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Energy Efficiency and Occupant Comfort Levels in a Nearly Zero Energy Building and Green Building

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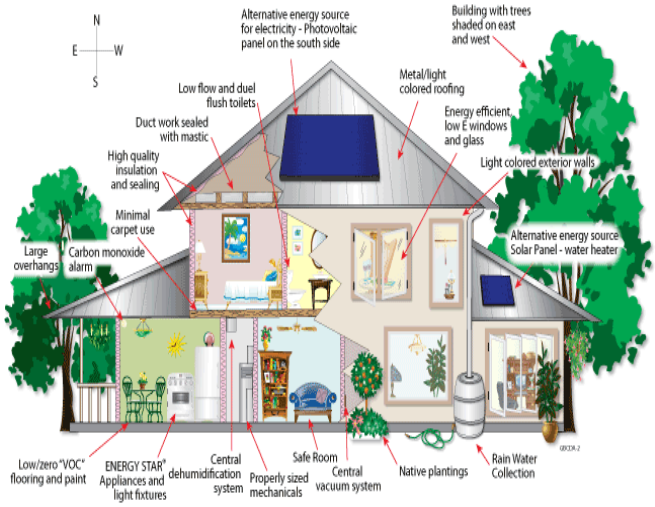
Abstract—*Buildings are found to be one of the biggest consumers of energy and one of the biggest producers of greenhouse gasses. Green buildings are the building that causes very little environmental interference as possible using environment friendly materials, requires low operational energy, utilizes renewable sources of energy to fulfil its requirements, follows high quality as a guideline for construction and must be economically viable. A building from the very starting of its construction has to fulfil the requirement to be a green building. A nearly zero energy building is very similar to the concept of green building but has the flexibility to be employed on existing building to become an energy efficient building and at the same time should be environment friendly. Tools like Vasari, GBS(Green Building Studio), Sefaira, e.QUEST and Energy Plus can be used for building energy analysis. Designing of an energy efficient controller can provide lighting energy saving utilizing daylight intelligently, Energy saving in HVAC system is coordination with renewable.*

Keywords*:Green Buildings, Renewable Resources, Nearly Zero Energy Building, Vasari, GBS, Sefaria, e.QUEST, Energy Plus, HVAC system.*

1. INTRODUCTION

From the environment point of view, buildings account for nearly half of all energy consumption and raw material used around the globe. In the direction to improve the condition, the concept of green building and nearly zero energy building emerged out to be very fruitful. A green building may be defined as a building which from very starting of its construction to commissioning and becoming operational, it is absolutely environmental friendly and utilizes natural resources to minimum consumption of energy. The grading for Green building is provided by LEED (Leadership in energy and environment development) and GRIHA. GRIHA was developed by TERI (The energy and research Institute) and suits the Indian standards.

The above Building shown represents a Green building. This utilizes the solar energy using photovoltaic panels for lighting purpose and also solar heat for heating systems and well equipped with dehumidifaction systems, central vacuum cleaning, Zero VOC floors and tiles, rain water storage e.t.c.



2. GREEN BUILDING RATING SYSTEM

LEED and GRIHA are two major rating systems. LEED (Leadership in energy and environmental design) certifies a building on 69 points whereas GRIHA (Green Rating for Integrated Habitat Assessment) certifies on 33 points.

The distribution of points for certification of a building is given in the table1

Table 1

S. No.	Criteria	Points
1	Sustainable sites	13
2	Water Efficiency	6
3	Energy & Atmosphere	17
4	Material & Resources	13
5	Indoor Environmental Quality	15
6	Innovation & accredited Points	5
	Total Points	69

Based on the grading system of LEED, the green buildings are awarded certification as in Table 2

Table 2

S. No.	Rating	Points
1	LEED certified Green Building	26-32
2	Silver Rated LEED certified Building	33-38
3	Gold Rated LEED certified Building	39-51
4	Platinum rated LEED certified Building	52-69

3. TOOLS AVAILABLE FOR ENERGY ANALYSIS OF A BUILDING

As the energy efficiency building design has become of utmost importance, whole building energy simulation devices are increasingly employed in the design process to help the architects and engineers determine which design strategies save energy and are cost effective. Today there are many engines that are capable of these whole building Analysis (WBEA).

Vasari/GBS is one of the Autodesk's design software that integrate conceptual modelling with WBEA, allowing the designers to make important design decisions in earlier phases of the project. BIM (Building Information Modelling) based design information and geometry can be used for modelling during the earlier stages of design process. Sefaria is a web based sustainability analysis platform specially built for conceptual design.

Energy plus is one of the most advanced, publicly available building energy simulation program, whose development began in 1996 with funding from US department of Energy. It contains a number of attractive features including sub hourly time sleeps, user configurable modular HVAC system that are integrated with a heat and mass balanced based zone simulation as well input and output data structures that can facilitate third party module and interface development.

Graphical user interface has recently been developed and released for Energy Plus (Open studio) and a software development kit has been developed to simplify the creation of application that use simulation model.

The building design incorporates several design incorporates several advanced design methods.

Table 3 shows modelling capabilities of such design features by the studied energy simulation tools.

Table 3

	Vasari/GBS	safaira	E-QUEST	Energy Plus
Natural ventilation	Yes	Yes	yes	yes
Radiant heating and cooling	No	No	yes	yes
Light shelves	Yes	yes	yes	yes
Occupancy sensors	Yes	yes	yes	yes
Heat recovery system	Yes	yes	yes	yes
Vertical geo exchange wells	No	yes	yes	yes

4. INTEGRATING NET-ZERO ENERGY AND HIGH PERFORMANCE GREEN BUILDING TECHNOLOGY

In recent years, Great efforts have been made in improving the energy and water efficiency of housing. Green Building improvements include the following:

- Water-conserving plumbing fixture
- Higher efficiency heating and cooling systems
- Improved insulation and radiant control in windows
- Better building envelop design for insulation and moisture control
- Advances in renewable energy technologies foe residential applications such as photovoltaics and wind energy.

5. FACTORS INVOLVED WITH A HEALTHY BUILDING AND ENERGY CONSUMPTION IN IT

1. Internal cooling load of a space in building consists of sensible internal cooling lead (Q_s) which changes the temperature and the latent internal cooling load.

   $Q_S = \frac{Qi\,(fd)(fu)}{60}$

   Where,

   Q_I = Instantaneous Cooling Load

   F_d = Factor of Duration

   = 0.8 If the equipment runs for less than or equal to 8 Hrs in a day.

   = 1.0 If the equipment runs for more than 8 hrs in a Day.

   F_U= Factor of Utilization

   Annual Cooling Load is given by

   $A_i = \frac{Qinternal\ N\ H}{1000}$ Mega Joule

   Where,

   N = No. Of months in which cooling is required.

   H = No. Of hours of running equipment in one month.

2. Stack effect powered by infilteration and exfilteration.

It is required and is responsible for "Indoor Air Quality (IAQ). Air flow by infilteration and exfilteration can be approximated by the equation :

$$F_a = \frac{V\ X\ CH}{3.6}$$

Where,

F_a= Air Flow Rate in Litre/second

V= Volume of the room in meter^3

CH= Air change required per hour

Energy Calculations are based on conditioning the infilteration air to the building design temperature and the humidity level.

The sensible heat exchange with infilteration air may be approximated by the equation.

$$Q_{SV} = f_a\ (T_1\text{-}T_2)\ X\ 4.34\ KJ/Hv$$

T_1 and T_2 are the higher and lower temperature respectively.

Latent Heat of Ventilation may be given by

$$Q_{LV} = f_a\ (H_1\text{-}H_2)\ X\ 10.84\ KJ/Hv$$

Where H_1 and H_2 are the higher and lower values of humidity. Annual ventilation energy consumption for one year is given by the equation.

$$A_V = \frac{Qv\ X\ DD\ X\ (no.of\ hours\ working\ per\ day)}{(T1-T2)X\ 1000}\ MJ$$

Where,

Q_V = Total Ventilation Load

DD = Degree days

Hence the total cooling load consumption = A

$= A_i + A_v$

3. Indoor Air Quality (IAQ)

Indoor Air quality refers to the quality of air inside building as represented by concentration of pollutant, Thermal temperature and relevant humidity that affect the health and performance of the occupant.

Indoor Air quality is degraded by inadequate ventilation, high temperature level, humidity level, indoor air pollution sources like oil, gas, tobacco, kerosene, wood, building materials and home finishing materials.

I. Low emissivity glasses can be used for windows in the building which restrict ultraviolet and infra red radiations to pass through it and the same time it does not obstruct the visible light to pass through.

II. Zero VOC (Volatile Organic Compound) parts and floor to be used to avoid high pressure of vapour causing health problem. For Example Formaldehyde evaporates at 19^{o}C and creates high vapour pressure adversely affecting the respiratory system.

III. Sensible Lumen Sensors can be employed at selected places in the building so that the lightning load can be controlled with the help of sunlight without compromising the illuminace required at various places.

6. CONCLUSION

Buildings being one of the highest worldwide consumer of energy, need much more attention for energy efficiency and at the same time the occupants deserve the best health atmosphere to breathe in and good comfort parameters. Green Building concept and nearly Zero energy building concept has become of utmost importance to achieve the goals. HVAC systems, Sensible cooling and heating systems, Illuminance control at various places have wide scope for improvement. Using Intelligent methods and using various softwares like Vasari/GBS, WBEA, Sefaria in Building Simulations, buildings can be made more energy efficient and environment friendly.

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