THE ESTABLISHMENT OF A SIMULATION CAPABILITY TO SUPPORT THE ENGLAND AND WALES BUILDING REGULATIONS 2006

Rokia Raslan, Michael Davies and Tadj Oreszczyn

CBES,
The Bartlett School of Graduate Studies,
University College London
WC1E 6BT
E-mail: r.raslan@ucl.ac.uk
michael.davies@ucl.ac.uk
t.oreszczyn@ucl.ac.uk

ABSTRACT

In support of the movement towards the integration of modelling in the design process, a unified simulation-based compliance methodology for the energy performance of buildings was introduced in the UK Building and Approved Inspectors (Amendment) Regulations 2006 (England and Wales).

As part of a larger project with the overall aim of presenting an analytical study of the process of introducing of this legislative approach to the UK construction industry, the paper reports on the status of the establishment of a simulation capability to support its use. Findings obtained via an industry-based survey undertaken during the initial phase of the application of the Building Regulations 2006 are discussed.

Survey results highlight significant issues, most notably in establishing both user and tool capability. The potential shortcomings in developing a tool capability are outlined and include an assessment of currently accredited tools and a summary of issues provided by practitioners in the field.

KEYWORDS

Building Regulations; Simulation Capability; Simulation Tools; Survey

INTRODUCTION

Building energy performance prediction can be defined as "the science of estimating the energy interactions within a building" (IISBE 2005). In recognition of the potential benefits it provides by facilitating the objective assessment of the overall performance of design proposals (e.g. Hensen and Nakahara 2001, De Wilde 2004 and Crawley et al. 2005), a global trend calling for the integration of Building Energy Performance Simulation tools (BEPS) in the design process has emerged.

The Building and Approved Inspectors (Amendment) Regulations (England and Wales) which came into force in April 2006 (DCLG 2006) reflect the fact that Regulations are increasingly moving from being prescriptive to performance based with the intention of providing greater flexibility for designers, while facilitating the introduction of issues associated with the EU Energy Performance of Buildings Directive (EPBD) such as the energy rating of buildings and encouraging the use of BEPS through the introduction of the National Calculation Methodology (NCM).

THE NATIONAL CALCULATION METHODOLOGY

The NCM is a simulation-based approach to verifying compliance with energy performance criteria as specified in Approved Document Part L (Conservation of Fuel and Power). The NCM adopts a holistic approach to assessing performance, utilising a computer simulation program (the "calculation tool") to perform the necessary compliance calculations which are expressed in terms of resultant CO_2 emission levels (SBSA 2006).

Since Part L distinguishes between various building types (domestic and non-domestic) and status (new or existing), different approaches are adopted in defining the NCM. For Part L2A (New Buildings other than Dwellings) it replaces the three alternative compliance routes offered in the 2002 Regulations and is defined as the single compliance methodology. A choice of various options for the calculation tool (Table 1) is allowed to enable the applicability of the methodology to the complex and largely undefined non-domestic building stock (Ortiz et al 2006)

The main tool options include the Simple Building Energy Model (SBEM), a simplified tool which along with its interface (iSBEM) is specifically designed for calculating compliance with Part L2A regulations (Kennett 2006) and the Dynamic

Simulation Method which relies on accredited commercial simulation software (which share a common database with SBEM) to perform the required calculations. An additional option which employs an accredited commercial interface with SBEM as the calculation tool is also available.

Table 1 Tool Options for the NCM

Option	Components	Accreditation
1	iSBEM+SBEM	Automatic
2	Software Suite	Entire Suite
3	Interface+SBEM	Only Interface

ESTABLISHING A SIMULATION CAPABILITY

An assessment of the cumulative impact of previous amendments to Part L included in the 1982, 1990, 1995 revisions, estimates that the net effect of their implementation may have only reached a third of the specified target (Olivier 2001). An essential factor in fully realizing the targets of the current Part L amendments is the credibility of the associated compliance methodology, assessed in terms of its applicability and the establishment of an adequate industry capability to implement it.

In the case of Part L1 (dwellings), the Standard Assessment Procedure (SAP)-previously in place for the 2002 Regulations-was updated (SAP2005) for use with the NCM. However, due to the unfamiliarity of the simulation-based approach adopted for Part L2, the subsequent need to establish the simulation capability to support its requirements presents a number of challenges to the UK construction industry. The various factors associated with establishing the simulation capability includes the following:

1-System capability: The successful introduction of any regulatory amendments requires a significant increase in resources (McDonough 2004), a clear system of monitoring and quality control and adequate notification of alterations to ensure consistency in the interpretation of the approach (FBE 2004). This paper does not focus on this critical issue although work is underway with regards to the 'policing' of the current system and will be reported at a later date.

2-Information capability: The nature of Approved Document L as a technical guidance document, rather than mandatory regulation, requires the provision of sufficient documentation outlining procedures to assist in understanding, prevent uncertainty and/or misinformation concerning implementation.

3-Tool capability: The provision of a tool capability entails not only the availability of BEPS software, but also the establishment of a clear mechanism for the technical accreditation of the array of tools available to ensure their suitability for use with the NCM.

4-User capability: The development of new simulation tools shows a continuous increase of capabilities and complexity, increasing the dependency on adequate modelling and expertise (De Wilde 2004). The NCM requires that users be capable of identifying building features that affect predicted building performance (De Wilde 2004) and, ideally evaluating and verifying simulation results. This requires adequately trained and certified professionals with specialized skill sets in the field of simulation.

EVALUATION OF THE SIMULATION CAPABILITY WITHIN THE UK LEGISLATIVE SYSTEM

To provide an overview of industry status with regards to the establishment of a simulation capability, an empirical survey-based study was undertaken during the initial stage of the application of the Building Regulations 2006. The survey aimed to provide a "snapshot" of the process involved in the introduction of the NCM, to be followed by a second survey during a later phase to gauge potential variations once practitioners have become more familiar with the amendments.

Since one of the main aims of the introduction of NCM was to integrate a simple and accessible energy compliance verification method within the design process, the theoretically targeted population (N) included all relevant practitioners in the construction industry (in England & Wales) such as architects, building services engineers and simulation specialists with potential involvement in the process of "producing" a building compliant with the criteria outlined in Part L2A. A review of registered practitioners in associated professional organizations (ODPM.B. 2004) cumulated in an overall estimate of over 65,000 individuals.

According to the strategic multistage sampling method adopted to address the large theoretical target population (Fowler 1993), 500 organizations and individuals were directly contacted to participate in the online self-administered survey utilizing Opinio, a web-based survey design and online hosting platform (Anon.). Over 230 responses were recorded with a response rate of over 45%. The 52 fully completed responses were considered in the final findings- an overall valid response rate of approximately 10%, which is considered a sizable proportion of the targeted population (de Vaus 1996) and conforms to the range found in similar studies (e.g. Altavilla et al 2004, Pilgrim et al 2003 and Mahdavi et al 2003).

KEY FINDINGS

While issues have been identified in establishing both a system and information capability (Taylor 2006), in

eliminating previous compliance methodologies in favor of a single, simulation based approach, the success of the NCM for Part L2 relies in large part on providing its core requirement, an accurate and usable calculation tool. However, it is widely held that the uptake of BEPS tools in the design process remains limited (Hensen et al 2004, De Wilde 2004), which suggests that providing adequate tools and encouraging their use, would prove most challenging. An analysis of survey findings supports this notion, outlining the following areas of concern, indicating major deficiencies in establishing both user and tool capability.

Limited Uptake and Low Usage Patterns:

- Participants rated computer simulation as the least preferred and most difficult method for performance prediction despite a general consensus with regard to the reliability of results.
- Organizational use of BEPS tools is still relatively low in comparison to other construction related computer programs such as 2D CAD. While 45% of participants reported that they most frequently used BEPS tools for daily tasks, on an organizational scale, the trend significantly differed with 2D CAD dominating use at 65%.
- Most work involving BEPS tools is carried out by building service engineers (47%) and specialized in-house departments (30%) with only a small percentage of architects and designers (11%) utilizing them.

Low User Proficiency, Experience and Training:

- The overall user proficiency of BEPS tools was relatively very low. The majority (57%) of organizations had less than 10% user proficiency rate in BEPS tools. In comparison the same percentage of organizations had a 70% or more usage rate with regards to construction related software.
- The average experience of participants was approximately 12.5 years, but the vast majority (over 70%) had less than 6 years experience in using BEPS tools with over one third of those surveyed only using them over the past two years.
- An estimated 40% of users had undergone some sort of either internal or external formal training, but a considerable percentage had relied on alternative methods of instruction such as teaching themselves (34%) or on peers/colleagues (11%).

Limited Tool Options and Capabilities:

- At the time the survey was conducted, only three accredited tools were available for use with the NCM. The most popular of which was the free, government-commissioned tool SBEM (28%) followed by the commercially based IES (28%) and TAS Building Designer (10%).
- One third (35%) of participants reported that they also use or intend to use other tools, most notably Hevacomp (which has been since been accredited as an interface) in addition to ESP, EnergyPlus and other in-house developed tools which have not yet been accredited.

Inadequate Information:

- Information relating to several key areas of the requirements for Part L was taken out of the Approved Documents and moved to secondary documents, many of which were only made available two months after implementation (Taylor 2006). The limited availability of procedural information and the lack of the clarity in what was available extended to information concerning software tools and their accreditation status.
- An additional issue of concern was that some practitioners knowingly preferred to use tools that were unaccredited since they found the accredited options to be unsuitable for their designs, unreliable or financially inaccessible.

ISSUES IN DEVELOPING A TOOL CAPABILITY

Several key criteria pertaining to aspects such as software applicability, complexity, interoperability and availability were outlined to ensure the suitability of the calculation tool (ODPM.A. 2004). Despite the existence of an accreditation system (TM33) for commercial software and interfaces, the suitability of these tools to support the requirements of the NCM remains an issue of debate, since no formal comparison between them has been carried out to confirm the consistency of results that they generate (Rawlinson and Hourshid 2006). A comparative analysis of the accredited tools/interfaces currently available highlights various limitations (Table 2).

A further detailed analysis of SBEM revealed that it inevitably (given the short developmental time-scale) had a number of issues, leading to a various difficulties in using the software during the design process. The main concerns associated with SBEM include its limited technical capabilities (e.g. its ability to handle only very basic building forms) and the input intensive format of the iSBEM, other issues include:

- It has been reported that SBEM gives a higher CO2 emissions benchmark than previously anticipated. Since software algorithms have not be made available in the public domain, users have found difficulties in identifying the contributing factors to this error (Rawlinson and Hourshid 2006)
- Due to limitations in system support and documentation, results are dependant upon the approach taken to building the model rather than the attributes of the design itself. It has been noted (Rawlinson and Hourshid 2006) therefore, that compliance is dependant upon the competence of the modeller.
- Since, the methods outlined in TM33 are specific to longitudinal dynamic thermal models, they were therefore not used for iSBEM. The actual accreditation process involved, at the time of writing, is also not available in the public domain, which reflects on user confidence with regard to results.
- SBEM is only supported on the Windows operating system.
- Similarly, with respect to accredited commercial software, a number of issues were found:
- A lack of inter-operability (communication and data-sharing) with other software systems.
- High cost due to the incorporation of features which may not be of use in all situations.
- Accredited versions of simulation software are only supported on the Windows operating system.

CONCLUSIONS

Inadequacies found in the available tools and the comparatively low percentage of practitioners who considered themselves proficient in using them were the main issues of concern during the initial stages of implementation. The implications of these issues continue to affect the current status and are likely to affect future development in this field with the next revision of Part L scheduled for 2010.

With regard to the availability of suitable tools, the development of SBEM within a short time-scale, inevitably led to several deficiencies in the software that were only discovered when it was used in practice. The alternative option of commercial software is high-cost and some of the more popular packages (e.g. ECOTECT) have yet to be accredited. Accredited interfaces can provide a short-term "middle-ground" cost effective option, but the long-term strategy should focus on making algorithms for SBEM available to enable its incorporation into more widely available tools in addition to a more widespread and extensive development and accreditation program.

With regard to the lack of user proficiency, procuring the required expertise in the form of (external) consultants or "supported technology deployments" in which specialist staff (and software) are "loaned" as a secondment to existing design team (McElroy and Clarke 1999, McElroy 2006) is a possible option. This can provide a temporary solution to meet current needs with a sustainable training program-based strategy and a clear system of quality control to check the competencies of certified/ competent persons (FBE 2004) set up to provide long term workforce requirements.

Table 2 Comparative Analysis of Tool Options for ADL2A

Name	Developer	Status	Complexity	Interoperability	Applicability	Availability
SBEM (iSBEM V1.2.a)	BRE/ DCLG	Accredited Tool/ Interface	Access-based input intensive format. No graphical output.	Limited interoperability, but allows use of alternative interfaces.	Limited applicability Suitable for basic building forms.	Available to download online for free.
TAS Building Designer V9.0.9	Cranfield Institute, UK/ EDSL	Accredited Software	A 3D CAD front-end allows building geometry to be input from CAD packages. Graphical interface makes for efficient data entry & modification.	CAD-linked 3D Modeller. Simulation data can be exported to Microsoft Excel, Word, etc. for customised report preparation	Suitable for more complex building forms. Not intended for detailed services layout design	Available from developer.
Virtual Environment V5.6 (VE Compliance)	IES Ltd, UK	Accredited Software	Building geometry taken from the <Virtual Environment> 3D building model. Data input supported by databases & labour saving editing facilities.	Imports 3D BIM & exports geometrical data in STL format to Star-CD. Shares information with ApacheCalc & ApacheSim via VE Integrated Data Model	Suitable for more complex building forms. Offers compliance testing by the two routes (SBEM – links to SBEM & ACM simulation route using ApacheSim)	Available from developer.
Southfacing Carbon Checker V1.0.0	Southfacing	Accredited Interface to SBEM	Minimised, simple step-by-step wizard. 2D & 3D interface for building geometry.	Import facility available for CAD packages	As a stand-alone interface for SBEM, it is more suitable for basic building forms	Available from developer. Lowest cost option.
Hevacomp Interface V22.40	Hevacomp	Accredited Interface to SBEM	Input is based on simple 2D tracing accessing databases of construction elements to create 3D models.	The interface allows access to all features of Hevacomp package, including links to EnergyPlus	As an interface for SBEM, compliance checking only available for basic building forms	Available from developer.

REFERENCES

Altavilla F., Vicari B., Hensen JLM., & Filippi M. 2004. "Simulation Tools for Building Energy Design", In: Proc. Ph.D. symposium Modelling and Simulation for Environmental Engineering, Czech Technical University Prague, 16 April.

Anonymity. http://www.objectplanet.com/opinio

Crawley, D., Hand, J., Kummert, M. & Griffith, B. (2005) Contrasting the Capabilities of Building Energy Performance Simulation Programs. Joint Report, US DOE, University of Strathclyde, University of Wisconsin & NREL.

Department for Communities and Local Government. 2006. The Building and Approved Inspectors (Amendment) Regulations 2006 Statutory Instrument 2006 No. 652 (Online) Available at: www.opsi.gov.uk/si/si2006/2006 0652.htm.Retrieved: 23-11-07

De Wilde P. 2004. Computational Support for the Selection of Energy Saving Building Components. Ph.D. thesis, Delft University of Technology.

De Vaus DA. 1996. Survey in Social Research. UCL Press. Fourth Edition.

FBE. 2004. "The Enforcement of Part L Workshop". Foundation for the Built Environment Held at BRE, Garston, 10 March 2004. (Online) Available at: www.diag.org.uk /pdf/FBE_BR_compliance_seminar_10Mar04. pdf. Retrieved: 15-10-06

Fowler FJ. 1993. Survey Research Methods. Sage Publications

Hensen J. 2004. "Towards More Effective Use of Building Performance Simulation in Design". Center for Buildings & Systems Tno–Tu/E Technische Universiteit Eindhoven

Hensen J & Nakahara N. 2001. "Building & Environmental Performance Simulation: Current State & Future Issues," Building & Environment, Vol. 36, No. 6, P. 671-672.

IISBE. 2005. Energy & Environmental Issues in the Building Sector. (Online) Available at: http://greenbuilding.ca/. Retrieved: 11-11-06.

Kennett S. 2006. "SBEM Put to the Test". Building Services Journal 02/06

Mahdavi A, Feurer S, Redlein A. & Suter, G. 2003. "An Inquiry into the Building Performance Simulation Tools Usage by Architects in Austria", In Proc. of 8th International IBPSA Conference 2003. Eindhoven, Netherlands.

McDonough S. 2004. CIBSE Response: Proposals for amending Part L of the Building Regulations & Implementing the Energy Performance of Buildings Directive. (Online) Available at:www.cibse.org/pdfs/CHPPartL2004.pdf. Retrieved: 10-06-06

McElroy LB. and Clarke JA. (1999) `"Embedding simulation within energy sector businesses'", *Proc. Building Simulation '99*, Kyoto, Sept.

McElroy LB. 2006. Presentation. IBPSA England Inaugural Event. Sheffield University. 13-09-2006.

ODPM.A. 2004. Proposals for Amending Part L & Implementing the EPBD - Collation of Issues Raised by Consultees. (Online) Available at http://www.diag.org.uk/pdf/Collation_of_Consultation_ Responses.pdf. Retrieved: 02-04-06

ODPM.B. 2004. Evidence base review of skills for sustainable communities. Available at http:// www.renewal.net/Documents/RNET/Research/ Evidencebaseskills.pdf Retrieved: 22-02-07

Olivier D. 2001. Building in Ignorance. Demolishing Complacency: Improving the energy Performance of 21st Century Homes. A Report Prepared for the Association for Energy Conservation

Ortiz J, Pout C, & Pérez-Lombard, L. 2006. "Go Figure". Building Science Journal. November 2006. (Online) Available at: http://www.bsjonline.co.uk/Story.asp?storycode=3076329&sto ryType=&featureCode=.Retrieved:01-11-06

Pilgrim M, Bouchlaghem, N, Loveday, & Holmes, M. 2003. "Towards the Efficient Use of Simulation in Building Performance Analysis: A User Survey" Building Serv. Eng. Res. Technol. 24,3 (2003) pp. 149–162

Rawlinson S & Hourshid B. 2006. Update on the Implementation of Building Regulations Part L 2006. Report David Langdon Davis Langdon's Research Team, Davis Langdon Mott Green Wall.

SBSA. 2006. Non-Domestic Energy Environment Consultation 2007. (Online) Available at: (www.sbsa.gov.uk/current_standards/pdfs/sectsixannexbnon-Domestic.pdf).Retrieved:11-11-06

Taylor J. 2006. Implementation Policy In Respect of Approved Documents F, L & P of the Building Regulations 2006. Report to the Executive Meeting of 26th June 2007