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The Transition to Led Illumination: A Case Study in "Faculty of Natural and Human Sciences" of Korça University

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Abstract:

This paper analyses the energy saving potential possible by changing the illumination schemes. Lighting plays a vital role in buildings, affecting visual comfort, health, well-being, and work performance. In the early days of modern lighting, incandescent and fluorescent lamps were the main focus in illumination technology, while now the lighting sector has experienced substantial transformations. Light-Emitting Diodes (LED) are bringing a lighting revolution to our cities not seen since the days of Thomas Edison. Today LEDs are among the most efficient lighting sources available and also provides additional advantages as a cool light, decreased maintenance cost, more flexibility, easier handling, extremely reliable, and have a much longer lifetime than almost all other types of lighting. However, like any new technology, they face barriers to adoption from a market unfamiliar with their benefits.

The case study is a university building in Korça city in Albania. The study shows a huge energy saving potential with the replacement of all existing conventional lightings (i.e., halogen and fluorescent) scheme with the LED lighting scheme, and the payback period is calculated to be less than four years.

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Key words: Lighting system, Light emitting diode (LED), Fluorescent lamps, efficient lighting technology, power conservation, payback period.

INTRODUCTION

In the early days of modern lighting, incandescence and fluorescence lamps were the main focus in illumination technology, while in recent times, the lighting sector has experienced substantial transformations. LED lighting technology is the primary reason for this revolution. Compared to traditional incandescent light, LEDs typically use about 25%-80% less energy and can last 3-25 times longer (Kim J, Kim G, 2010), (U.S. Department of Energy 2017). They are also significantly more efficient than most fluorescent lamps, with some chips able to emit more than 300 lumens per watt (Energy Alliance 2017). While the initial price of energy-efficient bulbs is typically higher than traditional incandescent, newer bulbs cost less to operate and saving the money over the life of the bulb (Kim J, Kim G, 2010). Today LEDs are among the most efficient lighting sources available, but in the near future they will reach far beyond any competing technology and become the technology of choice for most applications (European Commission, 2015), (Forbes Media LLC, 2017). LEDs are emblematic of the emerging clean revolution technologies which provide the minimal environmental impact that generates immense economic value and have the power to change our lives for the better. In 2016 electricity consumption for lighting was responsible for an energy consumption of around 1/6 to 1/5 of the worldwide electricity production. (Robert K. et al., 2016). An on-site survey of existing university buildings conducted by Chung and Rhee (Chung & Rhee 2014), determined the potential for energy conservation in the range 6–29%.

This paper aims to explore the importance of energy savings from the transition from the conventional lighting system to LED lighting. The case study is a university building in Korça city, Albania. The study shows a huge energy saving potential with the replacement of all existing conventional lighting (i.e., halogen and fluorescent) scheme with the LED lighting scheme. The payback period is calculated to be less than four years.

FEATURES OF LED LIGHTING

LED lighting is produced very different compared to other lighting sources such as incandescent bulbs and CFLs. LED lighting is a lighting equipment that uses light emitting semiconductors and is drawing greater attention as fourth-generation lighting technology following the candle, incandescent lamp, and fluorescent lamp. The most remarkable feature of LED lamps is that their operating life is 30 to 50 thousand hours and even more, which is twenty times longer than incandescent lamps and several times longer than fluorescent lamps. If a LED lamp is used for about ten hours a day, there is no need to replace it for more than ten years. Although once installed, LED lamps are almost maintenance-free. Furthermore, the luminance efficiency (lumen/Watt) is eight times as high as for an incandescent lamp.
Other advantages of led include:

- LEDs can emit light of an assigned color without the use of color filters that traditional lighting methods require.
- The solid package of the LED can be designed to focus its light without the use of reflector as in conventional lighting.
- Unlike fluorescent lamps that burn out more quickly when cycled frequently, LEDs are ideal for use in high-speed applications and where frequent ON-OFF is required. LEDs can be used for dimmer applications without a change in color.

- They do not change their color tint as the current passing through them is lowered, unlike incandescent lamps, which turn yellow.
- Fluorescent and incandescent bulbs are easily broken if subjected to external shock, while LEDs, also called "Solid-State Lighting (SSL) as they are made of solid material with no filament or tube or bulb to break are difficult to damage with external shock.
- LEDs light up very quickly compared to Pressure lamps and Fluorescent lamps. A typical LED bulb will achieve full brightness in microseconds.
- LEDs are not affected by cold temperatures - LEDs will start up even in subzero weather.
- In contrast to most light sources, LEDs radiate very little heat making stay comfortable and reducing the further air conditioning load.
- LEDs are environmentally friendly. They do not contain toxic elements, unlike compact fluorescent lamps.
- LEDs can be very small (smaller than two mm^2) and are easily populated onto printed circuit boards.

Since the bulb LED lamps were developed with a view to switching from incandescent and fluorescent bulb lamps, they have bayonet caps that are compatible for replacement of lamps without worrying about replacing the whole lighting appliance. So additional components and labor work are not required in most cases. Despite this, LED lighting possess some disadvantages, where the greatest is that the price is higher than more conventional lighting (measured in price per lumen). Though the price has decreased significantly in recent years, the cost of a LED lamp is still high, about ALL. 500-1000 much more expensive than ALL. 50-100 for an incandescent lamp, or ALL. 300-500 for a CFL lamp. Even so, since the operating cost can be largely reduced due to very high-energy efficiency and long operating life, reaching the break-even points takes no more than four years when an incandescent lamp is replaced by a LED (suppose the lamp is used about five to ten hours a day). There is also a concern that blue LEDs and cool-white LEDs are now capable of exceeding safe limits of the so-called blue-light hazard as defined in eye safety specifications such as ANSI/IESNA RP-27.1-05: Recommended Practice for Photo Biological Safety for Lamp and Lamp Systems.

A CASE STUDY OF REPLACING CONVENTIONAL LIGHTING SYSTEM (FLUORESCENT/HALOGEN) BY LEDS

The technical analysis that has been performed in this study shows a promising result for LED to replace the existing conventional fluorescent/halogen lighting. In light of this, a case study based on three floors building at the Faculty of Natural and Human Sciences. The studied building has three floors, three big halls, nine offices, 15 teaching classrooms, one library, and about 2000m2 outdoor lighted space that also plays an important role in electric energy consumption. The number of exact existing lighting has been estimated from the building by conducting a walking audit. As can be seen from Table 1 below, the 100% of offices existing lighting consists of T8, 36W lighting bulbs, 100% of teaching classrooms lighting also consist of T8, 36W lighting bulbs, while in halls, all lighting consists of T8, 18W. Although there are 14 Halogen outside lights, which are ON for the purpose of vigilance throughout the night. The outdoor lights are ON from 6 PM to 6 AM (Timing usage varies from season to season).

Table 1: The number of existing lighting estimated from the building

Area description	No. of T8-18W lighting bulbs	No. of T8-36W lighting bulbs	No. of halogen 75W lighting bulbs
Floor -1, Hall	24	0	0
Floor -1, Classroom	0	8	0

Floor -1, Offices	0	14	0
Floor 0, Hall	88	0	0
Floor 0, Classroom	0	106	0
Floor 0, Offices	0	42	0
Floor 1, Hall	48	0	0
Floor 1, Classroom	0	102	0
Floor 1, Offices	0	48	0
Outdoor Lighting	0	0	14
Library	32	0	0
Total number of bulbs for each type	**168**	**298**	**14**

Table 2 provides the relative estimated annual electricity consumption that comes from lighting in a studied building.

Table 2: Relative estimate of annual lighting electric power consumption

Area description	Lighting average operating hours per day	Average number of operating days per year	No. of lighting bulbs (no LEDs)	Power in watts per hours per bulb	Total power consumption (kWh/yr)
Floor -1, Hall	7	230	24	18	695.52
Floor -1, Classroom	2	150	8	36	86.4
Floor -1, Offices	6	230	14	36	695.52
Floor 0, Hall	8	230	88	18	2914.56
Floor 0, Classroom	7	150	106	36	4006.8
Floor 0, Offices	7	230	42	36	2434.32
Floor 1, Hall	8	230	48	18	1589.76
Floor 1, Classroom	7	150	102	36	3855.6
Floor 1, Offices	8	230	48	36	3179.52
Outdoor Lighting	12	365	14	75	4599
Library	6	200	32	18	691.2
TOTAL					24748.2

Table 2 shows that total annual energy consumption for lighting is about 25000 kWh. If we compare the data with the total annual electricity energy consumption (data obtained from monthly electric bills) we see that illumination is responsible for approximately 25% of total electricity energy consumption. The proposed method for electric energy consumption is by replacing all the existing halogen 75w outdoor lights with 35 watts LED types and all T8 fluorescent lamps with T8 LEDs with Integrated drivers. Two T8 LED models (9 watts and 18 watts) are taken into consideration for replacements. Although the T8 LEDs (retrofit) are installed more easily without the need of rewiring, I do not propose this type of T8 LEDs for three reasons. First, the electromagnetic ballasts currently installed in the existing fluorescent lighting device vibrate and make a loud buzzing noise that is very annoying. This is due to a fact that they are of a very low quality. The second reason is that existing starter and electromagnetic ballast are at the end of their life cycle and a fault of them will out of the function the LED bulb. The third reason is that T8 LEDs with Integrated Drivers are more efficient than T8 LED Retrofit, with no power loss from the removal of the existing ballast. Installation of T8 LEDs with Integrated Drivers involves electrical modification to the existing fixture in order to connect the tube to the power supply. The existing starter and its corresponding ballast must be removed from the fixture. LED T8 tubes are approximately 50% more efficient than a T8 tube. The wattage of the LED T8 tube is only 9W as compared to the T8 tube of 18W. Besides that, the illuminance level for LED T8 tube is greater than T8 fluorescent. Regarding outdoor lighting, 35W LED Roadway Lightings are taken into consideration for replacements of 75W halogen lamps.In Albania, the market price of a brand name LED T8 tube is about seven times higher than the matured T8 fluorescent lighting tube. Table 4 shows the models and Cost of proposed LED lightings.

Table 3: Light models and costs of proposed LED lightings

Lighting model	Price per unit (ALL)	No. of units	Total price for each lighting model
GE LED 9/T8 600MM	1000	168	168000
GE LED 18/T8 1200MM	1400	298	417200
35W LED Roadway Light	5000	14	70000
Total price for all lights			655200

As we can see from table 3, the total cost involved in lighting replacement is ALL. 655200

The labor cost for electrical modification to the existing fixture in order to connect the new LED tubes to the power supply is estimated to be about ALL. 50000

Since all of the new lights consume 50% less energy, the total power watts saving per year will be:

24748 kWh / 2 = 12374 kWh

If we calculate the current price of energy (14 Lek/kWh), the total financial savings per year is:

12374 kWh * 14 (ALL) = ALL 173236

From the above data, we can calculate the payback period.

Payback period = total cost of LEDs + labor cost / Financial saving per year.

(ALL. 655200 + ALL. 50000) / ALL. 173236 = 4 years.

If we although take into account the periodic replacement cost of old lighting bulbs, the payback period drops far below 4 years.

The study shows a possible huge energy saving potential by replacing the present system of conventional tube lights and halogen with LEDs. LED lifetime expectancy is 30000 to 50000 hours, thus, taking 30000 hours of life, a LED system will last for at least 10 years. These high-quality LEDs with their very long lifetime are getting cheaper, and the market is currently exploding. I want to emphasize that this paper does not intend to provide exact economic calculation based on the detailed lighting data, but rather to give some high-level indications on the order of magnitude the LED lighting can achieve, in terms of energy reduction and payback period.

CONCLUSION

The presented study and analysis suggest that LED tube has great potential to replace the conventional fluorescent and halogen lamp. Replacing incandescent light bulbs and fluorescent tubes with LEDs will lead to a drastic reduction of electricity requirements for lighting. LED lamps are still expensive compared to incandescent lamps and fluorescent lamps, but have greater saving potential. Switching to LED lights can counteract the environmental footprint of increasingly extensive displays and is a key part of the Clean Revolution technologies to create a safe climate, boost economic growth, and secure a prosperous future for all.

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