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# ENERGY EFFICIENCY IN GREEN BUILDINGS – INDIAN CONCEPT

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## ABSTRACT

Climate change, caused by the release of greenhouse gases (mainly carbon dioxide) into the atmosphere, has been recognized as one of the greatest threats of the 21st century. Share of energy consumption in India and China has also been on the raise due to sharp urbanization, population explosion, and intensive growth of IT and related business. Buildings are the dominant energy consumers in modern cities account upto 40% energy consumption. Their consumption can be largely cut back through improving efficiency, which is an effective means to lessen greenhouse gas emissions and slow down depletion of non- renewable energy resources. There is over 50% saving potential in the building sector and thus it is considered as a potential sector to meet the challenges of global energy and climate change. Along with introduction of energy efficiency measures, more effective means are needed to induce or compel greater efforts, especially to the signatories to the Kyoto Protocol. This technical paper discusses the role of energy efficiency in green buildings in Indian scenario to reduce the energy consumption and environmental degradation through Green House Gas emission (GHG). The possibility and benefits of harmonizing governmental and private-sector schemes are also discussed.

**Keywords**: Climate change, Green House Gas, Green Buildings, energy efficiency, Energy policies.

## 1. Introduction

Climate change, caused by the release of greenhouse gases (mainly carbon dioxide) into the atmosphere, has been recognized as one of the greatest threats of the 21st century [1] Being the largest primary energy consumers, buildings make the world's biggest contribution to this growing menace. World studies have acknowledged, buildings were responsible for 7.85Gt, or 33% of all energy-related CO2 emissions worldwide (Price et al., 2006) and these emissions are expected to grow to 11Gt (B2 scenario) or 15.6Gt (A1B scenario) by 2030 [2]. In developed countries such as US and UK, energy use in the building stock is responsible for producing about 50% of the nation's CO2 emissions. (Mazria and Kershner, 2008; DOE, 2006, EPA, 2003

India continues to develop; by 2030 it is likely to have GDP of 4 trillion USD and a population of 1.5 billion [1]. Energy consumption in India and China is also on the raise due to sharp urbanization, population explosion, and intensive growth of IT and related business. Buildings account for more than 41% energy consumption in developed countries. Energy consumption in building is mainly for building services like, HVAC, lighting, water heating, pumping and fans [2] amount to 40%. It is said that 18-20% of primary energy and 40% of total consumption takes place developed countries. like US and EU [2] (Fig.1a) and. (Fig. 1b). In USA, office buildings use about 16% more.

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The total amount of energy used by commercial buildings has risen significantly since the 1980s, reflecting a 50% growth in the total amount of office space available and a 33% increase in energy consumption per square foot of space. The result is a 70% overall increase in the amount of energy used by commercial buildings since 1980, as highlighted in fig.1(a)

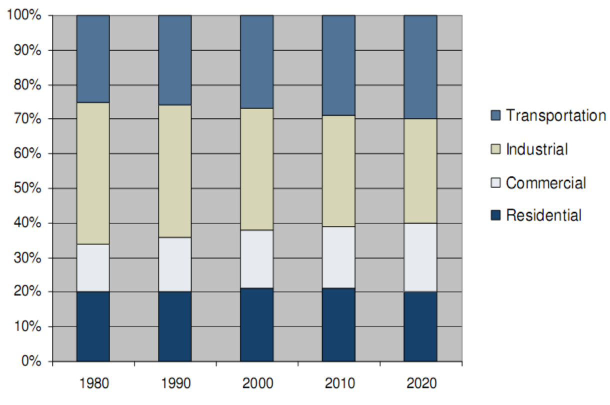


Fig. 1(a). Energy Consumption Forecast by Sector (United States), (Source: EIA)

In developed countries the energy consumption growth rate is only marginally higher compared to the population growth rate. In USA, energy consumption is projected to grow at 1.3% while the population growth rate is projected to grow at 0.8%.

In developing countries like India population growth rate is expected is expected to grow at 10%. This trend is straining the Indian energy sector to a large extent challenging the to grow at 1.3% while the energy consumption [3] rate energy planners for further fresh investments in power sector in addition to program for energy efficiency change.

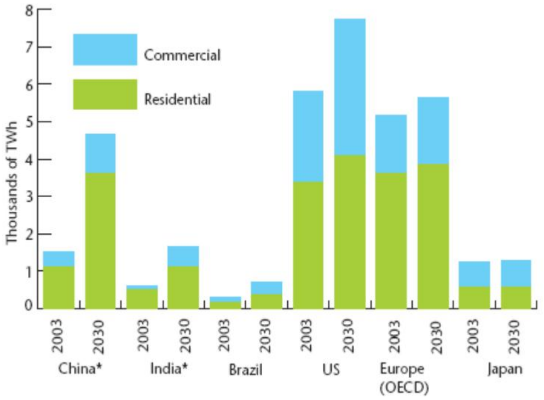


Fig. 1(b). Building energy projection by regions in 2003 and 2030 (Source: IEA, 2008).

As buildings are key to Asia's future, building heating and cooling are the most energy-intensive activities, followed by electricity use for lighting and appliances (Harvey, 2009). India being in a temperate climate, demand for cooling is more intensive than heating. Greenhouse gas emissions from buildings energy use significantly exceed those from transportation. It was predicted by International Panel on Climate Change (IPCC) that $CO_2$ emissions from buildings (including through the use of electricity) could increase from 8.6 billion tones in 2004 to 15.6 in 2030 under a high growth scenario [4]. Energy consumption at lower costs (passive methods) in buildings will offer greater potential to meet $CO_2$ reduction targets than any other sectors. Energy used for heating and cooling can be reduced through ventilation, heat sinks, the use of solar panel and improved insulation. Electricity consumption can also be reduced through use of CFL & LED lighting or increased use of natural lighting and the use of energy-efficient appliances [5]. Improved efficiency in the building sector and de-carbonizing the power sector could offer significant potential emissions reduction.

## 2. Compulsions of Going Green

Green Buildings save the resources in the entire lifecycle of the structure and it starts from Green design. Green design has environmental, economic and social elements that benefit all stakeholders, including owners and the occupants. Even though these broad benefits are oft discussed in the context of Green Buildings, it is interesting to go a step forward and compile the specific salutary spin offs that may come with Green Buildings.

With rapid improvements in construction techniques and ethos, it is possible that many of the contemporary office buildings being built across metropolitan cities in India may have already included some of the Green features listed in the table as part of the buildings being delivered for occupation

## 3. Indian Urban population and Energy consumption pattern in buildings

The global urban population is expected to grow from 47% of the total in 2000 to 70% in 2050. Figure 2 shows the rising urban population trend in developing countries like China, India and Brazil. The urban populations of China and India are continuing to grow rapidly to 2050, reaching more than one billion in China and India. By 2050, it is predicted that about 73% of the Chinese population will be urban, increasing from 40% in 2005[4]. In India drastic urbanization is mainly due to both socio–political motivation. Brazil's urbanization rate is beginning to reach saturation level and it is a much more urban country than others. The construction boom, especially in China, is increasing building energy demand dramatically with economic development and living standard improvement

In line with expanding development and population, India's building sector is expected to grow five-fold from 2005 to 2050 as two-thirds of the commercial and high-rise residential structures that will exist in 2030 are yet to be built (70%). While India's total energy requirement is projected to grow at 6.5 percent per year between 2010-11 and 2016-17 to support the country's projected growth rate, India is en route to becoming the world's second largest emitter of greenhouse gases [4].

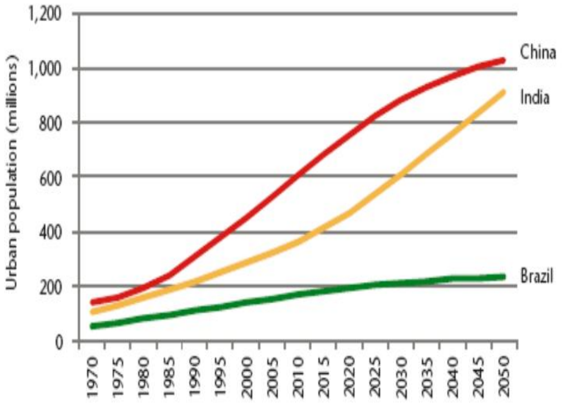


Figure 2. The rising urban population in developing countries (China, India, Brazil) (WBCSD, 2009).

Energy consumption varies widely by size, building type, culture and wealth. Average home size is 200m$^2$ in the US and only 40 m$^2$ in India. Average household energy consumption [5] varies due to culture, climate and wealth (Figure 3). Space heating is dominant in Europe due cold climate, while water heating is the main energy use in Japan.

Lighting and appliances, water heating and space heating share similar portions (28-33%) of household energy use in China, while cooking is the main energy use in India, especially in rural India, where many houses have no electricity access and biomass is the main energy source for cooking. With the rising wealth in developing countries, more energy will be used for electric appliances to meet the increasing living quality.

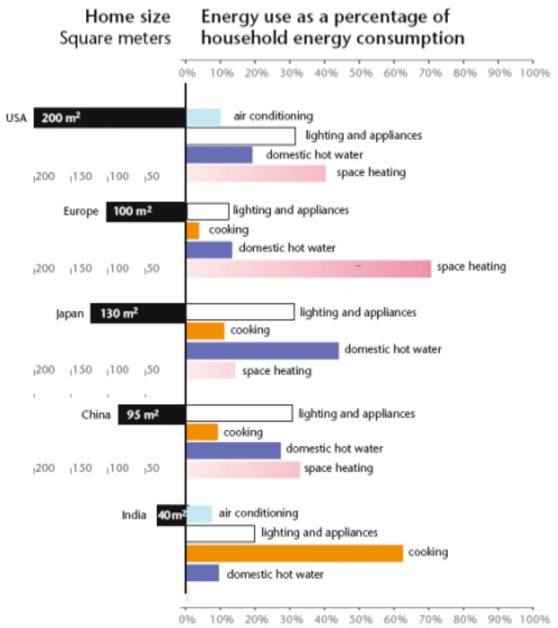


Figure 3. Global differences in home size and energy use (Source: WBCSD, 2009).

### 3.1 Building energy by sources

Electricity and natural gas are the main energy commodities used in OECD countries, (diesel is also used in developing counties like India and China) accounting for over 70% of total energy demand in 2005, while renewable (mostly traditional biomass) and coal contributed much higher shares of energy consumption in China, India and South Africa than developed countries (Figure 4), but the share is decreasing due to inefficient traditional biomass use. Development and urbanization are associated with increased electricity use, which significantly increased energy demand in China and India during the past years [6]. More efficient renewable energy resources are sought to meet the increased energy demand. It is accounted worldwide, taking into account its entire lifespan; buildings are responsible in each country for: 25 - 40% of the total energy use, 30 - 40% of solid waste generation, 30 - 40% of Global Green House Gas Emissions (CO2, N2 0, CH4, HFC, PFC, SF6).

### 3.2 Contributions by intelligent and green buildings to GHG reductions

High performance buildings reduce the overall demand for energy, helping to limit the need for new power plants. As many new plants still burn coal, this reduction also helps limit associated emissions.

Intelligent buildings make several contributions to reducing GHG emissions (table 1.). More than 40% CO2 emissions in developed countries come from eating, cooling and powering buildings. It was estimated that cutting UK building emissions by 25% would have a similar impact to take every car off the road in the UK. For existing buildings, good insulation, efficient boiler, window glazing and recovering heat from ventilation systems are efficient ways to reduce emissions

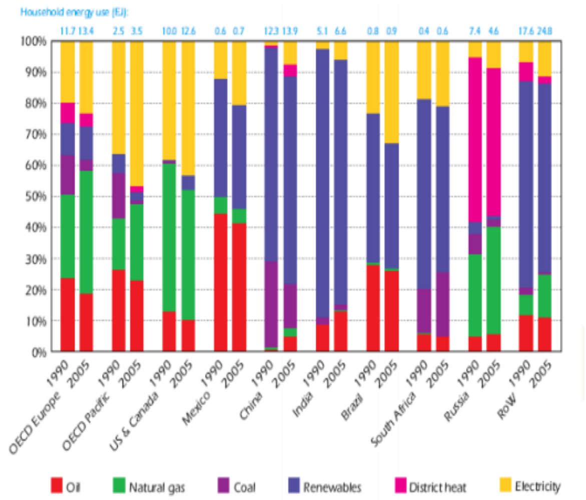


Figure 4. Household energy use by energy commodity

### 4. Key benefits of intelligent buildings

An intelligent building is one that uses both technology and processes to create a facility that is safer and more productive for its occupants and more operationally efficient for its owners. It exhibits key attributes of environmental sustainability to benefit present and future generations. Each building is unique in its mission and operational objectives, and therefore, must balance short and long term needs. A building is typically termed intelligent when the building's subsystems provide the occupants with productive and comfortable conditions by responding to their requirements and enhancing the workplace environment. Table1. Shows the key benefits of intelligent buildings

### 5. India's Sustainable Development

India's economic growth can only be sustained with corresponding to growth in infrastructure. Presently the growing demand is being met by crumbling infrastructure, such as road networks, city transport, water & sanitation etc. A solution to the contradiction requires a massive enlargement of urban infrastructure which will further require newer green and sustainable techniques for building this infrastructure. These newer techniques encapsulate the foundation of green buildings. Energy consumption and associated greenhouse gas emissions will continue to rise unless actions to direct the construction industry towards sustainable consumption and production are urgently taken.

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Table 1. Key benefits from intelligent buildings

| Real Estate Value | Sustainable Asset Management | Environmental Effects | Ultimate Effects |
|---|---|---|---|
| Improved indoor air quality (IAQ), productivity, and occupant satisfaction<br><br>Advanced capabilities to deal with "churn" (occupant turnover / evolving mission)<br><br>Reduced future capital expenditures<br><br>Higher resale value or lease rates | Optimized asset management and better space utilization<br><br>Reduced cost for moves, adds and changes (MAC)<br><br>Reduced capital costs including cabling, administration, training, and project management | Reduced greenhouse gas and carbon dioxide emissions<br><br>Reduced energy and water usage<br><br>Reduced construction and demolition waste<br><br>Leveraged renewable energy technologies | Healthier and more comfortable building environment<br><br>Improved long-term economic performance<br><br>Sustainability- easier to maintain and built to last<br><br>More competitive; "best of breed" procurement<br><br>More efficient use of O&M |

The objective of sustainable development is to reduce the baseline energy consumption by supporting adoption and implementation of efficiency measures in buildings is well supported in India by the use of energy efficient passive and active techniques. Compact planning is emphasized to enable daylight and naturally ventilated indoor areas. Landscaped courtyards are adopted as they act as a climate buffer and reduce glare. Efficient use of land, water, natural lighting and air make all the difference in achieving sustainability. Typically, the building envelope is designed differently in all six climatic zones keeping in view of the climatic advantage one can derive. As an example, the exposure of the south wall to sunlight is maximized by incorporation of a solarium in cold climates, whereas insulated reinforced cement concrete (RCC) diaphragm walls are used in hot climates to limit its direct radiation.

The integration of windows with light shelves and double-glazed windows with proper sealing further ensures the building efficiency and reduces cooling loads. Buildings oriented longitudinally along the east-west axis with openings along the north-south axis. for increased cross-ventilation and reducing summer gains. Passive and active systems are to be configured in accordance to the climatic zone to achieve the ambient temperature in the space. Passive systems such as radioactive cooling through roof ponds, earth air tunnel systems; direct and indirect evaporative cooling and solar water heating are prevalent in most parts of the country [7]. Active systems such as a hybrid chilled water system, chilled beams, thermal energy storage, vapor absorption systems, and under floor air-distribution systems have also been widely accepted in developed countries.

### 5.1 Background of Energy Efficiency in India

There is an urgent need to improve the energy efficiency of the Indian economy.

About 70% of the infrastructure in 2030, such as buildings, will be added in next two decades—between 2012 and 2032. The projections for energy demand in 2032 imply a fourfold increase in requirements. Such a dramatic increase of energy supply will be difficult to manage because of resource constraints.. In 2001, the Government of India (GoI) passed the Energy Conservation Act (ECAct, 2001) and the following year established the Bureau of Energy Efficiency (BEE) under its provisions. One of the first initiatives of BEE was to prepare an Energy Conservation Action Plan, which was released in August 2002. In June 2008, India released the first National Action Plan on Climate Change (NAPCC) outlining existing and future policies and programs addressing climate change mitigation and adaptation. The plan identified eight core 'national missions' including a National Mission for Enhanced Energy Efficiency (NMEEE).

Energy efficiency in building is an accumulation of energy efficiencies of appliances used like ACs, lighting, chillers, AHUs, Fans and various other systems. BEE as an national agency has been introducing and monitoring efficiencies of buildings and appliances in India. Figure 5 shows the annual energy-saving potential for about 25 products estimated in a recent study [15]. One can see that if finite amount of resources are available, a good strategy would be to focus on the top 7–10 appliances and capture most of the energy savings.

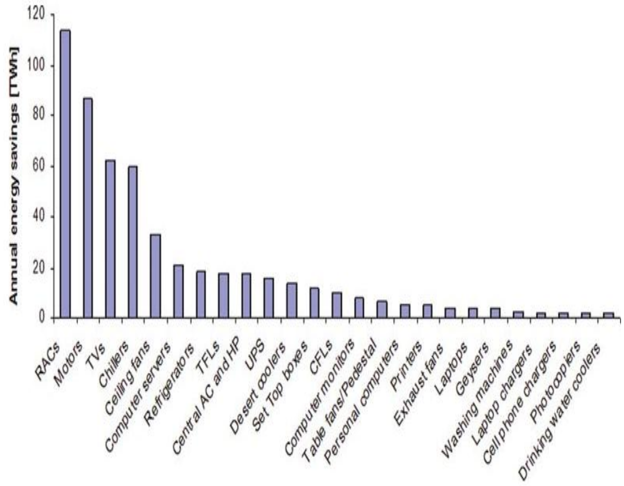


Fig.5 Annual saving potential of top 25 products.

### 5.2 Energy efficiency in Indian buildings

Majority of energy consumption in buildings occurs for HVAC, lighting pumping, etc, Higher the energy consumption greater the opportunities for energy efficiency Energy conservation and efficiency are the buzz words these days but developed [9] countries have left the developing world far behind. Awareness and dissemination of information are the keywords that lead to late start of the whole process. There is an urgent need to improve the energy efficiency of the Indian economy. About 70% of the infrastructure in 2030, such as buildings, will be added in next two decades [10] between 2012 and 2032.

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If this is built inefficiently, we will be locking-in this inefficiency The projections for energy demand in 2032 imply a fourfold increase in requirements. Achieving doesn't cost you much, but offers a lot many advantages, in terms of energy savings as well as environment protection.

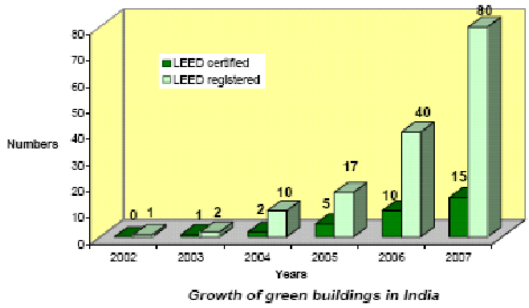


Fig. 6. Growth of green buildings in India

For existing buildings, good insulation, efficient boiler, window glazing and recovering heat from ventilation systems are efficient ways to reduce emissions. The benefits of energy efficiency in building are compelling, cost effective and can help consumers to save money in the long term. It helps to meet energy targets and resource energy shortage. There are many ways and means to achieve Energy efficiency in buildings can be achieved by adopting strategies like using low energy materials, insulation for walls, roofs, roof garden, glass carpet for roof, glass technology. Figure 6 shows the growth story of sustainable or green buildings in India. Though developed countries have gone far ahead, rest of the world is catching up, due to economic growth and infrastructure surge.

## 6. Integrated design Process

The integration design of buildings requires the integration of many kinds of information into an elegant, useful, and durable whole. An integrated design process includes the active and continuing participation of users and community members, code officials, building technologists, contractors, cost consultants, civil engineers, mechanical and electrical engineers, structural engineers, specifications specialists, and consultants from many specialized fields. The best buildings result from continual, organized collaboration among all players [6].

Building design for green buildings involves many professionals across different areas. Many factors need to be taken into account, including climate, building share, comfort levels, material and systems, and health. Figure 7. illustrates the interrelationships among these four main influences on energy efficiency and the key energy consumers. It shows that energy use are affected by many factors, for example, four factors including design, building envelope, equipment and infrastructure all have impacts on the energy needs for heating, ventilation and air conditioning (HVAC).

Building energy performance depends not only on the performance of an individual technology but also on how these perform as an integrated system. The building envelope is the starting point of energy efficient buildings, interacting with HAVC system and lighting, while design will bring together all elements influences energy efficiency [6].

An integrated design process involves all relevant participants from the start. Integration of both passive and active measures is crucial to effective building design and construction. Figure7. indicates that integrated design approaches will achieve the best performance in terms of energy saving.

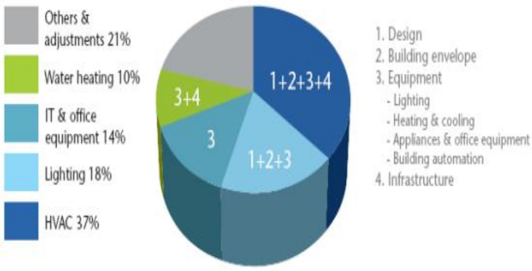


Figure 7. Design impacts on energy use (Source: (source:WBCSD, 2007)

Integrated design approaches could reduce energy use by as much as 72% [7]. But projects could be more expensive than individual solutions and thus require financial support and incentives from government regulation to reinforce this holistic approach. Integrating building with programmed and computerized networks (fig 8) of electronic devices for control and monitoring of systems such as HVAC, lighting, security, fire and life safety, and elevators (Known as building automation systems (BAS) and building energy management system (BEMS)) typically aim at optimizing the performance, start-up, and maintenance of building systems and greatly increase the interaction of mechanical subsystems in the building. This leads to improved occupant comfort, optimum energy consumption, and cost-effective building operation

### 6.1. Energy Efficient built - Green Building concept

Innovations in technology and production processes have resulted in significant changes in building industry. The future of buildings depends not only on innovation by homebuilders, but also on promotion by planners. Growth of green buildings in India Planners are interested in promoting innovative practices [14] that conserve the environment, improve quality and reduce costs. The direct emissions from energy use in buildings are only part of total footprints; moreover, structural green building planning can contribute to the sustainability development in terms of building location and public transportation (Harvey, 2009)

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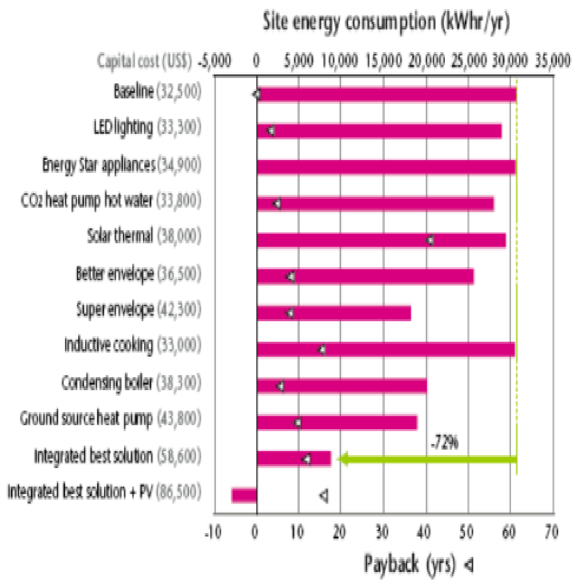


Figure 8. Integrated building design as best solution to reduce energy consumption (Source: WBSCD, 2009).

Green Building (GB) is synonymous with 'high performance buildings', 'sustainable design and construction' as well as other terms that refer to a holistic approach [15] to design and construction. Green Building design strives to balance environmental responsibility, resource efficiency, occupant comfort, well being and community sensitivity. The Green Building design includes all players in an integrated development process, from the design team (building owners, architects, engineers and consultants), the construction team (material manufacturers, contractors and waste haulers), maintenance staff and building occupants. The green building process results in a high quality product that maximizes the owner's returns on investment by sustained savings of energy by 40 -50 %, Water savings: 20-30 % and a good reduction in initial investment.

A Green Building is one, which incorporates several Green features. The appearance of a Green Building will be similar to any other building. However, the difference is in the approach, which revolves round a concern for extending the life span of natural resources; provide human comfort, safety and productivity. This approach results in reduction in operating costs like energy and water, besides several intangible benefits.

The Green building movement has gained tremendous momentum during the past 3-4 years, since the CII- Godrej GBC embarked [15] on achieving the prestigious LEED rating for its own centre at Hyderabad. The Platinum rating awarded for this building sparked off considerable enthusiasm in the country. Today a variety of green building projects are coming up in the country residential complexes, exhibition centers, hospitals, educational institutions, laboratories, IT parks, airports, government buildings and corporate offices. But recent statistics (fig.6) lists about 315 green buildings operational not only in four metros of India but also in fastest growing cities like Bengaluru and Hyderabad.

Looking at the merits GB offering, there is going to be a lot more growth for GB to come up in the years to come.

## 7. Bright Green Building

Another concept in the area of energy efficient and environment friendly building is the emergence of Bright Green Building (BGB). Bright green building is one that is both intelligent and green. It is a building that uses both technology and process to create a facility that is safe, healthy and comfortable, and enables productivity and well being for its occupants. It provides timely, integrated system information for its owners so that they may make intelligent decisions regarding its operation and maintenance, and has an implicit logic that effectively evolves with changing user requirements and technology, ensuring continued and improved intelligent operation, maintenance and optimization. A bright green building is designed, constructed, and operated with minimum impact on the environment, with emphasis on conserving resources, using energy efficiently and creating healthy occupied environments. Sustainability is measured in three interdependent dimensions: environmental stewardship, economic prosperity and social responsibility. Bright green buildings exhibit key attributes of environmental sustainability to benefit present and future generations.

In bright green buildings, fully networked systems transcend the simple integration of independent systems to achieve interaction across all systems, allowing them to work collectively, optimizing a building's performance, and constantly creating an environment that is conducive to the occupants. Bright green buildings provide a dynamic environment that responds to occupants 'changing needs and lifestyles. As technology advances, and as information and communication expectations become more sophisticated, networking solutions both converge and automate divergent technologies to improve responsiveness, efficiency, and performance. To achieve this, bright green buildings converge data, voice, and video with security, HVAC, lighting, and other electronic controls on a single network platform that facilitates user management, space utilization, energy conservation, comfort, and systems improvement. Fig.9 outlines the commonalities between intelligent and green buildings that form the basis of a bright green building and highlights the impact of that convergence.

As a pilot project in association with Czechoslovakia in India, concept of BGB was taken up. In January 2011, City of Delhi announced a pilot project to install [4] cool roofs on some government buildings in Delhi with high profile sites like the Delhi Secretariat as well as all government schools and some hospitals. Initiative has been taken up with the collaboration with Czechoslovakia; few buildings are being built with cool roof technology. Number of different cool roof materials is used, including elastomeric coatings, lime coatings and tiles.

Visibility of these demonstration projects to the public has helped to raise awareness of the energy saving and thermal comfort benefits of cool roofs.

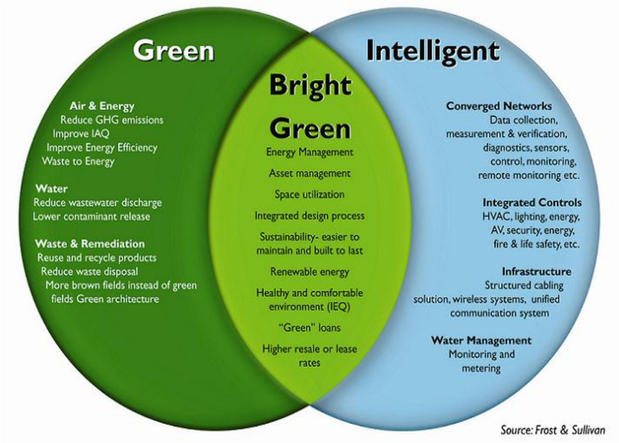


Fig. 9.Convergence of Intelligent and Green Buildings (source Frost & Sullivan)

## 8. Green building economy and investment

It is predicted that energy efficiency in building and appliances can reduce 1.6 Gt CO2 in 2020 and up to 7Gt CO2 in 2050. About $158 billion per annum between 2010 and 2050 are required to diffuse the energy efficiency technologies globally. According to study by McGraw Hill Construction, about half of new global commercial building projects will be planned as green buildings and 45% of retrofitting projects on existing buildings are targeted to improve energy performance. In terms of region, the fastest growing regional green building market is Asia, where the population of firms largely dedicated to green building is expected to jump from 36% today to 73% in 2013. More than half study firms expect to be largely dedicated to green building (on over 60% of projects), up from 30% today. Over 85% firms expect rapid or steady growth in sales and profit levels associated [16] with green building. GB brings in both energy efficiency as well as opportunities for economic investment divergence. GB is a win – win situation for all stake holders: developers, builders, policy makers and the world as whole.

## 9. Green building rating systems

Motivated by a desire to appear environmentally conscious, many commercial facilities have adopted "Green technologies" in order to earn "Green and Sustainable" certifications. The Green Buildings Ratings and Certification process has gained tremendous momentum over the last few years [17, 18, 19]. Particularly, growth in the number of projects certified by rating systems such as Energy Star and LEED has nearly doubled in size during this period [20].

In India, the Indian Green Building Council (IGBC) provides LEED ratings to structures and aims to make the country one of the leaders in green buildings by the year 2015.

The Green rating for Integrated Habitat Assessment (GRIHA) is the National Rating System of India. It has been conceived by The Energy and Resources Institute (TERI) and developed jointly with the Ministry of New and Renewable Energy, India. It is a design evaluation system for green building and is intended for all kinds of buildings across every climatic zone in India. According to a 2008 news report in the Indian Express, Mumbai had registered 30 green building projects, at the time the highest among Indian cities. Thanks to the gradual spread of awareness about eco-friendly constructions, there has been a considerable rise in the number of registered green buildings in India. According to 2008 IGBC data, there are 315 green buildings in India, of which 250 are commercial properties.

## Concluding Remarks

With the convergence of urbanization, globalization and a rapidly changing and expanding economy, India is experiencing a rapid spurt in building construction across a range of city activities and socio-economic spectrum, increasing consumption of building materials such as glass, cement, metals and ceramics. Maximum consumption of these energy materials is a reason for environmental degradation. LEED rating provided opportunities to introduce new products and materials. Now there is an imminent need for service providers, who would be required in large numbers, not in hundreds but thousands, as the movement is heading to reach greater heights. The green building movement is here to stay for the benefit of individuals, society and the country at large.

The application of codes like ASHARE / ECBC as a benchmark can help in designing high performance buildings. There exist tremendous opportunities to introduce new materials, equipment and technologies which can help enhance energy efficiency of buildings.

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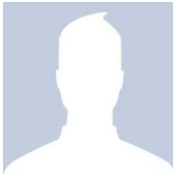

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