Software engineering challenges: Achieving zero carbon buildings by 2019

Conference or Workshop Item

Software Engineering Challenges: Achieving Zero Carbon Buildings by 2019

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Abstract

The planet Earth is warming up. There is an urgent need to reduce greenhouse gas emissions. Buildings account for almost 50% of UK carbon dioxide emissions. [1] *The UK Government have set out a programme to make all new buildings zero carbon by 2019. This will require a paradigm shift in how buildings are designed, with an increased reliance on computational modelling of building performance early in the design process.*

This paper outlines how architects have traditionally worked, the available software and how it is used. It discusses the challenges faced by building designers in achieving zero carbon buildings and then outlines how software tools might develop to meet not only the zero carbon challenge but also take the concept further to help design sustainable buildings.

Introduction

In 2007 the Government announced the intention that all new houses would be carbon neutral by 2016 in the "Building a Greener Future: policy statement" [1]. This is to be achieved by progressive tightening of Building Regulations legislation over a number of years. Consultations are currently taking place on the practicalities of legislating for public sector buildings and all new non-domestic buildings to be carbon neutral by 2018 and 2019 respectively [2]. All of the five plans for Britain to be sustainable in energy by 2050 outlined by MacKay are based on the assumption that all new buildings will require no space heating from 2010 [3]. This places a significant onus on building designers to alter their working practices.

Traditional architectural design practice

> *"Architects are centrally involved in a sector of the national economy that is responsible for between 40% and 50% of UK national emissions. The RIBA and its members therefore have a part to play and an opportunity to work with others to influence the future." [4]*

The design of buildings is a complex process, which traditionally has a prescribed number of stages, as set out in the "Architect's Job Book" [5]:

A and **B**: Appraisal and Design Brief
C: Concept, the client signs off the brief
D: Design development and detailed planning permission
E: Technical Design the last stage in the design development includes the required details, choice of materials and standards of workmanship

It can be seen that the technical design is scheduled to occur after the client has "signed off" the design and planning permission has been granted for the project. Traditionally, energy intensive technological solutions are then used to "solve" problems arising from lack of environmental considerations at the design stage, for instance over/under heating or lack of day lighting. To overcome these energy penalties the consideration of significant technical details will be required at a very early stage in the future. The design of zero carbon buildings will require a paradigm shift as to how new buildings are procured. Software will have a part to play in how designers assimilate, handle and design with the extra information necessary to achieve these proposed standards.

Design software

Architecture has gone through significant changes since the 1980s when CAD [Computer Aided Draughting/Design] was introduced and is continuing to change with the adoption of BIM [Building Information Modelling] software to design buildings by modelling them in 3D complete with parametric information. The market is dominated by American companies such as Autodesk and Graphisoft [6].

Building models are key to the calculations required to support zero carbon designs [7]. At present additional software is required to make calculations, leading to an iterative process, moving data between various tools [8][9].

Software problems/challenges/opportunities

The following list constitutes challenges and hence opportunities to the software research and development community:

1. **Quality of software to design and manage zero carbon buildings**

CAD, BIM, energy analysis and visualisation software requires a significant amount of time, both to learn and to achieve proficiency [7]. Although there have been significant improvements since the early days of Computer-Aided Draughting, opportunities still exist to make better software that is simpler and easier to use with interfaces that are more intuitive. Software needs to deal with the complete life-cycle of buildings, where one model is used from inception through construction, management, refurbishment and eventual re-cycling of the building fabric.

2. **Open source solutions for cheaper software**

CAD, BIM, energy analysis and visualisation software is extremely expensive. More than one package may be used in any one project. The software requires top end workstations and display devices to be used efficiently. The architectural profession includes a number

of large architectural practices with excellent IT resources and their own in house energy analysts who can afford this range and scope of software. However, there are a significant number of smaller firms; a recent survey showed that 11% of the profession work as sole practitioners [10]. These Architects will struggle with both the knowledge and data demands of designing to zero carbon standards. Open source software could provide one solution to this challenge.

3. Regional specific software packages

CAD, BIM, energy analysis and visualisation software are almost totally developed in the USA by large and well-resourced companies. In the UK the BRE [Building Research Establishment] has been at the forefront of the development of assessment and building code checking software, but this is not part of the early design process [7]. Opportunities thus exist for country-specific software that integrate products, building codes and legislation for use in supporting early design decisions, as opposed to retrospective design validation.

4. Integrated energy analysis and design software

At present, there is no software that "does everything", models need to be moved between analysis and modelling environments, with a significant time penalty and possible loss or corruption of data [7][8][9].

5. Interoperability of data to reduce market dominance

Interoperable standards such as the ifcXML [Industry Foundation Classes eXtensible Markup Language] specification and gbXML [Green Building eXtensible Markup Language] enable the movement of models between various types of software. However, the take up has been slow and incomplete with software companies not always in favour [11]. Opportunities exist in the development and refinement of these schemas.

6. Architects trained in zero carbon concepts

Training opportunities exist both in learning to use BIM and energy analysis software but also in learning the new skills/knowledge required by designers. The "Zero Carbon Homes Programme Delivery Timeline" states that it is critical that 75 % of all architects are trained in low and zero carbon homes concepts between 2010 and 2013 [12].

7. Visualisation to illustrate energy use

Visualisation is also key to understanding buildings and their environmental credentials, making this data available to decision makers and communities constitutes another software engineering challenge. Significant developments in the display of 3D models over the web are happening currently with the development of HTML 5 which may mean that browsers will not require 3D plugins [13]. New developments, such as tangible devices which allow a user to interact with digital information through the physical environment, enable new and interesting methods of interaction with building models and data [14].

8. Optimisation of the design process

There are opportunities in developing software which support a more sensible approach to design, with the software supporting and facilitating optimisation of the building model as the design progresses. This represents a paradigm shift away from retrospective code compliance checking, leading to a streamlined and efficient building design process.

9. Sustainable building design advisory systems

Consultation carried out by the Department of Communities and Local Government showed that there was demand for sustainable practices which go beyond zero carbon buildings [15]. Architects will be required in the future to handle new and demanding knowledge pertaining to designing sustainable and zero carbon buildings. Opportunities exist to create advisory systems, integrated into BIM software, which would provide timely, appropriate, relevant and understandable data to the architect to support design decision making.

10. More energy efficient building usage

The way in which an occupant uses and manages a building can have significant impact on the energy requirements. Opportunities exist for the design of ubiquitous devices and management systems to both control and educate building usage [16].

Conclusion

In response to the need to reduce carbon emissions the UK Government is forcing change on the construction industry through legislation. This paper has outlined the challenges faced by architects and building designers and identifies 10 opportunities this offers the software research and development community.

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