Effect on Energy use Due to Different Orientation: A Case Study of Commercial Building

[1]Anuj Pandey [2]Rinkesh Jadav [3]Panchal Jenil
[1,2,3]UG Student
[1,2,3]Department of Civil Engineering
[1,2,3]R.N.G.P.I.T. (F.E.T.R.), Bardoli, Surat, Gujarat, India

Abstract

Building requires energy in their life cycle from its construction work to demolition work. Studies on the total energy use during the life cycle of buildings are desirable to recognize phases of largest energy use and to develop strategies for its reduction. In the present paper, a review of the life cycle energy analysis of building is presented. The aim of this paper is to present an energy analysis by using building information modelling (BIM). The Building Information Modelling (BIM) software is used for the design of wide range of constructions; from small house to big apartment buildings. This program allow the architect, designer or civil consultant to perform several simulations of the energy behavior of a building in a timely manner, even before a single brick is put in place The study includes energy analysis of commercial building and the comparison of energy analysis data at different degree orientation. Building's life cycle energy demand can be reduced by reducing its operating energy through use of passive and active technologies even if it leads to a slight increase in embodied energy. It is observed that low energy buildings perform better than self-sufficient (zero operating energy) buildings in the life cycle context.

Keyword- BIM, 6D Model, Construction Management, Energy Analysis

---

I. INTRODUCTION

BIM is first and foremost a process, but it is more than that. BIM is a 3D model-based process that provides architecture, engineering and construction (AEC) professional information and tools to efficiently plan, design, construct and manage buildings and infrastructures.BIM is used for the production and management of construction information.

The essence of the BIM process is that it enables the creation of virtual 3D models that can be explored and manipulated, making it easier to understand the relations between spaces, materials and systems. A database generates a 3D image and creates building plans. By having possibility to build the whole project virtually before physical construction begins. This virtual assessment of models is what has been termed "build before you build"(Kathleen, undated), "build twice"(once virtually and once reality).The qualities of BIM is enclosed in the definition of BIM Task group who defines it as "essentially value creating collaboration through the entire life-cycle of an asset, understanding by the creation, collaboration and exchange of shared 3D models and intelligent, structured data attached to them".(BIM Task group 2016).Other authors have summarized BIM as a system that provides 'the right information, to the right people, at the right time' (Champan, 2013;CIOB, 2017).

BIM is a strong collaborative tool that helps the project team to work together and collaborate for delivering better built environment assess.

A. nD Modelling

1) 3D Model

3D BIM's visualizations capabilities enables participants to not only see the building in three dimensions before construction started, but also to automatically update these views along the project life cycle, from construction stage to demolition stage. BIM 3D helps architecture, engineering and construction (AEC) professionals to manage their collaboration more effectively in modeling and structural problems.

The 3D model is prepared in Revit Architecture is shown below:

Fig. 1: 3D model

2) 4D Model

4D-BIM (four-dimensional building information modelling) is used for construction site planning activities. The fourth dimension of BIM allows architecture, engineering and construction (AEC) professionals to extract and envisage the progress of the activities through the lifecycle of the project. The operation of 4D-BIM technology can result in improved control over clash detection or over the intricacy of changes occurring during the construction project. 4D BIM provides methods for overseeing and visualizing site status information, change impacts as well as supporting communication in diverse condition such as warning about risks to a site staff.

3) 5D Model

5D-BIM (fifth-dimensional building information modelling) is used for cost analysis. The fifth dimension of BIM associated with 3D and 4D (Time) allows architecture, engineering and construction (AEC) professionals to visualize the progress of their activities and related costs over time. The utilization of 5D-BIM technology can result in a more accuracy and expectedness of project's estimates, scope changes and materials, equipment or manpower changes.

4) 6D Model

6D-BIM (sixth-dimensional building information modelling) helps perform energy consumption analyses. The use of 6D-BIM technology can result in more accurate energy estimates earlier in the design process. It also allows for measurement and verification during building occupation, and improved processes for gathering lessons learned in high performance facilities.

II. LIFE CYCLE ENERGY ANALYSIS

Life cycle energy analysis is an approach that accounts for all energy inputs to a building in its life cycle. The energy used in the following phases: Manufacture, operation, demolition. Manufacture phase includes manufacturing and transportation of building materials. Operation phase includes activities related to the use of the buildings over its life span. The different energy used in each phase is discussed below.

III. EMBODIED ENERGY

Embodied energy is the energy utilized during manufacturing phase of the building. It is the energy of all the materials used in the building and technical installations, and energy used at the time of erection and renovation of the building.

IV. OPERATING ENERGY

It is the energy required for maintaining comfort conditions and day-to-day maintenance of the buildings. It is the energy for HVAC (heating, ventilation and air conditioning), domestic hot water, lighting, and for running appliances. Operational energy varies with climatic condition.

V. DEMOLITION ENERGY

At the end of building‘s service life, energy is required to demolish the building and transporting the waste material to landfill sites and or recycling plants. This energy is called as demolition energy.

VI. METHODOLOGY

First, The 3D model is prepare from 2D drawings in Revit Architecture(2016) and The energy analysis is perform on the commercial building "Radhika Royal" by using Green Building Studio (GBS) at different orientation mainly at 0 degree (North), 90 degree (East) ,180 degree (South), and at 270 degree (West). The data obtained is mention in tabular form and comparison of data is to get minimum energy consumption at a particular degree of rotation. The bar chart showing the energy consumption and costs are given in figure below:

It is the energy required for maintaining comfort conditions and day-to-day maintenance of the buildings. It is the energy for HVAC (heating, ventilation and air conditioning), domestic hot water, lighting, and for running appliances. Operational energy varies with climatic condition.

VII. RESULTS AND DISCUSSION

SRNO.	*DEFINATION*	*UNIT*	*0^O*	*90^O*	*180^O*	*270^O*
Energy Use Intensity						
1	*Electricity EUI*	*kWh/sm/yr*	*114*	*118*	*117*	*114*
2	*Fuel EUI*	*MJ/sm/yr*	*405*	*404*	*412*	*399*
3	*Total EUI*	*MJ/sm/yr*	*815*	*828*	*832*	*811*
Life Cycle Energy Use/Cost						
1	*Life Cycle Electricity Use*	*KWh*	*12721341*	*13501545*	*136214461*	*13224909*
2	*Life Cycle Fuel Use*	*MJ*	*45122672*	*46380602*	*48161552*	*46161122*
3	*Life Cycle Energy Cost*	*$*	*614208*	*646787*	*657148*	*635999*

Table 1: Building Performance Factors

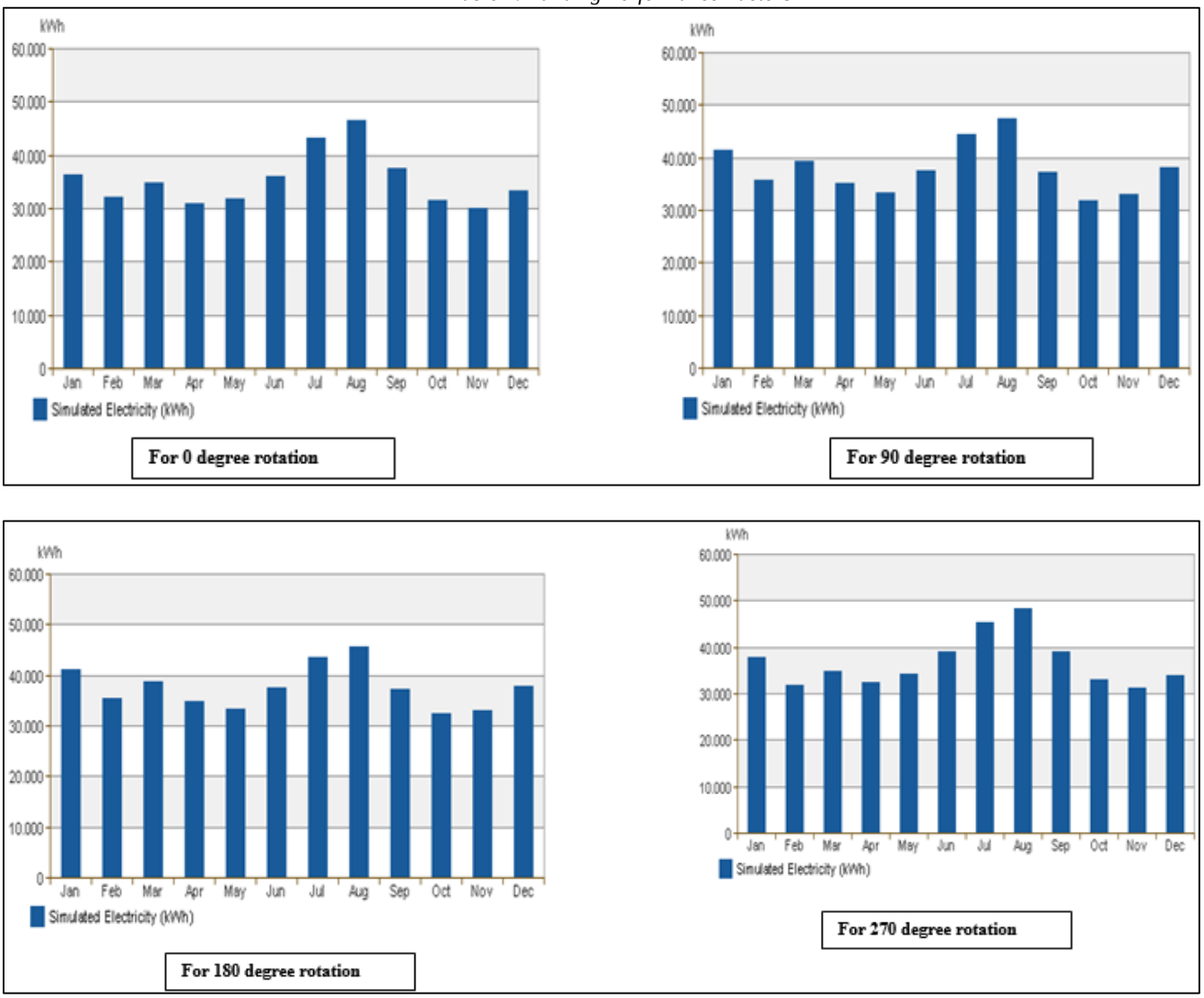

Fig. 2: Monthly Electricity Consumption

VIII. CONCLUSION

The conclusion of paper is reduction in energy use in building by only orientation of plan. The orientation of building plays an important role to reduce building energy consumption. In this study, it is found that building orientations mainly contribute to reduce active cooling on buildings compared with lighting and miscellaneous equipment. The percentage of energy use for heating, ventilation and cooling (HVAC) is 94% and the energy use for lighting and miscellaneous equipment is equivalent to 93%.

It is observed that the optimized orientation of the case study building in terms of Energy Use Intensity (EUI) is when the building faces North side. The yearly EUI for the best orientation is 12721341Kwh for 30 years life of building for 1.5% depreciation cost and total cost for this orientation is $614208(4,40,25815.23 INR).

IX. LIMITATION OF THE STUDY

There are some limitations should be addressed in this study. First, The Energy Analysis can be performed at the planning phase only. It is not very effective when construction of building is completed. The Energy Analysis for different orientation is not very effective at some locations.

REFERENCES

[1] T. Ramesh, Ravi Prakash, K.K. Shukla
https://www.researchgate.net/publication/229400115_Life_cycle_energy_analysis_of_buildings_An_overview
[2] K. Whitlock , F. H. Abanda , M. B. Manjia , C. Pettang , and G. E. Nkeng
http://www.ppml.url.tw/EPPM_Journal/volumns/08_01_January_2018/ID_174_8_1_47_55.pdf
[3] https://en.wikipedia.org/wiki/Building_information_modeling
[4] BIM handbook http://adeb-vba.be/the-guide-to-bim.pdf
[5] Daniel Martin Marin https://www.divaportal.org/smash/get/diva2:1130899/FULLTEXT01.pdf
Chapman, I. (2013).
[6] The right information at the right time, AEC Magazine, Available at: http://www.aecmag.com/comment-mainmenu-36/575-the-right-information-at-the-right-time, Accessed 19.02.2017
[7] Kathleen (undated).Innovative design and operation through BIM.
Available at:
https://static1.squarespace.com/static/57390d2c8259b53089bcf066/t/577e1ab48419c243feb20728/1467882 177327/BIMinNZ-Casestudy-3- Kathleen+Kilgour+Centre+Tauranga.pdf.
[8] Mukherjee S, Mukherjee S, Garg RD, et al (2013) Evaluation of topographic index in relation to terrain roughness and DEM grid spacing. J Earth Syst Sci 122:869–886. doi: 10.1007/s12040-013-0292-0
[9] Riley SJ, DeGloria SD, Elliot R (1999) A terrain ruggedness index that quantifies topographic heterogeneity. Intermountain Journal of Sciences 5: 1–4.
[10] Rini Mulyani ,Inna Kholidasari
https://www.researchgate.net/profile/Rini_Mulyani2/publication/324746668_the_impact_of_building_orientation_on_energy_use_a_case_study_in_bung_hatta_university_indonesia/links/5ae027f70f7e9b285945fa0f/the-impact-of-building-orientation-on-energy-use-a-case-study-in-bung-hatta-university-indonesia.pdf?origin=publication_detail
[11] Moore ID, Grayson RB, Ladson AR (1991) Digital terrain modelling: A review of hydrological, geomorphological, and biological applications. Hydrol Process 5:3–30. doi: 10.1002/hyp.3360050103
[12] Moral FJ (2010) Comparison of different geostatistical approaches to map climate variables: application to precipitation. Int J Climatol 30:620–631. doi: 10.1002/joc.1913
[13] Mukherjee S, Mukherjee S, Garg RD, et al (2013) Evaluation of topographic index in relation to terrain roughness and DEM grid spacing. J Earth Syst Sci 122:869–886. doi: 10.1007/s12040-013-0292-0
[14] Riley SJ, DeGloria SD, Elliot R (1999) A terrain ruggedness index that quantifies topographic heterogeneity. Intermountain Journal of Sciences 5: 1–4.

