Analysis of Illumination Lamp's Performance by Retrofit at University Building

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Abstract. The research is comprised of possible energy saving, life cycle cost analysis and settlement period of the lighting system in the university building using of the fluorescent lamp which is an analysis of the dataset lighting system. Cost profit analysis of retrofit with extra efficient illumination scheme in terms of probable energy saves, the study of life cycle expenditure and settlement phase was steered. Comparison of existing such as the luminous lamp (IL), fluorescent lamp (FL) and compact fluorescent lamp (CFL), and retrofitting of illumination system based on power utilization is offered. LED (Light emitting diodes) based lamp technology is comparatively with conservative luminous and expulsion lamps. The investigation concluded that considerable quantities of energy will be saved by using an energy efficient illumination system as well as cost and to some extent reduces emission. The evaluation result illustrates that with present technology, FL's and LED lamp are used for utility as well as for university building.

Keywords: Illumination lamps · Life Cycle Assessment · Power consumption Cost benefit analysis

1 Introduction

Lighting system has been retained vital role to confirm efficiency, ease, and security of residents in university buildings. Consequently, correct designing of lighting system has become necessary to get desired illumination with least quantity of electricity use. Version of lighting used for able to one-third of intake university building electricity. International Energy Agency (IEA) consists of worldwide consumption of electricity for lighting was distributed about; residential 28%, service 48%, industrial 16%, street and extra lighting 8%. It was expected that energy lessening able to residential 27% and commercial 30% area might be attained by substituting to power effectual machineries which were development of power electrical based energy redeemable policies [9].

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The terrific growth in unit electrical energy value was also one of causes for infiltration of such devices in existing power scheme. Though, extensive use of policy may possibly have a few injurious belonged on the quality of power. Capabilities require displayed that prevention was more economical next knowing point, instead of finding the solution to the next future problem [10]. Illumination is critical to students functioning in that it allows seeing things and performing activities. However, it is also important because it affects students and faculty beings psychologically and physiologically [20]. Almost overall domain as engineering, natural sciences, information technology, ICT, economics, trade, electronic commerce, atmosphere, health-care, and living science were roofed [21]. As period curriculums perception has become to a required assignment for learners in addition to stakeholder in software development and provides solutions to problems, that pictorial presentation in finest method is benefit to better understand it [22]. In the middle of dissimilar procedures for the decrease in power consumption, energy's standby wasteful lamps with energy well-organized lamp was one of the procedure. The investigation was revealed that illumination constitutes important portion in country's overall power consumption.

Replacement of Incandescent light with energy well-organized lamps decreases illumination power consumption besides helps in saving of energy throughout summer period by lowering icy necessities in buildings [11]. Illumination portion was about 23% of overall power consumption, according to the report of Swedish energy agency [12]. LED was ecological kindly, dissimilar compact fluorescent lamp (CFLs) because of inside mercury [2] which was poisonousness illustrious and produces the staid durability problem. The research was the selection of cost-effective and efficient lights in Indus university by comparing different factors of lights as efficacy, power

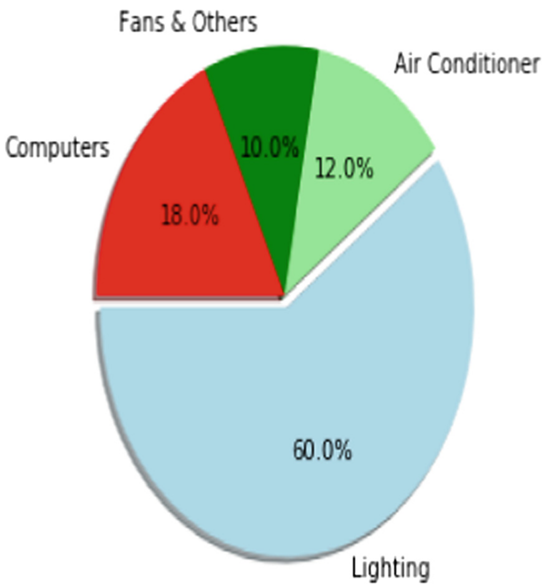

Fig. 1. Using different types of distributed loads in university building.

consumption, CRI, color temperature, life time, etc. Figure 1 shows that university building was utilized different loads such as 60% lighting and 18% computers.

Figure 2 shows that full diode bridge rectifier to transform AC into DC which was followed capacitor. It was delivered DC connection current, voltage source for the LED load. The constant source of current was used instead of voltage converter in LED ballast through minimalize voltage variant affected.

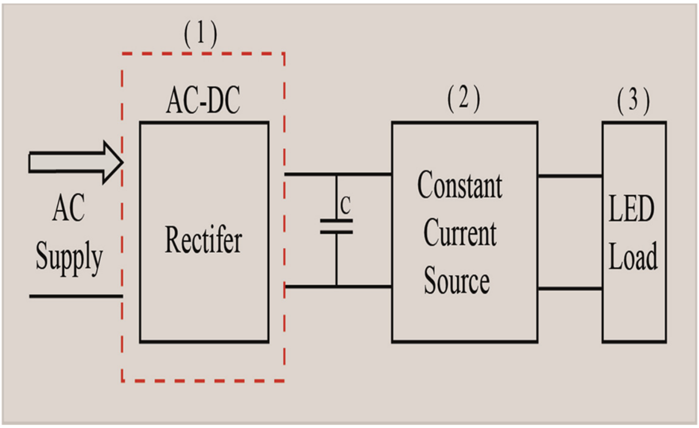

Fig. 2. Typical LED ballast

2 Methods and Material

2.1 Electrical Energy Consumption

Current fluorescent was expected for the entire department based on survey evaluated. EC (total energy consumption) of illumination scheme was resolute by N (number of lamps), W (power) recycled per fixture and operating period (OH) of lighting. Annual energy consumption for the current illumination scheme was designed based on the method as [8]:

$$\text{Electricity Consumption (EC)} = \frac{N \times W \times OH}{1000} \tag{1}$$

Electrical energy consumption is measured in Watt-time (watt-hours) which is the measure energy. ES (Energy saving) was the difference between current energy consumption (EC Current) and retrofit lighting (EC Retrofit) system.

$$\text{Energy Saving (ES)} = \text{EC Existing} - \text{EC Retrofitting} \tag{2}$$

BS (Bill saving) was calculated by multiplying ES with electricity tariff (ET).

$$\mathrm{BS} = \mathrm{ES} \times \mathrm{ET} \tag{3}$$

Operating cost (OC) was wanted on behalf of innovative retrofit scheme, which was N (total number of lamps), power consumption (in watts), OH (operating hours) and ET (electricity tariff) and considered as:

$$\mathrm{OC} = \mathrm{N} \times \mathrm{W} \times \mathrm{OH} \times \mathrm{ET} \tag{4}$$

PWF (Present worth factor) valued with upcoming money flow to be received in order to acquire existing value. Current value aspect was designed as

$$PWF = \sum_{1}^{N} \frac{1}{(1+r)^t} = \frac{1}{r}\left[1 - \frac{1}{(1+r)^N}\right] \tag{5}$$

PAY (payback period) calculated the quantity of time wanted to improve extra investment (increased cost ΔPC) on productivity development through lower operating costs which was solved by:

$$\Delta\mathrm{PC} + \sum\nolimits_{1}^{\mathrm{PAY}} \Delta\mathrm{OC_t} = 0 \tag{6}$$

The payback period was established by interposing among two ages when above expression modifications symbol. If operating cost was constant as a solution [13]:

$$\mathrm{PAY} = -\frac{\Delta\mathrm{PC}}{\Delta\mathrm{OC}} \tag{7}$$

2.2 Comparison of Lamps Illuminations

The comparison was ended on the foundation of financial and technical grounded. Clients have been normally not knowledgeable of illumination design vocabularies and lamp physiognomies. Clients were choice lamp on basis of consumption's power (Watts), instead of considered how often LUX unit of illumination, it was received in a given region. Some terms have been discussed with the comparison as Lumens, Efficacy, CRI, Illumination and THD [6–8]. Lumen was a unit of luminous flux, which was the dimension of the total amount of brightness of light, radiated from the source of light that was influenced according to glow function human eyes sensitivity to different wavelengths. It was just based on the output of light rather than energy consumption, thus represent more accurate measurement unit. Lamp's conformist was the decrease in early lumens to B50 (50%) and lamp's life was usually measured in hours.

Illumination (LUX Level): It was measured brightness level in the particular area that was lumen's total number dipping on the specified zone and was measured for example lumens per meter square.

Total Harmonic Distortion (THD): It was a portion of RMS (root mean square) harmonic worth contented of blinking measure to RMS value of the central component. Total harmonic distortion (THD) was used to specified harmonic contented in distorted voltage and current, correspondingly as THDV (Total harmonic distortion Voltage) and THDI (Total harmonic distortion current).

Color Rendering Index (CRI): It was the facility of sunny basis to render color indeed with no misleading tone seen below occupied spectrum warmer and its variety from poor quality(0) toward near to natural daylight(100) [5]. The Fig. 3 depicts that CRI of Incandescent and halogen is near to natural daylight and white LED is poor quality.

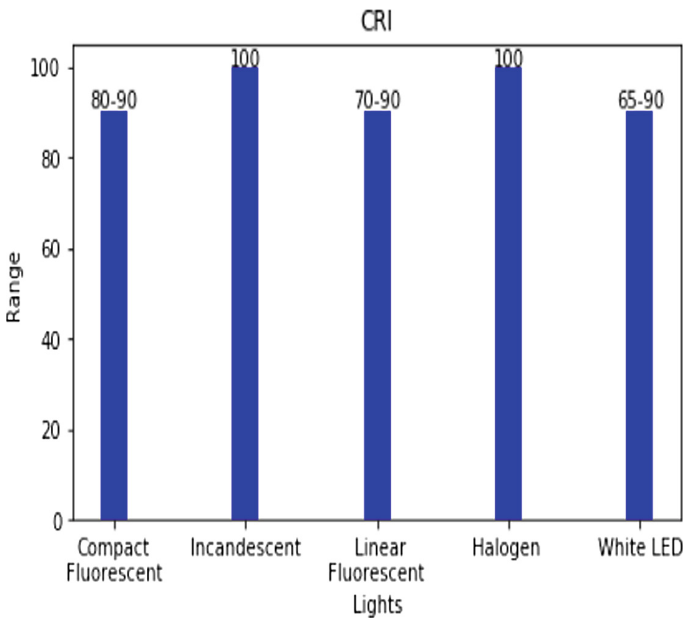

Fig. 3. Comparison of different lamps from color rendering index

Efficacy: It measured of how much lumen was emitted for given input power of electrical, which is precise in lumens per watt. Lamp's efficacy specified efficiency of lamp single. Energy consumption of regulator equipment such as transformers, ballasts, and further regulatory gear was not deliberate. The Fig. 4 shows that efficacy of linear fluorescent light is a high lumen per watt.

Color Temperature: It was the method to equate color of light from dissimilar kinds of lamps, which measured in Kelvin (K). It was frequently referenced as cool and warm light which was slightly blue and slightly orange, that evaluate by 5000 K as cool and 2700–3000 K as the warm light. Incandescent lamps and candles radiate warm, although sunshine and several fluorescent lamps emit cool. Figure 5 shows that color temperature of Compact Fluorescent, linear fluorescent light and White LED are warm light.

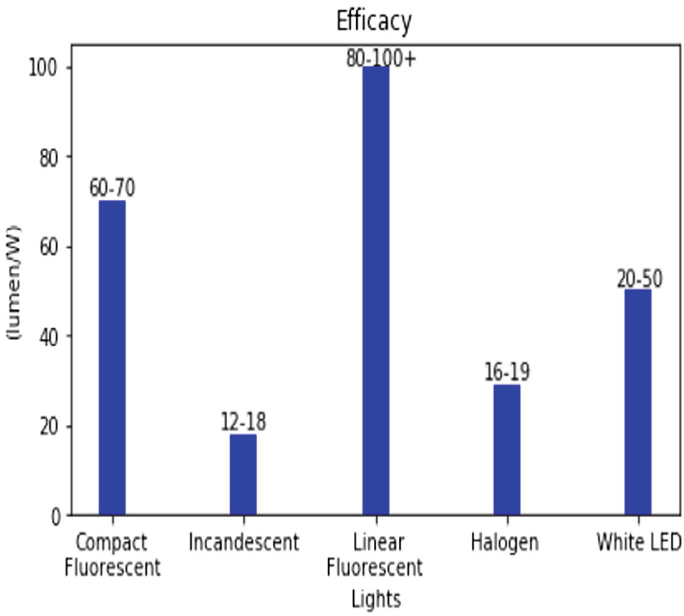

Fig. 4. Comparison of different lamps from Efficacy

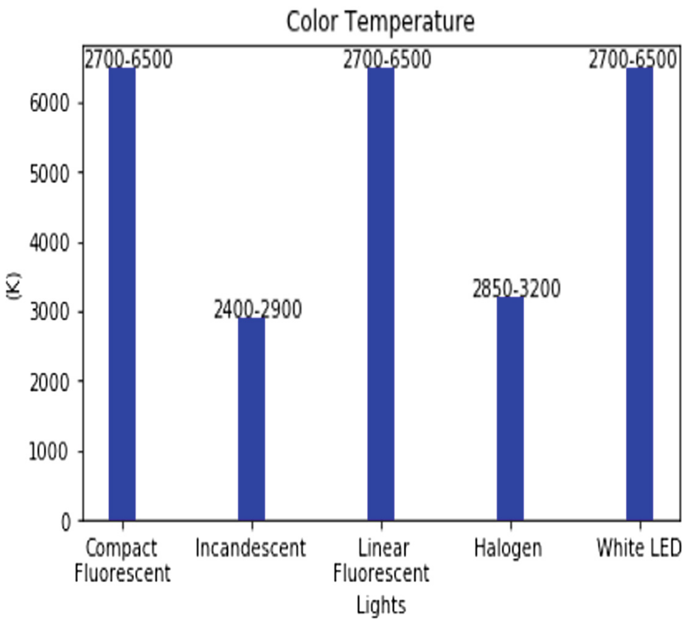

Fig. 5. Comparison of different lamps from color temperature (Color figure online)

Life Time: The middling life time of IL was typically about 1000 h which was much slighter than other illumination lamps. It was increased equal to 2000 h with addition, special unmotivated fumes within lamp tumbler. Conversely, release lamps have considerably upper life time than IL. LED package useful life was derived from lumens up keep until that was emitting of early output light L70 (70%) when it was quite high about 35×10^3–50×10^3 h. [14] Though, LED's life time luminaries was slighter than the life of LED because of the possible letdown in motorist, reflector. Now it was essential to differentiate between useful life and lifetime. The useful life of fixture referred to expected lumen upkeep of LED bases. Yet, fixture lifetime was associated with the consistency of gear's LED illumination fixture such that housing, wiring, electronics materials, connectors, seals. Whole LED luminaire lasts simply providing the critical element with shortest life exists [14]. Illumination investigators were stilled work to form some fresh procedure to estimation beneficial LED lifetime has taken all letdown instruments into deliberation [15].

Lamp Life: It was a pretentious using figure of on or off substituting maneuver. Frequent substituting maneuver lessens lamp's lifetime. Now halogen based ILs was unresponsive to substituting maneuver [15]. Though, in FL (fluorescent lamp), conductors misplace minute amount of covering each time lamp was exchanged on/off. Therefore ended stage of time, sufficient covering was scorched off and lamp miscarries to start. The motive, release lamps were not suggested where substituting rather repeated. CFL and LED lamps since equated to other lamps were affected via substituting maneuvers by reason of untimely breakdown in electric modules [16]. In EU standards for CFL and LEDs, the numeral of substituting maneuvers that illumination

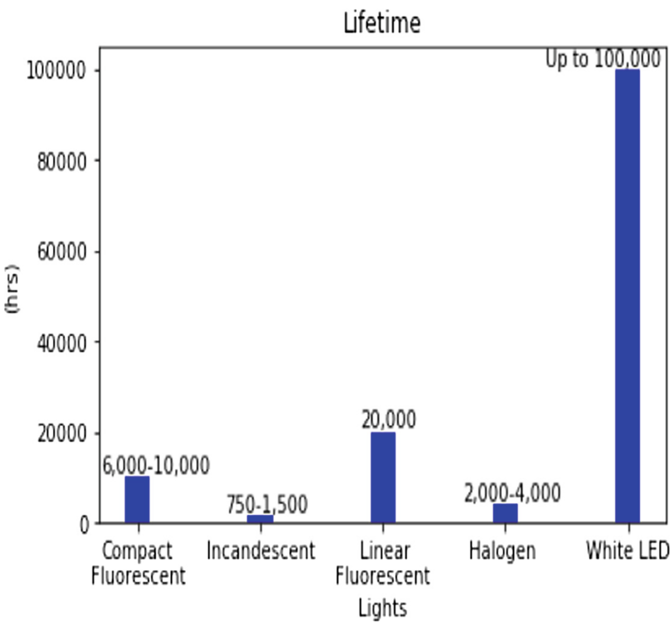

Fig. 6. Comparison of different lamps from lifetime

basis was weather beforehand untimely failure was larger than lamp life which in hours. Lamps claimed to endure recurrent substituting, numeral ought to be superiority than 60,000 buttons (on/off) cycles in standards of EU [17]. Figure 6 depicts that white LED is 100000 h.

Incandescent Light (IL): The incandescent light (IL) existence clean resistive load was not suffered by low power factor topics and so constantly current unity factor's power. It was not required a special electric driver for beginning purposes, hence no harmonic problem ascend. If the large number of low rating CFLs was used in giving position, the power factor necessity to be centrally rewarded [3]. LED lamps were modeled such as a voltage basis with low sequence resistance to boundary line present, which was a power factor usually much higher than discharge lamps. Energy's US Department vitality star program mandate least satisfactory power factors of 0.7 and 0.9 correspondingly for inland and profitable LED illumination [4]. Energy Saving Trust of UK was proven least a power factor of 0.7 with lengthy term impartial of 0.9 power factor aimed at integral LED bulbs [3].

3 Approach of Life Cycle Assessment

Life Cycle Assessment was a methodical approach that facilitates scholars to quantify ecological and sustainability influences across the variety of classifications for artifact ended the whole life cycle. It categorized and measured I/O (inputs, outputs) and ecological influences of a particular artifact on every phase of life cycle [1]. The overall technique for conducting an LCA was defined by ISO (International Organization for Standards) 14000 sequence. LCA's core stages according to ISO rules were goal and scope definition; IA (inventory analysis); impact assessment; and interpretation (Fig. 7).

3.1 Goal and Scope Definition

Goal's main aspects were an intentional application of study such as marketing, strategic planning, and product development; the purpose of study, for instance, to be published; intended viewers, comprised stockholders, managers, customers; and used as a relative analysis, whereby LCA outcomes were used to compare with other goods.

3.2 Inventory Analysis

Compiled and quantified of I/O for giving artifact scheme through the life cycle that contains procedural amounts for all pertinent unit procedures within system limitations. It was data excellence and processing steps that required activities to be finalized: data validation, linking data to unit procedures and to the functional unit.

3.3 Impact Assessment

It recognized and estimated extents and comparative significance of ecological influences arise from inventory investigation. I/O was allocated to influence kinds and

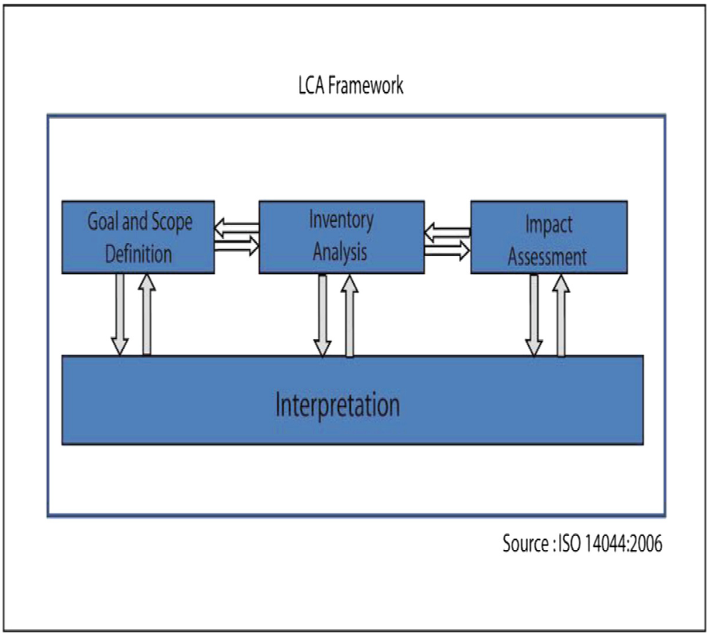

Fig. 7. Framework (ISO)

possible influences were quantified according to categorical factors which include: water, fossil fuels, chemicals, energy, and etc. by supply reduction, greenhouse gas emissions, land use, and water pollution. It was required elements have comprised as soon as conduct LCA for instance chosen of related influence kinds and classification.

3.4 Interpretation

Outcomes were assessed and checked to ratify that was reliable with goal of the study. As displayed in the figure, three other stages were linked to interpretation, which was a pivotal slice of the process and could lead to modifications in any fact of the process.

The valuation stage was attentive on augmenting reliability of study that comprises sensitivity checked on indecisions about data, calculations, allocation methods and assumptions. It comprises gap analysis, to ensure deficient part that has to be analyzed in classifying to meet the goal and scope of the study. Lastly, assessment contains a reliability test to make sure that methods and goal were gathered, for instance, data quality, time period, scheme boundaries.

4 Illumination's Life Cycle Assessment

US Department of Energy report, which synopses major findings of current appraisal on LCA further compared life cycle power utilization of LED lamps with IL and CFL in 2012 [18]. It represents 90% of entire lifecycle energy use on average from IL, CFL and LED lamps tracked by transport and manufacturing stages. Most of the doubts happen in the manufacturing stage of LED packaging supply to low as 0.1%, average as 6.6% and high as the 27% estimate specify by computing lifecycle energy consumption of LED lamps. The report covered energy in use was lifecycle ecological impact due to incandescent lamps as 60 W, CFL as 1.5 W and LED as 12.5 W. On behalf of comparison, the performance of LED lamp in 2012 was deliberated and proposed onward in 2017 with enhanced engineering approaches; performance and integrated circuit technology [19] which also included the impact of resource, soil, air and water.

Evaluated fifteen impact interest's measures transversely four lamp kinds deliberated, spider graphs were ready that was represented by spoke in the web, and comparative impact of all lamp variety were plotted on the diagram. Lamp category contains maximum influence of set analyzed describes scale symbolism by an external circle at the maximum distance from web center. Further products were next regularized to the distance from center signify severity of impact compared to the incandescent lamp. Folks sources with minimum impact were contained circle closer to the center and the maximum impact would be on web outer perimeter. The data plotted in the diagram was normalizing for the competence of illumination service measured in lumen hours.

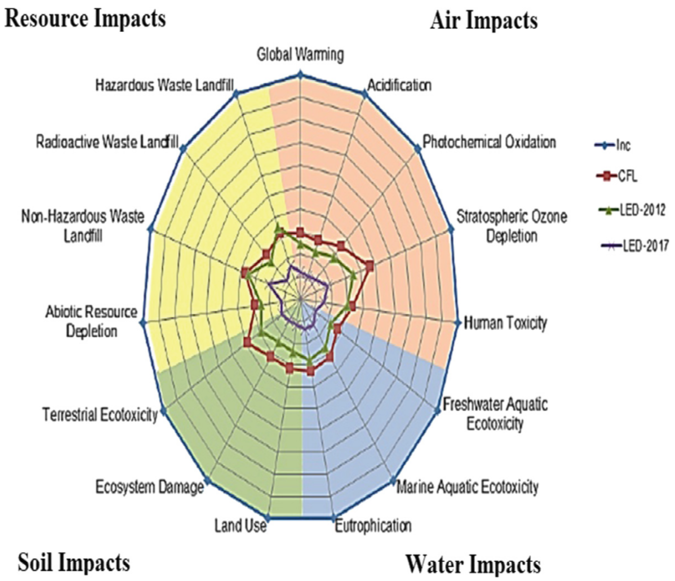

Fig. 8. LCA lamp's impacts analyzed comparative to incandescent

Figure 9 shows plots represent LED and CFL apparatus decrease fine within the outer circle, illustrated that IL was the uppermost impact per unit illumination service of everything lamps well thought-out. The discovery was not the purpose of the stuff content of single lamp; IL was the lowest mass and a minimum composite illumination system. It represented a low efficacy of a light source and resulted from big amounts of energy compulsory to produce light and various alternates were mandatory to length ranked life of LED lamp otherwise CFL. Producing an upper amount of electronic energy consumed per unit of light productivity reasons, considerable ecological impacts and outcomes in IL being more ecologically damaging across all fifteen impacts measured.

Although it was considerably lower impacts than incandescent, the dense fluorescent lamp was marginally further more damaging than 2012 inherently weight LED lamp against everything but harmful misuse landfill where mechanized of big aluminum warmth outcome used in LED lamp reasons collision to be a little larger for LED lamp than for CFL. The execution illumination source was estimated LED lamp in 2017, which obtain into version numerous potential enhancements in LED manufacturing, performance, and integrated circuit technology. Figure 9 indicates same results shown in Fig. 8, but diagram was adjusted to remove IL and deliver impacts comparative to CFL.

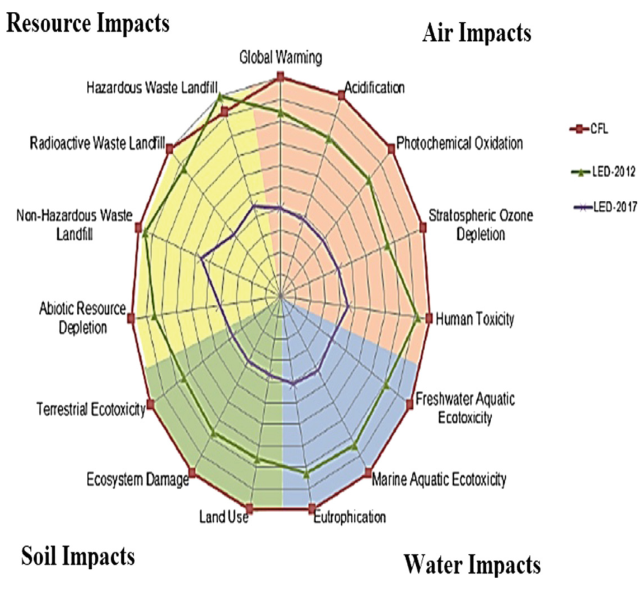

Fig. 9. LCA lamp's impacts analyzed comparative to CFL

5 Experimental Evaluations

In this research is a life cycle cost assessment to determine consumed lighting and numeral of possible retrofit of illumination scheme in the university building. Data is managed in all rooms of every block in the campus from the dataset which was contained numeral of illumination fixtures and operating hours. It was focused on fluorescent lamp in particular linear luminous, Compact fluorescent, Incandescent and Halogen then evaluate cost assessment which was a type of light cost effective and efficient. Data get from dataset was used to determine projected electrical energy investments and cost analysis of illumination retrofits. Figure 10 shows that the number of lamp, classroom, faculty room and corridor that have consumed compact fluorescent is 2454 and linear fluorescent is 2612.

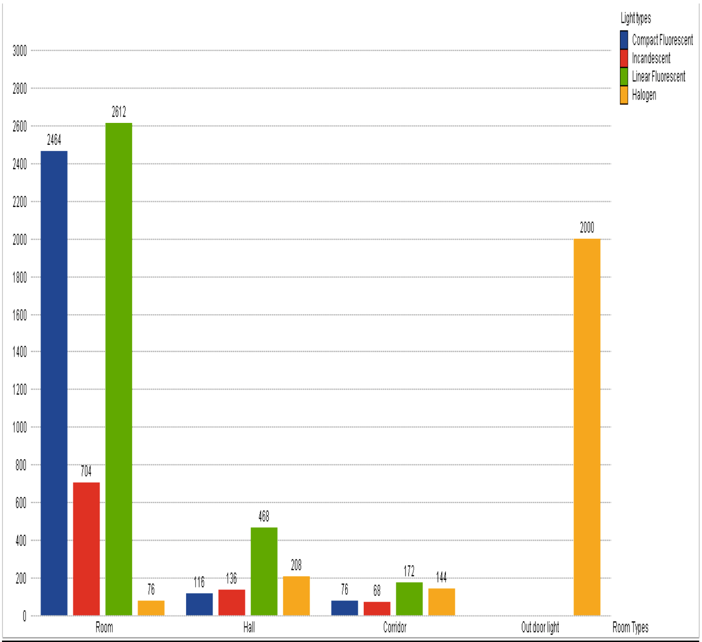

Fig. 10. A graph of different types of light used in university

Replacing each of four types of light lamp currently used at university building with an equivalent LED light lamp was effectively reduced power compulsory to illumination building, foremost to electric invoice investments over time. Table 1 considerable possible for investments using LED illumination lamp instead of Incandescent, Halogen, LFL, and CFL lamps which was maximum burning hours 100000 of LED lamps and measured formulas given as below which have been used in the table.

In research, 60 W/100 W (IL), 36 W (FL) and 26 W/18 W light was used for inside illumination. It velocity worth of overall lamps, establish from lamps' index was summarized in Table 1 illustrate LED lamps (12 and 30 watts) were also integrated into experiment result and recital data for IL, FL and CFL were experiencing.

$$n = N * Cost/Lamp \tag{8}$$

$$EC = OH * P \div 1000 \tag{9}$$

$$C = EC * R \tag{10}$$

$$LCC = C_{energy} * C_{lamp} \tag{11}$$

n = Number of lamp per cost
N = Number of lamp required for Operating Hours
EC = Energy Consumption (kWh)
OH = Operating Hours
P = Wattage Rating
C = Energy or Lamp cost
R = Tariff Rate
LCC = Life Cycle Cost

Table 1. Performance of IL, Halogen, LF and CF lamp and LED

Lamp	Burning hours	Watts	Bulb/lamp cost (Rs)	No. of bulbs	K-electric tariff rate (commercial)
Incandescent lamp	1500	100	40	908	Rs. 18
Halogen lamp	4000	60	80	2428	
LFL	20000	50	300	3252	
CFL	10000	25	200	2656	
LED lamp	100000	14	600	0	

Later mentioning burning hours of each lamp represented in Table 1 compared individually all lights with LED lamp. Table 2 shows the comparison of IL with LED lamp clearly shows that lifecycle cost of IL lamp is higher (216320) than LED lamp cost (33600) because running hours of 908 IL are equal to 14 lamps of LED. It is dangerous for the environment due to heating and green emission gases.

Table 2. Comparative of LED and IL lamp

Lamp	Burning hours	For 100000 h, no: of bulbs required	Cost of bulbs (Rs)	For 100000 h energy required (kWh) (100000 * W)/1000	Energy cost (Rs)	Life cycle cost (Rs)
IL	1500	908	36320	10000	180000	216320
LED	100000	14	8400	1400	25200	33600

Table 3 depicts the calculation and comparison of Halogen lamp with LED lamp has also limited users for usage of halogen lamp that higher (108000, 302240) in cost than LED lamp cost (25200, 84000) and burning hours (4000) of halogen are lesser

Table 3. Relative LED over Halogen lamp.

Lamp	Burning hours	For 100000 h, no: of bulbs required	Cost of bulbs (Rs)	For 100000 h energy required (kWh) (100000 * W)/ 1000	Energy cost (Rs)	Life cycle cost (Rs)
Halogen lamp	4000	2428	194240	6000	108000	302240
LED lamp	100000	98	58800	1400	25200	84000

than LED lamp (100000) burning hours. LED number of lamps required 98 lamps that are equal to 2428 Halogen Lamp by considering burning hours, in fact, have not economical for utilization purpose.

Table 4 depicts LF lamp which had led Incandescent lamp due to high (5000) energy consumption cost which is rarely used due to the higher cost of burning hours (20000) as compared to LED lamp 1400 energy consumption cost and burning hours (100000). LF lamp is 20000 Burning hours as the number of lamps required 3252 whereas LED lamp life time is 100000 h, as 651 numbers of lamp required.

Table 4. Comparative of LED and LF lamp

Lamp	Burning hours	For 100000 h, no: of bulbs required	Cost of bulbs (Rs)	For 100000 h energy required (kWh) (100000 * W)/ 1000	Energy cost (Rs)	Life cycle cost (Rs)
LF lamp	20000	3252	975600	5000	90000	1065600
LED lamp	100000	651	390600	1400	25200	415800

The evaluations of lamps calculated for CFL and LED lamp outcomes are depicted in Table 5 is a CFL lamp cost-effective due to burning hours and other factors that is the huge difference of cost such as 2656 CF lamps with the cost of 576200 can be equalized with 266 LED lamps having cost 184800 cannot feasible for normal use.

Table 5. Comparative LED over CF lamp

Lamp	Burning hours	For 100000 h, no: of bulbs required	Cost of bulbs (Rs)	For 100000 h energy required (kWh) (100000 * W)/ 1000	Energy cost (Rs)	Life cycle cost (Rs)
CF lamp	10000	2656	531200	2500	45000	576200
LED lamp	100000	266	159600	1400	25200	184800

Efficient light of source important factors mandated; minimum power consumption, high luminous efficacy and minimum life cycle cost that was resulted in concluded. Table 6 depicts that LED lamp life cycle cost (33600, 84000, 415800, and 184800) and power consumption is minimum (1400) that cost beneficial.

Table 6. Relative LED's advantages over IL, Halogen, LF and CF lamp

Lamp	Burning hours	For 100000 h, no: of bulbs required	Cost of bulbs (Rs)	For 100000 h energy required (kWh) (100000 * W)/1000	Energy cost (Rs)	Life cycle cost (Rs)
IL	1500	960	38400	10000	180000	216320
Halogen lamp	4000	2428	194240	6000	108000	302240
LF lamp	20000	3252	975600	5000	90000	1065600
CF lamp	10000	2656	531200	2500	45000	576200
LED lamp	100000	12	7200	1400	25200	33600
		98	58800			84000
		651	390600			415800
		266	159600			184800

6 Conclusion

This research was offered performance analysis of illumination lamps included incandescent lamp (IL), fluorescent lamp (FL), compact fluorescent lamp (CFL) and light emitting diodes (LED) lamps. Investigate the comparative impact of lamps towards power quality in terms of distortion was also accomplished. Present growth illustrated fabulous enhancement in performance of LED illumination and at the same instant decrease in cost growth. Comparison completed based on the retrofit of the power efficiency scheme extra outward. Life cycle cost of LED lamp is reduced that considered inexpensive compared to standard and further substitute technology. Because energy consumes LED reduced about half of CFL and LF. By retrofitting the existing system with LED did, power investments can be saved in the university building.

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