

User Preferences for a Simple Energy Design Tool: Capturing information through focus groups with architects

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ABSTRACT: In view of the stricter energy regulations, there is a growing need for early design support for low-energy dwellings. Currently, many tools exist to evaluate the energy performance of buildings. However, the uptake of these tools by architects is limited, largely due to the fact that they are too complex and not adapted to their working method. To maximize the usability of energy tools for architects in early design, information is needed about the designers' preferences and the way designers incorporate tools into their design process. The current paper reports on the results of three focus groups with architects and students in architecture addressing issues of data-input, output and the integration of energy tools in the architectural design process. The results provide information for researchers and tool developers to develop energy design support tools accordingly.

Keywords: energy design tool, early design phases, architects, focus groups

INTRODUCTION

The recast of the EPBD requires all new buildings to be nearly zero-energy by 2021 [1]. However, the design of low-energy and zero-energy buildings involves major conceptual, technical, and economical challenges for architects. Considering the importance of early design decisions on the final building performance, early design support for architects becomes increasingly important.

In this context, the integration of (dynamic) building simulation in the architectural design process provides major opportunities, but research shows that there is still a gap between both [2]. Most building simulation tools are not adapted to inform design decision-making in early design phases, but tend to focus on evaluation after decision-making [3].

While significant progress can be observed in the field of user-friendly data-input, the output of simulation tools often consists of difficult to interpret charts that are not in the architects' language and do not support design decision-making [4-6]. Accordingly, this issue requires careful consideration when developing new or improving existing tools. Recent developments focus among other on integrating sensitivity analysis to advice architects in designing energy efficient buildings [3,7] and on visualizing results using Kiviat diagrams allowing visual comparison of alternatives [8]. Though very interesting, they still tend to be rather difficult for architects' use regarding presentation method and/or feedback aspects. Although different surveys have been conducted on the use of simulation tools among architects [9-12], little research has been done on the architects' specific needs

to reduce the gap, or as Bleil de Souza [2] claims "responses to the problem tend to be interpretations of what the simulation community assumes the building designer needs rather than actual information from designers about what they effectively need".

Hence, to maximize the usability of energy tools for use by architects in early design, information is needed about the designers' preferences and the way they envision the incorporation of energy tools into their design process (DP). In this regard, the current paper reports on the results of three focus groups with architects and students in architecture, addressing their needs for energy design tools. Topics were related to data-input and output, and to the integration of tools in the architectural DP. Questions related to output concerned data display methods, but also aspects architects perceive as useful information to guide their decisions. The results provide information for researchers and tool developers to adapt existing tools or develop new tools that better fit the architects' language and working method. This research is part of a larger research project focusing on the development of an easy-to-use energy design tool, applicable for architects in early design and supporting them in the design of energy efficient dwellings. It builds on previous work in which interviews with architects and a large-scale survey were conducted [10]. While the former research mainly yielded general ideas and identified problems, the current research investigates the topic in depth, searching for solutions to reduce the gap.

METHODOLOGY

Aim was to get feedback from architects about their preferences for energy design tools to maximize the usability in the DP. We specifically chose focus groups as research method, as they allow for interaction between respondents [13] and thus a wider perspective of insights.

Group composition and recruitment

Three focus groups were conducted in November and December 2011, in Flanders (Belgium). The first two consisted of architects in practice and the third of master students in architecture.

The architects groups consisted of 10 participants each. Their age varied between 29 and 60. The majority of respondents works in small firms (1 to 3 associates), which is directly related to the typical Flemish context characterized by small-scale projects for private clients. There were architects with and without experience in energy efficiency, but all were well informed about Flemish energy regulations and corresponding energy performance indicators. The experienced architects in energy efficiency were well represented (14/20), probably due to their interest in the topic. Calls for participation were made at workshops and at the website of the largest Flemish architects association. Specific requirements were basic knowledge of Flemish energy regulation and performance indicators, and interest in an easy-to-use energy design tool.

The student group, consisting of 8 master students in architecture, was included for specific educational values of the tool. They had very little experience in the design of low-energy projects, but used software to calculate compliance to Flemish energy regulations in the context of a theoretic course. As such, they had basic knowledge of current energy regulations and performance indicators.

Focus of discussion

The focus groups were moderately structured and the discussion concentrated on two major themes, namely user-friendliness and output.

The first theme included topics related to data-input, interface design and usability in the DP and it was introduced using an active introductory question [14], being a short movie of a prototype for a SketchUp¹ plug-in (described below). As introduction for the discussion, the respondents were asked to record three items related to this prototype, being a positive, a negative and an incentive. Then, the discussion continued with a sequence of predetermined questions. In all three groups, the same questioning route was applied.

The second theme specifically focused on easy data interpretation and informing design decision-making, and also started with an active question. Respondents were first asked to record aspects that could provide useful feedback (i.e. focus on content of output). A slide was shown with multiple options from which they could choose, but they could also introduce other. They then were asked to draw an example of preferable data visualisation (i.e. focus on format and structure). The authors also composed an example in advance, which was shown after respondents finished their drawings. All images were collected and respondents were invited to provide feedback as the questions were proceeded.

Data collection and analysis

The analysis followed a systematic approach [15]. All conversations were tape recorded and video-taped and for each group all statements were categorized per theme and chronologically per respondent in order to examine if respondents' opinions changed during the conversation. These data were then analyzed for each focus group separately to discover patterns. Subsequently, the data sets of the three groups were compared to identify similarities and differences.

The prototype

A first rough prototype was developed and used as a basis for the first part [16]. It concerned an unfinished plug-in in SketchUp, allowing Flemish architects to easily and quickly perform an EPB² evaluation from the start of the design in a visual 3D environment. Data-input and output both take place in SketchUp and required geometrical data-input is extracted automatically, including building volume, orientation, room characteristics, etc. Default values are adopted for unknown parameters in early design (e.g. U-values of components), according to the type of project (passive house, low-energy, standard). In the plug-in, the drawing capacity of SketchUp is exploited to design the most essential user interfaces [16].

RESULTS AND DISCUSSION

Results of both parts are discussed below, with special focus on the second, as output is a major limitation of current tools.

Part 1: Data-input, interface design and usability in the design process

In general, architects and students were convinced of the potential to integrate energy performance assessment in sketch design being able to adapt the design early. Current EPB-assessment was perceived as post-

¹ <http://sketchup.google.com/>

² EPB = energy performance and indoor climate and concerns the Flemish version of the European EPBD. The EPB model is a simple steady-state calculation model.

evaluation. A number of architects believed that simple tools such as the prototype could facilitate energy performance assessment for architects, whereas this is now usually conducted by specialists in detailed design. The students particularly expressed the potential of the tool to contribute to the architectural design concept. In particular, simplicity, speed and ease-of-use were very important aspects. The choice for the simple modelling tool SketchUp was confirmed by all groups, being an efficient design, visualisation and communication means and used by the majority of participants for sketch design. An interesting comment was: *“It is good that all things you do almost intuitively as an architect such as placing windows or roofs in the right place, that the computer simultaneously does something with it and sticks a number to it, because that is something you cannot do intuitively”* (group 2; translated from Dutch). Absolute accuracy appeared to be less important, but the tool should provide a good indication, by implementing a range or percentage in which the results fall.

Interface design, data-input and modelling issues

The basic interface of the prototype, consisting of only five buttons was perceived positive. Also, the principle of exploiting SketchUp’s drawing capacities for the most essential user interfaces allowing to attribute several characteristics to the 3D-model in the drawing environment itself was appreciated for its intuitiveness. The system of default values according to different project types was clear according to all groups and the required data-input appeared to be sufficiently reduced and adapted to early design and allowed focusing on architectural design parameters. Additionally, several participants stressed the importance of being able to customise the values and define own concepts and patterns.

Some respondents strongly experienced a difference between modelling in SketchUp for design or communication purposes and for energy assessment. Regular models are often constructed differently and might comprise redundant attributes such as furniture. Therefore, it appeared to be important being able to remodel the design quickly or knowing in advance what is (not) allowed for energy assessments. Contrary, some respondents argued that early design models in SketchUp mainly comprise rough surface volumes for morphological studies and thus should be adequate for energy assessment. Nevertheless, the comments indicate that it is very important to keep modelling rules to a strict minimum to integrate energy efficiency in the DP. Looking at existing plug-ins for SketchUp, OpenStudio [17] enforces a number of modelling rules to define thermal zones, which is not consistent with architects’ working method, whereas the IES plug-in [18] is very user-friendly imposing almost no rules. Besides, the data

showed that different modelling methods should be supported.

The preferred method to attribute characteristics to the model (e.g. U-value of components) was by clicking on the particular wall and assigning the characteristic, following the inherent SketchUp method (e.g. to assign textures) and not by using dropdown menus. This method appeared to be most intuitive and user-friendly.

Usability in the design process

There was a general agreement that the usability in the DP is facilitated by the integration with SketchUp, but attention must be paid to the modelling method and geometrical changes must be easy to accomplish, as explained earlier. Apart from issues identified for user-friendly data-input, the concept of real-time feedback appeared to be of major importance to expand the usability of energy tools in the DP. This is further elaborated in part 2. Comparison of alternatives was also important for design assessment. The students specifically asked for identification of weaknesses in the 3D design model.

Regarding maximum time to use the tool, responses varied between ‘no extra time’, half an hour and a couple of hours. The latter was mainly addressed by participants who demanded rather detailed assessments. Hence, if the usage specifically concerns the impact of architectural design decisions on energy performance, required time must be minimal.

Issues were raised concerning the extent to which complex designs or programs are possible, ensuring that creativity is not hindered. Transparency was also mentioned in all groups. In particular, default values must be visible. Respondents also indicated that an overview of all data-input (e.g. wall area, window area per orientation, etc.), must be retrievable. Finally, exportation of input data for detailed EPB-calculations must be possible. This would increase the applicability of the tool in detailed design and appeared to be a strong incentive to use the tool, avoiding double work.

Part 2: Output and data visualization

To adapt the output to architects it must be easy to interpret, communicate in their language and be useful in supporting design decisions. Therefore, content of output, format and structure of output, and usability for design guidance were distinguished.

Content of output: feedback aspects

All respondents wanted feedback concerning legal requirements, particularly insulation level (K-level) and energy performance level (E-level) as imposed in Flemish regulations. Most respondents also indicated they want feedback on overheating, which is also

included in legislation. The majority asked for information concerning the net energy demand for space heating, a legal requirement since January 2012. Compactness was also frequently recorded. Considering heat gains and losses, solar gains were recorded most often, probably because of the strong link with the architectural design. Transmission and ventilation losses, and internal gains were mentioned considerably less. Nevertheless, the discussion revealed that these aspects are important as well, especially to assess critical factors in the design. In this context, the contribution of different parameters on gains and losses was also important, for instance the contribution of the roof in total transmission losses. In the first two groups, costs were also mentioned. Further, in both group 1 and 2 the idea was raised for being able to choose or tick off aspects to recall using a simple toolbar, as it allows adapting the output to the interests of different users.

Format and structure of output: data visualisation

From the participants' drawings and discussions it was very clear that the output should be visual and not just provide numbers. Colours, particularly green and red, should be used to facilitate interpretation. In group 1 and 2 bars were often sketched with colours merging from green to red and indicating the design performance (figure 1). Architects seem to be familiar to this representation method, which is probably related to their experience with energy certificates. Contrary, students did not draw these bars. They are probably unfamiliar with this, due to lack of practical experience.

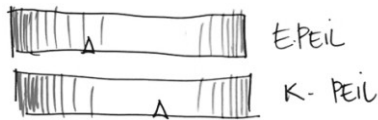


Figure 1: Excerpt from respondent's drawing on data visualisation (group 1)

Instead, the majority of students drew a 3D representation of a building with feedback visualised in this model. This indicates that students require a clear link between output (performance) and the model (design), which was further confirmed by discussions. In the architects groups similar drawings appeared but much less (figure 2). Nonetheless, discussions revealed that feedback in the 3D model concerning problem zones appeared to be of interest for them as well.

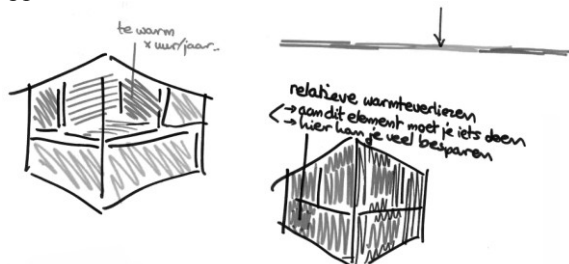


Figure 2: Participant's drawing on data visualisation (group 2)

Line-graphs and histograms scarcely ever appeared in the drawings, indicating that these graphics are not preferred among architects for design feedback.

In group 1, one participant proposed a radar graph as alternative for several individual bars (figure 3), stating that it clearly illustrates the design's performance on several aspects simultaneously. Other respondents of this group followed this opinion. A similar diagram was proposed by the authors (figure 3). In group 2, this diagram was also accepted well. This suggests that it might be a good visualisation method for design feedback. Few students however were not fully convinced of the diagram, whereas others clearly were. Several students proposed simple overview tables in SketchUp comprising basic performance indicators.

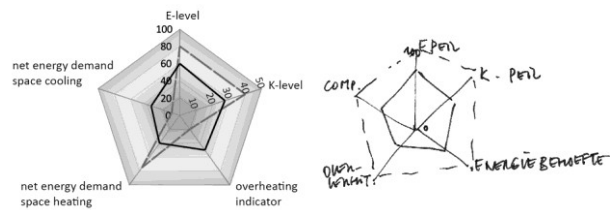


Figure 3: Excerpt from authors' output proposition (left) and from participant's drawing (group 1) (right)

Considering output structure, there was a general agreement that a distinction is needed between basic output, which should be provided real-time during modelling and designing, and more detailed output, which can be consulted to examine the performance in more detail and look for critical factors. Basic output should be provided in the SketchUp drawing environment and should be continuously available or through a collapsible window. It appeared to be sufficient to provide only core aspects in real-time for designing, being E-level, K-level, overheating and net heating demand, directly indicating how the design performs without overloading the model. Moreover, discussions revealed a necessity for a clear connection between data-input, design, and output, which would also enhance communication with clients. Output should be presented in close relation to the model in real-time, ensuring that the visual reference with the model is clear. This means that the traditional distinction between input and output interfaces, commonly for most energy tools, should be revised, which was also recognized by Bleil de Souza [5], who claimed that "the distinction between input and output interfaces could well be replaced by interfaces in which a mixture of interactions between understanding the behaviour of the building while conceiving, creating, manipulating and developing it are the aim".

Nonetheless, detailed feedback must be possible as well, but might be presented in external tabs or applications. Here, graphs can be included, as respondents also asked for more detailed feedback, including the distribution of gains and losses and impact

factors. A toolbar should be provided allowing users to compile their own output.

Design guidance: informing design decision-making

In general, it appeared to be extremely important to see the impact of design moves immediately. This would enhance understanding of the elements that play an important role in the building's performance. The former section already revealed the significance of real-time performance feedback in the drawing environment, indicating that output has to synchronize with data-input. This was frequently stated in all groups. Providing instantaneous feedback would help designers understand the impact of their design moves and assess critical factors. This was also essential considering the usability in the DP.

The necessity for a clear (visual) reference between performance and design could further be supported through indicating design problem zones into the 3D building model. Students specifically asked for outlining design problem zones very clearly and for very concrete feedback on the design's strengths and weaknesses. This is probably related to their limited experience.

Moreover, the output should clearly indicate the design's performance in relation to legal requirements. In all groups, respondents were convinced that benchmarking also helps understanding the design performance and facilitates communication with clients. Results should be compared with specific project types, e.g. passive houses.

Comparison of alternatives was seen as very important in all groups to weigh the pros and cons. Important was that variants can be visually compared, to clearly see the difference or leaps between two design alternatives. Alternatives should be possible in the context of both design alternatives and alternatives in the characteristics of the model (e.g. insulation thickness, building systems). Discussions revealed important insights into the practical side of manipulating design alternatives and architects' working methods. Particularly, the data disclosed that architects often copy-paste a design in SketchUp, resulting in several similar volumes or models in one file but with slight adaptations to visually compare them. This concerns morphological changes, but also changes in the placement of windows. This copy-paste method of having several models in one file without the need to save each model as another file name should be expanded for energy performance assessments. Besides, a need was reported for saving intermediate steps in the simulation logic, or a history of design actions. Respondents wanted to be able to go back to previous situations, following the principle of 'scenes' in SketchUp. These 'scenario's' were also important for communication with clients. Both issues were raised by

only few respondents, but in more than one group and other respondents agreed. As such, they reveal important information for the tool's configuration to provide an added value in the DP and to be effectively usable during designing.

There was some disagreement considering design guidelines. Although it appeared to be important, it is not clear how architects want guidelines. Nonetheless, the majority agreed that prescriptive guidelines are not preferred, and attached importance to their design freedom. Thus, except for few respondents, most did not want design recommendations. Providing impact factors of design parameters seemed to be interesting, but it was not very clear how to accomplish this. Feedback on the different aspects of heat gains and losses and the contribution of the different parameters on these aspects, seemed to be of interest to most respondents. However, for few students, this was not sufficient. They asked for very concrete indication of weaknesses and strengths.

With regard to sensitivity analysis to inform design decision-making as suggested in [3,7], it was not clear from the data whether or not this is preferred among architects. Although respondents indicated the usefulness of impact factors, the data tend to suggest that architects prefer experimenting in the 3D building model and not by manipulating parameters in the output outline. Common feeling was that alternatives or variants are not something that rolls out automatically. Instead, architects want to create them actively themselves. However, few students revealed they wanted to test the impact of a parameter in the output first before implementing it in the model. Therefore, this aspect requires further investigation and will be elaborated in future research. Finally, considering design guidance, the radar graph was appreciated by many participants, as indicated earlier.

Comparison between respondents

Among the architects, two viewpoints can be distinguished. Some architects primarily focused on the architectural design and were mainly concerned about early design parameters (e.g. orientation, compactness, glazing area and morphology). Predefined values for parameters such as U-values and building systems were important to reduce data-input and allowed focusing on architectural parameters. Simplicity and ease-of-use are key issues. All students can be associated with this viewpoint. On the other hand, some architects indicated preferences for rather detailed data-input and mainly focused on energy related aspects (e.g. insulation, thermal inertia, etc.). They stressed the importance of customized options for default values. Also, time required to perform energy assessments in the DP was often considerably longer. Similar trends also appeared for the second part, i.e. output. Whereas some respondents focused on simplicity and basic output,

others indicated preferences for more detailed feedback (e.g. related to building systems or renewable energy).

Despite these two viewpoints, several respondents fall somewhere in between. Most important however is that the tool is adapted to all architects. Therefore, an optimal balance must be strived for. Hence, the possibility for predefined values is important, but these values must be customizable. Considering output, core aspects are sufficient in real-time, but users must be able to assemble feedback aspects in detailed output representation.

From the third group it was very clear that students have less practical experience. They asked for very concrete output, indicating strengths and weaknesses of design. A clear link between performance and design was important for all groups, but in particular for the students. Feedback aspects indicated by the students usually had a direct link with the architectural design, including K-level, net heating demand, solar gains, etc. They did not discuss aspects such as building systems or thermal inertia, but mainly focused on the design and the architectural concept and how these affect the building performance. Besides, they also concentrated on the impact of building surroundings, and in particular on shading (trees, buildings, etc.).

CONCLUSIONS

This study analyzed the architects' preferences for a simple energy design tool through focus groups in Flanders. The results reported here may not extend to populations in other countries, but we do believe to be able to draw some conclusions.

The first part showed that default values in function of ambition level are interesting to adapt data-input to early design, but they must be customizable and transparent. The interface and input method must be intuitive and modelling rules must be avoided.

Considering output, the second part showed that not only the method but also the aspects (content) contribute to well informed feedback. Most preferred and frequently stated feedback aspects were related to regional energy code requirements. To inform the design decision-making process of architects for low-energy dwellings following aspects must be taken into account:

1. Architects need a quick indication of how the design performs and of the consequences of their design moves. This can be achieved by real-time performance feedback next to the building model. Only core aspects must be considered real-time to avoid overloading.

2. Problem zones must be clearly marked in the 3D building model, enabling architects to adapt the design goal-oriented.
3. Finally, detailed output must be provided to discover critical factors (causes of problem) and further allow goal-oriented design improving. In this regard, impact factors and comparison of alternatives were both important.

In general, these aspects demonstrate the significance of a clear connection between design and performance. Finally, researchers and design tool developers need to keep in mind that energy efficiency is not architects' only concern. Therefore, tools may not impose themselves. For instance, real-time feedback can be displayed in collapsible windows, only visible when the architect asks for it, instead of being continuously visible. Also, energy design tools have to be in accordance with architects working methods to fulfill an added value in the architectural DP (e.g. copy-paste method).

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