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BIM-Based Energy Analysis Using Edilclima EC770 Plug-In, Case Study Archimede Library EEB Project

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Abstract

In the recent years, energy efficiency issues as well as Building Information Modelling (BIM) have been the greatest and most challenging paradigms for the Architecture Engineering and Construction (AECO) industry in the context of Smart Cities. Digital models are used to analyse the existing building stock to promote a better management and retrofitting actions. Data modelling is the first step to pursue an integrated approach for the building lifecycle allowing simulations and analysis for different purposes through the interoperability process. This study aims to investigate the potential and the limitations of a BIM-based energy analysis by means of an Italian commonly used software for energy diagnosis and certificates, according to the quasi-steady method specified in the UNI/TS 11300-1:2008. The case study is a library with municipal offices in Settimo Torinese (Italy), which is the demonstrator of the ongoing Zero Energy Buildings in Smart Urban Districts (EEB) national cluster, which has the main scope to create a data management infrastructure able to integrate heterogeneous networks. The energy rate is evaluated from a simplified Revit architectural model, where the most significant components of the building in terms of energy are defined with a proper Level of Detail/Development (LOD) to easily set the energy model through the EC770 plug-in. In this way, the acquisition of geometrical data is allowed by the interoperability among software, speeding up the redundant preliminary phases of the simulation concerning the description of the building envelope.

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Keywords: building energy performance analysis; building information modelling; energy model; data exchange; existing buildings; EEB project.

The graphical interface needs to be improved to facilitate the general understanding of the building components provided by the BIM model. Shared parameters, schedules and families have also been implemented to maximize the information exchange as the process is still imperfect.

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However, the critical comparison of methodology and results has shown that the use of BIM in energy modelling practices can strengthen the reliability, consistency, and usability of energy data for a cost-effective building simulation.

1. Introduction

According to the European Directive 2010/31/CE (EPBD recast), improving the energy performance of the existing building stock is one of the highest priorities over the next several decades. To achieve this ambitious goal, many researches are under development as integrated and standardised methodologies, while tools to monitor and assess real building energy performance are still missing. At the same time, the digitalization process of public buildings involving BIM method represents a significant opportunity for the Administrations to monitor and control the Public Real Estate. The EEB Project pursues the objective of increasing energy efficiency of existing buildings through the pervasive use of non-invasive technologies for the real-time monitoring and control. As a part of the data management infrastructure, Building Information Modelling is used to generate and manage building information during the operational phase in order to achieve a baseline model for the energy and facility management objectives. The aim of this study is to explore the role that BIM plays in energy modeling practices and the issues that should be considered to make the process of data sharing effective. According to Patti et al. and Ronzino et al. [1,2], the energy analysis integrated in the construction process is moving from the building to the urban and district level, integrating digital models with the Information and Communication Technologies (ICT).

2. Methodology

Tests described in this paper have been performed on the Archimede Library, located in the central Piazza Campidoglio in Settimo Torinese (Italy), in the former “Paramatti” industrial area. It is a recent building designed to be an innovative cultural centre with a thousand of daily users and a place for testing new technologies. The building looks like a compact curved shape spreading over 6.000 m^2 on four floors above ground and includes a public library and municipal offices. The north facade is made by concrete blocks, while the others by a coating terracotta slabs acting as a ventilated wall with sunshades protecting openings.

2.1. Building Information Model

A preliminary on-site survey is aimed at verifying the “as is” documentation, cataloguing space and assets with regard to their typology and number and getting detailed measurements of a specific component, such as window frames. Autodesk Revit has been chosen for its ability to interoperate with other software through specific plug-in. According to the main scope of the research, the BIM model created includes an accurate building envelope’s characterization in terms of correct stratigraphy and transparent components’ properties as well as facility management information (i.e. room type, responsible structure, occupants). Thus, it becomes a significant repository of graphical and alphanumeric information useful to make several analyses and generate innumerable output mutually consistent. The concept of Level of Detail and of Development (LOD) has been applied in defining the model components, as described by the American Institute of Architects. For this study, LOD300 [3] is used to achieve a proper description of the building in terms of both graphic specifications and attached data. The same modelling standards and additional parameters implemented in this model have been used to analyse other public buildings involved in the project. In this way, a coherent system is established to obtain comparable data bringing a great value to the Public Heritage’s knowledge and management.

Table 1. General data of the building.

General data of the building					
Floor Number	4 + 2		Unconditioned gross volume	12.096	m^3
Total area	6.962	m^2	Transparent surface	458	m^2
Clear height between floors	3,5	m	Opaque surface	6.063	m^2
Total height	24,4	m	S/V	0,42	m^{-1}
Conditioned gross volume	32.030	m^3	Climatic zone	E	m^2
Conditioned net floor area	6.777	m^2	Degree days	2.617	°C

General data of the building taken from the BIM model are reported in Table 1. Some indicators like the relationship between the opaque and the transparent surface over the net/gross or heated/conditioned building area and volume are extracted from in-place masses and relative schedules (windows/rooms). The inventories are automatically updated as the model suffers changes, so a univocal relation between the extracted information and the effective elements present in the model is guaranteed.

2.2. Building Performance Simulations

The energy performance simulation was performed using the commercial software Edilclima, certified by the Italian Thermo-Technical Committee (CTI). The main goal is to evaluate the quality of data and understand the critical issues that occur during the information exchange between the Revit architectural model and the Edilclima energy model, using the Integrated Technical Design for Revit EC770 plug-in. Traditionally the input data describing the envelope are manually inputted and the building's geometry has to be re-designed for every plant view from 2D models. This implies a considerable amount of time and improves the probability of making errors. Thanks to the BIM methodology, data can be directly extracted from the 3D model and introduced in EC700 to evaluate thermal calculations. However, tests performed have shown that the complexity and the high degree of detail of the architectural model represent a disadvantage at this stage. Several components (i.e. decorations, staircases, assets) are not useful for the energy simulation and could slow down the calculation or include inaccuracies in the result. To overcome this problem, it is considered necessary to create an energy-focused model simplifying the previous one in order to perform the simulation, as shown in Fig. 1.



Fig. 1. Comparison between the architectural and the energy model.

The surrounding buildings or external obstructions can be overlooked, but must be converted into objects that generate shade into the building as their impact is indeed relevant. The building under study presents different types of internal use, large open spaces and offices with curved walls, suspended ceilings and floating floors. The ventilated façade is modelled in Revit as a wall with an air gap, while the external surface transfer coefficient is set equal to the interior one in EC770, according to the national standard. To ensure a correct recognition, walls must be properly oriented according to their stratigraphy and the walls joints must be configured as "miter".

It is important to note that the plug-in is not able to recognize the gross area of the dispersants structures in case of a curved wall, roof by extrusion and conical roof, assuming the same value of the net. This does not affect the evaluation much despite that it is considered a more unfavourable situation. However, the graphical visualization of these elements in EC770 is the most critical point detected. As seen in the image below, the curved walls are not displayed in the energy model, consequently also the openings hosted on them are not displayed. So it is necessary to verify the windows' presence in an analytical way, using Revit floor plans with codes to facilitate the correct shadings' association. This operation has made the process longer and more complex, introducing a large possibility of an error, due to the lack of information.

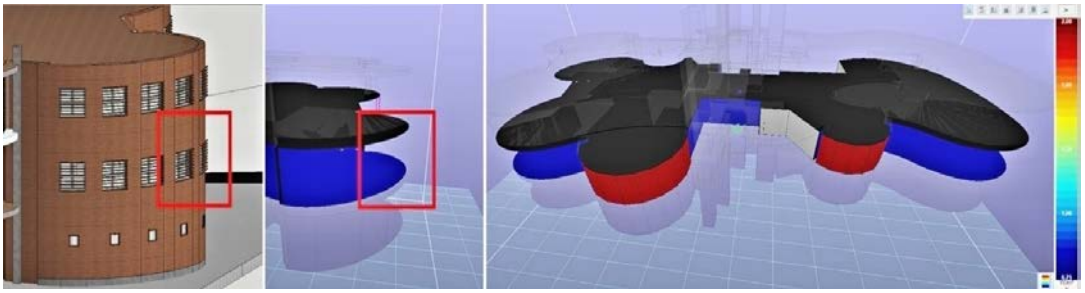

Fig. 2. Visualization problems of curved walls in the EC770 graphical interface.

With regard to transparent components, the software has problems in the recognition of their properties. For this reason, the Revit windows schedule has been previously set with all the necessary parameters to be supportive at this stage. Embedded Curtain Walls are recommended as the only ones correctly recognized by the software in terms of geometry and dimensions.

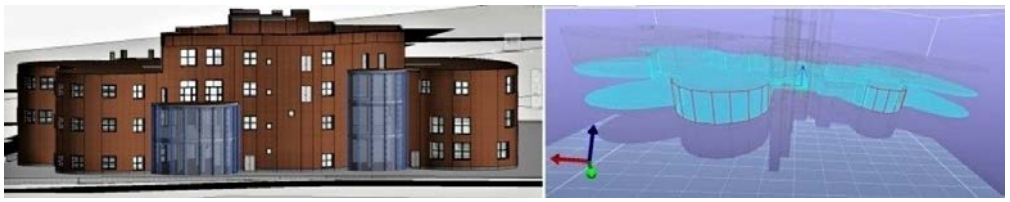

Fig. 3. Correct display of curtain walls in E770.

Concerning the evaluation of the shading factors, a metric generic model face based family has been created [4,5]. It has to be loaded into the project and placed on the external surface to consider, moving the handling points according to the obstacles. Some instance parameters are implemented to calculate using trigonometric formulas the angles related to horizontal (αF_{ov}) and vertical (αF_{fin}) solar projections and to obstacles (αF_{hor}), as shown in Fig. 4. It is also possible to act on the visibility of these parameters in order to consider only the actually present obstacles. It is recommended to duplicate and rename the family for each surface considered to facilitate data reading in the schedule. This method allows to significantly speed up the calculation.

In this case study, 102 different shading angle combinations were obtained considering both transparent and opaque components. In order to ensure a correct evaluation of the heated volume, all the building areas must be defined as spaces, including the ones delimited by suspended ceilings or floating floors. In this way, spaces contain accurate area and volume data used for load and energy consumption analysis. In addition, the delimits local option must be disabled for columns. In this case study "rooms" were not considered appropriate for the simulation as several room separation lines in the open spaces need to be removed before the exportation because they are interpreted by the energy software as opaque walls. So, spaces have been easily grouped by homogeneous thermal zones (reading room, conference room, restrooms, corridors, second floor offices, third floor offices, archive) using the Revit "vanes" command, taking advantage of the graphical visualization and facilitating the correct assignment in the energy model. Spaces without

the air conditioning system are generally classified as non-air-conditioned (i.e. staircases). At last, it is necessary to export the energy model set in E00 format to display data on EC700. At this stage, information about the system (heating, ventilation, cooling, hot water production, renewable sources) are manually entered according to available documents and CAD drawings as the Revit MEP equipment is currently not recognized by the tool.

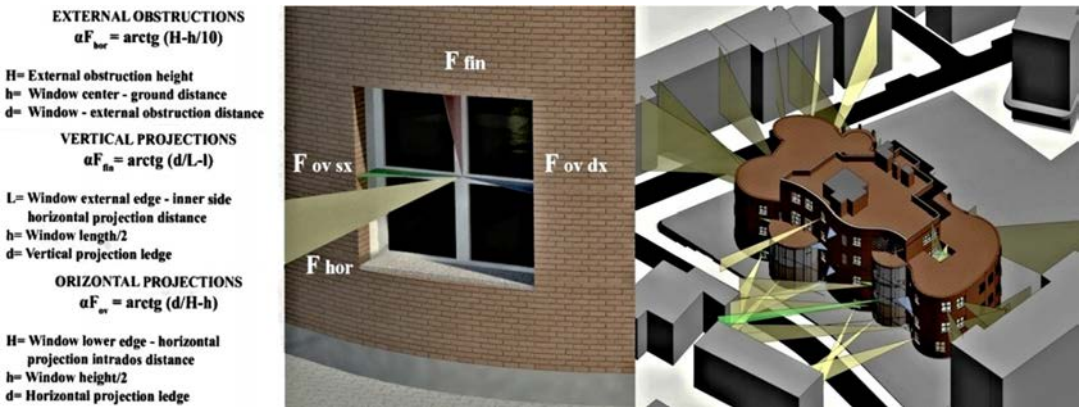

Fig. 4. Surface-based Revit family and parameters for the shading values calculation.

3. Results and Discussions

The study has shown that the energy certification performed from the BIM model with EC770 has achieved the same results of the traditional practice. Indeed, the global energy performance index obtained is 15,41 kWh/m^2 year compared to 15,30 kWh/m^2 year, attesting the C energy rating for both cases and almost equivalent CO_2 emissions. In particular, the heating performance index takes into account data coming from the model such as geometry, volume and transmittance. The difference is detected by only 0.65 percent, with a value of 13,93 kWh/m^2 compared to 13,84 kWh/m^2. The advantage of BIM-based energy modelling over the traditional approach is that the architectural model can be used to directly generate the geometry of the energy model, minimizing misinterpretations and improper approximations encountered in practice today. In this way, the architectural model remains consistent across users even if the high level of detail represents a critical issue, so it is necessary to introduce simplifications to make the simulation program manageable. Additional effort is also required to leverage BIM data in building analysis tools due to the lack of information exchange. The accurate modelling and the detailed calculation of transparent components and shadings through the use of a Revit customized family and shared parameters have resulted to higher and more precise values of solar gains. This fact has led to a class rating 5 compared to class 4 for the quality assessment of the enclosure for cooling. In traditional computing, shadings simplifications are usually introduced, considering the average values for all plans. Using the 3D model as a database, it is possible to increase the amount of data usable, saving time and reducing errors that inevitably occur when making repetitive calculations. However, a process must be adopted by the professionals that ensure accuracy of the information transfer to the energy model using BIM.

4. Conclusions

The building industry is currently very inconsistent in terms of adopting the exportation of data from BIM to analysis software. The primary limitation is that the export format of building information to data models such as IFC and XML is imperfect and does not always provide a reliable source of geometric data. Although most parties agree that there is much potential in the process, variables such as the type of software and/or analysis being performed, level of experience of the modeller, physical properties of the building, and personal preferences in terms of workflow are currently dictating the level of adoption [6].

Therefore, new researches and further development in this field are required to optimize the data sharing and to automate the process through common standards, making cost-effective the simulation.

References

[1] E. Patti et al., District Information Modeling and Energy Management, in: IT PROFESSIONAL, 2015, vol. 17 n. 6, p. 28-34. ISSN: 1520-9202, doi: 10.1109/MITP.2015.101

[2] A. Ronzino et al., The energy efficiency management at urban scale by means of integrated modelling, in: Energy Procedia, 1-3 July 2015, Elsevier, Lisbon, Portugal, 2015, vol. 83, p. 258-268. doi: 10.1016/j.egypro.2015.12.180

[3] BIMForum, 2015 Level of Development Specification (April 2015 Draft for public comment), retrieved from http://bimforum.org/lod/, 2015.

[4] F.M. Ugliotti et al., Turin Smart City: BIM and interoperability for data management, in: Proceedings of XXXVII International Conference of Professors of Disciplines of Representation, 17-19 September 2015, Turin, Italy, 2015.

[5] D. Bavastro et al., From the architectural model to the energy model: the use of BIM for the evaluation of the energy performance of buildings, in: Proceedings of the 2014 Building Simulation and Optimization Conference, 23-24 June 2014, University College London, London, UK, 2014.

[6] United States General Services Administration, GSA Building Information Modeling Guide Series 05 – Energy Performance. Version 2.0., retrieved from www.gsa.gov/bim, 2012.