Interoperability Map between BIM and BPS Software

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ABSTRACT

This empirical research focuses on the possible interoperability between (*Building Information Modeling*), the building energy performance requirements and BPS software (*Building Performance Simulation*). Within the practical use of these technologies sample paths will be analyzed within the interoperability processes between BIM and BPS. The aim is to support architects and energy consultants to choose the most appropriated software workflow to analyze buildings and fulfill the performance requirements given by the countries laws. Several study cases in interoperability and a summary of current research are presented and discussed. Finally a novel map of interoperability between these three areas is presented.

INTRODUCTION

Currently there is a need for energy models and digital simulation to verify the performance of designed buildings (Attia et al., 2009; Cho and Chen, 2011), both to achieve a good balance between energy efficiency and economic feasibility as well as to meet the various standards and certifications. Methodologies of Building Performance Simulation (BPS) have successfully advanced due to the accuracy of calculations, interface improvements, the use of large databases of materials, weather, etc. (Kummar, 2008). On the other hand BIM (Building Information Modeling) software are more common in offices of AEC industry (Architecture, Engineering and Construction). BIM software are known for powerful modeling objects such as walls, tiles, doors, windows, structures, HVAC equipment, etc. from which interdisciplinary coordination (clash detection), quantities schedules, 2d drawings, can be obtained (Eastman, 2008). However, for the context of this research the ability to assign extra information to those objects, the precision of geometry, the ability to create areas and project areas, etc. are highlighted.

SUMMARY OF CURRENT RESEARCH

Energy Performance. Most of specialists (consultants) in energy efficiency create their 3d models for energy analysis within the simulation software, and they must raise the complete model from scratch according to the type of analysis required. This analysis can be as simple as thermal analysis by zone or complex for lighting or

acoustic analysis, where greater geometric detail is required. We estimated that nearly 30 % of the time of the consultancy is aimed at modeling the project. Many countries, motivated by the alarming increase in energy consumption and costs in buildings have implemented several policies that aim to make the energy performance of buildings more efficient. For example the GSA (US General Service Administration) has published a "Guide to Energy Performance and Operations" related to BIM models to regulate energy use in their buildings. This reveals a concern at government level issues of energy efficiency in buildings.

BIM software. Most models made in BIM are not related to energy efficiency purposes, since BIM technology is still only used as a tool to support in the coordination, visualization, and cost of the building deliverables. Therefore BIM efforts made to obtain a precise geometry of the building have no impact during energy evaluation done by the energy consultants. Software vendors have slowly reacted to these needs for interoperability and some formats include just a few possibilities of exchange between BIM and BPS platforms (Figure 1). The key feature that enables the exchange is the existence of tools for areas in BIM software. These allow, once the walls of an enclosure are made, to insert a virtual volume within these walls. This is normally used to compute surfaces and area schedules; however, as we will show in this research, they have also the potential to become useful for automatic modeling of zones in the BPS software, saving to consultant the redundant task of modeling the entire building from scratch and improving modeling accuracy

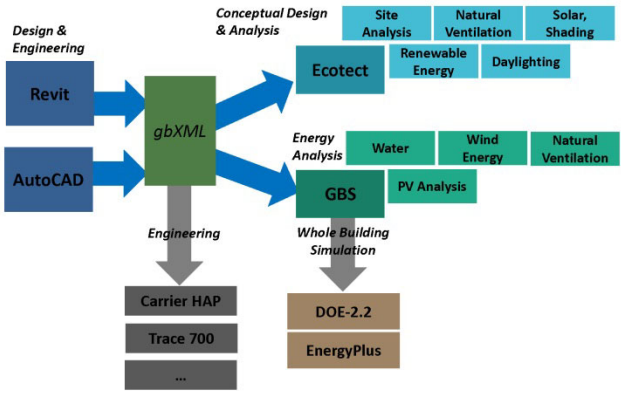

Figure 1. Interoperability proposed flow based Autodesk gbXML format. Source: Autodesk academic source material.

BPS software (Building Performance Simulation). BPS software (Design Builder, Ecotect, IES_VE, TAS, etc.) are considered in this research. The most commonly used formats for exchange with BIM are DXF, gbXML and the ifcXML, whose possibilities are summarized in Table 1. There are two types of formats for interoperability: those based in exporting full geometry of the building (i.e. DXF) to calculate daylight lighting, shadows, wind, ventilation, exterior solar gain; and those

based on spaces (i.e. gbXML, ifcXML) exporting information about areas and enclosures (usually called zones) to calculate thermal performance transmission of solar radiation, energy demand, sustainable rates, etc. Table 2 summarizes the ability of software BIM to export to these formats.

Research in BIM and BPS. The state of the art in this field presents: semiautomatic methodologies to export between BIM and BPS through a IFC for Energy+, by changing GST rules to export (Bazjanac, 2005-2008); development of interoperability between applications with emphasis on various models of buildings, including IFC and CIS/2 formats (Eastman, 2011); methods to standardize the content on 3D architectural models of buildings to obtain an effective model to enable energy efficiency simulations faster and more reliable during the life cycle (Osello, 2011); procedures and workflows between Revit gbXML and Trace 700, allowing a more complete HVAC equipment transfer (Ali, 2010). Howell proposes the XML, as the protocol for the transfer of subsets or "packages" relevant project information as a key opportunity to achieve interoperability between different disciplines, such as the case of gbXML. Lobos (2011) discusses a new parametric BIM based application for early design stages, where the urban codes determines the shape of the buildings. The application allows direct links to the analysis of energy efficiency.

Table 1. Exchange BIM-BPS formats. Own elaboration based on Autodesk manuals and tests. Self Elaboration.

DXF	gbXML	ifcXML
Drawing Exchange Format	Green Building extensible markup language	Industry Foundation Classes
- Geometry (2d/3d) - Layers - Materials*	- Building Type - Building Location - Geometry - Orientation - Area - Volume - Openings Location and Size (windows/doors) - Lighting, Electrical and - Occupancy Loads* - Space Type* - Condition Type* - HVAC Heating and Cooling Setpoints* - Outside Air* - Materials**	- Full geometric description in 3D - Object location and relationships - Properties (or parameters) of each object. - Structural, mechanical and energy analysis applications. - IfcSpaces

* Exported when they are added to Revit MEP models.
** depends on the BPS target software (i.e. Ecotect does recognize Materials, but Revit Architecture does not export them correctly).

As conclusions one can see that BIM developments and BPS have reached a high level for their specific areas, however interoperability between them is a new field. Worldwide, there are isolated but successful initiatives of use of BIM models for simulations through research BPS interoperability. Although interoperability between BIM and BPS has been highly researched in the past 10 years in the northern hemisphere, it has been mainly focused on specific performance using specific software.

Table 2. Capacity of BIM software to export to BPS. Self Elaboration

BIM	DXF	GBxml	IFCxml
Archicad	DXF	-	IFC 2x3 XML
Revit	DXF	GBxml	IFC 2x3 XML -
Microstation	DXF	-	-
Digital Project		-	-
Allplan	DXF	-	IFCxml

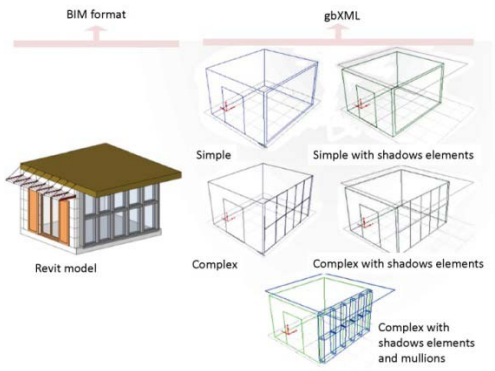

Figure 2. Examples of export Revit to gbXML. Self Elaboration from University of La Salle.

GOALS

The aim is to support architects and energy consultants to choose the most appropriated software workflow to analyze buildings and fulfill the performance requirements given by the countries laws. Our hypothesis suggests that by mapping the different of building energy requirements to interoperability between BIM and BPS software, we will generate valuable knowledge that will save time, increase accuracy in energy models and creating a workflow based on constant feedback between BIM and BPS environments. In the study cases BIM software (Allplan, Revit, Archicad, etc.), BPS software (Design Builder, Ecotect, IES_VE, TAS, etc.) and building energy requirements (heating/cooling, lighting, ventilation, water, acoustic, etc.) were considered. Graph techniques for mapping processes were used in the sequences described in each case of interoperability.

STUDY CASES AND MAPPING

During the development of this research six study cases of information exchange have been tested. They are summarized in Table 3, cases 2 and 3 are described below in detail. All cases were tested by practitioner architects in the post-graduate BIM courses at the Pontificia Universidad Católica de Chile (2012 and 2013). In all cases the proposed interoperability was successfully demonstrated.

Table 3. Cases of BIM-BPS information exchange. Self Elaboration.

Case	format	BIM -> BPS	Feature
1	DXF	Revit to Ecotect	lighting
2	gbXML	Revit to Ecotect	Heating / Cooling Demand
3	gbXML	Revit to Design Builder	Heating / Cooling demand Lighting
4	gbXML	Revit to TAS	*
5	RVT	Revit to Vasari	Solar gains
6	SKP	Sketchup to Vasari	Solar gains

* In these case it was found that the transfer is correct, but not performance calculations were made.

gbXML (Revit to Ecotect, Case 2). From the Revit software information is exported by using the gbXML format. During this process one must decide if a simple transfer (3d solid volumes) or complex transfer (with openings of doors and windows of the building details) is required. During the import process, the file in Ecotect is recognized as "Model / Data Analysis" type. Then, proceed to model the elements that this configuration does not allow to transfer (such as roof and shading projection elements), and create a material library that corresponds to each element, finally the model is able to perform studies of acoustic and thermal performance. The details of the transfer are shown in Table 4. This type of interoperability has the following advantages: it allows to use between 80% and 90% of room geometry created in BIM software and allows to add specific information for thermal analysis. And the following disadvantages: some elements change during export process, geometric translation errors can alter the export, geometry of the projecting elements of shading devices is not properly translated, manual materials assignment induce to human error, problems in identifying properly of element categories such as doors and windows, in imports from Autodesk Revit 2013 or higher Ecotect does not recognize some item types and take the “Guess” default material assigning (which means unknown) and it must be corrected manually. As there is no update to Ecotect software (Autodesk bought it in 2009 and was updated only until 2011) compatibility error with changes in coding when using Autodesk Revit 2013 or later, the solution is that the gbXML file obtained must be opened with a simple editor (i.e. notepad, WordPad) changing the type of file encoding to UTF -8 and then finally saved.

gbXML (Revit to Design Builder, Case 3). The first option to work in Design Builder based on information developed in Revit, is through the gbXML format

(Figure 3). To do this a complex export process must be run, including: filling the data information in Revit project properties, editing the power settings, exporting rooms, choosing “Export complexity” (simple or with shadow elements), calculation of area and volume. Once the model is imported into the Design Builder software then it is necessary to remake shadow and roofs elements. Once corrections of the volumes are made, the next step is to create a library of materials for the project and assign the corresponding materials the elements, finally to |add all the information about location, building functions and others useful for calculating thermal demands. The details of this transfer are shown in Table 4. This type of work has the same advantages and disadvantages as the previous case.

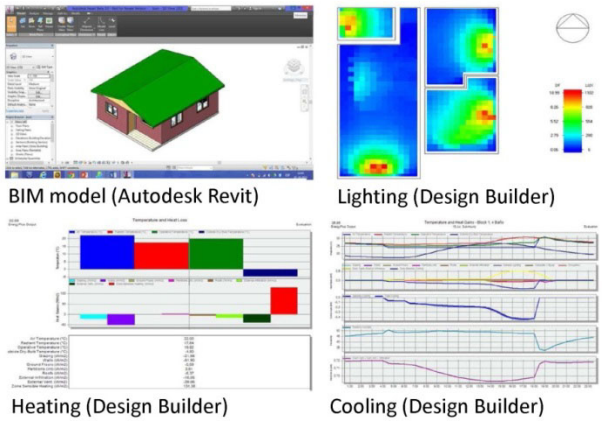

Figure 3. Interoperability BIM-BPS, if Revit and Design Builder. Self Elaboration.

Figure 4 shows the first map that summarizes the processes of information flow possibilities between BIM and BPS software according to a specific performance requirements as well as an overall point of view of the interoperability processes.

CONCLUSIONS

The great potential of interoperability between BIM-Energy Performance Requirements-BPS is proved. The novelty of the idea of mapping these processes of information exchange is observed and a new field for architects, researchers, and consultants arises. In this mapping process the positive and negative aspects of each transfer are shown. Overall BIM modeling saves time to users of BPS software, after import/export process BPS users only need to remake a few elements such as shadow devices and rooftops. Besides, increased feedback and accuracy is provided by BIM models. This map is partial and considers only some BIM- BPS software, it is expected to expand it in the future (i.e. Archicad and Ecodesigner, Revit to IES_VE, etc.). With these results we expect to encourage energy efficiency consultants to use BIM models and architects to deliver their BIM models ready to use DXF, gbXML,

ifcXML formats. Protocols that define such required information flows (such as GSA in USA) must be done.

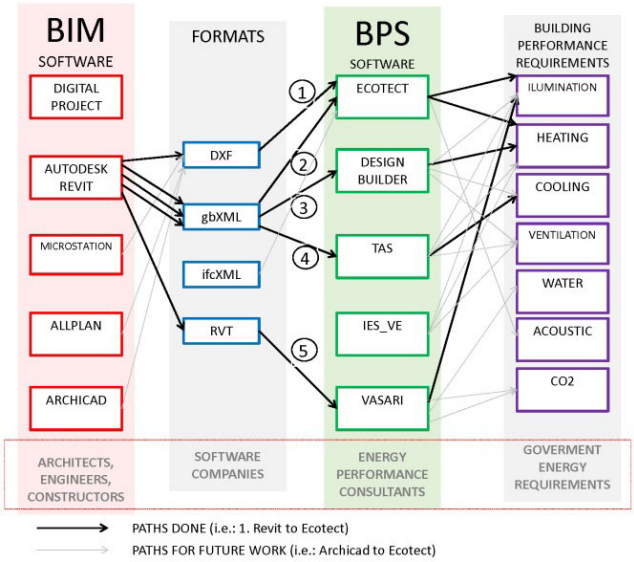

Figure 4. Map of information flow between BIM and BPS. Self-Elaboration.

Table 4. Summary of BIM-BPS exchange tests. Self Elaboration.

Elements and properties contained in the export file	gbXML: Revit to Ecotect	PLUG-IN: Revit to Design Builder.	gbXML: Revit to Design Builder	RVT: Revit to Vasari
Location	√	√	√	√
Geometry:				
Dimensions	√	√	√	√
Volumetric	√	√	√	√
Zone	√	√	√	
Zone Use	*	*	*	
Roof	√[1]	√	√	√
Ceiling	√[1]	√	√	√
External Walls	√[1]	√	√	√
Interior Walls	√[1]	√[3]	√[3]	√
Floor	√[1]	√	√	√
Door	√[2]	√	√	√
Window	√[2]	√	√	√
Materiality:				
Name	√[4]	√[4]	√[4]	
Layers	√[4]	√[4]	√[4]	
Physical Properties	√[4]	√[4]	√[4]	

[1] for Revit 2013 or later versions, these elements are not recognized.
[2] in 80% of the elements are recognized, otherwise the classification is "Guess".

[3] in 90% of the elements are recognized as an interior wall, otherwise are recognized as outer wall.
[4] Information provided by default.

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