INTERNATIONAL JOURNAL OF ENVIRONMENT
Volume-3, Issue-3, Jun-Aug 2014 ISSN 2091-2854
Received: 26 May *Revised: 16 July* *Accepted: 20 August*

ENERGY AUDIT OF SARDAR PATEL COLLEGE, CHANDRAPUR, CENTRAL INDIA

Prashik P. Kamble and Rahul K. Kamble*

Centre for Higher Learning and Research in Environmental Science,

Sardar Patel College, Chandrapur 442 402, India

* Corresponding author: rahulkk41279@yahoo.com

Abstract

Energy audit of Sardar Patel College was carried out in 2012-2013. Energy audit of the college revealed that annual electricity consumption was 93,984 units at a total cost of Rs 8,28,248/- (US$ 15059) with an average of Rs 8.66 (US$ 0.15) per unit. The per capita energy expenditure on a student comes out to be Rs 127.42/- (US$ 2.31) per annum, while including teaching and non-teaching faculty members it was Rs 121.80/- (US$ 2.21) per annum. To reduce the electricity consumption in the college various measures were suggested such as use of energy efficient appliances, task lighting, peak shaving and good housekeeping measures.

Keywords: Energy audit, Institutional energy audit, Energy conservation, Energy management, Audit

Introduction

Energy is an indispensible part of human life. Due to rapid urbanization and industrialization demand of energy is increasing day-by-day. However, the supply of energy has not increased proportionately. In this regard, demand site management will serve as a management tool to bridge the gap between supply and demand. Due to rapid industrialization and urbanization there is a tremendous stress—locally, regionally, and globally—between the demand and supply for energy, notably electricity and equally the demands for the protection of life, health, and the environment (Blix, 1991).

For the past two decades, India has had to face increasing defect in power supply, both for meeting its normal energy requirements as well as its peak load demand. The problem is acute during peak hours and summers, and necessitates planned load shedding by many utilities (suppliers) to maintain the grid in a healthy state. The average all India electricity shortages in 2009-10 were at 10% in terms of normal energy requirement and about 13% in terms of peak load. At an average GDP growth rate of 8%, the overall demand is expected to increase to about 1,097 billion kWh per year, including the demand from non-utilities. The energy demand and supply in India from 2005 to 2010 is depicted in table 1.

An energy audit is usually conducted to understand how energy is being used within an organization and to find out opportunities for improvement and energy saving. Energy audits are conducted to evaluate the effectiveness of an energy efficiency project or program (Hasanbeigi and Price, 2010).

According to the energy audit study carried out by Burlington County College, Pemberton, NJ campus in February 2008 to February 2009 it was found that college had an annual energy expenditure of electricity: 6,007,640 kWh at a total cost of $973,079; natural gas: 265,440 therms at a total cost of US $425,329 (Falkenstein, 2009). According to the report presented by Bard College Avon-on-Hudson, New York, USA in December 2009 it was found that the estimated annual savings of $433,964 was gathered with simple payback of 7.9 years for a project cost of $3,063,971. The energy audit study carried out in IIT-Bombay, Mumbai campus during January-April 2008 revealed that the campus had a connected electrical load of 5.3 MW as on April 2008 and a contract demand of 4.5 MVA, with energy bill for the year 2007 of Rs. 10.2 crores. The energy audit was achieved with the target of savings the electrical energy consumption to the extent of 20% (Abraham, 2008).

Taking into consideration the gap between demand and supply of electricity and colleges being one of the important consumers of electricity, an attempt has been made to carry out energy audit of Sardar Patel College, Chandrapur to ascertain the energy consumption pattern and to identify potential energy savings measures to be adopted. No studies have been attempted previously for energy audit of Sardar Patel College and this is the first study in this regard.

Study area

Sarvodaya Shikshan Mandal's Sardar Patel College (E $79^0$18'36" N $19^0$58'17", altitude 129 m amsl) was started in June 1970 and presently it is one of the prestigious college in Gondwana University, Gadchirloi, India. The college is offering more than 25 under graduate and similar numbers of post graduate courses in arts, commerce, science, computer science, library science etc. and has a junior college also. Presently, the college is catering to the educational needs of about 6500 students from Chandrapur city and nearby small towns. The college is situated in Ganj ward, near Ramala Lake in the heart of Chandrapur city. The college has mainly four buildings in the campus: girl's hostel building, office building, classroom/faculty building and post graduate departments and central library building. In addition to this, it has four rooms for sports and others activities. A canteen is situated in the college campus. College has a parking area inside the campus and two playgrounds. Out of these two playgrounds, the larger one is in front of faculty building and other smaller one in front of library building. The college is receiving three phase electricity 430/460 KV from the government supplier.

Energy Audit Methodology

Initial Energy Audit

Initial energy audit was carried out by site visiting and visual observations. The objective of this initial energy audit was to draw up the approximate picture of energy use, costs and to produce an approximate energy balance. Initial data was collected from different stockholders such as college staff for electricity consumption and through personal monitoring. College layout was drawn so as to understand the energy flow in it. The electricity supply to the college was of 430/460 KV main supply with three phase connection. It has four electric meters installed in different buildings. Each electric meter has its separate electric billing charges and operation charges with separate electrical demand. To ascertain the energy audit of the college, it was

divided into four sections. First section was the girl's hostel building, second was classroom buildings and laboratories, third was the administrative block which was situated in the middle of the college premises and fourth was the PG departments and library building which is located at the back of the college campus. The infrastructure in various sections of the college is depicted in table 2.

Energy Consumption Analysis

The major source of energy used in the college was electricity. The college was receiving three phase electricity 430/460 KV from the government supplier. The data which was collected for energy consumption by various buildings was analyzed for the period of March 2011 to February 2012 to ascertain electricity consumed per month and amount paid.

Table 1. Energy demand and supply

Financial year	Energy (MU)				Peak Demand (MW)			
	Demand	Availability	Shortage	%	Demand	MEt	Shortage	%
2005-06	631,024	578,511	52,513	8.3	93,214	81,792	11,422	12.3
2006-07	693,057	624,716	68,341	9.9	100,715	86,818	13,897	13.8
2007-08	737,052	664,660	72,392	9.8	108,866	90,793	18,073	16.6
2008-09	777,039	691,038	86,001	11.1	109,809	96,785	13,024	11.9
2009-10	830,594	746,644	83,950	10.1	118,472	102,725	15,747	13.3

Table 2. Infrastructure in the college

Particulars	Floors	Rooms	No. of lights	No. of fans	Other
Girls hostel	Four	44	1 CFL in each room	1 Ceiling fan	TV Hall, one guest room
Office building	Two	33	Sufficient tube lights	Sufficient fans	Photocopy machine, computers, printers, LCD, Air conditioners, high mask system etc.
Faculty building	Three floor spread over two buildings	98+ laboratories	3-4 tube lights in each rooms	2-3 ceiling fans in each room	In laboratory different equipments and instruments
Library building	Three	27+ PG laboratories	Sufficient tube lights	Sufficient ceiling fans	Photocopy machine, air conditioners, equipments and instruments in the laboratory

Table 3. Major electrical appliances and equipments in the college

Electrical appliances	Numbers	Wattage (in W)	Operation hrs/day	Monthly operating hrs	Monthly power consumption (kWh)
Tube light	550	40	8	240	528000
Fan	350	60	8	240	504000
Water cooler	10	410	10	300	123000
Computer	180	140	8	240	604800
CCTV camera	20	45	24	720	648000
Projector	12	455	2	60	327600
Air conditioner	12	2100	3	90	2268000
Exhaust fan (Large)	6	1200	2	60	432000
Exhaust fan (Small)	18	100	6	180	324000
Refrigerator (4 star rating)	12	600	8	240	172800
Water pump	10	2500	3	90	2250000
Oven	15	1000	1	30	450000
CFL bulb	110	18	8	240	475200
Photocopy machine	9	2500	3	90	202500
Focus lamp	6	1000	4	120	720000
Sound system	8	250	6	180	360000
Halogen	6	400	6	180	432000
Air cooler	4	210	6	180	151200
10% for unaccounted area					1252830
Total					13781130

The major electrical appliances and equipment in the college and approximate monthly power consumption (kWh) are depicted in table 3. From the table it can be observed that maximum number of electrical appliances includes tube lights (550 nos) followed by ceiling fans (350 nos) and minimum was air cooler (4 nos). Maximum monthly power consumption by electrical appliances was by 12 air conditioners (22,68,000 kWh) followed by 10 water pumps (22,50,000 kWh). The total monthly electricity consumption by appliances was about 1,37,81,130 kWh.

The electricity consumption and amount paid for various buildings of the college are depicted in figures 1-3. The figure 1 depicts monthly electricity consumption and amount paid for girl's hostel building. From the figure it can be observed that maximum electricity consumption of 3675 units was in October 2011 followed by 2917 units in April 2011. This maximum electricity consumption during this period can be assigned to university examination and change in seasonal pattern which leads to maximum utilisation of electricity for ceiling fans and tube lights. Between October and November, a sharp decline in electricity consumption from 3675 units to 1611 units can be assigned to winter vacation. In December electricity consumption was found to be higher (2093 units). Owing to winter season during this period electricity consumption was higher; this may be due to use of room heaters for keeping rooms warms and using hot water for domestic purposes. From January till April a steady increased in electricity consumption was observed which was due to commencement and progress of summer season. Higher electricity consumption months in the girl's hostel building were July to October and January to April. A sharp decline in electricity consumption was observed from May onwards till July. University examinations normally get over by first week of May and girl students who were occupying hostel rooms vacate it during summer vacations. As a result of which this decline in electricity consumption was observed. The minimum electricity consumption was observed in July. In July new academic session starts and students were in process of taking admission and no rooms in the girl's hostel were occupied as a result of which minimum electricity consumption was observed in this month. However, from July to August a rapid increase in electricity consumption was observed from 801 units to 2417 units. This rapid increased can be assigned to occupancy of rooms in girl's hostel by students as it was beginning of new academic session. From figure 1 it can be observed that there were two peaks of increased in electricity consumption in April and October. This increased in electricity

consumption during these two periods can be assigned to university examination in March-April and in October. The higher electricity consumption during this period proved higher use of tube lights and ceiling fans in summer and electrical heating appliances during winter. A sharp decrease in electricity consumption during July and November can be assigned to summer and winter vacations.

The monthly electricity consumption and payment for office building is depicted in figure 2. From the figure it can be observed that maximum electricity consumption was in June (4115 units) followed by February (3888 units) and October (3579 units). The maximum electricity consumption in June can be assigned to summer season as use of air coolers increases to reduce discomfort caused due to scorching heat. As in first week of June monsoon reaches to Chandrapur and natural relief due to rainfall from hot summer reduces electricity consumption drastically. From July to August and September to October a steady increase in electricity consumption was observed. This can be assigned to increase in work load due to various students related college work and university examinations. Second maximum electricity consumption peak was observed in October (3579 units). As this month coincides with change in season from rainy to winter—post monsoon season, discomfort cause due to this leads to maximum utilisation electricity. A sharp reduction in electricity consumption from October to November (3579 units to 1451 units) can be assigned to winter vacations and onset of winter season in Chandrapur. A steady increase in electricity consumption from November to February was due to resuming of office staff after winter vacations and increase in official work after winter examinations. A sharp increase in electricity consumption (from 1593 units to 4115 units) was observed in May as it coincides with summer season. A sharp decrease in electricity consumption was observed from June to July (from 4115 units to 1634 units). The electricity consumption in office building was higher from August to October and December to February and maximum in June.

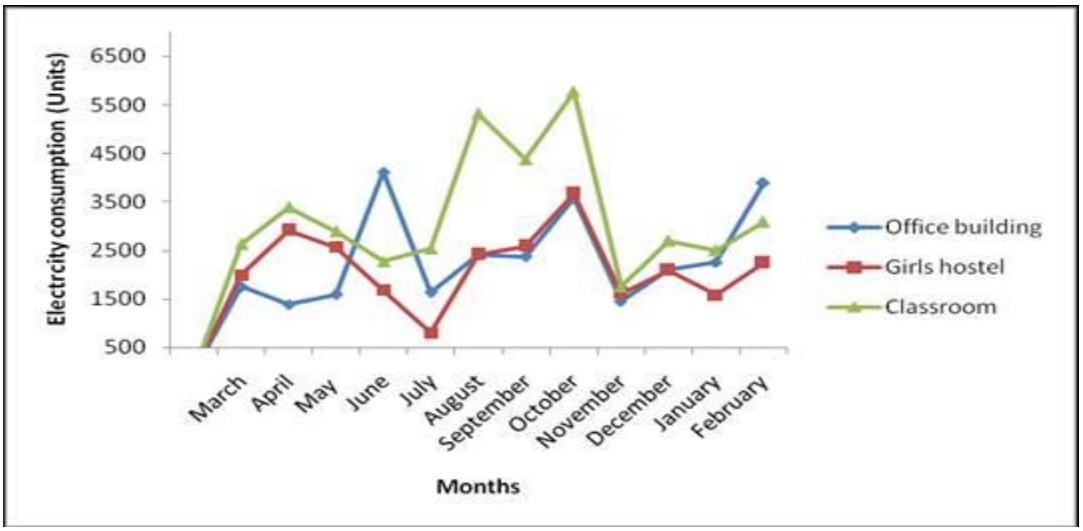

Figure 1. Monthly electricity consumption in the college

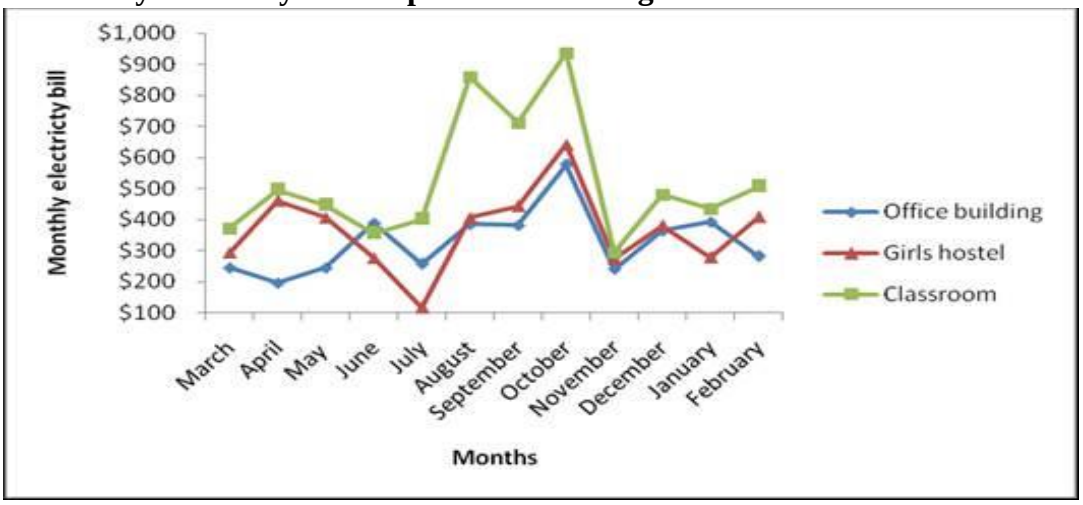

Figure 2. Monthly electricity bill (in US$) in the college

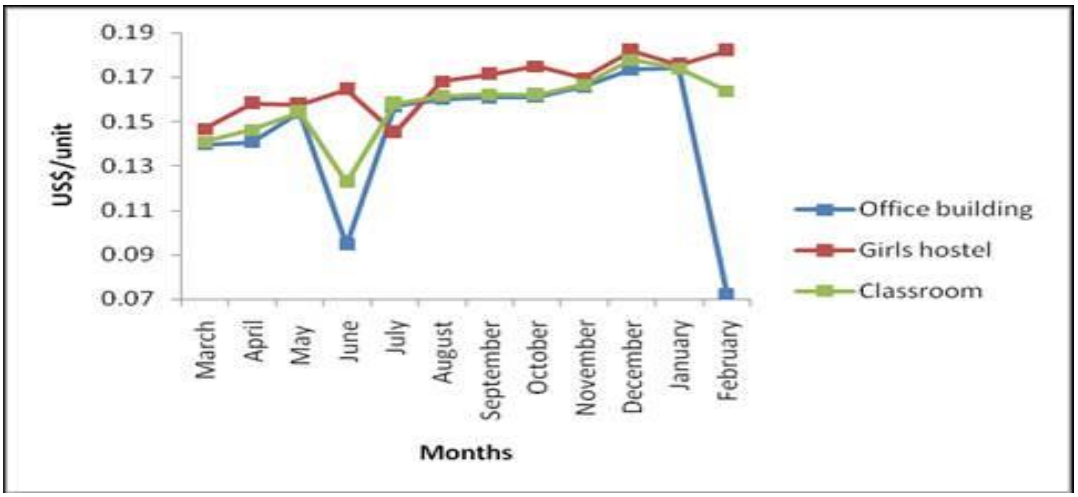

Figure 3. Monthly US$/unit charge in the college

Figure 3 depicts monthly electricity consumption and amount paid for classroom building. From the figure it can be observed that maximum electricity consumption was in October (5778 units) followed by August (5317 units). October being transition month from rainy to winter season—post monsoon, and to tackle with change in environment conditions maximum use of electricity was observed. From July onwards to October a sharp increase in electricity was observed (2533 units to 5778 units). This period coincides with beginning of a new academic session and practical's in laboratories. A sharp decline in electricity consumption from 5778 units to 1762 units was observed in October and November. The sharp decline can be assigned to winter vacations. A steady increase in electricity consumption from November (1762 units) onwards till April (3392 units) was due to reopening of college after winter vacations and resuming of classes and practical. April and May months had witnessed an increased in electricity consumption in classroom buildings. In this duration no classes and practical were conducted however, university theory examination were conducted on the third floor of this building thus this increased in electricity consumption was observed.

A monthly payment per unit paid by college is depicted in figure 4. It was observed that payment per unit were maximum for girl's hostel building Rs 10 (US$ 0.18) per unit for December and February whereas for office building and classroom building it was found to be similar throughout the year except minimum in February followed by June for office building. The higher charges per unit paid for girl's hostel building may be due to increase use of electricity than the sanctioned demand, as a result of which electricity consumption may falls in higher charging slab. From August to February per unit charges were above Rs 9 (US$ 0.16) per unit for girl's hostel building whereas for office and classroom building it was in the range of Rs 8.5 (US$ 0.15) to 9.75 (US$ 0.17) per unit. In December and January the amount charged for a unit was above Rs 9.5 (US$ 0.17) per unit for office and classroom building. From the figure 4 it is clear that maximum charges per unit were paid from August to January as this period coincides with the teaching, learning and office work.

The electricity consumption during peak period identified from Figures 1 to 4 was August to January where maximum electricity consumption was occurred. Electricity consumption for girls hostel building, office building and classroom building during this peak period was 13973 units (53.34 %), 14170 units (49.64%) and 22433 units (57.15 %) respectively. The payment made towards electricity consumption during this peak period (August-January) for

girl's hostel building, office building and classroom building was Rs 1,33,320 (US$ 2424) (55.26%), Rs 1,28,820 (US$ 2342.18) (59.20%) and Rs 2,04,420 (US$ 3716.72) (59.06%) respectively. This statistics highlights peak electricity consumption and maximum amount paid where for August to January. About 60% of the total electricity payment for office and classroom building was made during this period (August-January) followed by 55% for girl's hostel building. More than 50% electricity consumption was observed in all these three buildings and maximum of 57% for classroom building. The 57% electricity consumption during peak period in classroom building was responsible for 59% payment of electricity charges, whereas for 50% electricity utilisation in office building was responsible for about 60% payment of electricity charges.

Results

Energy audit of Sardar Patel College was conducted for the period March 2011 to February 2012 and it was found that maximum demand was 195.780 kW with electricity consumption of about 1,37,81,130 kWh per month (Table 3). The annual electricity payment for girl's hostel building was Rs 2,50,000 (US$ 4545.45) with an average of Rs 9.14 (US$ 0.16) per unit, for office building it was Rs 2,21,300 (US$ 4023.63) per annum with an average cost of Rs 8.03 (US$ 0.15) per unit. While in case of classroom building the electricity payment was Rs 3,56,948 (US$ 6489.96) per annum with an average of Rs 8.66 (US$ 0.15) per unit. The total of all three meters electricity charges was Rs 8,28,248 (US$ 15059) per annum. The total electricity consumption of the college was 93,984 units per annum, thus averagely per unit electricity cost was Rs 8.81 (US$ 0.16) per unit. The college is catering to the needs of around 6500 students, thus the electricity consumption by each students was approximately Rs 127.42 (US$ 2.31) per student per annum. The teaching and non-teaching faculty members of the college are approximately 300 in numbers. So, per individual electricity consumption in the college including students comes out to be Rs 121.80 (US$ 2.21) per individual per annum.

The peak electricity consumption period identified was August to January. From results it can be interpreted that more electrical consumption was in April, June, August, September, October and February from all three meters. Out of these months; October was the highest electricity consuming month for the college. The total electricity consumed in this period (August to January) was 1/3 of the total units consumed of all three meters in a year. April and

June are summer months and coincide with examination period which resulted into higher electricity consumption. Whereas, September and October were post monsoon period during which humid conditions existed and to get rid of such conditions use of ceiling fans for cooling purpose was higher thus leading to higher electricity consumption.

Recommendations for Energy Conservation

From the analysis of data it can be concluded that electricity consumption was higher in college. To reduce electricity consumption energy conservation measures are required to be adopted. Some of the measures for energy conservation and management which can be explored for Sardar Patel College are mentioned below.

- The maximum utilisation of electricity was observed during August-January and this leads to maximum amount charged towards payment of electricity bills. If peak shaving is carried out, then electricity consumption will get reduced as a result of change in charge slab, thus amount charged per unit.
- Use of renewable sources of energy has a potential for energy conservation and management. A solar power plant of adequate capacity on terrace of classroom building, library and office building can serve as a potential option to meet the energy demand of the college.
- The high intensity halogen lamps should be replaced by solar LED lamps in addition to this use of solar street lamp can be explored.
- The water pumps need regular monitoring and maintenance. Use of solar energy based water pumps can be explored.
- The old and obsolete electrical wiring in the college needs to be replaced with new and more efficient one.
- To check the loss of electricity during transmission sub meters should be placed at appropriate locations so as to tap locations for improvement in energy conservation.
- The nonworking and obsolete electrical appliances need proper maintenance and replacement after a due period of time.
- The ceiling fans should have regulators so as to control their speed as desired.
- Day lighting, skylights etc. may be considered. As tube lights were in maximum number (550 nos) and consumes about 5,28,000 kWh electricity. Classrooms with bright roofs

and large size window can reduce electricity consumption by using natural light and air for lighting and cooling purpose respectively.

- Selection of ballasts and lamps should be carefully done with high power factor and long-term efficiency.
- Use of electronic ballasts for fluorescent tube lights instead of electromagnetic ballasts should be explored. A total saving of about 15 to 20 watts per tube light can be achieved by electronic ballasts (UNEP, 2006).
- The classroom may be painted with light colours and using less lighting fixtures of lower wattages are recommended. Task lighting can be adopted so as to reduce background illumination lights placed it nearer to the benches in a straight line on rows of benches.
- The existing normal tube lights should be replaced by LED's which has merits of lesser power consumption (less than 1 watt per lamp); withstand high voltage fluctuation in power supply and longer operating life (more than 1,00,000 hours).
- The existing manual switches should be replaced through automated sensory switches.
- The water coolers in poor conditions need to be replaced with more efficient one.
- The normal power settings of computer need to be adopted.
- Occupancy sensors need to be installed to shut off lights when rooms are not in use.
- In addition to these recommendations "good housekeeping" measures needs to be incorporated for efficient energy management. These measures includes closing doors, turning off lights, increasing energy awareness among students and staff, regular maintenance and servicing of instruments and electrical appliances.
- Some of the measures which have a payback period of less than one year need to be implemented on priority basis. These are turning of idle equipment, improve maintenance of cooling equipments, improved compressed air systems, repair leaks, more efficient lighting, control heat loss through doors specially rooms having air conditioners.

References

Abraham, C., George, M., Jose, V. & Deshpande, S., 2008. Energy Audit of IIT Bombay Campus. Indian Institute of Technology-Bombay, Pawai, Mumbai.

Blix, H., 1991. Electricity and the environment-the basis for choices. *IAEA Bulletin*, 1991/3.

Falkenstein, J., 2009. Energy audit of Burlington county college. Demo Tech, Inc.

Hasanbeigi, A. & Price, L., 2010. Industrial energy audit guidebook: Guideline for conducting and energy audit in industrial facilities. Ernest Orlando Lawrence Berkeley National Laboratory.

UNEP. 2006. Energy Efficiency Guide for Industry in Asia, UNEP.