ECBC Impacts: Experiences from the ECBC Pilot Building in Rajasthan

Jyotirmay Mathur
Malaviya National Institute of Technology Jaipur, India

Co-presenter:
Tarush Chandra, Malaviya National Institute of Technology Jaipur, India
Contents

- Project description
- Site Climatic Conditions
- Benefits of Code Compliance Buildings
- Specifications of components and systems
- Simulation results
- Summary of experiences
How it got started:
• One partially conditioned floor of approx 4000sqm was existing prior to starting of project
• Project for adding one floor was initiated

Mid course corrections:
• Later decision for adding about one more floor taken
• Subsequently, decision of major retrofitting of ground floor taken

Present status:
• Currently half portion of first floor of building is functional
• Ground floor of the building is at finishing stage
• Top floor ready, furniture getting fitted
• Simulation of building is performed on the basis of design and specifications of installed systems
• Simulation will be revised after the ground floor is also finished
<table>
<thead>
<tr>
<th>Description</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building usage</td>
<td>Office cum computer centre</td>
</tr>
<tr>
<td>Building operation</td>
<td>Mon-Fri (8:00 am to 8:00 pm)</td>
</tr>
<tr>
<td></td>
<td><em>(except computer labs)</em></td>
</tr>
<tr>
<td>Total floors</td>
<td>Three (G+2)</td>
</tr>
<tr>
<td>Carpet area</td>
<td>11306 m²</td>
</tr>
<tr>
<td>Conditioned area</td>
<td>9959 m²</td>
</tr>
<tr>
<td>Unconditioned area</td>
<td>1347 m²</td>
</tr>
<tr>
<td>WWR</td>
<td>27 %</td>
</tr>
</tbody>
</table>
Building Location

(source: google map)
Climatic Conditions at Jaipur

Climatic zone: Composite

- Latitude: 26.5 ° N
- Longitude: 75.5° E
- Elevation: 390m
- CDD: 5732, 10°C base
- HDD: 141; 18°C base

Monthly Variation in Outdoor DBT and RH

- Outdoor dry bulb temperature
- Relative humidity

Months

Jan Feb Mar Apr May Jun Jul Aug Sept Oct Nov Dec

Mean Outdoor DBT (°C)

0 10 20 30 40 50 60

Mean Relative humidity (%)

0 10 20 30 40 50 60 70 80

6
Variation in outdoor temperature and humidity

Source: Indian Weather Data 2014, ISHRAE
Features of Design Center Building Project

Ramp casts a shadow on one side of west façade

Stair case, Corridor, and Facility area as buffer zones

Courtyard for daylight

Projected entrance for self-shading of façade for low east sun

Fins used on north side for protection from low evening sun
Features of Design Center Building Project (contd..)
Curved fin on first floor used to architecturally integrate extended second floor with ground floor

Glazing of entrance and building contour designed with self shading features
Motivation for ECBC Compliance and beyond

- Notification issued by Government of Rajasthan State
- Less operating cost of building
- Less connected load, reduced demand charges
- Reduced capacity of transformer, panel, circuit breakers etc
- Acceptable payback and IRR for ECMs motivated to go beyond ECBC
- Additional purpose: Learning by doing, capacity building, showcasing
ECBC Applicability Check

- Building type: Non-residential
- Connected load (estimated): more than 100 kW
- Not a new building but addition of two floors brings it under code coverage
- Change of HVAC, lighting and windows on ground floor also necessitates code compliance
ECBC compliance route

- Whole Building Simulation and not prescriptive route
- Reasons:
  - Flexibility in selection of elements and systems
  - Non-standard design of shading fin
  - Ground floor wall insulation difficult to implement


Project Description

Features of Envelope:

- **Roof:** XPS insulation and tiles on terrace
- **Wall:** 1.5” Sandwiched insulation (except ground floor)
- **Glazing:** DGU, with Low-E coating on surface-2, UPVC frame
- **Shading:** Vertical fins, overhangs

Technologies deployed

- **HVAC:** Through VRF units with heat pump
- **Heat recovery wheel**
- **Duct insulation:** PU foam
- **Lighting:** Dimmable LEDs, with daylight integration
- **Rooftop Solar PV:** 150 kW
# Measures for Wall and Roof

<table>
<thead>
<tr>
<th>U-Value of</th>
<th>Standard case</th>
<th>Proposed case</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wall (W/m²-°C)</td>
<td>0.440</td>
<td>0.72</td>
</tr>
<tr>
<td>Roof (W/m²-°C)</td>
<td>0.409</td>
<td>0.35</td>
</tr>
</tbody>
</table>

**Basis of decisions:**

- Under deck insulation used due to water proofing issue
- Decision about insulation on wall and roof was taken on the basis of payback analysis, including cost of avoided Tonnage
- Roof U-value is lower than code due to additional layer of inverted earth pots used
Glazing selection

**Basis of decisions:**

- Low SHGC High VLT (0.39) glass chosen through *daylight simulation*
- SHGC of glass kept slightly higher than prescriptive approach due to presence of shading by fins
- Rough calculations of adjusted SHGC using ‘M’ factor done by average length of fin
- Higher value of SHGC (*unadjusted*) was useful in having high VLT for daylight saving

<table>
<thead>
<tr>
<th>Glass properties</th>
<th>Standard case</th>
<th>Proposed case</th>
</tr>
</thead>
<tbody>
<tr>
<td>U- value (W/m²·°C)</td>
<td>3.3</td>
<td>2.2</td>
</tr>
<tr>
<td>SHGC (<em>unadjusted</em>)</td>
<td>0.25</td>
<td>0.28</td>
</tr>
</tbody>
</table>
The decision of glazing and lighting type was taken *together* with decision of using lighting control for ensuring *compatibility and benefits* of glazing and lighting.

This was necessary for utilizing properties of window for minimizing lighting energy consumption.

30% window area was kept operable to open this building in mixed mode.
- ECBC LPD : 10.8 W/m² (For office activity)
- LPD at project : 5.38 W/m²
- Types of lamps : LED
- Type of ballast : Dimmable for daylight integration
  (square for working area, 6” round for aisles and corridors)
- Type of fixtures: 2X2 square and 6” round down-lighters
- Simulation used for ensuring desired lighting level
Air-conditioning

- **Proposed case**
  - **System Type**: Variable Refrigerant Volume (VRF) Systems
  - **Units installed**: 54
  - **Capacity per unit**: 12 HP
  - **Total Capacity**: 648 HP

- **Standard case**

<table>
<thead>
<tr>
<th>System Type</th>
<th>RHFS (Reheat Fan System)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chiller</td>
<td>Screw</td>
</tr>
<tr>
<td>COP</td>
<td>3.05</td>
</tr>
<tr>
<td>Fan Control</td>
<td>Constant volume</td>
</tr>
<tr>
<td>Fan Schedule</td>
<td>8:00 to 20:00 Hours</td>
</tr>
<tr>
<td>Design Supply CFM</td>
<td>1,20,008</td>
</tr>
<tr>
<td>CFM/ Ton</td>
<td>306</td>
</tr>
<tr>
<td>Fan Power</td>
<td>0.001030 kW/CFM</td>
</tr>
</tbody>
</table>
Reason for using VRF systems

- Limited availability of water was forcing to use air cooled system
- Building is likely to have large diversity due to vacation of students, exam period, seminars and training programs, including closing of some sections over some periods, besides seasonal diversity
- Decision about exact usage of building had some uncertainties, modularity was better with VRF systems
Additional Features: SPV Plant

- Installed PV Capacity: 150 kW_p (3X50)
- Cell type: Crystalline Si
- Number of PV modules: 630
- Inverter Capacity: 50kVA*3/inverter
- Modules in a string: 15 (Nos)
- Strings in parallel: 14 (Nos)
- Power export to local grid enabled
Simulation results: Monthly summary

### Electric Consumption (kWh)

#### Standard case

- **Jan**: Area Lighting (10), Task Lighting (5), Misc. Equipment (15)
- **Feb**: Exterior Usage (20), Pumps & Aux. (10), Ventilation Fans (5)
- **Mar**: Water Heating (15), Ht Pump Supp. (10), Space Heating (5)
- **Apr**: Refrigeration (10), Heat Rejection (10), Space Cooling (5)

#### Proposed case

- **Jan**: Area Lighting (15), Task Lighting (10), Misc. Equipment (20)
- **Feb**: Exterior Usage (25), Pumps & Aux. (15), Ventilation Fans (10)
- **Mar**: Water Heating (20), Ht Pump Supp. (15), Space Heating (10)
- **Apr**: Refrigeration (15), Heat Rejection (15), Space Cooling (10)
Monthly Energy Consumption

Energy Consumption (kWhx000)

- Standard case
- Proposed Case
# Summary - Energy Savings

<table>
<thead>
<tr>
<th></th>
<th>Standard case</th>
<th>Proposed case</th>
<th>Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy consumption (MWh)</td>
<td>2192.40</td>
<td>1704.80</td>
<td>487.6</td>
</tr>
<tr>
<td>EPI (kWh/m²/yr)</td>
<td>194</td>
<td>151</td>
<td>22.16%</td>
</tr>
<tr>
<td>Annual peak demand (kW)</td>
<td>828.76</td>
<td>708.07</td>
<td>14.56%</td>
</tr>
<tr>
<td>PV electricity generation (MWh)</td>
<td>268.86</td>
<td></td>
<td>15.7% of proposed case</td>
</tr>
</tbody>
</table>
SPV Plant Generation

Annual generation (kWh): 268.86 MWh

MONTHLY GENERATION FROM SPV PLANT

<table>
<thead>
<tr>
<th>Months</th>
<th>Energy Generation (kWhx1000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan</td>
<td>22.26</td>
</tr>
<tr>
<td>Feb</td>
<td>22.07</td>
</tr>
<tr>
<td>Mar</td>
<td>24.7</td>
</tr>
<tr>
<td>Apr</td>
<td>23.62</td>
</tr>
<tr>
<td>May</td>
<td>23.51</td>
</tr>
<tr>
<td>Jun</td>
<td>20.08</td>
</tr>
<tr>
<td>Jul</td>
<td>18.56</td>
</tr>
<tr>
<td>Aug</td>
<td>18.34</td>
</tr>
<tr>
<td>Sep</td>
<td>22.54</td>
</tr>
<tr>
<td>Oct</td>
<td>27.6</td>
</tr>
<tr>
<td>Nov</td>
<td>24.31</td>
</tr>
<tr>
<td>Dec</td>
<td>21.27</td>
</tr>
<tr>
<td>Total</td>
<td>268.86</td>
</tr>
</tbody>
</table>
Whole Building Method provided flexibility in decisions based upon techno-economic basis

Some wall insulation can be offset by superior specifications of other components such as glazing, lighting, HVAC

Maximum energy saving comes through glazing, efficient lighting and HVAC

Decisions are to be taken in integrated manner since they influence each other’s performance

There exists significant potential of exceeding the efficiency level of ECBC

Design Centre Building has been designed for achieving 22% energy saving over ECBC level, utilizing simulation supported economic decisions

SPV integration further enhanced performance of the building by additional 15%
Acknowledgement

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Thank you for your time!

Questions?