Sustainable Facilities Management through Building Information Modelling

Giulia Carbonari
University of Greenwich
G.Carbonari@greenwich.ac.uk
Telephone +442083319108

Prof. Keith Jones
University of Greenwich
K.G.Jones@greenwich.ac.uk

ABSTRACT

Building Information Modelling (BIM) is an approach to improving the efficiency of the building process and potentially providing the key data set needed by facilities managers to operate buildings in a more sustainable manner. Whilst the design/construction phase of BIM is well advanced, the facilities management phase is not. Although attempts to develop similar facilities management models have been tried before, they have failed because of the complexity of data analysis and the inadequacies of the available computing technologies. However, the BIM concept could overcome these problems and provide the basis for a new information model for sustainable building operation and management. This paper will present the initial stages of a three-year project to develop a BIM solution to support the sustainable facilities management of a multiuse commercial building. The paper summarises the theoretical application of BIM to facilities management and presents the results of a small questionnaire survey and stakeholder workshop to ascertain facilities managers understanding of, an attitudes towards, BIM. The paper concludes that, whilst BIM isn't currently widely used by facilities managers, they are aware of its development and its potential applications in facilities management. The paper also concludes that facilities managers generally perceive BIM to be a potential facilitator to their work rather than an inhibitor.

Keywords

Facilities Management, Sustainability, BIM

1. INTRODUCTION

In 2011, the UK business sector was responsible for approximately 174 Mt of CO_2 (28.5% of the UK's total) emissions (DECC, 2013), the vast majority of which resulted from the consumption of energy to provide space heating/cooling, lighting and other support services. Achieving a reduction in CO_2 emissions in line with UK targets (80% by 2050) will require buildings to perform much more efficiently. Whilst improved energy performance of new buildings can be driven through green certification or changes to Building Regulations, the same instruments cannot easily be applied to existing buildings. Given the current rate of new building in the UK Commercial Building sector it is estimated that approximately 75% of the buildings that will

exist in 2050 have already been built (Ravetz, 2008). Thus reducing the energy consumption from commercial buildings by 2050 will have to come primarily from extensive fabric retrofits to existing buildings; through more efficient operation of buildings; or a combination of both. This paper will focus on the improving the operational performance of commercial buildings.

The performance of many buildings in use does not match their design expectations. Whilst some of the problems may be associated with poor commissioning or inappropriate design, others are attributed to a lack of understanding of how people actually use the buildings they occupy (Zieler et al, 2014) or the links between organisational structure, occupant behaviour and the energy-efficient design strategy (Christina et al, 2014). A study of green buildings in New Zealand identified the importance of the facilities manager in setting energy performance strategies and the need for improved operational level management tools to ensure the building's energy-efficient performance in use (Zieler et al, 2014). This paper will examine the extent to which building information modelling (BIM) can provide the platform for the development of improved facilities management models and tools.

Currently BIM comprise a set of tools that allow the implications of alternative building solutions to be evaluated prior to their adoption. The system effectively comprises a virtual model of a building which designers, constructors and clients can manipulate to explore a wider range of design solutions beyond those that would typically be available through CAD alone. Whilst BIM is currently being used at the design and construction phase of the building life cycle it has the potential to transform building operation and management through the provision of real time feedback on the performance of the building in use. Further, if building user attributes can be integrated into the BIM system this will allow occupant behaviour to be modelled in a way that informs facilities management solutions.

This paper summarizes the initial phase of a study of how BIM could be used by facilities manager to operate buildings in more a sustainable way. The paper presents an analysis of the literature and identifies theoretical relationships between facilities management, sustainability and BIM. The paper also highlights potential barriers to BIM implementation and presents the findings from a small questionnaire survey that examined attitudes towards BIM amongst facilities managers. The paper suggests that BIM could become an enabling tool which facilities managers could use to support the sustainable management of buildings

2. SUSTAINABLE BUILDINGS

Whilst there are numerous definitions of sustainability development, most of them embody the concept offered by Brundtland (1987) that "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs". In applying this principle built environment professionals generally seek to find a balance between the impact a building has on the environment, the benefit that the building brings to society and the economic cost to the owner/occupier. To this end the Counseil

International du Batiment (CIB) defined the goal of sustainable construction as "…creating and operating a healthy built environment based on resource efficiency and ecological design" (Kibert, 1994) and identified seven principles of sustainable construction: reduce resource consumption; reuse resources; use recyclable resources; protect nature; eliminate toxins; apply life-cycle costing; and focus on quality, which should drive every phase of the building life cycle. In recent years different countries have developed green building certification systems (e.g. BREEAM, LEED, DGNB etc.) that seek to ensure design and construction addresses the sustainability principles and, whilst these systems are beginning to have an impact on new buildings, they are not yet routinely applied to existing buildings. It is these buildings that pose a major challenge to both policy makers and built environment professionals as they seek to deliver a more sustainable built environment.

Whilst sustainability covers a wide range of issues, climate change, and by association energy use and CO_2 emissions, are currently perceived as the most critical issue that society needs to address. Adaptation of the existing built environment to meet changed weather patterns associated with inevitable climate change; and mitigation of future climate change through CO_2 reduction targets are forcing built environment professionals to re-examine their approach to building management (Desai and Jones, 2012). Whilst considerable attention has been paid to reducing CO_2 emissions from domestic buildings, very little research has focussed on understanding the drivers of energy use in commercial buildings. Indeed, one of the major challenges facing facilities managers is to develop whole-life performance models that draw information from building performance monitoring systems linked to integrated databases that allow a building to be managed in a sustainable manner (Ravetz, 2008).

3. SUSTAINABLE FACILITIES MANAGEMENT

Businesses address energy use and CO_2 reduction through their sustainable facilities management (SFM) strategy which integrates the operation of buildings (physical, technical, human and support systems) with the primary business objectives of the organisation. Regular monitoring of energy consumption informs adaptation; long term strategic objectives, linked to corporate social responsibility and primary business strategies drive mitigation (Desai et al, 2012). Adaptation and mitigation are also informed by the policy framework in which the business operates. Facilities managers, architects, engineers, building owners and users are responsible for assessing options, developing solutions and overseeing their implementation. However, whilst the broad principles that underpin a SFM strategy are known, it is less clear how such a strategy should be developed or implemented.

Facility managers need to develop sustainable solutions that integrate people, place, technology, products, values and services together to achieve a more sustainable operating environment (Lee and Kang, 2013). Facilities managers also need to provide an "umbrella" service that ensures any new sustainable (e.g. energy, water, waste management etc) ways of working do not adversely affect the ability of primary business units to effectively perform their primary function (Nielsen et al, 2009). The components of a successful SFM strategy were investigated in the BIFM sustainability survey (2013). The survey identified health and safety, waste management and

energy management, together with staff wellbeing and achieving KPIs as the most important aspects of a SFM strategy. The BIFM study also confirmed the generally held view that legislation/regulation, corporate image and organisational ethos were the main drivers behind the successful implementation of sustainability practices.

Finally facilities mangers shave to be aware of the role that end-users play in the performance of buildings in use (Azizi et al, 2014). In particular facilities managers need to consider the comfort of occupants in any energy management strategy (Hodges, 2005) and integrate individual user's behaviour (through user-centred approaches) into energy control systems to optimize a buildings energy performance in use (Zieler et al, 2014; Christina et al, 2014). If organizational, operational and end-user data can be effectively integrated into BIM then facilities managers could have a very powerful tool to help them manage their buildings more sustainably.

4. CAD and BIM

Technology has played an integral role in the construction industry for the past 40 years. In 1973 the first 3D design tools were produced that allowed designers to create, manipulate and edit solid 3D models of building entities (Eastman et al. 2011). In the early 80s 3D modelling morphed into the first Computer Aided Design (CAD) systems that linked digital designs to construction documents and facilitated the first real-time electronic communication between the different stakeholders involved in a construction project (Day 2002). In the early 1990s object-oriented CAD (OOCAD) was developed which linked building graphics with non-graphical data about common building elements (e.g. doors, walls, windows etc.) thus simplifying building section drawings (Autodesk, 2002). The latest technological evolution that the industry has faced is the development of BIM. In BIM both the technical and functional aspects of a building element (e.g. materials, quantities, suppliers, warranties and maintenance procedures) are stored as attributes of a "smart" building object. This said, BIM is much more sophisticated than a collection of smart objects suggests.

In 2008, Mervyn Richards and Mark Bew developed the BIM Maturity Diagram (Figure 1) in an attempt to explain the tools and techniques that are available or envisaged at the different levels and stages of BIM implementation. Level 0 BIM is effectively unmanaged CAD with minimal automated data exchange. Level 1 BIM envisages a managed environment where 2D or 3D CAD drawings provide a common data environment that has (ideally) standard data structures and formats but which supports little integration outside the dedicated application. Level 2 BIM seeks to integrate the 3D CAD environment with external tools and data that support time based scheduling and costing information. The relationship between data is generally managed through an enterprise resource planning system. Essentially this level is a practical realisation of the OOCAD models developed in the 1990s and is what the UK Government will require from all publically funded projects from 2016. Level 3 BIM envisages a fully open process where data integration between applications is managed by a collaborative model server. Level 3 BIM (iBIM or Integrated BIM) also extends the modelling regime into lifecycle management (potentially Level 4 BIM - Intelligent BIM) and it is at this phase that the facilities manager

could potentially use BIM to better manage the operation of a building. However, if this is to be achieved new tools and models need to be developed that allow the facilities manager to draw on the information contained in the BIM hub. The hub will also need to contain operational specific data (non-building data) that facilities managers need to make strategic and operational decisions.

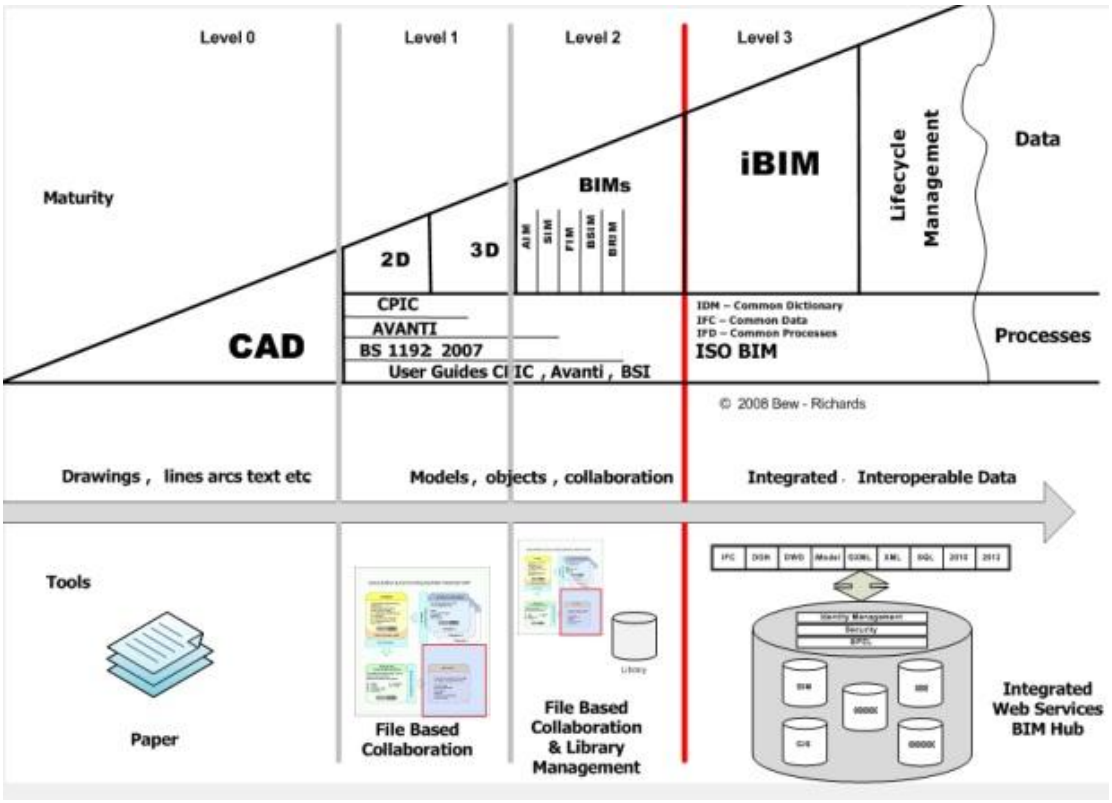

Figure 1 BIM Maturity Diagram

Source:http://www.bimtaskgroup.org/wp-content/uploads/2012/03/BIS-BIM-strategy-Report.pdf

5. LINKING BIM TO FACILITIES MANAGEMENT

Although the benefits of BIM are already being realised at the design and construction phase of the building life cycle, very few studies have examined it potential application at the operation and maintenance phase.

One of the few buildings that have implemented BIM for facilities management is the Sydney Opera House. An analysis of the advantages of BIM (CRC Construction Innovation, 2007) identified: consistency of data; intelligence of the model; multiple representations (2D and 3D); operational reports; an integrated source of information for third party software applications; and

integrated queries for data mining to support what-if scenarios as those attributes that would be most useful to the facility manager. Of these,

Consistency of data: is probably the most immediate useful attribute of a BIM FM model. Having a digital model that contains not only an accurate representation of the building "as-built" but also includes all the associated design, installation, commissioning, certification, operation, and management documentation should enable better maintenance management decisions to be reached and ultimately could support just-in-time maintenance planning along similar lines to that used in the automotive and aerospace industries. Such a BIM could also contain data on portable assets, including guarantees and maintenances instructions etc., which should in turn support routine inspection and statutory compliance testing and reporting using *third party software*.

An intelligent FM BIM could also support *data mining of what-if scenarios*. The ability to drill down through data to establish performance patterns across temporal and spatial domains is something that would allow facilities managers to identify recurrent faults in psychical systems or underperformance across building attributes (e.g. space usage etc.). Further, if the BIM also gathered information about the *operation* (performance) of the building in use (e.g. energy use of buildings) it would allow facilities managers to better understand the buildings they were managing and would allow them to develop and test alternative operational interventions through *intelligent modelling applications.* Attaching intelligence to spaces within a BIM would allow alternate space management strategies to be evaluated and attaching end-user feedback would allow user behaviour to be integrated into building performance modelling. The examples given above are all consistent with the theory of integrated logistic support and through life business modelling applied to the sustainable management of building services outlined by John et al (2005).

However, whilst BIM could offer the facilities manager many potential benefits; are facilities managers ready for BIM solutions? or is BIM another example of a solution looking for a problem?

6. RESULTS OF THE QUESTIONNAIRE SURVEY AND BIM FM WORKSHOP

In order to understand how facilities managers are responding to the development of BIM a questionnaire survey was distributed to facilities mangers existing web base platforms. The questionnaire sought to identify the current level of use of BIM FM and to identify those aspects of BIM FM that were thought to be most useful to the profession at this time. The questionnaire contained contextual questions about the experience of the person completing the survey; the size of the organisation they worked for; the FM software that they used; their approach to building management (including gathering user feedback); and their use (or intention to use) BIM. The questionnaire was available for 40 days online between September and October 2013 through specialized groups on LinkedIn (BIM" Construction Informatics, Sustainability &

Green Building; BIM Experts; British Institute of Facilities Management; Facilities Management Association; Facilities Management Group; Facilities Management Professionals UK; Facility Management Knowledge Forum; Facility Management made in Italy; Royal Institution of Chartered Surveyors). Eighty four responses were received of which 55 were partially complete and 29 were fully complete.

The questionnaire was accessible from all over the world and responses were received from several countries: the largest numbers were the United Kingdom (30 responses) and United States (18) and Italy (16 responses). Approximately 37% of the respondents were Facilities Managers, 15% Directors, 7% Project Managers and 7% Property Managers. All respondents had several years' experience in their field.

Most respondents (56%) routinely used facilities management software to help them manage their buildings. Software used ranged from central CAD systems through bespoke building maintenance systems to mobile devices. However, the majority of respondents (72%) didn't use BIM software. Further, those respondents who had used BIM had only used it for design and construction, and not for facilities management. Among those who don't currently use BIM, 36% of respondents indicated that BIM will be used in future, both to remain competitive for public bids and to satisfy the UK Government Soft Landings 2016 requirements.

To the question "which facilities management tasks can be assisted by using BIM?" respondents mainly concentrated on the strategic and building perspective: creating accurate description of the assets; developing preventative maintenance schedules; and tracking and maintaining lifecycle information about the building structure were identified as being the most useful (Figure 2). In addition to the predefined options to this question, respondents also listed other benefits in free text form. These included: commissioning and retro-commissioning activities; energy modelling; future remodelling; additions; expansions and replacement of systems at end of life; adequate preparation on maintenance activities; providing bill-of-quantities information on which to base maintenance investments; sustainability performance; and comments and advice on design. The answers to this question suggest that, although BIM isn't being widely used at present, there is a level of understanding and clear identification of potential applications that suggest that the facilities management profession are aware of BIM and of its potential to facilities management.

Although the majority of respondents perceived BIM as a facilitator rather than a hindrance for their job, there were concerns associated with the integration of BIM with existing technology and CAFM systems; and with the potential implementation costs and training (Figure 3).

Respondents were also asked how they thought BIM would affect their day-to-day work. Here respondents were equally divided between those who didn't think there would be substantial changes to their working practices (beyond reducing errors and improving efficiency) and those who did (more protocols and processes and longer work tracks). Finally, almost all the respondents believed that BIM will act as a facilitator, rather than an inhibitor to their work.

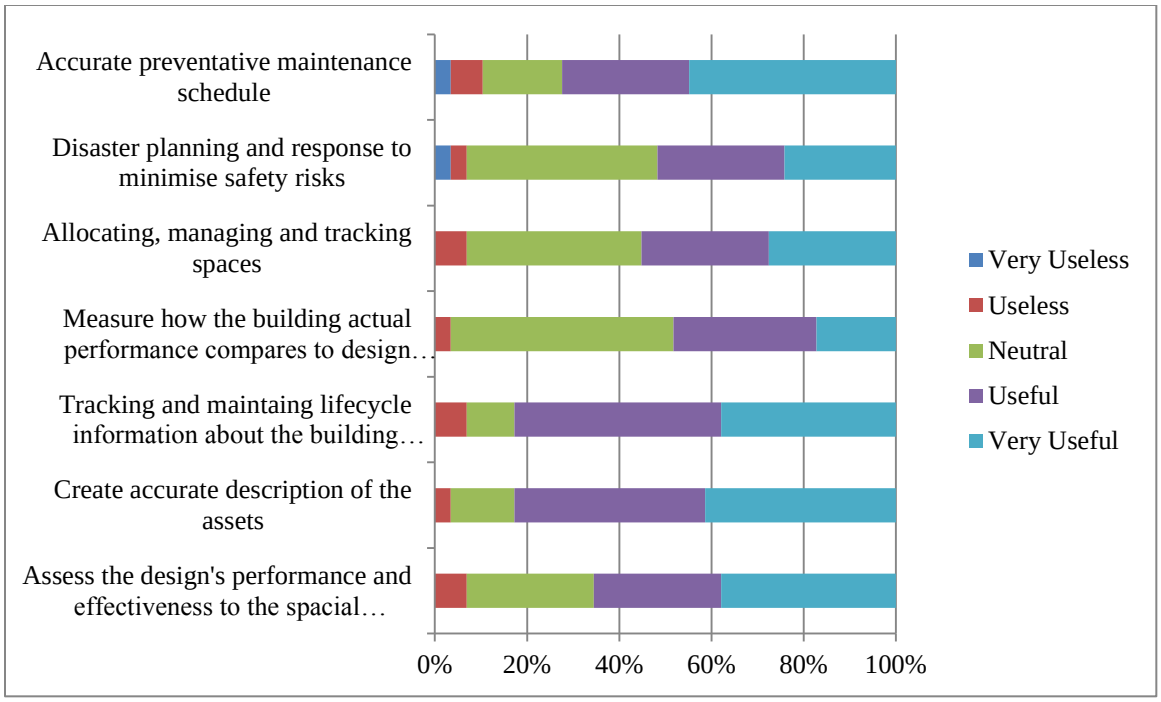

Figure 2 Evaluation of potential BIM benefits

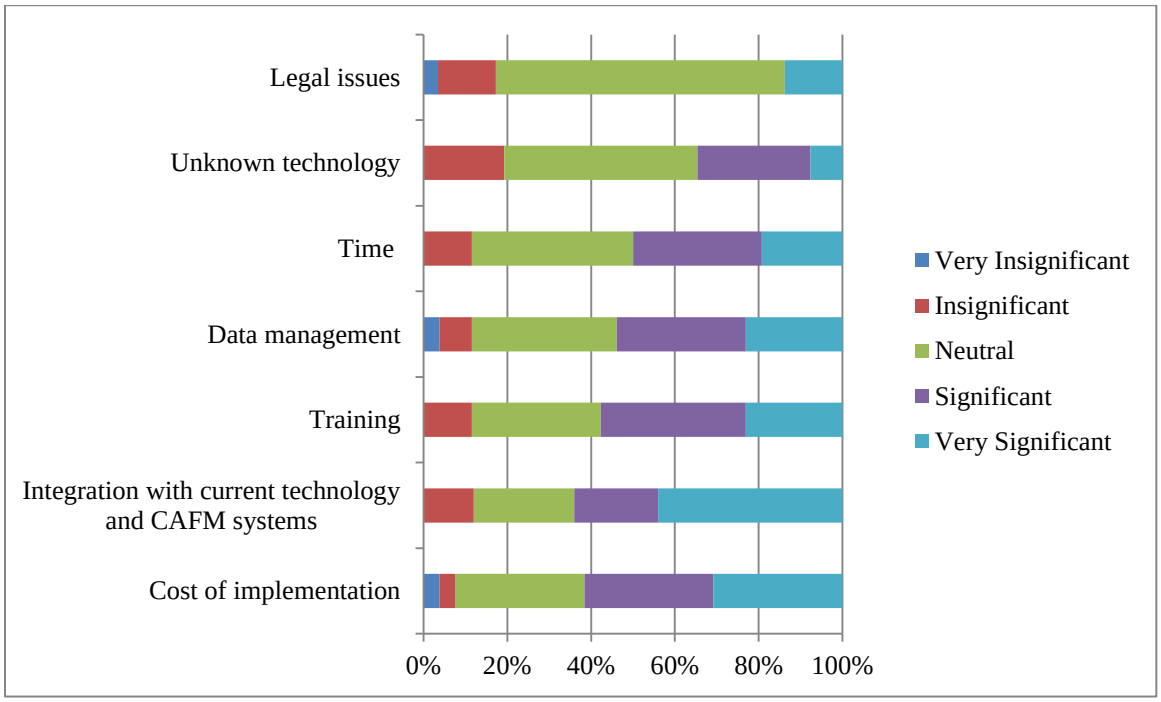

Figure 3 Evaluation of BIM concerns

A one day stakeholder workshop was held in January 2014 to explore practical problems associated with integrating BIM into FM services and to identify gaps in knowledge that need to be addressed. Attendance at the workshop was by invitation only and the audience was pre-selected to represent a knowledgeable (expert) and diverse stakeholder group representing FM service providers, clients, academia, UK Government, professional bodies and FM contractors. The meeting was held under "Chatham House Rules". Twenty two people attended the workshop. Whilst the workshop confirmed many of the findings of the questionnaire survey (the potential, focus and practical issues associated with developing BIM FM solutions) it also identified the need to develop new tools and models that: address soft services; accommodates cultural and behavioural characteristics; are responsive to changes in business strategy (in particular the sustainability agenda); and can demonstrate added value to core business if BIM FM is to really have an impact on the facilities managers perform their functions. The challenge of developing these tools and models forms the next phase of the current research project.

7. CONCLUSIONS

The results from the questionnaire addressed the potential acceptance of BIM by facilities managers. Respondents were generally aware of the topic and perceived BIM as a potentially useful tool for their work. Despite some doubts on how it could be integrated with existing CAFM software, and issues around training, facilities managers seem to be ready for its arrival and aware of its potential benefits to their work. The results of the questionnaire also confirm the range of potential applications that BIM FM could address, which include energy management and sustainability issues alongside the more obvious building management applications. In essence the questionnaire would seem to suggest that facilities managers are ready for the hand-over of Level 2 BIM models that will be generated over the next few years and, whilst they are unsure about how these models will be integrated with their existing systems, they do believe that these models will help them better manage the building. What were less certain from the questionnaire were attitudes toward Level 3 BIM. Whilst some respondents were aware of the potential of BIM to support whole life-cycle modelling, and the ability to integrate soft facilities management services into the model, the majority were not. This conclusion was reinforced in the stakeholder workshop where the need to develop new tools and models that supported integrated FM solutions (both hard and soft) was identified. The expert stakeholder group believed that the potential of BIM to provide facilities managers with an accurate "smart" model of their buildings will provide the basis for better building performance monitoring and control. The group also recognised that to realise this potential will require user behaviour to be modelled and integrated into BIM. This will be particularly relevant if BIM FM is to support sustainable facilities management. The next phase of this project will be to develop and test a series of BIM FM solutions to support the sustainable facilities management.

REFERENCES

Autodesk (2002). 'Building Information Modelling'. Available online: http://images.autodesk.com/apac_sapac_main/files/4525081_BIM_WP_Rev5.pdf (Accessed 20 Feb 2014)

Azizi, N., S., M, Wilkinson, S. and Fassman, E. (2014) 'Management practice to achieve energy-efficient performance of green buildings in New Zealand', Architectural Engineering and Design Management, Volume 10, Issue 1-2, pp 25-39

British Institute of Facilities Management (2013). 'Sustainability in Facilities Management' Report. Available online: http://www.sustainabilityinfm.org.uk/resources (Accessed 20 Feb 2014)

Brundtland, G., H. (1987) 'Our Common Future', Oxford University Press.

Christina, S., Dainty, A., Daniels, K. and Waterson P. (2014) 'How organisational behaviour and attitudes can impact building energy use in the UK retail environment: a theoretical framework', Architectural Engineering and Design Management, Volume 10, Issue 1-2, pp 164-179)

CRC Construction Innovation (2007) 'Adopting BIM for facilities management Solutions for managing the Sidney Opera House'. Available online: http://www.construction-innovation.info/images/CRC_Dig_Model_Book_20070402_v2.pdf (Accessed 20 Feb 2014)

Day, M. (2002). 'Intelligent Architectural Modelling'. AEC Magazine. September 2002. June 27, 2007

DECC (2013) ' Statistical Release - 2012 UK Greenhouse Gas Emissions, Provisional Figures and 2011 UK Greenhouse Gas Emissions, Final Figures by Fuel Type and End-user', Available online: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/193414/280313_ghg_national_statistics_release_2012_provisional.pdf (Accessed 20 Feb 2014)

Desai, A. & Jones, K. G. (2012) 'Facilities Manager's attitudes towards adaptation and mitigation', CIB W70 International Conference of Facilities Management, Cape Town.

Eastman, C., Teicholz, P. Sacks, R. and Liston, K. (2011). 'BIM Handbook: A Guide to Building Information Modelling for Owners, Managers, Designers, Engineers and Contractors'. 2nd ed. Hobeken, New Jersey, John Wiley & Sons.

Hodges, C.P. (2005). 'A facility manager's approach to sustainability'. Journal of Facilities Management. 3 (4), pp 312-324

John G., Loy H., Clements-Croome D., Fairey V. and Neale K. (2005) 'Contextual Prerequisites for the Application of ILS Principles to the Building Services Industry', Journal of Engineering, Construction and Architectural Management. Vol 12(4) pp 307-328.

Kibert, C. J. (1994) "Principles and a Model of Sustainable Construction" in Proceedings of the First International Conference on Sustainable Construction, 6 – 9 November 1994, Tampa, Florida, pp 1 – 9

Lee, S.Y. and Kang, M. (2013). 'Innovation characteristics and intention to adopt sustainable facilities management practices'. Ergonomics. 56 (3), 480-491

Nielsen, S.B., Jensen, J.O. and Jensen, P.A. (2009). 'Delivering Sustainable Facilities Management in Danish Housing Estates'. Proceedings of the CIMNE 2009 international conference on Sustainability Measurement and Modelling, Barcelona, Spain.

Ravetx, J. (2008) 'State of the Stock – What do we know about existing buildings and their future prospects?', Energy Policy, Vol 36, pp4462-4470

Zeiler, W., Vissers, D., Maaijen, R. and Boxem, G. (2014) 'Occupants' behavioural impact on energy consumption: 'human-in-the-loop' comfort process control', Architectural Engineering and Design Management, Volume 10, Issue 1-2, pp 108-130.