Building Models Design And Energy Simulation With Google Sketchup And Openstudio

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Abstract

The necessity to approach the zero net building design and the improving of building thermal performance augmented the need to use the energy simulation programmes in order to estimate the building energy consumption and virtually modify the structure and the construction material. Energy Plus software from the US Department of Energy introduced a plug-in for Google SketchUp drawing software known as Open Studio, this tool can be considered as a free licences powerful simulation tool available for all engineers to estimate and modify the buildings energy consumption. In this paper we presented a step by step simulation procedure to explain the software capability and encourage the use of the tool by engineers interested in energy efficiency calculations.

Keywords: Energy, Simulation, Google Sketchup, openstudio.

1. Introduction

The energy efficient buildings are highly recommended to achieve an energy rating which lead to more energy saving and cleaner environment. Computer simulation is an important tool in assessment the building energetic performance. The energy assessment is required in the design of new buildings or the refurbishment of existence one. The computer simulation can cover multi tasks processes including building wall and roof layers, window and door types, selecting loads and equipments, selecting the control strategy, estimates loads and calculating payback periods for the suggested system or building modifications.
Though, the modelling may carry certain inaccuracy depending on the available information about the building and its varying with actual case, but the simulation results still considered very useful to decide the final design decisions.

Many building software tools for evaluating energy efficiency, renewable energy, and sustainability in buildings are available e.g. TRNSYS, EnergyPlus, DesignBuilder, etc. Usually, the cost of such software is too high, but the US Department of Energy (DOE) encouraging the use of building energy simulation, consequently the department supporting some free software available to use by engineers (Weaver et al. 2012). In this paper we shall present the modelling and simulation of building energy using free software from the US Department of Energy and graphically supported by Google Sketch Up. It can be considered as a manual for researchers interested in the energy simulation.

Developed for the conceptual stages of design, GOOGLE Sketch Up is extremely powerful 3D software require basic skills to learn and easy to use. This software combines simple, powerful tools that simplify the 3D design on the computer.

The Open Studio is an open source plug-in for Google Sketch Up 3D drawing software from NREL (NREL) . The plugin helps to create and edit the building geometry in Energy Plus input files. Add a number of great use tools for building design in 3D. The plugin also allows you to launch Energy Plus simulations and view results without leaving Sketch Up.

2. INFORMATION ON THE BUILDINGS USE

Building in this paper is an interactive office buildings, a typical office occupations and schedules are considered in this work. The Advanced Energy Design Guide procedure presented by Pacific Northwest National Laboratory under contract for the U.S. Department of Energy project to achieve 50% energy savings above the requirements of ANSI/ASHRAE/IESNA Standard 90.1-2004 for different building types (E. et al. 2012), included two office building type, i.e. Medium size benchmark office building of D.O.E. (Thornton et al. 2009) and Small size office building (Thornton et al. 2010), both will be used in this study.

Similar to (Thornton et al. 2009; Thornton et al. 2010) it was assumed that the buildings peak occupancy take time between 8 AM to 5 PM Weekdays, 10-30% of peak on Saturday, and limited to 5% on Sundays and public holidays. In the buildings in this study, the number of occupants, Lighting, equipments and HVAC scheduling are based on values from office schedules in the ASHRAE Standard 90.1-2004 (ANSI/ASHRAE/IESNA 2010).

3. INTERFERENCE OF GOOGLE SKETCHUP

The Google Sketchup and OpenStudio interface briefly presented in this section, with overview of toolbars, menus and dialog boxes. The purpose of this section is to present the complete operation of the drawing program and get to know all their tools and their use.

Google Sketch 3D drawing software is free to download from Google Inc. (Google). On the program start up the following screen appears on Start using SketchUp (Figure 1).

To start a new OpenStudio project, go to the tool bar and click  to create a new Openstudio model from template, a list of US department of Energy (DOE) templates will be found in OpenStudio documentation to choose from as shown in Figure 2. In this study, basically we selected a medium office template, which later modified to match the building under study specifications.

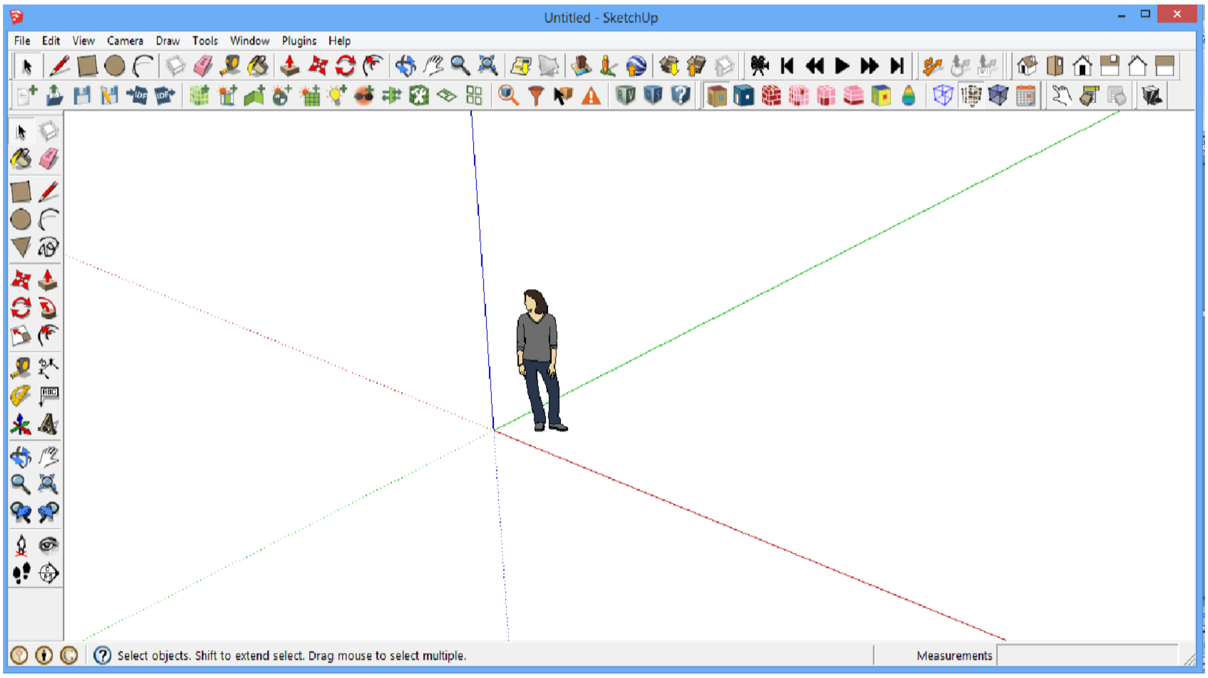

Figure 1. Display list to draw from Google SketchUp.

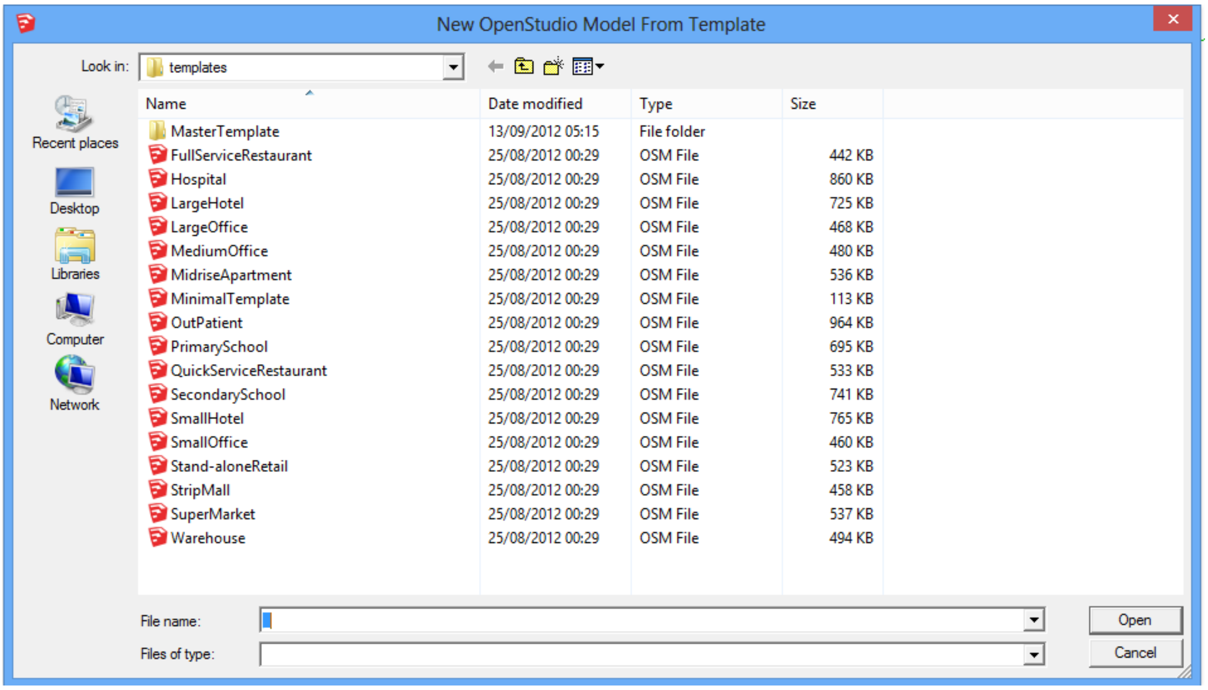

Figure 2. OpenStudio Template Models

To start building modelling in 3D, we select draw rectangle key, and draw a rectangle with the assigned building outer dimensions (55m x 33 m), as shown in Figure 3. With the offset key we select the core zone area (with 4.6 m offset from outer boundary), Figure 4. And complete the parameter zones drawing on the plan layout (Figure 5).

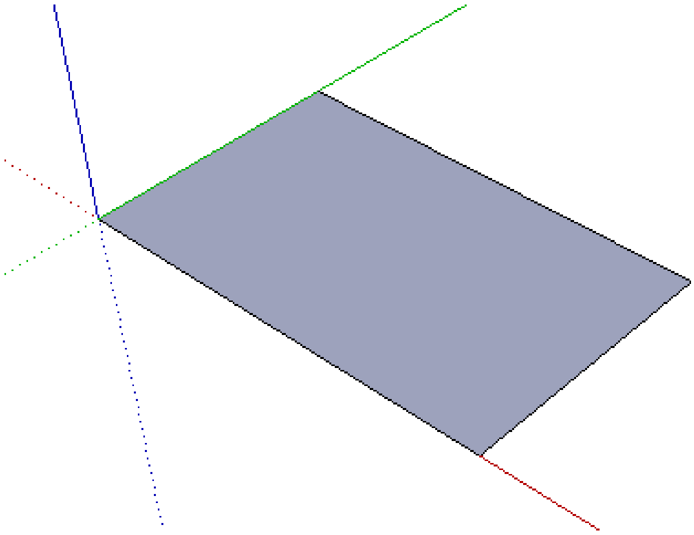

Figure 3. First Step in sketch the Floor Plan.

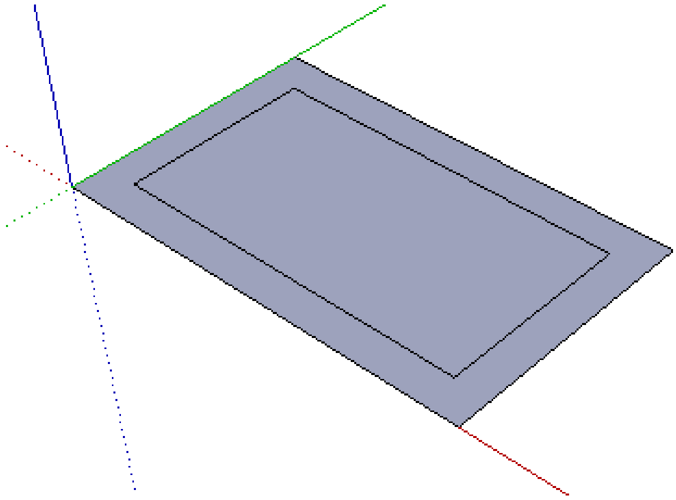

Figure 4. Set the Core Zone outline with Offset Order.

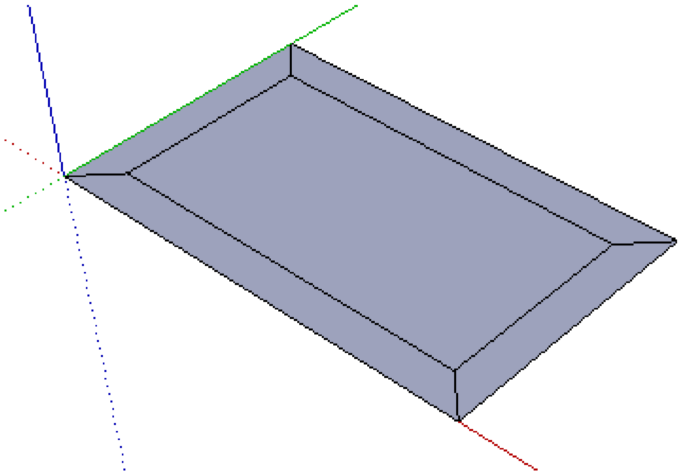

Figure 5. Sketching the Perimeter Zones.

Double click on any line on the diagram to select the whole plan layout, the press create space from diagram key, the window in Figure 6 will pop up, the data for the floor height and number of floors to be entered, in our case the floor height is 2.75, and 1 floor in each step in order to insert the plenum in a proper way as explained further.

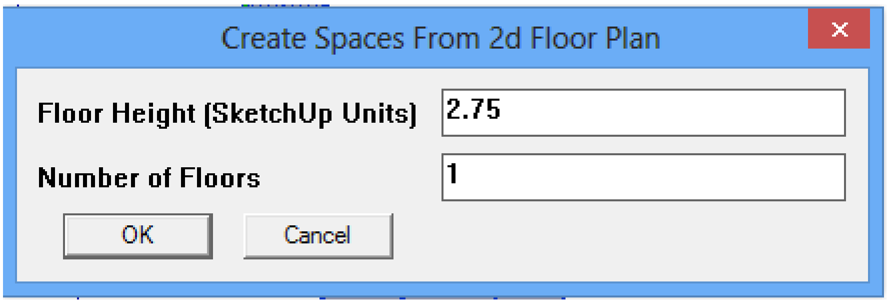

Figure 6. Create Space From Floor Plan Window.

The 3D diagram will be created with the medium office templates (Walls, Windows, Floors, Roofs and Ceiling) as shown in Figure 7.

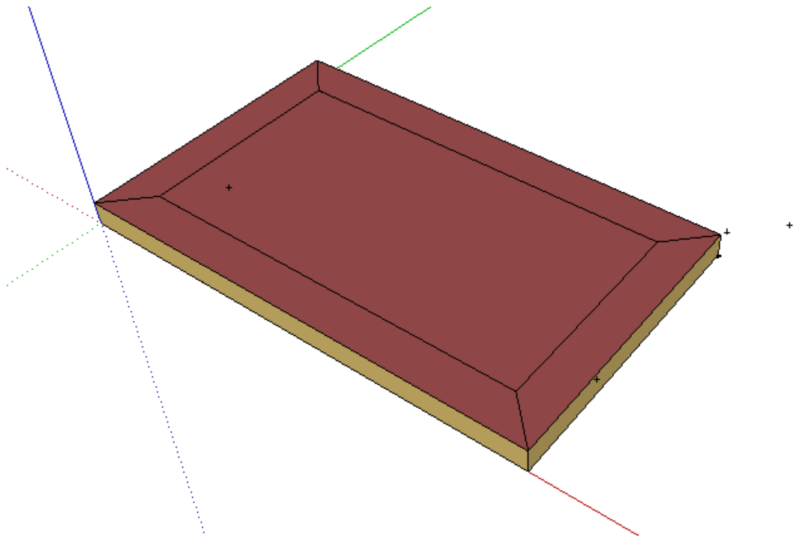

Figure 7. 3D Geometry for First Floor.

To add the Plenum, draw a new rectangle above the 3D diagram of the first floor (Figure 8), and create a new floor from the diagram (new rectangle) and specify the height to 1.25 m to create the plenum at the top of the first floor (Figure 9).

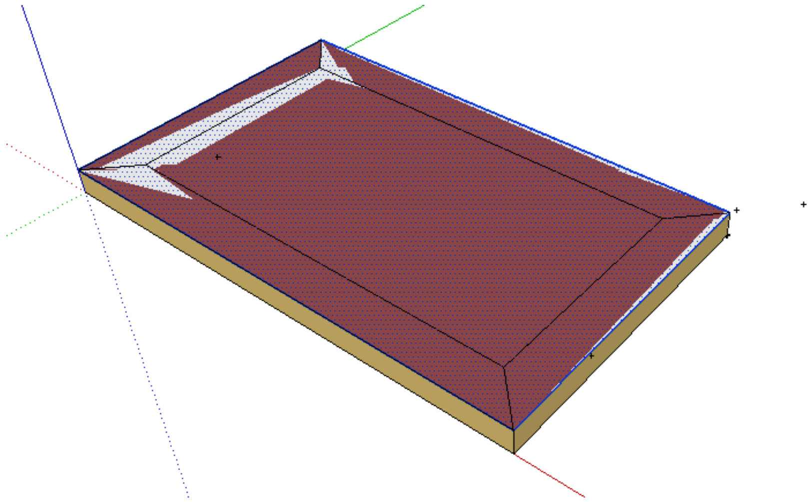

Figure 8. Sketch the Plenum Floor Plan.

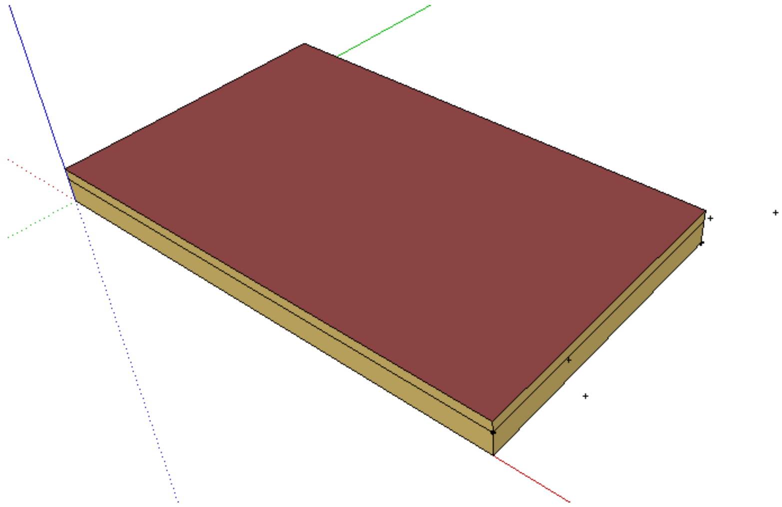

Figure 9. 3D Geometry of First Floor and Plenum.

Repeat the previous steps to create the second and third floors with plenum assigned for each floor (Figure 10).

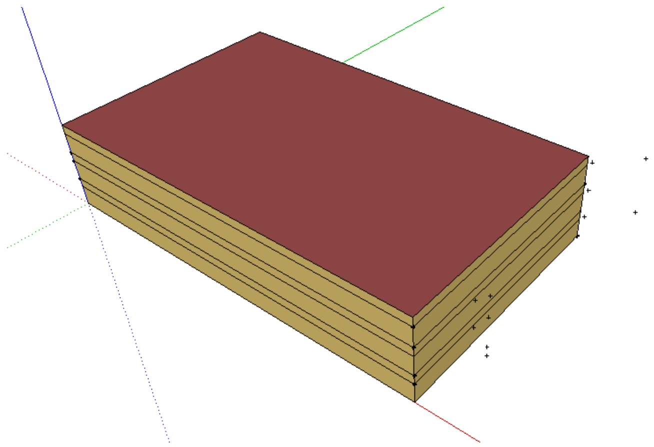

Figure 10. 3D Geometry of a Three Floors Building with Plenums.

Next step is to match the geometry surface, click the surface matching key, the window in Figure 11. will pop up, first intersect the zones surfaces by select “Intersect in Entire Model”, the “Match in Entire Model” to match all the surfaces. To see the effect of surface matching view model in X-ray mode and render by construction type, each construction will be assigned a different colour (Figure 12.)

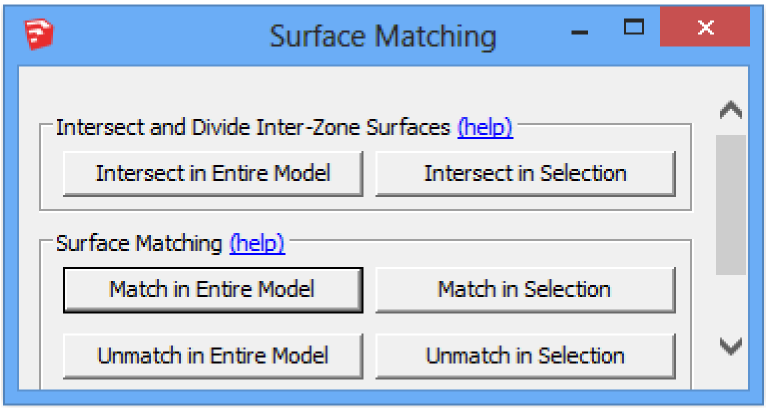

Figure 11. Surface Matching Window in OpenStudio.

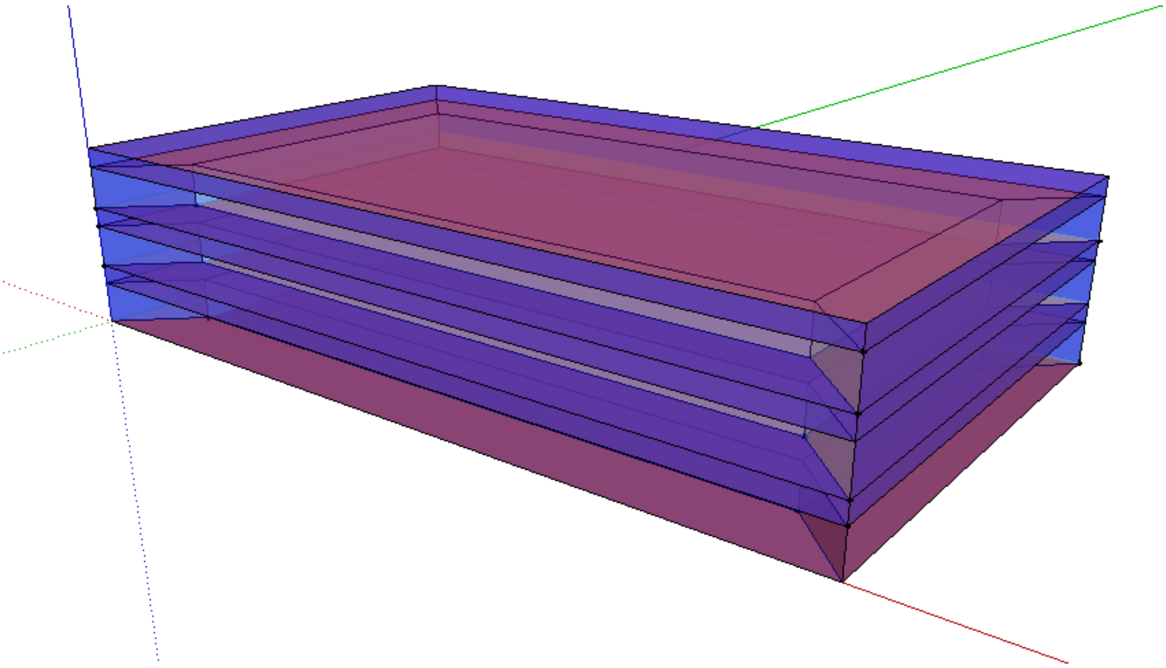

Figure 12. Office Building 3D Geometry in Construction Rending Mode.

The next step is to create fenestrations, return to the rending by surface type view and select “Hide Rest of Model” option, double click on any parameter zone, and then click on the external wall to be selected (Figure 13). From tool bar go to “plugins”, “OpenStudio user scripts”,” Alter or Add Model Elements” and then “Set Window to Wall Ratio” (Figure 14).

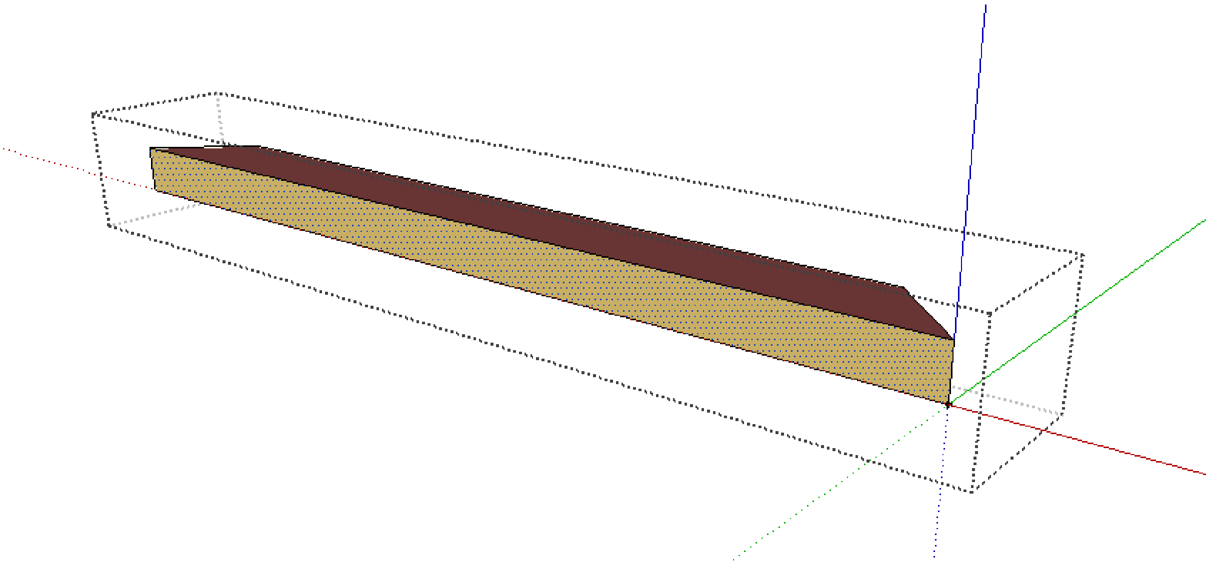

Figure 13. Single Space Selection View.

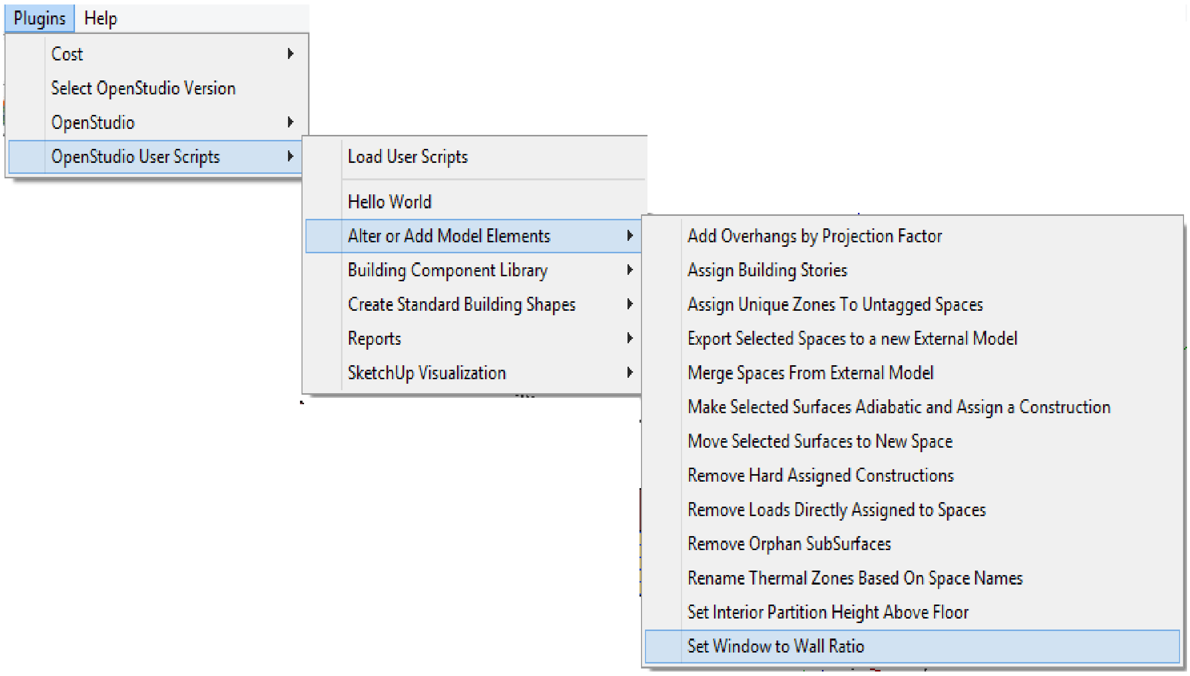

Figure 14. Set Window to Wall Ratio Tool Bar Access.

The window in Figure 15 will pop up, set the values to 0.4 (40% Window to Wall Ratio) and the offset to 0.76 m above floor. Repeat the same step for each external wall until we get the final shape of the building geometry (Figure 16).

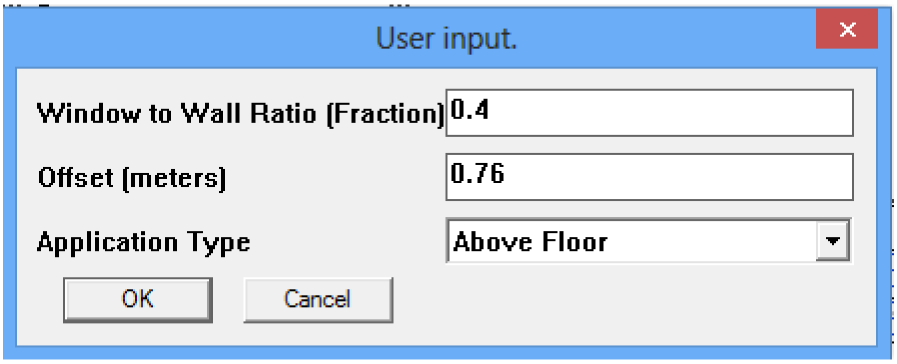

Figure 15. Set Window to Wall Ratio Window.

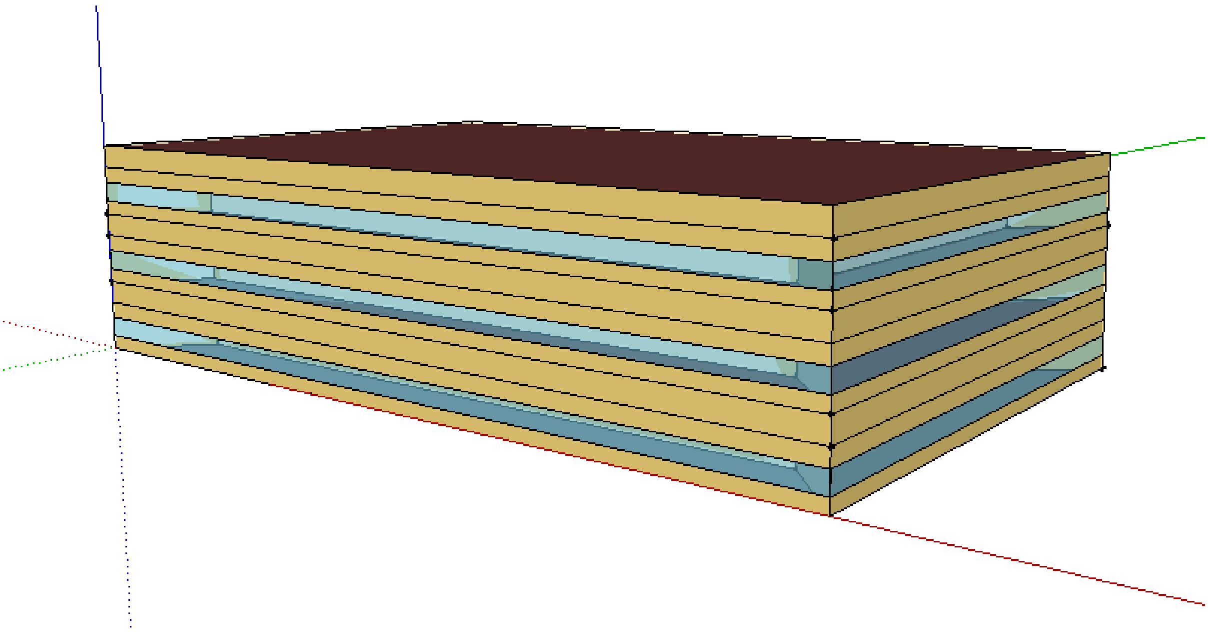

Figure 16. 3D Geometry of Office Building with External Windows.

The next step after the creation of the building 3D geometry is to apply the air condition zones to each space. First we select the space, by click the "Set Attributes for Selected Space" key the window in Figure 17 will appear, were we can select the space type, building story of selected space, construction set, thermal zone number, ideal load status and thermostat. The same step to be done for each space, until we get all Spaces assigned to 3 Story each with Core space , 4 parameter spaces and a plenum. The building will have 15 thermal zones (3 Core zones and 12 Parameter zones).

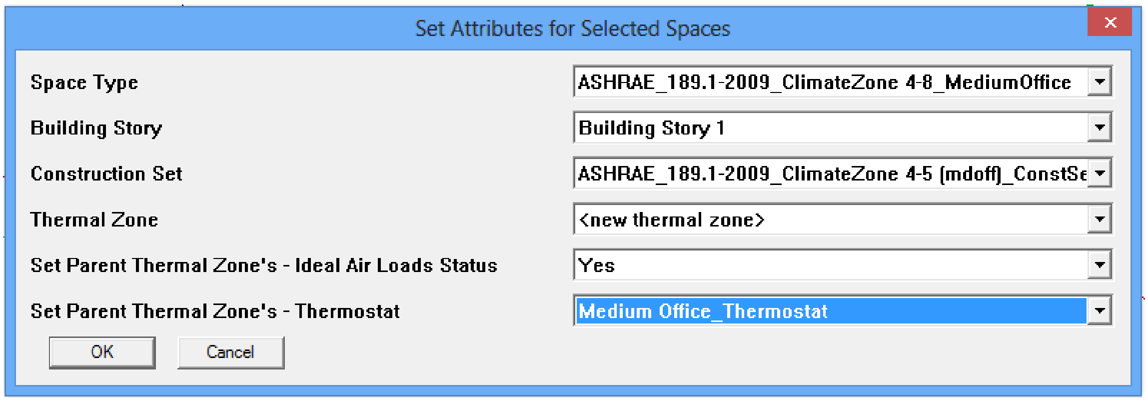

Figure 17. Set Attributes for Selected Space Window.

OpenOffice Inspector window (Figure 18) enables the user to change the building geometry in for ASHRAE standard to the construction layers described for each building. The previously described materials may not be found in the materials library, thus it's should be entered manually, then use the materials to create the constructions of each layer (External Walls, Interior Walls, Fenestration, Slab Floor, Interior Floors, Interior Ceiling and Roof). Similar steps required to create Space Loads and Scheduling. It will be more advantage to check each surface construction name.

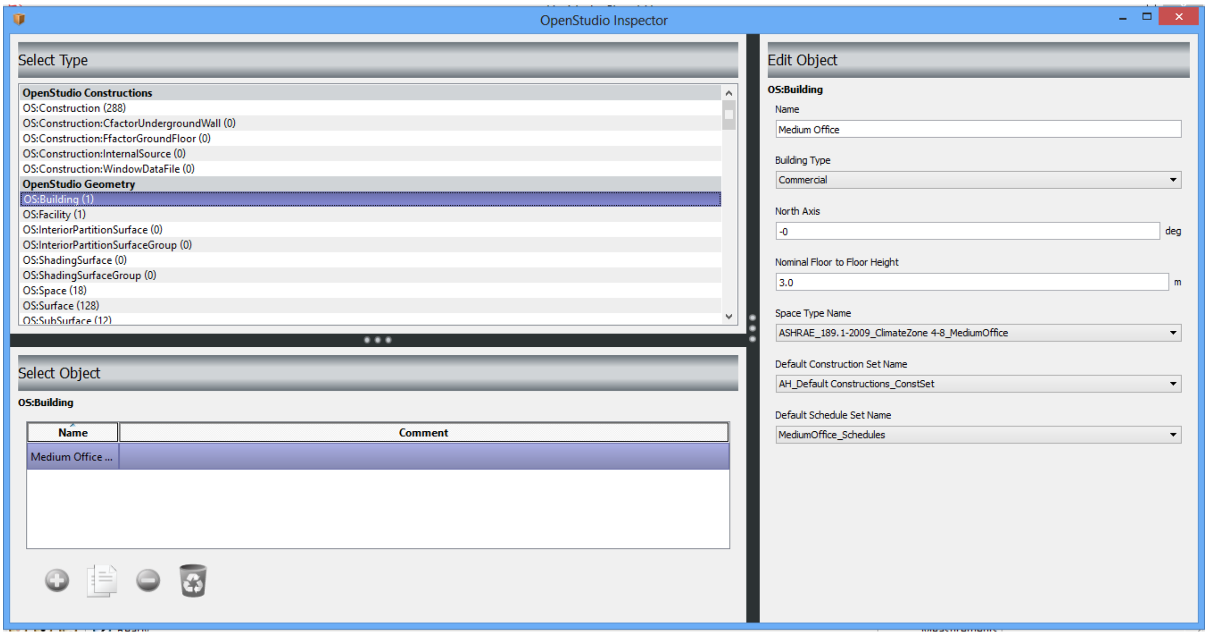

Figure 18. OpenStudio Inspector Window.

The Glazing material properties values (i.e. U-Factor, SHGC and the visible transmittance) can be edit from the OpenOffice inspector window. In Figure 19 the parameters of the glass properties stated. These values reduced to 2.5 $W/m^2.K$ (U-Factor) and 0.26 SHGC for modified glazing.

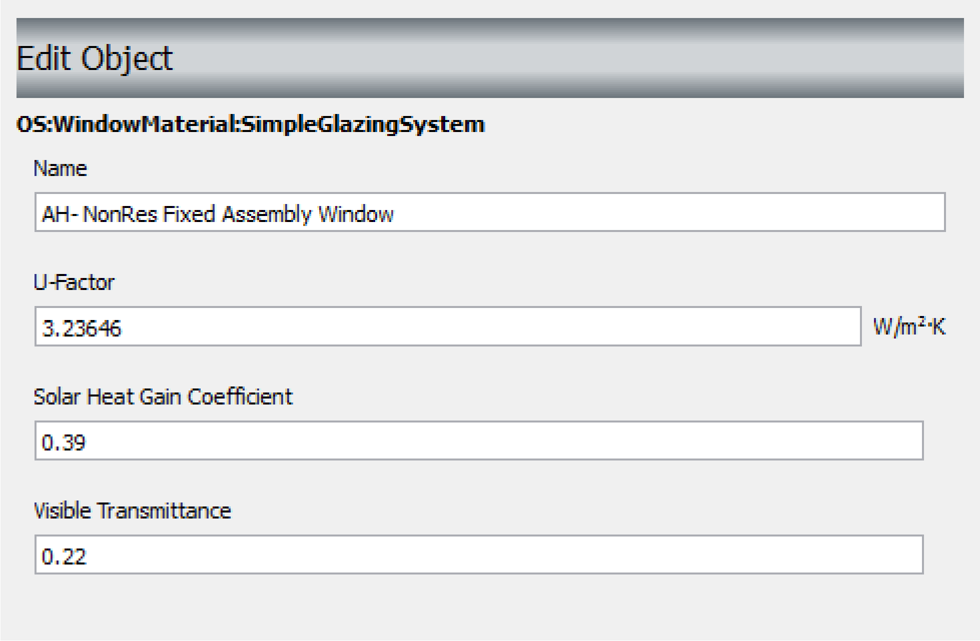

Figure 19. Glazing Material Specification Editing Window in OpenStudio Inspection.

Further modification for the building in this study is to add a hangovers for external windows (Figure 20), the same procedure for adding windows to external wall shall be recalled here, go to "Plugins", "OpenStudio User Scripts", "Alter or Add Model Elements" then select "Add Overhangs by Projection Factor" (Figure 21), repeat the procedure for all windows till we get all windows with overhangs.

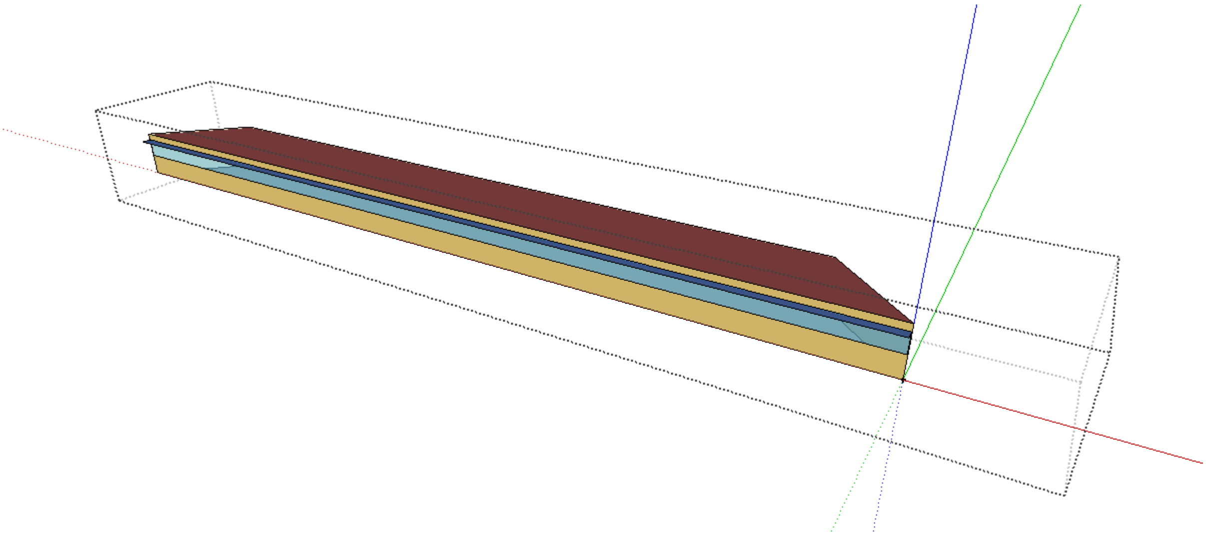

Figure 20. Adding an Overhang for External Window.

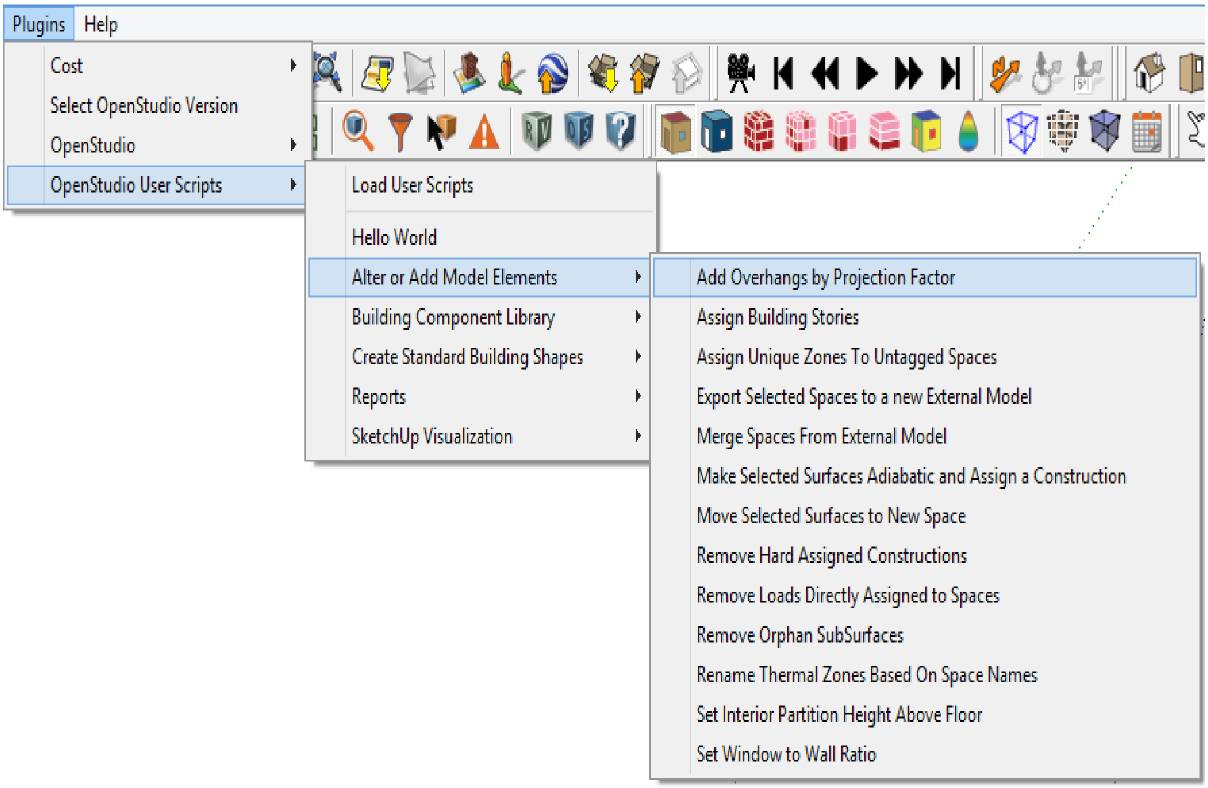

Figure 21. Toolbar Access to Add Overhang by Projection Factor in OpenStudio Plug-in.

BUILDING ENERGY SIMULATION WITH OPENSTUDIO

This section shall subject the building to the simulation using the Openstudio, used in this project for the calculation of loads and demonstrate how they have been introducing the input parameters according to the study done earlier enclosure. The scenarios to be simulated are:

1. Basic conditions.
2. Improved glazing with solar filter film.
3. Improved window with Overhangs.
4. Mixed condition (Solar film and Overhangs).

The "Launch to OpenStudio" option will open the OpenStudio exe. File (Figure 22), the toolbar on the left side help to set and modify building geometry specification, internal loads and operating schedules, add HVAC units, run simulation and results viewing , in addition to more detailed options.

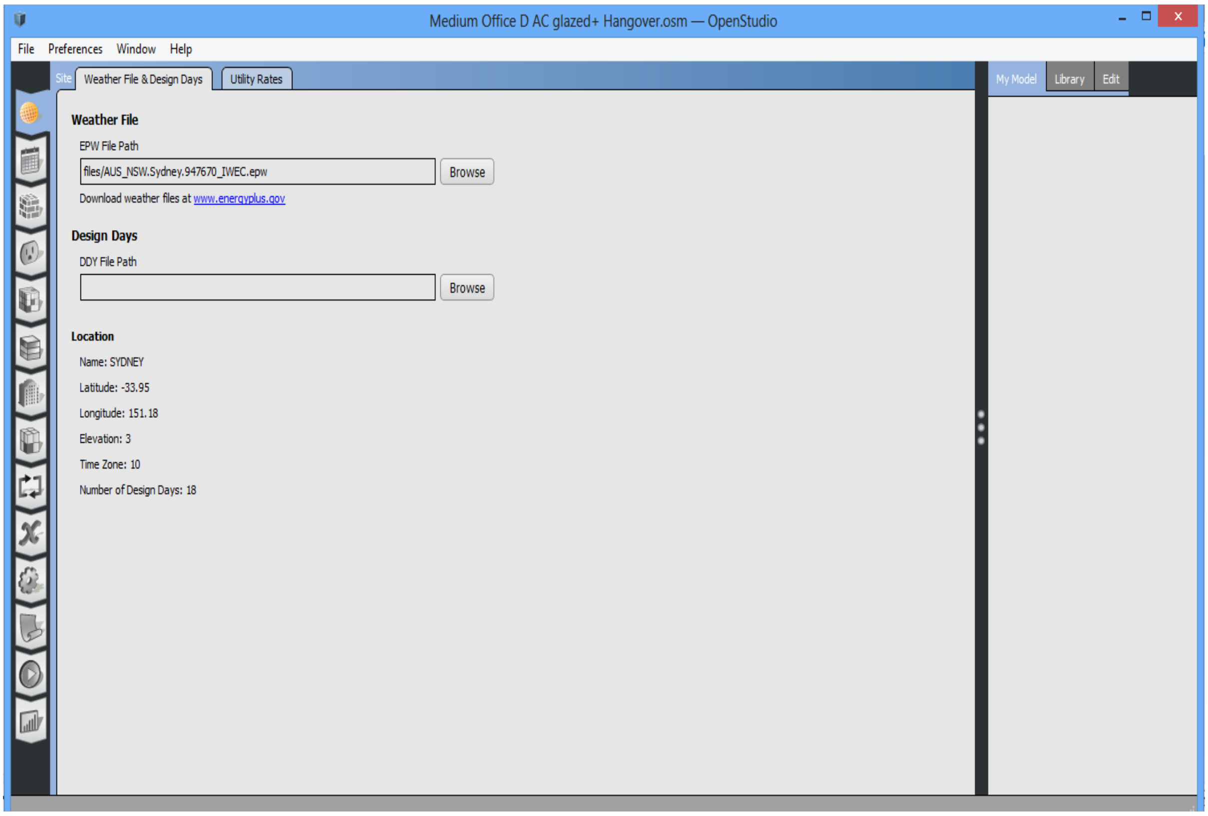

Figure 22. OpenStudio Panel Window.

The run simulation window will perform the building simulation with EnergyPlus software; EnergyPlus has its roots in two programs, BLAST and DOE-2. BLAST, Building Loads Analysis and System Thermodynamics and DOE-2 were developed and released in late 1970 and early 1980 as a tool for energy load simulation. Like original programs, EnergyPlus is a program of energy analysis and thermal load simulation. Based on the description of a building user-defined from the perspective of the physical (construction), mechanical systems, etc..

EnergyPlus calculates the heating and cooling loads necessary to maintain control set points thermal conditions in an HVAC system, and the energy consumption of primary plant equipment, and many details of other simulations that are necessary to check that the simulation is running as desired.

At the end of simulation process (Figure 23), we can view the result on “Results Summary” page (Figure 24). Detailed Electricity and Gas consumption for simulated building are listed and graphed. To get more detailed results for each space we can choose to open the “Results Viewer” (Figure 25), were the annual performance report for whole building is available. Double click on any Variable(s) on the left will plot the selected zone(s) annual variables on hourly bases (Figure 26).

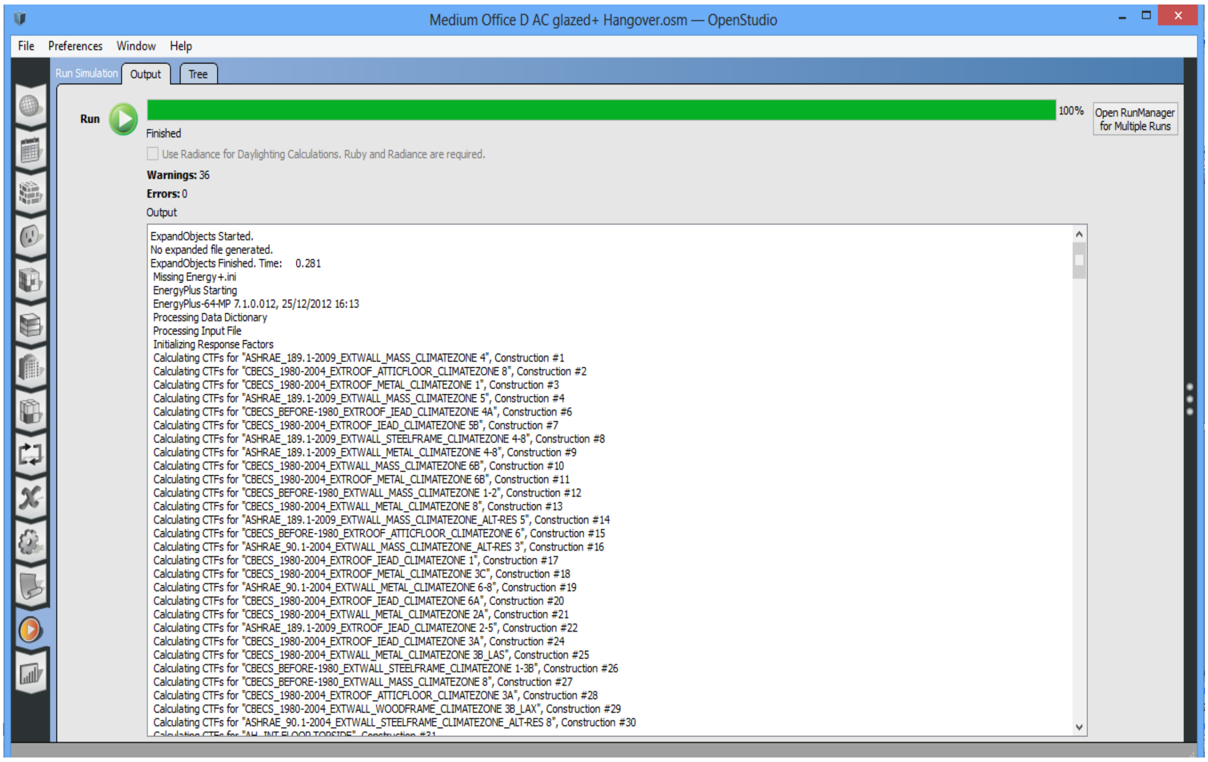

Figure 23. OpenStudio Simulation Window.

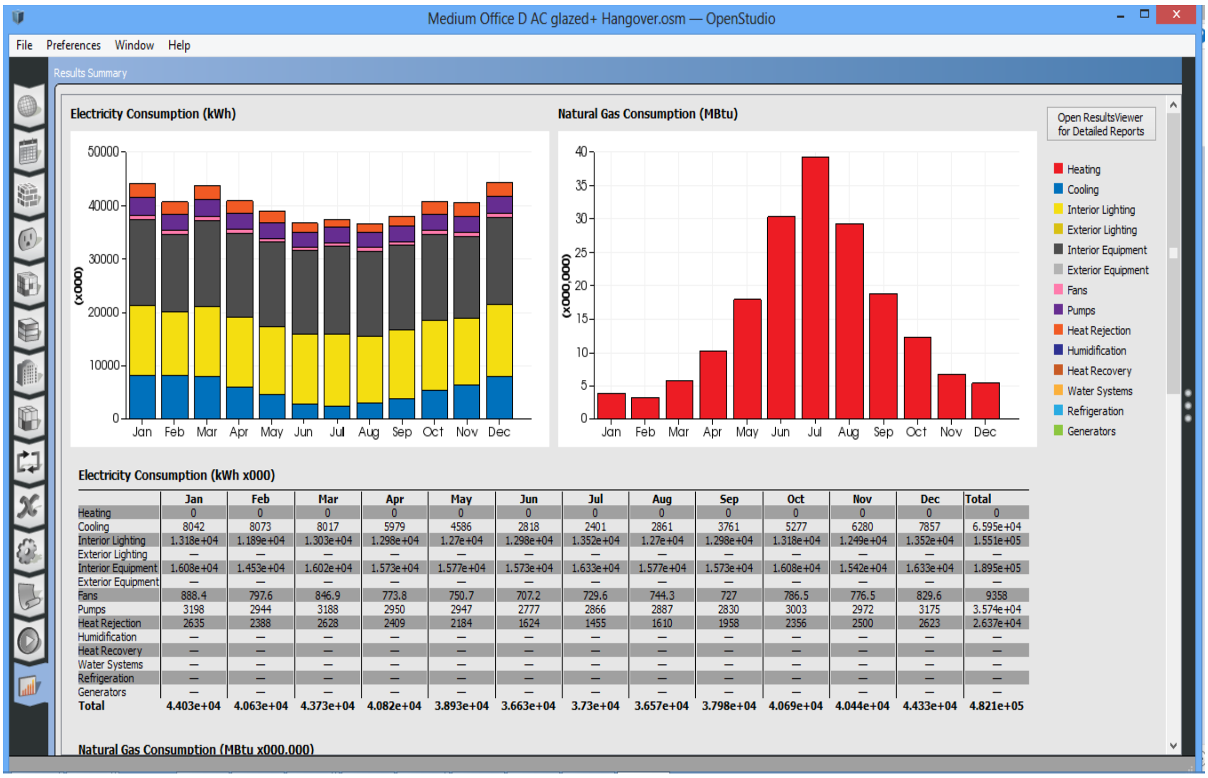

Figure 24. OpenStudio Basic Results Viewer.

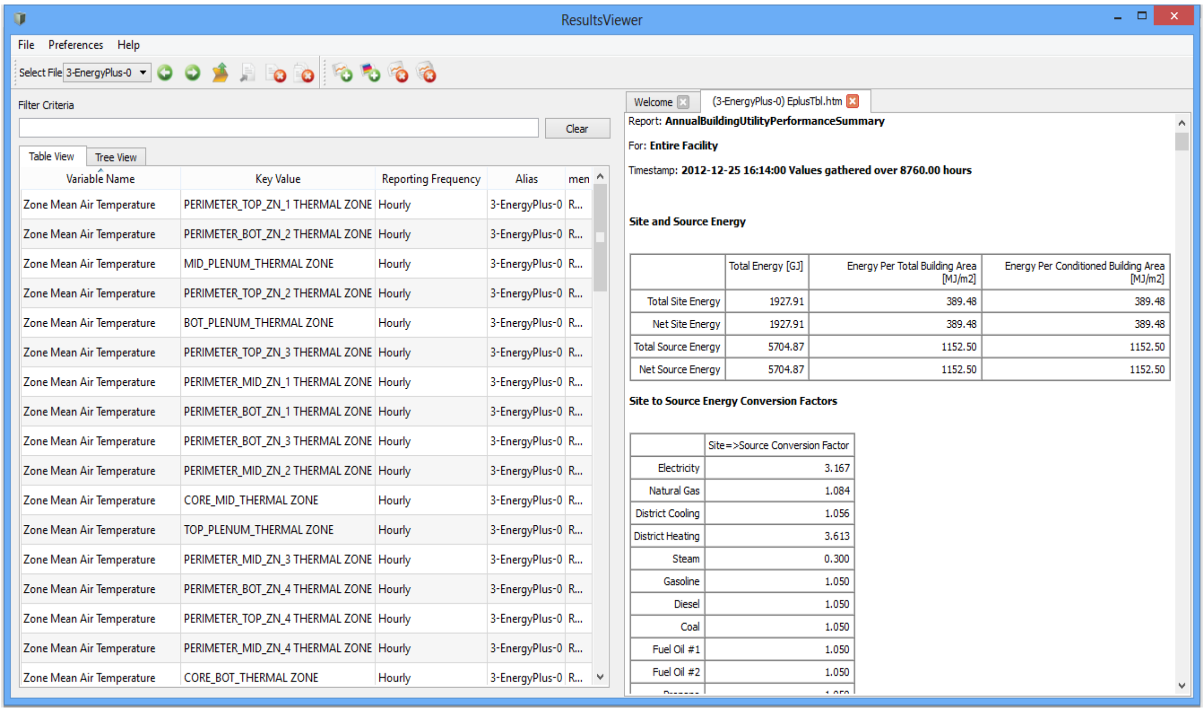

Figure 25. Results Viewer Window in OpenStudio Package.

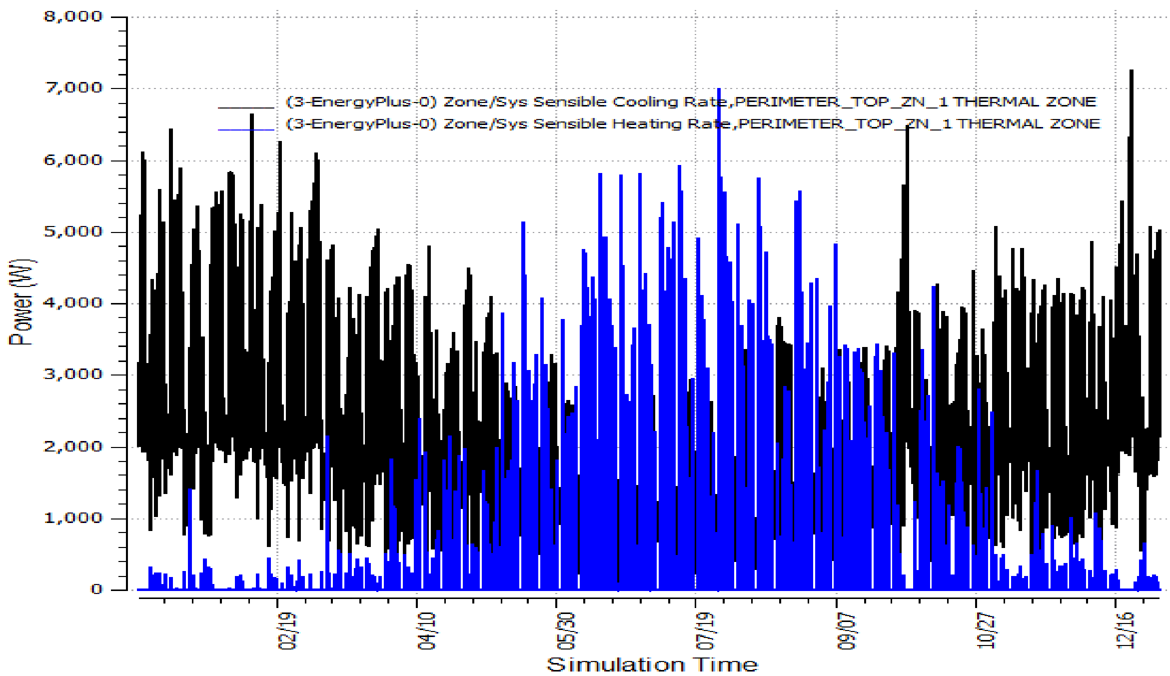

Figure 26. Perimeter Zone 1 Annual Cooling and Heating Loads on Hourly Bases.

The simulation results for the two building under study were given in the buildings simulation result section in this chapter to compare between results obtained from OpenStudio and these obtained from TRNSYS software package simulation. The OpenStudio results are used to estimate the HVAC systems electricity consumption for cooling.

CONCLUSION

The simulation with the Energy Plus OpenStudio plug in utilize the graphical interference with Google SketchUp presented in this work in the form of step by step manual guide. The software flexibility and accuracy promoted it as one of the best available options for energy calculation.

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