New Doctors in the Lighting Field


Myriam Ares: Human Lighting Demands. Healthy Lighting in an Office Environment. Continued on page 6...

Lux Europa 2005 Berlin
Lighting for Humans

There were more than 500 participants from 33 countries in Lux Europa 2005. 165 research work were presented in the form of presentations, presented posters and posters.

Lux Europa 2009 will be in Istanbul, Turkey.

Innovative Lighting for Monna Lisa


Monna Lisa was offered a new room at Louvre Museum in Paris which has been opened to the public since April 4, 2005. A great opportunity to develop an innovative lighting system. The lighting strategy elaborated by the architect Lorenzo Piqueras and the Lighting designer Marc Fontoynont was to propose a modern revision of glass ceiling techniques, largely used in the XIXth century for lighting museums and exhibition places. Daylight was optimized, and when its availability will be insufficient, it will be blended with artificial light so that electrical light would be as discreet as possible. The major glass surface (about 300 m²) was maintained, but new side “light cannons” were added to provide a better lighting of the paintings on the walls and contribute to the magnificence of the room. Combinations of laminated glass and polycarbonate panels were necessary to adjust the diffusion of light and the control of colors. To prevent light reflection on the painting of “Monna Lisa”, which is protected by a thick bullet proof glass, it was developed a specific anti-reflection, low iron glass, and used a small lamp to enhance the lumiance of the painting and hide the veiling reflections. This lamp uses various LED sources, the combination of which was optimized to recreate effects obtained with natural light, and adapted for optimal color rendering of the painting. Continued on page 3...
Introduction

The Executive Committee of the Energy Conservation in Buildings and Community Systems (ECBCS) program established a new research project (Annex) in June 2004 called Energy Efficient Electric Lighting for Buildings. Professor Liisa Halonen from the Lighting Laboratory of Helsinki University of Technology was elected for the Operating Agent of the Annex 45.

The objectives of Annex 45 are to identify and accelerate the use of energy-efficient high-quality lighting technologies and their integration with other building systems, to assess and document the technical performance of existing and future lighting technologies, as well as to assess and document barriers preventing the adoption of energy-efficient technologies, and to propose means to resolve these barriers.

Objectives

Identify and accelerate the use of energy efficient high-quality lighting technologies and their integration with other building systems

Assess and document the technical performance of existing and future lighting technologies

Assess and document barriers preventing the adoption of energy efficient technologies and propose means to resolve these barriers

Management of the Annex

Operating Agent: Finland, Helsinki University of Technology
Professor Liisa Halonen

Subtask A Leader: France, École Nationale des Travaux Publics de l’État (ENTPE)
Professor Marc Fontoynot

Subtask B Leader: Austria, Bartenbach Lichlabor GmbH
General Manager Wilfried Pohl

Subtask C Leader: Germany, Technische Universität Berlin
Professor Dr. rer. nat. Heinrich Kaase

Subtask D Leader: Finland, Helsinki University of Technology
D.Sc. Eino Tetri

For more information, please contact:

Liisa Halonen
liisa.halonen@hut.fi

Helsinki University of Technology

or check

the Annex website:
lightinglab.fi/IEAAnnex45
The painting had to be protected with a large glazing panel. Various specifications lead to a thick laminated glass. The glass is low iron, and with various antireflection coatings. Although the painting is covered with an extremely transparent glass, a veiling luminance due to the luminous environment of the room cannot be avoided. Furthermore, although the glass is highly transparent, the reflectance of the incoming daylight is high and the resulting illuminance of "Monna Lisa" becomes lower than the one on the other paintings. For this reason, we designed a specific lamp to boost the value of the illuminance on the painting, shooting on the painting upward, and suppressing the veiling luminance.

A detailed spectral analysis of the painting demonstrated the need for a particularly good rendering of the red-amber part of the painting (the areas dealing with the skin) but also of the blue green background, usually not well rendered in most paintings of that period.

Various colorimetric tests were conducted. The idea was to develop a spectral distribution which would not be that of the standard halogen light source, which gives a yellowish aspect to most paintings in museums. Our goal was to come close to the spectrum of natural light. But natural light is quite variable. Its Correlated Color Temperature (CCT, Kelvin) often varies between 2,000 K (sunset), 6,000 K (overcast sky) to 15,000 K for blue sky. In museums, due to the use of low illuminance values, it is found that Correlated Color Temperatures above 4000 K should not be used to avoid the impression of a "gloomy" environment. So a CCT between 3000 K and 4000 K appears to be a reasonable choice in an environment where values of illuminance are in the range of 200 lx.

But natural light is much more than a spectrum. It is a complex blend of spectrums, and these spectrums do not mix evenly in a space. When daylight penetrates interiors, the values of CCT vary on all indoor surfaces not only according to the variations of the CCT on the sky vault, but also in relation to the specific role of materials located outdoor and indoor.

We worked on the development of a light source which would supply a spectral distribution that would not be perfectly uniform over a painting. These small and unnoticeable changes where achieved using well defined color sources (LEDs) blended with a patented Fiber Optic system - FOCON. The system uses 7 LEDs, and the FOCON system not only blends their spectrum, but also transforms the circular light source into the trapezoid shape required by the painting. The result is a light with a spectral distribution close to the one of daylight after multiple reflections on outdoor and indoor surfaces.

The resulting values of illuminance remain lower than the one due to ambient lighting, in the range of 30 to 60 lx, so that the general effect is subtle enough. The LED lamps are turned on during all hours for which the museum is open.

Authors: Marc Fontoynont Building Sciences Laboratory ENTPE-CNRS, Lyon, France.
Lorenzo Piqueras, Architect, Paris, France

Lighting simulation of the new "Monna Lisa" room in Louvre, courtesy of Ingelux Consultants.

Detailed spectral analysis of the colours of Monna Lisa showed a significant shift to the yellow-orange area of the spectrum, a sign of aging to be attenuated by the lighting scheme.

Projector used for enhancement of Monna Lisa, using 7 LEDs, and one Optical Fiber component for framing (courtesy of Sklaer Lighting, Frankfurt)
Introduction

Lighting by using light emitting diodes (LEDs) and power line communications (PLC) are techniques which have considerable commercial expectations. The combination of these two techniques yields versatile, high efficiency and remote controllable lighting systems.

Background

Light emitting diodes (LEDs) are semiconductors that emit light when biased with a forward current. Light emission in semiconductors is due to radiative recombination of excess electrons and holes. The emitted radiation is in narrow wavelength band. The chemical composition of the semi-conducting element determines the peak wavelength of the radiation. LEDs produce light in a variety of colours covering the whole visible spectrum.

Power line communications (PLC) uses ordinary power cords for data transmission. PLC is widely investigated and it is regarded as a very interesting alternative for home networking and Internet access in 4G framework meaning its seamless interfaces with other networking technologies e.g. with Bluetooth or IRDIA devices.

Objectives

The objective was to make a demonstration prototype of a LED-luminaire in which luminous flux, colour temperature and spectral power distribution are controlled by PLC-system.

Accurate adjusting of colour temperature needs to take into account the dissimilar characteristics of AlInGaP and InGaN LEDs in order to fulfil qualitative and quantitative requirements for general lighting applications.

LED Luminaire

The prototype luminaire consists of 61 high-power LEDs. 1-W royal blue, green, amber and red LEDs with batwing spatial distribution were placed on a metal-core printed circuit board for better heat extraction. The system is connected to the computer via a power line network.

The light output of LEDs depends on its junction temperature. Therefore the LED luminaire is equipped with a feedback feature, which indirectly measures the junction temperature using the forward voltage and the known characteristics of the LEDs.

Results

Results have shown that the control strategy based on the forward voltage feedback is effective. Correlated colour temperature (CCT) of the light is controlled in real time and maintained within an acceptable range around the setup point.

Partners

Helsinki University of Technology
- Lighting Laboratory
- Communications Laboratory
- Applied Electronics Laboratory
CUBE - The Building Services Technology Programme
TEKES – The National Technology Agency of Finland
Companies
- Aker Finnyards
- Idman Oy
- Nokia Research Centre
- Nokia Real Estate
- Oy Osram Ab
- Salcomp
- SOK Kinteistötöiminnät
- Teknoware
- Oy Turku Energia
- EK-Light Oy
As part of the IEA Annex 45 Project the main focus of Technical University of Berlin (TUB) in Subtask C is on the development of a lighting control system with high level of intelligence and multiple levels of control that learn and adapt to user’s preference and behaviour.

The usage of wireless sensors and actuators is a key component for new lighting control systems. This is justified by the fact of the easy installation in a way that you don’t have to lay cables and damage walls. In this sense it is also possible to integrate such a system into existing buildings. On the other hand is it impossible to realize an intelligent lighting system without a lot of sensors and actuators to capture and control the environment.

At the moment there exists one experimental setup: It’s a 5 room apartment equipped with wireless devices, there are motion- and light- sensors. All light sources are directly controlled by a wireless push-buttons therewith it is possible to switch on or off and dim the light. All of the interaction between the user and the lighting controls is captured in a wireless base station for further analysis.

First measurements are taken from the experimental setup illustrated in the two distributions of motion all day long captured over 3 weeks from the bath and living room. A real time data processing unit allows wireless control of the lights through the base station.

TUB is currently working on the development of advanced control algorithms that are able to deal with the captured information from the environment to bring intelligent control decision to the actuators. The algorithms should include the capability to recognize and generalize user’s behaviour, preferences and habits. The algorithm should also be able to improve step-by-step the competence and decision-making ability of the system over the time. The policy contains among others a trade-off between energy consumption and user satisfaction.

Future research will focus on the analysis of the whole system under technical aspects of communication, reliability, learning rate and lighting.
New Doctors in the Lighting Field

Development of visual performance based mesopic photometry

At HUT Lighting Laboratory (Finland) the Doctoral Thesis work of Marjukka Eloholma was examined and approved on October 21, 2005. Her Thesis, entitled Development of visual performance based mesopic photometry, concerns vision in night-time driving conditions and the dimensioning of lighting at mesopic levels.

Photometry, the measurement of visible light, forms the basis of lighting units and is consequently the basis of all lighting technology and practice. Today all practical photometry is based on the photopic $V(\lambda)$ function established by CIE (Commission Internationale de l’Eclairage) in 1924. In the mesopic luminance region, below the photopic, the spectral sensitivity is however different. Mesopic lighting applications include e.g. road and street lighting, outdoor lighting and other traffic lighting conditions.

The Thesis indicates the evident need for visual performance based mesopic photometry. A European research consortium MOVE was formed, where mesopic visual performance was investigated on a scale never done before. The vision experiments of MOVE split the task of night-time driving into three visual sub-tasks and visibility data was generated simultaneously in five countries. The work of MOVE resulted in a model of mesopic spectral sensitivity of peripheral vision.

The MOVE model was applied to road lighting via luminance measurements. It was found that there may be substantial differences in dimensioning low luminance levels of road lighting depending on whether photopic or mesopic photometry is used. It is evident that the adoption of mesopic photometry could result in different classification of light sources in terms of their luminous output.

To be internationally accepted and used, a new mesopic photometric system has to be adopted and recommended by the CIE. The MOVE findings are integrated into the CIE TC1-58 work in order to contribute to the establishment of a future standard on performance based mesopic photometry.

A future standard on mesopic photometry - mesometry - will promote the development of mesopically optimised lighting products. It is foreseen that there will be strong motivation within the lighting community to adopt and use a photometric method that is valid and justified in the mesopic applications.

Human lighting demands Healthy Lighting in an office environment

The objectives of research of Myriam Ares were to characterize lighting conditions in current officetypes with regard to current standards and non-visual variables and to develop (conditions for) lighting concepts and system solutions that meet both visual and non-visual demands of humans.

Light influences the daily rhythm and well-being of humans in a physiological, psychological and biological way. Light not only enables humans to see. Beside visual photoreceptors, the human eye also contains (recently discovered) non-visual photo-receptor.

The test results showed that, to employee’s satisfaction, it is possible to realize healthy lighting concepts with higher illuminace levels than commonly used in office environments.


Models for spectral luminous efficiency in peripheral vision at mesopic and low photopic luminance levels

The doctoral thesis of research scientist Pasi Orreveteläinen was examined and approved on October 28, 2005 at Helsinki University of Technology. The title of the thesis is ‘Models for spectral luminous efficiency in peripheral vision at mesopic and low photopic luminance levels’. The work was performed at the HUT Lighting Laboratory.
The aim of this work was to find out how the spectral sensitivity of the human eye varies in peripheral vision at mesopic and low photopic luminance levels. Two different measurement methods were employed for this purpose. Reaction time and contrast threshold measurements were conducted at various mesopic and low photopic luminance levels in foveal and peripheral vision.

Both measurement methods revealed the same observations: at low photopic luminance levels, the currently used V(λ) function is not the best descriptive spectral luminous efficiency function for peripheral vision. The short wavelengths were underestimated by the V(λ) function.

A new spectral luminous efficiency function V_per(λ) was developed for peripheral vision at photopic light levels. This function is a linear combination of V(λ) and V10(λ) functions and takes into account the higher spectral sensitivity to short wavelengths as compared to the V(λ) function. At mesopic luminance levels, it was investigated how a linear combination of photopic and scotopic spectral luminous efficiency functions describes the spectral sensitivity of the eye in peripheral vision. A model for the mesopic spectral luminous efficiency function Vmes(λ) was developed for peripheral vision.

The results showed that this function describes the peripheral spectral sensitivity with best accuracy at mesopic luminance levels.

LEDs were used to illuminate the targets. The LEDs were attached to plastic tubes, which were in turn attached to holes drilled through the hemisphere.

---

**National Interest Groups**

**Finland**
Helvar Oy
* Max Bjorkgren
* Juha Muttilainen
* Pasi Hyyppä
* Henri Juslen

**France**
Ingelux
* Laurent Escaffre
* Christophe Marty

**China**
Shanghai Hongyuan Lighting & Electric Equipment Co
* Aiqun Wang

---

**Second Expert Meeting 15 – 16 September 2005, Berlin**
The second Expert Meeting of Annex 45 was on 15 – 16 September 2005, in Berlin, Germany. The meeting was hosted by Heinrich Kaase, Technische Universität Berlin. There were 27 participants from 17 countries. During the meeting a detailed action plan was created in group discussions and duties were divided among participants. Next Expert meeting will be on 6-7 April, 2006, Austria.

---

Pasi Orreveteläinen defended his thesis 28 October 2005. Honoured opponent was Professor János Schanda, University of Veszprém, Hungary.
Participants and Corresponding Members

**Australia**
Queensland University of Technology  
* Steve Coyne  
Arup Australasia  
* Phillip Greenup

**Austria**
Bartenbach LichtLabor GmbH  
* Wilfried Pohl  
Zumtobel Staff GmbH  
* Peter Dehoff

**Belgium**
Belgian Building Research Institute  
* Arnaud Deneyer  
Université Catholique de Louvain  
* Magali Bodart

**Canada**
University of British Columbia  
* Lorne Whitehead  
* Michele Mossman  
* Alexander Rosemann

**China**
Fudan University  
* Chen Dahua  
* Edward Yuan  
* Chen Yuming  
Shanghai Hongyuan Lighting & Electric Equipment Co  
* Wang Aiqun

**Finland**
Helsinki University of Technology  
* Liisa Halonen  
Eino Tetri

**France**
Ecole Nationale des Travaux Publics de l’État (ENTPE)  
* Marc Fontoynont  
CSTB  
* Ahmad Husaunndee  
* Michel Perrudeau  
Lumen Art  
* Susanne Fleischer

**Germany**
Technische Universität Berlin  
* Heinrich Kaase  
* Henri Kretschmer  
* Felix Serick  
* Mehmet Yenı  
Fraunhofer Institute  
* Jan de Boer

**Italy**
Università di Roma “La Sapienza”  
* Fabio Bisegna

**Japan**
National Institute for Land and Infrastructure Management  
* Yasuhiro Miki  
Tokai University  
* Toshie Iwata

**The Netherlands**
Delft University of Technology  
* Regina Bokel  
* M. van der Voorden

**Norway**
NTNU and SINTEF  
* Barbara Matusiak  
* Tore Kolás

**Poland**
Silesian University of Technology  
* Zbigniew Mantorski

**Russia**
Russian Lighting Research Institute  
Svetotekhnika  
* Julian Aizenberg

**Singapore**
National University of Singapore  
* Lee Siew Eang

**Sweden**
Lund University  
* Nils Svendenius  
* Sven Huldén  
WSP Elsteknik  
* Peter Pertola  
BAS Bergen school of architecture  
* Lars Bylund

**Switzerland**
Solar Energy and Building Physics Lab, EPFL  
* Nicolas Morel  
* David Lindelöf  
University of Applied Sciences of Western Switzerland  
* Gilles Courret

**United Kingdom**
University of Nottingham  
* Li Shao  
Helvar  
* Trevor Forrest

**USA**
Lawrence Berkeley National Laboratory  
* Stephen Selkowitz

---

**E³Light**

Annex 45  
Energy Efficient Electric Lighting for Buildings

Operating Agent  
Finland  
Professor Liisa Halonen  
Helsinki University of Technology  
Lighting Laboratory  
P.O.Box 3000  
FIN-02015 HUT  
FINLAND  
Phone +358 9 451 2418  
Fax +358 9 451 4982  
liisa.halonen@hut.fi

Website  
lightinglab.fi/IEAAnnex45

Editor  
Eino Tetri  
Helsinki University of Technology  
Phone +358 9 451 2420  
eino.tetri@hut.fi

Annex 45 Expert meetings  
3rd Expert meeting  
6-7 April, 2006, Austria

4th Expert meeting  
5-6 September, 2006  
Canada