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Building Energy Analysis of a School Building using Revit

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Abstract

Global warming and environmental issues have driven the demand for high efficient buildings. The integration of Building Information Modelling (BIM) and energy assessments tools to the construction process have contributed to proper selection of building materials and significant reduction in energy consumption. With BIM, the energy consumption is an integrated part of a building design, where energy analyses begin at the conceptual stage of the project. This study considers an energy analysis of a school building located in Spain. The building is an object of study in an inter-university project between INTI International University and another Spain university in 2018. Upon the completion of that project, the authors become interested in the energy usage of the building, which has not been completed then. The new analysis uses Autodesk Revit to develop a Building Performance Analysis (BPA) and to predict its energy performance, including the consideration of building materials and weathering effects. The analysis is able to estimate the CO2 emission, cooling and heating loads, and the electrical usage of the building. With a single and modern workstation, an engineer can carry out the complete analysis of a small building with ease.

Keywords

BIM, Building Performance Analysis

Introduction

Global warming and environmental issues have driven the demand for high efficient buildings. The demand comes from our collective consciousness that our simple daily activities can significantly change and negatively impact the environment that we live in, leaving the future generations with a world short on food, covered in toxic chemicals and full of diseases. With the demand comes the realization that we need to change our ways, starting in this case with how we construct buildings.

Riding on the rapid digitalization of information, the construction industry is making progress in the construction process. The integration of Building Information Modelling (BIM) and energy assessments tools to the construction process have contributed to proper selection of

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building materials and significant reduction in energy consumption. With BIM, the energy consumption is an integrated part of a building design, where energy analyses begin at the conceptual stage of the project (Gao, Koch, Wu, 2019).

This study considers an energy analysis of a school building located in Spain. The building is an object of study in an inter-university project between INTI International University and another Spain university in 2018. Upon the completion of that project, the authors become interested in the energy usage of the building, which has not been completed then. The new analysis uses Autodesk Revit to develop a Building Performance Analysis (BPA) and to predict its energy performance, including the consideration of building materials and weathering effects.

Methodology

The architectural model used for this project is the school building located in Malaga, Spain. It is a standard three-storey school building with building features, such as wall, roof, ventilation and lighting. Building features contain construction information such as dimensions and surface finishes, as well as thermal properties such as heat transfer coefficient and thermal resistance (R-value). Figure 1 shows a model of the school building.

Figure 1. A model of the school building.

Naturally, the building has rooms and zones. A room is defined as a closed area with information, while a zone consists of a number of rooms with shared information. Information here is not simply labels and descriptions, but also contains functional elements such as usage patterns, lighting policy, heat sources, and air-conditioning.

To perform a BPA, the first step is to define an energy model. With good BIM practice, the translation from an architectural model to an energy model should be painless. Nevertheless, the convenience comes from a history of data incompatibilities and subsequent developments (Gerrish et. al., 2017; Kamel and Memari, 2019). Pezeshki et. al. (2019) reported that the major issue has come now down to the different interpretation of the BIM standards by different software tools rather than broad incompatibility. Energy model consists of elements such as ceilings, floors, columns, panels, doors, windows, and all other interior mass and functional systems that defines an enclosure. The concept of rooms and zones are applicable here as well.

Next is the simulation engine. Autodesk Revit simulation engine is DOE-2, a free software developed by the Lawrence Berkeley National Laboratory. Other engines commonly used in the industry are EnergyPlus and Blast. The job of an engine is to simulate the heating, cooling, radiation and loads of the energy model over days and nights and different weather conditions of the four seasons. The engine defines weathering loads from the temperatures and humidity data contained in the weather file of a particular location on Earth. From the simulation, an engine can determine the detail energy consumption over time, in terms of electrical usage and CO2 emission.

Results and Discussion

Autodesk Revit generates a report that summarizes key results in graphs from the numerical output. The graphs provide a quick overview of the building performance. Figure 2 shows the monthly cooling load of the building over the year. The negative values in the graph represent heat losses, while the positive value represent heat gains. It is clear that during the summer months, the heat gains are highest. Building equipment, lighting and solar radiation contribute the most to the heat gains.

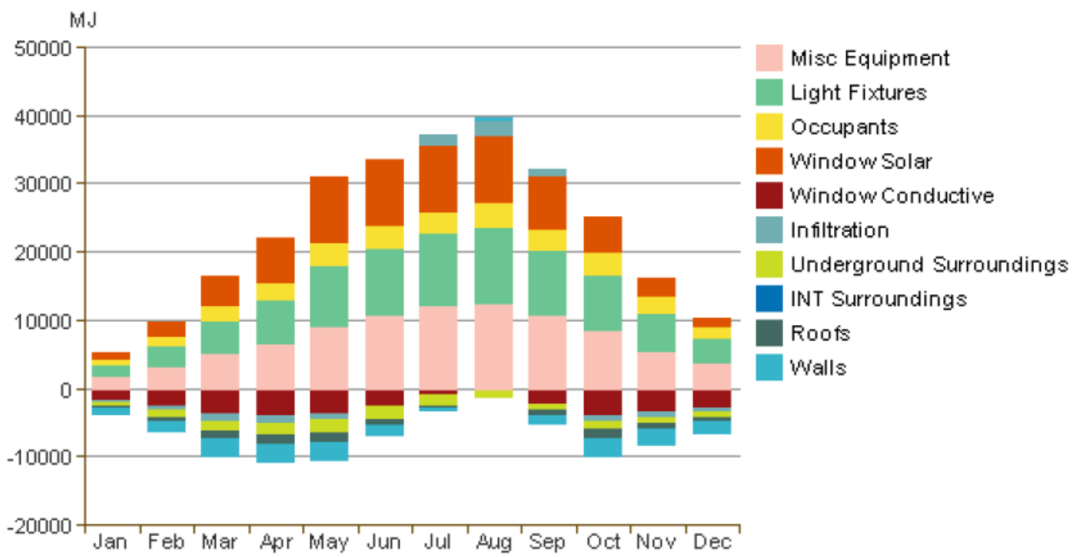

Figure 2. The monthly cooling load of the building over the year

Figure 3 shows the monthly heating load of the building over the year. From the graph, heating load is negligible during the months of July and August, while the total heat loss and heat gain is highest during January. The heat losses through the windows and walls are so significant that perhaps better materials or designs should be considered for the building.

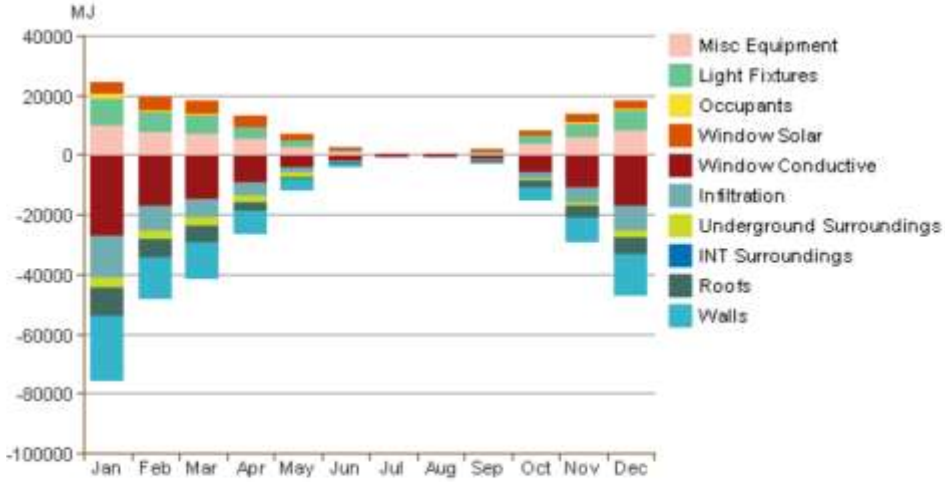

Figure 3. The monthly heating load of the building over the year

Figure 4 shows the monthly electricity consumption over the year. From the graph, it is clear that the consumption peaks during the summer season and the winter season. In the summer, the consumption is highest in August at a power of over 12 megawatt hours, which is higher than the winter peak in January at 11 megawatt hours. The lowest consumption is in October, which is only 8 megawatt hours.

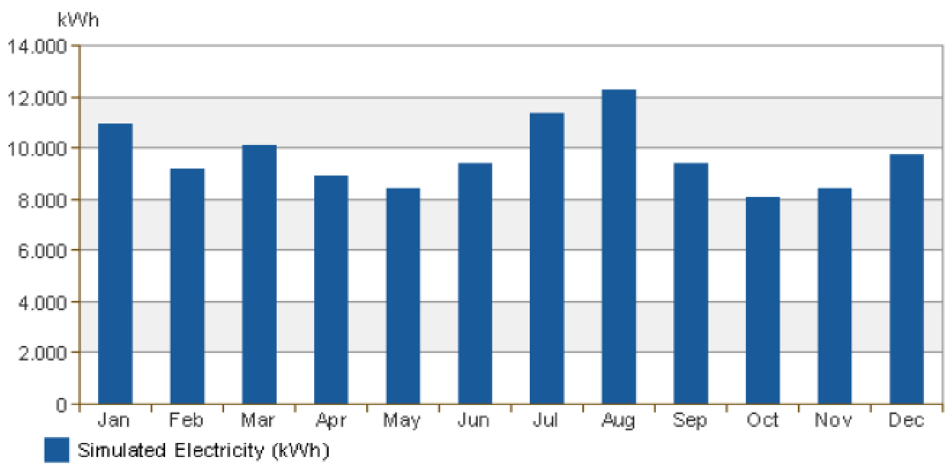

Figure 4. The monthly electricity consumption over the year

Figure 5 shows a breakdown of the electricity usage. Electricity is consumed almost equally between HVAC, lighting and building equipment. Power consumption for HVAC is the least at 31% or 35.5 megawatt hours per annum, while power consumption for building equipment is the most at 36% or 41.4 megawatt hours per annum.

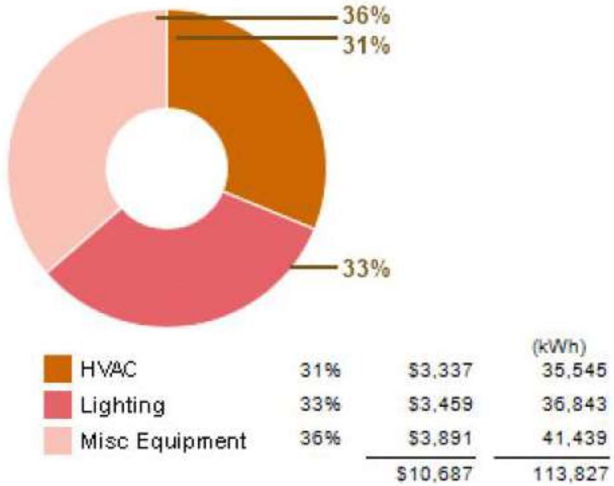

Figure 5. A breakdown of the electricity usage

Figure 6 shows a breakdown of the fuel consumption. The fuel consumption is mostly used to maintain the indoor comfort of the building, with the HVAC taking 93% or 397 gigajoules of the energy. With a mostly classrooms building, the energy usage of domestic hot water is only 29 gigajoules.

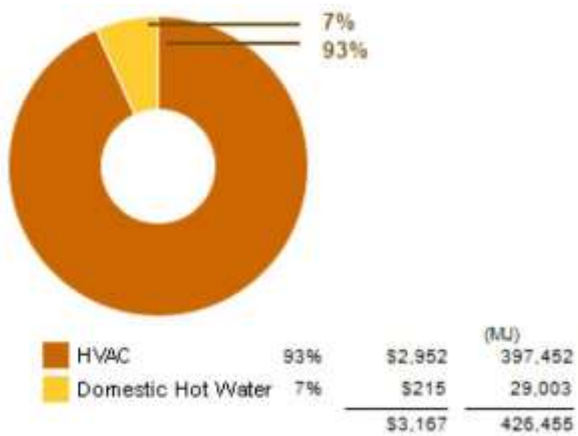

Figure 6. A breakdown of the fuel consumption

Figure 7 shows the CO_2 emission of the building. The majority of the annual 45 metric tons CO2 emission comes from electricity consumption. Although there is a potential energy saving with the installation of solar panels on the building roof, the saving is only slightly more than half of the fuel consumption.

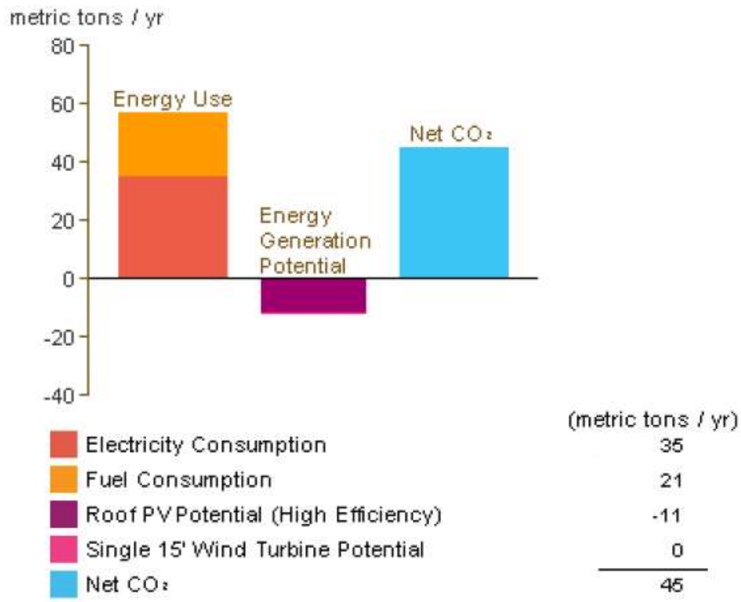

Figure 7. CO2 emission of the building

Conclusion

This project demonstrates the use of energy analysis under the BIM framework, where there is a reduction in the need of re-entering information in compatible systems. This is an advantage not only in saving time, but also in reducing copying errors and omissions of important data. The computational requirement is also not overwhelming in today's standard. With a single and modern workstation, an engineer can carry out the complete analysis of a small building with ease.

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