Towards 'Architect-friendly' Energy Evaluation Tools

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Abstract

Several studies demonstrate the importance of integrating energy analyses in the architectural design process. For this, a wide variety of building performance simulation programs are currently available. However, most of these tools are not in tune with the architects' approach and are not suitable for early design stages, when major decisions are made. Despite recent developments addressing the use of simulation in the design process (DP), the uptake by architects is still limited. Further, the importance of user's needs has repeatedly been reported in literature, but has rarely been investigated from an architect's point of view. However, researchers and design tool developers need this information to improve the compatibility of existing tools with the architectural DP and to develop new tools.

This research focuses on the use of energy evaluation tools by architects, and aims at a better understanding of the architect's preferences for these tools. The concept of 'architect-friendliness' was studied via interviews with 9 Flemish architects, and via a large-scale survey among 629 Flemish architects. The results provide important information for the development of energy tools that better fit the DP and better meet the architect's expectations. Finally, a conceptual framework specifying the concept of "architect-friendliness" is proposed.

1. INTRODUCTION

Different studies have demonstrated the potential role of building performance simulation (BPS) in making informed design decisions [1,2], and many researchers focus on the integration of BPS in the design process (DP) in various ways [3-7]. However, in practice, the uptake of simulation by architects is still limited [8,9] and many early decisions are entirely based on the designer's experience and intuition [10, 11]. Especially in small projects that lack engineering support due to limited budgets, BPS might be a valuable support to architects in the design of low-energy buildings. Previous studies have demonstrated reasons for not using BPS by architects. These covered among other things the architects' perception that the usage is beyond the scope of their work, professional shortcomings, a lack of know-how, and steep learning curves [8,9]. Major limitations of existing BPS tools included lack of user-friendliness, lack of integration with CAD software, extensive data-input, and the fact that they do not fit the DP.

Accordingly, most BPS tools are not adapted to the architects' approach. However, given the urgent question of climate change and stricter energy regulations, the use of BPS by architects is expected to be increasingly important. Therefore, to improve the uptake of BPS by this (growing) users group, an in-depth understanding of their needs and requirements is crucial. Better integration with CAD software, limited data-input in the architect's language, easy interpretable output, graphical representation of input and output, and use of defaults are among other frequently identified criteria for BPS tools [8,12,13]. The user-friendliness is probably the most often discussed tool criterion [13,14], but has rarely been investigated from an architect's point of view. Attia et al. [12] conducted a survey among simulation users in the U.S.A. to investigate the most important criteria for *'architect-friendly' [12]* BPS tools, but the context might be different in other countries.

To obtain a more elaborated view on the 'architect-friendliness' of energy simulation tools and the users' needs and preferences, semi-structured interviews were performed with 9 Flemish architects, and a large-scale survey was conducted among 629 architects in Flanders, Belgium. In both the interviews and the survey, a broad view was adopted for energy simulation tools, also including other types such as checklists, and is therefore referred to as 'energy (evaluation) tools'. A conceptual framework is proposed, providing tool developers important information for the development of energy tools that better fit the DP and better fulfill the architect's requirements.

2. INTERVIEWS

2.1. Method

Semi-structured interviews were performed with 9 Flemish architects, between June 2008 and October 2008, enabling the architects to actively contribute aspects that seem important to them and allowing them to elaborate more on their views, perceptions, and motivations.

The interviews were structured among three major themes, namely the DP, the integration of sustainability aspects in the design and the usage of and requirements for energy evaluation tools. This paper only reports on the last theme. Several topics were related to the EPB software ("Energy Performance and Indoor Climate"), a steady-state simulation program provided by the Flemish government to calculate compliance with regulations related to the European 'Energy Performance of Buildings Directive' (EPBD) [15]. The EPB legislation enforces a maximum energy performance level (E-level) and insulation level (K-level). The E-level stands for the level of primary energy use, calculated for standard climate conditions on a monthly basis and standard occupants' behavior. This primary energy use is compared to a reference value. The current legal requirement sets the maximum E-level at E80. The K-level takes into account the mean U-value of the building envelope and the volume compactness. The maximum is set at K45, representing a U_{mean}= 0,45 W/m²K, for a compactness of 1m. As an example, a passive house represents a K10 to K15 level and a E30 to E40 level, whereas a low-energy house with a yearly energy consumption of ca. 50 kWh/m² has an insulation level around K35 and an E-level of E60 to E70. Since most Flemish architects are familiar with the EPB software, this tool was used as a reference in the interviews. Consequently, architects were able to discuss experienced limitations of the software and future needs for energy tools.

2.2. Results

The interviews revealed that tool simplicity, intuitive tool usage, and limited time to operate a tool are extremely important aspects to architects. However, differences were identified for the latter, ranging from 5 minutes to 2 hours to operate a tool. One respondent stated that a truly user-friendly tool should be usable without consulting a manual, and explained the concept of 'simplicity' by referring to the 3D sketch tool "Sketch-Up". Sketch-Up is perceived as a very easy and intuitive to use tool, with easy navigation and a simple and clear interface, allowing to quickly create and compare different design ideas.

Apart from the ability to quickly create, test and compare alternative designs, the possibility to provide feedback on the impact of design parameters also appeared to be a very important criterion for energy tools. In particular, the impact of glazing percentage on the risk of overheating and the impact of insulation on the building's energy use were issues for which architects require additional feedback when designing.

Regarding the need for integrating energy tools with 3D CAD software, approximately half of the respondents considered an integration advantageously, while the other half perceived it to be unnecessary and preferred a simple manual input. There was also no clear agreement among the respondents on the need to provide design guidelines.

The data further identified a limited and quick data-input, and easy data review as important issues for an 'architect-friendly' energy tool. The laborious and time-consuming process of data-input and the difficult data review were the most frequently expressed limitations of the current EPB software, and hinder the usage of the software when designing since most design projects are often subject to change. Several ideas on reducing the input were elaborated during the interviews, such as using glazing percentages per orientation or standard constructions for walls, floors and roofs. The latter could easily be introduced by providing adaptable default values per project type.

Considering the output, the architects interviewed showed a particular interest in clear, simple and visual output, especially to support the communication with clients. In this frame, a cost-benefit analysis and payback time appeared to be important factors to convince clients, as many decisions are determined by the client's budget.

Other preferences are the visual aspect of input, output and interface, the transparency of the tool, the ease of navigation, and the conformance with regulations. Tools should also be non prescriptive and flexible in use.

Finally, other tool criteria introduced by the interviewees included an extensive component library, easy interpretable output and ease of learning. Regarding the usability of tools in the DP, some respondents emphasized instant feedback on design decisions and changes, and data-input adapted to (early) design phases. Accuracy of the results appeared to be of less importance than ease of use.

3. SURVEY

3.1. Introduction

In addition to the interviews, a survey was conducted, evaluating the architects' needs for energy tools among a larger group of respondents to corroborate the former results and to obtain more quantitative data.

In the past, several surveys have been conducted to investigate the architects' use of and requirements for BPS tools [8,9,12], but the context might be different in other countries. In Flanders, Belgium, energy legislation is very recent with the first energy code implemented in 1992. Further, in Flanders, architects often work independently or in small firms, mainly focusing on the design of small projects for private clients. However, tool developers may benefit from input from multiple views and contexts, as already indicated by Mahdavi [9].

3.2. Method

A self-administered questionnaire was distributed among 984 architects in Flanders. The questionnaire was structured around 4 major parts. This paper reports on the results of the first part, being the architects' use of and preferences for energy tools. Several questions were related to the EPB software, because most Flemish architects are familiar with this software. The survey was conducted during the course "Energy Conscious Architect", organized by the Flemish government in cooperation with the two main Flemish architects associations, and comprised three evenings of lectures on energy efficiency.

After a pilot study in June 2008, the final questionnaire was distributed to 319 architects attending the first series of the course in September and October 2008. The response rate was 70%. For this series, the number of participants was limited and at that time no extra courses were planned. Due to the success of the first series of the course, a second series was organized from December 2008 until February 2009. For this series more participants could subscribe and this time the subscription limit was not reached. A slightly updated version of the questionnaire was distributed to all 665 participants, with a response rate of 61%.

In total, 629 questionnaires were completed and returned, representing a response rate of 64%. 70% of the respondents was male and the median age was 36. A comparison to statistical data of all Flemish architects (6985 architects, of which 71,5% male)[1] indicates that the current sample is sufficiently representative for the Flemish architects' population. The questionnaire consisted of multiple choice questions for which the respondents could select several options and also provide additional options. In addition, the questionnaire included one open question on the user-friendliness of energy tools. Some questions are partly based on Lam et al. [8] and Mahdavi et al. [9], with adaptation to the Belgian context. The statistical program SPSS 16 was used for the analyses.

3.3. Results: Multiple Choice Questions

3.3.1. Use of Energy Tools in Daily Architectural Practice

The data revealed that the EPB software is used by 64% of the architectural practices of the respondents surveyed. This high usage can be explained by the legislative character of the software. Other energy tools (such as checklists, simulation software, software provided by construction firms, etc.) are only used by 10% or less. Of all tools, BPS software clearly scored lowest, with only 2% of usage.

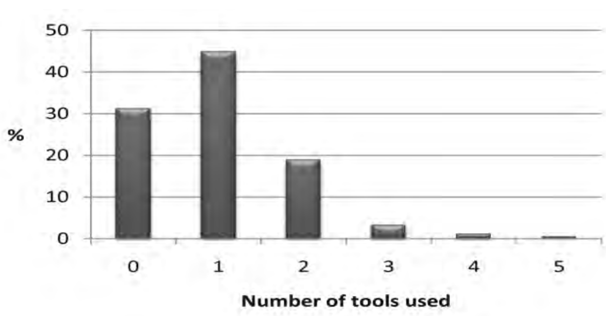

Figure 1. Number of energy tools used

[1] Data provided by the Order of Architects (Belgium)

As Figure 1 shows, the average number of tools used in the architectural practices of the respondents is 1 (45%), whereas 31% of the respondents does not use energy tools at all. Only 24% uses more than 1 tool to evaluate the energy performance of the design.

The data further revealed that the EPB software clearly dominates for single tool usage (92%), which can be explained by its legislative character. As a result, most of the architectural practices either use no tool or use the EPB software. Consequently, the current architects' use of energy evaluation tools is almost entirely limited to the EPB software, indicating that Flemish architects only evaluate the energy performance of the design for compliance with legal requirements.

Further, the size of the architectural firm appeared to be statistically significant. The EPB software is more often used by larger firms (6 associates or more), probably because larger firms often have a permanent availability of specialists for particular knowledge domains. For all other energy tools no statistically significant differences were found. Further analysis of the data indicated that there are also no statistically significant differences in the current use of energy tools for architects designing only residential buildings compared to architects also designing other project types such as public buildings, except for checklists, which are more often used by the latter.

3.3.2. Reasons for Not Using Energy Tools

As previously stated, 31% of the architectural practices of the respondents does not use energy tools. Figure 2 summarizes the reasons for this. The results are presented for both series of the survey separately due to statistically significant differences for two aspects, marked by a dotted rectangle in the figure.

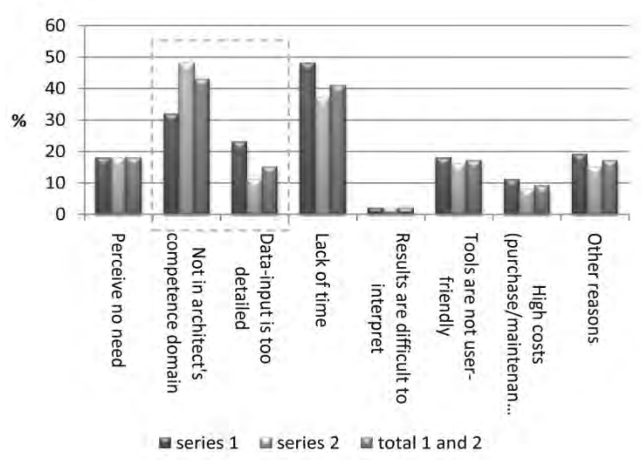

Figure 2. Reasons for not using energy evaluation tools

The major reasons for not using energy tools are the opinion that it is outside the architect's competence domain and lack of time. Consequently, the most frequently indicated reasons for not using tools are non tool specific. Detailed data-input and lack of user-friendliness appeared to be the most important tool specific reasons. Other cited reasons were mainly related to the outsourcing to specialists.

Architects of the second series seem to be more skeptical towards the usage of energy tools in general, since “the use of tools is outside the architect’s competence domain” was an important reason for not using energy tools for almost 50%, compared to 32% in the first series. For the first series, lack of time seemed to be an important reason for not using energy tools for the majority of the respondents (48%). These architects also tend to be more concerned about tool-specific functions, compared to the respondents of the second series. Almost 25% of the respondents of the first series considered a too detailed data-input as an important reason for not using tools, compared to only 11% of the respondents of the second series. These observed differences might be explained by the fact that the architects of the first series, who subscribed first for the course, may be more interested in energy use.

3.3.3. Energy Evaluation in the Design Process

The results in figure 3 show a tendency of increasing use of energy tools during design development. Energy tools are mainly used in detailed design phases. Less than 50% of the respondents who use energy tools, use them in the conceptual design phase (CDP).

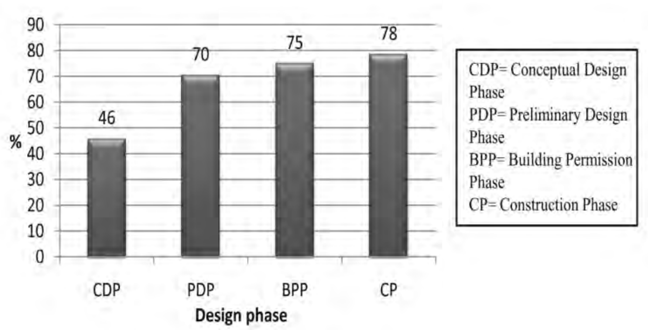

Figure 3. Use of energy tools in the design phases

When only considering the respondents who only use the EPB software, slightly different results are obtained. They use the EPB software considerably less in early design phases, with only 36% in the CDP and 62% in the preliminary design phase (PDP) (compared to 46% and 70% in figure 3). This might be explained by the fact that tools such as checklists may be easier to use in early design phases. Nevertheless, these results indicate that energy tools are rarely used to support early design decisions.

Figure 4 assesses the roles energy tools play in the DP. The results show that energy tools are mostly used to meet regulatory requirements in all design phases (over 70%), with a peak in the BPP (93%), but are much less used for all other roles. The response for all other roles is more or less evenly distributed among the design phases. Only small differences are present. Assessing the impact of design decisions is more important in early than in detailed design phases. Also, tools are used slightly less to fulfill the client’s wishes during design development. Again, these results imply that energy tools are currently mainly used for code compliance, but rarely for design purposes.

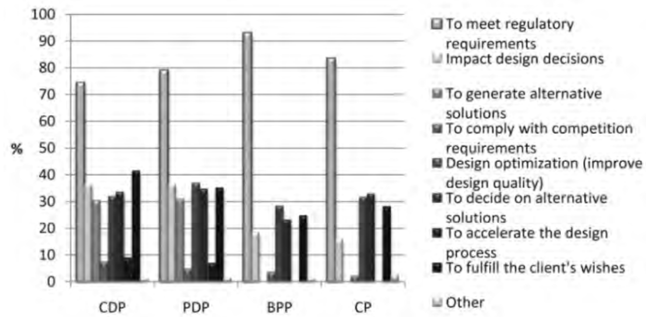

Figure 4. Reasons for using energy tools in the DP

3.3.4. Limitations of and Preferences for the EPB

59% of the respondents uses or has used the EPB software themselves, meaning that ca. 40% has never used it. The most frequently stated reason for not using the software is the outsourcing to specialists or to colleagues. Other reasons included among other lack of time, complexity of the program, lack of user-friendliness, and extra work.

There is also a clear tendency of decreasing use of the software with increasing age of the respondent (figure 5). 67% of the respondents younger than 31 uses or has used the software, compared to 58% of respondents between 31 and 40, and 54% and 53% of respondents between 41 and 50 years old, and older than 50 respectively. A possible explanation might be that younger architects are probably more motivated to learn new methods and to use energy tools. It is therefore likely that this tendency will continue in the future, indicating an increased uptake of energy tools.

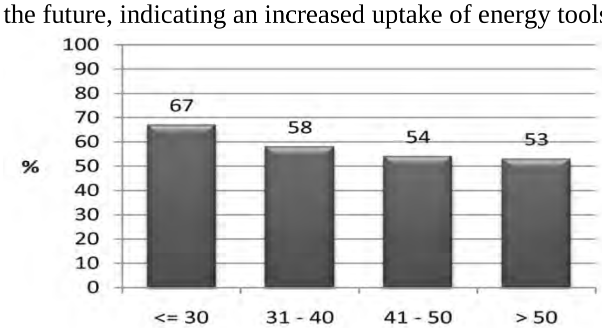

Figure 5. Use of the EPB software in relation to the respondents’ age

The design supportive character of the EPB software was further examined among the respondents who use or have used the program. The results point out that 53% of these respondents believe that the software does not provide sufficient support when designing. Further analysis of the data revealed statistically significant differences between both series of the survey, as summarized in table 1.

	Series 1	Series 2
Sufficient support	39%	52%
Insufficient support	61%	48%

Table 1. Design supportive character of the EPB software. Series 1 versus series 2.

61% of the respondents of the first series who use or have used the EPB indicated that the software does not provide sufficient support during the DP, compared to only 48% of the respondents of the second series. This difference is possibly due to the fact that architects of the first series might be more interested in energy, since they subscribed first for the course "Energy Conscious Architect".

Subsequently, other experienced limitations of the EPB software were examined for the respondents who use or have used the software (figure 6). The major experienced limitations are clearly lack of an extensive component library (67%), too complex software to provide instant feedback (62%), and detailed data-input (61%). Around 30% of the respondents perceives lack of integration with CAD software as an important limitation, whereas only 13% considers the lack of support for design decisions as a limitation. Other limitations mentioned are lack of user-friendliness and of transparency. For 2% of the respondents the EPB software has no limitations.

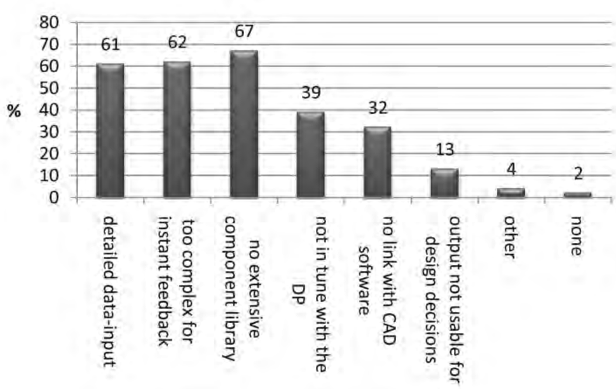

Figure 6. Limitations of the EPB software

Regarding the need for an energy design tool, facilitating intermediary design evaluations, if regulations become more severe in the future (E60), 88% of all respondents responded positive. Moreover, in this case 90% of the respondents currently not using energy tools in their architectural practice also expressed a need. These results indicate that if Flemish regulations become tightened, the need for a design supportive energy tool will be considerably high. Related to the size of the architectural firm, there was no statistically significant difference for this aspect, nor for the type of design projects. However, since 86% of the respondents focusing on residential projects only indicated a need, architects also need design support for the energy efficiency aspects of small projects.

When asked to provide an order of priority regarding the most important aspects, ease of use was ranked as the most important tool aspect. 'Provide guidelines for a specified E and K-level' and 'possibility for intermediary evaluations' had a shared second ranking. The next important tool aspect, ranked at the fourth place, was to provide feedback related to an expected E-level. The least important aspects were generation of design alternatives and a link with existing CAD software. However, further analysis of the data revealed that even the least important aspects (the lowest ranked criteria, i.e. link with CAD software and generation of design alternatives) were considered to be important by almost 60% of the respondents surveyed. Therefore, these aspects should also be taken into consideration when developing new or improving existing energy design tools.

3.3.5. Criteria for Energy Evaluation Tools

When considering the important criteria for energy evaluation tools in general (figure 7), ease of use is important for most of the respondents (90%), followed by conformance with standards and regulations (68%). Ease of learning, easy interpretation of the results, and price are all important tool criteria for about half of the respondents. For 31% of the respondents, a link with CAD software is important.

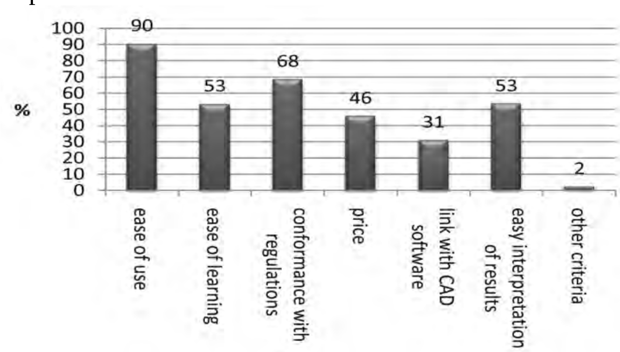

Figure 7. Criteria for energy evaluation tools

Considering specifically the aspects for which the respondents of the second series require feedback during the DP (figure 8), feedback on the impact of glazing percentage (80%) and insulation (76%) on energy use is clearly important to most architects, followed by feedback on the impact of glazing percentage on overheating (63%). The impact of thermal mass and orientation on energy use and the impact of shading devices on overheating risks are all of average importance, as indicated by about 50% of the respondents of the second series. Finally, around 40% of these respondents expressed a need for design feedback on the impact of thermal mass, orientation and insulation on overheating.

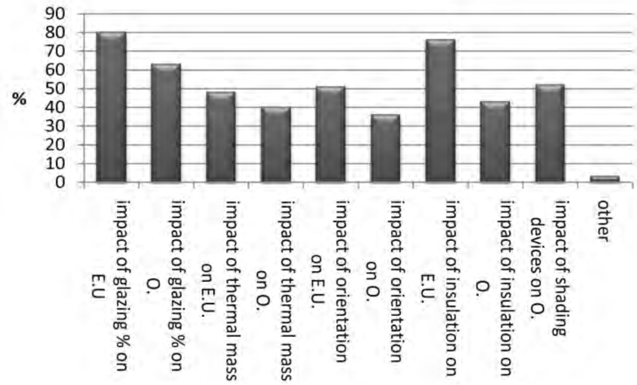

Figure 8. Feedback aspects for the respondents of the second series. (E.U.= energy use, O= overheating)

3.3.6. Factors for Design Decisions

23% of the respondents surveyed have realized a low-energy project with a maximum E-level of 60. When considering the factors influencing design decisions, 50% of these respondents usually decide on experience for the design of low-energy projects. Intuition is taken into account by 34% of the respondents. 44% makes intermediary EPB calculations and 38% appeals on specialists. Comparing these results to the factors that determine design decisions in general, it seems that architects rely less on experience for the design of energy efficient projects than for general design aspects (50% versus 85%). This further suggests that architects need more adequate support for the design of low-energy projects.

3.3.7. Current Use of 3D Modeling Software

57% of the respondents of the second series using 3D modeling software, uses Sketch-Up. All other programs (Revit, Archicad and Autocad) are more or less equally used (by around 10%), with the exception of Vector Works (17%).

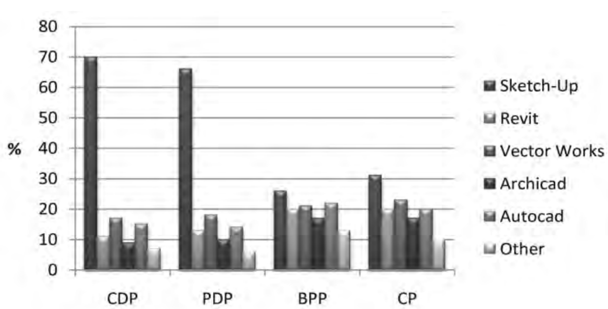

Figure 9. Most often used 3D tool in each design phase (CDP=conceptual design phase, PDP=preliminary design phase, BPP=building permission phase, CP=construction phase)

As figure 9 shows, Sketch-Up is clearly the most frequently used 3D tool in the CDP and the PDP among the respondents of the second series who indicated using 3D tools in these phases. During the BPP and the CP all 3D tools are more or less equally used. The clear domination of Sketch-Up in early design phases is important to keep in mind when considering the compatibility of BPS tools with existing CAD software.

A more detailed analysis showed that 3D modeling software is more widely used among younger architects (younger than 50). It is therefore likely that the usage of 3D tools will increase in the future.

3.4. Results: Open Question

The respondents of the second series of the survey were also asked to explain the user-friendliness of energy tools and their compatibility with the DP in an open question. 251 respondents had completed this question.

The data revealed that tool simplicity, intuitive tool usage, and time to use the tool are the most important aspects determining the user-friendliness of energy tools. Again, ‘Sketch-Up’ was sometimes referred to as example. Further, many respondents considered easy, fast, and minimum data-input, an extensive component database, a clearly structured interface with a restrained set of options, ease of learning, and the ability to quickly create, test and compare alternative designs to be important aspects for the user-friendliness of energy tools. Other frequently discussed aspects are: ease of interpretation of the results, a link with CAD software, and ease of data review. Finally, other aspects mentioned are: adaptability of library components, conformance with regulations, visual qualities of the tool, reliability of the output, providing impact degrees of parameters, transparency of the tool, input and output in the language of the architect, providing guidelines, and input from general to detail. User-friendly tools should also enhance the communication with clients. Considering the usability of energy tools in the DP, real-time feedback on design changes, limited data-input, speed of working, and ease of data review were frequently identified criteria. Other issues included among other: input from general to detail, providing guidelines, and usability in early design phases.

4. DISCUSSION

This paper discusses the results of interviews with 9 and a survey among 629 architects in Flanders, Belgium. Despite differences between architects’ populations in other countries these results may provide valuable information for tool developers, as they might benefit from multiple views.

The results showed that the current usage of energy tools in Flanders is mainly limited to the EPB software. Other tools, in particular BPS, are rarely used. This might partially be explained by the fact that Flemish architects are often not aware of the existence of other tools, as turned out from the interviews. The current uptake is primarily focused on fulfilling legal requirements, but rarely on addressing deeper design issues, and is mainly concentrated in detailed design phases. 31% of the respondents currently does not use any energy tool in the architectural practice. Similar findings were observed in previous studies [8,9].

Given the importance of integrating BPS in the DP and the possible increased uptake of energy tools by architects in the future (as indicated by the survey), it is of major concern to thoroughly take into account the needs of this (growing) user group. By combining multiple sources of information and providing the respondents the opportunity to elaborate on their views, this study yielded a comprehensive understanding about the concept "architect-friendly" in a Belgian context. Moreover, when comparing these results with previous studies in different geographic locations a number of similar findings emerge: a) detailed data-input is one of the major limitations of current BPS tools [8,9], b) the tools do not match the existing DP [8], c) important tool criteria include among other easy interpretable output, easy data-input, user-friendliness, better ease of learning [8,9], graphical input and output, simple navigation, use of default values, extensive component library, and ease of creating and comparing alternatives [12]. While the study of Lam et al. [8] highlighted the importance of an integration with CAD software, the study of Mahdavi et al. [9] showed more divided results. In the current study, the respondents' opinions were also more divided. The interviews revealed that this largely depends on the architect's preferred design media. Further, conformance with regulations was identified as a very important tool criterion. This was also observed in other studies [9,12]. Regarding the usability of tools in the DP, Attia et al. [12] stressed the importance of a quick energy analysis and the ability to examine the sensitivity of key design parameters. Similar findings were done in the current study. In addition to this, both the interviews and the survey stressed the importance of intuitive tool usage and limited time to operate the tool. This implicates that tools should easily be employable in other design media and activities, which might be implemented by introducing energy evaluation in 3D modeling software. For early design, Sketch-Up seems most appropriate considering its common usage in the early design stages. Sketch-up's popularity also applies to other countries [12].

Based on the results of the interviews and the survey a conceptual framework is synthesized, defining the concept of "architect-friendliness" of BPS tools (figure 10). The data revealed that the criteria considered by the respondents and contributing to the concept of "architect-friendliness" could be classified into four major themes, namely data-input, data-output, graphical user interface (GUI), and usability in the DP. An extra general theme is included, to incorporate important issues that could not directly be assigned to one of the other themes.

BPS tool	1 2 3 4 5
DATA-INPUT	
Limited data-input	
Quick data-input (time to create model is less than 1h)	
Input in the language of the architect	
Use of defaults to limit and facilitate data-entry	
simple and intuitive input process	
easy data review/change	
easy create alternative designs/options	
extensive library/database of building components	
input consistent with early design phase (basic input)	
from general to detail	
graphical representation of building geometry:	
3D modeler in simulation tool	
Possibility to import 3D CAD files	
Possibility to import from Sketch-Up	
Input via drawing software (for instance Sketch-Up)	
OUTPUT	
Easy interpretation (language of architects)	
graphical representation of output	
conformance with building codes and regulations	
impact of decisions/parameters (uncertainty/sensitivity)	
Simple but supportive information for design decisions	
Convincing output, to communicate with clients	
clearly indicate problem area(s)	
benchmarking	
output displayed in 3D building model	
generate reports for alternative designs/options	
reliability of the output	
adapted for different design phases	
INTERFACE	
visual communication of GUI	
clear, intuitive, and flexible navigation	
clearly structured with a restrained set of functions (simplicity)	
USABILITY in DP	
minimally interrupt the DP	
Data-input in tune with DP	
simplicity	
minimal time required to operate the tool	
adapted for use in early design	
quickly obtain solutions	
quickly and easily create, test and compare alternatives	
real-time feedback on design decisions and changes	
provide guidelines	
GENERAL	
adaptable default values	
highly visual	
transparency of the tool	
ease and intuitive in use	
short calculation time	
easy to learn	
adequate for local usage (units/materials/…)	
easy to use after long time of non-use	

Figure 10. Architect-friendliness: Conceptual framework.

Overall, similar findings were done between this study and studies in other countries, despite the different contexts. Certain aspects, such as integrating case study databases [12], were not observed in this study. Conversely, several issues such as clear output to facilitate communication with clients, though important in this study, were not addressed in the others. This may partially be due to the fact that the current study combined a survey with interviews and that the respondents could also actively contribute aspects they considered important. Several of these issues have also repeatedly been recognized by other researchers. Hence, the proposed checklist might possibly be generalizable to other regions, and might be a good base to better evaluate "architect-friendliness" and to develop future tools that fit the architect's expectations.

The scheme comprises two columns. The left column includes the five themes with corresponding criteria. The right column provides space to evaluate a particular tool. The assessment is based on a five point scale, 1 being "not present" and 5 representing "extremely good". The scheme primarily focuses on energy simulation tools, but its usage might be extended to BPS tools in general. The first section of the scheme includes important aspects to adjust the input to an architect user, such as limited and quick data-input. Considering the graphical representation of the geometry, four items were incorporated, of which 'input via modeling software' is considered to be the most architect-friendly, as it minimally interrupts the DP. In the output section of the scheme, the item "benchmarking" was added, though not explicitly derived from the study. Summarized, the results stressed the importance of easy interpretable output. By comparing the output of a project with the performance of a well-known example, such as a low-energy house, architects get a better understanding of the consequences of their results. The third section stresses the importance of a clear GUI. Considering the usability in the DP, aspects such as simplicity and easily create alternatives are important. The last section includes a number of general criteria.

5. CONCLUSION

This paper analyzed the user-friendliness of energy evaluation tools from an architect's point of view via interviews and a survey. The data showed that these tools might play a potential role in design support for low energy projects, also for small projects. Addressing the needs of the architectural design community is crucial to encourage the uptake of BPS tools by architects. Future research will focus on evaluating existing BPS tools according to the proposed scheme, and on ways to concretize the results. The latter will be done organizing focus groups with architects.

6. ACKNOWLEDGEMENTS

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