Energy Conservation – A Case Study

Article · November 2015

1 author:

Ramya Lekshmanan
Anna University, Chennai

International Journal of Applied Engineering Research ISSN 0973-4562 Volume 10, Number 9 (2015)

Energy Conservation – A Case Study

Ramya.L.N
Department of Electrical and Electronics Engineering,
KCG College of Technology, Chennai
ramyaln.eee@kcgcollege.com

Abstract— ***Energy is very important in the entire process of evolution, growth and survival of the world. The increasing energy demand has an adverse effect on the environment and also an increasing pressure for a government. For a developing country like India, the energy criterion decides the growth of the country. Being the third largest power producer in the world, energy demand and scarcity rules the country. Energy demand in our country is increasing exponentially. Energy conservation can be the best solution for the raising energy demand. Energy conservation is reducing the energy consumption by using less of an energy service. One of the important ways of to improve the energy conservation is energy audit. Energy conservation without compromising the usage is a great task. The paper focuses on the importance of energy conservation by considering the loads of a class room of an educational institution and considering the energy consumed by the present loads and recommending energy efficient appliances and an efficient yet simple sensor based model to reduce the energy consumption and comparing the results.***

Keywords— **Energy, energy conservation, energy audit, consumption of energy, PIR sensor**

INTRODUCTION

Energy generation is the most important deciding factor for a developing country like India. The total installed power capacity in India is around 255.012GW as of end of November 2014, being the world's largest producer of electricity in the year 2013 surpassing Japan and Russia with a global share of 4.8% in power generation. Renewable Power plants constituted 28.43% of the total installed capacity and Non-Renewable Power plants constituted the remaining 71.57%. As of March 2013, the per capita total electricity consumption in India was 917.2kWh.

The 17th electric power survey of India report claims that over 2010–11, India's industrial demand accounted for 35% of electrical power requirement, domestic household use accounted for 28%, agriculture 21%, commercial 9%, public lighting and other miscellaneous applications accounted for the rest. The electrical energy demand for 2016–17 is expected to be at least 1,392 Tera Watt Hours, with a peak electric demand of 218 GW. The electrical energy demand for 2021–22 is expected to be at least 1,915 Tera Watt Hours, with a peak electric demand of 298 GW. If current average transmission and distribution average losses remain same (32%), India needs to add about 135 GW of power generation capacity, before 2017, to satisfy the projected demand after losses. [1]

Energy conservation campaigns can be the better solutions for the ever raising energy demands. Energy conservation is reducing energy consumption using less of an energy service. Energy audit is an efficient service which investigates the possible ways of energy conservation in a building or a system without negative output.

The proposed work deals with energy audit, recommendations of energy efficient appliances and a simple sensor circuit to reduce energy consumption. The educational class room is taken into consideration as the fact the number of people involved is huge and the possibility of energy conservation is huge.

PROPOSED WORK

The paper proposes a simple idea on reducing the energy consumption. For the case study, a class room of size 129.53 sq.mt. that can accommodate 60 students is considered. There are nine ceiling fans, 9 fluorescent lamps. The following table shows the power rating, installed capacity and power consumption of the appliances.

TABLE I
POWER CONSUMPTION OF APPLIANCES

Electrical appliances	Quantity	Power rating of the appliances (watts)	Installed capacity (watts)	Actual power consumption (watts)
Ceiling Fan	9	60	540	720
Fluorescent lamp	9	40	360	450
Total				1170

For 30 days of a month, considering 22 working days with 8 working hours, the energy consumption is 205.93kWh per month and considering 10 working months, per year energy consumption is 2059.3kWh. It is also assumed that the appliances will run during the working days without interruption. Then the cost per year has been calculated as Rs.12, 355.80 at the rate of Rs.6/unit. This is for one class room in the educational institution. The institution has more than 45 such classrooms.

In order to minimize the energy consumption, energy efficient appliances are recommended to replace the existing ones and an idea is proposed about a sensor based switching model to switch on and off the lights and fans when required.

International Journal of Applied Engineering Research ISSN 0973-4562 Volume 10, Number 9 (2015)
© Research India Publications ::: http://www.ripublication.com

A. Energy Efficient Appliances

The Government of India set up Bureau of Energy Efficiency (BEE) on 1st March 2002 under the provisions of the Energy Conservation Act, 2001. The mission of the BEE is to assist in developing policies and strategies with a thrust on self-regulation and market principles, within the overall framework of the Energy Conservation Act, 2001 with the primary objective of reducing energy intensity of the Indian economy [2].

The star rating label of BEE implies the product's energy performance in the form of energy consumption, efficiency and cost of the product on a relative scale and saves money in the long run. A more efficient appliance pays the additional cost back early. The appliances considered are ceiling fan and fluorescent lamp.

1) Ceiling Fan: BEE tests the ceiling fans based on three parameters – air delivery, fan speed and power input and certifies using the term service factor which is the ratio of air delivery to power input. Table 2 shows the service factors based star rating plan for ceiling fans.[3]

TABLE II
STAR RATING OF CEILING FANS

Star Rating Index Calculation for Ceiling Fans	
Star Rating	**Service Value for Ceiling Fans**
1 Star	≥ 3.2 to < 3.4
2 Star	≥ 3.4 to < 3.6
3 Star	≥ 3.6 to < 3.8
4 Star	≥ 3.8 to < 4.0
5 Star	≥ 4.0

It is evident from the above table that, the service value is higher for high stat ratings, which indicates higher efficiency. Thus, it is recommended to replace the existing fans with the five star rated ceiling fans.

2) Fluorescent Lamp: BEE tests the fluorescent lamp with two important eligible factors – power input and luminance and has come up with the concept of efficacy which is the ratio of lumens and power input. Table 3 depicts the efficacy level of fluorescent lamps against star rating.

TABLE III
STAR RATING OF FLUORESCENT LAMP

Star rating	**Lumens per Watt at 0100 hrs of use**	**Lumens per Watt at 2000 hrs of use**	**Lumens per Watt at 3500 hrs of use**
1 Star	<61	<52	<49
2 Star	>=61 & <67	>=52 & <57	>=49 & <54
3 Star	>=67 & <86	>=57 & <77	>=54 & <73
4 Star	>=86 & <92	>=77 & <83	>=73 & <78
5 Star	>=92	>=83	>=78

It is evident from the table that higher the star rating, higher the efficacy level meaning the higher efficiency. It is recommended to install the 5 star rating fluorescent lamps replacing the existing fluorescent lamps.

Table 4 shows the difference in power consumption when the existing electrical appliances are replaced with five star rating appliances.

TABLE IV
DIFFERNCE IN POWER CONSUMPTION WITH 5 STAR RATED APPLIANCES

Electrical Appliance	**Quantity**	**Power rating in watts**	**Power Consumption with 5 star rated appliances (watts)**	**Power consumption with present appliances (watts)**	**Difference in power consumption (watts)**
5 star ceiling fan	9	50	450	720	270
5 star fluorescent lamp	9	28	252	450	198
Total			702	1170	468

For 30 days of a month, considering 22 working days with 8 working hours, the energy consumption after replacing the existing appliances with five star rating appliances is 123.552kWh per month and considering 10 working months, per year energy consumption is 1,235.52kWh. It is also assumed that the appliances will run during the working days without interruption. Then the cost per `year has been calculated as Rs.7, 413.12 at the rate of Rs.6/unit.

Table 5 shows the saving in energy per year being 823.78kWh and saving in cost per year being Rs. 4,922.68. This saving is only for one classroom. The institution has more than 45 such classrooms.

TABLE V
SAVING IN ENERGY CONSUMPTION AND COST

Existing appliances		Energy consumption with 5 star appliances		Energy saving per year (kWh)	Saving in cost per year (Rs.)
Energy Per year (kWh)	Cost Per year (Rs.)	Energy Per year (kWh)	Cost Per year (Rs.)		
2,059.3	12, 355.80	1,235.52	7,413.12	823.78	4,922.68

The fig 1 shows the bar chart comparing energy consumption between existing and 5 Star rating appliances. The energy consumed using 5 star appliances is far less than that of the existing system.

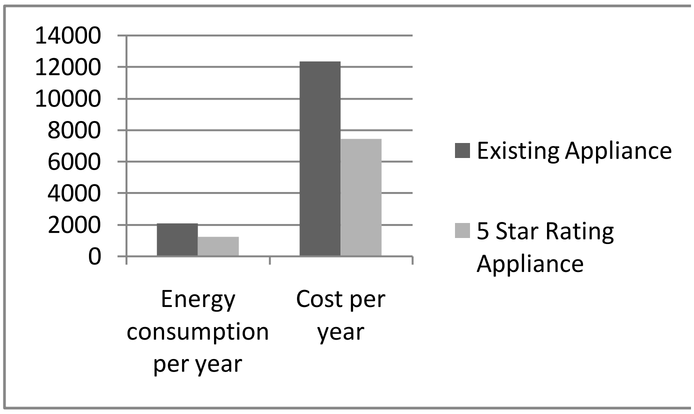

Fig. 1. Comparison between Existing and Replaced with 5 star appliances

B. *Sensor based switching model*

The intention of developing this simple basic sensor based switching model is to minimize the energy usage by switching on and off the switches when it is required. The switch will be switched on when the students are inside the class and will be switched off when the students are not inside the class. Also column wise switching on the lights and fans are also possible with this model i.e. , when the students are not sitting in any column of the benches, the fans and lights for that column will be switched off thus conserving energy.

The model uses a Passive Infrared sensor (PIR). An individual PIR sensor detects changes in the amount of infrared radiation impinging upon it, which varies depending on the temperature and surface characteristics of the objects in front of the sensor. When an object, such as a human, passes in front of the background, such as a wall, the temperature at that point in the sensor's field of view will rise from room temperature to body temperature, and then back again. The sensor converts the resulting change in the incoming infrared radiation into a change in the output voltage, and this triggers the detection. Moving objects of similar temperature to the background but different surface characteristics may also have a different infrared emission pattern, and thus sometimes trigger the detector [5].

The working of the sensor based switch is that, when there are students in a particular column, they will be sensed and communicated to the transistor and the switches for the fan and light will be switched on whereas the columns with no students, the fans and lights will not be switched on thus saving the energy. The students turn on the switch when they need it and generally forget to turn off when they leave for the lab session or for their home. This sensor based switching will not add additional facility to choose the actual requirement of light and fan for the students but will minimize the redundant power on the appliances and reduce energy consumption. It is assumed that the students of that class have 9 hours of lab hours per week. If the electrical appliances are automatically switched off for these 9 hours through the sensor based model, the energy waste can be minimized and hence the electricity bill.

There are many automated switches available in the Indian markets which are expensive. The advantages of this sensor based switching circuit are that it is very cost effective and efficient and can be easily fixed and used. The whole system costs about Rs.300 only and all are easily available. This model can be easily extended and upgraded.

The basic circuit of sensor based switching model is shown in Fig 2.

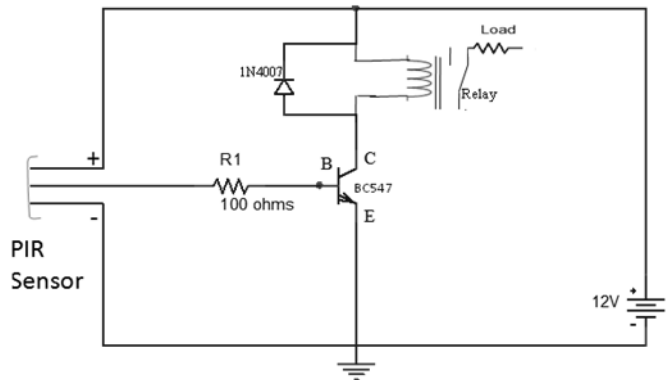

Fig. 2. Circuit diagram of the sensor based switching model

The presence of the students is sensed by the PIR sensor and the input is given to the driver transistor to which the relay is connected and in the presence of students the load, fluorescent lights and fans are switched on. If the absence of students is sensed, the relay will switch off the loads.

Table 6 can give the information of the energy consumed after installing the sensor based switching model. One month is assumed as 3 weeks as only 22 working days are considered.

Table 7 gives in a glance, the energy consumed after replacing the existing appliances after installing sensor based switching model.

Table 8 shows the energy conserved after replacing the existing appliances with 5 star rated appliances and after installing sensor based switching model per month assuming 22 working days per month and 8 working hours per day and the energy conserved per year with 10 working months assuming 2 months of vacation.

TABLE VI
ENERGY CONSUMED AFTER INSTALLING SENSOR BASED SWITCHING MODEL

Electrical appliances	Quantity	Power rating (watts)	Assumed total working hours per month	Lab hours per month	Energy consumption per month for 9 nos.(kWh)
Ceiling fan	9	50	22 x 8	9 x 3	67.05
Fluorescent lamp	9	28	22 x 8	9 x 3	37.548
Total					104.598

TABLE VII
ENERGY CONSUMPTION AFTER THE SENSOR BASED SWITCHING SYSTEM IS INSTALLED

Electric appliance	Energy consumption with the existing system per month (kWh)	Energy consumption with 5 star rated appliances per month(kWh)	Energy consumption with the sensor based switching system per month(kWh)
Ceiling fan	126.72	79.2	67.05
Fluorescent lamp	79.2	44.35	37.548
Total	205.92	123.55	104.598

TABLE VIII
ENERGY SAVING AFTER THE SENSOR BASED SWITCHING SYSTEM IS INSTALLED

Electric appliance	Energy Saving per month (kWh)	Energy saving per year(kWh)	Cost saving per years (Rs.)
Ceiling fan	59.67	596.7	3580.20
Fluorescent lamp	41.652	416.52	2499.12
Total	101.322	1013.22	6079.32

Fig 3 shows the comparison between the energy consumed and saving in cost by the existing system, 5 star rated system and sensor based switching system using a bar chart.

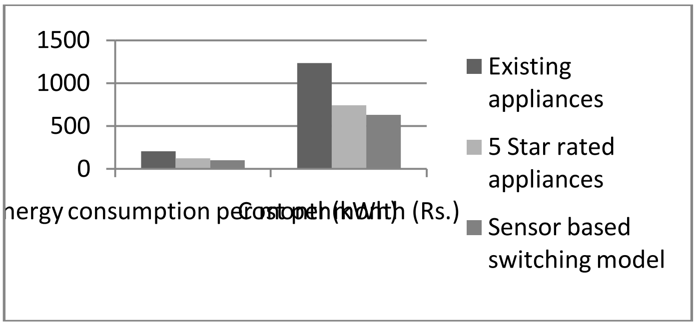

Fig. 3. Comparison of energy consumption per month between the three systems

CONCLUSION

The existing system, existing appliances replaced with 5 star rated appliances and incorporating sensor based switching model in the existing system were studied and compared. It can be seen that replacing the existing ceiling fans and lights with 5 star rating appliances can reduce the energy consumption by 82.37kWh per month and thus can conserve energy. Further incorporating the sensor based switching model can reduce the energy consumption by 18.95kWh per month. Also the CF6 emissions are controlled to a greater extent when 5 star rated appliances are used, thus making the system environment friendly.

Simple steps of domestic energy conservations are setting the refrigerator in optimal temperature, unplugging the plugs when the appliance is not in use, enabling the computer in sleep mode when inactive for a long period, setting the air conditioner in optimal temperature, using the naturally available renewable energy resources as much as possible. For every kilowatt hour of energy saved, 0.9 kg of carbon dioxide emission is reduced. These are few very basic steps that anyone can follow and conserve energy and thus reduce the bill amount and also contribute to fight against pollution, global warming and promise a better world to live for the future.

REFERENCES

[1] (2015) The Wikipedia website. [Online]. Available: http://en.wikipedia.org/wiki/Electricity_sector_in_India
[2] (2002) The BEE website. [Online]. Available: http://beeindia.in/
[3] (2013) The BEE website. [Online]. Available: http://www.beestarlabel.com/Content/Files/Schedule-8.pdf
[4] (2013) The BEE website. [Online]. Available: http://www.beestarlabel.com/Content/Files/Schedule2_TFL.pdf
[5] (2014) The Wikipedia website. [Online]. Available: http://en.wikipedia.org/wiki/Passive_infrared_sensor
C.Nagarajan and M.Madheswaran - 'DSP Based Fuzzy Controller for Series Parallel Resonant converter'- Springer, Frontiers of Electrical and Electronic Engineering, Vol. 7(4), pp. 438-446, Dec.12.