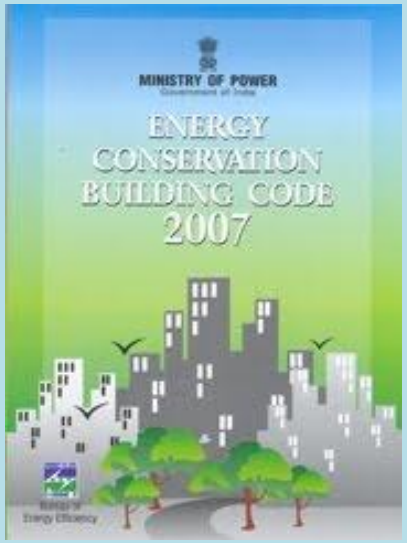
ECBC Impacts: Experiences from the ECBC Pilot Building in Rajasthan



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

Project Description

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

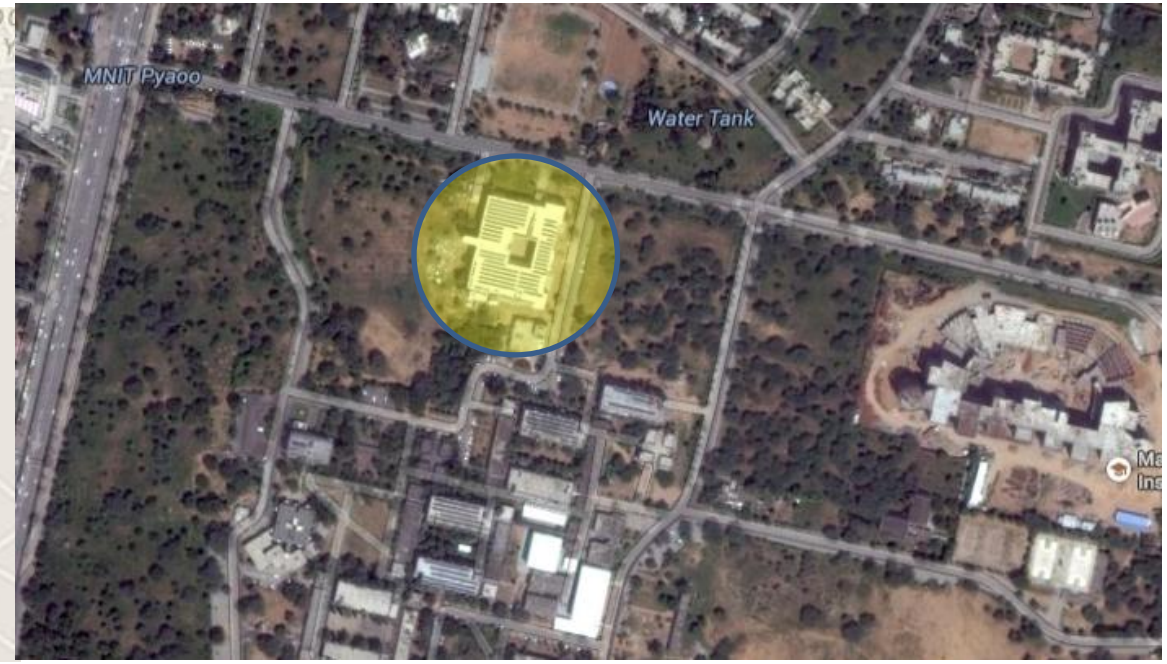
Present status:

- 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

Project Description *(contd.)*

❖ Building usage	:	Office cum computer centre
❖ Building operation	:	Mon-Fri (8:00 am to 8:00 pm) *(except computer labs)*
❖ Total floors	:	Three (G+2)
❖ Carpet area	:	11306 m^2
❖ Conditioned area	:	9959 m^2
❖ Unconditioned area	:	1347 m^2
❖ WWR	:	27 %

Building Location

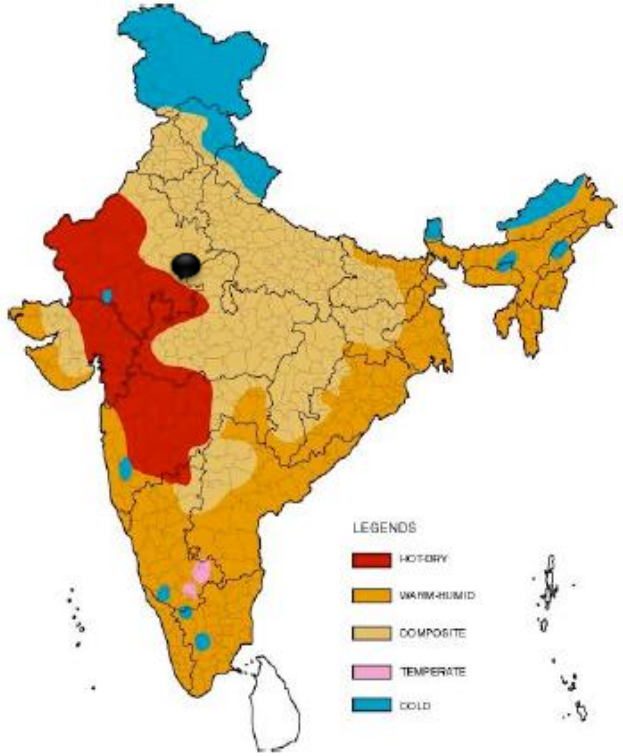


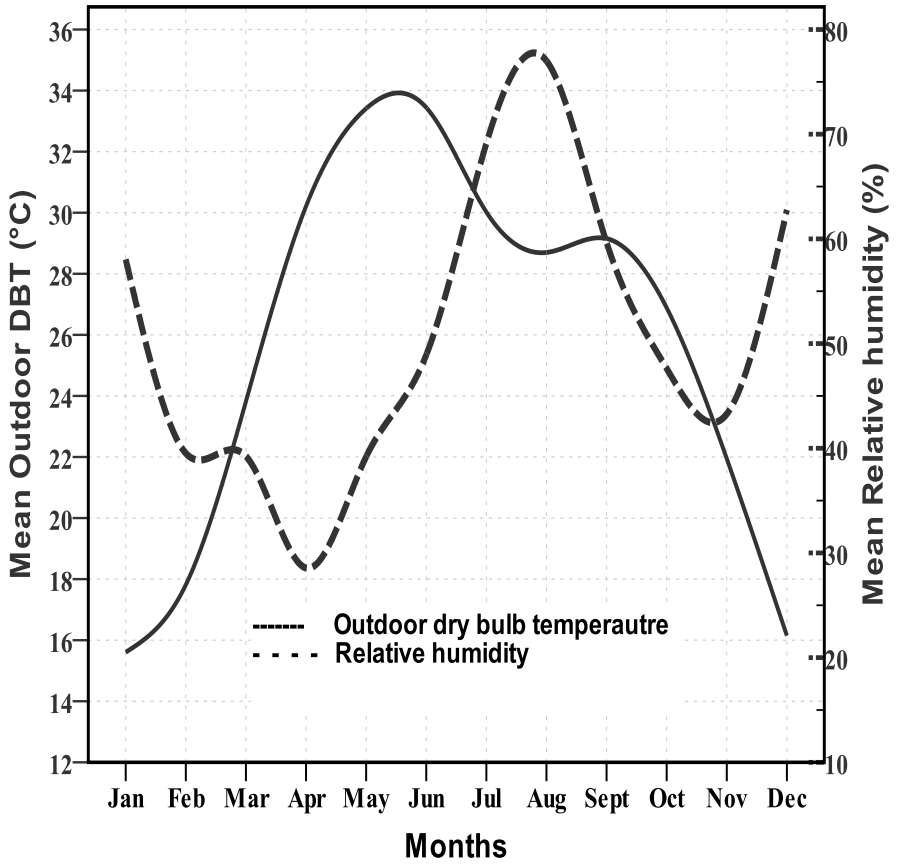
(source: google map)

Climatic Conditions at Jaipur

Climatic zone: Composite

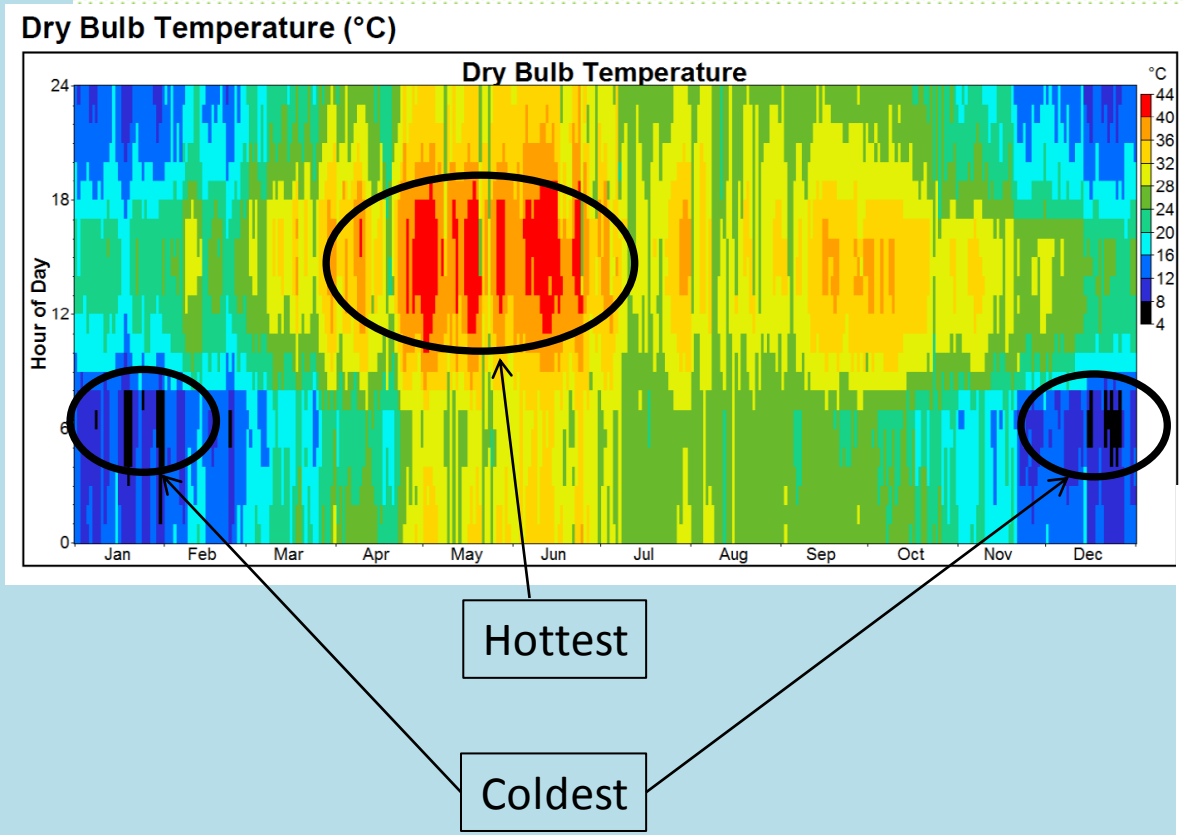
- Latitude: 26.5 ° N
- Longitude: 75.5° E
- Elevation: 390m
- CDD : 5732, 10°C base
- HDD : 141; 18°C base

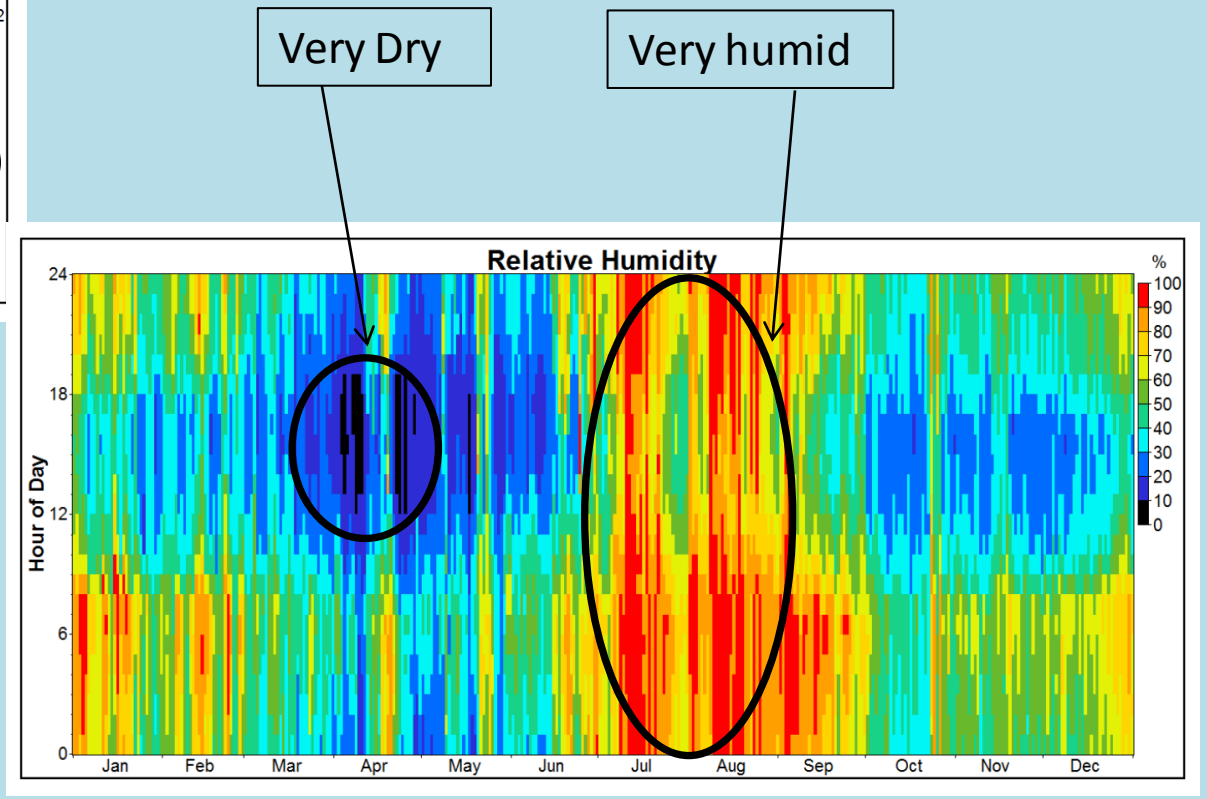




Monthly Variation in Outdoor DBT and RH

Variation in outdoor temperature and humidity



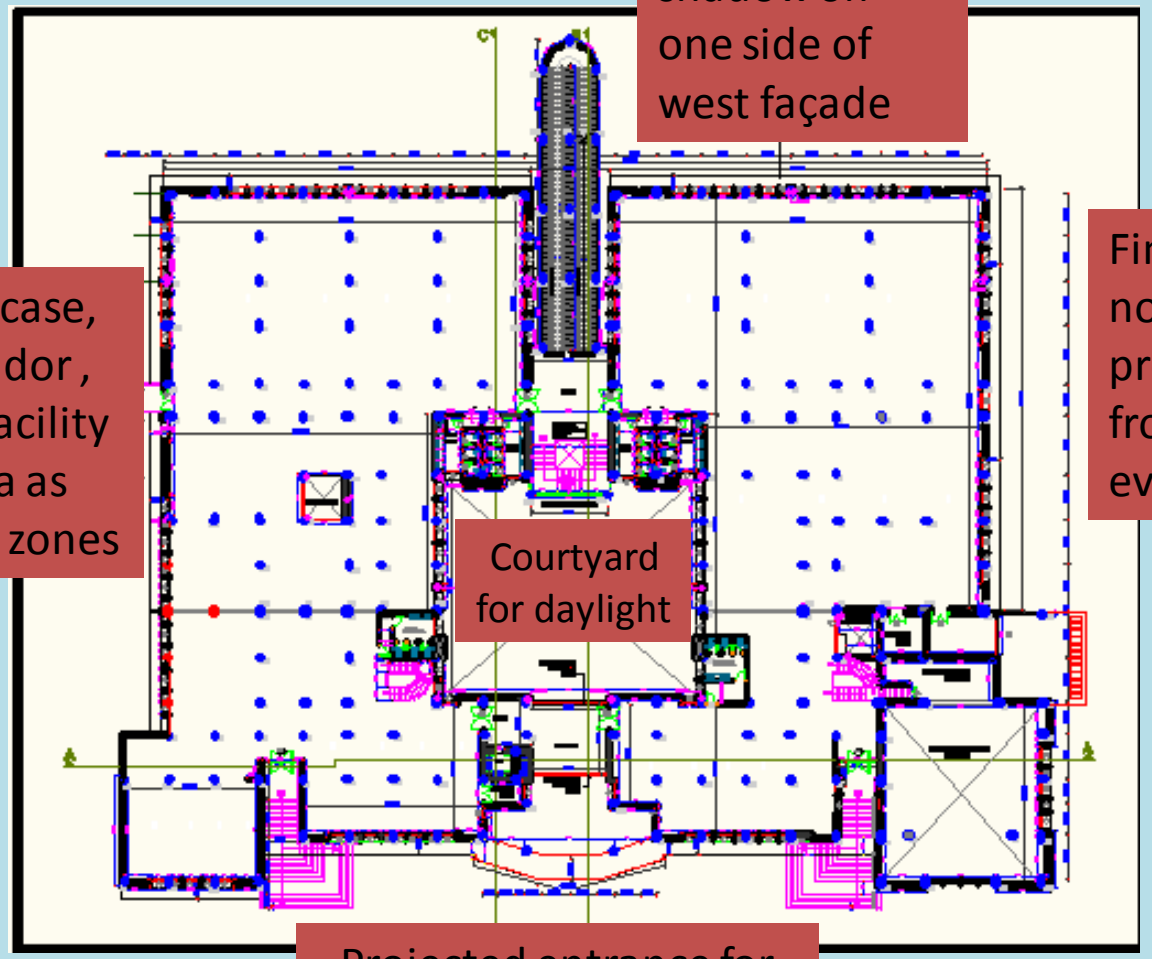


Source: Indian Weather Data 2014, ISHRAE

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



Fins used on north side for protection from low evening sun

Courtyard for daylight

Projected entrance for self shading of façade for low east sun

Features of Design Center Building Project *(contd..)*

Side View, West Facing

Elevation, East Facing

Side View, South Facing

Side View, North Facing

Features of Design Center Building Project *(contd..)*

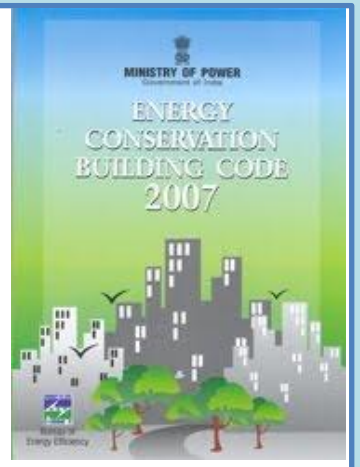
Curved fin on first floor used to architecturally integrate extended second floor with ground floor

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

U-Value of	Standard case	Proposed case
Wall (W/m^2-^oC)	0.440	0.72
Roof (W/m^2-^oC)	0.409	0.35

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

Glass properties	Standard case	Proposed case
U- value (W/m^2-^oC)	3.3	2.2
SHGC *(unadjusted)*	0.25	0.28

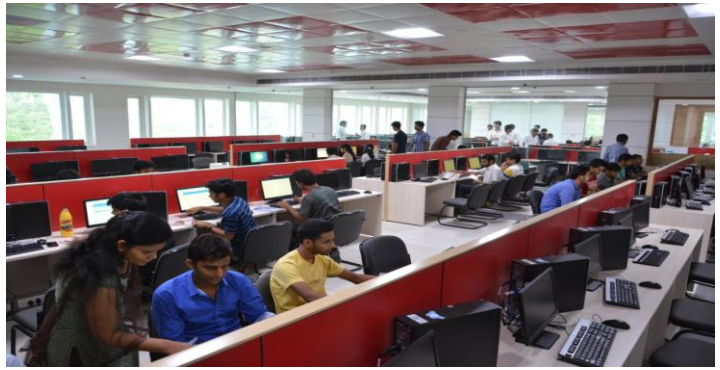
Basis of decisions:

- 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

Special care for window and lighting

- 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

Lighting Design



- ECBC LPD : 10.8 W/m^2 (For office activity)
- LPD at project : 5.38 W/m^2
- 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

System Type	RHFS (Reheat Fan System)
Chiller	Screw
COP	3.05
Fan Control	Constant volume
Fan Schedule	8:00 to 20:00 Hours
Design Supply CFM	1,20,008
CFM/ Ton	306
Fan Power	0.001030 kW/CFM

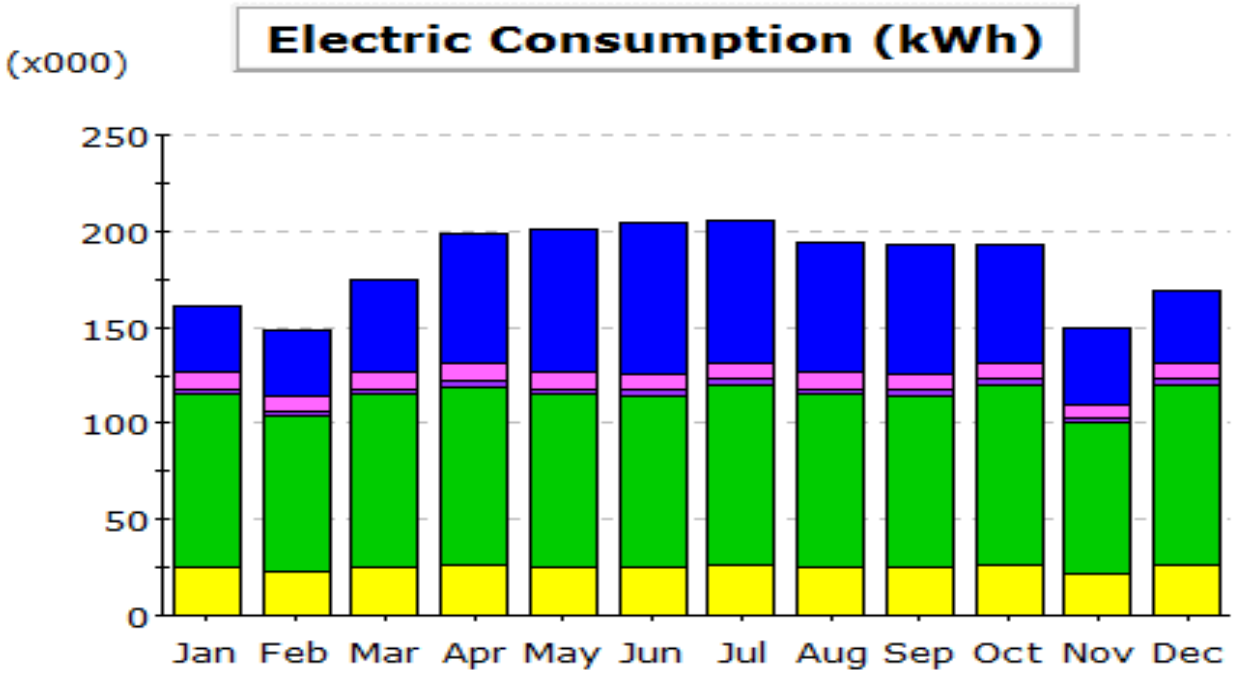
Reason for using VRF systems

- 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

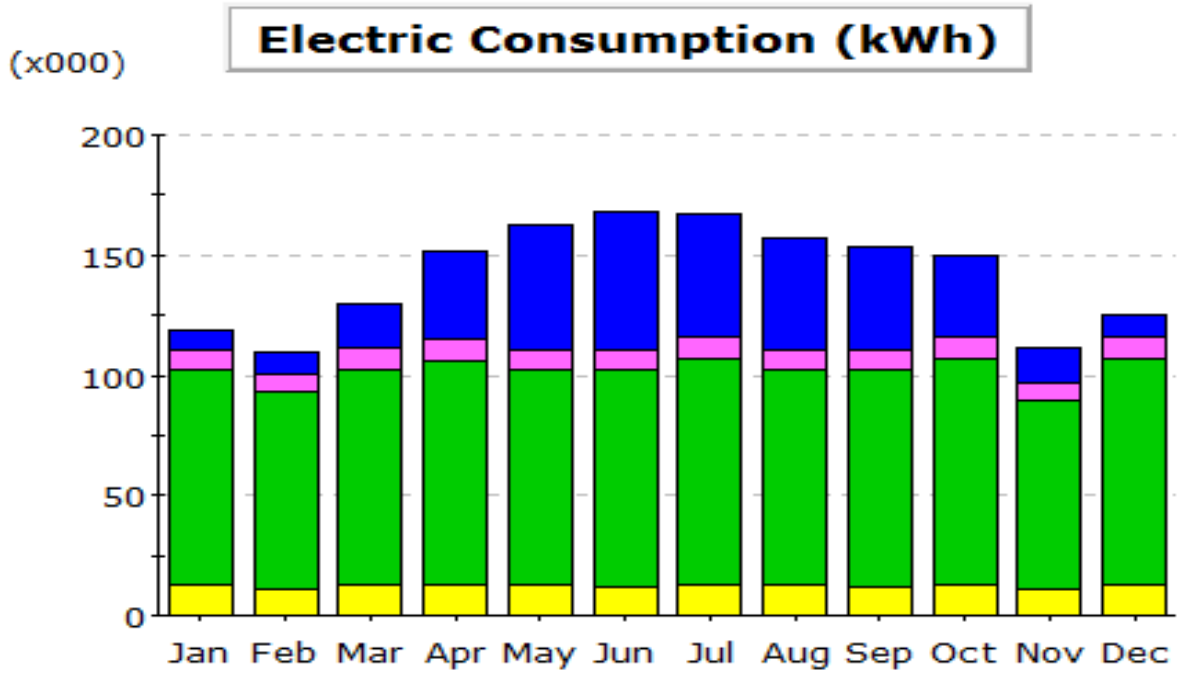
Additional Features: SPV Plant

- 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

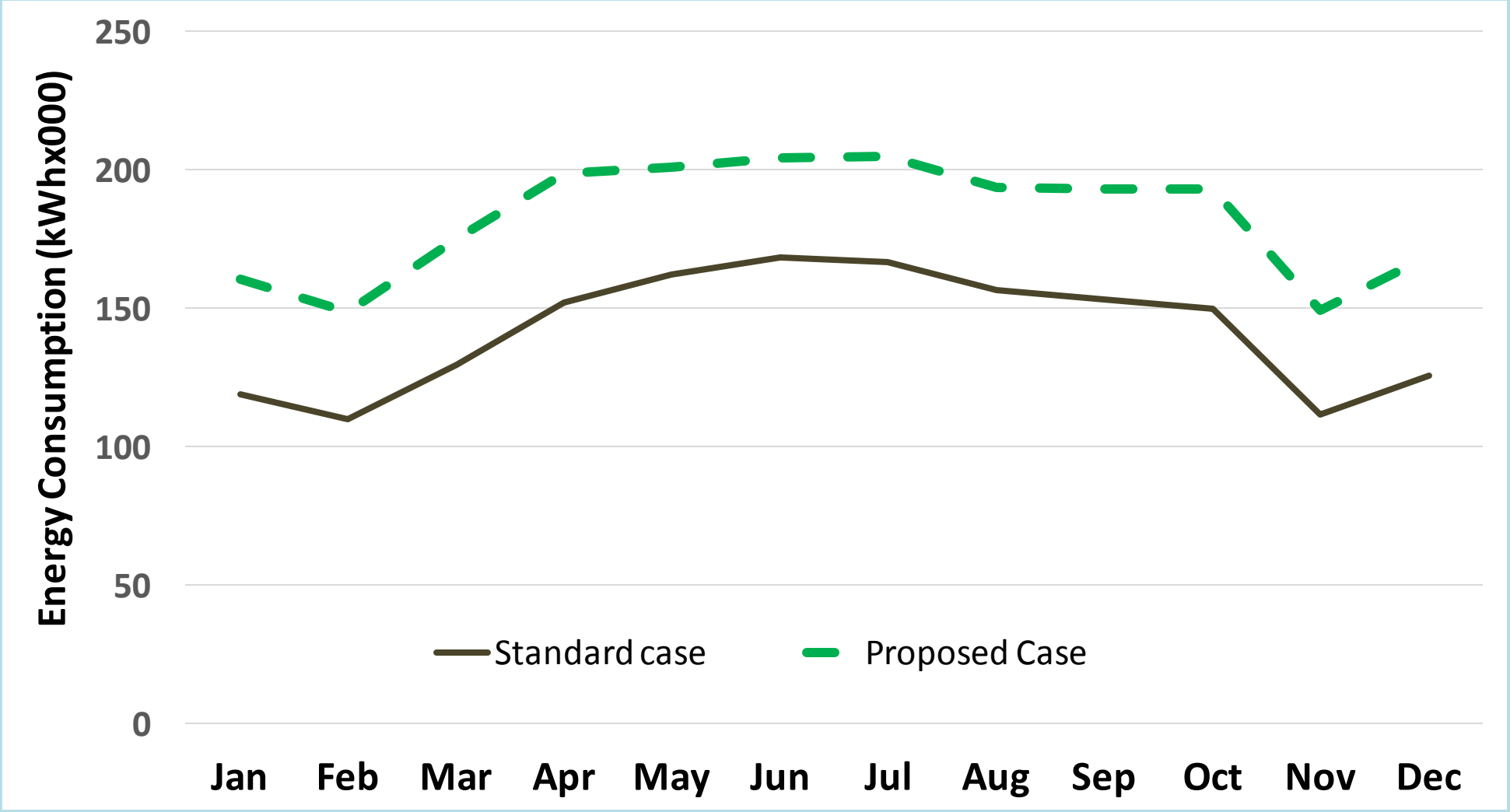


Standard case



Proposed case

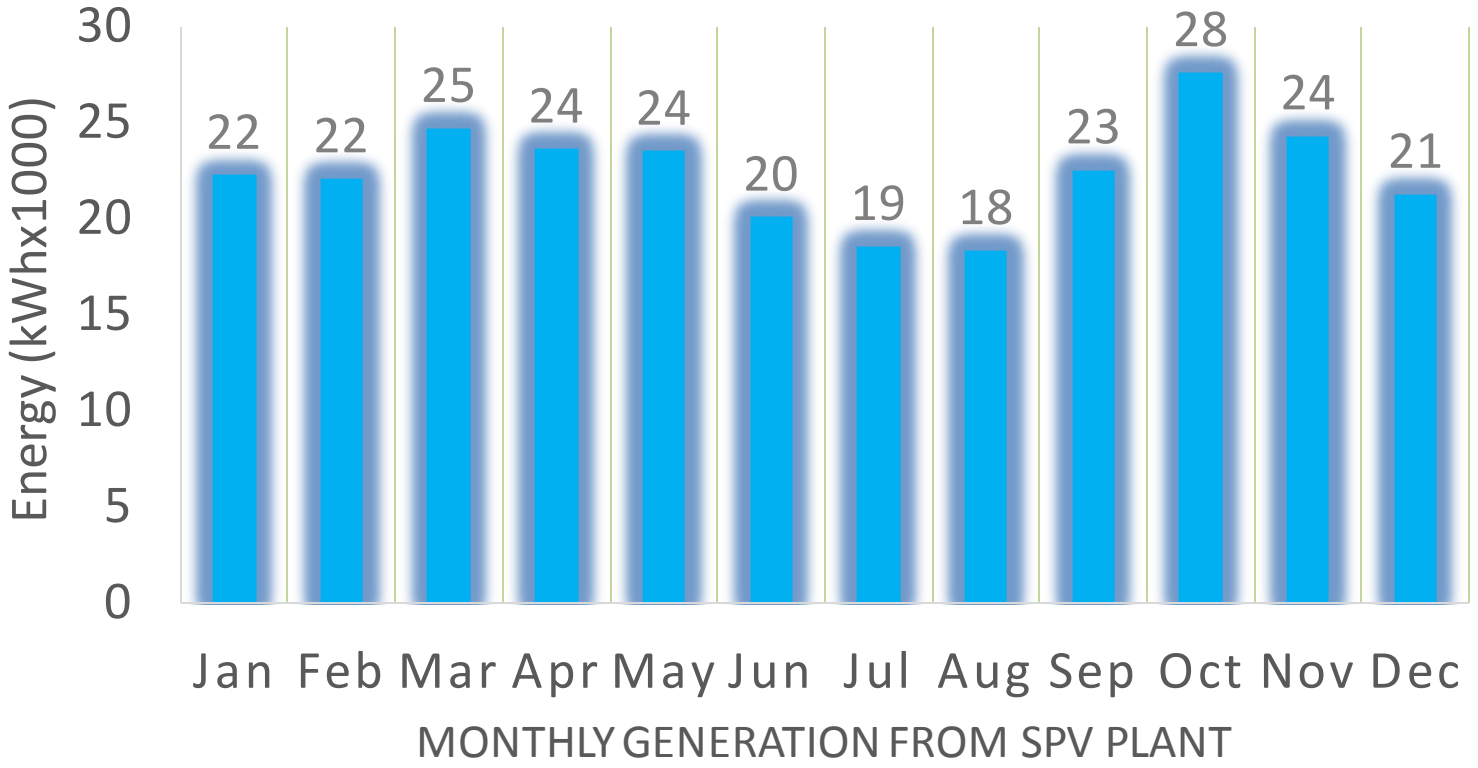
Monthly Energy Consumption



Summary - Energy Savings

	Standard case	Proposed case	Savings
Energy consumption (MWh)	2192.40	1704.80	487.6
EPI (kWh/m2/yr)	194	151	22.16%
Annual peak demand (kW)	828.76	708.07	14.56%
PV electricity generation (MWh)		268.86	15.7% of proposed case

SPV Plant Generation



Months	Energy Generation (kWhx1000)
Jan	22.26
Feb	22.07
Mar	24.7
Apr	23.62
May	23.51
Jun	20.08
Jul	18.56
Aug	18.34
Sep	22.54
Oct	27.6
Nov	24.31
Dec	21.27
Total	268.86

Summary of experiences

- 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

Dr. Vishal Garg

Mr. Shivraj Dhaka

Mr. Ashok Dhayal

Thank you for your time !

Questions ?