SOLAR HEATING & COOLING PROGRAMME
INTERNATIONAL ENERGY AGENCY

Lighting retrofit in current practice
Evaluation of an international survey

T50.C1

A Technical Report of IEA SHC Task 50
Advanced Lighting Solutions for Retrofitting Buildings

April 6, 2016

IEA Solar Heating and Cooling Programme

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A Technical Report of Subtask T50-C1

IEA SHC Task 50: Advanced Lighting Solutions for Retrofitting Buildings

2016-04-06

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PREFACE

Lighting accounts for approximately 19 % (~3000 TWh) of the global electric energy consumption. Without essential changes in policies, markets and practical implementations it is expected to continuously grow despite significant and rapid technical improvements like solid-state lighting, new façades and light management techniques.

With a small volume of new buildings, major lighting energy savings can only be realized by retrofitting the existing building stock. Many countries face the same situation: The majority of the lighting installations are considered to be out of date (older than 25 years). Compared to existing installations, new solutions allow a significant increase in efficiency – easily by a factor of three or more – very often going along with highly interesting payback times. However, lighting refurbishments are still lagging behind compared to what is economically and technically possible and feasible.

IEA SHC Task 50: Advanced Lighting Solutions for Retrofitting Buildings" therefore pursues the goal to accelerate retrofitting of daylighting and electric lighting solutions in the non-residential sector using cost-effective, best practice approaches.

This includes the following activities:

- Develop a sound overview of the lighting retrofit market
- Trigger discussion, initiate revision and enhancement of local and national regulations, certifications and loan programs
- Increase robustness of daylight and electric lighting retrofit approaches technically, ecologically and economically
- Increase understanding of lighting retrofit processes by providing adequate tools for different stakeholders
- Demonstrate state-of-the-art lighting retrofits
- Develop as a joint activity an electronic interactive source book ("Lighting Retrofit Adviser") including design inspirations, design advice, decision tools and design tools

To achieve this goal, the work plan of IEA-Task 50 is organized according to the following four main subtasks, which are interconnected by a joint working group:

Subtask A: Market and Policies
Subtask B: Daylighting and Electric Lighting Solutions
Subtask C: Methods and Tools
Subtask D: Case Studies
Joint Working Group (JWG): Lighting Retrofit Adviser

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 2013.

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 luminaires 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.

EXECUTIVE SUMMARY

Lighting retrofit strategies within existing buildings follow procedures similar to those used by designers during the first original construction of the building. Most decisions are taken accordingly at the conceptual stage, which is followed by planning and execution phases relying on technical procedures. Computer design and analysis tools play a significant role in this prospect by allowing modelling of lighting retrofit projects as well as performance evaluation and visualisation. In order to be efficient, the corresponding computer methods and tools should account for the practical workflow and practical needs of the stakeholders during renovation procedures

In order to contribute to better understand these topics, a survey was launched at international level. This survey has been proposed in eleven (11) different languages, (namely Danish, Dutch, English, Finnish, French, German, Italian, Japanese, Portuguese (Brazil), Slovak, Spanish), in order to gather information from the different cultures and countries. Altogether, French, English and German languages represent more than 80% of the 1100 answers collected. Among the outcomes of the survey we can highlight the following points:

- The main retrofit strategies used in current practice focus on the implementation of electric lighting technologies such as:
  - Use of switch-off occupancy sensors,
  - Improve luminaire technologies,
  - Promote task lighting where appropriate.

- In the preliminary design stage, the respondents mainly rely on their own experience while in the detailed design phase use computer simulations.

- Regarding the existing situation there is hardly ever information on energy consumption due to lighting, and most of time, the available information about the building or infrastructure is limited to 2D documents (no 3D information).

- Most of the respondents claim that they use a combined tool for electric and daylighting.

- Two simulation tools are dominating the studied market: Dialux and Relux.

- The tree main factors that most influence the choice of software are as follow:
  - User-friendly interface,
  - Time-efficiency (simulation quickness),
  - Cost.

- The three most important barriers that are identified are as follow:
  - Tools are too time-consuming in their usage,
  - Tools are too complex to use,
  - Tools are not integrated in CAAD software.

- The three main improvements that are mentioned to support the integration of electric lighting or daylighting considerations within the retrofit process are as follows:
  - Preliminary sizing of lighting system,
  - Calculation of pay-back time,
  - Providing key figures about energy consumption.

In conclusion, we note that the current tools while deemed globally satisfactory by the respondents, contain potential for improvement. In particular, it would be desirable that the tools can be used in early design stages, which requires great speed and simplicity of use, while enabling to perform global energy analysis and, ideally, also to include economic data.

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1. Introduction

Surveys and socio-professional studies carried out at national and international levels contribute to better understand the lighting retrofit process. Within the framework of subtask C1 (Analysis of workflow and needs), we initiated the distribution of an online survey dealing with ***lighting retrofitting in practice*** [1].

The questionnaire was available in the following languages:

- Danish
- Dutch
- English
- Finnish
- French
- German
- Italian
- Japanese
- Portuguese (Brazil)
- Slovak
- Spanish

After 6 months, more than 1000 answers were collected. The survey gives insights about the practical workflow of practitioners and leads to a better understanding of the real needs in terms of computer methods and tools. The results were dealt with on an international basis comprising all the countries contributions. The full text of the questionnaire (English version) can be consulted in the Appendices.

An online access to the database containing the results of the survey has been set up by first half-year of 2015 for the IEA-50 members.

The results of this survey were presented during the CISBAT'15 conference in Lausanne [1]

1 Paule, B., Kaempf, J., Dubois, M.-C., Lighting retrofit in current practice: Results from a survey of IEA Task 50, Proceedings ofn the CISBAT'15 Conference, Lausanne,

2. Results

2.1. Completed questionnaires

2.1.1. Number of respondents per language

Figure 1 shows the number of respondents according to the language.

- French speaking people are the most numerous (the Belgian and Swiss account for the vast majority of responses while the French are less than 20% of Francophones who responded, see also Figure 2).
- German speaking people mainly come from Germany but also from Switzerland and Austria.
- English speaking respondents are spread out over various countries but we must highlight that there is not a lot of respondents from UK and USA (these countries are not represented in this IEA-50 Task)
- Most of Dutch speaking respondents come from Belgium.

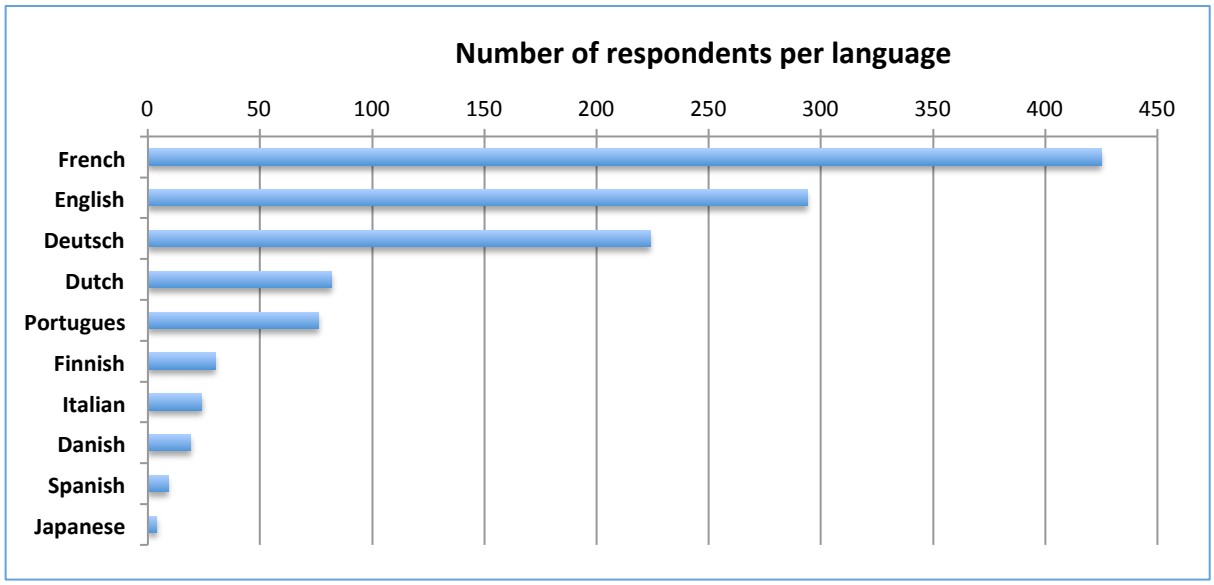

Figure 1: Number of respondents by language

2.1.2. Number of respondents per country

Figure 2 shows the number of respondents per country. As might be expected, the countries represented in the IEA-50 task are those that provide the greatest number of responses (France is an exception which can be explained by the fact that we asked the "Syndicat Français de l'Eclairage" to distribute the survey to its members).

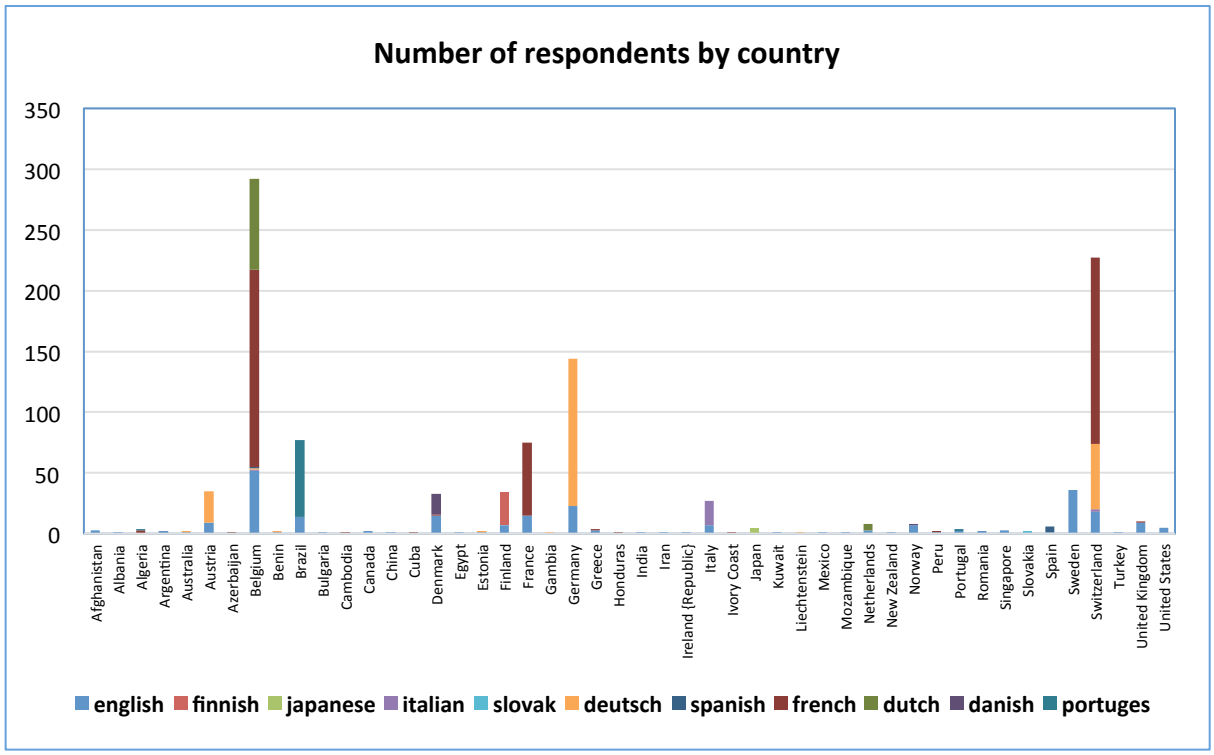

Figure 2: Display of the respondent as a function of the country

2.2. Analysis of the results

2.2.1. The role of lighting in retrofits

Question 1

In your current practice, how do you rate the importance of LIGHTING within the retrofitting process?

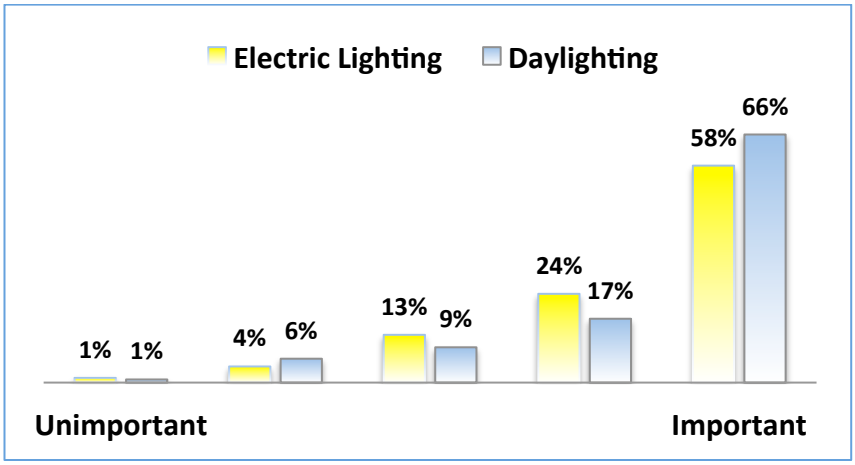

Figure 3: Rating of the importance of lighting in the retrofit process

Most of the respondents consider that electric lighting (58%) and daylighting (66%) are important to be considered in the lighting retrofit process. This reinforces the legitimacy of the objectives of this IEA-50 task that aims to promote the accelerated modernization of daylighting and electric lighting solutions.

Question 2

How often do you consider measures related to lighting in the early design stage of your retrofit projects?

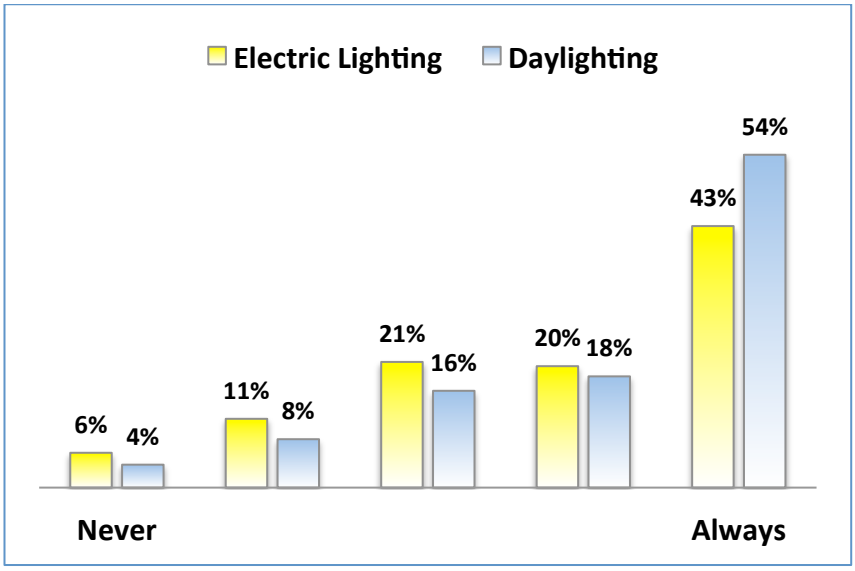

Figure 4: Frequency of the consideration of the lighting retrofit in the early design stage

Most of the respondents claim that they always take into consideration electric lighting (43%) and daylighting (54%) in the early design stages of the retrofit process. It is surprising that the score of daylighting is more important insofar as, during a renovation, the possible actions in this area are relatively lower than for electric lighting. On the other hand, it is noteworthy that if daylighting is not considered in the early design stage, it can hardly be considered later.

Question 3

In your current practice, when thermally retrofitting a building (e.g. windows replacement, cooling ceiling installation, etc.), how often do you also take into account lighting retrofit measures?

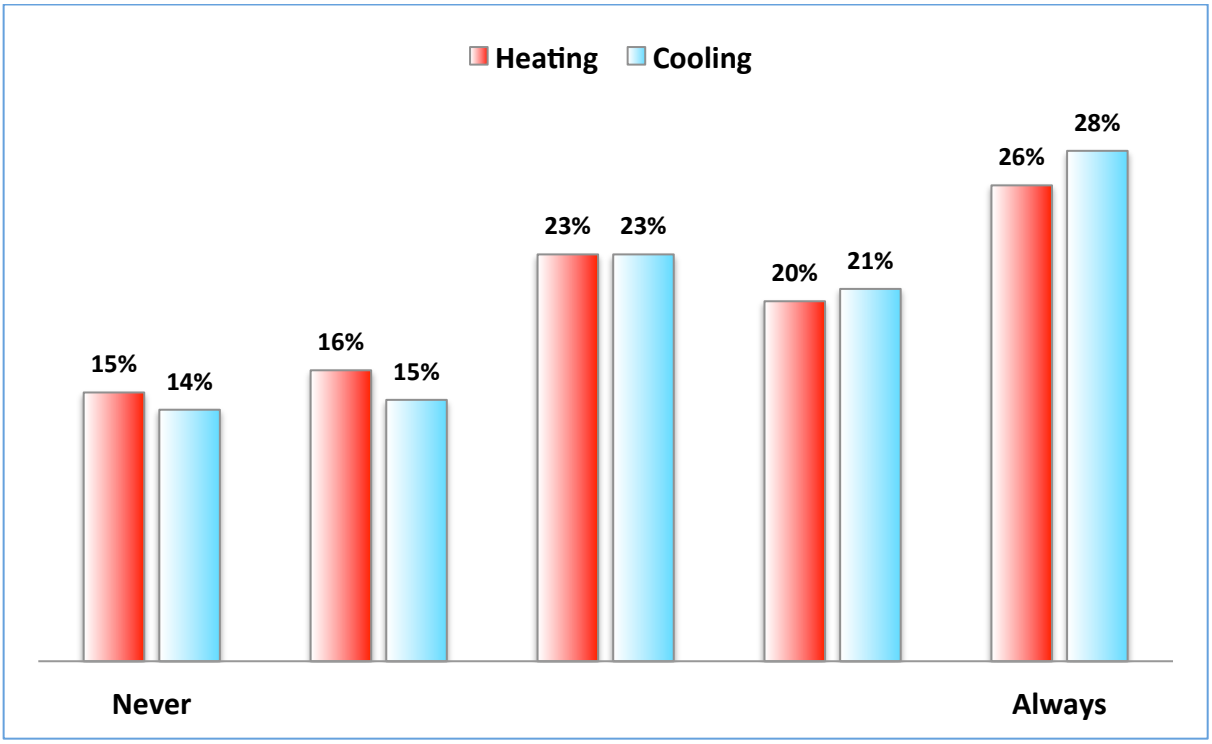

Figure 5: Rating of the integration of lighting purposes within thermal retrofitting

The integration of lighting retrofit measures within the thermal refurbishment process is mainly the same for heating and cooling. For about half of the respondents, the lighting retrofit is almost always taken into account regarding heating and cooling actions. Surprisingly, about 30% of the respondents never or almost never consider the lighting retrofit measures when thermally retrofitting a building. The main driver of the retrofitting measures is often linked to thermal regulations, which do not take into account lighting. For example, in Switzerland the Minergie-P® regulation for passive buildings can be achieved without glazed surfaces. To efficiently drive lighting retrofit measures, the regulation should embed specific lighting requirements.

Question 4

Among the following list, please select the main retrofit strategies (maximum of 8) you use in your current practice.

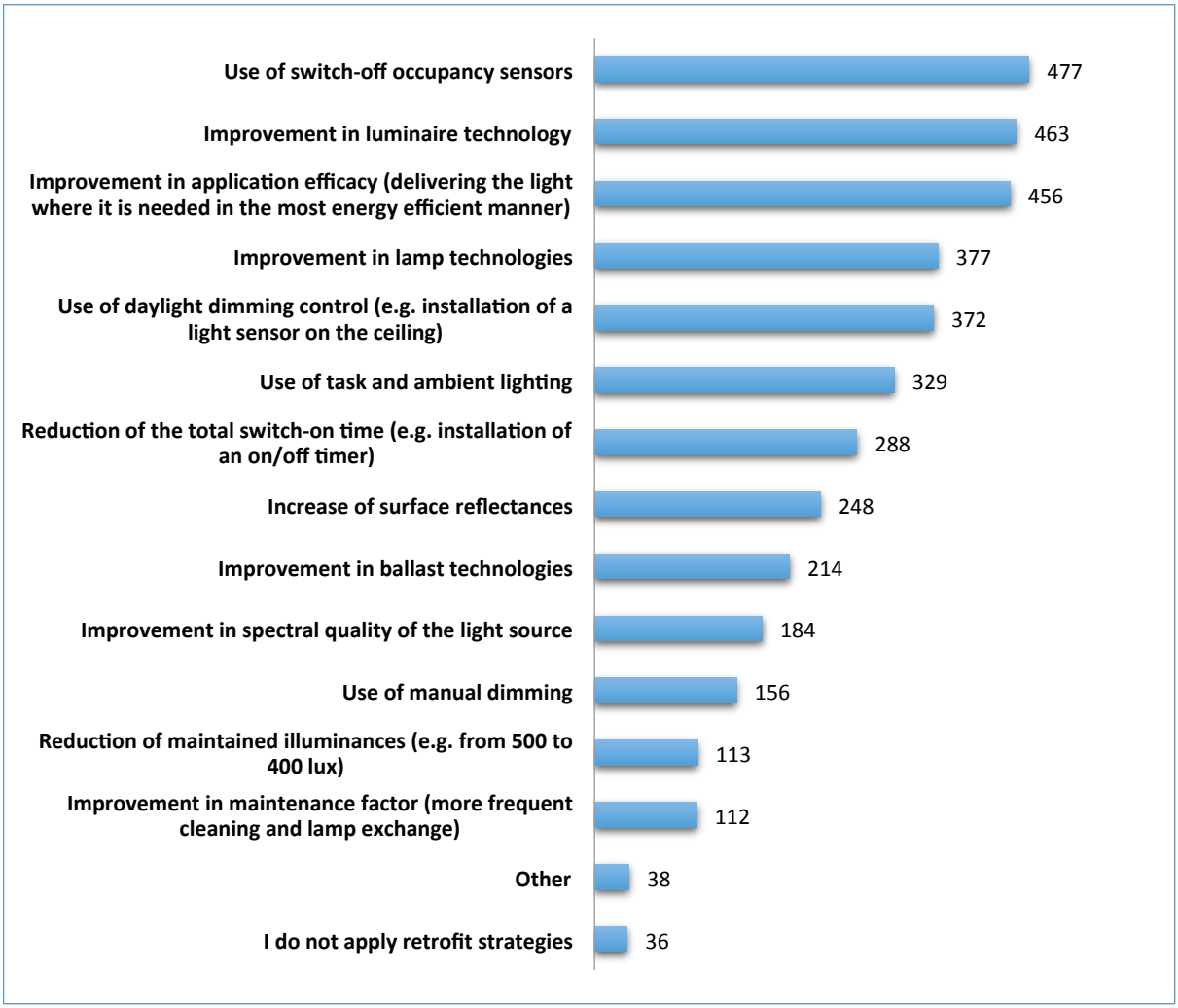

Figure 6: Ranking of the main retrofitting strategies employed

Going towards more efficient lighting technologies, using occupancy sensors to follow the occupation schedule and bringing the light to the task of the user are considered most frequently. The reduction of the maintained illuminances is not used in practice, unlike the reduction of the temperature set-point in thermal retrofit measures. The spectral quality of the light source (colour rendering, blue component, etc.) is not frequently considered in the retrofitting practice.

Other:

Comments written by the respondents
Dynamic window systems, including internal and external shading solutions
How human vision works, how the surface, light and space interact. That places human abilities to see in the centre and shape the technology after it. Not the other way around.
By using high reflectance light level can go down
All of the above
I am not a practitioner
Prioritising by company's electricity installation department
Daylight
In combination with a facade leading daylight in the building's interior, balanced control and regulation; usage of digital electricity for separated control of luminaires near to and away from the window
Daylight optimisation
Improvement of the maintenance factor because of better LED products and not because of shorter maintenance cycles
Daylight systems
Eliminate aesthetic deficits
Improvement of the lighting design particularly lighting solutions that are free of glare; improvement of the lighting ambience
These are the arrangements that I would recommend
Building Management System
To improve daylight
Where humans relate themselves relative to the room and new design based on the control of light – that is a suitable control system is installed (earlier time switch, new can be a combination of time-presence-daylight-dimming)
Also better allocation of lighting, but in our cases this is not often possible (convertible spaces)
Hard to answer because every case is different and requires a specific approach
Use of absence detector
Prefer absence detector
Maintenance: Take into consideration the costs of luminaires replacement
Light homogeneity and glare problems, more important in my opinion than a gross value
Maximize daylight
I am not directly involved in refurbishment
The lamp and ballast replacement occurs in specific cases (commercial / public buildings …)
What is a "task lighting"?
Valuation of daylight
Obtaining the Minergie label seems to be a minimum
Pass me the most of artificial light
The project is primarily integrated taking into consideration the daylight contribution, i.e. optimising it through trough appropriate tricks and strategies
Important : I am not involved in actual refurbishment, but I have a theoretical background in the topic. I indicated what I think are the most important aspects
Use of general artificial lighting as a complement of available daylighting
Use of LED technology
Computer simulation to determine distribution to reach required illuminance

2.2.2. The design methods within the retrofitting process

Question 5

In the following table, please indicate for each design phase, the type of tools or methods you use for DAYLIGHTING design (multiple answers possible).

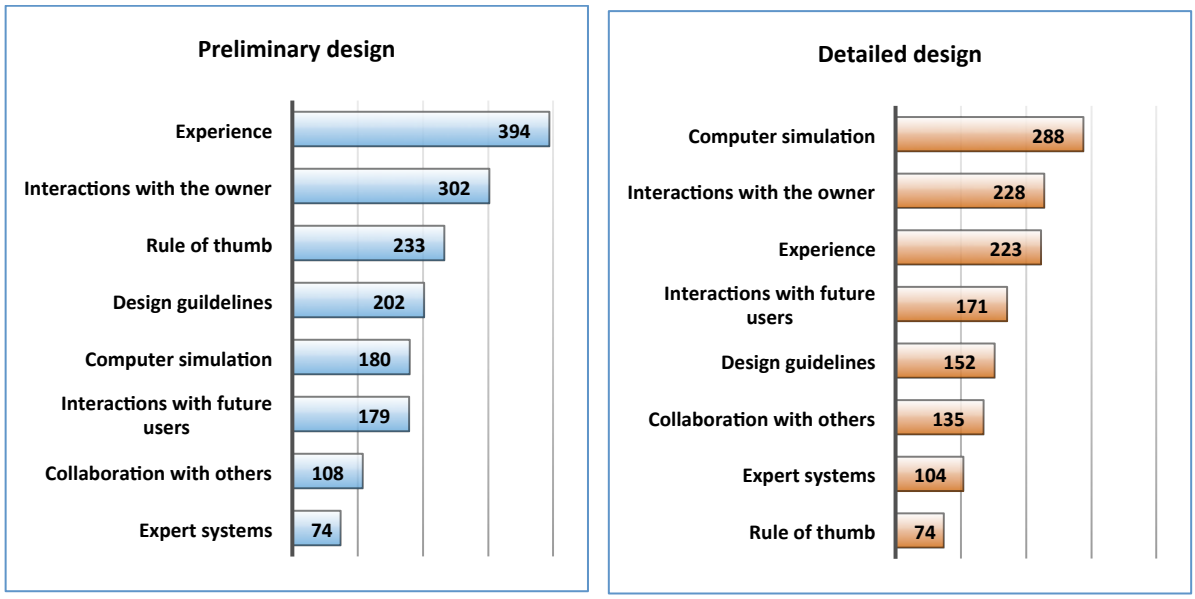

Figure 7: Ranking of the tools and methods used for daylighting design

In preliminary design, the respondents mainly rely on their own experience, rules of thumb and design guidelines. Computer simulations are less considered at this stage, but are essential at the detailed design phase. This may reflect the fact that common computer tools are too detailed and not adapted to preliminary design. Interactions with the owner remain important throughout the whole design process. Expert systems are not frequently used for the daylighting design.

Other:

Comments written by the respondents
Daylighting model
I don't do daylight planning
We don't want to say anything about this, but no expert system
Life cycle excel Tool
Scale mock up / models with specified materials in detailed planning
Cooperation with experts in lighting
Future users are often not known
Not relevant to me
Relux, dialux
Inhouse tools for quick estimation (P d) ; Relux, Daysim (D d)
Relux AG
Model studies and artificial sky
Daylight is not often simulated in ordinary design projects, because the relevance of daylight is small at winter time and it can even be a downside on the illuminance point of view

I don't do detailed daylight design
Lightlab simulations
DIAL+
On the utilization of daylight the openings of the buildings have a big impact and therefore the co-operation with the architect is needed in addition of the above mentioned parties
Interior materials and colours in detailed planning
Dialux
Architect
Collaboration with Architects
Simplified tool DIAL+
DIAL + or DAYSIM
Collaboration with the architect and the thermal engineer
DIAL Plus, Relux
Scale model
3d
Dial +, Ecotect
Collaboration with a lighting engineer or and electric engineer
Standards
Daylighting defined by the architects
Scale models
Scale modele occasionally
Relux Lesosai
Relux
Discussions with the Owner / Architect (electricity consulting engineering firm in my case)
Lighting manufacturer
I work empirically.
Physical models with use of HDR false color images
Daylighting quick calculations and use of technical standards
Graphic simulations
Interaction with designers
Daysim
Technical catalogues (brochures) of used products

Question 6

In the following table, please indicate for each design phase, the type of tools or methods you use for ELECTRIC LIGHTING design (multiple answers possible).

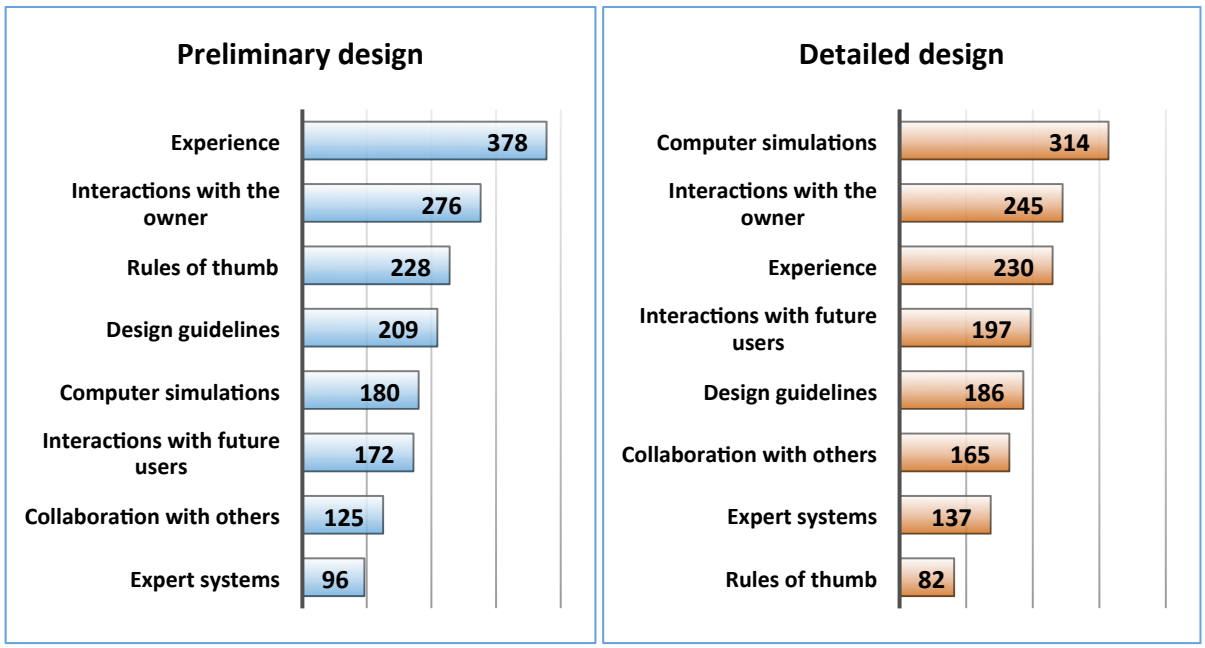

Figure 8: Ranking of the tools and methods used for electric design

For the electric lighting design, the global trends are similar to daylighting. Namely in the preliminary design phase, the respondents mainly rely on their experience and computer tools are essentially used in the detailed design phase. The owner remains at the centre of the decision process.

Other

Comments written by the respondents
In-situ measurements
Planner
In context of planning the building envelope we don´t do any planning of the building electricity
Sampling
The mix of German and English in this questionnaire sucks!
We don't want to say anything about this, but no expert system
Cooperation with experts in lighting and diagrams of the light element
SIA-Standard
The producer
Lighting consultant
Method of efficiency; Dialux, Relux
Relux AG
Information from the suppliers
Setting up sample illumination
See comment in question 1
Consultant

I am the expert – therefore now crossing that item. We try to take into account the users, if they are known in the design stage. Quite often this is not the case. Instead of the owner the representative of the opposing side is a professional building consultant or project management contractor, whose interest is to minimize the investment and installation costs.
Interior materials and colours in detailed planning
Simplified internal tool
Collaboration with the architect and the thermal engineer
Collaboration with lighting wholesalers
Collaboration with specialists
Light Lab
Dial Plus, Relux
None
Sometimes, lighting studies with Cebeo
Dial Lux
Lighting calculation proposed by the lighting manufacturer
Specialized engineer for some major projects
SIA 380/4 (Swiis Norm)
Scale models
Relux Lesosai
Relux
Discussions with the Owner / Architect (electricity consulting engineering firm in my case)
Collaboration with a lighting specialist
With electric engineer or lighting manufacturer
Empirically. The goal is to minimize (sobriety).
I don´t use.
Artificial lighting quick calculations and use of technical standards
Interactions with designers
Energy plus

Question 7

How do you usually handle the design and decision process concerning the integration of lighting technologies in retrofit projects?

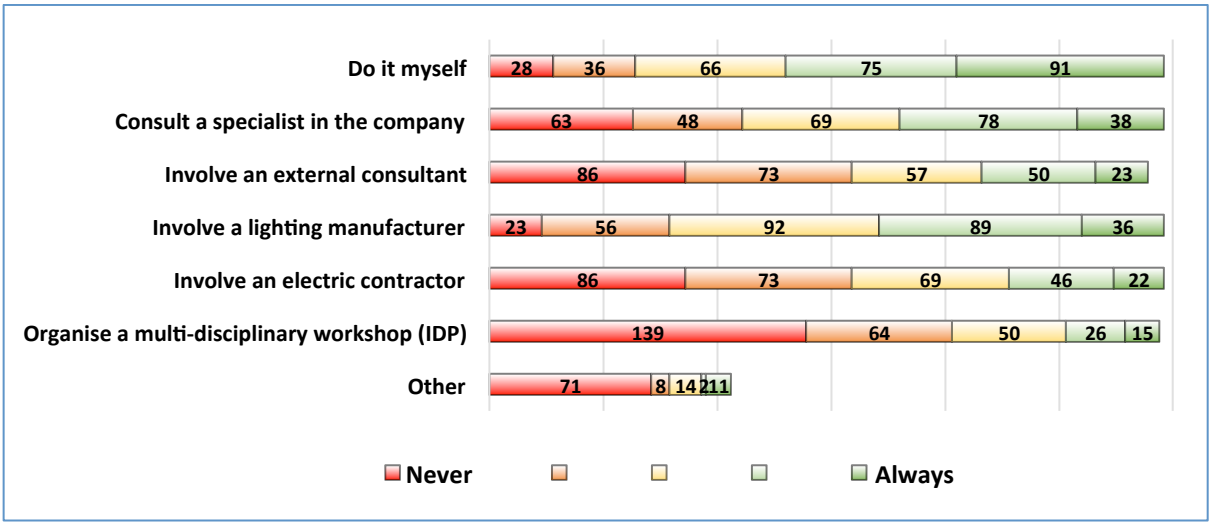

Figure 9: Ranking of the way the respondents handle lighting technologies in the design process

Most of the respondents handle the design and decision process themselves, and often involve a lighting manufacturer. Multi-disciplinary workshops are almost never used in the handling of the design and decision process.

Other

Comments written by the respondents
Work together with vendor
Work close together with the architect
Planer
We are lighting designers..
We are the lighting experts in the company
We are consulted as experts
I am an external consultant in energy efficiency in building design
I am the specialist
I do not
involve lighting designers
See comment in question 1
I never had to actually integrate a lighting technology in a project.
Process involves all the designers of the relevant systems. renovation is a team playing. One can not do it alone.
The architect of the project
Internet and sites
I give consultancy of daylighting and artificial lighting integration
I´m consultant in area
I design using technical brochures of manufacturers and computer simulations and specialized software.
I do it together with other experts and designers

Question 8

What kind of information about the building or infrastructure is usually available at the beginning of your lighting retrofit projects?

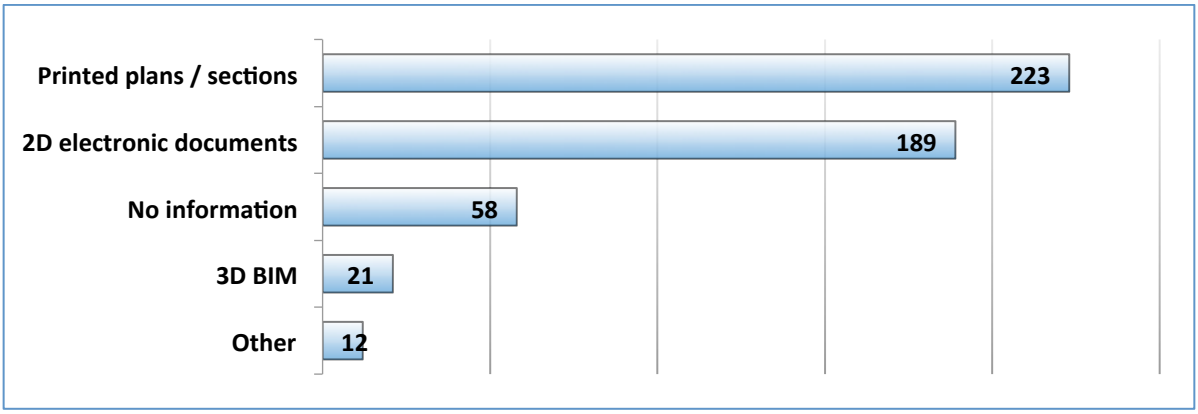

Figure 10: Available information on the BUILDING or INFRASTRUCTURE at the beginning of the lighting retrofit process

Most of the building or infrastructure information available is generally in printed form, which is consistent with the fact that generally old buildings are refurbished. The poor availability of electronic documents is 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 practitioners to create the latter before starting to make use of it.

Other

Comments written by the respondents
Depends on the project, sometimes there are only 2D drawings that are done from the old paper drawings. Sometimes the project can have 3D model. 3D models have increased considerably within last two years.
See comment in question 1
Quite often no documentation or the old plans of the building are off the mark, because a lot of undocumented changes have been done. Sometimes very detailed information is available. Depends on the case. Usually the default is that very little information is available.
All the three first mentioned, depends on the case.
Possible Description
Info from property management or building owner
The level of information varies, but the first thing we undertake is a site survey
Those supplied by users, plans, statistics, etc.
Printed plans and sections not updated and complete
Energy consumption
Survey of the pre-existing lighting system

Question 9

What "information" is usually available about the EXISTING LIGHTING SITUATION at the beginning of the lighting retrofit projects?

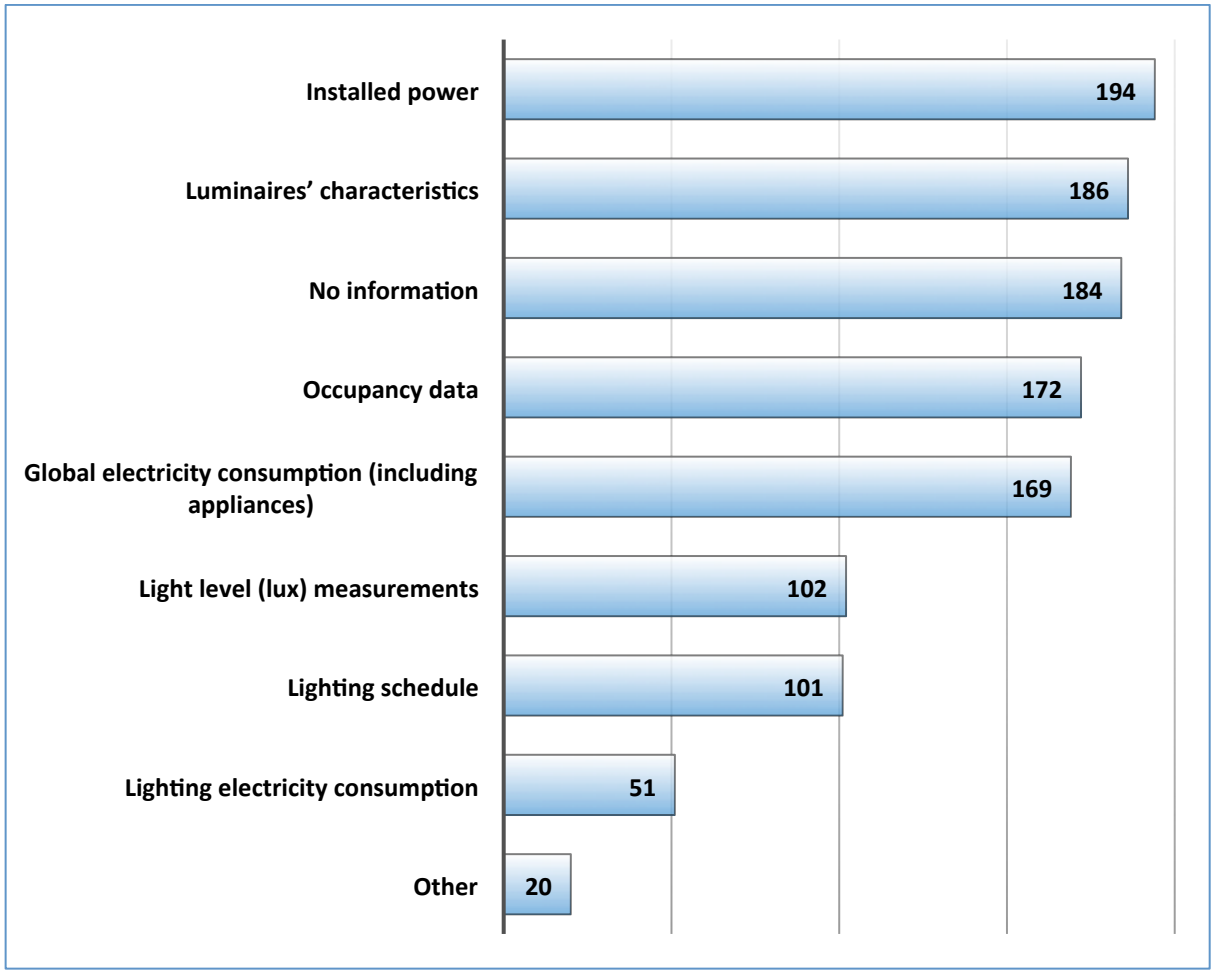

Figure 11: Available information on the EXISTING LIGHTING SITUATION at the beginning of the lighting retrofit process

The specific lighting electricity consumption is rarely known, unlike the total electricity consumption, which comprises also the other appliances. Installed power and luminaires' characteristics are often available; one should note that those could easily be determined by observation. Very often no information at all is available for the lighting retrofit. Light level measurements are not frequently available for the retrofit, leading to the conclusion that this information is not essential in the decision process.

Other

Comments written by the respondents
It is very different – often we must out ourselves and register (check?) and talk to the service people, if necessary
Daylighting simulation tools
For our tasks there is no information on the lighting situation necessary..
Depending on the project

Usually a building-inspection is necessary
Plans and sections of the existing situation
GENERAL LIGHTING DRAWINGS
See comment in question 1
Occupancy data is usually irrelevant, as occupancy patterns are changed by the retrofit work
Sometimes old drawings, sometimes not, sometimes one can see the situation on-site before demolition- sometimes not. All kinds of spaces – one can not generalise. So far I have never get the following information: illuminance measurements, knowledge of presence, control plan, lighting electricity consumption.
Usually no information about lighting, even the existing electrical plans are insufficient.
Audits and evaluations are often required to start a renovation
Comfort use
Usually little information available
The information that can be found on site (diagnosis).
Visits and on-site measurements
Rethink its way of living as a function of the wants and needs
Grid tension
Lamps characteristics

Question 10

When the project is completed, do you carry measurements or verifications to validate the expected efficiency or quality of the lighting retrofit project?

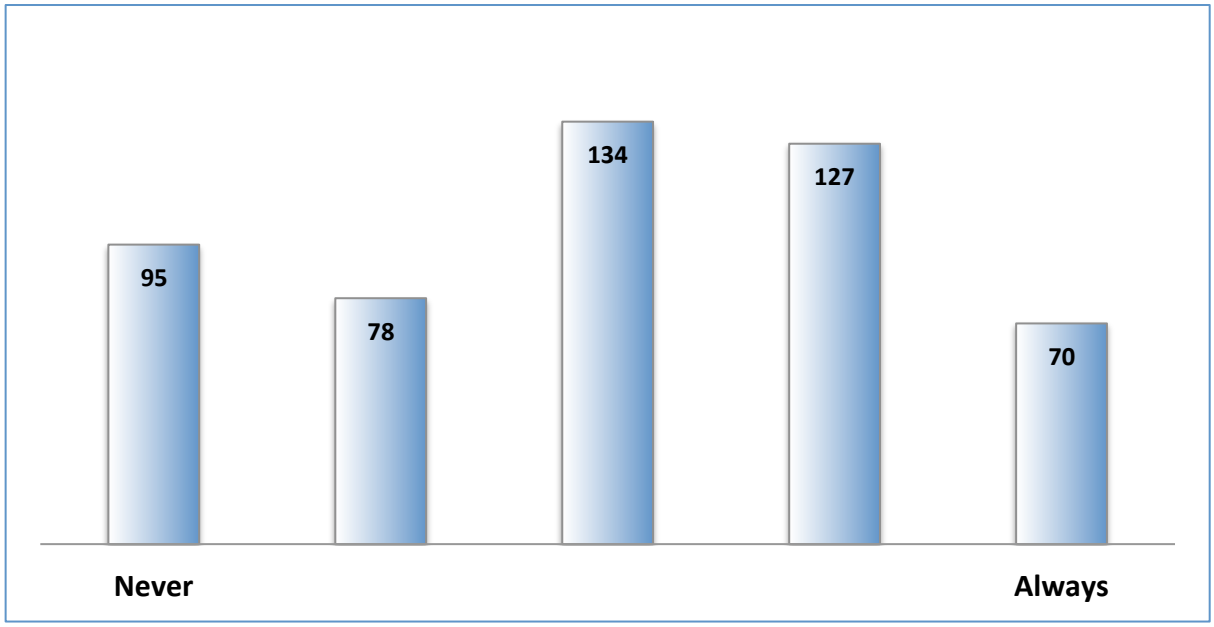

Figure 12: How often the respondents carry measurements or verification to validate the efficiency or quality of their lighting project

The answers of the respondents are evenly distributed; no noticeable trend can be identified.

2.2.3. Tools for lighting design

Question 11
How would you describe your current skills regarding lighting simulation tools?

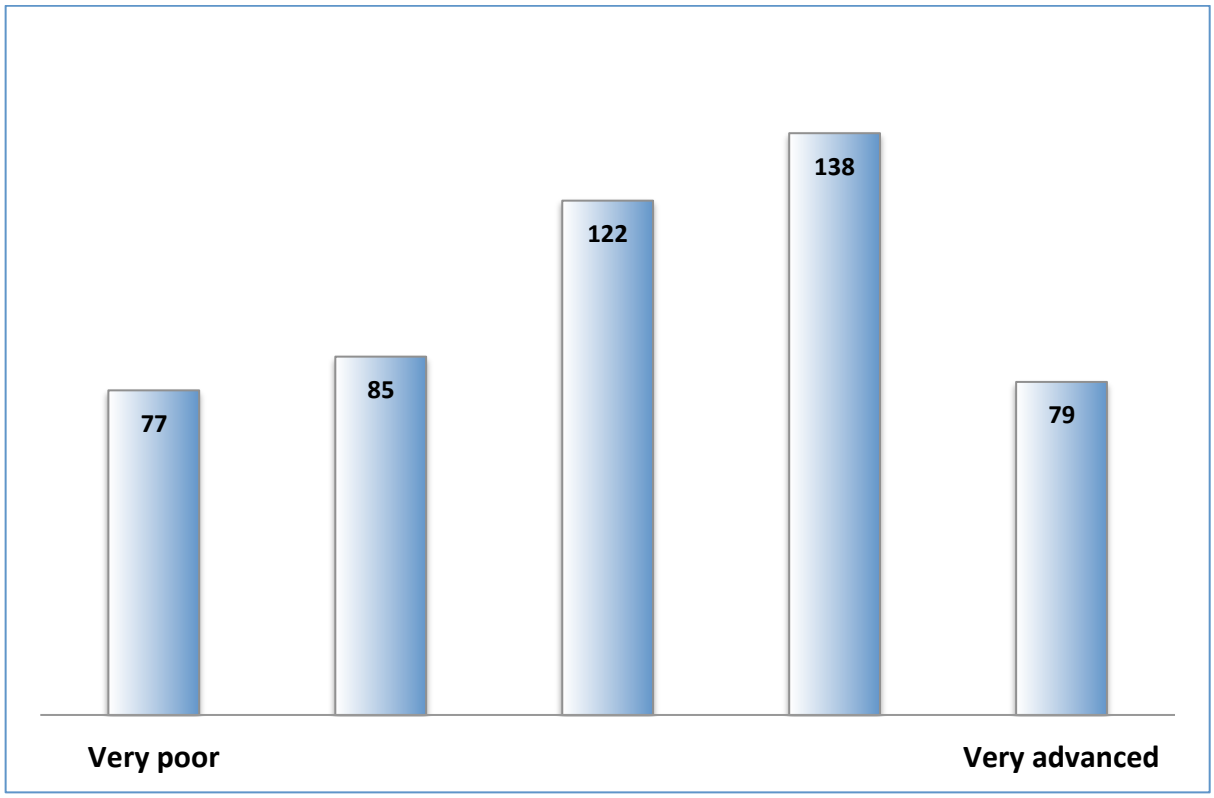

Figure 13: Skill of the respondent regarding lighting simulation tools

A great proportion of the respondents declare that their skills regarding simulation tools are acceptable (122) or advanced (138). About a third of the respondents describe their skills as poor or very poor.

Question 12

In your office / company, which type of tool(s) do you normally use for daylighting and electric lighting analysis?

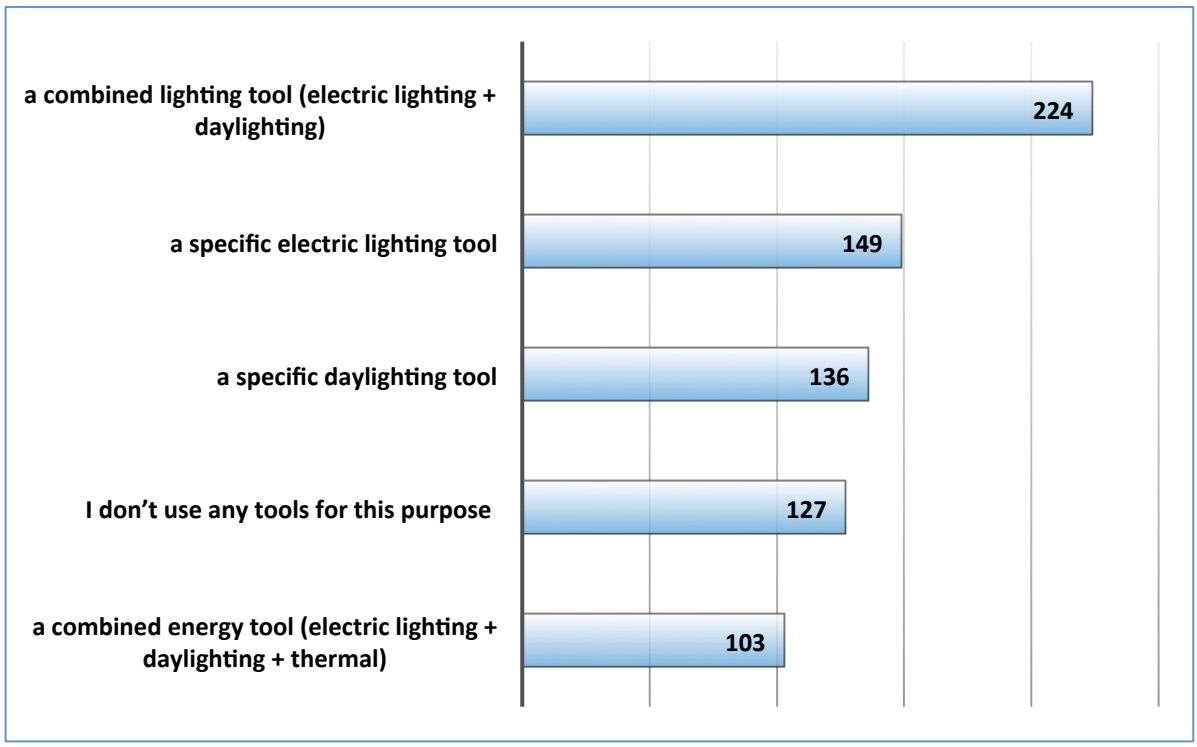

Figure 14: Type of tools used by the respondent for lighting analysis

The total number of respondents that use a specific tool for electric and daylighting (149 +136) is higher than the number of respondents who declare that they use a combined lighting tool (224). While most simulation tools available on the market allow to treat both subjects, it should be pointed out that software are focused on overcast sky analysis, which is a limitation. One can notice that still a significant number of people do not use any tool. Finally, combined energy tools (including thermal aspects) are not yet established in current practice.

Question 13

For each category listed below, indicate the method or computer tool currently used in your practice. Please enter the name of the tool(s)/method(s), identify the project phase of use and, finally, rate the tool.

In the following graphs, we only mention the tools that have been cited at least twice by the respondents.

13a: FACILITY MANAGEMENT *(e.g. global diagnostic tool including economic aspects)*

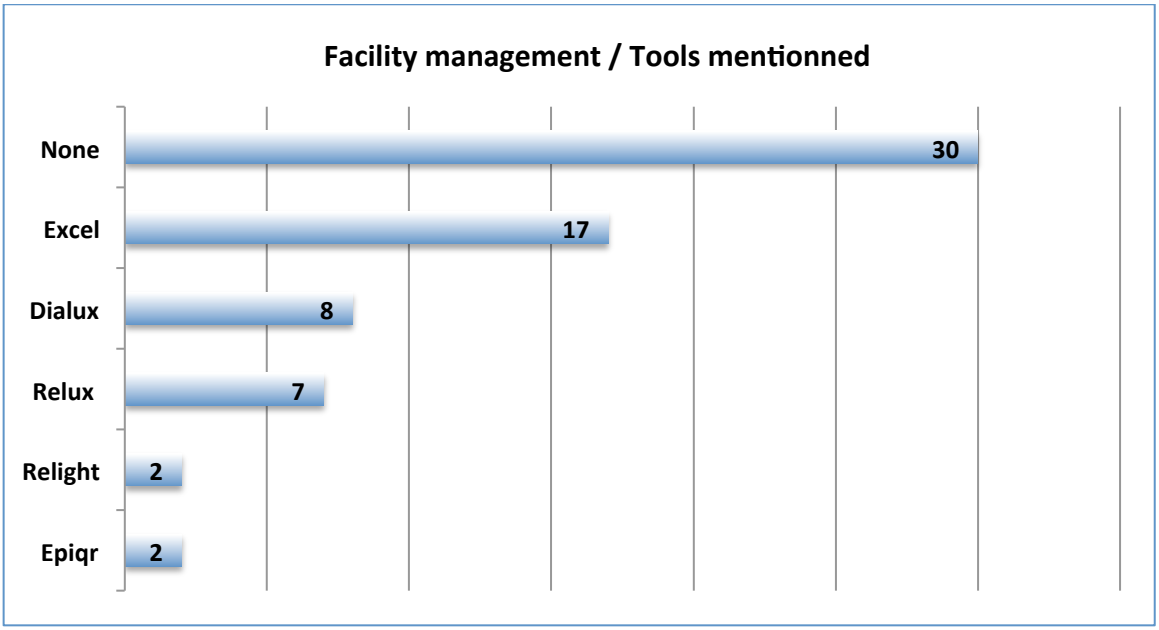

Figure 15: List of methods and tools used to handle facility management in the retrofit process

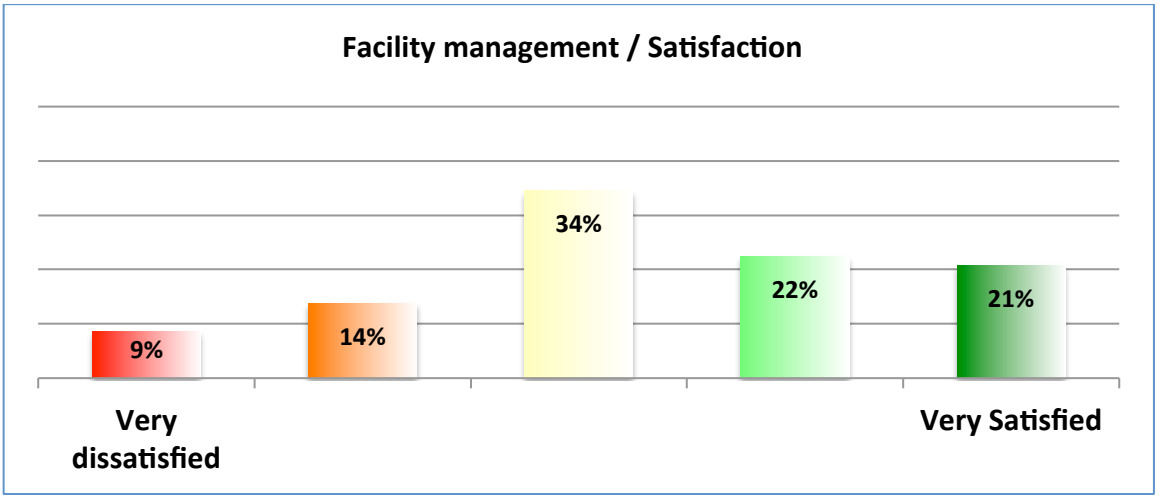

Figure 16: Global satisfaction on the Facility management tools

Most of the respondents do not use any facility management tool in the lighting retrofit process (~6%); some have built in-house Excel sheets. In Relux, a cost calculation (installation and maintenance) can be used for facility management. In comparison with the other types of tools (see further), the satisfaction level is quite limited.

13b: Computer-assisted architectural drawing (CAAD) / Computer-aided design (CAD)

(indicate the method or computer tool currently used in your practice)

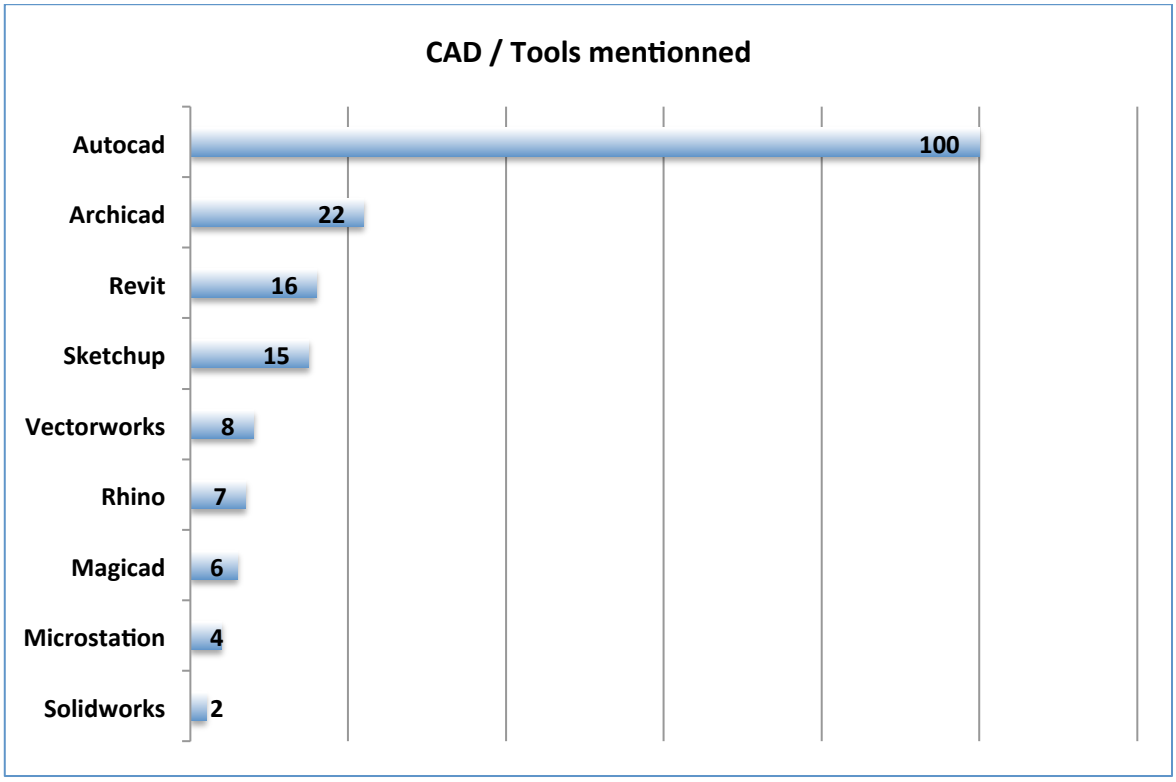

Figure 17: List of methods and tools used to handle CAAD / CAD in the retrofit process

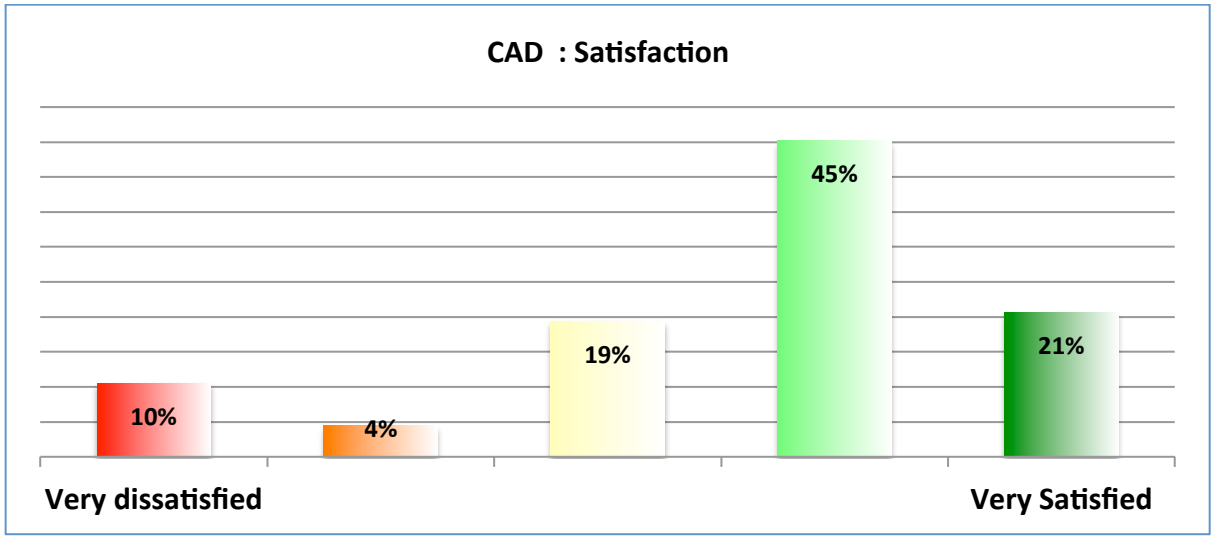

Figure 18: Global satisfaction on the CAAD / CAD tools

Autocad is a dominant key player on the market of CAAD/CAD, followed by Archicad, Revit and SketchUp. Many respondents of the questionnaire use a combination of two or more tools in their practice. The global satisfaction of 66% of the respondents in CAAD / CAD tools is high to very high.

13c: Visualization

(indicate the method or computer tool currently used in your practice)

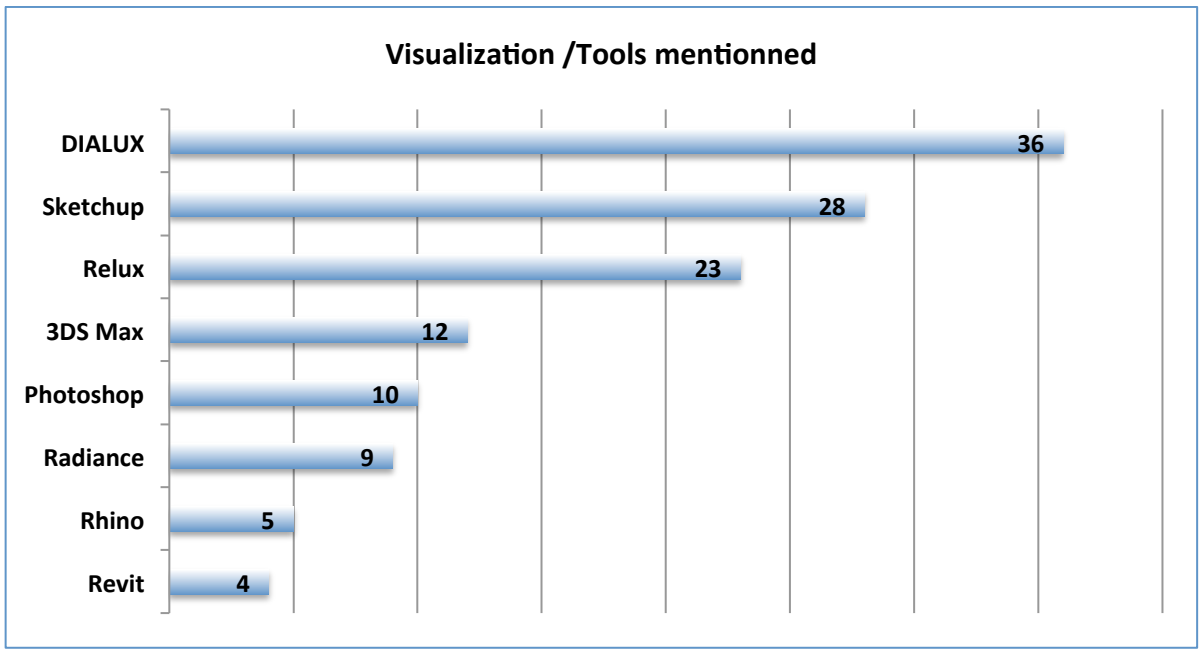

Figure 19: List of methods and tools used to handle Visualization in the retrofit process

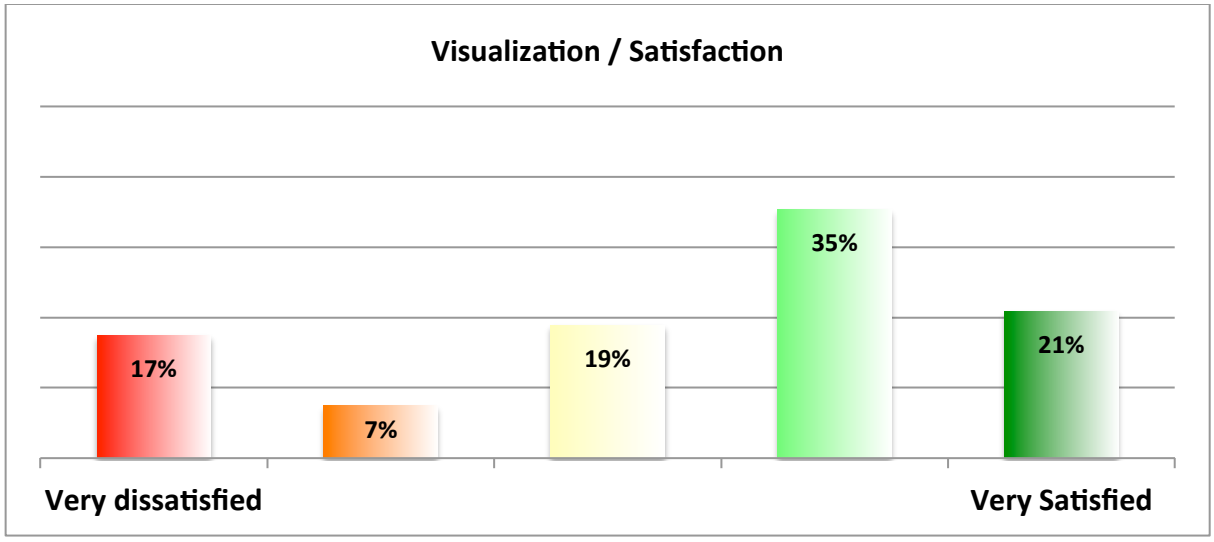

Figure 20: Global satisfaction on the Visualization tools

Dialux, Sketchup and Relux are the three most used tools for the project visualization in the lighting retrofit process. The global satisfaction is likewise the CAAD / CAD tools high to very high for 56% of the respondents. It is worth to be noted that 17% of the respondents are very dissatisfied with the Visualization tools.

13d: Simulation *(indicate the method or computer tool currently used in your practice)*

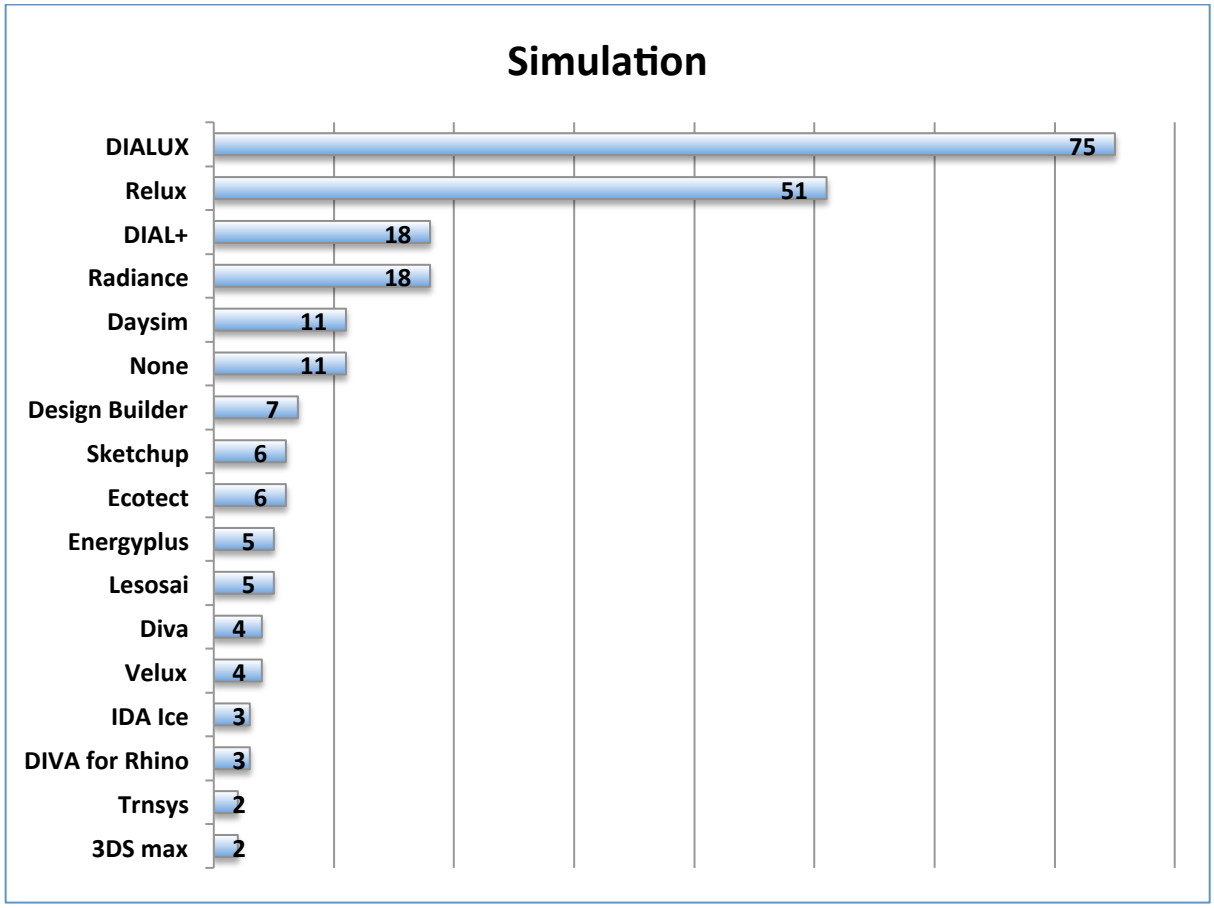

Figure 21: List of methods and tools used to handle Simulation in the retrofit process

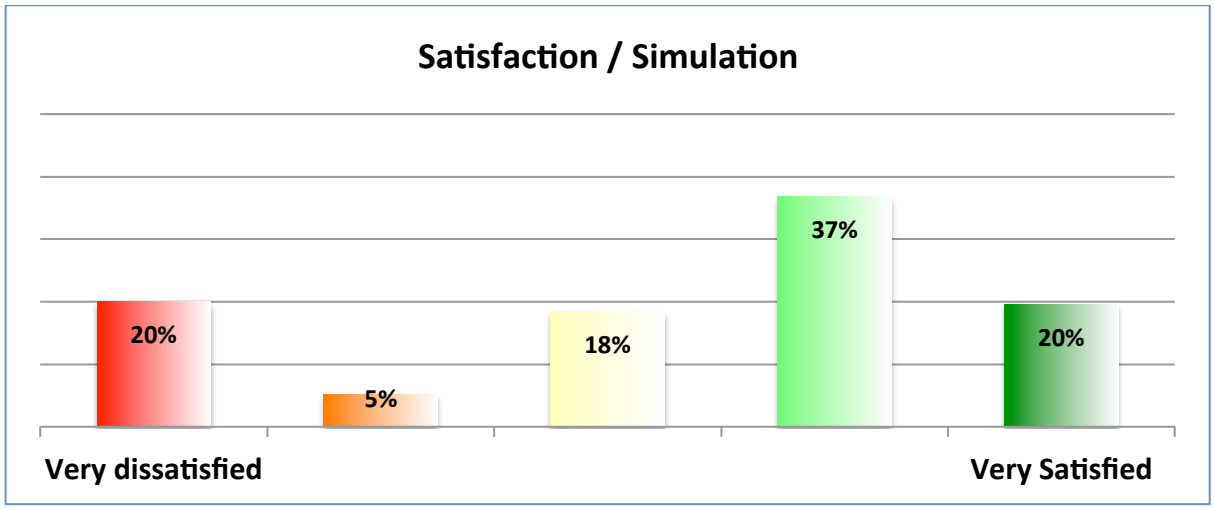

Figure 22: Global satisfaction on the Simulation tools

Dialux and Relux are the most used software by the respondents for the simulation of their lighting retrofit process. Those are followed by DIAL+ and Radiance. The global satisfaction for 57% of the respondents is high to very high, leaving 20% of them very dissatisfied.

In Figure 23, we have extracted the satisfaction for the four main simulation tools present in Figure 21. According to the respondents, Dialux and Relux are highly rated, Radiance has an average satisfaction and DIAL+ is in between.

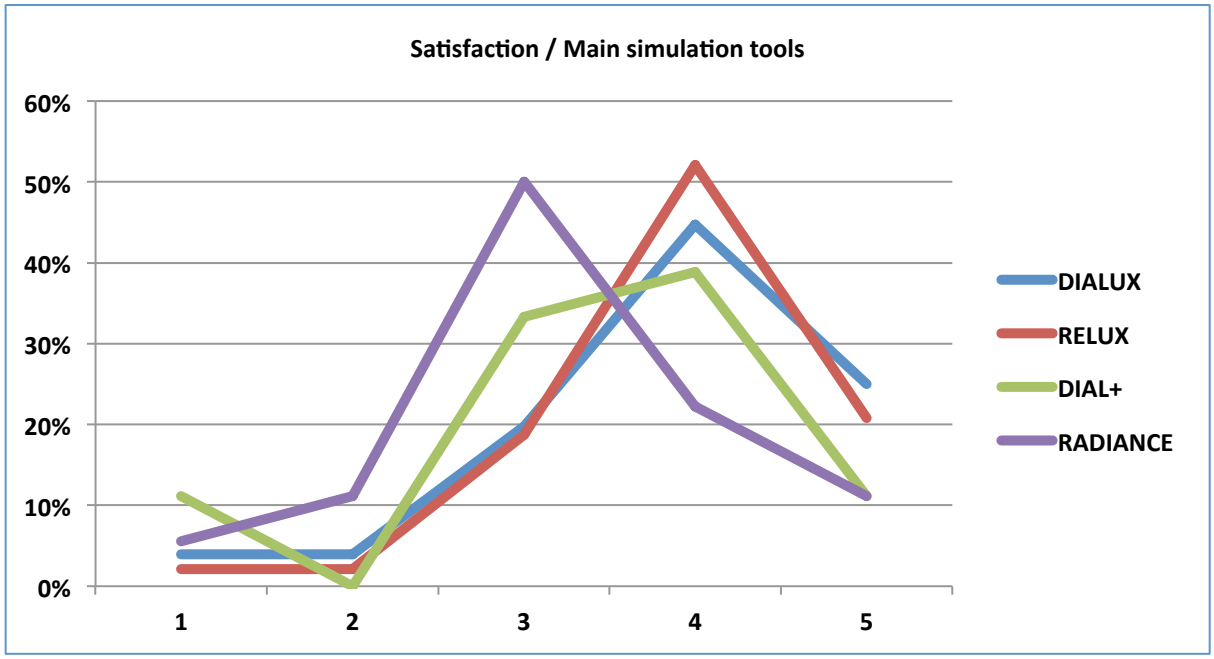

Figure 23: Satisfaction of the four main key players in the Simulation tools (1 = very dissatisfied, 5 = Very Satisfied)

13e: Other category? Namely:

(indicate the method or computer tool currently used in your practice)

Comments written by the respondents
3D visualization
Simplified Tools
No specifications possible
Energetic evaluation
Profitability calculation and life cycle calculation
Daylight
Thermal simulation separate
Lighting Simulation
Simulation
Luminance
Any tool
Energy
MINERGIE calculation
DESIGN BUILDER, VIRTUAL ENVIRONNEMENT
Thermal and lighting combination

Adobe Suite
Scale models
Experience and collaboration with specialists
Own calculation tool (Excel based)
Confidential
Scale models
Plans, section facades or 3D drawings
Site analysis, Daylighting potential
Minergie Calculation
Minergie
Scale model
Measurements
Hygrothermal simulations
Simulation
Self-developped calculation and simulation tools including environmental (?) analysis
Bsim (Danish energy and indoor environment simulation software)
Simulation calculation
COMFEN (LBNL)
Energetic calculation according to DIN V 18599
Interdisciplinary, integral planning with early identification of involved stakeholder
ibp:18599 (ibp = institute of building physics)
Excel Tool
TRNSYS
Lmk LabSoft
lesosai
Scale model
CAD
Experience in an existing building
Experience
Daylighting autonomy evaluation as a unction of daylight factor and required illuminance level
SIA 380/4 (Swiss Norm)
Mains
Luxmeter
Domus Eletrobras
Drawings and sketches
Apolux

Question 14

Please list the up to 5 factors that most influence your choice of software (In the list below, the issues have been sorted by the number of responses given by the respondents).

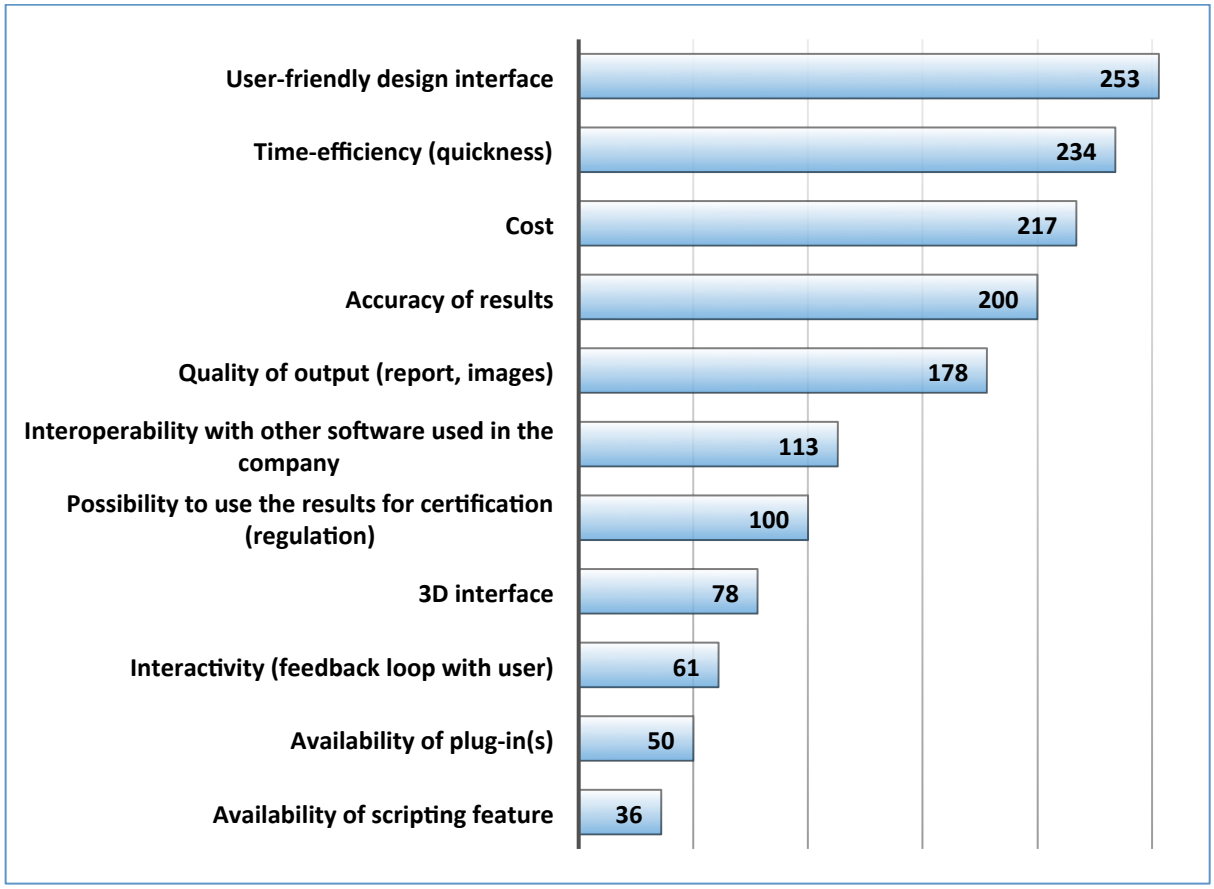

Figure 24: List of factor that most influence the choice of software

The major issue leading to the choice of the software is to have a user-friendly interface (253) that allows quick and efficient analysis (234). The cost of the software (217) is also a major concern, 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 those may not be too incentives. Surprisingly, 3D interfaces (78) seem not to be so important.

Question 15

Among the following list, please select the up to 5 most important barriers you identified when applying tools for lighting or daylighting design as part of the retrofit process?

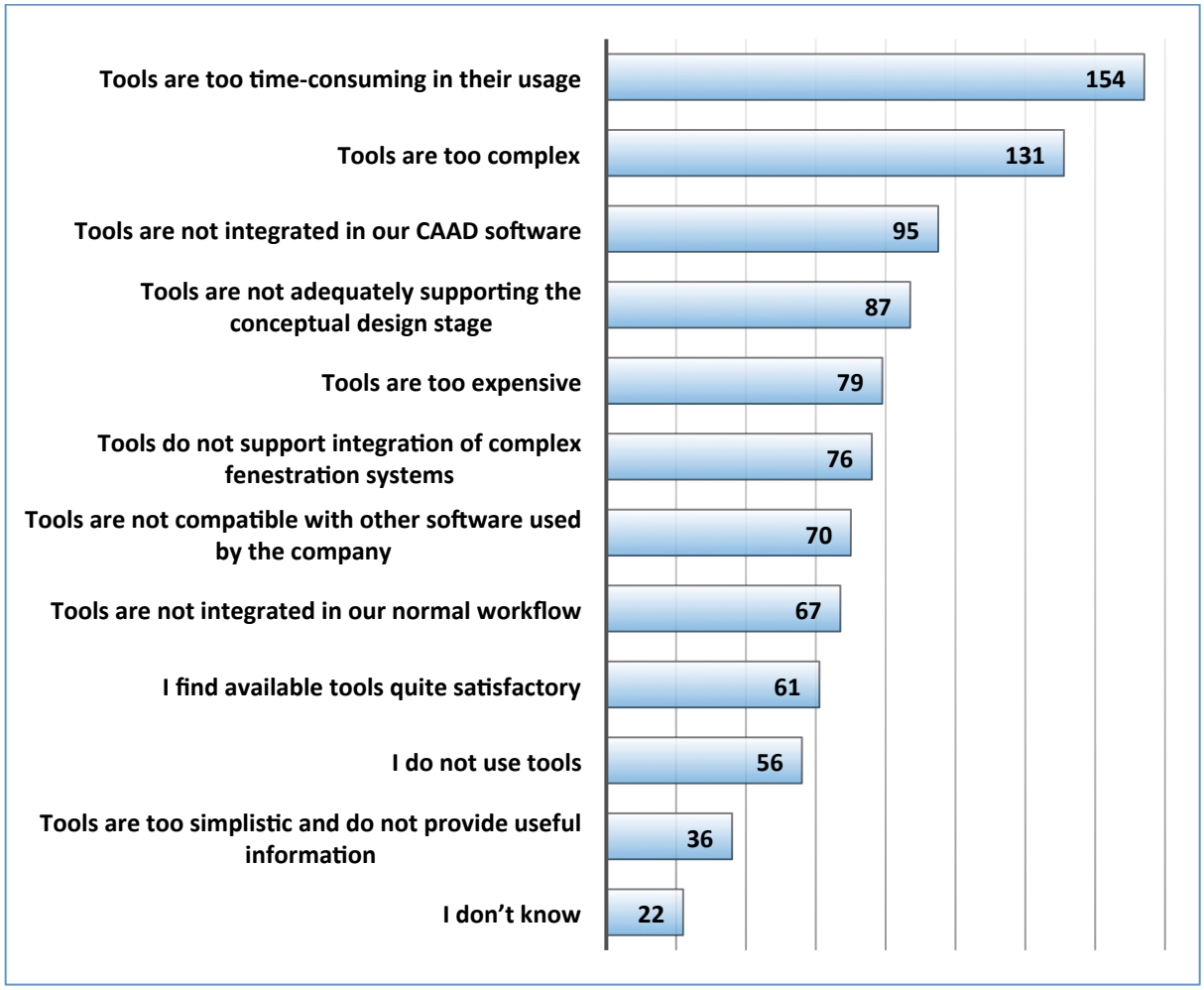

Figure 25: List of barriers identified when applying tools for lighting or daylighting design as part of the retrofit process

A significant number of respondents mentions 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. Finally, the number of people who find that available tools are quite satisfactory is not so high (61).

Question 16

Do you see the need for improved tools to support the integration of electric lighting or daylighting considerations within the retrofit process?

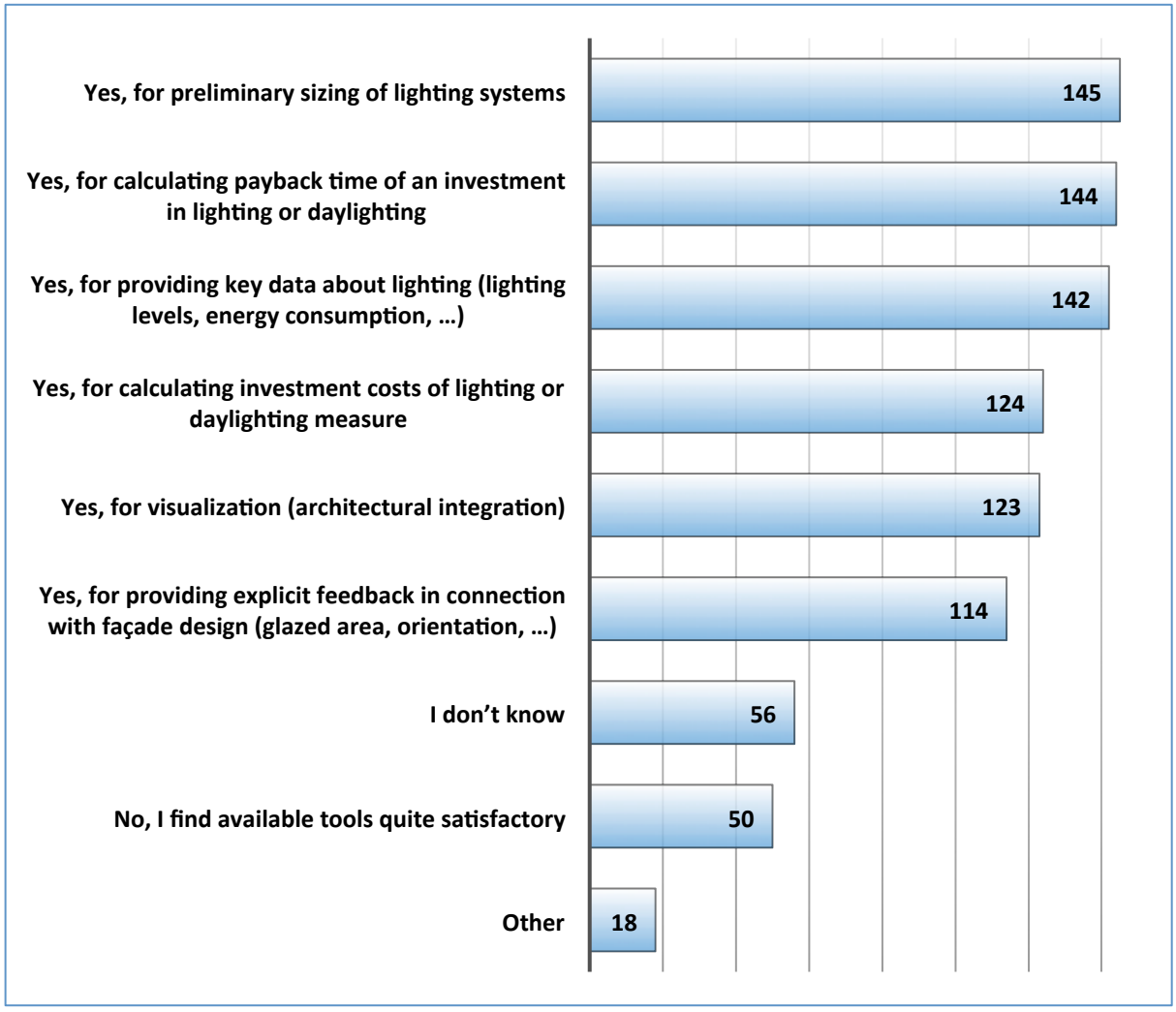

Figure 26: Needs for improvement of the tools to support the integration of electric lighting or daylighting consideration within the retrofit process

There is a consensus (145 answers) to say that there is a need for improved tools for preliminary sizing of lighting systems, for calculating payback time and investment in lighting and daylighting (144) and for providing key data about lighting levels and energy consumption (142). The general trend noticed in the results is that users always see possible improvements in the actual simulation tools.

Other

Comments written by the respondents
It doesn´t have to be calculated the ROI (Return on investment), but the total profit of ownership (life cycle costs)
Improvement of the interface (connection) between the tools
But we often don't use the possibilities for example of ArchiCad in this way because experts are consulted.

Optimizing of luminance analysis, away from illuminance
Relux-Pro meets a lot of the mentioned criteria
Yes, for providing explicit feedback in connection with roof design. Yes, to provide feedback on non-visual factors for the occupants.
to get a better view of the light distribution, light sets and visual images that show how we are seeing, not a computational model.
My application of these tool is often in teaching, so I believe that the answer would not be appropriate
Simple to use, but one should be able to check all perspectives in one or alternatively one structure model and luminaire positions should be usable in different programs.
Only for electric lighting
Provide us with simple tools
Specialists at our disposal for large projects
I would like to know tools
More integration with other areas of the renovation (energy, etc.)
We rely on lighting manufacturers simulation to substantiate our architectural studies
Software interoperability
I don´t know how to answer because I don´t have deep knowledge about the software.
Yes, to improve modelling.

Question 17

Please specify other needs regarding tools or methods: (open question)

Common requirements for LED lighting with long lifetime connected with lighting reduction factors for maintenance, lighting decay over time, and others
The tools should show which level of lighting design know how is necessary to get reliable results (the usage of the tool is allowed when you have 5 years of experience in lighting design….)
Connection to other programs, costs
Availability of data for daylight systems Tools:
1. Integration national Energy efficiency standards according to the law
2. Realize the appropriate information to create a maintenance plan for lighting systems and to easily identify the maintenance factor
Handling according to the DIN regarding to the energetic analysis should be integrated. Collective use of the building data input for all tools- universal interface.
It would be nice to have a user-friendly tool that simulates the technical equipment of the building in synergy with constructional components (like the relation of artificial light and daylight, natural and mechanical ventilation, together with thermal influence, climate and local influences. If you think of the complex interconnections it will take some time to develop further the user friendliness, the speed the transparency, output to expert stakeholders, input of data through the expert stakeholders and compatibility. I think its running out to a BIM
Consideration of the physiological influence of the lighting. Integration of colour, structures and surfaces
Visualizations are not suitable for the assessment of lighting quality, laypersons can be lead to believe in something that's not true. Why? You cant present the real luminance with the best tools, but they are relevant for the perception.
Calculation of the return of investment value

Easy and intuitive usage and input allow to use the tools more often
I need a tool that can adapt modification on a cross-application basis: a change of the luminaire luminous flux of a special luminaire has to be adapted (a) in the legend of the plan, (b) in the simulation and (c) in the tender specification.
Tools for thermal and lighting simulations are not compatible
Interface to thermal simulations. The model has to be reentered again and again
Interior designers use tools for visualization where the lighting is dictated very rudimentary. On the other hand DIALux is OK to make light studies but it is very basic to obtain an integrated design. Moreover, with the advent of OLED, be given the ability to create lighting designs in the future based on large luminous surfaces. Hereby the impact of daylight should optimally also can be calculated.
More holistic approach necessity, combine solar shading in & ex smart technology, with optimized lighting systems, with cooling and heating & ventilation. This is the real need for the future in order to reach nZeb building technology, and not separate Tools for these technologies. The future should optimize all these technologies!
The most interesting tools to be integrated in our normal workflow,
We model the same project in several different 3d software despite claims from software companies of import /export functions. It causes extra time usage and incohesive output data format.
Need for tools that are better integrated in existing CAD software
I like DIVA for Rhino. I wish it had an electric lighting component. I wish there was a good integrated lighting/energy simulation software package for early design.
Tools must take into account latest guidelines and research.
We are an environment consulting firm. Tools for daylighting: we use DIAL+ because it is fast to use, but the space configurations are far too simplistic and rendering (aesthetic) is low. Tools for electric lighting, we do not use any calculation tool, but simply an internal simplified table to estimate the needs and consumption of electric lighting (depending on the type of lighting and the type of command). That is enough for early design phases. In more detailed stages, we leave the engineer make the study, and we verify that its lighting concept study is correct and interesting from the point of view of energy consumption and comfort. So we do not really know the simulation tools for electric lighting.
Be able to integrate "complex" management types and have comparative ROI figures that take into account the natural / electric lighting and the type of command
As long as the tools do not understand what means "daylighting quality" (adaptation to human needs, and the building use), they will do nothing other than to hide the incompetence of the person using it.
For computer tools that do not take into account the actual geometry of a building (eg DIAL +) it would require that the software offers more possible configurations. In order not to make approximations and describe as faithfully as possible the project.
My knowledge of that area is low. Is there a plugin for Sketchup or VECTORWORKS?
Know where to go when you have a residential project and that you are not sure of your choice. Right now, when I have a doubt I am without help
Ability to easily model complex rooms.
I work mainly in the single-family residential. Daylighting solutions are an essential part of my mission as they allow to influence the quality of life as well as the energy consumption for heating an lighting the house. By contrast, the design of artificial lighting is almost impossible because the customer rarely has a clear notion of the need for on-site lighting. Most of lighting choices are therefore made on site, once the spaces are existing.
Above all simplicity, fed up with continuous training. It has to be as intuitive as I-Phone!
Simple intuitive interface for communication between the expert and non-expert client.
If the project allows it (high demand on lighting) and if the fees are sufficient, we integrate a lighting

consultant in the team
Connection to SIA regulation (SIA is the responsible organism for the constructions regulation in the Canton Ticino)
To improve interaction of users with Project – to translate in appropriate way user´s needs The reality of use and management of building – in each floor – and user.
Continued training of professionals.
Tools associated to building location object of retrofit with GPS and daylighting conditions due to geographic location of it ; also information about surroundings, external obstructions, buildings, vegetation or relief, and materials that can reflect lighting in the building
I don´t have any suggestions.
Maybe Building Information Modeling?

2.2.4. Background information for statistical purposes

Question 18

Among the following building categories, which one(s) correspond(s) best to your current practice?

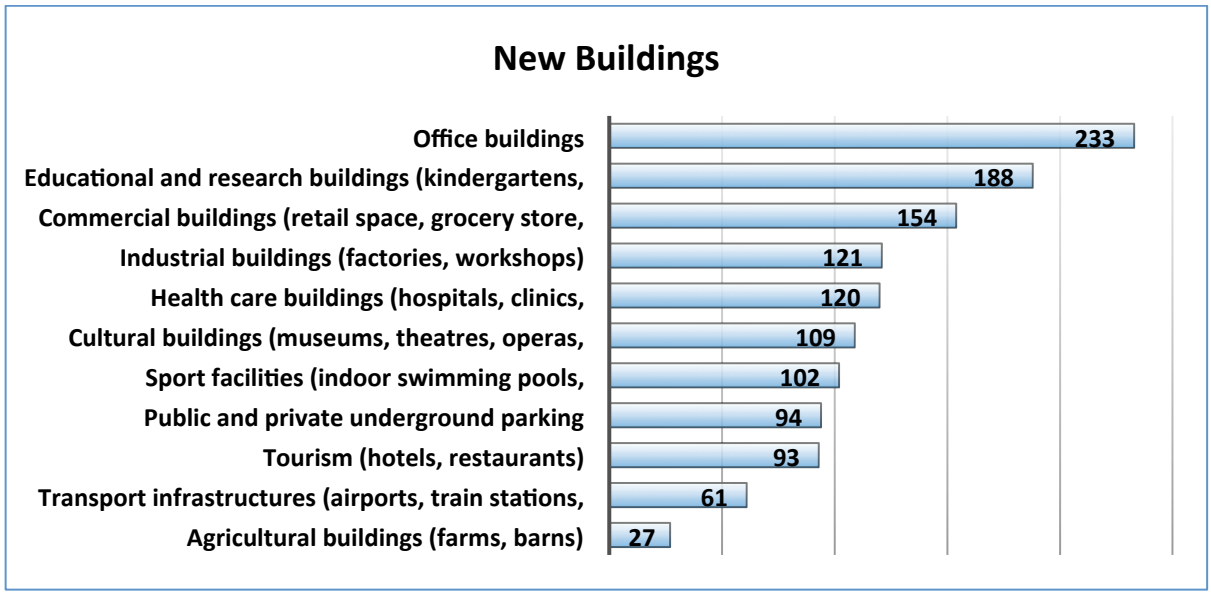

Figure 27: Among the following building categories, which one(s) correspond(s) best to your current practice for new buildings?

For new buildings, the major part of the building categories that correspond to the current practice are Office buildings (233), Education and research buildings (188) and Commercial buildings (154).

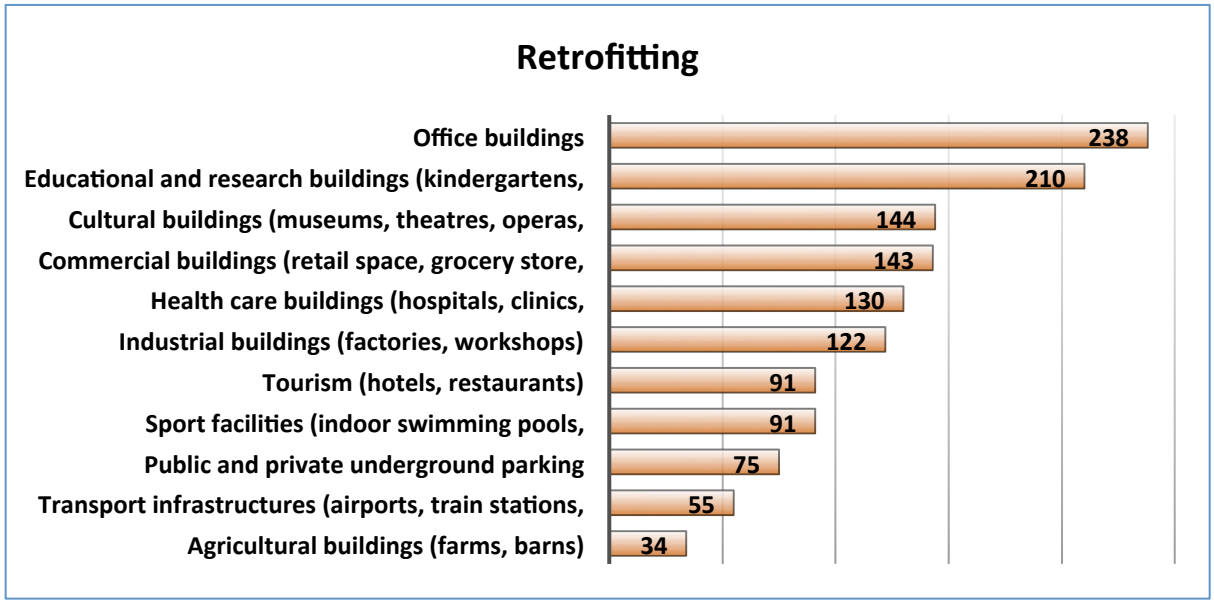

Figure 28: Among the following building categories, which one(s) correspond(s) best to your current practice for retrofitting?

For retrofitting buildings, the major part of the building categories that correspond to the current practice are Office buildings (238), Education and research buildings (210). Cultural buildings (144) and Commercial buildings (143) follow closely.

Question 19
Number of employees in your firm?

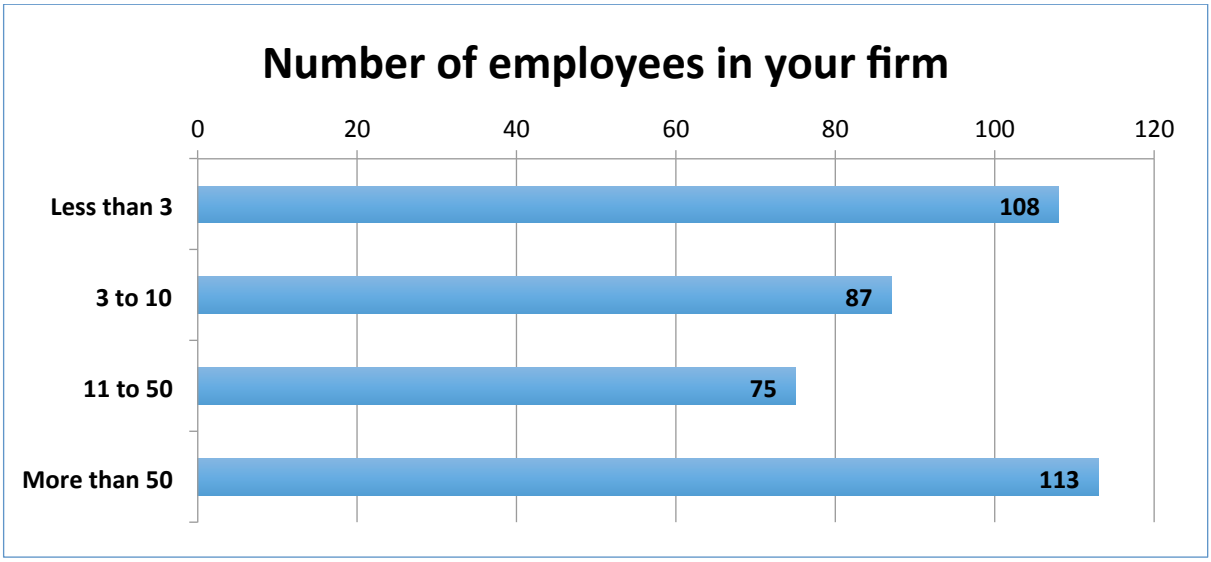

Figure 29: Number of employees in your firm

Surprisingly, companies with more than 50 employees are the most represented (113). In such firms, it is plausible that some people are specialized on lighting. On the other side micro enterprises are also well represented (108 + 87). Here we mainly find generalists who must be able to handle a wide set of skills.

Question 20
On which area is your firm active?

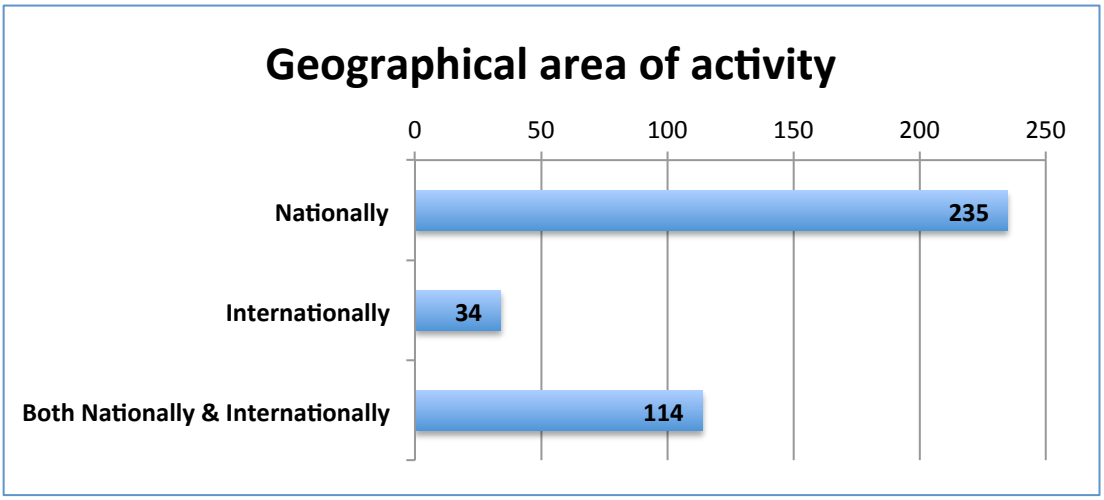

Figure 30: Geographical area of activity

The majority of the respondents are only active on a national level. This probably reflects the fact that, historically, the building sector has a strong local presence.

Question 21
What age group do you belong to?

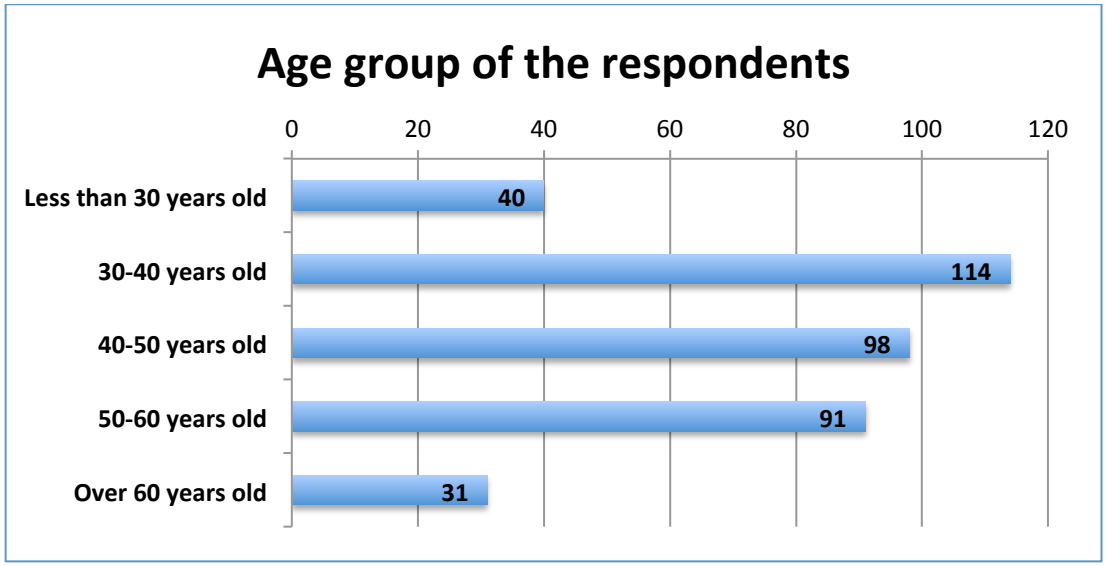

Figure 31: Age group of the respondents

This graph is representative of the age pyramid in the building sector, which is probably not so different from other industries.

Question 22
What is your Gender?

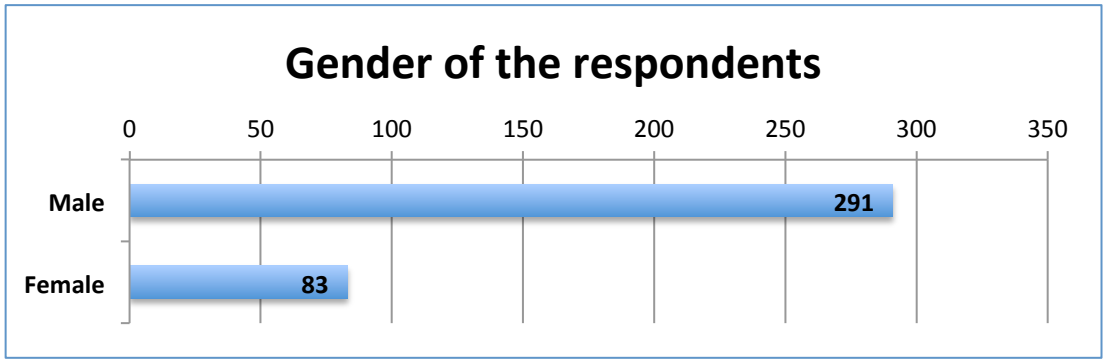

Figure 32: Gender of the respondents

Despite the fact that in recent years the female population is dominant in schools of architecture, this is apparently not the case in the whole building sector.

Question 23
What is your Background?

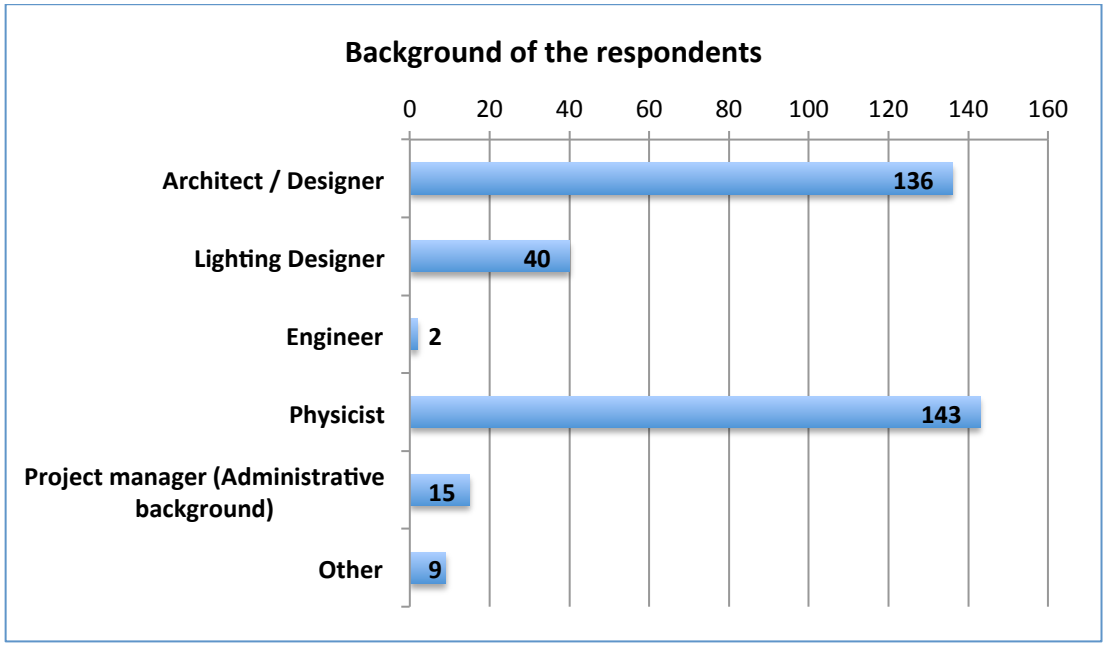

Figure 33: Background of the respondents

Architects and physicists represent the vast majority of respondents. In comparison, lighting designers are very few.

Question 24
Professional experience

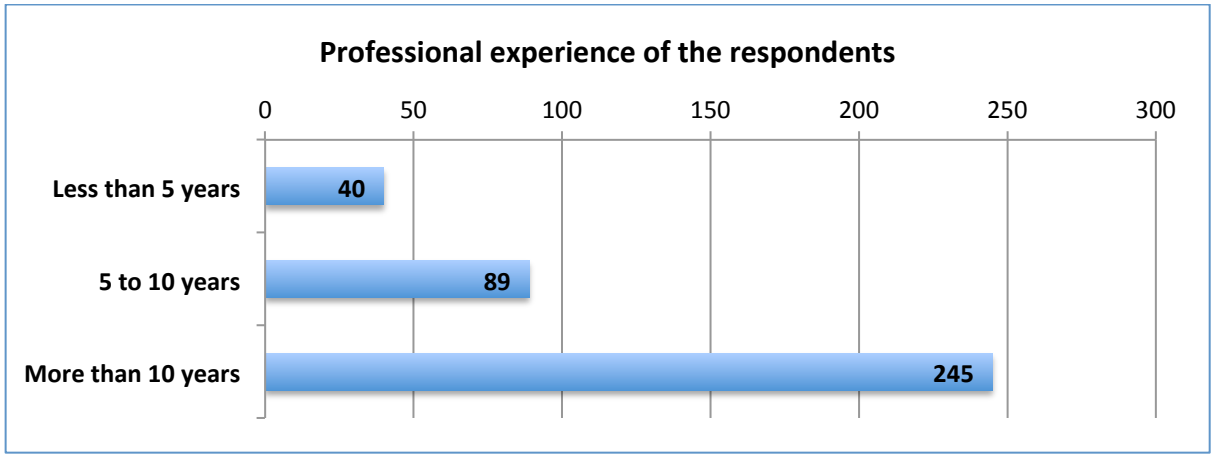

Figure 34: Professional experience of the respondents

About 2/3 of the respondents have more than 10 years of experience.

3. Conclusions

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) and, finally, 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 [1], [2].

References

1 1- IEA-41: LIGHT'SLABOUR'S LOST, Policies for Energy□efficient Lighting, 2006. M.-C. Dubois (Université Laval) M. Horvat (Ryerson University): International survey about digital tools used by architects for solar design, Subtask B2, 2010.

2 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.

APPENDIX

List of Questions

A. THE ROLE OF LIGHTING IN RETROFITS:

Question 1
In your current practice, how do you rate the importance of LIGHTING within the retrofitting process?

Electric lighting	Unimportant	○	○	○	○	○	Important
Daylighting	Unimportant	○	○	○	○	○	Important

Comments: ……

Question 2
How often do you consider measures related to lighting in the early design stage of your retrofit projects?

Electric lighting	Never	○	○	○	○	○	Always
Daylighting	Never	○	○	○	○	○	Always

Comments: ……

Question 3
In your current practice, when thermally retrofitting a building (e.g. windows replacement, cooling ceiling installation, etc.), how often do you also take into account lighting retrofit measures?

Heating	Never	○	○	○	○	○	Always
Cooling	Never	○	○	○	○	○	Always

Comments: ……

Question 4
Among the following list, please select the main retrofit strategies (maximum of 8) you use in your current practice.

- ○ Improvement in lamp technologies,
- ○ Improvement in ballast technologies,
- ○ Improvement in luminaire technology,
- ○ Use of task and ambient lighting,
- ○ Improvement in application efficacy (delivering the light where it is needed in the most energy efficient manner)
- ○ Improvement in maintenance factor (more frequent cleaning and lamp exchange),
- ○ Increase of surface reflectances,
- ○ Reduction of maintained illuminances (e.g. from 500 to 400 lux),
- ○ Improvement in spectral quality of the light source,
- ○ Reduction of the total switch-on time (e.g. installation of an on/off timer),
- ○ Use of manual dimming,
- ○ Use of switch-off occupancy sensors,
- ○ Use of daylight dimming control (e.g. installation of a light sensor on the ceiling),
- ○ Other: ……
- ○ I do not apply retrofit strategies

B. THE DESIGN METHODS WITHIN THE RETROFITTING PROCESS

Question 5
In the following table, please indicate for each design phase, the type of tools or methods you use for DAYLIGHTING design (multiple answers possible).

DAYLIGHTING	Preliminary design	Detailed design
Experience		
Rules of thumb		
Design guidelines		
Computer simulations		
Expert systems (e.g. advice based on simple questions)		
Interactions with the owner		
Interactions with future users		
Collaboration with others:		

Question 6
In the following table, please indicate for each design phase, the type of tools or methods you use for ELECTRIC LIGHTING design (multiple answers possible).

ELECTRIC LIGHTING	Preliminary design	Detailed design
Experience		
Rules of thumb		
Design guidelines		
Computer simulations		
Expert systems (e.g. advice based on simple questions)		
Interactions with the owner		
Interactions with future users		
Collaboration with others:		

Question 7
How do you usually handle the design and decision process concerning the integration of lighting technologies in retrofit projects?

- Do it myself *Never* ○ ○ ○ ○ ○ *Always*
- Consult a specialist in the company *Never* ○ ○ ○ ○ ○ *Always*
- Involve an external consultant *Never* ○ ○ ○ ○ ○ *Always*
- Involve a lighting manufacturer *Never* ○ ○ ○ ○ ○ *Always*
- Involve an electric contractor *Never* ○ ○ ○ ○ ○ *Always*
- Organize a multidisciplinary workshop (IDP) *Never* ○ ○ ○ ○ ○ *Always*
- Other: ..... *Never* ○ ○ ○ ○ ○ *Always*

Question 8
What kind of information about the building or infrastructure is usually available at the beginning of your lighting retrofit projects?

- ○ No information,
- ○ Printed Plans / Sections,
- ○ 2D electronic documents,
- ○ 3D BIM (Building Information Model),
- ○ Other: .....

Question 9
What "information" is usually available about the EXISTING LIGHTING SITUATION at the beginning of the lighting retrofit projects?

- ○ No information,
- ○ Luminaires' characteristics
- ○ Installed power,
- ○ Light level (lux) measurements,
- ○ Occupancy data,
- ○ Lighting schedule,
- ○ Global electricity consumption (including appliances),
- ○ Lighting electricity consumption,
- ○ Other information: .....

Question 10
When the project is completed, do you carry measurements or verifications to validate the expected efficiency or quality of the lighting retrofit project?

Never ○ ○ ○ ○ ○ Always

C. TOOLS FOR LIGHTING DESIGN

Question 11
How would you describe your current skills regarding lighting simulation tools?

Very poor ○ ○ ○ ○ ○ Very advanced

Question 12
In your office / company, which type of tool(s) do you normally use for daylighting and electric lighting analysis? (Multiple choice possible)

- ○ a specific daylighting tool,
- ○ a specific electric lighting tool,
- ○ a combined lighting tool (electric lighting + daylighting),
- ○ a combined energy tool (electric lighting + daylighting + thermal),
- ○ I don't use any tools for this purpose

Question 13
For each category listed below, indicate the method or computer tool currently used in your practice.
From a) to e), please enter the name of the tool(s)/method(s), identify the project phase of use and, finally, rate the tool.

13a: Facility Management (e.g. global diagnostic tool including economic aspects)

Name of the tool(s) / method(s): .....

Project phase: ○ conceptual phase / preliminary design, ○ detailed design / construction drawings

Satisfaction: Very dissatisfied ○ ○ ○ ○ ○ Very satisfied

13b: Computer-assisted architectural drawing (CAAD) / Computer-aided design (CAD)

Name of the tool(s) / method(s): .....

Project phase: ○ conceptual phase / preliminary design, ○ detailed design / construction drawings

Satisfaction: Very dissatisfied ○ ○ ○ ○ ○ Very satisfied

13c: Visualization:

Name of the tool(s) / method(s): .....

Project phase: ○ conceptual phase / preliminary design, ○ detailed design / construction drawings

Satisfaction: Very dissatisfied ○ ○ ○ ○ ○ *Very satisfied*

13d: Simulation

Name of the tool(s) / method(s): .....

Project phase: ○ conceptual phase / preliminary design, ○ detailed design / construction drawings

Satisfaction: Very dissatisfied ○ ○ ○ ○ ○ Very satisfied

13e: Other category? Namely: .....

Name of the tool(s) / method(s): .....

Project phase: ○ conceptual phase / preliminary design, ○ detailed design / construction drawings

Satisfaction: Very dissatisfied ○ ○ ○ ○ ○ Very satisfied

Question 14
Please list the up to 5 factors that most influence your choice of software

- ○ User-friendly design interface
- ○ Cost
- ○ Accuracy of results
- ○ Time-efficiency (quickness)
- ○ Interactivity (feedback loop with user)
- ○ Interoperability with other software used in the company
- ○ Availability of scripting feature
- ○ Availability of plug-in(s)
- ○ Quality of output (report, images)
- ○ 3D interface
- ○ Possibility to use the results for certification (regulation)

Other: ……

Question 15
Among the following list, please select the up to 5 most important barriers you identified when applying tools for lighting or daylighting design as part of the retrofit process?

- ○ Tools are not adequately supporting the conceptual design stage,
- ○ Tools are too expensive,
- ○ Tools are too complex,
- ○ Tools are too time-consuming in their usage,
- ○ Tools do not support integration of complex fenestration systems,
- ○ Tools are not integrated in our normal workflow,
- ○ Tools are not integrated in our CAAD software,
- ○ Tools are not compatible with other software used by the company
- ○ Tools are too simplistic and do not provide useful information,
- ○ I find available tools quite satisfactory,
- ○ I don't know
- ○ I do not use tools
- ○ Other: ……

Question 16
Do you see the need for improved tools to support the integration of electric lighting or daylighting considerations within the retrofit process?

- ○ Yes, for preliminary sizing of lighting systems,
- ○ Yes, for providing key data about lighting (lighting levels, energy consumption, …),
- ○ Yes, for providing explicit feedback in connection with façade design (glazed area, orientation, …),
- ○ Yes, for visualization (architectural integration),
- ○ Yes, for calculating payback time of an investment in lighting or daylighting
- ○ Yes, for calculating investment costs of lighting or daylighting measure
- ○ No, I find available tools quite satisfactory,
- ○ I don't know,
- ○ Other: ……

Question 17
Please specify other needs regarding tools or methods: (open question)

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.....
.....

D. BACKGROUND INFORMATION FOR STATISTICAL PURPOSES

D1 Regarding your Company

Question 18
Among the following building categories, which one(s) correspond(s) best to your current practice?

	New buildings	Retrofitting
Office buildings		
Educational and research buildings (kindergartens, schools, universities, laboratories)		
Cultural buildings (museums, theatres, operas, concert halls, exhibition buildings, civic centres, community halls)		
Commercial buildings (retail space, grocery store, shopping malls, warehouses)		
Health care buildings (hospitals, clinics, sanatoriums)		
Tourism (hotels, restaurants)		
Sport facilities (indoor swimming pools, gymnasium, rinks)		
Industrial buildings (factories, workshops)		
Agricultural buildings (farms, barns)		
Transport infrastructures (airports, train stations, bus stations)		
Public and private underground parking		

Question 19
Number of employees in your firm:

- ○ Less than 3;
- ○ 3 to 10;
- ○ 11 to 50;
- ○ More than 50

Question 20
Is your firm active?

- ○ Nationally
- ○ Internationally
- ○ Both nationally and internationally

D2 Regarding your Person

Question 21
What age group do you belong to?

- ○ less than 30 years old
- ○ 30-40 years old
- ○ 40-50 years old
- ○ 50-60 years old
- ○ Over 60 years old

Question 22
Gender:

- ○ Male
- ○ Female

Question 23
Background:

- ○ Architect / Designer,
- ○ Lighting designer,
- ○ Engineer,
- ○ Physicist,
- ○ Project manager (administrative background),
- ○ Other: ……..

Question 24
Professional experience:

- ○ Less than 5 years;
- ○ 5 to 10 years;
- ○ More than 10 years

Please add here any comment you wish to add to this survey (max 500 char).

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.....
.....

Would you like to receive the results of this questionnaire, please leave your email address hereafter:

Email : ……