THE IMPLEMENTATION OF A SIMULATION-BASED COMPLIANCE METHODOLOGY FOR THE UK BUILDING REGULATIONS 2006: AN INDUSTRY SURVEY

ROKIA RASLAN
MICHAEL DAVIES

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

ABSTRACT

In April 2006, the new Building and Approved Inspectors (Amendment) Regulations 2006 (DCLG 2006) came into force in the UK. Among the various amendments, one of the most significant was the introduction of the National Calculation Methodology (NCM), a simulation based compliance methodology for Approved Document Part L. The paper discusses the various drivers and potential issues associated with the legislative call for the integration of modelling in practice and presents the results of an industry survey undertaken in an aim to assess the effectiveness of the approach adopted to accommodate the transition in the UK.

KEYWORDS: National Calculation Methodology, simulation, Building Regulations 2006.

INTRODUCTION

Since the introduction of Computer-Aided Design (CAD) technology into architectural and engineering practices in the early 1960s, computational design support tools have become an integral part of the design and construction process. Prompted by the energy crisis of the 1970s, the construction industry developed an interest in understanding building-related energy issues consequently leading to the development of computer-based Building Energy Performance Simulation (BEPS) tools to support the decision-making process for energy efficient design (Morbitzer 2003).

By offering practitioners the ability to create virtual models of buildings and simulate physical processes within them (e.g De Wilde 2004 and Crawley et al. 2005) BEPS tools facilitated the objective assessment of the overall performance of design proposals potentially improving design quality, competitiveness, productivity and efficiency (Hensen and Nakahara 2001). Despite the growing interest in the integration of BEPS tools in the building design process (e.g Hui 2003) it is maintained by some that the full potential of their use has yet to be fully realized (Hensen et al 2004).

BEPS AS A REGULATORY TOOL: THE IMPLEMENTATION OF THE NCM

One of the main drivers for the uptake of BEPS that has emerged is the legislative call for integrated modelling in practice (Clarke and Tang 2004). This is supported by their potential to effectively address the requirements of two of the most important trends in building regulations:

- The steady shift from prescriptive to performance based standards (Marsh 2005), to which the concepts of performance prediction and assessment are fundamental (Hensen and Nakahara 2001).
- The ratification of the Kyoto Protocol (Parsons 2004) and the consequent introduction of more stringent energy policies requiring a high degree of accuracy when estimating energy performance (Bleil de Souza et al 2006).

In an aim to improve energy standards and homogenize related building regulations in the European Union, the European Energy Performance for Buildings Directive (EPBD) was introduced in 2002 (EU Directive 2003). As part of this strategy, the Directive advocates the integration of modelling

through Article 3 which requires that member states develop and adopt a National Calculation Methodology (NCM)-a unified simulation-based compliance methodology for the energy performance of buildings.

The amendments included in the new Building Regulations 2006 (England and Wales) stipulate the use of the NCM as the procedure by which compliance to the criteria set out in the "second tier" guidance document concerning the conservation of fuel and power Approved Document L (ADL), can be demonstrated. (ODPM 2005) For non domestic buildings (ADL2-Buildings other than Dwellings) this entails simulating a proposed design using a "calculation tool" and holistically comparing its performance in terms of CO_2 emissions to that of an equivalent notional building, compliant to 2002 Part L2 standards (Figure 1) (ODPM 2003). To maintain the degree of flexibility required to address the large variety and functional complexities characteristic of non-domestic buildings, rather than assigning a single "calculation tool", the use of any of a number of accredited BEPS software packages is allowed.

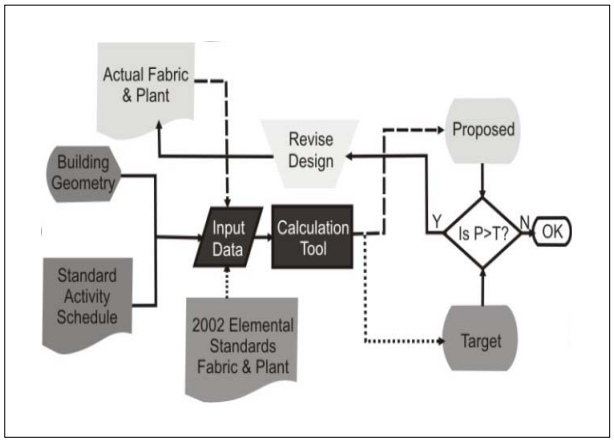

Figure 1: The National Calculation Methodology for Approved Document L2 (Buildings Other Than Dwellings)

ISSUES IN IMPLEMENTATION

Findings from previous studies have found that several factors such as the unavailability of appropriate tools and/or models, the extent of associated costs (De Wilde 2004) and the lack of the required degree of expertise (Hensen 2000) may impede the to effort to integrate the use of simulation tools during the design process. Additionally, the legislative integration of simulation through the implementation of the NCM depends on several factors, the fulfilment of which presents a set of unique challenges to the UK construction industry. These include:

1-The establishment of an adequate simulation capability, specifically through the provision of:

- System capability: a well developed and resourced regulatory system.
- User capability: adequately trained and certified professionals with specialized skill sets in the field of simulation.
- Tool capability: the provision of suitable BEPS software and the establishment of a mechanism for the technical accreditation of the array of tools available.
- Information capability: the provision of sufficient documentation outlining procedures.

2-Uncertainty around implementation caused by misinformation and/or difficulties in understanding the methodology and the procedures involved.

3-Issues of quality assurance concerning the validity of and confidence in the results of simulation exercises and issues relating to building control officers.

AN INDUSTRY SURVEY

An empirical survey-based study was undertaken starting in July of 2006 over an eight week period extending to the end of August 2006 to coincide with the initial phase of application of the Building Regulations 2006 and the introduction of the NCM.

Objectives

By providing an in-depth understanding of user capabilities, needs, opinions and expectations, the study aimed to quantify and evaluate the following:

- The effectiveness and efficiency of simulation as a compliance methodology
- The effectiveness of the approach adopted by the UK to accommodate the transition to the NCM.
- The success of the legislative approach as an effective means of encouraging the use of BEPS tools.

Methodology

An online self-administered survey was set up using Opinio, a web-based survey design and online hosting platform (www.objectplanet.com/opinio). A preliminary draft of potential questions was pre-tested by a number of experienced practitioners, producing the final version that was subsequently distributed via email invitation and through a link on RIBAnet (the Royal Institute of British Architects member community-www.riba.net) to over 200 architectural practices, environmental consultancies and engineering practices operating in England and Wales.

Selected questions aimed to provide two sets of inter-related information. Since the current literature does not appear to include a large-scale systematic study of BEPS tool use during the processes of building design and construction in the UK, the first set aimed to address this knowledge gap while the second was concerned with gauging the initial response of the industry to the introduction of the Building Regulations 2006 amendments and the NCM and the degree of awareness of its procedures through information and opinions provided by participants.

Discussion of Results

At the time of the compilation of this paper, the survey was still underway. However, over 90 responses had been collated; of which 40 were complete, equivalent to a response rate of almost 45%. While a considerable percentage of participants (28%) were architects and designers, the majority were technical specialists in the fields of engineering services, environmental consultation and building physics (64%) (Figure 2-a and 2-b) employed in large firms that offered specialized technical support (65%), rather than architectural design services (26%) (Figure 2-c and 2-d).

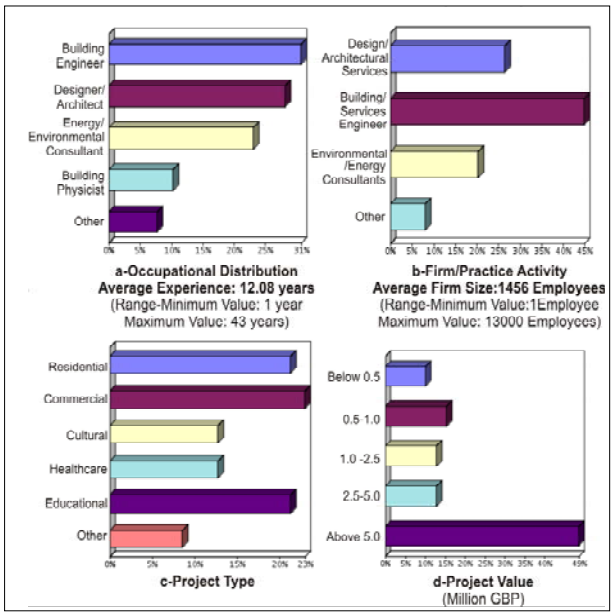

Figure 2: Participant Profile

General usage patterns of construction related software correlated to the large percentage of participants having a specialized technical background with 46% of participants reporting that they most frequently used energy modeling programs for their daily work tasks. (Figure 3-a) However, on an organizational scale, this percentage dropped to under 18% with 2D CAD tools generally dominating use (69%). (Figure 3-b)

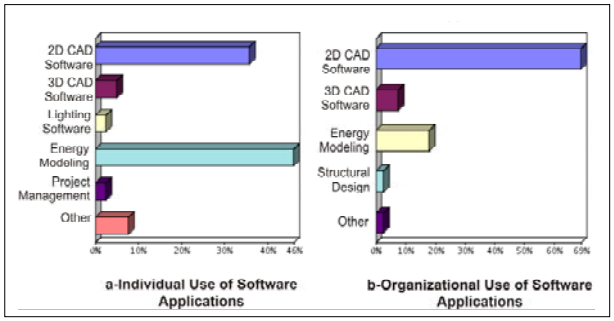

Figure 3: General Usage Patterns of Construction Related Software

Performance prediction was most frequently employed for HVAC related applications, such as heating/cooling and ventilation/air quality applications (53%). In comparison with other energy performance prediction methods, while engineering experience and rules of thumb ranked highest according to frequency and ease of use, computer simulation ranked lowest in both categories (Figure 4-a). This trend was reversed with regards to reliability of results with computer simulation ranking highest and the most popular two methods ranking lowest (Figure 4-b).

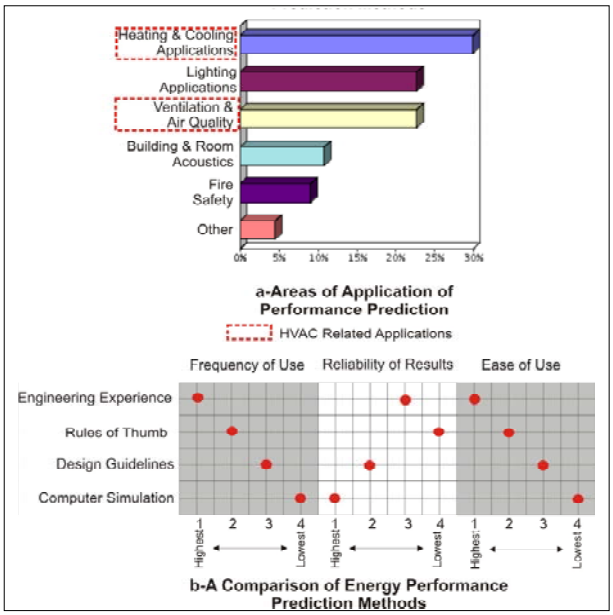

Figure 4: The Application of Performance Prediction

Specific findings concerning the use of BEPS tools outline the following:

- Drivers and influencing factors: Besides regulatory requirement, the use of BEPS tools was overwhelmingly attributed to a desire to improve design quality. Consequently, the factors that most affected the selection of particular BEPS (and other computer tools) were the plausibility of results and the reliability and stability of the software.

- Users: While one fifth of all organizations reported a 90% or more usage rate of construction related computer programs, nearly half (46%) had less than 10% proficiency rate in BEPS tool use with most users being self taught (30.5%). While the average experience of participants was approximately 12 years, the majority had under 6 years experience in using, BEPS tools with over 25% only using them over the past two years (Figure 5).

- Usage patterns: Most work involving BEPS tools is carried out by building service engineers (49%) and specialized in house departments (33%) with only a small percentage of architects and designers (12%)

utilizing them. BEPS tools were most frequently used during the design development phase, although not as extensively as other construction related software. The main areas of application included improving energy performance (30%) and minimizing overheating (27.5%).

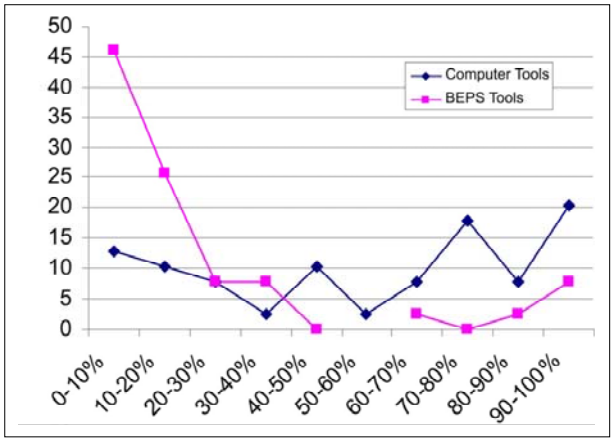

Figure 5: Percentage of Computer Software and BEPS Tools Users

For energy performance prediction, the three major tools in use are IES (http://www.iesve.com) (24.5%), SBEM (http://www.ncm.bre.co.uk) (23%) and TAS Building Designer (http://www.cadline.co.uk) (13%). With regard to the application of the National Calculation Methodology, as the only accredited tools, these continue to be the major tools which firms are using for that purpose. However while the majority of individuals maintained that the introduction of the NCM has affected their choice in selecting tools (82%), usually reverting to using SBEM, nearly a third reported that they also use or intend to use other tools (30%) that have not yet been accredited for Part L2 compliance (Figure 6).

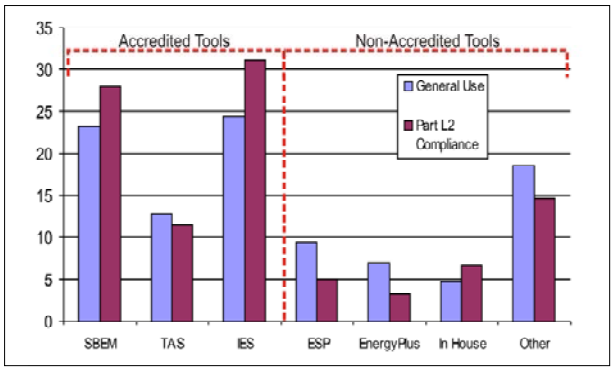

Figure 6: Use of BEPS Tools

Participants were required to provide an assessment of the application of the NCM to evaluate the viability of its implementation as the compliance methodology. In evaluating their overall experience in applying the NCM each participant was required to provide a rating for each of the following factors:

- Clarity: For information and training purposes most participants relied equally on official documentation (28%) and seminars (27%) but still regarded the NCM as unsatisfactory in terms of the directness of the methodology (43%).
- Usability: The general consensus was that the NCM was unsatisfactory in terms its usability (46%).
- Validity: Most (49%) considered the NCM satisfactory in terms of its adequacy as a measure of overall energy efficiency.
- Flexibility: Prior to the introduction of the NCM, the Elemental method was the most popular approach for Part L2 compliance (41%). The Carbon Emissions Calculation Method, the most similar to the current NCM was least preferred (28%). Similarly the NCM was not rated highly in terms of its flexibility with over 70% of participants rating it as either satisfactory or unsatisfactory.
- Efficiency: Task time also rated poorly with nearly 90% of participants considering it as either satisfactory or unsatisfactory.
- Reliability: While most participants reported that they would be only relying on their personal experience for output validation (36%), a considerable percentage (over 85%) considered it to have low result reliability.

Table 1: Participant Rating of the NCM

	Very Good	Good	Satisfactory	Unsatisfactory
Clarity	3%	20%	34%	**43%**
Usability	3%	8%	43%	**46%**
Validity	3%	14%	**49%**	34%
Flexibility	3%	26%	**40%**	31%
Efficiency	3%	9%	**47%**	41%
Reliability	3%	12%	**51%**	34%

CONCLUSIONS

The effectiveness and efficiency of simulation as a compliance methodology: It is evident that the use of BEPS tools still has a large potential for growth in the UK and its uptake is limited in comparison to other computer applications. As a computational design support tool for energy efficient design, other performance prediction methods are considered to be more usable and are therefore preferred. While BEPS tools are perceived to produce more reliable results than these methods, the issues of quality assurance are still of concern, especially with most participants relying on no other means than their personal experience for output validation.

The effectiveness of the approach adopted by the UK to accommodate the transition to the NCM: With respect to the fulfillment of the factors ensuring the success of NCM, due to the comparatively low percentage of individuals who consider themselves as

having an adequate level of proficiency in using BEPS tools (user capability) and the limited number of programs accredited for use (tool capability) the establishment of a simulation capability still remains to be fully realized.Despite the partial fulfilment of system support and documentation requirement, there still remains a degree of misinformation. For example, many participants were appear to be unaware of the fact that the tools they use are yet to be accredited or have chosen to ignore it at present.

The success of the legislative approach as an effective means of encouraging the use of BEPS tools: Various challenges concerning the success of the NCM exist, the implications of which will have a substantial effect on utilizing it as an approach to encouraging the use of BEPS tools. Participants generally expressed a degree of dissatisfaction with their experience in applying the NCM, mostly with respect to its clarity and usability. The full potential of encouraging the use of BEPS tools through the NCM as a legislative means will only be fully realized if it is more accessible to a larger percentage of practitioners in the field.

FURTHER RESEARCH

In an aim to asses the extent of the impact of the introduction of the amendments and the NCM and investigate the adaptability of the UK construction industry, further research will involve a second survey expected to take place during the period between March-July 2007, the results of which will be compared to those of the current survey. Additionally, an investigative case study involving the detailed analysis of output data from a specific simulation exercise presented to selected of architectural practices and/or specialized consultant services will be also be undertaken.

RECOMMENDATIONS

To ensure the success of the NCM as a compliance methodology and to realize it full potential in encouraging the integration of modeling and the use BEPS tools in practice, it is recommended that the following issues be resolved:

- The encouragement of the development and accreditation of more BEPS tools that offer simpler user interfaces suitable for use not only technical specialists, but also by architects and designers.
- The provision of adequate and updated information concerning the accreditation status of BEPS software available on the market.
- The establishment of a professional certification program for NCM related software.

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