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Research Article

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Study of Energy Saving in a Commercial Setup by Replacing Conventional Bulbs with LED Lights

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Abstract

In every walk of life, technology or household errands, commercial sector or Health sector everywhere energy is playing vital role and is the key to progress. Macroscopic analysis of worldwide energy utilization reveals that Lighting accounts for almost 20% of over-all power consumption. The demand for energy is incrementing swiftly over time with increase in populace, transmutation in life style, and advancement in technology. This urging call for sustainable energy resources to meet the ever escalating need has led to energy calamity which is the most imminent and colossal menace for economic stability of underdeveloped countries like Pakistan and is acting as a vacuum to inhibit the economic as well as social prosperity of the country. Several efforts have been made to fetch instant remedies and design long term plans to cope up with these alarming circumstances. While enlisting the possible solutions to this agitating situation, undoubtedly 'energy conservation' thrives at the top. Substantial energy savings can be achieved by reducing energy consumption by artificial lighting which has potential of energy preserving by utilizing efficient lighting technologies such as Light Emitting Diodes (LEDs). A case study is conducted for a commercial setup to compare the performance, appropriateness and financial effects of conventional bulbs and LED.

Keywords: Compact fluorescent light; Light emitting diode; Incandescent lamps; Conventional bulbs; Foot-candle

Introduction

Energy plays a major role in the long-run growth of the economy and is crucial in productivity of commercial sector. The core reason of this vitality is its cost-effectiveness, which is the reason why advanced economies focus on the idea of utilization of electrical energy in most efficient ways. Alongside Economic prosperity, Human development is dependent fundamentally on energy too. In a nut shell, Energy is the hub of progress. In Pakistan, massive electricity depletion has occurred due to demand supply gap leading to blackouts in residential areas and most importantly caused rigorous damage to the commercial sector. Prime solution to this problem is the application of the passive building design that conserves energy usage in buildings by smart technologies.

Artificial lighting consume one-fifth of global electrical energy [1] while 50-70% of general usage lighting is provided by conventional incandescent lamps (ICL) [2] that are 90-95% ineffectual. Energy preserving while upholding the required lighting level is a perplexing undertaking in designing lighting systems for buildings. Lighting is an immensely colossal growing source of energy demand and Green House Gas (GHG) emission. For artificial lighting most prevalent sources are the Incandescent Lamps (IL) and compact fluorescent lamps (CFL). IL is inept, converts 90% of electrical energy into heat [3] and short bulb life. CFLs are more efficient than incandescent bulbs in terms of energy saving [4] and durability but they contain hazardous material mercury [5], slow replications and recycling problems. This leads to a distinctive lighting technology called Light Emitting Diodes (LED). LEDs lights have the potential to overcome many such issues as they are good on low power consumption, diligent switching [6] minimal cost incurred on maintenance, better efficiency (lumen/ Watt), long-lifetime, high tolerance to moisture, no radiations, no recycling issues like CFLs and no inapt lamp failure as in the case of incandescent and eco cordial. Life Cycle Assessment has been used to understand the environmental impacts associated with each phase of the bulb's life. Where life cycle analyses have been conducted in the past, the long lifetimes of LED and CFL lamps are show to offset the manufacturing and disposal impacts as fewer lamps are required [7-9]. So, conventional light bulbs are replaced with LED for energy preserving, financial perspectives [10] better performance, high moderation to moisture, cool operation elongated life and are highly efficient.

The luminous level for work place is defined by Lux, lumen /watts and foot-candle. Table 1 shows the recommended illumination level for indoor lighting design for different environments.

Research Methodology

In proposed strategy first of all site for the project is selected and its indoor area is measured. By using Lux meter the existing illumination level of CFLS is measured. Obtained illumination level is matched with international standards of Illuminating Engineering Society of North America (IESNA). For the area under consideration a new lighting scheme is developed by using measurements of selected area and adding the standards for that specific environment to simulation software DIALUX 4.11. As per design, the hardware is installed and illumination level is measured for LED lights by using Lux meter and results are compared with that of CFL lights prior to installation of LED lights.

In order to check how viable the lightning scheme is, energy savings and cost savings calculations is being made. Finally payback period is calculated to justify the implementation of new lighting scheme.

Case study

The case study is based on 8th floor (7th level) of a commercial building which majorly comprises of offices is operated 12 hours in a

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day in 1 shift. The area of the 8th floor (7th level) is 11115 ft2. The floor has 21 number of offices, 2 AHU rooms, 2 Stair lobbies, washrooms, 1 data room, 1 electric room, 1 smoke stop lobby, and a store on its 8th floor (7th level). Total lighting load on this Floor is 10.930 KW. The floor was installed with 405 TBS (Tube Rod) lights and 26 CFL (Compact Fluorescent Lamps) suspended 2 ft below from roof. The illumination level on different test points with conventional bulbs (Tube lights and Energy savers) is measured by Lux meter and recorded as in Table 2.

Office type 01

Height of room: 12.000 ft., Mounting height: 10.000 ft., Light loss factor: 0.80, Values in foot-candles, Scale 1:48 (Table 3). Specific connected load: 0.93 W/sq.ft.=0.16 W/sq.ft./10 fc(Ground area: 224.99 sq. ft.) (Table 4).

Office type 02

Height of room: 12.000 ft., Mounting height: 10.000 ft., Light loss factor: 0.80, Values in foot-candles, Scale 1:87 (Table 5). Specific connected load: 1.06 W/sq.ft.=0.15 W/sq.ft./10 fc (Ground area: 396.01 sq.ft.) (Table 6).

Office type 03

Height of room: 12.000 ft., Mounting height: 10.000 ft., Light loss factor: 0.80, Values in foot-candles, Scale 1:62 (Table 7). Specific connected load: 0.89 W/sq.ft.=0.14 W/sq.ft./10 fc (Ground area: 315.01 sq.ft.) (Table 8).

Office type 04

Height of room: 12.000 ft., Mounting height: 10.000 ft., Light loss factor: 0.80, Values in foot-candles, Scale 1:91 (Table 9). Specific connected load: 0.90 W/sq.ft.=0.14 W/sq.ft./10 fc (Ground area: 621.01 sq.ft.) (Table 10).

Corridor

Height of room: 12.000 ft., Mounting height: 10.00 ft., Light loss factor: 0.80, Values in foot-candles, Scale 1:242 (Table 11). Specific connected load: 0.68 W/sq.ft.=0.32 W/sq.ft. /10fc (Ground area: 518.38 sq.ft.) (Table 12).

Figures above exhibit the layout design of LED luminaries for various types of offices under consideration and state the lux levels on different points in foot-candles. Figure 1 shows design layout of Incubator office 01 consist of 6 LED lights of 35 watt each, Figure 2 shows Incubator office type 02 consist of 12 LED lights of 35 watts each, Figure 3 shows Incubator office type 3 consist of 8 LED lights of 35 watt each, Figure 4 shows Incubator office type 04 consist of 16 LED lights of 35 watt, Figure 5 shows layout design of corridor consist of

Work Area	Foot-candles (fc)
Offices	50-100
Corridors	30
Medium contrast	50-100
Low contrast and very small task	100-200
Bathroom	30-40
Stair hall	10-20

Table 1: Recommended illumination level.

Location	Location	Power (Watt)	Total Quantity		Total Watts	Total KW
Offices	Tube Rod T5 1	28	150×2	300	8,400	8.400
Corridor	Tube Rod T5 2	14	42×2	84	1,176	1.176
AHU Rooms	Tube Rod TBS	36	7×2	14	504	0.504
Lift Lobby	Energy Saver	23	8	8	184	0.184
Washroom	Energy Saver	23	16	16	368	0.368
Data Room	Tube Rod TBS	36	1	1	36	0.036
Two Stairs	Tube Rod TBS	36	2×2	4	144	0.144
Electric Room	Tube Rod TBS	36	2	2	72	0.072
Smoke Store Lobby	Energy Saver	23	1	1	23	0.023
Store	Energy Saver	23	1	1	23	0.023
TOTAL					**10,930**	**10.930**

Table 2: Formulates total watts consumed by existing electrical scheme being used.

Surface	$E_{av}[f_c]$	$E_{max}[f_c]$	$E_{max}[f_c]$
Work plane	59	35	76

Table 3: Data of work plane-1.

No.	Pieces	Designation (Correction factor)	Φ (Luminaire) [lm]	Φ (Lamps) [lm]	P [W]
1	6	Glamox C62-R625×625 LED 3200 840 3×SU/CL (1.000)	3250	3250	35.0
			Total: 19500	Total: 19500	210.0

Table 4: Luminaire parts list-1.

Surface	$E_{min}[f_c]$	$E_{min}[f_c]$	$E_{max}[f_c]$
Work plane	71	36	94

Table 5: Data of work plane-2.

No.	Pieces	Designation (Correction factor)	Φ (Luminaire) [lm]	Φ (Lamps) [lm]	P [W]
1	12	Glamox C62-R625×625 LED 3200 840 3×SU/CL (1.000)	3250	3250	35.0
			Total: 39000	Total: 39000	420.0

Table 6: Luminaire parts list-2.

Surface	$E_{av}[f_c]$	$E_{max}[f_c]$	$E_{max}[f_c]$
Work plane	65	39	83

Table 7: Data of work plane-3.

No.	Pieces	Designation (Correction factor)	Φ (Luminaire) [lm]	Φ (Lamps) [lm]	P [W]
1	8	Glamox C62-R625×625 LED 3200 840 3×SU/CL (1.000)	3250	3250	35.0
			Total: 26000	Total: 26000	280.0

Table 8: Luminaire parts list-3.

Surface	$E_{min}[f_c]$	$E_{min}[f_c]$	$E_{max}[f_c]$
Work plane	66	32	85

Table 9: Data of work plane-4.

No.	Pieces	Designation (Correction factor)	Φ (Luminaire) [lm]	Φ (Lamps) [lm]	P [W]
1	16	Glamox C62-R625×625 LED 3200 840 3×SU/CL (1.000)	3250	3250	35.0
			Total: 52000	Total: 52000	560.0

Table 10: Luminaire parts list-4.

Surface	$E_{min}[f_c]$	$E_{min}[f_c]$	$E_{max}[f_c]$
Work plane	21	14	24

Table 11: Data of work plane-5.

No.	Pieces	Designation (Correction factor)	Φ (Luminaire) [lm]	Φ (Lamps) [lm]	P [W]
1	10	Glamox C62-R625×625 LED 3200 840 3×SU/CL (1.000)	3250	3250	35.0
			Total: 32500	Total: 32500	350.0

Table 12: Luminaire parts list-5.

10 LED lights of 35 watt each. Above All the figures shows the detailed luminary layout for the installation of lights and distance between them horizontally and vertically along with detail of work plane. Similar calculations are made using DIALUX 4.11 for the other miscellaneous rooms i.e., AHU rooms, Lift lobby washrooms, Data room, two stairs, electric room, smoke store lobby and store room.

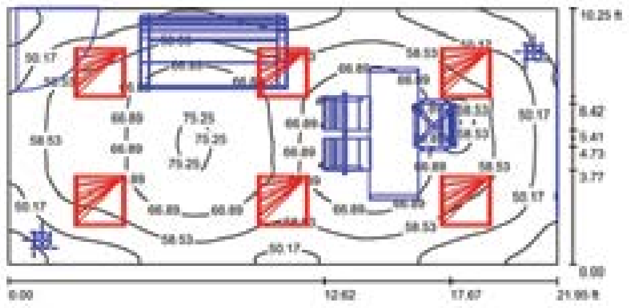

Figure 1: Layout design of incubator office type 01 by using DIALUX 4.11.

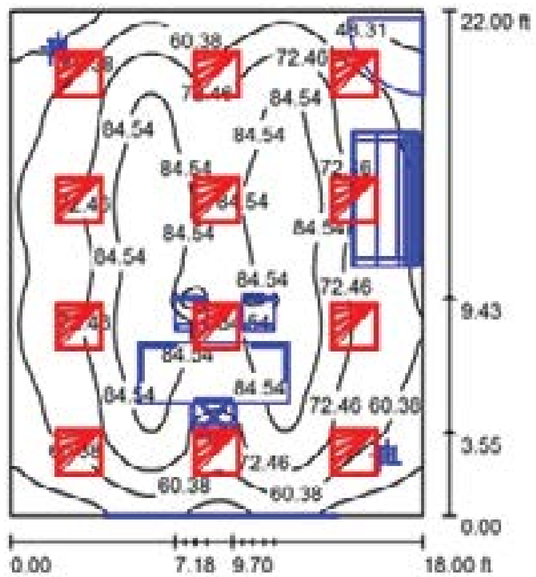

Figure 2: Layout design of incubator office type 02 by using DIALUX 4.11.

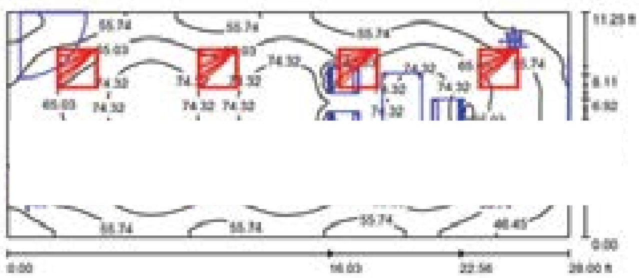

Figure 3: Layout design of incubator office type 03 by using DIALUX 4.11.

Equipment Installation

The lighting load of the floor was 10.930 KW which has been replaced with 8.15 KW new lighting load LED lights. The lights have been installed at the height of 10 ft from ground and the illumination level is recorded by Lux meter in foot-candle on work plane (3.00 ft.). The result shows that the lighting level in 8th floor (level 7) has very much improved after installation of LED lights (Table 13).

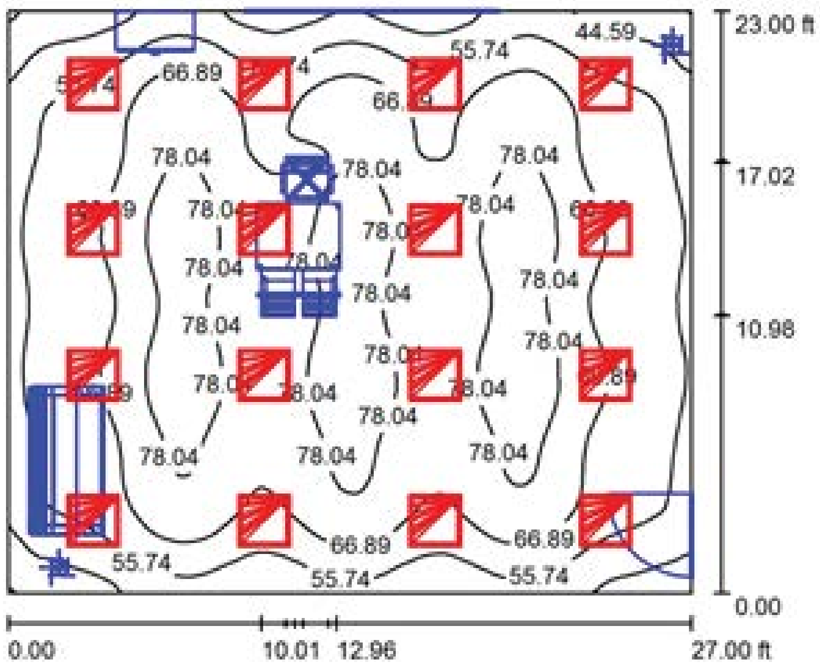

Figure 4: Layout design of incubator office type 04 by using DIALUX 4.11.

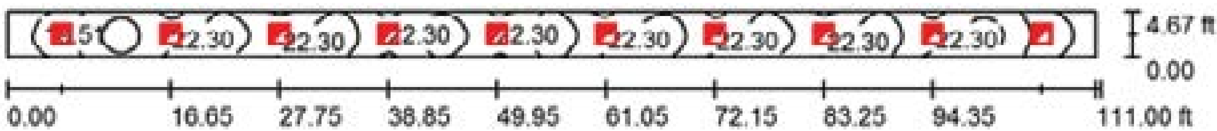

Figure 5: Layout design of corridor by using DIALUX 4.11.

Types of lights	No. of rooms		Quantity	Total Watts	Total KW	Installation Cost (PKR)	Units consumed/Day
Offices	21	Tube Rods	405 No (28w/Each)	10332	10.332	1296000	
Miscellaneous	11	Energy Savers	26 No (w/varies)	598	0.598	3900	10.930×12=131.16 KWH
Incubator Office -01	8	LEDs	48 No (35w/Each)	1680	1.68	132000	8.15×12=97.86 KWH
Incubator Office-02	4	LEDs	48 No (35w/Each)	1680	1.68	132000	
Incubator Office-03	8	LEDs	64 No (35w/Each)	2240	2.24	176000	
Incubator Office-04	1	LEDs	16 No (35w/Each)	560	0.56	44000	
Corridor	1	LEDs	28No (35w/Each)	980	0.98	77000	
AHU Room	2	LEDs	4 No (35w/Each)	140	0.140	11000	
Lift lobby	1	LEDs	2 No (35w/Each)	70	0.070	5500	
Washroom	1	LEDs	6 No (35w/Each)	210	0.210	16500	
Data room	1	LEDs	1 No (35w/Each)	35	0.035	2750	
Two Stairs	2	LEDs	4 No (35w/Each)	140	0.14	11000	
Electric Room	1	LEDs	1 No (35w/Each)	35	0.035	2750	
Smoke store Lobby	1	LEDs	1 No (35w/Each)	35	0.035	2750	
Store	1	LEDs	1 No (35w/Each)	35	0.035	2750	

Table 13: Conventional bulbs vs. LED lights.

Results and Discussion

Before installation of LED lights the floor was installed with 431 traditional bulbs with lighting load of 10.930 KW. To achieve the recommended illumination level and energy savings through an efficient lighting design and use of LEDs, these conventional bulbs were replaced with LED lights with lighting load of 8.15 KW while fixtures are not replaced. New LED lights are installed in existing fixtures. The wattage of luminaries and installation cost incurred on traditional and LED bulbs is shown in Table 13.

Financial effects

Light usage profile (full load):

Air cooling energy savings=97.86 × 0.19=18.59

Total lighting load with air cooling energy savings=97.86-18.59=79.26

The site is being operated 12 hrs/day and rate of electricity/unit is taken as PKR 12.06.

Annual cost of electricity consumed by conventional bulbs=131.16 × 12.06 × 365 = 577354 PKR

Annual cost of electricity consumed by LED lights=79.26 × 12.06 × 365= 348895 PKR

X = Annual Cost Saving/Year=228639 PKR

Initial investment:

On conventional bulbs=1299900 PKR

On LED lights (excluding fixture cost)=605000 PKR

Y= Difference of Installation Cost=694900 PKR

Simple pay back period (SPBP)

SPBP =Y/X =3.03 years

Conclusion

LEDs are the future technology highly promoted for their low energy consumption, long life, efficiency, reliability, and ease of use in improved and innovative designs and having potential to save energy. Case study for a commercial building Arfa Software Technology Park, Lahore using LEDs is carried out that shows 40% of energy saving and financial savings of 170617 PKR per year with payback period of 3.03 years. The results show that LEDs are best recommended for general lighting application and white LEDs are replacing incandescent and compact fluorescent lamps. The major disadvantage associated with LED lights is that the installation cost of these devices is still at higher side; however this issue can be resolved by replacing just the LEDs and not the fixtures as we have done in this project.

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