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Cost optimal analysis of lighting retrofit scenarios in educational buildings in Italy

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Abstract

The European Energy Performance of Buildings Directive (EPBD) recast proposes, a comparative methodology to calculate cost-optimal levels of minimum energy performance requirements for buildings. This paper presents a method able to select the best retrofit action for lighting system, selectively analysing the daylight conditions and applying the cost-optimal methodology for different scenarios proposed for two existing educational buildings located in Italy. With the aim to improve both energy efficient and visual comfort conditions, the retrofit scenarios include lighting solutions with different combinations. They consider the replacement of lamps with more efficient lighting sources and the application of lighting control.

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Keywords: Retrofit actions, lighting system, cost-optimal analysis, payback time

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1. Introduction

The educational buildings sector represents one of the most intensive part of energy consumption. In Italy the existing stock was built before 1980 and most of the buildings are obsolete. Thus, the retrofit of them can be relevant because of the poor energy performance of the stock, as well as for its high social value [1]. On the other hand, many studies demonstrated that retrofit actions can be very expensive and, if not well designed, their actual performances, both in terms of comfort and energy, could be lower than the expected ones [2]. An accurate predictive analysis of different possibilities of intervention and strategies is necessary to achieve good energy and comfort performances. Kesten Erhart et al. [3] presented a study developed within an initiative, financed by the Innovation and Quality Fund of Baden-Württemberg (Germany), that supports the development of universities as living laboratories to demonstrate and implement sustainability (Ministry of Higher Education, Research and the Arts, 2014). In particular, they investigated efficient ventilation and lighting solutions for the retrofitting of campus buildings, with a particular emphasis on a lecture hall.

As well-known, lighting systems accounts for approx. 19% (~3000 TWh) of the global electric energy consumption. For this reason, the retrofit action for lighting system can be a good strategy to achieve significant energy savings. In fact, also in this field, in many countries about 75% of the lighting installations are considered to be out of date (older than 25 years). With the aim of improving the lighting refurbishment process in non-residential buildings, in order to unleash energy saving potentials while at the same time improving lighting quality, a big team of experts are working on SHC Task 50. The main activities are developing a sound overview of the lighting retrofit market, planning trigger discussion, initiate revision and enhancement of local and national regulations, certifications and loan programs, increasing robustness of daylight and electric lighting retrofit approaches technically, ecologically and economically, increase understanding of lighting retrofit processes by providing adequate tools for different stakeholders, demonstrating state-of-the-art lighting retrofits and developing as a joint activity an electronic interactive source book including design inspirations, design advice, decision tools and design tools. Many studies have been carried out based on method developed within this task. Dubois et al. [4] presented some results from a large monitoring campaign performed in 22 buildings around the world as part of International Energy Agency (IEA) Task 50 “Advanced lighting solutions for retrofitting buildings”, addressing in particular the work of Subtask D, which aims to demonstrate sound lighting retrofit solutions in a selection of representative, typical Case Studies. A method to select the best retrofit action in terms of energy savings achievable and not too long payback time, is the cost-optimal methodology. It is a useful tool to address the evaluations of financial, energy and environmental issues. Through the balance between energy consumption and costs, it is possible to choose the best performing solutions, exploiting many variables and selecting different best configurations. Baglivo et al. presented the results of the application of a methodology to identify cost-optimal levels in new residential buildings located in a warm climate [5]. Chen et al. [6] proposed a cost-benefit evaluation method for building intelligent systems, using life cycle net present value (NPV) of all the costs and benefits, including tangible and intangible, as an index to evaluate the performance of the building intelligent systems. Some research focused on the economic analysis for retrofit of lighting system. n-Ho Yang, Eun-Ji Nam [7] did an economic analysis of the daylight-linked automatic on/off lighting control system installed for the purpose of energy savings in office buildings. Beccali et. al [8] demonstrated the importance to analyze different scenarios in order to select the best ones.

This paper presents a study on the application of cost-optimal methodology for different scenarios proposed for a existing school located in Italy. With the aim to improve both energy efficient and visual comfort conditions, the retrofit scenarios include different lighting solutions with different combinations. Several lighting configurations have been evaluated from an economic point of view for the energy retrofit projects.

2. Case studies

In order to apply the proposed method, two different case studies have been considered. Both of them are educational buildings and located in south of Italy.

The first one is the Liceo Classico “Antonio Calamo”. It is located in Ostuni (40°43'34"N, 17°34'20"E), 17.572901) in Apulia, in a suburb zone. The building has been built in 1960 and has three floors. It is used for about 10 hours during the working days and, occasionally during holydays. It is characterized by a "T" shape plan and it has a terrace.