

Case Study of Energy Saving in Building and Architectural Engineering Department, Bahahuddin Zakariya University Multan by Replacing Conventional Lights with LED Bulbs

Waqas Ahmad*, Aalia Faiz and Shimza Jamil

Architectural Engineering Department, University of Engineering and Technology, Lahore, Pakistan

Abstract

Artificial lighting uses a significant percentage of the electrical power being consumed globally. Power generation is one of the major issues for a progressing country like Pakistan, conversely the demand is growing due to increased population and advanced life style. This could lead to severe power shortages. To tackle this situation, a way is to reduce the demands by using energy efficient technologies. This will lead to required lighting provision by using lesser power. Using efficient bulbs like Light emitting diode (LED) instead of conventional fluorescent tube lights (FTL) provides energy efficient lighting system. A new lighting system is designed for the chosen building using DIALux 4.12 simulation software which fulfills the standard requirements of Illuminating engineers society of North America (IESNA). Installation of new lamps proved that the system consumes 47% lesser energy compared to the old conventional system and calculations shows a payback period of 1.734 years for the initial costs. These figures prove the economy of the newly designed system.

Keywords: Light emitting diode; Compact fluorescent lamp; Fluorescent tube light; Incandescent lights

Introduction

Pakistan now days have one of the biggest challenges of meeting its power demands. Due to shortage of power generated compared to the required, blackouts are more than a usual job for people. A lot of amount is being used for alternating power supply systems like UPS, generators, etc. to cope with the electrical load shedding which is affecting the economy of an individual. If we cannot increase our power generations currently, it is advisable to decrease the demand with the use of some advanced technologies. Designing the structures/building in a way that less power is required for the major purposes like lighting, heating, air-conditioning etc. Using the smart technologies, large amount of power can be saved.

It is found that about 20 to 50% of the total global power consumption is used for lighting systems of buildings [1]. So, using some smart lighting system can save a lot of power that will help to improve the economy as well as reduce the power demand, but this is not as simple as it seems. Reducing the power consumption of the any lighting system reduces the light output. To maintain the required light level while reducing the power consumption of a lighting system for a space is a tough task. This can be achieved by replacing the existing old lighting system by some new technology lights that are more efficient in lumen production and also the quality of light is fulfilling the requirements. Different types of lights are available in the market having different technologies. the most common are the incandescent lights, compact fluorescent lights (CFL 's), halogen lights, high intensity discharge lights (HID's), light emitting diodes (LEDs) etc. Our selected site was equipped with fluorescent tube lights which are replaced with LED lights. LED lights are more efficient (produce more lumen/watt), have longer life, are available in different colors, have instant start option, has minimum maintenance charges, are save against light jerks which can cause damage to incandescent lamp or a CFL. Following is the Table 1 which shows the comparison of the LED with other type of lamps [2].

Lights replaced with fluorescent tubes are having a color rendering index of 80. It is clear from the above table that LED bulbs are almost twice as efficient as the fluorescent tubes so power savings are obvious. From the Table 2 below it is found that the required illumination for our building is 30-50 foot candles. [3,4]. And detailed specifications of the chosen LED bulbs are shown in Table 3 [5].

Methodology of Research

First of all, project site is selected and its indoor areas are measured. Then the existing illumination level of conventional bulbs is measured by using lumen method. Illumination level thus obtained is matched with international standards of Illuminating Engineering Society of North America (IESNA). Thereafter, by using measurements of selected area, a new lighting scheme is developed for the area/site under consideration. Then hardware is installed as per design, and illumination level for LED lights is measured by using lumen method and results are compared with that of conventional lights prior to installation of LED lights. Calculations for energy savings and cost savings are made in order to check viability of the new lighting scheme

Type of Light	Output (lumens)	Ballast factor	Operational Wattage	Annual Consumption per bulb (24/7)
LED T8 bulb	1900 (119 lm/w)	1	16	140.16 kWh
Fluorescent T12 tube light	1800 (53 lm/w)	0.88	34	376.68 kWh

Table 1: Comparison between fluorescent tube lights and LED bulbs [2].

Work Area	Illuminance (foot candles)
Classroom/offices	30-50
Rough bench work	30
Medium Contrast	50-100
Low contrast and very small task	100-200
Welding precision	300-1000

Table 2: Required illumination level.

*Corresponding author: Dr Waqas Ahmad, Architectural Engineering Department, University of Engineering and Technology, Lahore, Pakistan, Tel: +92 42 99029227; E-mail: engrwaqasahmad97@gmail.com

Received: May 16, 2017; Accepted: June 24, 2017; Published: July 01, 2017

Citation: Ahmad W, Faiz A, Jamil S (2017) Case Study of Energy Saving in Building and Architectural Engineering Department, Bahahuddin Zakariya University Multan by Replacing Conventional Lights with LED Bulbs. Int J Adv Technol 8: 190. doi:10.4172/0976-4860.1000190

Copyright: © 2017 Ahmad W, et al. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

[6,7]. Finally, to justify the implementation of new lighting scheme, payback period has been calculated.

- Site Selection
- Areas measurement of Building
- Measurement of Existing Lumen Level
- Recommended Illumination Level for Work Plan
- Layout Design by using DIALux 4.12
- Hardware Installation
- Energy savings calculations
- Calculations of Cost savings
- Estimation of Payback period

Case Report

This case study is of Architectural Engineering Department UCE&T BZU Multan, which is educational institute having about 8 hours of working per day (Figure 1). The area of the building is 18000 square feet and height of building is 24 ft (12ft per storey). The building has faculty offices, class room’s, library, digital studios, and laboratory (Table 1). All rooms are equipped with fluorescent lights except HOD’s office having LED lamps. Total existing load for lighting of the building is 157.75 kWh/day. The building is installed with 335 conventional lights. Details are given in the Table 4.

Required lux level for all the lecture rooms, faculty offices, digital studio and library is 500 lux, for corridors 300 lux, for washrooms 200 lux, for staircases 100 lux according to recommendations of Illumination engineering society of North America [3]. Figure 1 below show the details of spaces on ground and first floor of the building that come under a specific room number.

LED Type	Wattage (watt)	Light output (lumens)	No.of switch cycles	Maintenance factor	Power factor	color	Wattage equivalent	Rated life time (hrs)	Starting time (sec.)
LED bulb 4.5 watt	4.5	470	20,000	0.7	0.5	Warm white	40 watt	15000	<0.5
LED bulb 9.5 watt	9.5	806	1,00,000	0.7	0.5	White	70 watt	15000	<0.5
LED bulb 13 watt	13	1400	50,000	0.7	0.5	Cool daylight	100 watt	15000	<0.5

Table 3: Detailed specifications of the chosen LED bulbs are as follows [5].



Figure 1: The details of spaces on ground and first floor of the building that come under a specific room number.

Sr#	Location	Type Of Light	Quantity	Wattage/lamp
1	HOD Office	LED	4	7 watt
2	Wash Room	Energy Saver	2	23 watt
3	Faculty Rooms	Fluorescents Tube Lights	16	40 watt
4	Support Staff Room	Fluorescents Tube Lights	8	40 watt
5	Library	Fluorescents Tube Lights	16	40 watt
6	Teaching Lab	Fluorescents Tube Lights	96	40 watt
7	F.Washroom	Fluorescents Tube Lights	8	40 watt
8	M.Washroom	Fluorescents Tube Lights	10	40 watt
9	Circulation Area	Fluorescents Tube Lights	55	40 watt
10	Main Entrance	Fluorescents Tube Lights	4	40 watt
11	Girls Room	Fluorescents Tube Lights	6	40 watt
12	Boys Room	Fluorescents Tube Lights	4	40 watt
13	Class Room	Fluorescents Tube Lights	64	40 watt
14	Store Room	Fluorescents Tube Lights	2	40 watt
15	Computer Lab	Fluorescents Tube Lights	16	40 watt
16	Digital Studio	Fluorescents Tube Lights	16	40 watt
17	Stairs	Fluorescents Tube Lights	2	40 watt
18	Stairs	Fluorescents Tube Lights	6	40 watt

Table 4: Details of existing conventional lights.

Using DIALux 4.12 following lighting design scheme is designed showing faculty and lecture room's lights layout along with the number of lamps.

Lumen method

Number of lamps can also be calculated manually by using Lumen Method. The equation is appended below

$$N = E \times A / F \times UF \times MF$$

Where,

N= Numbers of lamps required

E= Average illumination required in Lux

A= Area of working plane (m²)

F= Light output from Lamp (Lumens)

UF= Utilization factor (Light distribution from Lamp)

MF= Maintenance factor (Reduction in light output because of deterioration and dirt.)

Room 01:

(i) Calculation of number of lamps

$$N = E \times A / F \times UF \times MF$$

$$E = 500 \text{ lux; } A = 4 \text{ m} \times 4 \text{ m; } F = 1848 \text{ lumens; } U.F = 0.55; M.F = 0.67; N = 12$$

(ii) Spacing between fittings

Horizontal Spacing: From wall to luminary = 0.67 m; between two luminaries = 1.34 m

Vertical Spacing: From wall to luminary = 0.67 m; between two luminaries = 1.34 m

(iii) Layout of fittings (Figures 2 and 3)

Note: Calculated value of E is within permissible range .so the layout of fitting is satisfactory.

Room 02:

(i) Calculation of number of lamps

$$N = E \times A / F \times UF \times MF$$

$$E = 500 \text{ lux; } A = 3 \text{ m} \times 4 \text{ m; } F = 1848 \text{ lumens; } U.F = 0.55; M.F = 0.67; N = 9$$

(ii) Spacing between fittings

Horizontal Spacing: From wall to luminary= 0.69 m; between two luminaries= 1.286 m

Vertical Spacing: From wall to luminary = 0.5m; between two luminaries = 1.02 m

(iii) Layout of fittings (Figures 4 and 5)

Note: Calculated value of E is within permissible range, so the layout of fitting is satisfactory.

Room 03:

(i) Calculation of number of lamps

$$N = E \times A / F \times UF \times MF$$

$$E = 500 \text{ lux; } A = 3.6 \text{ m} \times 4.8 \text{ m; } F = 1848 \text{ lumens; } U.F = 0.55; M.F = 0.67; N = 12$$

(ii) Spacing between fittings

Horizontal Spacing: From wall to luminary= 0.780 m; between two luminaries= 1.14 m

Vertical Spacing: From wall to luminary = 0.77 m; between two luminaries = 1.14 m

(iii) Layout of fittings (Figures 6 and 7)

Note: Calculated value of E is within permissible range .so the layout of fitting is satisfactory.

Room 04:

(i) Calculation of number of lamps

$$N = E \times A / F \times UF \times MF$$

$$E = 500 \text{ lux; } A = 9.1 \text{ m} \times 7.3 \text{ m; } F = 1848 \text{ lumens; } U.F = 0.5; M.F = 0.67; N = 48$$

(ii) Spacing between fittings

Horizontal Spacing: From wall to luminary = 0.137 m

Vertical Spacing: From wall to luminary = 0.7 9 m

(iii) Layout of fittings (Figures 8 and 9)

Note: Calculated value of E is within permissible range .so the layout of fitting is satisfactory.

Room 05:

(i) Calculation of number of lamps

$$N = E \times A / F \times UF \times MF$$

$$E = 500 \text{ lux; } A = 9.1 \text{ m} \times 12.1 \text{ m; } F = 1848 \text{ lumens; } U.F = 0.55; M.F = 0.67; N = 8$$

(ii) Spacing between fittings

Horizontal Spacing: From wall to luminary = 1.35 m



Figure 2: Layout of fittings.

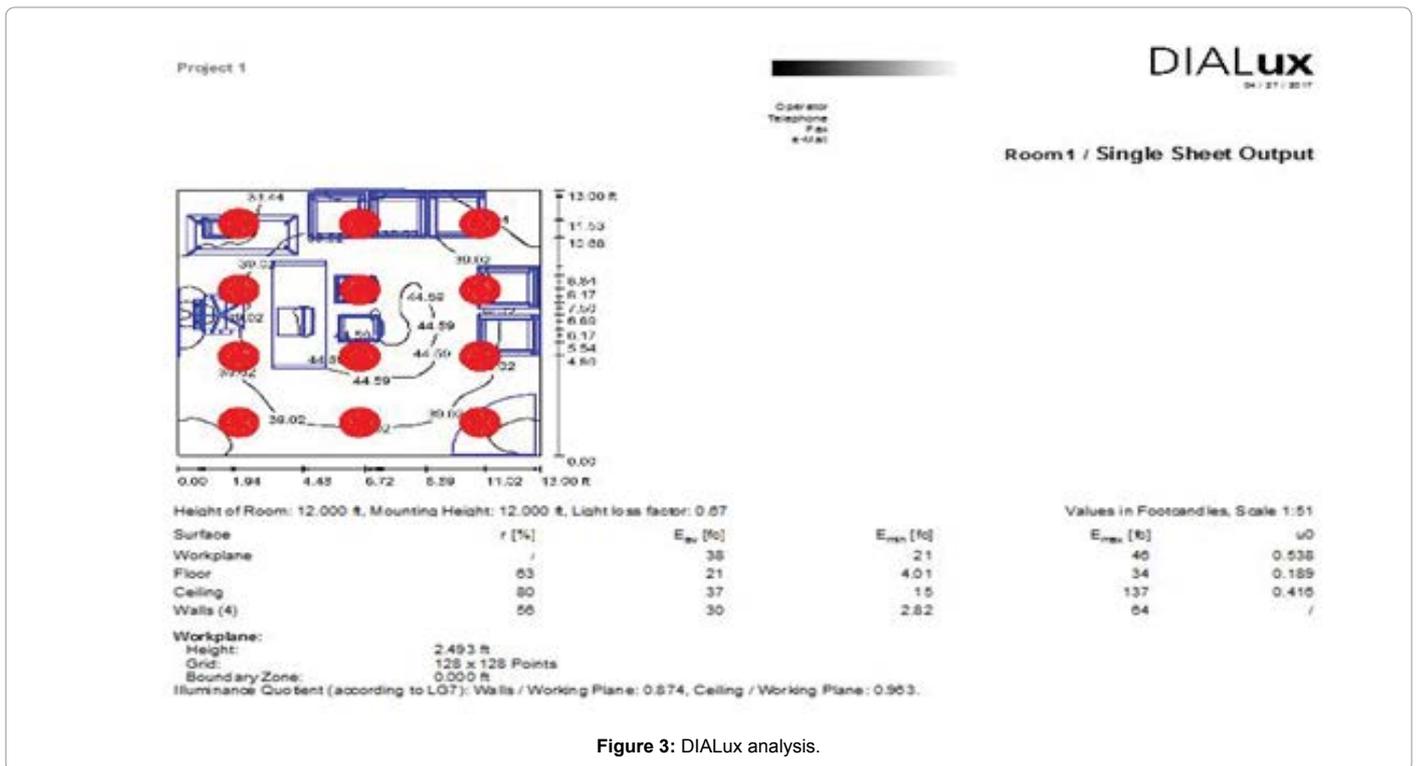


Figure 3: DIALux analysis.

Vertical Spacing: From wall to luminary = 0.94 m

(iii) Layout of fittings (Figures 10 and 11)

Note: Calculated value of E is within permissible range .so the layout of fitting is satisfactory.

Room 06:

(i) Calculation of number of lamps

$$N = E \times A / F \times UF \times MF$$

$E = 500$ lux; $A = 6.5 \text{ m} \times 4 \text{ m}$; $F = 1848$ lumens; $U.F = 0.55$; $M.F = 0.67$; $N = 20$

(ii) Spacing between fittings

Horizontal Spacing: From wall to luminary = 0.55 m

Vertical Spacing: From wall to luminary = 0.67m

(iii) Layout of fittings (Figures 12 and 13)

Note: Calculated value of E is within permissible range .so the layout of fitting is satisfactory.



Figure 4: Layout of fittings.

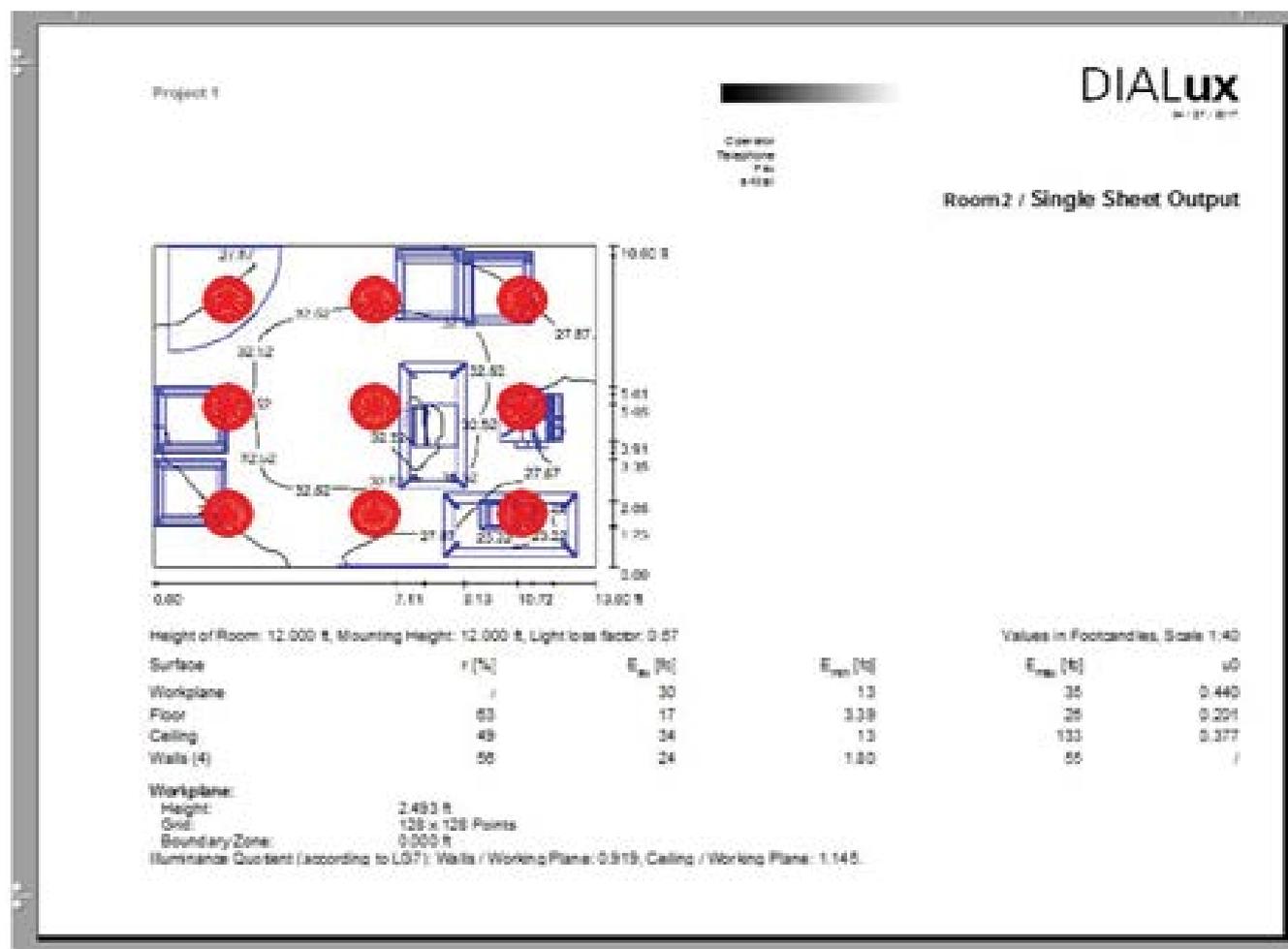


Figure 5: DIALux analysis.



Figure 6: Layout of fittings.

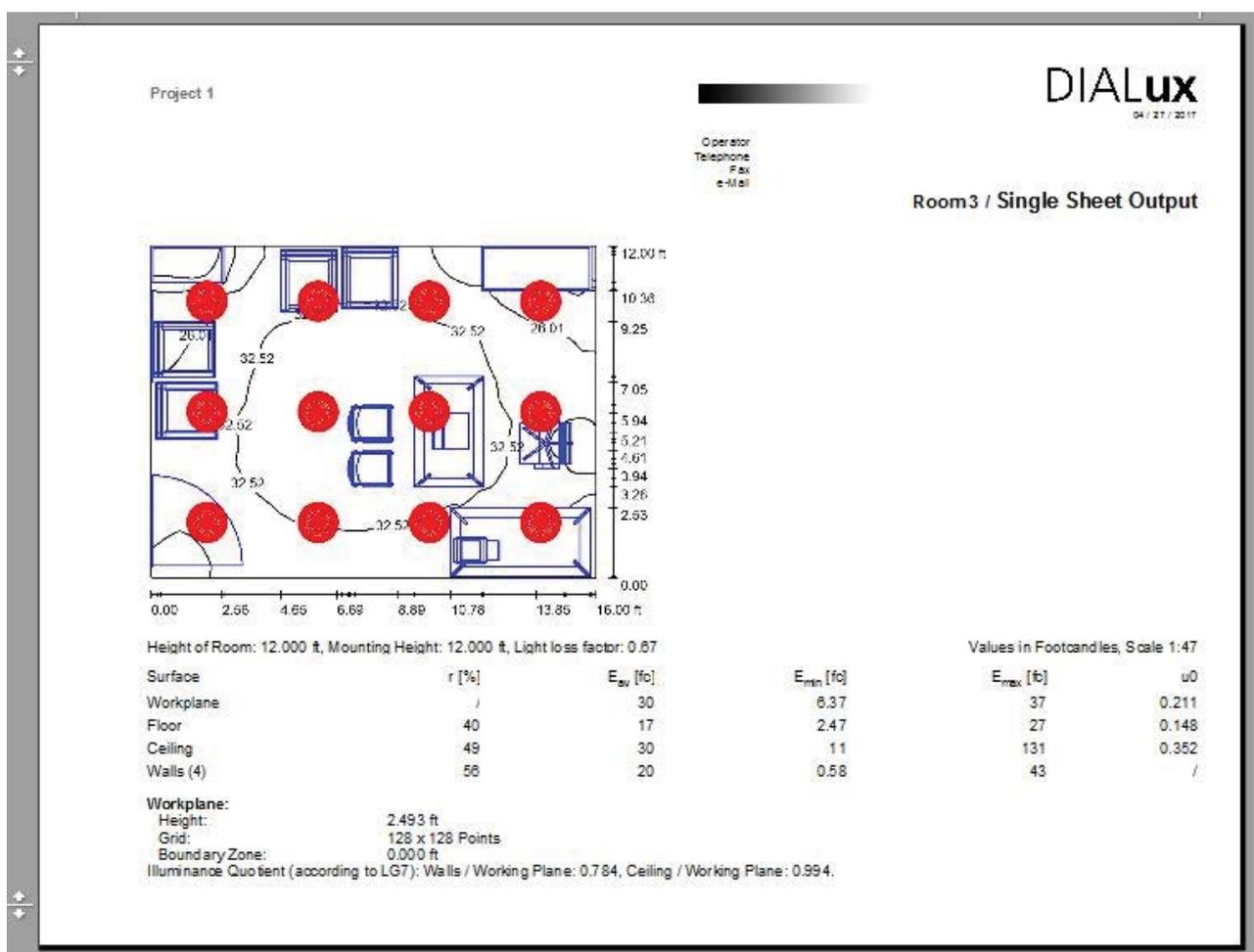


Figure 7: DIALux analysis.

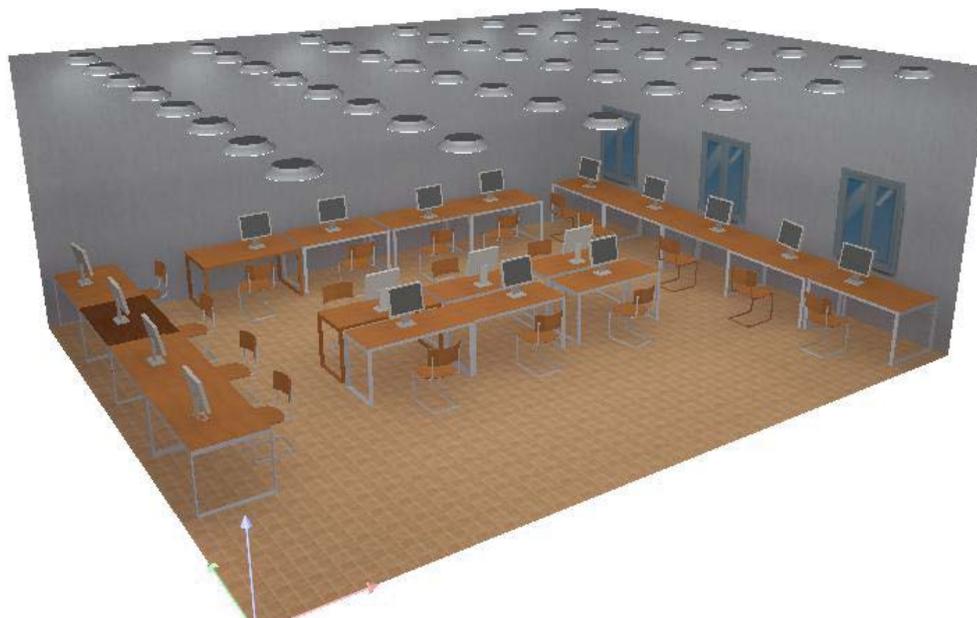


Figure 8: Layout of fittings.

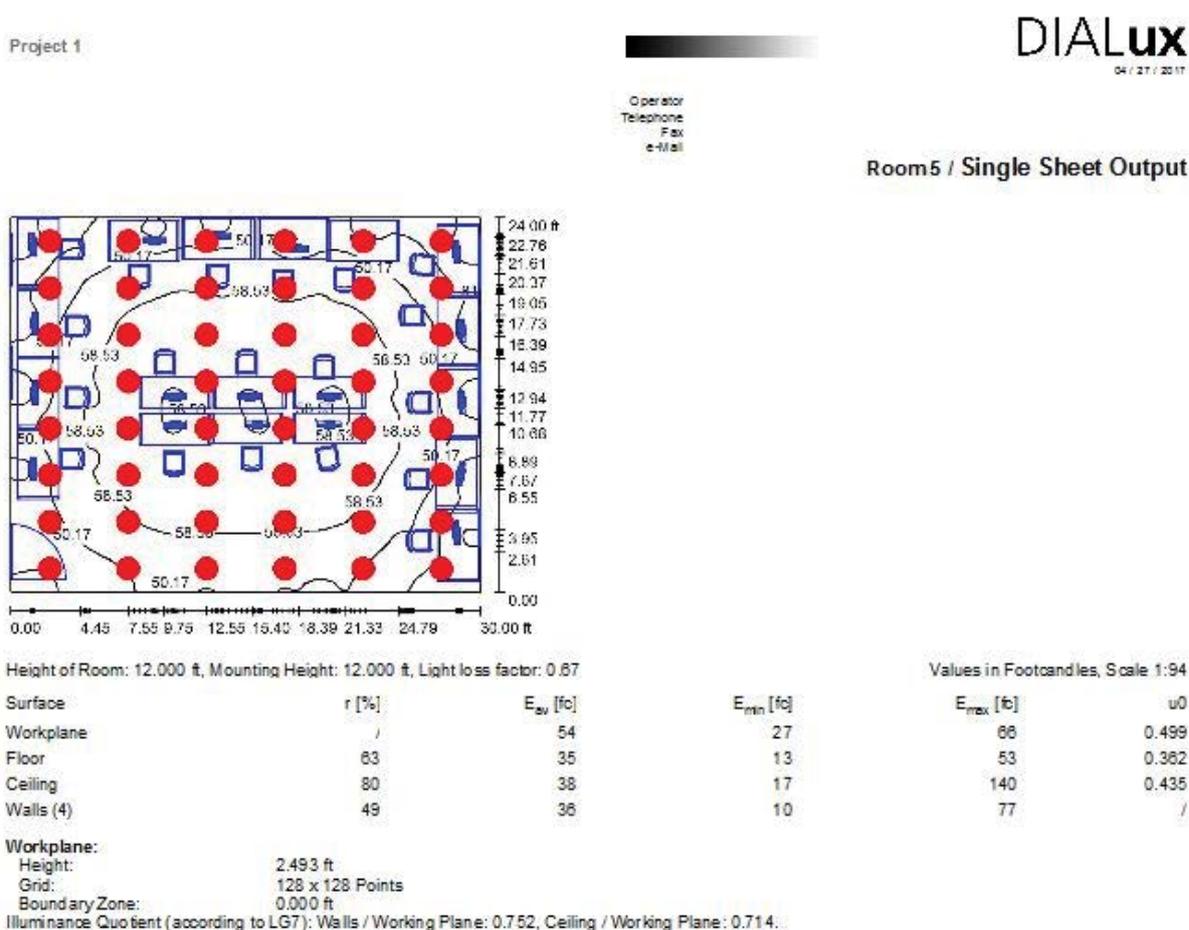


Figure 9: DIALux analysis.

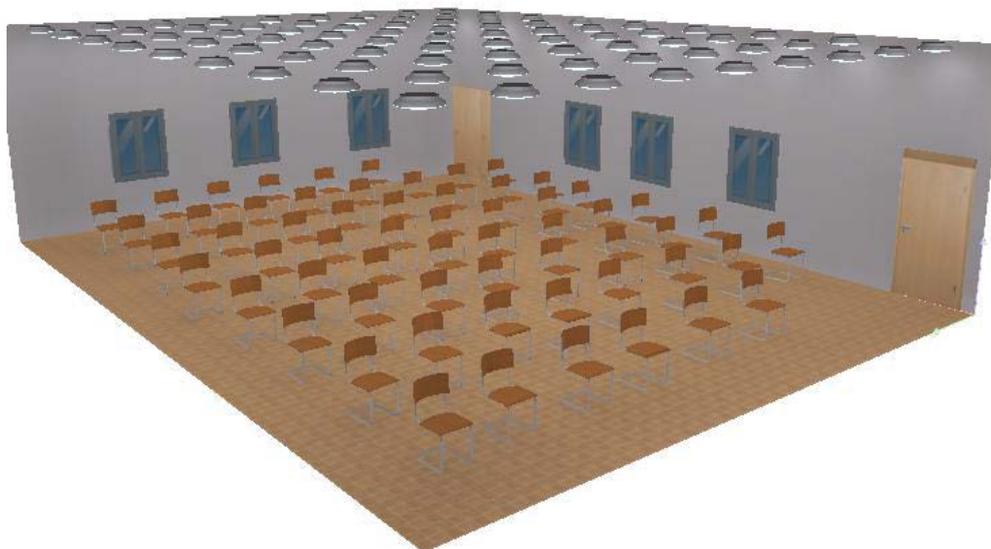


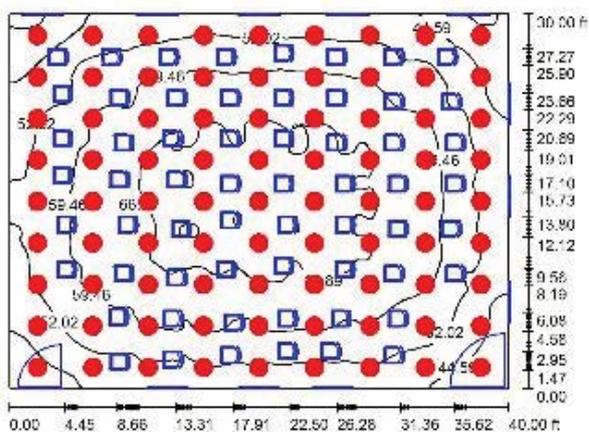
Figure 10: Layout of fittings.

Project 1

DIALux
04 / 27 / 2017

Operator
Telephone
Fax
e-Mail

Room6 / Single Sheet Output



Height of Room: 12.000 ft, Mounting Height: 12.000 ft, Light loss factor: 0.87

Values in Footcandles, Scale 1:118

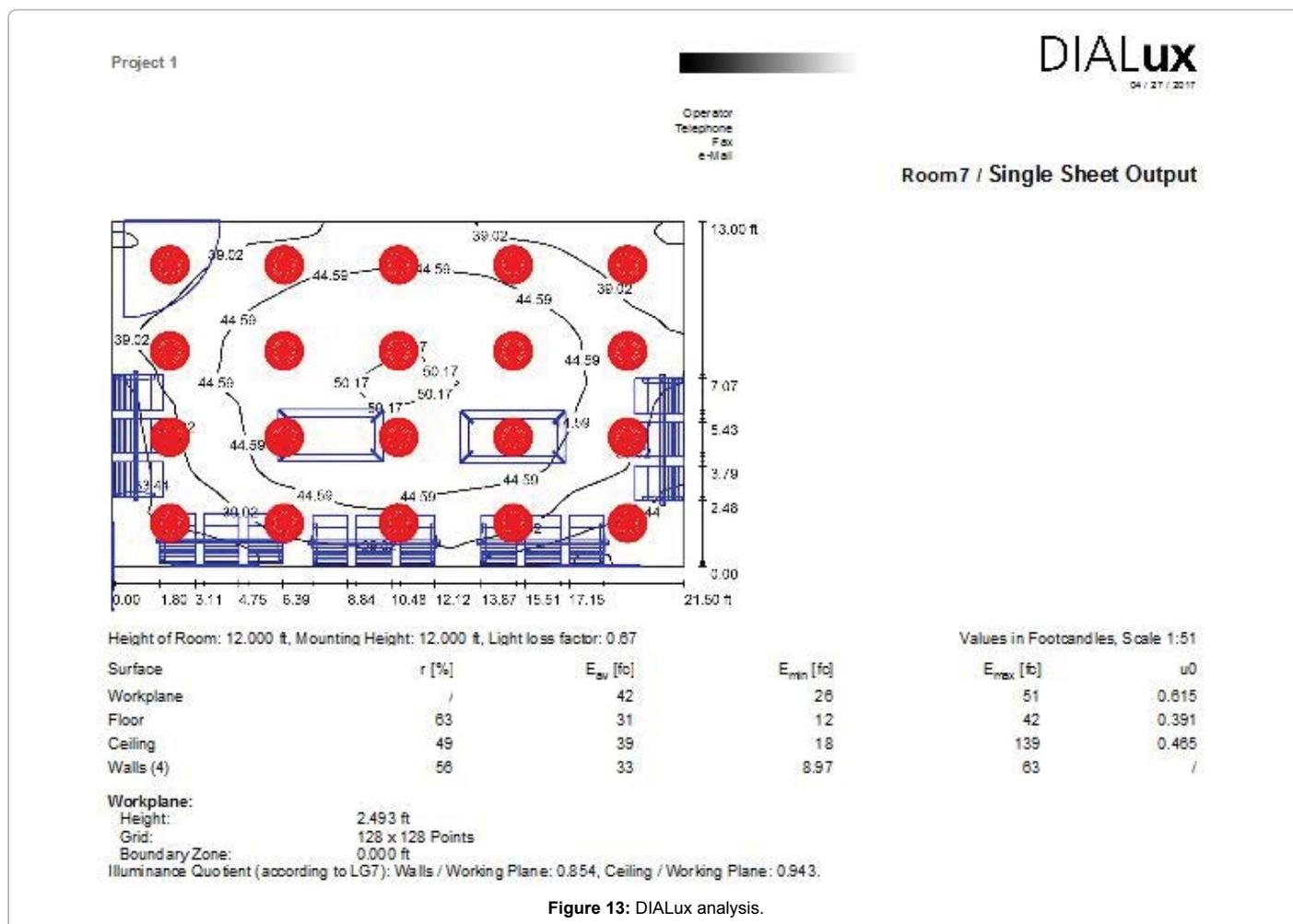
Surface	r [%]	E_{av} [fc]	E_{min} [fc]	E_{max} [fc]	u0
Workplane	/	57	35	89	0.612
Floor	63	47	32	58	0.674
Ceiling	49	44	20	145	0.458
Walls (4)	56	42	29	66	/

Workplane:
 Height: 2.493 ft
 Grid: 128 x 128 Points
 Boundary Zone: 0.000 ft
 Illuminance Quotient (according to LG7): Walls / Working Plane: 0.756, Ceiling / Working Plane: 0.760.

Figure 11: DIALux analysis.



Figure 12: Layout of fittings



Room 07:

(i) Calculation of number of lamps

$$N = E \times A / F \times UF \times MF$$

$$E = 500 \text{ lux}; A = 9.1 \text{ m} \times 6 \text{ m}; F = 1848 \text{ lumens}; U.F = 0.55; M.F = 0.67; N = 42$$

(ii) Spacing between fittings

Horizontal Spacing: From wall to luminary = 0.20 m

Vertical Spacing: From wall to luminary = 0.49 m

(iii) Layout of fittings (Figures 14 and 15)

Note: Calculated value of E is within permissible range .so the layout of fitting is satisfactory.

Hardware replacement

The department was equipped with 325 fluorescent tube lights, 6 compact fluorescent lamps (CFL) and 4 LED lights having a total lighting load of almost 13 kilo watts which has now been replaced by 311 LED lamps of 22 watts each. The newly installed lighting system has a total load of 6.84 kilowatts which is almost half of the old lighting system load. Lights have been installed at the ceiling height and the layout of all the rooms has been defined earlier. Lux level is measured after installing the new lights by using lux meter and the results are satisfying the required amount of light recommended by the IESNA. Not only the load of lighting is reduced also the lighting level is enhanced by installing LED's in place of CFL's.

Results and Discussion

As explained earlier that the existing conventional system having a very small number of CFL's and LED's with almost 97% of tube lights has now replaced with 311 LED's. Although the replacement of conventional lights with LED's need a large amount of initial investment which will be paid back through electricity savings in the time that will be calculated later in this study. Comparison of the old and new lighting system is given below in Table 5.

Electrical power savings

Load reduced to 6.842 kW in newly installed system from conventional 13.166 kW. So, the new lighting system designed consumes almost 52% of the conventional system.

Cost savings

Annual electricity costs of the old and new system, based on the fact that all the working 8 hours of the day lights are being used on full load, are as follows:

- α. Using 15 PKR / kWh cost for the electricity.
- β. 22.5 days working per month as Saturdays, Sundays are off.
- χ. Using 10 months per year because approximately 2 months are summer holidays in university.

Annual Electricity cost of Conventional bulbs = $13.166 \text{ kW} \times 8 \text{ hrs/day} \times 22.5 \text{ days/month} \times 10 \text{ months/year} \times 15 \text{ rupees/kWh} = 355,482 \text{ PKR}$

Electricity cost of LED lights in a year = $6.842 \text{ kW} \times 8 \text{ hrs/day} \times 22.5 \text{ days/month} \times 10 \text{ months/year} = 184,734 \text{ PKR}$

Annual cost savings = $355,482 - 184,734 = 170,748 \text{ PKR}$

Payback period

Initial Investment on the newly installed LED's = 1,328,800 PKR

Initial investment on the conventional bulbs = 1,032,600 PKR

Difference in installation costs = 296,600 PKR

Payback period = Diff. in installation costs / annual cost savings

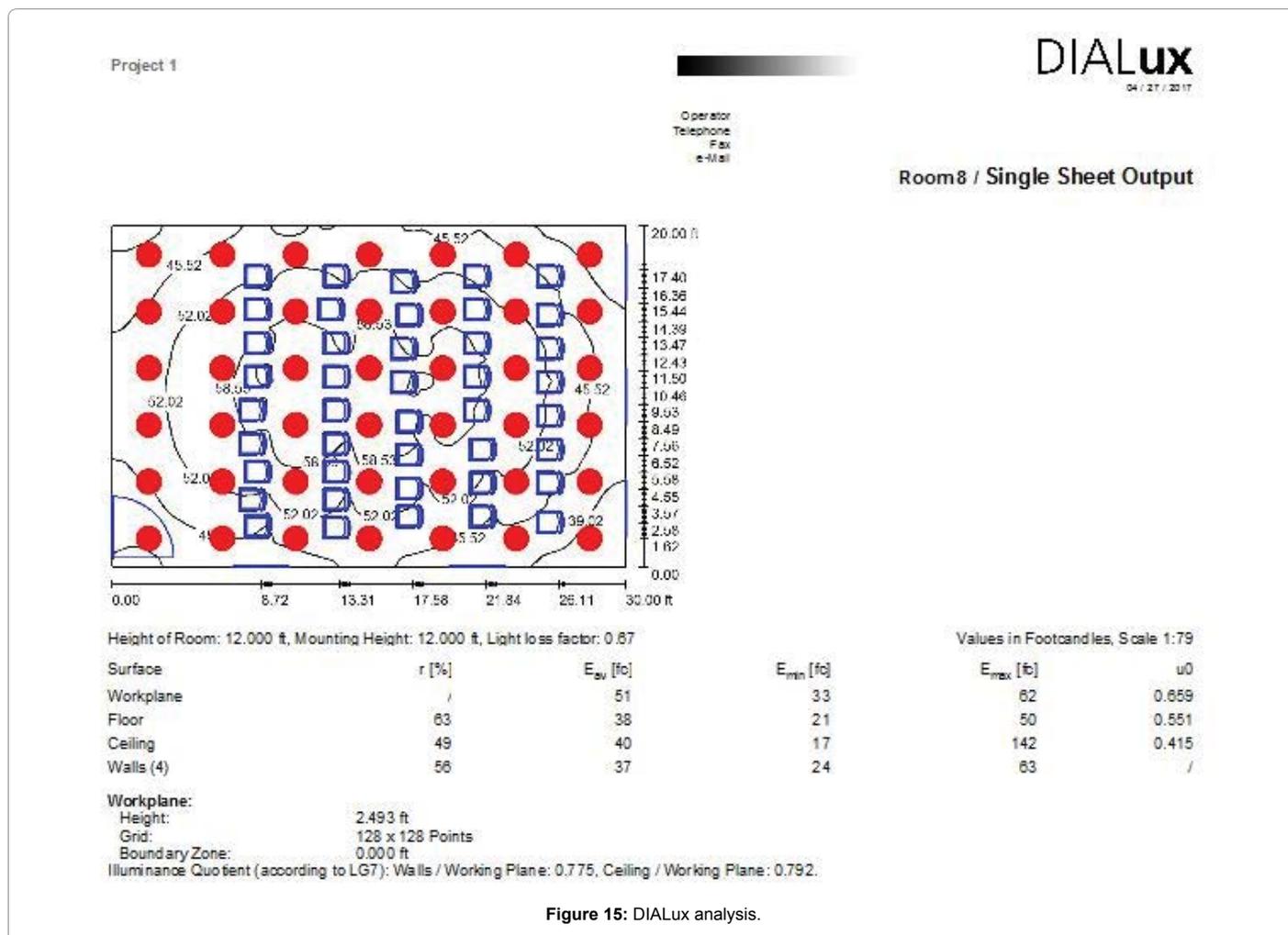
Payback period = $296,600 / 170,748 = 1.734 \text{ years}$

Conclusion

LED's are one of the best available technologies for lighting having low power consumption with provision of same light output as compared to other conventional lighting technologies available in Pakistan. They also have advantage of non-flickering effect over the compact fluorescent lamps. LED's have long service life with lesser loss of light over the service life. Latest LED lamps available as the one used



Figure 14: Layout of fittings.



Type of Lights		Quantity	Watt/lamp	Total Watts	Total kW	Installation Cost (PKR)	Units Consumed/day
Conventional	FTL	325	40	40x325=13000	13	10,32,600	=13.166kWx8hrs
	CFL	6	23	23x6=138	0.138		=105.328kWh
	LED	4	7	7x4= 28	0.028		
New LED lights	LED's	311	22	22x311=6842	6.842	13,28,800	=6.842kWx8hrs =54.736 kWh

Table 5: Comparison of the old and new lighting system.

in this specific project have color rendering index of up to 80 which ensures better quality of light compared to fluorescent lights that were previously installed. Case study for the educational institute proved that LED's are consuming almost 53% of the power that was being consumed by the conventional system hence providing 47% power saving in lighting. These savings leads to annual cost savings of 184,734 PKR. These figures confirm that LED's are the best available lights that can be used in place of FTL's, CFL's and IL. Moreover, due to huge production of LED lights in Pakistan, the installation costs has now reduced much as compared to the values one or two years ago.

References

- Lim SR, Kang D, Ogunseitan OA, Schoenung JM (2013) Potential environmental impacts from the metals in incandescent, compact fluorescent lamp (CFL), and light-emitting diode (LED) bulbs. Environmental Science & Technology 47: 1040-1047.
- Ryckaert WR, Smet KAG, Roelandts IA, Van Gils M, Hanselaer P (2012) Linear LED tubes versus fluorescent lamps: An evaluation. Energy and Buildings 49: 429-436.
- Mark SR (2000) Lighting handbook (9th edn). Illuminating Engineering Society of North America (IESNA).
- Dubois MC, Blomsterberg Å (2011) Energy saving potential and strategies for electric lighting in future North European, low energy office buildings: A literature review. Energy and Buildings 43: 2572-2582.
- Khorasanizadeh H, Parkkinen J, Parthiban R (2016) The Role of gender and education level on diffusion of innovation and use of technology: A case of LED in Malaysia. In: Proceedings of the World Congress on Engineering and Computer Science.
- Cadar S, Petreuş D, Radu E, Tiberiu F, Eugen D, et al. (2016) Temperature and power consumption for tungsten coil in the drying process of liquid samples. In: Electronics Technology (ISSE), 2016 39th International Spring Seminar. pp: 348-352.
- Herring H (1999) Does energy efficiency save energy? The debate and its consequences. Applied Energy 63: 209-226.