PROCEEDINGS

OF THE

LUX EUROPA 2017

European Lighting Conference

September 18-20, 2017

Ljubljana Slovenia

Lighting for modern society

Organised by

SLOVENSKO DRUŠTVO ZA RAZSVETLJAVO / SDR
LIGHTING ENGINEERING SOCIETY OF SLOVENIA

PROCEEDINGS

of the

Lux Europa 2017 Conference

Lighting for modern society

Hotel Union, Ljubljana, Slovenia
18-20 September, 2017

Lux Europa 2017
Year: 2017 ISBN 978-961-93733-4-7

Editorial Office
Lighting engineering society of Slovenia
Tržaška cesta 25, SI1000 Ljubljana
E-mail: matej.kobav@fe.uni-lj.si

Editor and Technical editor
Matej B. Kobav, University of Ljubljana, Slovenia

Lighting engineering society of Slovenia, Ljubljana, Slovenia
USB stick: 180 pieces

CIP - Kataložni zapis o publikaciji
Narodna in univerzitetna knjižnica, Ljubljana

628.9(082)(0.034.2)

EUROPEAN Lighting Conference (2017 ; Ljubljana)
Lighting for modern society [Elektronski vir] : proceedings of the Lux Europa 2017 / European Lighting Conference, September 18 - 20, 2017, Ljubljana, Slovenia ; organised by Slovensko društvo za razsvetljavo - SDR, Lighting Engineering Society of Slovenia ; [editor Matej B. Kobav]. - Ljubljana : Lighting Engineering Society of Slovenia, 2017

ISBN 978-961-93733-4-7
1. Gl. stv. nasl. 2. Kobav, Matej Bernard 3. Slovensko društvo za razsvetljavo
291707648

LUX EUROPA 2017
Lighting for modern society

Conference chair
Grega Bizjak, Slovenia

Local organising committee
Matej B. Kobav, Slovenia

Lux Europa Board of directors
Peter Dehoff (Austria)
Arnaud Deneyer (Belgium)
Laura Bellia (Italy)
Theo Mackaay (The Netherlands)
Wlodzimierz Witakowski (Poland)
Dionyz Gasparovsky (Slovak Republic)
Grega Bizjak (Slovenia)
Mario Rechsteiner (Switzerland)
Mehmet Kucukdogu (Turkey)
Peter Thorns (United Kingdom)

Lux Europa Paper Committee
Alex Rosemann
Alpin Yener
Anna Pellegrino
Arnaud Deneyer
Axel Stockmar
Banu Manav
Christoph Schierz
Dionyz Gasparovsky
Dusan Katunsky
Francesca Fragliasso
Grega Bizjak
Guy Vandermeersch
Jozef Hraska
Laura Bellia
Laura Blaso
Martin Lopusniak
Matej B. Kobav
Matteo Seraceni
Maurizio Rossi
Miomir Kostič
Peter Thorns
Piotr Pracki
Raisa Stolyarevskaya
Rengin Unver
Richard Kittler
Roman Dubnicka
Sermin Onaygil
Stanislav Darula
Valerio Lo Verso

Lux Europa Council
Peter Dehoff, Austria
Arnaud Deneyer, Belgium
Aljosa Sribar, Croatia
Karel Sokanski, Czech Republic
Bernard Duval, France
Axel Stockmar, Germany
Péter Schwarcz, Hungary
Halldor Steinsen, Iceland
Laura Bellia, Italy
Geertje Hazenberg, Netherlands
Wlodzimierz Witakowski, Poland
Dorin Beu, Romania
Anatoliy Chernyak, Russian Confederation
Miomir Kostić, Serbia
Dionyz Gasparovsky, Slovak Republic
Grega Bizjak, Slovenia
Antonio Corrons, Spain
Mario Rechsteiner, Switzerland
Mehmet Kucukdogu, Turkey
Peter Thorns, United Kindom
Frangiskos Topalis, Greece

Sponsors


Reverberi
Enetec

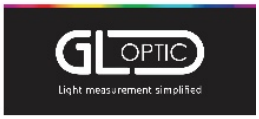

intra lighting
all visible


GE


LUMENIA
Think green, think better!


Strip's


zumtobel group


GL OPTIC
Light measurement simplified


ledluks
lighting solutions


Instrument
Systems
KONICA MINOLTA Group


VELUX®


JETI


luxtella


ILUMIPAN

Monday, September 18

8:00-18:30 Conference registration/Foyer

9:30-10:30 Opening Session

Moderator: **Grega Bizjak,** Slovenia

Room: White Hall (I+II+III)

- **Transnational Lighting Detectives**
  Aleksandra Stratimirović

11:00-12:30 Plenary session

Moderator: **Andrej Orgulan,** Slovenia

Room: White Hall (I+II+III)

- **"European Lighting Expert" - the European standard for knowledge in lighting**
  Matthias Hessling
- **Does higher illuminance encourage reassurance that it is safe to walk? Comparing different methods of analysis**
  Steve Fotios
- **Effective radiant flux for non-visual effects – is the illuminance and the melanopic irradiance at the eye really the right measure?**
  Kai Broszio
- **TM-30-15 and CIE-CRI-Ra: Investigation of colour rendering of white pc LEDs**
  Karin Bieske

13:30-15:30 Standards and regulation

Moderator: **Peter Dehoff,** Austria

Room: White Hall (II+III)

- **The International Lighting Vocabulary (ILV) – yesterday, today, tomorrow**
  Peter Zwick
- **The new EN 15193-1 to calculate the energy performance for lighting in buildings: analysis and application to reference building types**
  Chiara Aghemo | Laura Blaso | Simonetta Fumagalli | Valerio R.M. Lo Verso | Anna Pellegrino
- **Lighting role in green building rating systems: comparison between different assessment criteria in an Italian building**
  Laura Bellia | Francesca Fragliasso | Maria Maddalena Egger | Marina Mazza
- **The Interreg Project Dynamic Light**
  Axel Stockmar
- **Outdoor Adaptive Lighting in the new UNI 11248 Italian standard and results of experience**
  Paolo Di Lecce
- **Comparison of Different Methods of Distribution Factor Calculation**
  Peter Raynham | Peter Thorns

- **Documentation of Lighting Design**
  Dionyz Gasparovsky | Roman Dubnicka

13:30-15:30 Exterior lighting

Moderator: **Dionyz Gasparovsky,** Slovakia

Room: White Hall (I)

- **Mainstreet of Waldenburg (CH) "A non-everyday lighting solution"**
  Mario Rechsteiner

- **Multi-variable light distribution in road lighting increases safety and reduces the energy demand**
  Stephan Voelker | Juri Steblau

- **A New Dimming Control Scheme of LED Based Streetlighting Luminaires Based on an Embedded LED Model Implemented on an IoT Platform to Achieve Constant Luminous Flux at Different Ambient Temperatures**
  János Hegedüs | Péter Horváth | Tamás Szabó | András Szalai | András Poppe

- **A urban lighting renovation project to optimize environmental performance and reduce energy consumption: results of a measurement campaign**
  Anna Pellegrino | Gabriele Piccablotto | Rossella Taraglio | Dario Fisanotti | Alessandra Paruzzo | Gianpaolo Roscio

- **Metrology of road surface for smart lighting**
  P. Iacomussi | G. Rossi | P. Blattner | C. Chain | G. Gallee | T. Kubarsepp | M. Lindgren | F. Manoocheri | C. Van trang | P. Zehntner

16:00-17:00 Poster presentation

Moderator: **Peter Zwick,** Austria

Room: White Hall (II+III)

PPM01 • **Measuring Sustained Attention and Mood: Effects of Correlated Color Temperature**
Rengin Kocaoglu | Nilgün Olguntürk

PPM03 • **Comparison of the measurement methods of road lighting**
Roman Dubnicka | Lukas Lipnicky | Dionyz Gasparovsky

PPM04 • **Measurement of luminaires for road lighting**
Lukas Lipnicky | Roman Dubnicka | Dionýz Gašparovský

PPM05 • **Problems identified during measurement and assessment of blue-light hazard from arc welding process**
Andrzej Rybczyński | Agnieszka Wolska | Janusz Pikuła | Tomasz Pfeifer

PPM06 • **Improvement of monitor calibration using other than CIE 1931 Color Matching Functions**
Steffen Goerlich, Lev Bakhrakh

PPM07 • **Review of state of the art and new measurement methods for the determination of the reflection properties of road surfaces**
Sandy Buschmann

PPM10 • **Results from Monitoring the Energy Certification of Lighting in Buildings**
Dionyz Gasparovsky | Jana Raditschova | Peter Janiga

PPM11 • **Lighting Culture**
Károly Zsolt Molnár | Renáta Rebeka Szabó | József Nádas

16:00-17:00 Poster presentation

Moderator: **Stanislav Darula,** Slovakia

Room: White Hall (I)

PPM12 • **Beleuchtungstechnik 4.0 - The 4th Edition of a Lighting Education Book**
Dirk Seifert | Meike Barfuß | Alexander Rosemann

PPM16 • **Visual comfort evaluation methods in residential buildings: a simulation-based study**
Mandana Sarey Khanie | Milena Ślipek | Anders Thorseth | Daria Zukowska | Jakob Kolarik | Toke Rammer Nielsen

PPM17 • **First outcomes of an investigation about Daylighting knowledge and education in Europe**
Federica Giuliani | Natalia Sokol | Valerio R.M. Lo Verso | Federica Caffaro | Raquel J. A. V. Viula

PPM18 • **What's the matter with multi-layers facades?**
Bernard PAULE | Marine BERGES | Robert CELAIRE

PPM21 • **Advances in daylight simulation – validation and applications**
David Geisler-Moroder | Wilfried Pohl

PPM22 • **Tubular light-guide under broken cloud array – working plane illumination**
Ladislav Kómar | Miroslav Kocifaj

PPM23 • **Measuring daylight properties with five TCS230 sensors**
Klemen Zalokar | Matej B. Kobav

17:00-18:30 Poster viewing

Room: Foyer

Poster Number	Paper & Authors
PM01	Simplified model of spectral distribution of daylight in interior of the building Roman Dubnicka | Lukas Lipnicky
PM02	Preliminary experimental evaluation of electrotropic windows in a full scale test facility Sergio Sibilio
PM03	The optimal luminous intensity curves of luminaries for roadway lighting Jan Škoda
PM05	Lighting for cyclists: An eye tracking study in natural settings to investigate where they look Hussain Gasem | Jim Uttley | Steve Fotios
PM06	The role of ambient light level in accidents at pedestrian crossings Steve Fotios | Jim Uttley

PM07	A novel method for demonstrating that light encourages pedestrian activity Steve Fotios | Jim Uttley | Scott Fox | Hussain Gasem
PM08	Spectral reflectance of Argentinean road surfaces Pablo Ixtaina
PM09	Refurbishment of Lighting Systems in Kindergardens – Case Studies for Bratislava Dionyz Gasparovsky | Jana Raditschova
PM10	Concept of lighting system for experimental studies in interiors Piotr Pracki | Michal Dziedzicki
PM11	Indoor lighting: how a reflector can improve performance and how to assess it Simonetta Fumagalli | Laura Blaso | Giuseppe Leonardi | Adriano Antonelli | Diego Diaz Sanudo
PM12	Effects of high-purity LED light colors on time-sense perception Hiroshi Takahashi | Hayato Kikuchi
PM13	On the correlation between SQM data and zenith brightness Jaromír Petržala | Miroslav Kocifaj

20:30-22:00 Light Guerrilla - opening

Location: Trnovo park/Gradaščica, a park between Riharjeva, Finzgarjeva and Barjanska cesta
GPS: N46 02.604 E14 29.952

20:30 Opening of Light Guerrilla
21:30 Dance Performance: Liza Šimenc & Urša Rupnik: Meduza

Tuesday, September 19

8:00-18:30 Conference registration/Foyer

9:30-10:30 Plenary Session

Moderator: **Axel Stockmar,** Germany

Room: White Hall (I+II+III)

- **SenCity – Evaluating users' experiences of intelligent lighting for well-being in smart cities**
  Henrika Pihlajaniemi | Eveliina Juntunen | Anna Luusua

- **An Evaluation Method for Façade Renovation Strategies in Residential Buildings Using Gaze Responsive Visual Comfort Assessments**
  Mandana Sarey Khanie | Ślipek, M. | Zukowska D. | Kolarik J. | Nielsen T.R.

- **Exploring interaction with office lighting: a case study**
  Daria Casciani | Maurizio Rossi | Fulvio Musante | Simonetta Fumagalli

10:30-11:00 Coffee Break

11:00-12:30 Energy efficiency

Moderator: **Alexander Rosemann,** Netherlands

Room: White Hall (II+III)

- **Estimation of the Energy Efficiency Potential in Street Lighting in Serbia**
  Sabine Piller | Siegfried Brenke | Zoran Kapor

- **Experimental investigation of the correlation between power consumption and luminous flux of LED luminaires in adaptive road lighting**

Dimitris Panagiotis T. Nikolaou | Constantinos A. Bouroussis | Frangiskos V. Topalis

- **DALEC – evaluation tool for an integrated planning approach**
  Oliver Ebert | David Geisler-Moroder | Matthias Werner

- **Energy Efficient Lighting in University Buildings**
  Dorin BEU | Calin CIUGUDEANU | Andrei CECLAN

11:00-12:30 Measurements and photometry

Moderator: **Denan Konjhodžić,** Germany

Room: White Hall (I)

- **Luminance maps from High Dynamic Range imaging: calibrations and adjustments for visual comfort assessment**
  PIERSON Clotilde | WIENOLD Jan | JACOBS Axel | BODART Magali

- **"FluxGage" A Photometric Test System for LED Luminaires Based on Solar Panels**
  Christian Dini | Simon Rankel

- **Influence of measuring equipment parameters on recorded luminance values in context of glare measurements**
  Sebastian Slominski

- **On site photometric characterisation of concrete pavements with COLUROUTE device**
  Valérie Muzet | Joseph Abdo

- **Mobile methods of rated lighting parameters of illumination measurement - luminance and illuminance**
  A.B. Kuznetsova | M.A. Fedorishchev | A. Sh. Chernyak | A. G. Shakhparunyants

13:30-15:30 Lighting for human and their needs

Moderator: **Laura Bellia,** Italy

Room: White Hall (II+III)

- **Exploration of light-induced variations in cognitive task performance in real life**
  Karin Smolders | Yvonne de Kort

- **The impact of dynamic lighting on cognitive processes**
  Oliver Stefani | Liselotte Ilg | Achim Pross | Herbert Plischke

- **The myth of Baker-Miller pink: Effects of colored light on physiology, cognition and emotion**
  Oliver Stefani | Susanne Reithinger | Christoph Grabmaier | Achim Pross | Anke Huckauf

- **Illumination needs of patients with low vision**
  Kazim Hilmi Or

- **Artificial vision patients' illumination needs**
  Kazim Hilmi Or

- **Acute Diurnal Non-image Forming Effects of Light in Middle-aged Participants**
  Laura Huiberts | Karin Smolders | Yvonne de Kort

- **Health effects of biodynamic lighting in a clinics**
  Wilfried Pohl | Markus Canazei | Katrin Tanzer | Johannes Weninger

- **Influence of light condition on medication care in a hospital**
  M.P.J. Aarts | H.S.M. Kort | A.L.P. Rosemann | E.J.van Loenen

13:30-15:30 Exterior lighting

Moderator: **Péter Schwarcz,** Hungary

Room: White Hall (I)

- **Determination of veiling luminance for peripheral visual objects**
  Carolin Tatulla | Oliver Maak | Stefan Wolf | Christoph Schierz

- **Discomfort Glare caused by several LED sources**
  Joffrey Girard | Céline Villa | Roland Bremond

- **The treatment of light scattering in a volume and application to foggy traffic situations**
  Michael Marutzky

- **Disability and discomfort glare caused by today's automotive headlamps in interaction with road conditions**
  Kleinert, B. | Bogdanow, S. | Marutzky, M.

- **Investigating impediments to drivers' hazard detection ability: fog and sudden switch-off**
  Steve Fotios | Jim Uttley | Chris Cheal | Scott Fox

- **Urban environment illumination impact on user priorities and respond**
  Melita Rozman Cafuta

- **Does pedestrian useful visual field change at night?**
  Navaz Davoudian | Peter Raynham

- **Does lighting affect pedestrian flows? A pilot study in Lund, Market Harborough and Dublin**
  Jemima Unwin | Phil Symonds | Thorbjorn Laike

16:00-17:00 Poster presentation

Moderator: **Dorin Beu,** Romania

Room: White Hall (II+III)

PPT01 • **The effect of daylight on the elderly population**
Lorna Minu Flores Villa | Jemima Unwin | Peter Raynham

PPT03 • **Gender- and age-related preferences of the lighting conditions for activity and recovery**
Susanne Schweitzer | Clemens Schinagl | Gordana Djuras | Matthias Frühwirth | Hans Hoschopf | Friedrich Wagner | Birgit Schulz | Wolfgang Nemitz | Vincent Grote | Sybille Reidl | Paul Pritz | Maximilian Moser | Franz Peter Wenzl

PPT06 • **Daylight dependent, seasonal patterns in industrial incident data**
Jan Krüger | Holger Reyhl | Jens Kinne

PPT07 • **Age Difference in Comfortable Lighting -The Evaluation of the Lighting Environment in Real Space**
Oe Yuki | Inoue Youko

PPT10 • **An investigation on lighting matter in design guides of educational buildings**
Kasim ÇELIK | Rengin UNVER

PPT11 • **The Relationship Between Energy Saving and Visual Comfort in Different Lighting Sources**
Banu Tabak Erginöz | Yavuz C

PPT13 • **Optimization of lighting power consumption in buildings**
Tomaž Novljan | Janez Rihtar

PPT14 • **Illumination Levels for Office Work in Thailand: Standards vs Occupants' Perspective**
Tharinee Ramasoot | Satta Panyakaew

16:00-17:00 Poster presentation

Moderator: **Mario Rechsteiner,** Swiss

Room: White Hall (II+III)

PPT15 • **BIM and Lighting Design**
Robert Heinze

PPT17 • **An Expo Box for flicker**
Matjaž Colarič | Matej B. Kobav

PPT18 • **The engineering assessment of floodlighting designs**
Krzysztof Skarżyński

PPT19 • **Smart design of thin direct-lit luminaires**
Christian Sommer | Claude Leiner | Ladislav Kuna | Frank Reil | Paul Hartmann | Franz Peter Wenzl

PPT20 • **Using adjustment to evaluate discomfort glare**
Michael Kent | Sergio Altomonte | Steve Fotios

PPT21 • **Color characteristics of two-crystal LEDs for dynamic lighting**
Anna Savitskaya | Ruzana Delyan

PPT22 • **Research Progress on AlGaN-based Ultraviolet Light Emitters**
Jianchang Yan | Junxi Wang | Jinmin Li

PPT23 • **LED and HPS luminaires in Russian greenhouses**
L.B. Prikupets | V.G. Terehov

17:00-18:30 Poster viewing

Room: Foyer

Poster Number	Paper & Authors
PT02	Reducing of blue light hazard Jaroslav Štěpánek | Jan Škoda | Michal Krbal
PT03	Digital Light: Perception of projected visual signal from different perspectives Michael Marutzky
PT04	Realization of a Test Setup for a Smart Light Guiding System with Assistance Functions for Elderly People Christian Eßelmann | Kristin Gabel | Eva Schwenzfeier-Hellkamp
PT05	Experimental LED Luminaire for Investigation of Non-visual Effect of Light to Human Circadian System Mikuláš Parma | Petr Baxant | Jan Škoda
PT06	Study of LED Modulation Effect on the Photometric Quantities of Public Lighting? Karel Sokansky | Tomas Novak | Petr. Koudelka | Radek Martinek
PT07	Possibility of Bandwidth-widening with Luminescent Layer in LED Structures József Nádas | Vilmos Rakovics | István Réti
PT09	Distortion electrical power in the measurement of electrical parameters of luminaires Lukas Lipnicky | Roman Dubnicka | Peter Janiga
PT10	The implementation of the measurement system for measuring the luminous intensity distribution using the imaging luminance measuring device (ILMD) Piotr Michalek
PT11	The Comparison of different types of Spectroradiometers in terms of Uncertainty of measurement Martin Motyčka
PT12	Uncertainty of luminous intensity measurement with short photometric distance Marek Bálský | Petr Žák
PT13	Practical assessment of photobiological safety of light sources based on requirements of standard EN 62471 Andrzej Pawlak

Wednesday, September 20

9:00-10:30 Lighting for human and their needs

Moderator: **Arnaud Deneyer,** Belgium

Room: White Hall (II+III)

- **Office lighting hierarchies – lit surfaces contributing to visual appearance**
  Raphael Kirsch
- **Digital Lighting: A macro-economic view**
  Péter Schwarcz
- **Decision schemes for lighting controls - how to apply the TR 222**
  Peter Dehoff
- **Indoor lighting design with included non-image forming effects**
  Katja Malovrh Rebec | Marta Klanjšek Gunde
- **Environmental effects of wall colours in offices and user preferences**
  Fazila Duyan | Şensin Yagmur | Rengin Ünver
- **The effect of short exposure to coloured light on thermal perception: a study using Virtual Reality**
  Giorgia Chinazzo | Kynthia Chamilothori | Jan Wienold | Andersen Marilyne

9:00-10:30 Measurements and photometry

Moderator: **Karel Sokansky,** Czech republic

Room: White Hall (I)

- **The evaluation of measurement uncertainty of LED luminaire for industrial applications**
  G. Rossi | P. Iacomussi | M. Radis
- **Photometric and colorimetric testing of colour-tunable LED lighting products**
  Leloup Frédéric | Desnouck Pieter-Jan | Lootens Catherine
- **Research Progress on GaN-based LEDs and Solid-state Lighting in China**
  Jianchang Yan | Junxi Wang | Jinmin Li
- **Investigation of Wavelength Changes of the Leds Used for Illumination**
  Vedat ESEN | Bülent ORAL | Şafak SAGLAM
- **Inter Laboratory Comparison of LED Measurements Aimed as Input for Multi-Domain Compact Model Development within an H2020 R&D Project**
  András Poppe | Gábor Farkas | Ferenc Szabó | Julien Joly | Joël Thomé | Joan Yu | Karel Bosschaart | Eveliina Juntunen | Emmanuel Vaumorin | Alessandro di Bucchianico | Thomas Merelle
- **Application of Stray Light Corrected Array Spectroradiometers**
  Denan Konjhodžić

11:00-12:30 Lighting for human and their needs

Moderator: **Peter Thorns,** United Kingdom

Room: White Hall (II+III)

- **Human-centric Lighting**
  Gašper Čož

- **Important aspects of serious HCL – design**
  Klaus Bieckmann

- **Investigating a dose-response curve for daytime**
  Samantha Peeters | Karin Smolders | Ingrid Vogels | Yvonne de Kort

- **Impact of spectrum and illuminance on alertness – a quasi-field study in a lecture hall**
  Inga Rothert | Martine Knoop | Stephan Völker

- **Measurement of the effect of dynamic lighting on alertness, mood and sleepiness**
  Maria Nilsson Tengelin | Stefan Kallberg | Per Olof Hedekvist

11:00-12:30 Daylighting

Moderator: **Marta Klanjšek Gunde,** Slovenia

Room: White Hall (I)

- **A new standard for Daylight : Towards a daylight revolution**
  Arnaud Deneyeer

- **New daylight solutions for energy and health**
  Wilfried Pohl | David Geisler-Moroder | Christian Knoflach

- **Key learnings about daylight performance in demonstration buildings and potential outcomes**
  Jens Christoffersen | Nicolas Roy | Katarzyna Stefanczyk | Neza Mocnik

- **Daylight transmission via hollow light pipes with Fresnel (directional) reflection**
  František Kundracik | Ladislav Kómár | Miroslav Kocifaj | Ágnes Bazsó

- **Electrochromic glazings: Integrated dynamic simulation with DIAL+**
  Bernard Paule | Eloise Sok | Samuel Pantet | Julien Boutillier

13:30-15:00 Lighting for human and their needs

Moderator: **Piotr Pracki,** Poland

Room: White Hall (II+III)

- **Ledification: Revisiting Quality of Light**
  Pieter Seuntiens

- **Study of overhead glare discomfort from downlight luminaires**
  Lou Bedocs | Peter Thorns

- **Receptive field mechanism and pupillary light reflex for the assessment of visual discomfort**
  Gertjan Hilde Scheir | Peter Hanselaer | Wouter Rita Ryckaert

- **Testing Colour-Matching Functions - Perception of luminous color differences of white LEDs in relation to ambient luminous color and age of observers**
  Karin Bieske | Johannes Kolmer | Nicole Stubenrauch | Christoph Schierz | Anja Frohnapfel | Alexander Wilm

- **Office lighting characteristics determining occupant's satisfaction and health**
  Juliëtte van Duijnhoven | Mariëlle Aarts | Alexander Rosemann | Helianthe Kort

13:30-15:00 Daylighting

Moderator: **Tomaž Novljan,** Slovenia

Room: White Hall (I)

- **Metrics to predict visual discomfort in a daylit classroom**
  Raquel Viula | Truus Hordijk

- **Modelling the Luminance Coefficient Uncertainty using a Bidirectional Goniophotometer Facility**
  Alaaeldin Abdelmageed | Stefan Gramm | Stephan Völker

- **The new generation of an artificial sky: Simulating various overcast sky conditions**
  Stanislav Darula

- **High-resolution tilted surface illuminance/irradiance spectral model applicable to arbitrary sky conditions**
  Miroslav Kocifaj | Chris Gueymard

Oral presentations

Posters with presentations

Posters

Exploring Interaction with Office Lighting: a Case Study

Daria Casciani
Fulvio Musante
Maurizio Rossi
Department of Design
Politecnico di Milano
Milan, Italy
daria.casciani@polimi.it, fulvio.musante@polimi.it, maurizio.rossi@polimi.it

Simonetta Fumagalli
DTE-SEN-SCC Laboratory
ENEA
Ispra,Varese, Italy
simonetta.fumagalli@enea.it

Abstract— **Office lighting is fundamental for vision and for increasing wellness and working performances by considering the physiological and psycho-perceptual, the behavioural and social factors in relation to the working environment and activities. More than only functional, lighting is nowadays required to be flexible and customizable almost individually to deliver lighting quality for all. This article would analyse in detail the vantages and disadvantages of implementing LED lighting systems that provide lighting variability and control at a personal level, by describing, evaluating and critically reflecting on the characteristics of a prototype called Asterism realised at the Laboratorio Luce – Politecnico di Milano for technological assessment which was conducted at the ENEA DTE-SEN-SCC laboratory in Ispra (VA).**

Index Terms—**Interaction, Lighting Design, Lighting Prototype, Technological Assessment, User Evaluation**

INTRODUCTION

Office lighting is fundamental for vision, for increasing working performances and wellbeing, considering the physiological, psycho-perceptual and personal factors. In addition to this, the social and behavioural factors should be taken into account due to the contemporary working tasks which require individuals to quickly pass from a focused job (individual tasks of concentration or relax) to team activities (creative collaborations and meeting) [1]. Each of these activities can be performed with different postures and requires different luminous atmospheres, which need to be consistent with the context, the purpose and the performed work activities. The use of new technological tools is inducing new ways to gesture and to work both in the micro space of the human body postures as well as in the workspace [2]-[3]: the multimodal use of different technological devices for reading and working (pc, display, keyboard, tablet, smartphone etc.) is determining different visual field and visual tasks [4]. In addition to this, recent studies about office future trends reveal the importance of creating healthy spaces in which workers can be "energized" or "relaxed" or where they can have breakout periods of "daydreaming" to refresh mentally and to be more productive in the long term [5]. According to this premises, more than only functional, nowadays, lighting is required to be flexible and customizable almost individually in order to deliver lighting quality for all. In order to ensure that individuals are able to experience their favourite luminous atmospheres to accompany different working activities and tasks, lighting should be flexible by providing a certain degree of control in terms of illuminance [6], white correlated colour temperature tuning (Cool White-Warm White CCT) or spectral tuning [7], [8], [9], [10] but also lighting distribution [11] for circadian stimulation, for personal satisfaction [12] with positive outcomes in terms of energy efficiency [13]-[14].

RESEARCH SCOPES

The first wave of LEDification [15] has been already applied in the market, providing retrofit of the traditional illumination systems with LEDs at increased efficacy, reduced costs and enhanced reliability through thermal and optical management. Today, the second wave of the application of LEDs technology is driving the design of digitally controlled lighting systems combined with advanced sensors and data elaboration which allow to change the lighting performances by adapting to the need of those which occupy the illuminated spaces. The correct application of the new SSL technologies and smart lighting systems can have an influence in the human psycho-physiological well-being [16]-[17], concurring in improving the overall quality of life (mood, health, satisfaction) of individuals. Office lighting can influence people cognitive performances at work, improving alertness and vitality, providing better sleep quality [18]

and enhancing the general mood [19], through circadian rhythm activation/suppression. The quality of life of individuals can be enhanced also if they can control their lighting: when people work in environments that can be changed according to their personal preferences, they evaluate the lighting as of higher quality and the offices as more attractive, showing a more positive mood [20].

METHODOLOGY

The lighting performances allowed by the technological advances need to be supported by complex design decisions that should take into account the appropriateness of the lighting to the context and to the needs of the users [21]. This paper seeks to explore the relationship of users with individually customisable luminous experiences.

The LED lighting prototype, ASTERISM, was realized at the Laboratorio Luce – Politecnico di Milano with the research scopes to test the photometric aspects along with the tuning of white lighting, the efficiency and the lighting control. The case studies methodology [22] has been applied to test the activation or suppression of circadian stimulation, for behavioural control, for testing user interactions, for matching the colours with natural lighting (e.g. daylight during day, warmer dimmer light in evening), for cooling or warming the room to counteract exterior temperatures and for tuning lighting atmosphere according to users' preferences.

This article would analyse in detail the lighting performances provided by the LED prototype by describing, evaluating and critically reflecting on the results of the technological assessment conducted at the ENEA DTE-SEN-SCC laboratory in Ispra (VA).

CASE STUDY: ASTERISM

In this prototype, emphasis was put on the modularity of the lighting fixture for the multifunctional desk, adaptable to different working scenarios, from individual to collective working modalities. It is composed by several functional modules which ensure the maximum flexibility of installation in terms of spatial composition and lighting distribution/variation in relation to working activities. Asterism complies with standard EN 12464-1(2011) regarding omnidirectional glare reduction and consists of a supporting structure with connected lighting modules to create a constellation of luminous elements [23].

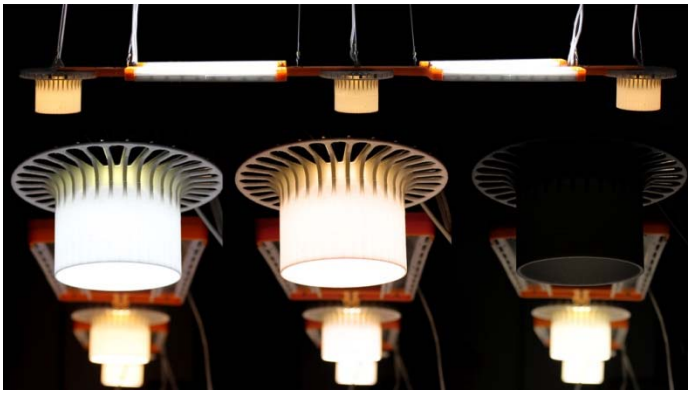


Figure 1. ASTERISM lighting performance: direct –indirect lighting prototype with different CCT and single modules controllability.

The main elements are:

- box for LED driver, Arduino board and XBee Shield mounted on the ceiling;
- three modules for direct illumination (down-light);
- four modules for indirect lighting (light-up);
- management and control system (interface).

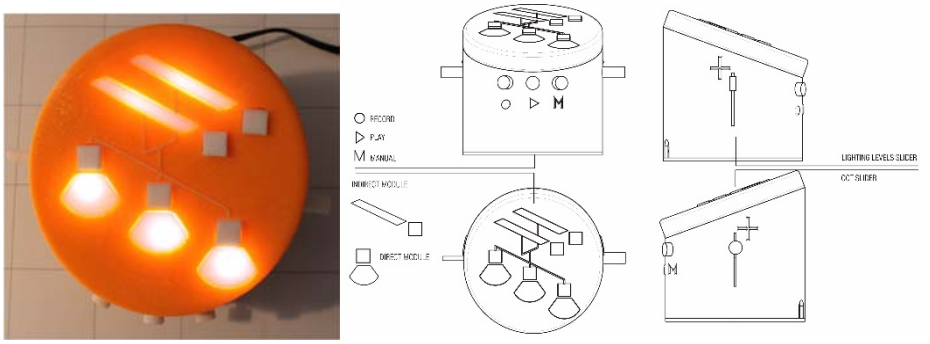


Figure 4. ASTERISM interface and control system

ASTERISM interface allows to control the lighting by selecting different pre-programmed lighting scenes. In addition to this, it allows to turn on and off each lighting module separately. The interface is provided with a visual diagram of switches representing the lighting modules: each switch allows to control manually the CCT (between 3000K and 6500K) and the intensity of each direct and indirect module. As reported in the literature review [24], individuals prefer to save their lighting settings: for this reason the interface was designed to allow to save personal lighting scenes for later recall.

TECHNOLOGICAL ASSESSMENT

A. The Installation

The prototype Asterim has been installed in a room of the ENEA building at Ispra (Italy). The room (4.75m x 5.25m x 2.70m), is provided with daylighting through a wide glass wall facing a big laboratory, the entrance glass door and a window (2m x 0.6 m) located in the upper part of a wall. As the room is located in the North side of the building and there is no direct sunlight. The furniture consists basically of a table (1m x 2m) with chairs, some bookcases, a refrigerator-freezer and a PC workplace. The room is used mainly as control room for the laboratory or meeting room for small groups. Asterism is the main lighting system, allowing monitoring of real usage. People were left free to dim the system according to their personal needs and preferences.

The lighting scenarios used in the tests were the followings:

- Scenario 1 – Workshop supports the multifunctional work during meeting and group activities. Each direct lighting module is turned ON (max intensity) along with the indirect lighting modules. CCT is tuneable.
- Scenario 2 – Focus ensures the creation of an environment suitable for individual work, where the increased focus on the visual task implies higher level of illuminance on the task with direct lighting modules ON. The surroundings are also evenly lit from indirect lighting modules. CCT is tuneable.
- Scenario 3 – Haven configures a private working environment, with only the direct lighting modules on the work surface of the desk, ensuring moderate levels of illumination in the visual task. Indirect lighting is turned off to reduce the perceived space of the room for a subjective solitary concentration. CCT is tuneable.

Figure.. 3 The room where Asterism is installed

B. The Tests

Photometric, radiometric and electrical tests have been performed, mainly to quantify real system performance:

- energy consumption of different elements (lighting modules, control interface) at full power and with different levels of intensity (dimming) and CCTs tuning between 3000K-6500K;
- dimming curve (luminous flux and spectral variation in relation with electric power);
- illuminance and spectral irradiance on the working plane in different dimming conditions: at full power and with different levels of intensity (dimming) and CCTs tuning between 3000K-6500K, for the individual modules and for the whole system;
- vertical illuminance and spectral irradiance at eye level, at full power and with different CCTs tuning between 3000K-6500K;

Energy efficiency of the system has been assessed.

As a general rule, as tests have been performed on field and not in laboratory conditions, care has been taken to minimize disturbance:

- ambient temperature always in the range 20-25°C
- stable conditions before measurements
- double fast measurements, with the system ON and the OFF, to decouple daylight contribution.

After some months of operation, a simple questionnaire has been proposed to assess qualitatively the system performance according to the users satisfaction.

RESULTS

Energy consumption and efficiency are important and are related to performance. Energy consumption is due both to the luminaire and to the control system. Electric power is about 100W at full power, independent from CCT, and global efficiency (auxiliaries and control included) is 62 lm/W, a very good value in this sense. Based on the measured values, consumptions of a typical winter and summer day have been hypothesized, in the "Workshop" scenario. The room is supposed to be occupied from 9am to 6pm, with a break during lunch time. Artificial lighting is in ON-mode and dimmed according to daylight (room occupied). Dimming in CCT, left to the users, does not influence energy consumption. Otherwise, it is in standby mode. As the controls are at the moment "manual", this simulation assumes very "smart" users (and it is indeed true at ENEA Ispra).

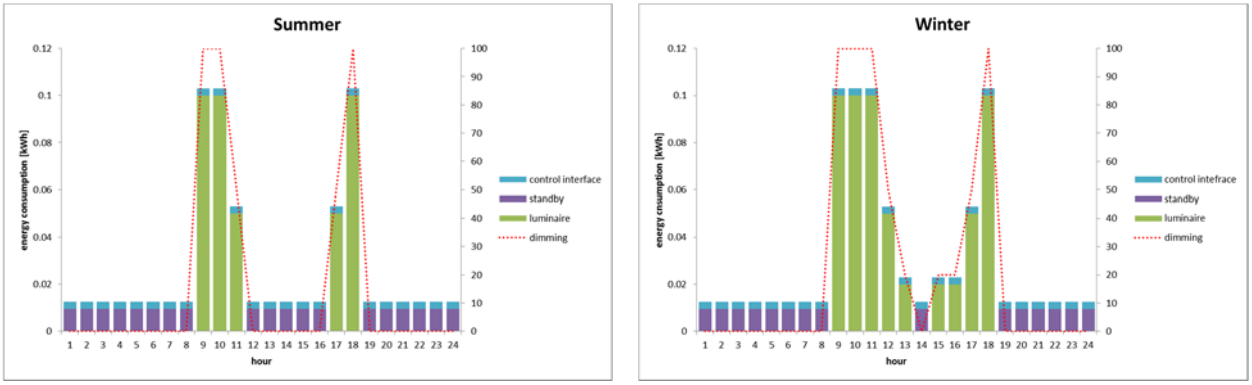


Figure 2. Energy consumption in summer and in winter

Standby mode consumption is not negligible, being 24% in winter and 36% in summer: this can be improved in the future, by adding a device to switch OFF the system, when people are not present. Dimming curve (flux=f(power)) has resulted to be linear and the spectral power distribution (SPD) of the light is independent from the flux-dimming level, ensuring good comfort in dynamic operations. The system is well calibrated, so that illuminance, at a given flux-dimming level, is independent from the white CCT: this is of great benefit for users, who do not have to adjust the amount of light when they move form cold to warm light or opposite. Finally, measurements of irradiance at eye level show that the contribution of the environment (i.e. surfaces of walls, furniture, ceiling) plays an important role: in the figure it is shown the normalized irradiance on the table (horizontal) and at eye level (vertical) with the luminaire totally ON (direct + indirect modules), only indirect ON and only direct ON.

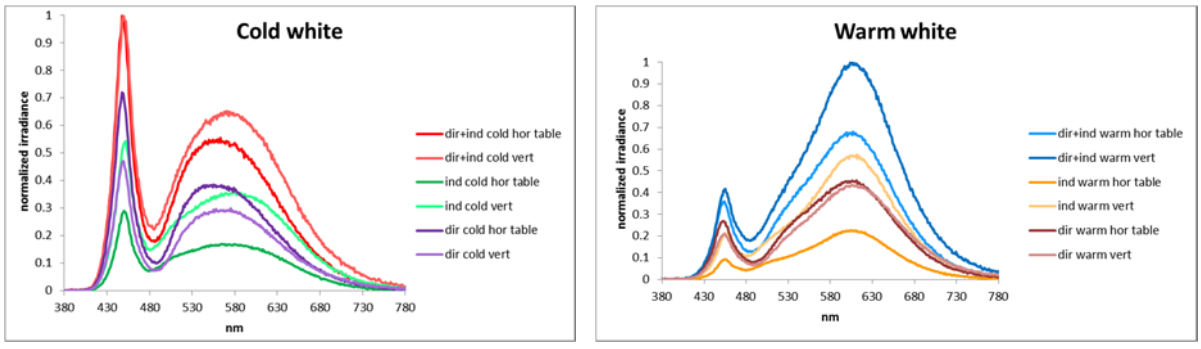


Figure 3. SPD changes measured at eye level and on the table, for indirect and direct lighting distributions

The contribution of the environment, visible from changes in SPD, are more evident for indirect lighting, as expected, and for cold white, as the furniture is light brown with a higher reflectance in "red" than in "blue".

Coming to user satisfaction, the following questionnaire has been proposed (with different timing, to 30 people):

- which type of activity do you perform in the room with Asterism?
- do you think the natural lighting is always sufficient for your tasks?

- do you prefer the old lighting system or Asterism?
- regarding Asterism:
  - do you consider the light sufficient for your tasks?
  - do you prefer direct, indirect or direct + indirect light?
  - do you prefer warm or cold light? Any preference for direct / indirect light?
- is it useful according to you the possibility of dimming? In amount of light? In white hue?
- is it simple to manage / control the Asterism system?

The principal activity in the room has been "meetings", physical or virtual (scenario "Workshop"), while somebody also use the room to work alone (scenario "Focus"). Natural lighting has not been considered as sufficient, mainly in the early morning or late afternoon, so that artificial lighting is needed. 100% of the people prefer Asterism to the old system (traditional fluorescent tubes).

One of the first outcome of the monitoring campaign was that people liked direct + indirect lighting also during individual work, preferring a wider visual angle (scenario "Focus") to a lighting only focused only onto the task area (scenario "Haven").

All the participants with one exception were satisfied with the amount of light with Asterism, taking into account the correct dimming. All the participants with one exception preferred direct + indirect light, in each working situation: the remaining person liked the possibility to choose, according to the mood of the moment (mainly in Focus). Most of the people (90%) preferred warm light, independently of the time of day or other parameters. One person (the same as before) preferred also in this case the personal freedom to choose. Everybody appreciated the possibility to change, both the amount and the CCT of light, but only 2 participants found easy to use the control interface, while the majority found it not user friendly and few people never tried themselves. The conclusion today is very positive. The discomfort with the control interface is perfectly understandable, being a prototype where a minimum training is required: this can be easily solved in future development of the system.

CONCLUSION

The technical characteristics of the installed and operative Asterism are in very good agreement with the design: the dimming is very well balanced, the spectrum is rich and the light distribution gives a pleasant result, beyond standard lighting requisites fulfilment. Energy efficiency is high. People appreciate the Asterism lighting system and appreciate the possibility to "customize". The improvement of the interface of the lighting system needs an iterative user testing and deeper evaluation which should be performed in order to assess the easy to learn first and the easy to use in terms of affordance, feedback and consistency for a more engaging user experience.

REFERENCES

[1] M. O'Neill and T. Wymer "Implementing Integrated Work to Create a Dynamic Workplace". Knoll, 2010
[2] Knoll Workplace Research "Evolving Design of Faculty Offices. Space Efficient Planning Solutions for the Private Office", 2013
[3] M. O'Neill, " Future Work and Workplace". Knoll research white paper, 2009
[4] Global Posture Study – Steelcase by Steelcase WorkSpace. "Futures researchers and the Steelcase Design Studio"
[5] Unum, "The Future Workplace – Key trends that will affect employee wellbeing and how to prepare for them today", 2014
[6] P. R. Boyce, J. A.Veitch, G. R. Newsham, C. C. Jones, J. H. Heerwagen, M. Myer, C.M. Hunter. "Occupant use of switching and dimming controls in offices. Lighting Research and Technology". 2006. 38(4): pp. 358-378.
[7] J. A. Veitch, E. E. Dikel, G. J. Burns, S. Mancini "Individual control over light source spectrum: Effects on perception and cognition". In Proc. of the 27th Session of the Commission Internationale de l'Eclairage, Sun City, South Africa Vienna, Austria: CIE; 2011, July. CIE 197:2011, Vol. 1, Part 1, pp. 213-8.
[8] K. Bieske, C. Schierz "Dynamic lighting—perception of luminous colour variation", in Proceedings of CIE 2010 "Lighting Quality and Energy Efficiency." Vienna (Austria): CIE. pp. 290-297.
[9] Á. Logadóttir, S. A. Fotios, J. Christoffersen, S.S. Hansen, D. D. Corell, C. Dam-Hansen, "Investigating the use of an adjustment task to set preferred colour of ambient illumination". Color Res Appl. 38(1): pp. 46-57. 2013
[10] A. Žukauskas, R. Vaicekauskas, P. Vitta, A. Tuzikas, A.Petrulis, M. S. Shur. "Colour rendition engine". Opt Express. 20(5): pp. 5356-5367. 2012
[11] K. Van Boerdonk, J. Mason, A. Dzmitry "User Interface for Task Lighting" in Open Office Proceedings of the workshop on User Interaction Techniques for Future Lighting Systems, 2011, pp. 23-27
[12] J.A. Veitch, E.E. Dikel, G.J. Burns, S. Mancini "Individual control over light source spectrum: Effects on perception and cognition". Proceedings of the 27th Session of the Commission Internationale de l'Eclairage, Sun City, South Africa Vienna, Austria: CIE; 2011, July. CIE 197:2011, Vol. 1, Part 1, pp. 213-8.
[13] A.D. Galasiu, G.R. Newsham, C. Suvagau, D.M. Sander "Energy saving lighting control systems for open-plan offices: a field study". 2007 Leukos. 4(1): pp. 7-29.
[14] D. Maniccia, B. Rutledge, M. S. Rea, W. Morrow "Occupant use of manual lighting controls in private offices". Journal of the Illuminating Engineering Society. 1999. 28(2): pp. 42-53.
[15] M. Martin, W. Herbert, N. Thomas, H. Friedhelm, "New Form Factor Luminaires and New Light Effects", LED professional, Luger Research e.U, Issue 48, 2015, pp. 16-21.
[16] R. F. Karlicek, Jr "Smart Lighting – More than Illumination", ACP Technical Digest 2012 OSA
[17] S. Walerczyk "Human Centric Lighting" in Architectural SSl 2012 pp. 20 - 26
[18] M. S. Rea, M. G. Figueiro, and J. D. Bullough, "Circadian photobiology: an emerging framework for lighting practice and research", Lighting Research and Technology. September 2002; vol. 34, 3: pp. 177-187
[19] K.M. Stephenson, C. M. Schroder, G. Bertschy, P. Bourgin " Complex interaction of circadian and non-circadian effects of light on mood: Shedding new light on an old story" Sleep Medicine Reviews 16 (2012) pp. 445 - 454
[20] J. A. Veitch, M.G.M. Stokkermans, G.R. Newsham, "Linking lighting appraisals to work behaviors". Environment and Behavior. 2013;45(2): pp. 198-214.

[21] J. A. Veitch, “Psychological processes influencing lighting quality”. Journal of the Illuminating Engineering Society 2001, 30(1), 124-140
[22] Z. Zainal, “Case study as a research method”, Jurnal Kemanusiaan bil.9, Jun 2007
[23] D. Casciani, F. Musante, M. Rossi, “Warm white, neutral white, cold white: the design of new lighting fixtures for different working scenarios”. In Proc. Colour and Colorimetry. Multidisciplinary Contribution Vo. XXI B Proceedings of the 12th Conferenza del Colore. Politecnico di Torino September 08-09, 2016 – Turin (Italy) Edited by Davide Gadia pp.81 -92, 2016
[24] K. Van Boerdonk, J. Mason, A. Dzmitry “User Interface for Task Lighting in Open Office Proceedings of the workshop on User Interaction Techniques for Future Lighting Systems”, 2011, pp. 23-27