on Energetics, 3rd International Youth Conference(IYCE), Vol-8, 2011.

[3] Harapajan singh, Manjeevan Seera, Mohamad Adha Mohamad Idin, Electrical Energy Audit a Malaysian University - A Case Study., IEEE International Conference on Power and Energy, Vol-8, No-12, 2012.

[4] Mehulkumar J Panchal, Ved Vyas Dwivedi and Rajendra Aparnathi .The Case study of Energy Conservation and Audit in Industry Sector. International Journal Of Engineering And Computer Science,Vol.3, Issue, pp 5298-5303,April,2014.

[5] S.L Uppal, A reference book .Electrical wiring and estimating costing. by Khanna publishers, Delhi-6.

[6] Chee Khiang Pang, Cao Vinh Le, Oon Peen Gan, Xiang Min Chee, Dan Hong Zhang,Ming Luo, Hian Leng Chan, and Frank L. Lewis. Intelligent Energy Audit and Machine Management for Energy-Efficient Manufacturing. Proceeding of International Conference on Cybernetics and Intelligent Systems (CIS), Qingdao, pp 142-147, September, 2011

[7] Inamdar H. P, Hasabe R.P .IT Based Energy management through Demand Side in the Industrial Sector. proceedings of International Conference on Control, Automation, Communication and Energy conservation, Perundurai, pp 1-7, June, 2009.

[8] Energy managers/ Auditors Guide books published by Bureau of Energy Efficiency.

[9] B.R Gupta, A reference book .Generation of electrical Energy. by Eurasia Publishing House (Pvt.) Ltd.

[10] Shashank Shrivastava, Sandip Kumar and Jeetendra Mohan Khare. Improving Industrial Efficiency by Energy Audit. International Journal of Scientific Engineering and Technology, Vol.2, Issue 4, pp 291-294, April, 2013.

[11] R. Hari Baskar, Hitu Mittal, Mahesh S Narkhede and Dr. S.Chatterji .Energy Audit–A case study. International Journal of Emerging Technology and Advanced Engineering, Vol.4,Special Issue 1, India, pp 73-78, February, 2014.

[12] Nissanga Nishad Rasanajan Mendis and Nisal Perera, .Energy audit: A Case Study., Proceedings of International Conference on Information and Automation, Shandong, pp 45-50, Dec., 2006.

[13] Noor.M. Maricar .Industrial Energy Audit Web Application using Data Mining Model. Proceedings of GCC Conference (GCC), Manama, pp 1-6, March, 2006.

[14] M Gokul, S Ponraj, S Rohan, M Venkatesh, D Prince Winston, B Praveen Kumar, "Energy Audit for Industries and Institution," International Journal of Advanced Research in Management, Architecture, Technology and Engineering (IJARMATE), Vol.3(2), 199-205(2017).

[15] Marimuthu, P., and B. Praveen Kumar. "Reconfiguration of 25 kW solar PV power plant."

International Journal Of Engineering And Computer Science 6, no. 6 (2017).

[16] D Prince Winston, M. Saravanan, "Novel Energy Conservation Scheme for Three Phase Induction Motor Drives Employed in Constant Speed Applications", Przegląd Elektrotechniczny, Vol. 88, Issue.11a, 2012, pp.243-247.

[17] Praveen Kumar B, Prince Winston D, Cynthia Christabel S, Venkatanarayanan S , "Implementation of a switched PV technique for rooftop 2 kW solar PV to enhance power during unavoidable partial shading conditions," J Power Electron 2017;17(6):1600–10.

