LIGHTING DESIGNERS IMPROVE LIGHTING ENERGY PERFORMANCE THROUGH USER-CENTRED LIGHTING DESIGN

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Motivation and Objective

Lighting designers can play a significant and lasting role in creating integrated daylighting and electric lighting solutions providing comfortable and visually appropriate conditions for the users of a space, as well as foster energy performance and sustainability. Lighting designers can apply strategies that inspire users to be more conscious of their own behaviour towards lighting energy use.

Reducing energy use was vital for developing new lighting products, mainly by increasing their efficiency, but higher efficiency has also led to the proliferation of lighting use in new areas, e.g. media facades. A focus on mere efficiency is thus physically limiting, and does not ensure that the anticipated energy savings actually materialise. Likewise, if the visual atmosphere and (day)lighting control interfaces are not living up to the expectations of users, anticipated energy savings can quickly dissipate. This suggests looking at the presence and activities of building users and their comfort needs.

Based on a survey of peer-reviewed research, mainly published during the last decade – conducted as part of IEA SHC Task 61/EBC Annex 77 on “Integrated Solutions for Daylighting and Electric Lighting: from Component to User-Centred System Efficiency” – the interrelationship between lighting solutions, user interface design, feedback systems, user behaviour and lighting energy performance has been assessed.

The aim was to identify user-centred strategies likely to lead to energy savings while maintaining user satisfaction and comfort. The full literature review with appropriate references will be available at http://task61.iea-shc.org/publications or from the authors.

Recommendations following from the Review

The decisions and behaviour of lighting users affect the energy use actually realised. On the other hand, the precise impact of this behaviour is difficult to quantify and seems to depend largely on the lighting design solutions and user interfaces selected. Consolidated evidence of the combined impact of these aspects is desirable. The review has highlighted the following:

Daylighting remains the preferred light source. Better daylighting and view conditions achieved through integrated design processes can result in occupants accepting lower illuminance levels from supplementary electric lighting, thus leading to substantial energy savings.

For achieving high user satisfaction and energy savings with daylighting, manual or partially automated ***shading devices*** are often more effective than fully automated ones. The former encourage more appropriate and frequent use if they benefit from feedback devices and when their controls are co-located with the controls for electric lighting. Shading automation is advised for opening the shading devices after sunset in order to maximise daylight provisions for the following morning, but different façade orientations require different control algorithms to account for sun penetration.

Dimming ***electric lighting*** can reduce energy use if the speed and range of variation is adjusted in such a way that users find it appropriate. Fully automated controls with occupancy sensor-based on/off switching need evaluation as they increase energy use in many cases, even when compared to manual switching. In some cases, it might be better to use manual lighting controls only if energy codes permit this.

Research on various ***information strategies and feedback systems*** on lighting use reported energy savings of 8 to 23%. Informing users of the need to reduce lighting loads, for example, can result in lower accepted illuminance levels. Lighting-based feedback (e.g. a dash light gradually shifting from green to red with increasing energy use) achieved a 21% lower energy use than numerical feedback indicating current consumption.

Lighting controls with built-in system-learning capabilities, i.e. adapting to user preferences over time, seem to be a promising path. A test in individual offices resulted in nearly 38% energy savings after a system-learning period of six weeks. Additional research is needed on how to best implement such systems in a variety of settings, e.g. in larger spaces with multiple occupants.

Intuitive and tangible lighting controls constitute another topic deserving increased attention. Studies highlighted how interfaces, placement and complexity of lighting controls discourage and bewilder users. On the other hand, intuitive controls have contributed to energy savings of up to 61% in a study linking lighting control interface design with energy use.

Social norms play an increasing role in affecting energy-use behaviour. They 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, others might be persuaded to do the same. In addition to individual and collective actions of employees, energy savings may also depend on the attitudes and engagement of management with respect to organisational culture and investment in sustainable technology.

Rebound effects increasing the use of energy associated with lighting – despite higher luminous efficacy (lm/W) of light sources – appear to be related to the perception that more efficient light sources can be used more frequently and perhaps in more places than previous sources. Other factors are increased lighting needs of an aging population and a higher area-per-person ratio in many building types, especially residences. More access to electricity in developing countries also increases lighting energy use, but this contributes to welfare gains, equality and justice. Further detailed studies on energy use (e.g. before and after lighting retrofits) in various sectors of the lighting market could identify areas where rebound effects pose particular threats to energy conservation targets.

Conclusions

With current technology, energy savings in the order of 5 to 30% seem plausible by making users more conscious of their behaviour regarding lighting energy use. This review found that several topics relevant to energy efficiency and user behaviour have not yet been sufficiently explored in lighting research. In particular, research on feedback systems and social norms in integrated lighting design is urgently needed. Lighting designers who understand the interactions between energy-related behavioural patterns and decision-making processes of owners, designers, suppliers, installers and end-users will have a clear advantage over their competitors when it comes to satisfying their customers and creating a more sustainable built environment. The review also showed that strategies are more successful when integrated design is applied. This calls for more communication between façade and lighting designers in future building processes. Finally, research on user-driven strategies is more important than ever, as the level of efficiency in lighting is getting so high that further gains from technological advances will be marginal.

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