FRI-K1-1-QHE-10

RESEARCH AND EVALUATION OF LIGHTING SYSTEMS AND LIGHTING DESIGN

Assist. Prof. Teodor Kyuchukov, PhD
Agrarian and Industrial Faculty
Department of Industrial Design
University of Ruse "Angel Kanchev"
E-mail: tkyuchukov@uni-ruse.bg

Abstract: *The paper reviews three approaches for the study and evaluation of the lighting systems. The constructive and holistic approaches are presented with content and concrete realization in lighting design. The aesthetic approach reviews the evaluation of the lighting design using a methodology based on the aesthetic acceptability status. The rating system is represented by a 5-point rating scale – with verbal and numerical evaluation. The evaluation procedure is conducted by independent experts. The individual assessments of experts form a complex assessment. For the different classes of application of the lighting systems, the rating is normalized according to the weight of the aesthetic criterion of the respective class.*

Keywords: *constructive approach, holistic approach, aesthetic approach, evaluation, lighting systems, lighting environmen, lighting design, rating scale, verbal and numerical evaluation, experts, aesthetic criterion, classes of application, ZET-model.*

JEL Codes: *L10, L11*

INTRODUCTION

Contemporary lighting has various manifestations and impacts. As a result the lighting environment should be evaluated in a multifactorial manner through a comprehensive evaluation system. The research and the evaluation of modern lighting systems distinguish two leading requirements, covering all fields of lighting – (a) *without energy over-expenditure* – lighting systems are to meet the lighting requirements for a given space, without energy over-expenditure and without compromising visual requirements to the lighting system only in order to reduce energy consumption; (b) *rational use of daylight* – to design and implement sustainable lighting systems with adequate equipment and management, with rational use of the available natural daylight. The harmonious development of the contemporary lighting environment is realized by the implementation of a systematic lighting design methodology, where the human-centric approach is a leading factor [5].

The methodology for the quality of higher education in the field of contemporary lighting design has been developed and presented in the ***GMmQ system*** (Generalized Methodological Model of Quality), [1]. This framework includes six leading dominants, one of which represents the Systemology of the lighting system and the lighting design – the ***SATI system*** (System Approach Towards Illumination), [13]. There several approaches examine the harmony of the lighting environment, three of which are constructive, holistic and aesthetic approaches.

EXPOSITION

1. CONSTRUCTIVE AND HOLISTIC APPROACH FOR RESEARCH AND EVALUATION OF LIGHTING SYSTEMS

The constructive approach is formal, without significant creative input. The constractive approach examines a ceratin object analytically and individually dividing it to its smaller components in order to explain the formation of the whole. The constructive approach is realized in the following sequence of operations: disassembly; identifying the elements without considering their interrelation, interaction, interdependence; accurate reproduction; assembly in the reverse order.

At the heart of the holistic approach is the understanding attributed to *Aristotle* that *"The whole is more than the sum of its constituent parts."* The holistic approach considers the object in its integrity, in its wholeness. It is a creative approach, based on the principle of a single whole, examined not only as a mechanical sum of its smaller components, but also in accordence to their interrelation, interaction, interdependence. The construction follows not only a technical organization order but it

also gives expression to a certain idea, a philosophy. The creative nature of the holistic approach allows for a comprehensive examination of the whole structure and its elements. It allows to manifest the synergy in the Gestalt (the good form), the synergetic interaction of the elements belonging to the whole.

The ***Automotive Lighting Sculpture concept (ALSc),*** [7,8,9] is a philosophical idea that examines the synergy between light and form. Morever, it explores the impact of the existing issues like the light pollution and the visual glare, two phenomena that have arisen as a result of the lack of creative symbiosis between road (street) and automotive lighting in the age of a rapid technological progress. The ALS concept reveals the hypothesis of the emergence of so-called *"engaged light"* and *"light information field"* leading to the development of the light organization pyramidal model (Fig. 1).

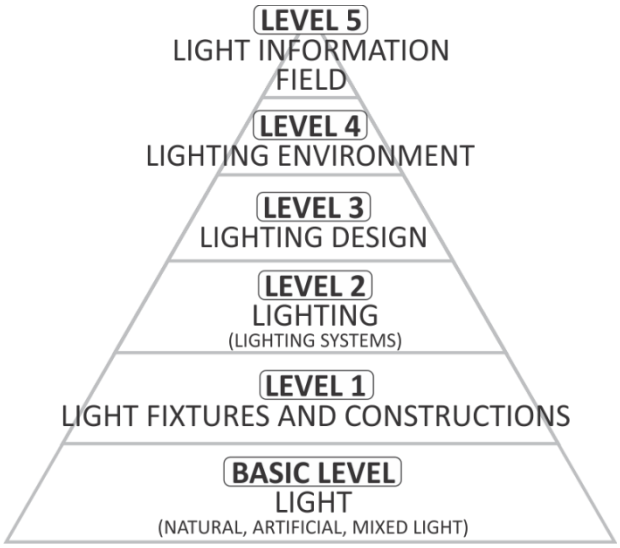

Fig. 1. Light organization pyramidal model

The levels of light organization are formulated according to the hierarchy of their development and scope of impact. The light organization starts with *the basic level* that represents the both natural and artificial light sources, with the emission of free generated light. The *first level* of the light organization belongs to the light fixtures and structures and their constituent elements: light sources, optical system, structural elements, electrical conductors and more. The *second level* of the light organization relates to the lighting (the organized light) that meets the technical quantitative and qualitative standards. The *third to fourth levels* of light organization include the design of lighting and the presence of harmonious lighting environment. The lighting environment provides and fulfils complex technical and aesthetic requirements, to the point of reaching the state of visual comfort.

The *fifth level* of the light organization introduces the semantic nature of light, as a source and carrier of information, with the introduction of the so-called "*light information field"* (including the *"intelligent lighting metacommunication"* and the *"ZET model"*). The ZET model (Fig. 2) included in the fifth level *"Light Information Field"* is an evolutionary step of the understanding of the light harmony. The model introduces a low level of chaos, corresponding to the state of light comfort and a high level of chaos, which determines the presence of light pollution and global overillumination. There has been also pointed out a phenomenon called *"harmony of light chaos"* describing a number of existing systems that often work individually to achieve one and the same goal. The ZET model represents the development of an existing model ([6], Figure 2.11, Hopkinson & Collins).

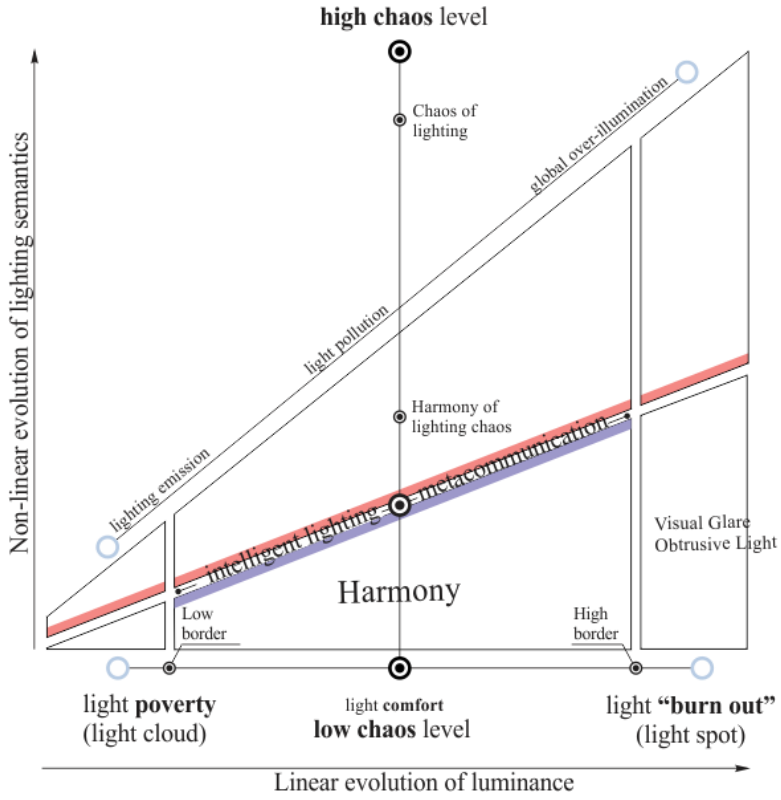

FIG. 2. The ZET-model. Introducing the intelligent (elegant) light metacommunication. An evolutionary step in the understanding of light harmony.

2. AESTHETIC APPROACH

2.1. AESTHETIC ASSESSMENT OF LIGHTING SYSTEMS.

The methodology for assessing the light systems aesthetics is related to the development of the light harmony. The evaluation system is based on the status of aesthetic acceptance. It can be used to evaluate different types of lighting, including industrial lighting, public outdoor lighting, and others. The system for the aesthetics evaluation of lighting products is based on a ***5-point scale*** - with verbal and numerical status (Table 2), [1].

Table 2

Assessment of lighting systems by the factor of aesthetic acceptance

AESTHETIC ACCEPTANCE		
Verbal evaluation	**Aesthetic acceptance status**	**Numerical evaluation**
HGH GRADE	Positive status of complete aesthetic acceptance.	5
VERY GOOD GRADE	Positive status of aesthetic acceptance.	4
GOOD GRADE	Positive status of partial acceptance.	3
SATISFACTORY GRADE	Negative status of partial aesthetic non-acceptance	1
POOR GRADE	Negative status of complete aesthetic non-acceptance.	0

The evaluation procedures are conducted by a group of at least five independent experts specialising in the field of industrial design (with lighting design experience) who are included in a national expert list and are selected at random [2,4,14,15]. The scores are given according to the rating scale presented in *Table 2*. The individual assessment $N_{5j,k}$ of each of the members of the expert group $k = 1 \ldots p$, forms the arithmetic mean score according to the criterion N,j which is set when making the final decision on the procedure for each of the participants $(j = 1 \ldots m)$:

$$N_{5,j} = 1/p \sum_{j=1\ldots m;\ k=1\ldots p} N_{5,j,p} \quad (1)$$

For the different classes, this rating is normalized according to the weight of the aesthetic criterion of the respective class.

2.2. CLASSES OF THE OUTDOOR ARTIFICIAL LIGHTING

In the implementation of the public outdoor artificial lighting, the functional and decorative factors have a variable behavior that depends primarily on the type of visual tasks that will be performed and on the purpose of the respective lighting system. *Table 3* shows the classes of application of outdoor artificial lighting related to the evaluation of different outdoor lighting systems: in accordance with the dominance of their functional and decorative purpose; with specification of their practical application.

Table 3
Classes of outdoor artificial lighting

APPLICATION CLASSES

Class	Characteristics of dominance	Application	Specifics of the application
CLASS 1	Dominance of the functional application	Streets in small sparsely populated settlements	For example, settlements with damping functions
CLASS 2	Dominant presence of the functional application and slight influence of the decorative element.	Collecting and servicing street lighting network. Centers, communication areas.	Including. inter-block spaces, playgrounds, etc.
CLASS 3	Parity between the functional and decorative application	Central and regional urbanized areas, representative and commercial streets, boulevards, squares.	Crowded places, a wide range of activities (state, municipal, public, commercial, educational, etc.).
CLASS 4	Dominant presence of the decorative application of lighting and slight influence of the functionality.	Lighting in pedestrian zone. Information lighting. Advertising lighting.	Implementation of the visual communication process.
CLASS 5	Domination of the decorative application.	Architectural and decorative lighting. Advertising lighting.	Places to relax and enjoy.

Table 4 represents an weight criteria assessment system of the outdoor artificial lighting, by the application classification according to the dominance of the functional and decorative factors.

Table 4
The relative weight of the criteria evaluated according to the class of application of outdoor artificial lighting

WEIGHT CRITERIA ASSESSMENT

Class	Class characteristics	RELATED WEIGHT (%) OF THE CRITERIA, ACCORDING TO THE CLASS OF APPLICATION OF THE OUTDOOR ARTIFICIAL LIGHTING			
		PRICE	ENERGY EFFICIENCY	TECHNICAL INDICATORS AND PERFORMANCE	AESTHETICS AND LIGHTING DESIGN
CLASS 1	Dominance of the functional application	50	25	20	5
CLASS 2	Dominant presence of the functional application and slight influence of the decorative element.	45	25	20	10
CLASS 3	Parity between the functional and decorative application	40	10	10	40
CLASS 4	Dominant presence of the decorative application of lighting and slight influence of the functionality.	35	5	20	40
CLASS 5	Domination of the decorative application.	20	5	20	65

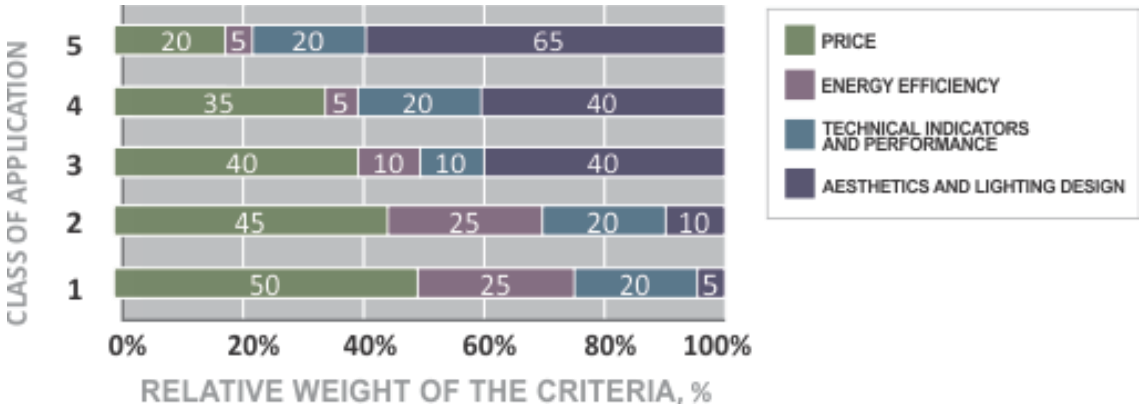

Figure 3. Comparative diagram of the criteria weights for the lighting classes

CONCLUSION

Modern lighting systems are undergoing a period of rapid technological progress, leading to the formation of a lighting environment far beyond the expectations that the society would share less

than two decades ago. The development of the lighting technology calls into question issues that are of particular importance today, such as the light pollution and the visual glare, and the global overillumination. These problems are to be solved with new creative approaches. A number of studies have shown that the artificial light must be used rationally, and that rationality must correspond to the level of intellectual and scientific development. Will light take on a new role in people's lives?

REFERENCES

Kyuchukov T. (2018). GMmQ. Generalised Methodical Model of the Quality of Higher Education. The Seventh Balkan Conference on Lighting, Balkan Light 2018., 20-22 september 2018, Varna, Bulgaria, Proceedings, p. 218-233 (ISSN 2603-414-X, (www.conference.nko.bg), [1].

Kyuchukov T. (2017). Lighting Technology and System Lighting Design in Industry 4.0 and Internet of Things. 56th Science Conference of Ruse University, 2017; Proceedings of University of Ruse, Quality Assurance in Higher Education Bulgaria, volume 56, book 9, p. 110-115 (***Оригинално заглавие*:** Кючуков Т. Светлинната технология и системният светлинен дизайн в индустрия 4.0 и Интернет на нещата ((IoT). 56та Научна конференция на Русенския университет, България, 2017; Научни трудове на Русенския университет, Качество на висшето образование, 2017, том 56, серия 9. Качество на висшето образование. с. 110-115, FRI -K1-2-QHE-09 (ISSN 1311-3321), (www.conf.uni-ruse.bg), [2].

Pencheva V., H. Beloev, R. Kyuchukov, T. Kyuchukov. Lighting and Light design in the Context of Standards and Guidelines for Quality Assurance in the European Higher Education area (ESG). Jurnal "Energy Forum", 2017, N 23/24, p. 19-28 (***Оригинално заглавие***: Пенчева В., Х. Белоев, Р. Кючуков, Т. Кючуков. Осветлението и светлинният дизайн в контекста на стандарти и насоки за осигуряване на качеството в Европейското пространство за висше образование (ESG). Сп. „Енергиен форум", 2017, N 23-24, с. 19-28) (ISSN 1313-2962), [3].

Kyuchukov, T. The Synergy Bridge. Energetics and Aestetics in Lighting. Jurnal "Energy Forum", 2017, N 23/24, p. 8-18 (***Оригинално заглавие***: Кючуков Т. Синергическият мост. Енергетика и естетика в осветлението. Сп."Енергиен форум", 2017, №№ 23/24, с. 8-24) (ISSN 1313-2962), [4].

Kyuchukov T. (2016). System "Human – Lighting Environment" in the Lighting Design. Energy Forum, Varna, Bulgaria, Proceedings, part two, 2, p. 23-25 (ISSN 2367-6728). (***Оригинално заглавие***: Кючуков Т. Системата „Човек – светлинна среда" в светлинния дизайн", Енергиен форум 2016. Сборник, част Втора, Варна, 2016, с. 23-25 (ISSN 2367-6728), [5].

Boyce P.R. (2014). Human factors in Lighting.Third edition. CRC Press, Taylor & Francis Group, LLC, 2014 (ISBN 978-1-4398-7488-2), [6].

Kyuchukov T. (2018). Vivals Periphery. Manifest of the Sculptural Fractal. Mediateh-Pleven, University of Ruse Publishing Centre, 2018, [7].

Kyuchukov T. Automotive Lighting Sculpture. Definition and Realization. Автомобилна светлинна скулптура. Концепция и реализация. 9th International Congress "Machines, Technologies, Materials" 19 - 21.09.2012, Varna, Bulgaria. Machines Technologies Materials. International virtual journal for science, technics and innovations for the industry. Year VI, Issue 10/2012 (ISSN 1313-0226), p. 52-55, [8].

Kyuchukov T. Automotive Lighting Sculpture. Born Beyond Existing Borders. Известия на съюза на учените – Русе, том 12, 2015 (Proceeding of the Union of Scientists Ruse, 2015) (ISSN 1311-106X), с. 98-107, [9].

Gregory R. L. Eye and Brain. The psychology of seeing. Fifth Edition, Oxford University Press and Princeton University Press, [10].

Кючуков Р. Системологични и семантични основи на светлинния дизайн. Автореферат на дисертация за присъждане на образователна и научна степен „Доктор". Русенски университет „Ангел Кънчев", 2012, [11].

Кючуков Т. Светлинно моделиране на светлинната среда. Управление на изкуственото осветление. Light Modeling of the Light Environment. Management of Artificial Lighting. Енергиен форум 2012, Варна, 2012, с. 496-502, [12].

Kyuchukov T. Systematic And Methodical Approaches To Lighting Design. "SATI" System. Методични подходи на системния светлинен дизайн. Система "SATI". 9th International Congress "Machines, Technologies, Materials" 19 - 21.09.2012, Varna, Bulgaria. Machines Technologies Materials. International virtual journal for science, technics and innovations for the industry. Year VI, Issue 10/2012 (ISSN 1313-0226), p.p. 3-4, [13].

Kyuchukov T. Methodology of the Aesthetic Quality Assessment of Lighting Systems in Public Procurement.Energy Forum 2014, Proceedings, Varna, p. 352-365. (***Оригинално заглавие***: Кючуков Т. Методология на естетическата оценка на светлинни системи за обществените поръчки. Енергиен форум 2014, Сборник доклади, Варна, 2014, стр. 352-365), [14].

Kyuchukov T. Contemporary street lighting. TD Installations, 2012, № 3 (ISSN1314-3492), p. 24-27 (***Оригинално заглавие***: Кючуков Т. Съвременно улично осветление. ТД Инсталации, 2012, № 3 (ISSN1314-3492), с. 24-27), [15].