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

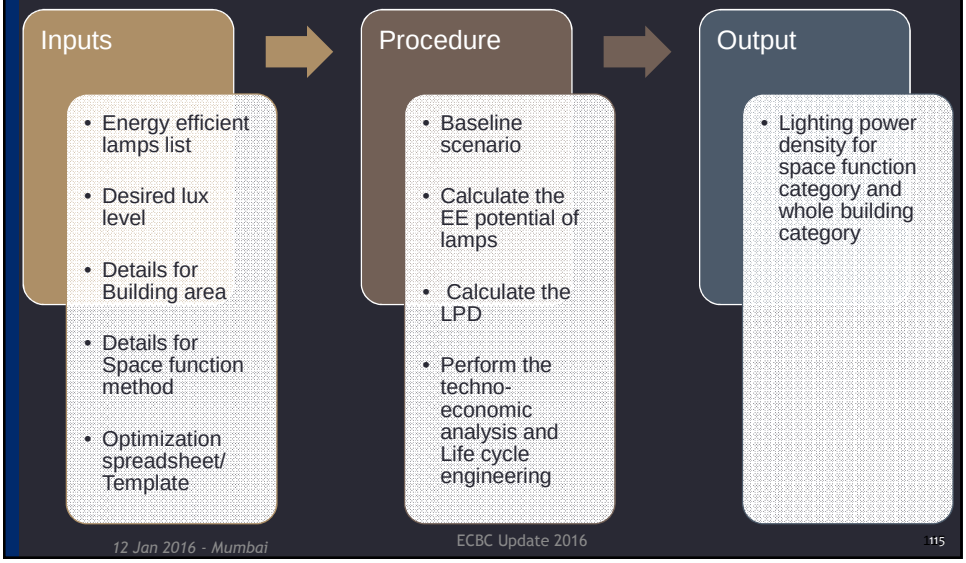
100 spaces for space by space method

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



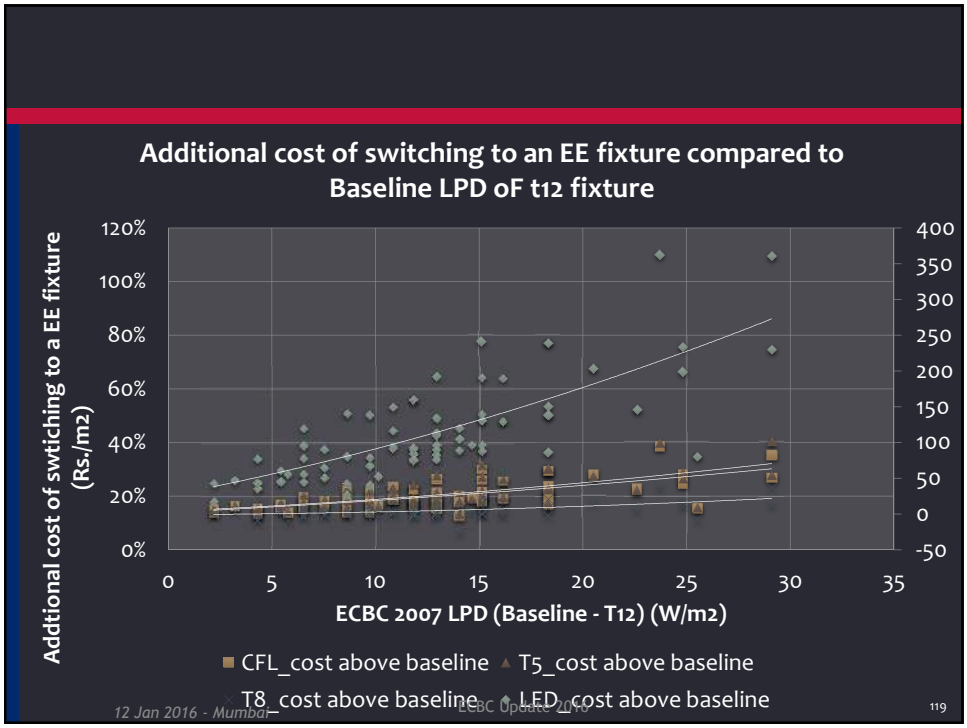
Key findings

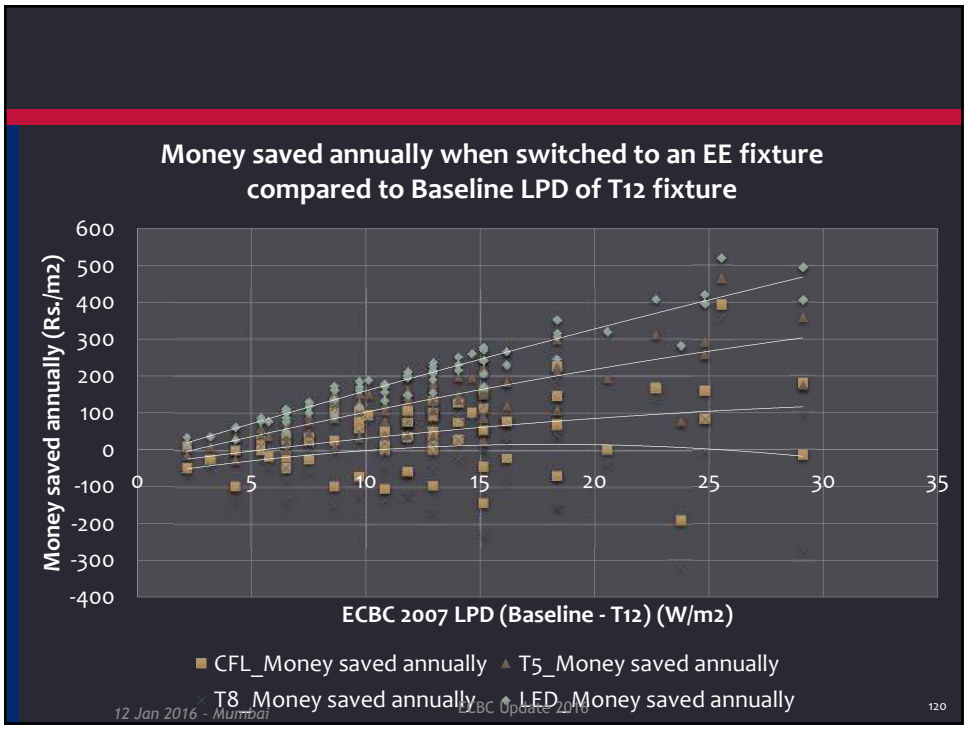
1. T12 (efficacy 45 lm/ watt) is least efficient and cheapest lamp type available in the market
2. T8 out performs T12 in efficiency by mere 14%.
3. Technology like CFL, T5, and LED outperform T12 by 30%, 50%, and 120% respectively
4. In a space like office, a reduction of nearly 40% and 60% in LPD is possible by replacing a T12 fixture with a T5 and LED respectively.

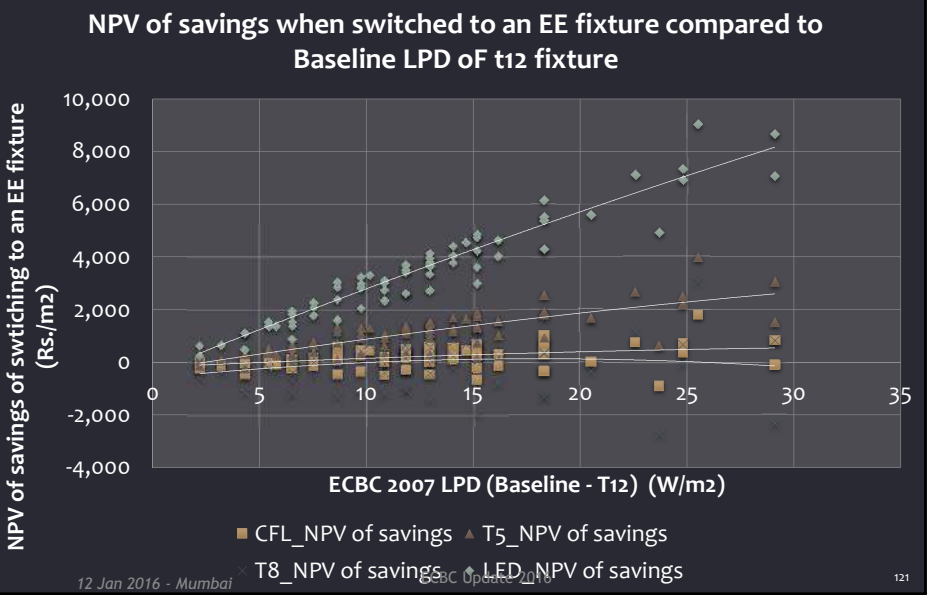
Key findings

5. Increased cost of energy efficient fixture could be compensated with increased efficacy of the fixture
6. 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

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
12 Jan 2016 - Mumbai
ECBC Update 2016
119


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
12 Jan 2016 - Mumbai
ECBC Update 2016
120



Key observations

1. Additional cost of switching to EE fixture is marginal for T5 fixture and CFL w.r.t baseline
2. LEDs are comparatively expensive.
3. Cost of light installation based on lighting design for a T5 and CFL are almost same.
4. Cost of T5 are 25% higher compared to CFL, the utilization factor of T5 are 22% less than CFL

Key observations

5. Money saved annually due to reduced energy consumption is nearly 3 to 4 times.
6. 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.
7. The simple payback of all EE fixtures is less than a year.

ECBC 2016 Recommendations

Space by space method - Approach

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

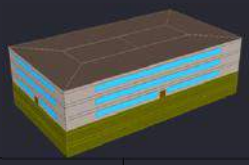
2. LPD estimate for Building area method
   a. The proportional average LPD for the whole building was estimated based on the proportional distribution of space and the estimated prescribed LPD values in space function stringency analysis

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

Offices – building area method (W/m2)

Office					
Built up Area (Sqft)	200,000				
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%



Controls

Controls scope in ECBC 2016

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
- LPD adjustment factor of 20% is applicable to office space if the provisions of permanent Task lighting (having independent controls) is provided to 75% of spaces

Automatic Lighting Shutoff

- Automatic control devises for Office spaces > 300 m²
  - Schedule based, for max 2500 m² and one floor
- Spaces < 25 m² – OS
  - Conference rooms
  - Classrooms, laboratories
  - Storage spaces > 15 m²
  - Hotel public toilets >25 m²
  - Hotel and hospital corridors (if building area is > 15,000 m²)

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

Controls scope in ECBC 2016

Exterior lighting controls

- Mandatory daylight sensor or time switch
- For all universities, IT campus, and buildings with a BUA > 15,000 m²
  –
  - 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

- if daylight area > 25 m² (manual or automatic)
  - 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
  - overides to daylighting sensor should not be allowed
- LPD adjustment factor of 20% is applicable to all space 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)

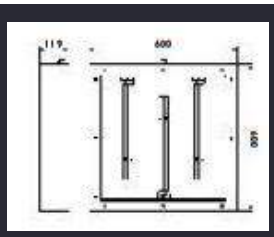
Luminaire wattage

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

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	13 W/m²
Padestrian walkways	2.0 W/m²
Stairways	10.0 W/m²
Landscaping	0.5 W/m²
Outdoor sales area	9.0 W/m²

3 X 36 W - CFL

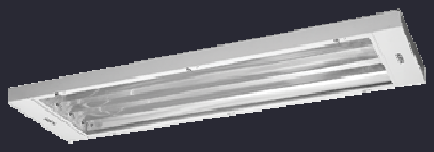


2 X 36 W - T8

2 X 40 W – T12

15 W downlighter LED

2 X 28 W – T5

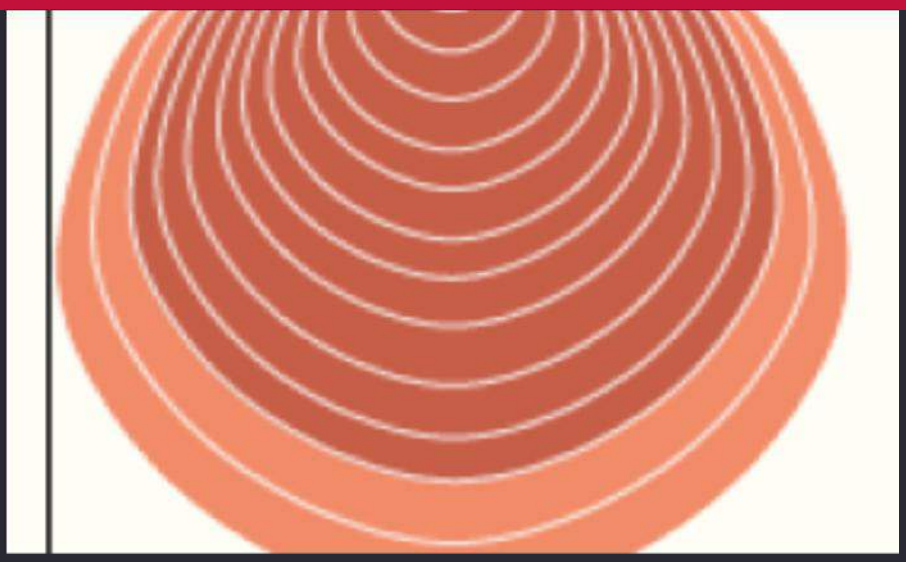


Controls

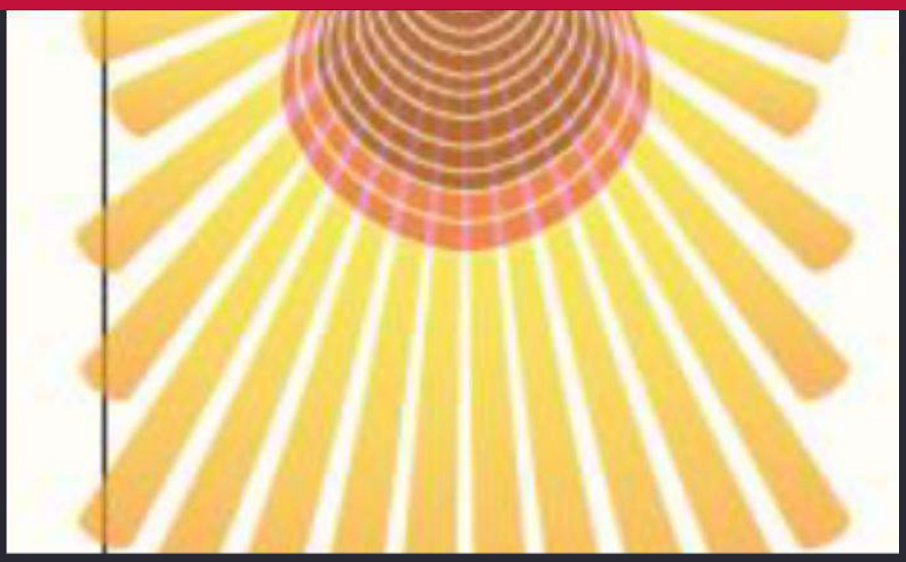
All controls graphics are from a ppt presented by Mohd. Rafi, Philips

Passive Infrared

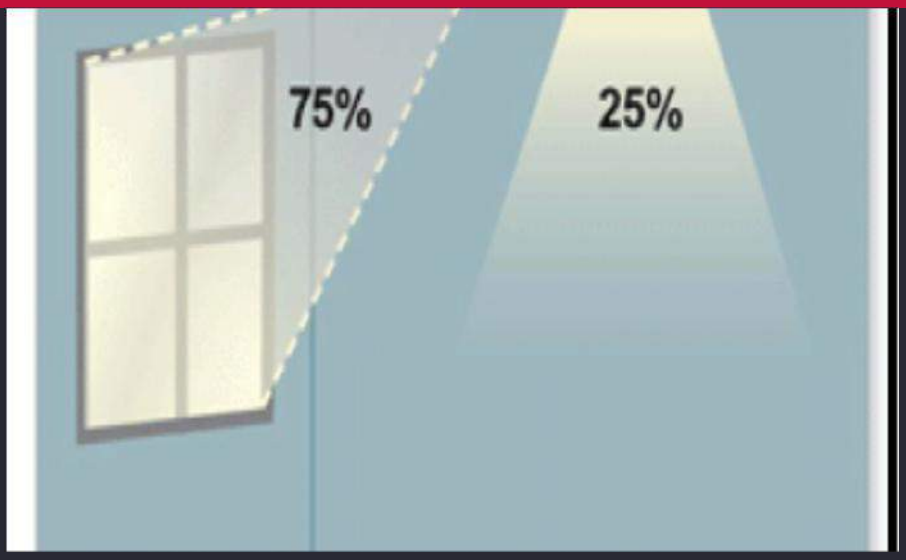
Ultrasonic/ Microwave



Dual technology (Infra + ultrasonic)

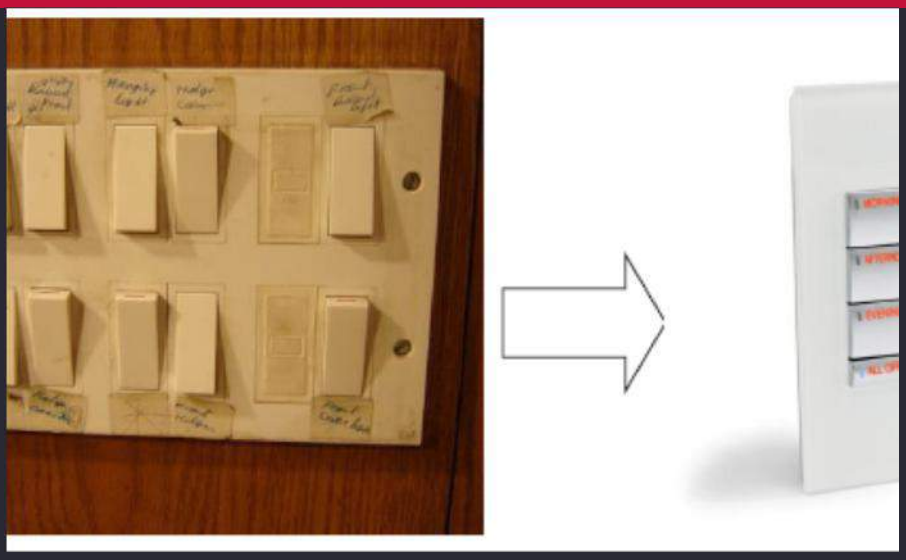


Daylight sensor



Stand alone occupancy sensor

Network system



Session 4

Comfort systems and Controls

Key Highlights

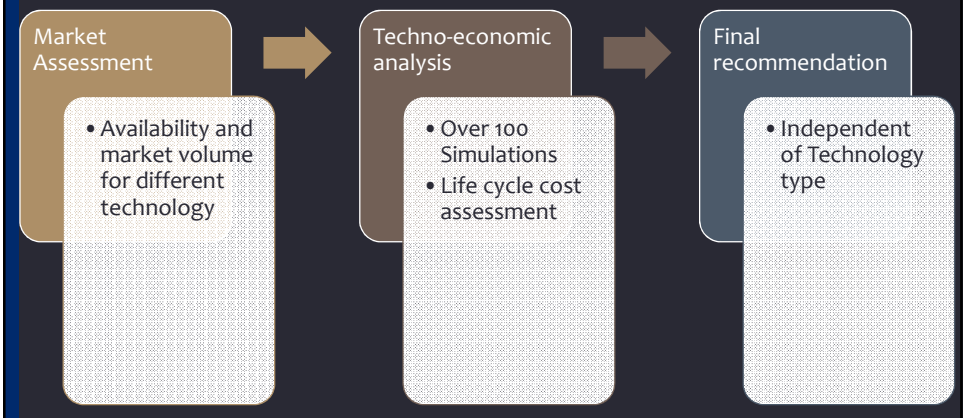
Wider Scope	Additional equipment, Thermal comfort, and Ventilation
Ease of Compliance check	Concept of W/ ton was introduced in Fans, Pumps and Cooling towers
System Efficiency	System efficiency ensures design flexibility and innovation
Advance controls requirement	Wider scope of controls requirement, 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

Chillers

Chiller: Process of recommendations



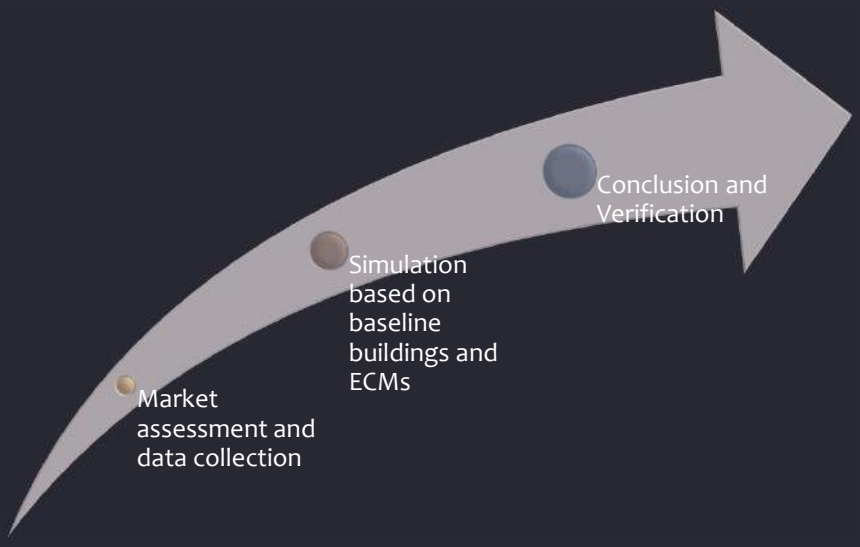
Chillers – ECBC 2016 Recommendation

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

- 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.

Air Systems

Air-System (Fans) - Process



Air-System (Fans)

3 methods of compliance are proposed:

Option 1 – Efficiency requirement only	Option 2 – Cooling capacity (W/ ton)	Option 3 – Air-volume (W/CMH)
• Mechanical and motor efficiency • Easy to check compliance • Ensure design flexibility	• Fan power linked to chiller capacity • Easy to check compliance • Requires addition factor on system diversity	• Fan power linked to air volume • Difficult to check compliance • Ensure design flexibility

Fans - ECBC 2016 recommendations (I)

Fan efficiencies							
System type	**Fan Type**	**Mechanical Efficiency**			**Motor Efficiency**		
		ECBC	**EE**	**SEE**	**ECBC**	**EE**	**SEE**
Central system / Duct able VRVs	Supply	70%	80%	85%	IE 2	IE 3	IE 4
	Return and Exhaust	65%	75%	80%	IE 2	IE 3	IE 4

Fans - ECBC 2016 recommendations (II)

Fan motor power per Installed cooling capacity of chiller (Watt/Ton)

System type	Constant fan system			Variable fan system		
	ECBC	EE	SEE	ECBC	EE	SEE
Central system / Duct able system	65 W/ kW_r (230 W/ ton_r)	60 W/ kW_r (210 W/ ton_r)	54 W/ kW_r (190 W/ ton_r)	90 W/ kW_r (315W/ ton_r)	77 W/ kW_r (270W/ ton_r)	71 W/ kW_r (250 W/ ton_r)

- Division of diversity of Air-side to water-side from the prescribed value to get adjusted requirement of fan power.
- Include supply, return and exhaust fan.

Fans - ECBC 2016 recommendations (III)

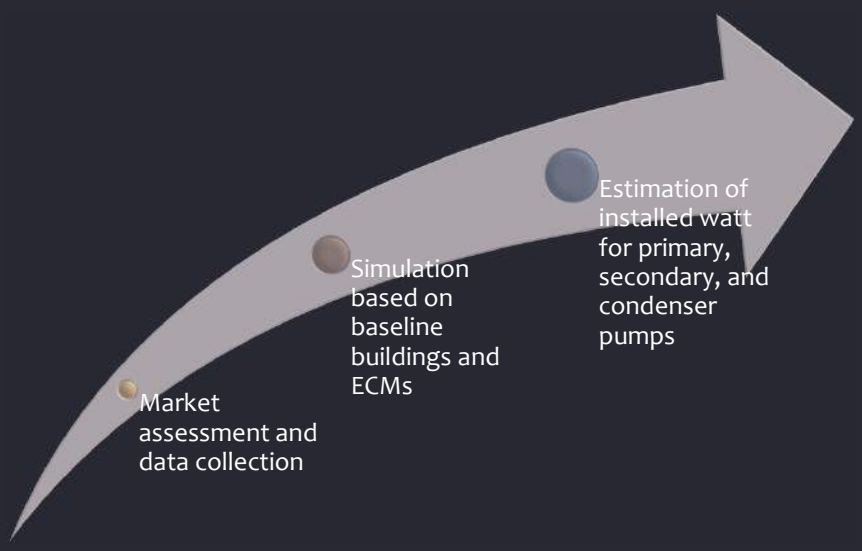
Constant fan system motor power per Installed fan volume (Watt/CMH)			
	ECBC	EE	SEE
Central system / Duct able	kW<=0.00048 * CMH	kW<=0.00043 * CMH	kW<=0.00039 * CMH

Variable fan system motor power per Installed fan volume (Watt/CMH)			
	ECBC	EE	SEE
Central system / Duct able	kW<=0.00066 * CMH	kW<=0.00059 * CMH	kW<=0.00053 * CMH

For energy efficient and super energy efficient building application of controls to the fans will be mandatory

Pumps

Air-System (Fans) - Process



Pumps - ECBC 2016 recommendations

	ECBC 2016 - installed pump capacity (Watt) per Installed cooling capacity		
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

Cooling towers – ECBC 2016

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 – ECBC 2016

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 Btu/h	83 % Ec

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

Unitary and Split Air conditioners – ECBC 2016

1. All the window AC and split AC less than 3 tons (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 –ECBC 2016

Cooling Capacity			ECBC 2007 - COP		ECBC 2016		EE Buildings		SEE Buildings	
Watts	Tons 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– ECBC 2016 recommendations

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
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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

ECBC 2016 recommendations – system efficiency for building cooling system

Minimum system efficiency (total installed equipment per cooling capacity kW/ kW_r)		
System type	Peak building cooling load (kW)	
	<3516 kW (1,000 tons)	≥ 3516 kW (1,000 tons)
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–ECBC 2016 (No change)

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

b. 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

c. 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)

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
- Basement vent controls
- Automatic damper control
- Automatic demand shed controls
- Economizer fault detection control

Controls – in ECBC 2016

- ✓ Time clock that (Mandatory):
  - 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 tons)

    » b. Heating systems < 5 kW (1.4 tons)

Controls – in ECBC 2016

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

Controls – in ECBC 2016

- ✓ 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**
    - **Class room** of size more than 80 m^2

Controls – ECBC 2016

Air side economizer

- ✓ 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 - ECBC 2016

Pipe Insulation with Minimum R-value ($m^2 \cdot K/W$) 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 - ECBC 2016 (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 – ECBC 2016

	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 -3	R -2	R-4	R -3	R-6	R- 3.5
Unconditioned Space	R- 0.6	None	R -2	None	R-3	None	R-3.5	None
Buried	R- 0.6	None	R -1.2	None	R-3.5	None	R-3.5	None

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

Design

1. Set points
2. Ventilation/ Fresh air
3. Exhaust
4. Natural ventilation

Natural Ventilated building

1. **Equation:**
   a. **Neutral temp. = 0.54 * outdoor temp. + 12.83**
      - *Where neutral temperature is the indoor operative temperature (˚C), and outdoor temperature is the 30-day outdoor running mean air temperature (˚C)*
   b. The 90% acceptability range for the India specific adaptive models for naturally ventilated buildings is ±2.38˚C

Mixed mode building

1. **Equation:**
   a. **Neutral temp. = 0.28 * outdoor temp. + 17.87**
      - *Where neutral temperature is the indoor operative temperature (˚C), and outdoor temperature is the 30-day outdoor running mean air temperature (˚C)*
   b. The 90% acceptability range for the India specific adaptive models for mixed-mode buildings is ±3.46˚C.

Ref: ***Manu, S., Shukla, Y., Rawal, R., de Dear, R., & Thomas, L. E. (2014). Developing an India Model for Adaptive (Thermal) Comfort: IMAC 2014. Ahmedabad, India: Centre for Advanced Research in Building Science and Energy (CARBSE), CEPT University. Submitted to the Ministry of New and Renewable Energy, Govt. of India and Shakti Sustainable Energy Foundation***

Ventilation

Ventilation

1. Natural ventilation
2. Mechanical Ventilation
3. Exhaust

No requirement of ventilation in ECBC 2007

Ventilation – ECBC 2016

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 (WBDG.org)
3. The unobstructed openable area of which is not less than 5% of the conditioned floor area of the naturally ventilated space.
4. 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 – ECBC 2016

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 – ECBC 2016

Demand Control Ventilation. Applicable if:

a. Occupant density >= 25 people per 100 m^2; and

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. Applicable performance standards?

Economizer

Economizer – ECBC 2016

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*

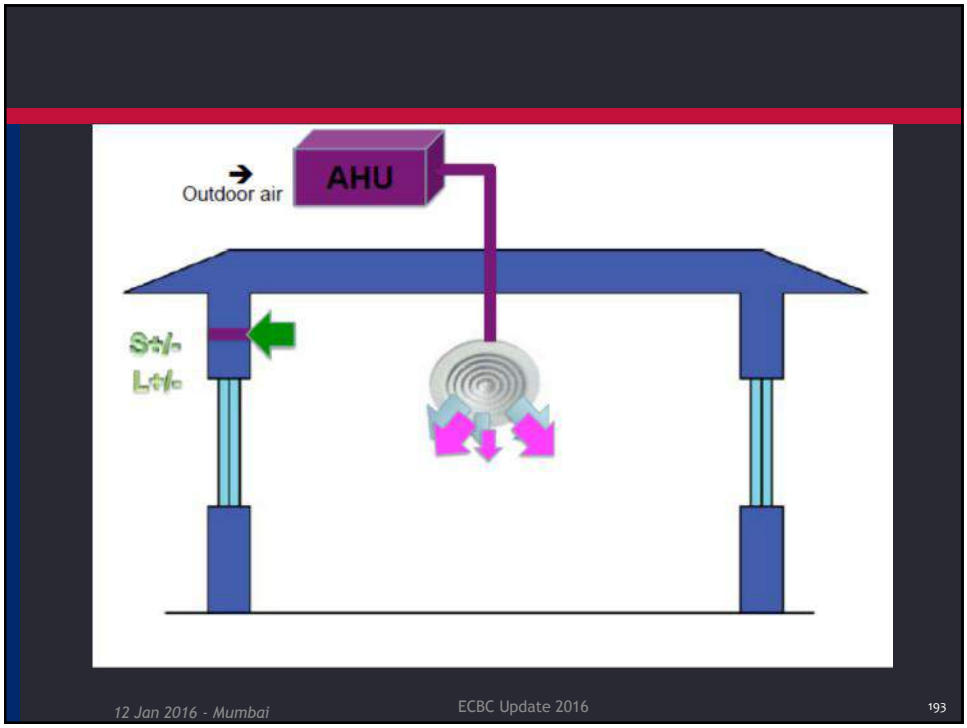
b. *Day time use in hot & dry*

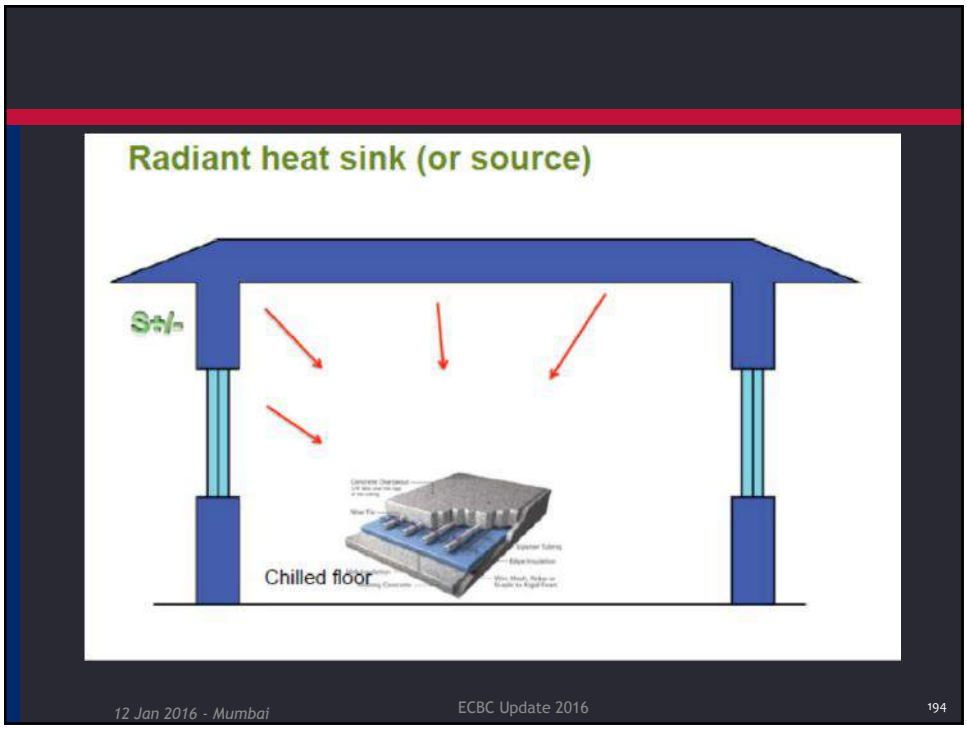
c. *Individual ceiling mounted fan < 3,200 l/s (6,500 cfm)*

Heat recovery

Heat Recovery scope

1. Air to air heat recovery
2. Based on building types and size
3. Heat recovery from DG sets


Outdoor air
AHU
S+/-
L+/-

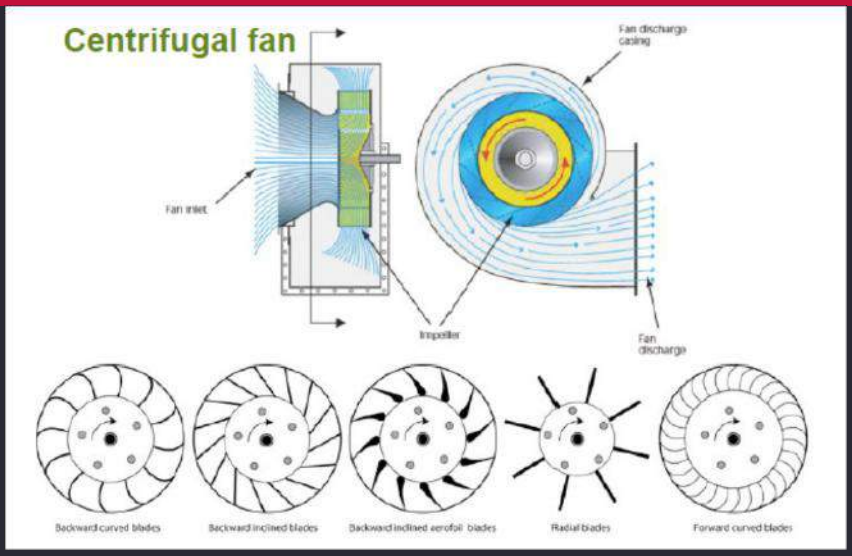

Radiant heat sink (or source)
S+/-
Chilled floor

Coils

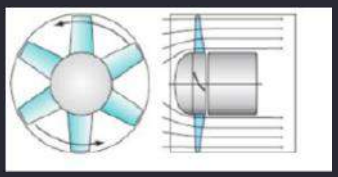
Filters

Filters - 2

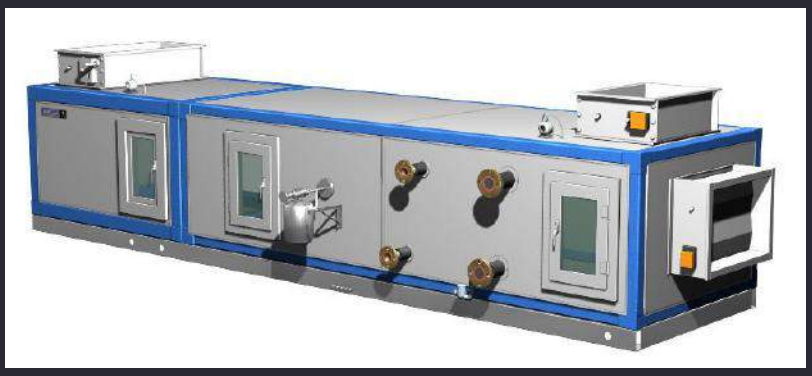
Centrifugal fan



Axial



AHU



Pumps

Chillers

Cooling towers

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

1. Equipment efficiency and design
   a. Transformers
   b. Motors
   c. Power Factor
   d. Electrical Metering and Monitoring
   e. Electrical Distribution Systems
2. Renewable Energy
3. Hot water
   a. Solar
   b. Other hot water equipment

Transformers – ECBC 2016

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 – ECBC 2016

Measurement and Reporting of Transformer Losses

- Use calibrated digital meters of class 0.5 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

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

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

True RMS power factor shall be corrected to 0.95? and above (Clarify, discuss with Manas)

Metering and Monitoring

Sub metering – ECBC 2016

	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	Comercial 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 – ECBC 2016

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 upto the panel level

Renewable Energy

Solar Energy Integration

ECBC 2016 - Requirements for MEPs

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 solar 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 solar 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

ECBC 2016 - Requirements for MEPs

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

ECBC 2016 recommendations

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

ECBC 2016 recommendations

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

ECBC 2016

- 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

Discussion and way forward

Thank you

PACE-D TA TEAM

FORMAT FOR SENDING COMMENTS

Please provide your comments on Energy Conservation Building Code – 2016 Regional Expert Consultation Workshop presentation, presented on Jan 12, 2016 in Mumbai, in the specified format. Comments on each session/ slide/ clause/sub-clause/ table/figure, etc, be stated on a fresh row of Table 1. Any suggestions or additional requirements that are advised in the revised version of ECBC should be listed in Table 2. Please email the comments to gshankar@beenet.in and govinda@edsglobal.com.

Dated: Jan 15, 2016

Title: **Energy Conservation Building Code 2016 – ECBC update process and Progress**

Name of the Commentator/ Organization: _____

Table 1: Comments on the presentation

Session number	Slide Number	Comments

Table 2: Suggestion or additional advised in updated ECBC

Section Name	Suggestion or Additional Requirements