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UK BUILDING ENERGY CALCULATION SOFTWARE APPROVAL SCHEME

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ABSTRACT

As part of the UK government Energy Performance of Buildings Directive (EPBD) initiative, the requirement of Asset and Operational Ratings for buildings since 2008 meant that software packages have recently been made available commercially to carry out calculations and produce the relevant documents. Prior to 2005, these software packages were unregulated and consequently the calculation and output were not standardised.

It is now a requirement for these software packages to be validated and approved as fit for commercial use under the UK Building Energy Software Calculation Approval Scheme (UK BECSAS in short).

This paper introduces the scheme, giving brief description of the processes involved and the implications of UK BECSAS to software vendors, stakeholders and to the implementation of the EPBD in the UK. It also highlights the issues in software that further necessitate software compliance and standardisation.

INTRODUCTION

Buildings in the UK account for approximately 50% of the country's energy consumption and co_2 emissions (30% from homes and 20% from commercial buildings). Inline with the European Union legislation, the EPBD, the Communities and Local Government (CLG) has introduced measures in England and Wales to improve the energy efficiency of buildings, which include:

- a general framework for a calculation methodology of the energy performance of buildings
- setting of minimum energy performance requirements
- the introduction of energy performance certificates for properties and recommendations for improvement
- the requirement for public buildings to display energy certificates

For these reasons, the revised Building Regulation Part L came into force, requiring new buildings to meet or surpass efficiency limits and design criteria that promote conservation of fuel and power. Subsequently, the legislation on Asset Rating and Operational Rating for buildings was introduced in 2008. An Asset Rating is an indication of energy performance potential of a building shown on an Energy Performance Certificate (EPC). An Operational Rating on the other hand gives the indication of the building energy consumption and hence, its CO_2 emission per unit floor area. This is presented on a Display Energy Certificate (DEC) prominently placed in a public area. These are similar to the concept of energy labelling used on rating electrical white goods. Both EPC and DEC ratings are derived using the building CO_2 emission.

To implement this new legislation, tools are required to calculate the energy performance of buildings and produce energy ratings and the associated documents. Various software packages are available on the market to complement the tasks where most have existed prior to the introduction of these new legislations for other functions of building simulation and modelling. They have subsequently been retrofitted to calculate and generate EPCs and DECs.

However, the implementation of these legislations, namely the related calculation methodologies, in the software packages lacked appropriate guidance and supervision. This presented a situation where unregulated software packages would produce non-standardised as well as potentially non-compliant output. To address this issue, the Communities and Local Government (CLG) has made it a requirement for all commercially available software to be validated and approved as fit for use. CLG implemented this on January 2008 through the UK Building Energy Calculation Software Approval Scheme (UK BECSAS). This requirement applies to software packages for calculating asset rating in domestic and non-domestic buildings and operational rating for public buildings.

TYPE OF SOFTWARE CLASS

NOS level

The National Occupational Standards (NOS) have been previously established by the government via close collaboration between Sector Skills Council and employers and professional bodies to define the levels of competencies required from individuals to carry out work in several sectors of industry. It describes the agreed statements of skills, knowledge and understanding for specific work. This would typically include issues such as the description of good practice at work, Health and Safety, the setting up of a statement of competence relevant to carry out the scope of work and the provision of a tool for managing workforce and quality control.

With regards to the property sector, the NOS have also been adapted to link assessor competence with building complexity. Although consultation is still on-going, the NOS have already been adopted in

practice where the range of classification derived designates the boundaries within which assessors of different level of competences are allowed to work in relation to building level of complexity. The general accepted three levels of competence are as follow.

NOS level 3 competence relates to generally simple existing buildings with features that could be easily modelled. These buildings do not have centralised air conditioning plant, but instead may have localised air conditioning units not exceeding 12kw cooling load. The heating system will comprise of a boiler under 100kw capacity. This could typically be converted houses, single or two-storey offices and shops. This level is specifically tailored to accommodate home inspectors, domestic energy assessors, surveyors and property agents.

NOS Level 4 relates to new and more complex existing buildings. These buildings are likely to include centralised air conditioning plant and a heating system with capacity greater than 100kw. Level 4 assessors will need to demonstrate that they have conducted energy assessments of new and existing non-dwellings through site visits, as well as through the examination of building plans and relevant information. Level 4 assessors may also be required to be competent in overseeing a team of specialists (e.g. data gatherers), ultimately taking full accountability over the completed energy assessment.

NOS Level 3 and 4 competencies are thought to be sufficient to cover approximately 80% of the UK building stock. Any further building complexity will require assessors with NOS Level 5 competencies. These buildings are generally complex in shape and construction, with the use of atria and complex facades. They are installed with complex services, central air handling plant, the use of combined passive heating and cooling strategies and BMS controls. Another attribute would be the use of on-site renewable or zero-low carbon energy generation.

There are five classes of software defined in UK BECSAS and they are briefly introduced below.

SAP class software

SAP is the UK government's Standard Assessment Procedure for energy rating of dwellings. As part of the UK national calculation methodology, it is used for evaluating energy performance and demonstrating compliance of dwelling with building regulations. SAP is an acronym adopted for class of software used to provide energy ratings for new dwellings.

RDSAP class software

RDSAP (Reduced Data SAP) is similar to SAP but is used for existing dwellings.

DSM class software

Dynamic Simulation Modelling (DSM) is a conventional reference that applied to building analysis software that model the dynamic response of buildings. Usually quite complex, the software could model and simulate elements of a building to high degree of detail and accuracy using algorithm-based approach.

DSM software could calculate the thermal response of building fabric and the operations of HVAC services at time steps of several minutes. It can solve multiple thermodynamics equations hence enable a more accurate prediction of thermal and energy performance of buildings and its interaction with its enveloping environment, weather conditions and design criteria. DSM software packages are mainly used for complex non-domestic buildings categorised under NOS level 5.

FI-SBEM class software

Generally, DSM type software is complex requiring large amount of experience and highly trained users. Whilst DSM is the ideal tool for complex buildings, its use for simpler building seems excessive and widely perceived as unnecessary. Therefore, the government commissioned BRE to produce the Simplified Building Energy Model (SBEM) and then its interface, iSBEM, that offer an alternative and a simplified solution to assessing approximately 80% of UK building stock consisting of low-level complexity buildings. SBEM is a compliance tool designed to be the government's platform for implementing the NCM modelling guide, which structures the interpretation of the compliance framework (Building Regulation Part L).

The use of SBEM to simplify the modelling of buildings would still require user training and accreditation of competency, however, is it significantly easier than that required for DSM software. NOS levels 3 and 4 assessors would use SBEM as the approved method for assessing buildings with complexities categorised under these NOS levels.

The term 'FI-SBEM' is used to refer to third-party versions of the BRE iSBEM software.

ORCalc class software

Currently, it is compulsory for government and public buildings exceeding 1000m² to have a Display Energy Certificate that informs the operational rating for the buildings as dictated by Article 7 of the EPBD (CLG, 2007). A software program is required to collate the relevant data, which include utility bills and floor area to the use of separable energy and on-site renewable energy. This software is classed as the ORCalc software, acronym for 'Operational Rating Calculator'.

PRE-UK BECSAS SCENARIO

The development in building-related software

Traditionally, the myriad of software packages available on the market were mostly custom-built to tackle different, often quite specific functions of building-related issues (Harper, 2008). A dedicated software program would be coded for solar calculation and design, whilst another specifically for

ventilation and air flow through building façade or space.

Eventually over the years, the trend was to move towards more integrated software functionality offerings, as developers rationalise the incentives of commanding as much a share in the increasingly popular market of building simulation and modelling. Combining the solutions for separate but at the same time linked issues in the built-environment complements the increasingly favoured concept of holistic approach in the construction industry. Whilst the flipside implied that software packages then became more difficult to master, it also meant that complex and more sophisticated packages offered potentially a one-stop, more effective and efficient, solution for taking a building from concept to completion.

Software developers have constantly worked to deliver products that satisfy this new demand and remain competitive in the marketplace. However, the process has not been straightforward. Cumulative uncertainties were intrinsically embedded as these software packages evolved and expanded, which is an inherent consequence of trying to do too much.

Similar to any other industry, there are sciences that are complicated with some particularly complex to represent mathematically. To this day, there remain sciences of thermal performances of materials, heat transfer and other building-related subjects that persist to have little understood about them. Scientists and engineers have derived numerous theorems and approaches to best-approximate their cause and effect. Others would tailor solutions best-suited for a specific area of application.

Institutions and professional bodies (such as CIBSE and ASHRAE) have long provided relevant guidance and 'rule of thumbs' for engineers and building designers. Recently, software developers have begun to adopt these in their products in efforts to mitigate deviation from mainstream and industry-accepted conventions. In spite of this, calculation of overall building energy and thermal performance remains generally complicated and complex; hence continues to demonstrate spread and uncertainties to a single solution between different calculation methodologies.

Furthermore, different calculation engines (e.g. Apache and Energy Plus) developed as the core to these integrated building simulation and modelling software packages featured their own algorithms and solvers. In addition, integrated calculation for overall building thermal performance and energy consumption from heating and cooling to lighting and ventilation is also very complex. This is due to the different building types, HVAC systems, use of clean technology and passive designs, the availability of intelligent BMS and, quite simply, complex building geometry. Therefore, in practice, it is a general expectation that inconsistencies (and errors) are intrinsic in the use of software for building modelling and simulation.

Despite all this, building simulation and modelling software continued to develop into a viable design tool and increasingly accepted for use in practice.

Software use in Building Regulation and EPBD

The evolution of Building Regulation Part L was significantly influenced first by the UK's commitment to the Kyoto Protocol and then, as a member state of the European Union, through the Energy Performance of Building Directive (EPBD). Up until 2002, the Building Regulation Part L, which is concerned with conservation of fuel and power, involved relatively simple and fundamental legislative requirements imposed on building design that are enforced by the building control body.

Through the EPBD legislation, which came into force across Europe on January 2003, and subsequently the eventual transposition of the EPBD into the UK law in April 2006, the Part L Building Regulation was revised and amended significantly. This resulted in a set of compliance requirements, which is more complex and comprehensive. Coupled with the calculation methodology for energy ratings, it requires the calculation of energy and thermal performance for the entire building.

The government hence had to identify the necessary means to support and complement the implementation of this legislation. The capabilities demonstrated by building-related software packages have enabled them to satisfy this role within the framework of the legislation. Building simulation and modelling software are now not only an increasingly valid design tool but also becoming a credible compliance tool.

Guidance and specification documents

The government (CLG) subsequently published guidance documents and specifications that outlined the calculation methodology defined in the legislation. Amongst these documents is the National Calculation Methodology (NCM), where procedures for demonstrating compliance and methods to calculate building energy use and produce building regulation compliance rating have been defined by CLG. Subsequently, the NCM expanded to include methodology for asset and operational ratings.

The NCM also dictates that compliance rating is to be carried out using approved building energy calculation software. It describes how building regulations should be interpreted and implemented in a software calculation methodology.

These documents are continuously being developed with the involvement of various stakeholders and expert task groups through countless consultations. The general format has been that software developers would update their software in accordance to the changes to these documentations.

Whilst these guidance documents were made available to software developers, they went about somewhat unsupervised. Inevitably, proprietary versions of translating the NCM began to emerge derived from developers' differences in interpretation and implementation. There was no appropriate body established to support the developers and to regulate dissemination of the documentations in a formal and standardised way.

Unregulated market

Naturally, with variety comes diversity. Whilst the different brands of software packages offer choices to users, they also introduce ambiguities and spread. The compounded effects of the issues highlighted thus far would be costly, more than merely resulting in inconsistent outputs. The knock-on effects include unreliable EPC and DEC assessment, compromising credibility in the public eye. This could cause backlash in the property market, affecting sale, lease and rental prices. Legal disputes would occur. If left unchecked, the delivery of EPBD would then incur a major setback.

Technical Memorandum 33

CIBSE published a technical memorandum (TM33) on Tests for Software Verification and Accreditation. The objective was to instil confidence in software users on the integrity of software calculation methodologies. TM33 functioned to verify that software could produce results, which are consistent with good practice and compliant with the methods in the CIBSE Guide A.

According to CIBSE, the tests in TM33 could be used to demonstrate that software tools meet the requirements set out in Regulation 17 of the Building Regulations, and Annex I of ODPM Circular 03/2006 with focus on thermal performance of buildings. The format of TM33 was derived with the intention of finding a balance between comprehensiveness and ease of application.

Early validation and accreditation programme

Previously, CLG had setup what was considered a preliminary phase of software validation and accreditation programme, which utilised the CIBSE TM33 as the assessment platform. For this purpose, TM33 was revised to incorporate issues related to the NCM modelling guide.

However, this applied specifically only to DSM class software. Compliances of these software packages were deemed paramount at that time due to the relatively higher commercial implications tied to their use on non-domestic buildings. Similarly, third-party domestic software packages (SAP) and iSBEM/SBEM were also being tested and accredited by BRE under the instruction of CLG.

As the EPBD delivery evolved, validation and approval via TM33 gradually became insufficient as gaps developed around compliance issues related to asset and operational ratings for buildings. TM33 was never intended to fully cover the interpretation of the NCM modelling guide and to validate compliance with Building Regulation.

When EPC became a requirement in the domestic and non-domestic sector and DEC compulsory for public buildings accessed by the public, it was time for CLG to revamp the programme and commission a more comprehensive scheme. Hence, UK BECSAS was conceived to blanket-cover validation and approval of both domestic and non-domestic software.

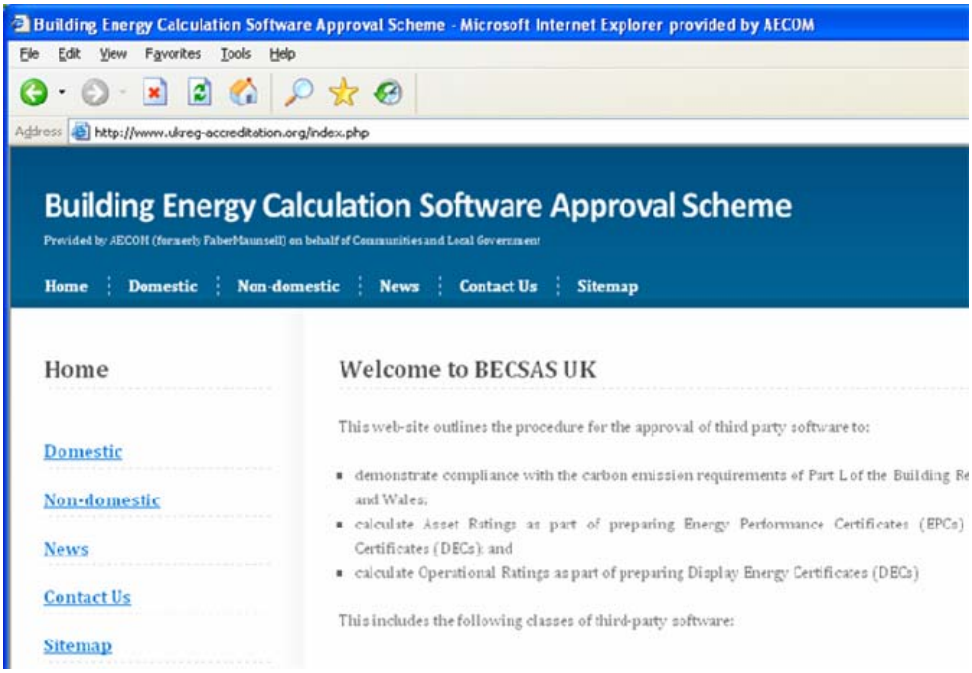

Figure 1 Snapshot of the UKReg-accreditation.org [www.ukreg-accreditation.org] *website*

THE UK BECSAS

Introduction

On January 2008, the Communities and Local Government (CLG) established and funded a scheme to facilitate validation and approval of building energy calculation software for compliance with guidelines and specification. The UK Building Energy Calculation Software Approval Scheme (UK BECSAS) has so far validated and approved scores of software in the following categories:

Domestic:

- Standard Assessment Procedure (SAP)
- Reduced Data SAP (RDSAP)

Non-domestic:

- Dynamic Simulation Modelling (DSM)
- Front-end Interface SBEM (FI-SBEM)
- Operational Rating (ORCalc)

The format of software validation is different for the domestic domain in that whilst the UK BECSAS manages the software developer applications, the BRE conducts the actual software testing and approval recommendations.

The scheme maintains a website (http://www.ukreg-accreditation.org, see Figure 1 for snapshot of the site) on behalf of CLG to manage information dissemination and function as a portal for software approval applications. Software packages approved by CLG are published on the website with details of their scope and application.

Types of application

There are three types of application under UK BECSAS: Full-validation, Re-validation and Self-validation. They can be differentiated based on several criteria as summarised in the chart shown in Figure 2.

Essentially, a full-validation application applies to new-entrant software not previously approved by CLG under BECSAS. The process will be exhaustive and comprehensive.

When there are significant changes in the software specification and guidance or due to a signicifant trigger event, CLG will demand that all software go through a re-validation process.

Software developers are advised that they are responsible for making sure that their software packages remain compliant when changes are carried out. CLG has warrant developers of approved software to self-validate their software whenever changes are made. As long as the developers could prove and verify that the changes do not affect software compliance, CLG would accept the new software release version and transfer the approval across.

In turn, developers should exercise prudence and inform the scheme if changes incurred a compromise on compliance. A full-validation by the scheme is usually then required. As a voluntary route, the self-validation application has been made available to accommodate this.

Depending on the type of application, there are potentially two stages – self-assessment and live-assessment.

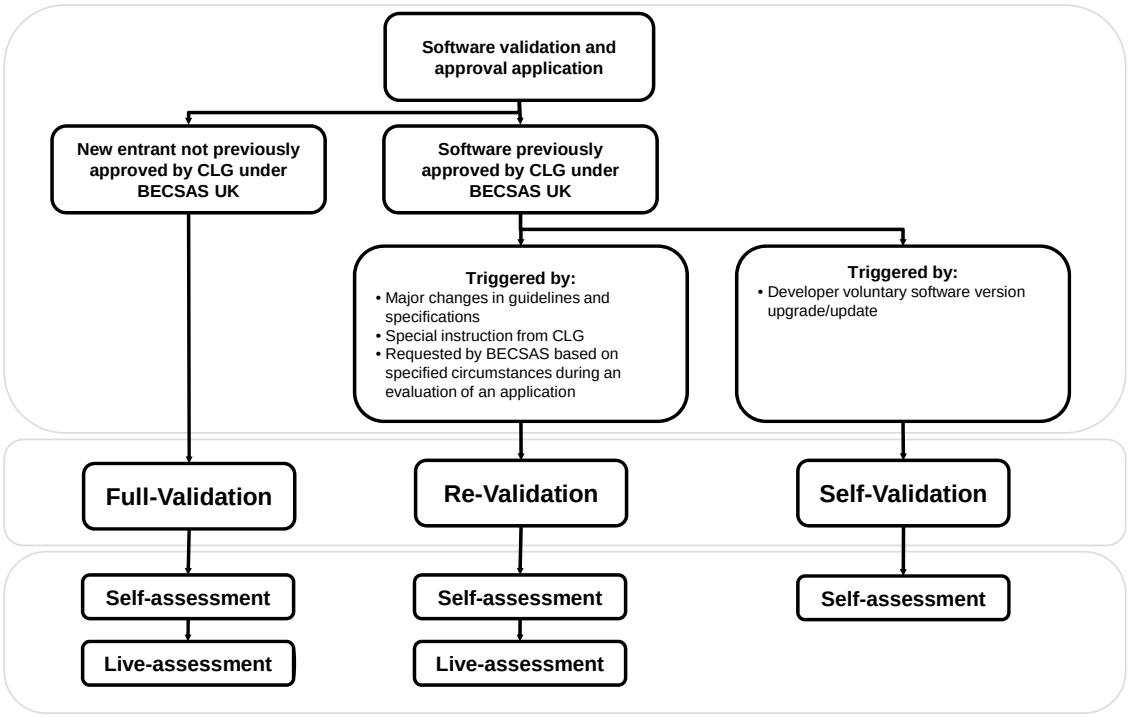

Figure 2 Types of application in UK BECSAS

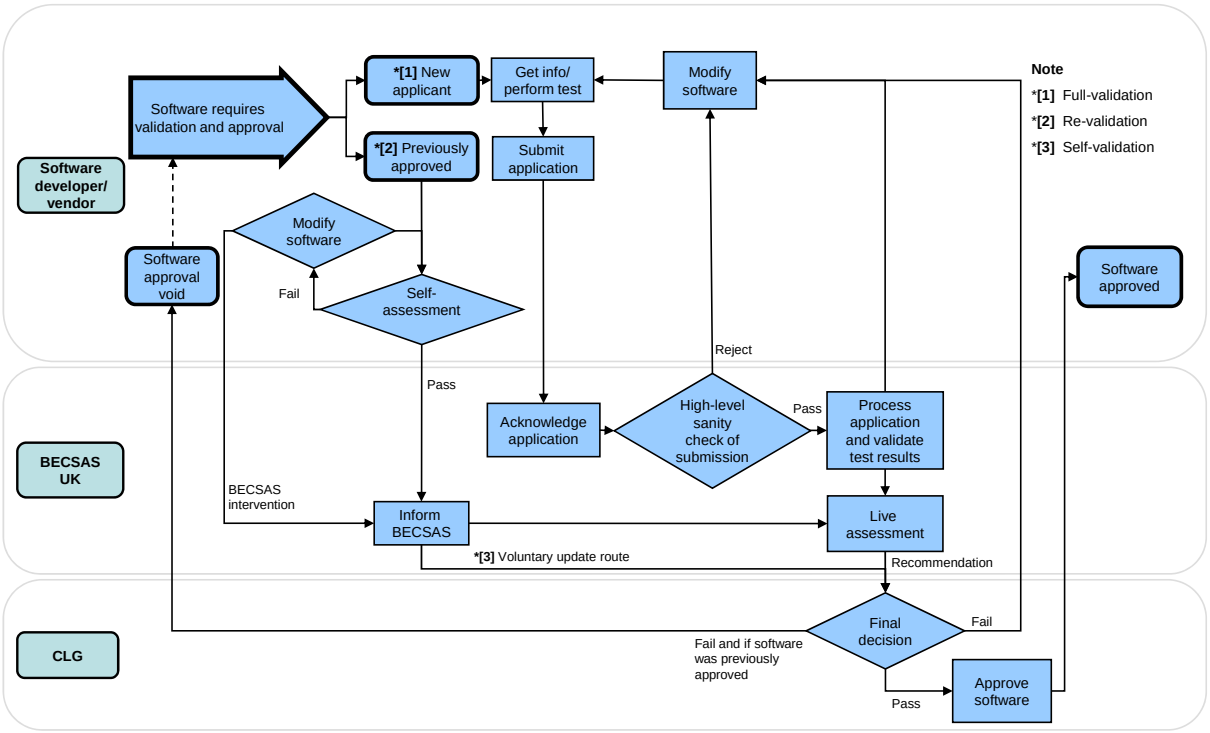

Figure 3 Map of process flow involved in UK BECSAS

The self-assessment procedure will rely upon the developer to carry out testing on their software based on test cases and criteria provided by UK BECSAS. Upon completing the assessment, developer will have to declare that their software is compliant. This will then be reviewed and verified by UK BECSAS via the test output submission.

The live-assessment session is a face-to-face meeting with the developer for ad-hoc testing to evaluate usability and functionality and to aid closer scrutiny of the software and highlight any previously undiscovered issues.

Process map

Previously approved software for compliance with Building Regulation Part L will have to be fully validated again under the UK BECSAS. Figure 3 maps out the process flow involved in the scheme. Essentially, this is divided into 4 parts:

- obtain test cases and criteria
- submit application with test results for validation
- attend live assessment, if applicable
- gain approval/differ application

Through the website, software developers could request for the test cases and test criteria for the relevant software class. When the developer has completed a software version release and has tested it against the test cases, they could submit an application to the scheme online or via email.

The application is filed, officially starting the validation process. The scheme checks the results against benchmarks and highlights any anomalies and discrepancies. This is then facilitated by a series of two-way correspondences with the software developer to resolve any outstanding issues. If relevant, the scheme invites representatives from the software developer to attend a live assessment session where the software could be interrogated more thoroughly.

When the scheme is satisfied with the outcome of the validation, it would report to CLG that the software is compliant with requirements and recommend the software be approved. Finally, at CLG's discretion the software is approved. Upon approval, the software developer would be notified and relevant details would be added to the website's approved software list. Stakeholders could then refer to the list for the latest information regarding the approval status of specific software and choose from there the software package most suited to their application.

In general, the validation for all the software classes takes a reasonably similar path. The following describes the test criteria for the different software classes in more detail.

ORCalc class test criteria

This software class consists of ten test cases covering various aspects of operational rating and assessment for the production of DEC and the advisory report. This includes tests for different benchmark types, occupancy level, provision of separable energy, type of main heating fuel, incorporation of low and zero carbon technologies, building location and the quality of measured data.

FI-SBEM class test criteria

The test package comprises six test cases with varying complexity and features. The tests interrogate issues such as thermal properties of building fabric, HVAC system, on-site renewable energy system setup and energy consumption. The production of BRUKL (Building Regulation UK Part L) and EPC documents are checked for compliance with benchmarked figures.

DSM class test criteria

There are two sets of tests devised for DSM class software. Software packages would still need to comply with TM33 requirements and thereafter, demonstrate reasonable agreement within a set tolerance with the Enhanced Test Models. These are ten test cases of several building types designed to assess software compliance with the NCM modelling guide. Specifically, the tests look at software accuracy in modelling the notional and reference buildings. Various building parameters are scrutinised, including heating/cooling energy, lighting energy, auxiliary energy, fabric properties and CO_2 emissions. This is also supplemented by a compulsory face-to-face meeting with the developer for open consultation and assessment of software.

Post-validation and approval

Conventionally, software packages are approved for the released version submitted for validation. This is stated in the CLG's approval letter and the scheme's recommendation letter. The software name and version number will be clearly listed on the website when a software package is approved for the first time and any further validation beyond that will be shown along with the latest compliance details.

IMPLICATIONS OF UK BECSAS

In general, the setting up of UK BECSAS would help fulfil government objectives and affect changes on various aspects in the building industry. In the first instance, the requirements in UK BECSAS directly affect software developers. By influencing their products, the impact of UK BECSAS will be transferred onto the various stakeholders in the building industry, including the public.

Implications to software developers

In order to market their software packages commercially in the UK, developers must obtain software approval from CLG. This status would imply that the software have been validated to government standards and approved for use in the marketplace to produce valid documents. To obtain and maintain this approval, developers are constantly forced to keep updated with changes in the guidance and specification. Any lapse could potentially affect the credibility hence the marketability of their product. CLG reserve the right to revoke any approval due to non-compliance hence this imposes a regulatory pressure on developers to conform.

The developers would be looking at spending just that extra effort and resources to keep up-to-speed with the demands of the government and the market place. Development budget will have to change to accommodate an allocation to meet compliance requirements. Assured by the quality and reliability of their own products, developer can convincingly market and promote their software packages.

Implications to stakeholders

With software having to go through validation and approval before they can be commercially marketed, stakeholders can have the confidence in the software they use. Approved software reduces an element of variability in the process of producing regulation compliance documents and energy ratings.

Energy assessors as well as clients can be assured that regardless of which software packages they use, the results will be credible and consistent. This implies a mitigated risk with the use of software and the quality of assessments could be significantly improved. There would be less potential disputes over why a software package gives a better rating compared to the other. In addition, building control authorities would be face fewer ambiguities when assessing planning permissions.

Ultimately, the benefits are eventually transferred to the end-stakeholders – building owners, occupiers and the public. Disputes over wrongly prescribed ratings, which went on to affect sales, rental, lease prices leading to commercial loses would be significantly minimised. Building occupiers and owners would obtain ratings representative of their investments and potential occupiers could begin to utilise these ratings to influence decision-making.

Implications to UK EPBD

It is based on the UK EPBD framework that the UK BECSAS was established by the government. Therefore, the objective of the scheme is simply to support the government in its aspiration in meeting its environmental commitments. The scheme has not been designed to be a regulatory body but more intended as an extension of CLG to facilitate software approval. In the coming years, the UK will be going through series of evolutionary changes with respect to the EPBD and its transposition into the UK law, more specifically, the UK building regulations. These will have an unprecedented impact on building related software. Ideally, UK BECSAS should be in position to ensure that software packages continue to conform to these imminent changes.

CONCLUSION AND FINAL THOUGHTS

These recent years have seen considerable changes in the UK building industry, aimed at reducing carbon emissions and conservation of resources. Already serving as a credible mainstream design tool, computer software is also recently rendered into becoming a compliance tool for buildings to cater for

new legal requirements under the EPBD. Computer software is now used to assess regulation compliance and for the production of energy labelling of various types of buildings, tasks of which critically requiring regulating and standardisation from the government.

The UK BECSAS was hence setup as part of the government's EPBD framework. The objective of the scheme is to facilitate validation and approval of software so that they are fit for commercial use to produce valid and credible documents.

One of the major challenges faced by UK BECSAS is to ensure not only the DSM class software comply with the NCM but also to align the different packages with each other. Then, the next charge is to bring DSM and FI-SBEM class software into closer alignment. Whilst the SBEM is built based on a derivation of the CEN standards and in particular the BS EN ISO 13790, which operates on monthly averaged data, DSM software engines run at finer time steps (hourly and minutes resolution). Therefore, the UK BECSAS has a significant task to tackle for what are effectively two different classes of software. This is projected to be an evolving process and ideally should feed back towards further revisions of the NCM modelling guide to achieve a close-loop overall improvement.

So far, UK BECSAS has been running smoothly and should have an overall positive impact. When this paper was written, software for air conditioning inspection was in the process of being included in the scheme. Scores of software packages have already been validated and approved and their compliance is constantly being monitored through either self-validation by the software developers or through validation by UK BECSAS. However, it is anticipated that follow-up efforts will be needed in light of further imminent changes in the EPBD and the UK building legislation.

ACKNOWLEDGEMENT

This paper has been reviewed by CLG and hence we would like to thank those involved in the review.

GLOSSARY

ASHRAE	American Society of Heating, Refrigeration and Air Conditioning Engineers
BECSAS	Building Energy Calculation Software Approval Scheme
BRE	Building Research Establishment
BRUKL	Building Regulation UK Part L
CIBSE	Chartered Institute of Building Services Engineer
CLG	Communities and Local Government
DEC	Display Energy Certificate
DSM	Dynamic Simulation Modelling
EPC	Energy Performance Certificate
EPBD	Energy Performance of Building Directive
FI-SBEM	Front Interface to SBEM (not BRE)
iSBEM	interface to SBEM (BRE)
NCM	National Calculation Methodology
NOS	National Occupational Standards
ORCalc	Operational Rating Calculator
RdSAP	Reduced SAP
SBEM	Simplified Building Energy Model
SAP	Standard Assessment Procedure
TM	Technical Memorandum (CIBSE)

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