BIM BREAKFAST BRIEFING

Enabling energy management and control for the construction sector

At the recent SEAI Energy Show, a panel of BIM experts (see inset) was challenged to explain how, while digitalisation of the construction process is recognised as the way forward if we are to realise net zero objectives, BIM is the enabling tool that will make it possible. In this special report by *Building Services Engineering* we capture the essence of their deliberations, and the conclusions drawn.

Alan Hore, Facilitator

As with all new processes and technologies, there is a learning curve for those involved. Hence the panel took a unique approach to the challenge by addressing how BIM can be used to harness all four primary quadrants of the energy cycle – *Plan:* Potential Energy; *Design:* Embedded Energy; *Build:* Operational Energy; *Operate:* Sustainable energy.

This paper outlines the experts' input, experiences and opinions on how BIM can best be utilised, and how the various challenges posed can be addressed by utilising BIM to manage and minimise energy aspects of construction.

As Chair for the session Dr Alan Hore outlined the urgent challenge of decarbonising the construction industry stating: "This morning we will look at how BIM can be used to control energy across the complete built environment lifecycle. The sector accounts for 39% of all energy-related CO2 emissions when adding building construction industry emissions. Global building floorspace is projected to double by 2060 and only 3% of investment in new construction is green and efficient. The sector has been locking in high emissions for decades and we need to do something about this urgently. The only way to tackle this is aggressively, and across the entire building lifecycle, and BIM is an ideal vehicle to achieve this."

BIM is a key part of the fourth revolution (digitalisation) of the AEC industry and an enabling tool for a cleaner and more sustainable built environment. This fact has been recognised by the European Commission and a number of H2020-funded projects, including BIMCert, are focusing on providing training frameworks and supports in order to upskill the industry.

This article, following previous publications from BIMcert, will provide additional summarised insights on how BIM can actively contribute to improving building stock and making the AEC industry more focused. It also addresses how the sector can more effectively achieve sustainability and energy efficiency goals and targets, and why upskilling the industry is a key requirement.

Speaker line-up

Facilitator: Dr Alan Hore, Head of Quantity Surveying, TU Dublin; Michael Curran, Chairman, CIBSE Ireland and Head of Building Services, Energy & Utilities, NUIG; Michael Earley, RIAI BIM Champion and BIM Manager, DAA; Dr Avril Behan, Project Director, Build Digital and Senior Lecturer, Faculty of Engineering and Built Environment, TU Dublin; and Joseph Mady, founder and Managing Director, Digital Construction Technologies (DCT) and BIM Champion, CIF's Mechanical & Electrical Contractors Association (M&ECA).

What exactly is BIM?

Although increasingly more adopted and recognised by the industry, there are still some who do not fully understand or recognise the significance of BIM. Thus we provide a simplified explanation from the UK's *National Building Specification* "… BIM is a process for creating and managing information on a construction project across the project lifecycle. One of the key outputs of this process is the Building Information Model, the digital description of every aspect of the built asset …"

We can describe Building Information Modelling (BIM) as a method based in modern digital technology. Its strength is in its ability to spatially and temporally connect structured information (databases) from a wide variety of sources via a 3D model data that can be logically queried to support full construction lifecycle decision-making and processes. These models are the foundation of enriched digital twins when linked with auxiliary tools and processes that can, among other things, be used to support sustainability trends in the construction sector.

Why BIM upskilling is necessary

There are increasing requirements for energy efficiency competencies and applicable skills, resulting from European decarbonisation and sustainable energy strategies.

Therefore, solving the problem of skills development for sustainable energy required by the construction sector, and stimulating demand for sustainable construction and a skilled energy workforce, is closely connected to the upgrading of the BIM skills of construction professionals and workers across all disciplines.

> *"By harnessing the capacity of the building sector, many countries can cut emission rates cost-effectively and achieve energy savings of more than 30%, according to the United Nations Environment Programme.[1]"*

As a sustainable energy supportive technology, BIM is a vital tool for reducing the carbon footprint in the construction sector. It is the backbone of the new "informed" way of working in the construction sector, triggered and targeted by digitilisation and equipped to manage the "full energy content" of construction. Such is the impact of BIM that the EU has supported, promoted and developed several policies and initiatives to foster digitalisation in the construction sector. These include *inter alia* the *Strategy for the sustainable competitiveness of the construction sector and its enterprises* (2012), the *EU BIM Task Group* and the upcoming *EU Digital Construction Platform*.

Digitilisation and the use of BIM in the construction sector are in their infancy in some regions so now is the time to promote their adoption to proactively and effectively reduce the carbon footprint and environmental impact of construction. BIM provides the data for monitoring and management of a building's energy consumption and this data

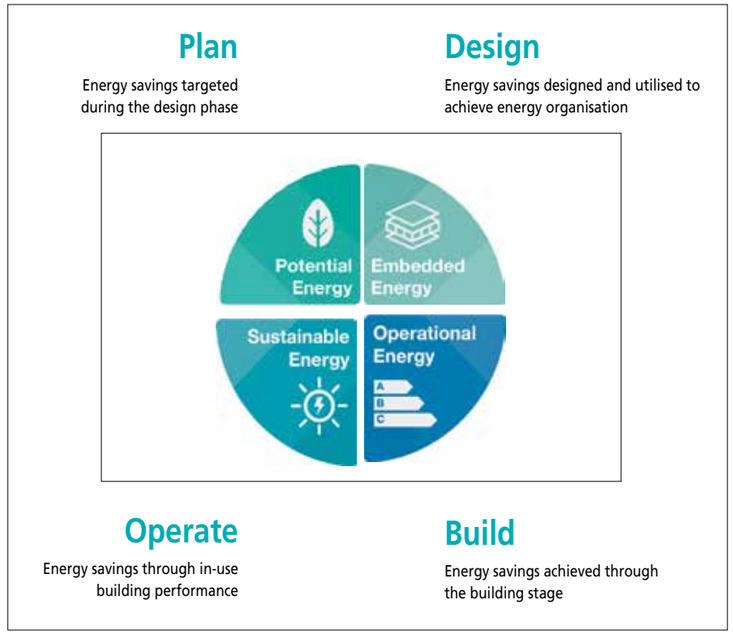

Figure 1 – Using BIM to manage the energy cycle in construction.
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can be used as information to make informed decisions on how best to manage the entire energy cycle of a building.

There are four segments within the energy life cycle in construction – potential, embedded, operational and sustainable energy. These four segments combined account for all the energy used in the complete construction lifecycle. They are mutually dependent and, as a result, cannot be considered separately. Decisions and actions are not mutually exclusive; decisions made within one segment have significant impacts across the entire energy circle. See Figure 1.

BIM-based energy modelling provides several benefits, including more accurate and complete energy performance analysis in early design stages, improved lifecycle cost analysis, and more opportunities for monitoring actual building performance during the operation and sustaining phases.

In addressing the audience at the start of the session, Eamon Sheils from SEAI highlighted the importance of taking a holistic and innovative approach to dealing with the challenges of climate change. He stated: "We cannot hope to meet our ambitious targets for 2030 and beyond without using every available tool at our disposal. SEAI, in our role to drive action in this area, recognise the potential of BIM to play a significant part in meeting this challenge. The ability to consider the sustainability of a building over its whole lifecycle and beyond, at its very inception, is the best way to ensure that we do not create adverse impacts from our national stock into the future. The ongoing monitoring of building performance is another essential aspect which we at SEAI would fully endorse."

1. Potential energy – targeted during the design stage

Planning and designing

In addressing the primary energy quadrant section of the session Michael Earley, RIAI BIM Champion and BIM Manager, DAA stated: "Every organisation that is responsible for planning, delivery, management and operation of building and infrastructure assets needs to establish a vision for sustainability which is executed through policy, strategy, management systems and guidelines. The execution of sustainability must be embedded in all phases of the delivery of a built asset, from assessment and need through to operation. BIM is a very important tool which allows building assets to be analysed and documented in a collaborative manner that is necessary to achieve a cohesive approach to the sustainable delivery of projects."

Energy savings are planned and targeted during the design phase. The intent is to utilise BIM tools to proactively reduce the gap between predicted and actual building performance. BIM can be used to model buildings and sequentially perform multiple analyses, enabling energy performance prediction that can be applied to compare design alternatives, allowing for an improved final decision.

Michael Earley

BIM the enabler – This involves using BIM as an enabler of effective collaboration between design disciplines and reducing performance disparity from conception. The BIM collaboration method and tools allow for more efficient coordination and avoidance of errors. This leads to a more efficient construction process, avoiding wastage and contributing to decarbonisation during this phase.

Fast and accurate processing – BIM software, based on the 3D data-enriched model, allows for simulations such as solar paths, solar gains, thermal behaviour and testing of M&E systems. Those, allied to other digital technologies such as cloud computing, AI and machine learning, are already – and will increasingly – allow testing and evaluation of several design options until we find the best solution.

The design stage will improve as BIM allows for better-informed decisions by cataloguing and predicting the future behaviour of the building more accurately with a data-based process.

Visualisation of energy loads – BIM tools allow us to analyse the model, enriched with the correct input of data, as well as to calculate and graphically visualise/represent the loads and performance of the building. They allow an easier, clearer and more direct interpretation and understanding of design choice and changes impacting building performance.

Performance ratio comparision – BIM tools additionally facilitate quantification (5D) which, when allied with simulation tools, permits a better-informed cost versus performance ratio comparison. That helps make informed decisions about the feasibility of design options, as well as comparison of the predictable energy savings and linked cost savings during the operational phase against the investment that is required in the construction phase. This is of the utmost importance to clearly illustrate that sustainability and energy efficiency are not only environmentally necessary but can also be profitable.

Full lifecycle approach – BIM involves a full lifecycle approach in the AEC industry, and the model is a digital twin of the built asset. BIM simulation tools enable the establishing and planning, from the inception/design phase, of a roadmap towards the most efficient way to run the building in the future.

2. Embedded energy – targeted during the construction stage

Building

Joseph Mady, Managing Director, Digital Construction Technologies (DCT), presented on Section 2 of the energy quadrant, the design stage that encompasses embedded energy. He opened his part of the presentation stating: "We need to fundamentally change our approach to how we design our buildings to ensure that we are building now for the future with 'building to disassemble' at the core of our methodologies."

BIM is recognised as a tool to support the visualisation of a building's energy performance. It covers sequence and schedule of construction aimed towards the application of sustainable construction materials and techniques, with minimum waste of energy and materials.

This enhanced approach using the BIM 4D (time scheduling simulation) and 5D (quantification) tools, allows for more efficient project management in the

Joseph Mady

construction phase, coordinating the works better, reducing construction time, avoiding clashes and coordinating the delivery of materials to site.

BIM virtually recreates not only the building but also the full site and its operations, enabling better preparation and coordination before any work commences. Using the 3D BIM model integrated with VR and AR technologies, site work can become more efficient and faster.

BIM-based digital design and visualisation also permits the better use, planning and site delivery of pre-fabricated components. In addition, data-rich BIM product catalogues can justify and enable an increased use of local materials. Using digital scanning, combined with BIM processes, integrates different digital data inputs and outputs into new digital workflows applied to construction.

This is a significant benefit of the 4th revolution, of which BIM is an integral part. For example, in the case of an existing building, a digital survey allows measurement of key hotspots requiring energy efficient improvements. BIM design can simulate and predict how to improve these, and how to implement advancements during the construction phase. During and after construction this can be re-measured, reusing the digital scanning techniques, and compared to the BIM model data to verify and reduce the gap between predicted design performance and built performance.

If we account for all this, it becomes evident that the reduction of waste – for example the carbon footprint of material transport and extra material required in case of clashes and amendment, in addition to surplus energy spent on installation and construction – is better achieved using BIM tools. Additionally, this improves construction quality and brings the predicted and actual energy performance in buildings even closer.

3. Operational Energy – targeted during the operation/service stage

Operate

Dr Avril Behan, Project Director, Build Digital and Senior Lecturer, Faculty of Engineering and Built Environment, TU Dublin led the presentation on Operational Energy.

She began by saying: "Skills matter … the construction sector must look to foster a digital culture that encourages continuous learning, agile development and innovation.

"With pioneering projects such as ARISE and BIMcert, the digital transformation of the sector is well underway. With enhanced skills across the workforce we can close the design performance gap and significantly control the operational

Avril Behan

energy performance of buildings. BIM is the "golden thread" that permeates all the energy quadrants and provides a visibility and control mechanism enabling carbon reduction at each step in the construction process. We face significant challenges in tackling climate change with buildings 'generating' 39% of annual global CO2 emissions. To address this, we need a workforce with suitable digital skills to reduce the embodied and operational carbon footprint in the sector."

Energy savings achieved through the building operation stage are monitored and managed on a continuous basis with lessons learned fed back to design teams for future projects. The practicality of implementing BIM is evident as it assists performance management through effective data management in building operations by supporting the interlinking of data environments (for example through BIM-supported energy management system of buildings). Effective energy management reduces the energy consumed while also maintaining occupants' health, safety and comfort conditions.

BIM is utilised to improve existing processes aimed towards sustainable use of energy. Smart buildings and smart buildings' usage are combined. Digital sensors and their monitoring platforms are connected to the building's BIM digital model, the Asset Information Model. The engagement of wider public stakeholders (occupants and users) into a standard action of improving buildings' energy performance is essential. Occupant behaviour and lifestyle choices in otherwise identical homes can vary energy performance by a factor of two or three times. Thus, education of building users and the further development of positive reinforcement interventions are essential to achieving the goals that BIM creates a platform to achieve.

4. Sustainable energy targeted during the end-of-life

Operate – Sustainable energy

Closing the energy circle and addressing the Sustainable Energy quadrant, Michael Curran, Chairman, CIBSE Ireland and Head of Building Services, Energy & Utilities, NUIG said: "In NUI Galway we value our campus as a 'living lab' that allows our students, researchers and staff to develop new technologies and ideas, mechanically and digitally, to help us achieve our ambitious carbon reduction targets. This will be achieved by using BIM tools, giving us better asset management, preventive maintenance scheduling, efficient use of energy, retrofits, reconstruction and renovation. It will also facilitate the enhancement of lifecyle management, allowing us to meet the targets set by our campus community.

Michael demonstrated that the four quadrants were inextricably linked in addressing the energy challenges in construction. He highlighted that, in connection, all four quadrants can be addressed using BIM as the common language of construction, a method of enabling an easier way of achieving energy savings through the lifetime of the building.

Michael Curran

Smart decisions made in the early design stage of construction, including the selection of materials with high recyclability and least carbon footprint when demolished, are part of not only reducing the embedded energy content of a building (construction), but also making buildings more sustainable (re-use of materials).

BIM is the tool that will help close the loop of energy and materials in a building's lifecycle. *Finis coronat opus.*

Energy for demolition or recycle/reuse is a constitutive part of the lifecycle energy of a building and, although in less amount, can still have a significant contribution to overall environmental performance. All materials and products, especially those with high insulation properties, may require substantial energy and carbon effects for recycling or disposal. EPDs (environmental product declarations) of building envelope materials are incorporated as non-graphical information in the BIM model and used by various stakeholders and professionals in the supply chain.

In the near future, BIM models (with the help of AI prediction) will integrate the future use and re-use of buildings into design. This will facilitate the easier change of use and refurbishment processes while reducing the energy requirements for demolition and the materials used in connection with new builds so that true circularity can be achieved.

A huge amount of building stock is already available globally. BIM can be used to analyse and find effective, sustainable and feasible ways to re-use those buildings, reducing the need for new builds. Simulation of energy performance using digital technology – BIM models and simulation – can further help justify sustainability-focused decision-making. BIM provides accessible, spatially-connected and easy-to -visualise data, including on the effectiveness of renewable energy systems, convincing the most sceptical and enabling further improvement and implementation towards our sustainable future.

Conclusion

Paul McCormack, Innovation Manager with Belfast Metropolitan College and the ARISE Project Co-ordinator, summarised the session stating: "BIM is the language of construction. With BIM we now have a digital tool that encompasses the entire built environment while enabling all operators to communicate effectively on a global basis.

"In the past, the different sections of the sector did not, or could not, communicate fully because of obstacles including different operational standards, language and geography. As a result of this, there were design/performance gaps resulting in poor performance and energy standards. BIM provides all of those operating within the four sectors of construction – Plan, Design, Build and Operate – with a platform within which to work in cohesion, communicate effectively and, as a result, achieve control over the four energy quadrants – Potential, Embedded, Operational and Sustainable.

For the first time in the built environment, we now have the tools to integrate all parts of the construction cycle, maximise energy savings and really control the C02 emissions of construction."

As we move forward, there is a need for construction techniques, policy formulation and policy implementation to be integrated into a balanced and coherent system delivering sustainability across the entire construction supply chain. In the EU's *Energy Roadmap 2050,* BIM is the most effective supportive technology for sustainable energy, reducing carbon footprint and increasing the energy efficiency in the construction sector.

Eamon Sheils at the podium with (seated) Alan Hore, Michael Earley, Joseph Mady, Avril Behan and Michael Curran.

BIM is a tool. It is one of the key enablers while the digital environment is the medium. It is the people who can make and implement the change. A tool is only as good as its operator.

Considering the importance of digitalisation, BIM is the new *modus operandi* of the AEC industry. It is the key method to help the industry achieve the energy efficiency and de-carbonisation targets required to tackle the existing threat of climate change. Upskilling the industry professionals operating in this new reality is paramount.

How do we facilitate this upskilling? The ARISE project (https://www.ariseproject.eu/) is developing a learning framework and associated materials based on a "system thinking approach" that will deliver better results in energy efficiency than traditional methods. This is a holistic methodological approach, based on training the industry from the ground up and including:

- BIM awareness and impact on AEC industry efficiency and benefits;
- The principles of BIM collaboration to help the various stakeholders to become less fragmented;
- Essential IT and digital skills to integrate professionals in this digital framework (especially blue collars);
- More specific subjects aimed at specific construction roles, pairing BIM skills with role requirements such as 3D modelling, 3D authoring for designers and 6D BIM simulation for designers, 4D BIM for contractors, project managers, etc.
- All the training and subjects are encompassed and interlinked within a sustainable environmental approach and context.

Training is broken down into bite-sized information, in order to facilitate progressive upskilling of the industry, across all sectors. It is delivered via blended methods, further facilitating the adoption by professionals and SMEs that operate in an already time- and budget-constrained context.

ARISE is ensuring that the construction sector has the data and tools required to operate in a more "informed" manner to optimise construction through comprehensive deployment of sustainable energy skills. ■

References

1. United Nations Environment Programme, accessed 12th July 2019.