LIGHTING RETROFIT IN CURRENT PRACTICE: RESULTS FROM A SURVEY OF IEA TASK 50

B. Paule[1]; J. Kämpf[2,3]; M.-C. Dubois[4]

1: Estia SA, EPFL Innovation Park, Lausanne, Switzerland

2: Solar Energy and Building Physics Laboratory, EPFL, Lausanne, Switzerland

3: kaemco LLC, La Riaz 6, Corcelles-Concise, Switzerland

4: Lund University, Energy and Building Design, Sweden

ABSTRACT

Surveys and socio-professional studies carried out at national and international levels contribute to a better understanding of the lighting retrofit process. Within the framework of the International Energy Agency Task 50 - Advanced lighting solutions for retrofitting buildings- and its subtask C1 focusing on the analysis of workflows and needs, an online survey on lighting retrofit was initiated in December 2014. After 9 months, more than 1000 answers were collected. The survey provides clear insights about the workflow of building professionals and leads to a better understanding of their needs in terms of computer method and tools.

One of the main outcomes of the survey is that retrofitting strategies used in practice essentially focus on electric lighting actions such as of luminaire replacement and the use of controls. Generally, daylighting strategies are not rated as the highest priority. The results also indicate that practitioners mainly rely on their own experience and rarely involve external consultants in the lighting retrofit process. Furthermore, the survey results suggest that practitioners are interested in user-friendly tools allowing quick evaluations of their project, with a good compromise between cost and accuracy, and producing reports that can be directly presented to their client.

The survey also emphasized that the main barriers in using simulation tools are essentially their complexity and the amount of time it takes to perform a study. Practitioners are keen to use tools at preliminary design stage and would like to be able to estimate the cost and other key figures (energy consumption and lighting levels). The paper concludes with recommendations for the building software developers to address the needs of practitioners in a more suitable way.

Keywords: Survey, Lighting, Daylighting, Retrofitting, Methods, Tools

INTRODUCTION

Lighting accounts for approximately 19%, i.e. 2900 TWH, of the global electric energy consumption. Projections [1] by the IEA show that if governments only rely on current policies, global electricity use for lighting will grow to around 4250 TWh by 2030, an increase of more than 40%. Research and developments in the field of energy efficient lighting techniques encompassing daylighting, electric lighting and lighting controls combined with activities bringing these techniques to the market can significantly contribute to reduce worldwide electricity consumptions and CO_2 emissions. These activities will therefore be in line with several different governmental energy efficiency and sustainability targets.

With a small volume of new building constructions in the developed countries (~3%/year), the energy saving potential through lighting and daylighting (façade) mainly lies in the retrofitting of the existing building stock. Furthermore, in emerging economies already several quite young buildings need to be retrofitted. As lighting retrofit activities mainly depend on electricity prices, which show big deviations worldwide according to the energy mix, different levels of product complexity and prices need to be considered for different markets. These local specifics therefore are addressed in an overarching international project: the IEA SHC Task 50 "Advanced Lighting Solutions for Retrofitting Buildings".

Within this Task, Subtask C focuses on computer design tools and analysis methods with the general aim to improve the understanding of retrofit processes. Within the framework of the project area C1 focusing on the analysis of workflow and needs, a survey was conducted on national level to understand the workflows, wishes and needs with respect to computer method and tools of the stakeholders involved in a lighting retrofit process.

This paper presents the methodology developed to create and distribute the survey, the results obtained and an analysis of the outcomes. The paper concludes with recommendations for building software developers to address the needs of building professionals in a more suitable way.

METHODOLOGY

The international survey was created based on a previous one developed as part of a recent IEA Task 41 called "Solar Energy and Architecture". The survey of Task 41 pursued similar goals as the current one i.e. the survey addressed methods and tools used by building professionals but the area of focus was active and passive solar energy use. Many questions from this previous survey were simply adapted to the topic of lighting and daylighting retrofit.

The IEA Task 50 experts jointly developed the survey and published the online questionnaire [2] where the specific themes were: the importance of lighting within thermal retrofitting, the main retrofit strategies, the actual approaches for lighting design, the available information and, finally, the method and tools used within the retrofit process.

The survey was translated in eleven languages: Danish, Dutch, English, Finnish, French, German, Italian, Japanese, Portuguese (Brazil), Slovak and Spanish. Its online form was created using SurveyMonkey [3] with one full questionnaire per language. A front page for the language selection was hosted at EPFL in Switzerland [4]. Task participants of each country achieved the dissemination of the questionnaire during a period of nine months between January and September 2014.

RESULTS AND DISCUSSION

After three quarters of a year, more than 1000 answers from building professionals were collected. Out of 1187 answers, French speaking people were the most numerous (425 answers, the Belgian and Swiss accounted for the vast majority of responses while the French provided less than 20% of French respondents). German speaking people (224 answers) mainly originated from Germany but also from Switzerland and Austria. English speaking respondents (294 answers) originated from various countries with very few respondents from UK and USA (countries not represented in this IEA-50 Task). Most dutch speaking respondents (82 answers) were from Belgium. The rest of the answers came from various countries and covered about 13% (n=162) of the answers.

Amongst the 17 questions related to the lighting retrofit process and the seven questions related to the background information, this paper focuses on only six themes in addition to providing some key information about the respondents.

Importance of lighting within thermal retrofitting

One of the first outcomes of the survey is that within the retrofitting process, lighting (electric lighting and daylighting) is considered as "Important" by the vast majority of the respondents (respectively 58% and 66%). This is positive since the lighting energy share in the energy bill of buildings becomes more and more important with thermally efficient buildings. This result is in line with the results obtained in IEA Task 41, where respondents judged in a vast majority that solar energy was "very important".

As shown in Figure 1, for about half of the respondents, the lighting retrofit is almost always considered when heating and cooling retrofit measures are taken. However, incentives should be initiated to change the behaviour of about 30% of the respondents that never or almost never consider the lighting retrofit measures when thermally retrofitting a building. Indeed, the main driver of the retrofitting measures is often linked to thermal regulations, which usually do not take lighting into account. As an example in Switzerland, the Minergie-P regulation for passive buildings can be achieved without any glazed surfaces impairing the daylight availability and imposing only electric lighting. Another example is the Swedish energy code, which does not include the tenants' electricity use (plugs loads and lighting) and therefore fails to provide an incentive for lighting retrofit.

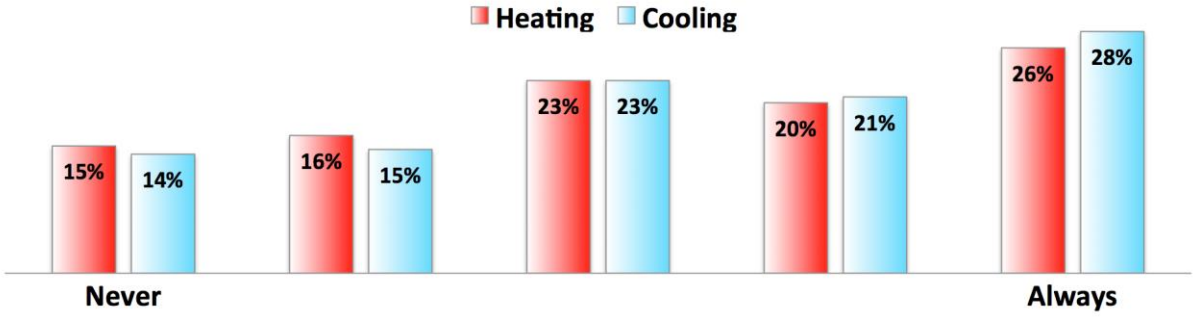

Figure 1: Rating of the integration of lighting purposes within thermal retrofitting

Main retrofit strategies

The three main retrofit strategies considered by the respondents are addressing only electric lighting technologies: going towards more efficient lighting technologies, using occupancy sensors to follow the occupation schedule and using task-ambient lighting design. The reduction of the maintained illuminance levels is not used in practice (e.g. from 500 to 400 lux), unlike the reduction of the temperature set-point in thermal retrofit measures. Furthermore, the spectral quality of the light source (colour rendering, blue component, etc.) is actually not frequently considered in the retrofitting practice.

Actual approaches for lighting design

In the preliminary design phase of the retrofitting projects considering daylight (Figure 2) and electric lighting, the results indicate that respondents mainly rely on their own experience by using rules of thumb and design guidelines. This is totally in line with previous results obtained as part of IEA Task 41 regarding active and passive solar energy. Computer simulations are indeed less considered at this stage, which may reflect the fact that common computer tools are too detailed and not adapted to the preliminary design stage.

Most of the respondents handle the design and decision process themselves, and often involve a lighting manufacturer. The results also show that multi-disciplinary workshops are almost

never used in the handling of the design and decision process. It is however to be noted that interactions with the owner remain important throughout the whole design process.

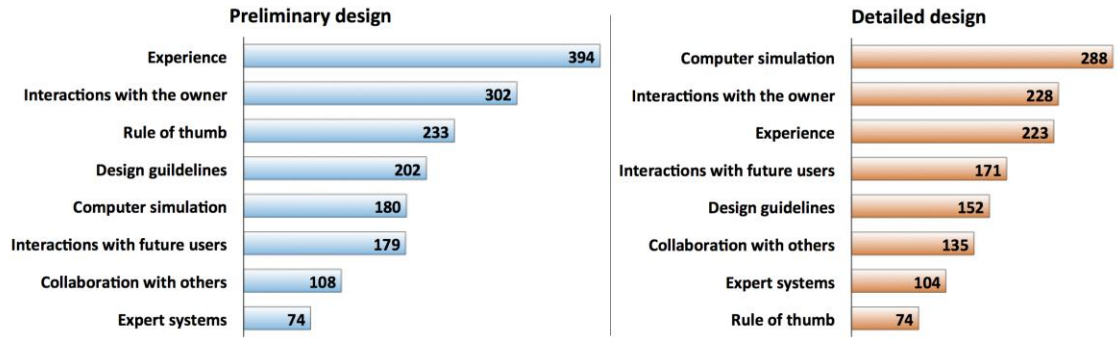

Figure 2: Ranking of the tools and methods used for daylighting design

Available information

From the survey, most of the building or infrastructure information is generally available in printed form, which is consistent with the fact that old buildings are generally refurbished. The poor availability of electronic documents is identified as a barrier to the use of computer simulation tools in the retrofitting process. Especially in the pre-design phase, the absence of BIM generates a large investment in time for the building professionals. Furthermore, the lighting electricity consumption is rarely known, unlike the total electricity consumption, which also comprises the other appliances. Installed power and luminaires' characteristics are often available; one should note that they can anyhow easily be determined by observation.

Methods and tools used within the retrofit process

The total number of respondents that use a specific tool for electric lighting (149) and daylighting (136) is higher than the number of respondents who declare that they use a combined lighting tool (224). This result is quite surprising since most of the leading simulation tools available on the market address the both subjects. Furthermore, one can notice in Figure 3 that a significant number of people do not use any tool. Finally, combined energy tools are not yet established in current practice.

Regarding respondents involved in the lighting retrofit process (501), a great number declare that their skills are acceptable (122) or advanced (138) and about a third describe their skills as poor or very poor, a result which is also in line with previous results of IEA Task 41. The tools and methods available are further divided into four categories: facility management, CAAD / CAD, visualisation and simulation. The answers of the respondents are analysed further down according to these categories.

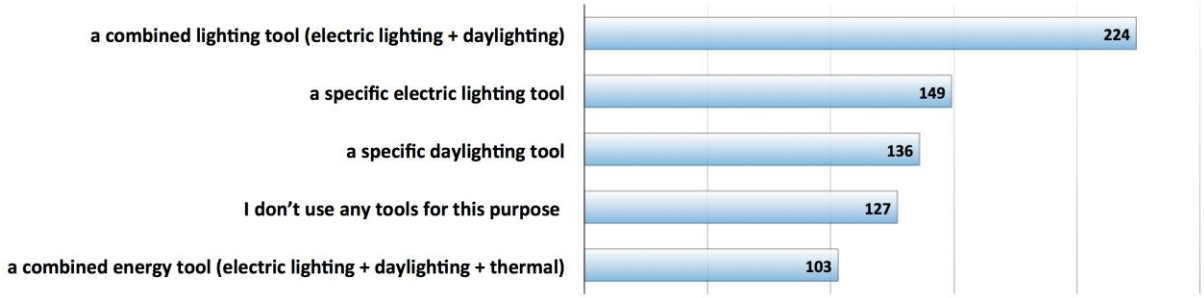

Figure 3: Type of tools used by the respondents for lighting analysis

In Facility management, most of the respondents do not use any tool in the lighting retrofit process; some have built in Excel sheets. In CAAD / CAD, Autocad is a dominant tool on the market, followed by Archicad, Revit and SketchUp. Many respondents of the questionnaire

use a combination of two or more tools in their practice and their global satisfaction is high to very high (at 66%). In Visualisation, Dialux, Sketchup and Relux are the three most used tools in the lighting retrofit process. The global satisfaction is similar to that of the CAAD / CAD category i.e. high to very high for 56% of the respondents. It is noteworthy that 17% of the respondents are very dissatisfied with the Visualisation tools.

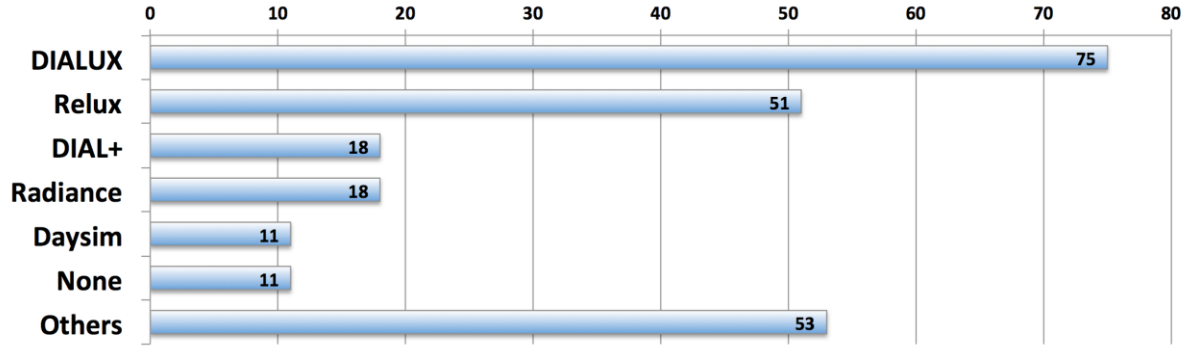

Figure 4: List of tools used to handle simulation in the retrofit process.

In Simulation (Figure 4), Dialux and Relux are the most used software by the respondents followed by DIAL+ and Radiance. The "Others" category includes the following tools: Design Builder (7), Sketchup (6), Ecotect (6), Energyplus (5), Lesosai (5), Diva (4), Velux Visualizer (4), IDA-ICE (3), DIVA for Rhino (3), Trnsys (2), 3DS-max (2), REVIT (1), SomfyDisk (1), Vasari (1), BSim (1), Lightworks (1), Photoshop (1). The global satisfaction for 57% of the respondents is high to very high, with a fifth (20%) very dissatisfied.

Figure 5 shows the list of factors that most influence the user's choice of software. The major issue leading to the choice is to have a user-friendly interface (253) that allows quick and efficient analysis (234). This result in again in line with results obtained in IEA Task 41. The cost of the software (217) is also a major concern, together with the accuracy of results (200) and the quality of the output produced to integrate in reports or presentations (178). Regulations are not often considered in the survey (100), showing that these may not provide real incentives.

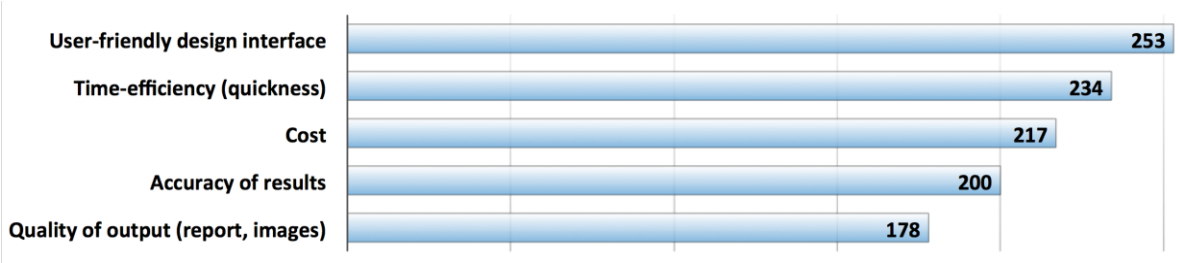

Figure 5: List of 5 factors that most influence the choice of software.

Some barriers were identified when applying lighting tools within the retrofit process: many of the respondents reported that tools are too time-consuming in their usage (154) and too complex (131). This is consistent with the fact that tools are considered as "not adequately supporting the conceptual design stage" by many respondents (87). The incompatibility with other software used by the company (70) and the fact that existing tools are not integrated in "normal workflow" (67) are mentioned by a significant number of respondents.
There is a consensus (145 answers) about the need for improved tools for preliminary sizing of lighting systems, for calculating payback times and investments in lighting and daylighting (144) and for providing key data about lighting levels and energy consumption (142).

General information on the respondents

For new buildings, the major part of the building categories that correspond to the current practice of the respondents were: Office buildings (233), Education and research buildings (188) and Commercial buildings (154). For retrofitting buildings, they were: Office buildings (238), Education and research buildings (210), Cultural buildings (144) and Commercial buildings (143).

Surprisingly, companies with more than 50 employees are the most represented (113) in the survey. In such firms, it is plausible that some people are specialized on lighting. On the other side Small and Medium Enterprises are also well represented (108), in which generalists who must be able to handle a wide array of skills are mainly found. Architects and physicists represent the vast majority of respondents. In comparison, lighting designers are very few but they also represent a rare species in the building sector. The majority of respondents have more than 10 years of experience and are only active on a national level, which probably reflects the fact that, historically, the building sector has a strong local presence.

CONCLUSION

An international survey distributed in 49 countries and translated in eleven languages collected more than 1000 answers from diverse professional groups relating to the lighting retrofitting of buildings. Current practice of the respondents, mainly architects and physicists, mainly entail the retrofit of office, educational and commercial buildings. Amongst these professionals, a majority considers the lighting retrofit process when thermally retrofitting the building, even though thermal regulations do not impose it. The retrofitting measures generally focus on electric lighting with more efficient lighting technologies, lighting controls and task ambient lighting. Rules of thumb and guidelines are mainly used at the pre-design phase, and computer simulation tools used at the detailed phase. The absence of BIM at the early stage of the retrofit process is a barrier to the use of computer tools, since only printed plans are available for the (generally) older building stock.

The methods and tools used by the practitioners involve specific daylight and electric lighting simulation tools, often combined but rarely including thermal calculations. The choice of software is mainly driven by user friendliness of the interface, the speed of the simulation process (data entry and computing time), its cost and the accuracy of the results. The main barriers in using digital tools are identified such as: too time consuming and too complex. Finally, the survey results suggest that the strongest need for improvement of the actual computer tools is connected to the pre-design phase for sizing lighting systems, for calculating payback times and investments and for providing key data about lighting levels and energy consumption. In general, many results of this survey are completely in line with the results of IEA Task 41 survey in the area of active and passive solar energy technologies.

REFERENCES

1. IEA-41: LIGHT'SLABOUR'S LOST, Policies for Energy-efficient Lighting, 2006.
2. M.-C. Dubois (Université Laval) M. Horvat (Ryerson University): International survey about digital tools used by architects for solar design, Subtask B2, 2010.
3. Dubois M-C, Horvat M, Kanters J (2011). Design tools and methods used by architects for solar design: results of an international survey in 14 countries. *CISBAT Conf.*, Lausanne (Switz.), Sept. 14-16. Book of abstracts p. 178.
4. Website: https://www.surveymonkey.com/, last visited: 04-14-2015.
5. Website: http://leso2.epfl.ch/task50/, last visited: 04-14-2015.