Integrated Solutions for Daylight and Electric Lighting - Newsletter 1

de Boer, Jan; Fontoynont, Marc; Geisler-Moroder, David; Gentile, Niko; Matusiak, Barbara; Osterhaus, Werner

2020

LUND UNIVERSITY

PO Box 117
221 00 Lund
+46 46-222 00 00

Newsletter 1

Overview and first results

May 2020

IEA SHC Task 61 / EBC Annex 77

Integrated Solutions for Daylight and Electric Lighting

FROM COMPONENT TO USER CENTERED SYSTEM EFFICIENCY

BACKGROUND AND OBJECTIVES

Lighting accounts for approximately 15 % of the global electric energy consumption and 5 % of greenhouse gas. Projections by the IEA show that if governments only rely on current policies, global electricity use for lighting will grow from around 2 900 TWh to around 4 250 TWh by 2030. Due to the world's growing population and the increasing demand for electrically driven services in emerging economies the increase will occur despite constant improvements in energy efficiency of lighting systems.

During the last years the focus shifts towards digitalized lighting. This offers the chance to overcome problems in the integration of daylight and electric lighting: (New) technologies equipped with sensors, "intelligent software" and wireless data communication introduce large possibilities to bring the separate market sectors of electric lighting and façade technology closer together.

Research and developments in the field of energy efficient lighting techniques encompassing daylighting, electric lighting and lighting controls combined with activities employing and bringing these techniques to the market can contribute significantly to reduce worldwide electricity consumptions and $C0_2$-emissions.

Task 61 will generate diverse outcomes for different stakeholders:

- **Designers**: New integrated tools, system overviews, design guidelines, system performance information.
- **Standardization bodies**: Integrated daylighting and electric lighting hourly energy rating method, spectral modelling (skies, components).
- **Industry**: Better integration of electric lighting and daylighting (façade) technologies.
- **Building managers**: More effective guidance on the calibration, ongoing adjustment and maintenance of integrated lighting control systems.
- **Policy makers**: Advice to stimulate deployment of successful, energy efficient lighting schemes with added benefits to the citizens.
- **Building users**: Improved indoor conditions to support health, comfort and energy efficiency.

This newsletter presents first results of IEA Task 61 addressing current topics in the integration of daylight and electric lighting.

Content

Subtask A: User perspective and requirements

Lighting requirements, user behavior and "personas"

Barbara Matusiak, NTNU, Trondheim, Norway

The first objective of the subtask is the consolidation of available knowledge on user's visual and non-visual needs and framing requirements for electric light and daylight. The second is to set up *use cases* in specific applications, reflecting typical temporal changes in the usage of interior spaces in public buildings. The third objective is providing so called "personas" as narrative descriptions of representatives of relevant user groups and use schedules for different categories of public buildings.

Lighting Requirements

Lighting quality

Lighting quality is the one, among many lighting concepts, which expresses the user perspective best. Lighting quality is an important goal of lighting designers and planners; however, it is difficult to define and to measure. The following definition of lighting quality has been used many years:

Lighting quality is a concept that allows excellent vision while providing high comfort.

A recent paper (Kruisselbrink, Dangol and Rosemann (2018)) tries to find measures that could be directly used for describing the lighting quality: quantity, glare, spectral power distribution, distribution of light, directionality and dynamics. The overview shows also that luminance distribution is a suitable way for at least getting useful information of the lighting quality. If spectral distribution is added to these measurements, an even better description of the lighting quality is obtained.

The above-mentioned definition of lighting quality has put the focus on the vision of humans, but it does not take into consideration aspects of light that have indirect and profound impact on human health and well-being. Those are the non-image forming aspects of light and some psychological aspects.

Therefore, work in the first project of Subtask A was structured according to the four main aspects:

1. Perception of light
2. Visual comfort
3. Psychological aspects
4. Non-image forming aspects

Visual perception

The amount of light is of crucial importance, but we must be aware of that different humans have different tasks and needs, see Figure 1. It must be possible to adapt the lighting situation to the single user. Furthermore, the daylight should be prioritized at workplaces demanding high level of visual performance, as it maintains alertness and physical well-being better than electric light. For children the possibility for long distance view, i. e. a view out, should always be of high priority since it has been shown that long distance view may help in avoiding myopia. To summarize, the illuminance levels should be related to the individuals and their individual needs, the lux numbers in standards and building regulations should be taken as guidance, not as a target. We already have standards for different types of work situations, but we should add the individual demands for different groups and even individuals.

Visual comfort

The most prominent problem regarding visual comfort for both, daylight and electrical lighting, is glare. However, the tolerance of daylight glare is higher than for electrical lighting. Different measures should be used for those two types of light sources and used with care. The time of day and task difficulty must be also taken into consideration. Flicker, both visual and subliminal must be avoided. Where the limits for flicker should be drawn is not clear, but measures have been proposed. We should also consider that there are individual differences in the sensitivity for flicker. Young people are more sensitive and also people with neuropsychiatric disorders.

Psychological aspects

Daylight has a positive impact on the experience of space, the effect increases with the size of window. Electrical lighting on the other hand may either have a positive or negative impact on the experience of space depending on other qualitative measures. Both natural and electric light, if delivered in a proper way, have positive impact on learning progress in schools. The window size should not be minimized also because of the view out of the window, which has positive effect on well-being, especially if the quality of the view is high and / or the view contains greenery.

Non-image forming aspects

There is so much evidence today that we could say that there are non-image forming effects of light with theoretical biologically based valid models. The development of knowledge of molecular endocrinology is rapid as is the neuro-physiological knowledge. New knowledge may change the recommendations. Daylight is suitable since our biological apparatus is developed for this. Electrical lighting should be developed in line with the new knowledge. The temporal aspect with light and darkness should not be underestimated. Measures for these aspects have been developed but are not standardized yet. The problem related to the high amount of time spent indoors should not be neglected. It is important to use the daylight as much as possible.

Report on integrated requirements

An extended literature study resulted in an overview on lighting recommendations for daylight and electric lighting, rf. to figure 2. This work is documented in the report ***IEA Task 61 ST A 1.1 Literature Review of User Needs, Toward User Requirements***. The report will shortly be made available via the task website.

Next Steps: Use Cases and Personas

To register the occupancy and the use pattern of the respective buildings, the "self-report method" has beed chosen. Self-reports are commonly used to measure human behavior since they are inexpensive, easy to administer and do not impinge on the privacy of the participant. In Figure 3 a part of the Lighting Diary form is shown. The user is asked to notice the time of any movement or activity and mark which change she has done. In addition, the outdoor light level are measured in 15 min intervals. The results will be used for "use mapping". The findings of this activity will then be aggregated in a set of typical use cases. Finally in the subtask, based on lighting requirements and use cases, so called "personas" as narrative descriptions of representatives of relevant user groups and use schedules for different categories of public buildings will be developed.

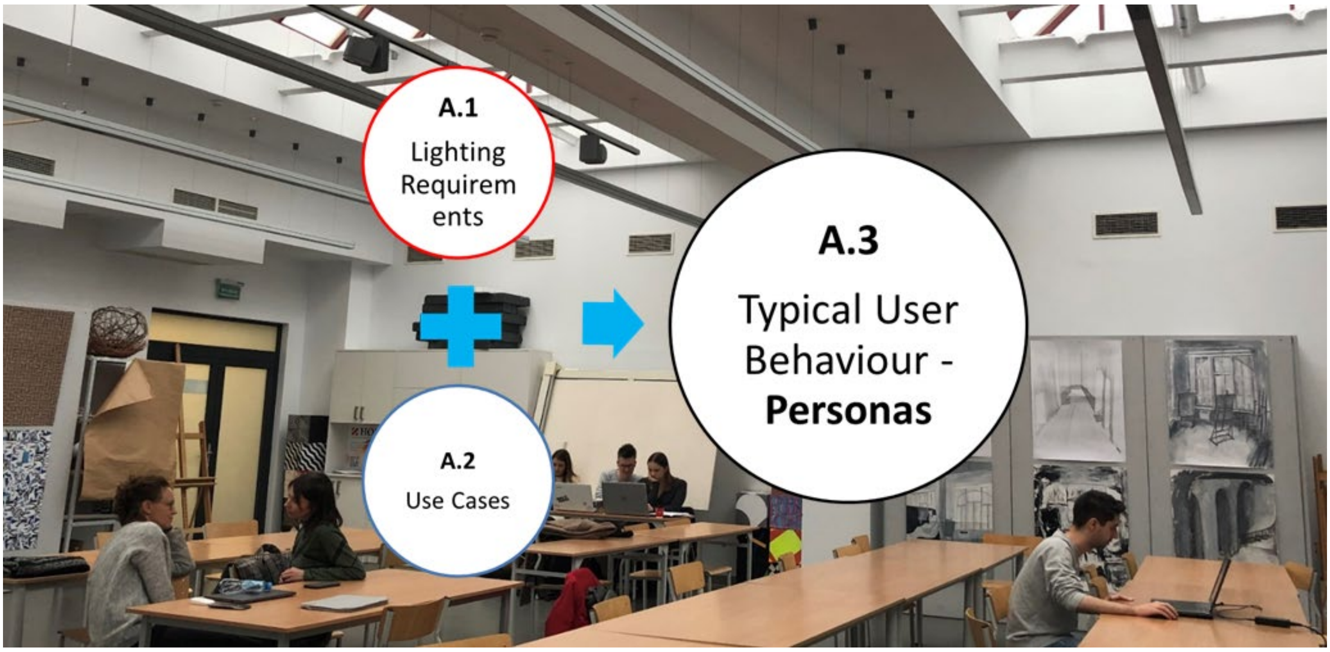

Figure 1: Activities of Subtask A on basis of indoor environments lit by day- and electric lighting, here workplaces at the university college in Gdansk, Poland.

	Daylight		**Electric light**	
Parameter	Measure	Standard value	Measure	Standard value
Workplace illuminance **General**	Target illuminance of daylight provision from windows	≥ 300 lux on the working place level ≥ 50 % of the yearly daylight hours ≥ 50 % of the space area	Mean E_h on the desk	Together with daylight ≥ 500 lux
	Spaces with skylights	as for windows but ≥ 95 % of the space area		
Workplace illuminance **Visual demanding**	Daylight provision from windows	≥ 750 lux on the desk ≥ 50 % of the yearly daylight hours	Mean E_h on the desk	1 000 lux
Workplace illuminance homogeneity **General**	Minimum target illuminance of daylight provision from windows	≥ 100 lux on the working level in room ≥ 50 % of the yearly daylight hours ≥ 95 % of the space area	Uniformity U_o (E_{min}:E_{mean}) on the desk	≥ 0.6
Workplace illuminance homogeneity **Visual demanding**	No measure	*Low level of uniformity on the desk by daylighting is mostly accepted*	Uniformity U_o (E_{min}:E_{mean}) on the desk	≥ 0.7
For more parameters, see the report IEA Task 61 SA 1.1 Literature Review of User Needs, Toward User Requirements.				

Figure 2: A part of a table showing integrated lighting recommendations.

	Movement	**Activity**			
Time	Location	Ceiling lamp		Desk lamp	Sun shade
	☐ Entering the room/workplace ☐ Sitting in the room ☐ Leaving the room but in building ☐ Leaving the building	☐ Switch on ☐ Switch off ☐ Do nothing	☐ Increase lighting level ☐ Decrease lighting level	☐ Switch on ☐ Switch off ☐ Do nothing	☐ 100 % ☐ 75 % ☐ 50 % ☐ 0 %

Figure 3: A part of the Lighting Diary form.

Subtask B: Integration and optimization of daylight and electric lighting

Survey on integrated control strategies

Marc Fontoynont, Aalborg University, Copenhagen, Denmark

In this subtask, we are addressing the evolution of control strategies, both for electric lighting and window components. We found from a first survey among more than 100 professionals worldwide that there was high expectations concerning control techniques for reducing energy usage, simplifying tasks of facility managers and also improving occupant satisfaction. Thanks to digitalization of lighting and LED-sources, dimming and controls is made easier and can be operated remotely with wired and wireless network, and also from outside the building itself, to facilitate maintenance operation.

Survey on integrated control strategies

Panel of more than 100 professionals from nine countries

The nine countries were Denmark, China, Belgium, Norway, Poland, Austria, Sweden, Italy and Germany, among a panel of more than 100 professionals. The following issues were addressed, dealing with control strategies.

1) Can these technologies lead to a reduction of energy consumption in buildings, through smarter management of artificial lighting and solar shading systems?
2) Can these technologies offer opportunities to simplify installation and maintenance and reduce costs?
3) Can they provide added satisfaction to occupants?
4) Can they be robust (reduced failure rate) and usable for a long time (future-proof)?

The findings from the summary suggest that the two main reasons for implement lighting control systems are the possibility to reduce the electric lighting consumptions and the opportunity to increase the user's wellbeing and thereby reduce complaints from the users. From a user perspective this means that the lighting system must ensure visual acuity and comfort by providing a sufficient level of illuminance and the ability to regulate the light level in relation to the task and the ambient light in the space and thereby create a pleasant light environment. Research suggests, when giving the users some manual control possibilities, the satisfaction with the lighting conditions in general increases. The users should be able to both increase and dim the light levels or completely turn it off. This suggests, if the lighting control system is designed to regulate the illuminance automatically, it should be provide some kind of manually override. This is supported by the findings in the surveys, where all countries in one way or another find it important to provide the users with some possibility of user control.

In relation to the importance of the user control the findings additionally suggest that the occupant control must be simple to operate. A control system which is easy and intuitive for the users to understand will most likely increase the chances of an "optimal" interaction with the system. If the system does not meet the users need or is too complex to use, the possibility that the users will try to override the control systems increases, and this will most likely results in increased energy consumption.

The predominant reason for installing lighting control systems is the possibility to reduce the energy consumption for electric lighting and to a certain degree to increase user comfort. This may explain why it mainly is found of importance to regulate (both automatically and manually) the illuminance levels and not the spectrum of light. This suggests, that the main purpose of the control system is to regulate the illuminance levels based on the surrounding conditions such as the daylight availability and only provide electric light when needed, e. g. based on presence of occupants and daylight control. From the survey it is also found to be desired to have some control of the shading system in relation to avoid glare from high daylight intensities and undesired solar radiation coming into the space, and thereby increase the risk of overheating resulting in an increased ventilation and / or cooling need leading to a higher energy use. However, in the two Scandinavian countries it is found of less importance with the possibility to control the shadings in order to reduce glare from daylight and undesired heat transmission in the space. This may be due to the higher latitude and thereby a lower intensity of the daylight.

Issues needed to be documented and investigated

In processing the results, we identified topics deserving specific attention (not in order of priority) :

- Energy gains (monitor gains specifically related to the control system-lighting and shading).
- Simple commissioning (should be able to be done rapidly, with good confidence).
- Calibration of sensors (very simple procedure, well documented, plug and play).
- Flexibility (re-commissioning, future proof: ability to modify the installation, add new components during the life of the installation).
- Zoning issues: ability to adapt to possible changes in the occupation of the building).
- Interface quality (facility manager / user): intuitive understanding, speed of operation.
- Individual placement: possibility of users to benefit from adapted and localized comfort conditions.
- Close loop control: possibility of systems to operate independently from a centralized control unit.
- Cost reduction of installation: Identify plug and play systems which could be installed in less time.

Next Steps
These expectations are basically on the demand side. In the next study, we focus on an analysis of the supply and will identify innovative routes and solutions.

Gathering of nomenclature
The members of the group found it useful to gather terms and definitions and identify categories of systems.

- For instance close loop vs open loop
- Centralized vs decentralized
- Independent or integrated in building management system (BMS)
- Fully automated, manual or hybrid
- Wireless or wired
- Internet connected or not

We also compared solutions developed for the residential and non residential market and compared available protocols for wireless such as Enocean, Z-Wave, ZigBee, Bluetooth, etc. and discussed pros and cons of such solutions.

This review stress the fact that a number of solutions need to be consolidated, and that clients and users suffer from the lack of standards.

Exploration promising solutions
The team today focuses on analysis new trends and solutions which will be deployed shortly. Also significant progress is achieved on the interfaces (using smartphones or tablets), using geo-localization functionalities in buildings, easing the tasks of facility managers. In parallel, there are some initiative to develop new control standards which may increase the confidence in systems and facilitate cooperation between players.

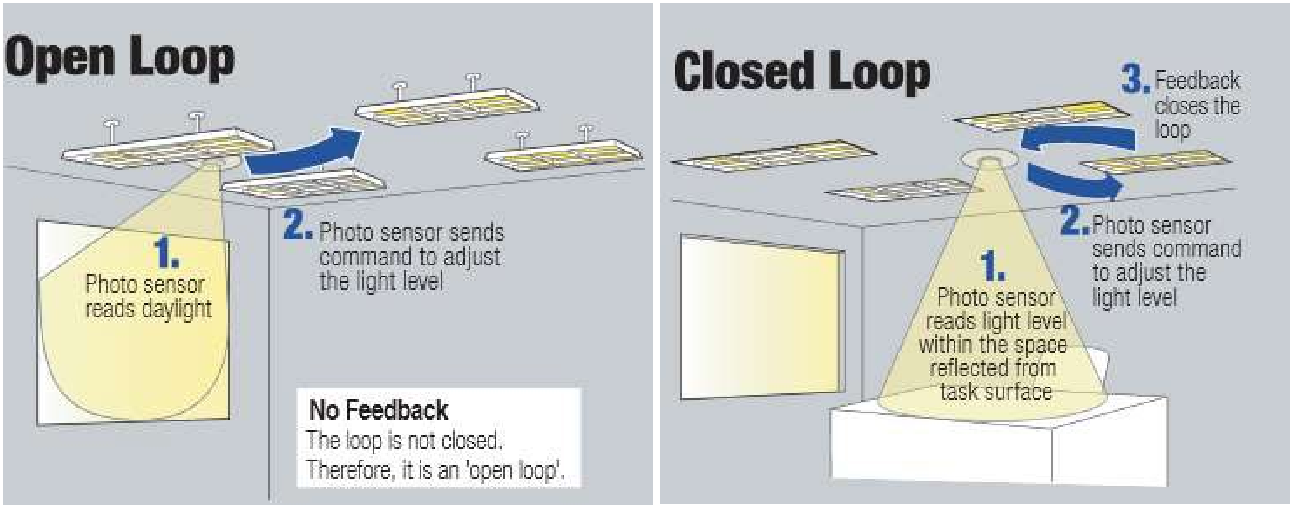

Figure 4: Open vs. closed loop daylight dependent electric lighting control.

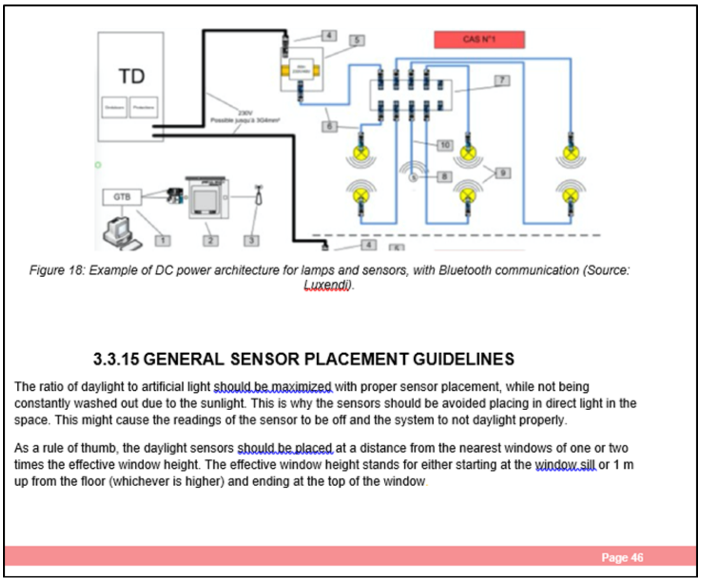

Figure 18: Example of DC power architecture for lamps and sensors, with Bluetooth communication (Source: Luxendi).

3.3.15 GENERAL SENSOR PLACEMENT GUIDELINES

The ratio of daylight to artificial light should be maximized with proper sensor placement, while not being constantly washed out due to the sunlight. This is why the sensors should be avoided placing in direct light in the space. This might cause the readings of the sensor to be off and the system to not daylight properly.

As a rule of thumb, the daylight sensors should be placed at a distance from the nearest windows of one or two times the effective window height. The effective window height stands for either starting at the window sill or 1 m up from the floor (whichever is higher) and ending at the top of the window.

Page 46

Figure 5: Excerpt from draft report "Critical review of existing control systems and their functionalities" (to be published soon).

Subtask C: Design support for practitioners – tools, standards, guidelines

Workflows and software for the design of integrated lighting solutions

David Geisler-Moroder, Bartenbach GmbH, Aldrans, Austria

Practitioners are using a wide variety of different workflows, methods and tools in the planning of integrated solutions for daylighting, electric lighting and lighting controls. Lighting design projects cover a huge variety of applications with different requirements as well as project types and sizes. Within the Subtask C "Design support for practitioners – tools, standards, guidelines" of the IEA SHC Task 61 / EBC Annex 77 currently applied workflows in practical applications have been reviewed.

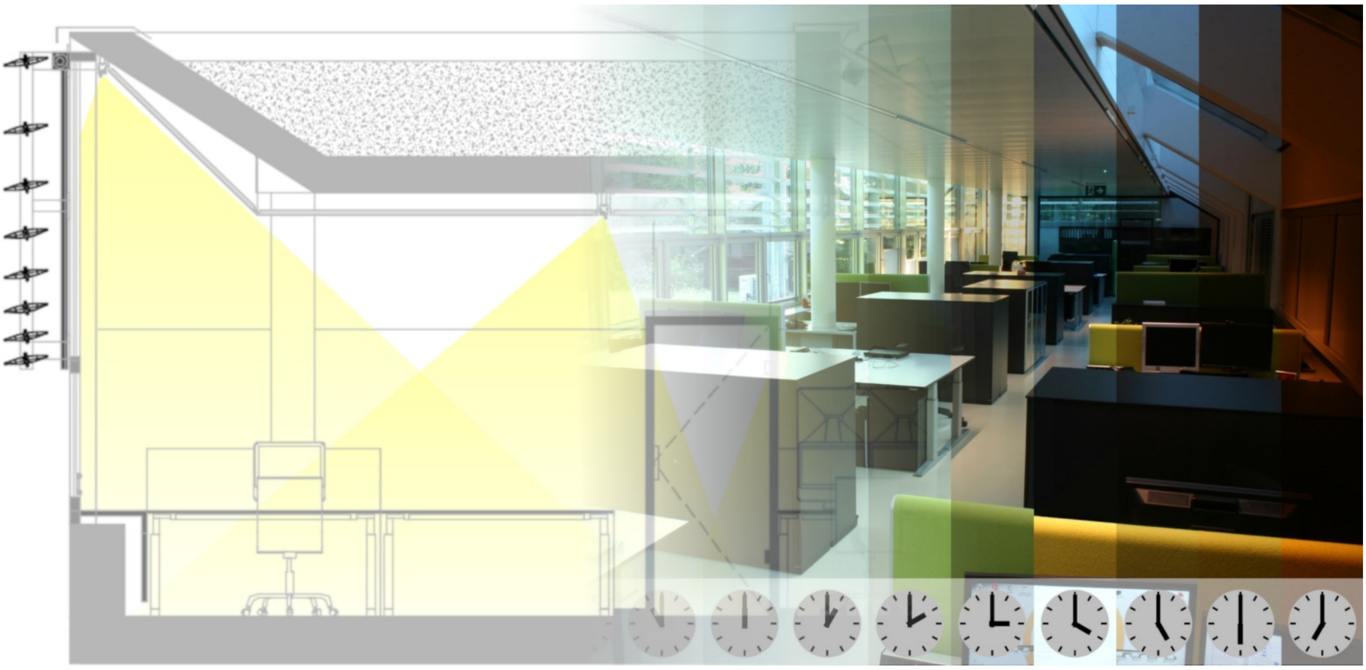

Figure 6: Schematic design of integrated daylighting and electric lighting solution and example sequence of interior lighting conditions in the Bartenbach R&D office.

Example design projects

In a first step three different projects with integrated daylighting and electric lighting solutions are presented. These example design projects are described in detail to give an idea how possible design projects with integrated lighting solutions look like and where the described workflows and tools might be applied. The three buildings are located in Austria, China and Germany, respectively, and represent modern office spaces which were recently built or renovated. Thus, the installed lighting solutions give a good represantation for the state-of-the-art technology.

Evaluation of design workflows

With the background of these example design projects, typical workflows for the planning process of integrated lighting solutions are collected and documented. They cover examples of workflows that are currently applied by practitioners in well-known design offices as well as information about design workflows as proposed in standards or guidelines such as ISO 16817 or the German LiTG Scope of Services. The evaluation documents project phases and their associated design depths as well as main problems and open issues. This allows to assess the applicability of the single workflows to specific design tasks. This analysis sharpens the understanding of the single steps in the design process, mentions the utilized software tools and highlights the areas where software still provides unsatisfactory support.

Figure 7: Selected example design projects with selected rooms: Bartenbach R&D office in Aldrans, Austria (left), DIAL Corporation Building in Lüdenscheid (center), and CABR NZEB in Beijing, China (right).

Analysis of simulation software tools

All described workflows utilize simulation software tools to a greater or lesser extent to support the planning process or to evaluate design options. To provide an overview of the possibilities, strengths, weaknesses and barriers of the state-of-the-art in lighting simulation, relevant and widely used software tools are analyzed and documented. A tabulated comparison of the features of the single tools gives a good indication which tools are suitable for which user group, design phase and application.

	Applies to Software + = yes, o = partly, -- = no											
	AGi32	ElumTools	DALEC	DIALux	DIAL+	DIVA-for-Rhino	FENER	GB SWARE Dali	Ladybug / Honeybee	PKPM	Radiance	RELUX
GENERAL INFORMATION												
Graphical user interface	+	+	+	+	+	+	+	+	+	+	--	+
Command line interface	--	--	--	--	--	--	+	--	--	--	+	--
CAD Import	+	+	--	+	--	+	--	+	+	+	+	+
3D Modeling	+	+	--	+	+	+	--	+	+	+	o	+
3D Rendering	+	+	--	+	--	+	--	+	+	+	+	+
Scripting	--	--	--	--	--	+	+	+	+	--	+	--

Figure 8: Extract from the comparison of analysed lighting design software tools.

Findings

The evaluation of planning workflows for the design of integrated solutions for daylighting, electric lighting and lighting controls shows a broad spectrum of approaches. This also reflects the variety and differences in real world lighting design projects. The described workflows can thus be seen as design processes representing well-working examples. All in all, they provide a toolbox of options and workflow steps to choose from and to assemble a specific workflow for the targeted project and its requirements. The investigated lighting design software tools provide the possibility for every checked feature. However, no single software can cover all relevant aspects. Similar to the workflows, also the tools are designed for specific applications with special focuses. Some are for example mainly developed for daylighting analyses, while others strongly focus on electric lighting design or BIM-functionality. As a general result one can see that basic functionality such as illuminance calculation is covered by all tools. On the other side, databases for either luminaires or daylighting systems, glare evaluations and the functionality to use BSDF-data for daylighting systems are only available in selected tools. Even more, the relatively new field of non-visual effects of lighting is hardly covered in the software systems. For this, special tools are available, which however have not been considered in the current work due to their limited functionality to evaluate integrated solutions for daylighting, electric lighting and control.

Report

The full report T61.C.1 is available on the Task's webpage: http://task61.iea-shc.org/Data/Sites/1/publications/IEA-SHC-Task61-Workflows-and-software-for-the-design-of-integrated-lighting-solutions.pdf

Subtask D: Lab and field study, performance tracking

Energy saving potential for integrated lighting solutions

Werner Osterhaus, Aarhus University, Aarhus, Denmark
Niko Gentile, Lund University, Lund, Sweden

Subtask D aims to demonstrate and assess currently available and typically applied concepts for daylighting and electric lighting design and their integration in order to better understand how these behave with respect to energy use, thermal and visual environment experience, maintenance, adaptability to new requirements as well as building user responses. This is addressed through a comprehensive literature review, targeted medium-term experiments in living laboratories, supplemented by short-term investigations of specific concepts in controlled research laboratory environments as well as performance tracking through "real" field studies in recently completed or retrofitted buildings across selected building types in several of the participating countries.

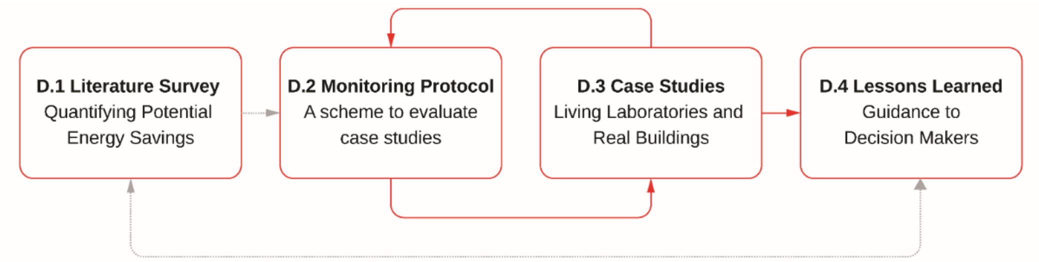

Figure 9: Project areas and workflow for Subtask D.

Literature review highlights

Measures for the reduction of electric energy loads for lighting have predominantly focussed on increasing the efficiency of lighting systems. This efficiency has now reached levels unthinkable a few decades ago. However, a focus on mere efficiency is physically limiting and does not necessarily ensure that the anticipated energy savings actually materialise. A literature survey of around 400 recent publications identifying control strategies and user behaviours leading to a reduction in lighting energy use provides important highlights.

Daylighting

Daylighting remains the preferred light source for the majority of users. Better daylighting provision – in combination with appropriate supplementary electric lighting – can lead to substantial energy savings. Building occupants typically accept lower illuminance levels when the essential illumination is provided (or is perceived to be provided) by daylight rather than electric lighting.

Energy Savings

Potential savings have been reported from the retrieved studies. These savings are often derived from a single study and are dependent on the specific context. In other words, the ecological validity of findings is usually low. Studies on strategies like information, feedback and social norms did not report energy saving performance. This is an interesting conclusion in itself, since the papers rather suggest that the potential is high, but deserves further exploration. Quantifying potential savings is fundamental to fostering the adoption of user-driven strategies on a large scale, since this would allow investors to make at least a rough estimation of returns. However, such quantification requires that studies are designed with an inter-disciplinary approach in mind. For example, during the review process, it was noticed that social science studies tend to provide comprehensive, but only qualitative results, while engineering studies tend to measure energy effects of the intervention, but their experimental designs lack solid theoretical frameworks and results cannot be transferred easily to other contexts. A study design involving expertise from different disciplines would eventually overcome these limitations. Encouraging users to be more conscious of their lighting energy use behaviour can likely achieve sizeable energy savings. However, the savings potential is purely hypothetical at this point and greatly affected by many aspects that are highly situation-specific. It seems therefore necessary to conduct more purposeful studies on integrated lighting design solutions addressing lighting and lighting-related energy aspects from daylight, electric lighting, and shading systems before better and more specific recommendations can be made.

Design recommendations

Manual or partially-automated shading devices provide higher satisfaction and encourage appropriate use, while fully-automated systems are more likely to be overridden. The use of manual and partially-automated shading devices benefits from feedback systems and users tend to act simultaneously on lighting and shading when the control interface is unique and conveniently located.
Energy savings can be fostered by dimming electric light, provided that the speed and range of variation is appropriately regulated. Shading automation may be limited to opening shading devices at the end of the day to maximize daylight, since users usually maintain the default setting.
Fully automated controls with occupancy sensor and on/off-switching should be avoided as they increase energy use in most cases, even when compared to manual switching. In some settings, it might even be better to use manual lighting controls only. Energy code requirements might require revision to permit this.
Lighting controls offering appropriate, gradual, and not noticeable changes in illuminance levels are less likely to annoy occupants. Those with built-in system-

learning capabilities, adapting to user preferences over time, seem to represent a promising path, but additional research is needed on how to best implement such systems in a variety of settings, especially in larger spaces with multiple occupants. Intuitive and tangible lighting controls constitute another topic deserving increased attention. Standards for lighting control devices can perhaps address this on the basis of accurate interdisciplinary scientific studies with different user groups.

Social Norms
Social norms play an increasing role in affecting energy-use behaviours. These can likely be reinforced by feedback from lighting and shading control systems via clearly articulated and intuitive, graphically-supported prompts. If some users, e. g. colleagues, are seen making an effort for energy conservation, other occupants might be persuaded to do the same.

Rebound Effects
It has been observed that rebound effects are increasing the use of energy associated with lighting – despite higher efficacy (lm/W) of light sources. This appears to be related to the perception that more efficient light sources can be used more frequently and perhaps in more places than those with lower efficacy. However, these effects might also be due to increased lighting needs of an aging population and a higher area-per-person ratio in many building types, especially residences. More detailed studies addressing energy use (e. g. before and after lighting retrofits) in various sectors of the lighting market would be useful to identify areas where rebound effects pose particular threats to energy conservation targets.

Case Studies in living laboratories and real buildings
Case studies are powerful sources of inspiration for practitioners. The case studies selected for more detailed, ongoing investigations focus on specific aspects of integrated lighting solutions across a variety of building types, climatic and cultural settings across ten countries participating in Subtask D.

Figure 10: Office at 4th floor of Navitas.

Navitas Building at Aarhus University
To gather data on energy performance, photometric characteristics experienced throughout specific days and seasons, circadian potential of daylight and electric lighting scenarios, as well as user behavior, three classrooms and six offices in a university building have been fitted with ceiling-mounted Raspberry-Pi-based cameras providing 180 ° high dynamic range images of the whole space. The images can be used to assess the lighting distribution from both daylight and electric lighting in the space, the use of solar shading devices by the room occupants and the prediction of energy use. Selected workstations have also been fitted with such a camera to assess luminance distribution and circadian stimulus of office workers over time. Illuminance data are logged at workplane height at nine locations in one office.

In addition, data from the central building management system are logged, providing information on the status of occupancy sensors, ceiling light sensors, dimming percentage of luminaire zones, room temperature and ventilation. In one office, the standard fluorescent luminaires will be disconnected and replaced by tuneable-white LED luminaires (ca. 2 700 K – 6 500 K) for selected periods to investigate the potential of dynamic lighting for the well-being of office workers.

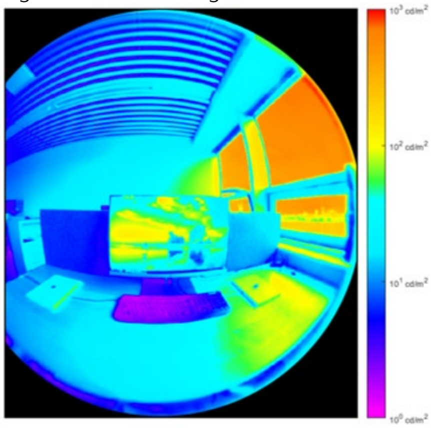

Figure 11: Luminance map captured by Raspberry-Pi-based camera at workstation.

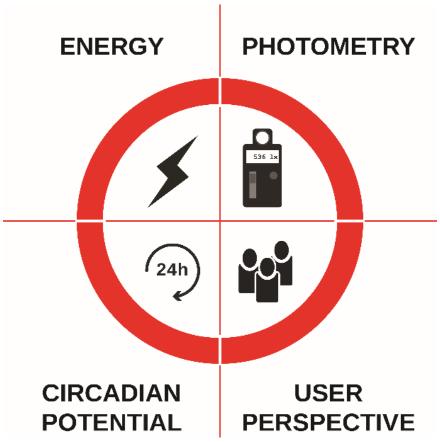

Figure 12: The four aspects evaluated for the case studies set out in the monitoring protocol.

As much as possible and in recognition of specific site conditions, data collection procedures for the case studies are following the guidelines set out in the monitoring protocol developed by Subtask D, Figure 12.

Joint Working Group I – Evaluation method for integrated lighting solutions

Hourly rating method to implement energy efficient lighting in standardization and DIALux evo

Jan de Boer, Fraunhofer Institute for Building Physics (IBP), Stuttgart, Germany

In lighting – dissimilar to other building trades – no simple, fast applicable, hourly, energy calculation and rating method is available. This impedes the design and optimization of innovative and energy efficient lighting installations like advanced façade technologies, "human centric light" and "smart & connected light" based controls. Based on a generic approach an implemention into international standardization and a simple multi-platform tool practically introducing the approach to stakeholders in the market are planned. Then, for use in daily lighting design, core parts of the approach are being implemented into the wide-spread and freely available lighting software DIALux evo.

Generic Approach

In lighting – dissimilar to other building trades – no simple, fast applicable, hourly, energy calculation and rating method is available. This impedes the design of innovative lighting installations (façade technology "human centric light" and "smart & connected light" based lighting controls). The energy saving performance cannot be rated and therefore not be optimized.

The method under development allows to perform local weather based calculations with a generic façade, rooflight and sloped roof model including dynamic shading and glare protection by daylight. In its computational core the approach will be based on the algebraic formalism of the so called "3-Phase Method". This breaks down hourly based daylight simulations, which went along with very high computational loads so far, to a simple algebraic calculation combining sky and outside luminance distributions with façade (BSDF) and room transfer coefficients to obtain natural indoor lighting levels. Based hereupon the method allows to model different daylighting control strategies including linkage with electric lighting control systems (e. g. linkage to indoor occupation sensing for blind controls).

The method will be in line with and supplement hourly calculation schemes for heating, ventilation, cooling, which are already fixed in energy standards world wide, to perform overall building energy balance calculations. It formally shall interface with BACS formalism and syntax as in ISO 16484 integrating lighting design with BACS design, implementation and commissioning in real buildings.

The approach shall be made available via three main channels, which will enable designers, industry and authorities to put new products and solutions in the field of energy efficient smart and connected lighting into place.

ISO Standardization

The method shall be included in the ISO TC's 274 Standard ISO 10916 "Calculation of the impact of daylight utilization on the net and final energy demand for lighting". A new work item for the revision of this standard has started. While preserving the existing simplified method the standard shall be extended and made future proof with the new, hourly rating methodology.

Free Tool

A free accessible multi-platform software tool encompassing the most significant design parameters and technical solutions is under development. It shall introduce the approach to stakeholders like lighting designers, industry and authorities in the market.

Implementation in DIALux evo

Key elements of the approach will be included into the widespread and freely available lighting design software DIALux evo (www.dial.de). The fundamental effort here will be to make the hourly-calculation of daylight supply, based on the above mentioned algorithm of the "3-phase method", available to the standard lighting design process with the software.

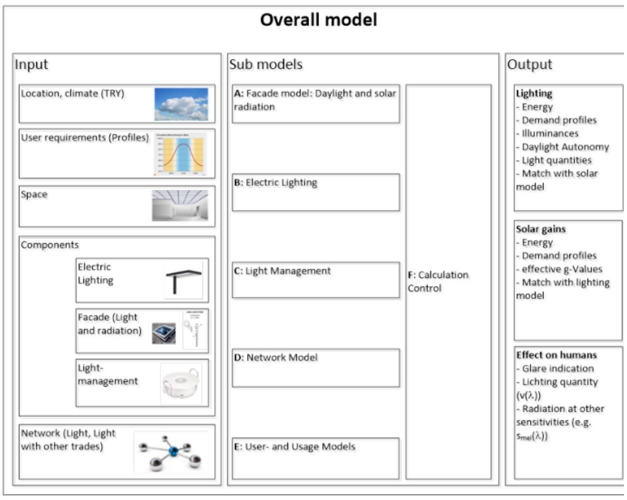

Figure 13: Overall model with input parameters, sub models, output and usage / application.

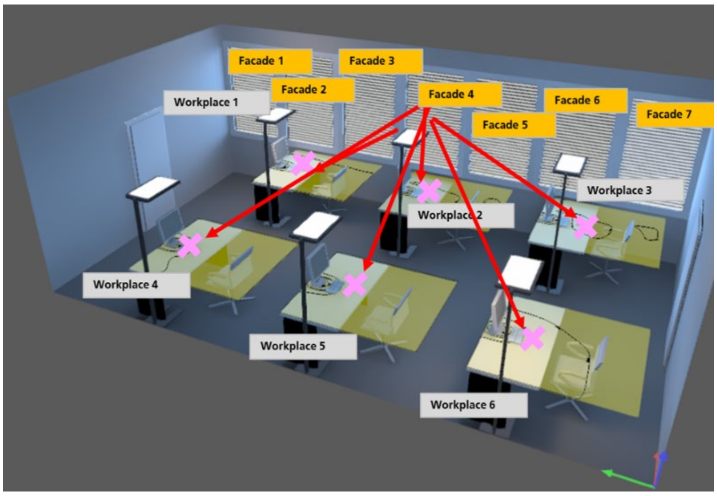

Figure 14: Concept of transfer coefficients showing the impact of façades onto workplace illuminance (simulation with DIALux evo).

Joint Working Group II – Virtual Reality (VR) based decision guide

Communicating integrated lighting solutions with dynamic visualizations

Marc Fontoynont, Aalborg University, Copenhagen, Denmark

Photorealistic interactive dynamic visualization can largely facilitate the understanding of integrated lighting solutions: for electric lighting, for daylighting, and for all possible situations combining the two by control systems. It can be useful to illustrate various options in the controls and the effects of these options. Such visualization will be distributed by the task to key stakeholders.

New means of communicating information on visual perception and energy efficiency for integrated lighting solutions shall be explored and brought into application by this activity. An interactive and immersive communication package will be produced based on input from the different subtasks to visualize various electric and daylighting strategies in selected environments as 3D – Virtual Reality interfaces and standard output formats of course as well (Figure 15). These sequences should facilitate the understanding of the control strategies through a passive or active simulation of lighting controls with response to daylight variations (Figure 16). Round about seven to eight different case studies will be elaborated and then made accessible via the task-website at the end of the task. Aside a procedure how to set up these sequences will be made available.

Figure 15: VR Decision Guide as part of an interactive communication package with output to various formats.

Figure 16: VR Decision Guide to provide interactive lighting experiences.

Further information on IEA-SHC Task 61 / EBC Annex 77

IEA SHC Task 61 / EBC Annex 77 officially started in January 2018 and it will continue until June 2021. IEA Task 61 is organized in four Subtasks and one Joint Working Group, in which with an evaluation method for integrated lighting solutions and a Virtual Reality (VR) based decision guide are being developed. More information is available under http://task61.iea-shc.org/.

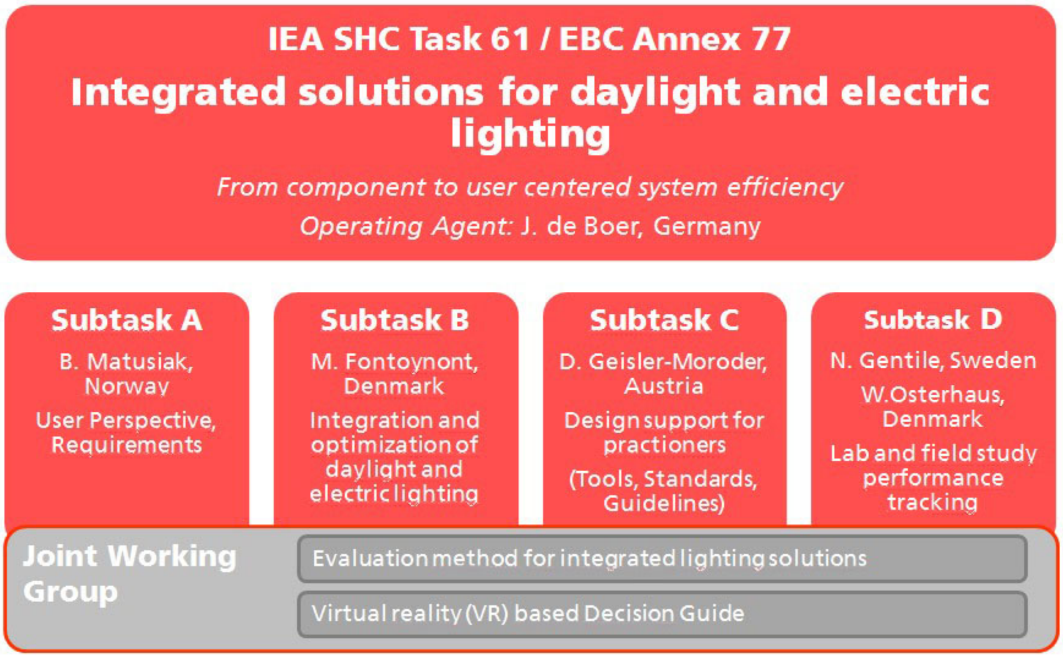

Figure 17: Structure of IEA SHC Task 61 / EBC Annex 77.

Within IEA SHC Task 61, 46 lighting experts from 32 mainly scientific institutions of 17 countries are working together. Since the start of Task 61 five expert meetings have been held in Lund / Sweden (March 2018), Lausanne / Switzerland (Sept. 2018), Beijing / China (March 2019), Gdansk / Poland (Sept. 2019) and via web (March 2020). The personal meetings were each organized in combination with a public industry workshop to trigger experience exchange with practitioners. The next meetings are scheduled for Aversa / Italy and Berkley / USA.

Figure 18: Participants of the 4th task meeting in Gdansk, Poland.

Participating countries and experts

Australia
Queensland University of Technology
Veronica Garcia-Hansen

Austria
Bartenbach GmbH
David Geisler-Moroder
Hella GmbH
Robert Weitlaner

Belgium
Belgian Building Research Institute (BBRI)
Arnaud Deneyer
Bertrand Deroisy
Ruben Delvaeye
Université Catholique de Louvain
Sergio Altomonte

Brazil
University of Brasilia
Prof. Cláudia Amorim

Canada
University of Toronto
John Alstan Jakubiec

China
China Academy of Building Research
Yu Cheng
Tao Luo
Soochow University
Zhen Tian

Denmark
Aarhus University, Department of Engineering
Prof. Werner Osterhaus
Danish Building Research Institute (SBi)
Prof. Marc Fontoynont
Sophie Stoffer
Dansk Center for Lys
Eik Lykke Nielsen
Velux A/S
Jens Christoffersen

Germany
DIAL GmbH
Dieter Polle
Daniel Witzel
Fraunhofer Institute for Building Physics IBP
Jan de Boer
Daniel Neves Pimenta
Simon Woessner
Fraunhofer Institute for Solar Energy Systems ISE
Bruno Bueno
Technische Universität Berlin
Aicha Diakite

Italy
Universita Degli Studi della Campania
Giovanni Ciampi
Michelangelo Scorpio
Sergio Sibilio

Japan
Kyushu University
Yasuko Koga

Netherlands
Eindhoven University of Technology
Alexander P.L. Rosemann
Signify (Philips, Interact)
Peter Fuhrmann

Norway
Norconsult AS
Biliana Obradovic
Norwegian University of Science and Technology NTNU
Barbara Matusiak

Poland
Gdansk University of Technology
Justyna Martyniuk-Peczek
Natalia Sokol

Slovakia
Institute of Construction and Architecture, Slovak Academy of Sciences
Stanislav Darula

Sweden
Inform Design
Marios Liaros
Harris Poirazis
Lund University
Niko Gentile
Thorbjörn Laike

Switzerland
Université de Fribourg
Julien Nembrini
Jérôme Kaempf
Estia SA
Bernard Paule
École Polytechnique Fédérale de Lausanne (EPFL)
Jan Wienold
Yujie WU

U.S.A
Lawrence Berkeley National Laboratory
Eleanor Lee
Anyhere Software
Gregory J. Ward

Task Information

Integrated Solutions for Daylighting and Electric Lighting: From component to user centered system efficiency

Operating Agent

Germany
Jan de Boer
Fraunhofer Institute for Building Physics, IBP
Stuttgart, Germany
Phone +49 (0) 711 / 970-3401
Fax +49 (0) 711 / 970-3399
Email jdb@ibp.fraunhofer.de

Duration

January 2018 – June 2021

Website

http://task61.iea-shc.org/

Editorial Information

Authors

Jan de Boer
Marc Fontoynont
David Geisler-Moroder
Niko Gentile
Barbara Matusiak
Werner Osterhaus

Editor

Jan de Boer