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Interactive study on BIM-Energy performance in building

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Abstract: Energy saving in the building is a whale of matter to reduce the impact on the user consumption bills. The move for alternative and sustainable energy resources promotes the future energy need for all the residential and commercial sectors, which is considered vital. The technology of intelligent sensors and energy controlling devices adds up the values for the Energy Performance in a controlled manner. Building Information Modeling and Energy auditing with optimised energy utilisation is considerably need for our nearing future. Careful analysis in selecting building material and used with a calculated geometrical area of the building conform with natural resources is discussed in the present study. Power Consumption of a residential complex with different floor levels is observed for energy auditing study. Energy auditing was done on various parameters, namely human behaviour impact, thermal, materials used, the orientation of the building, Electronics used etc. Further BIM tools used for the building model to analyse and optimise the energy with a cost estimate reduce electric bills' onus, especially for the low-income household. After careful analysis of the building, various enhancements were suggested to the residents to reduce power consumption.

Keywords - Energy Auditing, Building Information Modeling, Human behaviour impact.

I. INTRODUCTION

The present reality is worried about using energy from the way toward assembling its effects on both society and the climate. From the information acquired by United Nation Statistics Division Energy Indicators distributed on 31st-March-2020, India is one of the biggest energy-creating nations with an energy supply of 38083 petajoules. It has given a commitment of 15.73% in environmentally friendly power in the year 2017. The utilisation of energy has expanded definitely in the private structure area by 70%, i.e., there is an ascent of 5 Exajoule (EJ) in private structures and 3EJ in non-private structures in the range of 2010 to 2018 according to the IEA, Global Status Report for Buildings and Construction 2019. With an expansion of the hazard because of an Earth-wide temperature boost, the AEC likewise is attempting to roll out an improvement in the field by discovering the arrangements brought about by energy, i.e., continually following the need of energy-productive structure practices and attempting to keep awake to date. The BIM is persistently refreshing, making work straightforward by using the information accessible in a data set divided among partners to gain the work ground speedy and diminish the expense with legitimate choices and difficulties confronted. The BIM data trading between various applications makes a deficiency of information for the necessary outcomes the arrangements have been refreshing by different organisations and explores. The BEPS needs to use the data from BIM and execute energy recreation; however, information trading gives the exact outcomes.

II. BUILDING ENERGY PERFORMANCE

P. Singh [1] Says that, with increasing dependency of our advanced life on the computerised family hardware, higher energy request has presented critical weight on power utilisation in significant lodging models. It is proposed to utilise Building Information Modeling (BIM) to display a house and assess its energy execution. According to S. Habibi [2], BIM can facilitate testing the building theoretically on various aspects. It underlines how combining these procedures with BIM can improve the development cycle and empower elective methodologies. F.H. Abanda [3] has given a simple way to analyse the energy consumption of building virtually with the help of Building Information Technology (BIM). Initially, a simple structure is displayed utilising Revit, one of the leading BIM apparatuses. This model is analysed in the Green Building Studio, distinctive structure directions are embraced, and their effects on the entire structure energy are examined. According to T. Gerrish [4], using the BIM to analyse the building's Energy Utilization. It also helps you find the Places needing to be redesigned in a plan before construction of the building or places to enhanced in a prebuilt plan to have optimum electricity usage and reduce unnecessary electricity usage, which allows the designers to make environment-friendly designs.

As per I. Othman [5], BIM is an essential part of the construction industry as it helps in surveying the land on which the building construction devlops. The stability of the building can be tested even before the construction is done. Planning of the building can be done faster and more efficiently. B. Huang [6] found from Surveys that BIM (Building Information Modeling) is presently a generally utilised device for design, designing, and structural designing. The use of BIM innovation can help improve the development

business's proficiency and help assess the maintainability of green structures. Studies by H. Kim [7] reveals, To lessen petroleum product based energy utilisation in structures, various strategies have been proposed. In any case, building energy analysis (BEA) is ordinarily directed late in the plan by energy investigator trained professionals. Building Information Modeling (BIM) furnishes the client with a chance to investigate distinctive energy-saving choices in the planning cycle while staying away from the tedious cycle of reappearing all the structure calculation, fenced-in area HVAC data crucial for a complete energy examination. As studied by F. Rezaei [8], Life cycle Analysis (LCA) and Building Information Modeling (BIM) is done in the early and point by point building configuration stages. A helpful data set was created to set up the Revit yields as the LCA model's suitable contributions. The ecoinvent information base was utilised to wellspring of life cycle stock (LCI) information for every material. A. Andriamamonjy[9] presented a forward-thinking outline of the chief exploration points and examination patterns inside the Building Information Model (BIM) research space. It likewise offers a nitty gritty audit of the reconciliation of BIM and Building Energy Performance Simulation (BEPS). The various methodologies to improve interoperability are inspected along with the different utilisations of such a mix (BIM with BEPS) in writing. Studies by X. Xu [10] revealed that the dire necessity for energy preservation and ozone-depleting substance outflow decrease in the structure area had been perceived at the most elevated level of governments around the planet. One possible arrangement is the use of Building Information Modeling (BIM) to defeat the building energy execution hole (BEPG), characterised as the inconsistency between the planned and genuine energy utilisation in structures. S. Rokooei [11] describes BIM as Building Information Modeling (BIM) is turning into an extensive communitarian measure in the development business. The job of BIM as an organiser of undertaking framework is like the obligations of a venture administrator. BIM incorporates various controls by powerful correspondence, investigates the task frameworks for constructability, and gauges ventures' expense and season. F. M. Ugliotti [12] said that Computerised models are utilised to break down the current structure stock to advance superior administration and retrofitting activities. The energy rate is assessed from a rearranged Revit engineering model, where the main segments of the structure regarding energy are characterised with an appropriate Level of Detail/Development (LOD) to set the energy model through the EC770 module handily. R. S. Nizam[13] presented a structure to assess the epitomised energy content inside the local BIM climate. This system's execution is outlined by improving an instrument to assess material encapsulated energy, transportation energy, and development energy. A model of the instrument has been executed on a case task to build up the system's functionality. R. Santos [14] and his team created a BIM-based Environmental and Economic Life Cycle Assessment (BIMEELCA) instrument. The BIMEELCA apparatus is utilised to help the emotional cycle during the beginning stages of a project and check the possibility of directing programmed BIM-based LCA and LCC investigations in tall structure projects. A 250 m tall structure condo, inn, and place of business is utilised to approve the device's handiness at the early plan stage.

III. SOFTWARES AND PARAMETERS

In this paper, the BIM tool Autodesk Revit has been utilised for demonstrating the model building. Autodesk Revit tool is making the data exchange between more platforms and exchanging and using computer systems or software. The model includes geometry, geographical data, physical specifications and solar data from the geography[15]. Further, the various kinds of simulation tools were analysed, and Autodesk Insight 360, Green Building Studio are used. Autodesk Insight 360 and Green Building Studio conducts an analysis based on design inputs automatically [16]. The structure is analysed using the tool Staad Pro to verify the modal's structural integrity and utilise the smart analysis data. Energy Auditing being a vast topic study, the following were taken as parameters for study purpose. An investigation on the impact of building orientation on energy consumption in a domestic building using emerging BIM (Building Information Modelling) design, Energy Saving Techniques, Person Behavioral Impact, Material Analysis and Cost.

3.1 GREEN DESIGN

Green Design helps build an approach to minimise human health, environment and focus on sustainability. Green designing helps in moving towards environment-friendly structures. Most green buildings do not need all of these features of Green Design characteristics [17]. A few of the attributes in green design considered are as follows:

Space Usage
Window Wall Ratio
Orientation,
Geographical and Climatic Conditions.

3.1.1 SPACE UTILITY

Space utilisation measures the facility's size and puts together occupancy data movement throughout the property to understand the frequency with specific areas and the existing layout yields. Measuring space utilisation is essential in managing the organisation's budget and resource allocation and providing safety and reassurance to occupants. Moreover, with space utilisation data, unnecessary expenditures can be cut or find ways to repurpose underutilised areas. Understanding individuals interaction with the impact space they spend in can conserve energy by controlling lighting and heating in vacant areas. Space utility enhancement can have a significant impact on the carbon footprint.

3.1.2 WALL WINDOW RATIO

The Wall Window Ratio is one of the essential points to be considered in a building. More the windows, more the sunlight, more the sunlight, more the solar Radiation. WWR can maintain the airflow, Radiation and temperature difference[18]. These parameters appropriate the mean radiant temperature[19].

3.1.3 ORIENTATION

Sense of direction of building impacts the electricity. The effect plays a role in the WWR, Human behaviour and temperature difference.

3.1.4 GEOGRAPHY

Geographical data is vital for understanding the weather conditions, temperature, humidity, human behaviour.

3.2 ENERGY-SAVING TECHNIQUES

Green Building Concepts, Smart sensor and technology utilisation can save energy but not pile.

3.3 Personal Behaviour Impact

The person behavioural impact is a vital issue that depends on multiple criteria. These are categorised as Physiological, Behavioural Impact, Economical Behavioural Impact. The Psychological Impact is generally seen on a small-scale issue, but its impact is significant. The economical impact is usually seen in many places.

3.4 Valuvation

The necessity of Economical Valuing for the materials adapting in the structure is essential. The economical valuing helps find the need for material with the future perspective and the time it uses to recover the cost, relates sustainability and alternative aspects, making a resolution approach[20].

IV. Experimental Studies

4.1 Case For Application

For illustration, a residential building with five floors in the state of Andhra Pradesh, in India, was selected as the main modal and states of Punjab, Telangana and Chattisgarh were also analysed for understanding variations.

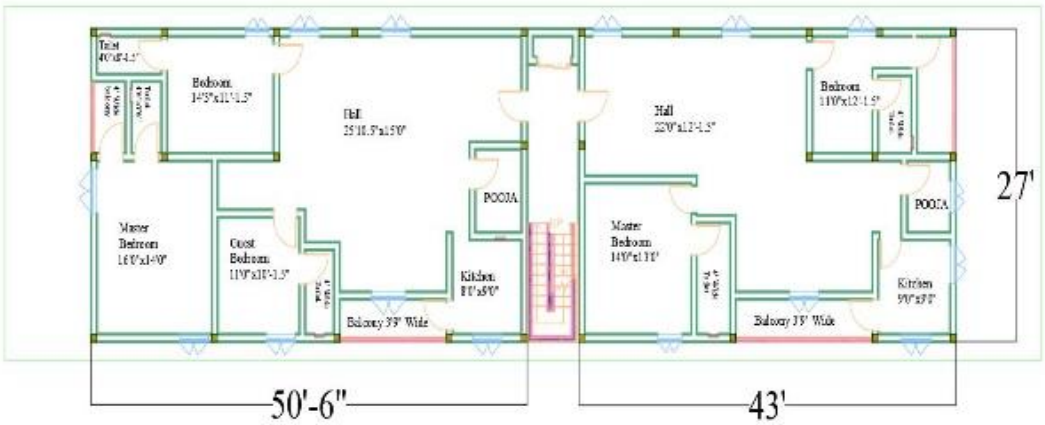

Figure 1: Floor Plan of Model

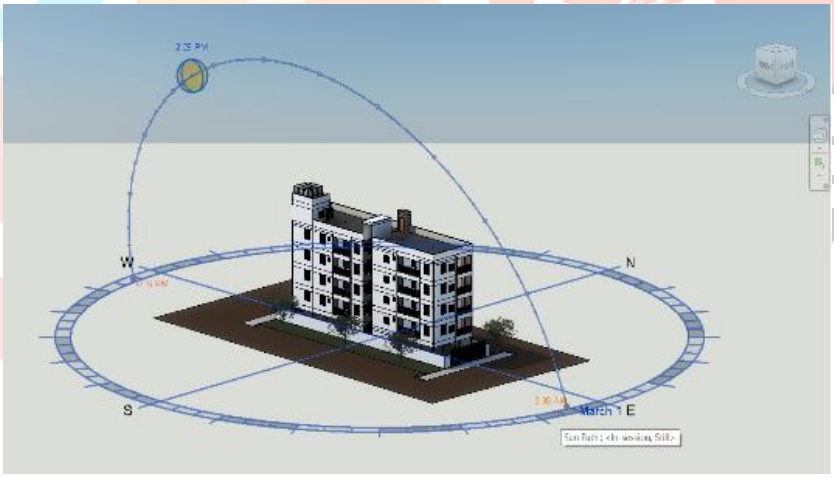

Figure 2: Replicated Model in Revit

4.2 Human Behaviour Impact

Human behaviour impact is calculated from the unruffled survey data. Later an energy calculation is done with the local estimate followed, and a calculator is made. The preliminary study for the location follows the major load-bearing types of equipment, and the average time usage is calculated per day.

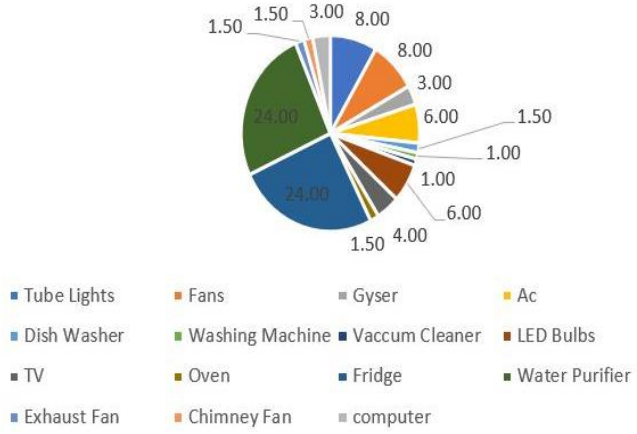

Figure 3: Average Usage Time of gadgets

Study 1: The Actual Bills were analysed, and the average bill value is calculated from the previous bills, and a 20% extra to the highest value considered is taken as an error percentage to high value for understanding the human behaviour impact in the living area in different locations. A logarithmic graph is pulled out from the congregate data with an uncomplicated calculation by erecting cost per unit area per person, and the trendline equation is bought from the graph.

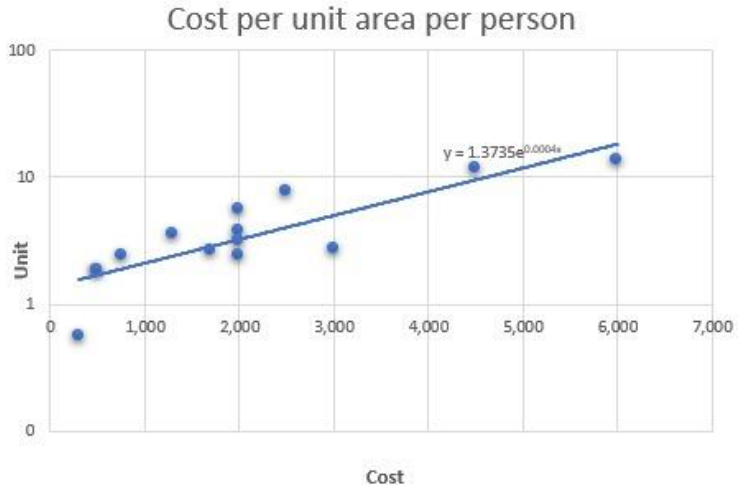

Figure 4: A Logarithmic Graph of cost vs cost per unit area per unit person

Study 2: Considering the Economic Impact, a factor is generated from the survey called the human reality economic factor. This describes the error percentage by human behaviour to the actual usage of electricity.

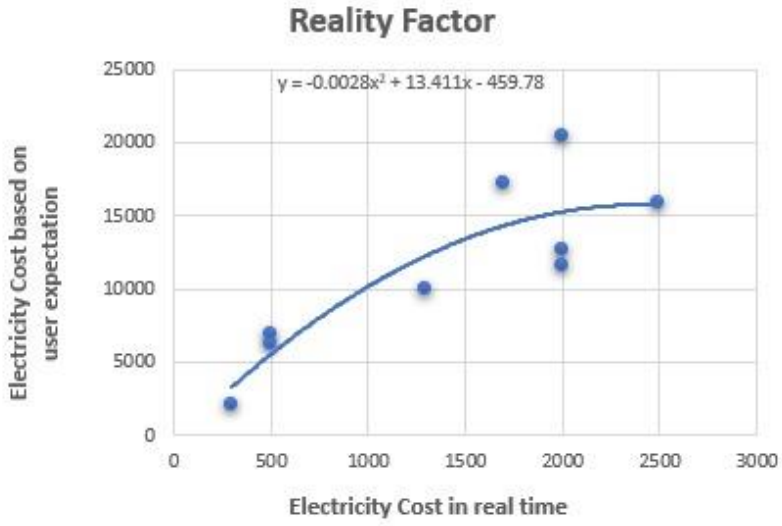

Figure 5: Reality Factor

Economical valuing is executed with the Green Building Concepts and intelligent sensor application with the rough market cost value. The electricity invoice value calculation is carried out as per Retail Supply Tariffs of APSPDCL, FY 20-21.

Table 1: Economical Valuing for the structure utilising GBC's and Intelligent Sensors

Units after using GBC Traffic Range	Per unit cost(Rs)	Consumption	Bill (Rs)
0 -50	2.65	50	132.5
51 - 100	3.35	50	167.5
101 - 200	5.4	100	540
201 - 300	7.1	100	710
301 - 400	7.95	100	795
401 - 500	8.5	100	850
>500	9.95	1113.454	11078.87
		Total	14273.87
Actual Cost Saved			369.80
Additional cost involved in utilising smart sensor			34370
Assuming additional cost for solar and pieso sensors, including installation and service charges			30000
Total Additional cost			64370
Comparing the saving with the additional cost			
The actual cost saved per month			369.80
Number of months for the cost recovery			174.07
Number of years for cost recovery			14.5

4.3 HUMAN THERMAL COMFORT

The temperature calculations were carried out with the indoor and outdoor temperatures calculated and the geolocation humidity. R-value is playing a significant impact on WWR[21]. The R-value impacts the wall thickness using brick data[22] from thermal comfort living for just a 2 degree Celcius in the range of 240mm to 440mm. The calculation is taken from equation(1)[23].

$$T_d = T_{mr} - \frac{U}{K_{is}(T_i - T_o)} = T_i - \frac{R_{is}}{R_{mrt}(T_i - T_o)} \quad (1)$$

Where, Td is temperature difference,

T_{mr} = Mean Radiant Temperature(MRT),

T_i = Indoor Temperature,

T_o = Outdoor Temperature,

U = Overall heat transfer coefficient,

R_{is} = Indoor Thermal Resistance,

K_{is} = Indoor Thermal Resistance,

Rmrt = Thermal resistance at MRT,

4.4 ENERGY SIMULATION IN AUTODESK INSIGHT

Autodesk Insight identifies a nearby weather bureau using the location provided and analyses the results automatically.

Figure 6: Insight Model

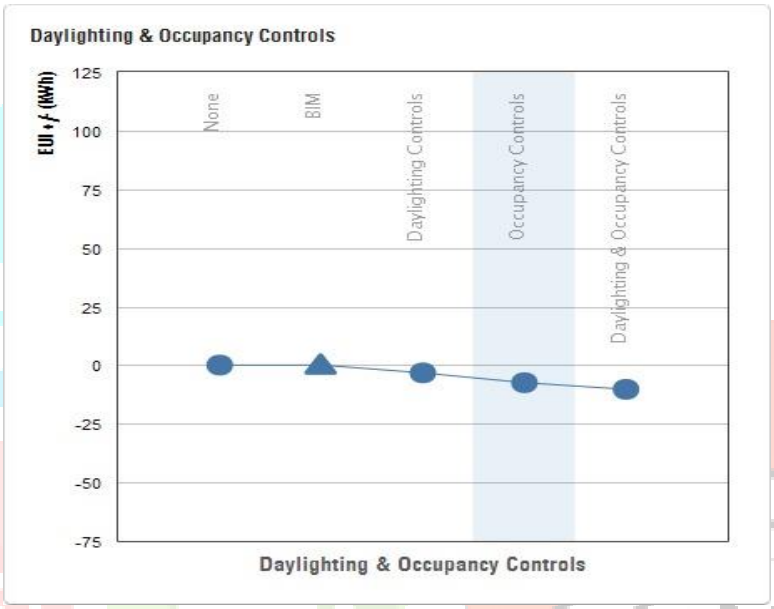

Figure 7: Energy Use Intensity of daylighting and occupancy controls

V. RESULT

The Economical Valuving is showing the need for installing an apparatus/equipment based on human conditions. The maximum number of years for cost recovery was 40 years from the actual impact for this structure. The structure is affected by changing the thickness of the wall with the change in load. The dead load is calculated as per IS standard 875-1987 part-1, and then the structure is analysed in Staad Pro for checking the structural integrity and changes in the sections or design. Also, increasing loads have increased the section's requirement affecting the BOQ.

The Radiation in the building is affecting human behaviour as building orientation changes. The pie charts below show the orientation impact at 0 degrees and 90 degrees. Though the lighting decreased at 90 degrees by 0.5%, mechanical equipment such as fans, pumps & aux increased by 0.8%.

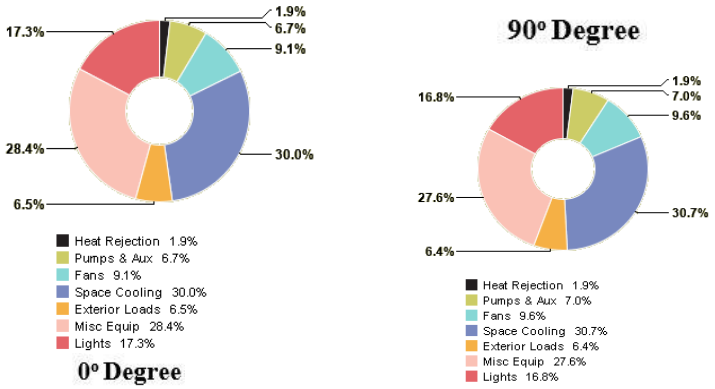

Figure 8: Autodesk GBS Electricity usage for orientations 0° Degree vs 90° Degree

VI. CONCLUSION

Numerous factors influence the energy desires and building envelope, dweller behaviour, building parts, building orientation, building size, and form. BIM has considerable edges for a much better understanding of existing environmental conditions (e.g. acoustic, thermal, and lighting). The traditional building energy modelling is not incorporated into the digital style and recognised as a tedious method. Building info modelling is considered a digital modelling method of generating and managing coordinated and consistent building information throughout the building lifecycle. The captured building in-formation is provided to alternative decision-making tools to optimise the building performance and to accomplish the property goals. Building info modelling-based building energy modelling may be a current ramification of the building info modelling technology, which may minimise the time and price of building energy modelling, measure completely different style alternatives quickly, and improve energy modelling accuracy, leading to higher building energy performance. Though BIM cannot simulate actual user behaviour in buildings, it's a awfully effective and economical style analysis and construction method. The reality factor conceptual framework for analysing the human behaviour impact develops a package resolution within the forthcoming analysis. Builders, designers, managers and project house owners will get well-being choices in their decision-making from this study to judge additionally. Choosing an optimised combination of intelligent building choices was the decision-making target of this analysis considering energy saving and price trade-off.

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