How to calculate electricity savings by switching to LED lighting

Authors

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Type of activity

An exercise that can be posed in physics and chemistry classes, as well as in economics. It is related to SDG 12 "Ensure sustainable consumption and production patterns".

Target educational level

It can be addressed to the last courses of High School students and to any university student.

Source: https://www.inese.es/el-mayor-obstaculo-a-la-hora-de-ahorrar-es-la-falta-de-planificacion/

Source

https://outsidebcn.com/calcular-ahorro-electricidad-iluminacion-led/

Gathering information

When deciding to change a traditional lighting installation to LED lighting, it is important to know how to calculate the electricity savings that this change will represent in the cost of the monthly bill. There are two main factors related to the products that we must consider: to know how to calculate the savings that this change will entail, which accounts for the performance or efficiency of a lamp, and its durability.

- ☑ The **efficacy** is the ratio between the luminous flux emitted and the power consumed by that lamp, that is, the ratio between what it emits and what it consumes. To save electricity, we will have to change the low-efficiency lamps that we have for other lamps with higher efficacy. In this way, we will obtain the same emissions while reducing consumption. This would be the first part of the savings to be calculated.

- ☑ **Durability** is the useful life of the lamp and is measured in hours. It is the number of hours it will last when it is on. The longer the durability of a lamp, the less often it will need to be replaced with a new one, and therefore the less we will spend on replacements. That would be the second part of the savings to calculate.

LED lamps provide these two types of savings.

- They have a very high efficacy, around 80-90%, compared to the very low efficacy of halogens, which is around 20%.

- They have a very high durability, about 40,000 hours of life or more, on average, compared to the 4,000 hours of life of a halogen.

How is the electricity saving calculated when replacing halogens with LEDs?

To calculate these savings, we must determine what we would spend on each of the options, both in terms of consumption and replacements, and check the difference in expenditure.

Calculation of electricity costs

To make this calculation, the price of electricity should be multiplied by the consumption of the lamp:

Electricity cost (€) = Electricity Price (€/kWh) x Electricity Consumption (kWh)

Where electricity consumption is found by multiplying the power of the lamp by the time it remains on:

Electricity consumption (kWh) = Power (kW) x time (hours)

Let's look at an example

Problem statement

What is the annual savings on the electricity bill of a shop that replaces its 10 halogen lights in the shop window, each of 50 W, with the equivalent of 7 W LEDs, assuming that they are on for an average of 12 hours a day (from 10 am to 10 pm)?

Solution

We calculate the consumption of the halogens:

- Time = 12 hours x 365 days = 4380 hours

- Halogen power = 50W x 10 units = 500 W
- Halogen consumption = 500 W x 4380 h= 2190000 Wh

As the price of energy comes in kWh, we divide it by 1000 to get the kWh.

- Halogen consumption = 2190000 Wh x 10^{-3} kW/W= 2190 kWh

Repeating the calculations for the LED bulb:

- Led consumption = 70 W x 4380 h = 306600 Wh = 306.6 kWh

Now we calculate the cost of both options. For this we take the price per kWh from our electricity bill, e.g. now 0.33161 €/kWh.

- Halogen cost = 2190 kWh x 0.38966 €/kWh* = 853.36€
- LED cost = 306.6 kWh x 0.38966 €/kWh* = 119.47 €

The saving in consumption of the shop window would be 733.92€ per year (not including taxes and multipliers).
(*) Price of electricity on 6/9/2022 between 18:00 and 19:00h, according to https://tarifaluzhora.es

We now calculate the cost of replacements.

If these bulbs are on for 4380 hours a year, we now calculate how many years a halogen bulb lasts, how many years an LED bulb lasts and, knowing the cost of each one, we will obtain the savings in replacements. We will see that although LED is still more expensive than halogen, the change is amortised in less than a year and after that it is all savings.
We take the durability data, 4000 hours of life for a halogen bulb and 40000h for the LED. And the selling prices, €3 for a halogen bulb and €6 for an LED bulb.

Duration (years life) = Lifetime hours / hours on per year

- Duration Halogen = 4000h / 4380 h year = 0.91 years

- Lifetime Led = 40000h / 4380 h year = 9.1 years

In the 10 years that an LED bulb will last, we will have to change the halogen bulbs 10 times, this translated into expenditure would be:

- Halogen investment = 10 bulbs x 3€ x 10 changes = 300€
- Investment in LED = 10 bulbs x 6€ x 1 change = 60€

This represents a saving in replacement costs of €240 over 10 years, which annually corresponds to €24/year.

Therefore, adding the two savings together, the total savings for changing the light bulbs in the shop window would be 759.92 euros per year.

We can use this calculation for any lighting we have in our home or workplace, we can even do the calculation for a single lamp separately and see how much we could save over the year with each replacement.

Additional savings factors resulting from switching to LED lighting

Other factors that can lead to additional savings on the electricity bill each month and that are directly derived from the replacement of traditional lighting (e.g. halogen and incandescent, to an LED lighting system) are:

- On the one hand, savings in energy expenditure on air conditioning, due to the drastic reduction in heat emission generated by LED lighting.
- On the other hand, in the case of extensive lighting installations (such as a fashion shop), it may be possible to reduce the contracted power term, since in the case of an establishment that has, for example, 100 units of 50W halogens and changes them for 100 units of 7W LEDs, the reduction in consumption is from 5kW to 700W, leaving a margin of contracted power that can be adjusted, thus reducing the costs or fixed terms of the bill.