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Energy Analysis and Optimization of a Commercial Building Using BIM in Vizianagaram District- A State of Art Review

D. Vishwak Sena [a], K. Lahari [b], K. Bhanu Prakash [c], L. Madhuri Veni [d], D. Shyamala [e]

[a,b,c,d,e] **UG Students, Department of civil engineering, GMR Institute of Technology, Rajam, Vizianagaram District, 532127.**

ABSTRACT:

Building information modelling (BIM) is a modern data information platform and management tool that promotes the development of green buildings. The energy problem is the biggest single economic drag in the present situation. In this project there is an attempt to implement BIM adoption in the construction industry. Using Autodesk Insight 360 and Green Building Studio, an energy analysis and optimization case study of a commercial building is choosen. This study explores the energy performance of an commercial building in order to optimize energy use by rotating the building 360 degrees at 45-degree intervals and utilizing BIM to install energy-efficient construction materials. Existing commercial buildings have lower energy use and annual cost savings. The annual energy and financial savings are 12497.292 kwh and 1874.55 rupees, respectively. Applying factors to energy analysis can result in improved conceptual design with good environmental effectiveness, thus assisting in the pursuit of environmental sustainability.

Keywords: BIM, Autodesk insight 360, Green Building Studio, Energy performance, Optimize energy, Environmental sustainability

INTRODUCTION:

In the ever-evolving field of architecture, engineering, and construction, the pursuit of sustainable and energy-efficient building design has gained paramount importance. As the world grapples with environmental concerns and the need for more efficient resource utilization, professionals in the AEC industry are turning to innovative methods to enhance the energy performance of buildings. One such method that has gained significant traction is Energy Analysis using Building Information Modeling (BIM).

Building Information Modeling (BIM) is a holistic digital representation of a building's physical and functional characteristics. It encompasses not only the geometric aspects of a building but also its spatial relationships, material properties, and performance attributes. BIM serves as a collaborative platform where architects, engineers, contractors, and other stakeholders can create, share, and manage information about a building throughout its lifecycle.

Energy analysis within the BIM framework leverages this rich repository of data to assess and optimize a building's energy consumption and performance. By integrating energy analysis into the design and decision-making processes, professionals can make informed choices that result in more sustainable, efficient, and cost-effective buildings.

Several software tools are available for conducting energy analysis of buildings, leveraging Building Information Modeling (BIM) data. These tools help architects, engineers, and designers assess and optimize the energy performance of buildings. Some of the softwares used for the purpose of Energy analysis are Autodesk Revit, EnergyPlus, OpenStudio,DesignBuilder, eQUEST, Green Building studio, IES VE (Virtual Environment)

Key Benefits of Energy Analysis Using BIM:

- Early Design Insight: Energy analysis through BIM allows design teams to evaluate different design alternatives during the conceptual and schematic design phases. This early insight empowers decision-makers to identify the most energy-efficient strategies and make informed choices that can significantly impact a building's performance.
- Integrated Approach: BIM facilitates the seamless integration of architectural, structural, mechanical, and other design disciplines. Energy analysis takes advantage of this collaboration by enabling interdisciplinary teams to work together and optimize building systems for maximum efficiency.
- Performance Prediction: By simulating the building's energy performance, BIM-based analysis tools can forecast energy consumption, daylighting levels, thermal comfort, and more. This predictive capability aids in setting realistic performance goals and ensures that the final building meets or exceeds these targets.

- Cost Savings: Energy-efficient designs often lead to reduced operational costs over the building's lifecycle. BIM-supported energy analysis helps identify energy-saving measures, such as selecting energy-efficient HVAC systems, optimizing insulation, and utilizing renewable energy sources.
- Regulatory Compliance: Many building codes and standards mandate energy performance requirements. BIM-enabled energy analysis assists in demonstrating compliance with these regulations, ensuring that the building meets the necessary standards.
- Renovation and Retrofitting: BIM's ability to capture as-built conditions makes it invaluable for energy analysis during renovation and retrofit projects. Design teams can evaluate the impact of various energy-saving interventions on existing structures.
- Environmental Sustainability: Energy analysis aligns with the broader goals of sustainability and reduced environmental impact. By minimizing energy consumption, buildings contribute positively to their surroundings and the planet.

GREEN BUILDING STUDIO:

Green Building Studio (GBS) was a web-based building energy analysis tool developed by Autodesk, the same company behind popular software like AutoCAD and Revit. GBS was designed to assist architects, engineers, and designers in evaluating the energy performance and environmental impact of building designs.

In the quest for more sustainable and energy-efficient building practices, tools like Green Building Studio (GBS) emerged as innovative solutions to assess, optimize, and refine architectural designs. Developed by Autodesk, GBS represented a pioneering approach to building energy analysis that enabled architects, engineers, and designers to integrate environmental considerations into their projects from the earliest stages of conception.

Green Building Studio facilitated a holistic approach to sustainable design by offering a web-based platform that harnessed the power of computational analysis and simulation. Through GBS, professionals could not only visualize the aesthetics of a structure but also quantify its potential energy consumption, thermal performance, and environmental impact. This tool bridged the gap between design creativity and data-driven decision-making, paving the way for more ecologically responsible buildings.

Key features of Green Building Studio included:

- Energy Analysis: GBS allowed users to input building geometry, materials, HVAC systems, and other design parameters, and then performed energy simulations to estimate the building's energy consumption, annual energy costs, and carbon emissions.
- Daylighting Analysis: The tool also offered daylighting analysis, helping designers assess the quality and distribution of natural light within a building's interior spaces. This helped optimize lighting design for energy efficiency and occupant comfort.
- Solar Radiation Analysis: GBS provided insights into the solar radiation exposure on the building's surfaces, which was valuable for understanding potential shading effects and optimizing solar panel placement.
- Climate Data: The tool integrated with weather data to enable simulations that considered the building's energy performance across different climate zones.
- Sustainability Metrics: GBS could generate sustainability metrics, such as LEED (Leadership in Energy and Environmental Design) certification scores, helping users assess how well a design aligned with sustainable building standards.
- Design Alternatives: Users could compare different design alternatives side by side to identify the most energy-efficient options.
- Web-Based Collaboration: GBS was a cloud-based platform, allowing multiple team members to collaborate on energy analyses from different locations.

INSIGHT 360:

In the realm of sustainable building design and energy analysis, Autodesk Insight 360 emerged as a robust tool aimed at empowering architects, engineers, and designers to create environmentally responsible and energy-efficient structures. Developed by Autodesk, the same company behind renowned software like AutoCAD and Revit, Insight 360 integrated seamlessly with Building Information Modeling (BIM) workflows to provide real-time analysis and optimization of building performance.

Insight 360 sought to bridge the gap between design and data-driven decision-making, offering a platform that allowed professionals to explore various design scenarios and assess their impact on energy consumption, lighting quality, thermal comfort, and more. By enabling designers to consider sustainability factors from the earliest design phases, Insight 360 played a pivotal role in shaping the next generation of ecologically conscious buildings.

Key Features and Contributions of Autodesk Insight 360:

- Real-time Performance Analysis: Insight 360 provided instant feedback on a building's energy performance, allowing designers to understand how design decisions influenced factors like energy consumption and occupant comfort.

- Energy Analysis: The tool allowed users to input design information, including building geometry, materials, and systems, to simulate energy consumption and estimate energy costs. This enabled design teams to identify opportunities for energy savings and optimization.
- Daylighting Analysis: Insight 360 facilitated the evaluation of daylighting strategies within a building. Designers could assess natural lighting levels, distribution, and potential glare, leading to better lighting design and reduced reliance on artificial lighting.
- Thermal Comfort Assessment: The tool enabled the evaluation of thermal comfort parameters, helping ensure that building occupants would experience optimal indoor conditions.
- Environmental Impact Metrics: Insight 360 provided data to assess a project's alignment with sustainability certifications such as LEED, allowing designers to quantify their building's positive environmental impact.
- Design Iteration: Designers could explore multiple design alternatives, making real-time adjustments and observing their effects on performance. This iterative process enabled the selection of design solutions that balanced aesthetics with energy efficiency.
- Integrated with BIM Workflows: Insight 360 seamlessly integrated with BIM platforms like Revit, leveraging the rich information present in the BIM model to drive energy analysis and optimization.
- Cloud-Based Collaboration: Cloud connectivity allowed team members to collaborate on analysis from different locations, promoting multidisciplinary communication and coordination.
- Visualization: The tool presented analysis results through clear visualizations, making it easier for designers to understand and communicate the implications of their design choices.

GENERAL

- Energy analysis using Building Information Modiling (BIM) involves using digital models and simulations to assess the energy performance of a building over a year. It is a computational process used to simulate and analyse the energy performance of a building, system or process. Energy modelling is commonly employed in the design evaluation of buildings to optimize energy efficiency, reduce energy consumption, and make informed decisions about design alternatives (Parameters) and upgrades.
- The procedure for doing the Energy analysis of a Residential building involves the following steps:
- Step 1: Planning and design the Residential building
- Step 2: Altering the parameters helps to reduce energy consumption
- Step 3: Energy Analysis of the building using softwares

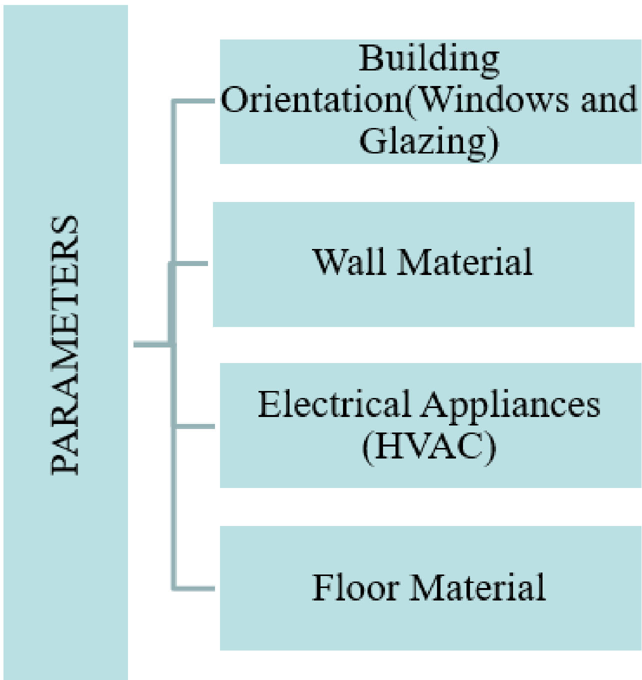


FIGURE 1 : PARAMETERS

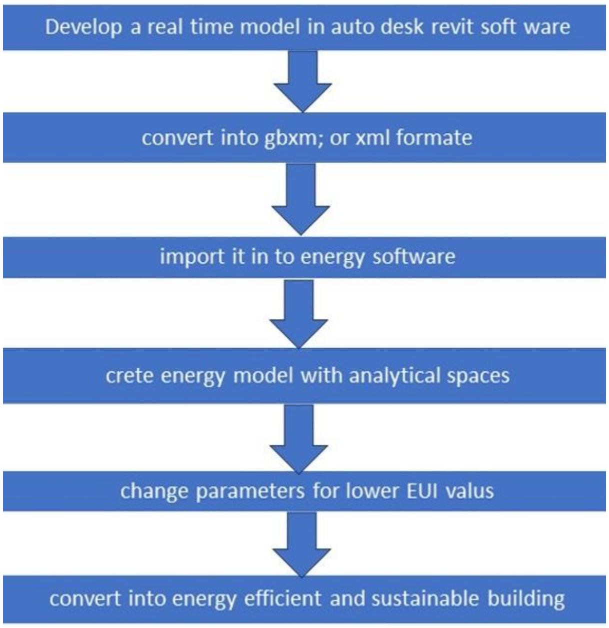


FIGURE 2 : ENERGY ANALYSIS PROCESS

DESIGN OF A COMMERCIAL BUILDING

Designing a commercial building using Autodesk Revit involves a series of steps. Revit is a powerful Building Information Modeling (BIM) software that streamlines the architectural design process. The following steps represents the process for designing a commercial building in Revit.

1.Project Setup:

- Create a new project in Revit and specify the project location, units, and other project settings.

2.Architectural Design:

- Develop the conceptual design of the building, including the layout of rooms, walls, and spaces.
- Use Revit's drawing and modeling tools to create the building's floor plans, elevations, and sections.

3.Structural Design:

- Coordinate with structural engineers to design the building's structural elements, such as beams, columns, and foundations.
- Use Revit's structural tools to model these elements.

4.MEP (Mechanical, Electrical, Plumbing) Design:

- Work with MEP engineers to design the building's mechanical, electrical, and plumbing systems.
- Model ductwork, pipes, conduits, and electrical fixtures using Revit's MEP tools.

5.Interior Design:

- Design the interior spaces, including selecting materials, furniture, and fixtures.
- Use Revit to model interior components and create detailed interior layouts.

6.Documentation:

- Generate construction documents, including plans, elevations, sections, and details, directly from the Revit model.
- Ensure that all design elements are accurately represented in the documentation.

7.Collaboration:

- Collaborate with the project team, including architects, engineers, and contractors, by sharing the Revit model and using BIM 360 or other collaboration tools.

8.Analysis and Simulation:

- Perform energy analysis, daylight analysis, and other simulations if required to optimize the building's performance.

9.Cost Estimation:

- Use Revit's integrated tools or third-party software to estimate the cost of construction based on the model.

10.Renderings and Presentations:

- Create realistic renderings and presentations of the design to communicate the project's vision to stakeholders and clients.

11.Review and Revisions:

- Continuously review and revise the design based on feedback from the project team and client.

12.Permitting and Approvals:

- Prepare and submit the necessary documents and plans for permitting and regulatory approvals.

13.Construction and Project Management:

- During construction, use Revit for construction administration tasks, such as tracking changes, managing RFIs (Requests for Information), and documenting progress.

14.Facility Management:

- After construction, use the Revit model for facility management and maintenance, creating a digital twin of the building.

15.Handover:

- Hand over the final Revit model and documentation to the client for their records and ongoing use.

ENERGY ANALYSIS OF THE BUILDING

Energy analysis of a building refers to the process of evaluating and quantifying the energy performance and efficiency of a structure. This analysis is typically conducted to understand how a building consumes energy and to identify opportunities for improving its energy efficiency and reducing energy costs. It plays a crucial role in sustainable building design and management. In this project two softwares called Green Building studio and Insight 360 are used to carry the energy analysis of designed building.

FIGURE 3: GBS and Insight 360

Green Building Studio

Energy model of the building is created in Rivet for the purpose of Energy analysis of building. Created Energy model is exported in the form of gbXML file and imported into Green building studio for the Energy analysis.

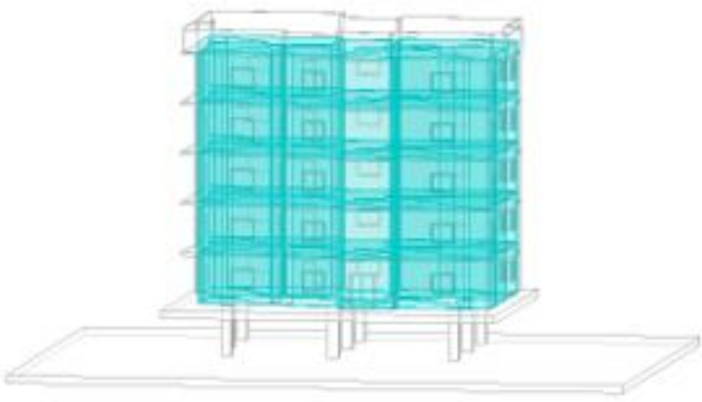


FIGURE 4: Energy Model

The process for the analysis is carry out as given below:

1.Create a GBS Account:

- Start by creating an account on the Green Building Studio website if you don't already have one.

2.Project Setup:

- Log in to your GBS account.
- Create a new project for the building you want to analyze.

3.Building Geometry and Data Entry:

- Input the building geometry and details. You may have options to import building information from design software like Autodesk Revit or AutoCAD.
- Specify the location of the building, including climate data, local weather files, and site characteristics.

4.Building Model and Geometry Import:

- Create or import the 3D model of your building into GBS. This can be done using industry-standard formats like gbXML, DXF, or IDF.
- Ensure that the building's geometry and envelope are accurately represented in the model.

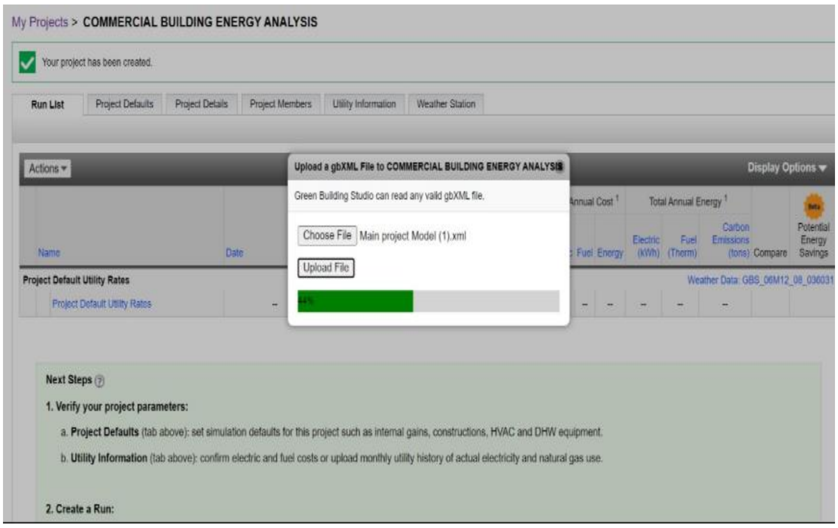


FIGURE 5: GBS uploading

5.HVAC System and Energy Modelling:

- Define the HVAC (Heating, Ventilation, and Air Conditioning) system for the building.

- Input the thermal properties of building materials and systems, including insulation, windows, and HVAC equipment.
- Set up occupancy schedules and loads for lighting, equipment, and appliances.

6.Simulation and Analysis:

- Configure simulation settings, such as the analysis period (e.g., annual, monthly, hourly), simulation type, and desired output metrics (energy consumption, peak demand, etc.).
- Initiate the simulation. GBS will use cloud computing resources to perform detailed energy simulations based on your inputs and settings.

7.Results and Visualization:

- Once the simulation is complete, you can access a range of results and visualizations, including energy consumption, heating and cooling loads, daylighting analysis, and more.
- Evaluate the energy performance of the building and identify areas for improvement.

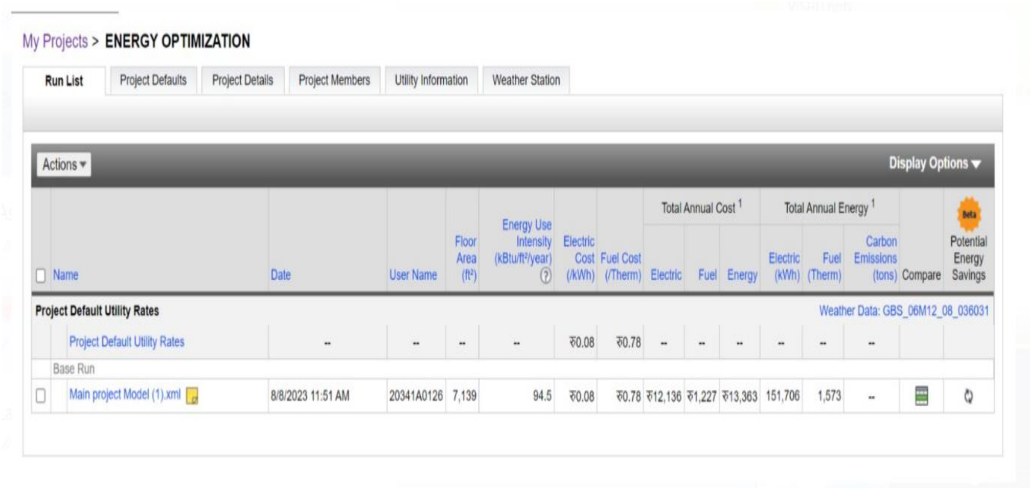


FIGURE 6: EUI Value

8.Optimization and Iteration:

- Use the insights gained from the analysis to make informed design decisions that can improve the building's energy efficiency.
- Iterate on the design, making adjustments to building components, HVAC systems, or other parameters as needed.
  - Windows and Glazing: The type, size, and placement of windows affect natural lighting, solar heat gain, and heat loss.

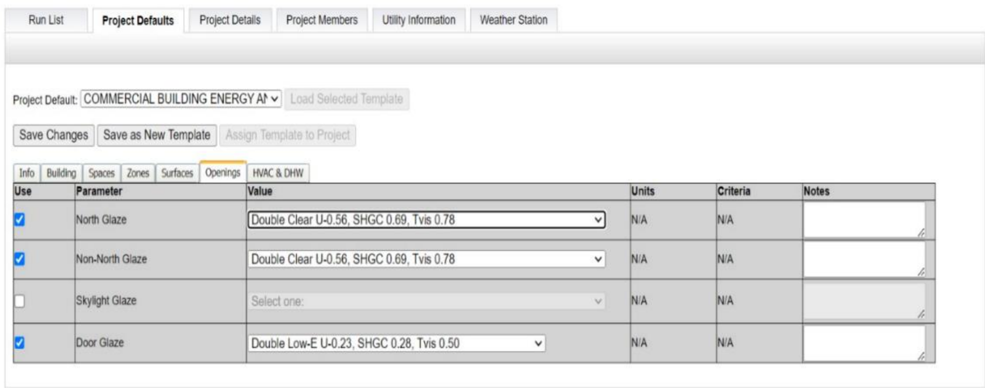


FIGURE 7: Windows and Glazing

- HVAC Systems: The efficiency and type of heating, ventilation, and air conditioning systems influence energy consumption.

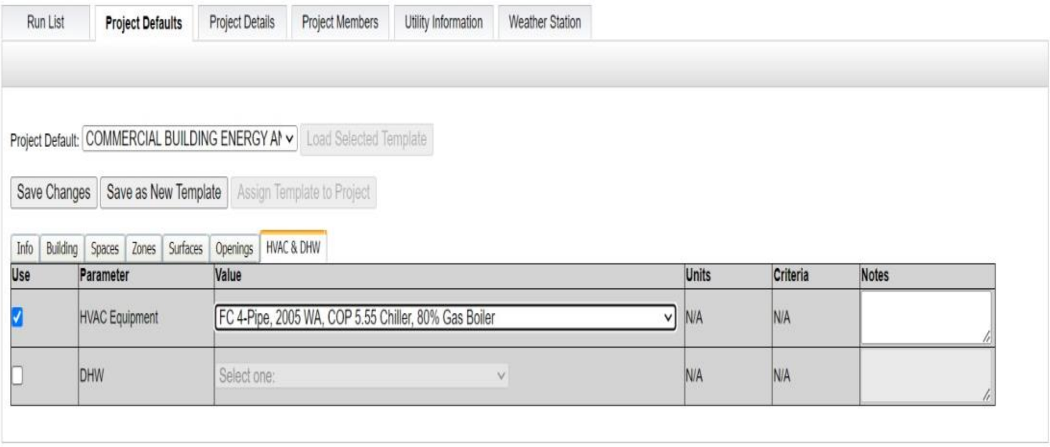


FIGURE 8: HVAC System

- Appliances and Lighting: Energy-efficient appliances and lighting systems can significantly reduce electricity usage.
- Renewable Energy Sources: Integration of solar panels or wind turbines can provide on-site renewable energy generation.
- Building Envelope: Materials used in walls, roofs, and floors impact insulation and thermal performance.
- Thermal Mass: The ability of building materials to store and release heat affects indoor temperature stability.

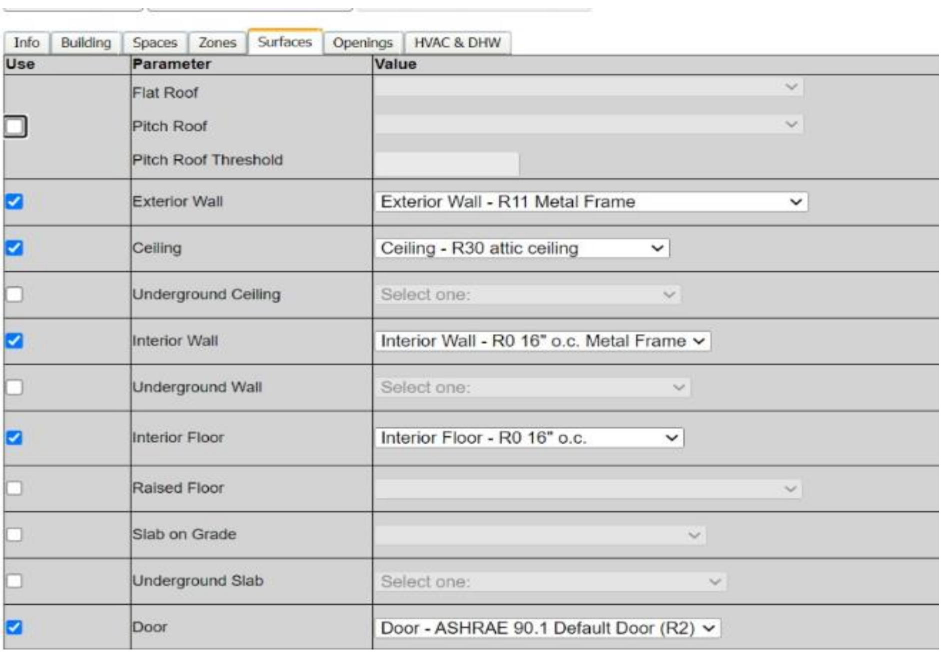
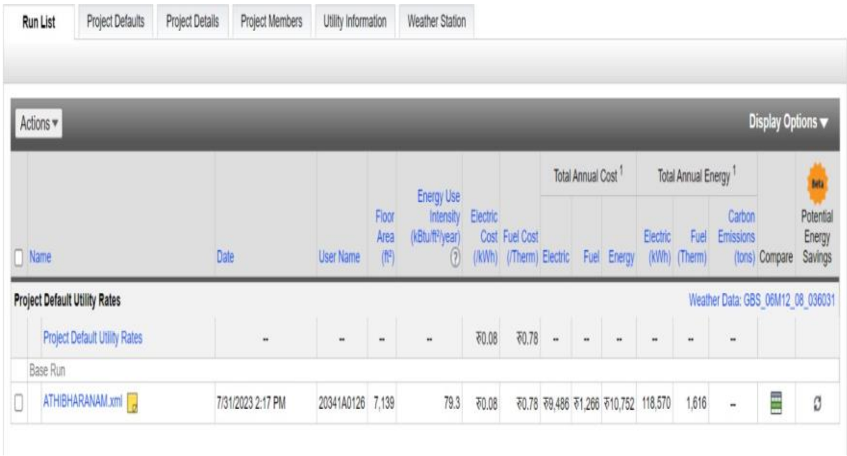


FIGURE 9: Roofs and Walls

9.Report Generation:

- Generate reports summarizing the energy analysis and findings. These reports can be useful for stakeholders and for compliance with green building certification programs like LEED.



Run List | Project Defaults | Project Details | Project Members | Utility Information | Weather Station

Actions ▾ Display Options ▾

Name	Date	User Name	Floor Area (ft²)	Energy Use Intensity (kBtu/ft²/year)	Electric Cost (/kWh)	Fuel Cost (/Therm)	Total Annual Cost [1] Electric	Total Annual Cost [1] Fuel	Total Annual Cost [1] Energy	Total Annual Energy [1] Electric (kWh)	Total Annual Energy [1] Fuel (Therm)	Carbon Emissions (tons)	Compare	Potential Energy Savings
Project Default Utility Rates												Weather Data: GBS_06M12_08_036031		
Project Default Utility Rates	--	--	--	--	₹0.08	₹0.78	--	--	--	--	--	--		
Base Run														
ATHIBHARANAM.xml	7/31/2023 2:17 PM	20341A0126	7,139	79.3	₹0.08	₹0.78	₹9,486	₹1,266	₹10,752	118,570	1,616	--		

FIGURE 10: After optimization

10.Collaboration and Sharing:

- Collaborate with team members by sharing project data and results within the GBS platform.

11.Cost Analysis (Optional):

- Depending on your needs, you can also perform cost analysis to evaluate the economic feasibility of different energy-efficient measures.

12.Documentation and Compliance:

- If your project aims for green building certifications, ensure that the analysis meets the documentation requirements of the certification program.

13.Continuous Monitoring (Optional):

- After the building is constructed, you can use GBS to monitor and verify its actual energy performance compared to the predicted results.

CONCLUSION:

In recent years, BIM has been a source of innovation and cooperation in the construction sector, allowing for more efficient project management and risk assessment. BIM has gained relevance in the sustainability, capacity, growing productivity, infrastructure cost, and presentation of a clear image of construction difficulties with information technology. BIM improves the quality of a project's overall performance in terms of time, cost, quality, productivity, and safety. The findings and conclusions of the energy analysis of a building are presented in this chapter. Future proposals have also been made in this regard. This chapter is divided into three sections, the first containing the findings. The conclusion is discussed in the second section, which is based on energy analysis and optimization of the building, and the third section includes recommendations. Finally, there are a few recommendations that will be best for enhancing performance and design in the future. From the 1980 s and up to now, there has been increasing in the analysis of the energy approach. This results in the increasing importance of sustainable design and building performance optimization. The BIM-based system is very suitable for enhancing the performance and plan of a building. So, this study has concluded that for the different design choices at the critical time of a project, the methods of building energy analysis utilizing Autodesk Revit and Autodesk insight are the best techniques for AEC. (1) The primary purpose of this research is to examine the factors that impact the development of energy-efficient structures and energy usage and to develop new methods for improving the energy efficiency of new building developments. (2) From optimal energy utilization designs, there will help in the enhancement of green solutions in energy consumption and the advancement of green solutions in energy utilization will be facilitated by using optimal energy consumption design. (3) Understanding the outcomes of energy simulations can assist stakeholders in completing a design that consumes the least amount of energy while promoting sustainability. (4) Energy use decreased from east to west and west to north, whereas it increased from north to east and south to west. From the research's data and analysis, it is recommended for future research that (i) From these research tools, the experts get the opportunity to present more accurate data for the betterment of building design to minimize energy usage with the help of these tools. (ii) For the last few decades, Pakistan has faced a massive energy shortage. There is also an increase in the demand for energy usage over time. This research will reduce energy usage in the early design phases of Buildings that are already built in the fields of HVAC, insulation, etc. (iii) Cost is one of the significant factors in developing sustainable usage preferences. There should be a comprehensive check of charge with the relationship to optimum energy reduction. (iv) The use of the latest techniques in the early time of the design process and the best optimization variables may help in the reduction of energy usage. (v) Using virtual technology in the early stages of the design process, per the ARCHITECTURE 2030 challenge, may help achieve a considerable decrease in energy usage and help establish optimal energy patterns. The requirements of the industry, the pursuit of the construction 4.0 concept, digitization in the construction industry and the green deal and other requirements for environmental behavior confirm the importance of solving this research topic.

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