# How the economical viability of redesigning the lighting system is affected in a typical classroom in Greece by lighting design and daylight zones

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## Abstract

The excessive energy consumption in Greek typical classrooms is already well known. With values of power density larger than 20W/m$^2$, actions for minimizing consumption are compulsory. However, there are case studies that instead of creating energy savings, the results lead to malpractices. Retrofitting the existing luminaires with LED lamps, overrate the necessary number of luminaires in the typical classroom and underestimate the daylight penetration in some of them. This paper examines in brief the potential malpractices and presents the results of installing larger amount of luminaires than necessary concerning the economic viability of a project.

## Introduction

While the power density of the typical classroom in Greece (>20W/m$^2$) is still above the limitations of the Greek energy efficiency regulation of buildings (<8.4W/m$^2$) [1], there is an ongoing effort to upgrade the artificial lighting system. However, with the absence of strict regulations, there is still a lost opportunity of energy savings while many malpractices occur.

One major malpractice is the retrofit of the existing luminaires by replacing the T8 florescent tubes with T8 LED lamps. Some of the reasons of the malpractice are:

- Luminaire does not have CE mark anymore after the replacement of lamps. A LED lamp is already an electronic device, which is being combined with a different one, namely the luminaire with the existing ballast. Typically, this action is against the existing laws.
- There is no photometry file for the new combination of luminaire – LED lamps, in order to calculate the exact amount of light that is needed in classroom. The absence of a photometric file (*.ldt or *.ies) is also against existing laws [1].
- LED lamps are less efficient than LED luminaires, have smaller heatsinks and flickering occurs.
- Usually LED lamps are heavier than fluorescent lamps and combining them with old lamp holders, could be dangerous for injuring the students.

Another serious malpractice is the specification of more luminaires than it really is being needed in a classroom.

## The typical grid of luminaires used in classrooms

In Table 1 the number of luminaires installed in classrooms of public domain school buildings is presented [1, 2]. In most classrooms and especially in school buildings, which have been constructed before 2010, the number of luminaires in each classroom is equal or more than 9 (Figure 1). However, the few new renovated classroom are still equipped with 9 or 6 luminaires, while the number of luminaires could be 4.

**Table 1.** Number of luminaires installed in classrooms of public domain school buildings [2-4].

| Building's date of construction | Number of luminaires | Building's date of construction | Number of luminaires |
|---|---|---|---|
| …-1970 | 18 | 2000 – 2008 | 9 to 12 |
| 1970 -1980 | 9 to 18 | 2008 - 2010 | 9 |
| 1980 - 2000 | 9 to 12 | 2010 – present | 6 to 8 |

**Figure 1.** Plan Left: Typical artificial lighting system in a classroom of public domain school buildings. 9 luminaires of T8 2 x 36W with electromagnetic ballast. Right: An example of installation of 4 luminaires in a classroom of a private school [5].

## Estimating the appropriate number of luminaires

In Table 2 and Figure 2 are presented the corresponding results by using six and four luminaires in the typical classroom. The guidelines [3] concerning artificial lighting refer only to illuminance value (300lx) while the European Norms [6] refer also to uniformity (>0,6 min/average) and glare (UGR <19). The corresponding results concerning photometric quantities are almost equal as also the power density. However, the cost of scenario A is 1/3 more expensive than B because with the advent of the LEDs the same luminaire (depending on the driver) can be set in many power levels. With other words the different values of power don't affect the price of the luminaire. As long as, the lighting needs are fulfilled according to EN standards, the selection of scenarios with fewer luminaires should give more economic viability to a renovation project in classrooms.

**Table 2.** Comparing the results of applying six or four luminaires in the typical classroom.

| Scenario | Photometric results | Power of each luminaire (W) | Power density (W/m²) | Cost |
|---|---|---|---|---|
| A: use of 6 luminaires | 306lx, Uo 0.63, UGR 19 | 28.7 | 3.63 | 6 luminaires x 100€ each +labor costs for 6 luminaires |
| B: use of 4 luminaires | 302lx, Uo 0.66, UGR 19 | 41.0 | 3.46 | 4 luminaires x 100€ each +labor costs for 4 luminaires |

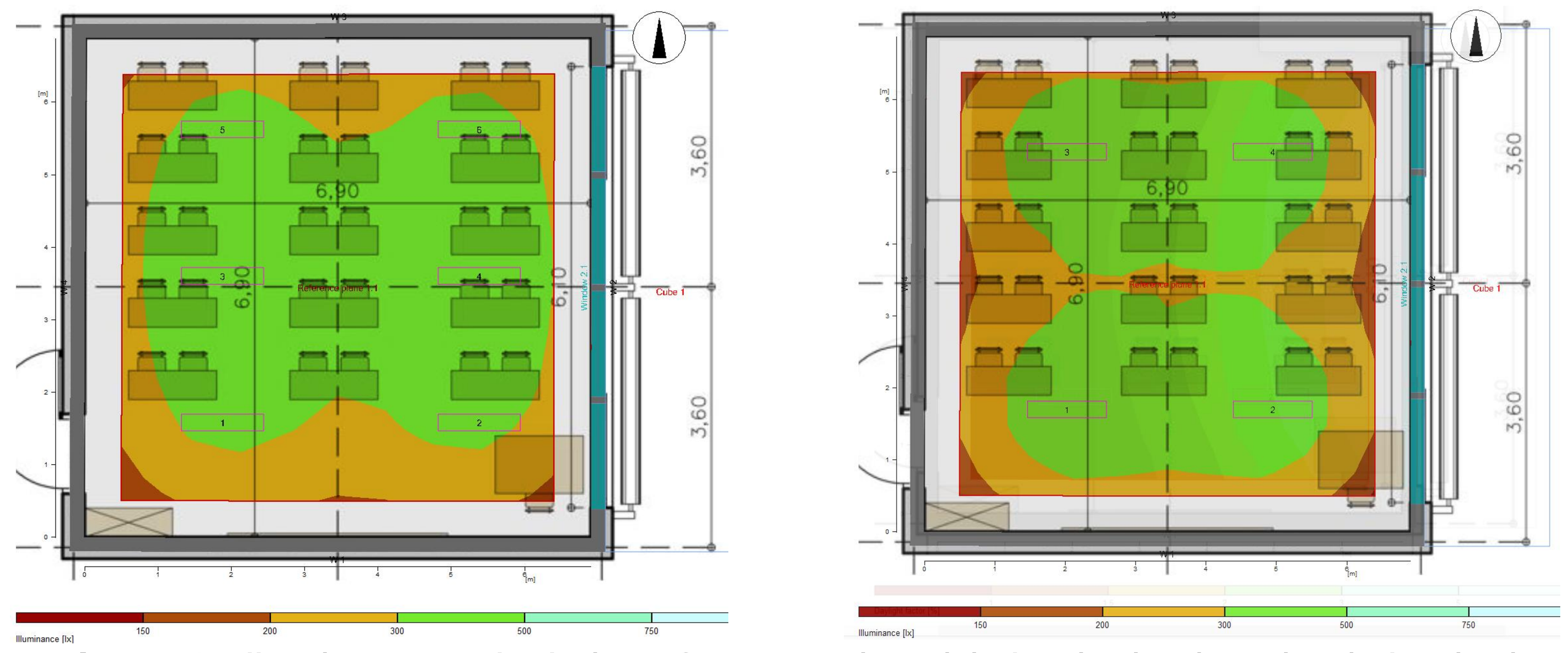

**Figure 2.** Illuminance calculations for scenario A (six luminaires) and B (4 luminaires)

## The role of determining the corresponding daylight zone

Determining the daylight zone inside a building is very crucial for the installation of the photosensors. Inside the daylight zone each luminaire must be controlled from a photosensor. In figure 3 is presented the determination of the daylight zone of the typical classroom. According to EN 15193, the depth of the daylight zone is 2,5 times the height of the window, namely 4,25m (Figure 3, left). This results in controlling only 2 luminaires by a daylight harvesting technic, whereas defining a daylight zone by the Daylight Factor (Figure 3, right) results in 4 luminaires.

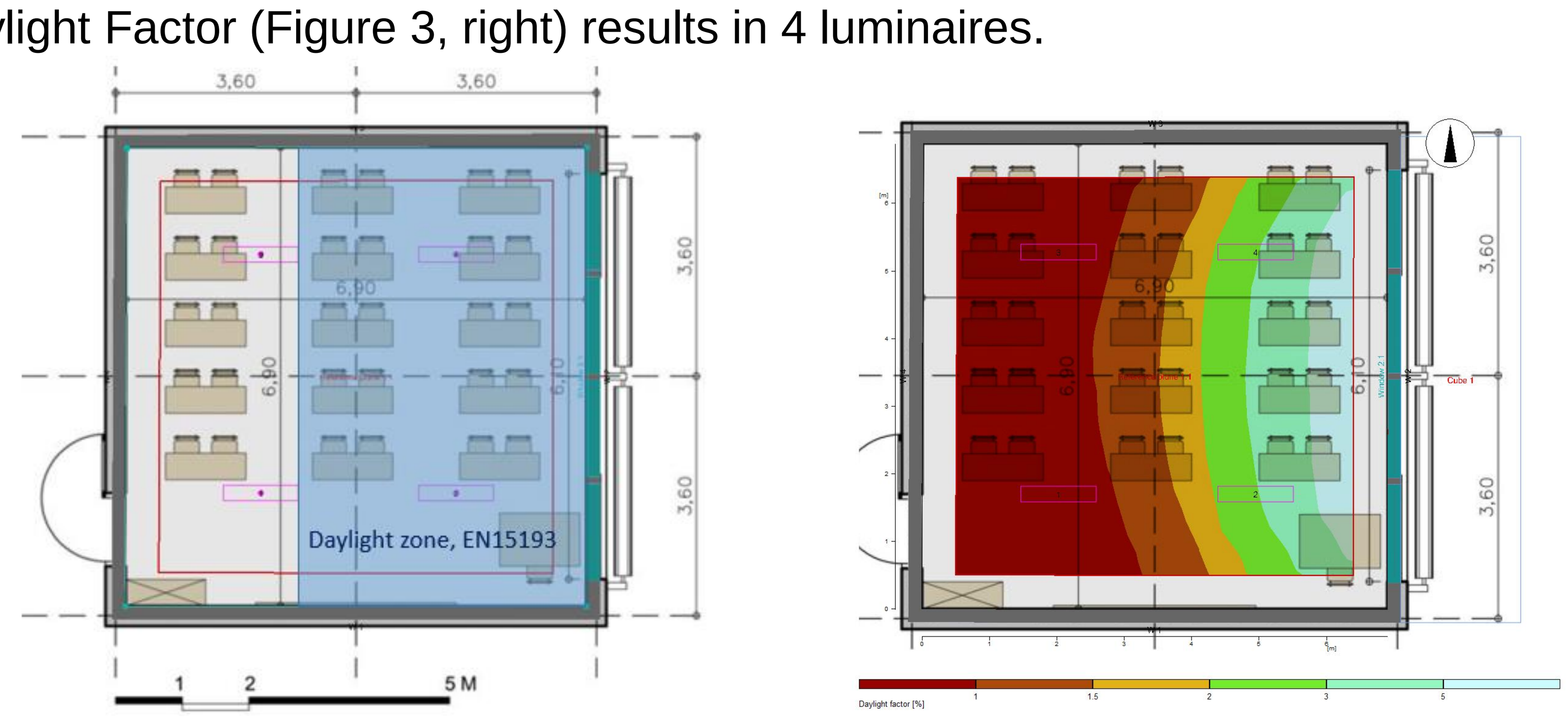


**Figure 3.** Left: Daylight zone according to EN 15193 Energy performance of buildings. Right: Daylight Factor calculations for entire space, DF=1,89%. According to CEN Daylight, the minimum value of DF to exceed 300 lx during 50% of daylight hours is 1.5% for Athens, Greece.

## Conclusions

The proper lighting design must not be limited into achieving the necessary lighting needs only. Determining the most beneficial number of luminaires and exploiting the daylight zones to the most of it are crucial factors to the economic viability of a new renovation of classrooms. Greece as a member state of the E.U. has the obligation to adapt actions and laws concerning near zero energy buildings (nZEBs) until 2020. School buildings and other education buildings (universities etc) are an important part of the building sector in Greece. By adapting four luminaires in each classroom and determining the proper daylight zone the goal of nZEBs should be easier.

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## References

1. Energy efficiency regulation of buildings "KENAK" – TOTEE 20701 (2017)
2. Buildings' Infrastructures S.A. (Ktiriakes Ypodomes S.A., http://www.ktyp.gr), Ex-Organization of School Buildings (http://www.osk.gr)
3. Guides for constructing School Buildings, 2008 Organization of School Buildings (http://www.osk.gr).
4. L. T. Doulos, M. Papadatou, A. Tsangrassoulis, Energy saving potential by retrofitting the artificial lighting system in the typical classroom in Greece, International Conference Energy in Buildings 2017 Saturday October 21, 2017 –Athens, Hellas
5. L. T. Doulos, C. Kapetanios, A. Tsangrassoulis, Harvesting daylight in a classroom, the case study of Leontios School, International Conference Energy in Buildings 2017 Saturday October 21, 2017 – Athens, Hellas
6. EN 12464-1: Light and lighting—lighting of work places Part 1: Indoor work places, 2011.

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