

# **GREEN BUILDING –** ***Structural & Civil Techniques***



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## **Introduction**

Global warming and climate changes have become a major concern for mankind today. In order to ensure that, development and environment conservation go hand in hand, major corporations around the world are empowering projects to slow down depletion of natural resources.

We spend 90% of our lives in buildings that protect us from the extremes of the nature like heat, cold, rain, wind, snow etc. However, our buildings use enormous amount of energy, water, and material throughout their life cycle. They also create a large amount of waste and have a profound effect on ecosystem.

The economic, health and environmental impact of our homes is apparent in our society. To meet the challenges of our built environment, a new way of designing & construction has evolved. It's a Green Building, this system follows design and construction practices that significantly reduce or eliminate the negative impact of the building on the environment and the occupants. In this paper we discuss structural and civil aspects for construction of green building.

## **What is a Green Building?**

Green building is the practice of promoting optimum utilization of resources like water , energy & material by the way of which , reducing building impacts on human health and the environment during the building's lifecycle, through better design, construction, operation, and maintenance which includes:

- Efficient use of energy, water, and other resources,
- Protecting occupant health and improving employee productivity,
- Reducing waste, pollution and environmental degradation.

## **Features of Green Building**

- Green building materials
- Reduced Energy Use
- Reduced Waste

## **Building Simulation Analysis**

Building simulation solutions allow you to address the thermodynamic complexities involved in construction of a building and undertake integrated performance appraisals of various options at a reasonable cost. For the first time, the construction industry has the computer aided tools to make assessments that are very close to the physically validated results. Simulation provides a way to assess the benefits of particular schemes, improve life cycle performance, enhance design quality, appraise climate change mitigation measures, undertake scenario based energy planning, link energy and health and enable inter-organization partnerships. The biggest advantage for simulation at the design stage is to integrate the different technical domains and identify the trade-offs to arrive at an optimum solution.

Building simulation analysis follows a systematic approach to ensure the most accurate output. It includes a detailed study of the following factors:

- |                                  |                              |
|----------------------------------|------------------------------|
| i. Energy Analysis               | ii. Fenestration Analysis    |
| iii. Solar Insolation Analysis   | iv. Daylight Analysis        |
| v. Location Analysis             | vi. Light Pollution Analysis |
| Vii. Reflection & Glare Analysis | viii. Shadow Analysis        |
| ix. Visibility Analysis          | x. Acoustic Analysis         |

**Energy Analysis:** The purpose of energy simulation is to estimate the total annual energy consumption of buildings so as to inform the building design process to create energy efficient choices. Energy analysis takes into account variety of factors involved in the design, including but not limited to:

**Fenestration Analysis:** It is the study of glazing and fenestration systems to determine their thermal, solar and optical properties. Fenestration systems play a very important role in the energy requirement of the building, hence this analysis assumes significance. The results of fenestration analysis can be used as an input into energy simulation in buildings. This helps in selection of optimum fenestration system for the building depending on location, orientation etc

**Solar Insolation Analysis:** It is the amount of electromagnetic energy (solar radiation) incident on the surface of the earth. Solar insolation analysis is the study of incident solar radiation impacting on building. Incident solar radiation (insolation) refers to the wide spectrum radiant energy from the Sun which strikes on surface. This includes both a direct component from the Sun itself (sunshine) and a diffused component from the visible sky (skylight). Depending on the site chosen, it can also contain a reflected component from other surfaces in the model and the ground. The objective of the analysis is to determine the amount of radiation received on the various surfaces of the building being analyzed to identify options for installation of Photovoltaic modules. It also helps in selection of facade materials that would support better interior environmental quality while improving energy efficiency.

**Daylight Analysis:** Good design for building requires sufficient daylight for tasks performed within a space. This is achieved by providing enough means to let in diffused light from the sky, but keep out direct light from the sun to prevent heat gain and glare. Daylight analysis is the process by which the amount of diffused sunlight that enters into the interior of a building is estimated. This analysis does not take into account the direct sunlight entering into the building, but it uses the luminance of the standard overcast sky from weather files as the measure of the exterior diffused sunlight. It helps us assess the impact of the exterior surfaces on the entry of this light into the interior floor space of the building.

**Location Analysis:** The early consideration of environmental constraints and possibilities will help the creative designer to conceive a building whose design draws upon these factors. Location analysis enables designers to exploit climatic conditions in order to maintain comfort, minimizing the need for artificial control or the choice of suited materials. A typical location analysis covers:

- Wind patterns: Prevailing wind conditions, seasonal wind and the temperature of wind
- Temperature: Average, maximum and minimum rainfall
- Humidity: Humidity conditions persisting in an area and in selection of appropriate materials for facade and building interiors
- Climate summary: The micro-climate of a site dictated by topography, altitude and urban density
- Rainfall: Average daily rainfall

**Light Pollution Analysis:** Light pollution is excessive or obtrusive artificial light that disrupts ecosystems and has adverse health effects. This analysis aims to quantify the level of light pollution. It covers the following aspects.

- Light trespass: Luminance values at certain site physical locations
- Over Illumination: Evaluation of areas exceeding the suggested lighting power density
- Sky Glow: Brightening of sky caused by outdoor lighting and natural atmospheric and celestial factors

**Reflection & glare Analysis:** Reflection analysis helps in understanding the glare-pattern on the site. This helps in designing the facade of the property with an understanding of its implications to nearby locations (e.g. pools, parking, roads). Using reflection analysis, it is possible to calculate and display the effects of reflections in the same way as shadows. Using a sun-path diagram, the entire annual potential for reflections at the selected focus point on a building can be obtained at any given point.

**Shadow Analysis:** As shadows and reflections are an important aspect of building design, shadow analysis enables an understanding of the extent to which shadows from other local structures affect the specific property that is being designed. This helps to take the right decisions regarding placement of parking lots, solar panels, windows etc. Viewing shadows in this manner allows the designers to focus on specific objects that can hinder or support some of the functional aspects of the design, or quickly see the location of sun-patches as they travel across the floor and up a wall.

**Visibility Analysis:** Even at a preliminary design stage, it can be important to know the degree of visibility of specific objects from different parts of the building and workspaces. Visibility analysis helps in obtaining a useful assessment of the areas in a room that have adequate views to the outside through windows and openings. This analysis involves setting up the points over the floor plane of each room of analysis and then selecting the appropriate windows, allowing quick calculation of the exact area of unobstructed window visible from the point.

**Acoustic Analysis:** Acoustics plays major role in degrading the environmental quality of space which may lead to occupant discomfort. Acoustic Analysis deals with analysis of sound inside the room, sound transmission through rooms, speech intelligibility and background noise levels inside the room. The main objective of this analysis is to reduce reflections of sound inside the room, reduce the sound being transmitted from outside and increasing the quality of speech inside the room.

Building simulation program analyzes the various components of the structure at every step, allowing practitioners to explore a building's life cycle performance at the design stage, so that problems can be identified and corrected before they arise.

### **Green Techniques:-**

**Emphasis of four 'R's:-**Via sound designing, construction and building commissioning without compromising structural durability, indoor pollutant levels, ventilation, building code requirements, or marketability includes:-

**Reduce:** - lower quantity of building material, resources, and embodied energy are used.

**Reuse:**-construction materials that are practical and structurally sound are reused.

**Recycle:** - recycled materials are used, and home is designed for recyclables.

**Renewable:** - energy from natural sources and renewable building materials are emphasized.

The technique which emphasizes these four 'R's are called as ***Green Techniques***. These Green techniques can be classified as follows:-

**Structural or civil techniques.**

**Electrical techniques**

- **Conservation techniques**
- **Generation Techniques**

**Special systems/ techniques**

❖ **Structural Techniques:-**

**Insulated wall:-**

All of us pay to heat and cool our homes and wish we could pay much less than we do. In a typical home, space conditioning and comfort bills can account for up to one-half of a home's energy bills with the remaining portion due primarily to water heating, lighting, and appliances. Installation of the cost-effective level of insulation is extremely important. Homeowners can affect their energy usage, save money, and help the environment all at the same time. Investing in energy-efficient options, such as insulation, will provide a continued payback to the homeowner and a more enjoyable and comfortable living environment for many years, as well as a reduction in emission of greenhouse gases.

**Types:-**

1. Air gap insulation
2. Cotton insulation
3. Mineral wool insulation
4. Plastic Fiber insulation

**Green Cement:-**

Green Cement is a combinations incorporating limestone, fly ash or ground granulated blast-furnace slag can be specified and, in some exposure conditions, may be more appropriate. The cement industry is actively recovering the energy from wastes by increasing the use of non-fossil fuels such as waste solvents; refuse derived fuel (RDF), certain unrecyclable paper and plastics, sewage pellet, and meat and bone meal. Using these alternative fuels not only reduces the need for landfill sites or disposal by incineration but also helps preserve our finite reserves of fossil fuels.

**Fly ash brick:-**

This is a fine, glass-powder recovered from the gases of burning coal during the production of electricity. These micron-sized earth elements consist primarily of silica, alumina and iron. When mixed with lime and water the fly ash forms a cementations compound with properties very similar to that of Portland cement. Because of this similarity, fly ash can be used to replace a portion of cement in concrete, providing some distinct quality advantages.

Adding fly ash to stabilized soil bricks or ordinary bricks can increase their compressive strength. Other benefits include:

- 1) Low water absorption
- 2) Less consumption of mortar
- 3) Economical & eco-friendly
- 4) Low energy consumption
- 5) No emission of green house gases

### **Transparent roof / sustainable day lighting**

Lighting accounts for around 15% of the energy bill in most homes, and around 25% in commercial buildings. The most sustainable lighting is natural daylight. It is not only a free renewable resource but it also has well-documented health benefits. Careful architectural design is required to maximize natural light in a building while maintaining indoor temperature regulation and reducing direct light glare. The strategic placement of windows, skylights, light shafts, atriums and translucent panels in harmony with other building components, such that light is reflected evenly throughout internal spaces, is known as day lighting design



### **Green Roofs:-**

It consists of covering the roof by the plantation of the different types. Other than enhancing the aesthetic sense it acts as the natural insulation.

#### **Construction:-**

The basic build up of a green roof is three layered: - drainage, filter and vegetation layer. Each layer needs to fulfill several functions to decrease the height and the weight of the overall build-up.

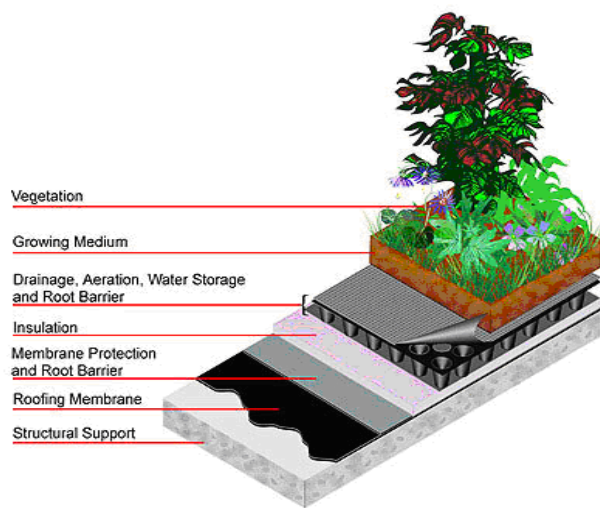
**Vegetation:** Type of planting depends on depth of the growing medium layer as well as other factors.

**Growing medium:** Grain size, water retention, air volume, and weight and nutrient reserves. The soil needs to be stable, not prone to settlement, well aerated even with water saturation and free of weeds.

**Drainage:** This layer retains drains water off the roof, protects the root proof layer from being mechanically damaged, retains water for times of drought and provides the substrate with a balanced supply of water and air.

**Insulation:** Warm roof rigid insulation

**Root membrane:** This prevents roots from damaging the waterproofing. The membranes specification depends on the planned landscape and the slope of the roof.



Construction



Building with Green Roof

### **Green Paints:-**

According to the EPA, the air inside a home is, on average, two-to-five-times more polluted than the air outside. Paint is a large contributing factor to poor indoor air quality and can emit harmful chemicals, such as VOCs, for years after application. There are serious health and environmental concerns surrounding paint. Using paints that are free of Volatile Organic Compounds (VOCs) such as benzene and toluene, free of heavy metals such as lead or cadmium, and/or made of post-consumer recycled content can aid in reducing exposure to toxics both for you and your environment.

### **Eco Wood:-**

Eco wood is the wood produces and processed by the man himself by recycling. Also the wood manufactured from baggase of sugarcane can be classified into this category. This type of wood can again be recycled and reused. Thus it helps to keeps to environment healthy.

### **Green Glasses**

Green Glass products are used in exterior applications both for energy generation( glass for photovoltaic applications) and energy conservation(tinted glass, solar control reflective glass, low-e glass etc.)as well as for interior applications( arsenic-free designer range, environmental friendly copper and lead free mirrors etc.).

## **❖ Electrical Techniques:-**

### **Conservation Techniques**

1. Optimum use of natural light.
2. Replacing incandescent lamps by compact fluorescent lamps (CFL's).
3. Replacement of conventional fluoescent lamp by energy efficient fluoescent lamp.
4. Replacing of mercury/sodium vapour lamp by halides lamp.
5. Replacing HPMV lamps by high pressure sodium vapour lamps.
6. Replacement of luminaries by more energy efficient luminaries.
7. Replacement of conventional ballast by energy efficient ballast.
8. Obtain flexibility in light control circuit by using sensors, microprocessors.

## Generation Techniques

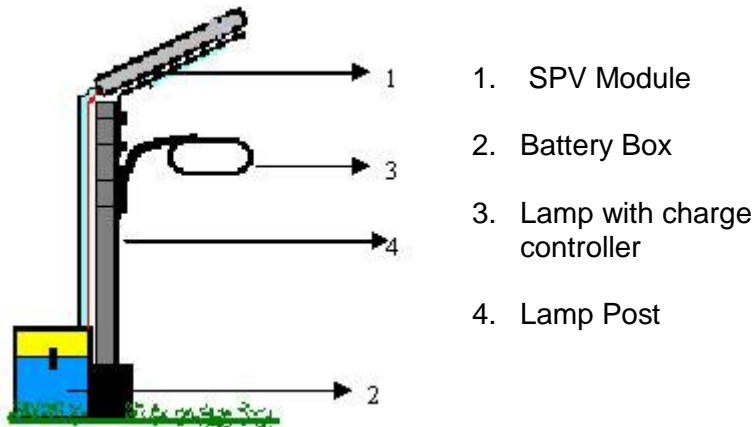
### Solar Lighting:-

The system is provided with battery storage backup sufficient to operate the light for 10-11 hours daily. The system is provided with automatic ON/OFF time switch for dusk to dawn operation and overcharge / deep discharge prevention cut-off with LED indicators.

The solar street light system comprise of :-

- 74 W Solar PV Module
- 12 V, 75 Ah Tubular plate battery with battery box
- Charge Controller cum inverter (20-35 kHz)
- 11 Watt CFL Lamp with fixtures

4 meter mild steel lamp post above ground level with weather proof paint and mounting hardware. The SPV modules are reported to have a service life of 15-20 years. Tubular Batteries provided with the solar street lighting system require lower maintenance; have longer life and give better performance as compared to pasted plate batteries used earlier.

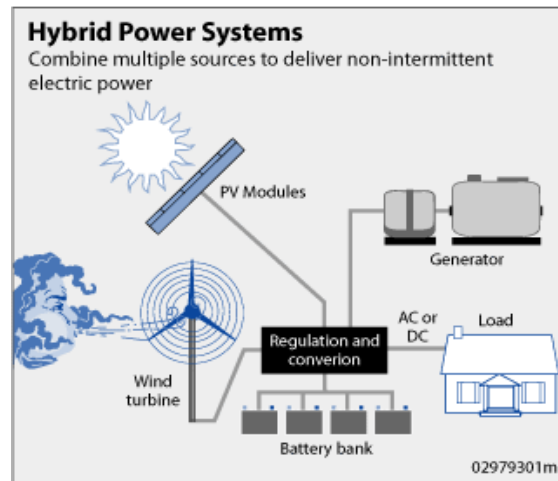


Other Green Techniques in Electrical Field includes Energy Conservation in the appliances like Refrigerator, Oven, Air-Conditioners etc.

### Solar-Wind Hybrid:-

Hybrid systems are usually a combination of photovoltaic with wind turbines and/or generators running on diesel or biofuels. Power generated by the PV array during the day is stored in the battery bank through an energy manager, which controls the complete system.

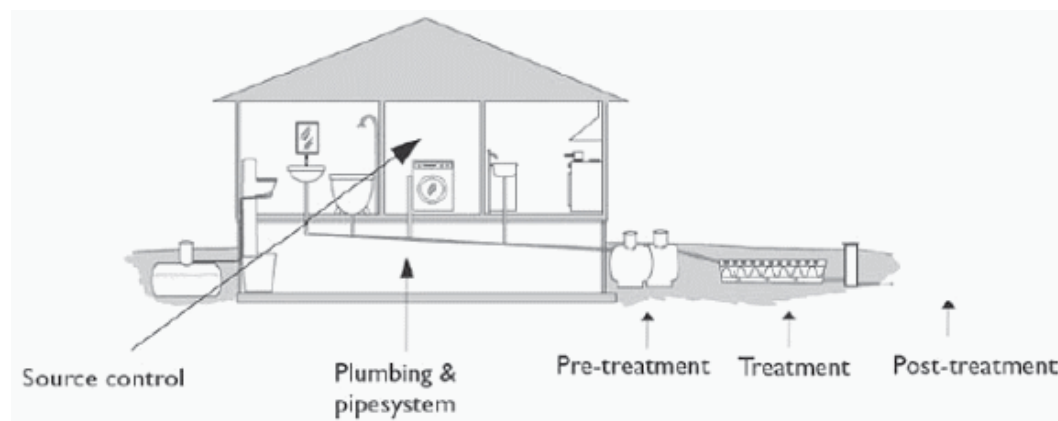
Hybrid systems make optimal use of sunlight and wind speeds - the two main resources readily available in the South Asian sub-continent. When the solar resource is low during the monsoon, the wind is quite strong and vice versa. The resultant hybrid system thus offers an optimal solution at a substantially lower cost. It is ideal for electrification of remote villages in India.



### ❖ Special Techniques:-

#### Grey water Management:-

All household wastewater, except toilet waste, is called grey water. Grey water from washing dishes, showers, sinks and laundry comprises the largest part of residential wastewater. This water when Filtered and recycled can be used in the toilets, or for irrigation.



#### Afforestation:-

This green technique includes planting of deciduous trees around/surrounding the building. These trees have special property that they shade their leaves in the winter and allow the sun's heat to enter inside the house. While during summer, it has maximum leaves so that the building gets natural cooling.

#### Rain water harvesting:-

Rain water harvesting is a process of collecting the rain water that falls on terraces and roof tops during the monsoons and storing it in tanks, pits, trenches, bore wells, unused wells etc. or directing it so that it percolates into the ground water.

Rain water harvesting includes:-

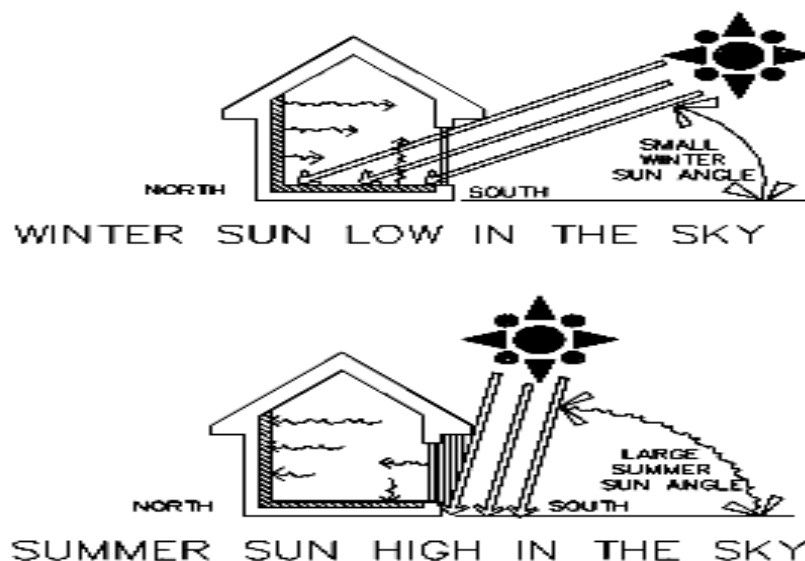
1. Collecting rain water.
2. Purifying it to an extent.
3. Directing it to subsoil spaces below the plot where it can be stored, by gravity or mechanical means.

### **Passive solar heating and cooling**

Your building's windows, walls, and floors can be designed to collect, store, and distribute solar energy in the form of heat in the winter and reject solar heat in the summer. This is called passive solar design or climatic design. Unlike active solar heating systems, passive solar design doesn't involve the use of mechanical and electrical devices, such as pumps, fans, or electrical controls to move the solar heat.

Passive solar buildings range from those heated almost entirely by the sun to those with south-facing windows that provide some fraction of the heating load. The difference between a passive solar home and a conventional home is design. The key is designing a passive solar building to best take advantage of your local climate.

You can apply passive solar design techniques most easily when designing a new commercial building or home. However, existing buildings can be adapted or "retrofitted" to passively collect and store solar heat.



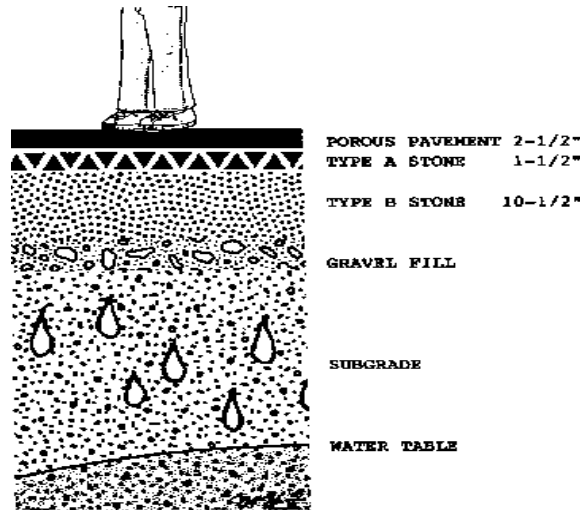
### **Prevention of soil erosion**

The goal of this strategy is to reduce or eliminate runoff due to impervious (watertight) surfaces. Minimizing or eliminating impervious surfaces by designing driveways, walkways, and patios that allow storm water runoff to infiltrate into the ground minimizes the impact on aquatic systems. Uncompacted gravel, crushed stone and open or porous paving blocks can be used for Walkways and other light traffic areas.

What kind of paving is required depends on the porosity of the soil below the paving. Runoffs cause serious erosion problems. Wash water from vehicles could contain harmful elements which

can damage water systems below the ground. A carefully designed paving system can filter off the damaging elements from such wash water and filter only good water into the ground water reserves below. While the filtering process happens, micro-organisms in the soil can digest oils and greases and break into harmless gases.

### **Porous Paving**



Its possible to use green crops amidst the paving, making it look aesthetically pleasing while also enriching the soil with plants.

### **Scope of Green Buildings in India**

Architects and builders have begun using green principles like water harvesting and waste management in their projects. They emphasize the use of eco friendly building materials like fly-ash cement and blocks, steel and tiles, recycled aluminum, bamboo based products, green roofing products and so on. On the technology front too, there are a lot of options available to build green homes. Energy saving air conditioners, high performance glass windows, water saving solutions, composting toilets, and efficient building management systems are just some of them.

Tapping solar energy is another method used by green homebuilders in India. The use of a photovoltaic array on the rooftop is a good source of alternate energy as are solar thermal arrays. This way energy can be obtained from the environment, stored and used as required. A combination of innovative green ideas and high technology may be able to address India's energy and water needs.

Now the Indian Green Building Council (IGBC) has introduced a system of rating green homes. This system is India's first foray in the sector. It will rate a building's infrastructure, eco friendly design, waste management, water and other natural resource conservation systems, among others. If you conserve natural resources while building and living in your home, you not only save money but also lay the foundation for a healthy lifestyle. With the increasing number of green projects, the IGBC sees a great future in going green. Will this give people an opportunity to build designer homes? In the wake of the recent rise in oil prices, will green homes be an answer to India's ever increasing demand for energy?

The Confederation of Indian Industry (CII) works to create and sustain an environment conducive to the growth of industry in India, partnering industry and government alike through advisory and consultative processes. CII is a non-government, not-for-profit, industry led and industry managed organization, playing a proactive role in India's development process. CII – Sohrabji Godrej Green Business Centre (CII – Godrej GBC), a division of Confederation of Indian Industry (CII) is India's premier developmental institution, offering advisory services to the industry

on environmental aspects and works in the areas of Green Buildings, Energy Efficiency, Water Management, Renewable Energy, Green Business Incubation and Climate Change activities. The Centre sensitizes key stakeholders to embrace green practices and facilitates market transformation, paving way for India to become one of the global leaders in green businesses by 2015.

### **Need for `Zero Energy Building`**

The government is planning to enact a renewable Energy law that would stipulate mandatory procurement of prescribed minimum renewable energy in each state. The move is aimed at diversifying the country's energy mix that is dominated by oil, gas & coal as basic fuel feed. The new legislation is expected to give legal teeth to renewable energy policy that failed to get the desired investment in the sector.

So, taking a step ahead of Green Building, `**Zero Energy Building`** is the answer to this new step.

### **Introduction to Zero Energy Building**

A Zero Energy Building (ZEB) combines state-of-the-art, energy-efficient construction and appliances with commercially available renewable energy systems, such as solar water heating and solar electricity. The combination results in a home that produces its own energy—as much or more than it needs. Even though the home might be connected to a utility grid, it has net zero energy consumption from the utility provider. In other words, a zero energy building is a structure that produces more electrical or thermal energy, than it uses.

This can be measured in different ways (relating to cost, energy, or carbon emissions) and, irrespective of the definition used; different views are taken on the relative importance of energy generation and energy conservation to achieve energy balance. Although zero energy buildings remain uncommon in developed countries, they are gaining in importance and popularity. The zero-energy approach is promoted as a potential solution to a range of issues, including reducing carbon emissions, and reducing dependence on fossil fuels. Most ZEB definitions do not include the emissions generated in the construction of the building and the embodied energy of the structure which would usually invalidate claims of reducing carbon emissions.

A building approaching zero energy use may be called a *near-zero energy building* or *ultra-low energy house*. Buildings that produce a surplus of energy during a portion of the year may be known as *energy-plus buildings*. An energy autarkic house is a building concept where the balance of the own energy consumption and production can be made on an hourly or even smaller basis. Energy autarkic houses can be taken off-the-grid.

### **Cost**

The most criticized issue about constructing environmentally friendly buildings is the price. Photo-voltaic, new appliances and modern technologies tend to cost more money. Most green buildings cost a premium of <2%, but yield 10 times as much over the entire life of the building. The stigma is between the knowledge of up-front cost vs. life-cycle cost. The savings in money come from more efficient use of utilities which result in decreased energy bills. Also, higher worker or student productivity can be factored into savings and cost deductions. Studies have shown over a 20 year life period, some green buildings have yielded considerable amount of money per square foot back on investment. It is projected that different sectors could save billions of rupees on energy bills.

## **Conclusion**

In an environmentally stressed world, green buildings are moving from an exotic curiosity to a necessity. Buildings are perhaps the single greatest stress on the environment, accounting for the world's fresh water withdrawals, one-quarter of its wood harvest, and two fifths of its material and energy flows. In such a scenario of shortages of clean water and other materials, and the possibility of devastating climate change, the greening of buildings constitutes a collective vital. Given the political difficulties of obtaining energy, and likely future shortages of conventional energy sources, we cannot ignore the enormous conservation that green buildings make possible. And buildings with natural materials and lighting also create a happier, healthier, more productive atmosphere.

Yet evaluating, What makes a building green? is a critical task. Green buildings may be considered as a checklist of environmentally friendly elements, and such checklists are needed to authenticate that a given building is as environmentally friendly as it claims. Then the barrier between natural and artificial will break, as buildings move towards a harmony with natural processes. And, instead of being a great drain on energy and a destructor of ecosystems, buildings are evolving toward being part of a healthy, managed environment. A strong awareness of the advantages of green buildings, a conscious effort to change, will speed this process along. In the future years and decades the green building techniques will become commonplace for political, environmental, and economic reasons.

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