Zurich, June 15-17 2016
Sustainable Built Environment (SBE) Regional Conference

Expanding Boundaries:
Systems Thinking for the Built Environment

INCREASE THE EFFICIENCY IN SUSTAINABLE CONSTRUCTION USING BIM

Carsten K. Druhmann[1]*, Simon Ashworth[2], Heinz J. Bernegger[2]

[1,2] Institute of Facility Management, ZHAW School of Life Sciences and Facility Management, Grüental, P.O. Box, 8820 Wädenswil, Switzerland

*Corresponding author; e-mail: carsten.druhmann@zhaw.ch

Abstract

The assessment of the degree of sustainability (environmental, social and economic) of real estate assets became possible through the development of standards and certification schemes. Clear defined criteria and indicators enable sustainability assessments to be made. Parametric 3D-building models provide the ideal starting point for analysis of buildings in terms of their sustainability with respect to many different aspects which can influence a buildings sustainability: energy consumption, operating efficiency, environmentally friendly building materials, flexibility of use, life cycle costs. This paper presents the results and challenges of a pre-project in the form of a tested workflow of a smart BIM-based rating system using an example from the Swiss Standard for Sustainable Building Switzerland (SNBS) and the international DGNB (Adapted for Switzerland) systems. Furthermore, a concept for a generic assessment platform is outlined which is able to convert the results of a parametric 3D-building model for use by the desired label and thus to attain the respective certification with much less effort.

Keywords:

Facility Management (FM); Sustainability Assessment Systems; Building Information Modellinganagement (BIM); Planning and construction accompanying Facility Management (pcFM); Life Cycle Management (LCM)

1 INTRODUCTION

1.1 The need for proving sustainability

There is a global consensus that the built environment needs to create more sustainable buildings and minimize their impact on the environment. With increasing concerns regarding global warming this has become an urgent requirement. Sustainable buildings are vitally important not only from an environmental perspective. Research by [4], considered different studies which conclude that improving buildings' energy performance leads to economic savings up to 30% which means that energy efficiency, as a part of sustainability, is not only ecologically, but also profitable. Such research has led to many corporates and investors having a special interest in using and investing in sustainable buildings [3].

This resulted in the recent past in an increased demand for demonstrably sustainable buildings in Switzerland. Numerous investors reported to the authors, that they have enough capital to invest in sustainable buildings, however they report the market for sustainable buildings is very limited. This meant that investors have begun increasingly to order sustainable buildings.

This led to two further questions: "How can investors order a sustainable building?" and "How can the designs be monitored and evaluated to prove the designs are achieving the desired level of sustainability and is it possible to incorporate optimization early during the planning phase?" The market shows that numerous sustainability rating systems are available. Which offer investors the opportunity to order the buildings to meet a specified sustainability quality level (e. g. DGNB Platinum). However, what is not so clearly established is a process that shows investors how they can understand the sustainability outcomes during the planning and construction phase and get involved continuously (e. g. in individual exemplary decisions). Through the

G. Habert, A. Schlueter (eds.): Expanding Boundaries © 2016 vdf Hochschulverlag AG an der ETH Zürich
DOI 10.3218/3774-6_94, ISBN 978-3-7281-3774-6, http://vdf.ch/expanding-boundaries.html

paradigm shift towards BIM new possibilities are opening up.

1.2 How BIM can help with sustainable building design

In short BIM is an integrated, software-based process which uses virtual representations of buildings and infrastructure etc. throughout the whole lifecycle [e. g. 8]. BIM has the potential to contribute to the design, construction and commissioning of buildings, helping to achieve lower environmental impacts. This could be through increased energy efficiency, reduced CO2 emissions, less material consumption, or improved usability and optimising of the buildings by Facility Managers in the operational phase.

It is critical to understand BIM not just as a 3D-Tool but as a process which leads to enriched additional asset information and enables better and more accurate analysis and evaluations of the building to be carried out in the design phase. This might include daylighting and solar studies, material and product libraries containing embodied energy and Life Cycle Assessment (LCA) and Life Cycle Costing information, as well as deconstruction, maintenance and building management information for the entire lifecycle of a building. BIM allows stakeholders to understand how a building is constructed in great detail and to have a better grasp of how the building should perform and later, how it might be taken apart. To achieve this, the required specialist consultants' resources have to be shifted to earlier stages in the design process. Once evaluation, analysis and compliance tools with links to BIM are created, different design options could be more easily compared. This should lead to better informed decision making at early stages, reducing the risk of abortive design or the bolting on of 'eco-design features' (which are inherently less cost-effective) in later stages [7].

With BIM and these other tools, access to automatically calculated and current design data can be created which will be useful for environmental issues, such as heat-loss analysis calculating floor and surface areas and volumes, improved logistics, flexibility and optimization of support processes. For an optimal effect, the process should be formally integrated with Building Performance Evaluation (BPE), and Post Occupancy Evaluations (POE). A good example of such a process is the Soft Landings framework initiated by the UK Government [2].

In summary, there are many reasons for BIM to be incorporated in the sustainable planning of buildings. Since BIM maturity in many countries is still in early to middle stages of adoption and implementation [5], there are hardly any workflows and procedures established that enable the interaction between sustainable design, construction and operation with BIM.

2 BIM-CONCEPT FOR AN EFFICIENT IMPLEMENTATION OF THE EVALUATION OF SUSTAINABILITY

The significant opportunity of BIM for sustainability assessment is the ability to do it in a smart way. This means to keep any extra effort as low as possible and to use the technology to address the increasingly complex interrelationships and not to let them slip out of focus, which often happens with manual actions.

The concept required a workflow to be developed which makes it possible, to verify compliance with a certain sustainability level during the planning phase in an efficient way. The concept is based on the criteria in the SNBS [6] and uses the internationally recognized and adapted to Switzerland DGNB rating system (Label Holder Switzerland: Swiss Green Building Council SGNI) [9]. The process assessment of a sustainable building addresses the specific information requirements for digital 3D-building models. This information can then be used to estimate the creation effort (existing functionality) and estimated programming effort (new features) and their implementation within software tools like a BIM model checker.

Sets of rules are then created for all assessment criteria on which information can/should be contained in the BIM model attributes (e.g. for obstacle-free building design, which could of course be used independently of any sustainability labelling). With these rule sets digital 3D building models (via IFC export) can be analysed and evaluated with respect to the criteria of sustainability. This provides (intermediate) results which can be used to optimize the design and also improve the models themselves (e.g. information content). The actual evaluation of the sustainability performance of the proposed building is done in a separate, rating/certification platform. In this analysis, the results of the model checker can be imported and rated with the underlying standard of SNBS, or the Swiss DGNB rating system (available for different types of use; operationalized for Swiss standards). Based on this result on the one hand, the design of the building can be optimized efficiently in terms of desired Level of Sustainability by the client (second element of the evaluation results). On the other hand, the label can be awarded in a cost-effective manner (if desired). The following figure visualizes the solution:

G. Habert, A. Schlueter (eds.): Expanding Boundaries © 2016 vdf Hochschulverlag AG an der ETH Zürich
DOI 10.3218/3774-6_94, ISBN 978-3-7281-3774-6, http://vdf.ch/expanding-boundaries.html

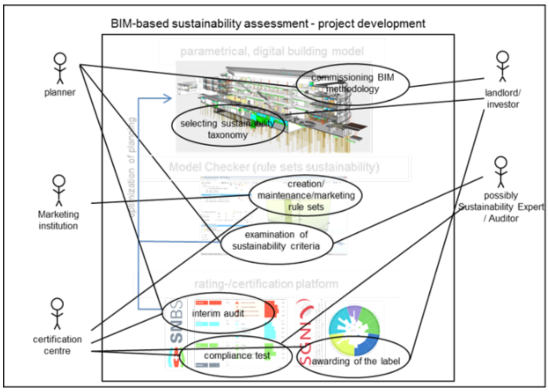

Fig. 1: BIM-based sustainability assessment - project development.

3 PRE-PROJECT FINDINGS AND RESULTS

3.1 Creating a model for testing

For the first test of the concept the authors dispensed with a current, real project for this time. Thus the requirement of a BIM for testing the various sustainability criteria can be better controlled. According to the Conceptual Process Model [1] - BIM process for existing buildings – a 3D building model of an occupied building was created (use: education and office use; ca. 3`500 m2 gross floor area) was created via Laser Scanning.

For the development of the model, appropriate criteria had to be established in advance which could be used with a model and the attributes for the exemplary sustainability impact assessment. The selected criteria were: "flexibility and conversion feasibility", "plan qualities" and "cleaning and maintenance friendliness of the building" (taken from the Swiss DGNB system).

3.2 Selection of tools

Finding the right tools for testing the workflow required considerable effort. The selection process focused on choosing software with IFC interoperability in order to be independent of a particular BIM software platform.

Based on market research on the internet four model checking programs were finally selected. The result of the search and the properties of each product are shown in Table 1.

name of product	manufacturer	description	source
BIM Review Essentials	BIMreview	tool for controlling projects allowing participants; to visualize and check models e. g. collisions etc.	www.bim-review.com
Navisworks	Autodesk	Tool for engineers and architects; to compare federalistic organized models e.g. to check collisions and distribute results between participants	www.autodesk.com
Solibri Model Checker	Solibri	tool for all project participants; rules based testing and analyzation; theoretically unlimited testing of model behavior	www.solibri.com
Tekla BIMSight	Tekla	for engineers and architects; to compare federalistic organized models e.g. to check collisions and distribute results between participants	www.teklabimsight.com

Tab. 1: market survey model checker (extraction).

Each tool was assessed and in order to evaluate the programs on the shortlist for their suitability for the sustainability impact assessment. The Solibri Model Checker was selected as the most appropriate software to consider mainly because of its capability to work with rule sets [10], which provides several options for model testing and data export.

Within this test phase the requirements for data import and results were formulated coming from the model testing. The programming of the rating/certification platform will be part of an upcoming R&D project at the IFM.

3.3 Testing the workflow

Using the example of the criteria "flexibility and conversion capacity" (Swiss DGNB System) seven indicators have to be analysed in more detail: area efficiency, height of ceilings, building depth, vertical access, floor plan distribution, construction and technical building equipment. Each indicator is based on geometric values of the building. The check carried out by the Model Checker provided excellent results and even allowed playing back the results achieved in accordance with the evaluation system for use in the planning process. The Model Checker provides good support to the achievement of sustainability goals. However, due to missing sub-models the criteria “building equipment” and the “quality of use areas” could not be fully tested.

During the test, the three selected evaluation criteria (see 3.1) were found that the results of the sustainability assessment stand or fall with the quality of parametric 3D building models. Is the model, for example, not built storey by storey and each plot well drawn and attributed, no testing was possible [11].

4 CONCLUSIONS

Looking at the sustainability evaluation systems, it is clear that not all criteria are available out of a BIM-(workflow), as we know it today. This means that the rating/certification platform has to have the capability to read the rest of the information from other sources, otherwise input by hand is necessary. While single criteria/indicators of sustainability rating systems (preferably geometry-based) can be examined and evaluated in an efficient way from a BIM model, many criteria can be evaluated not only by using BIM. To do so other tools have to be developed, e. g. a rating-/certification platform, which could create the achieved label as a by-product.

In order to realize in the future an efficient and meaningful BIM-based sustainability assessment, a requirement profile of the building model needs to be defined as a standard, so that the necessary tools can be specifically designed to make the assessments.

G. Habert, A. Schlueter (eds.): Expanding Boundaries © 2016 vdf Hochschulverlag AG an der ETH Zürich
DOI 10.3218/3774-6_94, ISBN 978-3-7281-3774-6, http://vdf.ch/expanding-boundaries.html

The next research and project steps are:

- create a catalogue of information requirements for sustainable construction of the desired standard, interpreted for implementation in BIM (e. g. Level of Development, LOD)
- define the flow of information between different systems (e.g. BIM software such as Vectorworks, ArchiCAD, Revit, Solibri model checker and the certification platforms)
- extend the model checker (new rule functions)
- create rule sets, which are formed according to Swiss standards and guidelines (e.g. obstacle-free building); which can then be used in any (BIM) – project, regardless of sustainability certification
- programming of an application for assessing the sustainability of buildings based on established certification systems (possibly SNBS, Swiss DGNB, LEED, BREEAM etc.)

5 ACKNOWLEDGMENTS

A special thanks goes to Christoph Kuster (Computer Works AG, Münchenstein) for providing a temporary license of Solibri ModelChecker and to Martin Wyss (MSc Student at IFM – ZHAW) for testing the software.

6 REFERENCES

1. Ashworth, S. & Druhmann, C. (2015). Integration of FM and asset management expertise in digital 3D building models. In: Journal für Facility Management: Wissenschaft trifft Praxis , 10, Vienna 2015, pp. 38-52.

2. BIM Task Group. BIM Task Group . [4. August 2014]. WWW: http://www.bimtaskgroup.org

3. CSR. CSR SUSTAINABILITY REPORT 2013 [online]. CSR Limited, 2013, [cit. 2015-11-25]. WWW: http://www.csr.com.au/Community-and-Sustainability/Sustainability/Documents/SustainabilityReport2013_Full.pdf

4. Dorta, N., Assef, P., Cantero, J. & Rufino, G. Implementing BIM techniques for energy analysis: A case study of buildings at University of La Laguna. Environmental Security, Geological Hazards and Management, 2013. Spain. pp. 61-67.

5. Kassem, M., Succar, B., & Dawood, N. Building Information Modeling: analyzing noteworthy publications of eight countries using a knowledge content taxonomy. In: R. Issa & S. Olbina (Eds.), Building Information Modeling: applications and practices in the AEC industry, ASCE Technical Council on Computing and IT. University of Florida, 2013.

6. NNBS. Sustainable Construction Network Switzerland. Bern, 2015. [01.12.2015]. WWW: www.nnbs.ch

7. Pelsmakers, S. BIM and its potential to support sustainable building. RIBA Enterprises Ltd, 2013. [cit. 2015-11-25] WWW: http://www.thenbs.com/topics/bim/articles/bimPotentialSupportSustainableBuilding.asp

8. Pellekoorne, P.-G. Analyse der BIM-Software Autodesk Revit 2013 anhand der Modellierung eines Gebäudes der Technischen Universität München. Munic 2012.

9. SGNI. Schweizer Gesellschaft für nachhaltige Immobilienwirtschaft – Swiss Green Building Council. Zurich, 2015. [03.12.2015]. WWW: www.sgni.ch

10. Solibri Inc. (2015). Solibri. Abgerufen am 03. 06 2015 von http://www.solibri.com/de/1.

11. Wyss, M. (2015). Effiziente Nachhaltigkeitsbewertung in BIM-basierten Planungs- und Bauprozessen. [Unpublished Bachelor's thesis]. Institute for Facility Management ZHAW, Zurich Switzerland.

DOI 10.3218/3774-6_94, ISBN 978-3-7281-3774-6, http://vdf.ch/expanding-boundaries.html