TOOLS AND METHODS FOR SOLAR BUILDING DESIGN: RESULTS OF IEA TASK 41 INTERNATIONAL SURVEY

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1. Abstract

As part of the IEA-SHC Task 41 'Solar Energy and Architecture' an international survey was carried out. This paper presents its results for Subtask B which especially focuses on methods and tools for solar design applied by architects. Building professionals, mainly architects, were contacted via email and asked to participate in a web-based questionnaire about their use of methods and tools for solar design and related themes, such as barriers for the use of tools or their design process. In addition, general data concerning the architectural office (size, type of buildings) and personal facts (age, experience and profession) were collected. Fourteen countries participated in the survey and a total of 627 responses were received, but only 350 were filled out completely or almost completely and therefore analysed in detail.

Although the response rate was lower than expected, the results clearly point out that there is a high awareness of the importance of solar energy use in buildings, but that a number of barriers regarding the widespread application of digital tools for solar design during the design process still exist.

The survey confirms results of former investigations, done by other researchers, presented in a literature review in the second official report of Subtask B, which shows that architects are lacking of digital tools for solar design especially adequate for the Early Design Phase (EDP).

The identification of opportunities, obstacles, and requirements expressed by professionals and suggestions for improvements will help to formulate the next step of the Subtask B work plan, which will consist in developing guidelines for both professionals and software tool developers in order to encourage and accelerate the development and application of solar energy design in building projects.

2. Introduction

Within the scope of the Solar Heating and Cooling Programme (SHC Programme) the International Energy Agency (IEA) has initiated Task 41, which deals with the topic 'Solar Energy and Architecture'. The Task is divided into three Subtasks:

- Subtask A (STA): Criteria for Architectural Integration
- Subtask B (STB): Methods and Tools
- Subtask C (STC): Concepts, Case Studies and Guidelines

The main objectives of the Task are to support the development of high quality architecture for buildings with integrated solar energy systems and technologies and to improve the qualification of buildings professionals, especially architects, and the communication and interactions between engineers, manufacturers, clients and architects.

In 2010, an international survey was carried out. According to the focus of interest it was split into two parts: STA addressed architectural integration of solar energy systems and STB concentrated on the design process for solar architecture. In this paper, only the results of the STB survey are presented.

The objectives of the survey for STB were:

- To identify barriers of existing design methods and tools for solar design
- To identify architects' needs for improved methods and tools

An extensive literature review of relevant reports and articles, published between 1993 and 2011, was done in addition to carrying out the survey. The review showed that although there have been developments in the acceptance and use of computer tools for architectural design, some of the issues have remained unchanged over time. Users have had and still have the same complaints about tools used for solar design: missing interoperability of software, lack of training or documentation on applications, incomprehensible or poor representation of results. The major need expressed has been the wish to work three dimensional and to have the possibility to quickly and iteratively obtain concrete results.

The full report that includes detailed literature review as well as results of the survey analysed using descriptive statistics is titled *T.41.B.2 International survey about digital tools used by architects for solar design* and is published on the official IEA-SHC Task 41 website (http://www.iea-shc.org/Task41).

3. Method

The survey was designed jointly by the group of international experts on solar architecture, researchers, academics and professionals that are participants of the IEA-SHC Task 41. It contained 23 questions divided in the following sections:

- General questions related to solar energy use
- Questions concerning design methods
- Questions concerning tools
- Informative questions about the respondents (such as size of the firm, years of experience, age, gender, etc.)

There were three different kinds of questions: single selection questions, multiple selection questions and open end questions. The survey was translated into 10 languages and distributed in 14 countries: Australia, Austria, Belgium, Canada, Denmark, France, Germany, Italy, Korea, Norway, Portugal, Spain, Sweden, and Switzerland.

Each country had a national coordinator responsible for distributing the survey link on the Internet. Data collection lasted from May 3rd 2010 to October 22nd 2010. Since Australia joined the Task 41 only in September 2010, their survey was extended until the end of November 2010.

The focus group of this survey consisted mainly of architects and other building practitioners. The main target group was thus architects, but other professionals were able to answer the survey as well. Although envisioned differently, due to the lack of resources, the national contact lists were not developed in the same way in every country. The lists included architectural organizations, architects and other building professionals. The addresses were also collected in different ways: from personal contacts, research on the Internet to the listings of national societies of architects and public telephone directories. The survey link was also published in magazines or newsletters and the professionals were asked to forward the survey link to colleagues. For these reasons, and because the number of readers and subscribers was unknown, it has been difficult to determine the response rate with precision.

A total of 627 surveys were received, and 350 surveys were included in the analysis. The others were empty or had only answers to one or two questions.

Although the precise response rate was difficult to calculate due to mentioned reasons, a rate of 6% was roughly estimated considering only directly contacted persons. This is a low response rate, which may reflect the limitations of distributing the survey, or which may be interpreted as a lack of time for answering the questionnaire or a general minor interest in solar energy design in some of the 14 countries. There is the risk that the results might have been biased, since it may be assumed, that the majority of those who chose to take the survey were professionals who were already interested in solar energy use and therefore more likely to spend time responding the questions.

4. Results

4.1 Respondents' profile

Most respondents (66%) worked in small firms with 1 to 10 employees. The building projects included a wide selection of different building types, with residential buildings being the most common ones (27%). The respondents were mainly nationally active (71%). Two thirds of respondents were male and one third female. The respondents' average age was 47 and 74% of them declared to have more than ten years of professional experience. Most respondents were architects or designers (88%), others were engineers (7%), physicist (1%) or other professionals (5%).

4.2 Interest in solar energy

The first question was about the importance of solar energy in the current architectural practice (see Fig. 1).

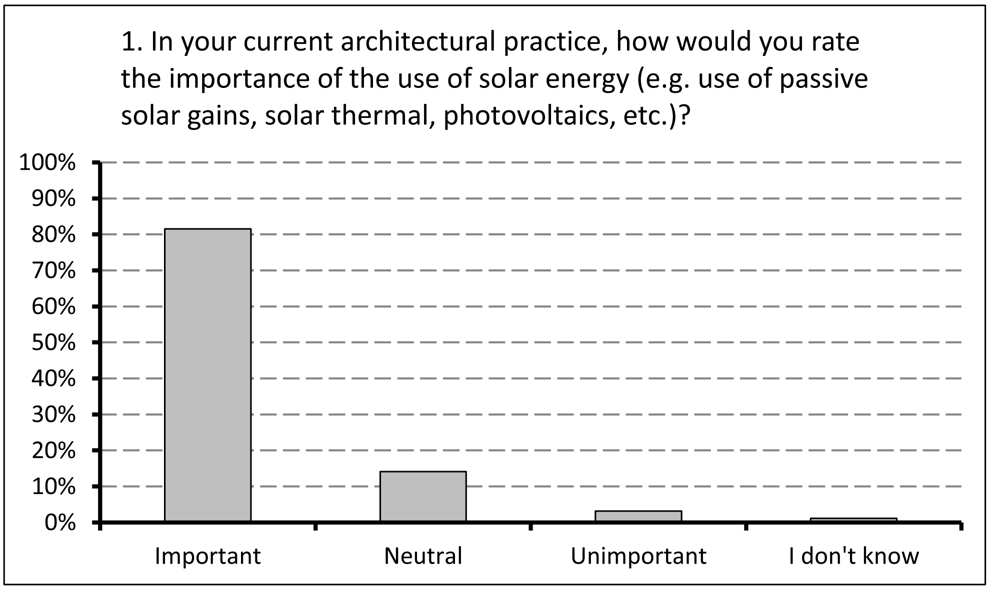

Fig. 1: Rating of the importance of solar energy in the respondent's current architectural practice (n=346).

Some 82% of the respondents declared that solar energy aspects were important in their current architectural practice. The awareness of solar energy aspects was declared to be high. But when asked about the application of solar energy and solar energy system in the projects (question 2), the results showed that there is still a gap between theoretical awareness and project realization (see Fig. 2).

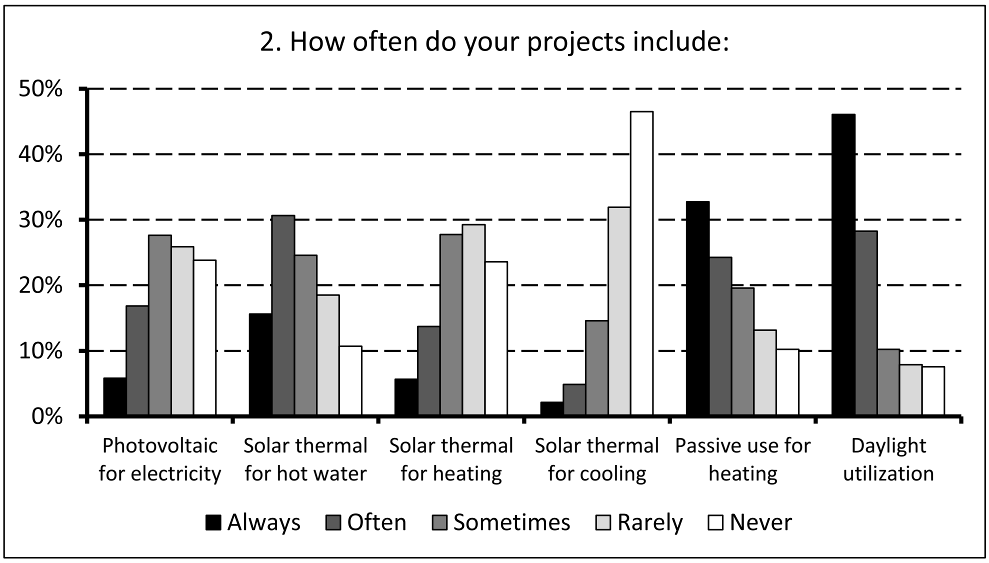

Fig. 2: Application frequency of solar energy utilization (n=325 to 342; depending on category).

'Daylight utilization' was the most common solar design strategy. Some 74% of the respondents answered they included it 'often' or 'always' in their projects. 'Passive solar for heating' was the second most common strategy, with 57% of respondents who 'often' or 'always' included it.

Coming to active solar energy systems, 47% 'often' or 'always' included 'Solar thermal for hot water use' in their projects, while 'Photovoltaic' (23%) and 'Solar thermal for heating' (20%) were less common. 'Solar thermal for cooling' was the least common strategy. It was only used by 7% of the respondents 'often' or 'always'.

4.3 Methods for solar design

The results of the questions concerning the solar design methods showed that the respondents used a variety of different design processes (see Fig. 3).

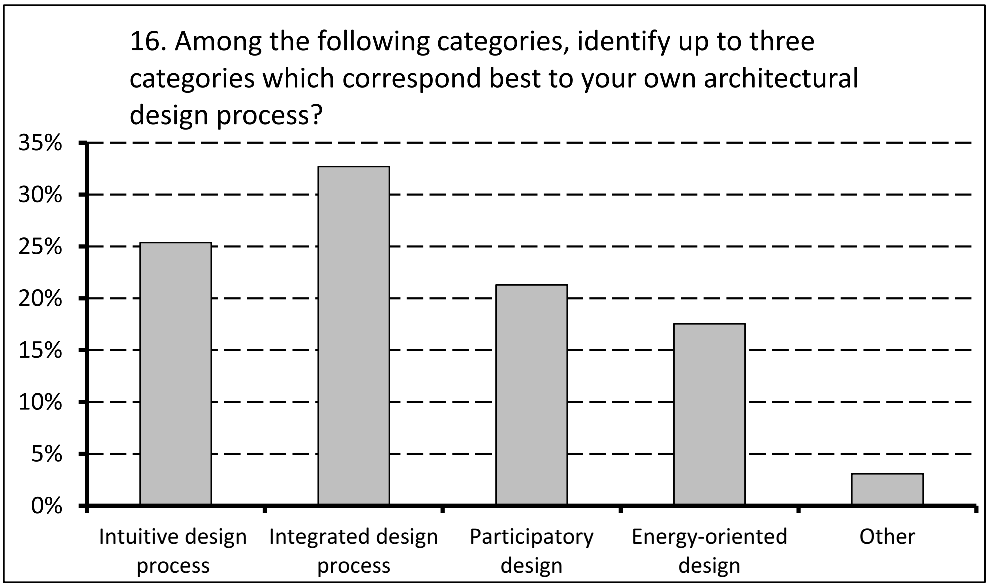

Fig. 3: Types of architectural design processes applied by the respondents (n=587).

The most common design process was the 'Integrated design process (IDP)' applied by one third of the respondents. The rest of the responses were split between the following design processes: 'Intuitive design process' (25%), 'Participatory design' (21%) and 'Energy-oriented design' (18%).

Over two thirds (69%) of the respondents stated that solar energy technologies would first be considered during the conceptual design phase, underlining the need for well-developed tools for that phase.

Most respondents stated that they base their design process upon experiences (23%), interaction with the project owner (21%) and collaboration with other professionals (16%) (see Fig. 4).

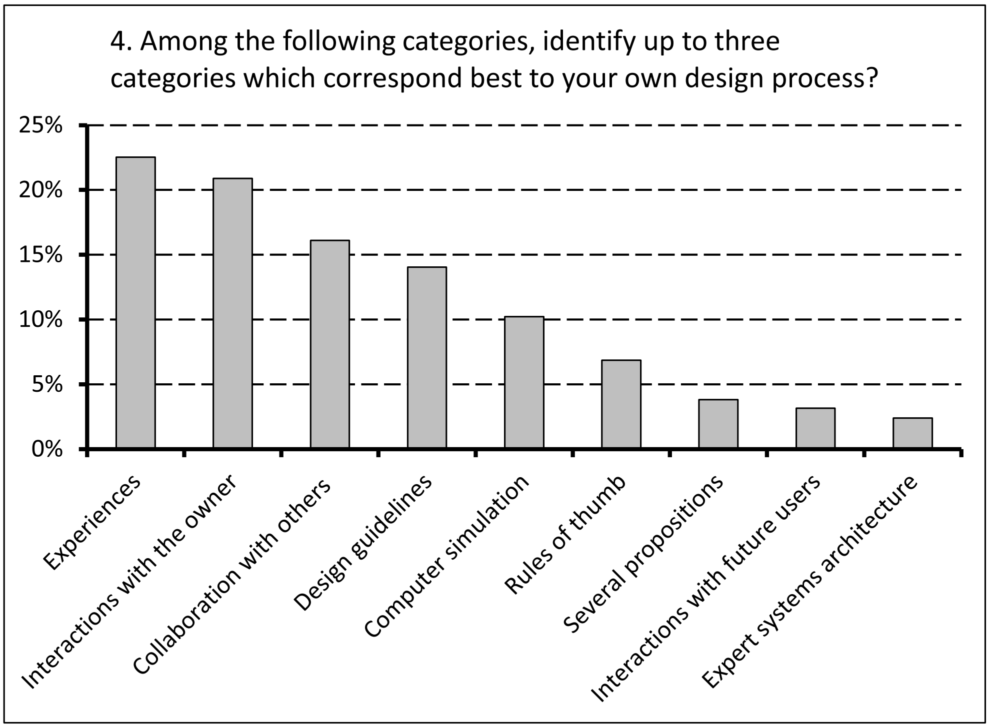

Fig. 4: Categories corresponding to design process (n=913).

The decision making in small projects in the conceptual design phase was largely handled by the architect alone (53%). Only a minority of respondents was likely to involve a solar energy specialist, building science specialist or another professional in this phase. Multidisciplinary workshops played a fairly small role with a 6 to 10% response rate depending on design phase.

For large and more complex projects, the results indicated that respondents were more likely to involve specialists already in the conceptual phase, but still a third of respondents stated that this phase was handled solely by themselves. Multidisciplinary workshops also played a more important role than in smaller projects (10 to 12% depending on project phase).

4.4 Tools for solar design

The professionals were asked about their skills with different tools for solar design (see Fig. 5).

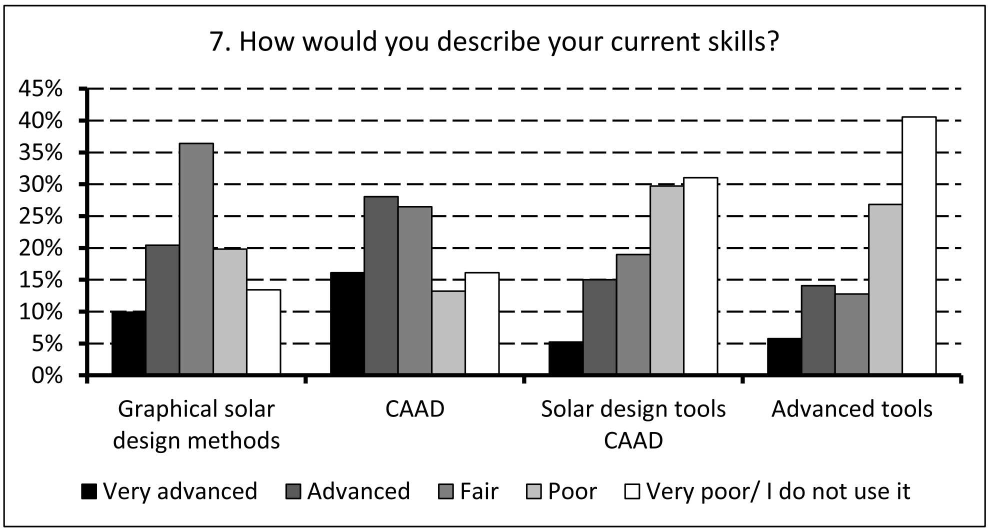

Fig. 5: Current skills with different tools for solar design (n=303 to 310; depending on category).

One third of the respondents described their skills with graphical solar design methods as 'fair' (36%), one third as 'advanced' or 'very advanced' (30%). One third admitted having either 'poor' or 'very poor' (33%) skills. Most respondents described their skills with CAAD (computer-aided architectural design) software as 'advanced' (28%) or 'very advanced' (16%). CAAD tools are an integral part of architects' practice, but still 29% describe their skills as 'poor' or 'very poor'. With regards to solar design tools in CAAD and advanced simulation tools, the majority answered that they considered their skills to be 'poor' (30% and 27% respectively) or 'very poor' (31% and 41% respectively).

The question concerning the design phases in which various software tools were used (question 8; see Fig. 6), returned several results: The most commonly used CAAD tools were AutoCAD, Google SketchUp, Revit Architecture, ArchiCAD, Vectorworks and 3dsMax. The most commonly used visualization tools were Artlantis, V-Ray, RenderWorks and Maxwell Render. While Ecotect, RETScreen, Radiance, Polysun, PV*Sol, PVsyst were the most common tools for simulation.

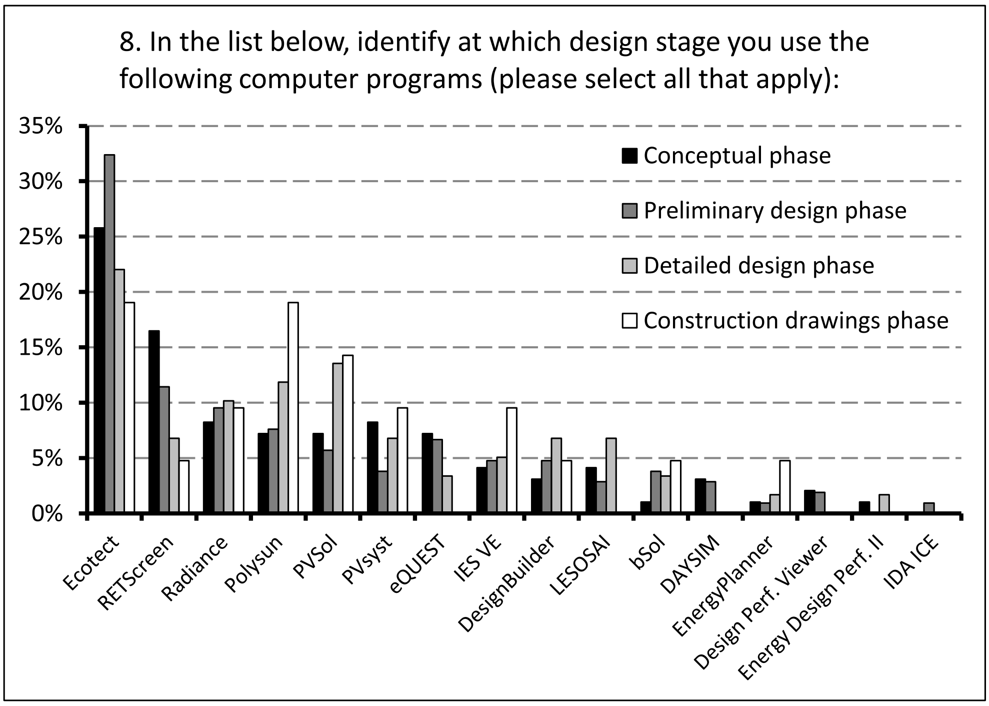

Fig. 6: Simulation tools used during the different design stages (n=282).

The most common CAAD, visualization and simulation tools were used during all project phases, but the tools' relevance differed for the different phases. That was well reflected in the responses. CAAD tools prioritising a simple user interface and fast modelling (e.g. Google SketchUp) were used more extensively during the Early Design Phase (EDP), while more complex tools (e.g. Revit Architecture, AutoCAD) were more common in later project phases (see Fig. 7).

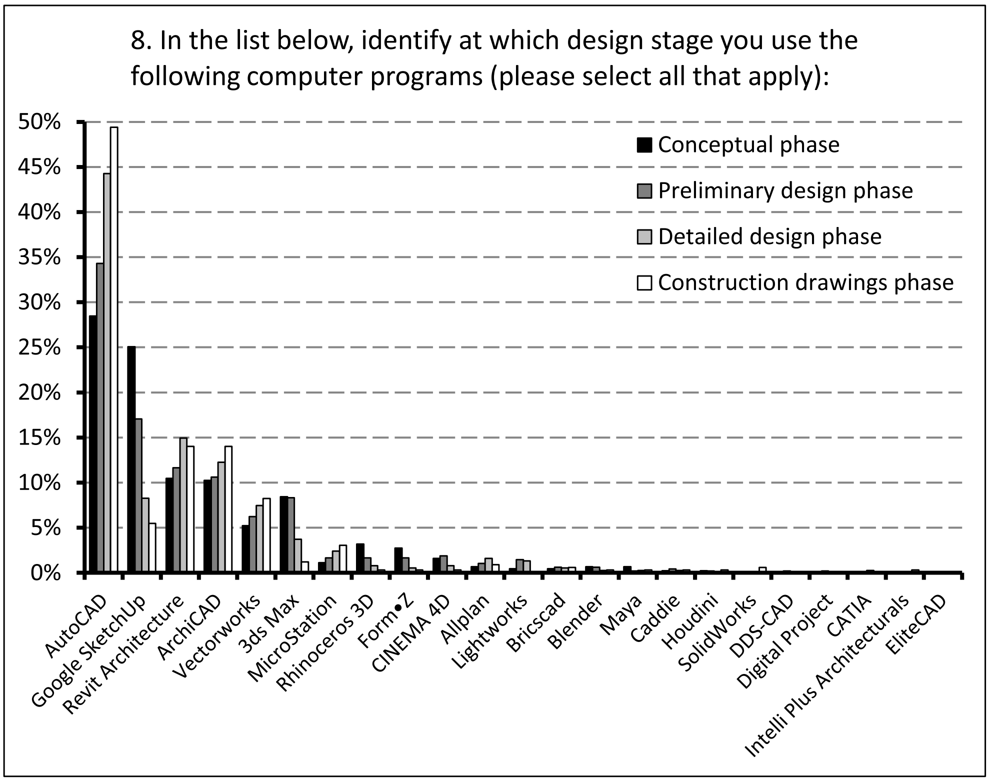

Fig. 7: CAAD tools used during the different design stages (n=1623).

A similar trend was visible towards the application of simulation software, with some products being preferred during EDP (e.g. Ecotect, RETScreen) and others being used more intensively at later stages (e.g. Polysun, PV*Sol). The most common visualization programs were evenly used during the different design phases.

Question 9 concerned the three most important factors for choosing software tools (see Fig. 8).

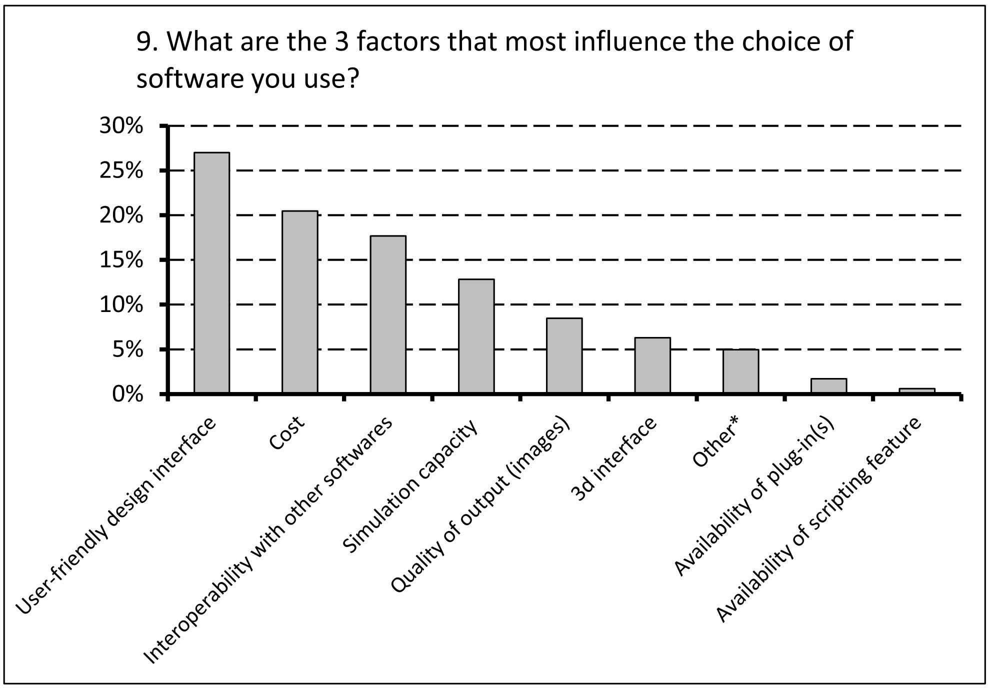

Fig. 8: Factors that influence the choice of software (n=356).

The factor that most influenced the respondents' choice of software was a 'user-friendly interface' (27%). The next most common factors were 'costs' (20%), 'interoperability with other software' (18%) and 'simulation capacity' (13%). 'Quality of output (images)', '3d interfaces', 'availability of plug-ins' and 'availability of scripting features' were considered to be less important (see Fig. 8)

4.5 Satisfaction and barriers with tools

Respondents reported various degrees of satisfaction with their chosen software programs (CAAD, visualization and simulation tools) in terms of support for solar building design (question 11). For many programs, the response rate was too low to formulate any meaningful conclusion.

The most common barriers reported by respondents are shown in Fig. 9.

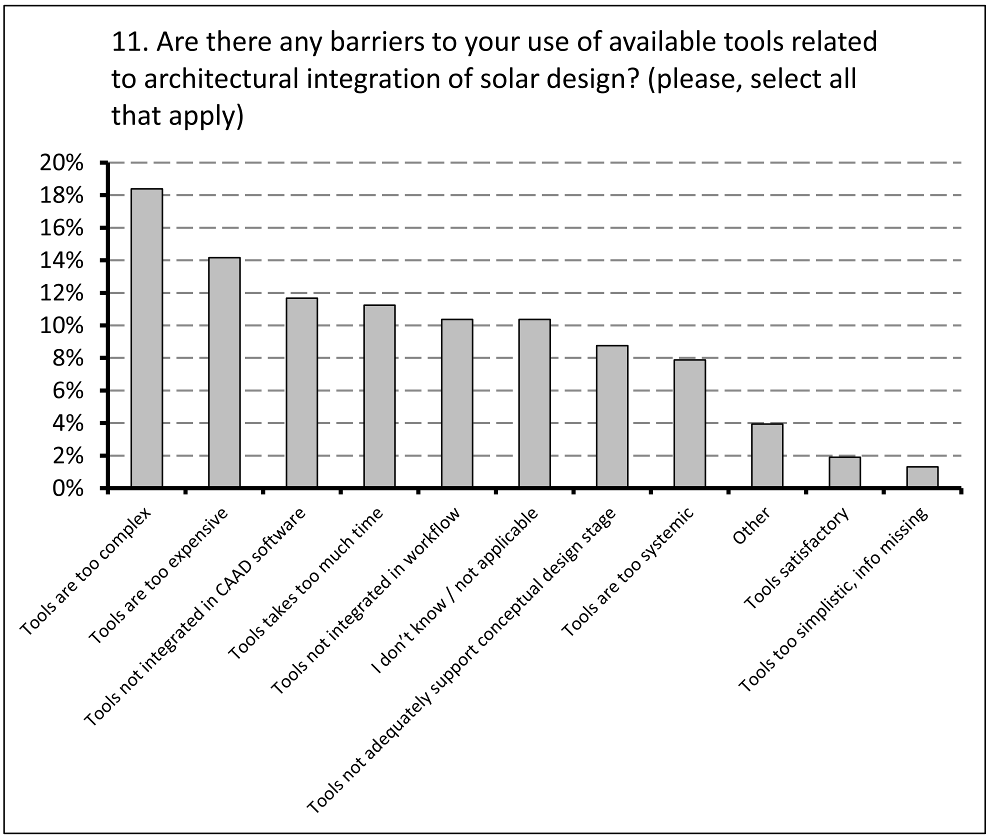

Fig. 9: Barriers for the use of available tools related to architectural integration of solar design (n=685).

The barrier which was stated most was: 'Tools are too complex' (18%). Other common barriers were 'Tools are too expensive' (14%), 'Tools are not integrated in CAAD software' (12%) and 'Tools take too much time' (11%). Respondents also stated that the tools did not adequately support conceptual design (9%), that they were too systemic (8%) and that they were not integrated into their normal workflow (10%). Only 2% reported to be satisfied with the existing tools.

4.6 Improvements needed

Asked about their need for improved tools for each design phase (question 12; see Fig. 10), respondents stated that they would like to have improved tools for the conceptual phase, especially for visualization (28%), preliminary sizing (20%) and tools which provide explicit feedback (18%), as shown in Fig. 10. For the preliminary design phase, respondents requested improved tools for preliminary sizing (26%) and tools which provide key data (22%) and explicit feedback (20%). For the detailed design phase improved tools for key data (28%), preliminary sizing (18%), explicit feedback and visualization (both 16%) are requested. The most common response for the construction drawings phase was 'I don't know/ not applicable' (29%). However, respondents also asked for improved tools for key data (21%), for preliminary sizing (16%), and for tools which provide explicit feedback (10%).

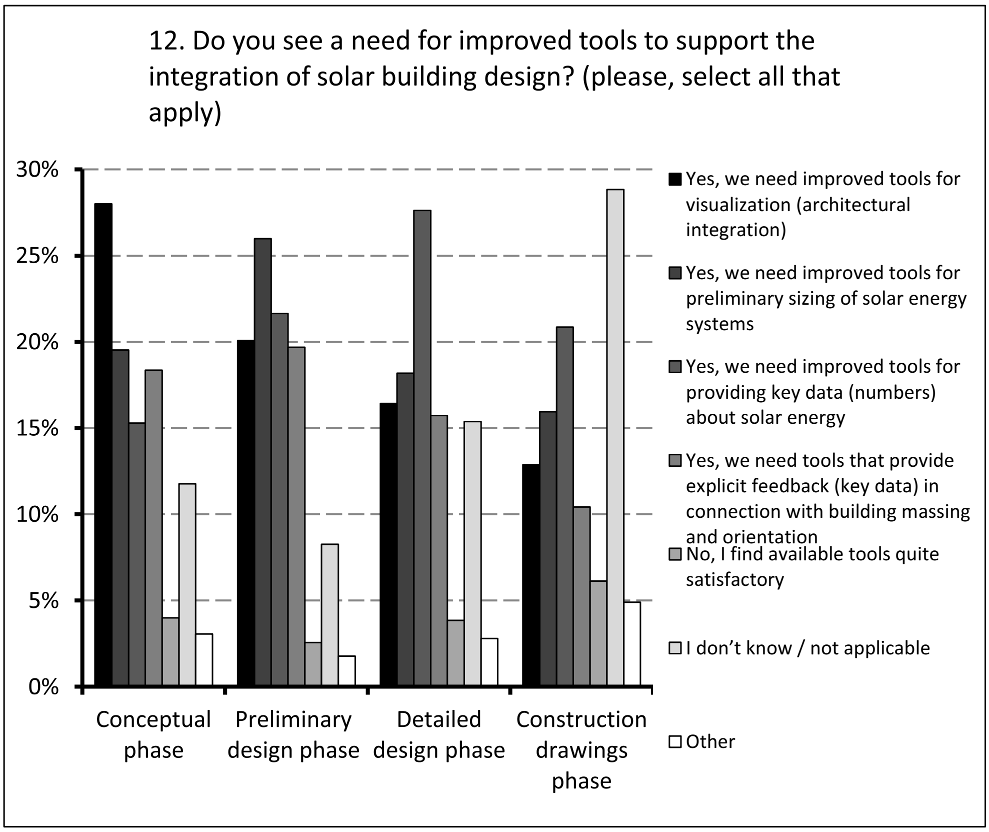

Fig. 10: Need for improved tools for integration of solar design (n=1382).

5. Conclusion

It was interesting and surprising to observe that the needs expressed by users have remained relatively unchanged over time, as shown by both, the literature review and the survey. Both strongly indicated the need for further development of software tools for solar architecture, focusing on a user-friendly, visual tool that is easily interoperable between different modelling software packages, and which generates clear and meaningful results. There is a need for tools to be easily compatible with the existing workflow of architects. Also, since each design phase has its own requirements and specifications, software tools should be able to adapt to specific design phases.

The survey indicated a high awareness about solar aspects among respondents. However, this was combined with a limited application of solar energy technologies in the daily practice, suggesting the need for further skill development and tools to accelerate the use of these technologies in buildings. The survey generally shows that the work-force related limitation is a main factor responsible for the limited application of solar design.

Despite the fact, that the survey had the named limitations, a number of concrete examples of practitioners' needs and suggestions for improvement have been identified.

6. Outlook

After the analysis of the international survey results, regional analyses of the data are planned for every participating country with sufficient response rate. In addition a detailed statistical analysis of the survey responses is currently in work by a Master's student at Ryerson University; results will be published in a separate article in the autumn 2011.

The results of the survey and the literature review are the groundwork for developing guidelines for architects and software developers. These guidelines will be completed during the last year of the Task 41

STB work plan (2011 to 2012).

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8. References

Dubois, M.-C., Horvat, M. and Kanters, J., 2011, Tools and methods used by architects for solar design: results of an international survey in 14 countries, accepted to be presented at CISBAT 11 - Clean tech for sustainable buildings: from nano to urban scale, Lausanne, Switzerland, September 14-16, 2011.

Horvat, M., Dubois, M.-C., Snow, M., Wall, M. (eds.), 2011. International survey about digital tools used by architects for solar design, Report T.41.B.2, International Energy Agency, Solar Heating and Cooling Programme. Available at http://www.iea-shc.org/publications/task.aspx?Task=41

Kanters, J., 2011, Adequacy of current design tools and methods for solar architecture – results of IEA-SHC Task 41's international survey, in Bodart, M. and Evrard. A. (Ed.), PLEA 2011 – 27th Conference on Passive and Low Energy Architecture - proceedings, Louvain-la-Neuve, Belgium, July 13-15, 2011, Vol. 2, pp. 65-70.