Construction Technology, Challenges and Possibilities of Low-Carbon Buildings in India

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ABSTRACT: *Buildings alone are responsible for 38% of all human Green House Gases emissions (20% residential, 18% commercial). It is the industrial sector which contributes the most to Climate Change. But, according to the Intergovernmental Panel on Climate Change (IPCC), it is also the sector which presents the most cost effective oppurtunities for GHG (Green House Gases) reductions. According to the Stern Review on the Economics of Climate Change, our emissions would have to be reduced by 80% compared to current levels in order not to exceed the Earth's natural capacity to remove GHG from the atmosphere. Low-Carbon buildings (LCB) are buildings designed and constructed to release very little or no carbon at all during their lifetime. These buildings are buildings which are specifically engineered with GHG reduction in mind. We studied and have presented in our current work, that the different construction practices of such environment friendly Low-Carbon buildings, its existence and Possibilities in Indian Scenerio.*

Keywords – *Low Carbon Buildings, GHG, LCBs in India, Construction methodology, Zero CO_2 Emission, Green Buildings.*

1. INTRODUCTION

Buildings are of crucial importance to mitigation of global greenhouse gas emissions, and likewise to the global demand for energy. The buildings sector contributes to approximately one-third of global final fuel and power consumption1 whilst emitting 8.1 Gt of CO_2 per year. Developed countries are primarily concerned with existing buildings while fast-developing economies such as China and India are focused on the large floor areas of new construction. By 2050 over 80% of global business-as-usual buildings' emissions (including indirect emissions from the power sector) could be avoided in low-Carbon scenarios that may limit global warming to 2°C. A range of technologies and policies offer efficient solutions to existing demands but public intervention needs to be pushed in the right direction if it is to fully deliver on the Visualization of a low-Carbon future. That this future does not look so different to the world today is an image which today's customer can buy into. Low Carbon buildings will not look or feel very different from today's buildings and people need not be concerned that they would threaten existing lifestyles.

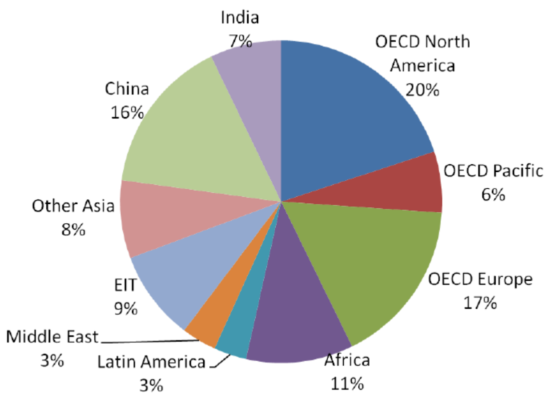


Fig 1.1: Energy Demand in the Building Sector by Country and Region

2. BUILDING'S LIFE CYCLE

Fig 2.1 Broad Phases of a building's life-cycle

The above illustration (which is broadly consistent with a similar exercise conducted by the UK Green Building Council3) takes a holistic view of the CO2 emissions across the broad areas of a building's life cycle:

- **Design:** emissions occurring from outset of a project through the process of design (energy and transport use by architects, planners and engineers, for example). However, the real scope for this sector to reduce CO2 is through the impact design makes on emissions from occupation and use.

- **Manufacture:** emissions associated with the domestic production of construction products/materials as well as emissions embodied in imported products/materials.
- **Distribution:** emissions as materials and people are transported to and from site.
- **Construction:** direct and indirect CO2 emissions (combustion and energy use) from on-site operations – but excluding refurbishment and demolition, which are accounted for separately below.
- **Operation (in use):** emissions resulting from the occupation and use of the asset, heavily influenced by occupier behavior.
- **Refurbishment/demolition:** direct and indirect emissions (again, combustion and energy use) from the process of refurbishment and from eventual demolition and disposal.

3. INNOVATIVE MEASURES FOR LOW CARBON BUILDINGS

3.1 Pre-construction and design innovations include:

- **Modelling and software tools,** which could become faster and more accurate in maximizing the use of passive design strategies;
- **Tools to identify retrofit opportunities quickly, cheaply and accurately –** measures that minimize intrusion to identify opportunities in existing buildings to improve energy performance e.g. heat cameras linked to vehicles or laser surveying tools allowing insulation panels to be pre-assembled;
- **Design tools and services** providing greater expertise and knowledge in domestic buildings and their services to complement micro-generation and district heating, to allow their integration during construction works or simplify their adoption as a future retrofit measure.

3.2 Build process innovations include:

- **Smart manufacturing processes,** e.g. off-site construction, where individual modules are pre-manufactured and assembled on-site, and modern on-site construction and manufacturing, and tighter supply chain integration;
- **Industrialized retrofit techniques,** new construction methods to reduce the cost of refurbishing existing buildings and improving the performance of refurbished buildings.

3.3 Building Operation Innovation Includes:

- **Smart controls and systems diagnostics,** predictive, intelligent householder-oriented building controls and diagnostic applications that optimize performance of building services (e.g. central heating);
- Assisting **behavioral change** by providing users with clear information, incentives and innovative tools with which to interact with buildings.

3.4 Materials and Components Innovation Includes:

- **Improved fenestration**, to improve the functional performance of windows to provide appropriate levels of light, insulation, shading and ventilation.
- **Advanced insulation products,** lighter-weight, thinner, cheaper insulation to meet the increasing standards of Part L Building Regulations and the Code for Sustainable Homes – these may include solid wall insulation or more advanced phase change and nano materials;
- **Low carbon cooling and ventilation,** a variety of technologies to service buildings with lower energy demand: natural ventilation methods, ventilation heat recovery and other techniques to replace conventional technologies and solutions.

4. LOW CARBON BUILDING MATERIALS

Low carbon building materials and products have been the subject of research and development. This has resulted in many innovative building material products through the use of by-products and recycled products. Some examples of recently developed low-carbon materials and products in the market includes the following materials.

4.1 Carbon sink building materials and products:

Bamboo products have recently received a lot of attention, due to its fast-growth, renewability and availability in both tropical and subtropical climates.

Laminated bamboo has been found to be tougher than soft steel, and the surface is harder than that of red oak timber and fiberglass.

Consequently, bamboos have been widely used in building structures, screen walls and as roofing components. Bamboo products have also found application in the high-end building market, for example, treated bamboo flooring.

Fig 4.1 Application of Carbon-sink materials in buildings

4.2 Low-carbon bricks:

These have been rolled out for mass production and implementation since 2009.

The use of 40% fly ash (Ritch, 2009) helps to reduce embodied carbon found in conventional bricks.

Fly ash is a fine glass powder that consists primarily of silica, iron and alumina. It is a byproduct of coal combustion from electricity generation and is disposed of after being separated from the flue gas.

4.3 Green concrete:

The raw materials to form conventional concrete can be substituted with byproducts of industrial processes and recycled materials.

For example, carbon intensive Portland cement can be substituted by fly ash and granulated blast-furnace slag.

Aggregate or sand can be substituted by washed copper slag, and granite by recycled granite from demolished debris.

4.4 Green tiles:

These are ceramic material made from over 55% recycled glass and other minerals.

The products turn waste glass into tiles for use in building's internal and external flooring and cladding.

The sparkling recycled glass components add an aesthetic quality to the products.

4.5 Recycled metals:

The production process of metal products is highly carbon intensive. However, the life cycle performance of metal products can significantly reduce their production energy consumption, for example, by 95% for Aluminium, 80% for lead, 75% for zinc and 70% for copper.

This is because repeatedly recycled metals can still maintain their properties (Stewart et al., 2000).

Other forms of utilizing metal products without the full recycling process (which includes re-melting the old metal products and re-molding them into new products) is to reuse existing metal structural components, such as steel columns and beams that still maintain their structural performance.

Lastly, building-unrelated metal products, such as shipping containers, can also be adaptively reused in new building projects.

Fig 4.2 Examples of Timber Construction Detail

Fig 4.3 Re-using of shipping containers in new buildings

Table 4.1 Estimated Carbon Emission Savings (Source: Ruter, 2011)

Substituted Building Components	Brick Wall	Carpet	Aluminium Window
Substituting Building Components (timber) (1 cubic meter equivalence)	Timber Stud Partition	Wooden Flooring	Wooden Window
Estimate Emission savings (1 metric tonne CO_2 Equivalence)	1.66	1.38	7.71

5. CONSTRUCTION TECHNOLOGY FOR LOW CARBON BUILDINGS IN INDIA

In the Eleventh Five-Year Plan (2007–2012), the objective of the energy efficiency R&D programme was to enable, develop, and support the testing and marketing of energy-efficient products.

The national programme focuses on the following areas: energy-efficient buildings and building components (such as low-cost insulation materials, and simulation software) and energy-efficient appliances (such as energy-efficient ceiling fans, and low-cost light emitting diodes (LED)

Table 5.1 Energy Efficient Technologies in buildings for India (Source: MoEF, India)

Technology Category	Products
Energy Efficient Envelope	- Roof and wall insulation - High performance glazing - Energy efficient masonry - Heat reflective paints - Heat reflective tiles
Efficient Lighting Systems and Control	- Energy efficient lamps and luminaires
Efficient HVAC system and Control	- High COP Chillers - Variable Speed drives in motors - Economizers - Heat recovery wheels
BEE star rated appliances	- Air Conditioners, Ceiling Fans, Frost free refrigerators, Fluorescent tube lights, Storage Water Heaters, Color televisions, LPG stoves, washing machines.

A few emerging technologies recommended by the Building Materials and Technology Promotion Council (BMTPC) for further exploration to ensure better quality products are listed below:

- Panel building system using steel mesh, polystyrene core and chipping concrete
- Technology using expanded steel mesh panels, polystyrene beads and alleviated concrete
- Pre-stressed, pre-cast, pre-fab technology using hollow core slab, beams, columns, solid walls, stairs, etc.

- Monolithic concrete technology using plastic/aluminum composite formwork
- Pre-cast concrete panels using concrete, welded mesh and plates, polystyrene core
- Industrialized 3-S system using cellular lightweight concrete slabs and pre-cast columns
- Glass fibre reinforced gypsum/rapid wall building system technology.

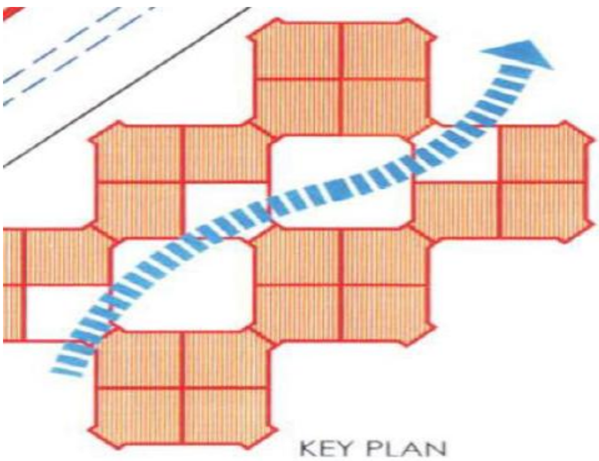
Fig 6.1 Low Carbon Building Construction in Delhi (Source: Anangpur Building Centre, 2013)

6. CASE STUDY ON CONSTRUCTION OF LCBs IN INDIA

Project Name: Relocation of illegal squatters in the southern ridge forest area of Delhi, India.

Materials and Methods:

- Low Embodied Energy: Re-used Stones in combination with engineered blocks cast onsite.
- Onsite Waste Management
- Apart from Government funding the beneficiary families were expected to contribute in terms of labor and casting of walling materials.



7. CHALLENGES & POSSIBILITIES FOR LCBs IN INDIA

7.1 Current Domestic Policies:

- **Solar Mission:** As part of its National Action Plan on Climate Change (NAPCC – see Annex II for summary), the Indian government has introduced a national Solar Mission with the goal of installing 20,000 MW of solar capacity in India by 2020.
- **Energy Efficiency Mission:** Another initiative under India's NAPCC is the National Mission for Enhanced Energy Efficiency (NMEEE). By and large respondents praised the mission and its specific policies, including building codes and the star rating system for the energy performance of appliances.

7.2 Challenges to Low Carbon Growth:

- One of the challenges cited most frequently by top Indian climate experts is the need to meet poverty reduction needs and expand access to energy services while at the same time moving India down a low carbon development growth path.
- The difficulty in adopting low carbon energy technologies is due mostly to the additional cost and in some cases technical barriers to implementation.

Table 7.1 Future Emissions Pathway (Source: McKinsey & Company in August 2009)

Factor	Unit	2005	2030 Reference Case	2030 Abatement Case
GDP Growth	Percent	-	7.5	7.5
Population	Billion	1.10	1.47	1.47
Energy Demand	Billion Tons of oil equivalent	0.5	1.8	1.4
Power Demand	Terawatt-hour	700	3870	2910
Power Capacity	Gigawatts	150	760	640
GHG Emissions	Billion tons CO_2e	1.6	5 to 6.5	2.8 to 3.6

7.3 Issues to Overcome:

- Sustainability measures should be recognized as part of building valuation, even though they may result in lower operating/energy costs.
- Rectifying Low awareness of the need to consider sustainable design solutions before higher cost technology solutions.
- Rectifying Lack of awareness among consumers and building owners of efficient building systems, large scale demonstration projects and testing capabilities.
- Rectifying Lack of user knowledge on how to assess the skills of professionals they employ.

8. CONCLUSION

India is moving in the right direction for low carbon development with strong domestic policies and international engagement. Collaboration and open stakeholder involvement from a range of fields including government, industry, academic and civil society is essential in carving out the details of the path ahead in order to ensure that the best policies are implemented to promote environmental sustainability, spur innovative businesses and meet the poverty reduction and basic access needs of India's large underserved population. In this paper, we have collectively presented the overview on 'Technology for Low Carbon Buildings as well as India's scenario towards Low carbon Building Sector in future'.

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