A software vision to enable the holistic design of low carbon buildings

Conference or Workshop Item

A software vision to enable the holistic design of low carbon buildings

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Abstract. The need to reduce the energy used by buildings and the resultant carbon emissions is changing how they are designed, look and work. This position paper outlines the urgent need for new software that integrates thermal simulation with building information modelling. A vision for the software is presented.

Introduction

The aim of this research is to develop a design for software to assist architects in the creative design of buildings that are highly energy efficient and thus reduce the associated carbon emissions. Due to increased awareness of climate change, many countries are legislating for low carbon buildings. This will result in a potentially huge international market for integrated building and energy simulation software. The software could reduce design time, whilst enabling architects to maintain high design standards in a post-carbon society.

These changes in design will arise from the need to reduce dramatically the energy used by buildings and the associated carbon emissions. It is estimated that over 45% of current carbon emissions in the UK come from buildings [1]. The UK Government has set a legally binding goal of an 80% reduction in carbon emissions by 2050, with all new building designs to be zero carbon by 2019 [2]. A consequence is that architects will be restricted in their design approach and the resulting buildings may be aesthetically poor [1].

By 2020 new building designs in the UK and Europe will be very different to those produced at the beginning of the century. They will incorporate:

- Highly insulated external walls
- Less glazing
- Highly controlled ventilation
- Closely monitored and controlled heating, cooling and lighting systems
- Renewable energy devices such as photovoltaic and solar collectors, ground source heat pumps and have connections to wind turbines.

The need for new building design tools

As illustrated by Figure 1, existing practice involves the application of software to two separate processes: the design of buildings by architects and the checking for

compliance with thermal standards by engineers. Current software tools used by these professionals only address the needs of their own specialism. Different modelling techniques are used with poor interoperability of data, resulting in loss of time and potentially un-reliable results.

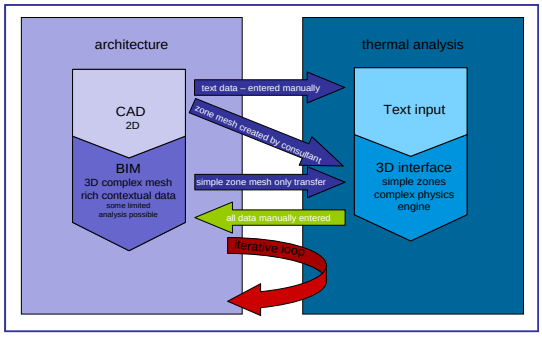
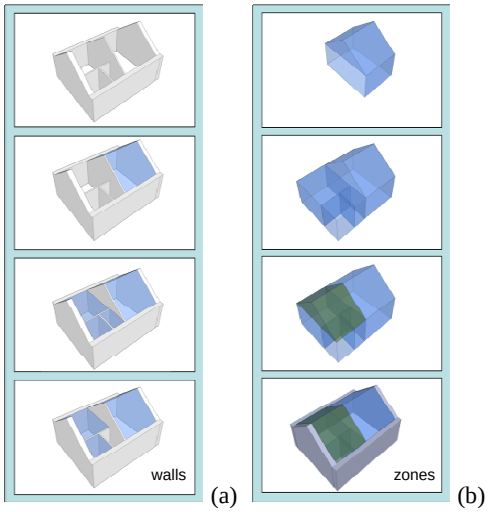


Fig. 1. The relationship and data transfer for the two processes: the design of building by architects and the checking for compliance with thermal standards by engineers

Architectural design software works by modelling buildings in terms of enclosing elements such as walls, floors and roofs. Thermal simulation software works by modelling buildings as zones comprised of thermally consistent volumes. Analysis of these tools and processes has led to the conclusion that, in order to allow architects the freedom to explore innovative solutions, future design software should combine these modelling methods.



(a) (b)

. Fig. 2. The two methods of modelling (a) design software employs enclosing objects such as walls and floors, with the zones identified (b) thermal simulation software employing zones

Figure 2 shows the two methods. The left illustration shows how design software uses objects such as walls as enclosing elements, with zones identified at the end of

the process. The right image shows how the same building can be assembled by arranging zones first and then adding walls.

Research undertaken with architectural students has involved eliciting early requirements for the software. These students were selected because they had practical experience of both types of software and are also aware that when they qualify they will have to practice in a low carbon design environment with numerous, rigorous and at times contradictory standards. Tasks that they found most difficult, when using thermal simulation software, were the interpretation of thermal analysis data and making the changes to the construction details of their designs that were necessary to make them more thermally efficient. They strongly endorsed the requirement for integration of tools. From these findings design goals have been established for the software. It should:

- Integrate design and thermal analysis functions methods to enable continuous energy monitoring through all stages in the design process
- Enable the interpretation and understanding of the results of thermal analysis by designers
- Incorporate knowledge and design decision support systems.

The vision

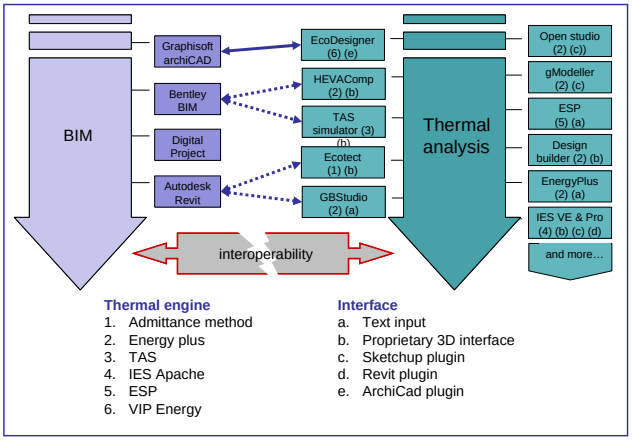


Fig. 3. The relationship between BIM and thermal analysis software

Design software employed to model buildings is increasingly taking the form of BIM [Building Information Modelling]. BIM software handles the building geometry, spatial relationship of building elements in 3D and quantities and properties of building components. The industry is dominated by a few large corporations selling expensive software, as illustrated in Figure 3. Thermal simulation is designed to model as closely as possible a real-world physical process. There are many types of thermal simulation software available from a wide range of software companies, many using the same, freely available, thermal engine -

EnergyPlus, developed by the U.S. Department of Energy[3]. However, there is limited integration of the two types of software, with poor interoperability of data [4].

In order to meet the challenge of designing to low energy standards, architects will need good tools that model complex inter-related systems that will empower effective decision making.

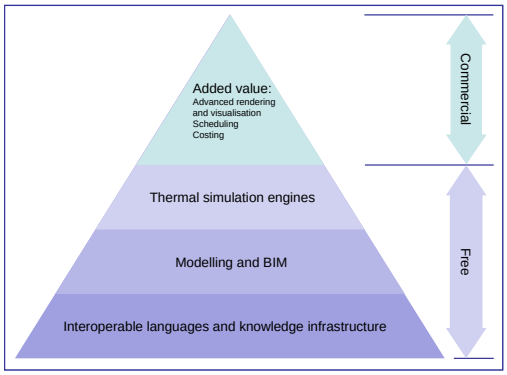


Fig. 4. **T**he vision for the free software built upon interoperable standards and knowledge infrastructure, BIM concepts and a range of thermal simulation engines

The vision for this software is illustrated in Figure 4. It should be built upon regulated interoperable standards and a freely available knowledge base. The 3D modelling approach could be based upon the use of zones to define spaces rather than enclosing surfaces, see figure 2. Information relating to these enclosing surfaces should then be built up in the BIM. This is the opposite to the current situation. It would be capable of utilising a range of underlying thermal simulation engines.

Development of these software tools will need support from both policy making bodies and those planning to develop and market the technology. The core software should be made freely available to assist anyone to reduce the energy requirements of any building with which they are involved. Financial opportunities lie with the ability to add value through additional proprietary feature such as advanced rendering and visualization, scheduling and costing.

References

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[4] P. Ferrari, N. Silva, and E. Lima, "Building Information Modeling and Interoperability with Environmental Simulation Systems," *Innovations and Advances in Computer Sciences and Engineering*, T. Sobh, ed., Dordrecht: Springer Netherlands, 2010.