Lighting Solutions with People in Mind

The collaborative project, SHC Task 61 / EBC Annex 77 on Integrated Solutions for Daylight and Electric Lighting: From Component to User Centered System Efficiency, is wrapping up its work in June 2021 and results from these three and half year project are coming in. This article presents the first results of the Task's work on user requirements and design support for practitioners against the backdrop of integrating daylight and electric lighting. The Task experts joined forces to extensively investigate both user perspective and needs as well as state-of-the-art design workflows. The findings are documented in two Task reports, "Literature review of user needs, toward user requirements" and "Workflows and software for the design of integrated lighting solutions."

Literature Review of User Needs, Toward User Requirements

This report's main objective is to rethink and reformulate user requirements for lighting (daylighting and electric lighting) in public buildings based on a thorough literature study.

The concept of lighting quality is one among many lighting concepts that express the user perspective best. The following definition of lighting quality has been used for many years:

> Lighting quality is a concept that allows excellent vision while providing high comfort.
>
> *Kruisselbrink, Dangol and Rosemann, 2018*

In this article, the authors tried to find measures to use to describe lighting quality – quantity, glare, spectral power distribution, distribution of light, directionality and dynamics. The article also shows that mapping the luminance distribution is a suitable way to get useful information on the lighting quality. If the spectral distribution is added to these measurements, an even better description of the lighting quality is obtained.

The definition mentioned above for lighting quality focuses on humans. But, it does not consider aspects of light that have an indirect and profound impact on human health and well-being. These are the non-image forming aspects of light and some of the psychological elements as addressed in the report chapters:

- Visual perception
- Visual comfort
- Psychological aspects of lighting (view out, perceived quality of space, privacy, etc.)
- Non-image forming aspects of light (ipRGCs action spectrum, hormones, etc.)

By thoroughly reviewing literature dealing with these four basic aspects, the Task experts could revisit several lighting quality criteria, both image-forming and non-image forming. They also could compare between qualities of electric lighting and daylighting.

Based on the literature review, the experience of the Task experts involved, and the series of industry workshops coordinated with the Task's industry partners, the Task has identified a number of important measures for creating a better lighting environment, including both daylight and electric lighting (see Table 1). Included are most of the measures available now. The Task experts collected most of the measures from standards and others from ongoing projects and then specified the recommended threshold values.

Based on the many results from the literature review that showed a significant impact of daylight on people, we recommend daylight as a primary source supplemented by electrical light. As much as is practically affordable, electric light should be adjusted to individual needs, or at least differentiated between standard and visually demanding tasks.

The information in the table below should not be considered as absolute solutions but rather as guidelines. Revisions to these 'guidelines' will be done as scientific evidence calls for their updating. Below is a section of Table 1 on page 31 of the Task report summarizing the daylighting and electric lighting measures and recommended threshold values.

Workflows and Software for the Design of Integrated Lighting Solutions

Practitioners are using a wide variety of 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 Task's work in Subtask C: Design Support for Practitioners – Tools, Standards, Guidelines applied workflows in practical applications were reviewed and summarized in this report.

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	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 $E_{horizontal}$ 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 $E_{horizontal}$ on the desk	1000 lux
Workplace illuminance homogeneity	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 Uo (E_{min}:E_{mean}) on the desk	≥ 0.6
Workplace illuminance homogeneity Visual demanding	Minimum Target illuminance of Daylight provision from windows	≥ 200 lux on the working level in room ≥ 50% of the yearly daylight hours	Uniformity Uo (E_{min}:E_{mean}) on the desk	≥ 0.7

The evaluation of planning workflows to design integrated solutions for daylighting, electric lighting, and lighting controls shows a broad spectrum of approaches. And reflects the variety and differences in real-world lighting design projects as illustrated in three office projects in Austria, China and Germany highlighted in the report. The described workflows can 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 a project.

The investigated lighting design software tools provide the possibility for every checked feature. However, no single software can cover all the relevant aspects. Similar to the workflows, the tools are designed for specific applications with special focuses. For example, some are mainly developed for daylighting analysis, while others focus on electric lighting design or BIM (Building Information Modeling) 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. And, the relatively new field of non-visual effects of lighting is hardly covered in the software systems. For this, special tools are available but have not been considered in the Task's work due to their limited functionality to evaluate integrated solutions for daylighting, electric lighting and control.

Both Task reports are available on the SHC Task 61 webpage, publications.

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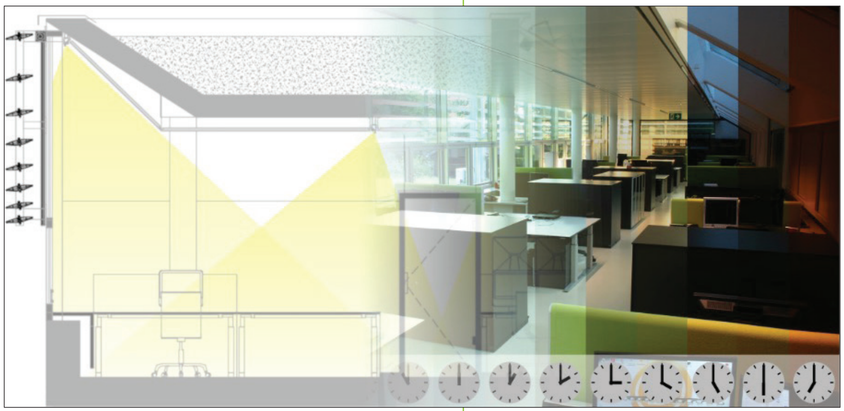

▲ **Schematic design of integrated daylighting and electric lighting solution, and example sequence of interior lighting conditions in the report's design project at the Bartenbach R&D office in Austria.**