Cost-effectiveness analysis and energy balance of lighting installations based on LED lamps and traditional fluorescent lamps

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Abstract: **The publication discusses and compares traditional fluorescent lamps, which are still in use for the most part, with modern electroluminescent lamps, which are being more and more often installed. An energy balance was prepared for both types of lighting. Then, a cost-effectiveness analysis was made to present the features of LED lighting in relation to the current prices of illumination equipment and electric energy. Finally, the article presents conclusions based on the analyses.**

Keywords **Cost-effectiveness analysis, energy balance, LED , lighting installation, fluorescent lamp.**

I. Introduction

Electroluminescent lighting is becoming more and popular, exerting larger influence in the market. When set beside other sources of light, LEDs undoubtedly have many advantages, such as [3]:

- better electrical and lighting efficiency,
- considerably smaller heat losses,
- high resistance to shocks,
- very long operating time,
- possibility of precisely directing the luminous flux.

Yet, the cost of LED lighting is its basic disadvantage. Thus, this article attempts to present an objective look at electroluminescent lighting by showing the cost-effectiveness of these systems through a relevant analysis and energy balance.

II. Lighting fixtures and light sources

For comparison purposes, two types of ceiling raster fixtures were chosen[2, 4]:

- Brilux RASTRA LED 302 2×16W T8 (fig. 1),
  - intended for electroluminescent lamps;
- Philips FINESS TCS 198 2×36W TL-D (fig. 2),
  - intended for fluorescent lamps.

Both fixtures are equipped with lamps of the same dimensions. They are not interchangeable, however, for the simple reason that the light sources are designed for different power supply units, which are installed in appropriate fixtures. The LEDline T8-12 16W lamps (fig. 3) are used with the Rastra fixtures by Brilux, while the fixtures by Philips use the TL-D 36W fluorescent lamps (fig. 4) [1, 5]. Tables I and II list the parameters of the fixtures and light sources.

The fixtures may be used above all in offices, shops, bureaus, dark corridors, and even in classrooms.

III. Analysis of the example of application

A classroom (fig. 5) served as the basis for the analysis of the costs of electroluminescent lighting. The room, 70[m^2] in area and 3,5[m] in height, is intended for a group of a maximum of 30 students. According to the PN-EN 12464-1 standard "Light and lighting. Lighting of indoor workplaces", the illumination system should meet the following requirements [6]:

- lighting intensity ≥500 [lx];
- colour rendering index ≥80;
- glare index ≤19;
- luminance uniformity ≥0.7.

TABLE I
PARAMETERS OF APPLIED LIGHTING FIXTURES [2, 4]

Parameter	 Fig. 1.	 Fig. 2.
Company	Brilux	Philips
Type	RASTRA LED 302	FINESS TCS 198
Refill Lamps	2 × T8 16W electroluminescent	2 × TL-D 36W fluorescent
Flux	3000[lm]	6000 [lm]
Fitting pow.	35[W]	80[W]
Power supp.	230[V] 50[Hz]	230[V] 50[Hz]
Price	500[PLN]	200[PLN]

TABLE II
PARAMETERS OF USED LIGHT SOURCES [1, 5]

Parameter	 Fig. 3.	 Fig. 4.
Company	Brilux	Philips
Type	LEDlineT8-12/16W	TLD36W/840
Lamp pow.	16[W]	36[W]
Flux	1360[lm]	2780[lm]
CRI	>80	>85
Colour temp.	4300[K]	4000[K]
Light tinge	Natural	Natural
Life time	50.000[h]	8.000[h]
Price	150[PLN]	20[PLN]

The amount of the fixtures to fulfil the above criteria was calculated by means of the Relux Professional program. As was indicated by the results, it was necessary to use thirty Rastra LED 302 fixtures or sixteen Finess TCS 198 ones [7].

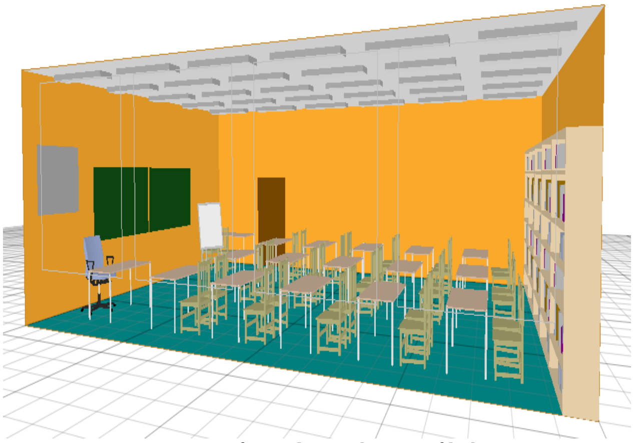

Fig. 5. Room for analysing the cost of lighting

IV. ANALYSIS OF ELECTIRC ENERGY CONSUMPTION

To calculate energy consumption, the concept of an average yearly operating time t_p is required, i.e. the number of hours during which artificial lighting works in a year. In the case of the room analysed, it is usually estimated at t_p=2000[h].

The installed power P_z (number of fixtures l_o × power of one fixture P_o) in the classroom is:

- 1050[W] – electroluminescent lighting,
- 1280[W] – fluorescent lighting.

Thus, yearly electric energy consumption E_r (i.e. $P_z \times t_p$) is 2100[kWh] and 2560[kWh] respectively.

Amounting to almost 500[kWh] as it does, the difference is considerable. Given that 1[kWh] costs 0,5[PLN] approximately, it is possible to save as much as 250[PLN] a year on lighting one classroom. If implemented in the whole school, the savings could run to a few or even more than ten thousand PLN a year.

V. BALANCE OF COSTS

In analysing a total operating cost it is necessary to include the expenditure on new lamps and the replacement thereof. Having a specified average life time, they need to be maintained periodically. While the maintenance period of fluorescent lamps is 4 years, LED ones are maintained every 25 years. The cost of one operation (the price of lamps + labour) is 1050[PLN] and 9400[PLN] respectively.

Total cost-effectiveness balance should also include the investment outlays on the purchase and installation of fixtures:

- 17,000[PLN] – LED lamps,
- 5,200[PLN] – fluorescent lamps.

In view of fluorescent lamps, the total cost of LED lamps is so large that they will start to pay for themselves after more than 80 years (fig. 6).

All of the energy and economic calculations presented in this article were based on the current prices of fixtures, light sources and energy. If, however, the prices of lighting equipment fell approximately by 1/3, the return period would be 30 years (fig. 6). Again, if LED equipment became cheaper by half, the return period would be almost 10 years (fig. 6), making this type of lighting very competitive in the market.

The diagram in figure 6 compares electroluminescent lighting (assuming varied prices of fixtures and light sources) with fluorescent installations with regard to a long-term return on investment.

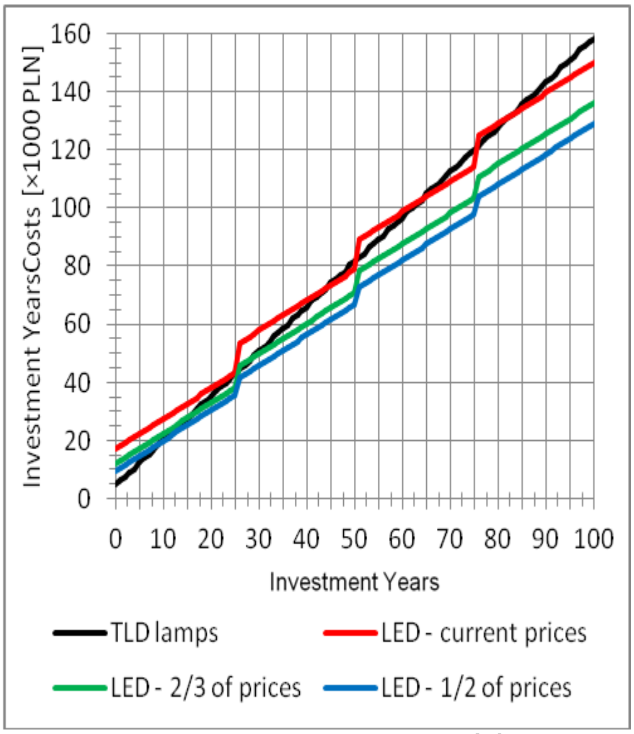

Fig. 6. Long-term investment return on LED lighting

VI. SUMMARY

As can be seen from the energy analysis, using LED lighting is much more cost-effective in respect of the consumption and costs of electric energy. But it is quite the reverse if all investment is taken into consideration.

Every new product that appears in the market is expensive - and so is LED lighting. Probably later the production costs of this equipment will fall, as will do its retail prices. It might be even a twofold slump. Then, this would be the most beneficial type of lighting with regard to its quality and cost-effectiveness.

VII. REFERENCES

[1] Brilux LEDlineT8/16W Datasheet.
[2] Brilux RASTRA Datasheet.
[3] Collective work: "Illuminating Engineering '09. Guide - Information". Polish Committee of Lighting SEP. Warsaw 2009.
[4] Philips FINESS Datasheet.
[5] Philips TLD36W/840 Datasheet.
[6] Polish-European Norm PN-EN 12464-1.
[7] Relux Professional User Manual.