Recent Advances in Energy Conservation Techniques for Buildings Workshop:
From Micro Scale to Urban Level
British Council Researcher Links Programme
Coventry University and Istanbul Technical University
4-8 December 2017, Istanbul Turkey

Evaluate and Measure Performance of the Building Design to Reduce Energy Consumption

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Abstract

Understanding a construction site and the impacts associated with building on it has been for a long time a primary concern of green professionals (Emarald Architecture 2008). Traditional design results in adverse effects on the environmental and therefore concerned architects are attempting to minimize the problems of the past and create a new path to follow for the future. Therefore, Green Buildings can be proposed as a solution that reduces energy consumption while maintaining occupant comfort. The technics of the Green Design collected over the years by concerned professionals to eliminate the negative impact on the environment. These technics are not always requiring high-technology solutions; even low- technology solutions can make measurable differences such as using energy simulation programs to evaluate design alternatives to provides more factual data to identify improvements and confidently suggest building design alternatives that will reduce energy consumption. In this study some basic passive design strategies are applied and represented in scenarios. The results, impact percentages of each parameter changes in each scenario were given credit rather than focusing on quantitative results. The methodology of this research consisted of numerous simulations to provide energy efficient design alternatives that properly apply to a structure.

Key Words: *Energy Simulation Tool, Energy Efficiency, Green Design Strategies,*

1. INTRODUCTION

As global energy-generating resources are being depleted at exponential rates, the amount of energy consumed and wasted cannot be ignored. The building industry is the largest consumer of energy; therefore, it gives a great responsibility and the opportunity to designer to include energy-efficient methods to design efficient and cost-effective ways of reducing energy loss in the areas has potential to lose as means of saving energy and reducing adverse environmental impacts. Because buildings have a long-life cycle of 15 or more years, it is important to properly design them to prevent errors that might pose a lasting burden on society over their lifetime. In contrast to buildings, automobiles, used for approximately 10 years, more frequently evaluated and improved, thus enabling the more rapid detection and correction of design flaws (Lenchner 2009).

A future including sustainable energy may result from using energy simulation software to accurately estimate energy consumption that achieves the potential results derived through simulation analysis. In the long term, green/sustainable design is not an option but a necessity. A sustainable energy future is possible through on integrated green design solutions. Energy-modeling tools assist green design professionals with making informed decisions on energy performance during the early planning phases of a design project, such as determining the most advantageous combination of building assembles, choosing mechanical systems and materials, appropriate window and shading device size and shape and determining building orientation on the site. The BIM, Building Information Modeling and integration of energy analysis to BIM software it is possible to predict energy consumption and to derive operation cost of a building project even pre-occupancy (Azhar & Brown, 2009;

Eastman, Sacks, & Liston, 2008; Krygiel & Nies, 2008). It is the one of the well-known and sector-wide benefit of BIM that enabling taking decisions on life-cycle stages of a project in design stage (Eastman et al., 2008). In this research study will indicate that even the post-design stage what it means during construction, still give us a chance to make necessary corrections to eliminate the negative impact on the environment while save a good portion of energy expenditure.

1.1 Problem/Solution

Green design technics and the judicious combination of building assembles materials comprise a solution to excessive amount of energy consumption problem. The research high lights the technics are not require high-technology. Selecting an appropriate orientation and accordingly adding shading devices are design considerations which will not require high technology. However, we need some predictable tools that measure energy consumption in this case the BIM, energy analysis software recommended to evaluate design considerations.

1.2 Methodology

The 20,000 square meter, under construction, additional faculty building for the Antalya Bilim University is selected as a study subject, Figures 1thrue 3 shown some mass models created for the case study. The method accomplished by using Revit-Green Building Studio, Energy Simulation Modeling Tool to determine the relative energy efficiency on the topics of orientation and shadings. The model has been implemented appropriate energy settings which are in compile with the real project data energy analysis study and has been set and then executed in Autodesk Insight-a cloud-based energy analysis program. Autodesk Insight is a cloud-based energy analysis and simulation tool that providing examination of different scenario related with a building project.

1.2.1 Scenario – 1

This scenario, the structure was examined in its current state without any modification or intervention. The building footprint is comprised in rectangular plan and long side is faced to east and west side. The main entrance is provided from north side. The shading elements are not added to the design and existing glazing ratio in each side is approximately 30%. Furthermore, there is no insulation in neither walls nor floors.

1.2.2 Scenario – 2

Shading elements are only component added to the openings of the eastern, southern and western facades without changing the form or orientation of the structure, see Figure 4. Also, the upper part of the roof in the Atrium is covered but the sides left open, see Figure 5. The goal is to reduce the energy use by preventing overheating while providing illumination. Due to sun movements, adjustable vertical shading applied on the west and the east façade; because of low angle of the sun while horizontal shading on the top of the window applied on the south façade; because of high angle of the sun.

1.2.3 Scenario – 3

The main difference from this scenario from the first and second scenarios is rotating to the 90-degree clockwise direction to use longer façade for the full potential of the winter sun to reduce energy use in heating, see Figure 6.

Energy analysis study has been executed in Autodesk Insight a cloud-based energy analysis program to indicated us to make informed decisions about energy performance even during construction; however, making this study in earlier stage of design for full benefits is better. The research tries to draw attention that even post-design, during construction still give us to make necessary changes for sake of environment, social and economic benefits.

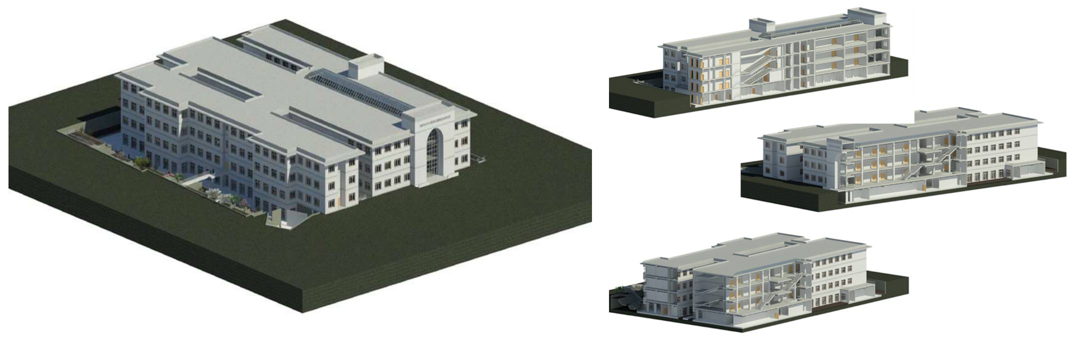


Figure 1. Case study model, Antalya Bilim University additional building, a mass model and vertical section models created in Revit to simulate energy performance

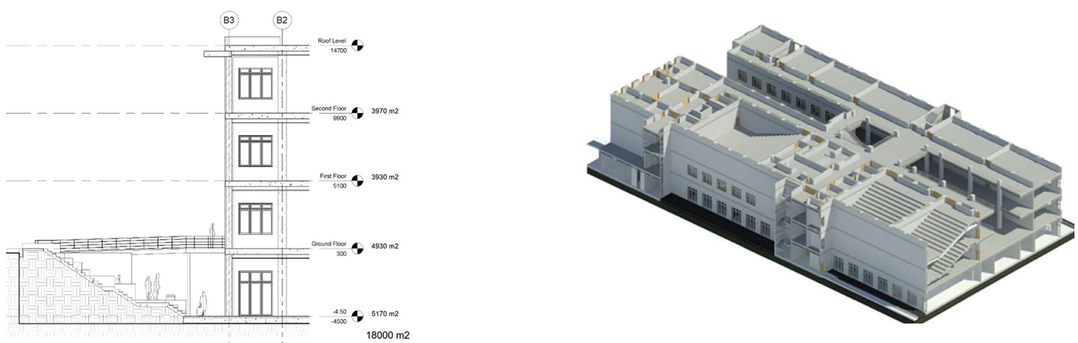


Figure 2. A section and horizontal section model

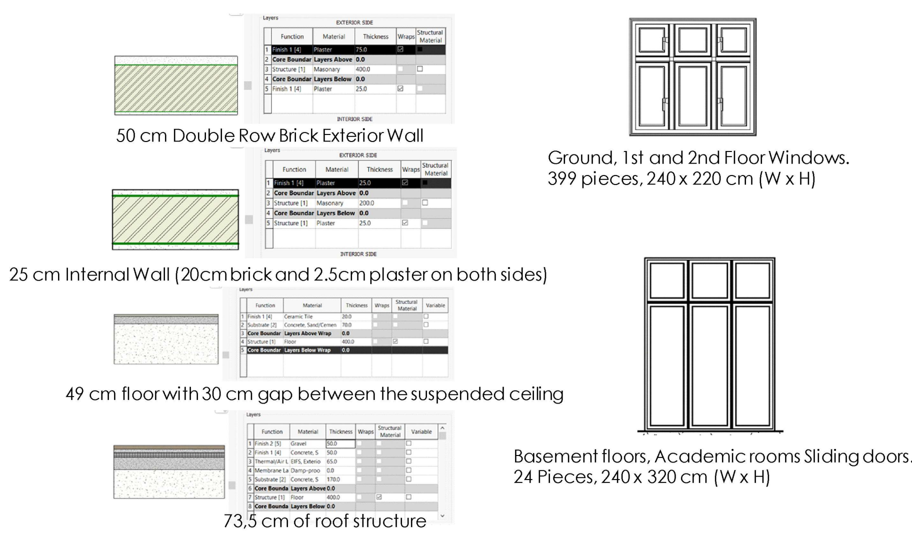
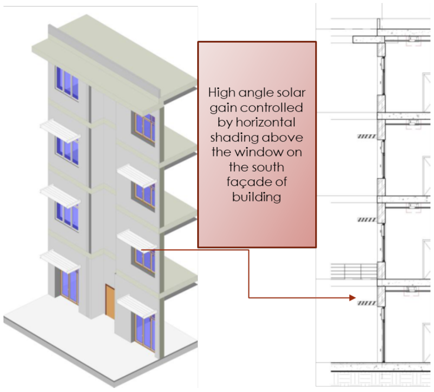


Figure 3. Structural features of the case study model



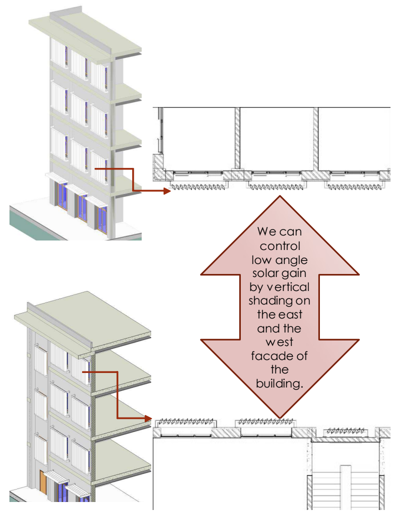


Figure 4. South (left) horizontal and
East-West (right) façade vertical shading elements

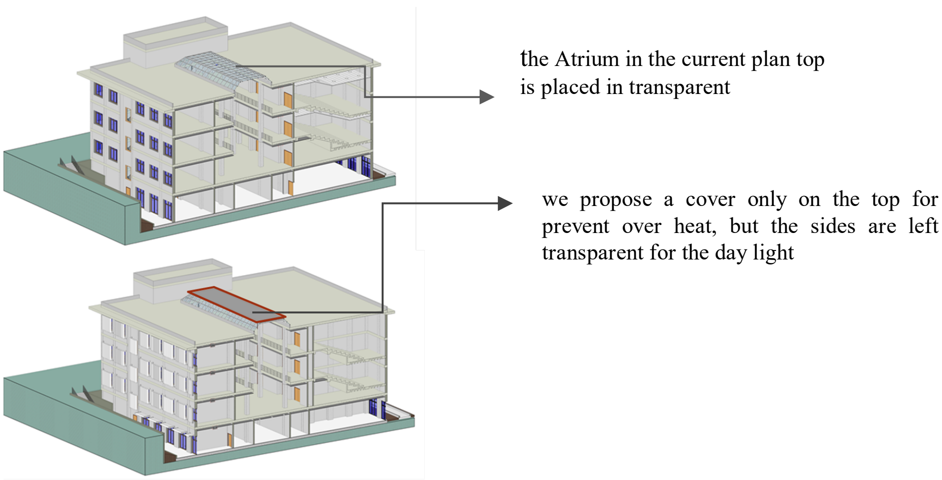


Figure 5. case study model sections indicate that the current Atrium design on the first scenario (top) and proposed roof covered by shading elements Atrium design on second and third scenarios (bottom)

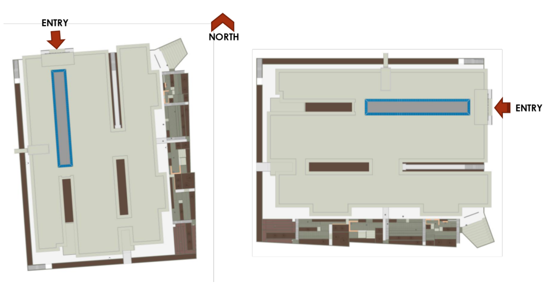


Figure 6. The left side current situated on the first and second scenarios; the right side shown the rotation on the third scenario study models.

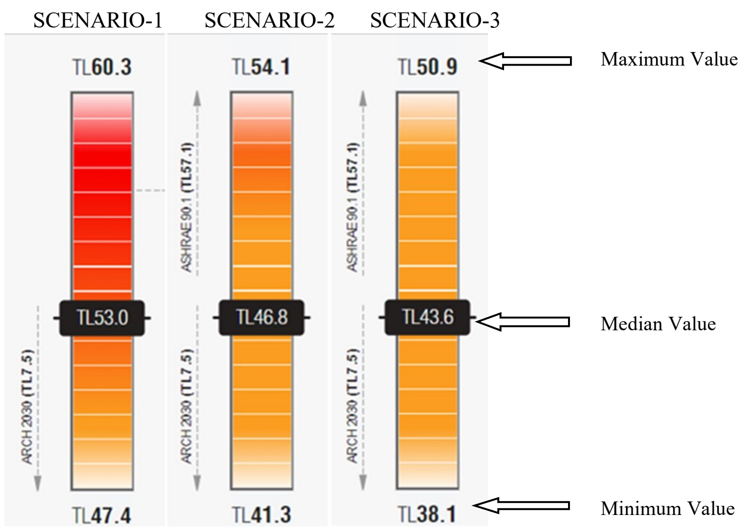


Figure 7. The result for the annual operation cost per m2 is derived in Turkish Currency.

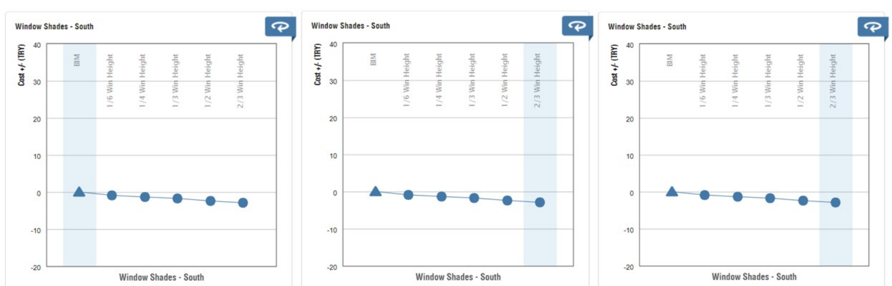


Figure 8. Effect of window shades in operation cost. It is demonstrated in the figure that addition of shading elements to south elevation decrease the operation cost. However, if shading element is not implemented, the operation cost is the highest value.

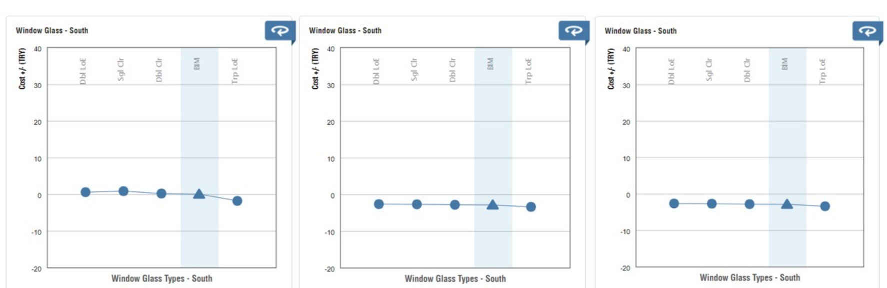


Figure 9. The analysis result shows that, operation cost in Scenario 2 and 3 are lower than Scenario 1. Due to have same operation cost, the reason for these differences may be addition of shading elements because only the shading elements are common attributes in Scenario 2 and 3.

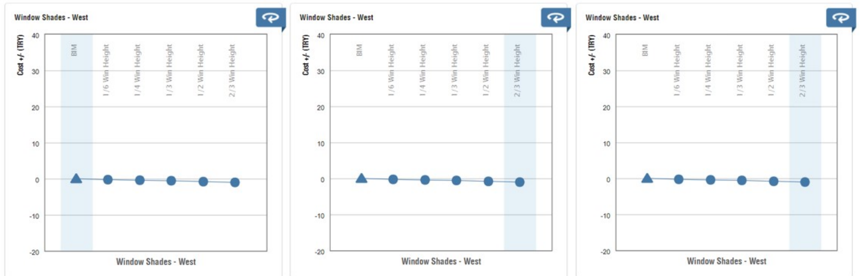


Figure 10. It is represented in figure that implementation of shading elements decreases the operation cost as stated in analysis result of Scenario – 2 and 3.

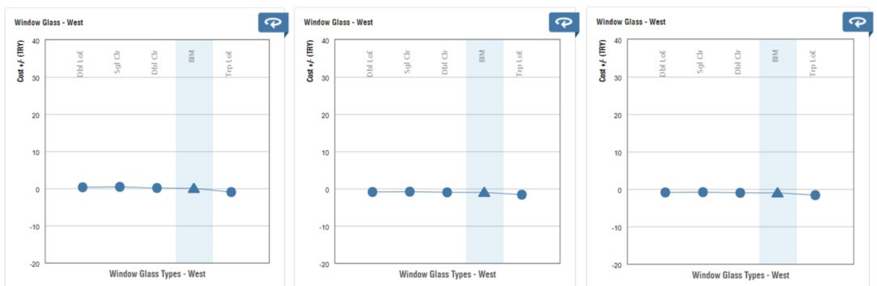


Figure 11. It is demonstrated in the figure that implementation of shading elements to west side decrease the operation cost.

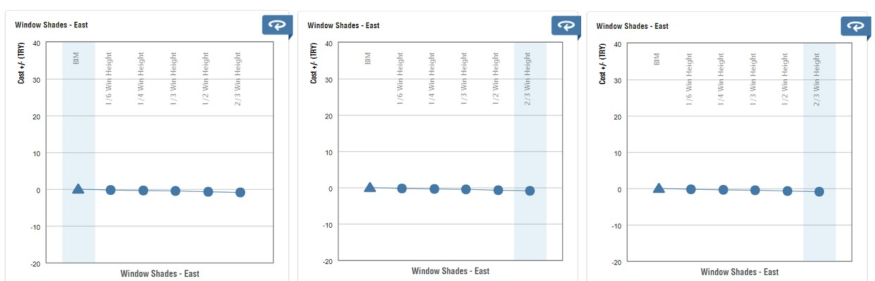


Figure 12. The figure demonstrates that implementation of shading elements in east side decrease the operation cost in both Scenario 2 and 3.

2. DISCUSSION

Considering the available alternatives among BIM and energy analysis tools, Autodesk Revit for mass modelling and Autodesk Insight utilized in this case study for calculating operation cost and determining effect of changes on addition of shading elements to building and rotation of building. The aim of this study is unveiling the major parameter that impact building operation cost much influentially than other. Thus, especially, basic passive design strategies are applied and represented in scenarios. In this study results, impact percentages of each parameter changes in each scenario were given credit rather than focusing on quantitative results, see Figure 7. Building designers have begun to recognize the benefits of simulation modeling tools in developed countries; however, these tools are not accepted as design tools in Turkey and most design professionals are either ignoring nor aware of the capacity and potential of these tools.

The research indicates confidently that computer simulations models are one of the simplest and most reliable methods of evaluating energy performance and operation cost in pre-occupancy and identifying cost-effective ways of conserving energy (Rahdi 2008). The technic of the research study will ultimately assist designers and educate builders and building owners about the non-familiar green building strategies and technics.

3. CONCLUSIONS AND RECOMMENDATIONS

In this study, by implementing three scenarios to a building, effect of implementation of shading elements and orientation changes has been investigated. It is resulted that, shading elements decrease 11.7% to total operation cost while both implementing shading elements and changing the orientation of the building decrease 17.7% to total operation cost; see Figure 7 for more detail. As we see from the Figure 7, scenarios between the first and the second we will be saved 124,000 Turkish Lira on operation cost. As of February 23rd, 2018, currency, the saving is 23,476 British Pound or 32,767 US Dollars. And this saving was only possible by adding shading devices which is during construction stage; because we cannot change so much of the design nevertheless still there is a room for saving no matter the stage of a project. If the such study will be performing on earlier, the project will have a chance to change the rotation of the structure which is Scenario between the first and third it will be save 188,000 Turkish Lira. As of February 23rd, 2018, currency, the project will be saved 35,590 British Pound or 49,676 US Dollars on the operation cost.

Figures 8 thru 12 for shown the results of analyses of three scenarios are explained by compared with each other. In each figure, from left to right presented scenarios 1, 2 and 3. The overall results may be further validated by adding more case studies with applying same scenarios.

According to the research study, these tools offer a prospect for the professionals to provide more factual data to identify improvements and confidently suggest building design alternatives that will reduce energy consumption.

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