ANALYSIS OF LIGHTING SYSTEM IN COMMERCIAL SECTOR

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Abstract— According to a research by MIT Technology Review, in October 2015,at least 300 million of India's 1.25 billion people live without electricity. With increasing energy demand along with an upsurge in electricity costs, people are searching for ways to abate their electricity expenditures. There are viable alternatives available for the masses which will help in achieving the desired reduction in costs as time passes. The key path here would be to reduce the undesirable losses due to inefficient light sources while adapting new technologies which can generate electricity in required quantities and at an optimum cost. This paper focuses on a thorough analysis of inefficiencies in various light sources and its solution by substitution of existing light sources with more efficient light sources.

I. INTRODUCTION

Light sources have seen an evolution throughout the ages, where initially the use of incandescent bulbs was quite popular. But as time passed, people realized the importance of energy saving and the presence of more efficient light sources, and started moving towards more efficient light sources, which were able to suffice their needs in terms of cost as well as physical properties. Incandescent bulbs were found to be inefficient in many ways, such as consuming excessive energy, having a short life span and generation of excess heat. On the other hand, inspite of CFLs being widely used in today's world, the newly developed LEDs prove to be better than the CFLs in many ways, such as having a life span of about 2-4 times as compared to CFLs, as well as giving the same amount of brightness at a lower rated power.The main aim of this paper is to use the available technology in commercial area where it is economically profitable.

II. ANALYSIS

We have selected D J Sanghvi College of engineering for our analysis. The experiments were conducted at Shri T. P. Bhatia Jr. College of Science, Mumbai. The experiment involved using various light sources and determining their kWh rating. We also understand the consumption pattern of various light sources from this experiment. An analog energy meter is used for this experiment.The experimental setup consists of a wattmeter, voltmeter, ammeter, energy meter and a light source i.e. load.The power input is connected to the wattmeter, with an ammeter in series and a voltmeter in parallel to the input source.The wattmeter is connected to the input of the energy meter. The output of the energy meter is connected to the load.The power (P), voltage (V) and current (I) readings are recorded from the wattmeter, voltmeter and the ammeter respectively.

The kWh calculations are to be done as follows:

1. Record the time required (T) for a fixed number of rotations of the disc of the energy meter (N).
2. The energy meter constant (C) is to be taken as 375 rotations/kWh.
3. The recorded energy for T seconds would be equal to N/C.
4. The actual energy for T seconds will be equal to P x T / 1000 / 3600 kWh.
5. Accordingly, we can calculate the energy consumption of the load for one hour, i.e. we get the kWh rating of the light source.

3.1 CALCULATIONS

A. SYSKA 36W Led Panel

Voltage: 215V
Current: 0.2A
Power: 29.2W
Energy consumption:
Revolutions: 0.1
Recorded energy: 0.1 / 375 = 2.667×10^{-4} kWh
Actual energy: 29.2 x 34 / 1000 / 3600 = 2.7577×10^{-4} kWh
34s = 2.667x10 -4 kWh
.'. 3600s = 1 hour = 0.0282 kWh

B. PHILIPS 12.5W LED BULB

Voltage: 205V
Current: 0.1A
Power: 13.5W
Energy consumption:
Revolutions: 0.1/10 = 0.01
Recorded energy: 0.01 / 375 = 2.667×10^{-5} kWh
Actual energy: 13.5 x 8 / 1000 / 3600 = 3×10^{-5} kWh
8s = 2.667×10^{-5} kWh
.'. 3600s = 1 hour = 0.012 kWh

C. PHILIPS 10W LED BULB

Voltage: 210V
Current: 0.1115A

Power: 11W
Energy consumption:
Revolutions = 0.7 / 10 = 0.07
Recorded energy: 0.07 / 375 = 1.867×10^{-4} kWh
Actual energy: 11 x 42 / 1000 / 3600 = 1.283×10^{-4} kWh
42s = 1.867×10^{-4} kWh
.'. 3600s = 1 hour = 0.016 kWh

D. WIPRO SMARTLITE 11W CFL

Voltage: 210V
Current: 0.1A
Power: 7W
Energy consumption:
Revolutions = 0.1 / 10 = 0.01
Recorded energy: 0.01 / 375 = 2.667×10^{-5} kWh
Actual energy: 7 x 12 / 1000 / 3600 = 2.333×10^{-5} kWh
12s = 2.333×10^{-5} kWh
.'. 3600s = 1 hour = 0.007 kWh

E. PHILIPS 100W TUNGSTEN BULB

Voltage: 209V
Current: 0.25A
Power: 79W
Energy consumption:
Revolutions: 2
Recorded energy: 2 / 375 = 5.333×10^{-3} kWh
Actual energy: 79 x 200 = 4.389×10^{-3} kWh
200s = 4.389×10^{-3} kWh
.'. 3600s = 1 hour = 0.0959 kWh

F. PHILIPS 40W TUNGSTEN BULB

Voltage: 220V
Current: 0.4A
Power: 32W
Energy consumption:
Revolutions: 0.1
Recorded energy: 0.1 / 375 = 2.667×10^{-4} kWh
Actual energy: 32 x 33 / 1000 / 3600 = 2.933×10^{-4} kWh
33s = 2.667×10^{-4} kWh
.'. 3600s = 1 hour = 0.2909 kWh

The experiment was performed using the following light sources.

TABLE 1: RATINGS OF LIGHT SOURCES

APPLIANCE	RATING
Syska 36W LED panel	0.0282 kWh
Philips 12.5W LED bulb	0.12 kWh
Philips 10W LED bulb	0.016 kWh
Wipro Smartlite 11W CFL	0.007 kWh
Philips 100W tungsten bulb	0.0959 kWh
Philips 40W tungsten bulb	0.2909 kWh

3.2 WORKING PARAMETERS

An analysis is carried out for the energy consumption of the light sources in D. J. Sanghvi College of Engineering. Considering the college is working for 12 hours a day and 24 days a month. The replacement of CFL and regular tungsten bulbs with LED lighting has been carried out along with the analysis of cost of operation and replacement.
The description of the number of light sources on each floor of the college and the costs of the CFL as well as LED light sources are as shown below:

TABLE 2.1: NUMBER OF LIGHT SOURCES ON THE 1ST FLOOR

LOCATION	TUBELIGHTS	CFLs
LIBRARY	222	148
TOILET- 4	16	12
TOTAL	238	160

TABLE 2.2: NUMBER OF LIGHT SOURCES ON THE 2ND FLOOR

LOCATION	TUBELIGHTS	CFLs
CLASSROOM-9	432	224
STAFFROOM-6	80	52
TOILET-4	16	12
LABORATORY-5	138	64
COMPUTER LAB	56	48
CORRIDOR	70	12
TOTAL	792	412

TABLE 2.3: NUMBER OF LIGHT SOURCES ON THE 3RD FLOOR

LOCATION	TUBELIGHTS	CFLs
CLASSROOM-6	192	192
STAFF ROOM-6	28	88
TOILET-4	16	12
LABORATORY-6	144	72
CORRIDOR	86	12
TOTAL	466	376

TABLE 2.4: NUMBER OF LIGHT SOURCES ON THE 4TH FLOOR

LOCATION	TUBELIGHTS	CFLs
LABORATORY-5	116	64
CLASSROOM-6	192	192
STAFF ROOM-5	10	106
CORRIDOR	98	19 + 3 x 30W CFL + 9 x 10W Bulb
TOILET- 4	16	12
TOTAL	432	405

TABLE 2.5: NUMBER OF LIGHT SOURCES ON THE 5TH FLOOR

LOCATION	TUBELIGHTS	CFLs
Drawing Hall	112	72
Classroom- 4	128	128
Staff Room- 5	10	106
Laboratory- 8	192	96
Toilet- 4	16	12
TOTAL	458	414

TABLE 2.6: NUMBER OF LIGHT SOURCES ON THE 6TH FLOOR

LOCATION	TUBELIGHTS	CFLS
CORRIDOR	88	12
LABORATORY-8	192	96
CLASSROOM-7	126	112
TOILET-4	16	12
STAFFROOM-4	10	96
TOTAL	432	328

Thus after calculating the total number of light sources, we have found that there are a total of 2818 tubelights, 2083 15W CFLs, 36 30W CFLs and 54 incandescent bulbs which are to be replaced by equivalent LED lights and LED bulbs.

IV. LIGHT SOURCES AND THEIR SPECIFICATIONS

TABLE 3: CATALOGUE OF LIGHT SOURCES

LIGHT SOURCES	WATTS	MODEL	LUMENS	LIFE IN HOURS	NO. OF LIGHT SOURCES
CFL bulbs	15	Philips 15691-0	900	12000	2083
LED	12	Philips 42693-2	900	25000	2083
CFL bulbs	30	Philips 38324-0	1650	10000	36
LED	19	Philips 42187-5	1650	40000	36
CFL tube light	36	Philips 34513-2	2610	15000	2818
LED	22.5	Philips 42721-1	2500	50000	2818
Incandescent	15	Philips 16811-2	110	2000	54
LED	3.5	Philips 42780-7	180	25000	54

5.1 SAMPLE CALCULATION FOR ELECTRICITY COST

To calculate the total electricity cost for our college, the consumer category and consumption slab comes under LT X-A, for Government Hospitals and Educational Institutions.

TABLE 4: CONSUMPTION SLAB FOR COMMERCIAL SECTOR

Sl. No.	Consumer category & Consumption Slab	Fixed/ Demand Charge per month	Wheeling Charges (Rs/kWh)	Energy Charge (Rs/kWh)	Regulatory Asset Charge (Rs/kWh)
8	LT VIII – Crematoriums and Burial Grounds	Rs 225	1.80	4.80	0.86
9	LT IX - Agriculture	Rs 25 per HP	1.80	1.01	0.34
10	LT X – Public Services				
(A)	Government Hospitals & Educational Institutions	Rs 275	1.80	5.50	0.92

5.2 kWh CONSUMPTION PER LIGHT SOURCE

TABLE 5: ENERGY CONSUMPTION

LIGHT SOURCE	CFL WATTAGE	CFL kWh	LED WATTAGE	LED kWh
TUBE LIGHT	36W	26000	22.5W	14700
CFL LAMP	15W	8500	12W	7500
CFL LAMP	30W	320	19W	200
INCANDESCENT BULB	15W	225	3.5W	50
TOTAL	35045		22450	

Total savings in energy consumption after substitution is approximately 12600 kWh per month.

5.3 SAMPLE CALCULATION FOR 36W CFL TUBE LIGHT (26000 kWh per month)

The electricity cost will be:
275 + 26000 x (1.8 + 5.5 + 0.92)
= 275 + 26000 x 8.22
= `213995 per month.

VI. SAVINGS IN COST

TABLE 6: TOTAL ELECTRICITY COST OF CFLs AND LEDs

PARAMETERS	TOTAL KWH PER MONTH	TOTAL COST PER MONTH
CFL	35045	288570
LED	22450	183409

Thus we see that the total cost saving = `105161/month = `1261932/year.

VII. REPLACEMENT COST OF LIGHT SOURCES

Number of working hours per year = 12 x 24 x 12 = 3456 hours.
The replacement cost is calculated on comparison of light sources on the basis of the life span of 50000 hours.
Thus, 50000 hours in years, equals (50000 / 3456) = 14.47 years = around 15 years.
We find the total cost of light sources for 50000 hours and accordingly estimate the cost for 3456 hours i.e. one year.

TABLE 7.1: 36W CFL SUBSTITUTION COST

PARAMETER	36W TUBELIGHT	22.5W LED
COST PER PIECE (IN ₹)	45	700
LIFE (IN HOURS)	15000	50000
REQUIREMENT FOR 50000 HOURS	4	1
TOTAL COST (IN ₹)	180	700
COST FOR 2818 LIGHTS (IN ₹)	507240	1972600

Savings in 15 years = -`1465360, which equals -`97691 per year.

TABLE 7.2: 15W CFL SUBSTITUTION COST

PARAMETER	15W CFL	12W LED
COST PER PIECE (IN ₹)	110	110
LIFE (IN HOURS)	12000	25000
REQUIREMENT FOR 50000 HOURS	5	2
TOTAL COST (IN ₹)	550	280
COST FOR 2083 LIGHTS (IN ₹)	1145650	583240

Savings in 15 years = `562410, which equals `37494 per year.

TABLE 7.3: 36W CFL SUBSTITUTION COST

PARAMETER	30W CFL	19W LED
COST PER PIECE (IN ₹)	300	350
LIFE (IN HOURS)	1000	4000
REQUIREMENT FOR 50000 HOURS	5	2
TOTAL COST (IN ₹)	1500	700
COST FOR 36 LIGHTS (IN ₹)	54000	25200

Savings in 15 years = `28800, which equals `1920 per year.

TABLE 7.4: 36W CFL SUBSTITUTION COST

PARAMETER	15W INCANDESCENT	3.5W LED
COST PER PIECE (IN ₹)	25	230
LIFE (IN HOURS)	2000	25000
REQUIREMENT FOR 50000 HOURS	25	2
TOTAL COST (IN ₹)	625	460
COST FOR 54 LIGHTS (IN ₹)	33750	24840

Savings in 15 years = `8910, which equals `594 per year.

Thus the total savingsin replacement per year = `(-97691 + 37494 + 1920 + 594) = -`57683.

THEREFORE, THE TOTAL SAVINGS CONSIDERING THE ENERGY CONSUMPTION AND REPLACEMENT OF LIGHT SOURCES IS `(1261932 – 57683) = `1204249PER YEAR.

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