

# ILIGLOW

Intelligent Lighting Institute | Edition 2, November 2014

/ ILI @ GLOW

/ The quantified self in light

/ Meaningful Artificial Illumination

/ Intelligent Outdoor Lighting Systems

/ Light, Art & Science

/ And more....

**TU/e**

Technische Universiteit  
Eindhoven  
University of Technology

Sagitta Peters | Managing director



## Welcome

Dear reader,

It gives me great pleasure to present to you the second edition of the ILI Magazine. The first edition, which we published in April of this year, introduced the ILI vision on Engineering Natural Light and showed the progress we have made on this theme over the years. During the past six month developments within ILI accelerated and we thought you might be interested in learning the progress we made. Firstly, we can mention that the Lighting Flagship with Philips, which is a unique one-on-one public private partnership with more than twenty PhD students, has been launched successfully. Practically all PhD positions have been filled with talented students who have embarked on their studies with great enthusiasm.

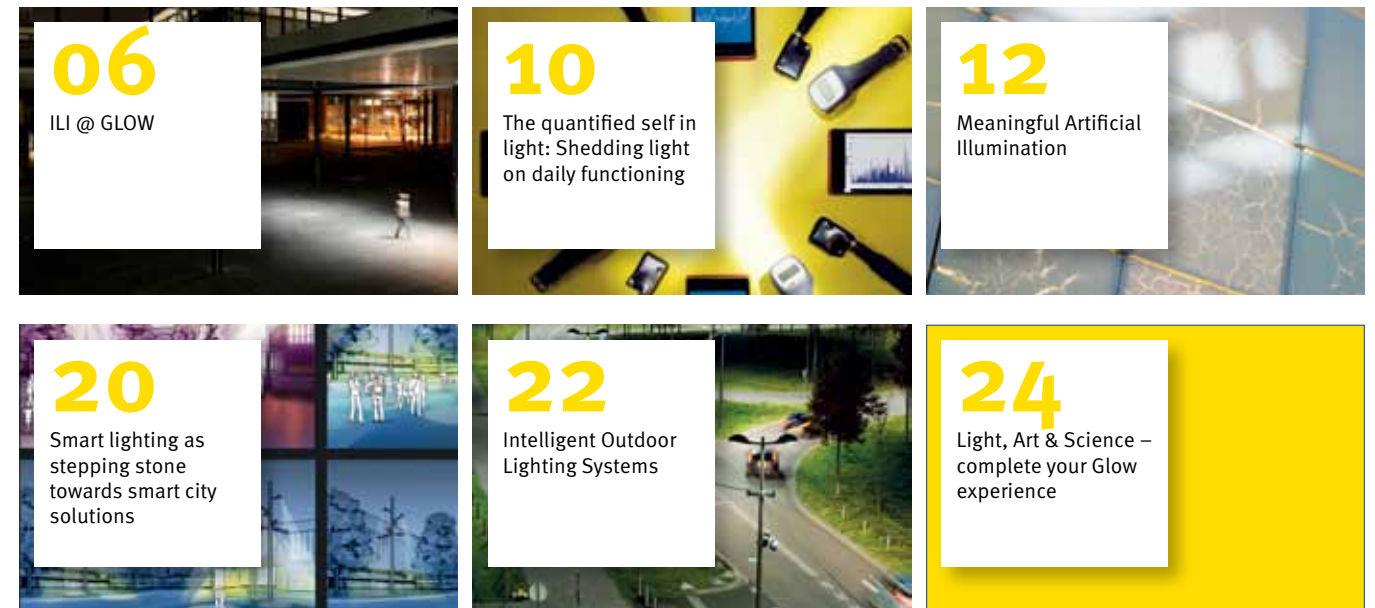
In addition we have restructured our research programs into the following four lines of investigation; Light by Design, Bright Environments, Sound Lighting and Open Light. Furthermore, substantial progress was made with the introduction of our lighting educational program, whose first editions attracted more than a hundred bachelor and honors students who are eager to learn the principles of lighting and its effect on the behavior and wellbeing of people. Finally, we are proud to mention that also this year we will have a strong presence at GLOW, the renowned light festival of the city of Eindhoven, which will take place from 8 until 16 November. All this great progress made us decide to compile a new edition of the ILI magazine and we hope you will find the developments as exciting as we do.

Pleasant reading.

Cover: Bart van Overbeeke

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**Editorial** // ILI 2014 is the yearly magazine of ILI for ILI members, colleagues, collaboration partners, policy makers and related companies. ILI is published in November // Editorial staff - Harold Weffers, Samantha Sperling (editors in chief) // Design - Volle-kracht, Eindhoven // Illustrations - ILI // Article contributions - Moesasji & ILI // Photography - Bart van Overbeeke Fotografie, Philips Communications, ILI // Contact - P.O.Box 513, 5600 MB Eindhoven The Netherlands - T: +31(40)247 5990 - E: ili@tue.nl // Copyright 2014 by TU/e ILI. All rights reserved.



# Calendar

## September 29 - 3 October, 2014

ThemawEEK Welzijn van Duurzaam Verlicht.

<http://www.duurzaamverlicht.com/>

## October 18-26, 2014

Dutch Design Week

**Location:** Several places in Eindhoven

## October 29, 2014

Connected Future Conference

**Location:** Van der Valk Congress & Event Centre, Eindhoven

[www.connectedfuture.nl](http://www.connectedfuture.nl)

## November 8-15, 2014

Glow Festival

**Location:** Eindhoven

Includes ILI OPENLIGHT installations at GLOW NEXT

## November 10-11, 2014

Experiencing Light 2014, international conference on the effects of natural and artificial lighting on human wellbeing.

<http://www.experiencinglight.nl>

**Location:** Eindhoven

## November 11-13, 2014

Ambient Intelligence conference

**Location:** Eindhoven

<http://www.ami-conferences.org/2014/>

## November 13, 2014

Smart Lighting Event: The future of light, it's up to you!

**Location:** Nat.Lab. Strijp-S

## November 20, 2014

ASPO (Associatie voor Sociaal Psychologisch Onderzoek)

Symposium "Environmental psychology": Designing environments that stimulate desired behavior.

**Location:** Utrecht

## December 15, 2014

ILI Annual Public Outreach Event

**Location:** TU Eindhoven, Zwarte Doos

## March 6, 2015

Inaugural Lecture, Prof.Dr.-Ing. habil. Alexander Rosemann

**Location:** TU Eindhoven

## ILI Theses

April 2014 - October 2014

### Powered by nature: the psychological benefits of natural views and daylight

Femke Beute – September 2014

PhD advisors: prof.dr. C.J.H. Midden, dr.ir. Y.A.W. de Kort

### Measuring the Stratumseind Experience (PDEng – Thesis)

Indre Kalinauskaite – September 2014

Advisors: Dr. H. van Essen, Dr. A. Haans

### Inverse Methods for Illumination Optics Corien Prins – September 2014

PhD advisors: prof.dr.ir. W.L. IJzerman, dr.ir. J.H.M. ten Thije Boonkamp

### Distributed Smart Lighting Systems: Sensing and Control

David Ricardo Caicedo Fernandez – June 2014

PhD advisors: prof.dr.ir. J.W.M.

Bergmans, dr. A. Pandharipande, dr.ir. F.M.J. Willems

### Modelling and Simulations of Virtual Natural Lighting Solutions in Buildings

Rizki Armanto Mangkuto - May 2014

PhD advisors: prof.dr.ir. J. Hensen, prof. dr.ir. E. van Loenen, dr.ir. M.B.C. Aries.

### Designing for Adaptive Lighting Environments

Remco Magielse - April 2014

PhD advisors: prof.dr.ir. J.H. Eggen, prof. dr.ir. C.C.M. Hummels, dr.ir. J.W. Frens

## Intelligent Lighting Institute Annual Outreach Event

During the 2014 edition of the ILI Annual Public Outreach Event, on 15 December 2014, we will show the results of recent research & innovation projects related to our three research programs Sound Lighting, Bright Environments, and Light by Design as well as our creative art program Open Light.

During this event, we will also present some of the early results of our strategic partnership on Lighting with Philips and showcase a selection of the valorization activities related to technologies developed in the context of ILI during earlier activities. For more information and registration, please go to <http://intelligentlightinginstitute.eventbrite.com/>

Emile Aarts | Scientific director

# Engineering Natural Lighting Experiences: The original ILI vision is still direction setting



As of the launch of the Intelligent Lighting Institute in 2009 we have been acting on a vision that we called Engineering Natural Lighting Experience. In the original formulation it states that "Over the past centuries mankind has created extensive artificial environments in which we live, work, rest, and recreate. Many of these environments have contributed to our social wellbeing, but along the way we lost the use of natural (day) light, thus falling short on the beneficial qualities that can go with it. It is our profound belief that by using digital LED technology and deep insights in the effect of light on human behavior we can re-create the world's view on natural light in all domains of our daily life, such as health, well-being, safety, and sustainability."

After five years of existence we can conclude that this vision still stands and that it provides direction to the activities within the Intelligent Lighting Institute. The same holds for our way of working which is aimed at creating a scientific community of practice dedicated to intelligent lighting solutions with a scientific and application-based approach; establishing partnerships with stakeholders in the public-private domain, applying a multidisciplinary and multifunctional research approach that is concept driven and evidence based, and finally realizing human centric real-life test beds.

To optimally leverage synergy between the various research activities with ILI and to align our activities with the Lighting Flagship we have set up in 2014 as part of the Digital Innovation Program we developed with Philips, we restructured our programs along the lines of the following four activities: Light for Design, Bright Environment, Sound Lighting, and Open Light. The main difference with the previous program structure is that we abandoned the separation between in-door and out-door lighting and that we reorganized the design activities.

The Eindhoven region has the ambition to sustain its leading position in lighting research and innovation, which it has built over the past century. With strong industrial leaders such as Philips, Cofely, and NXP, and in close cooperation with the municipality of Eindhoven, ILI has set up a ground breaking lighting research program that should reveal the true benefits of the many novel solution opportunities that are enabled by the LED light revolution.

# ILI @ GLOW

This year, ILI is involved in three installations at GLOW

Author | Rombout Frieling

As the annual forum for Light & Architecture and attracting over 500K visitors in 8 days, GLOW is a fascinating platform for the Intelligent Lighting Institute: to show new propositions to the public and to experiment with new possibilities. This year, ILI will be involved with three projects, mainly at the experimental GLOW NEXT part at Strijp-S.

At GLOW NEXT, the installation RIDIG MOTION shows how motion is made up out of the frames – and how our minds can be tricked by the way lighting is applied to this. By varying the frequency of illumination, the installation shows how we can perceive movement very differently. Is this why we perceive the world around us often as static, whilst

the atoms and particles are continuously in motion?

Also at GLOW NEXT will be (DIS) APPEARANCE, an installation playing with our perception of depth. The work will be installed at the MU bowl, part of one of the largest skateboard halls of Europe, Area 51. Reacting to the movements of skaters, the installation asks the question: can the skater change the shape of the bowl through lighting?

Both RIGID MOTION and (DIS) APPEARANCE have been conceived and developed by 5 second-year Bachelor students. They are outcomes of the OPENLIGHT honours programme. The purpose of this programme is to educate students to come up with light installations and to make these happen in the harsh reality, dealing with all

practical matters. OPENLIGHT also aims to develop such projects into a format that can travel around various festivals, which is what has happened to the installations WAVES and IRIS which have been developed at last year's GLOW NEXT.

Dr.ir. Philip Ross, in collaboration with ILI, will also run a public experiment called during GLOW NEXT. The experiment is based on earlier studies by ILI to see if crowds and flows of people can be steered by light. In various lighting patterns, both static and dynamic, the installation will explore if correlations can be found and visualise these in real-time. The experiment is named Lux Agitat Molem and puts the university's Motto - Mens Agitat Molem – literally in a new light: namely that Light can move the Matter.



## Installations Glow next

Light is a fascinating subject. Yet it is also intangible. GLOW NEXT is a new initiative to share the understanding and passion for light. By presenting installations that are about light – and that may hence even be dark. By letting local technologists, designers, researchers and students explore the boundaries of what we know and develop new experimental works. And by showing the state-of-the-art developments in the world, with work from a.o. Thomas Leveritt and Carlo Ratti (MIT).

GLOW NEXT takes place on Strijp-S in Eindhoven, the former Forbidden City of Royal Philips.

The GLOW festival will take place in Eindhoven from 8-16 November. For more information see [www.glow-eindhoven.nl](http://www.glow-eindhoven.nl)



# Exciting work to do in the City of Light

Since April 2014, Alexander Rosemann, is the freshly appointed full Professor and Chair of Building Lighting at the TU/e. He 'arrived happily' at the City of Light, as he calls it. Rosemann pursued an impressive scientific career in lighting and worked among others in Berlin, Manchester, Berkeley and Vancouver, both on the academic side and in industry. His aim is to put his experience and overview to work for ILI.



Prof. Alexander Rosemann

Rosemann: "I started my science education in electrical engineering. However, during that time I found that people cannot easily relate to all the talking about signals, integrated circuits and so on. This eventually triggered me to explore a small niche in electrical engineering: lighting. When you research, design and discuss lighting, people from very different backgrounds can join the conversation. That's great, and it is exactly a big chunk of what we're studying: what is good lighting? What is lighting that serves people?"

## Glow

"Recently, I learned a new word in my Dutch language course: droombaan (dream job). As soon as the vacancy was brought to my attention, it immediately felt like a dream job for me. It offers many positive challenges. Here, I can develop my own ideas, be part of project teams within the university and beyond, and most

importantly, I can explore the future, help find solutions that make society move forward. It is a quite responsible job, too, since we produce the next generation of lighting professionals. And on top of all this: working in a city that is rooted in light and embraces light - think of all the lighting innovations, Lichtjesroute and Glow - is simply great."

## Three pillars of light

Since 70% of our sensory experiences is visual, light and therefore lighting play a major role in all areas of life. Everybody has - consciously or not - an opinion on and an understanding of lighting. Rosemann: "If we apply this to Building Lighting, you can clearly see a shift in perspective from 'how bright should it be' to 'how does this light influence my well-being'. In my Chair group, we focus on three pillars. The first one, Light & Energy, doesn't need any further explanation. With Light & Environment - the second one

- I mean the visual environment; does the light create a supportive atmosphere for people? Or does it disturb them? Can they perform the way they want? The third pillar, Light & Health, is a relatively new set of questions focussing on the impact of light on our well-being and health. In order to create a good lighting situation, you need to balance these three pillars. This leads to many new questions: how to create good lighting in an office environment, in a home, hospital, school and other buildings that serve a particular need. There is a lot of exciting work to do in these fields!"

## Guiding principle

ILI forms a very good basis to team up with scientists in all kinds of disciplines to tackle and answer questions from many different angles. That's what makes this institute very strong. I have worked on the three main stages of the market transformation curve in lighting:

innovation, growth to commercial maturity, and succession of the old technology through new codes and regulations. Returning to a place that generates ideas, I want to introduce the market transformation curve as a guiding principle. The potential of any idea has to be measured against its economical and societal value. I think it is a great honour to be able to contribute here, at ILI."

# The quantified self in light: Shedding light on daily functioning

Authors | Femke Beute and Karin Smolders

Recent developments in LED lighting and smart controls have provided new opportunities to realize flexible ambient light scenarios optimally tuned to the user's needs. These needs may vary from person to person, but also over time. Quantifying a person's momentary state and type of activity during his or her daily routine offers new possibilities for future intelligent lighting systems to provide personalized light settings throughout the 24-h day.

## Light matters

Exposure to light deeply affects our functioning throughout the 24-h day, including performance, sleep, alertness, mood, and health. It is well known that light is crucial for vision. Moreover, light is an important time cue for our biological clock, regulating daily and



seasonal rhythms in, for instance, sleep and wakefulness, mood, alertness and pain perception. In addition, light induces instantaneous changes in alertness, mood and cognition and influences behaviour more directly. Given the fact that most of our days are action packed and largely spent indoors, we would be wise to strive for healthy light exposure. Yet what a healthy light regime entails exactly is still hard to define and may differ from day to day and from person to person.

## Daytime light exposure

Recent studies performed at ILI have demonstrated that light exposure during daytime does affect alertness, vitality, and performance, not only in the confines of controlled laboratories, but in everyday life. When we tracked persons' continuous exposure and mental status throughout the day, we learned that after periods of brighter light exposure, people felt more alert and more vital. Yet these vitalising effects appear to vary with time of day and differ for morning and evening types. Our research also shows that the source of light is important. People generally prefer daylight to artificial light, even when the artificial light is matched in intensity and colour temperature. The effects of light not only depend on timing, intensity and spectrum, but may also depend on contextual factors such

as personal preferences, the type of task a person engages in, and whether a person already feels alert or fatigued. These outcomes illustrate the complexity and dynamic character of the relation between light and daily functioning.

## The quantified self approach

The quantified self approach, a term coined by Gary Wolf and Kevin Kelly in 2007, describes a trend entailing self-tracking of inputs (e.g. food intake, light exposure), states (e.g., mood, vitality), and performance. Recent technological advancements in ambulatory measurement enable users to recognise and understand patterns in these phenomena across days, weeks and months. Given the enormous growth in fields of data science and wearable sensors, this will soon provide researchers as well as individual users with deeper insights in daily dynamics in behaviour, mood and light exposure patterns and how they interact.

## From insights to interventions

But the quantified-self approach in light will enable us to do more than understand the complex relation between light exposure and 24-hour functioning. These same insights and technologies can then be used for

tailored advice and interventions. They could, for instance, help insomniacs improve their sleep through dosed light exposure, help prevent the onset of seasonal depression, or help students improve their ability to concentrate by increasing the light level when they feel less alert. Moreover, integrating knowledge from lighting research with ambulatory sensing of dynamics in individuals' sleep-wake rhythm, activity pattern, momentary state and light exposure in intelligent lighting solutions will offer new possibilities to provide 24-h lighting schemes tuned to users' need. Such intelligent lighting systems offer promising potential to contribute to persons' quality of life in all life domains, work, health, and leisure.

# Meaningful Artificial Illumination

**Authors** | Jacob Alkema and Harm van Essen

**Humans demonstrate an appreciation of natural lighting above artificial lighting. This not only relates to regular daylight, but also to the experienced qualities of the colours of the sunset, the dynamics of light through the leaves of a tree or the sparkles of light on water surface. This appreciation leads to the concept of ‘Meaningful Artificial Illumination’: Illumination based on the everlasting beauty of natural light.**

Copying or imitating is an obvious method to design a more natural looking artificial light. Examples of these are numerous. Successful examples (LED-candlelight, wake-up light) and less successful examples (artificial fire places, polar light simulators) can be found. Every imitation however just resembles the atmosphere

of the real natural light; it’s impossible to imitate all the aspects of the natural experience. The natural artificial lighting is often not experienced as authentic (wake-up light) or doesn’t convince (virtual window). Indistinguishable from real isn’t a statement applicable for natural artificial lighting. What makes a natural lighting experience so ‘real’? So natural?

Contrary to using nature as a source of inspiration or imitation our approach is based on an understanding of the underlying qualities that are appreciated in natural light. These qualities are formulated and categorized by analyzing natural light appearances, in both artificial and natural lighting. We introduce a framework of qualities in order to help a designer understand natural light, to guide the design process or to evaluate the lighting design.

‘Association with a natural light source’, for example, is a quality to describe artificial light. Bright spots of light with

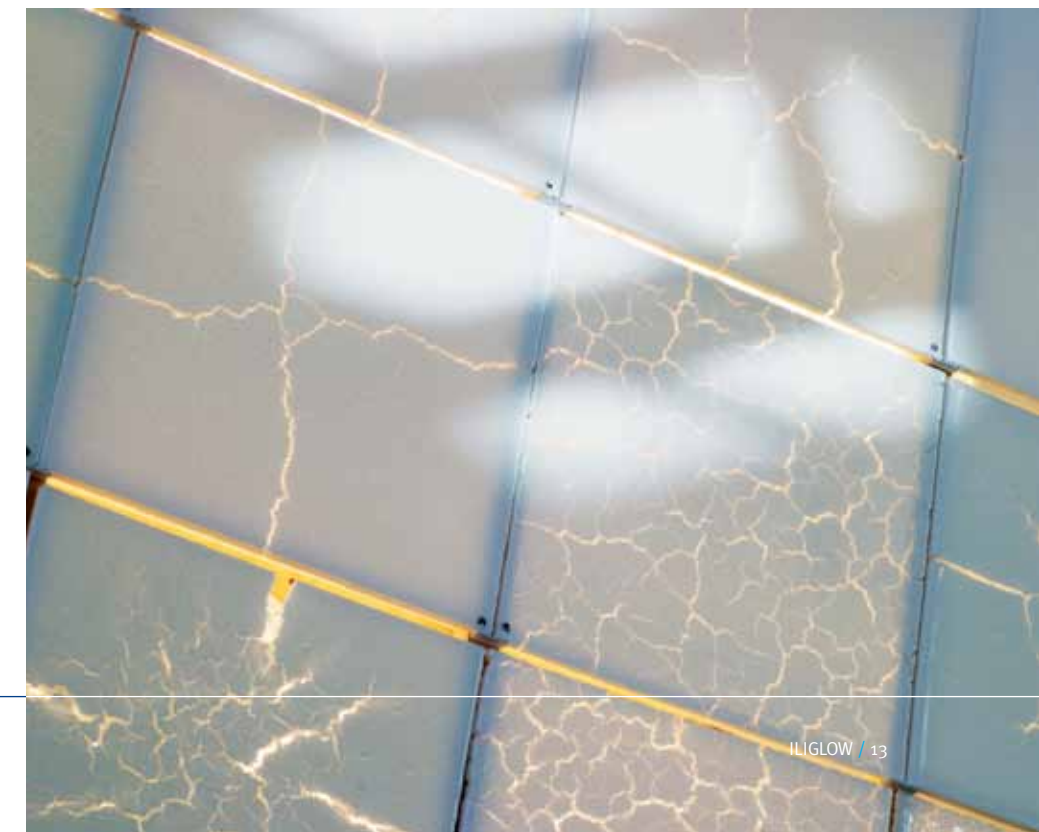
sharp lines gives the impression daylight is shining in (picture top right, Nindya Nareswari). The spots are associated with a natural light source, the sun. This sounds obvious but this is not always the case; the same spots made through a visible light source immediately destroy this association.

Another example is the quality ‘imagination’. Natural light patterns can stimulate someone’s imagination. Picture bottem right shows an artificial light installation, expressing this quality. According to spectators this light installation resembles natural phenomena like a ‘dry desert’, ‘thunderstorm’ or ‘snow’. A wall made of this material, for instance in a room without any daylight, can stimulate the notion of natural light.

Over 50 industrial design students of TU/e applied some of the formulated qualities to design artificial natural lighting. Their interpretation of naturalness was a valuable input for our research. Interesting was the absence of visible artificial light

sources in their design. These sources hamper the natural light experience; natural light isn’t emitted from a product. Students understood intuitively the role of the luminaire. Specific design solutions helped to complement our framework. The quality ‘scale’ for instance is added, natural light has a sense of ‘size’. Especially phenomena (lunar eclipse, polar light, rainbow) are hard to translate into a genuine experience due to the lack of the quality ‘scale’. The design studies expressing these phenomena lead to effects instead of real natural light experiences.

The concept of Meaningful Artificial Illumination will be further developed. Full-scale models help us to test the impact of natural artificial light and to gain more information about qualities and improving our research. In the future the new Main Building Living Lab is a possible scope of application. Proposals will be made for rooms with little or no daylight and for spaces used during the darker winter-days. The research about the long-term experiences and effects on humans helps us to evaluate the concept and to propose next generation convenient lighting.





# ILI Short

## NEW PROJECT

### 3 TU.Bouw Lighthouse project Energy efficient Façade Lighting

“Together with project partners from TU Delft and BL Lighting, Vancouver, Canada, the Building Lighting Group of TU/e sets out to investigate energy efficient façade lighting. Optical fibres are used to highlight façade features but instead of using conventional light sources such as reflector lamps, this project looks into the feasibility of using lasers. This can lead to a reduced energy consumption and subsequently reduced operational costs. This lighting system will be tested for its photometric characteristics and demonstrated in a pilot installation.”

<http://www.3tu.nl/be/en/Lighthouse%202014/Energy%20Efficient%20Facade%20Lighting/>

## NEW PROJECT

### 3 TU.Bouw Lighting house project the LIGHTVAN

“Together with project partners at TU Delft and the Industrial partners VELUX Nederland, Romazo and Aldus Bouwinnovatie, the Building Lighting Group at TU/e contributes to building a multi-functional mobile light laboratory in a transport van (The LIGHTVAN) with a removable façade at its back side.

Inside the van measurement equipment for lighting research will be placed as well as a table and a chair for research participants. The LIGHTVAN can be brought to different locations and oriented for various sun directions.”

<http://www.3tu.nl/be/en/Lighthouse%202014/the%20LIGHTVAN/>

### NEW IMPULSE -SPARK PROJECT Creating Healthy Environments – Hospitals

This new 2 PhD project focuses on improving healthcare effectiveness and outcomes by improving environmental conditions not only for patients, but particularly for professionals in hospitals. Other studies have shown that there is a direct correlation between staff satisfaction and patient satisfaction.

The understanding of the impact of lighting, including day lighting and control strategies will provide a pathway towards good visual and healthy illumination for health care professionals. Project partners are the Building Lighting Group at TU/e, Hogeschool Utrecht Faculty Healthcare, Meander Medisch Centrum in Amersfoort, Jeroen Bosch Ziekenhuis in 's Hertogenbosch and Philips Research.

### Recognition for Dr. Myriam Aries

Myriam Aries, assistant professor in the Building Lighting group, has received an award from the “Nederlandse Stichting voor Verlichtingskunde (NSvV)” recognizing her outstanding efforts as a member of the organizing committee for the LICHT 2014 conference in Den Haag/The Hague. Her responsibilities were extended by her additional appointment as chair of the conference program committee. The LICHT 2014 is a bi-annual conference of the lighting associations of Germany (LiTG), Austria (LTG), Switzerland (SLG), and the Netherlands (NSvV). The conference took place from September 21 to 24 and attracted nearly 500 participants from the lighting industry, universities and other stakeholders.

### Eindhoven joined the ENoLL network

The city of Eindhoven has joined the European Network of Living Labs (ENoLL) in the 8th wave of applications. Among the reasons for awarding the membership are the collaboration with ILI in the roadmap urban lighting and ENIGMA projects, the Living Lab Stratumseind as well as the Living Light Labs on the university campus.

*(for logo and images: see [www.enoll.org](http://www.enoll.org))*

### New European Union H2020 project

“Open Architectures for Intelligent Solid State Lighting Systems” (OpenAIS) has been granted. In this project, TU/e ILI collaborates within a consortium of 10 partners from 5 European countries. Together, the consortium aims to build the open system architecture for IP connected intelligent lighting systems of the future. TU/e ILI has two PhD student positions open for this interdisciplinary project. One of these students will be at the Department of Mathematics and Computer Science, and the other one will carry out lighting research within the Department of Industrial Design.

### Lighting Workshop in Helsinki

Dr. T. Ozcelebi, the manager for the ILI “Bright Environments” research program on intelligent lighting control and interaction, is part of the organizing committee of the workshop “Beyond the Switch: Explicit and Implicit Interaction with Light”. This workshop will be held in Helsinki on October 26, 2014 and is organized in conjunction with the NordiCHI'14 conference. If you would like to participate in this workshop, you can register at the conference website - <http://nordichi2014.org/>. For more information on the workshop: <http://lightingworkshop.wordpress.com/>

### De-escalate nominated for Don Berghuijs Safety Award 2014

ILI's De-escalate project was nominated for the prestigious Don Berghuijs Safety Award, organized by the Blomberg Institute. As one of the last three contestants in this competition, the project will present itself during a captain's dinner on December 10. The prize will be handed by the Dutch minister of Infrastructure and the Environment, Melanie Schultz van Haegen. <http://www.blomberginstituut.nl/veiligheidsamenleving/don-berghuijs-award-2014/overzicht/>

### Eurostars valorization grant for PILCS

The PILCS – Personalized Intelligent Lighting Control System – proposal, a collaboration between ILI and Lighten and Moto Muto (both Denmark), has received a valorization grant in the Eurostars Eureka program. The project will run from November 2014 – April 2016.



# Beyond trial and error in lighting optics design

Illumination optics is an important field in the lighting industry. However, the knowledge is gained merely by experience and stored in the heads of a small group of aging engineers. In practice, optical design for lighting applications is a process of trial and error and thus time-consuming and expensive.

“Finding good optical design engineers in the field of lighting is a challenge. Mostly, these kinds of engineers have already worked in the industry for 25+ years, so it is more craftsmanship than science.” Wilbert IJzerman, head of LED Solutions at Philips Lighting and part-time professor at the TU/e, is trying to counter this problem with the development of appropriate models and algorithms to feed design tools and processes. “Also from the academic side, there was no serious attention for the optical side of lighting. A few groups have conducted studies on the subject, but they mostly opted for a singular approach, in physics or mathematics.

This has resulted either in abstract descriptions that design engineers cannot easily put into practice or in algorithms that work in one specific case only.”

## Roadmap

So IJzerman - with the enthusiastic support of Klaas Vegter, CEO of Philips Lighting – started developing a dedicated research program. “We made a 10-year roadmap, containing six relevant topics. And the times were in our favor. Within ILI, the TU/e and Philips Lighting launched a flagship agreement, a joint research program in which our plans fitted seamlessly.”

## Controlled scattering

The first example is a research project focused on the scattering of light. IJzerman: “You could say that LED as the current standard in lighting technology, is outperforming. The light is too bright for a lot of applications. So the industry found

a way to counter this. We scatter a part of the released photons by placing a phosphor coating or shield between the dye and the eye. However, we lacked exact knowledge of the scattering behavior, we didn’t completely understand it and we had no accurate and reliable models. So what we made was always designed-by-experiment: make a range of different scatter particle concentrations and see what works best. This is time-consuming and ineffective. We are trying to find a model that describes and predicts the behaviour of the scattering in a reliable way. At the TU/e, we’re performing experiments in which we use a plasma to position dust particles in a regular pattern and try to find a way to measure the interaction between the particles and the wavelengths of the light...”

## Inverse methods

A second project studies ‘inverse methods’. IJzerman: “Say you want to achieve a certain light distribution. You know the

distribution characteristics of the source, but what optical structure should you use? Nowadays, optical engineers do this on the basis of experience and craftsmanship. But it remains a sort of trial and error situation. Therefore, we are trying to put this classical craftsmanship into a computer code. We want to have algorithms that can define the shape of the optical structure in order to effectively produce a certain light image. Today, we can take much more freedom in the design. Classical incandescent lamps heat up, restricting your design freedom and usage of materials enormously. Today, we can work in plastic. However, we hardly use our freedom because we do not know how to design it properly.”

## Good lighting systems

“In the end. We want to make more energy-efficient and functional luminaires. With our six research projects, we are making steps towards more control in the design and the development of these lighting systems. Within ILI, we are the hardware guys. The core of ILI might be more on the perception side of light, but you need good lighting systems for that. We have just started and we are still shaping the program, but we are happy to collaborate with ILI, as it brings together all kinds of lighting professionals.”



Prof. Wilbert IJzerman

# ILI In the media

April 8, 2014. Interview Elke den Ouden (ILI) and Monique List (city of Eindhoven) were interviewed on smart lighting for cities by BNR Radio at the Hannover Messe.

After the press release about the de-escalate project and Stratumseind several television shows paid attention to the topic.

**RTL EditieNL**

<http://www.rtlxl.nl/#!/editie-nl-216694/22f48c69-0609-4217-a16e-do600989d6fe>.

**NOS Journaal**

<http://www.uitzendinggemist.nl/afleveringen/1383619>

Kick-off creative industries Click NL during Dutch Design Week.

<http://www.clicknl.nl/blog/verslag-kick-off-nwo-projecten-24-oktober-eindhoven-dynamo/?lang=en>

April 12, 2014, Antal Haans Bijdrage aan debat “Techniek, veiligheid en openbare ruimte” tijdens de dag van de filosofie.

September 1, 2014. Mariëlle Aarts on BNR news radio, Eye openers. House as control room.

<http://www.bnr.nl/event/eyeopeners-live/609233-1407/eyeopeners-live-je-huis-als-control-room>

*Youtube movie compilation of live show & interview:*

<http://www.youtube.com/watch?v=Zh4FnGchTLC#t=67>

*Picture of interview BNR nieuwsradio, September 1st 2014: Mariëlle Aarts speaks about “...”*

September 15, 2014, Mariëlle Aarts, Radio interview OMROEP MAX program “Wekker-Wakker”! Goede verlichting goed voor de gezondheid.

<http://nostalgia.radios.nl/uitzendingen/2014-09-15/uitzendingen.html>

September 15, 2014, Mariëlle Aarts, newspaper article in all papers of “The persdienst”

*Abstract:* <http://www.ed.nl/algemeen/binnenland/goede-verlichting-in-huis-maakt-ouderen-gezonder-1.4532944>.

Dutch Magazine “Stedebouw & Architectuur” special issue on lighting, September, 2014 nr. 5, interview – panel discussion, Yvonne de Kort “Licht is een digitaal medium geworden”.

A. Haans en Y.A.W. de Kort, publication in “Justitiële verkenning, nr. 4 (2014). Indammen van sociale agressie met dynamische verlichting. The De-escalate project

Yvonne de Kort, publication in the book “Verkeerskunde” nr. 5, (2014). Interview “Revolutionaire interesse voor licht in techniek en wetenschap”,

Elke den Ouden was invited as guest editor for a special issue on lighting of the Dutch magazine “Stedebouw & Architectuur”. A combination of recent projects in urban and indoor lighting, as well as trends in lighting, give a comprehensive overview of what is currently going on in lighting. The special issue is released in September 2014, summaries (in Dutch) of the articles can be found on <http://www.acquirepublishing.nl/stedebouw-en-architectuur>.

M.B.C. Aries and A.L.P. Rosemann Niet slecht voor een dashboardlichtje” Artikel in “Eigenhuis” magazine, jaargang 41 pages 43-45 (2014)

# The secret life of light

## The first USE course trajectory has gone full circle

**Author | Yvonne de Kort**

In the fall of 2013, ILI started its new course program on the bachelor level. Eighty-six students enrolled in the multidisciplinary USE trajectory: three subsequent courses on light and lighting in the second year of their bachelor program, geared toward the perspective of User, Society, and Enterprise. The students came from all programs offered in TU/e’s Bachelor College.

This first generation of students has now come full circle. They first participated in the introductory course, during which they learned the basics on light and light perception, and important themes in domains of health & wellbeing, smart urban lighting, and interaction with light. Then they took the advanced course. Students each selected two in-depth modules – on measurement, effects, design strategies or business models – and then prepared research proposals in multidisciplinary groups, which they defended in front of a jury of experts. But the crown on this program was formed by the projects.

Some were design oriented, others focused on research, and they showed a wide variety of themes. Research groups investigated the effects of coloured lighting on the perception of taste, and light spots to influence snacking behaviour during television watching. One group studied the behaviour of groups of strangers in absolute darkness – an experience not many of us have encountered before. Yet another influenced interpersonal distance between people in an experiment on the market hall. Design groups developed ideas for the shop of the future, or explored lighting technologies as new tools for teaching, one group developed design ideas for an interactive installation in the Van Abbe museum.

The goal of our educational program is training engineers from different backgrounds, uniquely equipped to face the challenges in lighting innovation. Bringing an interesting and useful course program to an audience this varied (students from programs as diverse as physics and psychology, biomedical and architecture) proved to be an enormous challenge. At times I felt the teachers were learning as much as the students. But now that we have come full circle for the first time, and have seen just what

students delivered, and how they appreciated this program on lighting, our conviction has only grown stronger. Not a happy end, but a promising start, with over 125 students starting new in the program this year.

**Student testimonials copied from the course evaluation:**

*“You can really perform a research, from the literature study, writing a proposal, to searching participants and performing the research. Besides that I liked to work with students of other departments and see their visions on the project”.*

*“As a physics student, it’s interesting to see how other kinds of research are done. I learned a lot from my supervisor”*

*“It made me aware of (and more curious about) the effects light has and how to apply this knowledge into a design”.*



# Smart lighting as stepping stone towards smart city solutions

**Authors** | Elke den Ouden, Antal Haans, Fred Langerak, Rianne Valkenburg, Hans van Diem (Philips Lighting)

Many cities have the ambition to become smart cities and are rolling out extensive sensor networks. But becoming 'smart' is more than just collecting data. Lighting proves to be a powerful actuator that enables the transformation of the collected data into meaningful applications that truly increase the quality of life in the city.

## Light as actuator

The good news is that LED and the integration of lighting into smart sensor networks create new opportunities to not only reduce energy consumption and light pollution, but at the same time create additional value at no extra cost. Smart lighting solutions can increase the perceived personal safety and comfort and make areas more hospitable so that people feel welcome and the economic

vibrancy is boosted. ICT-based lighting solutions enable integrated services benefiting society and individual citizens. Smart lighting becomes an actuator to increase quality of life in the city.

## Adaptive light

ILI-LightHouse is currently collaborating in the Amsterdam Smart Light project on Hoekenrodeplein where an adaptive lighting solution is implemented to create different atmospheres that fit with the use of the square at a particular moment. Next to dimmable lighting the system consists of people counting sensors to trigger the lighting scenarios. What is most interesting is that the system itself provides objective data on the amount of people present and the duration of their stay related to the different lighting settings. Data analysis makes it possible to turn the system into a learning system, which also over time can ensure that the targets to increase the hospitality of the square are being met.

## Data-enabled services

A self-learning lighting system is able to constantly adjust the lighting on the basis of real-time and historical street usage data in order to optimize both energy savings and safety perceptions, but the more interesting services may well go much further. ILI is also involved in making Eindhoven's pub street Stratumseind a more pleasant and safe place by applying smart lighting to reduce aggression. At Stratumseind an extensive set of sensors is installed to provide a wide range of real time (e.g. sound, people count, social media watching), and delayed data (e.g. police reports on incidents, determination of the origin of mobile devices). Historical data from past incidents is used to establish correlations between incidents and specific parameters. The great challenge lies however in the integration of the different types of information collected with the ultimate aim to create new, perhaps hitherto unanticipated, insights about escalation at Stratumseind. With these



insights lighting scenarios can be designed and tested on their impact on the mood and behaviour of people. In the coming months lighting scenarios will be activated based, partly, on real-time data collection.

## Collaboration & new business models

Building the smart lighting systems as mentioned above requires the collaboration between both public and private parties to get access to all the relevant information,

but also to be able to integrate this information into a solution. Moreover, as these projects aim to go beyond mere pilot projects it is important that a viable business model is being developed at the same time to make sure that the proposed solution is structurally implemented. Traditionally urban lighting is a product-based industry, but for smart lighting solutions a service-based model may be more applicable. Municipalities may be able to provide basic infrastructures for smart lighting solutions, but because value is created for other stakeholders as

well there can be new business opportunities with related services in urban spaces for a wider range of customers. ILI is currently setting up a research program to address data-driven smart lighting business models.

*Note: a more extensive publication on this subject can be found in the Open Innovation Yearbook 2014, see also publication list on page 27 of this magazine.*

# Intelligent Outdoor Lighting Systems

Author | Tanir Ozcelebi

Cities understand the advantages of branding themselves as unique, beautiful and secure places. Lighting plays a special part in establishing that identity. In 2014, TU/e Intelligent Lighting Institute, Philips Research and ST Microelectronics are collaborating in an EIT ICT Labs project called 'Intelligent Outdoor Lighting Systems

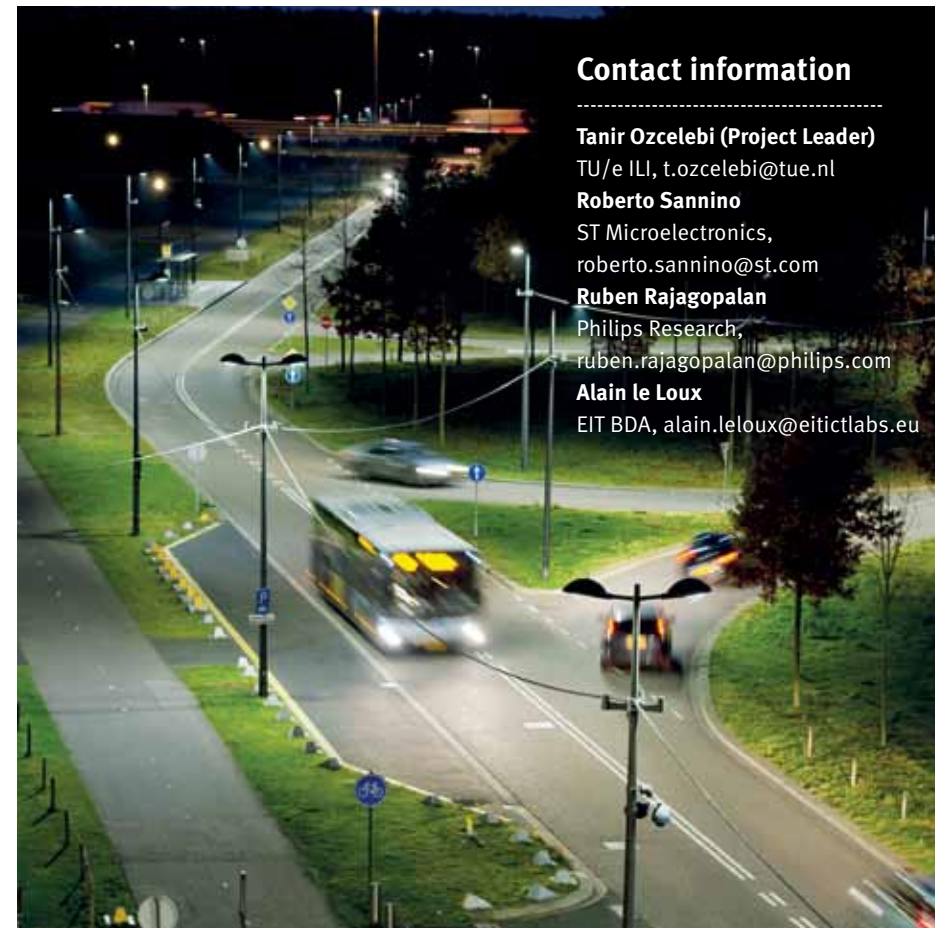
(IOLS)' towards an integrated intelligent outdoor lighting luminaire solution that will allow improved energy efficiency, user experience and safety feeling in cities. The partners integrate their technologies of lighting control, environment sensing and data analytics in a smart urban lighting luminaire, that is capable of intelligent scene classification and real-time dynamic actuation of outdoor lights.

## Improved energy efficiency

With restrictive legislation and the United Nations' Kyoto Protocol, switching to energy-efficient light sources is high on every city's agenda. Intelligent lighting solutions create a unique identity and transform the night scene with lighting solutions that also enhance your city's green credentials.

## Enhanced user experience

Intelligent lighting solutions can enhance the streets, squares and parks that give each city its unique personality. They beautify and inspire, bathing the city with crisp white light or dynamic color schemes to create attractive and inviting atmospheres. Enhancing life in the city and giving night-time socializing more sparkle and appeal.



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## Increased feeling of safety

Lighting environments making people feel safe and welcome are key to creating a livable city. The challenge is to be able to provide lighting to suit each zone, from residential areas and public spaces to busy highways and industrial parks. Light when and where you need it, in precisely the right levels to make the city safer for drivers, pedestrians and residents.

Products resulting from this project will expand the extent of Smart City applications by leveraging on advanced intelligent sensing platforms in a similar way as it happened over the last decade for consumer systems, such as gaming stations and smartphones, which can nowadays fully support the capability of sensing the environment and capturing information regarding the surrounding context. These products will also support introduction of additional functionalities/ services such as traffic and security management.

<http://www.eitictlabs.eu/news-events/news/article/intelligent-outdoor-lighting-shines-on-midsummer-night/>





# Light, Art & Science – complete your Glow experience

Author | Yvonne de Kort

From 8 till 15 November, Eindhoven is of course THE place to be. During Glow 2014, some fifty light artists will fight the darkness and gloom of autumn and bring the city in motion. But engineers and scientists too have selected this event to showcase their work and inspire the world and each other. Two scientific conferences, an inspiration & discussion event, and a symposium will bring together an international community of light researchers, engineers and policy makers. Together, these events present the perfect prelude to the International year of light and light-based technology.

## Experiencing Light 2014

The first scientific event is the Experiencing Light Conference. This international two-day conference on the effects of light and wellbeing is seeing its third edition this year. As in earlier years, it aims to provide a state of the art overview of how light influences mood and emotions, comfort and performance, and physical and mental health. The conference provides an excellent opportunity for academics and practitioners with an interest in research, theory, technologies, design, and applications related to the effects of lighting on people to meet and hear about recent findings.

This year's edition is offering numerous oral and poster presentations by scientists across the globe on five light themes: (1) Perception of light, (2) Circadian & performance effects, (3) Daylight & office lighting, (4) Light & experience – indoor, and (5) Light & experience – outdoor. In contrast, two inspiring keynotes will be given around the theme of darkness. The

first Keynote speaker is Paul Bogard, author of the brilliantly written book *The End of Night: Searching for Natural Darkness in an Age of Artificial Light*. His testimony on behalf of the dark presents the perfect start to the evening's social event. The following morning, Steve Fotios, Professor of Lighting and Visual Perception at the University of Sheffield will choose the perspective of the lonely pedestrian at night as he discusses the sense and nonsense of current research practice – and its implications - in street lighting.

## Strijp S and GLOWNEXT

Both Experiencing Light and Aml 14 have selected Strijp S as the perfect backdrop for their event. The former Philips factory area is now the new creative heart of Eindhoven and host to GLOWNEXT. GLOWNEXT at Strijp-S is an innovative and experimental light art platform and a way for light applications to show social engagement.

## Aml 14 European Conference on Ambient Intelligence

Aml14 is the acronym of the International Joint Conference on Ambient Intelligence. Ambient Intelligence represents a vision of the future where we shall be surrounded by invisible technological means, sensitive and responsive to people and their behaviours, deliver advanced functions, services and experiences. Although not centred on lighting per se, the conference does deal with those technologies that will need to bring the functional backbone of Intelligent Lighting Solutions. Ambient intelligence is expected to combine concepts of ubiquitous technology, intelligent systems and advanced user interfaces putting the humans in the centre of technological developments. Now hosting the eleventh edition of this event and attracting a growing community of Ambient Intelligence researchers, the conference is featuring numerous themes among which the Internet of Things, Smart Buildings and Cities, Data Science, Smart Healthcare and Healing Environments, and Ambient Persuasion. Three inspiring keynotes will be delivered. Dr. Satyen Mukherjee (Sr. Director at Philips Research North America) drives the development of the Philips Research Strategy in North America and identifies and drives cross program initiatives in research. Dr. Maurits Kaptein (Radboud University), explores heterogeneity in people's responses to influence strategies and possible applications of such heterogeneity. He is also a Co-founder and the Chief Scientist of Persuasion API.

Dr. Kenji Suzuki, (Center for Cybernetics Research & Faculty of Engineering, Information and Systems, University of Tsukuba, Japan) is expert in domains of social, cognitive and assistive robotics, and machine initiative and awareness.

## Smart Lighting Event 2014

The city of Eindhoven is on its way to implement smart lighting solutions in the public environment, based on the vision and roadmap urban lighting Eindhoven 2030 (supported by ILLI LightHouse). Over the coming decades the city, companies and knowledge institutes will collaborate with citizens to create a smart city. As part of this transition the city of Eindhoven organises an inspirational vision event for policy makers, scholars, and the general public. Central themes are experience, participation and ethics in smart lighting. Elke den Ouden is one of the keynote speakers at the event.

## Holst Symposium & Memorial Lecture

The Holst Symposium & Memorial Lecture is an annual event organized by Philips Research and TU/e since 1977. For the third year in a row, the organization committee has chosen a lighting-related theme. This year's theme is '100 Years of Innovation with Light', and aims to provide both a historical and visionary perspective on lighting and its effect on people. Four

eminent speakers from academia and industry will deliver a lecture: Prof.dr. Cees Ronda (Philips Research), Dr. Robert F. Karlicek jr. (Smart Lighting Engineering Research, Rensselaer NY), Prof. Steve Fotios (University of Sheffield), and Luc Lafortune (Lighting Designer Cirque du Soleil). The recipient of this year's medal is dr.ir. Robert Cailliau, co-inventor of the World Wide Web.

## Experiencing Light 2014

10-11 November, Strijp-S Eindhoven.

<http://www.experiencinglight.nl>

## Aml14

11-13 November, Strijp-S Eindhoven.

<http://www.ami-conferences.org/2014/>

## Smart Lighting Event 2014

13 November, Nat.Lab, Strijp-S, Eindhoven.

<http://www.smart-circle.org/lighting/>

## Holst symposium

13 November, TU/e campus Eindhoven.

<http://www.tue.nl/en/university/about-the-university/academic-events/holst-memorial-lecture>

# ILI Top publications

## April 2014 - October 2014

**M.P.J. Aarts, M.B.C. Aries, J. Straathof, J.v.Hoof**

Dynamic lighting systems in psychogeriatric care facilities in the Netherlands: a quantitative and qualitative analysis of stakeholders.  
*Indoor and Built Environment*, online May 8, 2014

**R.A. Mangkuto, M.B.C. Aries, E.J. van Loenen, J.L.M. Hensen**

Simulation of virtual natural lighting solutions with simplified view.  
*Lighting Research & Technology*, Vol. 46, Number 2, page 198-218 (2014-4)

**B.W. Meerbeek, M. te Kulve, T. Gritti, M.P.J. Aarts, E.J. van Loenen, E.H.L. Aarts**  
Building automation and perceived control: A field study on motorized exterior blinds in Dutch offices.

*Building and Environment*, 79, 66-77

**R.A. Mangkuto, M.B.C. Aries, E.J. van Loenen and J.L.M. Hensen**

Simulation of virtual natural lighting solutions with a simplified view  
*Lighting Research and Technology*, 46(2), 198-218 (2014)

**S.A.M. Offermans, H.A. van Essen and J.H. Eggen**

User interaction with everyday lighting systems  
*Personal and Ubiquitous Computing (DOI)* 10.1007/s00779-014-0759-2 (2014)

**A. Haans**

The natural preference in people's appraisal of light.  
*Journal of Environmental Psychology*, 39, 51-61 (2014)

**C.R. Prins, J.H.M. ten Thije Boonkamp, T.W. Tukker, W.L. Ijzerman**

An inverse method for color uniformity in white LED spotlights.  
*Journal of Mathematics in Industry*, 4-5 (2014)

**C.R. Prins, J.H.M. ten Thije Boonkamp, J. van Roosmalen, W.L. Ijzerman, T.W. Tukker**

A Monge-Ampere-solver for free-form reflector design.  
*SIAM J. on Scientific Computing* 36, B640-B660 (2014)

**K.C.H.J. Smolders and Y.A.W. de Kort**

Bright light and mental fatigue – effects on alertness, vitality, performance and physiological arousal.  
*Journal of Environmental Psychology*, 39, 77-91 (2014)

**M.B.C. Aries, M.P.J. Aarts and J.J.P.M. van Hoof**

Daylight and health: a review of the evidence and consequences for the built environment  
*Lighting Research & Technology*, in press (2014)

**F. Beute and Y.A.W. de Kort**

Natural resistance. Effects of exposure to nature on self-regulation, mood, and physiology in an ego-depletion paradigm  
*Journal of Environmental Psychology*, 40, 167-178 (2014)

**F. Beute and Y.A.W. de Kort**

Salutogenic Effects of the Environment: Review of Health Protective Effects of Nature and Daylight  
*Applied Psychology: Health and Well-Being*, 6 (1), 67-95 (2014)

**E.M.L. Daemen, I.C.M. Flinsenbergh, E.J. van Loenen, R.P.G. Cuppen, R.J.E. Rajae-Joordens**

Adaptable Healing Patient Room for Stroke Patients – A Staff Evaluation  
*Journal of Methods of information in Medicine*, 53 (4), May 2014.

**Y.A.W. de Kort, J.A. Veitch**

From blind spot into the spotlight.  
*Journal of Environmental Psychology*, 39, 1-4 (2014)

**R. Mangkuto, S. Wang, B. Meerbeek, M. Aries, E. van Loenen**

Lighting performance and electrical energy consumption of a virtual window prototype.  
*Applied Energy* (2014)

**M. Perz, I.M.L.C. Vogels, D. Sekulovski, L. Wang, Y. Tu, I.E.J. Heynderickx**

Modelling the visibility of the stroboscopic effect occurring in temporally modulated light systems.  
*Lighting Research and Technology*; published online before print (2014)

**M.G.M. Stokkermans, I.E.J. Heynderickx**

Temporal dark adaptation to spatially complex backgrounds: effects of an additional light source.  
*Journal of the Optical Society of America A*, 31,7. (2014)

**E. den Ouden, R. Valkenburg, E.H.L. Aarts**

Service Design Based on Smart Urban Lighting. Chapter in: Open Innovation 2.0. Open Innovation Yearbook 2014. Published by the European Commission, ISBN: 978-92-79-33017-9

**Thomas M.M. Meyfroyt, Sem C. Borst, Onno J. Boxma, Dee Denteneer**

Data Dissemination Performance in Large-Scale Sensor Networks  
*Journal: ACM SIGMETRICS Performance Evaluation Review*, Volume 42 Issue 1, Pages 395-406, June 2014  
<http://dl.acm.org/citation.cfm?id=2591981>

**Anagnostis Tsiatmas, Stan P.M.J. Baggen, Frans M.J. Willems,**

**Jean-Paul M.G. Linnartz, Jan W.M. Bergmans**  
An Illumination perspective on visible light communications.  
*IEEE Communications Magazine*, July 2014





