

# ENERGY ANALYSIS OF BUILDINGS

K. Deepa<sup>1</sup>, B. Suryarajan<sup>2</sup>, V. Nagaraj<sup>2</sup>, K. Srinath<sup>2</sup>, K. Vasanth<sup>2</sup>

<sup>1</sup>Associate Professor: Civil Engineering Department, Prathyusha Engineering College, Thiruvallur, Tamil Nadu.

<sup>2</sup>U. G Student: Civil Engineering Department, Prathyusha Engineering College, Thiruvallur, Tamil Nadu.

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**Abstract** - Buildings demand energy in their life cycle right from its construction phase to demolition phase. High energy consumptions may lead to serious environmental impacts like increase in the rate of global warming. Therefore, it is important to study the energy consumption of building at the conceptual stage. One of the recent method to evaluate energy consumption of buildings is Energy analysis using Building Information Modeling (BIM) tools –Autodesk Insight, BIM is an intelligent 3D model-based process that gives Engineers the insight tools to more efficiently plan, design, construct, and manage buildings and infrastructure. BIM assist designers assess different design alternatives at the conceptual stage of a building life so that effective energy strategies are attained within the building constraints. This paper seeks to integrate the use of BIM based energy analysis in predicting the energy consumption of a Library building. For this purpose, the Autodesk Revit Software and Autodesk Insight which is a cloud based energy analysis program are used.

**Key Words:** BIM, Autodesk Revit, Autodesk Insight, Energy Analysis.

## 1. INTRODUCTION

Buildings are constructed for residential, office and commercial purposes all over the world. They are major contributors to socio-economic development of a nation and also utilize a large proportion of energy and available natural resources. Worldwide, 30–40% of all primary energy is used for buildings and they are held responsible for 40–50% of greenhouse gas emissions [1]. It is therefore essential for the building construction industry to achieve sustainable development in the society. Sustainable development is viewed as development with low environmental impact, and high economic and social gains. Professional architects and engineers are more concerned about the sustainability and energy performance of proposed buildings. Analyzing the Energy consumption of buildings at the conceptual design stage is very helpful for Designers when selecting the design alternative that leads to a more energy efficient facility.

### 1.1 Building Information Modelling (BIM)

BIM is an intelligent model based process that connects architectural, constructional and engineering professional so they can more efficiently design, build and operate buildings. With BIM, designers can create 3D model that include data associated with physical and functional characteristics. BIM

collaborate architects, Engineers and contractors on coordinated models giving everyone the insight of the project and help them work more efficiently. It provides insight into the design's constructability, improving the efficiency and effectiveness of the construction phase and also provide better understanding of the building's future operation and maintenance.

### 1.2 Autodesk Revit Architecture

Autodesk Revit Architecture is a robust architectural design and documentation software application created by Autodesk for architects and building professionals. The tools and features that make up Revit Architecture are specifically designed to support building information modeling (BIM) workflows. Revit was intended to allow architects and other building professionals to design and document a building by creating a parametric three-dimensional model that included both the geometry and non-geometric design and construction information, which is also known as Building Information Modeling or BIM. The 3D model of a building required for the energy analysis process is created using this Revit software.

### 1.3 Autodesk Insight

Autodesk Insight is a cloud based Energy Analysis Program which helps to improve energy and environmental performance throughout the building life cycle by letting us integrate Energy analysis, lighting analysis and solar analysis for a holistic approach to building performance design. This tool is only available to subscribers of Autodesk software and students for a period of 3 years.

## 2. REVIEW OF LITERATURE

Buildings consume energy both directly or indirectly in all phases of their life. The energy consumed by the building is broadly classified into two types; Embodied energy and Operating energy. The energy utilized during manufacturing phase of the building is called the Embodied energy. It includes the energy content of all the materials used in the building and technical installations, and energy incurred at the time of erection/construction and renovation of the building. Operating energy is the energy required for maintaining comfort conditions and everyday maintenance of the buildings. It also includes the energy for HVAC (heating, ventilation and air conditioning), domestic hot

water, lighting, and for running appliances. It largely varies on the level of comfort required, climatic conditions and operating schedules.

Adalberth [2] on his paper presented a method describing the calculation of the energy uses during the life cycle of a building. He reported that 85% of the total energy usage was required during the operation phase and 15% in construction phase. The transportation and process energy used during demolition of the structure require only 1% of the total energy. T. Ramesh, Ravi Prakash, K.K. Shukla [3] proposed that life cycle energy use of buildings depends on the operating (80–90%) and embodied (10–20%) energy of the buildings. Normalized life cycle energy use of conventional residential buildings falls in the range of 150–400kWh/m<sup>2</sup> per year (primary) and office buildings in the range of 250–550kWh/m<sup>2</sup> per year (primary). He also proposed that the life cycle energy demand can be reduced by reducing its operating energy.

Oladokun and Odesola (2015) [4] noted many number of limitations in the existing modeling techniques of energy analysis which include: lack of transparency in the model algorithms; inability to account for the complex, interdependencies and dynamic nature of the issue of energy consumption and carbon emissions; limited evidence to show for the occupants-dwelling interactions; and lack of capacity to accommodate qualitative data input. Recently in 2017, A. S. Shivsharan, Mrs. D. R. Vaidya, Prof. R. D. Shinde [5] highlighted that BIM provides us with a proper sustainable design because it helps to iteratively test, analyze and also improve design of building. They further concluded that Increase in the number of analysis tools is a sign to the increasing importance of sustainable design in architecture and the need to optimize building performance. Therefore, with all the literature studies it can be concluded that the BIM-based design is ideally suited for delivering the kind of information that can be used to improve design and building performance.

### 3. METHODOLOGY

For the purpose of the Energy analysis of building with the help of Autodesk INSIGHT and Revit software, a case study of a Library building was used. Library building (G+3) project is located at Thiruvallur, Tamilnadu, India. The three dimensional model of the building is created using Revit Architecture and the model is further analyzed using Autodesk insight.

The Energy simulation of a building involve the following steps;

- Collect the Drawings and information about the building to be studied.
- Create a 3D model using the Autodesk Revit software with the help of the drawings collected.
- Change the energy setting like building type, building operating schedule, type of HVAC system etc. as per your need.
- Locate your building using Internet Mapping Service inbuilt in Autodesk Revit.
- Automatically create a building energy model using the analyze panel in Revit software.
- Analyze and run results in the Autodesk Insight over the cloud.
- Estimate the energy use of the building.

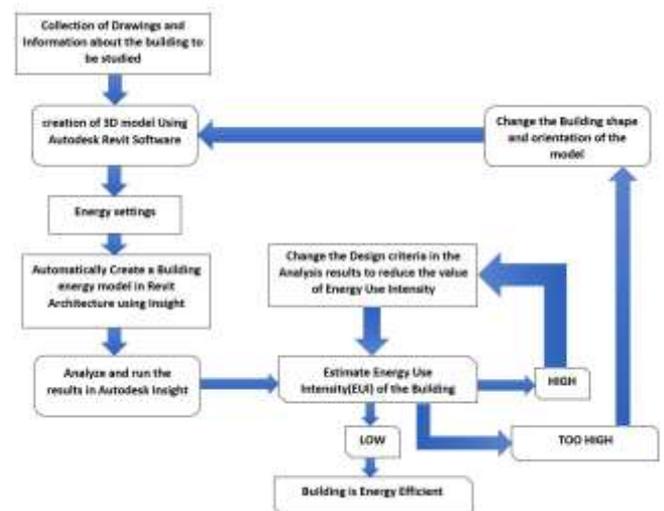


Fig -1: Methodology

A 3D model is created using Autodesk Revit software with the help of Floor plans available of the building.



Fig -2: 3D model created in Autodesk Revit Software

We need to sign in to the Autodesk Account in order to use the Insight tool for energy simulation which is a cloud based Software. Update the Project location details in the location setting using either Internet mapping service or Default city list, also select the type of building, the use of building type in the Schedule section, if the project is actual ongoing project or just study for academic purpose and other details in the Energy setting and Advance Energy setting Option which is also available in the Analyze panel in Revit. The Project Location will help in determining the nearest Weather Station & weather details of the area of project, which helps in the analysis process. If the thermal properties of the building materials are to be considered, we can select that using the material thermal properties option available in Revit. Options like conceptual types of the individual building elements can be changed in the conceptual types option in Advanced energy settings. Some of the values are default set in the software.

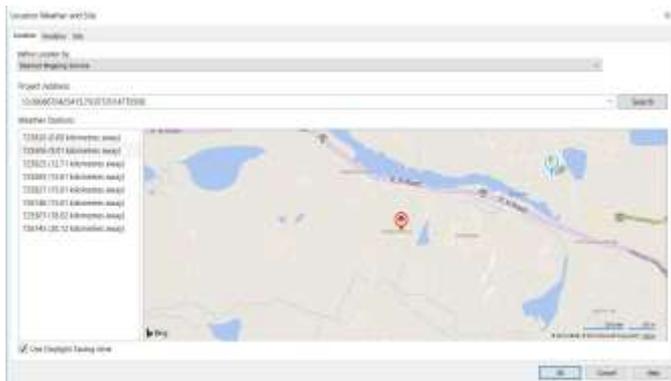


Fig -3: Locating the Building in Revit using internet mapping Service



Fig -4: Energy Setting in Revit

After completion of the all the energy and advanced energy settings, click on create energy model which automatically generates the energy analytical model, design options and potential performance outcome with insight. You can access the result of the energy analysis either through Autodesk Insight website or the Insight tool inbuilt in Revit Software.

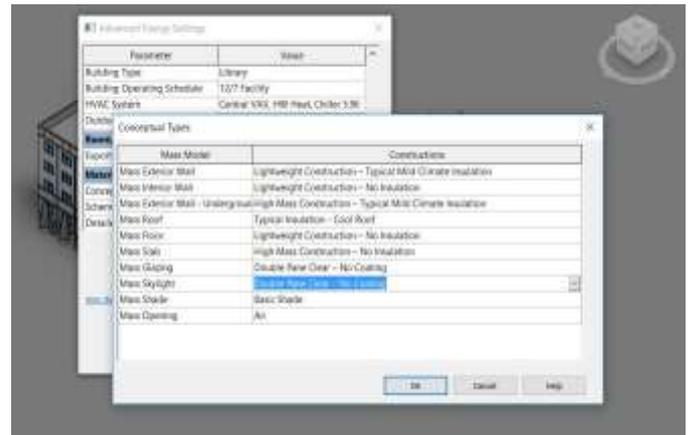


Fig -5: Advanced Energy Setting in Revit

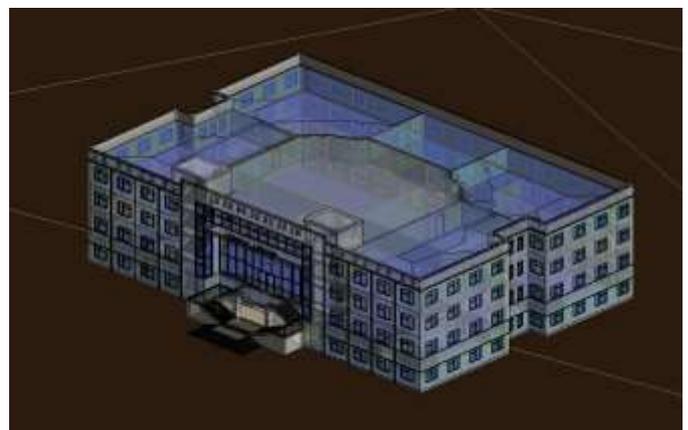


Fig -6: Energy Model

#### 4. RESULTS

Access energy and environmental performance data in Insight tool inbuilt in Revit or by logging into Autodesk Insight website. The analysis process will take some time depending upon the complexity of the project and Insight will notify you through mail once the analysis process is complete.

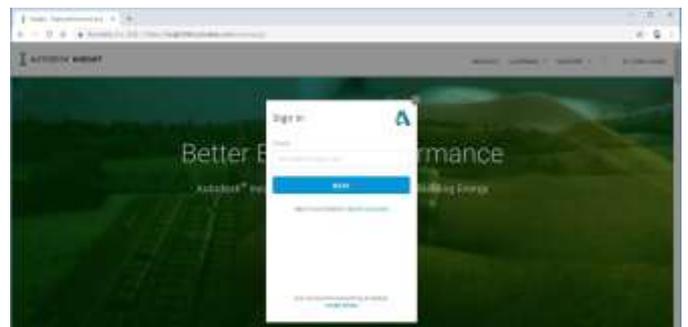


Fig -7: Advanced Insight Website



Fig -8: Notification from Autodesk Insight

The energy consumption of the building will be calculated as Energy Use intensity (EUI) in kWh/m<sup>2</sup> per year based on the energy setting of the project. EUI is calculated by dividing the total energy consumed by the building in one year by the total gross floor area of the building. The analysis report will have many Design options like Operating schedule, window to wall ratio, HVAC systems, building orientation, lighting efficiency to alter and control the energy consumption of the building. The analysis report not only provide us with the Energy use intensity of the project but also the energy cost of the project per square meter per year.

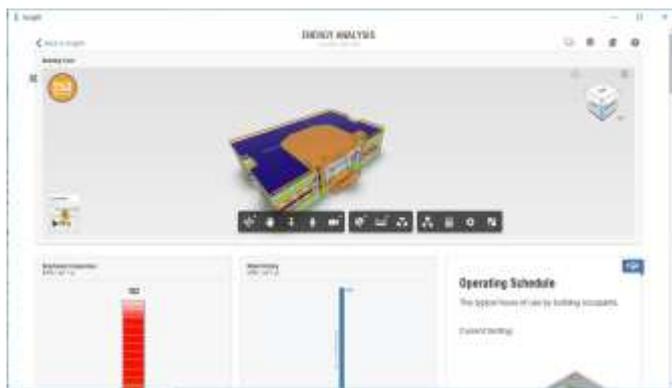


Fig - 9: Interface of Insight

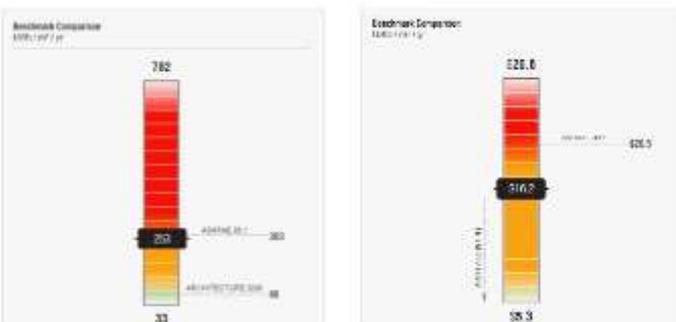


Fig -10: Range of Energy Use Intensity and Energy cost before changing Design Criteria

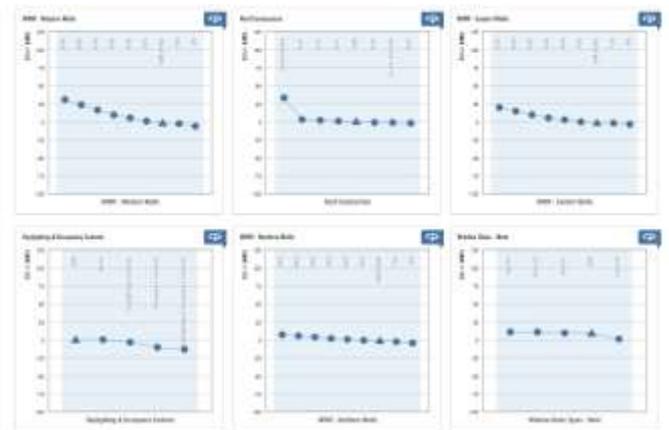


Fig -11: EUI vs Different Design criteria (Graphs)

To reduce the overall energy use intensity of the building, we can change the range of each design criteria and see how much the change in design of individual features like window to wall ratio, operating schedule etc. can affect the energy consumption of the whole building. Say for example if we change the operating schedule of the building to 12/6 from 12/7 then the EUI value will change to a considerable amount. Similarly, we can change each of the individual design criteria in the process of reducing the energy consumption of the building.



Fig -12: Changing Operating Schedule setting in Insight

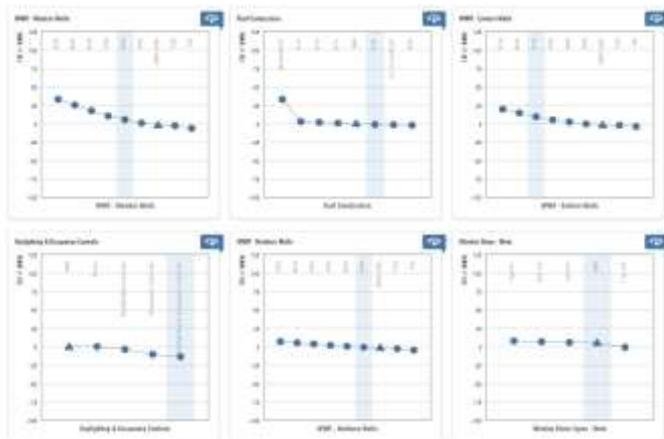


Fig -13: changing Various Design Criteria



Fig -14: EUI after altering the Design criteria

We could note that the EUI value of the building has changed from 253 kWh/m<sup>2</sup>/year to 211 kWh/m<sup>2</sup>/year after changing various design criteria in the insight. We could easily bring the energy use intensity value and the energy cost of the building to desired amount by altering each and every design criterion in the insight analysis. Autodesk insight also give us an advantage of comparing two energy models with different shape, orientation and energy settings for choosing the best suitable building model to achieve minimum energy consumption and energy cost.



Fig -15: Model comparison in Insight

## 5. CONCLUSION

The energy analysis method has been constantly evolving over the years starting in the year 1980's till now. Increase in the number of analysis tools shows the increasing importance of sustainable design in architecture and the need to optimize building performance, The BIM-based design and documentation system is ideally suited for delivering the kind of information that can be used to improve the design and performance of the building. Therefore, we would conclude that this method of energy analysis of building using Autodesk Revit and Autodesk insight is the best suitable and modern method that assist designers, architects and engineers to assess different design options at the conceptual stage of a building.

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