Residential House Design with Solar Analysis to Optimize Energy Consumption

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Abstract.

Energy consumption is a sector of keen interest since the discovery of electricity. Continuous research work is being done in this field. Now a day, people have become more cautious towards the consumption of energy at home, office or workplace. Various parameters have been developed to determine a device's energy efficiency. A house is comprised of multiple electronic gadgets, working all at a time or one after another. A house fully dependant on the mains supply, will hence, is more costly as the devices all together draw huge energy. This is main reason why people are switching to renewable source of energy. Today, some houses have installed solar panels at the roof to provide electricity partially, parallel to the mains supply.

But to make the house even more energy efficient, certain design factors should be considered. A house while its construction, must be based on the standards laid by the Indian Standard and Indian Green Building Council. Owing to these standards, one can understand and implement better energy efficient techniques. In this paper, the primary work is on the design of a house with respect to the path of the sun. The study will revolve around how to design a residential house in accordance with all the natural factors, Indian Standards and Green Building specifications.

Keywords. Solar Energy, Energy Efficiency, Green Building, Design, Sustainability, etc.

1. INTRODUCTION

People always favour comfort over hard-work, when it comes to living in own house. For example, a person will choose to switch on an AC rather fill water in a cooler and then switch it on. Change of lifestyle has evolved electronic gadgets to smoothen the living. Today, almost every device is available for every task. But deploying a device has energy consumption too. May be the device runs on low power, but consumption can't be ignored. Hence, choosing limited number of electronic devices to carry out day to day work with least compromise in the standard of living is a matter of great concern. When a dream house is being constructed, the architect or the engineer has to keep several factors in mind like cross-ventilation, luminance, aesthetics, architectural consideration, structural framing, etc[1][2].

Also, the position of the house has a major impact on the consumption of energy. During daytime, the sun radiates light as well as heat. If proper planning is not done to obstruct the sunrays partially, then the fans and the ACs in the house will have to work for more hours than normal. Say, the kitchen is not well ventilated, and then the warm gases will scatter all around the house and make the interior temperature hot and humid. So, fans need to work for more hours, even, air purifiers might be deployed to help. In winter, sunrays act as natural warmers. The more the sunrays enter the house, the warmer the house will be. But in summer, that will be a problem. So all these revolves around the concept of designing a house based on analysis of solar path.

2. DESIGN OF INFRASTRUCTURE AND METHODOLOGY OF RESEARCH

Figure 2.1. Typical Proposal of a Residential Building

The United Nations has led several sustainable developmental goals for a sustained environment in future by adopting some scientific practices[3]. Hence, through the method of passive design of a building and tools like Autodesk Revit, it is possible to discuss the analytics of the project, owing to the norms laid by the Indian Standard codes and Green Building rating specifications.

2.1. Solar Path Simulation

The approach to obtain a sustainable design for any building can be classified in three ways[4]. First, the basic building design factors like site location, landscaping, orientation, construction materials, etc. Second, the passive systems like ventilation, heating-cooling, day-lighting, comfort, etc. And third, the electronic and mechanical devices deployed in the building like ACs, chillers, heat pumps, furnaces, solar heaters, etc[5]. All these factors help engineers and architects to determine the comfort and aesthetics of the building. A simple and modern house is planned and designed through software. A green site is chosen and designed accordingly. A three dimensional model is designed in software to observe the solar path over various seasons and time[6]. From the observations and simulations, it is evident that the position of sun is almost overhead during the day with an altitude angle of 83° during April-May season and during the December-January season, the sun is seen much inclined and with an altitude angle of 54°[7]. Figure 2.1.1 and Figure 2.1.2 describes the solar analysis performed on a conceptual residential house with directions respectively. This helps to understand and improve the position of the house for better energy efficiency.

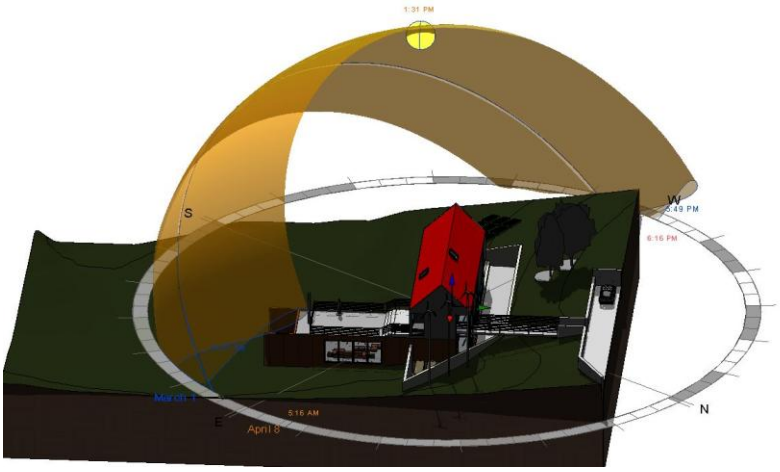

Figure 2.1.1. Solar Analysis model with solar path simulation

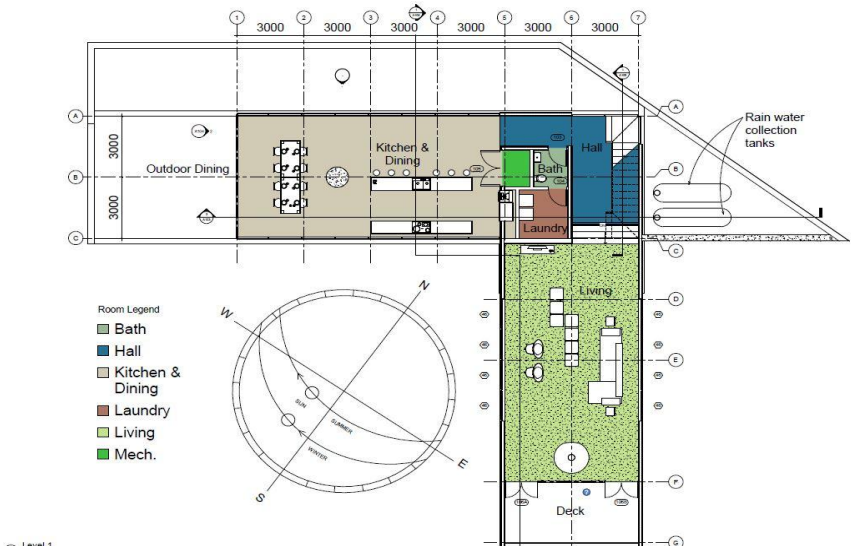

Figure 2.1.2. Proposed house plan with direction

2.2. Selection of Material

Most of the materials used in the building are sourced near the project site. Utilization of construction waste as raw material can be good process to eco-friendly construction. Fly-ash bricks, glass, aluminium and ceramic tiles, which have post consumer and industrial waste, are used in constructing the building to encourage usage of recycled materials. Bagasse based composite wood can be used for making the furniture. Use of low Volatile Organic Compound (VOC) paints and coatings, adhesives, sealants and carpets can also enhance the building to be green and efficient[8]. Energy efficient lighting design through LEDs is also enacted. All these factors result in less carbon footprints in the environment due to construction.

2.3. Energy Efficient Applications

In modern homes, there are a variety of electronic devices used to comfort us. Deploying more and more electronic devices increases the carbon footprints on the environment and causes pollution[9][10]. Also, the position of the house impacts a major role in application of electronic devices at home. Like, from solar path analysis model, it is observed that north facing façade houses are better than south facing ones. Hence, it has greater sunlight than other homes. Hence, natural ambience can be established at that home without deploying much electronic devices. Cross-ventilation in the home ensures good air flow and maintains air quality. The house exposed to sunlight all the time, the walls will absorb more heat and hence, the interior will get heated up. In that case, ACs is mandatory. But the number of ACs can be reduced if the house location was adjusted as per solar path analysis. Hence, from light saving to maintaining ambient temperature, a house designed using solar path analysis model and green building specifications, can be much efficient in terms of energy and serviceability.

3. RESEARCH OUTCOMES AND OBSERVATION

A study is performed with a 3D model of a house in a conceptual design environment and project climate settings[11]. Solar study was performed to analyze how the shade from the landscape and surrounding models are affecting the site. Different views of the conceptual design are given below in figure 3.1 and figure 3.2 respectively.

Figure 3.1. Exterior view of the proposed residential model

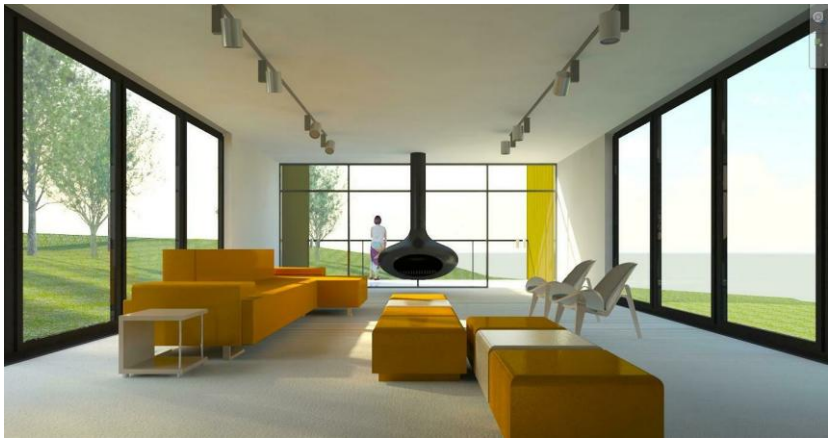

Figure 3.2. Interior view of the proposed model

4. CONCLUSION

The demand for energy is increasing rapidly with increase in population and urbanization. The global construction industry produces the maximum carbon footprints in the environment. Hence, designing and planning of a project before the construction can help monitor and reduce the carbon emissions. There are billions of houses around the globe. Let's say, using solar analysis and green building specifications, if only 1 unit of energy can be conserved per house per day, then the gross savings in energy around the globe will be gigantic. Hence, energy management is a key point to focus at the present. Implementing preventive measures from the beginning of a project will result in energy

efficiency for the whole service life of the project. And the conservation figures will be green enough. Introduction of BIM (Building Information Modelling) has proved a great step towards sustainable construction, engineering and architecture. Also, building energy parameters help monitor the energy usage time to time. Combining all the factors, it will be possible to fully rely on renewable energy for all needs at housing level.

5. REFERENCES

[1] Szokolay SK, Brisbin C. Introduction to architectural science: the basis of sustainable design. Oxford: Architectural; 2004.

[2] Dekay M, Brown GZ, Bennett S, Cartwright V. Sun, wind & light: architectural design strategies. Hoboken: John Wiley & Sons; Feb. 2014.

[3] Petri, I.; Kubicki, S.; Rezgui, Y.; Guerriero, A.; Li, H. Optimizing Energy Efficiency in Operating Built Environment Assets through Building Information Modeling: A Case Study. Energies 2017, 10, 1167. https://doi.org/10.3390/en10081167.

[4] Vimal Chandrasekaran. A Study on Sun Path of Coimbatore & Its Irradiation Effects on Buildings using Ecotect Software & Design Recommendations for Minimizing the Heat Gain. International Journal of Architecture & Infrastructure Planning. 2019; 5(2): 36–47p.

[5] Capeluto IG. Energy performance of the self-shading building envelope. Energy and buildings. 2003 Mar 1; 35(3): 327-36

[6] Kumar, R. (2020a). Sustainable Supply Chain Management in the Era of Digitalization, Issues and Challenges; Handbook of Research on Social and Organizational Dynamics in the Digital Era. IGI Global, 2020, ch021. pp. 446-460. Doi: 10.4018/978-1-5225-8933-4.

[7] Banerjee, S. & Chakraborty, S. (2022). A detailed study of Automation Techniques at Home that contribute to Energy Efficiency; International Conference on Intelligent Energy Management in Smart Cities.

[8] Maurya, A., Kumar, R., Bharadwaj, U., Rawat, P. and Kumar, M. (2021); Sustainable Building Design: Energy Analysis of a Residential Building using Autodesk Revit," 2021 2nd International Conference on Intelligent Engineering and Management (ICIEM), 2021, pp. 441-446, doi: 10.1109/ICIEM51511.2021.9445376.

[9] Chel, A. and Kaushik, G. (2018). Renewable energy technologies for sustainable development of energy efficient building. Alexandria Engineering Journal, 57, 655–669.

[10] Nikpour, M., Kandar, M., Ghesemi, M., Ghomeshi, M. and Safizadeh, M., Heat transfer reduction using self-shading strategy in energy commission building in Malaysia, Journal of Applied Sciences 9 (2012) 897-901.

[11] Autodesk, Ecotect Analysis, Training Packages, Demo Toolkit, CFD Analysis, Visibility analysis (2010).

Biographies

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