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Introduction:

The Indian construction industry is experiencing a fast rate of growth with a sustained increase in gross built-up area of 10%1 per annum over the last decade. Demand for housing, expansion of organized retail, commercial office spaces by multinationals, the setting up of special economic zones (SEZs), are all increasing. This is spurred on by increasing per capita income and standard of living.

Energy consumption and associated greenhouse gas emissions will therefore continue to rise unless actions to direct the construction industry towards sustainable consumption and production are taken urgently.

More positively, the practice of green building is becoming more popular in some sectors. The secretariat of India's bespoke green-building rating scheme Green Rating for Integrated Habitat Assessment (GRIHA) has set a target for five million square meters of built up space to be GRIHA compliant by the end of 2012. Further, the Indian Green Building Council also targets to register ninety three million square meters of built up space with LEED India.

What is Green Building?

It can be defined as an integrated approach to design with a special emphasis on climatology, solar passive architecture, bio-climatic design and low energy architecture to achieve appropriate human comfort, low-energy, low-cost community development, use of recycled municipal/domestic waste as building material; and a financial model that may be implemented for successful promotion of sustainable building.

Green Building Rating of India

There are two prominent green rating systems that co-exist in India. One system, Green Rating for Integrated Habitat Assessment (GRIHA), is the national rating system for the country endorsed by the Ministry of New & Renewable Energy (MNRE), Government of India. Another system, Leadership in Energy and Environment Design (LEED), has been launched by the India Green Building Council (IGBC). The Centre for Environmental Sciences and Engineering at IIT Kanpur, the first GRIHA compliant building of India, and the Institute for Rural Research and Development (IRRAD), Gurgaon, which is a LEED India

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compliant building have been used as case studies to highlight the nuances of the two green rating systems.

Both green rating systems aim to quantify the environmental, economic and socio-economic benefits of green building design with emphasis on sustainable site planning optimized energy performance, efficient materials and construction practices, water and waste management strategies and indoor environmental quality. The rating systems also emphasize life cycle cost analysis so that the client has an option of making informed choices when opting for green technologies which may have an initial incremental cost with acceptable pay back periods.

Energy Efficient Building

In case it is not feasible for a given building project to be compliant with the green rating system, energy efficiency is addressed as the next major sustainability parameter to be addressed. The Bureau of Energy Efficiency (BEE) provides an option for new buildings to be compliant with the Energy Conservation Building Code (ECBC), which contributes to significant energy savings through the operation of an efficient building, contributing to CO2 emission reduction. The Fortis hospital building, which is ECBC compliant, indicates the implications in terms of building specifications and benefits from compliance with the code.

Further, the BEE has also developed a scheme for star rating of existing buildings that meet the energy efficiency benchmarks as established, to further narrow the parameters of sustainability in building design. As discussed in this report, the Reserve Bank of India (RBI) building at Bhubaneswar has been awarded the first five stars rating for being energy efficient. The report goes on to describe the key barriers and way forward for incorporation of sustainable, green and energy efficient building design parameters in the Indian building sector. It provides an outline of the knowledge gap at various levels, issues pertaining to lack of effective enforcement of policies; and lack of financial incentives, which deter stakeholders from large scale adoption of sustainable design strategies and energy efficient technologies.

Energy Efficient Techniques for Green Building

Although new technologies are constantly being developed to complement current practices in creating greener structures, the common objective is that green buildings are designed to reduce the overall impact of the built environment on human health and the natural environment by:

- Efficiently using energy, water, and other resources
- Protecting occupant health and improving employee productivity
- Reducing waste, pollution and environmental degradation

Green building brings together a vast array of practices and techniques to reduce and ultimately eliminate the impacts of new buildings on the environment and human health. It often emphasizes taking advantage of renewable resources, e.g., using sunlight through passive solar, active solar, and photovoltaic techniques and using plants and trees through green roofs, rain gardens, and for reduction of rainwater run-off. Many other techniques, such as using packed gravel or permeable concrete instead of conventional concrete or asphalt to enhance replenishment of ground water, are used as well.

While the practices, or technologies, employed in green building are constantly evolving and may differ from region to region, there are fundamental principles that persist from which the method is derived: Siting and Structure Design Efficiency, Energy Efficiency, Water Efficiency, Materials Efficiency, Indoor Environmental Quality Enhancement, Operations and Maintenance Optimization, and Waste and Toxics Reduction.The essence of green building is an optimization of one or more of these principles. Also, with the proper synergistic design, individual green building technologies may work together to produce a greater cumulative effect.

On the aesthetic side of green architecture or sustainable design is the philosophy of designing a building that is in harmony with the natural features and resources surrounding the site. There are several key steps in designing sustainable buildings: specify 'green' building materials from local sources, reduce loads, optimize systems, and generate on-site renewable energy.

(a) Siting and structure design efficiency

The foundation of any construction project is rooted in the concept and design stages. The concept stage, in fact, is one of the major steps in a project life cycle, as it has the largest impact on cost and performance. In designing environmentally optimal buildings, the objective is to minimize the total environmental impact associated with all life-cycle stages of the building project. However, building as a process is not as streamlined as an industrial process, and varies from one building to the other, never repeating itself identically. In addition, buildings are much more complex products, composed of a multitude of materials and components each constituting various design variables to be decided at the design stage. A variation of every design variable may affect the environment during all the building's relevant life-cycle stages.

(b) Energy efficiency

Green buildings often include measures to reduce energy use. To increase the efficiency of the building envelope, (the barrier between conditioned and unconditioned space), they may use high-efficiency windows and insulation in walls, ceilings, and floors. Another strategy, passive solar building design, is often implemented in low-energy homes. Designers orient windows and walls and place awnings, porches, and trees to shade windows and roofs during the summer while maximizing solar gain in the winter. In addition, effective window placement (day lighting) can provide more natural light and lessen the need for electric lighting during the day. Solar water heating further reduces energy loads.

Onsite generation of renewable energy through solar power, wind power, hydro power, or biomass can significantly reduce the environmental impact of the building. Power generation is generally the most expensive feature to add to a building.

(c) Water efficiency

Reducing water consumption and protecting water quality are key objectives in sustainable building. One critical issue of water consumption is that in many areas, the demands on the supplying aquifer exceed its ability to replenish itself. To the maximum extent feasible, facilities should increase their dependence on water that is collected, used, purified, and reused on-site. The protection and conservation of water throughout the life of a building may be accomplished by designing for dual plumbing that recycles water in toilet flushing. Waste-water may be minimized by utilizing water conserving fixtures such as ultra-low flush toilets and low-flow shower heads. Bidets help eliminate the use of toilet paper, reducing sewer traffic and increasing possibilities of re-using water on-site. Point of use water treatment and heating improves both water quality and energy efficiency while reducing the amount of water in circulation. The use of non-sewage and greywater for on-site use such as site-irrigation will minimize demands on the local aquifer.

(d) **Materials efficiency**

Building materials typically considered to be 'green' include (Expanded polystyrene) rapidly renewable plant materials like bamboo (because bamboo grows quickly) and straw, lumber from forests certified to be sustainably managed, ecology blocks dimension stone, recycled stone, recycled metal, and other products that are non-toxic, reusable, renewable, and/or recyclable (e.g. Trass, Linoleum, sheep wool, panels made from paper flakes, compressed earth block, adobe, baked earth, rammed earth, clay, vermiculite, flax linen, sisal, seagrass, cork, expanded clay grains, coconut, wood fibre plates, calcium sand stone, concrete (high and ultra high performance, roman self-healing concrete) etc. The EPA (Environmental Protection Agency) also suggests using recycled industrial goods, such as coal combustion products, foundry sand, and demolition debris in construction projects Building materials should be extracted and manufactured locally to the building site to minimize the energy embedded in their transportation. Where possible, building elements should be manufactured off-site and delivered to site, to maximise benefits of off-site manufacture including minimising waste, maximising recycling (because manufacture is in one location), high quality elements, better OHS management, less noise and dust.

(e) **Indoor environmental quality enhancement**

The Indoor Environmental Quality (IEQ) category in LEED standards, one of the five environmental categories, was created to provide comfort, well-being, and productivity of occupants. The LEED IEQ category addresses design and construction guidelines especially: indoor air quality (IAQ), thermal quality, and lighting quality.

Indoor Air Quality seeks to reduce volatile organic compounds, or VOC's, and other air impurities such as microbial contaminants. Buildings rely on a properly designed HVAC system to provide adequate ventilation and air filtration as well as isolate operations (kitchens, dry cleaners, etc.) from other occupancies. During the design and construction process choosing construction materials and interior finish products with zero or low emissions will improve IAQ. Many building materials and cleaning/maintenance products emit toxic gases, such as VOC's and formaldehyde. These gases can have a detrimental impact on occupants' health and productivity as well. Avoiding these products will increase a building's IEQ.

Personal temperature and airflow control over the HVAC system coupled with a properly designed building envelope will also aid in increasing a building's thermal quality. Creating a high performance luminous environment through the careful integration of natural and artificial light sources will improve on the lighting quality of a structure.

(f) **Operations and maintenance optimization**

No matter how sustainable a building may have been in its design and construction, it can only remain so if it is operated responsibly and maintained properly. Ensuring operations and maintenance(O&M) personnel are part of the project's planning and development process will help retain the green criteria designed at the onset of the project. Every aspect of green building is integrated into the O&M phase of a building's life. The addition of new green technologies also falls on the O&M staff. Although the goal of waste reduction may be applied during the design, construction and demolition phases of a building's life-cycle, it is in the O&M phase that green practices such as recycling and air quality enhancement take place.

(g) Waste reduction

Green architecture also seeks to reduce waste of energy, water and materials used during construction. During the construction phase, one goal should be to reduce the amount of material going to landfills. Well-designed buildings also help reduce the amount of waste generated by the occupants as well, by providing on-site solutions such as compost bins to reduce matter going to landfills.

To reduce the impact on wells or water treatment plants, several options exist. "Greywater", wastewater from sources such as dishwashing or washing machines, can be used for subsurface irrigation, or if treated, for non-potable purposes, e.g., to flush toilets and wash cars. Rainwater collectors are used for similar purposes.

Centralized wastewater treatment systems can be costly and use a lot of energy. An alternative to this process is converting waste and wastewater into fertilizer, which avoids these costs and shows other benefits. By collecting human waste at the source and running it to a semi-centralized biogas plant with other biological waste, liquid fertilizer can be produced. This concept was demonstrated by a settlement in Lubeck Germany in the late 1990s. Practices like these provide soil with organic nutrients and create carbon sinks that remove carbon dioxide from the atmosphere, offsetting greenhouse gas emission.

(h) Cost and payoff

The most debatable issue about constructing environmentally friendly buildings is the price. Photo-voltaics, 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.

Sustainability Challenges for the Indian Building Sector

India has one of the fastest growing construction sectors in the world. New construction spending has grown by as much as 10% in the last five years and built floor area has more than doubled. This increase in construction activity is being driven by rapid urbanization. About 30% of India's 221.1 million households are now in urban areas with the urban population projected to more than double by 2050.

Demand for commercial building has also increased dramatically, fueled by a boom in the services sector which has been estimated to have added 53% to the value of GDP in 2008 alone. The amount of built office space is projected to increase from approximately 200 million m^2 in 2009 to 890 million m^2 by

2030, an increase of more than 70%. (The figure in the Eco-III report is 870 million m^2; however these are different from the commercial built up rates projected in the BCC project).

Many new office buildings import typical glass-curtain wall design which increase demand for mechanical cooling in India's predominantly warm climate. Recent studies of the energy performance of commercial buildings in India indicate that energy efficiency is poor by international standards, which has the effect of locking Indian cities in to in-efficient and potentially uncompetitive building stock for decades (TERI in GEA).

Unchecked, greenhouse gas emissions from electricity used in existing buildings alone could increase by 247% by 2050. If the energy-efficiency of new-buildings constructed over the same period is not improved, the total electricity related emissions from buildings could be more than 390% higher than current levels5. Green house gas emissions associated with building material manufacturing are also likely to spike over the next decade, increasing the need to consider lower embodied energy approaches to construction.

Energy demand is also increasing in rural India where programs are underway to bring electricity to the more than 400 million people that lack access to basic energy services. Providing such basic services to all of its citizens will require a 3 to 4 fold increase in primary energy supply and a 5 to 6 fold increase in electricity generation over 2005 capacity by 2030.

Such factors contributed to the building sectors proportion of total national commercial energy consumption rising from 14% in the 1970's to approximately 33% by 2005, an increase in energy use in buildings of approximately 8% per year. Given that 55% of India's electricity is generated from coal-fired power plants, the energy performance of buildings is an increasingly significant factor in national greenhouse gas emissions.

These issues are being addressed by policy makers. As Section 4 describes the new ECBC and BEE programs aim to deliver significant operating energy efficiency gains from India's commercial building sector. Full implementation of the Energy Conservation Building Code for example could reduce energy consumption in new commercial buildings by 25-40%. Further potential energy savings of 25% could be achieved with cost-effective retrofitting of existing commercial buildings.

Indian cities are among the worlds most vulnerable to impacts of climate change. Given 50-60% of Indian's will be living in cities by 2050, the role of buildings in providing climate change adaptation options is fundamental to sustaining prosperity and well-being. A key climate change pressure on the built-environment is the diminishing availability of water for urban areas.

Solar Model for Green Buildings

India's first Solar Housing Complex, has been constructed in the New Town area of Kolkatta city in the State of West Bengal. The project has been executed by the West Bengal Renewable Energy Development Agency (WBREDA) with partial support of Ministry of New and Renewable Energy, Government of India and State government agencies.

Solar Housing Complex

This is the first building integrated photo voltaic (BIPV) project in India using the net metering system of power transfer to grid, implemented under the newly formulated policy guidelines of the West Bengal

State Electricity Regulatory Commission (WBERC). The housing complex (figure shown below) comprises twenty five reasonably priced plush bungalows, a community hall and a swimming pool developed on a 7125 square metre plot in New Town Kolkata.

A financially viable model was developed in order to promote energy efficient and renewable energy based housing. Since most projects are owner driven, this is a unique example where the developer community has driven the initiative to showcase that to build green is not expensive.

A public private partnership was established whereby the finances were put together by seeking 50% advance (of the total cost of each house) from independent house owners at the beginning.

Source: Majumdar, M.(2008). TERI

Key sustainable design parameters

The key principles of green building design such as site planning, energy and water efficiency, use of appropriate materials and good indoor environmental quality have been maintained. Further, principles of sustainable building design have also been addressed by devising suitable economic models for owners of houses and addressing social and cultural requirements by planning for and providing areas and buildings for community activities.

The complex is a unique model in India and has been developed on the concept of ‘zero use of conventional electricity’. The following issues have been addressed during the planning, design and construction of the sustainable housing complex.

a. **Site planning**

• Maximum solar and wind access to individual houses in the hot and humid climate zone of Kolkata.
• Gravity-based sewerage system to reduce sewerage pumping energy

• Appropriate landscaping to modulate air flows within site, divert air flows to rooms, shade paved areas (to reduce heat island effect)
• Stand alone high mast solar street lights with battery at the top and high power fluorescent lights.
• Battery operated pick-up van.
• Solar PV operated name plate and signage.
• Solar PV operated garden lights.

b. **Building envelope and system efficiency**

• Passive solar features with swimming pool in South
• Solar Chimney
• Adequate ventilation and natural lighting
• Use of Light Emitting Diodes (LED)/Compact Fluorescent Lamp (CFL) lighting fixtures
• Energy efficient electrical appliances have been installed in the houses and the complex

c. **Use of renewable energy**

• Outdoor lighting using solar photovoltaic based street lighting. All the 17 streetlights are fitted with solar photovoltaic panels.
• There is a swimming pool heated by solar energy.
• Evacuated tube collector (ETC) based solar water heater of 130 litres per day (lpd) capacity to meet hot water requirements. The small water tank in the solar heater has a thermal insulation which provides round-the-clock hot water supply.
• 2.0 kW roof top solar PV with grid connectivity, metering and stand alone facility for 4 hours operation. Each bungalow has own "power plant" on the rooftop, comprising a solar photovoltaic panel with a capacity of two kilowatts. Household gadgets and electric installations can run on solar power during the day. Post sunset, with the generation dwindling, the system automatically switches to grid supplied electricity.
• The PV system also has an in-built power back-up system, which stores around 3 kilowatts of power. So, in case of an emergency at night, say during power cuts, one can switch to the back-up to harness stored power. An inverter helps the "switchover" post-sunset. All residents have been advised to opt for LEDs and CFLs for lighting.

d. **Water efficiency**

• Use of pervious paving to maximize groundwater recharge
• Hydro-pneumatic water supply system with 40% less energy consumption.

e. **Economic feasibility for the owner**

• Each house in the complex was priced ranging from USD 86,000 to USD 90,000 for a built-up space 165 square metres with an open area of 80 square metres. The land area for each house is 200 square metres. Each owner has rights to the land and generates own power for domestic use as well as for feeding the grid.
• Since net metering is being adopted, the users export electricity to the grid and thus fall in the lower consumption (and thereby tariff) slab. The option of net metering can also be used when the house is unoccupied.

f. **Social and cultural considerations**

• A community centre and a swimming pool have been provided for use by the occupants
• WBREDA is in-charge of general maintenance for the first year while each installation — be it the heater, inverter or solar lights — comes with a five-year guarantee.

g. **Urban planning and transportation**

• Efficient infrastructure planning by minimized road lengths, aggregate utility corridor
• Consolidated pedestrian and automobile paths
• Centralized car parking
• Use of battery-operated vehicles for intra-site

Architecture of the building

The first element to take into consideration about architecture of a building is how it takes advantage of the climatic conditions in a particular region.

Bhubaneswar’s climate is warm and humid, so architecture must allow the wind to ventilate naturally and the sun to light the building without heating too much.

Historically, Indians open their buildings at the South for the wind and at the East for the sun.

That’s why the ratio and orientation of windows is important to check in order to evaluate natural lighting and natural ventilation.

A good-quality cooling insulation and building envelope allows reducing the space-conditioning loads, so these are also elements to check

Green Building Architecture, LBHS

LBHS is an architecture college situated in the suburbs of Mumbai, in India. It is a prime example of **Green Building Architecture.** The city of Bombay is a bit crowded, and as such, land is at a premium. So, the location provides enough space for expansion and providing sufficient infrastructure to students.

This project is special because it has implemented many energy-saving devices and techniques to make it one of the first green building designs in India. From light sensors for auto-switching of lights, to water recycling, use of solar arrays and use of earth air tunnels, this project has done everything. It is a very interesting case study. The designers have aimed at developing an semi-autonomous building, almost self-sufficient building complex.

It is inferred that such buildings **reduce environmental impacts, increase security, and lower costs of ownership.**

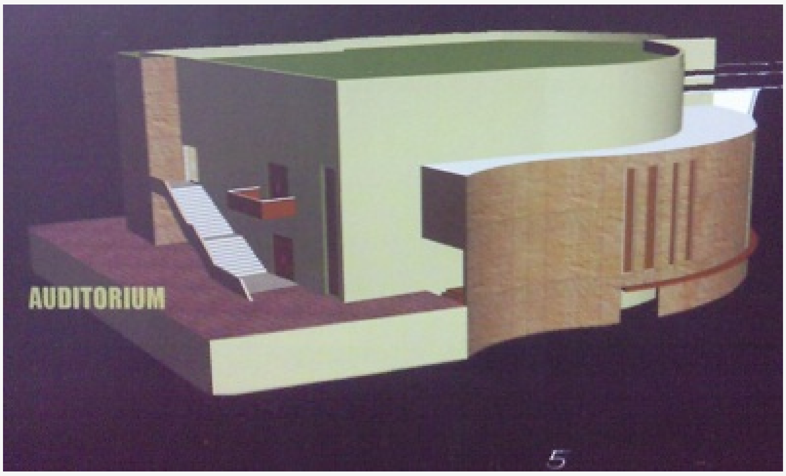
Segmentation of Space

This project is spread into a vast area. The available space is divided into public and semi-public zones.

Auditorium, Restaurant and Exhibition halls requiring services are placed adjacent to the service road. **Amphitheater**, the main interaction hub, is placed centrally orienting in the North-West direction to capture the wind flow. This keeps the open-air amphitheater cool in the evening with a gentle North-Western breeze.

Auditorium

It is located near the entrance and given a formal outlook for usage reasons. There is an entire buffer floor for flexibility. Open spill-over areas around it provide a comprehensive view of the stage.



Auditorium at LBHS, Mumbai

Exhibition Block

There are three large halls at different levels which are used to exhibit various things and host architecture fairs from time to time. Sit-out serves as an interaction space at the rear side of the block. The open-air exhibition has a **retractable covering** around the edges. Considering the rains and heavy winds in the Konkan area, tensile material has been chosen for roofing for the exhibition halls.

Exhibition Block at LBHS Mumbai

Eco-friendly Roof

Green, eco-friendly roof insulates the conference block, auditorium and exhibition block from external weather and temperature, thus saving energy costs over the long term. Shading, evapo-transpiration and filtering are functions of the green roof infrastructure.

Provision of Earth Air Tunnel

Another interesting feature of this college is an Earth Air Tunnel to cool down temperatures during the summer season, in order to reduce energy costs.

Water Recycling

In order to reduce water consumption, this project has implemented “water recycling” at the site. The recycled water is probably used for watering the gardens maintained by the college.

Solar Cell Arrays

Surprisingly, the college generates electricity with the help of 32 Solar Cell Arrays. There is not enough data to understand how this generated power is utilized and how it affects their power bills.

Air Conditioning by Gas-fired Ammonia absorption Chillers

The entire college is air-conditioned, and this unit provides air conditioning at a very low cost. In fact, it uses 75% less power than a comparable conventional air conditioning unit.

Light Sensors

There are movement sensors in important places which can detect the presence of people, which regulates the light switches. This is a very interesting case study. Many interesting and mature techniques have been used to reduce energy consumption and reduce dependence of the college on the grid.

GREEN RATING FOR INTEGRATED HABITAT ASSESSMENT (GRIHA)

It is the national green building rating system for India, endorsed by the Ministry of New and Renewable Energy (MNRE), Government of India (GoI). The rating system acts as an integrating platform for all relevant Indian codes, standards, strategies and policy instruments for buildings directed towards our national priorities. It consolidates and builds upon the National Building Code (NBC) 2005, the Energy Conservation Building Code (ECBC) 2007, the environmental clearance norms and standards mandated for large construction projects by the Ministry of Environment and Forest (MoEF), the energy labeling programs for appliances by the BEE, several programs of the MNRE focused on utilization of renewable energy sources in buildings; and the priorities set forth by the Ministry of Urban Development (MoUD) on implementation of infrastructure projects in sixty three cities under the Jawarharlal Nehru National Urban Renewal Mission (JNNURM).

GRIHA provides a rating of up to five stars for green buildings. Developed for new commercial and residential buildings, the rating system sets benchmarks for air conditioned and non air conditioned buildings in five climatic zones, namely hot-dry, warm-humid, composite, temperate and cold. A major objective of the rating is to promote passive solar techniques for optimizing indoor visual and thermal comfort; where a building is assessed on its predicted performance over the entire life cycle from inception through operation.

The 11th Five Year Plan (2007-2012) aims to achieve GRIHA compliance for five million square metres built up area, out of which about two million square metres of built up area is registered and GRIHA compliant (as of December 2009).

GRIHA comprises a set of 34 criteria addressing sustainable site planning, optimized energy performance, use of efficient materials and construction practices, integration of water and waste management strategies, indoor environmental quality and; health, comfort and safety of human beings benchmarks.

Centre for Environmental Sciences and Engineering at IIT Kanpur

Centre for Environmental Sciences and Engineering at IIT Kanpur is the first 5 star GRIHA rated building, in which an integrated approach has been adopted to comply with the design, construction and operation guidelines set forth by the rating system. Quantitative and qualitative measures have been incorporated to achieve and surpass performance benchmarks for key resources such as energy and water through implementation of traditional and vernacular knowledge of architecture along with present day technology.

The building comprises wet labs which are non-air-conditioned spaces on ground floor and dry labs that are air-conditioned spaces on the first floor. Building design and envelope has been optimized through selection of appropriate wall and roof construction and thorough adoption of solar passive measures after studying the sun path analysis to provide shading devices for windows and roof, which shall reduce energy demand to condition the spaces.

All the commitments as described in GRIHA to optimize the system design and to achieve thermal comfort in non air conditioned spaces have been followed. This has resulted in annual energy savings that exceed the performance benchmark for composite climates set by GRIHA. Water conservation measures have been adopted in the building through selection of efficient fixtures and rain water harvesting. The building uses electricity generated by integrated photovoltaic panels. Rain water is harvested and treated waste water is reused for irrigation. The building is fully compliant with the ECBC. An integrated approach to design of the building has resulted in about 59% energy savings in the building performance.

The base case Energy Performance Index (EPI) of the building was 240 kWh per square metre per annum. The envelope was improved upon by adding ECBC compliant insulation to the external walls and roof. After addressing appropriate orientation and incorporation optimum envelope design, the EPI reduced to 208 kWh per square metre per annum. Next, artificial lighting systems were optimized by reducing the lighting power density of the building from 20 W per square metre to less than 10 W per square metre. T5 tube lights which are high efficiency tube lights and CFL lamps were used. The EPI reduced to 168 kWh per square metre per annum.

After the lighting system was optimized, the efficiency of the HVAC system was improved by selecting more efficient chillers. The EPI further reduced to 133 kWh per square metre per annum. Next the building controls were added to the mechanical systems primarily the HVAC. Building controls manage the operating schedules, temperatures, pumps etc. That is to say that the building control systems turns up or turns down the HVAC system according to the number of users, time of the day, year etc. This allows for less usage of energy when the occupancy of the building is low or temperature outside is moderate or in any such similar condition. This further led to a reduction of 25 kWh per square metre per annum.

And finally a passive Earth Air Tunnel was coupled with the HVAC system. The earth-air tunnel drastically reduces the energy required for conditioning of air by utilizing the thermal properties of earth as a heat exchanger. In the end, the final EPI of the building was 98kWh per square metre per annum, a 59% reduction in energy consumption compared to the initial stage. The final case was fully ECBC compliant and as a result achieved a 5-star rating on the GRIHA rating system.

Leadership in Green Building Design (LEED)

The Indian Green Business Center (IGBC), under the Confederation of Indian industries (CII) is facilitating the LEED rating of the United States Green Building Council (USGBC). Introduction of the LEED Rating system has stimulated innovation within the building materials supply industry. High albedo roofing materials, high performance glass, waterless urinals, fly ash bricks for walls, roof insulation materials, high CoP (coefficient of performance) chillers and energy simulation services are now being made available in the market.

The IGBC has launched LEED India for Existing Buildings (EB), New Construction (NC), Core and Shell (C&S) and Indian Green Building Council (IGBC) Green Homes, which represent the measurable indicators for global and local concerns in the Indian scenario. Based on the points achieved, the building may be eligible for LEED certified, Silver, Gold or Platinum Rating.

ENERGY CONSERVATION BUILDING CODE 2007

The Bureau of Energy Efficiency, Government of India, launched the ECBC (Energy Conservation Building Code) in 2007 for commercial buildings with peak demand in excess of 500 kW or connected load in excess of 600 kVA. Analysis done during the development of the ECBC shows energy savings in the range of 27%–40% in an ECBC-compliant building over a typical commercial building with annual energy consumption of 200 kWh per square metre.

The ECBC sets minimum energy performance standards for the design and construction of large new commercial buildings. It encourages energy-efficient building systems, such as building envelope; lighting; HVAC; water heating; and electric power distribution, within the building facilities while enhancing thermal and visual comfort, and productivity of the occupants.

The objective of the ECBC is to reduce the baseline energy consumption by supporting adoption and implementation of efficiency measures in buildings.

Commercial Typical Building Energy Use:

Average Energy Consumption:

HVAC	55%
Lighting	14%
Electronics	27%
Others	4%

ECBC covers the following components:

- Building Envelope (Walls, Roofs, Windows)
- Lighting (Indoor and Outdoor)
- Heating Ventilation and Air Conditioning (HVAC) systems
- Solar Hot Water Heating
- Electrical systems

ENERGY STAR RATING OF OFFICE BUILDINGS

In order to accelerate the energy efficiency activities in existing commercial buildings, the BEE has developed the scheme for star rating of buildings. The programme is based on actual performance of the building, in terms of specific energy usage (in kWh per square metre per year). Initially, the programme targets warm humid, composite, and hot and dry climatic zones for air-conditioned and non - air-conditioned office buildings. The program is designed to rate office buildings on a 1-5 star scale, with 5-Star labeled buildings being the most energy efficient. The star rating program for existing buildings will subsequently be extended to other climatic zones and building types. EPI in kWh per square metre per year is considered for rating the building. Bandwidths for EPI for different climatic zones have been developed based on percentage air-conditioned space. The Star rating Program provides public recognition to energy efficient buildings, and creates a “demand side” pull for such buildings. Buildings with a connected load of 500 kW and above are considered for BEE star rating scheme.

Energy Performance Certificate will provide the home owner with an accurate assessment of the energy efficiency of their home and its environmental impact. Both of these are assessed on a scale A to G as follows:
A - 93-100 Points

B - 81-92 Points

C - 66-80 Points

D - 51-65 Points

E - 36-50 Points

F - 21-35 Points

G - 1-20 Points

The factors that would affect building energy efficiency in India (Bhubaneswar - climate type - warm and humid) would be the following (TERI)

- Architectural design (Building Orientation, landscape design, shading design, window to wall ratio, etc.)
- Natural lighting and artificial lighting systems (maximizing natural light ingress while cutting direct heat gain)
- Envelope materials and specifications (insulation, albedo, thermo-physical properties of the materials, etc.)
- Ventilation and air-conditioning systems (cross ventilation, passive cooling and heating systems, hybrid systems, HVAC systems, etc.)
- Controls (BMS, auto-control sensors, etc.)
- Renewable energy technologies for energy supply
- Water and waste water management systems (to reduce pumping energy and reduce the dependency on municipal supply)

Reserve Bank of India (RBI), Bhubaneswar

The RBI building at Bhubaneswar, Orissa has been awarded the first BEE Star Rating for office building in India. Since the air conditioned area of the building is more than 50% and the EPI for the building is 82kWh/m^2 per year, it lies in the bandwidth of less than 90 kWh/m^2 per year; hence has been awarded the five star rating.

BEE starts certification for energy efficient buildings-RBI gets 5-star

MONDAY, 02 MARCH 2009 05:27 LATHISH PV

Reserve Bank of India (RBI) is showing the way as far as energy conservation in the Capital is concerned. Its office building in the Capital has been tagged with a four-star based on its energy efficiency by the Bureau of Energy Efficiency (BEE). The RBI office building in Bhubaneswar has snagged the prestigious 5-star.

Get ready for certified energy efficient buildings now. Bureau of Energy Efficiency (BEE), after having started a star rating programme for electronic goods, is extending the scheme to buildings as well. The ratings, meant only for offices at present, will award certificates to buildings based on their energy consumption over a period of at least one year.

The programme officially launched by Union power minister Sushil Kumar Shinde, will be voluntary. Organizations that apply to BEE will be assessed on their power consumption and awarded star ratings from one to five, with five signifying a highly efficient building. It takes off from the energy conservation building code that had been enforced in May 2007. So far around 500 buildings have been designed according to it.

"At present, the programme is only for office buildings. Buildings that have been operational for a year or more only can apply for the certification as their power bills for one year would have to be considered. Based on that and the area under use, we will calculate their energy performance index,'' said Ajay Mathur, director general, BEE.

Also, according to officials only `officiable' portions of the buildings will be considered for assessment which means basements and terraces will be left out.

Cities have been put into three climatic zones composite, hot and dry, hot and humid and separate assessment parameters have been formulated for each. "We have studied buildings on the basis of their energy consumption and collected data of over 700 buildings across the country in last two years. We have seen an energy growth of about 12-13% each year. Even though the scheme is voluntary, we hope that demand will regulate construction. Once users realise the benefits of energy efficient buildings and low power bills, they will ask to purchase or rent such buildings and builders will have to adopt better construction practices,'' said Mathur.

However, only existing buildings will benefit from the programme since a building has to be in existence for at least one year to qualify for the audit. "New buildings can probably take tips from LEED or GRIHA codes developed by separate organizations for energy efficient buildings so that when they are finally assessed, they can get a good rating,'' added Mathur.

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Though the programme for rating office buildings on a 1-5 scale was formally inaugurated last week, BEE went a step forward to tag RBI offices in Bhubaneshwar and Delhi first. "We carried out a survey and found that the RBI office buildings were pioneers in energy conservation and gave them the tags based on their performance. We are hopeful that many more office buildings will apply for star ratings in the future. The rating programme will bring the buildings public recognition and help tenants understand that they will be paying a lower power bill because their building has been officially renognised as energy efficient. Also, the building owner will be able to position the building as a premier one,'' said Ajay Mathur, director general, BEE.

To encourage more building owners to come forward and apply, Shinde also announced that the first 100 buildings which would apply for the scheme would get a waiver of the Rs 1 lakh registration fee. "The programme is not just for government buildings.

We want to see more participation from private buildings for the programme,'' said Shinde. According to RBI officials, they identified energy conservation as a goal in 1998 and started implementation process two years later. "We roped in BSNL to conduct a periodical energy audit for us and make it a point to incorporate all suggestions. Energy conservation has helped bring down our power consumption drastically and reduced our electricity bill by upto 50%,'' said Anand Prakash, general manager, RBI Delhi.

The energy audits (held every two years) have helped RBI officials keep a close tab on power consumption. "We have guidelines to follow. The technically feasible short-term measures are implemented immediately while the long-term measures which require capital investment are examined and an appropriate decision is taken considering the aging, technology and payback period,'' said an RBI official.

RBI officials added that making their building energy efficient came at a huge investment also. "The energy efficient chiller package itself costs crores,'' said one official. The use of solar energy has also been examined by RBI and solar water heating system has been provided in many of its offices.
Source - Economic times, Times of India

Conclusion:

The rapid growth in India's building sector no doubt presents opportunities for improving the living conditions and livelihoods of millions of people. However, in order to be sustainable the environmental pressures of increased demand for resources coupled with a rapidly changing climate must be addressed. Incentives are required to expand the acceptability and implementation the vernacular approach to design and construction of buildings.

The mode of implementation, policy environment, certification, legislation and economic incentives have been described to support the adoption of green and energy rating systems for buildings.

The demand for buildings compliant with any green rating requires impetus due to a perceived notion of high initial incremental costs for green buildings. Financial incentives in the form of property tax concession or other subsidies from the government would encourage a larger adoption of the rating systems. A strong policy mandate at the local level to enforce compliance with GRIHA or LEED rating systems is also required.

In cases where compliance with a green rating system is not feasible, it is possible for the building to be compliant with the Energy Conservation Building Code (ECBC) which contributes to significant energy savings through the operation of an efficient building, contributing to GHG emission reduction. In order to mainstream compliance with ECBC, the BEE has taken several initiatives.

The way forward will be to bridge the large knowledge gap that exists at various levels, invest in research and development on local design, construction and materials suitable to the country that may be incorporated in modern buildings, and enforce implementation of policy in the building sector. Further, extensive training of architects, engineers and consultants is also being undertaken by the BEE across India.

Additionally, financial incentives will also provide the much required impetus to move away from unsustainable building design and construction practices, which are progressively creeping into practices of building in the cities of India through sustainable practices for the benefit of human beings in different forms like health and wellbeing, material resources, water efficiency, energy efficiency, sustainable site planning and solid waste management

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