Sustainable Building Alliance

Linking SBA metrics to IFCs and BIM

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Executive Summary

The BIM (Building Information Modelling) approach consists in setting up a kind of "central repository" that can manage the whole building and project information for the entire life cycle of the facility. The exchanges with this BIM can be made using a common open format which is the IFC (ISO standard). The IFCs are supporting different kinds of information (i.e. Architecture design, HVAC description, Thermal analysis, etc.) and therefore the main asset of the BIM approach is to be able to couple together different key players around the same model and the same data.

Regarding the SBA Core metrics, they are the result of different calculation processes coupling different kind of information. Among other, the information required to perform such calculations (Quantity Take Off, gross area, total numbers of building components) are most of the time already existing in BIM. Therefore, there is an obvious point trying to link Sustainable tools with BIM. On the other side of the process, after having performed a sustainable analysis, there is also a need to store the result in the BIM.

The research carried out in this study will address these particular points through the following studies:

- Explaining & mapping how the SBA metrics fit into Industry Foundation Class structures (how BIM/CAD tools can provide input data for LCA);
- Analysing different LCA modules integrated with commercial product model based building design software;
- Identifying and analysing what is expected to be delivered by the on-going EC projects in this domain (ICT support to Sustainable Assessment with a special attention to BIM oriented approaches).

The project consortium counts two organizations VTT (leader) and CSTB. It started in January 2011 and ended in December 2011. This document represents the final report of the conducted work.

IFCs of today are the result of a long work started in the 1990s and supported by the buildingSMART organisation (http://www.buildingsmart.com). One of the main goals of buildingSMART (through its Model Support Group) is to develop and maintain open international standards for Building Information Modelling (Open BIM). Thus a major output of buildingSMART is a common data schema that makes it possible to hold and exchange relevant data between different software applications. But there is still a need to provide with a better integration of external data sources, e.g. product libraries.

IFC classes or objects represent generic categories of element (e.g. wall, beam, space) with quite few attributes associated with a class to transfer information relevant to a manufacturer; IFCs incorporate a mechanism called Property Sets (PSets) which allow information publishers to dynamically allocate new properties to an object they wish to describe. Since there are numerous alphanumeric attribute definitions depending on discipline, life-cycle stage, building regulation and region, there will never be a complete set of internationally standardized attributes. Therefore, IFC defined property sets intent to standardize a basic set of properties, whereas other property sets can be regionally defined, or agreed upon in projects. The current drawback,

however, is that there is no specification of the semantics of PSet information outside that published in the IFC distribution (the buildingSMART Data Dictionary, formerly known as the International Framework for Dictionaries or IFD, seeks to provide a solution for this).

The current stable release of IFC specification (IFC2x3 TC1, 2007) enables the BIM/CAD tools to provide basic input data for LCA: the building model comprised of elements (e.g. wall, beam, space) with their geometry and materials; the environmental characteristics of the functional units (elements) still need to be set by the LCA tool (or its user) since these are not exchanged. Software tools utilising this to import BIM data already are available; these are most often used for energy simulation & analysis, but some tools also for thermal comfort and indoor air quality simulations with IFC import exist. This current version of IFCs, however, does not support capturing the results of the analysis in BIM as values of indicators as defined in SBA metrics. This shortcoming will be solved to large extent (with the exception of indoor environment quality) in the next IFC release IFC4, available as preview version (also known as IFC2x4 Release Candidate 3). The new version will also enable exchanging environmental characteristics by means of environmental indicators. These are both added as Property Sets:

"**Pset_EnvironmentalImpactIndicators**" that captures the characteristics of the functional unit by means of environmental indicators, and

"**Pset_EnvironmentalImpactValues**" that allows describing environmental impact values of an element.

Regarding the SBA core metrics, the main identified gap is about the management of Indoor Environment Quality (IEQ). As defined, this notion of IEQ counts two major indicators that are the **Thermal comfort** and the **Indoor air quality** (IAQ). Looking at the existing and already defined Property Sets in the IFC, there are no specific Pset dedicated to this later notion of IAQ. Also, even the notion of thermal comfort is not explicitly mentioned as defined in SBA metrics, but there is possibility to provide information to assessment tools in Property Sets as required min/max summer/winter temperatures of spaces and their performance history (monitored temperatures of spaces).

This study shows also that most of the construction elements that are taken into account in indicator calculation are already supported through IFC entities or IFC property sets. The IFC language seems to be now mature enough to play its role of standard for exchange of information around the BIM. There are more than 130 software referenced on the BuildingSMART web site that is "IFC compliant" (http://buildingsmart-tech.org/implementation/implementations). It shows mainly that the editors are now convinced by the equation BIM+IFC= interoperability and this list will continue to increase over the time.

In the scope of this study it is also worth to notice that so far only a few of them have been identified in the area of "Building Performance / Energy simulation & analysis". It means mainly that it is an emerging area and even if many software are available, only a few of them are identified as IFC compliant. Even public authorities are now convinced by a BIM / IFC based way of working and in some countries, national tendering conditions were modifies and require now IFC BIM from construction design competitors or builders, in order to get the virtual clone of the real delivered building.

Some gaps are still to be filled for a full implementation of the SBA metrics but most of the work is already covered and we do suggest in this study that a proposal from the SBA to BuildingSMART should be the elaboration of a property set dealing with the Indoor Environmental Quality (preferably already in upcoming IFC4). Software tools can be expected to support IFC4 release in a few years' time, and the essential question here is, if and how widely the Property Sets for environmental indicators and values are going to be implemented. The commercial software implementations of IFC specification are supporting certain subsets of the whole model, Model Views that are needed for exchange of information between certain types of software applications. In order to have tools to support the environmental Property Sets, Model Views including them need to be specified, and this should happen based on expressed user requirements - according to buildingSMART standard for processes (formerly known as the Information Delivery Manual or IDM). We recommend that SBA and its members take initiative in developing an IDM for environmental analysis.

SBA Core Indicators – What Is Being Analysed

SBA core indicators consist of 10 individual indicators, in 6 sub-categories of 3 main categories. Resource depletion meters the use of non-renewable primary energy and water consumption. In total cost of building operations these two form the majority of expenses, thus have great impact in facility management and interest of building owners.

Indoor environment quality includes thermal comfort and indoor air quality. Thermal comfort meters the minimum and maximum temperatures for summer and winter settings where indoor air quality emphasizes the concentration of CO_2 during the occupied period and formaldehyde concentration in indoor air. Indoor environment quality impacts health and is an interest for building users.

Building emissions consist of global warming potential and assesses the amount of CO_2 a building produces per unit. Solid wastes production is calculated in tonnes of waste, and includes hazardous, non-hazardous, inert and nuclear waste. Both these indicators impact environment on national and global levels and therefore are important factors in decision making.

Software Features

Building, infrastructure and area design is gradually shifting from 2D-drawing into building information modelling. Commercial software introduced in SBA BIM Final Report ware gathered from current markets, which mean that the software programs are in very different stages compared to each other. The most advanced programs use online-service which allows uploading of building information model into a web service.

Online access is an important feature from user's point of view because it allows fast access to information regardless of user's physical location. The data can be shared over the Internet fast. Online service is offered by Autodesk products Ecotect Analysis and Green Building Studio.

Majority of the examined programs are user-friendly in the means of program add-ins. Program add-ins allow the user to export BIM data into a separate analysis program from the modelling

software. The analysis results can be viewed in the modelling program itself or in an external program. EcoDesigner for ArchiCAD, VE-Gaia, VE-Pro, VE-Toolkits and VE-Ware.

A few of the calculation and analysis programs do not have BIM integration what so ever but are very usable in the sense of producing results in familiar programs such as Microsoft Excel. Examples of programs which output Excel-compatible data for analysis are Athena Impact Estimator for Buildings and EnergyPlus (BIM integration available through third party software).

ArchiPhysik, Climawin, BSim and IDA Indoor Climate and Energy and RIUSKA represent powerful analysis tools which are able to import and export data with BIM software programs but are external programs.

Software Needs from User Point of View

Software has a short lifespan and develops fast. Building information model programs such as Autodesk Revit and Graphisoft ArchiCAD release new versions once a year. The quickly evolving software put extra pressure on analysis programs development. The availability of different analysis software is much greater than modelling programs due to ease of producing mathematical models for specific subjects. From user point of view analysis programs need to be easily accessed, preferably built-in modelling programs for quickest analysis possibilities or at least online web services which allow fast development of the analysis programs themselves without user's program update requirements. The weakest user adaptability is possibly with programs which require user education, are external, expensive and offer solution for limited indicator analysis.

Table 1 Summary chart of software

External non-BIM	External-BIM	Integrated-BIM
Athena Impact Estimator for Buildings		Autodesk Ecotect Analysis
ArchiPhysik		Autodesk Green Building Studio
Climawin		Graphisoft EcoDesigner
BSim		VE-Gaia
	IDA Indoor Climate and Energy	VE-Pro
		VE-Toolkits
		VE-Ware
BEES	**RIUSKA**	
EnergyPlus		
	CSTB ELODIE	

Online analysis tool

BIM software integrated tool or an add-in

BIM data export-import software tool

IFC compatible