Energy Conservation Building Codes - Overview

Two day Intensive Training Program on ECBC

UNDP-GEF-BEE and EMC Kerala

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Energy consumption was 9.2% with peak deficit at 10.1%.
India matched the global strides towards CLIMATE CHANGE as well as took its first step towards energy security through
- The Energy Conservation Act in September 2001
- Followed by the Electricity Act in 2003

In June 2008, PM Dr Manmohan Singh released India’s first National Action Plan on Climate Change (NAPCC), highlighting 8 major sectors
The Energy Conservation Act, 2001

- The Act provides for institutionalizing and strengthening of delivery mechanisms for Energy Efficiency services in India and
- Provides a much needed Coordination between the various allied agencies
The important Features of the Energy Conservation Act, 2001 are:

- **Standards and Labeling** - for electrical equipment
- **Designated Consumers (DCs)** – to install energy auditing and monitoring for energy intensive DCs
- **Energy Conservation Building Codes** – for new buildings exceeding the connected load of 100 kW
- **Establishment of the Bureau of Energy Efficiency (BEE)** to monitor and implement the EC Act, 2001
Why Look for energy efficiency in buildings?
Precedent.....
Precedent

*Form generated from*

- Climate
- Function
- Availability of materials
- Culture

Respecting Nature!
Modern Movement
Modern Movement

*Form generated from*

- Technology to serve man
- Urbanization

Controlling Nature !!
Present
Contemporary Architecture

Form generated from

- “WANT” and not the “NEED”
- Ultra Urbanization

Exploiting Nature !!
IPCC Fourth Report observes that the building sector has the greatest potential amongst all sectors for energy savings resulting in reduction of GHG emissions.
Energy Efficiency in Government Buildings was the first step

- Rashtrapati Bhawan,
- Prime Minister’s Office and Defence Ministry blocks in South Block,
- Rail Bhawan,
- Sanchar Bhawan,
- Shram Shakti Bhawan,
- Transport Bhawan,
- R&R Hospital,
- Terminal I, Terminal II and Cargo Sections of Delhi Airport, and
- AIIMS.

Energy savings potential between 23\% to 46\% was identified in the above buildings.
% Saving Vs Typical Buildings

<table>
<thead>
<tr>
<th>City</th>
<th>24 Hr Operation Buildings</th>
<th>Daytime Use Buildings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delhi</td>
<td>40%</td>
<td>37%</td>
</tr>
<tr>
<td>Ahmedabad</td>
<td>40%</td>
<td>36%</td>
</tr>
<tr>
<td>Kolkata</td>
<td>39%</td>
<td>34%</td>
</tr>
<tr>
<td>Bangalore</td>
<td>27%</td>
<td>33%</td>
</tr>
<tr>
<td>Shillong</td>
<td>29%</td>
<td>34%</td>
</tr>
</tbody>
</table>

National Energy Savings = Code Stringency × Level of Compliance × Adoption Rate
Similar savings can also be expected in modern high-rise urban buildings.

The average energy use for typical commercial building is 200 kWh/sq. meter/year.

Mandatory enforcement of ECBC can reduce the energy use by 30-40% to 120-160 kWh/sq. meter/year.

Nationwide Mandatory enforcement of ECBC will yield a saving of 1.7 billion kWh for 2005-2006.
Energy consumption in Buildings

Total Energy Consumption
- Operational Phase: 80%
- Construction and Demolition: 20%

Appliances and processes
- Lifts, Pumps etc
- Lighting
- Ventilation and Cooling
Energy Efficiency Measures

Cheapest Solution

Passive design of building

Use of Efficient Systems

Use of Renewable Energy

Most Expensive Solution
To provide **minimum** requirements for the energy efficient design and construction of buildings.
**Scope of ECBC**

- Applicable to buildings or building complexes that have a connected load of 100 kW or greater
- Generally, these buildings have more than 1000 sq m of conditioned space
- Provisions of ECBC apply to:
  - *Building Envelopes*
  - *Mechanical systems and equipment*
  - *Service Hot Water Heating systems*
  - *Interior and Exterior Lighting systems*
  - *Electrical Power and motors*
- National Building Codes (NBC) is the reference document for ECBC
ECBC Administration and Enforcement

- Compliance Requirements
  - Mandatory Requirements
  - New Buildings
    - Compliance with Section 4 to 8 or whole building performance Method
  - Additions to Existing Buildings
    - When additions plus the existing building exceeds the 1000 sq m
    - Only the additions can comply, or both the additions and the existing building can comply
    - Existing conditioning systems need not comply, but all additional equipment and systems must comply
ECBC Administration and Enforcement

- Alterations to Existing Buildings
  - Where existing building exceeds 1000 sq m., any alterations need to comply
  - The entire building can be made compliant, as if it were a new building
Exemptions under ECBC

- The provisions of this code do not apply to:
  - Buildings that do not use either electricity or fossil fuel
  - Equipment and portions of building systems that use energy primarily for manufacturing processes and
  - Multi-family buildings of three or fewer stories above grade, and single-family buildings.
ECBC-Compliance Approach

Mandatory
- Section 4.2 Envelope
- Section 5.2 HVAC
- Section 6.2 Service Hot Water and Pumping
- Section 7.2 Lighting
- Section 8.2 Power

Prescriptive
- Section 4.3 Envelope
- Section 5.3 HVAC
- Section 7.3 Lighting

OR

Tradeoff
- Section 4.4 Envelope

OR

Whole Building Performance Method
- Section 4-Envelope
- Section 5 - HVAC
- Section 7 - Lighting
- Section 8 - Power
Compliance Documents

Building Envelope

- insulation materials and their R values,
- fenestration U factors,
- solar heat gain coefficients (SHGC),
- visible light transmission and air leakages,
- overhangs and sidefins,
- building envelope sealing details
Heating, Ventilation and Air Conditioning

- Systems and equipment types
- Sizes, efficiencies and controls
- Economizers
- Variable speed drives
- Piping insulation
- Duct sealing, insulation and location
- Requirement for balance report
Service Hot Water Systems

- Solar Water Heating System with detailed calculations to meet 20% hot water demand
- Heat Recovery system details
- Gas heater system details

Lighting Systems

- Lighting schedule, showing types, number and wattage if lamps and ballasts
- Automatic lighting shut off
- Occupancy sensors and other lighting controls
- Lamp efficacy for exterior lamps
**Electrical Power**

*Electric Schedules showing transformer losses*

*Motor efficiencies*

*Power factor corrections devices*

*Electric check metering and monitoring systems*
Built up area is 4240 sqm of which 1912 sqm is air conditioned

- **Key energy efficiency features that added to cost (35 lacs)**
  - High performance glazing (Incremental cost of Rs 12.5 lacs)
  - Roof insulation (Incremental cost of 7 lacs)
  - Efficient lighting with controls (Incremental cost of 9 lacs)
  - High efficiency chillers/pumps/fans (about 34 TR which is 30% of total tonnage was saved, hence there was a decrease in cost by about 4 lacs)
  - Earth air tunnel (11 lacs)

- **Annual energy savings : 18.5 lacs..simple payback of 2 years**
Optimization-building material

Initial energy consumption: 240 kWh/m² yr

Building envelope

- Brick wall
- RCC roof without insulation
- Single clear glass for windows

- Cavity brick wall with insulation
- Roof insulation with fiber glass
- Shading on roof
- Double glass for windows

240 kWh/m² per annum

208 kWh/m² per annum

13% energy savings
Optimization of Lighting Design

Lighting optimization

• Efficient fixtures
• Efficient fixtures & lamps
• Efficient layout
• Daylight integration

Achievement
LPD=1.3W/ft²

Illumination levels as per standards:
Laboratory: 400 lux
Corridors: 200 lux
Work plane (faculty room): 300 lux
Optimisation of HVAC system

HVAC system

• Air-cooled chiller

- Water-cooled chiller CoP=4.88 (complying with minimum efficiency requirements of the Energy Conservation Building Code)

\[168 \text{ kWh/m}^2 \text{ per annum}\]

\[133 \text{ kWh/m}^2 \text{ per annum}\]

21% energy savings
Optimisation of HVAC design

HVAC system

- No controls used in HVAC system

- Controls used in HVAC system
  - Variable speed drives for chilled water pumps
  - Efficient load management
  - Earth air tunnel for fresh air treatment

- 133 kWh/m² per annum
- 98 kWh/m² per annum

26% energy savings
Annual Energy Savings

Initial energy performance

61% savings

Final energy performance

EPI = 240 kWh/m² per annum

Envelope optimisation

EPI = 208 kWh/m² per annum

Lighting optimisation

EPI = 168 kWh/m² per annum

Efficient chiller

EPI = 133 kWh/m² per annum

Controls for HVAC system

EPI = 98 kWh/m² per annum
Thankyou
Relevance and impact of low energy passive strategies and ECBC strategies

Reference: High Performance Commercial Buildings in India, TERI and White Box Technologies, USA
Microsoft Building, Hyderabad

1. Built up Area 55741 m², consisting of office spaces, multi purpose rooms, cafeteria, meeting rooms, conference halls and atrium space.

2. Conditioned space 45057 m² with 10 hr use and 5 working days

### Building Lighting System
1. LPD 8.15 W/m²
2. No daylight Sensors
3. No Occupancy Sensors
4. Visual Comfort - NBC 2005

### Building Design
1. Longer façade inclined to NE-SW
2. Wall and roof not shaded
3. WWR 70%

### Building Envelope
1. Wall U value 1.85W/m²k
2. Roof U value 0.232W/m²k
3. Glass U Value 1.66W/m²k
4. Glass SHGC 0.18

### Building HVAC System
1. Water Cooled Centrifugal Chiller
2. COP 6.6
3. Variable Air Flow System
4. VFD in AHUs
5. Thermal Comfort – NBC 2005

### Building Performance

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>Cooling Demand</td>
<td>2210 TR</td>
</tr>
<tr>
<td>Electric Load</td>
<td>2830 kW</td>
</tr>
<tr>
<td>Energy Performance Index</td>
<td>150 kWh/m²/year</td>
</tr>
</tbody>
</table>
What if the building had been designed as a conventional building?

**Building Design**
1. Longer façade inclined to E-W
2. Wall and roof not shaded
3. WWR 70%

**Building Lighting System**
1. LPD 20 W/m²
2. No daylight Sensors
3. No Occupancy Sensors
4. Visual Comfort-NBC2005

**Building Envelope**
1. Wall U value 1.98 W/m²k
2. Roof U value 1.78 W/m²k
3. Glass U Value 6.17 W/m²k
4. Glass SHGC 0.61

**Building HVAC System**
1. Unitary System (split window Ac)
2. COP 2.9, EER 8.4
3. Constant Air Flow System
4. Thermal Comfort –NBC 2005

**Building Performance**

<table>
<thead>
<tr>
<th>Metric</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Cooling Demand</td>
<td>2340 TR</td>
</tr>
<tr>
<td>Electric Load</td>
<td>4710 kW</td>
</tr>
<tr>
<td>Energy Performance Index</td>
<td>208 kWh/m²/year</td>
</tr>
</tbody>
</table>
WHAT IF THE MICROSOFT BUILDING HAD ONLY ECBC FEATURES?

1. Building Envelope as per ECBC
2. LPD As ECBC
3. Chiller COP and controls as per ECBC
4. Other features remain same as in conventional case

Building Performance

<p>| | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Cooling Demand</td>
<td>1770TR</td>
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<tr>
<td>Electric Load</td>
<td>3070 kW</td>
</tr>
<tr>
<td>Energy Performance Index</td>
<td>145 kWh/m2/year</td>
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WHAT IF THE MICROSOFT BUILDING HAD ONLY LOW ENERGY DESIGN FEATURES

1. Best Building Orientation
2. Wall and roof shaded
3. Other features remain same as in conventional case

Building Performance

<p>| | |</p>
<table>
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<tr>
<td>Cooling Demand</td>
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<tr>
<td>Electric Load</td>
<td>3910 kW</td>
</tr>
<tr>
<td>Energy Performance Index</td>
<td>173 kWh/m2/year</td>
</tr>
</tbody>
</table>
What if the building had both ECBC and Low Energy Features?

**Building Design**
1. Longer façade inclined to N_S
2. Wall and roof shaded
3. WWR 40%

**Building Lighting System**
1. LPD 10.8 W/m²
2. Day and artificial light integration
3. Dimming Sensors and occupancy sensors
4. Visual Comfort-NBC2005

**Building Envelope**
1. Wall U value 0.44W/m²k
2. Roof U value 0.261W/m²k
3. Glass U Value 3.3W/m²k
4. Glass SHGC 0.20

**Building HVAC**
1. Centrifugal Chiller
2. COP 6.3
3. Variable Air Flow System
4. Variable frequency drives in pumps and AHU fans
5. Thermal Comfort –NBC 2005

**Building Performance**

<table>
<thead>
<tr>
<th>Metric</th>
<th>Value</th>
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</thead>
<tbody>
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<td>Cooling Demand</td>
<td>1560 TR</td>
</tr>
<tr>
<td>Electric Load</td>
<td>2760 kW</td>
</tr>
<tr>
<td>Energy Performance Index</td>
<td>129 kWh/m²/year</td>
</tr>
</tbody>
</table>