Energy Efficient Sustainable Building

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Energy Efficient Sustainable Building

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Abstract- **The need of the day is to construct a building which typically contributes to improve a common mans health, comfort and productivity. "Green" or "sustainable" buildings use key resources like energy, water, materials, and land more efficiently than buildings that are just built to code. Green building now integrates a wide range of building design, construction, and operation and maintenance practices to provide healthier living and working environments and minimize environmental impacts. Crucial to the success of green building has been the application of integrated design principles which create buildings that dramatically lower energy consumption, use renewable energy, conserve water, harness natural sources of light and ventilation, use environmentally preferable materials, minimize waste and create healthy and productive environments. Thus this paper mainly discusses the different energy efficient techniques in lighting, heating and cooling systems that can be implemented to obtain an energy efficient sustainable building.**

***Keyword-*:** **Green buildings, sustainable building, energy efficient, day lighting.**

I. INTRODUCTION

The world has witnessed incalculable technological achievements, population growth, and corresponding increases in resource use since Industrial Revolution. Thus we are recognizing the "side effects" of our activities: pollution, landfills at capacity, toxic waste, global warming, resource and ozone depletion, and deforestation. These efforts are straining the limits of the Earth's "carrying capacity"—its ability to provide the resources required to sustain life while retaining the capacity to regenerate and remain viable. The industry's growing sustainability ethic is based on the principles of resource efficiency, health, and productivity. Realization of these principles involves an integrated, multidisciplinary approach-one in which a building project and its components are viewed on a full life-cycle basis. This "cradle-to-cradle" approach, known as "green" or "sustainable" building, considers a building's total economic and environmental impact and performance, from material extraction and product manufacture to product transportation building design and construction, operations and maintenance, and building reuse or disposal. Green building features can include high-tech, modern practices such as sensor-controlled and compact fluorescent lighting, high-efficiency heat pumps, geothermal heating, photovoltaic cell arrays and solar chimneys, on-site cleaning and reuse of wastewater; as well as simple and often time-tested practices like attention to building orientation and design, increased use of fresh air and natural light, improved insulation, radiant cooling systems that take advantage of naturally occurring conditions, managed forest or salvaged lumber products, recycled concrete aggregates, green roofs, rainwater collection, waterless urinals, facilities for bicyclists, permeable pavers, cork flooring, and use of local products. The USGBC estimates that green building, on average, currently reduces energy use by 30 percent, carbon emissions by 35 percent, and water use by 30 to 50 percent, and generates waste cost savings of 50 to 90 percent.[1]

II. CARBON- NEUTRAL AND NET ZERO-ENERGY

Definitions vary and are often used interchangeably but "carbon neutral" buildings are generally understood to be those that require no GHG-emitting energy to operate. They do this by combining on and off-site renewable energy generation with ultra-efficient building materials and equipment.

A number of definitions exist for net zero-energy. Generally, however, the term is used to designate buildings that generate as much energy as they use over the course of a specific period of time, usually a year, but they can use carbon-based energy from the grid when needed. The carbon-based energy would then be replaced with surplus renewable energy when the latter is generated on-site.

III ENERGY EFFICIENCY BUILDINGS

Approximately 50 percent of the energy use in buildings is devoted to producing an artificial indoor climate through heating, cooling, ventilation, and lighting.[4] A typical building's energy bill constitutes approximately 25 percent of the building's total operating costs. Estimates indicate that climate-sensitive design using available technologies could cut heating and cooling energy consumption by 60 percent and lighting energy requirements by at least 50 percent .[5]

1) Plants contribution in Energy Conservation

Leaves account for most of the captured particles, with conifer trees performing particularly well. Research shows that trees in a parkland setting can filter out up to 85% of suspended particles. The percentage is reduced to approximately 40% in the absence of foliage on deciduous trees in winter [2]. The leaves of climbing plants provide a large surface area capable of filtering out dust, pollutants and possibly even viruses [3].

Trees and shrubs can help reduce overall energy use in buildings. The amount of energy saved depends on the building type, choice of tree species, positioning around the building and the prevailing climate. For example, by planting deciduous trees on the west side of an exposed building:

- wind penetration can be significantly reduced
- shading provided in summer

- solar gain achieved in winter.

Savings on energy costs by the careful planting of trees can, for a conventional house over a one year period, be as much 25% [6].

2) Daylighting

Daylighting is the practice of bringing light into a building interior and distributing it in a way that provides more desirable and better-quality illumination than artificial light sources. This reduces the need for electrical light sources, thus cutting down on electricity use and its associated costs and pollution. Studies substantiate that daylighting creates healthier and more stimulating work environments than artificial lighting systems and can increase productivity up to 15 percent.

1. Daylighting also provides changes in light intensity, color, and views that help support worker productivity. Surveys have shown that 90 percent of employees prefer to work in spaces with windows and a view to the outside.
2. In one study, 75 percent of office and factory workers stated that daylight provides better quality illumination than artificial light. Daylighting significantly reduces energy consumption and operating costs. Energy used for lighting in buildings can account for 40 to 50 percent of total energy consumption. In addition, the added space-cooling loads that result from waste heat generated by lights can amount to three to five percent of total energy use. Properly designed and implemented daylighting strategies can save 50 to 80 percent of lighting energy.[4] Daylighting requires the correct placement of openings, or *apertures,* in the building envelope to allow light penetration while providing adequate distribution and diffusion of the light. A well-designed system avoids excessive thermal gains and excessive brightness resulting from direct sunlight, which can impair vision and cause discomfort.[7] To control excessive brightness or contrast, windows are often equipped with additional elements such as shades, blinds, and light shelves.

Table 1
Recommended illumination level

Type of activity	-3,-2 Weight (Footcandles)	-1 to 1 Weight (Footcandles)	2 to 3 Weight (Footc andles)
Public space with dark surrounding	2	3	5
Simple orientation for short temporary visit	5	7.5	10
Working space with occasional visual task	10	15	20
Visual task for high contrast or large size	20	30	50
Visual task for medium contrast or small size	50	75	100
Visual task for low contrast or small size	100	150	200
Visual task for low contrast or very small size over prolonged period	200	300	500
Exacting and prolonged visual task	500	750	1000
Very special visual task of extremely low contrast and small size	1000	1500	2000
Weight Factor Determination			
Task and worker characteristics	Weight		
	-1	0	+1
Worker age	Under 40	40-55	Over 55
Speed or/and accuracy	Not important	Important	Critical
Reflectance of background	>70%	30-70%	<30%

Source: Illuminating Engineering Society. Lighting Handbook.
(New York: IES, 1979.)

Table 2
Recommended Surface Reflectance Values

Surface	Range of surface reflectance (Low –High)
Ceiling	80%-90%
Wall	60%-65%
Floor	20%-50%

3) Traditional Daylighting Strategies Sidelighting

(i) Maintain a favorable room aspect ratio

The ratio of ceiling height and window height to depth of room from window as shown in fig 1.

(ii)Specify the appropriate room reflectivity (surface reflectance)

The amount of light that can be reflected to the back of a space from an outside wall with windows, and thus the comparative illumination levels between front and back, is controlled by the reflectivity of the interior surfaces. The higher the reflectivity, the greater the illuminance values at the back of the space. Reflectance values also affect background brightness levels and therefore contrast ratios of task to background refer to Table 2.

(iii)Rely on clerestories in addition to windows

In this strategy, which combines sidelighting and toplighting, vertical windows in a higher space are positioned adjacent to other windows as in Fig 2 . This method provides an excellent means of delivering daylight deep into an interior space.

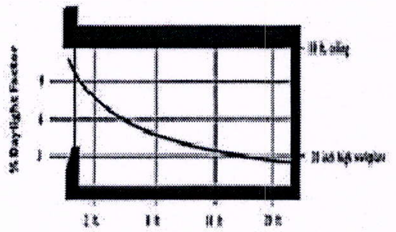

Fig 1: Illumination relative to distance into room from window

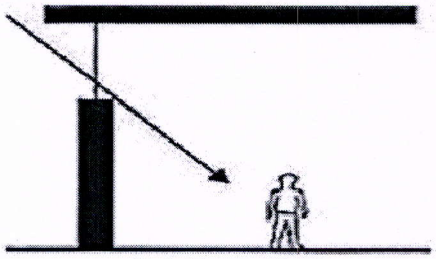

Fig 2: Clerestory Roof

Toplighting

(i) Consider a sawtooth roof form.

A sawtooth roof uses a series of repetitive clerestories to provide uniform illumination over a large area as in fig 3 and is best designed in concert with passive solar heating and cooling strategies. The glazed openings in the sawtooth commonly face north, thereby providing a diffuse and uniform source of daylight. To take advantage of solar gains for heating purposes in colder climates, it may be advisable to face the openings south. In this case, however, solar controls may be needed to prevent glare, high contrasts, and veiling reflections.

(ii) Consider the use of roof monitors.

Monitors are a type of clerestory that usually involves a stepped roof, allowing light to enter from two or more directions at once as in fig 4. Monitors usually benefit from an overhang on the southern, eastern, and western exposures. An inherent advantage of using monitors is that the roof tends to act as a reflector or a light shelf for the monitor above. Extension of the roof plane to the interior of the glazing can sometimes enhance this effect while providing additional relief from direct sunlight penetration. In addition, monitors are less likely to leak than skylights.

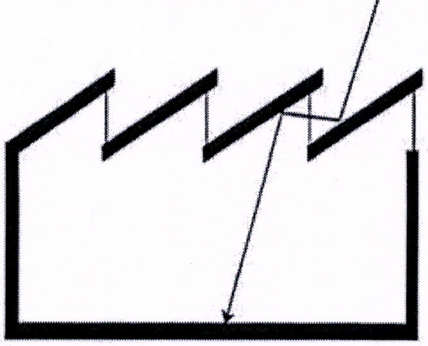

Fig 3 : Sawtooth Roof

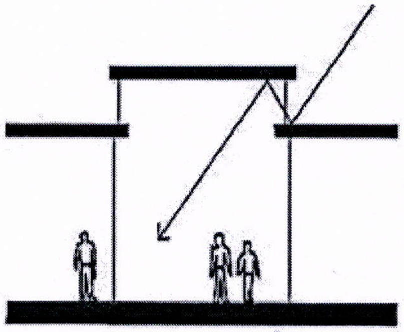

Fig 4: Monitors Roof

Skylights

Skylights, horizontal openings in a roof, are the most common daylighting strategy in single-story buildings. When used judiciously, they offer the most efficient means of bringing light into a building because they generally have a 180-degree view of the sky. They are usually laid out on a grid so that the distance between the skylights is roughly 1.5 times the distance between the floor and ceiling planes. Optimal skylight-to-floor ratios may range from 5 to 10 percent or higher depending on the transmittance of the glass, the efficiency of the skylight design, the required illuminance level, the ceiling height, and whether the space is mechanically air conditioned. Some problems with skylights include the potential for water leakage, the loss of some thermal insulation at the skylight locations, and the generally higher cost of the roof structure. Another drawback is the potential for heat gain during the warmer seasons, causing thermal discomfort or increased cooling costs. Because most skylight installations require diffuse glazing for solar control, they do not provide views to the outside.

(iii)Light shelves with windows

The light shelf is an extremely useful tool when used in conjunction with sidelighting strategies. This mechanism, a horizontal surface at or above eye level, serves to reflect light falling above the vision window up onto the ceiling and therefore deeper into the room Fig 5. At the same time, it reduces illumination immediately adjacent to the window, where illumination levels are typically too great to work comfortably.

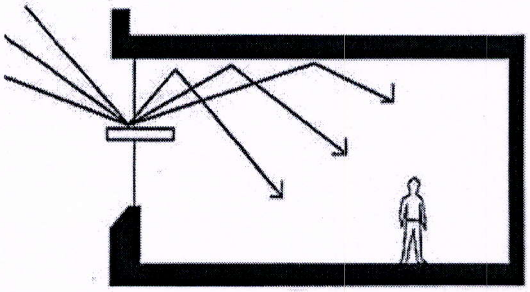

Fig 5: Light Shelf

4) Innovative Sidelighting and Toplighting Systems:

The primary challenges in sidelighting applications are: (1) the need for control of solar light and heat gains near windows; and (2) the transfer of light to the deeper zones away from the windows in order to extend the effective depth to which daylighting may be achieved. The following innovations can address these issues.

- Solar optic lens film (SOLF)
- Molded acrylic prismatic glazings or prismatic panels;
- Specular blinds or mirror panels;
- Holographic or diffraction-grating glazings
- Reflective films.
- Solar shade and awning systems.

Consider advanced light-shelf systems.These systems utilize many of the same advanced glazing technologies as solar shading systems; however, they are arranged in projecting configurations that look and act like standard light shelves but offer much better control of light direction and higher efficiencies. Advance light shelf is shown in fig

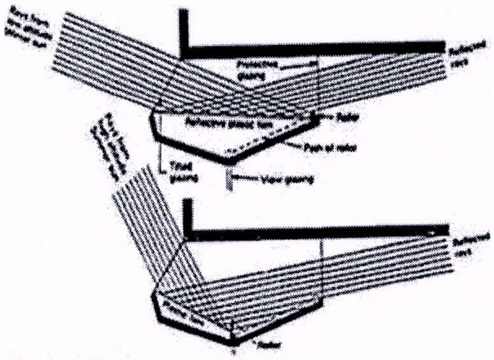

Fig 6: Advance light shelf

Innovative Core Daylighting Systems:
Consider light-pipe distribution.

Light-pipe distribution has been commercialized for use with high-output luminaries in commercial buildings where special security requirements, difficulty of access, or explosive or corrosive environmental conditions are present. The efficiency of lightpipe distribution is approximately 50 percent from source to delivered illumination.[8]

Available systems include those where the light transfer is internal only, or where the pipe itself is a continuous light source. [9] Daylighting applications using this technology for light distribution use concentrating collectors or heliostats as high-intensity light sources.

Control Strategies:
Integrate lighting controls to respond to available daylight.

To capitalize on the potential energy savings associated with daylighting strategies, it is usually necessary to automate the reduction of electrical lighting operation. This can be accomplished in a variety of ways; however, hardware complexity, cost, wiring complexity, and types of lighting systems are all affected by desired control strategies.

Photosensors can be use for locating and calibrating purpose. Correct location and calibration of the photosensor for all daylighting control systems is critical. Ordinarily, a single photosensor will control a group or zone of light fixtures in order to reduce system cost. The sensor should "see" a mixture of both natural and electrical light and should not be located so as to be "fooled" by movement of occupants or objects in the space.

5) Passive Solar Heating:

(i) Analyze building thermal-load patterns.
An important concept of passive solar design is to match the time when the sun can provide daylighting and heat to a building with those when the building needs heat.

(ii) Integrate passive solar heating with daylighting design.

(iii) Design the building's floor plan to optimize passive solar heating.

Orient the solar collection surfaces, for example appropriate glazings in windows and doors, within 15 degrees of true south, if possible. Because of the solar path, the optimum orientation for passive solar buildings is due south.

(iv) Identify appropriate locations for exposure to beam sunlight.
Overheating and glare can occur whenever sunlight penetrates directly into a building and must be addressed through proper design. A "direct-gain" space can overheat in full sunlight and is many times brighter than normal indoor lighting, causing intense glare.
Generally, rooms and spaces where people stay in one place for more than a few minutes are inappropriate for direct gain systems.

(v) Avoid glare from low sun angles.

6) Passive Solar Cooling

Design strategies that minimize the need for mechanical cooling systems include proper window placement and daylighting design , selection of appropriate glazings for windows and skylights, proper shading of glass when heat gains are not desired, use of light-colored materials for the building envelope and roof, careful siting and orientation decisions, and good landscaping design. Install fixed shading devices, using correctly sized overhangs or porches, or design the building to be "self-shading." Fixed shading devices, which are designed into a building, will shade windows throughout the solar cycle. They are most effective on the south-facing windows. Plant trees or bushes to shade the windows at the right time of day and season. Limit east/west glass. Glass on these exposures is harder to shade from the eastern morning sun or western evening. Design the building to take advantage of natural ventilation. Use ground coupled cooling. Ground coupling is achieved by conductive contact of the building with the earth. The most common strategy is to cool air by channelling it through an underground tunnel. Another strategy provides cool air by installing a tube in the ground and dripping water into the tube. This reduces the ground temperature through evaporation. Use evaporative cooling strategies. This cooling method works when water, evaporating into the atmosphere, extracts heat from the air. Evaporative cooling is most appropriate in dry climates, such as the Southwest. Use dehumidification in humid climates.

7) Thermal Storage

There are two basic thermal storage strategies using thermal mass. "Direct" thermal storage materials, such as concrete masonry or tiles, are placed directly in the sunlight so that intense solar energy enters them quickly. "Diffuse" thermal storage materials are placed throughout the building. They can absorb heat by radiation, the reflectance of sunlight as it bounces around a room, and via air heated elsewhere in the building. Trombe walls can provide carefully controlled solar heat to a space without the use of windows and direct sunlight, thus avoiding potential problems from glare and overheating, if thermal storage is inadequate. Double gypsum board throughout the building Increase the thermal capacity of a building . Water-storage containers can be used for thermal mass.

Water has a very high thermal capacity, about twice that of common masonry materials. Water also has the advantage that convection currents distribute heat more evenly throughout the medium.

8) Active Solar Systems

Active solar collector systems take advantage of the sun to provide energy for domestic water heating, pool heating, ventilation air preheat, and space heating. Active solar systems should be integrated with a building's design and systems only after passive solar and energy-conserving strategies are considered. Major components of a system include collectors, the circulation system that moves the fluid between the collectors and storage, the storage tank, a control system, and a backup heating system.[4]

9) Photovoltaics

Photovoltaic (PV) technology converts direct sunlight to electricity using semiconductor devices called solar cells. Photovoltaics are almost maintenance-free and seem to have a long life span. The photoelectric conversion process produces no pollution and can make use of free solar energy. Mainly the durability, simplicity and minimal resources used to produce electricity via PV systems make this a highly sustainable technology. PVs are currently cost-effective in small, off-grid applications such as microwave repeaters, remote water pumping, and remote buildings. In fact, worldwide PV manufacturing is growing at a healthy annual rate of more than 20 percent, and the focus of research is to reduce the cost of PV systems, and to integrate PV into building design. The most common technology in use today is single-crystal PVs, which use wafers of silicon wired together and attached to a module substrate. Thin-film PV, such as amorphous silicon technology, is based on depositing silicon and other chemicals directly on a substrate such as glass or flexible stainless steel. Thin-film PV materials can look almost like painted glass. They can be designed to generate electricity from a portion of the incoming light while still allowing some light to pass through for daylighting and view. Thin films promise lower cost per square foot, but also have lower efficiency and produce less electricity per square foot compared to single-crystal PVs. PV panels produce direct current, not the alternating current used to power most building equipment. Direct current is easily stored in batteries and then inverter is used to transform the direct current to alternating current. The cost of reliable batteries to store electricity, and the cost of an inverter, increase the overall cost of a system. With an inverter creating alternating current, it is possible to transfer excess electricity generated by a photovoltaic system back into the utility grid rather than into batteries for off-grid systems. In this case, the utility grid becomes a virtual storage system. Most utilities are required to buy such excess site-generated electricity back from the customer. Building owners in such states will find PVs more economically attractive.

Building Integration

Rack-mount PV systems or mount them directly on roof and wall surfaces

Optimizing the panel's tilt to the sun improves performance. Most existing commercial buildings have large, flat roofs exposed to lots of sun, making them good candidates for PV arrays. New buildings can be designed with sloped surfaces that can optimize PV exposure to the sun. The PV panels can be designed as the primary "weather skin" for sloped roofs or walls and can be integrated into shading devices.

Watch for the commercial availability in the near future of partially transparent
PV panels for use as window-shading devices. The panels would allow diffuse light through a window while also producing electricity from energy that would otherwise be rejected from the building.

IV CONCLUSION

Thus the study discussed the different energy efficient heating and cooling techniques that can be implemented in a green building in a sustainable manner. All these techniques are already under practice in developed countries. An energy defiant country like India should undertake such techniques for better utility of power

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