ENERGY EFFICIENT LIGHTING - PILOT PROJECT AT UNIVERSITY OF BELGRADE

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Abstract: *Electricity for lighting accounts for approximately 20% of global power consumption and 6% of worldwide greenhouse gas (GHG) emissions. A switch to efficient on-grid and off-grid lighting globally would save more than $140 billion and reduce CO_2 emissions by 580 million tonnes every year. The United Nations Environment Programme (UNEP) project entitled "Global Market Transformation for Efficient Lighting" (or: en.lighten initiative) aims at accelerating global market transformation to environmentally sustainable lighting technologies by developing a coordinated global strategy and providing technical support for the phase-out inefficient incandescent lamps to reduce CO_2 emissions and the release of mercury from fossil fuel combustion. This study, through very first project within en.lighten initiative, in Serbia, that have been carried out in lecture hall "A" of Faculty of Mechanical Engineering University of Belgrade, has aim to show a great potential for energy savings and reduction of carbon dioxide at University of Belgrade . The activities on this pilot project included the replacement of all inefficient lighting in the Atrium, as well as installation of modern lighting control system. This result in saving, annually, up to 75 per cent of the electricity consumption and will lead to the reduction of 64 tonnes CO_2 emissions per year, compared to the situation before project activities.*

Key words: energy efficient lightning, CO_2 emissions, energy efficient policy, lighting control system.

1. INTRODUCTION

In most developing countries, the gap between electricity supply and demand is increasing rapidly. Countries must consider the high cost of new power generation and increasing fuel prices when making policy choices. Climate change and the need for utilizing existing resources sustainably, requires immediate action to reduce carbon emissions. According to the International Energy Agency, lighting accounts for approximately 19% of global electricity consumption. Improvements in energy efficiency help to reduce electricity demand, consumption and associated greenhouse gas emissions. The transition to energy efficient lighting is a straightforward and cost-effective approach to addressing climate change [1].

Countries around the world are beginning to phase out inefficient incandescent lamps. Some developed countries have established effective approaches to eliminate inefficient lamps via mandatory minimum energy performance standards. Following an integrated policy approach will significantly increase the likelihood of a successful transition to efficient lighting, leading to national financial, energy and environmental benefits. It will also streamline the process for those involved in designing and implementing policy [2].

The United Nations Environment Programme (UNEP)-Global Environment Facility (GEF) *en.lighten initiative* was established in 2009 to accelerate a global market transformation to environmentally sustainable, energy efficient lighting technologies, as well as to develop strategies to phase-out inefficient incandescent lamps to reduce CO2 emissions and the release of mercury from fossil fuel combustion. The initiative is a public/private partnership between the United Nations Environment Programme, OSRAM and Philips Lighting, with the support of the Global Environment Facility. The National Lighting Test Centre of China became a partner in 2011 and the Australian Government joined to support

developing countries in Southeast Asia and the Pacific in 2013. [3].

Energy efficiency for the Republic of Serbia is one of the fundamental objectives of energy policy and one of the five strategic priorities for the development of the energy sector. During recent years Serbia has worked hard to strengthen its capacity to achieve better results in the field of energy efficiency. Numerous positive results in this field are achieved, through the adoption of a series of legislative acts, public campaigns and numerous invested funds allocated from the budget and from international donations. Republic of Serbia is aware of importance of efficient lighting, but because implementation costs and poor condition of energy efficiency in other sectors, currently isn't on priority list.

This paper presents results achieved within the first *en.lighten initiative* project in Republic of Serbia. The visual and energy performances for a using energy-efficient lighting installations and daylight-linked lighting controls as well presence sensors were examined.

2. ENERGY EFFICIENT LIGHTING IN SERBIAN POLICY

An integrated policy approach ensures that all pertinent policy aspects related to energy efficient lighting are considered in the development of a National Efficient Lighting Strategy. Each country should determine how the elements of the integrated policy approach fit within their national context and ensure that all relevant authorities and stakeholders are involved to guarantee a consensus-based process in the development of a National Efficient Lighting Strategy. Participating national stakeholders include: ministries related to energy and the environment; distribution companies; energy efficiency agencies; private sector organizations and civil society groups.
Once the National Efficient Lighting Strategy has been finalized and approved by all relevant stakeholders, countries should ensure the support and cooperation of high level authorities to guarantee the full adoption and implementation of the strategy into the existing national regulatory framework [2].

First national action plan for energy efficiency of Republic of Serbia for period 2010 to 2012 stipulates replacing conventional incandescent bulbs with energy efficient bulbs in households and public and commercial sector. It is stipulated that this replacement will be achieved in period 2010 to 2018 for households, and 2011 to 2018 for public and commercial sector. This energy efficiency measure will be done through public promotions and by giving energy efficient bulbs to citizens and institutions. Estimated savings achieved by this measure in 2018 are 0.0172 Mtoe for households and 0.0473 Mtoe for public and commercial sector [4].

In 2011 Ministry of Environment, Mining and Spatial Planning of Republic of Serbia adopted Building Energy Efficiency Regulation ("Official Gazette RS", No 061/2011) [5]. This regulation stipulates in detail energy performance and method of calculation of thermal properties of buildings, as well as energy requirements for new and existing buildings. Article 16 of the this Regulation stipulates that Energy-efficient lighting systems that are installed in a buildings must meet the requirements specified in Serbian standard SRPS EN 15193 - Energy performance of buildings - Energy requirements for lighting. As well as the same Regulation stipulates that efficient use of energy for lighting is provided primarily using natural light, and if that is not possible, then should be use energy efficient bulbs and associated elements. In non-residential buildings shall additionally provide lighting control systems depending on the intensity of natural light and presence in the room.

According Law on Efficient Energy Use ("Official Gazette RS", No 25/2013) [6] all bodies and institutions of the public sector, including public utilities, are obliged to take measures to improve energy efficiency in buildings which they are used, conducting primarily economically justified measures that create the greatest energy savings in the shortest period of time. Measures to improve energy efficiency for the authorities, in addition to activities aimed at increasing efficiency energy use, include instruct its employees on energy efficiency measures and ways of their implementation and the establishment and implementation of energy efficiency criteria in the procurement of goods and services. Procuring entities in the public procurement of goods and services specified by law which stipulates terms, conditions and procedures for procurement, shall while deciding on the selection of suppliers take into account the energy efficiency goods and services and should strive to purchase the goods that belong to the highest class of energy efficiency. The Minister shall prescribe the minimum criteria in terms of energy efficiency in the public procurement of goods and services. During purchase or renting of the building or parts of the building for the purpose of authorities, organizations and public enterprises, energy efficiency of buildings or part thereof should be take into account as criterion.

Republic of Serbia has made a great progress in energy efficiency field during the last years. Numerous legislative acts are developed and adopted, however, for a more efficient implementation of actions there is a need for

capacity building and raising awareness, especially, on the local level.

Efficient lighting, due implementation costs and poor condition of energy efficiency in other sectors, currently isn't on priority list. The process of developing the National Efficient Lighting Strategy would contribute to raising awareness and capacity building in addressing the problem of efficient lighting and climate change. Projects like this, workshops, public promotions rises awareness of efficient lightning but these activities are almost impossible to implement without financial and technological support from and capacity building by the international community.

3. DESCRIPTION OF THE PROJECT ACTIVITIES

Project objectives including next tasks:

- fact finding on national policies for energy efficiency lighting,
- setting up a national team,
- identification of demonstration site,
- preparation and coordination the change of lighting.

3.1 Identification of the demonstration site

Within the task of identification of potential demonstration site, National team, consisting of representatives of University of Belgrade Faculty of Mechanical Engineering, OSRAM and Ministry of Development and Environmental Protection of Republic of Serbia in consultation with UNEP, considered several locations.

Buildings of state University of Belgrade:

- Faculty of Civil Engineering,
- Faculty of Architecture,
- Faculty of Technology and Metallurgy,
- Faculty of Mechanical Engineering.

Government buildings:

- Building of Republic Hydrometeorological Service of Serbia,
- The Palace of Serbia,
- Building of Ministry of Finance and Economy,
- Building of the National Assembly.

Building of elementary school "King Peter II Karadjordjevic".

Taking into consideration Project eligibility criteria (state building, potential for replacement if inefficient lightning, visibility of project results) and condition of lightning in all seen buildings, Atrium A of Faculty of Mechanical Engineering is recognized as a most suitable solution.

3.2 Description of demonstration site

Faculty of Mechanical Engineering is the oldest and the largest educational and scientific institutions in the field of mechanical engineering in Serbia and former Yugoslavia. Present faculty building has been desinged in 1955. and its construction is completed in 1960. Building has been built to the highest standards of that time and was one of the most modern faculty buildings in this part of Europe. During the previous decades building suffered minimal changes. Today, from energy efficiency point of view, building is in very poor condition.

For this project, it is important to note that the inefficient lightning prevails in the building (incandescent lamps and old type of fluorescent tubes), so there is a great potential for electricity savings by replacement of inefficient with efficient lightning. Considering that current lightning does not provide sufficient illumination, setting up new efficient lighting systems at Faculty would have additional effect in the form of raising the studying conditions and student's health.

Fig. 1. *Lecture hall "A" before*

Lecture hall "A" (Fig. 1), is the main atrium at Faculty, and the largest one at the whole University of Belgrade (250 m^2, 500 seats). Before the project activities the condition of lightning was in very bad condition, not only from energy efficiency point of view, but from visual aspect. It should be mention that construction and position of atrium provides very few daylight, even during the sunny days.

Examinations of the visual and energy performances in atrium before the project activities have shown that installed capacity of lightning was 25 kW, with only ON/OFF regulation, while the average illuminance was approximately 50 lx, despite the recommended classroom standard value of 500 lx [7].

3.3 Designing a new lighting system

Since the project activities didn't involve only simple change of inefficient with efficient bulbs, but overall replacement of all electrical installations, installation of new lightning and control systems, it was needed to conduct detail design of all important parameters of new system.

RELUX software package was used in order to determinate the number and position of lamps and sensors. Simulation process, that's included 3D

modeling of atrium (Fig. 2), involved two scenarios that have
been further evaluated: a) Case 1- maximum luminous flux at work regime: E_{av}=1000 lx: E_{min}=500 lx (Fig. 3); b) Case 2 – reduced luminous flux in order to achieve recommended illuminance level: E_{av}=500 lx: E_{min}=300 lx (Fig. 4). This process was carried out to obtain information about the system at maximum work parameters, as well as during the work parameters reduced by control system.

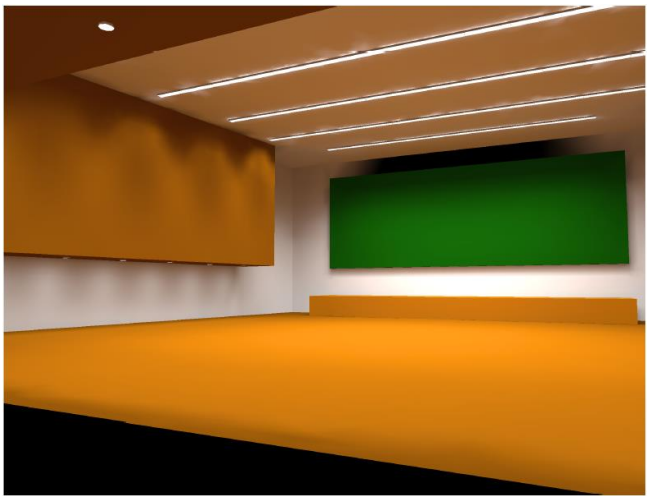

Fig. 2. *3D model of lecture hall*

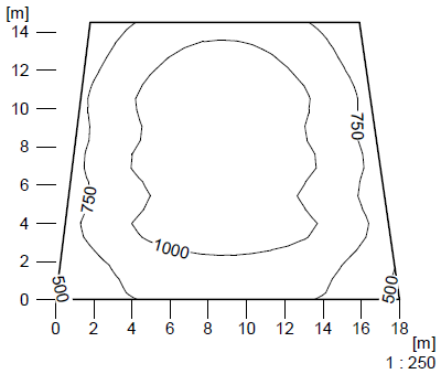

Fig. 3. *Case 1- Isolines representation [lx]*

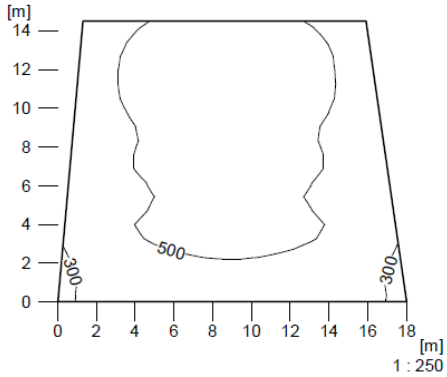

Fig. 4. *Case 2- Isolines representation [lx]*

Table 1. *Project results*

Installed capacity of lighting [kW]		Illuminance [lx]		Estimated Savings (up to) [MWh/y]	Reduction of CO_2 emissions (up to) [t_{CO2}/y]
Before replacement	After replacement	Before replacement	After replacement		
25	9.784	~50*	~500**	67.1	63.4

*From 20 – 100 lx, depending of position;
**From 270 – 1190 lx, depending of position and work regime.

Fig. 5 *Lecture hall "Before and After"*

The lighting system is managed by means of a sub-control system that uses a specific digital addressable lighting interface (DALI) to control the luminaires through photosensors, occupancy sensors and switches. The actions of the lighting control sub-system are:

- on/off switching in response to input from the occupancy sensors (automatic control) or from the wall-mounted switches (manual control),
- dimming in response to input from the photosensors.

The control system automatically performs the task of regulating the electric light to provide an average maintained illuminance of 500 lx on the work planes. The dimming ballast regulation was planned to work between 100% and 10%, while the light was turned off below 10%. This specific planning of the dimming regulation was decided on to reduce energy consumption: below a dimming level of 10%, the emitted luminous flux was considered useless because of the daylight predominance. The occupancy sensors were programmed to switch off the lights 10 min after the last presence is detected in order to reduce energy waste [8].

4. RESULTS

The replacement of all inefficient lighting in the lecture hall will result in saving, annually, up to 75 per cent of the electricity consumption, depending of control system. And will lead to the reduction of 63.4 tonnes CO_2 emissions per year, compared to the previous situation (Table 1.).

5. CONCLUSION

Electricity for lighting accounts for almost 20% of electricity consumption and 6% of CO_2 emissions worldwide. According to the International Energy Agency, approximately 3% of global oil demand can be attributed to lighting. If not addressed immediately, global energy consumption for lighting will grow by 60% by the year 2030. This would have dramatic consequences for climate change. The phase-out of inefficient incandescent lamps and their replacement with higher efficiency products such as light emitting diodes (LEDs) or compact fluorescent lamps (CFLs) provides one of the most straightforward and cost effective ways to significantly reduce carbon emissions [2]. Lighting systems consume around 30%–40% of the electricity used in commercial buildings. This typically amounts to about one third of a building's electricity bill. Nevertheless, the use of electricity for lighting is generally inefficient. Consequently, there is potential to improve the energy efficiency of lighting systems throughout the world. In the past, studies from a number of countries have shown that the adoption of energy efficient lighting technology has the potential to substantially reduce the amount of energy used in commercial and industrial buildings [9]. Bering in mind all this important

information, it is very important that Republic of Serbia continuously improve energy efficiency in lightning sector. The first step on that way is the bringing into force adequate policy instruments and capacity building.

The en.lighten initiative is a very important tool in the fight against climate change. Pilot project, presented and evaluated in this study, shows that, with somehow small investments, it is possible to achieve significant savings in electricity consumption and therefore reduce CO2 emissions. The replacement of all inefficient lighting in the lecture hall of the Faculty of Mechanical Engineering is one of the activities supported by Ministry of Energy, Development and Environmental Protection that contributes to increase the energy efficiency and through that, reduction of greenhouse gas emission. The Ministry strongly supports both awareness raising and capacity building initiatives, as well as investing into the education regarding this important issue, and therefore, it is of great importance to further promote the example of good practice to the wider audience, in particular students of Belgrade University.

With annual savings up to 67 MWh and 63 tCO2, as well as raised illuminance from insufficient to standard level, this pilot project is a step in the right direction, paving the way towards efficient lightening in Republic of Serbia.

1. REFERENCES

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