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The methodology and survey on energy saving and greening illumination for application in the automobile industry

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Abstract. The automotive industry is the decisive industry and the driving force behind the development of the Slovak economy. Slovakia has become one of the leading automobile manufacturers in Central Europe, whose progress began in the early 90's. Vehicle workshops provide wide spectrum of work on vehicles - assembly, welding, painting, repair, maintenance, cleaning, care and tuning which has to be implemented extremely carefully. In automobile production working environment demands on lighting are diverse and challenging and often use more energy on lighting than in other production plants. Insufficient daylight is frequent, and often windows are only located on one side, meaning that bright, homogeneous general illumination of workshops is a fundamental condition for precise, safe work. This paper describes the original methodology drawn up on the basis of valid legislation with point of view of the assessment of lighting systems in a vehicle workshops with regard to ensuring of a visual comfort and creation of requested working conditions for a visual activity, taking into account the energy saving and efficient of illumination.

1. Introduction

The automotive industry is the decisive industry and the driving force behind the development of the Slovak economy. Slovakia has become one of the leading automobile manufacturers in Central Europe, whose progress began in the early 90's. The share of production in 2016 in total industrial production in Slovakia reached 44% and the automotive industry accounted for 35% of the industrial exports. Slovakia, with 191 vehicles, has maintained world leadership in the number of cars produced per thousand inhabitants.

Vehicle workshops provide wide spectrum of work on vehicles - assembly, welding, painting, repair, maintenance, cleaning, care and tuning which has to be implemented extremely carefully [9]. In automobile production working environment demands on lighting are diverse and challenging and often use more energy on lighting than in other production plants. Insufficient daylight is frequent, and often windows are only located on one side, meaning that bright, homogeneous general illumination of workshops is a fundamental condition for precise, safe work [1].

Good lighting in the workplace with well-lit task areas is essential for optimising visual performance, visual comfort and ambience, especially with an ageing workforce [3]. And the beneficial effects of good lighting extend much further than it was originally thought. Over the last two decades more studies has consistently shown that light has not only a positive influence on health, well-being, safety but productivity too [2,7]. Sustainable illumination is an important business issue, not only to minimise environmental impact but also to conform to legislation, save on energy costs

and reduce carbon footprint without affecting output. Energy saving lighting is the way to a green future. Sustainability meeting our needs today without compromising the resources future generations will need touches everything we do as a company. Using only as much light as is needed when it is needed is key to reducing energy consumption [6].

2. The efficient utilization strategies of lighting

Global trends indicate that energy consumption in manufacturing is an important aspect to support next generation of sustainable eco-factories [4]. Characteristics of automotive industry are large and high spaces, fixed working positions, long work periods, various levels of illuminance, high bay lighting, central lighting control, restricted maintenance opportunities etc. [5, 7]. Recent developments in lighting technology combined with planned lighting control strategies can result in very significant cost savings, typically in the range of a third to a half of the electricity traditionally used for lighting [1]. Up to 75 % of a conventional lighting cost is wasted cost - money spent on light that simply isn't required. An intelligent lighting system applies the correct level of light when needed to help meet carbon emissions targets, legislation requirements and dramatically reduce expenditure, whilst improving efficiency, comfort and safety [3].

Most projects of lighting are based on proposals for ensuring uniformity of the intensity of illumination on a horizontal plane of comparison, for observing the recommended ratio of illuminance and brightness between the place of a visual task and its immediate surroundings. Expect the surfaces and colours of the room, in which the lighting system is installed, are an important part of the lighting system, because they influence lighting both in terms of its uniformity and of its utilization of light energy [6].

Standards for lighting usually provide the recommended values for the overall average intensity of illumination, ratios of illuminance at the areas of visual tasks and at their surroundings, the colour rendering indices CRI (expressing the rate of discoloration), the values of the glare index and the values of the correlated colour temperature CCT (STN EN 12 464-1).

There are several options of lighting solutions, but for the optimal choice it is first of all necessary to know the work tasks, i. e. the visual tasks to be implemented in the work area and to select accordingly the type of lighting. Currently, there is a sufficiently large selection of lighting fittings at the market, having conventional as well as modern design and are suitable for any premises [6]. There is an increasingly wide offer of lighting fittings and of lighting solutions that are using light emitting diodes (LEDs) as light sources, which is indicating the future direction of development of the lighting technology [3]. The basic characteristics of the lighting devices using LEDs, such as miniaturization, long service life (50,000 hours), efficiency, reliability, security, adjustability, instant start, clearly defined colours, are inspiring architects and lighting designers to search for new application possibilities.

3. Lighting design methodology

Based on the lighting systems efficient utilization strategies analysis of lighting systems efficient utilization and through its synthesis with the options of intelligent control were for a design and calculation of lighting systems analyses of the reference shop energy-saving lighting system designs were carried out. The results of the rationalization procedures and measures that have been made for the purpose of a reduction of energy demand of industrial operations lighting systems, were the basis for a development of a methodical procedure of designing of energy-efficient lighting systems in the sphere of engineering shops.

The methodology presented in this paper is drawn up on the basis of valid legislation of the assessment and evaluation of lighting systems in a working environment with regard to ensuring of a visual comfort and creation of requested conditions for a visual activity, taking into account its energy efficiency. The main parts of this methodology are divided into individual branches, by putting together of which, a sequence of steps and conclusions arise, which the methodology was developed for. The methodology for designing of efficient lighting systems is drawn up on the basis of valid

legislation of the assessment and evaluation of lighting systems in a working environment with regard to ensuring of a visual comfort and creation of requested conditions for a visual activity, taking into account its energy efficiency. This methodology is applicable for automobile industry especially. The base steps we can describe as follow:

- Assessing the current state of the illuminated space/workshops
- Evaluation of working space according visual conditions of workers and compare of the parameters with technical - illuminated norms
- Choosing of the lighting system components for the more project variants
- Calculations of lighting system variants
- Selecting of the optimum variant.

Upon defining of the characteristics of the system technical devices, for further advance in the greening process, it is needed to choose an appropriate tool for a calculation of lighting system (Figure 1). It is possible to carry out the calculation by various calculation methods or by designing and calculating computer tools intended for the elaboration of the lighting systems design and calculation. In this step, it is important to choose an appropriate type of the calculation and to take all circumstances related to the lighting system into account. Very important parameter that is to be taken into consideration, is the maintaining factor value that is directly connected with a proposal of the maintenance schedule of the lighting system. The determination of a correct value of the maintenance factor has a large influence on total economy of the lighting system during the period of its utilization. The applications of correct calculations and proposal results, in this stage of designing, in elaborated optional solutions which comply with the occupational and health protection requirements and, at the same time, are energy-efficient and economically profitable.

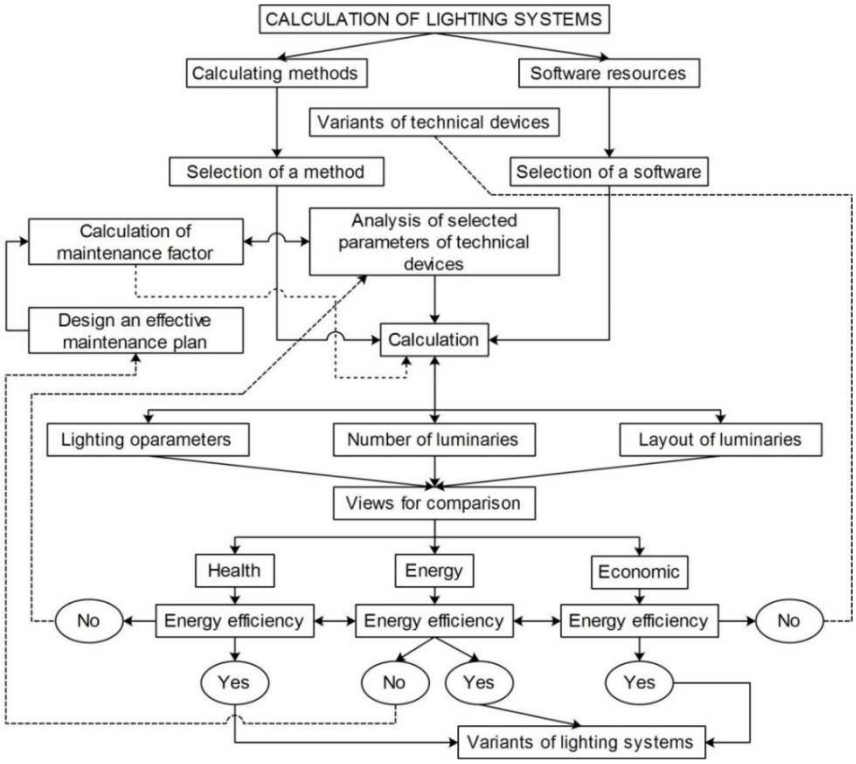

Figure1. Diagram calculations of lighting systems.

4. The procedure for selecting the optimal alternative solution

In the last stage of the lighting systems designing process, the elements of intelligent control systems are implemented into the optional proposals, which offer considerable energy sources savings based

on the implementation of sensors and daylight contribution, human motion sensors, time regimes introduced or by a creation of the luminaire groups and therefore it is important, considering the given type of the workplace, to assess all possibilities of the lighting control and regulation in the installation. The final stage of the lighting systems ecologisation, particular options are compared from the point of view of energy efficiency and total investment and operational costs. In the case of a lighting system reconstruction, a comparison of the initial status and proposed option will be elaborated, taking energy savings and related financial savings, as well as attained lighting parameters of the system into account. The methodological procedure for selecting the optimal alternative solution are given on Figure 2.

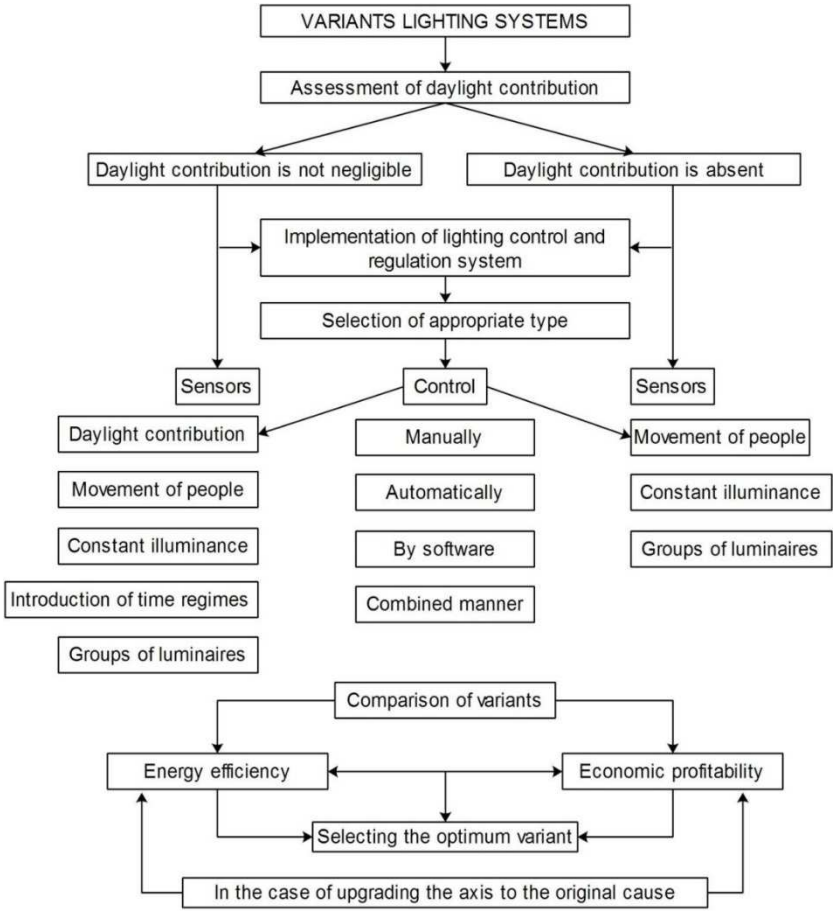

Figure 2. Diagram selected optimum variant.

5. Discussion

The presented contribution deals with actual issues, the search for rationalization measures in the energy consumption for lighting in the automobile industrial factory. Lighting systems is no small part of the share of total energy consumption, so it is necessary to look for energy savings opportunities in this area. In Slovakia, especially in industrial plants exist some of lighting systems that do not meet the requirements of energy efficiency, but what is worse, for employees do not ensure an nor optimum the lighting requirements at work, which is the primary function of lighting workplaces.

A high user acceptance guarantees undisturbed operations and consequently energy savings. Existing buildings have specific constraints and requirements. There is a need to analyse the existing lighting system and to determine the upgrade possibilities considering the technical and economical constraints [7]. Therefore, an audit of the existing lighting installation is necessary. Advanced control requires elements such as electronic dimmable ballasts and distributed electric indoor grids. Similarly,

the use of wireless technologies (switches, sensors, etc.) is a suitable solution for retrofit so that the placement and exploitation costs can be limited.

Lighting control strategy limits the operation time of the lighting system based on the occupancy time of a space and actual of daylight [10]. The time scheduling control strategy enables is used to reduce the operating hours of the lighting installation with switching on or off automatically based on time schedules and occupancy patterns for different zones. Lighting Management Systems allow building operators to integrated lighting systems with other building services such as heating, cooling, ventilation, in order to achieve a global energy approach for the whole building, in particular for green building or an energy-producing building. On the Figure 3 is illustrated general scheme for energy efficient design of lighting control [11].

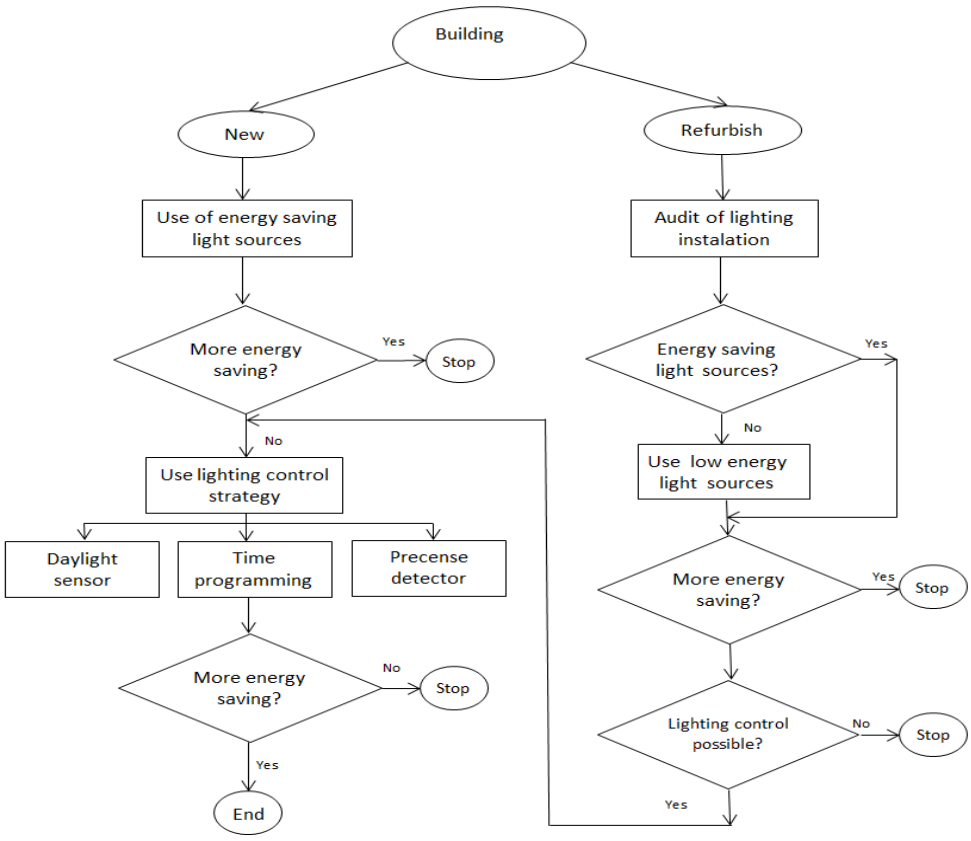

Figure 3. General scheme for energy efficient design of lighting control.

For that reason, is important to take design of lighting systems increased attention. However, not only after aspects of energy efficiency, which will ultimately brings also financial savings for consumers, but mainly with a view to ensuring a safe working environment for employees. Energy-efficient lighting solutions for industry can help to reduce environmental impact and save on costs, at the same time as increasing quality and productivity.

6. Conclusion

Based on a synthesis of theoretical assumptions and practical verification options to streamline lighting systems engineering operations is presented in the paper designing methodical process economic and energy-efficient lighting systems. Processed methodology served as the basis for drawing up. Within this methodology were conducted measurements of parameters of lighting in production areas of engineering establishments, which were found unsatisfactory. After analysing quantitative and qualitative parameters and variants with respect to options to achieve energy savings have been processed variants linked with the steering system and regulation lighting. For the draft to

arrive at a solution that provided a reduction of energy consumption by half at double the amount of illuminance values in operation, which is how we assume sufficient results in search of rationalization measures with regard to the reducing energy consumption. It is essential that in future lighting design practices, maintenance schedules and life cycle costs will become as natural as illuminance calculations already are. A sustainable lighting solution includes an intelligent concept, high quality and energy efficient lighting equipment suitable for the application, and proper controls and maintenance in the industrial interiors. Today new components are coming on the market like smart windows and intelligent automatic blinds that allow obtaining significant energy savings. The lighting management/control systems can easily be associated with others technical equipments (HVAC - Heating, ventilation, and air conditioning) can be done to decrease energy consumption and improve general comfort. Such solutions can allow industrial workshops operator to provide the right amount of light where and when it is needed. The complexity of the lighting system with blinds, air condition and others so becomes essential for a good integration and using not only in industry but in various living indoor. Although somewhere the lighting control systems do not run as expected or do not work at all because they were improperly installed or because the facility managers or occupants do not understand them, the right commissioning process will reduce these problems and contribute to energy saving generally. The article should contribute to the solve of energy saving problem - as a major aim of the future industrial development. The gaol of this article was to emphasize the importance of the energy sources, to show the methodology of energy saving and efficient illumination applicable in automobile industry, too that can reduce the impact of CO_2 emissions on the environment and save energy costs, as well as total costs. With global climate change and looming reality, designing low energy buildings needs to consider capricious climate variations at play.

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