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PERFORMANCE OF LIGHTING SYSTEM OF A PHARMACEUTICAL INDUSTRY

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Abstract

Lighting constitutes a main portion of energy consumption in commercial as well as in industrial sector. The Energy Auditing is the key of the consumption which stabilize the situation of energy crisis by providing the conservative measures. Any organization so called bulk consumer of electrical energy gives emphasis to adopt suitable technology or scheme of energy conservation to minimize the unwanted power shutdown either incidentally or by load shedding. As the energy costs increases, possible efforts are to be done to minimize the energy consumption of lighting installations and efficient use of the energy consuming equipments . This follow three basic directions: new more efficient equipment (lamps, control gear, etc.), utilization of improved lighting design practices, replacing excess energy consuming equipments from energy efficient equipments, improvements in lighting control systems to avoid energy waste for unoccupied and daylight hours. In this paper an Energy audit has been conducted in the Pharmaceutical industry to estimate the energy consumption. In this Energy audit, the cost analysis and pay back periods have been calculated by replacing the higher consumption lamps with Energy efficient lightning also checking the feasibility of the different departments of the industry from energy point of view. The profit of implementing the energy efficiency measures in industry are considerable both in terms of energy savings and cost savings.

Keywords: Energy Audit, Installed Load Efficacy Ratio, Energy Efficient Measures, Payback Period.

1. INTRODUCTION

Lighting plays a very vital role in enabling people to carry out their tasks safely, efficiently and without discomfort, however electric lighting can account for around 30-40% of your electricity bill. An energy efficient lighting system combines, low running and maintenance cost, with good effective lighting and can reduce the facility's lighting cost by up to a third. Energy performance of various types of buildings - office, industrial, healthcare, educational and other buildings - is a widely discussed issue at different levels. The solution of energy performance of lighting systems of these buildings is also a part of these discussions. Lighting is a large and rapidly growing source of energy demand and greenhouse gas emissions. In 2005, grid-based electricity consumption for lighting was 2650 TWh worldwide, which was about 19% of the total global electricity consumption. Furthermore, each year 55 billion litres of gasoline and diesel are used to operate vehicle lights. More than one-quarter of the population of the world uses liquid fuel (kerosene oil) to provide Lighting (IEA 2006). A more efficient use of the energy used for lighting would limit the rate of increase of electric power consumption, reduce the economic and social costs resulting from the construction of new generating capacity, and reduce the emissions of greenhouse gases and Other pollutants into the environment. At the moment, important factors concerning lighting are energy efficiency, daylight use, individual control of light, quality of light, emissions during the life-cycle, and total costs.

Energy audit is a process of checking the way energy is used and identify areas where wastages can be minimized if not totally eradicate. Energy audit consists of several tasks which can be carried out depending on the type of audit and the function of audited facility. It started with review the historical data of energy consumption which can be compiled from the electricity bills. These data is important in order to understand the patterns of energy used and their trend. After obtaining the information on energy consumption, the next step is to set up an energy audit program. Therefore Energy Audit is essential part has to be carried out as it determines several energy saving techniques which can be opted within an organization to reduce electricity consumption. To achieve optimal energy efficiency in buildings, energy audit is able to reduce energy wastes and provides the cost benefit. The Energy audit and Energy conservation measures described in the research paper does not only provide a very different perspective to the wastage and energy crisis and energy security but also an implementation platform that addresses all aspects of managing several energy sources. Present case study of PARSH PHARMACEUTICALS LTD mainly deals with analyzing the lighting system in the industry, checking the lighting efficacy of the different areas of the industry by applying the concept of Energy Audit.

2. LITERATURE REVIEW

Before conducting the detailed Energy Audit of the case organization, a significant literature review was carried out to appreciate the field of research. This section systematizes reviews of literature which provides necessary information regarding energy auditing technique and its implementation. Some important reported research studies related to Energy Conservation are mentioned below:-

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S.N.	Research Paper	Author	Summary of the Work
1	A Case Study on Energy Conservation & Audit for Household Applications	Kongara Ajay	This paper analyses the amount of wattage consumed by different devices and suggested necessary replacements and showed the net savings.
2	Energy Audit of a Industrial Site : A Case Study	Matteo Dongellini	This paper presents the results of a preliminary energy audit carried out on 8 large industrial buildings of a famous car manufacturing holding in Italy
3	Energy Conservation Measures in a Technical Institutional Building	P. Loganthurai	In this paper it was proposed to implement energy conservation through energy efficiency and energy management
4	Electrical Energy Conservation in Underground Mines	Mr. Ganapathi. D. Moger	In this paper, the various electrical equipments used in the opencast and underground coal mines are listed in the literature work, their specifications & operations are explained.
5	Potentials for reducing primary energy consumption through energy audit in the packaging paper factory	Nikola Tanasic	This paper provides measures to increase energy efficiency of the packaging paper production process together with the quantification of the potential savings in the primary energy consumption are also presented in the paper.
6	Optimizing The Energy In An Educational Institution Using Energy Audit Technique	Arun Govind M	This paper provides the initial investment and the payback period calculations of each Block in Educational buildings with effective replacement.
7	Energy Audit of a Food Industry	Kaur Poonam, Thakur Ritula	From the survey, it was found that, luminance was poor, in few areas. After implementing ILER technique, illuminance was under permissible limit.

3. RESEARCH PROBLEM

Research Problem

Before conducting the electrical energy audit of the industry, the industry and workers were working in the environment in which old and inefficient energy consuming systems were used. Some of the problems are mentioned below:-

1. Inefficient lamps and/or ballasts
2. Mounting height of lamps too high
3. Reflectors of poor luminaries efficiency
4. Maintenance of reflectors not proper due to dirt/dust accumulation
5. Poor Maintenance of wall, floor and roof reflectance levels
6. Reduction in light output of lamps over time due to lumen depreciation
7. Low voltage

4. METHODOLOGY ADOPTED

In case industry ***Parsh Pharmaceuticals, Ujjain, Madhya Pradesh***, ayurvedic medicines are manufactured. Energy Audit is the key to a systematic approach for decision-making in the area of energy management. The purpose of this test is to calculate the installed efficacy in terms of lux/W/m^2 for general lighting installation. The calculated value can be compared with the norms for specific types of interior installation for assessing improvement options.

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Table 1: Target lux/W/m² (W/m²/100lux) values for maintained illuminance on horizontal plane for all room indices and applications (6)

Room Index	Commercial Lighting, (offices, Retail stores etc.) & very clean industrial applications, Standard or good colour rendering. Ra: 40-85	Industrial lighting (Manufacturing areas, Workshops, Warehousing etc.) Standard or good colour rendering. Ra: 40-85	Industrial lighting installations where standard or good colour rendering is not essential but some colour discrimination is required. Ra: 20-40
5	53 (1.89)	49 (2.04)	67 (1.49)
4	52 (1.92)	48 (2.08)	66 (1.52)
3	50 (2.00)	46 (2.17)	65 (1.54)
2.5	48 (2.08)	44 (2.27)	64 (1.56)
2	46 (2.17)	42 (2.38)	61 (1.64)
1.5	43 (2.33)	39 (2.56)	58 (1.72)
1.25	40 (2.50)	36 (2.78)	55 (1.82)
1	36 (2.78)	33 (3.03)	52 (1.92)

Calculate the Room Index: $RI = \frac{L \times W}{Hm(L + W)}$

Table 2: Determination of Measuring Points(6)

DETERMINATION OF MEASUREMENT POINTS	
	Minimum number of measurement points
Below 1	9
1 and below 2	16
2 and below 3	25
3 and above	36

Installed Load Efficacy Ratio (ILER)

The Installed load efficacy ratio is defined as the ratio of installed load efficacy and targeted load efficacy

ILER = Installed load efficacy/ Target Installed Load efficacy

ILER indicates the efficiency of lighting end use. The following table can be used to qualify comments.

Table 3: Indicators of performance based on ILER (6)

ILER	ASSESSMENT
0.75 or above	Satisfactory to good
0.51 to 0.74	Review Suggested
0.5 or less	Urgent action required

The reasons for ILER to be lower than desired can be due to any of the following.

1. Inefficient lamps and/or ballasts
2. Mounting height of lamps too high
3. Reflectors of poor luminaire efficiency
4. Maintenance of reflectors not proper due to dirt/dust accumulation
5. Poor Maintenance of wall, floor and roof reflectance levels
6. Reduction in light output of lamps over time due to lumen depreciation

Table 4: Different Department and Corresponding Areas

Department	Total Working Area (m^2)
Stores	123.75
Mixing	12.27
Filling Section	12.27
Packing	18.605
Weight Quality	12.27
Labeling	12.7
Tablet Section	12.69
Malt Section	12.27
Pulverising	12.27
Office	28

The detailed procedure to determine the Installed Load Efficacy Ratio (ILER) is explained below in the form of table:-

Table 5:- Steps involved in Calculation of Installed Load Efficacy Ratio (ILER)

STEP 1	Measure the floor area of the interior	Area = -----------------------m^2
STEP 2	Calculate the Room Index	RI = ----------------------------
STEP 3	Determine the total circuit watts of the installation by a power meter if a separate feeder for lighting is available. If the actual value is not known a reasonable approximation can be obtained by totaling up the lamp wattages including the ballasts:	Total circuit watts = ----------
STEP 4	Calculate Watts per square metre, Value of step 3/ value of step 1	W/m^2 = ---------------------

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STEP 5	Ascertain the average maintained illuminance by using Lux Merter, Eav maintained	Eav. Maint. = -------
STEP 6	Divide 5 by 4 to calculate lux per watt per square metre	Lux/W/m² = ---------------
STEP 7	Obtain Target Lux/watt/m² Lux for the type of Interior/application and RI(2):	Target Lux/W/m² = ------------
STEP 8	Calculate Installed Load Efficacy Ratio (6/7)	ILER = --------------------

5. RESULTS & DISCUSSIONS

Before conducting the energy audit, the case organization has been working in the environment in which working conditions were not upto the standard level. Due to this, different types of lightning issues arises. These problems have been discussed earlier. To overcome these problems it was decided to use the concept of energy audit in which installed load efficacy concept is used to find whether the installed setup is at the satisfactory level or not. After successfully implementing it encouraging results were obtained. These results are shown below in the form of tables.

Table 6: Installed Load Efficacy ratio (ILER) for Store

S. No	Calculation: Installed Load Efficacy ratio (ILER)	Unit	Value
1	Length of Room	m	16.5
2	Width of Room	m	7.5
3	Floor Area	-	123.75
4	Height of lamp from the plane of measurement	Hm	4.75
5	Room Index		1.08
6	Total circuit watts	W	650
7	Calculate Watts per square metre	w/ m²	5.25
8	Measured average room illuminance	lux	156
9	Installed Lighting Efficacy	Lux/w/ m²	29.71
10	Target Lighting Efficacy from reference: BEE	Lux/w/ m²	40
11	Installed Load Efficacy ratio (ILER)		0.74
12	**ASSESSMENT**	Review Suggested	

Similarly Installed Load Efficacy ratio (ILER) for different departments is mentioned below:-

1. For the Packing Section, the Room Index calculated is 0.83, calculated Installed Light Efficacy is 11.95 Lux/w/m², and the Target Light Efficacy as per BEE Standards is 36 Lux/w/m². So the calculated Installed Load Efficacy Ratio (ILER) is 0.33. This means that The Review is Suggested for better results.
2. For the Labeling Section, the Room Index calculated is 1.1, calculated Installed Light Efficacy is 17.68 Lux/w/m², and the Target Light Efficacy as per BEE Standards is 40 Lux/w/m². So the calculated Installed Load Efficacy Ratio (ILER) is 0.44. This means that Urgent Action is required for better results.
3. For the Tablet Section, the Room Index calculated is 1.06, calculated Installed Light Efficacy is 32.41 Lux/w/m², and the Target Light Efficacy as per BEE Standards is 38 Lux/w/m². So the calculated Installed Load Efficacy Ratio (ILER) is 0.85. This means that The Result is Satisfactory to Good.

Now as per the results obtained by the above analysis of all the departments with the concept of Installed Load Efficacy Ratio (ILER), it has been shown that some of the departments do not have illuminance as per the desired standard. So, to reduce the above effect and maintaining the required ILER, the low efficient lightning has to be replaced with the efficient lightning. The possible replacements are suggested to solve the above problems.

Table 7:- Replacing Convention 18 W CFL by 8 Watt LED lamp

Sr. No.	Parameter	Units	Value
AI	Conventional CFL	No.	22
AII	Rated Power of Existing 18 Watt CFL	Watt/ unit	18
B	Operating Hrs	Hrs/day	11
C	Operating Annual Days	Days/Year	330
D	Unit Consumed Annually (AI*AII*B*C)/1000)	kWh/Year	1437.4
	REPLACEMENT		
E	Energy Efficient 8 W LED lamp	Watt/unit	8

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F	Unit Consumed Annually	kWh/Year	638.88
G	Energy Saving (Old- New Annual Consumption)	kWh/Year	798.6
H	Total Annual Energy Cost Saving @ Rs. 5.0 per unit	INR	3993
	COST BENEFIT CALCULATION		
	Per Unit Cost@ Rs.80/-	INR	80
I	Total Capital Cost	INR	1760
J	Labor & Other Cost	INR@2/Fix	44
K	**TOTAL INVESTMENT**	INR	1804
L	Net Annual Saving	INR	3993
M	Simple payback (Investment/annual savings)	Yrs	0.45

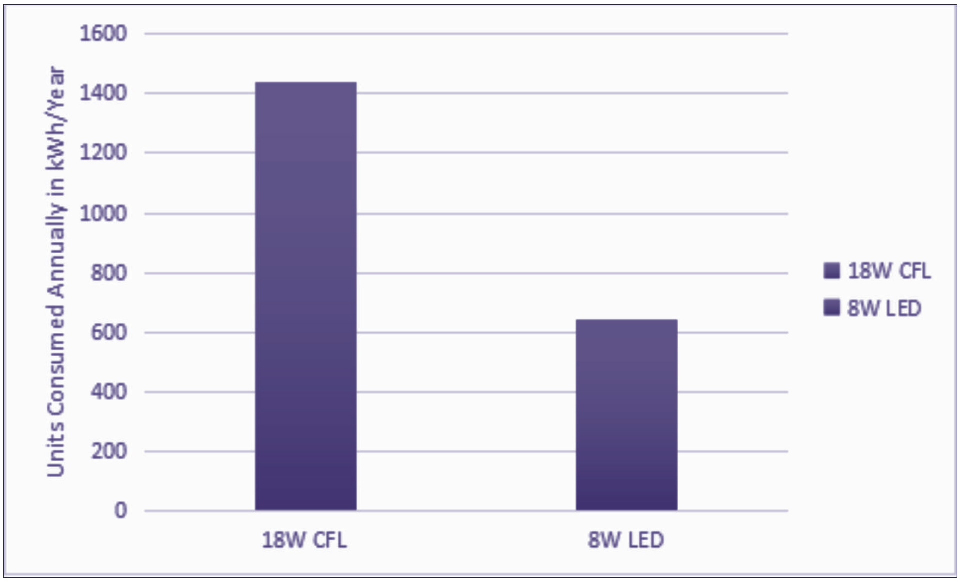

Fig.1 Comparison of Unit Consumption by 18W CFL and 8W LED Lamp

Similarly the Electrical unit consumption for the different replacements are:-

1. The Annual unit consumption of 42 quantity of T-12 & T-8 Tube lights is 4620 kWh/Year, which when replaced with T 5(18 Watt LED Tube light) consumes 2079 kWh/Year, which is represented by Fig 2. Total energy saving within a year by replacing is about 2541 kWh/Year and the Net Payback period is found to be 0.76 Years.

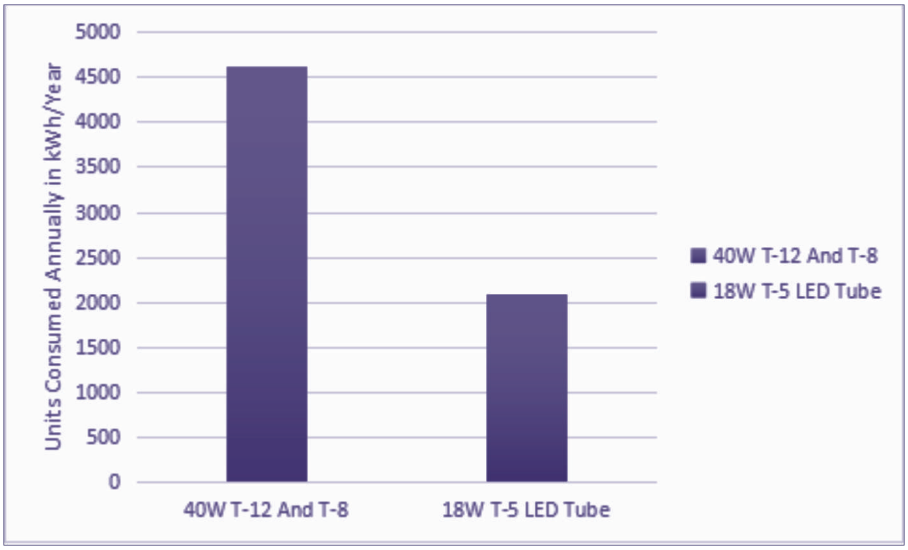

Fig.2 Comparison of Unit Consumption by 40W T-12 And T-8 Tube and 18W T-5 LED Tube

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2. The Annual unit consumption of 6 quantity of 9*2 Watt CFL lights is 392 kWh/Year, which when replaced with 6 Watt LED lamp consumes 130.7 kWh/Year, which is represented by Fig 3. Total energy saving within a year by replacing is about 261.4 kWh/Year and the Net Payback period is found to be 0.32 Years.

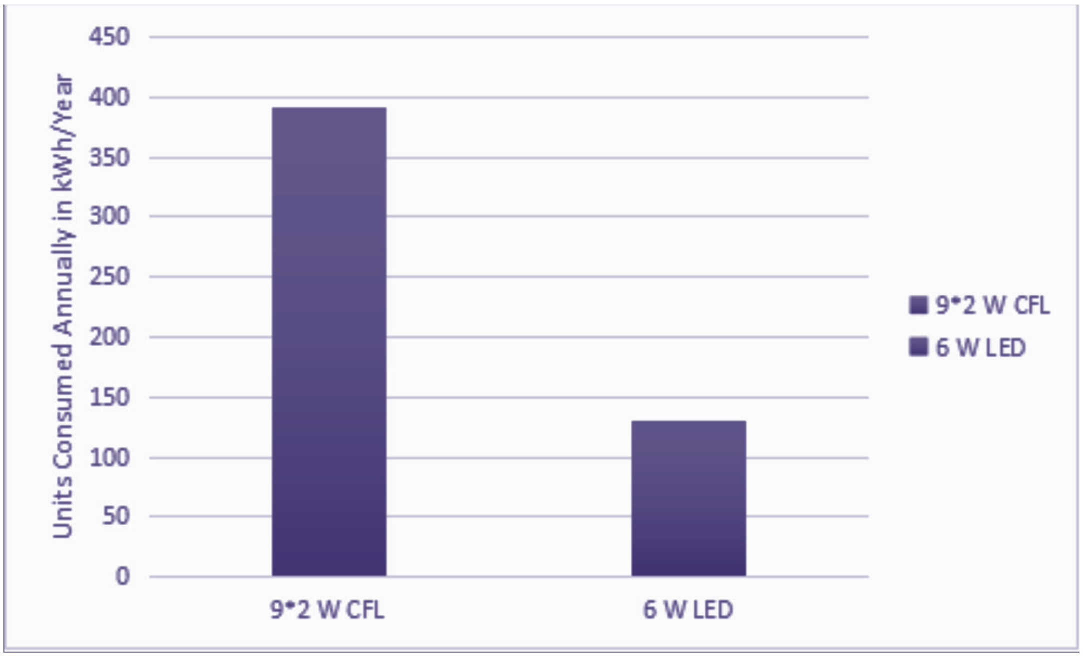

Fig.3 Comparison of Unit Consumption by 9*2 W CFL and 6 W LED Lamp

3. The Annual unit consumption of 11 quantity of 18*2 CFL lights is 1437.5 kWh/Year, which when replaced with T-5(11 Watt LED Tube) consumes 439.2 kWh/Year, which is represented by Fig 4. Total energy saving within a year by replacing is about 998.2 kWh/Year and the Net Payback period is found to be 1.08 Years.

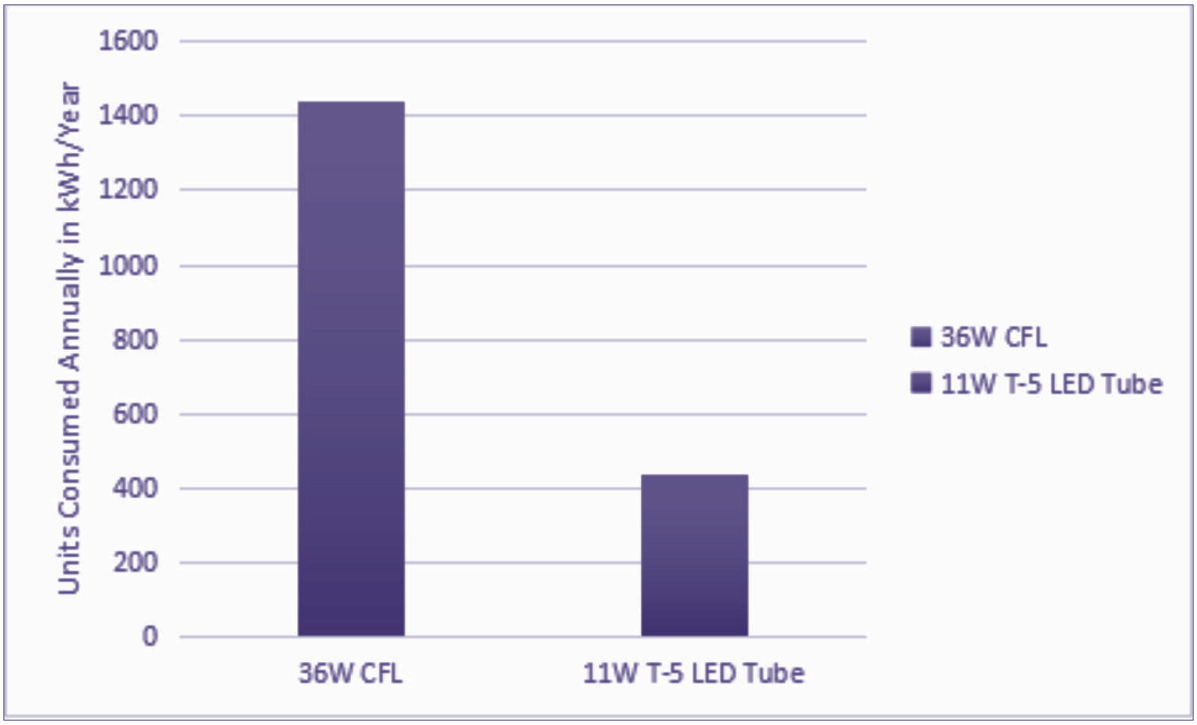

Fig.4 Comparison of Unit Consumption by 36W CFL and 11W T-5 LED Tube

4. The Annual unit consumption of 4 quantity of 250 Watt Metal Halide lights is 3960 kWh/Year, which when replaced with 100 Watt LED lamp consumes 1320 kWh/Year, which is represented by Fig 5. Total energy saving within a year by replacing is about 2640 kWh/Year and the Net Payback period is found to be 1.2 Years.

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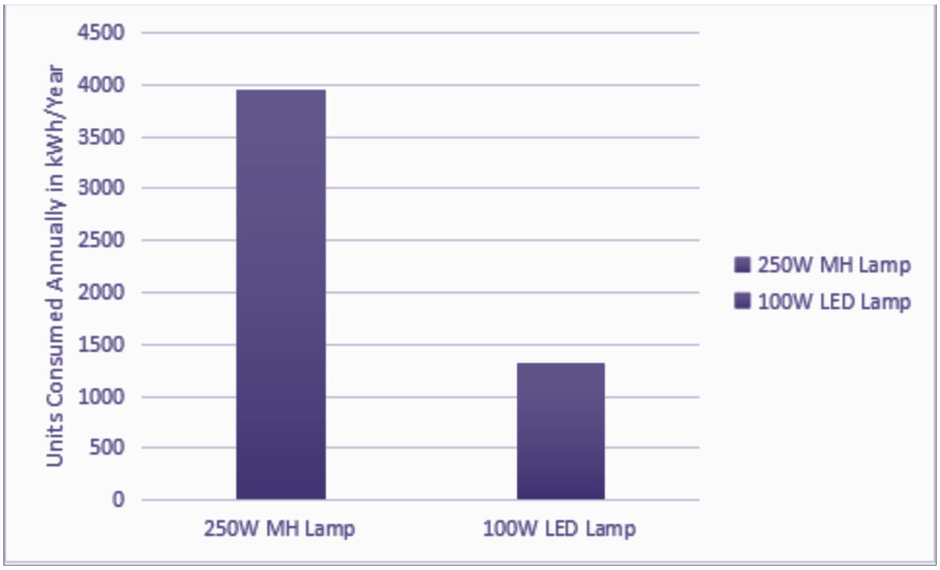

Fig.5 Comparison of Unit Consumption by 250W MH Lamp and 100W LED Lamp

6. CONCLUSION

Like all other industries Pharmaceutical Industries are also facing the problems like Energy Mismanagement, low use of natural light, unnecessary use of lighting system, use of in efficient lighting system. These problems have been addressed in this study by implementation of Installed Load Efficacy Ratio Technique in the Pharmaceutical industry. In this case study, the existing lighting system with low illuminance as per the predefined standards have been suggested to replace with the efficient lighting system. After implementing the above recommendations highly encouraging results have been obtained. Following conclusions have been drawn after assessing these results:

1. The Installed Load Efficacy Ratio for the different departments of the industry has been improved are:-
   i. The ILER for Stores has been improved from 0.74 to 0.89, which is Good And Economic.
   ii. The ILER for Filling Section has been improved from 0.46 to 0.79, which is Satisfactory to Good.
   iii. The ILER for Packing Section has been improved from 0.33 to 0.76, which is Satisfactory to Good.
   iv. The ILER for Labeling Section has been improved from 0.44 to 0.75, which is Satisfactory to Good.
2. As the Annual Units Consumption has been reduced to a great level without compromising the illuminance and the visibility of different sections so that the ILER can be increased to a satisfactory level.
3. So after successful replacement of the Energy Inefficient Lighting System with that of Energy Efficient one, a huge amount of saving has been achieved as well as greater illuminance is also achieved for better working conditions.

To understand it in details the following table has been prepared, which represent the average Payback period of the investment.

Table 8: Simple Payback Period

Sr. No.	Energy Conservation Measures	Energy Saving (kWh/Yr)	Investment Required (Rs.)	Simple Pay Back Period (Year)
1	Replacing Convention 18 W CFL by 8 Watt LED lamp	798.6	1,804/-	0.45
2	Replacing Convention T-12 & T-8 Tube by T-5 (18 Watt LED Tube)	2541	10,060/-	0.76
3	Replacing Convention 9*2 W CFL by 6 Watt LED lamp	261.4	1,180/-	0.86
4	Replacing Convention 18*2 W CFL by T-5 (11 Watt LED Tube)	998.2	5,610/-	1.08
5	Replacing Convention 250 W MH by 100 Watt LED lamp	2,640	16,160/-	1.2
6	Replacing 200 & 100 W Bulb by 18 Watt LED Tube	1,476	4,680/-	0.4
7	Replacing 100 Watt exhaust fan by 50 Watt Energy Efficient Exhaust Fan	990	14,080/-	1.9
	Total	**9,705.2**	**53,574/-**	**0.95**

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