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Report of the sub-committee for development of National Sustainable Habitat parameters for energy efficiency in Residential and Commercial Buildings

Model Energy Efficiency Guidelines for Integration into Building Byelaws

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Preface

Construction sector is one of the key elements for economic growth, directly and indirectly. The sector (including buildings) typically provides 5-10% of employment at national level and normally generates 5-15% of GDP (UNEP, 2007). At the same time, this sector is resource consuming during the entire life cycle-right from extraction of materials to manufacturing, transportation, construction and operation of the infrastructure/building. Energy consumption in buildings gives rise, directly and indirectly, to as much as 40%[1] of CO2 emissions and represents more than a third of global consumption. The demand for energy to run appliances such as televisions, air conditioning and refrigerators is also increasing substantially with rise in living standards. This puts additional pressure on the emissions balance, which needs to be countered by achieving energy efficiency improvements. Climate change will further increase site energy demand as people shall seek to maintain comfort levels in more extreme conditions. IPCC (2007) indicates towards some potential low hanging fruits (cost-effective and easily implementable) to reduce energy consumption in buildings and thereby mitigate carbon emissions from the sector. Most of these ways have been intuitively known but for want of a clear cut implementation methodology supported with relevant legal tools and market dynamics could not be realized. Policy instruments play a very crucial role for wide-scale implementation of any program and capable of transforming market in the desired direction if implemented in an integrated manner.

Green buildings entail promotion of energy efficiency, land sustainability, water efficiency, resources efficiency and better building environment. Such buildings have minimal adverse impacts on the built and natural environment. They are designed to minimize the total environmental impact of the materials, construction, operation and deconstruction while maximizing opportunities for indoor environmental quality and performance; saving money, reducing waste, increasing worker productivity and creating healthier environment for people to live and work. A sustainable building minimizes the demand on non-renewable resources, maximizes the utilization efficiency of these resources when in use and maximizes the reuse, recycling and utilization of renewable resources. It maximizes the use of efficient building materials and construction practices; optimizes the use of on-site sources and sinks by bio-climatic architectural practices; uses minimum energy to power itself; uses efficient lighting, air-conditioning; efficient daylighting integration; maximizes the use of renewable sources of energy; uses efficient waste and water management practices; and provides comfortable and hygienic indoor working conditions. In a nutshell, such buildings look at the design, construction and operation of a building in an integrated manner.

1 Source: www.wbcsd.org

India has seen a surge of policy instruments to mainstream energy efficient buildings. Energy Conservation Act, 2001 was the landmark event which led to the setting up of Bureau of Energy efficiency. There have been efforts by Ministry of New and Renewable Energy to promote green buildings through adoption of indigenous building rating systems. Another key development in recent years has been the National Action Plan on Climate Change (NAPCC). As a response to combat the impacts of climate change, the Prime Minister's Council on Climate Change has released India's National Action Plan on Climate Change (NAPCC) on June 30, 2008. The NAPCC, along with its eight missions[2], serves as the first country-wide framework on climate change with the approval and support of the Government of India. These eight NAPCC missions map out long term and integrated strategies to achieve key national goals from the climate change perspective. One of the missions is the National Mission on Sustainable Habitat encompassing three components, viz.

1. Promoting energy efficiency in the residential and commercial sector
2. Management of municipal solid wastes, and
3. Promotion of urban public transport

In an attempt to promote energy in the residential and commercial sectors, the mission emphasises on the extension of the Energy Conservation Building Code (ECBC), use of energy efficient appliances and creation of mechanisms that would help finance demand side management. From implementation perspective, the strongest tool available in the existing institutional set up for promoting energy efficiency in the residential and commercial sector lies in 'bye-laws'. So far, the bye-laws have been developed as design guidelines for design of buildings and building systems including services with a focus on safety and comfort. An additional dimension of energy efficiency can further be introduced in these bye-laws to have a holistic approach towards sustainability. In line with this, modern Energy Efficiency guidelines have been developed to be integrated in the existing building bye-laws framework. These Energy Efficiency guidelines have been developed considering the wide variation in climatic conditions across the length and breadth of the country.

2 The eight missions of the NAPCC are:
National Solar Mission, National Mission for Enhanced Energy Efficiency, National Mission on Sustainable Habitat, National Water Mission, National Mission for Sustaining the Himalayan Ecosystem, National Mission for a Green India, National Mission for Sustainable Agriculture, and National Mission for Strategic Knowledge for Climate Change

Guidance note on Interpretation of this document –

The document has been divided into four sections viz 'Generic energy efficiency guideline', 'Climate specific energy efficiency guidelines', 'Latitude specific guidelines' and 'Best practices'.

The 'Generic Energy Efficiency Guidelines' are applicable for various categories of the building irrespective of their climate location. This section focuses on lighting, ventilation requirements, energy efficiency in lighting, HVAC systems, renewable energy utilization etc.

The 'Climate Specific Energy Efficiency Guideline' section provides guidance on thermo physical properties associated with various envelope elements such as wall, roof, windows, skylight etc. These properties vary for different climate zones so the values shall be considered for the respective climates.

In the 'Latitude Specific Guideline' section the generic solar angles, on various cardinal directions, which need to be cutdown to reduce heat gain through fenestration, have been specified. These angles have been calculated for representative cities on different latitudes and for a more specific solution solar analysis tool may be used to calculate the angles.

In addition to the above mentioned guidelines an alternative approach i.e. the "Whole Building Performance Method" has also been proposed. Its prescriptive approach in which one needs to estimate the EPI of the building and has to make sure that EPI of the proposed building complies with 3 star or above rating as developed by BEE for various building categories.

The 'best practices' section gives guidance on day lighting, selection of glazing, designing of shading devices, different roof and wall compositions to achieve ECBC recommended values, and low flow water efficient fixtures for the reference.

Model Energy Efficiency Guidelines for Integration into Building Byelaws

The model energy efficiency guidelines are divided into 3 major categories namely –

1. Generic energy efficiency guidelines (common to all climates and latitudes)
2. Climate specific energy efficiency guidelines
3. Latitude specific guidelines

It may be noted that the recommendations have been written in a guideline format and are not written in a language that make them legally binding. It is thus envisaged that a regulatory body shall suitably reword the guidelines to make them mandatorily applicable and legally binding. It may also be noted that the guidelines have been drawn upon from the ECBC 2007, NBC 2005, GRIHA guidelines, LEED guidelines and TERI's indigenous research on energy efficient /green buildings

1. General energy efficiency guidelines:

The general energy efficiency guidelines are for:

1. Lighting and ventilation (natural and mechanical)
2. Energy efficiency in lighting systems
3. Energy efficiency in HVAC systems
4. Mechanical ventilation
5. Energy efficiency in electrical systems
6. Renewable energy utilization
7. Energy efficient Envelope
8. Low flow plumbing fixtures

(I) Lighting and Ventilation requirements *(Applicable to all use premises):*

a. **Natural –**

All spaces (including first basement level beneath to the ground floor) shall have, for admission of light and air, openings, such as windows and ventilators, opening directly to the external air or into an open-to-sky courtyard. Doors shall not be counted towards the area of opening in walls for lighting and ventilation purposes.~~. Specific reference can be made of subsection 4.2 for day lighting requirements, and subsection 5.4 for natural ventilation requirements, from 'Section I, Part VIII – Lighting and Ventilation' of the National Building Code of India. The latest version of the Code shall be made use of at the time of enforcement.~~

b. **Artificial/Mechanical –**

In spaces (including basements) where the light and ventilation requirements are not met through daylight and natural ventilation, the same shall be ensured through artificial lighting and mechanical ventilation, as per 'Part VIII, Building Services Section I, Lighting and Ventilation' of the National Building Code, of India. The latest version of the Code shall be made use of at the time of enforcement.

(II) Energy Efficiency in Lighting:

Interior Lighting

1. For buildings other than residential
   a. Lamps – Lamps used for general lighting shall conform to the following
      - Point Light Source – All the point light sources installed in the building for general lighting shall be CFL or LEDs or equivalent.
      - Linear Light Source – All the linear light sources installed in the building for general lighting shall be T-5 or at least 4 Star BEE rated TFLs or equivalent
   b. The installed interior lighting power shall not exceed the LPD (lighting power density) value as recommended by ECBC 2007 (Chapter 7, section 7.3)
   c. Lighting controls shall be installed as recommended by ECBC 2007 (Chapter 7, section 7.2.1) in buildings with connected load of 100 kW or more.

   * Exemption to (a) – Spaces in the building where high bay lighting is required

2. For Residential Buildings
   a. Lamps – Lamps used for general lighting scheme shall conform to the following
      - Point Light Source – All the point light sources installed in the building for general lighting shall be CFL or LEDs or equivalent.
      - Linear Light Source – All the linear light sources installed in the building for general lighting shall be T-5 or at least 4 Star BEE rated TFLs or equivalent
   b. The installed interior lighting power shall not exceed the LPD (lighting power density) value as recommended by ECBC 2007 (Chapter 7, section 7.3)

Exterior Lighting

For Commercial, Multi-storey Residential Complexes, Group Housing Societies, Apartment complexes

a) Lamps – External lighting sources shall have minimum luminous efficacies as per the table given below

S No.	Light Source	Minimum allowable luminous efficacy (lm/W)
1	CFLs (compact fluorescent lamps)	50
2	LEDs (light emitting diodes)	50
3	Fluorescent Lamps	75
4	Metal Halide Lamps	75
5	High Pressure Sodium Vapour Lamps	90

b) The installed exterior lighting power density for the respective applications shall be in accordance with ECBC 2007 (Chapter 7, section 7.4)
c) Lighting controls shall be installed as recommended by ECBC 2007 for external lighting (Chapter 7, section 7.2.1.4)

(III) Energy Efficiency in HVAC systems design(Applicable to all use premises):-

a. Energy efficiency in HVAC system design for buildings

- The inside design conditions of a conditioned space shall conform to National Building Code 2005 (Part 8, section 3)
- The outside design conditions shall conform to National Building Code 2005 (Part 8, section 3)
- Efficiency of the equipments installed shall comply with ECBC 2007 requirement (Chapter 5, section 5.2.2)
- The distributed cooling systems (Unitary air conditioners/ Split air conditioners) shall be at least BEE 3 Star rated products.
- To avoid the conductive heat losses through piping and ductwork insulation shall be provided as recommended by ECBC 2007 (section 5.2.4)

(IV) Mechanical ventilation:

All the kitchen and bathroom spaces in a residential building shall conform to the following requirements:

a. Design exhaust systems in bathrooms and kitchen as per the requirements of ECBC 2007 highlighted in the table below:

Minimum Intermittent Exhaust flow requirements

Location	Minimum Air flow	Minimum airflow
Kitchen	For <9.3 m^2 area – 100 cfm	For >9.3 m^2 – proportionally increase - ~~volume~~volumentric flow rate
Bathroom	For <4.64 m^2 area – 50 cfm	For >4.64 m^2 – proportionally increase ~~volume~~volumetric flow rate

(V) Energy Efficiency in Electrical Systems (Applicable to all use premises):

For buildings with connected load more than 100 kW

- The power factor of the building shall be maintained above 0.95
- The transformer losses at 50% load and 100% load shall be in accordance with the conditions specified in ECBC 2007 (Chapter 8, section 8.2.1)
- The efficiency of the motors installed shall comply with ECBC 2007 requirements (Chapter 8, section8.2.2)
- The service water heating equipments and systems installed shall comply with ECBC 2007 requirements (Chapter 6, section 6.2)
- Minimum three star BEE rated appliances shall be utilized wherever BEE rating exists for such appliance category

- Lighting and plug loads shall be segregated in the wiring to the extent possible

(VI) Utilization of Renewable energy in:

1. **Lighting**

a. **Residential Buildings –**

Establishments coming under the category of multi-storey residential and group housing societies, apartment complexes shall comply with the following

- 15% of the total external lighting load shall be met through renewable energy sources (solar, wind, biomass, fuel-cells and so on)

b. **For commercial, institutional, industrial, mixed use buildings –**

Establishments coming under this category shall comply with the following

- 5% of the total lighting load shall be met through renewable energy sources (solar, wind, biomass, fuel-cells and so on)

2. **Hot Water System**

Solar Water Heating Systems shall be installed to meet 20% of hot water requirement in the following categories of buildings, viz:

a. Industries where hot water is required for processing
b. Hospitals and Nursing homes including Government Hospitals.
c. Hotels, Motels and Banquets halls
d. Jail Barracks, Canteens.
e. Multistorey residential, group housing societies, apartment complexes, hostels
f. All residential buildings built on a plot of size 500 sqm and above falling within the proposed urbanisable limits of the master plan.
g. All Government buildings, Residential schools, Education Colleges, Hostels, Technical/Vocational Education institutes, District Institutes of Education and Training, Tourism Complexes and Universities etc.

(VII) Envelope ~~Controlling Air-leakage through Openings and Fenestrations:~~Performance

All the Air-conditioned spaces in a residential and non-residential shall conform to the following-

a. Air leakage for glazed swinging entrance doors and revolving doors shall not exceed 5.0 l/s-m2.
b. Air leakage for other fenestration and doors shall not exceed 2.0 l/s-m2.

(VIII) Sanitary accommodation- Low flow plumbing fixtures *(Applicable for all use premises):*

All the plumbing fixtures including toilets, faucet aerators and showerheads shall be fixed with low-flow plumbing fixtures that save substantial amounts of water compared to conventional fixtures while providing the same utility.

The quantitative standards for flow and flush values of fixtures can be taken from references such as the ‘Green Plumbing Code of India’.

(IX) Metering *(Applicable for buildings ~~all use premises~~other than residential buildings):*

Install individual metering equipment at strategic locations to monitor the energy consumption of various equipment and systems. Refer to ECBC section 8.2.4 for further details.

2. Climate specific energy efficiency guidelines for air-conditioned buildings:

The climate specific energy efficiency guidelines are classified for different climates

1. Composite/Hot & Dry/Warm & Humid has the same specifications
2. Moderate climate

(I) Composite/Hot & Dry/Warm & Humid climates (other than residential buildings):

1. **External Wall specifications**- Thermal performance of external walls shall conform to ECBC 2007 recommendations. Typical wall constructions which comply with ECBC requirements are listed in the Schedule on wall specifications.

Wall assembly U-factor requirements as per ECBC 2007

Climate zone	24-Hour use buildings Hospitals, Hotels, Call centres etc.	Daytime use buildings Other building Types
	Maximum U-factor of the overall assembly (W/m^2K)	**Maximum U-factor of the overall assembly(W/m^2K)**
Composite/Hot & Dry/Warm & Humid	0.44	0.44

2. **Roof specifications:** Roof shall conform to the ECBC 2007 requirements. Typical roof constructions which comply with ECBC requirements are listed in the Schedule on roof specifications

Roof assembly U-factor requirements as per ECBC 2007

Climate zone	24-Hour use buildings Hospitals, Hotels, Call centres etc.	Daytime use buildings Other building Types
	Maximum U-factor of the overall assembly (W/m2K)	**Maximum U-factor of the overall assembly(W/m2K)**
Composite/Hot & Dry/Warm & Humid	0.261	0.409

Note:

1. Over-deck insulation if provided needs to be treated with proper water proofing treatment ensuring no water ingress into the insulation.
2. In association with insulation, cool roof as prescribed in 4.3.1.1 ECBC 2007 can also be used, to partially reduce insulation costs.
3. ~~Projects can also combine vegetated Green Roof in association with insulation, in order to positively affect the micro climate around the building.~~

3. **Windows -** *Windows as per ECBC requirement shall conform to the following:*
    a. The U-factor (overall heat transfer coefficient) for a fenestration product (including the sash and frame) shall be determined as per ECBC 2007 requirements.
    b. The SHGC (solar heat gain coefficient) for a fenestration product (including the sash and frame) shall be determined as per ECBC 2007 requirements.
    c. The U-factor and SHGC for the fenestration product determined as per §1 and §2, shall conform to the ECBC 2007 recommended values given in the table below for vertical fenestrations.

Vertical Fenestration U-factor and SHGC Requirements as per Energy Conservation Building Code (U-factor in W/m2K)

Climate	Maximum U-factor (W/m^2-K)	Maximum SHGC for WWR ≤ 40%	Maximum SHGC for 40%<WWR≤60%
Composite/Hot & Dry/Warm & Humid	3.30	0.25	0.20

    d. Lower SHGC can be achieved either through selection of high performance glass or through combination of glass and external shading devices. The methodology to design external shading devices is described in Schedule on window design

4. **Skylights –** *The U-factor*(overall heat transfer coefficient) *and SHGC* (solar heat gain coefficient) shall be determined as per the ECBC 2007 recommended values given in the table below for skylights

Skylight U-factor and SHGC Requirements as per Energy Conservation Building Code (U-factor in W/m2K)

Climate	Maximum U-factor (W/m^2-K)		Maximum SHGC	
	With curb	Without curb	0-2% SRR	2.1-5% SRR
Composite/Hot & Dry/Warm & Humid	11.24	7.71	0.40	0.25

Note: SRR is the total skylight area of the roof to the gross exterior roof

(II) Moderate climate (other than residential buildings):

1. **External Wall specifications**- Thermal performance of external walls shall conform to ECBC 2007 recommendations. Typical wall constructions which comply with ECBC requirements are listed in the Schedule on wall specifications.

Wall assembly U-factor requirements as per ECBC 2007

Climate zone	24-Hour use buildings Hospitals, Hotels, Call centres etc.	Daytime use buildings Other building Types
	Maximum U-factor of the overall assembly (W/m^2K)	Maximum U-factor of the overall assembly(W/m^2K)
Moderate	0.44	0.44

2. **Roof specifications:** Roof shall conform to the ECBC 2007 requirements. Typical roof constructions which comply with ECBC requirements are listed in the Schedule on roof specifications

Roof assembly U-factor requirements as per ECBC 2007

Climate zone	24-Hour use buildings Hospitals, Hotels, Call centres etc.	Daytime use buildings Other building Types
	Maximum U-factor of the overall assembly (W/m2K)	**Maximum U-factor of the overall assembly(W/m2K)**
Moderate	0.409	0.409

Note:

1. Over-deck insulation if provided needs to be treated with proper water proofing treatment ensuring no water ingress into the insulation.
2. In association with insulation, cool roof as prescribed in 4.3.1.1 ECBC 2007 can also be used, to partially reduce insulation costs.
3. ~~Projects can also combine vegetated Green Roof in association with insulation, in order to positively affect the micro climate around the building.~~

3. **Windows -** *Windows as per ECBC requirement shall conform to the following:*

a. The U-factor (overall heat transfer coefficient) for a fenestration product (including the sash and frame) shall be determined as per ECBC 2007 requirements.

b. The SHGC (solar heat gain coefficient) for a fenestration product (including the sash and frame) shall be determined as per ECBC 2007 requirements.

c. The U-factor and SHGC for the fenestration product determined as per §1 and §2, shall conform to the ECBC 2007 recommended values given in the table below for vertical fenestrations.

Vertical Fenestration U-factor and SHGC Requirements as per Energy Conservation Building Code (U-factor in W/m2K)

Climate	Maximum U-factor (W/m^2-K)	Maximum SHGC for WWR ≤ 40%	Maximum SHGC for 40%<WWR≤60%
Moderate	6.90	0.40	0.30

d. Lower SHGC can be achieved either through selection of high performance glass or through combination of glass and external shading devices. The methodology to design external shading devices is described in Schedule on window design

4. **Skylights –** *The U-factor*(overall heat transfer coefficient) *and SHGC* (solar heat gain coefficient) shall be determined as per the ECBC 2007 recommended values given in the table below for skylights

Skylight U-factor and SHGC Requirements as per Energy Conservation Building Code (U-factor in W/m2K)

Climate	**Maximum U-factor (W/m^2-K)**		**Maximum SHGC**	
	With curb	**Without curb**	**0-2% SRR**	**2.1-5% SRR**
Moderate climate	11.24	7.71	0.61	0.40

Note: SRR is the total skylight area of the roof to the gross exterior roof

3. Latitude specific guidelines: Shading design for various latitudes

Apart from the above mentioned climate specific guidelines on window design, the shading design can also be designed based on the latitude of a city. The following tables provide critical solar angles on various cardinal directions to be cut through horizontal, vertical or combination of these two as shading devices so as to reduce direct solar radiation gain in a space. While designing shading devices for a building, in a particular city, the critical angles may be taken for the city having nearest latitude to the below mentioned or for a more precise solution, can be calculated with the help of solar analysis tools .

1. Latitude at 10°

City			
Tiruchirapalli			
Latitude	**10.8**		
Longitude	**78.7**		
Solar Angles to be cut on various cardinal directions			
Cardinal Directions	**Date**	**HSA (Horizontal Sun Angle) Degree**	**VSA (Vertical Solar Angle) Degree**
North	June 2nd	66	78
East	April 30th	-	50
West	April 30th	-	50
South	February 15th	-45	65
North-East	April 30th	40	50
North-West	April 30th	-	58
South-East	April 30th	-	60
South-West	April 30th	50	60

2. Latitude at 15°

City			
Belgaum			
Latitude	**15.5**		
Longitude	**74.3**		
Solar Angles to be cut on various cardinal directions			
Cardinal Directions	**Date**	**HSA (Horizontal Sun Angle) Degree**	**VSA (Vertical Solar Angle) Degree**
North	June 8th	70	82
East	April 9th	-	44
West	April 9th	-	54
South	March 2nd	-50	66
North-East	April 9th	49	53
North-West	April 9th	-	62
South-East	April 9th	-	50
South-West	April 9th	36	59

3. Latitude at 20°

City			
Bhubneshwar			
Latitude	**20.2**		
Longitude	**85.8**		
Solar Angles to be cut on various cardinal directions			
Cardinal Directions	**Date**	**HSA (Horizontal Sun Angle) Degree**	**VSA (Vertical Solar Angle) Degree**
North		-	-
East	June 6th	-	56
West	June 6th	-	46
South	March 21st	-57	70
North-East	June 6th	34	57
North-West	June 6th	-	50
South-East	June 6th	-	66
South-West	June 6th	57	61

4. Latitude at 25°

City			
Allahabad			
Latitude	**25.5**		
Longitude	**81.7**		
Solar Angles to be cut on various cardinal directions			
Cardinal Directions	**Date**	**HSA (Horizontal Sun Angle) Degree**	**VSA (Vertical Solar Angle) Degree**
North		-	-
East	June 11th	-	55
West	June 11th	-	50
South	April 4th	-53	70
North-East	June 11th	41	62
North-West	June 11th	-	57
South-East	June 11th	-	63
South-West	June 11th	51	62

5. Latitude at 30°

City			
Dehradoon			
Latitude	30.3		
Longitude	78.0		
Solar Angles to be cut on various cardinal directions			
Cardinal Directions	Date	HSA (Horizontal Sun Angle) Degree	VSA (Vertical Solar Angle) Degree
North		-	-
East	June 16th	-	52
West	June 16th	-	50
South	April 16th	-56	70
North-East	June 16th	43	58
North-West	June 16th	-	60
South-East	June 16th	-	58
South-West	June 16th	46	62

Example of window design

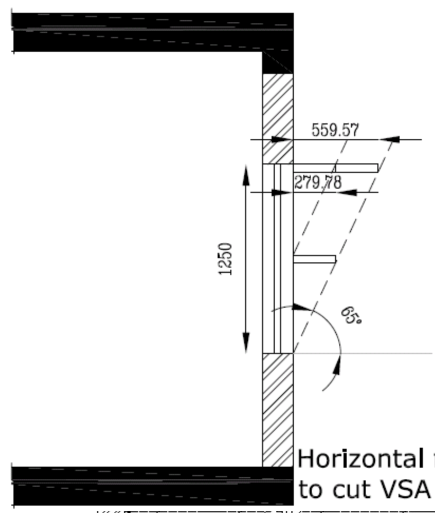
A sample shading design for latitude 10° is shown below. The shading for other cities in the subsequent latitudes can be done using the same methodology.

Example to design a shading device for a window:

For a window of height 1.25 m and width 3m, design shading device has to be designed to cut HSA of -45° and VSA of 65° for south orientation (From the above table).

Design of shading device to cut the VSA

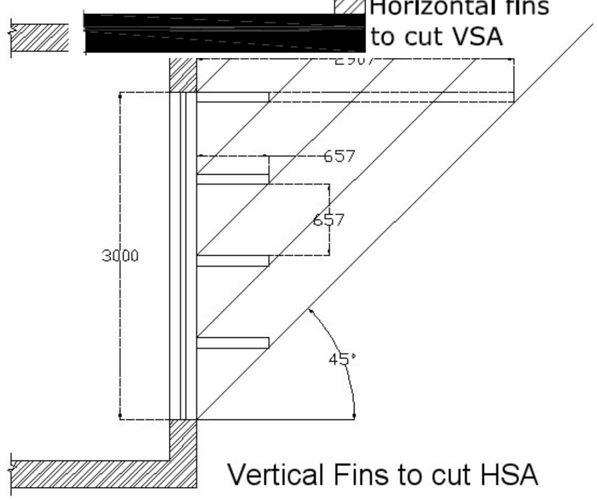
- ✓ The vertical solar angle of 65° can be cut by providing a single horizontal overhang of length 559mm or it can be cut by providing three horizontal projections each of length 279mm placed at a distance of 600mm as shown in the figure.
- ✓ The length and spacing can be calculated either by the drafting softwares like Auto-cad, sketchup etc. by graphical method or it can be manually calculated by the mathematical formula given below –



Horizontal fins to cut VSA

Depth of shading device = Spacing between the shading device x {tan (90 -VSA)}

For a given VSA either of the values for Depth or Spacing between shading overhangs can be selected to get the value of other one.



Vertical Fins to cut HSA

Design of shading device to cut the HSA

- ✓ The horizontal solar angle of 45° can be cut by providing a single vertical fin of length 2907mm or it can be cut by providing four vertical fins each of length 657mm placed at a distance of 657mm as shown in the figure.
- ✓ The length and spacing can be calculated either by the drafting softwares like auto-cad, sketchup etc. by graphical method or it can be manually calculated by the mathematical formula given below –

Depth of vertical fins = Spacing between the vertical fins x {tan (90 -HSA)}

Whole Building Performance Method

The whole building performance method is an alternative approach to the requirements suggested in the various sections of the energy efficiency guidelines in the above part of this document.
Whole building energy performance method is based on computer simulation. This requires an energy modeling of the proposed design of the whole building, factoring in all the proposed ECMs (Energy Conservation Measures) to arrive at the projected overall annual energy consumption of the building.
A building shall comply with the whole building performance method when the estimated EPI (energy performance index) of the building qualifies it for getting at least 3 Star BEE rating in the respective building categories, as given in the table below, for different climates even though the building may not comply with the specific requirements mentioned in the energy efficiency guidelines. Simulations shall be carried out on the software provided by BEE.

Table – BEE Star rating for Office building

Building having more than 50 % air conditioned built-up area

Climatic Zone- Composite	
EPI(kWh/sqm/year)	**140**
Climatic Zone - Warm and Humid	
EPI(kWh/sqm/year)	**150**
Climatic Zone - Hot and Dry	
EPI(kWh/sqm/year)	**130**

Building having less than 50 % air conditioned built-up area

Climatic Zone- Composite	
EPI(kWh/sqm/year)	**60**
Climatic Zone - Warm and Humid	
EPI(kWh/sqm/year)	**65**
Climatic Zone - Hot and Dry	
EPI(kWh/sqm/year)	**55**

Table – BEE Star rating for BPO building

EPI (Energy Performance Index)	
Climatic Zone- Composite	
EPI(kWh/sqm/year)	**350**
Climatic Zone - Warm and Humid	
EPI(kWh/sqm/year)	**360**
Climatic Zone - Hot and Dry	
EPI(kWh/sqm/year)	**215**
Climatic Zone – Temperate	
EPI(kWh/sqm/year)	**300**

AAhEPI (Average annual hourly EPI)	
Climatic Zone- Composite	
AAhEPI(Wh/hr/sqm)	**35**
Climatic Zone - Warm and Humid	
AAhEPI(Wh/hr/sqm)	**40**
Climatic Zone - Hot and Dry	
AAhEPI(Wh/hr/sqm)	**25**
Climatic Zone - Temperate	
AAhEPI(Wh/hr/sqm)	**30**

EPI values provided here have been calculated considering the total built-up area excluding the parking area of the building. Also the energy considered here includes grid supplied, DG generated power only and energy generated through renewable energy sources is excluded.

Note – As BPO is distinct from other office buildings in terms of the building usage pattern, such as the facility can be 24x7, 24x5, 18x7, 18x5, 16x7, 16x5 hours operational, the AAhEPI(average annual hourly EPI) shall be calculated for the respective building to compare with the benchmark. Given below is the formula for calculate AAhEPI

$$\text{AAhEPI (Wh/hr/sqm)} = \frac{\text{EPI x 1000}}{\text{Daily hrs of operation x days of operation in week x 52 weeks in a year}}$$

SCHEDULE

OPTIMISATION OF WINDOW DESIGN (for AC and Non AC spaces)

This a good practice guideline and can be annexed with the bye law

For Air-conditioned buildings

1. The U-factor (overall heat transfer coefficient) for a fenestration product (including the sash and frame) shall be determined as per ECBC 2007 requirements.
2. The SHGC (solar heat gain coefficient) for a fenestration product (including the sash and frame) shall be determined as per ECBC 2007 requirements.
3. The U-factor and SHGC for the fenestration product determined as per §1 and §2, shall conform to the ECBC 2007 recommended values given in the table 1 below for vertical fenestrations –

```For vertical fenestration as recommended in Energy Conservation Building Code (ECBC), 2007

| Climate | Maximum U-factor ($W/m^2$-K) | Maximum SHGC for WWR ≤ 40% | Maximum SHGC for 40%<WWR≤60% |
|---|---|---|---|
| Composite | 3.30 | 0.25 | 0.20 |

4. Lower SHGC can be achieved either through selection of high performance glass or through combination of glass and external shading devices. There are two methodologies to design external shading devices which are explained below.
5. Methodology 1 : In Air conditioned buildings

In Air conditioned buildings shading devices can be designed using the ECBC guidelines. ECBC recommends the following method for designing shading devices:

(a) Overhangs and /or fins may be applied in determining the SHGC for the proposed design.

(b) An adjusted SHGC, accounting for overhangs and/or side fins, is calculated by multiplying the SHGC of the unshaded fenestration product times a Multiplication (M) factor. The 'M' factor can be read from the table below:

SHGC "M" Factor Adjustments for Overhangs and Fins as per ECBC requirements

| | | Overhand "M" Factors for 4 projection Factors | | | | Vertical Fin "M" Factors for 4 Projection Factors | | | | Overhang + Fin "M" Factors for 4 Projection Factors | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Project Location | Orientation | 0.25 - 0.49 | 0.50 - 0.74 | 0.75-0.99 | 1.00 + | 0.25-0.49 | 0.50 - 0.74 | 0.75 - 0.99 | 1.00 + | 0.25 - 0.49 | 0.50 - 0.74 | 0.75–0.99 | 1.00 + |
| North latitude $15^0$ or greater | N | .88 | .80 | .76 | .73 | .74 | .67 | .58 | .52 | .64 | .51 | .39 | .31 |
| | E/W | .79 | .65 | .56 | .50 | .80 | .72 | .65 | .60 | .60 | .39 | .24 | .16 |
| | S | .79 | .64 | .52 | .43 | .79 | .69 | .60 | .56 | .60 | .33 | .10 | .02 |
| Less | N | .83 | .74 | .69 | .66 | .73 | .65 | .57 | .50 | .59 | .44 | .32 | .23 |
```

than 15^0	E/W	.80	.67	.59	.53	.80	.72	.63	.58	.61	.41	.26	.16
North latitude	S	.78	.62	.55	.50	.74	.65	.57	.50	.53	.30	.12	.04

(c) For better understanding, consider the following example explained step by step for designing shading design in the south orientation.

Step 1

1. Calculate the Window Wall Ratio (WWR) of the orientation.
2. In this example WWR of 30%.

Step 2

1. Locate the Orientation of the fenestration to which the façade is facing. In this example, South orientation is considered
2. Select a glass and obtain the thermal performance properties from the manufacturer. In this example, glass with SHGC of 0.41 is considered.
3. Depending upon the latitude of the city, find out the Multiplication factor required to achieve ECBC recommended SHGC. For example, on South orientation, SHGC of glass is 0.41, but the required SHGC as per ECBC is 0.25 for WWR 30%. The above required SHGC can be calculated by multiplying the glass SHGC with the multiplication factor. So Multiplication Factor required is: M = Required SHGC/SHGC of glass. In this case it is 0.25 / 0.41 which is 0.60. Tiruchurapalli falls under latitude below 15deg., thus 0.62Multiplication Factor for south orientation will be selected.
4. Refer Table above (as per ECBC) to find out the Projection factor required to achieve the calculated M and accordingly design the overhang. In this case the projection factor is 0.50 (from the above table)

Step-3

1. Projection factor (PF)= Depth of the overhang/height of the window. Considering the height of the window as 1.25m, and Projection factor (P) required is 0.50 (from step 4), Depth of the over hang = 1.25 x 0.50
   = 0.625m
2. So 0.625m is the depth of the overhang (Horizontal shading device) is required to achieve an adjusted SHGC of 0.25 on South orientation.

Best practice guidelines:

Apart from the above mentioned 3 categories of guidelines there are few best practice guidelines and certificates which are common to all climates and latitudes. These are:

1. Day-lighting
2. Wall Thermal specifications as per ECBC requirements
3. Roof Thermal specifications as per ECBC requirements
4. Low flow plumbing fixtures

Day lighting

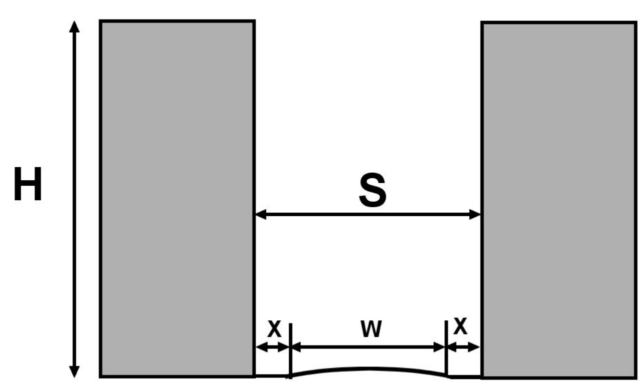
Day-Lighting in Office and Residential Buildings –
It should be noted that all the recommendations in this section of day-lighting are indicative only. Several parameters such as projection over windows, the window frame area or the reflectance values can vary on a case to case basis. So a detailed analysis should be carried out for estimation of daylight availability in such cases.

Case I - When there are surrounding obstruction (other buildings) to a Building –
This is the most commonly occurring case in an urban scenario where every building is surrounded by other buildings. In such cases the day-light received through the fenestration in a space is quite affected by various factors such as height and distance of adjacent building, continuity of the buildings (width of the buildings), geometry of the adjacent building, the reflectance values of the external surfaces opposite to the window etc.
To study the impact of surrounding building on day-lighting, analysis has been carried out to understand impact of a few definitive parameters such as Height, Separation, Window Wall Ratio, and Visible Light Transmittance of Glass for two adjacent buildings in two different settings. In one scenario the building at the daylight receiving end is an office building and the other one considered is a residential building.

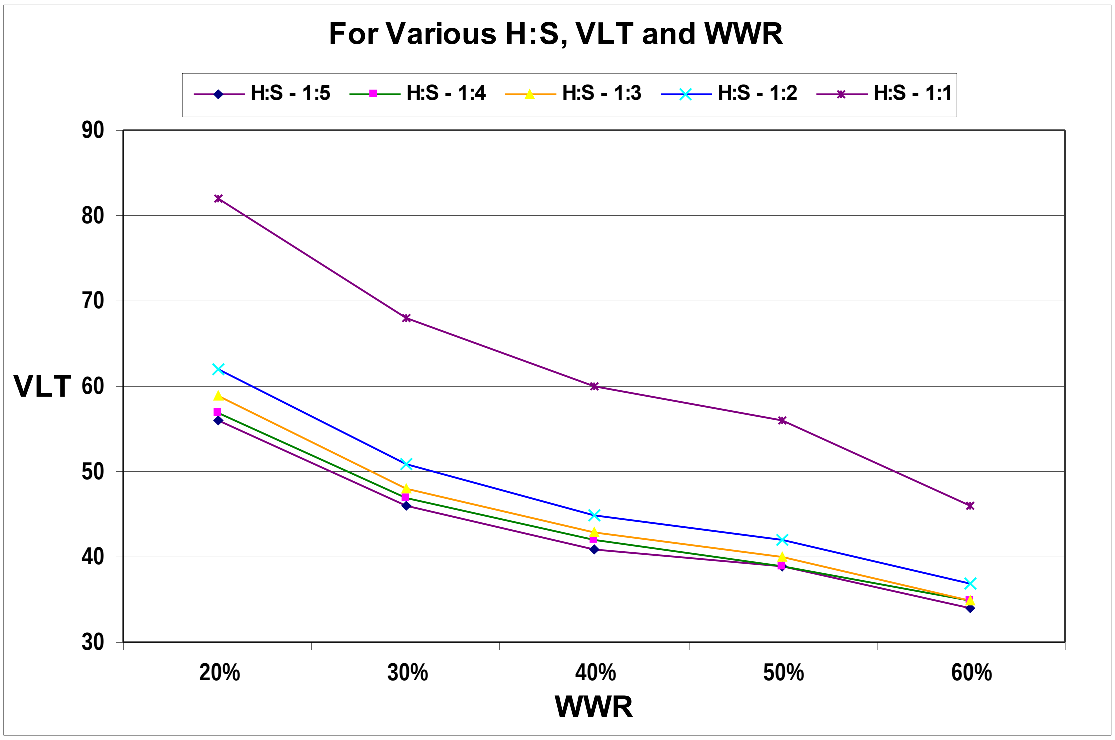
Office Building with surrounding obstructions (buildings) -

Correlation between Height, Separation, WWR (window wall ratio) and VLT (visible light transmittance) for two buildings to achieve required daylight in spaces –

As per the figure shown here
H = Height of the building
W = Width of the road
X = Setback on both side
S = Separation between two buildings i.e.
S = W + 2X



To achieve adequate daylight (required daylight factor as mentioned in SP41, at the centre of daylighted zone as defined in ECBC 2007, in a space situated on ground floor) in '**air-conditioned office type of space**' the WWR and required VLT with respect to various H/S ratios should be read from the graph given below -



Example explaining the above graph – If two buildings are located such that the H:S is 1:2, then to achieve the adequate daylight in a space having 60% WWR one need to provide a glass of VLT around 37% or for the same H:S as 1:2 and for a glass of VLT around 45% the WWR around 40% will be required for adequate daylighting.

In the above graph various VLTs have been considered as in the air-conditioned office spaces we usually find the glasses are having different light transmittances. If the building is non conditioned, in that scenario, for a particular H:S ratio and corresponding WWR, one will quite easily achieve the adequate daylighting as in non conditioned building windows will be opened for admission of outside air and hence at the same time the amount of daylight entering through fenestration will be more as compared to a closed window with certain value of VLT for the glass.

Residential building with surrounding obstructions (buildings) –

To achieve adequate daylight in 'non-conditioned residential spaces' where clear glass is installed the WWR required with respect to various H/S ratios should be read from the table given below –

H/S ratios (height to separation between buildings)	Minimum WWR (%)Required for adequate day lighting
1:5	10
1:4	10
1:3	10
1:2	20
1:1	20
2:1	50
3:1	60

Case II - When there are no surrounding obstructions (other buildings) to a Building –

When the buildings are quite far from each other (when H/S ratio is more than 1:3, as mentioned in Part VIII section 4.4.3 NBC 2005) a window can be considered as a non obstructed window. For such cases one can provide the combination of WWR and VLT of glass so as to achieve adequate daylight (daylight factors at the centre of daylight zone) in an office space as per the table given below

Relation between WWR and VLT to achieve recommended daylight factors in an office space

Daylight Factors at the Centre of the day lit zone of composite climate zone										
Visual Light Transmittance of Glass (%)	DF for WWR 10%	DF for WWR 20%	DF for WWR 30%	DF for WWR 40%	DF for WWR 50%	DF for WWR 60%	DF for WWR 70%	DF for WWR 80%	DF for WWR 90%	DF for WWR 100%
10	0.3	0.5	0.6	0.7	0.8	0.8	0.9	0.9	0.9	0.9
20	0.6	1.0	1.2	1.4	1.5	1.7	1.7	1.8	1.8	1.9
30	1.0	1.6	1.8	2.1	2.3	2.5	2.6	2.7	2.7	2.8
40	1.2	2.1	2.4	2.8	3.1	3.3	3.4	3.6	3.6	3.7
50	1.5	2.6	3.1	3.5	3.8	4.1	4.3	4.5	4.5	4.6
60	1.9	3.1	3.7	4.2	4.5	5.0	5.2	5.4	5.4	5.6

Note: Design sky conditions as per NBC 2005

1. Outside design sky illuminance considered is 8,000 lux
2. 1 DF in above table is equivalent to 80 lux
3. To convert these DF values for different climates for which NBC suggest different outside illuminance levels one can use the following formula for conversion –

Design sky illuminance recommended for the particular climate in NBC

Converted DF =

DF value read from above table X 8000

4. Recommended design sky illuminance as given in NBC 2005 for different climates are as below –
    1. Hot & Dry – 10,500 lux
    2. Warm & Humid – 9000 lux
    3. Composite – 8000 lux
    4. Temperate – 9000 lux
    5. Cold – 6800 lux
5. Example to convert DF for respective climates from the above give table –

For WWR 20% and VLT as 40% the DF value given in the above table is 2.1. To convert this value for cold climate the formula can be written as

6800

Converted DF =

2.1 X 8000

= 2.47

Wall Thermal Specifications as per ECBC requirements

The typical wall constructions that comply with the ECBC requirements are given below-

Double brick wall:

Material/Construction	U-factor (W/m^2-ºC)
Double brick wall with extruded polystyrene 2.4"-32kg/m3	0.38
Double brick wall with extruded polystyrene 3"-32kg/m3	0.31
Double brick wall with expanded polystyrene (thermocol) 3"-24kg/m^3	0.41
Double brick wall with phenolic foam 2.4"-32kg/m^3	0.37
Double brick wall with phenolic foam 3"-32kg/m^3	0.30
Double brick wall with Polyurethane 2.4"-32 +2 kg/m^3	0.33
Double brick wall with Polyurethane 3"-32 +2 kg/m^3	0.27
Double brick wall with Polyisocyanurate slab 2.4"-32 +2 kg/m^3	0.33
Double brick wall with Polyisocyanurate slab 3"-32 +2 kg/m^3	0.27
Double brick wall with Bonded Mineral Wool (Rock or glass wool) 2.4"-64 kg/m^3	0.43
Double brick wall with Bonded Mineral Wool (Rock or glass wool) 3"-64 kg/m^3	0.35

Single brick wall:

Material/Construction	U-factor (W/m^2-ºC)
Single brick wall with 2.4"extruded polystyrene insulation between gypboard and external brick wall 32kg/m3	0.36
Single brick wall with 3"extruded polystyrene insulation between gypboard and external brick wall 32kg/m3	0.30
Single brick wall with 2.4"phenolic foam insulation between gypboard and external brick wall 32kg/m3	0.35
Single brick wall with 3"phenolic foam insulation between	0.32

Material/Construction	U-factor (W/m^2-ºC)
gypboard and external brick wall 32kg/m3	
Single brick wall with 2.4"Polyisocyanurate slab insulation between gypboard and external brick wall 32 +2kg/m3	0.34
Single brick wall with 3"Polyisocyanurate slab insulation between gypboard and external brick wall 32 +2kg/m3	0.28
Single brick wall with 2.4"Bonded Mineral wool (Rock wool or glass wool) insulation between gypboard and external brick wall 64kg/m3	0.40
Single brick wall with 3" Mineral wool (Rock wool or glass wool) insulation between gypboard and external brick wall 64kg/m3	0.34

Roof Thermal Specifications as per ECBC requirements

For air-conditioned buildings

The typical roof constructions that comply with the ECBC requirements in air-conditioned buildings are given below-

Material/Construction	U-factor (W/m^2-ºC)
Foam concrete or perilite instead of mud phuska	0.069
RCC slab with extruded polystyrene 2.4"-36kg/m3	0.380
RCC slab with extruded polystyrene 3"-36kg/m3	0.312
RCC slab with expanded polystyrene (thermocol) 3"-24kg/m3	0.409
RCC slab with Phenolic foam 2.4"-32kg/m3	0.363
RCC slab with Phenolic foam 3"-32kg/m3	0.301
RCC slab with Polyurethane spray 2.4"-42 ± 2kg/m3	0.319
RCC slab with Polyisocyanurate spray 2.4"-42 ± 2kg/m3	0.329
RCC slab with Polyisocyanurate spray 3"-42 ± 2kg/m3	0.267

In roofs, the U-factor for the overall assemblies or minimum R-values for the insulation must be complied with the provisions of the Code.

Low flow water efficient fixtures

Use of efficient plumbing fixtures, sensors, auto valves, pressure reducing device wherever possible can result in significant reduction in water consumption. As per MoEF guidelines, water reduction can be achieved upto 36% using water conserving fittings as

Water closets (WCs):

- ✓ Conventional toilets use 9 litres of water per flush. Low flush toilets are available with flow rate of 6.0 litres and 3.0 litres of water per flush.
- ✓ Dual flush adapters can be used for standard flushing for solid waste and a modified small flush for liquid waste
- ✓ Flush valves with 20-25 mm inlets can be used for restricting the water flow

WC faucets, wash basin taps, and kitchen taps:

- ✓ Faucets and taps can have flow rates upto 25 litre/min. The flow rate can be reduced without compromising on the water pressure by having restrictors, pressure inhibitors and aerators. Auto control valves can further help in reducing wastage.
- ✓ Pressure reducing device: Aerators and pressure inhibitors for constant flow. Use of aerators can result in flow rates as low as 2 litre/min, which is adequate for hand washing purpose. Installation of flow regulators may be done where the aerators cannot be installed.
- ✓ Auto control valves: Installation of magic eye solenoid valve (self-operating valve) can result in water savings. The sensor taps has automatic on and off flow control. It functions with parameters such as distance and timing.

Urinals:

- ✓ The conventional urinals use water at a rate of 7.5-11 litres per flush.
- ✓ Low flush urinals use only 2 litre/flush
- ✓ Use of electronic flushing system or magic eye sensor can further reduce the flow of water to 0.4 litres per flush
- ✓ Waterless urinals use no water

Shower heads:

- ✓ Conventional showerheads can deliver water at flow rates above 25litres/min.
- ✓ A perfectly pleasant shower can however, be obtained with flow rates well below 10 litres/min
- ✓ Shower heads fitted with aerators and pressure regulators can reduce flow rates as low as 4.5litrs/min and their use will show a significant saving.

Mandating of Certification for Energy Performance of Buildings

The total share of electricity consumption by domestic sector and commercial buildings is about 30%. Commercial building and establishment sector is an energy intensive sector and has also been included as a "designated consumer" under the Energy Conservation Act (2001) but so far has not been notified. Air-conditioning and lighting are two most energy consuming end-uses in the building sector. Modern office buildings in newly developed areas enable higher quality standards of working conditions that are essential for sectors like IT, Financial services etc from the point of view of attracting customers as well as employees. However, the energy performance index (EPI) of such spaces ranges from 200 to 400 kWh/sq m/year whereas similar buildings in developed nations have EPI of less than 150 kWh/sq m/year.

It is critical that policy interventions are essential to improve energy efficiency in both new construction as well as existing buildings. There are a number of measures such as building codes, policy interventions, labeling/rating systems, appliance standards, etc to streamline efforts to promote energy efficiency in the buildings sector. Building rating systems are a popular tool to add momentum in achieving energy efficiency in buildings. These help in assessing the level of performance of the building and provide opportunities in reducing the O&M costs of the building besides creating a market pull towards environmentally sustainable buildings.

In order to enable rapid transformation towards energy efficiency in buildings, policies and measures that create a "supply push" (such as codes and standards) need to be supplemented by policies and measures that simultaneously create a "demand pull" as well. This "demand pull" attracts building users towards energy efficient buildings, and thus create a preferential market demand. On the "supply push" side, the Government of India has developed the Energy Conservation Building Code (ECBC) which provides minimum energy performance standards for energy efficient commercial buildings with a connected load of 100 kW and above. The ECBC is currently a voluntary programme, with a number of states adopting it as a mandatory requirement.

There are a few building codes and building rating systems prevailing in India that have been developed by different organizations for ensuring energy efficiency and sustainable buildings. The Ministry of Environment and Forest (MoEF) undertakes the Environment Impact Assessment and Clearance (EIA) for large building and construction projects (Ministry of Environment and Forest, 2007). Builders and developers need to obtain an EIA clearance before construction. As per the stipulations any building and construction project, with built up area 20,000 – 150,000 m2, require EIA clearance from the Ministry of Environment and Forests, Central Government. While all township and area development projects covering more than 50 ha and built up area more than 150,000 square meters in the states are required to get environment clearance from the State Environment Impact Assessment Authority before any construction work is started on the project.

After the introduction of ECBC, MoEF has started requiring ECBC compliance while undertaking EIA for all building and construction projects falling under their purview.
Similar to the LEED rating system, developed by the U.S. Green Building Council (USGBC), the LEED-India promotes a whole-building approach to sustainability by addressing performance in the following five areas: (1) sustainable site development, (2) water savings, (3) energy efficiency, (4) materials selection and (5) indoor environmental quality. LEED-India rated buildings meet the specifications of ECBC 2007, NBC 2005, MoEF guidelines, and Central Pollution Control Board norms.

GRIHA rating system has incorporated the provisions of the NBC 2005, ECBC, and other Indian Standard codes. In 2008, GRIHA has been launched by the Ministry of New and Renewable Energy, the Government of India. Various rating systems of IGBC including LEED India are also recognised by some of the State Governments for incentives and clearances. Rating systems of IGBC also have referenced various Indian codes, where applicable

Similarly, the Bureau of Energy Efficiency developed a Star rating programme for buildings which is based on the actual performance of a building in terms of its specific energy usage in kwh/sqm/year. The programme rates office buildings on a 1-5 Star scale, with 5 Star labeled buildings being the most efficient. Various categories of buildings such as office buildings (day use and BPOs), Shopping Malls, Hotels, Hospitals and IT parks in the five climatic zones have been identified under the scheme.
In summary, ECBC has been developed as India's first building energy code that focuses specifically on the compliance of minimum energy efficiency standards for commercial buildings. Both LEED and GRIHA rating systems have adopted ECBC as a minimum compliance requirement. It is expected that GRIHA and LEED-India voluntary rating systems will eventually be integrated into the ECBC, once it is made mandatory by the Government of India.