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ENERGY IS LIFE BEE CONSERVE IT

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

Energy Conservation Building Code – 2016
National Expert Consultation Workshop

New Delhi

May 27, 2016

Presentation Overview

1. Session – 1 – ECBC Background and ECBC 2016 Development Process & 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

Session - 1

ECBC Background and ECBC 2016 development Process & Methodology

Energy Conservation (EC) Act, 2001

1. Energy Conservation Act was in acted in 2001
2. Specifies powers of Central and State Government.
3. Bureau of Energy Efficiency was established under this Act
4. As per the Act
   a. **energy conservation building codes** means the norms and standards of energy consumption expressed in terms of per m^2 of the area wherein energy is used and includes the location of the building
   b. **"building"** means any structure or erection (or part), after the rules relating to ECBC have been notified, which is having a connected load of 100kW or contract demand of 120 kVA and above and is intended to be used for commercial purposes

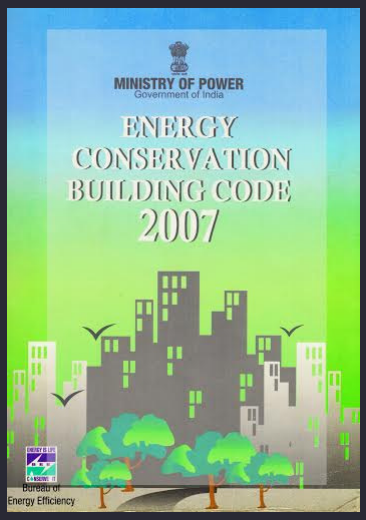
EC Act, 2001 – Powers to Central Government

1. Specify any user as a designated consumer (14 e)
2. Prescribe Energy Conservation Building Codes (14 p)
3. Amend the ECBC (14 q)
4. Direct buildings to comply with ECBC (14 r)
5. Create awareness and conduct training programs (14 t)

EC Act, 2001 – Powers to State Government

1. Amend the ECBC (15 a)
2. Notify ECBC (15 a)
3. Direct buildings to comply with the ECBC (15 c)
4. Create awareness and conduct training programs (15 e)
5. Designate inspecting agency (17 – 1)

Energy Conservation Building Code 2007

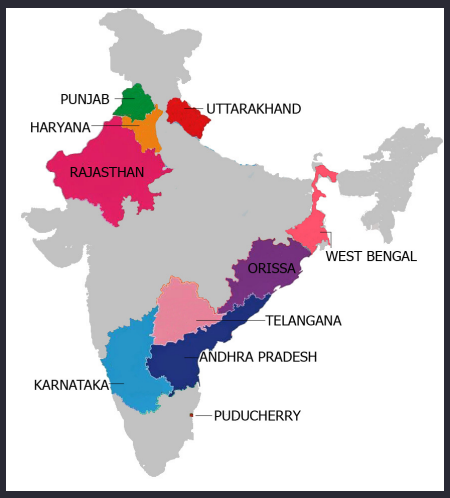


- Fulfills the requirement of EC Act 2001
- Launched by Ministry of Power in May 2007
- Purpose – Minimum requirement for the EE design and construction
- Applicable to commercial buildings with connected load greater than 100 kW or contract demand greater than 120 kVA (2009 amendment)

ECBC implementation status in India

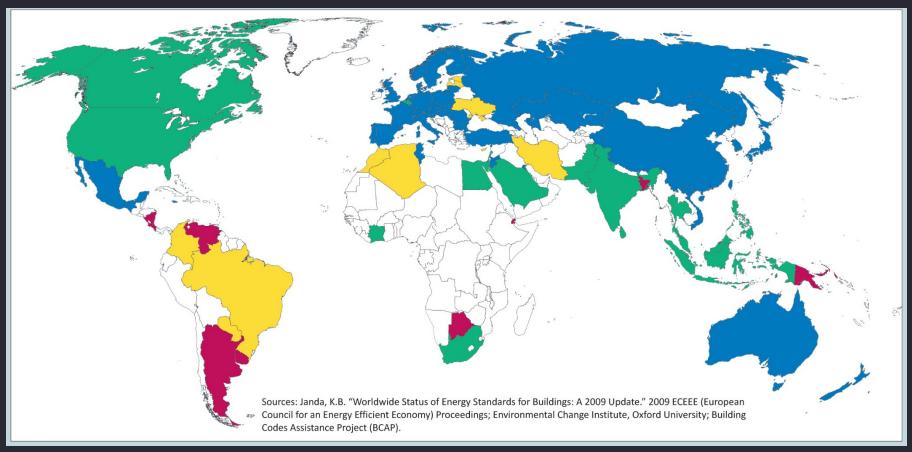
- ECBC amendment (20):
  - Odisha, Punjab, Karnataka, Rajasthan, Andhra Pradesh, Telangana, Uttara khand, UT of Puducherry, Uttar Pradesh, Kerala, Gujarat, Tamil Nadu, Haryana, Chhattisgarh, Maharashtra, West Bengal, Himachal Pradesh, Bihar, Madhya Pradesh, Assam, Goa

ECBC implementation status in India

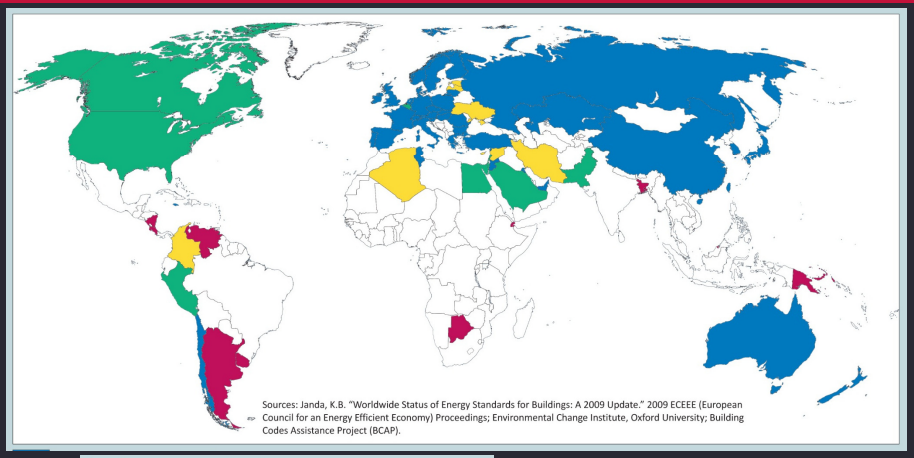


- States completed ECBC notification (10)
  - Odisha
  - Punjab
  - Karnataka
  - Rajasthan
  - Andhra Pradesh
  - Telangana
  - Uttara khand
  - UT of Puducherry
  - Haryana
  - West Bengal

Worldwide Status of Building Energy Codes – Non Residential



Worldwide Status of Building Energy Codes – Residential



Vision for ECBC 2016

- In the 12th Plan, ECBC update is a priority
- nZEB target for India
- Mandatory implementation and enforcement of ECBC
- Response to the technological advancement
- Response energy scenario of India

Key objectives of ECBC 2016 development

1. Focus on passive strategies
2. Ease of compliance
3. Establish a baseline of energy performance
4. Address different building types in various climatic zones
5. Increase the purview of ECBC
6. Integrate other government policy standards into ECBC (S&L program, building Star rating etc)

ECBC update committee

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, 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

Steering Committee

Chair - Director General, Bureau of Energy Efficiency

Other members - MNRE, MoUD, BIS, CPWD, SDA, USAID, UNDP, IGBC, USGBC, GRIHA

Planned meetings –

1. Proposed in June 2016
2. These meetings to continue till the code is ready for notification

Administration and Compliance

1. **Chair - Mr. Sanjay Seth, Bureau of Energy Efficiency**
2. **Convener - Mr. Girja 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, Ex Prof – IIT Delhi**
2. **Convener - Mr. Girja 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 -** Late Mr. H. S. Mamak.

   Mr. Gulshan Aghi, Ex- President of ISLE

1. **Convener - Mr. Girja Shankar, Bureau of Energy Efficiency**

Members

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

Comfort Systems and Controls

1. **Chair - Dr. R. S. Agarwal, Ex Professor Indian Institute of Technology Delhi**
2. **Convener - Mr. Girja 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, Professor and Dept Head, IIT Delhi**
2. **Convener - Mr. Girja 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. Manas Kundu, International Copper Association India
5. Mr. Hemanth, International Copper Association India

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. Green Building Council Incorporation - India (GBCI)
4. Centre for Science and Environment (CSE)
5. Alliance to Save Energy (ASE)
6. 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 (IBC)
5. Confederation of Indian Industry (CII)
6. Confederation of Real Estate Developers Associations of India (CREDAI)
7. Glazing Society of India (GSI)
8. Indian Insulation Forum (IIF)
9. Indian Glass Manufactures Association

Industry Associations

9. Refrigeration and Air-Conditioning Manufacturers Association of India (RAMA)
10. Indian Society of Heating Refrigerating and Air Conditioning (ISHRAE)
11. International Fenestration Forum (IFF)
12. Council of Architects (COA)
13. UPVC Doors and Windows Manufacturer Association (UWDMA)
14. Indian Society of Lighting Engineers (ISLE/ ELCOMA)
15. International Copper Association India (ICAI)

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 (SPA)
10. University School of Architecture and Planning (USAP)

Bilateral and Multilateral Agencies

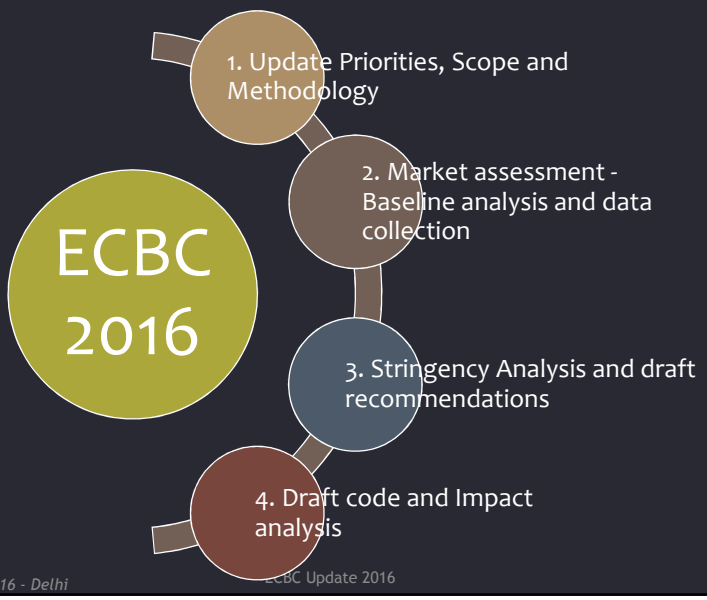
1. Swiss Agency for Development and Cooperation (SDC)
2. French Development Agency - Agence Française de Dévelopement (AFD)
3. Gesellschaft für Internationale Zusammenarbeit (GIZ)
4. Kreditanstalt fur Wiederaufbau (KFW)
5. Shakti Sustainable Energy Foundation (SSEF)
6. Indo- EU Building Program
7. United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

Regional meets

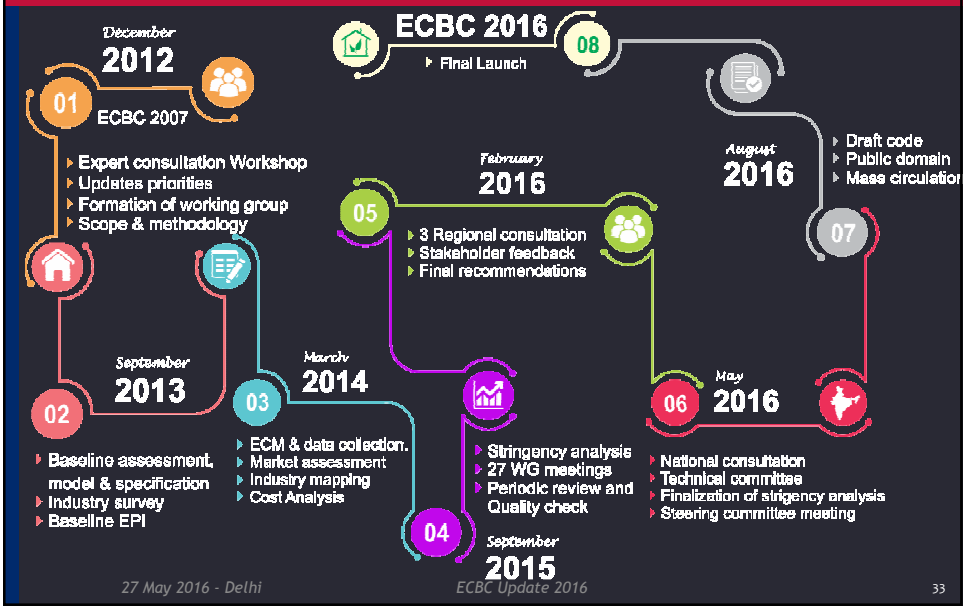
Comments and feedback received in the last three regional consultations has been incorporated into this presentation

ECBC Update Methodology

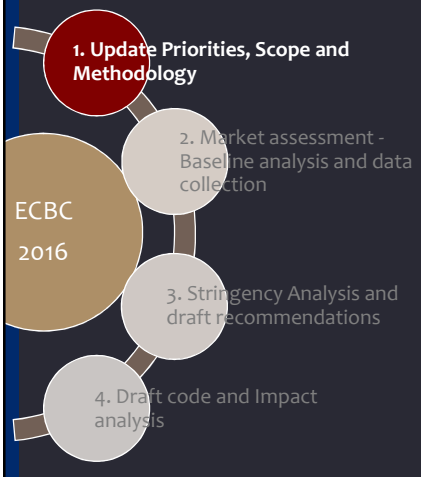
Key Steps



ECBC Update Journey



Step 1 – approach and update priorities



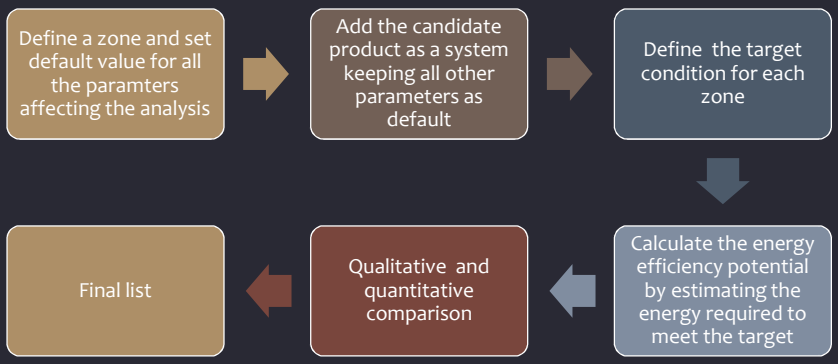
ECBC update – approach

1. Component Approach
2. Life Cycle Cost Approach
3. Energy Performance Index (EPI)

   Approach: Bench Marking and Star Rating

Component Approach

In this approach, the stringency of each building material or component is analyzed independently of the rest of the materials, components, and other building specifications



Life Cycle Cost Approach

The methodology that considers the Life cycle cost (LCC) of a product, guiding the designers towards qualitative assessment.

- Includes cost like initial investment, maintenance cost, salvage cost etc. in LCC
- Varies with different external factors like climatic zones, building type, usage pattern etc

EPI Approach- Bench Marking and Star Rating

The EPI indicates the total energy used in a building every year to the total built up area (air-conditioned or non air-conditioned) and is reported in units of kWh/sq.m/ year

Need of EPI

- Component approach is conservative and ignores specific opportunities available at different sites
- It also ignores influence of one component, with in a system, over another.

Key update priorities concluded in Year 2012

ECBC 2007

KEY UPDATE PRIORITIES

Concluded based on the consultation meet dated Dec 20, 2012 and feedback received thereafter

Renewable integrations

Easy to understand, implement, and show compliance

Ensure design flexibility and should address loop holes

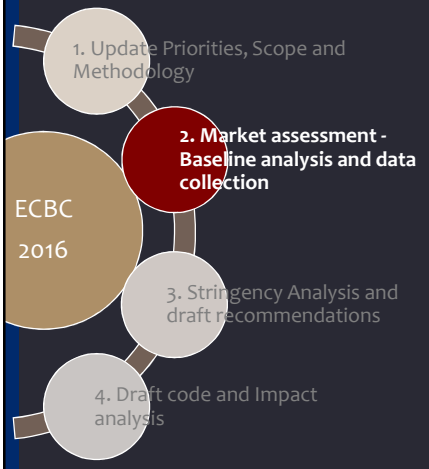
Comfort systems section to include all key components

Should integrate and promote passive design strategies

Should be developed specific to Indian conditions

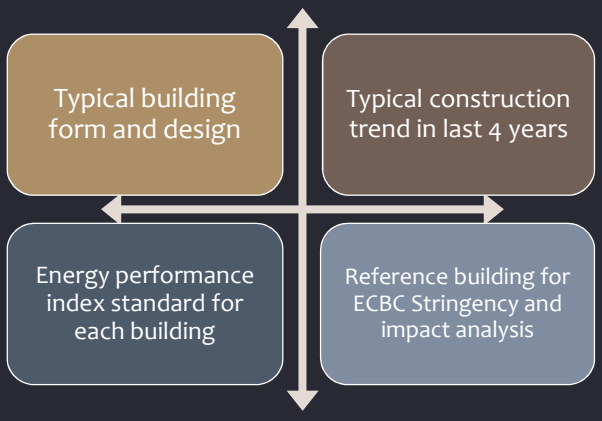
Align with the current market scenario and technologies

Step 2 – Market assessment



1. Develop the Baseline typologies
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



Scope

- Non residential buildings as defined in **NBC**
- Consider all building components
- Basic material/ system specifications

Survey for baseline analysis

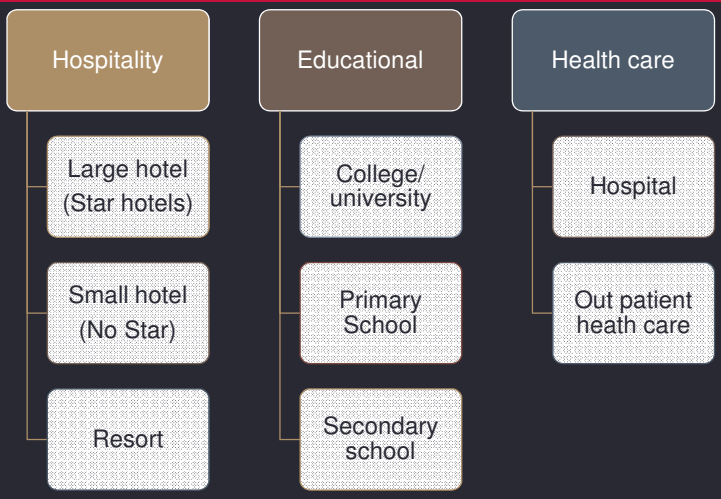
Targeted Categories

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

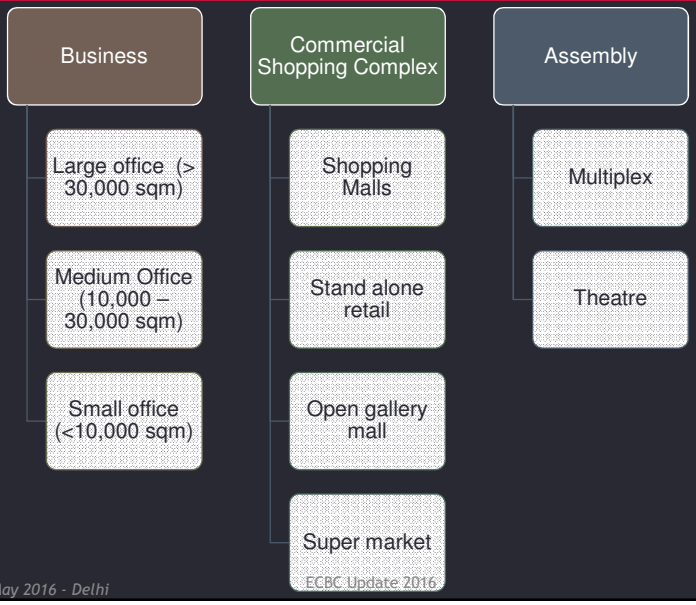
Diversity in targeted categories

- 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

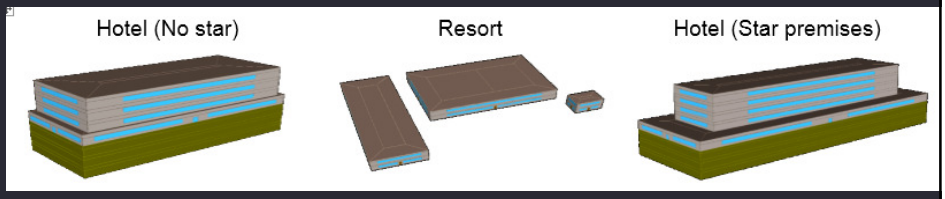
Building categorization



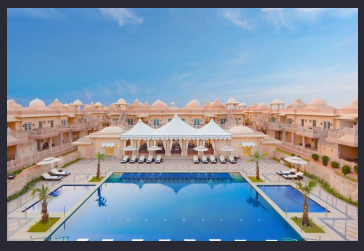
Building categorization



Type 1 - Hospitality



Sarovar, Mumbai

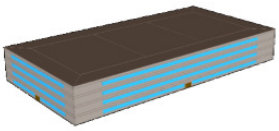


ITC, Manesar

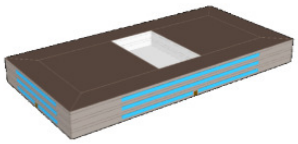
Radisson Blu, Guwahati

Type 2 - Educational

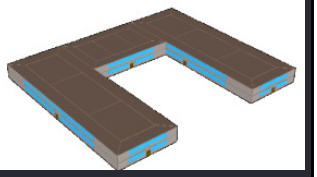
University Academic Building



Secondary School



Primary School



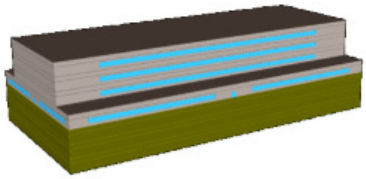
Lovely University, Noida

St. Xavier's School, Kolkata

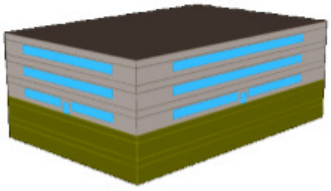
Tagore Public School, Jaipur

Type 3 - Health Care

Hospital (150+ beds)



Outpatient/ health care

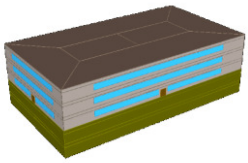


Fortis, Delhi

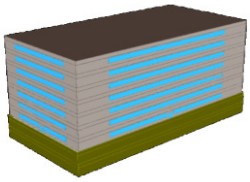
Max, Gurgaon (upcoming)

Type 4 - Business

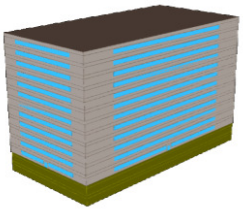
Small office (< 10,000 m^2)



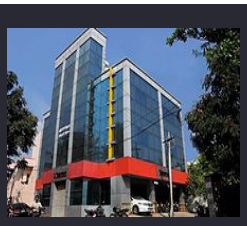
Medium office (10,000 - 30,000 m^2)



Large office (>30,000 m^2)



HCL, Noida

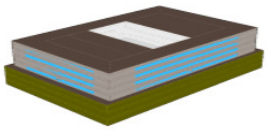


Tata Power, Noida

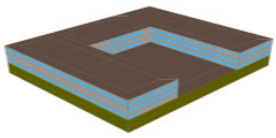
Corporate Tower, Delhi

Type 5 - Commercial Shopping Complex

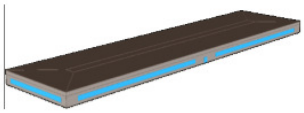
Shopping Mall



Open Gallery Mall



Strip Retail Shops



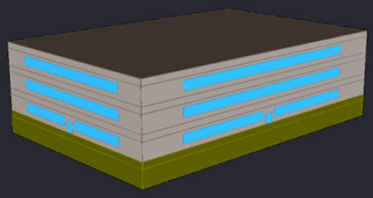
Ambience Mall, Delhi

Cyber Hub, Gurgaon

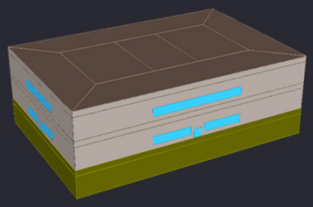
Street Retail, Pune

Type 5 (Conti) & Type 6 – Assembly

Super Market (type 5)



Theater (Type 6)



Big Bazaar, Delhi

PVR, Delhi

Data collection

Energy Conservation Measures

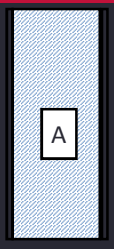
Data collection and collation

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

Energy conservation measures list - wall

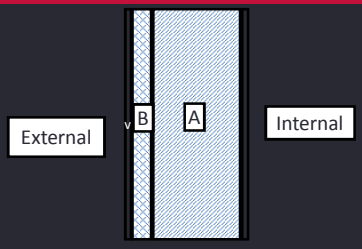
- Wall material types
  - Heavy weight wall
    - Brick wall
    - Cement stabilized brick wall
  - Medium weight wall
    - Fly ash brick
    - Hollow concrete block wall
    - AAC block wall
    - Insulated block wall
  - Light weight wall
    - Gypsum board wall
- Construction types
  - Single mass wall
    - with External insulation
    - with internal insulation
  - Cavity Wall
    - external heavy mass
    - internal heavy mass
    - both side heavy mass

Mass wall



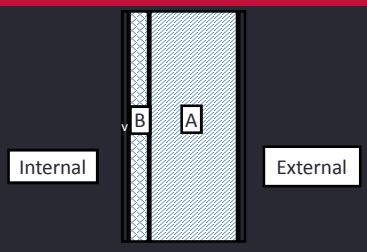
Material (A)	Thickness (mm)	U value range
Brick	230	**Lower Limit:** 12 mm plaster, 230 mm brick, 8 mm plaster: **2.1 W/m² K**
Cement Stabilized earth block	250, 375	
Fly Ash Brick	200, 300	
Hollow Concrete Block	200, 300	
Insulated Block	200, 300	**Upper Limit**: 12 mm plaster, 200 mm AAC block, 8 mm plaster : **0.63 W/m² K**
Autoclaved Aerated Concrete Block	200, 300	

Single mass wall (external insulation)



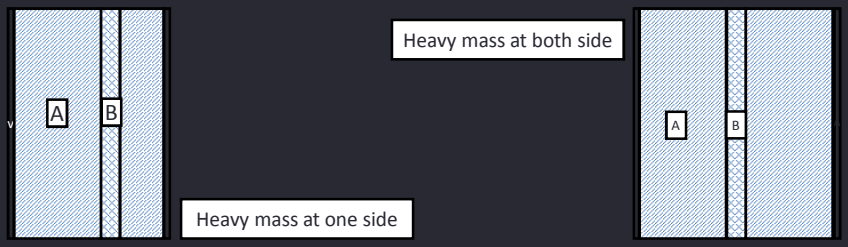
Material (B)	Thickness (mm)	U value range
Extruded polystyrene (XPS)	25, 50, 75, 100	**Lower Limit:** 12 mm plaster, 25 mm XPS, 230 mm brick, 8 mm plaster : **0.73 W/m² K** **Upper Limit:** 12 mm plaster, 100 mm Polyurethane/ Polyisocyanurate, 200 mm Flyash wall, 8 mm plaster : **0.21 W/m² K**
Expanded polystyrene (thermo Cole) (EPS)	25, 50, 75, 100	
Polyurethane/ Polyisocyanurate	25, 50, 75, 100	

Single mass wall (internal insulation)



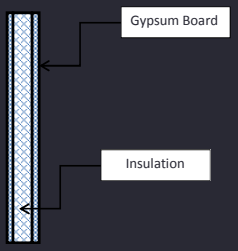
Material (B)	Thickness (mm)	U value range
Extruded polystyrene (XPS)	25, 50, 75, 100	**Lower Limit:** 12 mm plaster, 25 mm bonded mineral wool, 230 mm brick, 8 mm plaster : **0.81 W/m² K** **Upper Limit:** 12 mm plaster, 100 mm Polyurethane/ Polyisocyanurate, 200 mm Fly ash, 8 mm plaster : **0.16 W/m² K**
Expanded polystyrene (thermo Cole) (EPS)	25, 50, 75, 100	
Polyurethane/ Polyisocyanurate	25, 50, 75, 100	
Bonded Mineralwool (Rock/ glasswool)	25, 50, 75, 100	

Cavity mass wall



Material (B)	Thickness (mm)	U value range
Extruded polystyrene (XPS)	25, 50, 75, 100	**Lower Limit:** 12 mm plaster, 230 mm brick, 50 mm Air gap, 115 mm brick, 8 mm plaster : **1.22 W/m²K** **Upper Limit:** 12 mm plaster, 200 mm AAC block, 100 mm Polyurethane/ Polyisocyanurate, 100 mm AAC block, 8 mm plaster : **0.15 W/m²K**
Expanded polystyrene (thermo Cole) (EPS)	25, 50, 75, 100	
Polyurethane/ Polyisocyanurate	25, 50, 75, 100	
Bonded Mineralwool (Rock/ glasswool)	25, 50, 75, 100	
Air gap	25, 50	

Light weight wall

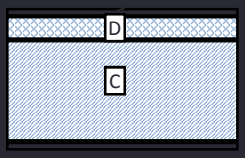


Lower Limit: 12 mm Gypsum Board, 25 mm Mineral wool, 12 mm Gypsum Board : 1.23 W/m^2 K

Upper Limit: 12mm Gypsum Board, 100 mm Polyurethane/ Polyisocyanurate, 12 mm Gypsum Board: 0.19 W/m^2 0

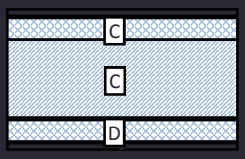
Material (B)	Thickness (mm)	U value range
Extruded polystyrene (XPS)	25, 50, 75, 100	**Lower Limit:** 12 mm Gypsum Board, 25 mm bonded mineral wool, 12 mm Gypsum Board : **0.96** W/m^2 K **Upper Limit:** 12mm Gypsum Board, 100 mm Polyurethane/ Polyisocyanurate, 12 mm Gypsum Board: **0.22** W/m2-K
Expanded polystyrene (thermo Cole) (EPS)	25, 50, 75, 100	
Polyurethane/ Polyisocyanurate	25, 50, 75, 100	
Bonded Mineralwool (Rock/ glasswool)	25, 50, 75, 100	
Air gap	25, 50	

Roof (over deck insulation)



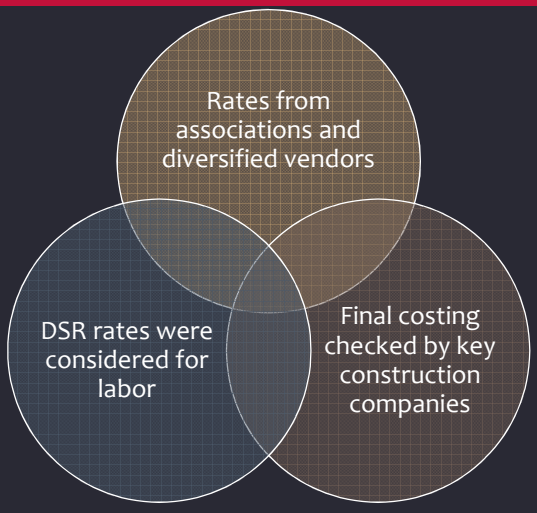
Material (C)	Thickness (mm)	
Concrete Slab	150	
Material (D)	**Thickness (mm)**	**U value range**
Extruded polystyrene (XPS)	25, 50, 75, 100	**Lower Limit**: 50 mm brick bat coba, 150 mm concrete slab, waterproofing, 25 mm plaster: **2.51 W/m^2 K** **Upper Limit:** 100 mm Polyurethane/ Polyisocyanurate, 150 mm concrete slab, waterproofing, 25 mm plaster: **0.2 W/m^2 K**
Expanded polystyrene (thermo Cole) (EPS)	25, 50, 75, 100	
Polyurethane/ Polyisocyanurate	25, 50, 75, 100	
Brick bat coba	50	
Mud Fuska	75	

Roof (under deck insulation)



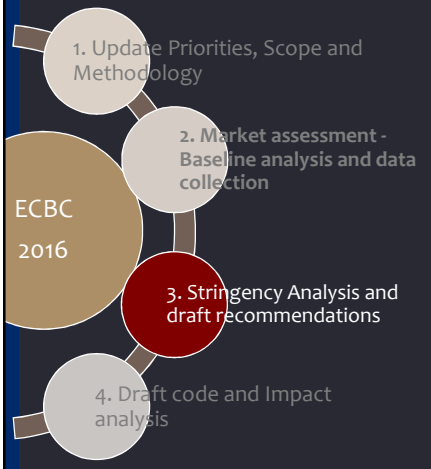
Material (C)	Thickness (mm)	
Concrete Slab with brick bat coba	200	
Material (D)	**Thickness (mm)**	**U value range**
Extruded polystyrene (XPS)	25, 50, 75, 100	**Lower Limit**: 50 mm brick bat coba, 150 mm concrete slab, waterproofing, 25 mm plaster: **2.51 W/m² K** **Upper Limit:** 100 mm Polyurethane/ Polyisocyanurate, 150 mm concrete slab, waterproofing, 25 mm plaster: **0.19 W/m² K**
Expanded polystyrene (thermo Cole) (EPS)	25, 50, 75, 100	
Polyurethane/ Polyisocyanurate	25, 50, 75, 100	
Bonded mineral wool	25, 50, 75, 100	

Cost analysis for collated data



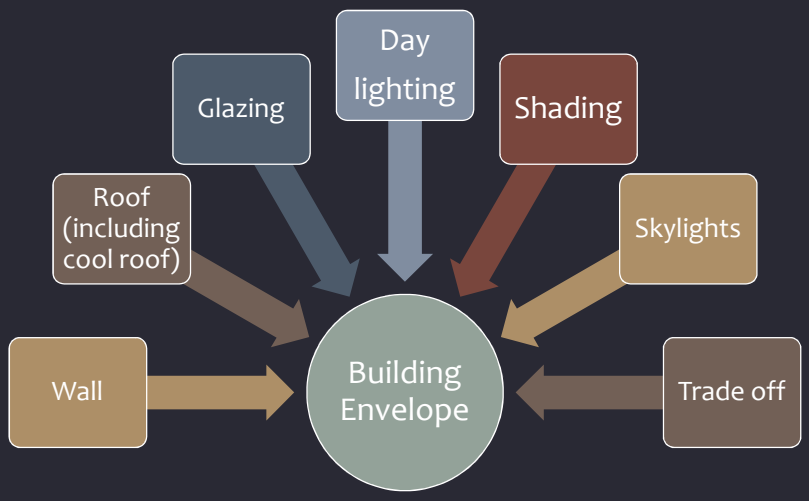
All cost were reviewed and approved by the Working Groups

Milestone 3 – Stringency Analysis



1. Stringency analysis
   a. Building envelope
   b. Lighting and Controls
   c. Comfort Systems and Controls
   d. Electrical and Renewable

Building envelope: Scope



Lighting and Controls - Scope

1. Interior and Exterior lighting requirement
2. Controls
3. Requirement on Luminaire efficiency

Comfort Systems and Controls – Scope

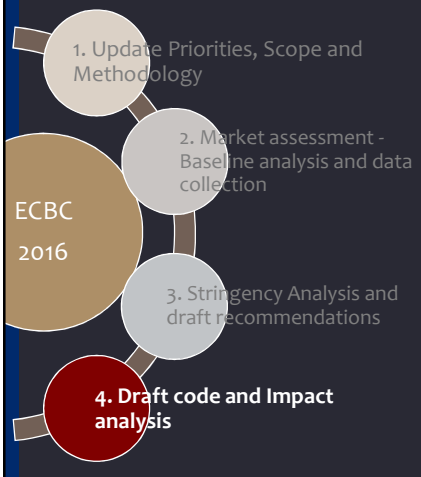
- Chillers:
  - Water/ air Cooled
- Unitary Air-Conditioners :
  - **VRF system**
  - Single/ Multi Spilt Unit
  - window AC
- **Pumps**
  - **Chilled-Water Pump**
  - **Condenser Water Pump**
  - **Hot water pumps**
- **Air Distribution System :**
  - **AHU and FCUs**
  - **Fans – Centrifugal/ Axial**
- **Cooling towers**
- **Boilers**
- **System efficiency**
- Controls
- **Natural Ventilation**
- **Set points**
- Ducts and pipe insulation
- Heat recovery and economizers
- **Low energy comfort systems**

New additions are highlighted

Electrical and Renewable - scope

- Equipment efficiency and design
  - Transformers
  - Motors
  - Power Factor
  - Electrical Metering and Monitoring
  - Electrical Distribution Systems
  - *Recommended additions –*
    - *Voltage Unbalancing*
    - *Harmonic Distortion*
    - *Size of Neutral Conductors*
    - Uninterruptible Power Supply
- Renewable energy
- Hot water
  a. Solar
  b. Other hot water equipment

Milestone 4 – Final recommendations



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

Session 2- Code scope and application

Administration and Compliance

Scope

Sizes of Buildings:

Building complexes with

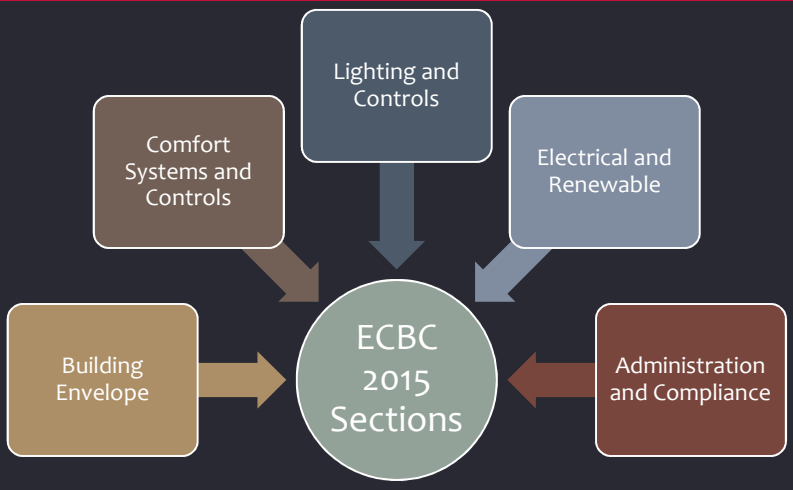
1. a connected load of 100 KW, or greater or
2. a contract demand of 120 KVA or greater or,

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



Exclusion – Plug loads, Vertical Transportation, Process Load, Diesel Generator

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)

Energy Performance Index –
definition recommended for ECBC – Discussion Point

EPI shall be kWh/ m^2/year in terms of purchased & generated electricity divided by built up area in square meter. However the total electricity would not include electricity generated from on-site renewable sources such as solar photovoltaic etc.

Built up area exclude the basement area

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 for sizes not covered in ECBC
   d. any other building materials and system performance criteria.

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

Administration and Enforcement

- Compliance Approach
- Compliance Requirement
- Administration Requirement
- Compliance Documents

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

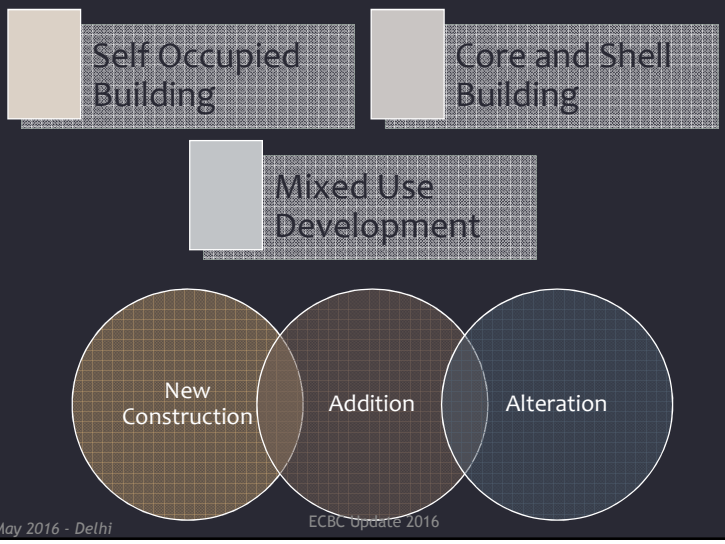
Applicable buildings

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

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.

Owner/ Developer shall be responsible for demonstrating compliance for core and shell (C&S) buildings

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.

If residential is less than 10% of total space, whole building needs to be shown compliance with ECBC. If residential is more than 10%, only non-residential part of the building should comply with ECBC.

Prescriptive – Each building category portion of the mixed use development to comply with the respective requirement stated in ECBC.

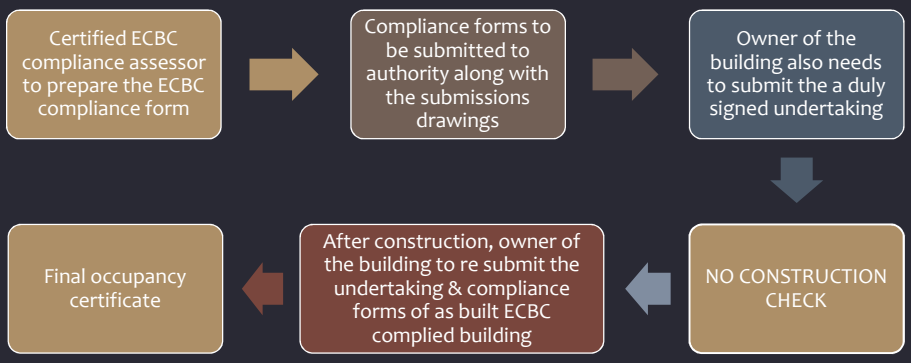
Whole building - Area Weighted averages should comply with ECBC EPI requirements.

Enforcement jurisdiction

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

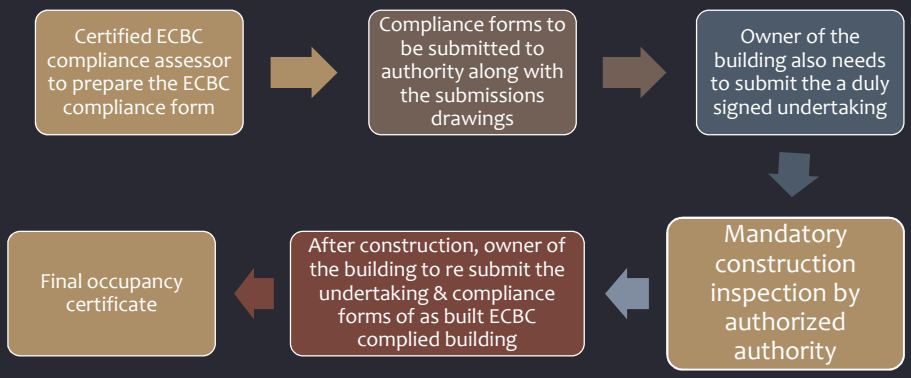
ECBC compliance process – Phase 1

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



ECBC compliance process – Phase 2

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



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

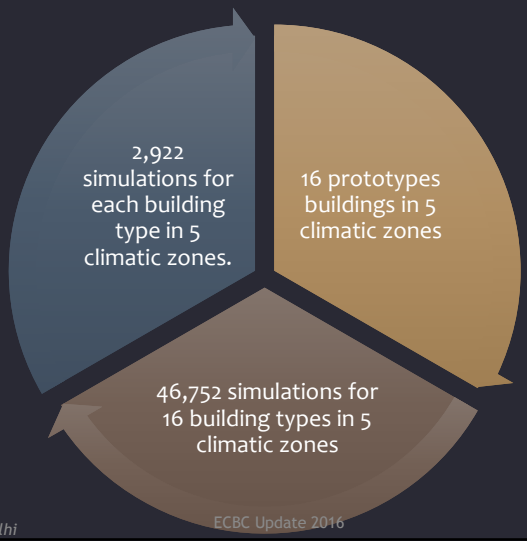
- Phase 1-
  - Plans and specifications shall show all pertinent data and features of the building, equipment, and systems.
  - Sufficient detail to be provided to permit the Authority Having Jurisdiction to verify that the building complies with the requirements of this code.
- Phase 2-
  - Construction verification compliance documentation

Session 3

Building Envelope

Building envelope: Stringency Path

Stringency analysis for wall, glazing, and roof



Wall (Prescriptive)

	Composite	Hot and dry	Warm & humid	Temperate	Cold
ECBC 2007 8 hours	0.44	0.44	0.44	0.44	0.35
ECBC 2007 24 hours	0.44	0.44	0.44	0.44	0.37
ECBC 2016 Day time	**0.40**	**0.40**	**0.40**	**0.55**	**0.34**
Office and school < 10,000 m²	*0.63*	*0.63*	*0.63*	*0.63*	*0.40*
EE building	0.34	0.34	0.34	0.4	0.22
SEE Building	0.22	0.22	0.22	0.22	0.22
ECBC 2016 24 hours	**0.40**	**0.40**	**0.40**	**0.40**	**0.34**
EE building	0.34	0.34	0.34	0.34	0.22
SEE Building	0.22	0.22	0.22	0.22	0.22

Roof (Mandatory)

	Composite	Hot and dry	Warm & humid	Temperate	Cold
ECBC 2007 8 hours	0.40	0.40	0.40	0.40	0.40
ECBC 2007 24 hours	0.26	0.26	0.26	0.40	0.26
ECBC 2016 Day time	**0.30**	**0.30**	**0.30**	**0.30**	**0.28**
School building < 10,000 m²	*0.54*	*0.54*	*0.54*	*0.54*	*0.30*
EE building	0.25	0.25	0.25	0.25	0.20
SEE Building	0.18	0.18	0.18	0.18	0.18
ECBC 2016 24 hours	**0.30**	**0.30**	**0.30**	**0.30**	**0.28**
Hospitality buildings	*0.19*	*0.19*	*0.19*	*0.30*	*0.19*
EE building	0.20	0.20	0.20	0.20	0.20
SEE Building	0.18	0.18	0.18	0.18	0.18

Glazing (Prescriptive)

	Composite	Hot and dry	Warm & humid	Temperate	Cold
WWR	*40%*	*40%*	*40%*	*40%*	*40%*
ECBC 2007 standard	U - 3.3 SHGC - 0.25 VLT - 0.2	U - 3.3 SHGC - 0.25 VLT - 0.2	U - 3.3 SHGC - 0.25 VLT - 0.2	U - 6.9 SHGC - 0.40 VLT - 0.2	U – 3.3 SHGC - 0.51 VLT - 0.2
Proposed	U - 3.3 $SHGC_{non\ north}$ - 0.27 $SHGC_{north}$ - 0.5 VLT - 0.27	U - 3.3 $SHGC_{non\ north}$ - 0.27 $SHGC_{north}$ - 0.5 VLT - 0.27	U - 3.3 $SHGC_{non\ north}$ - 0.27 $SHGC_{north}$ - 0.5 VLT - 0.27	U - 3.3 $SHGC_{non\ north}$ - 0.27 $SHGC_{north}$ - 0.5 VLT - 0.27	U – 2.8 $SHGC_{all}$ - 0.62 VLT - 0.27

EE and SEE requirement–
Meet all the proposed requirements of ECBC 2016 and maintain a minimum selectivity ratio of 1.5 for EE buildings and 1.75 for SEE buildings
$SHGC_{north}$ of 0.5 is applicable for latitude ≥ 15°, for latitude < 15°, $SHGC_{north}$ to be same as $SHGC_{non\ north}$

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

Discussion points -

1. Naturally ventilated buildings in temperate climatic zone is exempted from the wall insulation requirement
2. Warm & humid climate and insulation water absorption issue

SEF table for 28 °N (Prescriptive)

	28 °N											
	Box Frame				Overhang				Fin			
Projection Factor	**0.25**	**0.5**	**0.75**	**1**	**0.25**	**0.5**	**0.75**	**1**	**0.25**	**0.5**	**0.75**	**1**
North	1.25	1.47	1.66	1.81	1.09	1.18	1.25	1.30	1.13	1.22	1.30	1.36
East/ West	1.37	1.85	2.37	3.37	1.21	1.45	1.74	2.06	1.11	1.20	1.27	1.33
South	1.58	2.47	3.62	4.63	1.28	1.59	1.95	2.26	1.18	1.35	1.46	1.55
North-East/ North-West	1.47	1.86	2.25	2.57	1.17	1.35	1.48	1.75	1.21	1.34	1.55	1.69
South-East/ South-West	1.47	2.25	2.90	3.68	1.26	1.60	1.94	2.19	1.14	1.27	1.35	1.44

Example	SHGC	0.25 (say)

	28 °N											
	Box Frame				Overhang				Fin			
	0.25	**0.5**	**0.75**	**1**	**0.25**	**0.5**	**0.75**	**1**	**0.25**	**0.5**	**0.75**	**1**
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	0.49	0.53	0.29	0.33	0.34	0.36

Similar table for latitude 13 °N is also added in ECBC

U value requirement for shaded buildings (Prescriptive)

				U value (W/m2K)
	Climate zone	**Orientation**	**SHGC**	**Shading PF ≥ 0.4**
Day time buildings and naturally ventilated buildings	All except cold climate	Non North	0.27	5.0
Rest all categories as per the previous tables				

- Still under the review of Working Group
- Key discussion points

✓ Applicability

✓ Pros and Cons

✓ Comments on the proposed concept

Daylighting requirement (Mandatory)

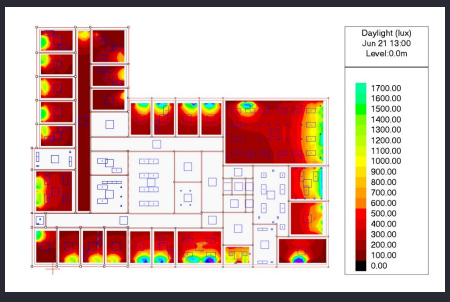
Daylighting requirement (manual or simulation)		% above grade area meeting the UDI requirement for 90% of the time in an year
All buildings except*	< 3 storey building (above grade)	40%
	> 3 storey building (above grade)	45%
* Resort	All type	45%
*Shopping malls/ complex	All type	10%

For simulation approach, BEE approved software shall be used

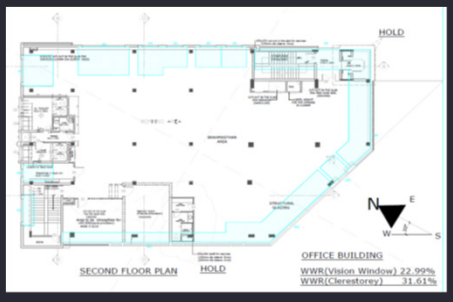
For manual approach, day light extent to be marked/ estimated on the architectural plan to estimate the final percentage area

Compliance method

Simulation Approach



Manual Approach

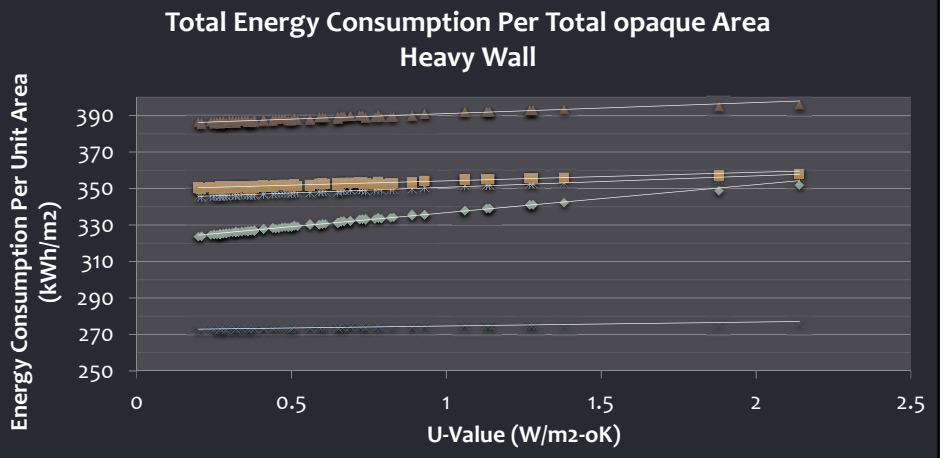


Manual approach for daylighting compliance

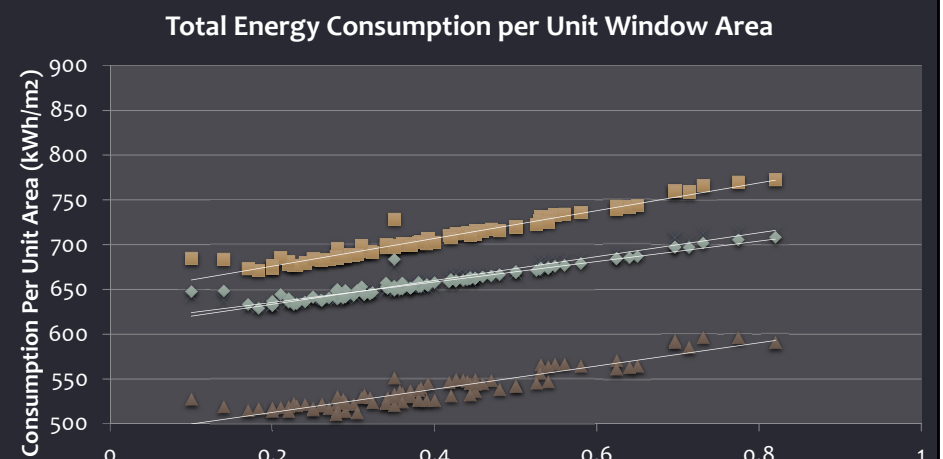
Day lighting penetration potential – Manual approach for vertical fenestration (n X head height, n is as per the table below)									
			North	South/ East	West	North	South/ East	West
	Window type	Shading	VLT < 0.3			VLT ≥ 0.3		
Delhi	All window types	No Shading	1.4	1.0	0.5	1.5	1.1	0.7
Chennai			1.5	1.3	0.6	1.6	1.5	0.8
			Non West		West	Non West		West
	window type	Shading	VLT < 0.3			VLT ≥ 0.3		
All lattitude types	Vision window	All shading types with PF>0.4	1.5		1.1	1.8		1.5
	Clerestorey		1.8		1.6	2.1		1.8

Key Analysis Results

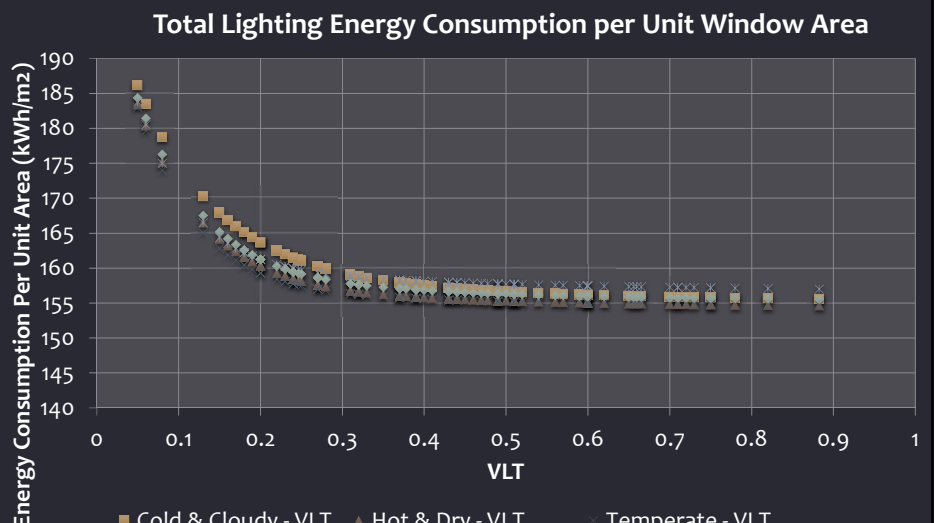
Heavy wall in all climatic zones – Small office (8 hours)



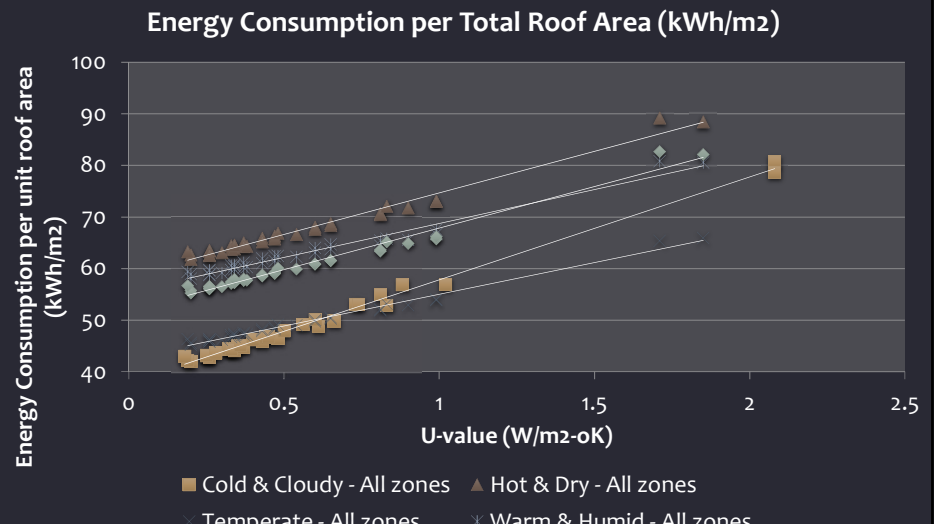
Glazing performance in all climatic zones - Small office (8 hours)



Glazing performance in all climatic zones - Small office (8 hours)

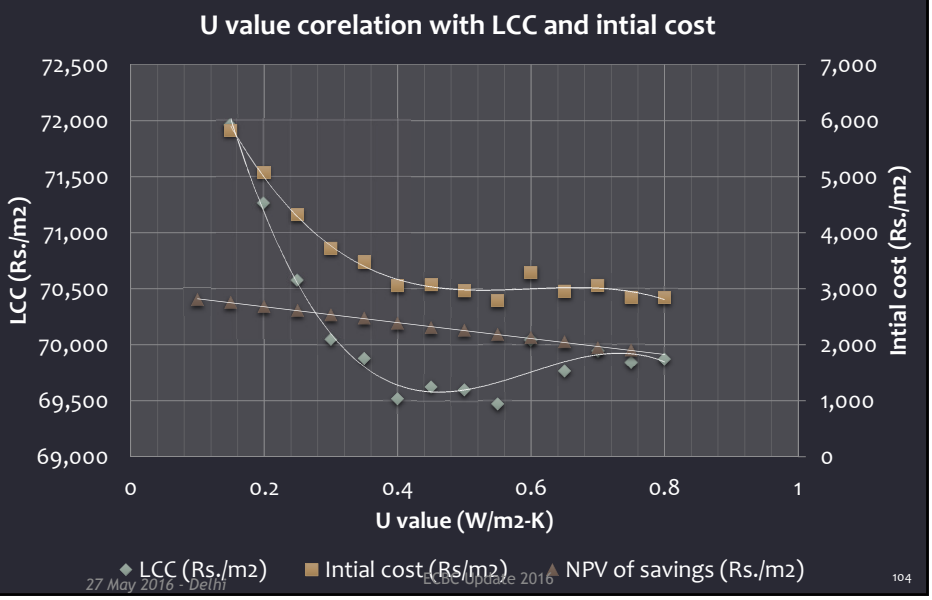


Roof performance in all climatic zones - Small office (8 hours)

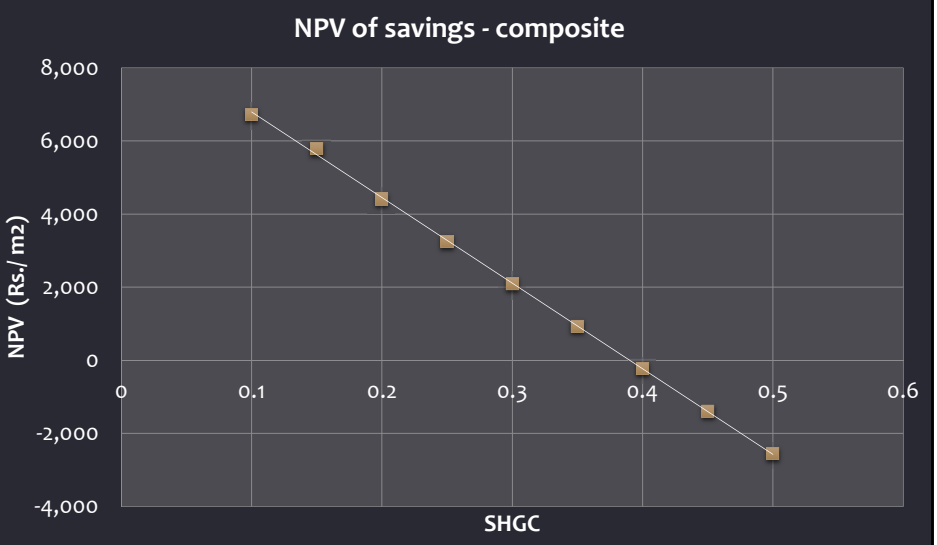


Life Cycle Cost Analysis

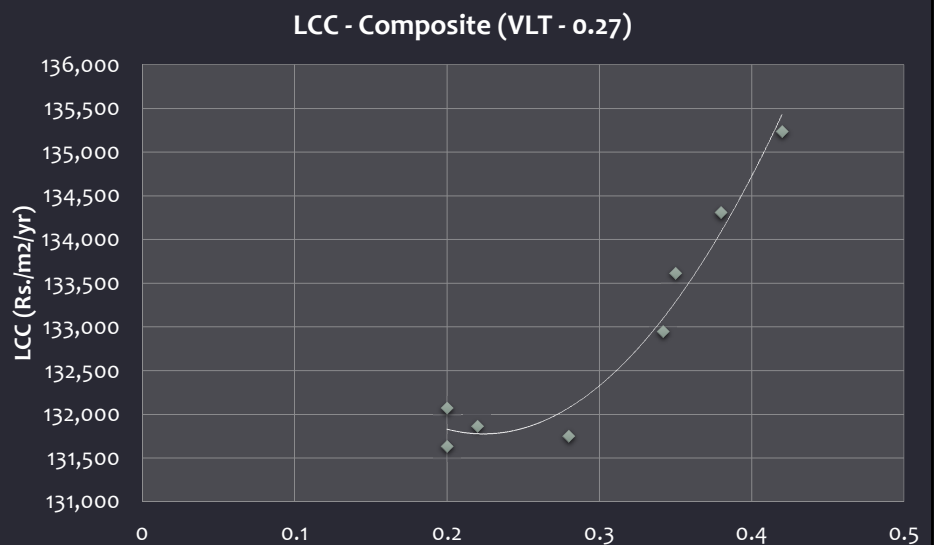
LCC, NPV, and initial cost – wall in composite



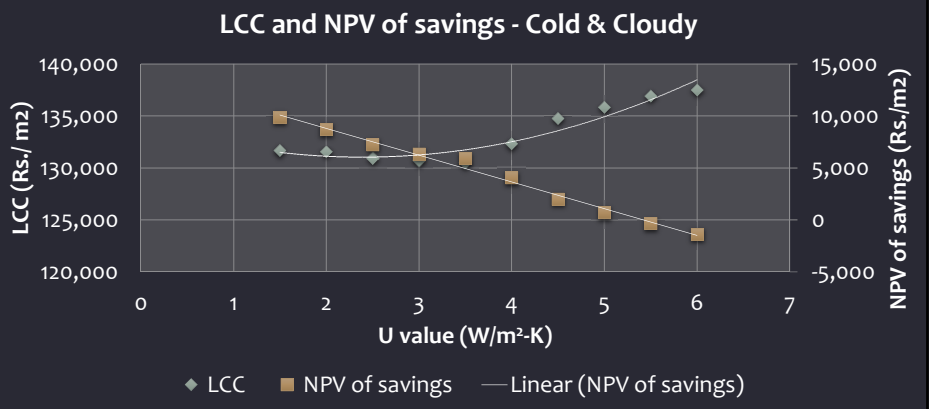
NPV of Savings – Glazing in Composite



LCC – Glazing in Composite



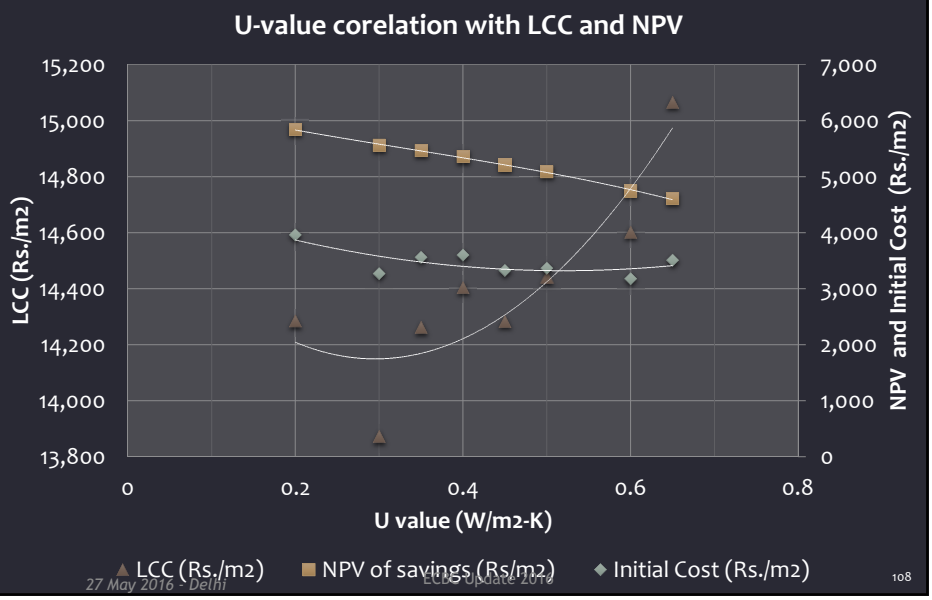
LCC and NPV – Glazing in Cold & Cloudy



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

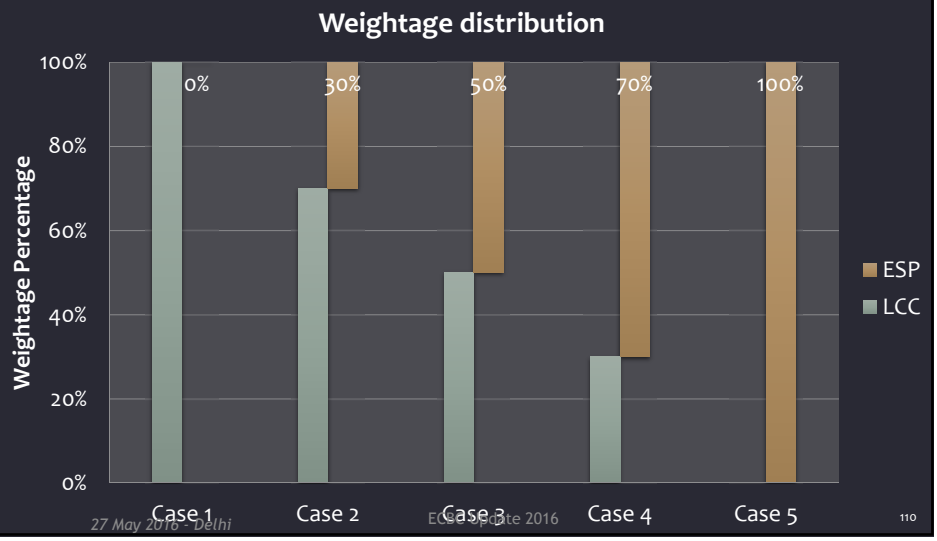
Small office, 8 hours, composite LCC and NPV , Roof



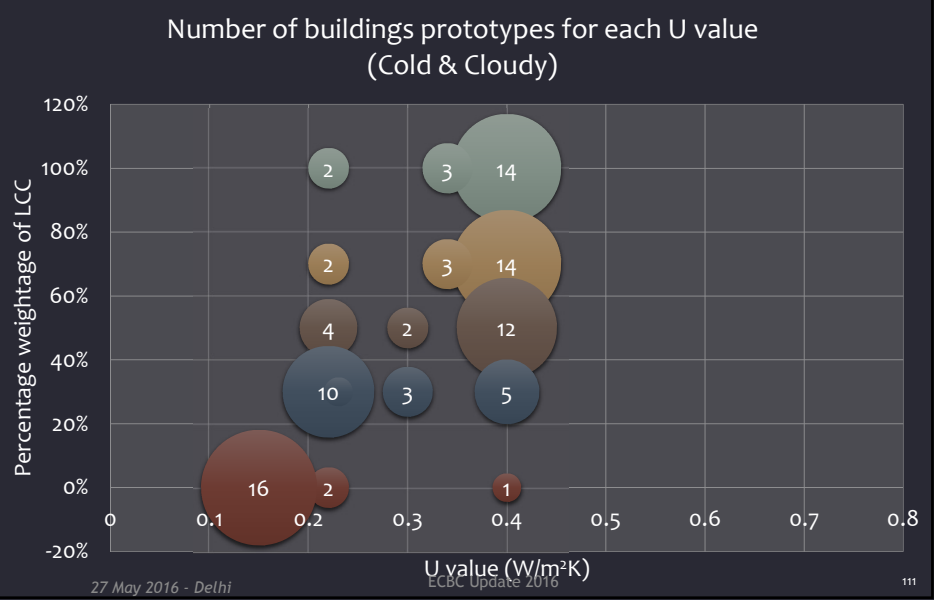
Analyzing 16 prototypes in 5 climatic zones

Analysis approach

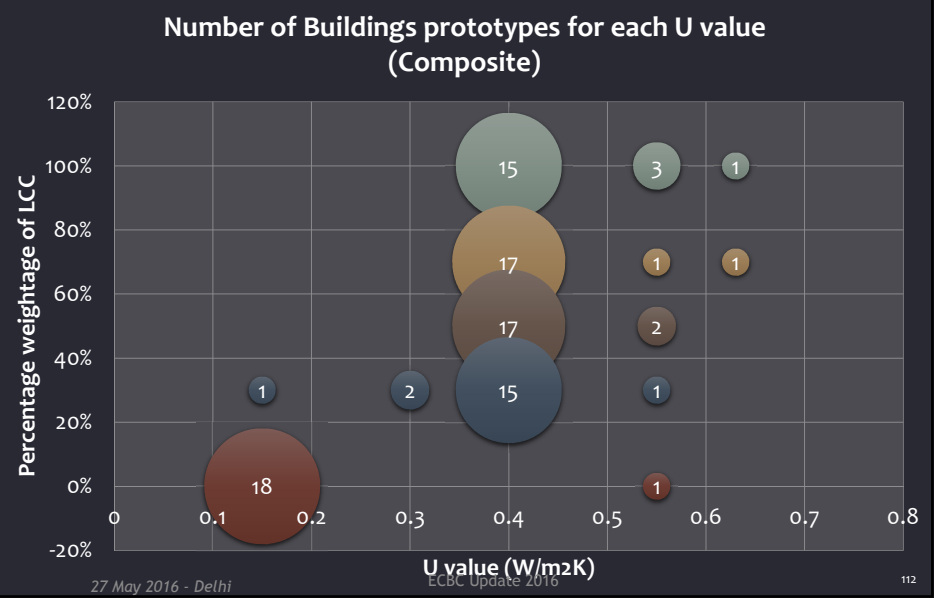
5 combinations were analyzed based on the weightage to LCC and energy saving potential (ESP)



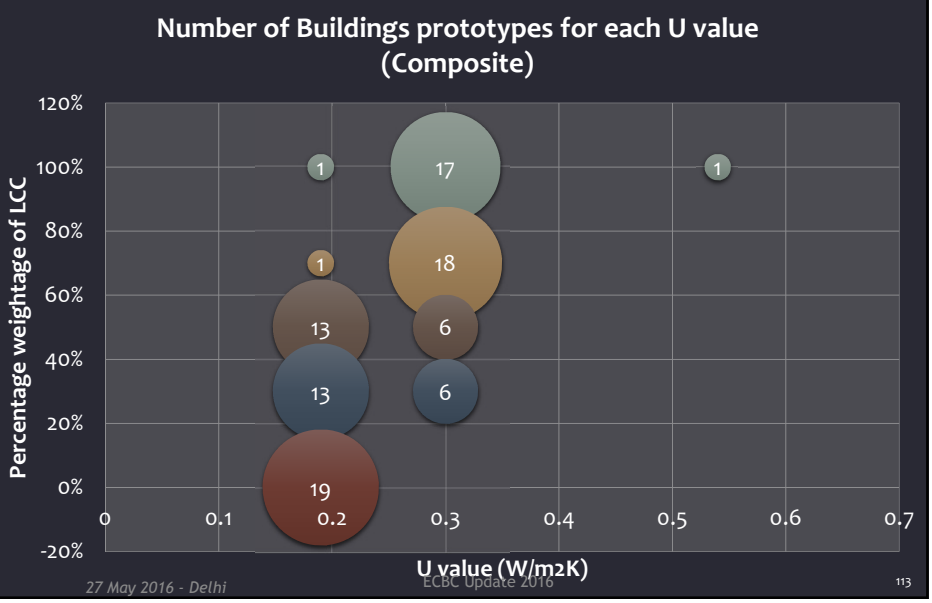
Cold and Cloudy – Wall Insulation



Composite - wall



Composite - Roof



SHGC values for different orientations

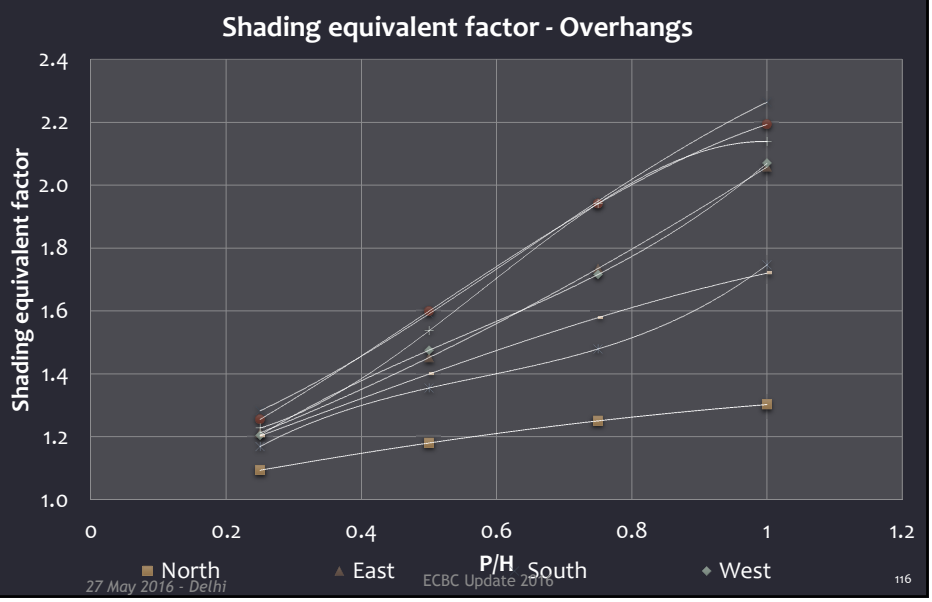
1. The SHGC recommendation of 0.27 for other orientation, except south orientation, could be relaxed.

2. Estimate the trend line equation for each orientation

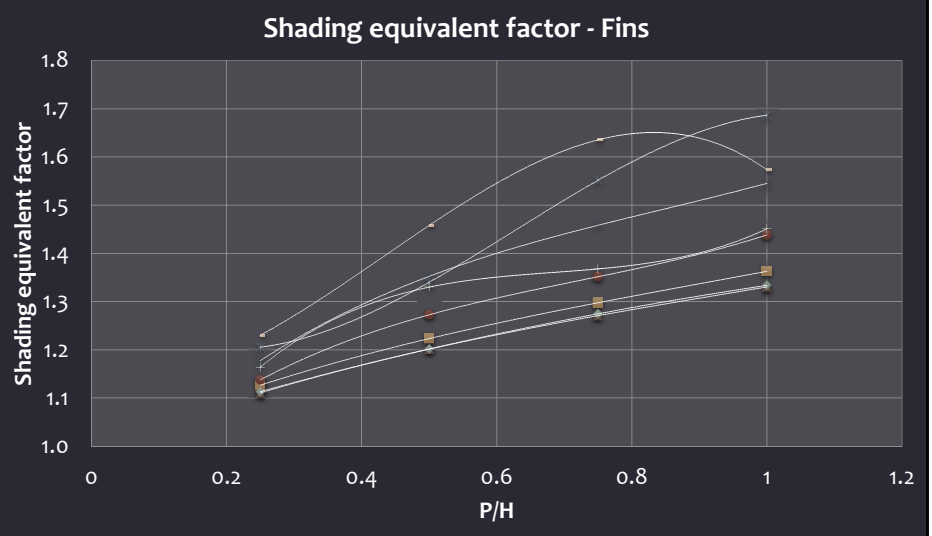
3. Equate the energy consumption of south orientation with 0.27 SHGC with other orientation, estimate the equivalent SHGC for N/ E/ W orientation

Shading Analysis

Overhangs – (28 °N)



Fins – (28 °N)



SEF table for 28 °N (Similar for other latitude degrees)

	28 °N											
	Box Frame				Overhang				Fin			
Projection Factor	**0.25**	**0.5**	**0.75**	**1**	**0.25**	**0.5**	**0.75**	**1**	**0.25**	**0.5**	**0.75**	**1**
North	1.25	1.47	1.66	1.81	1.09	1.18	1.25	1.30	1.13	1.22	1.30	1.36
East/ West	1.37	1.85	2.37	3.37	1.21	1.45	1.74	2.06	1.11	1.20	1.27	1.33
South	1.58	2.47	3.62	4.63	1.28	1.59	1.95	2.26	1.18	1.35	1.46	1.55
North-East/ North-West	1.47	1.86	2.25	2.57	1.17	1.35	1.48	1.75	1.21	1.34	1.55	1.69
South-East/ South-West	1.47	2.25	2.90	3.68	1.26	1.60	1.94	2.19	1.14	1.27	1.35	1.44

Example	SHGC	0.25 (say)

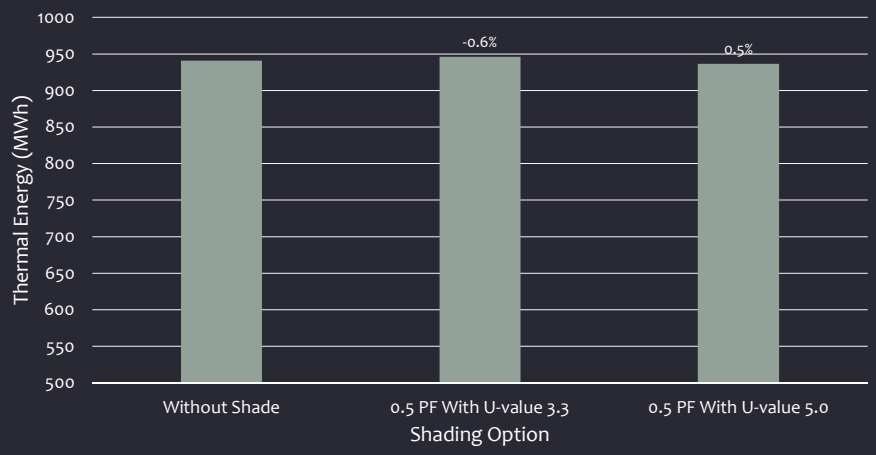
	28 °N											
	Box Frame				Overhang				Fin			
	0.25	**0.5**	**0.75**	**1**	**0.25**	**0.5**	**0.75**	**1**	**0.25**	**0.5**	**0.75**	**1**
South	0.39	0.62	0.90	1	0.32	0.40	0.49	0.57	0.29	0.34	0.36	0.39
South-East	0.37	0.56	0.72	0.92	0.31	0.40	0.49	0.55	0.28	0.32	0.34	0.36
South-West	0.35	0.56	0.78	1	0.31	0.38	0.49	0.53	0.29	0.33	0.34	0.36

Similar table for latitude 13 °N will be added

U value exemption for shaded buildings

				U value (W/m2K)
	Climate zone	**Orientation**	**SHGC**	**Shading PF ≥ 0.4**
Day time buildings and naturally ventilated buildings	All except cold climate	Non North	0.27	5.0

Thermal energy variation with different glazing combination



Day lighting Analysis

Day lighting Requirement

Daylighting Analysis

Concept
- Useful Daylighting Index
- Manual and simulation compliance format
- Ease to show and check compliance

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

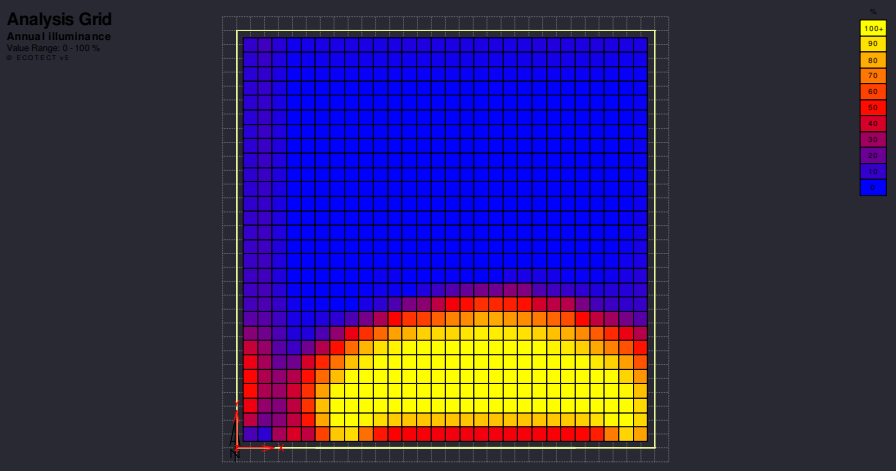
Simulations
- 220 simulations were done for one set of results

Useful Daylight Illuminance (UDI)

1. UDI metric bins hourly time values based upon three illumination ranges, 0-100 lux, 100-2000 lux, and over 2000 lux. It provides full credit only to values between 100 lux and 2,000 lux for at least 90% of the time.

2. 220 simulations were done to document the extent possible with different façade combinations in each orientation for 2 latitudes. The results for useful daylight extent for south orientation in Chennai is shown in next few slides

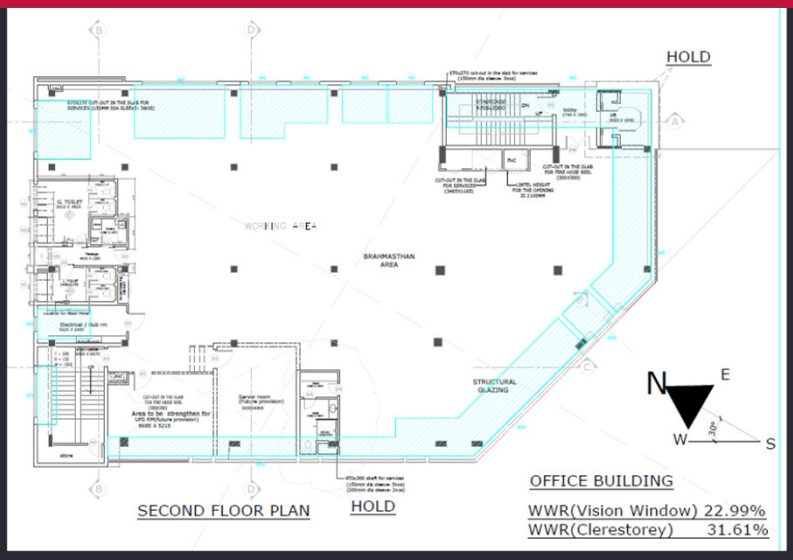
Case 2 – Vision window - No shading and VLT > 0.3

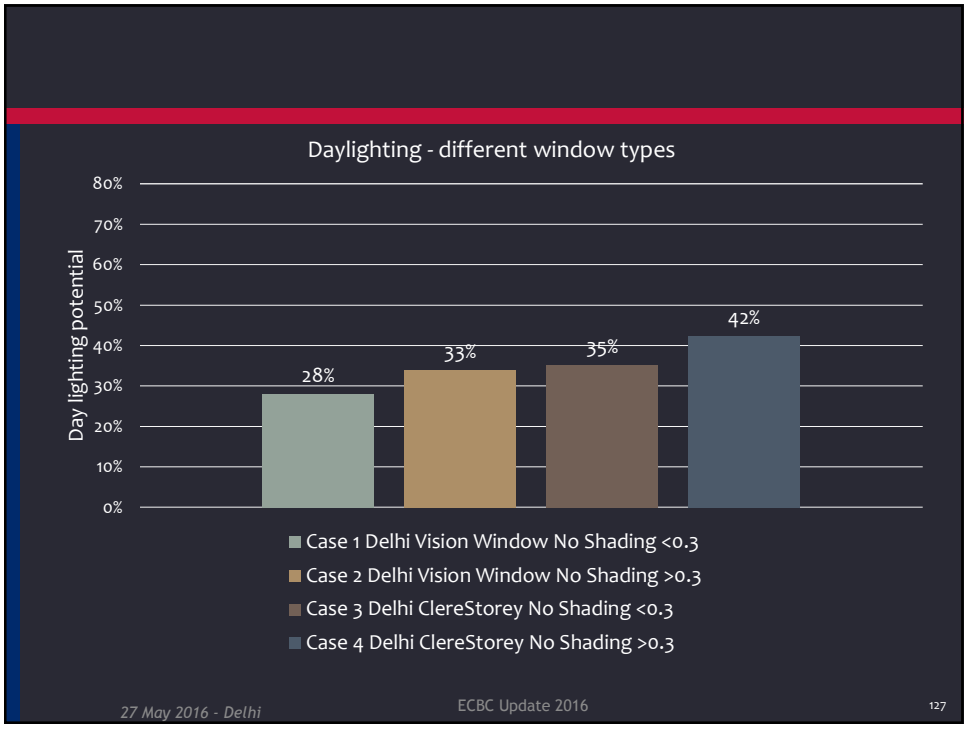


Manual approach for daylighting compliance

Day lighting penetration potential - manual for vertical fenestration (n X head height, n is as per the table)									
			North	South/ East	West	North	South/ East	West
	Window type	Shading	VLT < 0.3			VLT ≥ 0.3		
Delhi	All window types	No Shading	1.4	1.0	0.5	1.5	1.2	0.8
Chennai			1.5	1.3	0.6	1.6	1.5	1.0
			Non West		West	Non West		West
	window type	Shading	VLT < 0.3			VLT ≥ 0.3		
All lattitude types	Vision window	All shading types with PF>0.4	1.5		1.1	1.8		1.5
	Clerestorey		1.8		1.6	2.1		1.8

Manual Compliance Method - Floor Plan




Daylighting - different window types
Day lighting potential
80%
70%
60%
50%
40%
30%
20%
10%
0%
28%
33%
35%
42%
Case 1 Delhi Vision Window No Shading <0.3
Case 2 Delhi Vision Window No Shading >0.3
Case 3 Delhi ClereStorey No Shading <0.3
Case 4 Delhi ClereStorey No Shading >0.3
27 May 2016 - Delhi
ECBC Update 2016
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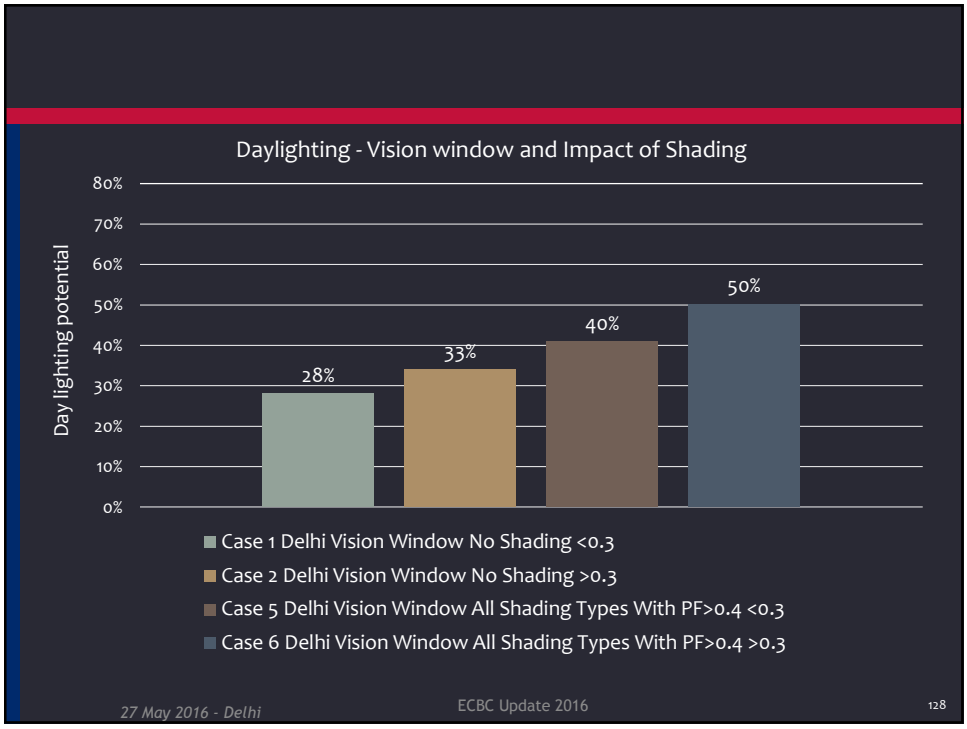
Daylighting - Vision window and Impact of Shading
Day lighting potential
80%
70%
60%
50%
40%
30%
20%
10%
0%
28%
33%
40%
50%
Case 1 Delhi Vision Window No Shading <0.3
Case 2 Delhi Vision Window No Shading >0.3
Case 5 Delhi Vision Window All Shading Types With PF>0.4 <0.3
Case 6 Delhi Vision Window All Shading Types With PF>0.4 >0.3
27 May 2016 - Delhi
ECBC Update 2016
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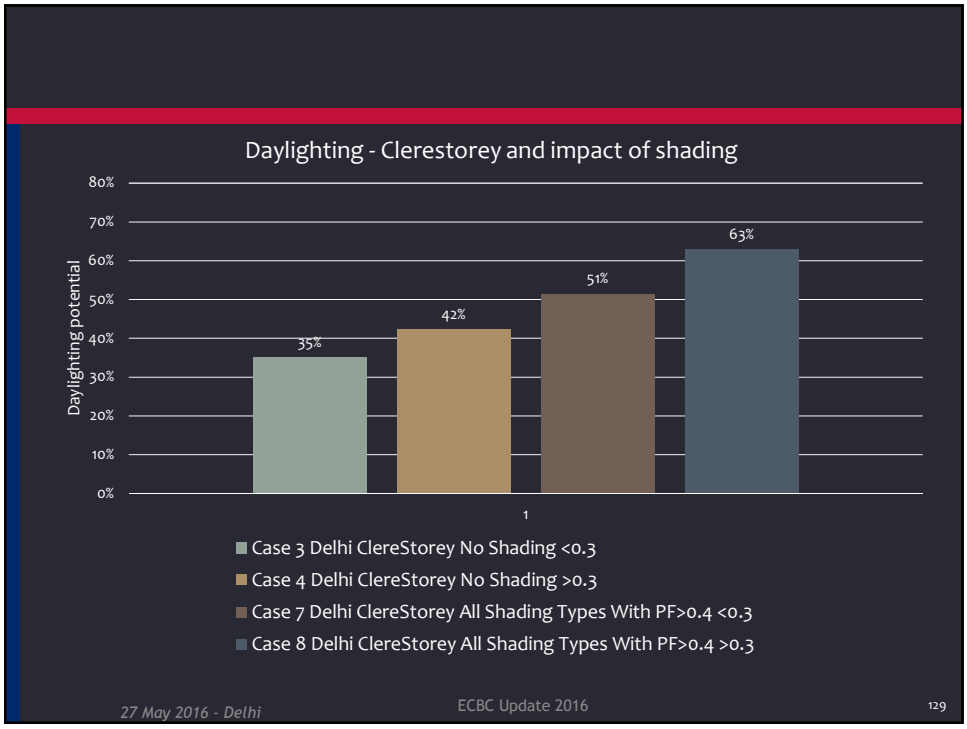
Daylighting - Clerestorey and impact of shading
Daylighting potential
80%
70%
60%
50%
40%
30%
20%
10%
0%
35%
42%
51%
63%
1
Case 3 Delhi ClereStorey No Shading <0.3
Case 4 Delhi ClereStorey No Shading >0.3
Case 7 Delhi ClereStorey All Shading Types With PF>0.4 <0.3
Case 8 Delhi ClereStorey All Shading Types With PF>0.4 >0.3
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ECBC Update 2016
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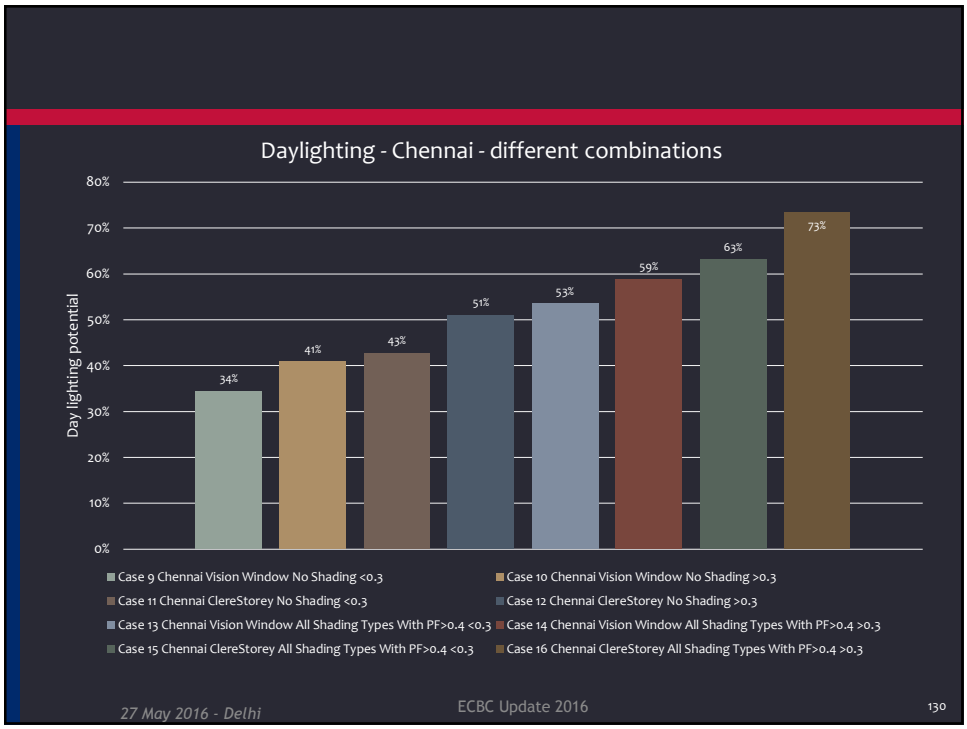
Daylighting - Chennai - different combinations
Day lighting potential
80%
70%
60%
50%
40%
30%
20%
10%
0%
34%
41%
43%
51%
53%
59%
63%
73%
Case 9 Chennai Vision Window No Shading <0.3
Case 10 Chennai Vision Window No Shading >0.3
Case 11 Chennai ClereStorey No Shading <0.3
Case 12 Chennai ClereStorey No Shading >0.3
Case 13 Chennai Vision Window All Shading Types With PF>0.4 <0.3
Case 14 Chennai Vision Window All Shading Types With PF>0.4 >0.3
Case 15 Chennai ClereStorey All Shading Types With PF>0.4 <0.3
Case 16 Chennai ClereStorey All Shading Types With PF>0.4 >0.3
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Cool roof

Cool roof (Mandatory)

1. Roofs with slopes less than 20 degrees shall have an initial solar reflectance of no less than 0.7 and an initial emittance no less than 0.75.

2. Solar reflectance shall be determined in accordance with ASTM E903-96 and emittance shall be determined in accordance with ASTM E408-71 (RA 1996).

Session 4

Lighting and Controls

Lighting and Controls - Process

150 products under 5 lamps categories – LEDs, T5, T8, CFL, T12.

8 controls types

Details like lamp wattage, efficacies, utilization factor tables, cost

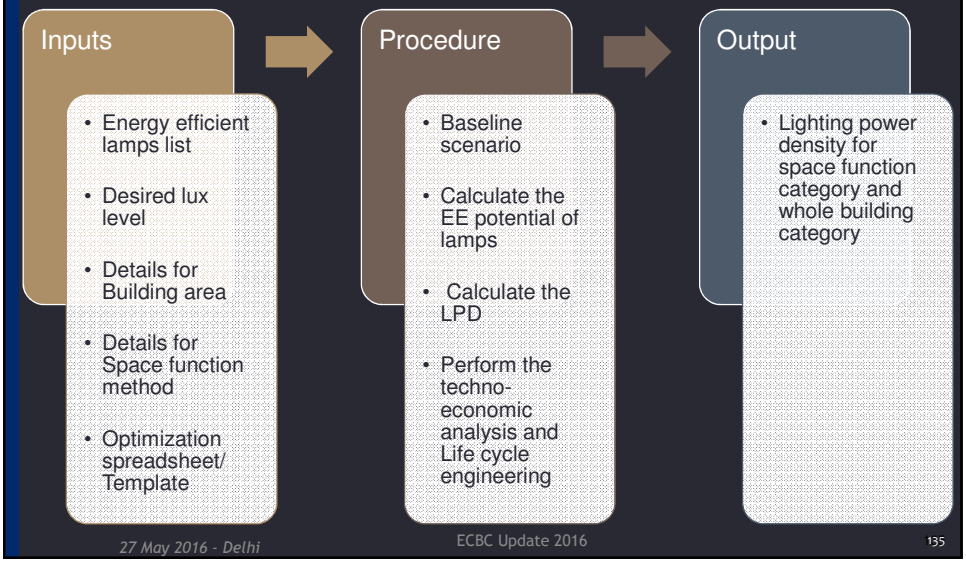
100 spaces for space by space method

16 building prototypes for building are method

500+ LPDs based on different spaces and lamp categories

Undertaken techno-economic analysis

Methodology for lighting stringency analysis



Key findings from data collation survey

1. T12 (efficacy 45 lm/ watt) is least efficient and cheapest lamp type available in the market

2. Technology like CFL, T5, and LED outperform T12 by 30%, 50%, and 120% respectively

3. In a space like office, a reduction of nearly 40% and 60% in LPD is possible by replacing a T12 fixture with a T5 and LED respectively.

Key findings from data collation survey

4. Increased cost of energy efficient fixture could be compensated with increased efficacy of the fixture

5. ECBC 2007 LPD values are easily achieved with any fixture with an efficacy of 45 - 60 lm/ Watt (T12 or T8)

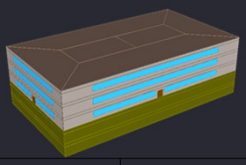
   50 % of space LPD listed in ECBC 2007 could be met with T12, and additional 30% could be met with T8

LCC Estimation for each lamp type

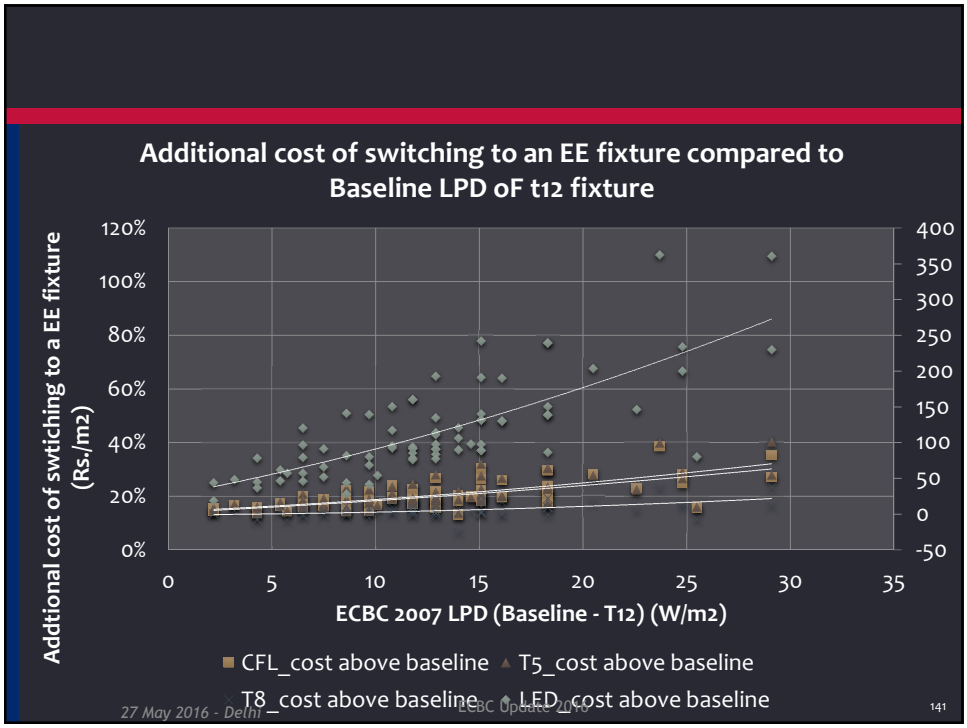
Recommendations									
Recommendations	CFL		L3 - CFL						
	Total cost (Rs/ m2)	LPD (W/m	Annual Energy used (9 hours) (kWh/m2)	Savings above baseline (kwh/ m2)	Money saved every year	Add. cost (Rs/m	Cost to save per unit	Simple pay back (yrs)	NPV of savings (Rs./m
Office									
Enclosed	51.45	15.3	32.06	-5.51	-56.76	35	-6.30	-0.61	-260
Open Plan	51.45	15.3	32.06	-5.51	-56.76	35	-6.30	-0.61	-260
Restrooms	19.29	5.7	12.02	9.80	101.08	11	1.12	0.11	463
Stairway	18.37	5.5	11.45	3.18	32.75	9	2.88	0.28	150
Storage	22.97	6.8	14.31	5.04	51.96	16	3.09	0.30	238
Workshop	73.50	21.9	45.79	0.33	3.42	56	168.49	16.34	16
Service/Repair	22.97	6.8	14.31	2.56	26.44	12	4.80	0.47	121
Bank/Office									
Banking Activity Area	61.25	18.2	38.16	-1.94	-19.96	47	-24.49	-2.38	-91
Convention Center									
Audience Seating	22.97	6.8	14.31	2.56	26.44	12	4.80	0.47	121
Exhibit Space	45.93	13.7	28.62	2.88	29.68	-1	-0.36	-0.03	136

Offices – building area method (W/m²)

Office					
Built up Area (m²)	20,000				
Form	Rectangle				
Aspect Ratio	1.8				
Number of Floors	3				
Number of Basement	2				
Space Distribution (%)		ECBC 2007	ECBC 2016	EE Buildings	SEE buildings
Office Space	80		10.0		
Circulation	5		7.1		
Reception and Lobby	5		9.1		
Services	10		6.8		
Total	100	**10.8**	**9.5**	**7.6**	**5.0**
Percentage reduction			**12.1%**	29.5%	53.1%



Lighting: Life Cycle Cost Analysis


Additional cost of switching to an EE fixture compared to Baseline LPD oF t12 fixture
Addtional cost of swtiching to a EE fixture (Rs./m2)
120%
100%
80%
60%
40%
20%
0%
400
350
300
250
200
150
100
50
0
-50
0
5
10
15
20
25
30
35
ECBC 2007 LPD (Baseline - T12) (W/m2)
CFL_cost above baseline
T5_cost above baseline
T8_cost above baseline
LED_cost above baseline
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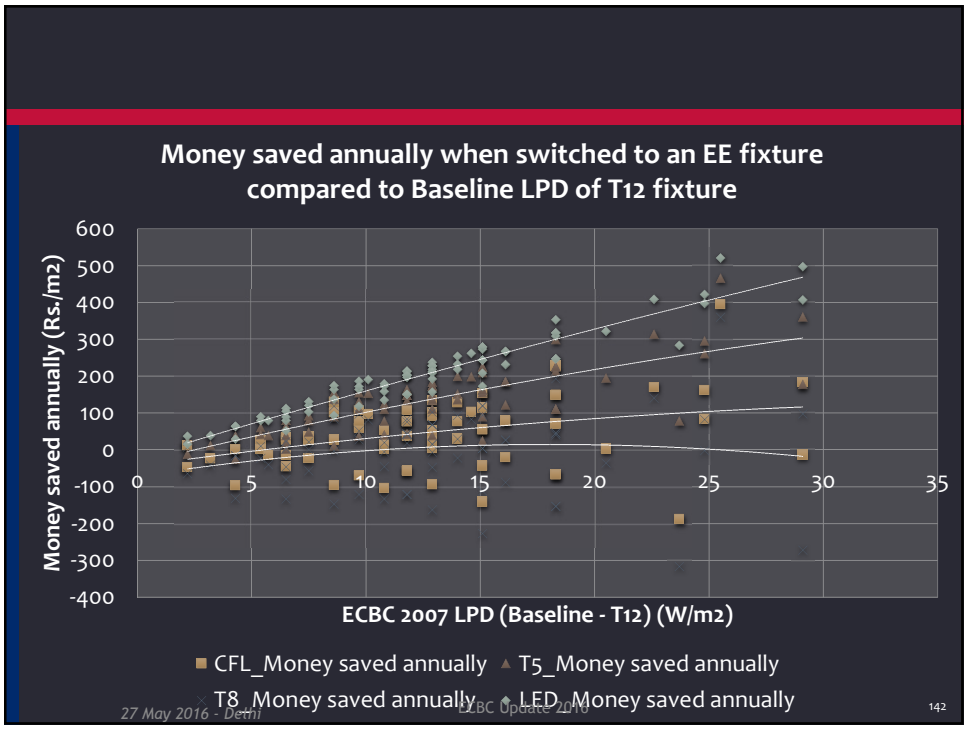
Money saved annually when switched to an EE fixture compared to Baseline LPD of T12 fixture
Money saved annually (Rs./m2)
600
500
400
300
200
100
0
-100
-200
-300
-400
0
5
10
15
20
25
30
35
ECBC 2007 LPD (Baseline - T12) (W/m2)
CFL_Money saved annually
T5_Money saved annually
T8_Money saved annually
LED_Money saved annually
27 May 2016 - Delhi
ECBC Update 2016
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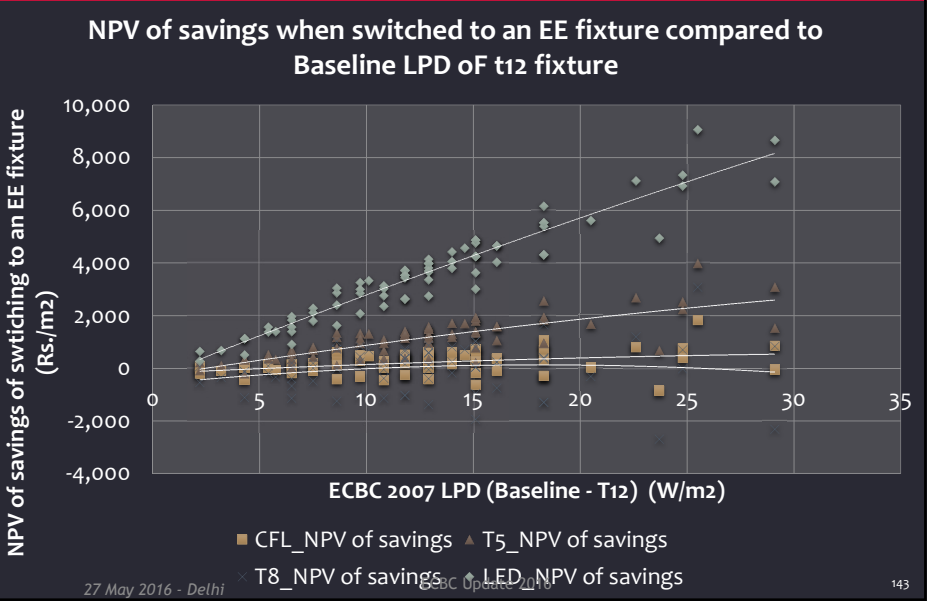


Key observations

1. Additional cost of switching to EE fixture is marginal for T5 fixture and CFL w.r.t baseline. LEDs are expensive.

2. Cost of light installation based on lighting design for a T5 and CFL are almost same.

3. Cost of T5 are 25% higher compared to CFL, the utilization factor of T5 are 22% less than CFL

Key observations

4. Money saved annually due to reduced energy consumption is nearly 3 to 4 times.

5. NPV of the energy saved during the life period of a fixture is 5 - 8 times the total fixture cost based on per unit fixture requirement making the up gradation very lucrative.

6. The simple payback of all EE fixtures is less than a year.

ECBC 2016 Recommendations

Light Power Density requirement – Approach (Mandatory – Discussion Point)

1. LPD estimate for space by space method
   a. Key spaces in a buildings more efficient than supporting areas
   b. Requirement for EE buildings and SEE buildings are 20% and 50% more efficient than ECBC requirement respectively
2. LPD estimate for Building area method
   a. The proportional average LPD for the whole building was estimated based on the proportional distribution of space and the estimated prescribed LPD values in space function stringency analysis

LPD recommendations for Building area method

LPD comparison as per whole building area method (W/m2)					
	ECBC 2007	ECBC 2016	% reduction	EE Building	SEE Building
Office Building	10.8	**9.5**	12.1%	7.6	5.0
Hospitals	12.9	**9.7**	25%	7.8	4.9
Hotels	10.8	**9.5**	12%	7.6	4.8
Shopping Mall	16.1	**14.1**	12.5%	11.3	7.0
University and Schools	12.9	**11.2**	13%	9.0	6.0
Library	14	**12.2**	13%	9.8	6.1
Dining: bar lounge/leisure	14	**12.2**	13%	9.8	6.1
Dining: cafeteria/fast food	15.1	**11.5**	24%	9.2	5.8
Dining: family	17.2	**10.9**	37%	8.7	5.5
Dormitory	10.8	**9.1**	16%	7.3	4.6
Fire station	10.8	**9.7**	10%	7.8	4.9
Gymnasium	11.8	**10**	15%	8.0	5.0
Manufacturing facility	14	**12**	14%	9.6	6.0

LPD recommendations for Building area method

LPD comparison as per whole building area method (W/m2)						
	ECBC 2007	ECBC 2016	% reduction	EE Building	SEE Building	ASHRAE 90.1 – 10
Motion picture theater	12.9	**9.43**	27%	7.5	4.7	8.9
Museum	11.8	**10.2**	14%	8.2	5.1	17.2
Post office	11.8	**10.5**	11%	8.4	5.3	9.4
Religious building	14	**12**	14%	9.6	6.0	10.8
Sports arena	11.8	**9.7**	18%	7.8	4.9	8.4
Transportation	10.8	**9.2**	15%	7.4	4.6	8.3
Warehouse	8.6	**7.08**	18%	5.7	3.5	7.1
Performing arts theater	17.2	**16.3**	5%	13.0	8.2	15.0
Police station	10.8	**9.9**	8%	7.9	5.0	10.3
Workshop	15.1	**14.1**	7%	11.3	7.1	12.9
Automotive facility	9.7	**9**	7%	7.2	4.5	8.8
Convention center	12.9	**12.5**	3%	10.0	6.3	19.4
Parking garage	3.2	**3**	6%	2.4	1.5	2.7

Offices – space by space method (W/m2)

Lamp category	NBC standard	NBC Lux (Avg)	ASHRAE (lux)	ASHRAE 2010-13	ECBC 2007	ECBC 2016	% reduction	EE buildings (20% efficient)	SEE buildings (50% efficient)
Enclosed	300-500-750	**400**	400	11.9	11.8	**10.0**	15%	8.6	5.4
Open Plan	300-500-750	**400**	400	10.5	11.8	**10.0**	15%	8.6	5.4
Banking Activity Area	300-500-750	**400**	400	14.8	16.1	**12.6**	22%	9.3	5.8
Conference/Meeting	200-300-500	300	400	13.2	14.0	**11.5**	18%	9.2	5.7
For Elevator	150-200-300	200	215	6.9		**9.1**	N/A	7.3	4.6
Corridor/Transition	**70-150**	100	50	7.1	5.4	**7.1**	N/A	3.6	2.3
Restrooms	100-150-200	**200**	300	10.5	9.7	**7.7**	21%	6.1	3.8
Stairway	50-100-150	100	50	7.4	6.5	**5.5**	16%	4.4	2.7
Storage	50-100-150	100	100	6.8	8.6	**6.8**	21%	5.4	3.4
Electrical/Mechanical	50-100-150	100	215	10.2	10.1	**7.1**	30%	5.7	3.5
Workshop	200-300-500	**400**	400	17.1	20.5	**17.1**	17%	13.7	8.6
Service/Repair	100-150-200	150	200	7.2	7.5	**6.8**	9%	5.5	3.4

With similar approach, more than 150 spaces will be listed

Controls

Controls scope in ECBC 2016 (Mandatory)

Space controls

- Independent controls for
  - Max 250m² if space <1000m²
  - Max 1000m² if space >1000m²
- Override the shutoff control for max 2 hours
- Readily accessible

Mandatory for buildings > 20,000 sqm – discussion point

Automatic Lighting Shutoff

- Automatic control devises for Office spaces > 300 m²
  - Schedule based, for max 2500 m² and one floor
- Spaces > 25 m² – Occupancy
  - Conference rooms
  - Classrooms, laboratories
  - Storage spaces > 15 m²
  - Hotel public toilets >25 m²
  - Hotel and hospital corridors

  Turns off within 15 mins, for only 95% light of the space

Controls scope in ECBC 2016 (Mandatory for all buildings)

Exterior lighting controls

- Mandatory daylight sensor or time switch
- For all universities, IT campus, and buildings with a BUA > 15,000 m^2
  - avg light source efficacy of not less than 70 lumens/W
  - All landscaping lighting should have an Installed motion detector for 80% of the landscaping and street lighting (on/off or 50% dimmable)
- Façade lighting or signage have separate time switch

exceptions - emergency lighting,

Daylighting controls

- all corridors, lobby, and toilets
- manual or automatic control within 5 meters of a window
  - switch level set point adjusted btw 50 to 1000 lux
  - delay of >2 mins, and differential > than 50 lux
  - dimmed or stepped to 50% of total power
  - Over rides to daylighting sensor should not be allowed
- **Incentive** - LPD adjustment factor of 20% is applicable, within the daylight zone, to any spaces if > 70% of space is having daylight controls

EE and SEE buildings – controls requirement

1. Mandatory requirement of centralized system of lighting controls
   a. Schedule based operation
   b. Day light sensor controls
   c. Dimmable controls (manual or automatic)

Luminaire wattage

a. Luminaire efficacy should be 0.7 or above

b. If luminaire has a permanently installed ballast, the considered wattage of the system shall be the operating input wattage of overall system based on the manufacturer or laboratories

c. If luminaire doesn't not have a permanently installed ballast, the considered wattage of the system shall be maximum labeled wattage of the luminaire

d. Considered wattage of all other luminaire types shall be the specified wattage of the luminaire

Exterior lighting (Mandatory)

Exterior lighting application	Power Limits
Building entrance (with canopy)	10 W/m² of canopied area
Building entrance (w/o canopy)	90 W/ linear m of door width
Buiding exit	60 W/lin m of door width
Building façade	5 W/m² of vertical façade area
Emergency signs, ATM kiosks, Security areas façade	1 W/m²
Parking areas (covered/ basement)	2.2 W/m²
Driveways (covered/ basement)	3 W/m²
Driveways and parking (open/ external)	1.6 W/m²
Pedestrian walkways	2.0 W/m²
Stairways	10.0 W/m²
Landscaping	0.5 W/m²
Outdoor sales area	9.0 W/m²

Recommended value for EE and SEE buildings are 20% and 50% efficient to the ECBC 2016 recommendation

Session 4

Comfort systems and Controls

Key Highlights

Wider Scope	Additional equipment, Thermal comfort, and Ventilation
Ease of Compliance check	Concept of W/ ton was introduced in Fans, Pumps and Cooling towers
System Efficiency	System efficiency ensures design flexibility and innovation
Advance controls requirement	Wider scope of controls requirement, specific to space and building
Low Energy Comfort System and Natural Ventilation	ECBC 2016 to include compliance path for low energy comfort systems as well as Natural Ventilations
Technology Independent Requirement	Recommendation for chillers are technology independent

Comfort Systems and Controls – revised Scope

- Chillers:
  - Water/ air Cooled
- Unitary Air-Conditioners :
  - VRF system
  - Single/ Multi Spilt Unit
  - window AC
- Pumps
  - Chilled-Water Pump
  - Condenser Water Pump
  - Hot water pumps
- Air Distribution System :
  - AHU and FCUs
  - Fans – Centrifugal/ Axial
- Cooling towers
- Boilers
- System efficiency
- Controls
- Natural Ventilation
- Set points
- Ducts and pipe insulation
- Heat recovery and economizers
- Low energy comfort systems

Set points

Based on the study done by CEPT University

Natural Ventilated building

Indoor Operative Temperature = (0.54 x outdoor temperature) + 12.83

- *Where, indoor operative temperature (°C) is neutral temperature, & outdoor temperature is the 30-day outdoor running mean air temperature (°C).*
- *The 90 percent acceptability range for the India specific adaptive models for naturally ventilated buildings is ± 2.38°C.*

Delhi: Indoor Operative Temperature = (0.54 x 33.0)+ 12.83 = **30.68 °C**

Mixed mode building

Indoor Operative Temperature = (0.28 x outdoor temperature) + 17.87

- *Where indoor operative temperature (°C) is neutral temperature & outdoor temperature is the 30-day outdoor running mean air temperature (°C).*
- *The 90 percent acceptability range for the India specific adaptive models for mixed-mode buildings is ± 3.46°C.*

Delhi: Indoor Operative Temperature = (0.28 x 33.0)+ 17.87 = **27.1 °C**

Air-conditioned building

1. **Air temperature based approach:**

Indoor Operative Temperature = (0.078 x outdoor temperature) + 23.25

- Where indoor operative temperature (°C) is neutral temperature & outdoor temperature is the 30-day outdoor running mean air temperature (°C).
- The 90 percent acceptability range for the adaptive models for conditioned buildings is ±1.5°C.

Delhi: Indoor Operative Temperature = (0.078 x 33.0)+ 23.25 = **25.8 °C**

Air-conditioned building

2. **Standard Effective Temperature Based Approach:**

Indoor Operative Temperature = (0.014 x outdoor temperature) + 24.53

- Where indoor operative temperature (°C) is neutral temperature & outdoor temperature is the 30-day outdoor running mean air temperature (°C).
- The 90 percent acceptability range for the adaptive models for conditioned buildings is ±1.0°C.

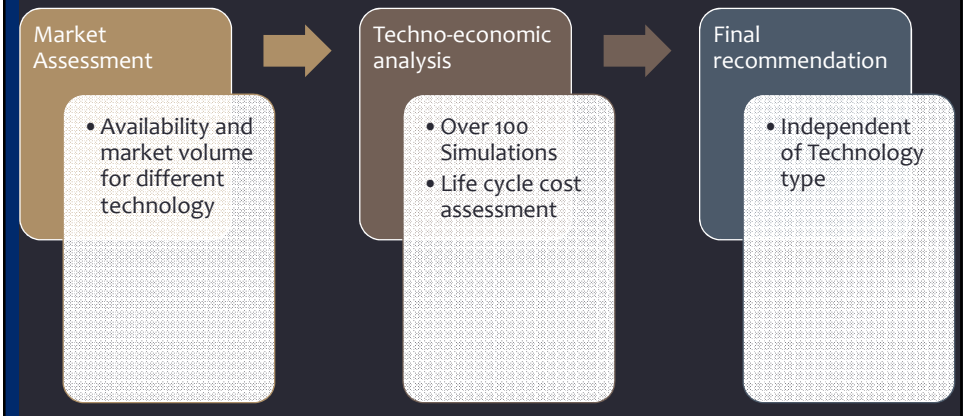
Delhi: Indoor Operative Temperature = (0.014 x 33.0)+ 24.53 **= 24.99 °C**

Note: Above equations are not applicable for outdoor running mean temperatures below 15°C.

Chillers

(Mandatory –Discussion point)

Chiller: Process of recommendations



Chillers – ECBC 2016 Recommendation: Option 1

		ECBC 2016 (MEPs.)		EE	SEE
	Equipment Class	Constant	VSD	COP	COP
Air Cooled Chiller	<530 kW (<150 TR)	3.0	2.7	3.3	NA
	≥530 kW (≥150 TR)	3.0	2.7	3.3	NA
Water cooled chiller	<530 kW (<150 TR)	5.5	5.0	5.8	6.1
	≥530 & <1050 kW (≥150 and <300 TR)	5.8	5.2	6.1	6.3
	≥1050kW (≥ 300 TR)	6.1 (5.8)	5.5	6.3	6.5
	≥2110 kW (≥ 600 TR)	6.3	5.7	6.5	6.7

Discussion on relaxed COP for Distributed chiller systems ?

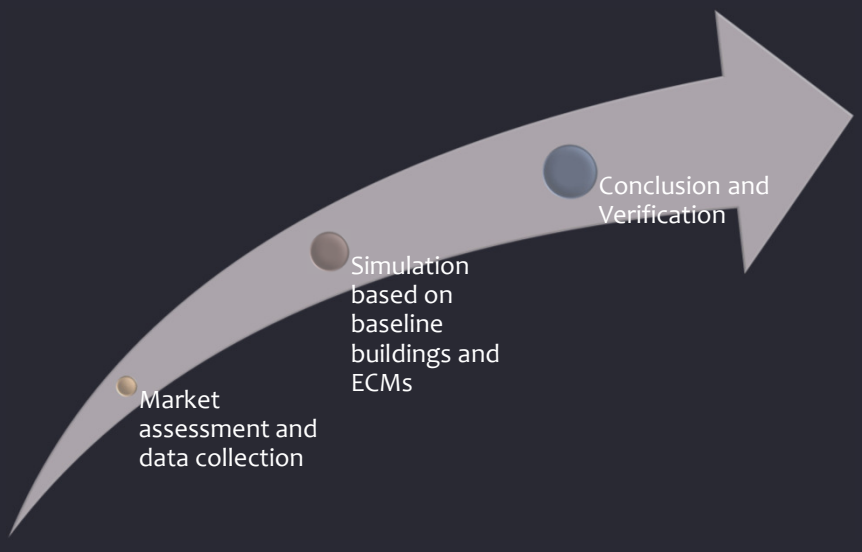
- The values in small brackets () in water cooled chillers are screw chiller COPs for reference only.
- The COP of VSD compressor based chiller are 10% less of fixed speed chiller COP.
- Number of Air-cooled chiller can be restricted.

Chillers – ECBC 2016 Recommendation: Option 2

		ECBC 2016 (MEPs)	EE building	SEE building
	Equipment Class	**COP**	COP	COP
Air Cooled Chiller with condenser electrical	<530 kW (<150 TR)	**3.0**	*3.3*	NA
	≥530 kW (≥150 TR)	**3.0**	*3.3*	NA
Centrifugal Water Cooled	< 530 kW (<150 TR)	**5.0**	5.6	5.68
Centrifugal Water Cooled	≥530 & <1050 kW (≥150 and <300 TR)	**5.55**	5.8	6.23
Centrifugal Water Cooled chillers	≥1050kW (≥ 300 TR)	**6.1**	6.3	6.48
water cooled centrifugal	≥2100 kW ≥ 600 TR	***6.2***	6.5	6.7
Reciprocating Compressor, Water Cooled Chiller	all sizes	**4.2**	4.7	5.4
Rotary Screw and Scroll Compressor, Water Cooled	<530 kW (<150 TR)	**4.7**	5.0	5.8
Rotary Screw and Scroll Compressor, Water Cooled	≥530 & <1050 kW (≥150 and <300 TR)	**5.4**	5.5	6.3
Rotary Screw and Scroll Compressor, Water Cooled	≥ 1050 kW (≥ 300 TR)	**5.75**	6.0	6.45

Air Systems

Air-System (Fans) - Process



Fans – recommendations (Prescriptive)

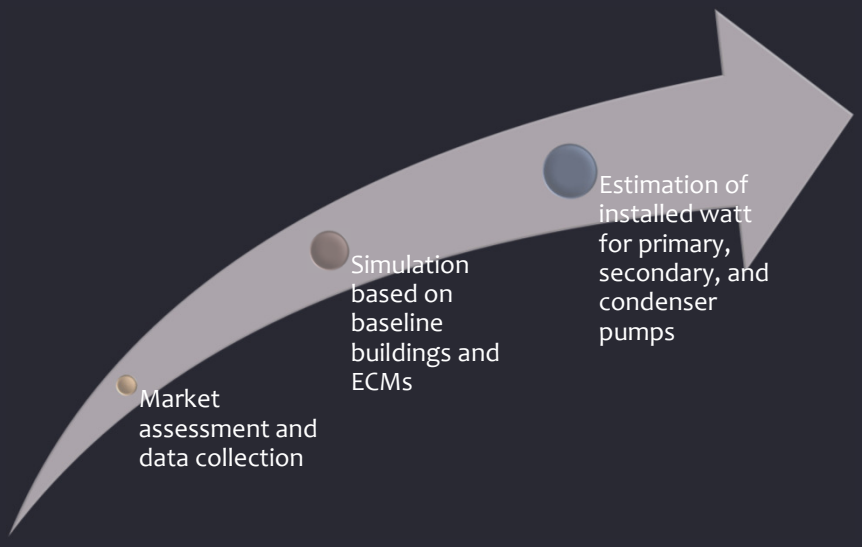
Fan efficiencies							
System type	Fan Type	Mechanical Efficiency			Motor Efficiency		
		ECBC	EE	SEE	ECBC	EE	SEE
Central system / Duct able VRVs	Supply	60%	65%	70%	IE 2	IE 3	IE 4
	Return and Exhaust	55%	60%	65%	IE 2	IE 3	IE 4

Fan efficiency requirement applicable to motor power exceeding 0.37 kW.

Discussion point – different efficiency for supply & return fans recommended?

Pumps

Pump energy efficiency - Process



Pumps – recommendations (Prescriptive)

ECBC 2016 - installed pump capacity (Watt) per Installed cooling capacity at a building level chilled water system

System type	ECBC 2016	EE building	SEE building
Chilled water Pump (P + S)	18.2 W/ kW_r (64 W/ ton_r) with VSD	16.9 W/ kW_r (59.5 W/ ton_r) with VSD	14.9 W/ kW_r (52.5 W/ ton_r) with VSD
Condenser water pump	17.7 W/ kW_r (62.3 W/ ton_r)	16.5 W/ kW_r (58.1 W/ ton_r)	14.6 W/ kW_r (51.2 W/ ton_r)
	With 70% efficiency	With 75% efficiency	With 85% efficient pumps

Pumps requirements for district chiller system is limited to the installed efficiency requirement of individual pump equipment only

Cooling towers (Prescriptive)

Equipment type	Rating Condition	ECBC 2016
Propeller or axial fan open/ closed -circuit cooling towers	95°F/ 35°C entering water 85°F/ 29°C leaving water 75°F/ 24°C wb outdoor air	0.017 kW/kW_r (0.062 kW/ton_c) *0.31 kW/ L/s* *(≥38.2 gpm/ hp)*
Centrifugal fan open/ closed -circuit cooling towers	95°F/ 35°C entering water 85°F/ 29°C leaving water 75°F/ 24°C wb outdoor air	0.034 kW/kW_r (0.12 kW/ton_c) (0.59 kW/ L/s) ≥20.0 gpm/ hp

Assumption - 3.2 gpm/ ton
Tonnage considered for analysis is the cooling capacity
EE buildings and SEE buildings to have additional controls requirements

Boilers (Prescriptive)

Equipment type	Sub category	Size category	Minimum efficiency
Boilers, hot water	Gas fired	<88 kW	80% AFUE
		>=88 kW and <=732 kW	75% Et
		>732 kW	80% Ec
	Oil fired	<88 kW	80% AFUE
		>=88 kW and <=732 kW	78% Et
		>732 kW	83 % Ec

AFUE - annual fuel utilization efficiency
Ec - combustion efficiency (100% less flue losses)
Et - Thermal efficiency

Unitary and Split Air conditioners (Mandatory)

1. All the window AC and split AC less than 3 TR (10.5 kW_r) of cooling and/ or heating capacity will be as per BEE star rated programs
2. ECBC 2016 recommendation level
   - Minimum performance building – 3 star labelled (as for commercial use)
   - Energy efficient (EE) building – 4 star labelled
   - Super EE building – 5 star labelled

Unitary, Split and Packaged Air conditioners

Cooling Capacity			ECBC 2007 - COP		ECBC 2016		EE Buildings		SEE Buildings	
Watts	TR of Refri	kWr	Water Cooled	Air Cooled	Water Cooled	Air Cooled	Water Cooled	Air Cooled	Water Cooled	Air Cooled
≤10,500	≤ 3	≤ 10.5	NA	NA	NA	BEE 3 Star	NA	BEE 4 Star	NA	BEE 5 Star
> 10,500	> 3	>10.5	2.67	2.11	3.55	3.28				
17,500	5	17.5	2.92	2.50	3.55	3.28				
26,250	7.5	26.25	2.92	2.63	3.55	3.28				
35,000	10	35	3.04	2.59	3.55	3.28				
52,000	15	52.5	3.06	2.60	3.55	3.28				

Variable Refrigerant Flow Air Conditioner (Mandatory)

1. BEE is under process to develop the test standards on VRF based on Indian conditions
2. ECBC 2016 will refer to the conclusions of this study for mandatory requirements
3. Until the study is under process, ASHRAE 90.1 2010's COP levels for VRF will be referred for all analysis

Variable Refrigerant Flow Air Conditioner– ASHRAE 90.1 2010

Equipment type	Size category	Minimum Efficiency (2010)
VRF Air Conditioners, Air cooled	<19 kW	3.28 COP
	>=19 kW and < 40 kW	3.29 COP
	>= 40 kW and < 70 kW	3.26 COP
	>= 70 kW	3.02 COP

- BEE is under process to develop the test standards on VRF based on Indian conditions
- ECBC 2016 will refer to the conclusions of this study for mandatory requirements
- Until the study is under process, ASHRAE 90.1 2010's COP levels for VRF will be referred for all analysis

Precision Air Conditioner units
(Mandatory - Applicable to buildings with BUA> 20,000 sqm)

Equipment type	Net Sensible Cooling Capacity[a]	Minimum SCOP-127[b]	
		Downflow	Upflow
Air Conditioners, Air cooled	<19 kW	2.20	2.09
	>=19 kW and < 70 kW	2.10	1.99
	>=70 kW	1.90	1.79
Air Conditioners, Water cooled	<19 kW	2.60	2.49
	>=19 kW and < 70 kW	2.50	2.39
	>=70 kW	2.40	2.29

a. Net Sensible cooling capacity = Total gross cooling capacity - latent cooling capacity – Fan power
b. Sensible coefficient of performance (SCOP-127): A ratio calculated by dividing the net sensible cooling capacity in watts by the total power input in watts (excluding reheater and dehumidifier) at conditioned defined in ASHRAE standard 127)

- This is under the review of WG meeting
- Discussion points - comments on inclusion of the it in the code

System efficiency

Methodology to compute the system efficiency – ECBC 2016

Estimate the peak cooling demand for different building type, climate zone and size using energy simulation

Considered major components under chilled water plant i.e. chiller, chilled water and condenser water pump

Assumption are made as per Indian perspective (NBC/ ECBC 2016 recommendations) and surveys

Determine electrical power at Full load conditions of each components

System efficiency for building cooling system (Prescriptive)

Minimum system efficiency (total installed equipment per cooling capacity kW/ kW_r)		
System type	Peak building cooling load (kW)	
	<3516 kW (1,000 TR)	≥ 3516 kW (1,000 TR)
Central chilled water plant (Water cooled)	0.21 (0.75 kW/ ton_r)	0. 20 (0.70 kW/ ton_r)

- Central water plant includes chillers, chilled water and condenser water pumps and cooling tower.
- Values of EE building and super EE buildings will be derived based on the finalized ECBC 2016 recommendations

System balancing (Mandatory)

a. Requires written balance report for a HVAC system if total conditioned area exceeding 500 m^2

Discussion point - Written balancing report for HVAC system by 3rd party should be required if total conditioned area exceeding 5000 m^2

a. Air system balancing
   - To first minimize throttling losses
   - If fan system power is greater than 0.75 kW, fan speed shall be adjusted to meet design flow conditions

b. Hydronic system balancing
   - To first minimize throttling losses
   - Trim pump impeller or adjust pump speed to meet design flow conditions (if pump motor < 7.5 kW)

Economizer

Economizer

Applicable on Air side economizer if

a. A design supply capacity over 1,200 l/s (2,500 cfm); and

b. A total mechanical cooling capacity over **15.8 kW**

Exceptions to above are:

a. *Projects in the warm-humid climate*

b. *Day time use in hot & dry*

c. *Individual ceiling mounted fan < 3,200 l/s (6,500 cfm)*

Heat recovery

Heat Recovery scope

1. Air to air heat recovery –
   a. 70% recovery effectiveness for all systems greater than 2100 l/s and minimum outdoor air supply of 70%.
2. Heat recovery from Diesel or gas fired Generator sets
   a. Minimum 50% heat recovery from DG sets in all hotels and office buildings having area greater than 20,000 m^2

Controls

Controls – recommendations (as per market trend)

- Time switches/ Off hour / automatic setback, start, shut-off controls
- Temp/ Set point/ humidity control
- Occupancy control
- VAV controls
- Automatic damper control
- Automatic demand shed controls
- Economizer fault detection control

Time clock that (Mandatory)

a. Mandatory for all offices and malls above 15,000 m^2

b. Mandatory for all Universities

- Automatically start and stop (different schedules)
- Retain programming and time setting
- Accessible manual override

a. Exceptions to the above are:

» a. Cooling systems < 17.5 kW (5 TR)

» b. Heating systems < 5 kW (1.4 TR)

Temperature Control (mandatory)

a. Mandatory for all day time offices and malls above 20,000 m^2

- temperature dead band of 3°C (5°F)
- For warm and humid climate zone, should maintain the humidity less than 60%
- Mandatory thermostat setting control for all guest rooms of a hotel/ motel
- Mandatory for rooms size < 25 sqm

Controls

✓ **Cooling Towers and Closed Circuit Fluid Coolers (Mandatory)**

- Mandatory for building more than 20,000 m^2 of BUA
- Should have either two speed motors, pony motors, or variable speed drives controlling the fans.
- Should be capable to reduce the fan speed to at least two third of installed fan power

✓ **Dampers for Air Supply and Exhaust Equipment (Mandatory)**

- dampers that automatically close upon fan shutdown or spaces served are not in use.

Occupancy control (mandatory)

- ✓ **Occupancy control (mandatory)**
  - De-energized the system when no occupants for following:
    - **Hotel guest room**
    - **Toilets in hotels** and offices with more than 2 WCs and/ or 3 urinals
    - **Conference and meeting rooms in offices**
    - **Any room in a school or university which is** more than 80 m^2

Automatic Demand Shed Controls (EE & SEE building)

a. Applicable for HVAC systems with DDC to the Zone level for non critical zones

b. remotely setup the operating temp set points by 4 degrees by centralized program

c. programmed to provide an adjustable rate of change for the temperature setup and reset

d. The controls shall have features like - Disabled, Manual Control, Automatic Demand shed control

e. 20,000 sqm slab for BMS requirement – basic – controls and hair handlers

Supply Air Temperature Reset (EE & SEE)

1. Multi-zone HVAC systems must include controls that automatically reset the supply-air temperature in response to building loads, or to outdoor air temperature.
2. Controls shall reset the supply air temperature at least 25% of the difference between the design supply air temperature and the design room air temperature.

Exception:

Climate zone - Warm-humid

Chilled Water Temperature Reset (EE & SEE)

1. Chilled water system with a design capacity exceeding 87.5 kW (25 TR) supplying chilled water to comfort conditioning systems
   a. Shall include controls that automatically reset supply water temperatures by representative building loads (including return water temperature) or by outdoor air temperature.

   Exception:

   - *Where the supply temperature reset controls causes improper operation of equipment.*
   - *Hydronic systems that uses variable flow to reduce pumping energy*

VAV fan control (SEE building)

a. The fan shall have controls or devices that will result in fan motor demand of no more than 30 % of their design wattage at 50 % of design airflow when static pressure set point equals one-third of the total design static pressure, based on manufacturer's certified fan data.

Air side economizer control (SEE building)

- ✓ Economizer dampers shall be sequenced with the mechanical cooling equipment and shall not be controlled by only mixed air temperature.
- ✓ Air economizers shall be capable of automatically reducing outdoor air intake to the design minimum outdoor air quantity when outdoor air intake will no longer reduce cooling energy usage.
  - ✓Specify High-limit shutoff

Pipe insulation (Mandatory for all hotels, all hospitals, and buildings with BUA >10,000 m²)

Pipe Insulation with Minimum R-value (m²·K/W) Steam, steam condensate, hot water, domestic water, and cooling system like chilled water, brine, and refrigerant)							
Heating System	ECBC 2007	ECBC 2016		EE Building		SEE building	
Operating Temp/ pipe size (mm)	All size	< 40	>= 40	< 40	>=40	< 40	>=40
94°C to 121°C	0.74	0.9	1.2	1.1	1.3	1.5	1.5
60°C to 94°C	0.74	0.7	0.7	0.8	0.8	1.0	1.3
40°C to 60°C	0.35	0.4	0.7	0.5	0.9	0.7	1.1
Cooling System	ECBC						
Operating Temp/ pipe size (mm)	All size	< 25	40-100	< 25	40-100	< 25	40-100
4.5°C to 15°C	0.35	0.4	0.7	0.5	0.9	0.7	1.2
< 4.5°C	0.35	0.9	1.2	1.1	1.3	1.5	1.5
Refrigerant Piping	ECBC						
Split System		< 25	40-100	< 25	40-100	< 25	40-100
4.5°C to 15°C	0.35	0.4	0.7	0.5	0.9	0.4	0.7
< 4.5°C	0.35	0.9	1.2	1.1	1.3	1.5	1.5

Pipe insulation (Conti..)

a. For any pipe located in partition within a conditioned space or buried,
   a. a reduction in R value by 0.2 shall be permitted but not less than R - 0.4

b. For any pipe located in partition outside a building with a direct exposure to external atmosphere, direct sun, shall require
   a. an additional R value of 0.2 over and above the requirement stated in the table in previous slide

c. For building in temperate climate zone,
   a. a reduction in R value by 0.2 shall be permitted compared to values in table in previous slide but not less than R - 0.4

Duct insulation (Mandatory for all hotels, all hospitals, and buildings with BUA>10,000 m²)

	ECBC 2007		ECBC 2016 (Min performance)		EE building		SEE building	
Duct Location	**Supply Ducts**	**Return Ducts**	**Supply ducts**	**Return ducts**	**Supply ducts**	**Return ducts**	**Supply ducts**	**Return ducts**
Exterior	R-1.4	R-0.6	R -1.4	R – 0.6	R -1.4	R – 0.6	R -1.4	R – 0.6
Unconditioned Space	R- 0.6	None	R -0.6	None	R -0.6	None	R -0.6	None
Buried	R- 0.6	None	R -0.6	None	R -0.6	None	R -0.6	None

Required Insulation (R-values in $m^2 \cdot K/W$)

Design

1. Ventilation/ Fresh air
2. Exhaust
3. Natural ventilation

Ventilation

Ventilation (Mandatory)

1. Natural ventilation
2. Mechanical Ventilation
3. Exhaust

No requirement of ventilation in ECBC 2007

Ventilation

1. **General Requirements.**

   All habitable spaces shall be ventilated in accordance with the requirements of this section and the outdoor air-ventilation rate of NBC.

2. **Design Requirements.**

   Every space shall be designed to have outdoor air ventilation according to natural ventilation or mechanical ventilation:

Natural Ventilation

1. permanent openings, windows, doors, louvers, etc
2. Targeted area should be no more than 14 m from the operable wall or roof openings
3. Unobstructed openable area of which is not less than 5% of the conditioned floor area of the naturally ventilated space.
4. All installed ceiling fans should be of minimum 3 star rated
5. Openable area shall be based on the free unobstructed area.

EXCEPTIONS: *Naturally ventilated spaces in hotel/motel guest rooms shall be open to and within 8 m of operable wall or roof openings to the outdoors.*

Mechanical Ventilation

1. **Mechanical ventilation** – system capable of providing an outdoor air rate no less than:
   a. The conditioned floor area of the space times the applicable ventilation rate from NBC

Exception: *Transfer air – air could be transferred from other ventilated spaces if:*

- *Space having no sources of indoor air contaminants; and*
- *The outdoor air that is supplied to all spaces combined, is sufficient to meet the requirements of NBC for each space individually.*

Ventilation

Operation and Control Requirements for Minimum Quantities of Outdoor Air.

a. Times of occupancy. all times when the space is occupied.

Exception 1: *Demand control ventilation.*

Exception 2: *Temporary reduction. The average rate for each hour should be >= than the required ventilation rate.*

Ventilation

Demand Control Ventilation. Applicable if:

a. Occupant density >= 40 people per 100 m^2;

Exception 1: *Classrooms, call centers, continuously occupied office spaces, healthcare facilities and medical buildings, and public areas of social services buildings*

Exception 2: *Spaces that have processes or operations that generate dusts, fumes, mists, vapors, or gases and are not provided with local exhaust ventilation, such as indoor operation of internal combustion engines or areas designated for unvented food service preparation, or beauty salons shall not install demand control ventilation.*

Exception 3: *Spaces with an area of less than 15 m^2, or a design occupancy of less than 10 people per NBC standard recommendations.*

Low energy comfort system and other supporting EE equipment

1. Evaporative cooling
2. Economizer
3. Heat recovery

Other low energy comfort systems

1. Evaporative Cooling
2. Desiccant cooling system
3. Solar air conditioning
4. Tri- generation (Waste to heat)
5. Radiant cooling system
6. Ground source heat pump
7. Adiabatic cooling system

Discussion point -

Incentive - Building installing any of the above low energy comfort system would be exempted from the mandatory requirements of comfort systems and control section

Session 6

Electrical and Renewable

Key Highlights

1. Integration of renewable energy requirement
2. Integration of other Indian standards (IS standards) and BEE studies with ECBC to have similar requirements
3. Advance metering and sub metering requirements

Electrical and Renewable – revised scope (All mandatory – discussion points)

- Equipment efficiency and design
  a. Transformers
  b. Motors
  c. Power Factor
  d. Electrical Metering and Monitoring
  e. Electrical Distribution Systems
  f. DG sets
  g. *Voltage Unbalancing*
  h. *Harmonic Distortion*
  i. *Size of Neutral Conductors*
  j. Uninterruptible Power Supply
- Renewable Energy
- Hot water
  a. Solar
  b. Other hot water equipment

Transformers

a. Minimum acceptable efficiency at 50% and full load rating.

b. Oil type transformer – as per IS 1180 (up to and including 33kV)

   a. Voltage class 11 kV to 22 kV, the permissible total loss values < 5%

   b. Voltage class 22 kV to 33 kV, the permissible total loss values <7.5%

c. Dry type transformer – as per IS 11171

Voltage Drop

a. Feeders. maximum *voltage drop* of 2% at design load.

b. Branch circuit: maximum *voltage drop* of 3% at design load.

Transformers

Measurement and Reporting of Transformer Losses

- Use calibrated digital meters of class 0.2 or better and certified by the manufacturer for all measurement of losses
- All transformers of capacity of 500 kVA and above would be equipped with additional metering class current transformers (CTs) and potential transformers (PTs) additional to need of Utilities so that periodic loss monitoring study may be carried out.

Motors

ECBC 2016 requirement is fulfilled by the minimum requirement stated in the IS 12615. For all building type, size, and climate zone

- ECBC 2016 – IE 2
- Energy efficient (EE) building – IE 3
- Super EE building – IE 4

- Motor horsepower ratings shall not exceed 20% of the calculated maximum load being served
- Motor nameplates shall list the nominal full-load motor efficiencies and the full-load power factor

DG Sets

1. BEE star rated product is mandatory for the ECBC compliance
2. For all building greater than 20,000 m^2
   a. ECBC 2016 requirement – minimum 3 star rated product
   b. EE requirement – minimum 4 star rated product
   c. SEE requirement – minimum 5 star rated product

Power Factor Correction

Power Factor Correction

All electricity supplies exceeding 100 A, 3 phases shall maintain their power factor range at the point of connection as below:

ECBC 2016 recommendation level

- ECBC 2016 (MEPs) – 0.97
- Energy efficient (EE) building – 0.98
- Super EE building – 0.99

What should be recommended value for True RMS power factor? – Discussion point (0.97/ 0.95)

Metering and Monitoring

Sub metering

	120 kVA to 250 kVA	250 kVA to 600 kVA	more than 600 kVA
Minimum requirement for metering of electrical load			
Energy kWh	Required	Required	Required
Demand kVA	Required	Required	Required
Total power factor	Required	Required	Required
Minimum requirement for seperation of Electrical Load			
HVAC system and components	Required	Required	Required
Lighting (interior and exterior)	Required	Required	Required
Domestic hot water	Not required	Required	Required
Plug loads	Not required	Required	Required
Renewable power source	Required	Required	Required
Mandatory requirement for building type over the requirement stated above			
Commercial mall/ retail	Façade lighting	Elevator, escalators, moving walks	
Offices	Data centers		
Hotels	Commercial kitchens		
In case of tenant based building, metering should be provided as per the above requirement at a location from where each tenant could attach the services.			

Power Distribution System

Power distribution system

The power cabling shall be adequately sized as to maintain the distribution losses not to exceed **3%** of the total Power usage. Record of design calculation for the losses shall be maintained.

ECBC 2016 recommendation level

- Minimum performance building – 3.0%
- Energy efficient (EE) building – 2.0%
- Super EE building – 1.5%

Load calculation to be calculated up to the panel level

Voltage Unbalancing

Voltage Unbalancing – Definition

In a three-phase system, the degree of voltage unbalance is expressed by the ratio (in per cent) between the RMS values of the negative sequence component and the positive sequence component of the voltage. This ratio may be approximated as:

Voltage unbalance (%) =

$$\frac{\text{Maximum deviation from the average of the three-phase voltages} \times 100\%}{\text{average of the three-phase voltages}}$$

Voltage Unbalancing – ECBC 2016 recommendation

- ECBC 2016 will limit the voltage unbalance in distribution networks operating at 33kV and below.
- voltage unbalance to be measured in relation to the negative phase sequence component of the supply voltage.
- The magnitude of the negative phase sequence component is **within 2% of the positive phase sequence** component then the unbalance is acceptable.
- This limit is to be taken for the combined affect of all new and existing loads at the point of common coupling

Compliance requirement – (Discussion point)

unbalanced three-phase loads or phase to phase loads may be evaluated by the following expression

$$VU\ (\%) = \frac{\sqrt{3} \times \text{negative phase sequence Component of the loads (A)} \times \text{line voltage} \times 100\%}{\text{Three–phase short circuit level at exit point (MVA)}}$$

load connected only between two phases may be calculated as

$$VU\ (\%) = \frac{\text{single phase load (MVA)} \times 100\%}{\text{three phase short circuit level (MVA) at that point}}$$

- Measurement Interval = 10 mins
- Monitoring Period = 1 week
- Acceptance Percentage = 95%

Total Harmonic Distortion

Total Harmonic Distortion

1. Total Harmonic Distortion (THD)
2. Total Demand Distortion (TDD)

The ratio I_{SC}/I_L is the ratio of the short-circuit available at the point of common coupling (PCC), to the maximum fundamental load current.

Total Harmonic Distortion (THD)

System Voltage at the PCC	THD Limit
1. 400V	5%
2. 6.6, 11 and 20kV	4%
3. 22kV to 400kV	3%

Total Demand Distortion

Individual harmonic order (odd harmonics)

	I_{sc}/I_L	TDD
1.	**<20***	5.0
2.	**20<50**	8.0
3.	**50<100**	12.0
4.	**100<1000**	15.0
5.	**>1000**	20.0

Even harmonic are limited to 25% of the odd harmonic limits above.

1. Current distortions that result in a dc offset, e.g. half-wave converters are not allowed.
2. *All power generation equipment is limited to these values of distortion, regardless of act
3. Where

- I_{sc}= maximum short-circuit current at PCC.
- I_L= maximum demand load current (fundamental frequency component) at PCC

Neutral conductors

Neutral Conductors

Comply with the prescribed requirement of National Electrical Code (latest version)

For a polyphase circuit in which imbalance may occur in normal service, through significant inequality of loading or of power factor in the various phases, or through the presence of significant harmonic currents in the various phases, the neutral conductor shall have a cross-sectional area adequate to afford compliance with permissible conductor operating temperature for the maximum current likely to flow in it.

Uninterruptible Power Supply (UPS)

UPS energy efficiency requirement

1. ECBC to introduce the EE requirements for any UPS used in the buildings greater than 10,000 m^2
2. Future S&L requirement to take precedence
3. UPS Size — EE requirement on 100% Load
   a. kVA < 20 — 90.2%
   b. 20 <= kVA <= 100 — 91.9%
   c. kVA > 100 — 93.8%
4. Discussion point – Compliance?

Renewable Energy

Renewable Energy Integration

1. RE systems include technologies designed to capture solar, wind, geo-thermal, water, or bio based energy to satisfy onsite electric power demand.

2. ECBC to limit itself to the onsite RE generation only. Purchase of RE certificate to be considered only after the concerned legislation is notified by the Center or the State Government

RE provisions for future installation (Mandatory)

All buildings applicable to ECBC 2016 will have mandatory provisions of future installation of renewable energy. Compliance requirement-

1. **Minimum area** - Dedicate a minimum area as RE zone
   - For non-residential: Least of, area > 10 % of roof area or area required for the generation of energy equivalent to 1% of total peak demand or connected load
   - Exceptions: If have solar hot water/ solar electric systems
2. **Shading –**
   - No obstructions shall be located in the RE zone.
3. **Main Electrical Service Panel**
   - shall have a minimum rating for amps
   - shall have a reserved space to allow for the installation of a double pole circuit breaker for a future solar electric installation

RE provisions for future installation (Mandatory)

4. **Provision of highlighted on construction documents:**
   - location for inverters and metering equipment
   - pathway for routing of conduit from the RE zone to the point of interconnection with the electrical service.
   - routing of plumbing from the RE zone to the water-heating system.
   - structural design loads for roof dead load and roof live load

EE requirement

a. EE building scope for RE will be divided into 2 parts:
   - PART 1 - Fulfil all requirements of MEPs
     - Mandatory 2% of total electricity demand to be generated on site through renewable energy
   - PART 2 - Mandatory 3% of total electricity demand to be generated on site through renewable energy for following:
     - Hotels/ Motels over 25,000 m^2
     - Resorts over 12,500 m^2
     - University over 30,000 m^2
     - IT parks and offices over 30,000 m^2

SEE Requirement

a. SEE building scope for RE will be divided into 2 parts:
   - PART 3 - Fulfil all requirements of MEPs
     - Mandatory 4% of total electricity demand to be generated on site through renewable energy
   - PART 4 - Mandatory 6% of total electricity demand to be generated on site through renewable energy for following:
     - Hotels/ Motels over 25,000 m^2
     - Resorts over 12,500 m^2
     - University over 30,000 m^2
     - IT parks and offices over 30,000 m^2

Service Hot Water

Solar

Other hot water equipment

Solar hot water

- Solar water heating
  - For facilities like hotels and hospitals with a centralized system
  - If building area < 20,000 m^2, at least 20% of the design capacity
  - If building area > 20,000 m^2, at least 40% of the design capacity

Exception to above:

- *Systems that use heat recovery for at least 40% of the design hot water capacity.*

- Equipment efficiency
  - Solar water heater - IS 13129 Part
  - Gas Instantaneous Water heaters - IS 15558
  - Electric water heater - IS 2082

ECBC 2016

- Supplementary heating system
  - Maximum heat recovery from hot discharge system like condensers of air conditioning units
  - Use of gas-fired heaters wherever gas is available
  - Electric heater as last resort
- Heat Traps
- Swimming pools
  - If heated to > 32°C (90°F), then minimum insulation value of **R-4.1**
    - Exception to above: Pools deriving over 60% of their energy from site-recovered energy or solar energy source.

Feedback

1. Technical committee is required to provide feedback on
   a. Approach
   b. Scope
   c. Draft recommendations
   d. Compliance

Key highlights of ECBC 2016 – Summary of key changes in ECBC 2007

Integration of all other current and future Government Policies, relevant standards

New sections in ECBC 2016-

ECBC 2016 to have an International benchmark

Code specific to Indian conditions – Climatic and Construction

Pave the way for future nZEB

3 different sets of requirement – ECBC 2016 MEPs, EE buildings, SEE buildings

Wider scope in Comfort systems and controls, Integration of low energy comfort systems, natural ventilation, set points, Controls

Wider scope for Electrical & Renewable

Daylighting, Shading requirement with relaxed U value

Focus on compliance and enforcement

Integration of Renewable Energy and integration of IS standards

More relevant spaces included in the LPD requirement. Focus on controls

Comprehensive list of definitions to avoid manipulation and Focused compliance forms

Compliance for New Construction, Core & Shell, Tenant lease type etc

For any comments, concerns, and feedback, please contact
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The presentation and template to provide comments is uploaded on BEE's website
https://beeindia.gov.in/content/new-construction

Discussion and way forward

Thank you

PACE-D TA TEAM