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Vesna Spasojević-Brkić
Mirjana Misita
Dragan D. Milanović

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Vesna Spasojević-Brkić
Mirjana Misita
Dragan D. Milanović

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PREFACE

Since the first symposium in Belgrade, Serbia nearly two decades ago, in 1996, International Symposium on Industrial Engineering - SIE has been held regularly every 3 years. It represents an opportunity for researchers in the Industrial Engineering community to review and evaluate their scientific achievements over the period since the previous SIE, share their most recent results and ideas, and discuss possibilities for new directions in research, joint experiments and observing campaigns.

The aim of the 6th International Symposium on Industrial Engineering – SIE 2015 is to contribute to a better comprehension of the role and importance of Industrial Engineering and to point out to the future trends in the field of Industrial Engineering. The Symposium is also expected to foster networking, collaboration and joint effort among the conference participants to advance the theory and practice as well as to identify major trends in Industrial Engineering today. According to these goals the Symposium addresses itself to all experts in all fields of Industrial Engineering to make their contribution to success and show capabilities achieved in the work that has been done are very welcomed. SIE 2015 provides an international forum for the dissemination and exchange of scientific information in industrial engineering fields through the large number of multidisciplinary topics.

The book brought together 80 papers and more than 220 authors from 19 countries, namely from Serbia, Germany, Portugal, Spain, France, Iran, Finland, Switzerland, Israel, Hungary, Canada, Lybia, China, FR Macedonia, Italy, United Kingdom, Taiwan, Russia and Bosnia and Herzegovina. The submitted full length manuscripts were peer-reviewed, and selected for publication by experts in their respective fields. The authors ranged from senior and renowned scientists to young researchers. Only unpublished papers were accepted and the first author is responsible for the originality of the paper. All papers are classified into seven chapters:

- Plenary Lectures,
- Risk Management,
- Human Factors,
- Production and Quality Management,
- Information Technologies,
- Engineering Management and
- Other Technologies in Industrial Engineering.

We expect that papers and discussions will contribute to better comprehension the role and importance of Industrial Engineering in this and other countries, both in domain of scientific work and everyday practice.

Our efforts in organizing would not succeed without the considerable help of the members of Scientific Program and the financial help of Ministry of Education, Science and Technological Development was greatly supportive for the success of the entire project.

At the end, the editors hope, and would like, that this book to be useful, meeting the expectation of the authors and wider readership and to incentive further scientific development and creation of new papers in the field of Industrial Engineering.

Welcome to the 6th International Symposium on Industrial Engineering – SIE 2015! We wish to all participants a pleasant stay in Belgrade and are looking forward to seeing you all together at the 7th Symposium on Industrial Engineering – SIE 2018.

Belgrade, September 2015

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SIE 2015 6th International Symposium on Industrial Engineering 24th-25th September 2015 FACULTY OF MECHANICAL ENGINEERING STEINBEIS ADVANCED RISK TECHNOLOGIES INNOVATION CENTER FME

PREPARING BIM MODEL FOR ENERGY CONSUMPTION SIMULATION

Marko S. Jarić[1], Nikola J. Budimir[1], Igor Svetel[1]*
[1] Innovation Center, Faculty of Mechanical Engineering, University of Belgrade, Kraljice Marije 16, 11000 Belgrade, Serbia
* corresponding author: isvetel@mas.bg.ac.rs

Abstract. *Recently, the BIM technology combined with software energy analysis tools have been promoted as the solution for energy efficient design. The paper investigates if the mentioned technologies provide effortless energy consumption simulation and finds that more development is needed to achieve that goal. By giving a quick overview of the appropriate processes for the most common BIM applications and related energy consumption simulation tools, this paper tries to foster building designers to use energy simulation tools regularly.*
Key words: *Building Information Modeling, BIM, energy analysis, ArchiCAD, Revit, model preparation*

1. INTRODUCTION

The use of computer based building performance simulation in traditional architectural design processes was hindered by the significant time and skill required to create building model for energy simulations. The BIM technology, based on rich information models of buildings containing not only geometric data like traditional CAD models but exhaustive description of all building attributes covering entire lifespan [1], appears as the proper candidate to provide missing models.

The seamless data transfer from BIM applications to energy simulation tools is complicated by the fact that simulation tools use simplified building model that represents only spaces in the building. For that reason, the BIM model needs special preparation to fit the needs of software energy simulation tools.

The paper presents model preparation process for two BIM applications (ArchiCAD and Revit) and accompanied energy simulation tools (EcoDesigner, Energy Analysis Tool, Green Building Studio, Ecotect and Riuska).

2. PROCESS

The ArchiCAD 16 comes with the built-in energy consumption evaluation application - EcoDesigner. Within ArchiCAD 16 it is necessary to create zones in the building, to be able to determine the proper surface and volume facilities required for the whole energy building analysis. From the version 17, the program requires from the user to define energy blocks, a larger building sections with same thermal properties.

In addition to this, it is necessary to include in the "Options" menu the geographical location of the object so that software can adopt automatically the appropriate climate parameters from Strusoft Climate Server or user should enter weather data manually from EnergyPlus simulation software. Finally, before starting energy evaluation software the user need to include appropriate parameters for heat generation and fuel prices.

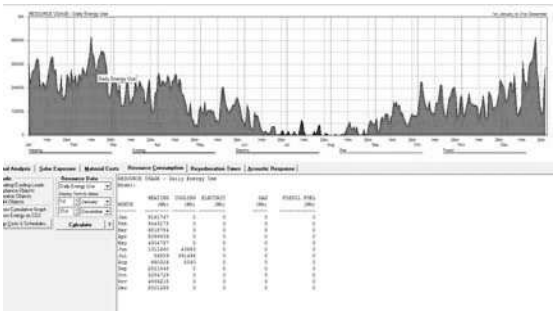

Figure 1. Report from Ecotect Analysis software

To start analysis in the Ecotect software the user also needs to make building zoning in the ArchiCAD application and then save the energy model using the gbXML [3] format. Upon importing data in the Ecotect application it is necessary to define thermal performances, material costs, solar exposure, etc.

using built-in tools. Based on all that data the application generates evaluation report (Figure 1).

The process of analyzing energy consumption of the building in Revit 2013 is carried out in several stages. After the geometrical model of the building is finished it is necessary to include all of the characteristics of the building elements. This is primarily related to the characteristics of the floor, the walls, ground, mesh, elements of heating system, air conditioning, elements of electric system, plumbing, furniture, etc.

Conducting energy analysis of object in Revit 2013 is performed using tools that are in the main menu "Analysis". This analyzer provides the capabilities to perform static, dynamic, thermal and electrical performance of the formed object. In the first stage of the analysis the zoning of the object is first carried out using the option “Zone” in the main menu. After that, using the “Space” option in the menu the space properties of each object will be determined. This way the object is fully defined in terms of the layout and dimensions of all work areas and volumes.

The actual simulation starts by selecting the option “Energy Analysis” in the menu “Analysis” and then by selecting option “Energy settings”. Using this option the user defines the object type and its location, makes the choice of the analysis level, selects building infiltration class, the type of the structure, the type of the report for the analyzes, etc. After completing this phase user should selected the “Heating and Cooling Loads” function from menu. By starting this application the user is presented with the view containing rough image of the object with zones in the left side of the window and data of the object which is to be analyzed on the right side. By selecting the option “Calculate” in this window the actual simulation starts.

Depending on the chosen geographical location the application automatically takes data on weather conditions from the Web Service, and produces a report on the necessary forces for heating/cooling facility, together with its maximum values, while depending on the detail of the report the data may be related to the entire object or for every single predefined entity.

The process of analyzing the performance of the object in Green Building Studio web software is also carried out in several stages. There process differs depending on whether the model is created in the ArchiCAD or Revit application.

The process of preparing the model created in ArchiCAD 16 for the Green Building Studio's requires third party gbXML export utility. The process of zoning required by the export utility differs from that required by the built-in energy evaluating tool software and already established zones can not be used. The process can be obtained manually following instructions, or by using a plug-in that automates the process. Under the “Design extras” option in the “Design” tab in the main menu there is the “Place zones” tab that activates the plug-in. The utility works in the separate window that enables definition of the appropriate zones in the object. To define the interior surfaces the option “Place Zones in Rooms” is selected which enables adoption of categories inside of the building, as well as their visibility in the site. A similar operation is carried out to define the building's external areas and their visibility by selecting option “Place Zones to Exterior”. To fully define the area of the object it is also necessary to check if the area relates to the whole model or to the current level, and to select option “ignore small gaps”. After the completion of this process all parts of the object are defined and within of each section a table is featured giving basic information related to this unit. This information includes the names of units, its category, area and height. If we want to change some of the characteristics of particular entity the left mouse click should be performed on the related table followed by right click to open the properties window in which the parameters can be changed. Thus prepared model is ready for further analysis. From the top menu a “File” tab in main menu is selected and under option “Save as the” option to export the model as gbXML file is selected. Thus formed file is imported to the Green Building Studio software for further analysis.

The process of object analysis in the Green Building Studio program is conducted in following steps. Upon opening main application window the option “My projects” from the main menu is selected followed by the selection of the option “Create a New Project” from the menu box. The next step is the selection of options which requires entering of data related to the object in 3 steps. In the first stage the Project name, Building type, Schedule, and Project Type are defined. Second phase includes the location of the object, Time zone, Currency and Weather station. The third stage involves input of the Data Access Preference, Contact Preference and Autodesk Green Building Studio Web Service. Upon completing these steps a message that the new project is created appears.

Further procedure involves selecting an option “Continue to Application” after which the window is opened with the menu box with the following options Run list, Run charts, Project Defaults, “Project Details”, “Project Members”, “Utility Information”, and “Weather Station”. In this menu the user can perform further adjustments of the project in terms of project participants, weather station, details of connecting to schedule zone in the facility, the data related to water and sanitation facility as well as data related to energy prices. After defining all possible building features it is possible to choose the “Run list” option from the “Run” menu in order to import the gbXML file.

It is necessary to note that the building model created in either of the analyzed BIM applications must be fully defined; otherwise the DOE 2.2 [5, 2] engine blocks its analysis. Care must be taken that all materials within an object and their characteristics are defined entirely. Also, it should be ensured that each roof object is defined in a proper way, because this feature often leads to failure of importing the gbXML model in the Green Building Studio.

On the other hand, process of preparation models from Revit to Green Building Studio is same as the already mentioned process for Revit's built-in energy evaluation tool.

After successfully importing gbXML file a “Heating and Cooling Loads” option is selected. From this procedure the drop-down menu opens in which the option “Export” is selected and then the file extension is selected which is in this case is gbXML. Upon choosing the extension the working window opens in which the left side view shows the zoned property and the right side shows the basic characteristics of the building. There, the user can choose whether he/she wants presentation of the general or of the detailed characteristics of the building. Upon selecting “Next” option in the lower part of the window the “Save” dialog box opens enabling the file to be saved using the gbXML file format which fully completes the process of preparing the object for the analysis in Green Building Studio software.

Preparation of building model for the energy analysis in Riuska software is similar to the one already described for the Green Building Studio. The process in ArchiCAD 16 is same as the model preparation process for analysis in EcoDesigner. After the basic building model is finished all the characteristics necessary to fully define building elements like walls, windows, doors, radiators, pipes, etc. should be included. Zoning process is conducted as is previously described. Upon completion of this operation the object and zones are fully defined which enables export of the building model using the IFC [4] file format. Saving object as IFC is implemented under “Save as” option in the “File” tab of the main menu. In the dialog box the user should select the “General Translator” option. Only thus formed object can be further introduced in Riuska simulation tool.

The process of preparing the object in Revit 2013 for Riuska is quite simple. After completion of model all objects need to be fully defined in terms of the elements that comprise it, with all their characteristics. Next, the option “Export” is selected from the main menu and “IFC 2x3” is selected as the extension option.

The process of energy analysis in Riuska software is conducted in several steps. Upon starting the application, the user chooses option “File” in main menu, and then option “Import building information model” (BIM). That opens an IFC reading method dialog box. Within this window two possibilities are offered: “Import 3D geometry” and “Import only space 2D borders-Walls”. The process continues by selecting first option, and checking “Import also the unknown types of Spaces Boundaries”, and “Use "Merge" method to remove cracks between adjacent internal walls” sub options. After that, the actual IFC file is selected.

Next, the new window titled “New Case simulation” opens that asks the user to give the name of the new object to be simulated and provide specific information for the object that was previously analyzed.

After the model is imported into the program the window opens requiring the user to provide further settings that are necessary for energy analysis simulation. In the left part of the window there is an option for entering location of the object and the menu “Space groups” containing two commands “Building” and “System”. In the command “Building” there is the option “Storeys” and within it sub option “Level” that enables the user to define size and level of object or any part to be analyzed.

On the other hand, in the command “System” there is an option “Air conditioning space groups” that enables the user to define settings related to heating energy, cooling energy, HVAC system, lighting energy, equipment electricity and other necessary equipment for the distribution and consumption of energy for object. When the user finishes all the required settings on the right of working window he/she selects the option “Calculate” after which the program provides appropriate results (Figure 2).

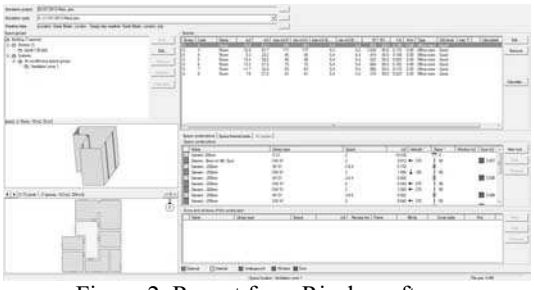

Figure 2. Report from Riuska software

3. CONCLUSIONS

Most software vendors advertise their energy consumption simulation tools as easy to use additions to existing BIM applications that enables designers to get appropriate results on the click of the button.

The paper shows that this process is not so straight forward and that even within same BIM application different simulation tools requires separate processes. This fact still hinders the use of software energy simulation tools in everyday architectural practice. On the other hand, if the designers withhold from the use of those tools no progress will be achieved toward better software applications. By

giving a quick overview of the appropriate processes for the most common BIM applications and related energy consumption simulation tools, this paper tries to foster building designers to use energy simulation tools regularly.

4. ACKNOWLEDGEMENT

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