HIGH EFFICIENCY LIGHTING AND CONTROL STRATEGIES FOR ITS IMPROVING

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ABSTRACT:
This paper focuses on high efficiency lighting for wide range of users. It is only one of opportunities that provide high returns for large, medium and small enterprises, public organizations, schools, hospitals, householders etc. The physical terms, technical characteristics, economical and environmental aspects have been drafted. Also, several measures for improving lighting efficiency are elaborated. A few examples show how lighting efficiency drastically affects our budget. Additionally, we advert impact of light sources on emissions of greenhouse gases (primarily CO2). Also, some scenarios in modern lighting control, investigated by authors are discussed.

Keywords: *lighting sources, lighting efficiency, emission, control*

1. INTRODUCTION

Lighting directly affects our economy. It accounts for about 33% of typical commercial energy usage and can range up to 60%. In many cases, lighting is the most cost effective efficiency upgrade you can perform, especially with financial incentives from the utilities and other sources. Furthermore light affects our health, safety, morale, comfort, and productivity. Technologies developed during the past 10 years can help us cut lighting costs 30% to 60% while enhancing lighting quality and reducing environmental impacts. To save energy while maintaining good light quality and quantity, you need to understand: lighting principles and terms, types of lighting and how each works, measures to improve lighting energy-efficient as well as economic aspects of your investments [1], [2].

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2. LIGHTING PRINCIPLES AND TERMS

The most common lighting term you will hear is *efficacy*. This is the ratio of light output from a lamp to the electric power it consumes and is measured in lumens per watt (*LPW*). The second parameter is *life* that correspondents to the lifetime in *Hours*. High-quality lighting is fairly uniform in brightness and has no *glare* (i.e., excessive brightness from a direct light source). Eliminating glare is essential to achieving good lighting quality. Lamps are assigned a *color temperature – CR* (according to the Kelvin temperature scale) based on their "coolness" or "warmness." Cool light is preferred for visual tasks because it produces higher contrast than warm light. Warm light is preferred for living spaces. The artificial light sources vary widely in their *color rendering indexes* (*CRI*). The CRI says how accurately colors can be determined under different light sources (i.e., 100 the best, 22 very poorly). There are several categories of lighting: *ambient, task*, and *accent*. Ambient lighting provides general illumination for performing daily activities as well as security and safety. The goal of task lighting is to provide enough illumination so that tasks can be completed accurately but not provide so much light that entire areas are illuminated. Accent (ambient) lighting illuminates walls so they blend more closely with naturally bright areas like ceilings and windows.

3. TYPES OF LIGHTING

There are five basic types of lighting: *incandescent, fluorescent, high-intensity discharge, low-pressure sodium and LED lighting*.

Incandescent is the least expensive to buy and the most expensive to operate (standard bulbs). It has the shortest life span of the common lighting types and is relatively inefficient compared with other lighting types. The most common types of incandescent lights are standard incandescent and tungsten halogen.

Fluorescent is an energy efficient lighting choice because it is about five times more efficient than incandescent lighting (5 x higher efficacy). Compact fluorescent lamps (CFLs) combine the efficiency of fluorescent lighting with the convenience and popularity of incandescent fixtures and save up to 75% of the initial lighting energy. They require ballast in order to work properly.

High-Intensity Discharge (HID) lamps provide the highest efficacy and longest service life of any lighting type. They are commonly used for outdoor lighting and in large indoor arenas. HID lamps use an electric arc to produce intense light. They also require ballasts, and they take a few seconds to produce light when first turned on. The three most common types of HID lamps are mercury vapor, metal halide, and high-pressure sodium.

Low-pressure sodium lights are the most efficient artificial lighting and have the longest service life. Where color is not important, this light is a good choice because it renders all colors as tones of yellow or gray. Security lighting often uses this type of lighting.

LED lighting (light emitting diode) is a new-generation lighting suitable for ambient lighting, shops, sings, battery operated lamps, car lighting and so on. It is extremely low power lighting. For comparison, an inefficient 50-watt incandescent and 15 watt fluorescent "exit" lights could be replaced with 1.8 watt LED lighting, consuming only 4% of the energy used by incandescent bulb. The disadvantage of LED lighting is relatively high price (but decreasing). The LED lighting has extremely long life (up to 50,000 hours, about 6 years!).

The lighting characteristics with energy efficient recommendation lamps are summarized in Table 1.

Table 1. Characteristics of different lighting sources

	Lamp	Efficacy (LPW)	LIFE (Hours)	Energy Efficient	Indoors/ Outdoors
	Standard Incandescent	8-24	750-1500	☻ ☻ ☻	Indoors/ Outdoors
	Tungsten Halogen	12-36	1000-3000	☺ ☻ ☻	Indoors
	Mercury Vapor	20-63	12000-24000	☺ ☻ ☻	Outdoors
	Fluorescent (tabular)	41-91	7500-24000	☺ ☺ ☻	Indoors
	Compact Fluorescent (CFL)	50-83	7500-10000	☺ ☺ ☺	Indoors
	Metal-Halide	56-125	10000-20000	☺ ☺ ☺	Indoors/ Outdoors
	Low pressure sodium	100-183	10000-18000	☺ ☺ ☺	Outdoors
	LED	10-70	35000-50000	☺ ☺ ☺	Indoors/ Outdoors

4. HOW TO IMPROVE LIGHTING EFFICIENCY

Here are some important tips for improving lighting efficiency

– Use natural lighting as much as possible.

– Turn off lights when area is unoccupied. It can be done manually or automatically (by photo sensitive electronics devices).

– Turn off lights near windows: If your lights can be controlled separately, turn off those nearest the windows if natural light is adequate.

– Use timer switches to control lights. Good examples are warehouses, which are seldom occupied, and washrooms where lights (and fans) tend to be forgotten.

– Use motion sensors to switch lights off. Motion sensors work well in areas that are limited in size, have irregular occupancy patterns and where persons tend to forget to turn off lights, Fig. 1.

– Use photocell to control outside lighting

– Use task lighting and less overhead lights. Use overhead lighting to illuminate very localized tasks is not optimal. Overhead lighting could be reduced to minimum levels for safety and ambient lighting. A desk lamp is a good example of task lighting to complement ambient lighting.

– Use reduced wattage lamps. If the illumination level in a space is excessive, use lamp with lower wattage; this will provide illumination reduction accompanied by a power reduction without the need for major lighting system redesign.

– Remove unnecessary lamps where lighting levels exceed your needs (Delamping).

– Use only necessary safety and security lighting: At night and when areas are unoccupied, make sure that only lights left on are those needed for safety, security or some other specific purpose.

– Replace incandescent lamps with CFL. It provides same amount of lighting but uses up to 1/6 of energy.

– Replace standard fluorescent “T12” tubes with more efficient “T8” fluorescent tubes.

– Replace standard ballast with electronic.

– By replacing a mercury vapor lamps with a metal halide, you get the same lighting level – and approximately 30% reduction in energy costs. When light color is not critical, high-pressure sodium lamps provide another way to save. They use approximately 50% less energy than mercury vapor while providing no change in lighting levels.

– Use LED lighting in case of signs, advertising, garden, pools, display shops, emergency lighting, decorations and so on.

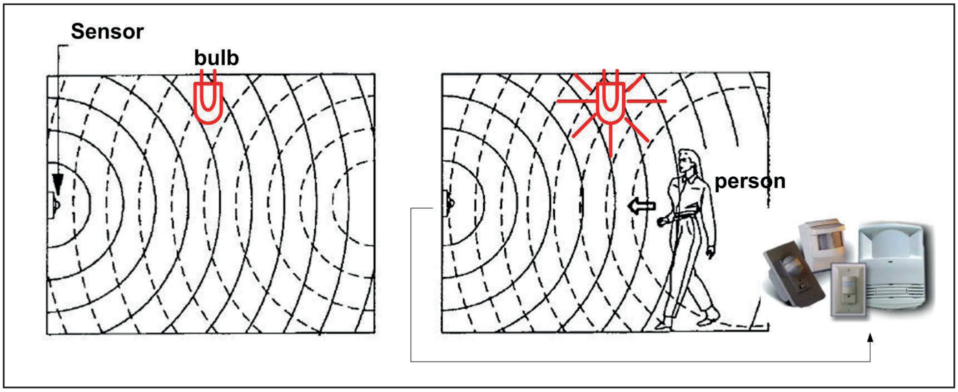

Figure 1: Occupancy sensors in function of improving light efficiency

5. SIMPLE ENERGY SAVING CALCULATOR

By only two examples we will show how energy efficiency could be drastically improved by changing only the bulbs in existing (old) fixture

Example 1: Changing incandescent bulb with CFL. *For Montenegro we know input parameters as:*

Energy Cost, €/kWh= €0.06
Labour Cost, €/hr = €3.00
Time to Change Bulb, min=15
Run Time, hrs/day=12.

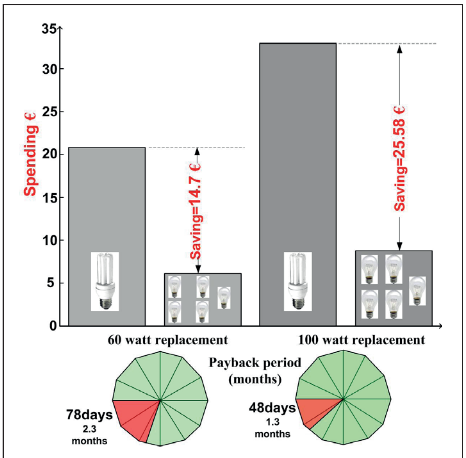

Figure 2: CFL against classical bulbs

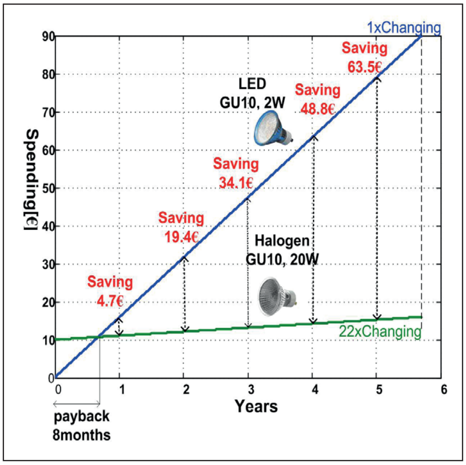

Figure 3: LED against halogen.

How much I will save changing incandescent lamps with CFL lamps? What is payback period in months? The answer is given in figure below. Changing higher wattage bulbs will save more and your payback period during lest payback period, Fig. 2.

Example 2: Changing halogen bulbs for display shop. *Replace 20W halogen by 2W LED. The prices are 1€ and 10 € respectively. LED bulb has life of 50000Hours vs 2500Hours of halogen. The diagram below shows efficiency of LED lighting compared to standard halogen. As example, changing 100halogens lamps in one shop with LED will save 6.350€ during LED's lifetime (5 years). Vice versa, we will have to change halogen lamp at minimum 22 times for lifetime of LED lamp, Fig. 3.*

6. ENVIRONMENTAL ISSUES

Since energy efficiency lighting sources (as CFLs) use less power to supply the same amount of light as an incandescent lamp of the same lumen rating, they can be used to decrease energy consumption at the location they are used in. In countries where electricity is largely produced from burning fossil fuels, the savings reduces emissions of greenhouse gases (primarily CO2) and other pollutants; in other countries the reduction may help reduce negative impacts from radioactive waste, hydroelectric plants, or other sources. For example, one CFL replacing an incandescent can cut CO2 emissions by 373 kg in five years. Replacing 17 bulbs reduces enough CO2 to equal removing one car off the road for a every year [3]. The next contraverse in pollutant emission is case of mercury. CFLs, like all fluorescent lamps (e.g., long tubular lamps common in offices and kitchens), contain small amounts of mercury and (about 4mg for 25Wats) it is a concern for landfills and waste incinerators where the mercury from lamps may be released and contribute to air and water pollution. Some manufacturers such as Philips and GE make very low-mercury content CFLs (claimed 2mg). Fig. 4 shows mercury use of compact fluorescent lamp vs. incandescent lamp when powered by electricity generated from coal. It can be concluded that mercury lamp itself contains more mercury than incandescent one, but having in mind emission produced by burned fossils it is more efficient.

7. CONTROL SCENARIOS

Integrated lighting controls can significantly improve building performance, increase energy efficiency, and enhance occupant comfort and satisfaction with the built environment. While previous text has shown that simple lighting controls such as occupancy sensors are effective at reducing the amount of electrical energy used for lighting in commercial and householder spaces, advanced lighting control strategies have the potential to achieve even greater energy savings and offer many advantages over simple controls. During last three-four years in Applied Electronics Laboratory (APEG), Faculty of Electrical Engineering, University of Montenegro are actual research and development activities in field of home automatization. The emphasis is on development efficient systems for improving energy saving considering different consumers. Thus, the extreme idea is to develop integrated, modular and flexible system for home automatization named ISKA (Integrisani Sistem Kućne Automatizacije) [4]. Currently, the scenarios 1, 2, 3 are developed and tested, Fig. 5, while their integration through range of gateways in global network is under construction.

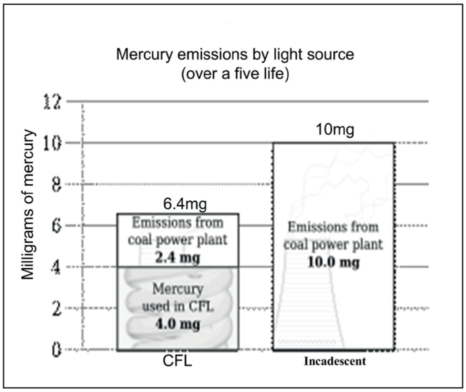

Figure 4: Mercury use of compact fluorescent lamp vs. incandescent lamp when powered by electricity generated from coal.

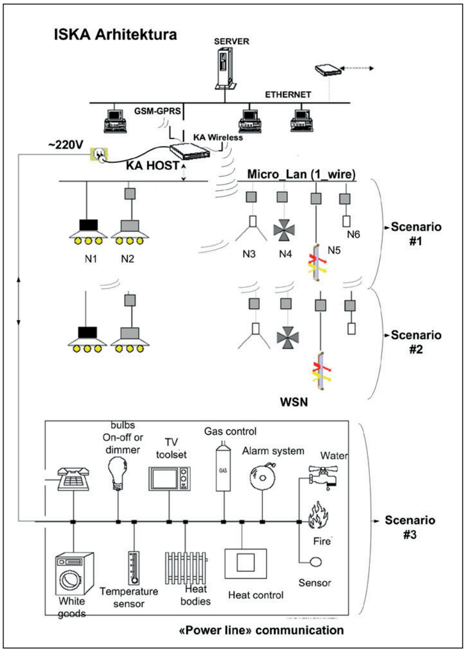

Figure 5 (right): Integral control system for improving energy efficiency

8. CONCLUSION

Taking care of the lighting efficiency provides one of the best opportunities for energy savings. The initial investments are small, but returns can be significant. The above are only basic things you need to know about lighting efficiency. Modern control strategies can help us to additionaly improve energy eficiency so much more lighting efficiency. Also, in designing and planning such systems environmental issues are extremely important and such should be taken in consideration.

9. REFERENCES

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VISOKO EFIKASNO OSVJETLJENJE I KONTROLNE STRATEGIJE ZA NJEGOVO UNAPREĐENJE

SAŽETAK:
Rad opisuje visoko efikasno osvjetljenje, namijenjeno širokom krugu korisnika, koje predstavlja jednu od mogućnosti uštede za velika, srednja i mala preduzeća, škole, bolnice domaćinstva itd. Daju se fizički termini, tehničke karakteristike, ekonomski efekti i uticaj na životnu sredinu. Preporučuju se jednostavne mjere za poboljšanje svjetlosne efikasnosti, a sa nekoliko primjera se ilustruje ekonomska računica. Dodatno se ističe uticaj svjetlosnih izvora na emisiju gasova (primarno CO2). Takođe, diskutuju se neki od scenaria moderne kontrole u sistemima osvjetljenja, ispitivanih od strane autora.

Klučne riječi: *izvori osvijetljenja, svijetlosna efikasnost, emisija, kontrola*