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HABILITATION THESIS
– ABSTRACT –

INTEGRATIVE LIGHTING

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Integrative lighting take into consideration visual, emotional and biological effects of the lighting system on humans. This concept replace the older approach 'human centric lighting' and it is a change of paradigm which no longer is limited to the quality of lighting system (illuminance level, uniformity, glare limitation, colour rendering and colour temperature), energy efficiency (energy consumption reduction, increasing of the luminaire luminous efficacy, control system etc.), to architectural approach (luminaire design, architectural concept) but take into consideration also non-visual aspects (impact on circadian rhythm and subsequently on human health and wellbeing). This new approach of lighting has a direct influence on lighting system sustainability, which is more than visual comfort and energy consumption as it involves the impact on human health and environment.

New assessment systems for green buildings as BREEAM and LEED, take into consideration the reduction of light pollution and of blue light, and the impact on environment for the whole life cycle of the lighting system. The switch from discharge lamps to LED lamps meant not only the removal of mercury from fault lamps, but also new challenges, due to the inhibitor effect of the blue light (typical for LED lamps) on melatonin secretion.

Chapter 1 ,Why are so important lighting/darkness?' presents different points of view related to this topic, including sociological one. This chapter presents a short story of the lighting, including the evolution of public lighting in Romania, and the relation between lighting/darkness and religions.

Chapter 2 ,Lighting measurements campaigns in Romania' is related to educational buildings, but also to Romanians airports and started from the observation that illuminance level, uniformity and colour rendering index do not comply with SR EN 12464 and NP 061-2022 requirements. Lighting measurements done in non-retrofit buildings, showed that unfortunately they do not comply and the values of the maintained average illuminance from most of the classrooms from schools and high-schools are between 119 lx – 243 lx, under the required level of 300 lx, and in the case of university buildings vary from 208 lx – 413 lx, under the required level of 500 lx. In the case of illuminance uniformity, for all measured buildings it is under the required value of 0.6, which means eyes accommodation problems. The correlated colour temperature, it varies from 3000 K to 10000 K, with fluctuations in the same room due to an un-professional lamp replacement from facility management. Regarding colour temperature, Ra index was 70 in most of the rooms with fluorescent lamps. This lighting measurement campaign was intended for data collection for public authorities and for lighting designers involved in retrofit solutions. Starting with 2021, the new version of SR EN 12464 requires 500 lx in schools, and this fact combined with low existing illuminance values may not lead to high reduction in installed lighting power, as it may be expected, but it will increase performance, comfort and wellbeing.

Chapter 3 'Circular economy and life cycle assessment in lighting'. For the moment, lighting industry is still a linear economy, despite extensive use of LEDs, ban of incandescent lamps and fro 2023 of the fluorescent lamps (T8)and declaration of being green and human centric. LED have dramatically changed the lighting industry by enhancing the luminous efficacy of the luminaires by almost 4 times, compared with T8 fluorescent lamps, increased the lifetime by 3-4 times, new opportunities for lighting control systems (including tunnable white – change of colour temperature) and with a bigger role for sensors. Unfortunately, this change of technology produced a huge quantity of lighting waste (lamps and luminaires included) as a total replacement was needed for the old luminaires based on discharge and fluorescent lamps. At the Lighting Engineering Laboratory – LEL from Technical University of Cluj-Napoca we tried to retrofit an old luminaire with four lamps T8 de 18 W with an LED

version, but the final product was an LED luminaire with a luminous efficacy of 57,67 lm/W, which is three times less than the state-of-the-art luminaires (approximative 160 lm/W). Different papers regarding Life Cycle Assessment – LCA were most interested on lamps and conventional ballasts than electronic ballasts and drivers. Thanks to European project Erasmus KA2 HiEduCarbon, for the first time in Romania we manage to assess and interior LED luminaire, produced by VEM Lighting SRL, Bucharest. LCA calculation was performed using One Click LCA software. The results showed that the main contributor of the LED luminaire to GWP-fossil expressed in kg CO_2e is the operational energy consumption with a percentage of 96,046%. The biggest impact on environment during the manufacturing process of the LED luminaire is caused by the aluminium parts, LED module and LED driver.

Chapter 4. 'Future of lighting: technologies and sustainability' explore the future of lighting: in the last 15 years the speed of changes has accelerated, and if in 2010 it was a talk about 'LED-ification', then from 2015 about digitalization, the rhythm has increased a lot. There are few companies that still manufacture luminaires with T5 fluorescent lamps, but all of them are proposing solutions for lighting control, mostly based on DALI protocol. The spot is on the sustainability side of the lighting systems, and this is approached differently by assessment systems Passive House Institute, BREEAM, LEED and WELL. Chapter 4 is focussing on the American systems LEED and WELL, not only because it uses different ASHRAE standards, but also because it takes into consideration the non-visual effects. The introduction of Equivalent Melanopic Lux - EML, an alternative proposed measure which is evaluated based on the intrinsically Photosensitive Retinal Ganglion Cells (ipRGCs) response curve, instead of cone's one. For performance verifications, EML is measured on the vertical plane at the occupant's eye level.

Chapter 5 ,Plans for career's evolution and development' present the implication on different national and European projects. The author is national manager for European projects HiEduCarbon, CoME EAsy, EXCITE and recently RenPlusHomes and member in ENTREC projects: OLGA, NetZeroCities, BluePrint and eUT4ALL, which is an opportunity for future PhD students. The topic of this projects ranges from LCA calculations for products, buildings, and organisations, positive buildings, to lighting solutions for cities decarbonisations. Other directions represented by professional education in the area of lighting, which started in 2012 by the creation of a new occupation: Lighting Specialist. A different direction is the research for new solutions for energy efficiency improvement, including the integration of lighting control systems in the Building Management System, and here there is an ongoing cooperation with companies like Signify, Zumtobel and Erco. The last part is dedicated to a vision related to lighting future and on this topic there are many possible lighting research directions like adaptive photometry, new types of sensors and DC solutions for luminaires powered by PV systems.

My future PhD students need to be prepared to anticipate new directions in lighting, to have a critical vision on different developments, make the difference between company's marketing and field results (based on measurements, research studies available on journals and lighting conferences, in order to have a clear picture). The innovation capacity combined with a trans disciplinary vision will contribute to a new generation of top specialists in the area of integrative lighting.