Partnership to Advance Clean Energy-Deployment (PACE-D)
Technical Assistance Program

Regional Expert Consultation Workshop
Mumbai

Jan 12, 2016

This is a DRAFT presentation on ECBC update process and Progress. This is a confidential document and is for stakeholder review and comments only.

Please use the shared/uploaded template only to provide comments and feedback. The template is also attached in the last slides for your reference.
Presentation Overview

1. Session – 1 – Process and Methodology
2. Session – 2 – Administration and Compliance
3. Session – 3 – Building Envelope
4. Session – 4 – Lighting and Controls
5. Session – 5 – Comfort Systems and Controls
6. Session – 6 – Electrical and Renewable
7. Session – 7 – Discussion and Way forward

Expected outcome of the meetings

1. Finalized code vision, scope, and update methodology
2. Comments on the overall ECBC update process and progress
   - baseline and stringency analysis
3. Feedback on the update ECBC code recommendations
4. Consensus on the code stringency as per the market standard
5. Region specific comments
ECBC 2016 Recommendations

Presentation Overview

1. Session – 1 – Process and Methodology
2. Session – 2 – Administration and Compliance
3. Session – 3 – Building Envelope
4. Session – 4 – Lighting and Controls
5. Session – 5 – Comfort Systems and Controls
6. Session – 6 – Electrical and Renewable
7. Session – 7 – Discussion and Way forward
Expected outcome of the meetings

1. Finalized code vision, scope, and update methodology
2. Comments on the overall ECBC update process and progress
   - baseline and stringency analysis
3. Feedback on the update ECBC code recommendations
4. General awareness
5. Consensus on the code stringency as per the market standard
6. Regional and national specific comments

Session - 1

Process and Methodology
Vision

1. In the 12th Plan, ECBC update is a priority area for BEE
2. Reference code for future – nearly zero energy buildings
3. Mandatory implementation and enforcement of ECBC
4. Response to the technological advancement and integrate market changes
5. Response to the current and projected energy scenario of India

Key objectives

1. Establish a baseline of energy performance
2. Address different building types in various climatic zones
3. Integrate the use of renewable energy
4. Integrate other government policy standards into ECBC (S&L program, building Star rating, PPAT program, appliance star rating etc)
5. Focus to passive strategies – low energy comfort systems, day lighting, natural ventilation
ECBC update committee structure

ECBC Steering Committee
Chair: Director General (DG), BEE,
Convener: Energy Economist (EE), BEE
Members: USAID, UNDP, MNRE, MOUD, SDAs, BIS, IGBC & ADaRSH/ GRIHA

1: Administration and Compliance working group
2: Building Envelope working group
3: Comfort systems and controls working group
4: Lighting & Controls working group
5: Electrical & Renewable working group

ECBC Technical Committee
Chair: Energy Economist (EE), BEE
Convener: Asst. Energy Economist (AEE), BEE
Members: Chair of the individual technical Working Groups
Building sector Stakeholders: BIS, CPWD, Indian Railways, MES, SDAs, CREDAI, Builder community, Bilateral and NGO Organization

Role of the Committees

Steering Committee
• Steer the whole process imperative for further development and implementation of ECBC to meet the objectives of 12th plan
• Meet twice a year

Working Groups
• Identify update priorities in ECBC 2007, provide technical guidance and review each stage of code development
• Meet on a monthly basis

Technical Committee
• Review the development of ECBC from a technical perspective at each step.
• Meet on a quarterly basis
Steering Committee

Chair - Director General, Bureau of Energy Efficiency
Other members - MNRE, MoUD, BIS, CPWD, SDA, USAID, UNDP, IGBC, USGBC, GRIHA

Planned meetings –
1. Start once the draft code is ready
2. The meetings are planned in FY 2016 – 2017
3. The meetings will continue till the code is ready to be notified

Administration and Compliance

1. Chair - Mr. Sanjay Seth, Bureau of Energy Efficiency
2. Convener - Mr. Girija Shankar, Bureau of Energy Efficiency

Members
1. Mr. Srinivas Chary, Administrative Staff College of India
2. Mr. K. K. Joadder, Town & Country Planning Organization
3. Mr. C. K. Verma, Central Public Works Department
4. Mr. Sumit Sengar, Bureau of Indian Standards
5. Mr. Sunit Mathur, State Designated Agency- Rajasthan
6. Mr. C. S. Prasad, Indian Building Congress
7. Mr. C. Shekhar Reddy, CREDAI
8. Chair of all other Working Groups
Building Envelope

1. Chair - Dr. N. K. Bansal, Center for Environmental Planning & Technology
2. Convener - Mr. Girija Shankar, Bureau of Energy Efficiency

Members
1. Ar. Sanjay Prakash, SHiFt: Studio for Habitat Futures
2. Ar. Ashok B. Lall, Ashok B Lall Architects
3. Ar. Vinod Gupta, Space Design Consultants
4. Mr. Prabhakar Singh, Central Public Works Department
5. Ar. Anurag Bajpai, Green Tree
6. Dr. Rajan Rawal, Center for Environmental Planning & Technology
7. Ms. Mili Majumdar, TERI

Lighting and Controls

1. Chair - Mr. Gulshan Aghi, Indian Society of Lighting Engineers
2. Convener - Mr. Girija Shankar, Bureau of Energy Efficiency

Members
1. Late Mr. H. S. Mamak
2. Mr. Shyam Sujan, ELCOMA
3. Mr. Prabhakar Singh, Central Public Works Department
4. Mr. Rajeev Sharma, CPWD
5. Dr. S. K. Bhattacharyya, Central Building Research Institute Roorkee
6. Dr. H C Kandpal, Independent Consultant
7. Mr. Deepak Gupta, Halonix
8. Mr. H. R. Vaish, ISLE
9. Mr. P. K. Sood, ISLE
### Comfort Systems and Controls

1. **Chair** - Dr. R. S. Agarwal, Indian Institute of Technology Delhi
2. **Convener** - Mr. Girija Shankar, Bureau of Energy Efficiency

**Members**

1. Dr. Milind V Rane, Indian Institute of Technology Mumbai
2. Mr. G C Modgil, Sterling India
3. Mr. Ashwini Mehra, ISHRAE
4. Mr. Ashish Rakheja, AEON
5. Mr. R. K. Mehta, Mr. Seemant Sharma, and Mr. Rahul Garg, RAMA
6. Dr. Rajan Rawal, CEPT
7. Dr. Jyotirmay Mathur, Malaviya National Institute of Technology, Jaipur
8. Ms. Archana Walia, CLASP

### Electrical and Renewable

1. **Chair** - Dr. Bhim Singh, Indian Institute of Technology Delhi
2. **Convener** - Mr. Girija Shankar, Bureau of Energy Efficiency

**Members**

1. Mr. Vivek Arora, Indian Electrical and Electronics Manufacturers Association
2. Mr. Arun K Tripathi, Ministry of New and Renewable Energy
3. Mr. Prabhakar Singh, Central Public Works Department
4. Mr. Baldev Mamtani, International Copper Promotion Council
5. Mr. Hemanth, International Copper Promotion Council
Number of Meetings conducted for WGs –

Technical Committee
Government

1. Ministry of New and Renewable Energy (MNRE)
2. Ministry of Urban Development (MOUD)/ TCPO/ CPWD
3. All State Designated Agencies (SDAs)
4. Bureau of Indian Standards (BIS)
5. Central Building Research Institute (CBRI)
6. Building Material and Technology Promotion Council (BMTPC)

NGOs

1. GRIHA Council
2. Indian Green Building Council (IGBC)
3. Centre for Science and Environment (CSE)
4. Alliance to Save Energy (ASE)
5. Natural Resources Defense Council (NRDC)
Industry Associations

1. The Indian Institute of Architects (IIA)
2. Builders Association of India (BAI)
3. National Real Estate Development Council (NAREDCO)
4. Indian Building Congress
5. Confederation of Real Estate Developers Associations of India
6. Glazing Society of India (CSI)
7. Indian Insulation Forum (IIF)
8. Indian Glass Manufacturers Association

ECBC Update 2016
12 Jan 2016 - Mumbai

Industry Associations

1. Refrigeration and Air-Conditioning Manufacturers Association of India (RAMA)
2. Indian Society of Heating Refrigerating and Air Conditioning (ISHRAE)
3. International Fenestration Forum
4. Council of Architects (COA)
5. UPVC Doors and Windows Manufacturer Association (UWDMA)
6. Indian Society of Lighting Engineers (ISLE/ELCOMA)
7. International Copper Promotion Council (ICPCI)
8. ECBC empaneled professionals
9. ECBC master trainers

ECBC Update 2016
12 Jan 2016 - Mumbai
Academics and Research

1. Indian Institute of Technology Delhi/ Mumbai / Roorkee
2. Malaviya National Institute of Technology (MNIT)
3. Center for Environmental Planning and Technology (CEPT)
4. Indian institute of Information Technology (IIIT) – Hyderabad
5. Lawrence Berkely National Lab (LBNL)
6. Oak Ridge National Laboratory (ORNL)
7. Pacific Northwest National Lab (PNNL)
8. Devi Ahilya Vishwavidyalaya (hot water and electrical)
9. School of Planning and Architecture
10. University School of Architecture and Planning (USAP)

Bilateral and Multilateral Agencies

1. Swiss Agency for Development and Cooperation (SDC)
2. French Development Agency - Agence Française de Dévelopement (AFD)
3. Gesellschaft für Internationale Zusammenarbeit (GIZ)
4. Kreditanstalt für Wiederaufbau (KFW)
5. Shakti Sustainable Energy Foundation (SSEF)
6. Indo- EU
7. United Nations Environment Programme (UNEP)
8. United Nations Development Programme (UNDP)
Planned Meetings for Technical Committee

1. West Zone, Mumbai – Jan 12, 2016
2. South Zone, Bangalore – Jan’16 (TBD)
3. East Zone, Kolkata – Feb’16 (TBD)
4. North Zone, Delhi – Feb’16 (TBD)

ECBC Update Methodology
Key Steps

ECBC 2016

1. Update Priorities, Scope and Methodology
2. Market assessment - Baseline analysis and data collection
3. Stringency Analysis and draft recommendations
4. Draft code and Impact analysis

12 Jan 2016 - Mumbai

Working Groups
- Market Assessment
- Technical analysis
- International practices
- Expert comments

Technical committee
- Regional Workshops
- National Workshops
- Public Review

Steering Committee
- Draft code review
- Final notification

12 Jan 2016 - Mumbai
Step 1 - approach

1. Conducted Industry outreach
   a. Expert Consultation workshop (Dec 2012)
   b. Survey
   c. Interviews – BEE, SDA, Experts

2. Collated the update priorities and taken WG comments

3. Developed the scope and methodology for ECBC 2016
   a. Integrated the industry comments
   b. International best practices
   c. Suitable to Indian conditions
   d. Integrating other government programs

ECBC update – approach

1. Component Approach

2. Life Cycle Engineering (LCE) Approach

Step 2 - approach

1. Develop the Baseline typologies
   a. Building categorization as per NBC
   b. 5 climatic zones
   c. Baseline construction specifications and technology
   d. Baseline EPI

2. Data collection and collation
   a. Building Envelope – wall, roof, glass
   b. HVAC – chillers, fans, pumps, VRF, cooling towers and controls
   c. Lighting and controls – Lamps and Luminaire

Baseline objective and scope

- Typical building form and design
- Typical construction trend in last 4 years
- Energy performance index standard for each building
- Reference building for ECBC Stringency and impact analysis

Non residential buildings as defined in NBC
Consider all building components
Basic material/system specifications
Survey for baseline analysis

Targeted Categories
- Professionals - Architects/ Civil engineers/ MEP engineers
- Manufacturers – HVAC, lighting, Façade

Diversity in targeted categories
- Climatic zones diversity
- Diversity in building category experiences
- Diversity in the project clientele
  - Government building
  - Local small scale developer
  - Renowned developer
  - Individual or corporate owner

Building categorization

Hospitality
- Large hotel (Star hotels)
- Small hotel (No Star)
- Resort

Educational
- College/university
- Primary School
- Secondary school

Health care
- Hospital
- Out patient health care
Building categorization

**Business**
- Large office (> 30,000 sqm)
- Medium Office (10,000 – 30,000 sqm)
- Small office (<10,000 sqm)

**Commercial Shopping Complex**
- Shopping Malls
- Stand alone retail
- Open gallery mall
- Super market

**Assembly**
- Multiplex
- Theatre

Type 1 - Hospitality

- Hotel (No star)
- Resort
- Hotel (Star premises)
Type 2 - Educational

University Academic Building  Secondary School  Primary School

Type 3 - Health Care

Hospital (150+ beds)  Outpatient/ health care
Type 4 - Business

Small office (< 10,000 m²)
Medium office (10,000 - 30,000 m²)
Large office (>30,000 m²)

Type 5 - Commercial Shopping Complex

Shopping Mall  Open Gallery Mall  Strip Retail Shops
Type 5 (Conti) & Type 6 – Assembly

Super Market (type 5)                         Theater (Type 6)

Big Bazaar, Delhi PVR, Delhi

Data collection and collation

Building Envelope
- 350 wall combinations
- 87 glazing products
- 37 roof combinations
- 3 Shading types

Comfort Systems and Controls
- 110 Chillers data
- 60 pumps data
- Market assessment for HVAC

Lighting and Controls
- 120 lamps products
- 20 Controls products
Cost analysis for collated data

Rates from associations and diversified vendors

DSR rates were considered for labor

Final costing checked by key construction companies

All cost were reviewed and approved by the Working Groups

Milestone 3 - approach

1. Stringency analysis
   a. Building envelope
   b. Lighting and controls
   c. Comfort systems and controls
   d. Electrical and renewable
   e. Administration and compliance
Milestone 4 - approach

1. Conduct regional and national workshop (in process currently)
2. Address the stakeholder feedback
3. Prepare draft code
4. Public domain comments
5. Conduct Impact analysis

ECBC Update 2016
12 Jan 2016 - Mumbai

Session 2

Administration and Compliance
Scope

Sizes of Buildings:

- Building complexes with
  1. a connected load of 100 KW, or greater or
  2. a contract demand of 120 KVA or greater or,

Exemptions:

The provisions of this Code do not apply to:

1. Equipment and portions of building systems that use energy primarily for manufacturing processes

Applicable Building Systems

- Comfort Systems and Controls
- Lighting and Controls
- Electrical and Renewable
- Building Envelope
- Administration and Compliance

Excluded – Plug loads, Vertical Transportation, Process Load, Diesel Generator, Data Center
Energy efficiency levels in ECBC 2016 scope

1. 3 levels of stringency will be set in ECBC 2016:
   - Minimum efficiency requirement for ECBC 2016 (MEP)
   - Energy efficient buildings (EE)
   - Super energy efficient buildings (SEE)

2. Energy Performance Index requirement

Precedence

1. Safety, Health, And Environmental Codes.
   a. Where this Code is found to conflict with safety, health, or environmental codes, the safety, health, or environmental codes shall take precedence.

2. Precedence of BEE’s star rating program

3. Precedence of other policy effects like
   1. Refrigerant Phase Out program etc.
   2. Future renewable energy policy developed by MNRE
   3. Norms and Standards of BEE
Reference Standards

1. National Building Code (NBC) 2005 is the reference document/standard for –
   a. lighting levels,
   b. HVAC, comfort levels, natural ventilation, pump
   c. motor efficiencies, transformer efficiencies
   d. any other building materials and system performance criteria.

2. Resolve potential overlap with NBC
   a. Proactive coordination with NBC Update
Compliance Approaches

1. Prescriptive Approach
2. Whole building performance (WBP) Approach

Final outcome –
1. Report EPI based on approved tool and design parameters
2. Applicable for both prescriptive and whole building performance approach

Compliance requirement

Applicable buildings
1. Hospitality
2. Educational
3. Health care
4. Assembly
5. Business
6. Commercial Shopping complexes

Focused climatic zones
1. Temperate
2. Composite
3. Hot and dry
4. Warm and humid
5. Cold
Categories based on building use

- Self Occupied Building
- Core and Shell Building
- Mixed Use Development
- New Construction
- Addition
- Alteration

Self Occupied

New Buildings

- Comply with either the prescriptive or Whole building performance requirement

Additions or alteration to Existing Buildings

- If connected load demand of addition plus the existing building > 100 kW or 120 kVA.
Core and Shell Buildings

Core and shell buildings where the developer or owner will only provide the base building and its services. Base building will include common areas, circulation areas, parking, basements, services area, and open site area.

- Building envelope
- Renewable energy systems
- Electrical systems (installed by developer/owner)
- Comfort systems and controls (installed by developer/owner)
- Lighting systems and controls (installed by developer/owner)

Legal undertaking that fit out manual for the tenant will have a mandatory requirement of ECBC compliance in interior fit outs.

Mixed Use Development

Mixed use development may be defined as a single building or a group of buildings housing a combination of residential, commercial, business, educational, hospitality and assembly uses.

- Prescriptive – Each building category portion of the mixed use development to comply with the respective requirement stated in ECBC.
- Whole building - Area Weighted averages should comply with ECBC EPI requirements.
Enforcement jurisdiction

1. Authority having jurisdiction
   a. Development Authorities (DA)
   b. State designated agencies (SDA)
   c. Municipal Corporations/ULBs
   d. Local Bodies

ECBC compliance process – Phase 1

First phase of ECBC compliance will be effective for first 5 years of implementation.

Certified ECBC compliance assessor to prepare the ECBC compliance form → Compliance forms to be submitted to authority along with the submissions drawings → Owner of the building also needs to submit the duly signed undertaking

Final occupancy certificate ← After construction, owner of the building to re-submit the undertaking & compliance forms of as built ECBC complied building ← NO CONSTRUCTION CHECK
ECBC compliance process – Phase 2

Second phase of the ECBC compliance will be effective after 5 years of ECBC compliance implementation.

Certified ECBC compliance assessor to prepare the ECBC compliance form → Compliance forms to be submitted to authority along with the submissions drawings → Owner of the building also needs to submit the a duly signed undertaking

Final occupancy certificate → After construction, owner of the building to re submit the undertaking & compliance forms of as built ECBC complied building → Mandatory construction inspection by authorized authority

Compliance tools

1. Approved software for compliance – ECO-Nirman
2. Approved software for whole building approach
3. Approved tools for showing compliance with prescriptive approach –
   • Approved calculation methodology and tools
Penalties

1. Owner’s responsibility
2. In case of non-compliance, action could be taken as per the existing laws
3. No construction check will be done in the first phase and till BEE’s approved standardized process for construction check is not available.

Compliance Documents

• Phase 1-
  • Plans and specifications shall show all pertinent data and features of the building, equipment, and systems.
  • Sufficient detail to be provided to permit the Authority Having Jurisdiction to verify that the building complies with the requirements of this code.

• Phase 2-
  • Construction verification compliance documentation
Session 3

Building Envelope

Building envelope: Stringency Path

Stringency analysis for wall, glazing, and roof

- 16 prototypes buildings in 5 climatic zones
- 2,922 simulations for each building type in 5 climatic zones.
- 46,752 simulations for 16 building types in 5 climatic zones.
### ECBC 2016 recommendations - wall

<table>
<thead>
<tr>
<th></th>
<th>Composite</th>
<th>Hot and dry</th>
<th>Warm &amp; humid</th>
<th>Temperate</th>
<th>Cold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ECBC 2007 8 hours</td>
<td>0.44</td>
<td>0.44</td>
<td>0.44</td>
<td>0.44</td>
<td>0.352</td>
</tr>
<tr>
<td>ECBC 2007 24 hours</td>
<td>0.44</td>
<td>0.44</td>
<td>0.44</td>
<td>0.44</td>
<td>0.369</td>
</tr>
<tr>
<td>ECBC 2016 Day time</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
<td>0.55</td>
<td>0.34</td>
</tr>
<tr>
<td>Office and school &lt; 10,000 m²</td>
<td>0.63</td>
<td>0.63</td>
<td>0.63</td>
<td>0.63</td>
<td>0.4</td>
</tr>
<tr>
<td>EE building</td>
<td>0.34</td>
<td>0.34</td>
<td>0.34</td>
<td>0.4</td>
<td>0.22</td>
</tr>
<tr>
<td>SEE Building</td>
<td>0.15</td>
<td>0.15</td>
<td>0.15</td>
<td>0.22</td>
<td>0.15</td>
</tr>
<tr>
<td>ECBC 2016 24 hours</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
<td>0.34</td>
</tr>
<tr>
<td>EE building</td>
<td>0.34</td>
<td>0.34</td>
<td>0.34</td>
<td>0.34</td>
<td>0.22</td>
</tr>
<tr>
<td>SEE Building</td>
<td>0.15</td>
<td>0.15</td>
<td>0.15</td>
<td>0.15</td>
<td>0.15</td>
</tr>
</tbody>
</table>

### ECBC 2016 recommendations - roof

<table>
<thead>
<tr>
<th></th>
<th>Composite</th>
<th>Hot and dry</th>
<th>Warm &amp; humid</th>
<th>Temperate</th>
<th>Cold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>1.65</td>
<td>1.65</td>
<td>1.65</td>
<td>1.65</td>
<td>1.97</td>
</tr>
<tr>
<td>ECBC 2007 8 hours</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
</tr>
<tr>
<td>ECBC 2007 24 hours</td>
<td>0.261</td>
<td>0.261</td>
<td>0.261</td>
<td>0.409</td>
<td>0.261</td>
</tr>
<tr>
<td>ECBC 2016 Day time</td>
<td>0.3</td>
<td>0.3</td>
<td>0.3</td>
<td>0.3</td>
<td>0.28</td>
</tr>
<tr>
<td>School building &lt; 10,000 m²</td>
<td>0.54</td>
<td>0.54</td>
<td>0.54</td>
<td>0.54</td>
<td>0.3</td>
</tr>
<tr>
<td>EE building</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.2</td>
</tr>
<tr>
<td>SEE Building</td>
<td>0.18</td>
<td>0.18</td>
<td>0.18</td>
<td>0.18</td>
<td>0.18</td>
</tr>
<tr>
<td>ECBC 2016 24 hours</td>
<td>0.3</td>
<td>0.3</td>
<td>0.3</td>
<td>0.3</td>
<td>0.28</td>
</tr>
<tr>
<td>Hospitality buildings</td>
<td>0.19</td>
<td>0.19</td>
<td>0.19</td>
<td>0.3</td>
<td>0.19</td>
</tr>
<tr>
<td>EE building</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>SEE Building</td>
<td>0.18</td>
<td>0.18</td>
<td>0.18</td>
<td>0.18</td>
<td>0.18</td>
</tr>
</tbody>
</table>
## ECBC 2016 recommendation - Glazing

<table>
<thead>
<tr>
<th>WWR</th>
<th>Composite</th>
<th>Hot and dry</th>
<th>Warm &amp; humid</th>
<th>Temperate</th>
<th>Cold</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>40%</td>
<td>40%</td>
<td>40%</td>
<td>40%</td>
<td>40%</td>
</tr>
<tr>
<td><strong>Baseline</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>U</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
<td>5.27</td>
</tr>
<tr>
<td>SHGC</td>
<td>0.39</td>
<td>0.39</td>
<td>0.39</td>
<td>0.39</td>
<td>0.82</td>
</tr>
<tr>
<td>VLT</td>
<td>0.41</td>
<td>0.41</td>
<td>0.41</td>
<td>0.41</td>
<td>0.87</td>
</tr>
</tbody>
</table>

| **ECBC 2007 standard** | | | | | |
| U | 3.3 | 3.3 | 3.3 | 6.9 | 3.3 |
| SHGC | 0.25 | 0.25 | 0.25 | 0.40 | 0.51 |
| VLT | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |

| **Proposed** | | | | | |
| U | 3.8 | 3.8 | 3.8 | 3.0 | |
| SHGC | 0.27 | 0.27 | 0.27 | 0.62 | |
| SHGC | 0.27 | 0.27 | 0.27 | |
| SHGC | 0.5 | 0.5 | 0.5 | |
| VLT | 0.27 | 0.27 | 0.27 | 0.27 | |

U value in W/m²·K, SHGC value is maximum limit, VLT value is minimum limit.

## Shading Requirements

- **5 Projection factors considered**: 0, 0.25, 0.5, 0.75, 1
- **3 types**: Overhangs, fins, and box frame
- **4800 simulations in EnergyPlus**
- **Equations to easily estimate the SEF**
- **2 Latitudes considered**
- **8 Orientations**

12 Jan 2016 - Mumbai
SEF table for 28 °N (Similar for other latitude degrees)

<table>
<thead>
<tr>
<th>Projection Factor</th>
<th>Box Frame</th>
<th>Overhang</th>
<th>Fin</th>
</tr>
</thead>
<tbody>
<tr>
<td>North</td>
<td>0.25</td>
<td>0.5</td>
<td>0.75</td>
</tr>
<tr>
<td>East/ West</td>
<td>1.25</td>
<td>1.47</td>
<td>1.66</td>
</tr>
<tr>
<td>South</td>
<td>1.37</td>
<td>1.85</td>
<td>2.37</td>
</tr>
<tr>
<td>North-East/ North-West</td>
<td>1.58</td>
<td>2.47</td>
<td>3.62</td>
</tr>
<tr>
<td>South-East/ South-West</td>
<td>1.47</td>
<td>2.23</td>
<td>2.90</td>
</tr>
</tbody>
</table>

Example: SHGC 0.25 (say)

South: 0.39 0.62 0.90 1 0.32 0.40 0.49 0.57 0.29 0.34 0.36 0.39
South-East: 0.37 0.56 0.72 0.92 0.31 0.40 0.49 0.55 0.28 0.32 0.34 0.36
South-West: 0.35 0.56 0.78 1 0.31 0.38 0.40 0.53 0.29 0.33 0.34 0.36

Similar table for latitude 13 °N will be added

12 Jan 2016 - Mumbai

Daylighting Requirement

Daylighting Analysis

Concept
• Useful Daylighting Index
• Prescriptive and simulation compliance format
• Ease to show and check compliance

Guiding Parameters
• Glare
• Visual light transmittance
• Latitude angle
• Orientations
• Window types
• Ease of compliance

Simulations
• 220 simulations were done for one set of results

12 Jan 2016 - Mumbai
Daylighting requirement

<table>
<thead>
<tr>
<th>Daylighting requirement (prescriptive or simulation)</th>
<th>&lt; 3 storey building (above grade)</th>
<th>40%</th>
</tr>
</thead>
<tbody>
<tr>
<td>All buildings except*</td>
<td>&gt; 3 storey building (above grade)</td>
<td>45%</td>
</tr>
<tr>
<td>* Resort</td>
<td>All type</td>
<td>45%</td>
</tr>
<tr>
<td>*Shopping malls/ complex</td>
<td>All type</td>
<td>10%</td>
</tr>
</tbody>
</table>

For simulation approach, BEE approved software shall be used.

For prescriptive approach, day light extent to be marked/estimated on the architectural plan to estimate the final percentage area.

Prescriptive approach for daylighting compliance

<table>
<thead>
<tr>
<th>Day lighting penetration potential - prescriptive for vertical fenestration (n X head height, n is as per the table)</th>
<th>North</th>
<th>South/ East/West</th>
<th>North</th>
<th>South/ East</th>
<th>West</th>
</tr>
</thead>
<tbody>
<tr>
<td>Window type</td>
<td>Shading</td>
<td>VLT &lt; 0.3</td>
<td>VLT ≥ 0.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delhi</td>
<td>All window types</td>
<td>No Shading</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chennai</td>
<td>Vision window</td>
<td>Clerestorey</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All latitude types</td>
<td>All shading types with PF&gt;0.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Non West</td>
<td>West</td>
<td>Non West</td>
<td>West</td>
<td></td>
</tr>
<tr>
<td></td>
<td>VLT &lt; 0.3</td>
<td>VLT ≥ 0.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delhi</td>
<td>All window types</td>
<td>No Shading</td>
<td>1.4</td>
<td>1.0</td>
<td>0.5</td>
</tr>
<tr>
<td>Chennai</td>
<td>Vision window</td>
<td>Clerestorey</td>
<td>1.5</td>
<td>1.3</td>
<td>0.6</td>
</tr>
<tr>
<td>All latitude types</td>
<td>All shading types with PF&gt;0.4</td>
<td>1.5</td>
<td>1.1</td>
<td>1.8</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td>1.8</td>
<td>1.6</td>
<td>2.1</td>
<td>1.8</td>
<td></td>
</tr>
</tbody>
</table>
Key Analysis Results

Heavy wall in all climatic zones – Small office (8 hours)

Total Energy Consumption Per Total opaque Area

Energy Consumption Per Unit Area

Total Energy Consumption Per Total opaque Area

U-Value (W/m²·K)

- Composite - Heavy wall
- Cold & Cloudy - Heavy wall
- Hot & Dry - Heavy wall
- Temperate - Heavy wall
- Warm & Humid - Heavy wall
Glazing performance in all climatic zones - Small office (8 hours)

**Total Energy Consumption per Unit Window Area**

- **SHGC**
- Hot & Dry - SHGC
- Temperate - SHGC
- Warm & humid - SHGC
- Composite - SHGC

**Total Lighting Energy Consumption per Unit Window Area**

- **VLT**
- Cold & Cloudy - VLT
- Hot & Dry - VLT
- Temperate - VLT
- Warm & Humid - VLT
- Composite - VLT
Roof performance in all climatic zones - Small office (8 hours)

Energy Consumption per Total Roof Area (kWh/m²)

Energy Consumption per unit roof area (kWh/m²)

U-value (W/m²·K)

- Cold & Cloudy - All zones
- Hot & Dry - All zones
- Temperate - All zones
- Warm & Humid - All zones
- Composite - All zones

Life Cycle Cost Analysis

12 Jan 2016 - Mumbai
ECBC Update 2016
**LCC, NPV, and initial cost – wall in composite**

![Graph showing the relationship between U value, LCC, and initial cost.](image)

**NPV of Savings – Glazing in Composite**

![Graph showing the relationship between SHGC and NPV of savings.](image)
LCC – Glazing in Composite

LCC - Composite (VLT - 0.27)

LCC (Rs./m²/yr)

SHGC

LCC and NPV – Glazing in Cold & Cloudy

LCC and NPV of savings - Cold & Cloudy

U value (W/m²-K)

LCC (Rs./m²)

NPV of savings (Rs./m²)

a. Corresponding values of SHGC against U value 3 W/m²K is 0.37, 0.46, 0.62.
b. Considering the importance of solar radiation, 0.62 could be recommended
Small office, 8 hours, composite
LCC and NPV, Roof

U-value correlation with LCC and NPV

Analyzing 16 prototypes in 5 climatic zones
Analysis approach

5 combinations were analyzed based on the weightage to LCC and energy saving potential (ESP)

Weightage distribution

Cold and Cloudy – Wall Insulation

Number of buildings prototypes for each U value (Cold & Cloudy)
Composite - wall

Number of Buildings prototypes for each U value (Composite)

Composite - Roof

Number of Buildings prototypes for each U value (Composite)
**SHGC values for different orientations**

1. The SHGC recommendation of 0.27 for other orientation, except south orientation, could be relaxed.
2. Estimate the trend line equation for each orientation
3. Equate the energy consumption of south orientation with 0.27 SHGC with other orientation, estimate the equivalent SHGC for N/ E/ W orientation

---

**Shading Analysis**
Overhangs – (28 °N)

Fins – (28 °N)
Box frame – Overhangs + fins – (28 °N)

Shading equivalent factor - Box frame (Overhang + fins)

P/H

Shading equivalent factor

1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0

0 0.2 0.4 0.6 0.8 1 1.2

North
East
South
West
North-East
South-East
South-West
North-West

Brick wall Insulated block wall

ECBC Update 2016

12 Jan 2016 - Mumbai
AAC block wall

Fly ash wall

Cement stabilized brick wall

Hollow concrete block wall
Polyurethane spray foam

Image ref: www.treehugger.com

Single and double glazing

Single vs Double Glazed

- Single: Outside temperature permeates through
- Double: Minimal outside temperature permeates through
  - Spacer
  - Two Sheets of Glass
  - Sealed Air Space
  - Air Tight Seal (around entire frame)
Energy conservation measures list - wall

- **Wall material types**
  - Heavy weight wall
    - Brick wall
    - Cement stabilized brick wall
  - Medium weight wall
    - Fly ash brick
    - Hollow concrete block wall
    - AAC block wall
    - Insulated block wall
  - Light weight wall
    - Gypsum board wall

- **Construction types**
  - Single wall
  - with External insulation
  - with internal insulation
  - Cavity Wall
    - external heavy mass
    - internal heavy mass
    - both side heavy mass

---

**Mass wall**

<table>
<thead>
<tr>
<th>Material (A)</th>
<th>Thickness (mm)</th>
<th>U value range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brick</td>
<td>230</td>
<td>Lower Limit: 12 mm plaster, 230 mm brick, 8 mm plaster: 2.1 W/m²K</td>
</tr>
<tr>
<td>Cement Stabilized earth block</td>
<td>250, 375</td>
<td></td>
</tr>
<tr>
<td>Fly Ash Brick</td>
<td>200, 300</td>
<td>2.1 W/m²K</td>
</tr>
<tr>
<td>Hollow Concrete Block</td>
<td>200, 300</td>
<td></td>
</tr>
<tr>
<td>Insulated Block</td>
<td>200, 300</td>
<td></td>
</tr>
<tr>
<td>Autoclaved Aerated Concrete Block</td>
<td>200, 300</td>
<td>Upper Limit: 12 mm plaster, 200 mm AAC block, 8 mm plaster : 0.63 W/m²K</td>
</tr>
</tbody>
</table>
### Single mass wall (external insulation)

**Diagram:**
- **External**
- **Internal**

<table>
<thead>
<tr>
<th>Material (B)</th>
<th>Thickness (mm)</th>
<th>U value range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extruded polystyrene (XPS)</td>
<td>25, 50, 75, 100</td>
<td>Lower Limit: 12 mm plaster, 25 mm XPS, 230 mm brick, 8 mm plaster : 0.73 W/m²K</td>
</tr>
<tr>
<td>Expanded polystyrene (thermo Cole) (EPS)</td>
<td>25, 50, 75, 100</td>
<td>Upper Limit: 12 mm plaster, 100 mm Polyurethane, 200 mm Flyash wall, 8 mm plaster : 0.21 W/m²K</td>
</tr>
<tr>
<td>Polyurethane</td>
<td>25, 50, 75, 100</td>
<td></td>
</tr>
</tbody>
</table>

### Single mass wall (internal insulation)

**Diagram:**
- **Internal**
- **External**

<table>
<thead>
<tr>
<th>Material (B)</th>
<th>Thickness (mm)</th>
<th>U value range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extruded polystyrene (XPS)</td>
<td>25, 50, 75, 100</td>
<td>Lower Limit: 12 mm plaster, 25 mm Glass Fiber, 230 mm brick, 8 mm plaster : 0.81 W/m²K</td>
</tr>
<tr>
<td>Expanded polystyrene (thermo Cole) (EPS)</td>
<td>25, 50, 75, 100</td>
<td>Upper Limit: 12 mm plaster, 100 mm Polyurethane, 200 mm Flyash wall, 8 mm plaster : 0.16 W/m²K</td>
</tr>
<tr>
<td>Polyurethane</td>
<td>25, 50, 75, 100</td>
<td></td>
</tr>
<tr>
<td>Bonded Mineralwool (Rock/ glasswool)</td>
<td>25, 50, 75, 100</td>
<td></td>
</tr>
<tr>
<td>Glass fiber and mineral fiber</td>
<td>25, 50, 75, 100</td>
<td></td>
</tr>
</tbody>
</table>
## Light weight wall

<table>
<thead>
<tr>
<th>Material (B)</th>
<th>Thickness (mm)</th>
<th>U value range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extruded polystyrene (XPS)</td>
<td>25, 50, 75, 100</td>
<td>Lower Limit: 12 mm Gypsum Board, 25 mm Glass fiber, 12 mm Gypsum Board: 0.23 W/m² K</td>
</tr>
<tr>
<td>Expanded polystyrene (thermo Cole) (EPS)</td>
<td>25, 50, 75, 100</td>
<td>Upper Limit: 12 mm Gypsum Board, 100 mm Polyurethane, 12 mm Gypsum Board: 0.19 W/m² K</td>
</tr>
<tr>
<td>Polyurethane</td>
<td>25, 50, 75, 100</td>
<td></td>
</tr>
<tr>
<td>Bonded Mineralwool (Rock/ glasswool)</td>
<td>25, 50, 75, 100</td>
<td></td>
</tr>
<tr>
<td>Glass fiber and mineral fiber</td>
<td>25, 50, 75, 100</td>
<td></td>
</tr>
<tr>
<td>Air gap</td>
<td>25, 50</td>
<td></td>
</tr>
</tbody>
</table>

## Cavity mass wall

<table>
<thead>
<tr>
<th>Material (B)</th>
<th>Thickness (mm)</th>
<th>U value range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extruded polystyrene (XPS)</td>
<td>25, 50, 75, 100</td>
<td>Lower Limit: 12 mm plaster, 230 mm brick, 50 mm Air gap, 115 mm brick, 8 mm plaster: 1.22 W/m² K</td>
</tr>
<tr>
<td>Expanded polystyrene (thermo Cole) (EPS)</td>
<td>25, 50, 75, 100</td>
<td>Upper Limit: 12 mm plaster, 200 mm AAC block, 100 mm Polyurethane, 100 mm AAC block, 8 mm plaster: 0.15 W/m² K</td>
</tr>
<tr>
<td>Polyurethane</td>
<td>25, 50, 75, 100</td>
<td></td>
</tr>
<tr>
<td>Bonded Mineralwool (Rock/ glasswool)</td>
<td>25, 50, 75, 100</td>
<td></td>
</tr>
<tr>
<td>Glass fiber and mineral fiber</td>
<td>25, 50, 75, 100</td>
<td></td>
</tr>
<tr>
<td>Air gap</td>
<td>25, 50</td>
<td></td>
</tr>
</tbody>
</table>
### Roof (over deck insulation)

<table>
<thead>
<tr>
<th>Material (C)</th>
<th>Thickness (mm)</th>
<th>U value range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete Slab</td>
<td>150</td>
<td></td>
</tr>
<tr>
<td>Material (D)</td>
<td>Thickness (mm)</td>
<td>U value range</td>
</tr>
<tr>
<td>Extruded polystyrene (XPS)</td>
<td>25, 50, 75, 100</td>
<td>Lower Limit: 50 mm brick bat coba, 150 mm concrete slab, waterproofing, 25 mm plaster: 2.51 W/m²K</td>
</tr>
<tr>
<td>Expanded polystyrene (thermo Cole) (EPS)</td>
<td>25, 50, 75, 100</td>
<td>Upper Limit: 100 mm Polyurethane, 150 mm concrete slab, waterproofing, 25 mm plaster: 0.2 W/m²K</td>
</tr>
<tr>
<td>Polyurethane</td>
<td>25, 50, 75, 100</td>
<td></td>
</tr>
<tr>
<td>Brick bat coba</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Mud Fuska</td>
<td>75</td>
<td></td>
</tr>
</tbody>
</table>

---

### Roof (under deck insulation)

<table>
<thead>
<tr>
<th>Material (C)</th>
<th>Thickness (mm)</th>
<th>U value range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete Slab with brick bat coba</td>
<td>200</td>
<td></td>
</tr>
<tr>
<td>Material (D)</td>
<td>Thickness (mm)</td>
<td>U value range</td>
</tr>
<tr>
<td>Extruded polystyrene (XPS)</td>
<td>25, 50, 75, 100</td>
<td>Lower Limit: 50 mm brick bat coba, 150 mm concrete slab, waterproofing, 25 mm plaster: 2.51 W/m²K</td>
</tr>
<tr>
<td>Expanded polystyrene (thermo Cole) (EPS)</td>
<td>25, 50, 75, 100</td>
<td>Upper Limit: 100 mm Polyurethane, 150 mm concrete slab, waterproofing, 25 mm plaster: 0.19 W/m²K</td>
</tr>
<tr>
<td>Polyurethane</td>
<td>25, 50, 75, 100</td>
<td></td>
</tr>
<tr>
<td>Bonded mineral wool</td>
<td>25, 50, 75, 100</td>
<td></td>
</tr>
<tr>
<td>Glass fibre</td>
<td>25, 50, 75, 100</td>
<td></td>
</tr>
</tbody>
</table>