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# DEVELOPING LIGHTING TO MAKE BUILDINGS MORE ENERGY EFFICIENT

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**Abstract-** All over the world energy reduction and saving has become an obsession for both governments and businesses as well as for consumers. Although the latest estimates of availability of fossil fuels for energy, it is not an obsession but a necessity. The energy efficiency of buildings is a field that does not escape this need. Within this field, lighting is an important part. Traditional bulbs will be retired from European markets by decision of the European Parliament. But there are other types of lights that are normally used by customers: halogens, low-consume lights, fluorescent lights, … In our supermarkets and obviously in the shops dedicated to light, LEDs are opening a new way to be "eco-light", that is, to save energy when you are lighting a room or a space. In this paper we present a study for energy reduction in buildings through the use of this type of lights.

**Keywords:** Light, Energy Efficiency, Energy Reduction, LED, Buildings.

## I. INTRODUCTION

Specialists are three important technological milestones in the history of illumination: the first is achieved by illuminating Edison through a filament. Then came the technology of fluorescence, and in 1969 was released the first LED acronym that respond to the term "light emitting diode", i.e., light produced by a joint (similar to those of a normal transistor).

To reach the current situation have been many studies and developments needed to underpin this technology. In 1921, Albert Einstein was awarded the Nobel Prize in physics for the photoelectric effect, i.e. the appearance of an electric current in certain materials when they are illuminated by electromagnetic radiation. Conversely, some materials, when subjected to an electric current, they emit light, as detected in 1923 Lossew. Under this principle, in 1962, the engineer Nick Holonyak, after some experiments with gallium arsenide (GaAs), it proved possible to obtain high levels of light emission based on PN junctions. Thus started the first practical LED in the visible spectrum issued. At first, these LEDs were red, and given its low luminosity, began to be used as indicators of household equipment such as indicators on / off or digital displays.

Since then the LED technology has been developed until today, which is gradually taking a leading role in the world of both exterior and interior lighting. Its applications are growing, from its beginnings as an indicator to its wide range of utilities today: sensing devices, lighting of liquid crystal displays of mobile phones, PDAs, calculators, light bulbs.

Regarding the electrical aspect in the building there are two key areas: reducing electricity consumption and optimize resources. One of the areas to be covered is the lighting. And both of the above can be met through the use of LED lamps.

The reduction in energy consumption is obvious and perhaps the most outstanding advantage. But in addition to maintenance, especially in public buildings where there is a proliferation of fluorescent lamps, is also reduced, since the life of this new enlightenment is considerably higher.

LED technology is causing a revolution in the lighting market. We could say that today has not yet reached the maturity necessary to undertake general lighting projects of all kinds of variety of lamps (fluorescent, halogen ...), but the developments are so fast and so strong that changes tomorrow we will have nothing to say regard.

The reduction of consumption of a single LED bulb can be more than 12 times compared with traditional bulbs (50W to 4W) and more than 3 times compared with the so-called "low" (from 14W to 4W) . This reduction in consumption means a share of around 65% in households, can reach 80% in public and offices buildings.

## II. LEDS

A LED, English acronym of Light Emitting Diode (LED), is a semiconductor device that emits monochromatic light when biased in direct and is crossed by electric current. The color depends on the semiconductor material used in the construction of the diode and can range from ultraviolet through the entire spectrum of visible light to infrared. The latter are referred to IRED diodes (Infra-Red Emitting Diode).

The semiconductor device is commonly encapsulated in a plastic cover more resistant than glass is usually used in light bulbs. Although the plastic may be colored for aesthetic reasons only and has no impact on the color of the light emitted. Usually the cover has a flat face that indicates the cathode which is also shorter than the anode.

Unlike incandescent lamps which can be fed with AC or DC current, the LED continuously works only with the latter because it only conducts electricity when in direct polarized as conventional PN diodes, so that if AC powered LED flashes when illuminated only half of the cycle. You must choose either the current through the LED to get a good light intensity, the operating voltage is from 1.5 to approximately 2.2 volts or the range of intensities to run through it goes from 10 to 20 mA in the diode red and 20 to 40 mA for the other LEDs. The first LED emitting in the visible spectrum was developed by General Electric engineer Nick Holonyak in 1962.

## III. LED APPLICATIONS

Since in 1962 he created the first practical LED in the visible spectrum issued, LED technology has been developed until today, where little by little is taking center stage in the world of both exterior and interior lighting. Its applications are growing, from its beginnings as an indicator to its wide range of utilities today: sensing devices, lighting of liquid crystal displays of mobile phones, PDAs, calculators, light bulbs.

Regarding the electrical aspect in the building there are two key areas: reducing electricity consumption and optimize resources. One of the areas to be covered is the lighting. And both of the above can be met through the use of LED lamps.

## IV. FROM WATTS TO LUMENS

Watts are used to measure the power of a lamp (that is, the electricity it consumes). This is not the same as the quantity of light that a lamp produces, which is measured in lumens.

However, a major change is occurring now in the case of lamps. In the past, the majority of the available light bulbs were conventional incandescent bulbs, which for a given quantity of light always used the same power, so you had 25W, 40W, 60W, 75W, 100W lamps etc.

Today, the same quantity of light (around 750 lumens) can be produced by an incandescent bulb using 60 W, a halogen bulb using 42 W, or a compact fluorescent lamp using 15 W. This already causes confusion that manufacturers try to solve by giving equivalence with incandescent bulbs such as "this 15W energy saving lamp is equivalent to a 60W lamp".

In the future, incandescent bulbs will be gradually phased out. In Europe, this process has started in September of 2010 and will finish in 2012. Consumers will be left with lamps having all sorts of unfamiliar and incomparable wattages.

Measuring the performance of a lamp in lumens allows direct comparisons of light quantity (which is the service actually offered by the lamp), rather than relying on an awkward wattage-based comparison system between lamps having different energy efficiency. Such complicated information provision also makes it easier to manufacturers to make exaggerated claims.

In fact, since 1998 it has been compulsory to display also the lumens on the packaging of lamps carrying the EU Energy Label, so this information is not new.

From 2010 it will remain compulsory to display the watts, the only change will be that the display of lumens will have to be larger than the display of watts. This is done so that people grow accustomed to comparing lamps based on their real performance (the quantity of light produced) and not their wattage, which has become an unreliable and complicated method of comparison between lamps having different energy efficiency.

During the preparation of the measure, this provision was fully supported in Europe by Member States and stakeholders, including consumer organisations.

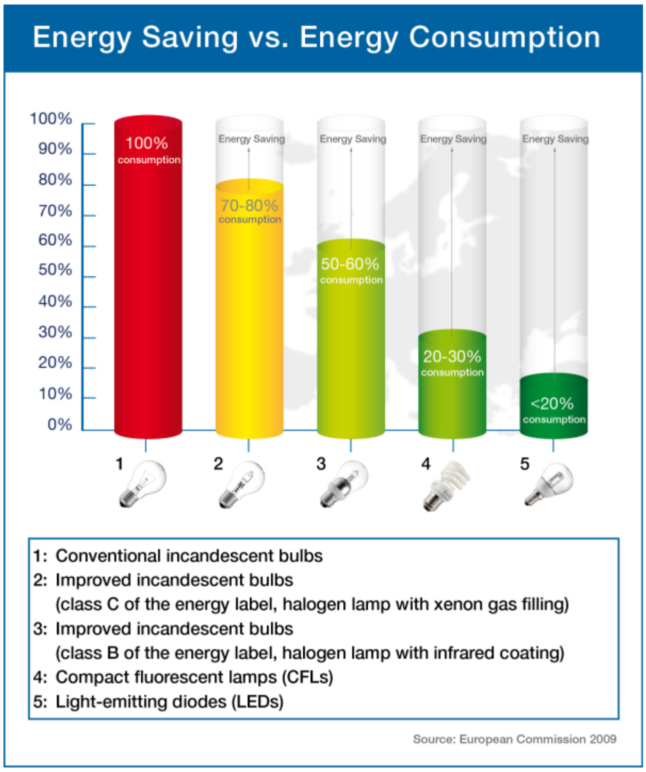


Figure 1. Energy comparation among different types of bulbs

## V. ACTION OF LIGHT

Lighting technique involves two basic elements: the production of light source and the object to be illuminated.

The magnitudes and fundamental units of measurement used to evaluate and compare the qualities and effects of light sources are:

- Luminous flux ($\Phi$) (lm)
- Luminous intensity ($I$) (cd)
- Illuminance ($E$) (lx)
- Luminance ($L$) (cd/m$^2$)
- Luminous efficiency ($\eta$) (lm / W)
- Amount of light ($Q$) (lm.s)

### A. Luminous flux

Luminous flux (light output) ($\Phi$): The energy transformed by the light sources cannot be exploited fully for the production of light. For example, an incandescent lamp consumes a certain power that transforms into radiant energy, of which only a small part is seen by the eye as light, while the rest is lost as heat. A radiant energy of a light source that produces a luminous sensation is called luminous flux.

The luminous flux is represented by the Greek letter $\Phi$, where its unit is lumen (lm). 683 lumens are equivalent to one watt, issued at wavelength of 555nm, which corresponds to the maximum sensitivity of the human eye.

The light output gives us an idea of the amount of light emitted by a light source, such as a light bulb in all directions. But we need to know how to distribute the flow in each direction of space and for that we define the light intensity.

**B. Light intensity**

Luminous intensity ($I$): This scale refers only to a direction referred to and contained in a solid angle w.

As a surface magnitude corresponds to a plane angle measured in radians, a volume scale corresponds to a sound or stereo angle that is measured in steradians.

The radian is defined as the plane angle corresponding to a circular arc of length equal to the radius. The steradian solid angle is defined as corresponding to a spherical cap whose surface is equal to the square of the radius of the sphere.

The luminous intensity of a light source is equal to the flux emitted in a direction per unit solid angle in that direction. Its symbol is I, and its unit is the candela (cd). The candela is defined as the luminous intensity of a point source emitting a luminous flux of one lumen into a solid angle of one steradian.

**C. Illuminance**

Illuminance ($E$): The luminous flux incident on a surface, divided by the size of the surface ($S$). Illuminance is the amount of assessment of the level of illumination of a surface or a space zone.

Its unit of measurement is the lux (lx), equivalent to the illumination falling on each square feet of a surface on which evenly distributes a luminous flux of one lumen. ($1 \text{ lx} = 1 \text{ lm/m}^2$)

The illuminance depends on the distance from the focus to the illuminated object. It is similar to what happens when we heard a car away and at first we hear loud and clear, but will decline to miss. What happens to the illumination is known as the inverse square law that relates the light intensity and distance to the source. This law is only valid if the direction of incident light beam is perpendicular to the surface.

**D. Luminance**

Luminance ($L$): Previous magnitudes report on properties of light sources (luminous flux or light intensity) or the light reaching a surface (illuminance). But we have said nothing of the light entering the eye that ultimately is what we see. This is what luminance is.

Luminance is called the relationship between light intensity and the apparent surface ($S \times \cos\alpha$) seen by the eye in a particular direction. Its symbol is $L$ and its unit is the $\text{cd/m}^2$. It is also possible to find other units like Stilbe ($1 \text{ sb} = 1 \text{ cd/cm}^2$) or nit ($1 \text{ nt} = 1 \text{ cd/m}^2$).

**E. Performance light**

As mentioned when discussing the luminous flux not all the energy consumed by a lamp (light bulb, fluorescent, etc…) is transformed into visible light. Partly energy is lost as heat, partly in the form of non-visible radiation (infrared or ultraviolet, etc.).

To get an idea of the useful energy portion of the luminous efficiency, performance light is defined as the ratio between the luminous flux produced and consumed electric power, which comes with the characteristics of the lamps (25 W, 60 W, ...). It is represented by the lumen per watt (lm / W).

**F. Quantity of light**

Amount ($Q$): This quantity is important only to know the luminous flux in situations like flash photography or to compare different lamps as the light emitted over a period of time. Its symbol is $Q$ and its unit is the lumen second (lm s).

## VI. ADVANTAGES

Technically, the use of LED light will carry the following advantages:

- Low power consumption. This is the main advantage and the reason that LED lamps are so successful.
- Low Voltage: Minimizing the risks of electrocution.
- Low temperature: The LED is powered by low voltage, thus consuming little energy and therefore emits little heat. And it does not have filament. But it is not true the general belief that LED lamps do not emit heat. Yes they do. Much less than incandescent bulbs, but emit heat. And so it is necessary to have heat sinks.
- Small spectral width: The LEDs have a small spectral width, thus making them the perfect lighting system for artificial vision because in this way the camera captures with much more detail the object.
- Wide spectral band: The LED is a device fixed wavelength but that can work in a wide band of spectrum. To cover the whole bandwidth available on the market an array of LEDs that we used for illuminating a specific wavelength or what is the same in a certain color (red, green, amber, white …).
- Faster response: The LED has an operating response much faster than the halogen and fluorescent, the order of some microseconds.
- Brighter light. Sometimes it is important when you need to focus the light for any particular purpose.
- Seamless Lighting: Absorbs possible vibrations because the LED does not have filament or gas.
- Increased durability and reliability. Till 100.000 hours of use.

## VII. DEVELOPMENT

To perform the comparison with the LED lighting will be necessary to provide data of the lighting that you want to compare. These data are such as: type, model, horsepower, voltage, length (only in case of fluorescent), hours of operation per day and units.

The characteristics of the lighting will be needed to compare to make a correct choice of LED lighting, so that this get compatibility between the two illuminations and low cost of change.

By developing a program in Visual Basic we achieve that the application makes the right choice according to the specified parameters. Once the election, made a calculation by which we say the profitability of changing the lighting. Similarly we see that savings through photographic models.

The program consists of various functions and commands, which the database link made with the final program.

For the first implementation of this program has created a database in Excel containing the characteristics of all the illuminations, and their necessary ancillaries (transformers, ballasts ...). This has been done previously captured information on the lamps and their characteristics.

In the database each type of lighting and extras have been differentiated in Excel sheets.

On each page we have classified the different models and their characteristics are specified so that comparison as accurate as possible, covering all the appropriate parameters. These parameters are chosen by setting the purpose for which the lamp is; in this case it is important to the cap and the lumens of each lamp.

This database can be modified and altered, given that some data will have to change margins for filters, etc.. With these changes the result achieved will be the same in response to changes made or new entry. This will get a base that fits what the market supply.

Then through the use of Visual Basic that has Excel will create a window or dialog box that will serve as a user interface for the application (Figure 3). Ie the window will be worked on at the time of comparison, which specify the characteristics of the lamp which compares and return a result set of data that make it easier to know if the replacement gives desired results.

The window or dialog box is composed of different objects which are scheduled to take the necessary action at every moment.

At the top are the selectors to determine the main characteristics that differentiate one from another light. We will specify by order, type (incandescent, halogen, fluorescent), then model (candle type, standard, mate ...), then finally power and voltage.

Each selector, which is present in the combo box interface, will appear as you selected earlier. If any of the information is wrong it shall be introduced change and update the above data. If the lighting is fluorescent display a selector which specifies the length of the existing fixture. A selection of the data into the program, click on the button "OK" and then the program will filter these characteristics in the previously created database to stay only with the features of our lighting.

| modelo | Codigo de pedido | Lampara | Pot |
|---|---|---|---|
| ESTANDAR CLARA | 364067 84 | Standard 15W E27 230V A55 CL 1CT | |
| | 364050 71 | Standard 15W E27 230V A55 CL 2CT | |
| | 354501 84 | Standard 25W E27 230V A55 CL 1CT | |
| | 354808 71 | Standard 25W E27 230V A55 CL 2CT | |
| | 363565 71 | Standard 25W E27 125-130V A55 CL 2CT | |
| | 355959 71 | Standard 40W B22 230V A55 CL 2CT | |
| | 354860 71 | Standard 40W E27 230V A55 CL 2CT | |
| | 355928 71 | Standard 40W E27 125-130V A55 CL 2CT | |
| | 356017 71 | Standard 60W B22 230V A55 CL 2CT | |
| | 354563 84 | Standard 60W E27 230V A55 CL 1CT | |
| | 354921 71 | Standard 60W E27 230V A55 CL 2CT | |
| | 363817 71 | Standard 60W E27 240V A55 CL 2CT | |
| | 355980 71 | Standard 60W E27 125-130V A55 CL 2CT | |
| | 354594 84 | Standard 75W E27 230V A55 CL 1CT | |
| | 354983 71 | Standard 75W E27 230V A55 CL 2CT | |
| | 355898 71 | Standard 100W B22 230V A55 CL 2CT | |
| | 354624 84 | Standard 100W E27 230V A55 CL 1CT | |
| | 355041 71 | Standard 100W E27 230V A55 CL 2CT | |
| | 363985 71 | Standard 100W E27 240V A55 CL 2CT | |
| | 363602 71 | Standard 100W E27 125-130V A55 CL 2CT | |
| | 056030 05 | Standard 150W E27 230V A65 CL 1CT | |
| | 024763 05 | Standard 200W E27 230V A80 CL 1CT | |
| | 099808 05 | Standard 300W E40 230V A88 CL 1CT | |
| KRYPTON STANDARD | 021540 84 | Krypton 40W E27 230V E50 WH 1CT | |
| | 340702 84 | Krypton 60W E27 230V E50 WH 1CT | |
| | 021588 84 | Krypton 75W E27 230V E50 WH 1CT | |
| | 021601 84 | Krypton 100W E27 230V E60 WH 1CT | |
| | 126085 05 | Krypton 150W E27 230V E75 WH 1CT | |
| SOFTONE STANDARD | 366283 84 | Softone 25W E27 230V T55 WH 1CT | |
| | 366306 84 | Softone 40W E27 230V T55 WH 1CT | |
| | 366603 85 | Softone 60W E27 230V T55 AP 1CT | |

Figure 2. Different types of lights

## VIII. CONCLUSIONS

In this article a comparative study on the energy consumption of conventional lighting with that comes from LED lights is presented.

We have studied not only the consumption of different types of lamps and bulbs (both LED and the usual type-fluorescent, incandescent and halogen), but its durability, the viability of replacing existing lamps by other LED type (so that only then need to change the "bulb" and not the entire fixture) and the light they provide compared with the current.

In the market there are many lighting systems with which the LED must compete. The LED is a relatively new and unknown in this field, compared to others who spent years on the market (incandescent, halogen, fluorescent).

With the results of the article notes that the replacement of one type of light on the other is a small domestic household savings, a huge savings for local retail and public buildings and offices, a decrease in the necessary production power with a consequent decrease in the occupation of the electrical system of power transmission and distribution (in areas such as the Spanish Mediterranean will be a relief to avoid cuts from overcharging) and a decrease in the emission of $CO_2$ into the atmosphere.

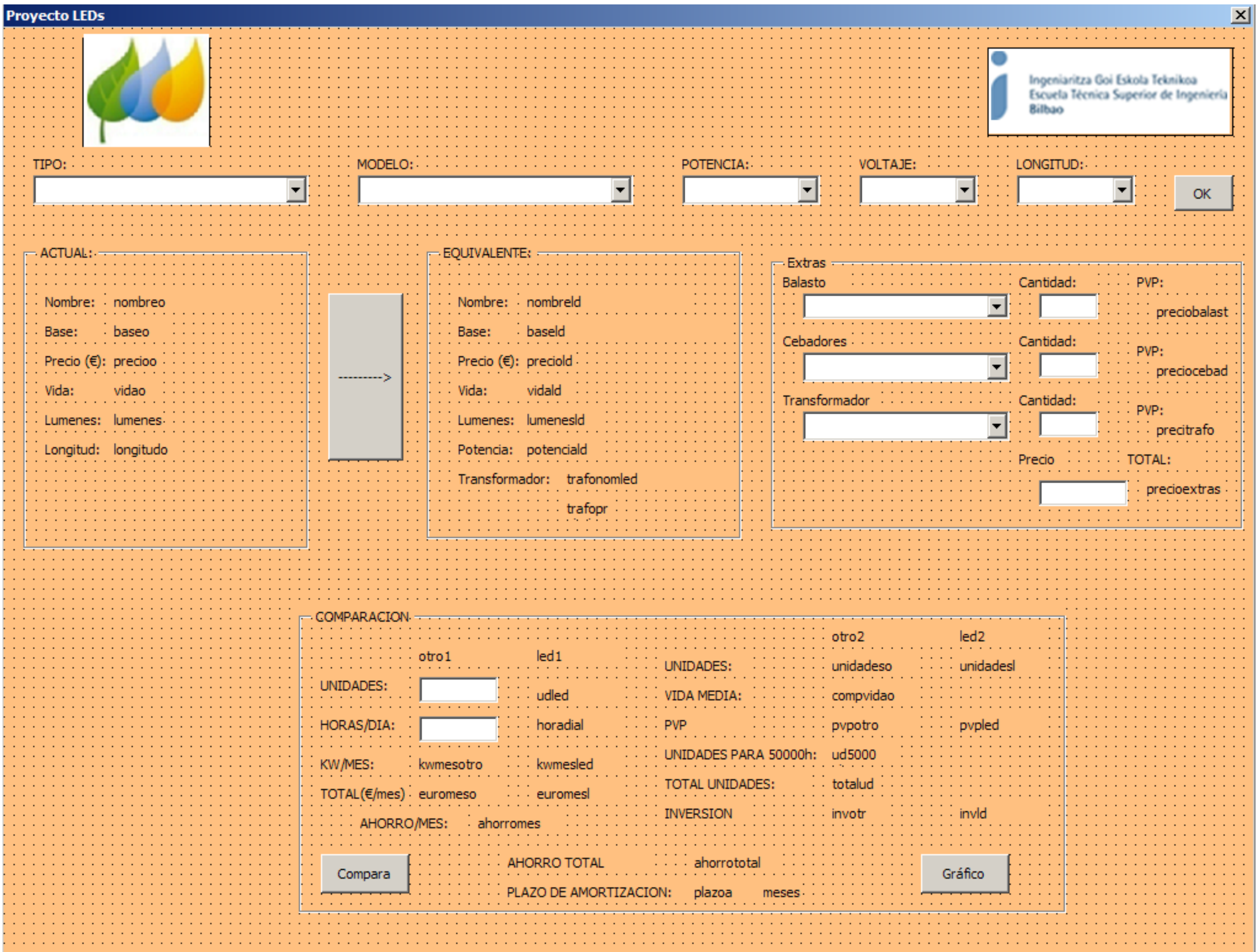


Figure 3. Interface

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## BIOGRAPHIES

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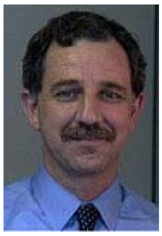

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