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Modeling And Energy Analysis of An Educational Building by Autodesk Insight and Green Building Studio

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Abstract

Buildings consume substantial energy throughout their life cycle, contributing significantly to global warming and environmental degradation. To address this challenge, early-stage energy performance assessment is critical. This study applies a BIM-based energy modeling methodology to predict and analyze the energy performance of a multi-storied educational (library) building located in Gulshan-2, Dhaka, Bangladesh, with a total floor area of approximately 8,830 m^2. The research methodology integrates Autodesk Revit 2021 for building modeling and Autodesk Insight, a cloud-based energy analysis tool, to evaluate electricity, fuel, and water consumption at the conceptual design stage. The results indicate a total Energy Use Intensity (EUI) of 94.8 $kWh/m^2/year$ and a mean annual energy cost of 7.06 $USD/m^2/year$. Detailed parametric analysis reveals that HVAC systems (18.03 $kWh/m^2/year$), plug load efficiency (38.21 $kWh/m^2/year$), and lighting efficiency (38.57 $kWh/m^2/year$) are the dominant contributors to overall energy consumption. Envelope-related parameters such as window-to-wall ratio, shading, glazing, wall construction, and roof construction exhibit comparatively lower but measurable impacts, with orientation-specific variations across the north, south, east, and west facades. The significance of this study lies in demonstrating the effectiveness of BIM-based energy analysis for early-stage decision-making in tropical climates. The findings provide quantitative insights into key energy drivers and highlight priority areas for optimization, enabling designers and policymakers to implement cost-effective and climate-responsive energy strategies. This approach supports sustainable educational building design in rapidly urbanizing contexts such as Bangladesh.

Keywords

BIM, Autodesk Revit, Autodesk Insight, Green Building Studio.

Introduction

Energy modeling and performance analysis of educational buildings have become increasingly important, as the building sector accounts for nearly 40% of global primary energy consumption

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and about 30% of greenhouse gas (GHG) emissions (IEA, 2023; IPCC, 2022; Ürge-Vorsatz et al., 2020; UNEP, 2021). Sustainable building design is widely recognized as a key strategy for mitigating climate change, reducing operational costs, and improving indoor environmental quality (Azhar et al., 2011; Kibert, 2016; Pérez-Lombard et al., 2008; USGBC, 2022). Educational buildings play a critical role not only in academic activities but also in shaping environmental awareness among future generations (Ali et al., 2019; Filippín et al., 2018; Kwok & Grondzik, 2018).

High energy consumption in educational facilities contributes significantly to CO_2 emissions and increases operational costs while placing stress on energy supply systems (IEA, 2023; Pérez-Lombard et al., 2008). Inefficient energy management often results in poor thermal comfort, adversely affecting occupants' health, productivity, and learning performance (Kats, 2006; Mendell & Heath, 2005; Schneider, 2002). Consequently, energy-efficient and climate-responsive design strategies are essential for achieving sustainable educational environments.
Energy modeling is subject to uncertainties arising from occupant behavior, climate variability, and equipment performance, leading to deviations between predicted and actual energy use (Fumo, 2014; Menezes et al., 2012). Risk-based techniques such as Monte Carlo simulation and sensitivity analysis are increasingly applied to quantify uncertainty and identify influential parameters (Hopfe & Hensen, 2011; Tian et al., 2018).

Several building energy simulation tools are available, ranging from BIM-based platforms such as Autodesk Revit integrated with Autodesk Insight and Green Building Studio (GBS) to advanced engines like EnergyPlus and TRNSYS (Attia et al., 2012; Crawley et al., 2001). In tropical climates, passive design strategies natural ventilation, solar shading, and daylight optimization have proven effective in reducing energy demand, as demonstrated by net-zero energy educational buildings in hot-humid regions (Garde et al., 2010; Kwok & Grondzik, 2018).

Despite these advancements, limited research integrates occupant behavior, uncertainty analysis, and passive strategies for tropical educational buildings, particularly in developing countries (Andersen et al., 2013). This study addresses these gaps by applying a BIM-based energy modeling framework to evaluate energy performance and recommend cost-effective, climate-appropriate design solutions for educational buildings in Bangladesh.

Methodology

The general project information includes data of organizations, authors, and explicit development records as address and project status. We have considered the University of Information Technology and Sciences (UITS) as our project. The edifice was situated on University Avenue, but it clearly defined its status as the final structural design. It is shown in Figure 2

Figure 1. 3D View of UITS

Evaluation Process

The evaluation process followed Autodesk's Revit energy analysis workflow (Autodesk, 2021) with additional steps to analyze energy losses from individual building components. Eight main stages were defined: 2D architectural drawings were refined to remove unnecessary elements before creating a detailed 3D model, including all architectural features influencing energy performance, such as façade junctions, cantilevers, and shading from vegetation (Autodesk, 2021; O'Donnell et al., 2013). The building's real-world location was configured in Revit, including exact latitude, longitude, and elevation, with the nearest weather station selected for accurate climatic data (Pérez-Lombard et al., 2008; Crawley et al., 2001). Analytical model resolution was optimized, and the building type was set to School/University, with corresponding default operational schedules and HVAC configurations. Specific occupancy, lighting, and power use schedules were customized to reflect actual expected usage patterns (Kwok & Grondzik, 2018; Ali et al., 2019) Figure 2.

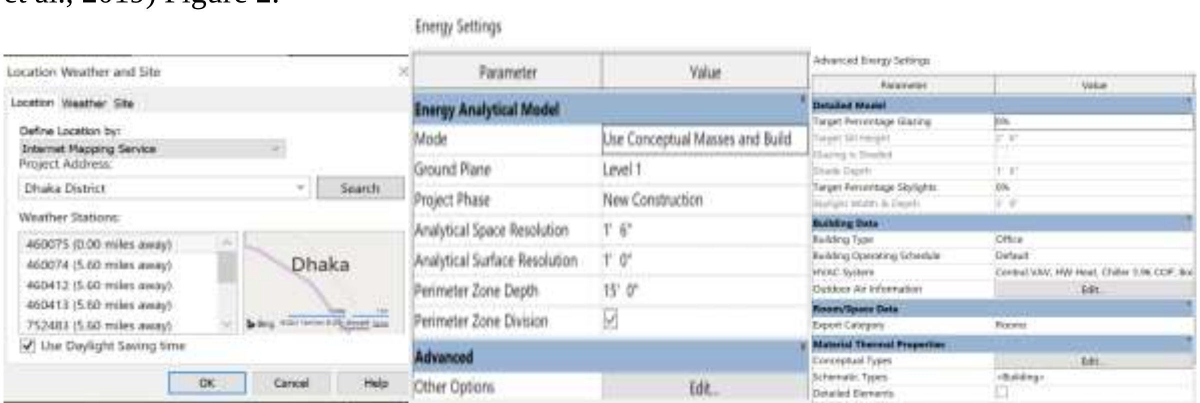

Figure 2. Weather station selected and Advanced energy settings.

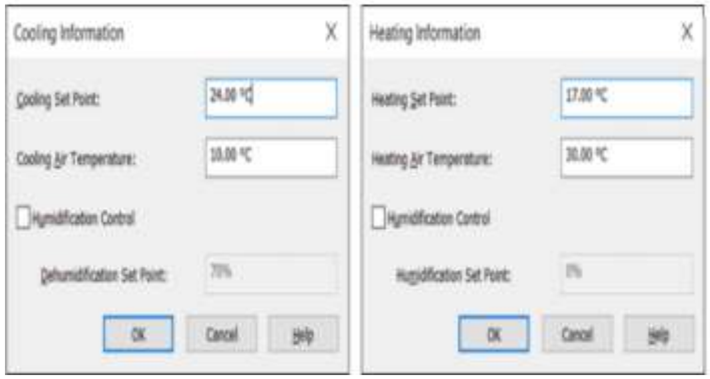

Figure 3. Heating & Cooling set points.

For this case, the school areas occupancy was set up with a variation between 5 to 90 percent of use, and it was distributed during the day according to the predicted and currently operable hours. It is shown in Figure 3.

MODELING & ANALYSIS

For energy analysis using Autodesk Revit and Autodesk Insight, this study adopts a case study approach focusing on an educational building. The selected case is the University of Information Technology and Sciences (UITS), located in Gulshan-2, Dhaka, Bangladesh. A detailed 3D BIM model was developed in Autodesk Revit 2021 based on architectural drawings and project documents. The workflow included data collection, BIM model development, configuration of energy parameters (building type, schedules, HVAC systems), geolocation using Revit’s mapping service, automatic generation of the analytical energy model, and cloud-based simulation using Autodesk Insight and Green Building Studio (GBS). The process enabled estimation of annual energy consumption and operating costs, ensuring realistic and reliable energy performance evaluation.

Creating the Project

After launching Revit 2021, a new project was created using the default Construction Template from the recent screen. Revit automatically generated initial levels and elevations, which were adjusted according to project requirements by modifying the elevation views and adding additional levels where necessary through the Architecture tab. The ground floor (GF) plan was then selected from the Project Browser, and the architectural CAD drawings were imported as references. Structural columns were placed by selecting appropriate column types from the Structure tab, with custom sizes created by duplicating and editing existing types when required. Walls were modeled by selecting suitable wall types from the Architecture tab and tracing the CAD reference lines.

Structural floors were created using Floor: Structural for the ground level and Floor: Architectural for upper levels by defining floor boundaries and completing the sketch in edit mode. Stairs were modeled using the Stair tool with straight-run configuration, specifying base and top levels and repeating the process for all floors. Elevators were loaded from the library, modified as needed, and placed at the designated locations. Finally, doors and windows were inserted level by level using the Architecture tab, and the complete building model was reviewed in the default 3D view to ensure accuracy and consistency before proceeding to energy analysis.

Results and Discussion

The Large Model View (LMV)

The energy model is submitted to Insight, as well as the Energy Cost Range (ECR), EUI (click on the ECR dial to toggle between cost and EUI), and the location specified Figure 4.

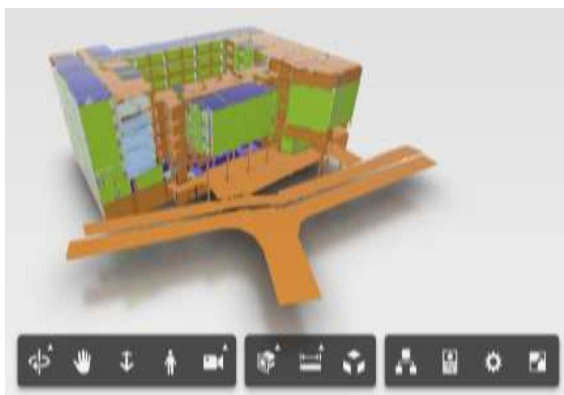

Figure 4. Model View in Revit

Building Orientation

The building energy model was analyzed using Autodesk Insight, where key performance indicators such as Energy Use Intensity (EUI) and energy cost were evaluated through the Large Model View (LMV). Parametric analyses were conducted to assess the impact of building orientation, envelope characteristics, internal loads, HVAC systems, operational schedules, and photovoltaic (PV) integration on overall energy performance. Results indicate that building orientation had negligible influence on energy consumption for the selected configuration. Envelope-related parameters such as window-to-wall ratio (WWR), window shading, and glazing type across all orientations (north, south, east, and west) showed relatively low individual EUI contributions, generally below 2 kWh/m²/year, suggesting limited sensitivity under the assumed design conditions. Similarly, wall construction had a minimal impact, while roof insulation (R60) showed a moderate contribution with an EUI of 6.63 kWh/m²/year.

In contrast, internal and operational parameters were identified as dominant energy drivers. Lighting efficiency and plug load efficiency contributed the highest EUI values, 38.57 kWh/m²/year and 38.21 kWh/m²/year, respectively, followed by the operating schedule (33.57

kWh/m²/year) and HVAC systems (18.03 kWh/m²/year). Daylighting and occupancy controls provided moderate energy savings. The integration of photovoltaic (PV) systems, considering panel efficiency, payback limit, and surface coverage, resulted in a notable energy offset of 22.02 kWh/m²/year, demonstrating significant potential for renewable energy adoption.

Energy Analysis Report

I. Energy, carbon and cost summary
II. Annul CO2 emissions
III. Annual energy
IV. Life cycle energy

This section presents a comprehensive summary of the building's energy consumption, carbon emissions, and associated costs, including annual energy use, annual CO_2 emissions, and life-cycle energy performance. The simulation outputs, illustrated in Figure 5, show the project run summary and monthly electricity consumption, while Figure 6 presents monthly fuel consumption alongside corresponding temperature variations. Together, these figures highlight the influence of climatic conditions on energy demand and provide insight into the building's operational efficiency, environmental impact, and long-term energy performance.

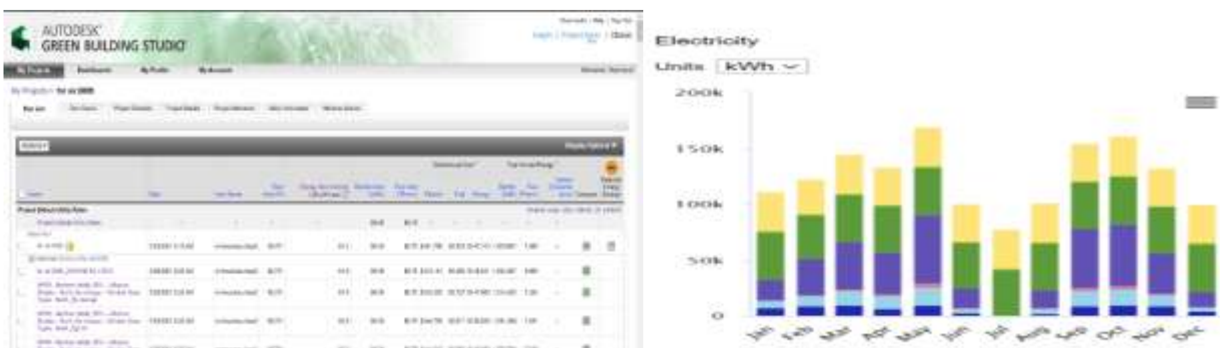

Figure 5. Project Run list and Monthly Electricity consumption.

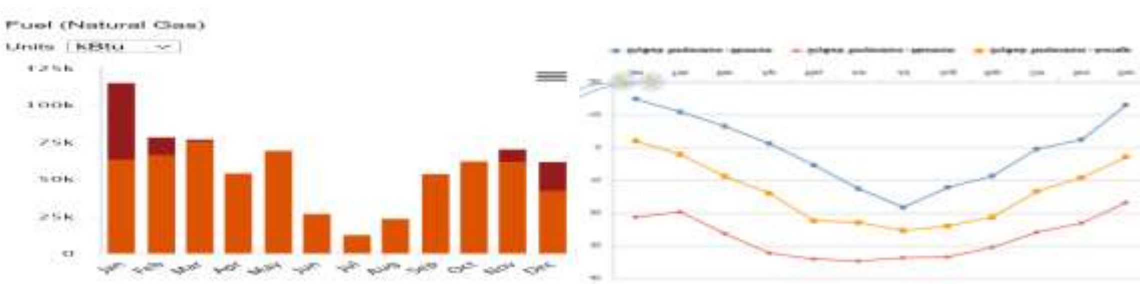

Figure 6. Monthly Fuel consumption and Monthly temperature

Annual Electric and Fuel End Use

I. Space heating 0.1%
II. Heat rejection 1.2%
III. Pumps and aux 5.3%
IV. Fans 7.1%
V. Space cooling 25.3%
VI. Exterior loads 1/0%
VII. Misc equip 33.3%
VIII. Light 26.7%
IX. Space heating 13.2%
X. Hot water 86.8%
XI.

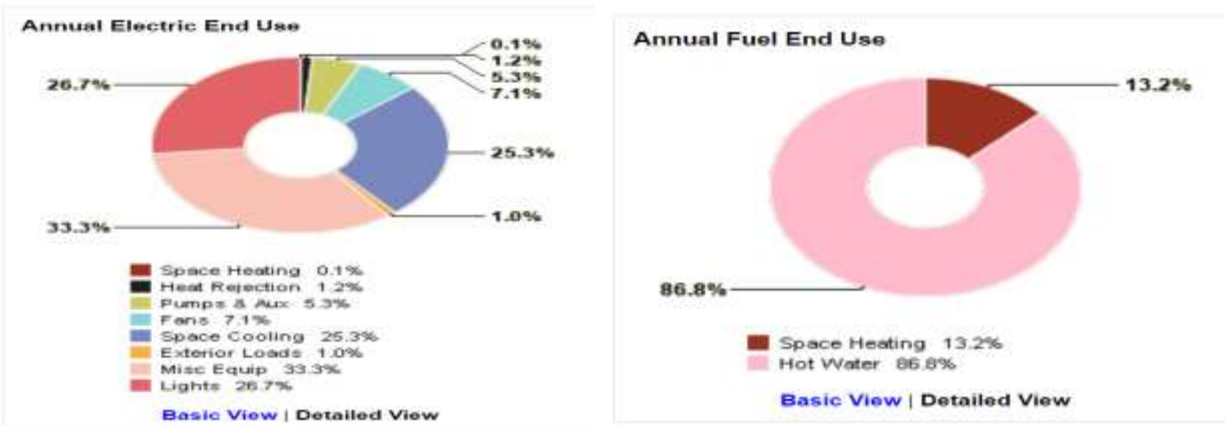

Figure 7. Annual electric and fuel end use

Photovoltaic Potential

Green Building Studio (GBS) analyzed all exterior building surfaces including walls, roofs, and windows to evaluate the potential for photovoltaic (PV) electricity generation. Both horizontal and vertical surfaces were considered for PV installation. The analysis provides detailed insights into the building's solar electricity generation potential, required investment costs, and payback period. Figure 8 illustrates the results of the solar electricity potential analysis for the studied building.

Photovoltaic Potential (more details)	
Annual Energy Savings:	153,406 kWh
Total Installed Panel Cost:	$850,876
Nominal Rated Power:	106 kW
Total Panel Area:	8,292 ft²
Maximum Payback Period:	40 years @ $0.09 / kWh

Figure 8. Solar electricity potential

Discussion

Energy optimization in Revit provides an integrated framework for improving building energy performance throughout the entire life cycle, from conceptual design to operation. By automatically generating analytical energy models from the Revit structural model and leveraging industry-standard simulation engines with cloud-based parallel computing, the platform enables efficient evaluation of multiple design scenarios through a range-based optimization approach. In recent years, building energy analysis has gained increasing importance, particularly following regulations such as the Energy Performance of Buildings (EPB) Directive, which emphasize sustainability and energy efficiency. Energy performance can be assessed using forward approaches based on building characteristics or inverse approaches relying on measured consumption data. Effective energy analysis also requires consideration of site selection, climatic conditions, and the integration of renewable energy systems such as photovoltaic panels. Autodesk Revit Structure offers a streamlined and user-friendly environment that supports both building design and energy simulation, making it a practical tool for sustainable building assessment. In addition, strategies such as rainwater harvesting further enhance resource efficiency and overall building sustainability.

Conclusion

Energy analysis of buildings has become increasingly important in response to the global emphasis on sustainable design and optimized building performance. The use of Autodesk Insight enables designers to reduce energy waste and operational costs by supporting informed, data-driven design decisions at early project stages. In addition, Autodesk Green Building Studio (GBS) facilitates the estimation of water demand and fuel consumption, contributing to more effective resource management. The integrated application of Autodesk Revit, Insight, and GBS offers a modern, accurate, and efficient framework for comprehensive building energy analysis. The methodology adopted in this study was well suited to the selected case study building, providing valuable insights into energy and resource performance and enabling potential improvements to be identified prior to construction.

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