

# Green Building Based on BIM

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## Abstract

**Background/Objectives:** In India BIM will grow by 20% in next few years, for account of environmental parameter and rising demand. Using BIM with sustainable design and green construction techniques including maximizing the conservation of resources is referred as Green BIM. In the present study energy performance of a residential building is analyzed for different locations with software as well as manually. **Methods/Statistical Analysis:** First of all, building model is designed by using Revit software. After that model is converted in GBS which is one of the most important energy simulation tool integrated with Revit software. The model is located in different locations to study their energy impacts on the whole building. The energy use at different locations of model is concluded that large quantity of energy can be saved during its life cycle, in a well-located building. Therefore, the difference of both overall electricity uses and fuel uses are 35727 kWh & 54870 Therms, respectively. **Findings:** The combined energy cost saving between the best (New Delhi) and unfavorable (Brasilia, Brazil) is \$19143 throughout a 30-year period. This provides a comparison with traditional method and resulted that how building cost affected annually as well as life cycle. **Improvement/Applications:** It improves the construction quality and reduces the energy use in the building. BIM is a platform which provides some complete and interactive components in a building to create a new type of an energy model.

**Keywords:** Energy Analysis, Green BIM, Green Building, Revit, BIM, GBS

## 1. Introduction

Green BIM is the process of design buildings which are naturally accountable and resource effective during the building's life-cycle. Building information modelling simplifies incorporation, compatibility and connection in the construction industry by providing 3D view of a project containing all the parameters and its mechanisms. It is ideal for transfer the information enables to improve design and building presentation. BIM based different software, used according to work and requirement that results in data loss during the process of information exchange and unwanted duplication of work data restore. BIM is a dimensional tool which supports effective design and construction technique. Lack of interoperability for sustainable data has the effect of restraining the application of BIM in design phase. It is a manipulation method and intellectual modelling package which can be effectively operating in 3D, 4D and 5D to increase production,

to scale back value, operation prices and time during designing & construction. A model is used to provide a complete set of predictable forms which is reliable and precise<sup>1</sup>. About 95% of companies are use the Green BIM technique for energy simulation, 79% of firms use non-green BIM for replacements which are slow from currently increase of 21%. BIM tool is used for the purpose of sustainable design with rapid increase in importance of energy efficiency performance of a building<sup>2</sup>. Building information modelling with sustainable design is linked by model to provide useful data for analysis described on an estimated performance and important sustainable features. For example, BIM provides a tool which translates the model into non-exclusive plan for workable design data. A BIM model is used as a database for data exchange and integration based on the IFC. For the design segment, BIM agrees for multidisciplinary data covered in one model, which makes a chance for sustainability methods to combine during the design process<sup>3</sup>.

BIM helps industries like buildings, substructure, services, and plant segments mix design, simulation, and conception into their workflows. This provides greater awareness on how use to more efficiently land, water and material throughout the lifecycle of infrastructure and common building. It also leads to more efficient use of materials and contributes towards reduction of waste. So, BIM is central to assessing resource usage in projects and supports sustainability in building construction<sup>4</sup>. It provides a summary of Building Information Modelling explanations and combined analysis tools which help to evaluate building presentation, arrange savings, and applications toward conserve energy, reduce effective costs, improve building air quality, reduce water uses and serving for encounter sustainability energy productivity goals. It discusses on the BIM contain instructions for relationship across organizational boundaries<sup>5</sup>. Some say during construction work the new technologies are offer an opportunity to the model shift of building, while other proposes that effective implementation of BIM needs the technologies and changes to the current work of team members<sup>6</sup>.

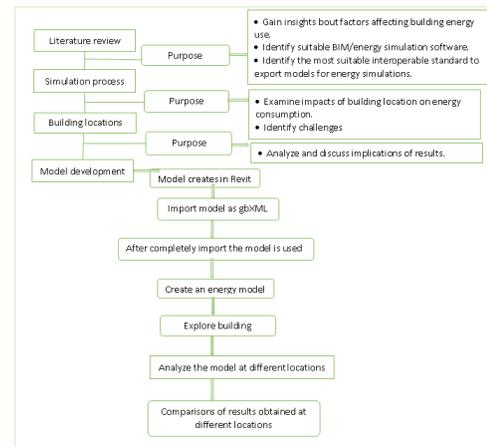
Architects and engineers are share information more effectively related to sustainability with the help of BIM applications, such as daylighting and energy consumption, and thus the sustainability analysis can be seamlessly integrated into the design process. BIM also helpful for designers to utilize the existing building data to improve default configuration of building early stages of new building design<sup>7</sup>. BIM software provides efficient solutions to ease the environmental effects for construction process. For instance, a 3D BIM model was proposed to measure the CO<sub>2</sub> footprint in a house construction process and to provide recommendations for improving construction activity schedule and to reduce associated emissions. Existing study emphasized that Building Information Modelling technology is used for waste reduction which is an important aspect of sustainable construction<sup>8</sup>. BIM is a tool useful for the integration of smart and valuable models that makes important information with a common data environment. In many cases BIM is used for information sharing and reuse for interoperability between prevalent tools in the Architecture Engineering and Construction industry<sup>9</sup>. Hence best opportunity for energy performance study and sustainability measures is to be linked in BIM model<sup>10</sup>.

Traditional design methods are restricted in term of frequently analyzing sustainability for the period of the design process due to continuous information<sup>11</sup>. For designing, the US Department provides information about 417 analysis

tools to evaluate the renewable energy, sustainability measure and energy efficiency of buildings<sup>12</sup>. Energy analysis should be intricate and exclusive according to result sometimes is delayed till end of the design process<sup>13</sup>. Niewoehner<sup>14</sup> further suggested that actual integration of the information database to produce same analysis of daylighting, use of energy and heat loss/heat load. Some suggested that BIM supported the subsequent features of building massing as well as efficient design which is used to analyze the building to improve its cover efficiency. The tool used to determine the heat transfer over building cover in the direction to attain load due to heating and cooling effect<sup>15</sup>.

## 2. Methodology

In this research study the work flow is represented diagrammatically as in Figure 1.



**Figure 1.** Framework of methodology<sup>16</sup>.

- The first step contains literature review relevant to the study. Definitely, BIM and energy analysis software and factors affecting building energy use, are reviewed. This is used to understanding the relation between building energy location and energy use. An appraisal of BIM and analysis tools are used towards evaluate their suitability of study.
- Second step consist of different software used in earlier step to investigate the model and energy simulation process. The detail of the simulation process is given in Figure 1.
- Third step contains simulation processes which are used for model by recognized information. Select a model with evaluated characteristics and well-known locations are important to allow researcher for simply analysis and to understand the findings

from reiterating the different location of model to confirm the computational results are accurate or not.

- Fourth step is based on analysis of different location of a building model, for computation of results is compared with another data. This is sort method, to serve as a justification of the whole calculation.

### 3. Interoperability Issues

In this part interoperability conditions/ activities are often fail to aware about the ability of communication challenges and levelling interoperability faced by construction professionals. Important long-term trials are remaining discuss different stages of aspect mandatory to support all construction activities such as analysis, planning, coordination details, creation processes. Also, industry groups struggle continues for evaluate the certification and testing of implementations of interoperability standards to certify that reliable data transfer in quick progress is finished by software designers toward repetitive process. Model which is shown in Figure 2 create in Free CAD software to check the interoperability with other software. For check the compatibility of software the model is exported to IFC and saves as IFC file. It creates IFC word file during run this model in another software like Autodesk Revit software. The IFC file is shown in Figure 3. IFC is an important language used by all engineering fields that permits sharing information between whole AEC/FM project members and store the important data in one simulated model which is conserved and used during the project life. Encouragement of the BIM to maximum opportunity is trying due to inadequate change of the energy simulation and BIM. But, the use of BIM tools for simulation

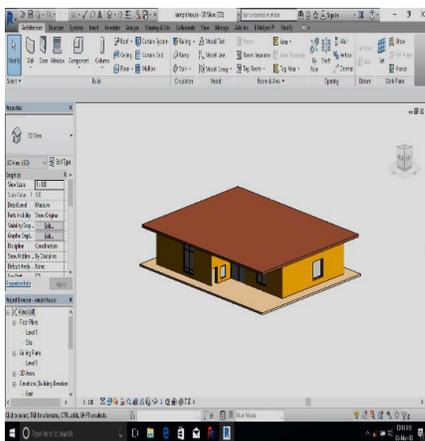


Figure 2. Exported Free CAD model run in Revit software.

of energy is well known, whereas an organized method to transfer the essential information is yet missing. Data exchange between simulation programs and BIM is now restricted to transfer the 3D view of the building projects.

### 4. Model Development

First of all, information collected about creation of model on Revit software and creates a model in it (Figure 4). For energy simulation, a model is exported to gbxml (Figure 4). After that model is completely transformed and save as a gbXML file (Figure 5) and automatically read this file by using GBS which is integrated with Revit software. Energy simulation in autodesk Revit software provides effective details which is the requirement of Green Building Studio. It can automatically select the nearest weather station of a building in order to obtain appropriate information during the simulation process. According to location selection set the sun path setting to create a proper energy simulation results. Because the sun path changes with locations as in Figure 6 and also change the energy performance of a building effectively due to heating and cooling load.

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Figure 3. IFC file for individual elements.

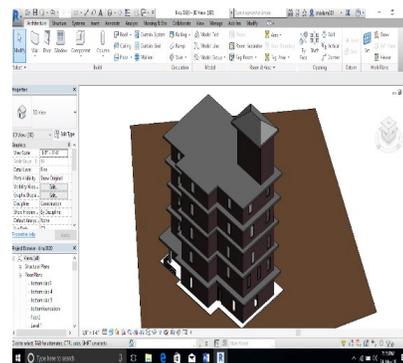


Figure 4. 3D model created in Revit software.

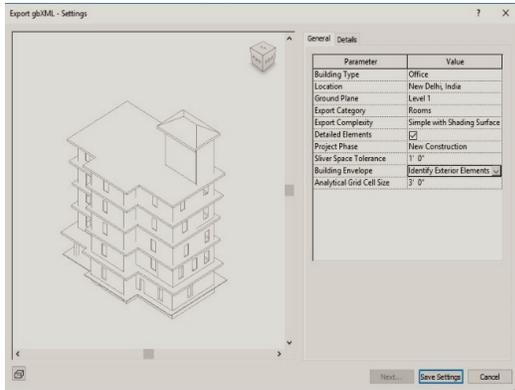


Figure 5. Model is exported into gbXML.

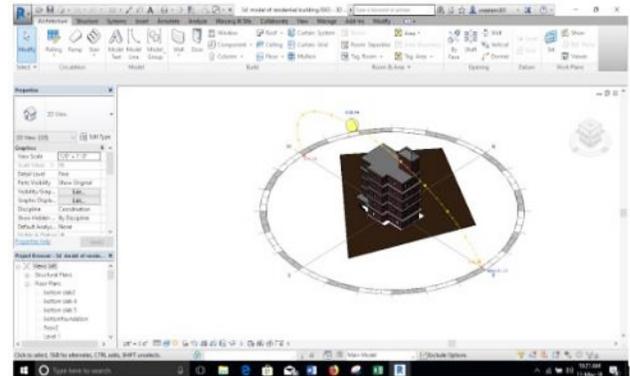


Figure 6. Sun path settings according to locations for energy simulation.

## 5. Analysis

The analysis and discussion are very important for understanding the bond among location and energy use of building. The following assumptions are adopted during analysis:

- For 30-year period total life cycle cost of the building is taken with a discount factor of 6.1%.
- It is not including the energy loss for electronic transmission.

In analysis gas is referred as “fuel”.

For the analysis of energy consumption of a building have to choose six locations such as Brazil, Mumbai, Calcutta, Bangalore, New Delhi and Shimla (Himachal Pradesh). Brazil is the abroad location opposite to these alternate locations which is used to check the energy use/cost difference between same building models analyzed in Indian location. Annual energy use/cost analysis is shown in Figure 7.



Figure 7. Annual energy uses for electricity and fuel.

## 6. Result and Discussion

The summary of latitude and longitude for different locations are given in Table 1 and the total use and cost of energy for electricity and fuel with including factors such as sun path which are given in Table 2.

- **Brazil** - This location is closest to weather station 122722. The outdoor temperature is maximum at 91°F and minimum at 70°F. The total annual energy use for electricity and fuel are 32272 KWh and 125 Therms with total costing of \$4029.
- **Mumbai** - This location Mumbai India closest to weather station 706679 and the outdoor temperature is maximum at 91°F and minimum at 68°F. The annual use of electricity and fuel are 34206 KWh and 119 Therms respectively with the total cost is about \$2830.
- **Calcutta** - This location is closest to weather station 454320 and the outdoor temperature maximum at 91°F and minimum at 70°F. Due to temperature variation, annual electricity and fuel energy are consumed 31638 KWh and 167 therms respectively with the total costing is \$2593.
- **Bangalore** - This location is closest to weather station 719105 and the outdoor temperature maximum at 98°F

**Table 1.** Summary of locations with its longitude and latitude

Test	Locations	Longitude	Latitude
1	Brasilia (Brazil)	14.23°S	51.93°W
2	Mumbai	19.07°N	72.87°E
3	Calcutta	22.5°N	88.36°E
4	Bangalore	12.9°N	77°34'E
5	New Delhi	28°40'N	77°2'E
6	Shimla (HP)	31°06'N	77°13'E

and minimum at 50°F. The annual fuel and electricity consumed 27826 KWh and 173 therms respectively both the cost is \$2362 in total.

- **New Delhi** - The location is closest to weather station 429042 and the outdoor temperature maximum at 114°F and minimum temperature 37°F. The total annual electricity and fuel energy used 29902 KWh and 294 Therms respectively with a cost is \$2623 in total.
- **Shimla (Himachal Pradesh)** - This location is closest to weather station 429042. The outdoor temperature maximum at 114°F and minimum at 37°F. The annual electricity and fuel energy are consumed 24604 KWh and 298 Therms with total cost of \$3325.

For Annual cost,

$$\begin{aligned} \text{Average annual cost (\$)} &= 4029 + 2830 + 2662 + 2362 \\ &\quad + 2623 + 3325/6 \\ &= \$2971.9 \end{aligned}$$

For life cycle cost,

$$\begin{aligned} \text{Average life cycle cost (\$)} &= 54870 + 38541 + 36259 + \\ &\quad 32168 + 35727 + 45282/6 \\ &= 40474.5 \end{aligned}$$

Average of all locations has been used to determine the lowest cost as \$2971.9, which represents mid place of the 5th and 6th test. Choose the smallest value which represent as a location Bangalore. The average of total annual energy for fuel and electricity are determined as test 5 is 29902 kWh and 294 therms respectively with both of total cost is \$2623. The summary of life cycle cost and annual cost are given in Table 2. The annual cost for energy use is shown in (Figure 7) ranges from lowest value \$2362 to highest value \$4029. Also, the life cycle total energy cost ranges from \$32168 to \$54870 with a difference of \$22702 (Figure 8,9).

**Table 2.** Energy use and cost data of building with factors considered (such as sun path)

Test	Location	Annual energy use		Life cycle use		Annual energy cost (\$)	Life cycle cost (\$)
		Electricity use (KWh)	Fuel use (therms)	Electricity use (KWh)	Fuel use (therms)		
1	Brasilia (Brazil)	32272	125	968169	3754	4029	54870
2	Mumbai	34206	119	1026184	3571	2830	38541
3	Calcutta	31638	167	949164	5018	2662	36259
4	Bangalore	27826	173	834842	5190	2362	32168
5	New Delhi	29902	294	897081	8838	2623	35727
6	Shimla (HP)	24604	298	738130	8961	3325	45282

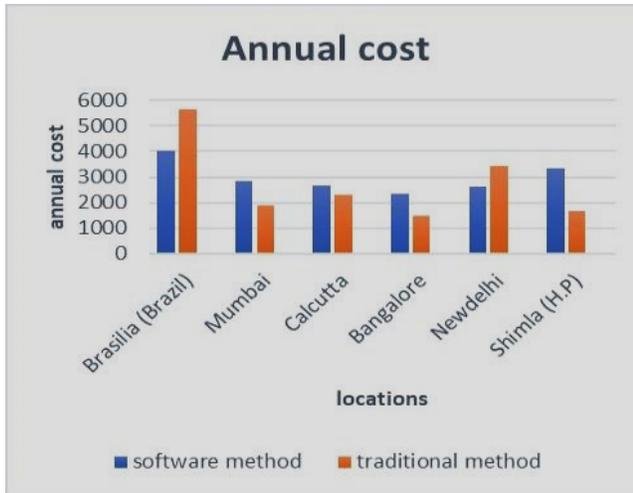


Figure 8. Annual cost for changed locations.

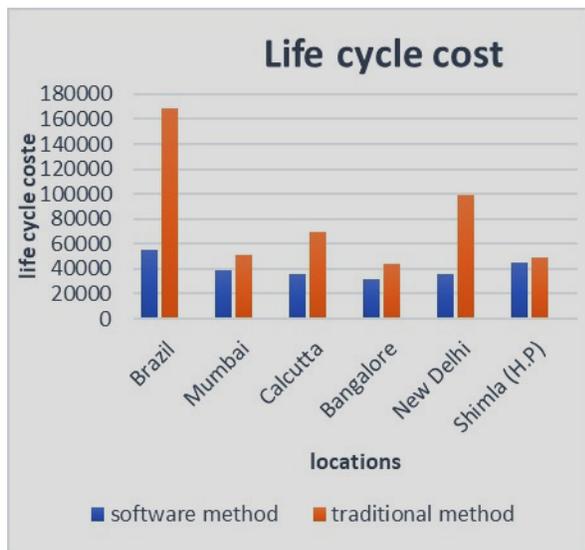


Figure 9. Life cycle cost of changed locations.

**Annual cost**

Electricity use = 32272 KWh  
 Cost = electricity use \* actual cost  
 = 32272 KWh \* \$0.17/KWh  
 = \$ 5486.24

Fuel use = 125 Therms  
 Cost = fuel use \* actual cost  
 = 125 Therms \* \$ 1.21/Therms  
 = \$152

Annual energy cost = \$5486.24 + \$152  
 = \$5638.24

**Life cycle cost**

Electricity use = 968169 KWh  
 Cost = electricity use \* actual cost  
 = 968169 KWh \* \$ 0.17/KWh  
 = \$164588.73

Fuel use = 3754 Therms  
 cost = Fuel use \* Actual cost  
 = 3754 Therms \* \$ 1.21/ Therms  
 = \$ 4542.4

Total Life cycle = \$164588.73 + \$4542.4  
 = \$169131.2

**6.1 Traditional Method**

In this method we have to use software-based analysis with actual rate of electricity and fuel along with locations adopted for the analysis and determine their cost annually as well as life cycle. The actual cost rate for different locations as given in Table 3.

Table 3. Actual cost rate of fuel and electricity for different locations

Test	Locations	Electricity cost \$/ KWh	Fuel cost \$/ therms
1	Brasilia (Brazil)	0.17	1.21
2	Mumbai	0.05	1.41
3	Calcutta	0.07	0.59
4	Bangalore	0.05	0.40
5	New Delhi	0.11	0.51
6	Shimla (HP)	0.05	1.41

**6.2 For Brasilia Brazil**

Electricity rate = \$0.17/KWh

Fuel rate = 1.21/ Therms

For the check have to use software data with actual cost and determine the annual cost as well as life cycle cost. So, for annual cost following steps are involved

As above calculation has to determine the annual as well as life cycle cost for all other locations with as actual cost which is given in Table 3. By using the above procedure traditional method for calculation of energy costs in different locations and determine energy costs for all locations which are given in Table 4.

**Table 4.** Traditional costs for all locations which are taken for analysis

Test	Locations	Annual energy use		Life cycle use		Actual electricity rate (\$)/KWh	Actual fuel rate (\$)/Therms	Annual energy cost (\$)	Life cycle energy cost (\$)
		Electricity use (KWh)	Fuel use (therms)	Electricity use (KWh)	Fuel use (therms)				
1	Brasilia(Brazil)	32272	125	968169	3754	0.17	1.21	5638.24	169131.2
2	Mumbai	34206	119	1026184	3571	0.05	1.41	1878.3	51544.6
3	Calcutta	31638	167	949164	5018	0.07	0.59	2313.3	69503.5
4	Bangalore	27826	173	834842	5190	0.05	0.40	1460.5	43818.0
5	New Delhi	29902	294	897081	8838	0.11	0.51	3451	98846.6
6	Shimla (HP)	24604	298	738130	8961	0.05	1.41	1650.3	49541.5

The two-method software method and traditional method which are used to compare analysis of energy cost for annually as well as life cycle use. Out of these two-methods the software method is very useful and efficient method for cost as well as time consuming.

## 7. Impact of Building Location on Energy Use

It is appropriate to produce quantitative data used to report the objectives of the research. This research work is focused on 3D model create in Autodesk Revit software to test the building performance at a different location. A building is located in different locations relative to the temperature difference which can affect the ability of heating the building cover through solar energy. With a full investigation, the relationship is clear between the two variables, a level which one affect with the other, it is justified that a series of data is not appear important from year-to-year. The effect of life cycle energy cost on a building location is considerable. The lowest annual energy cost \$2362 at location Bangalore and upper range of \$4029 at location Brasilia (Brazil) with increase difference of \$1667. The total difference of annual energy cost over a 30-year period is best location (\$35727) and the unfavorable location (\$54870) is \$19143.

## 8. Limitations and Opportunity

In this research work the capability of BIM buildings for energy consumption against the parameters and their locations, before building development suggested that opportunities to explore the alternatives related to energy use. When building is evaluated by using manual or traditional techniques, it provides great opportunity to avoid

mistakes. During simulation the mistakes are very tough to precise, when building is already in operation or use. But, ability of BIM is high in making decision effectively.

- The weather station chosen depends on the location of the building. Thus, the location and weather stations are chosen by default city and by internet mapping system.
- A model created in Revit software is broad and precise before is exported via gbXML to simulation tool. There is not a same relation between the energy simulation software and BIM.
- It is very difficult to avoid errors completely due to inhabitant's presence in a building. As claimed in Ryan and Sanquist that the behavior of inhabitants is change and create accurate model is impossible. A big challenge offers to agreement with most energy simulation tools.

## 9. Conclusion

The various factors which affect the energy use of a building which include building location, size and shape and its parts. In internal spaces heat and light occurred which reduces need for energy use. It results to improve efficiency and reduce energy use with reducing heating and lighting units. In the energy simulation process, BIM is considered important factor for used to create a high potential in sustainable building design. Thus, evaluate the energy performance effectively before construct the building on site. In this study autodesk Revit software is used to analyze energy performance by adopted different building locations. It finds the results that a well-located building can save \$19143 from evaluation of energy throughout its lifetime. In this study the poorest location is at Brasilia, Brazil (Test 1) while the best is at New Delhi

(Test 4) for conserve the energy. At the end it proves that building location can also affect the energy use as well as cost. In the traditional method existing software data is used with actual cost to compare which methods are useful, precise and accurate. It concluded that the annual cost of different location is decrease in maximum locations but the lifecycle cost is slightly increased. The best location New Delhi consume less energy and cost in both annual as well as life cycle in both the method between software method and traditional method with an annual cost difference is \$828.

## 10. Acknowledgment

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