

NZEB at CEPT University: A Living Laboratory

Yash Shukla

Centre for Advanced Research in Building Science and Energy,
CEPT University, Ahmedabad

Adaptive Comfort and Retro commissioning

EDGE 2017, ASHRAE Region-at-large, Sub region II, 8th December 2017, Mumbai

What is a Net Zero Energy Building?

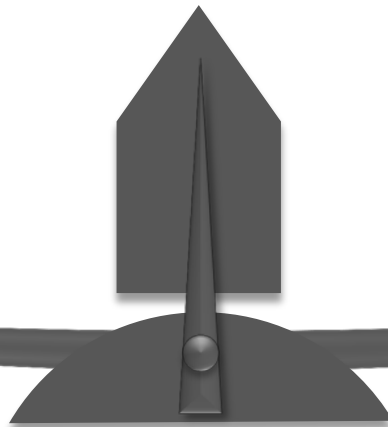
Consumption

Building Size
Energy Efficiency

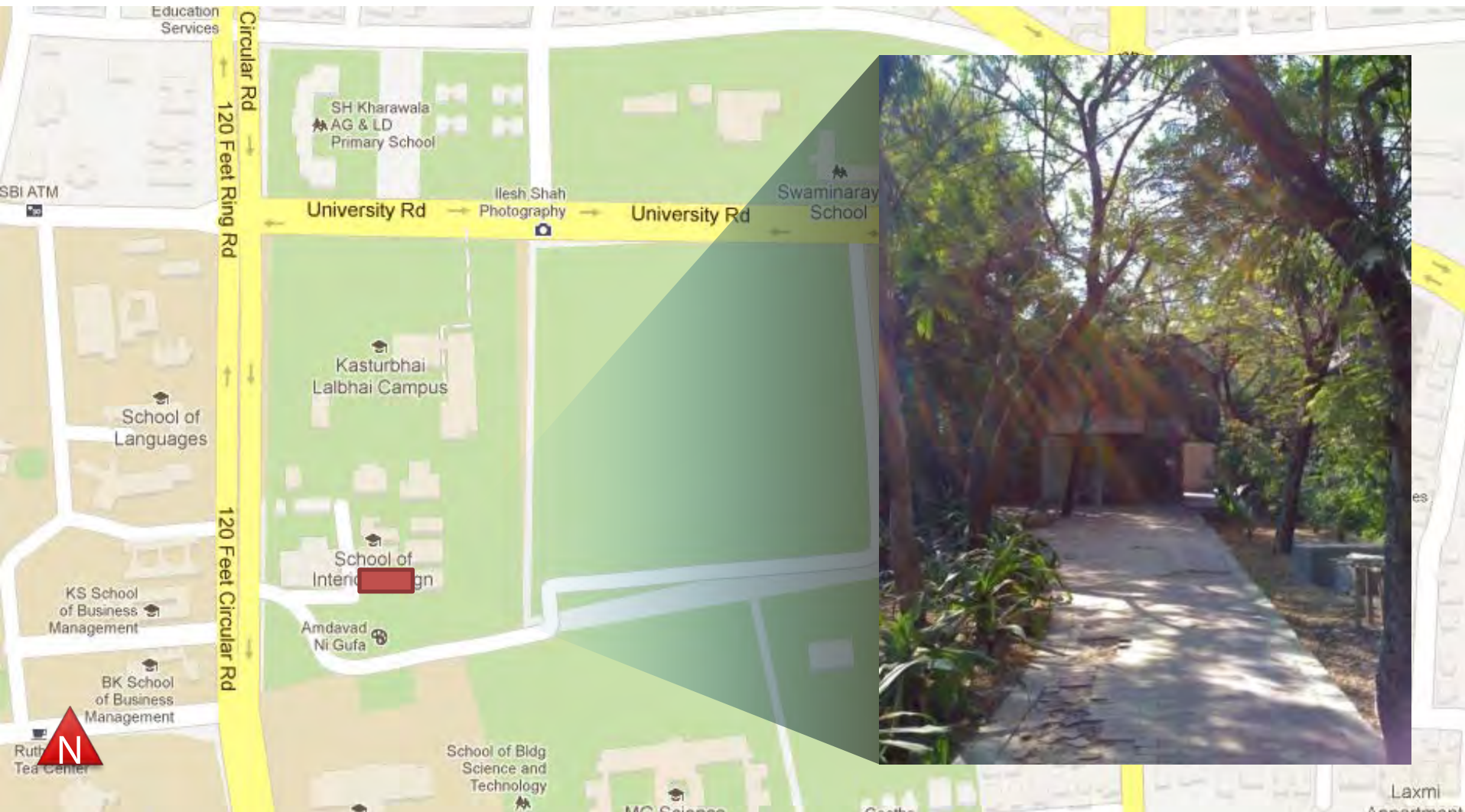


Generation

On Site Renewable Energy
Renewable Energy Credits



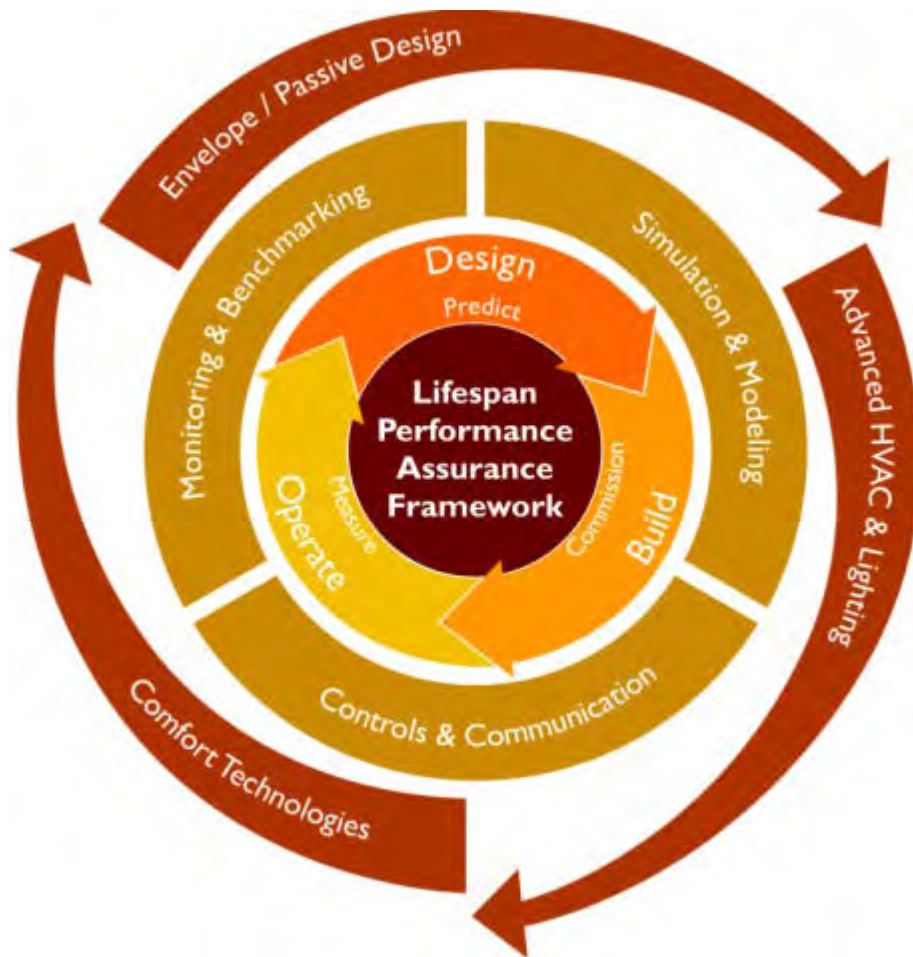
CEPT University Campus Site



Motivation for NZEB

- Application of Theories
- Example that can be replicated
- Living Laboratory
- Source of new knowledge

Building Performance with Life cycle Analysis Approach



- Design
- Construction
- Operation

Building Performance with Life cycle Analysis Approach

How to ***Design*** for Building Energy Efficiency
Design as per Adaptive Thermal Comfort Model

How to ***Construct*** for Building Energy Efficiency
Construct to increase comfort hours and increase
efficiency of building mechanical system

How to ***Operate*** for Building Energy Efficiency
Operate to reduce energy consumption

Iterative Design Process

- Predesign
- Conceptual Design
- System Development
- Systems Optimization

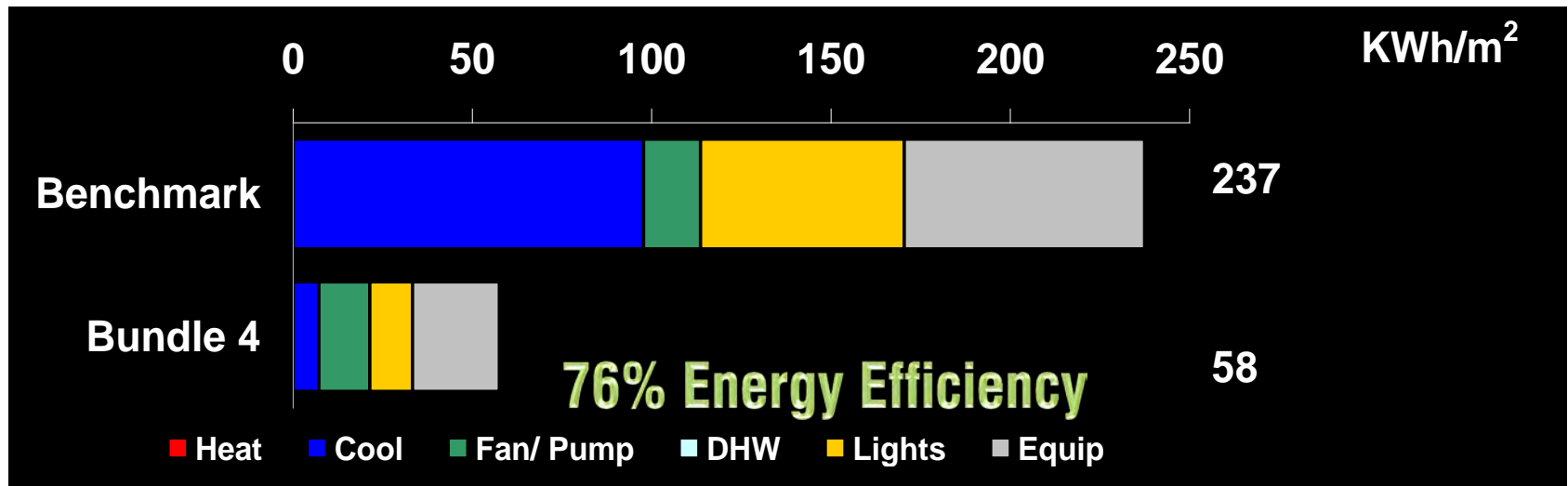


Three in-person charrettes in Ahmedabad
Over 20 virtual meetings and presentations

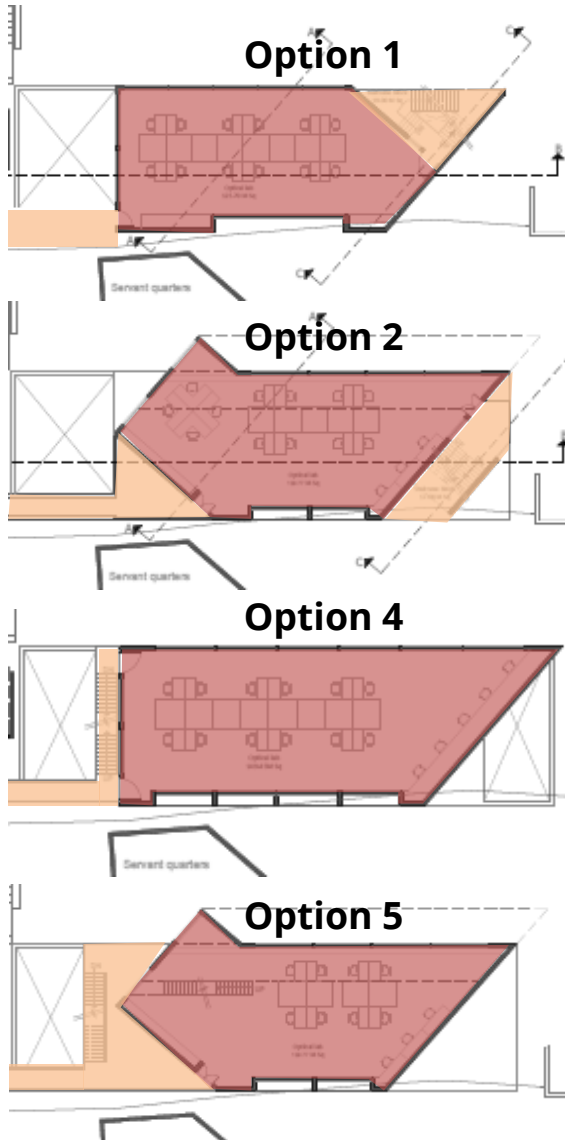
Pre-design Goals

Pre-design energy simulations of a benchmark building

Investigated 80 energy conservation measures (ECMs) in the Ahmedabad climate

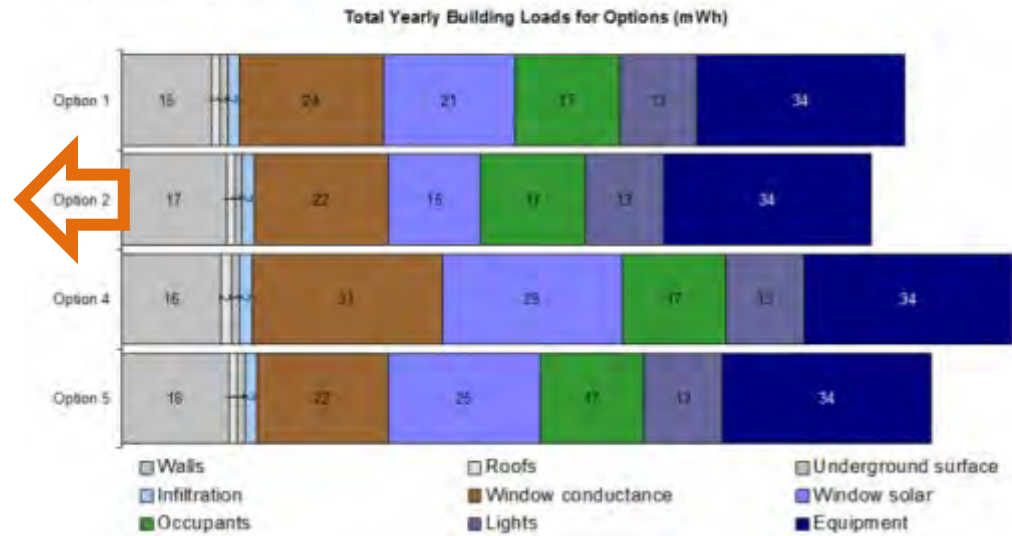


Building Massing Analysis



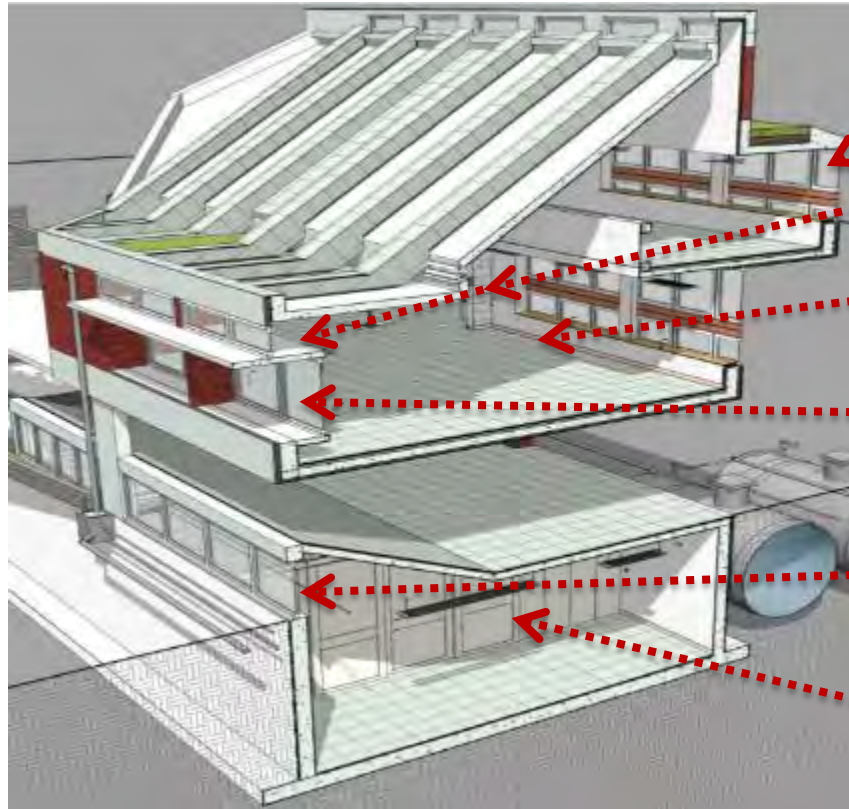
Building Cooling Loads

Building loads vary with the building massing and orientation. The graphs below show the yearly cooling loads for each option.



Daylighting Analysis Areas

Sunshading, Illuminance, Luminance, Daylighting Autonomy, UDI



Sizing of North Windows

Sizing of Lightshelves

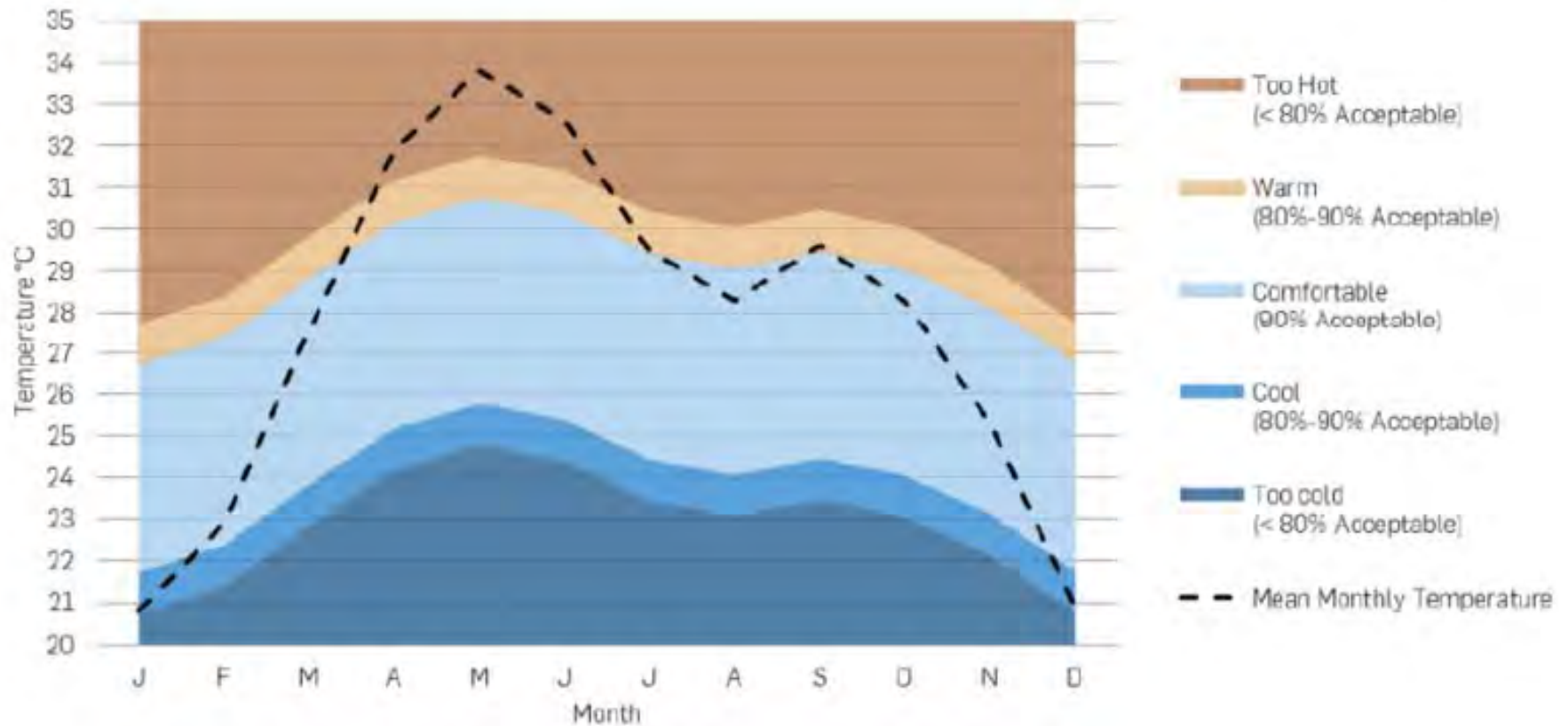
Interior wall finishes

Sizing of South Vision Windows

Sizing Basement Light Monitor

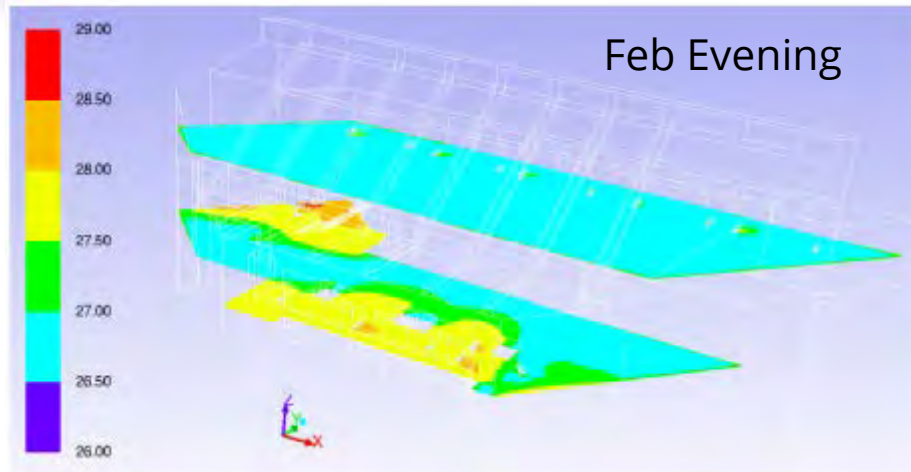
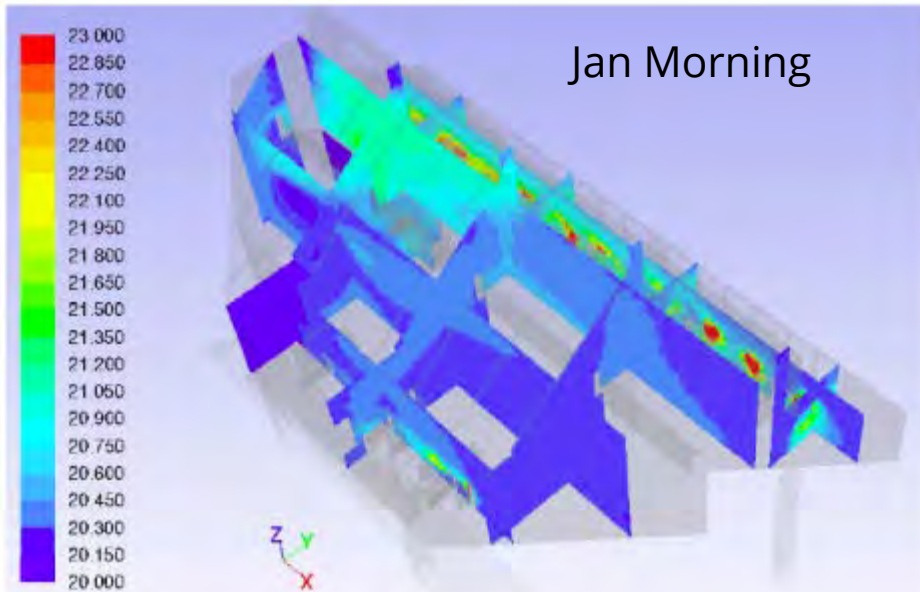
Sizing of Basement Courtyard Windows

Adaptive Thermal Comfort



Passive Cooling Potential

Assess Thermal Comfort and Natural Ventilation with CFD Model



Month	Morning	Afternoon	Evening
Jan	Windows Closed	Windows Open	Windows Open
Feb	Windows Closed	Windows Open	Windows Open
Mar	Windows Open	No	No
Apr	No	No	No
May	No	No	No
Jun	No	No	No
Jul	No	No	No
Aug	No	No	No
Oct	Windows Open	No	No
Nov	Windows Open	No	Windows Open
Dec	Windows Closed	Windows Open	Windows Open

Schematic Design and Operational Strategies



Comfortable Outdoor Environment



Hot Outdoor Environment

HVAC Systems

- Primary and secondary cooling systems
 - Radiant System
 - Dedicated outdoor air system
 - VRF / VRV
- Chilled water plant
 - Variable speed
 - Inverter chiller

HVAC Systems

Net Zero Energy Building - HVAC Systems

Radiant Panel

Insulation
ECOPHTEL (Graphite lightweight construction panel)
Meander tube
Nonwoven
Steel sheet ceiling (various designs)

Manifold

Floor Standing Concealed Type VRF Indoor Unit

DC fan motor
Highly efficient DC motor
Sine wave drive

Heat exchanger
High-efficiency R410A heat-transfer tube
Configuration of the finned heat-transfer tube

Heat exchanger
High-pressure low-volume fan
The bat wing fan realizes low sound level.

Vector-controlled inverter
The inverter boosts efficiency by controlling R410A and a twin-rotary DC compressor.

Vector iFDO control
changes the motor current wave to a smooth sine pattern so that noise emitted from the drive units is greatly reduced.

Heat exchanger
Increased, wide range efficiency is realized

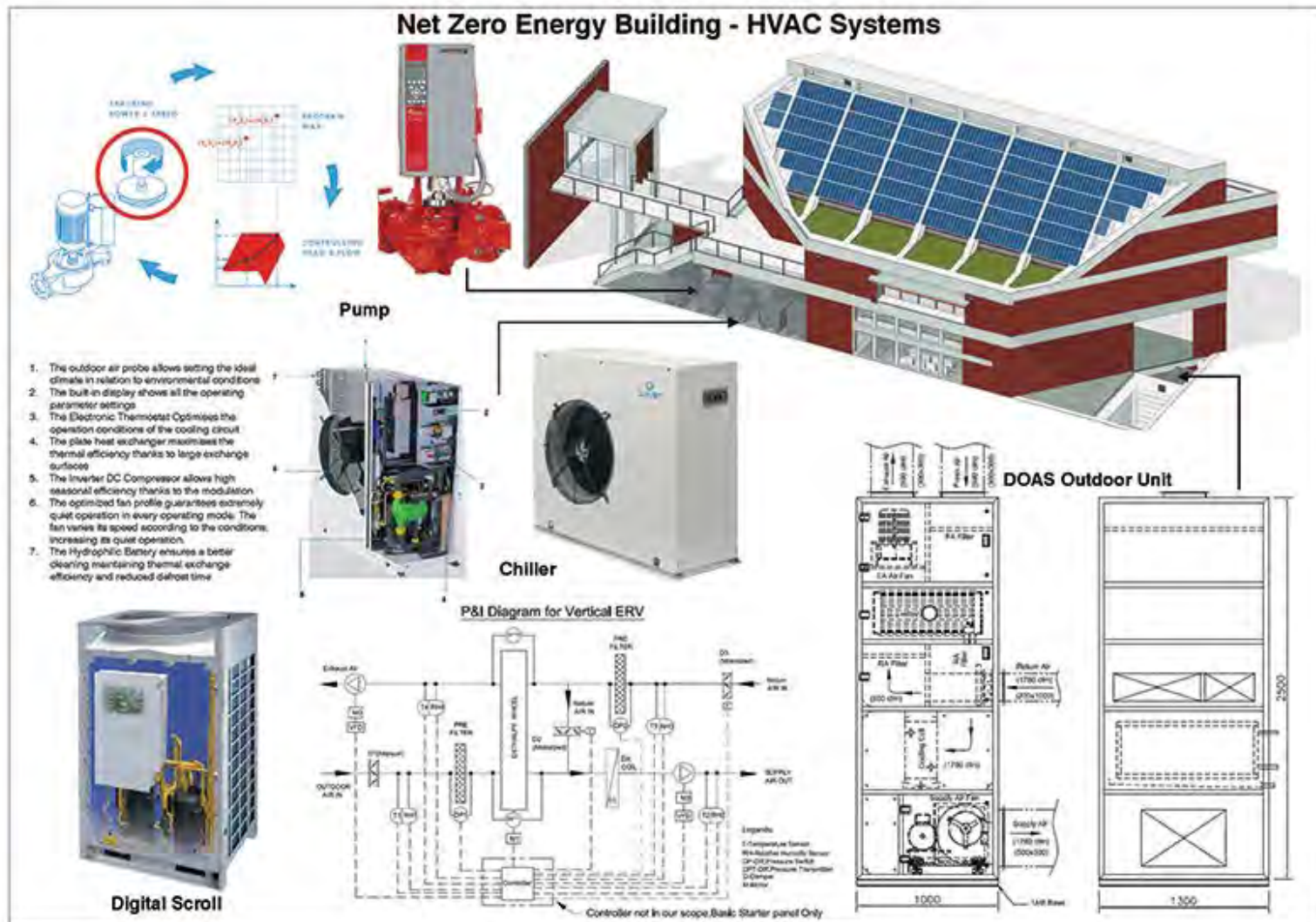
DC driven motor with rare-earth magnet
- Compact
- Higher efficiency
- Higher power motor torque
- Precise manufacturing technology in the compression parts
- Higher efficiency (in wide range)
- Higher reliability

VRF Outdoor Unit

High-wall Type - VRF Indoor Unit

Space required for installation and servicing

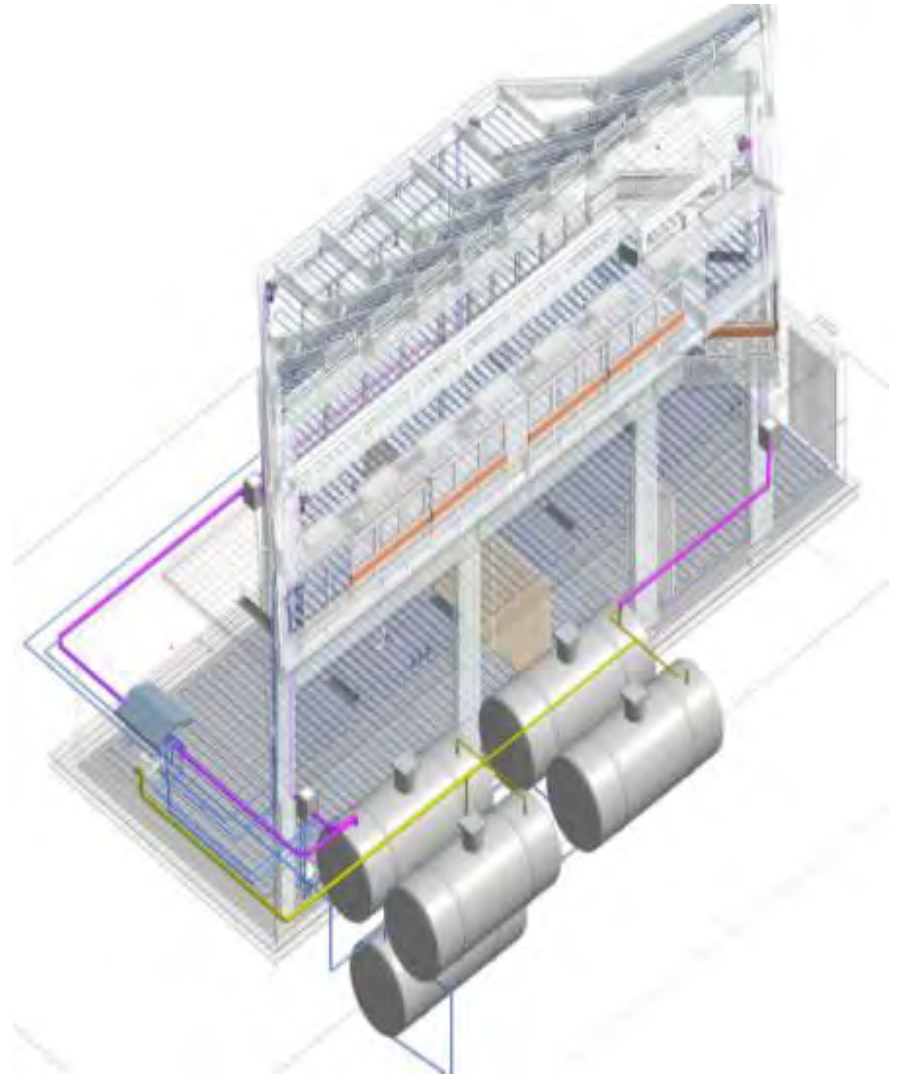
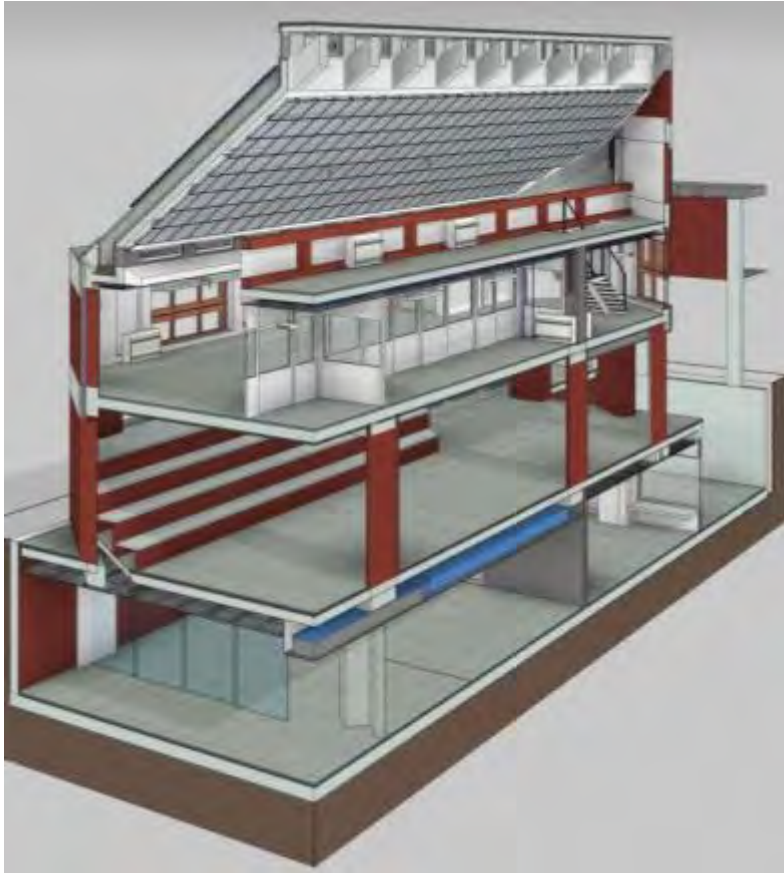
HVAC Systems



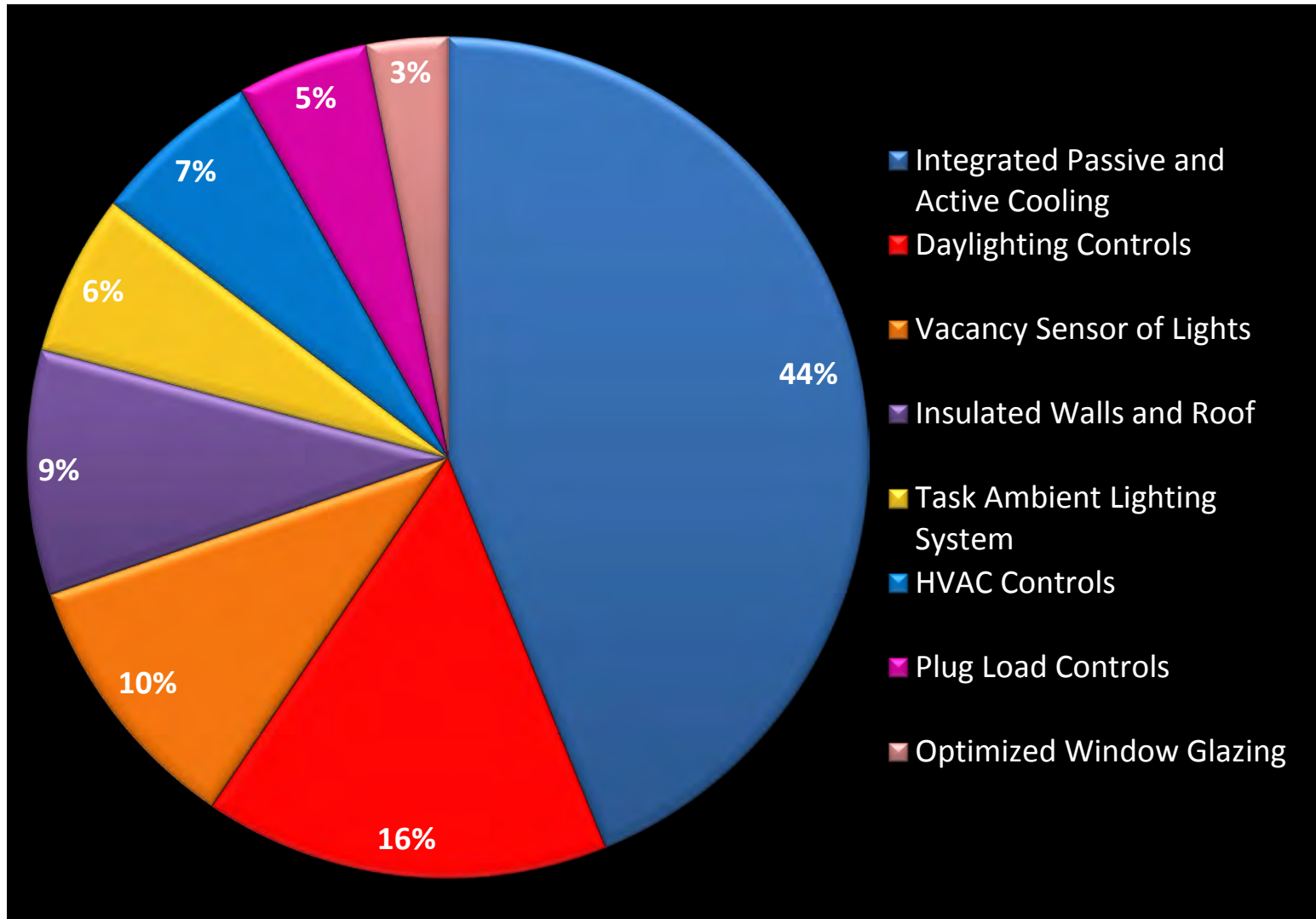
Building Integrated PV



BIM System Integration



Savings by Measure Type

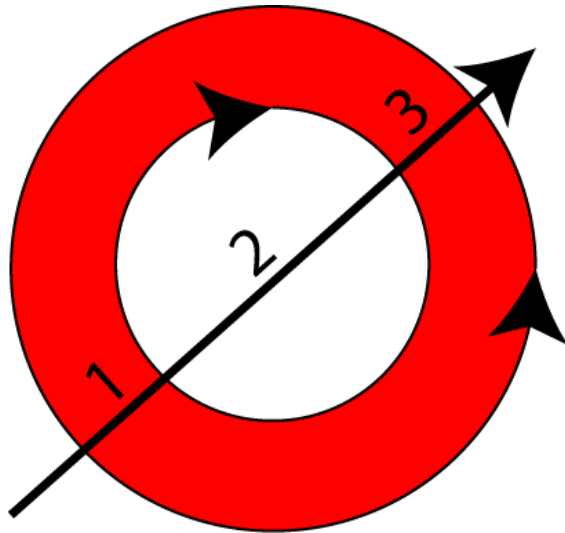


Building External Views



Building Internal Views





“Every line is the perfect length if you don't measure it”

-Marty Rubin

Monitoring and Control - NZEB



Building Information Systems

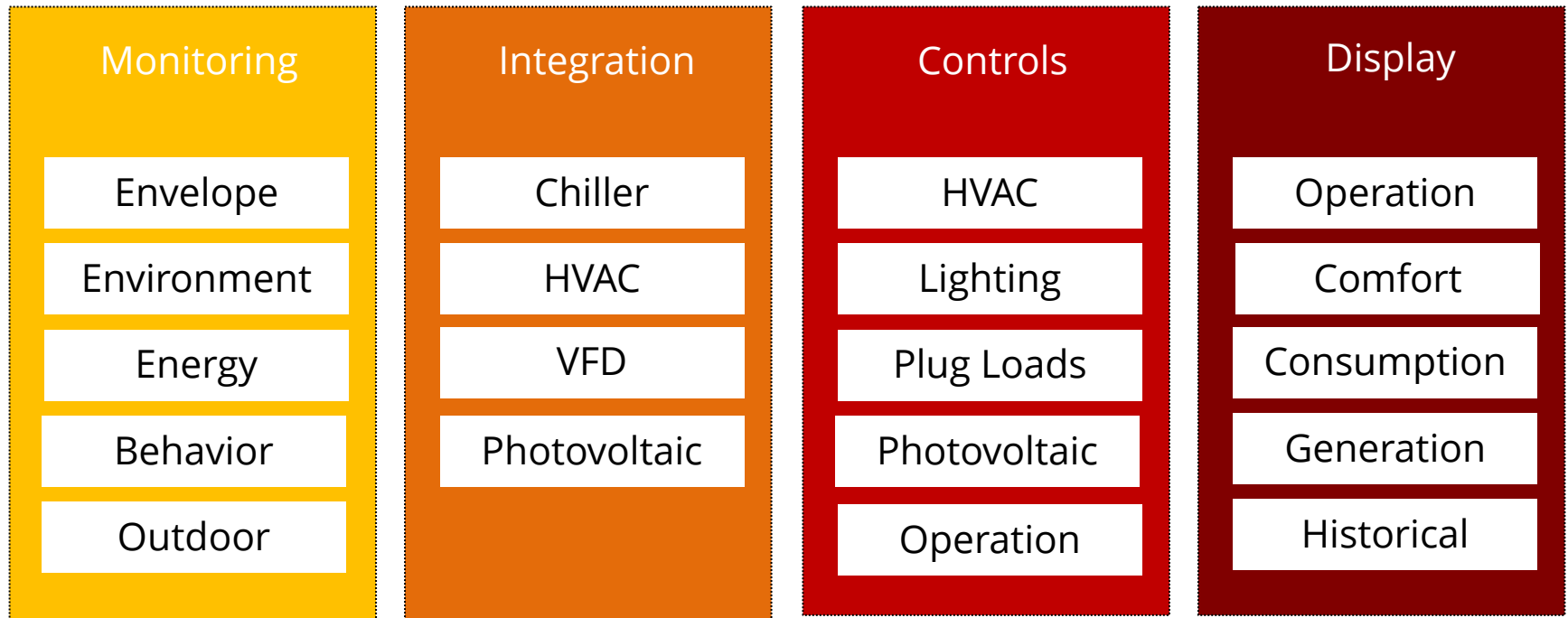
- Thermal Comfort, Temp – Humidity
- Visual Comfort, Light
- Occupancy
- Outdoor conditions
- Equipment usage



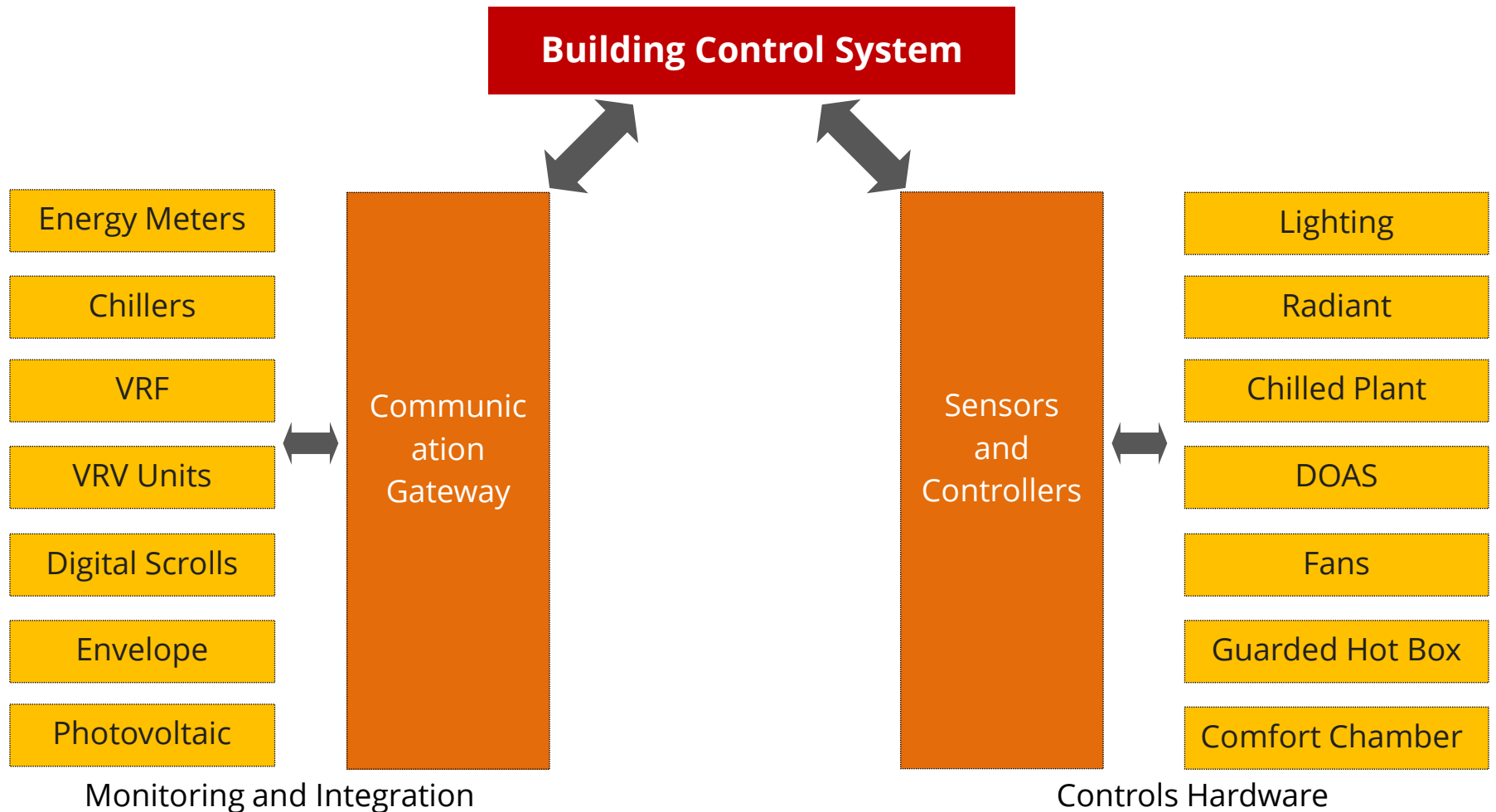
Building Management Systems

- Energy Management
 - Energy used to maintain comfort
 - Energy used for equipment

Monitoring and control system



Details of Monitoring, Integration and Controls Philosophy



Building Energy Monitoring System

NET ZERO ENERGY BUILDING, CEPT UNIVERSITY



Outdoor Weather Conditions

Temp. °C :
RH % :



Energy

Consumption kw :
Generation(SPV) kw :



Basement

Energy Consumption kw :
Temp. °C :
RH % :



Ground Floor

Energy Consumption kw :
Temp. °C :
RH % :



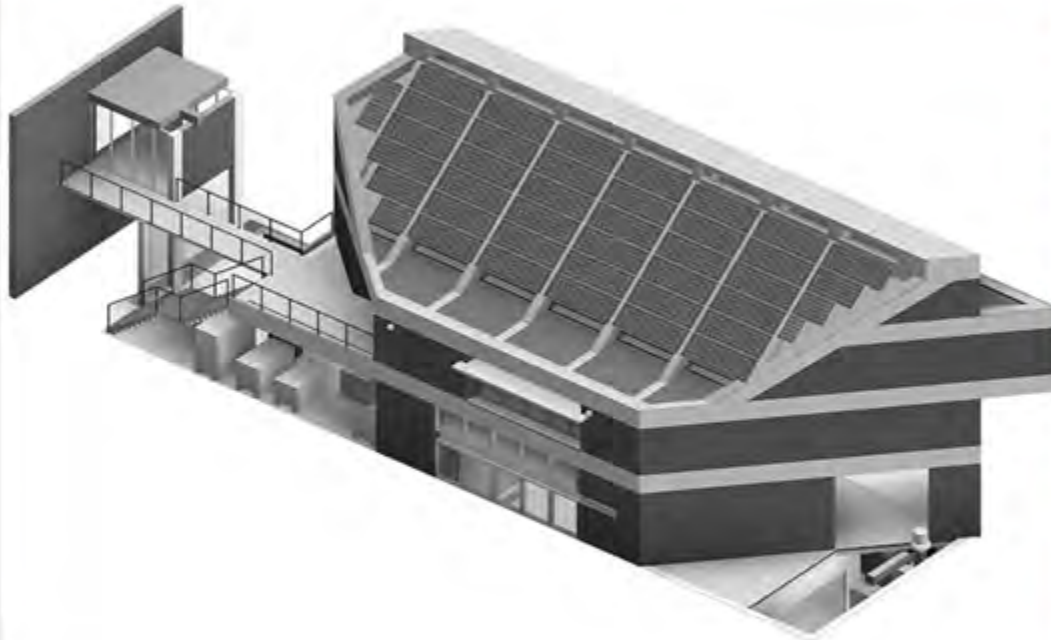
First Floor

Energy Consumption kw :
Temp. °C :
RH % :



Mezzanine Floor

Energy Consumption kw :
Temp. °C :
RH % :



Radiant System

Energy Consumption kw :
Temp. °C :
RH % :



Dedicated Outdoor Air System

Energy Consumption kw :
Temp. °C :
RH % :



Variable Refrigerant Flow

Energy Consumption kw :
Temp. °C :
RH % :



Fan & Lights

Energy Consumption kw :
Temp. °C :
RH % :



Thermal Comfort Chamber

Energy Consumption kw :
Temp. °C :
RH % :



TCC Chiller

Energy Consumption kw :
Temp. °C :
RH % :



TCC Air Handling Unit

Energy Consumption kw :
Temp. °C :
RH % :



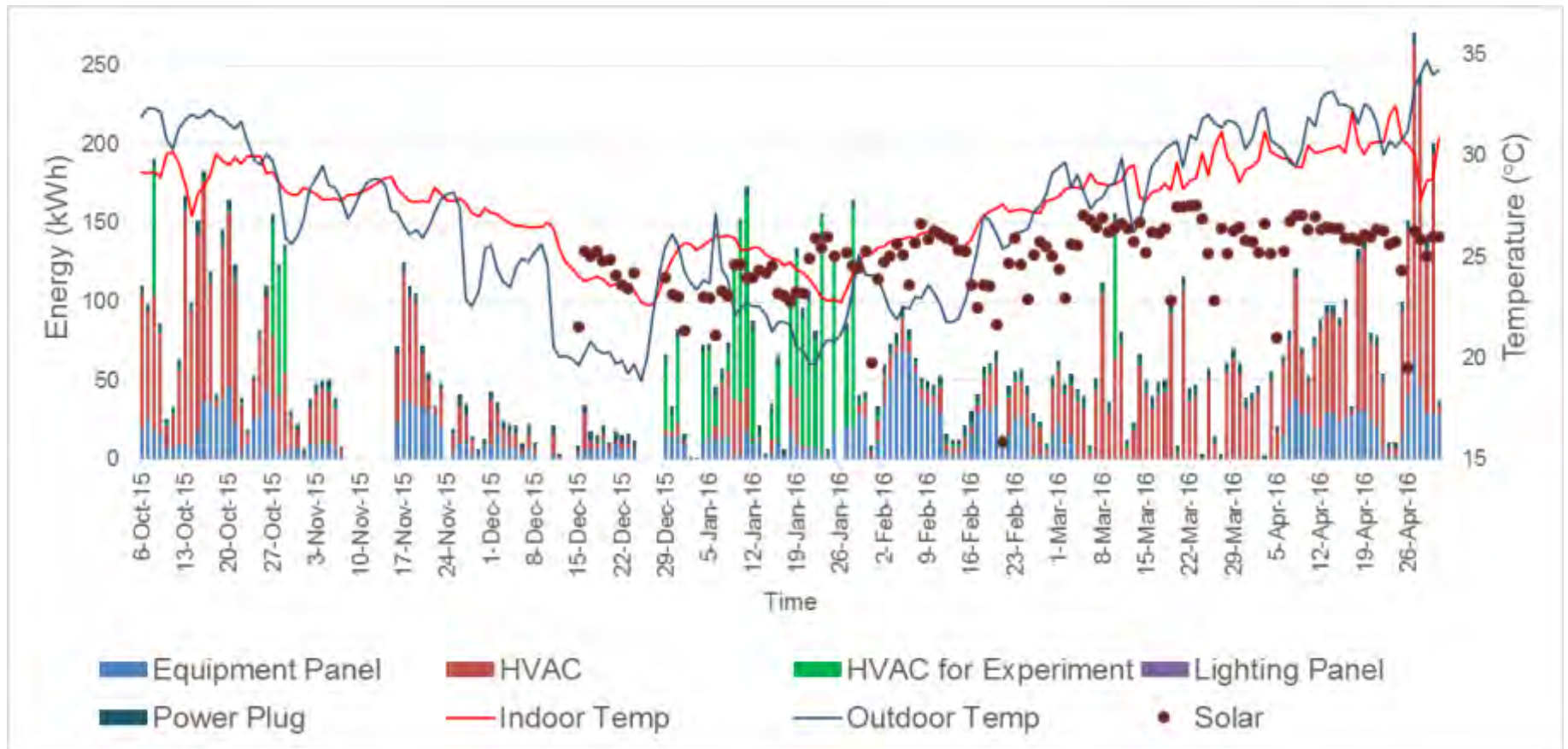
Guarded Hot Box

Energy Consumption kw :
Temp. °C :
RH % :

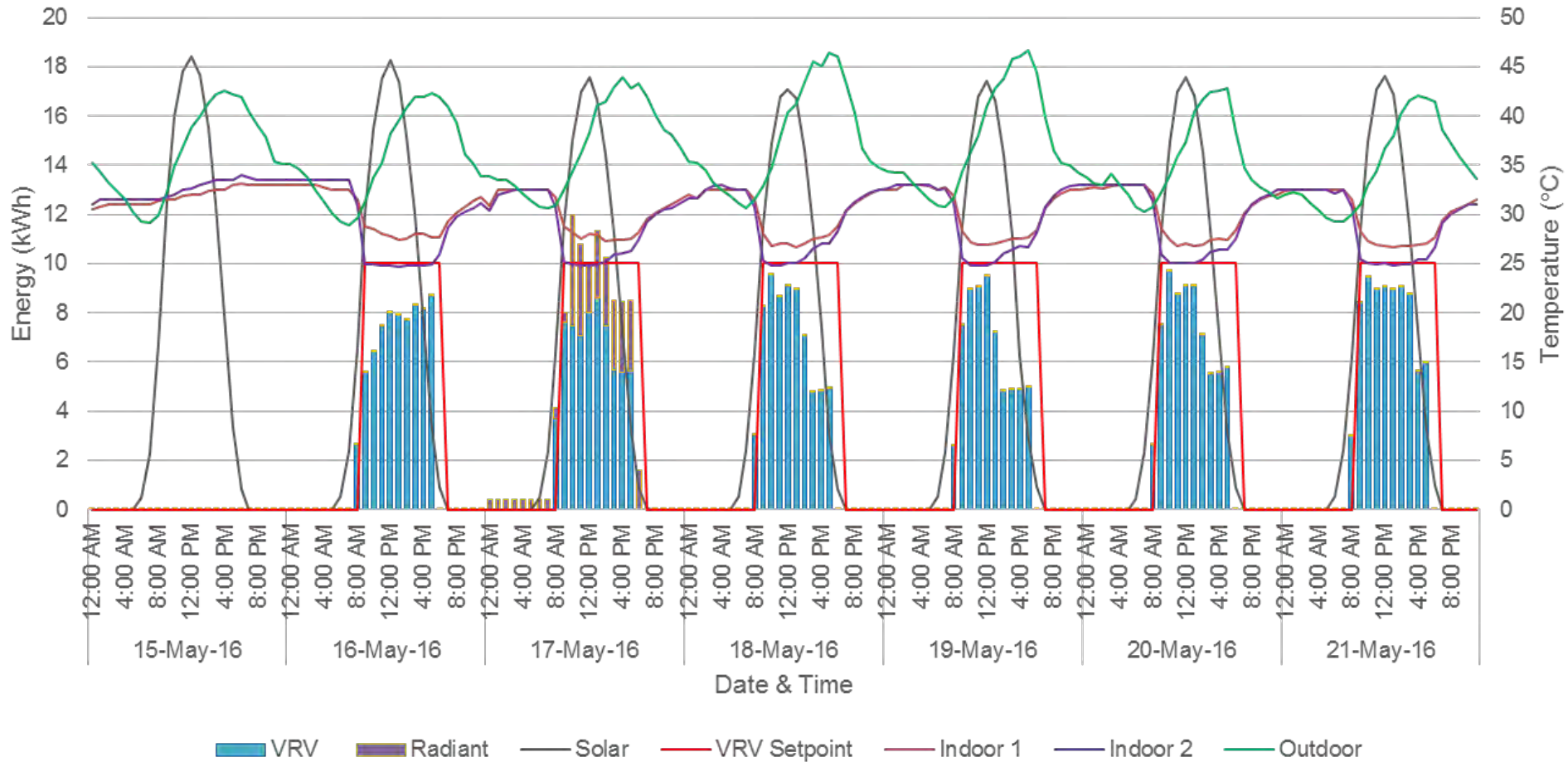
Building Energy Monitoring System



Environment and Energy

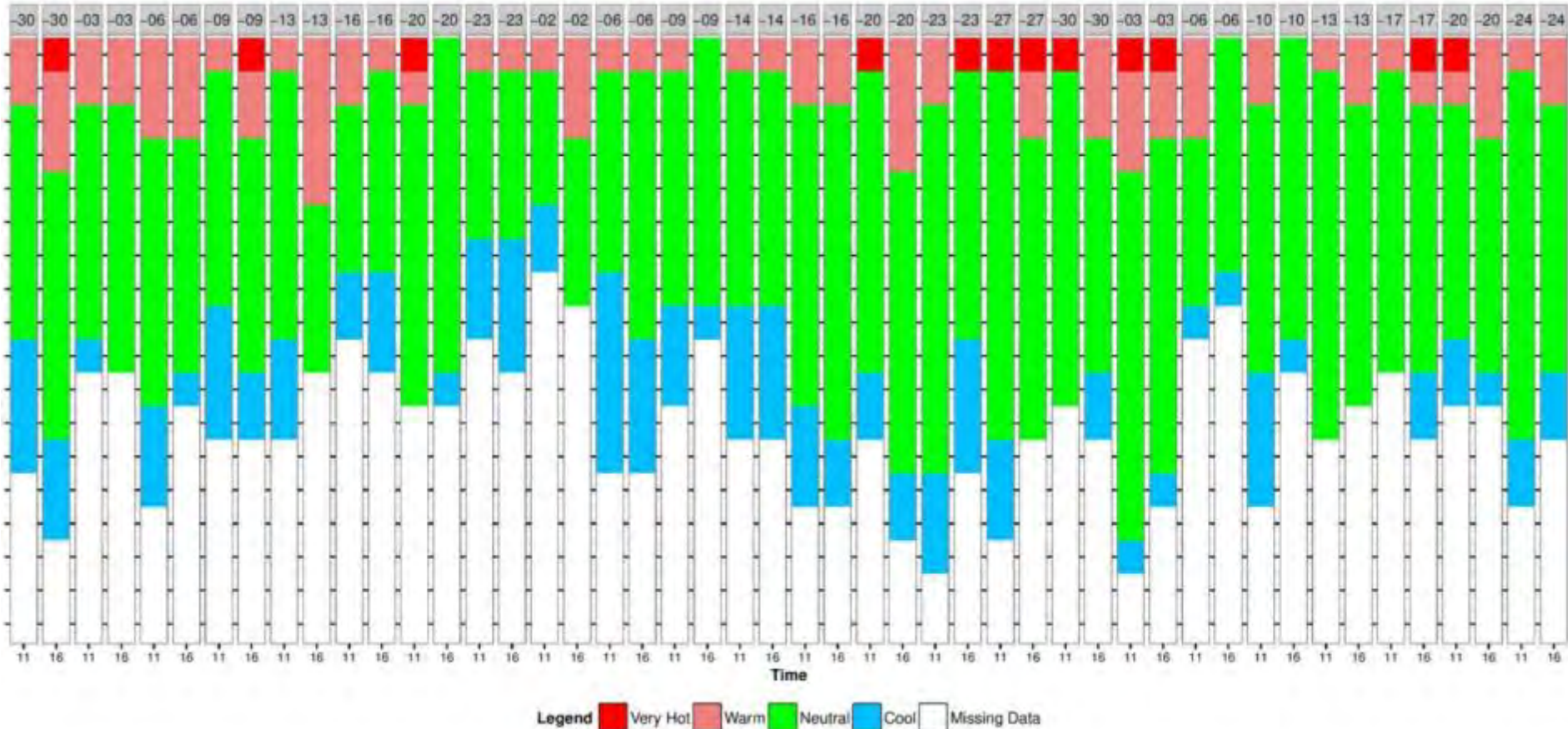


Environment and Energy



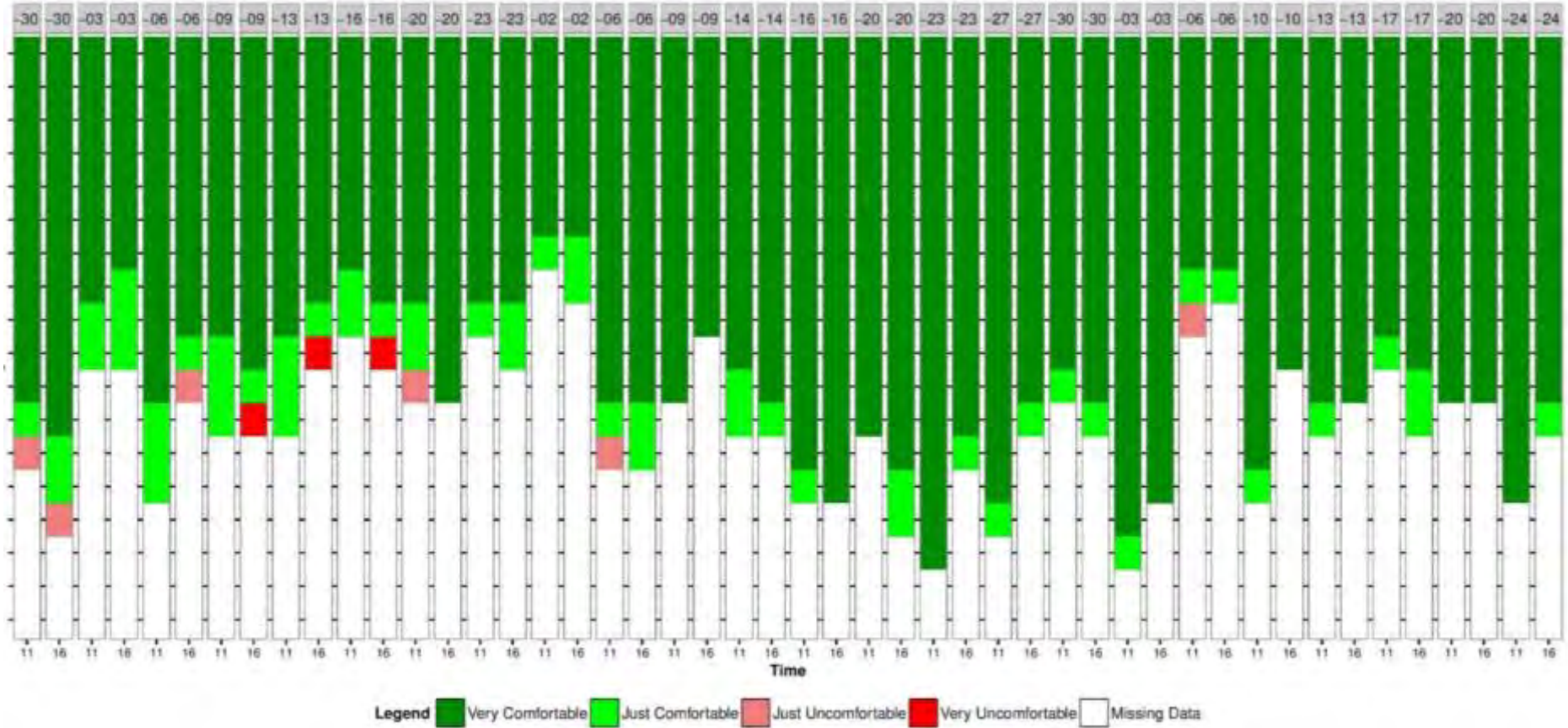
Thermal Comfort Surveys and Occupant Feedback

How do you describe your current thermal sensation?



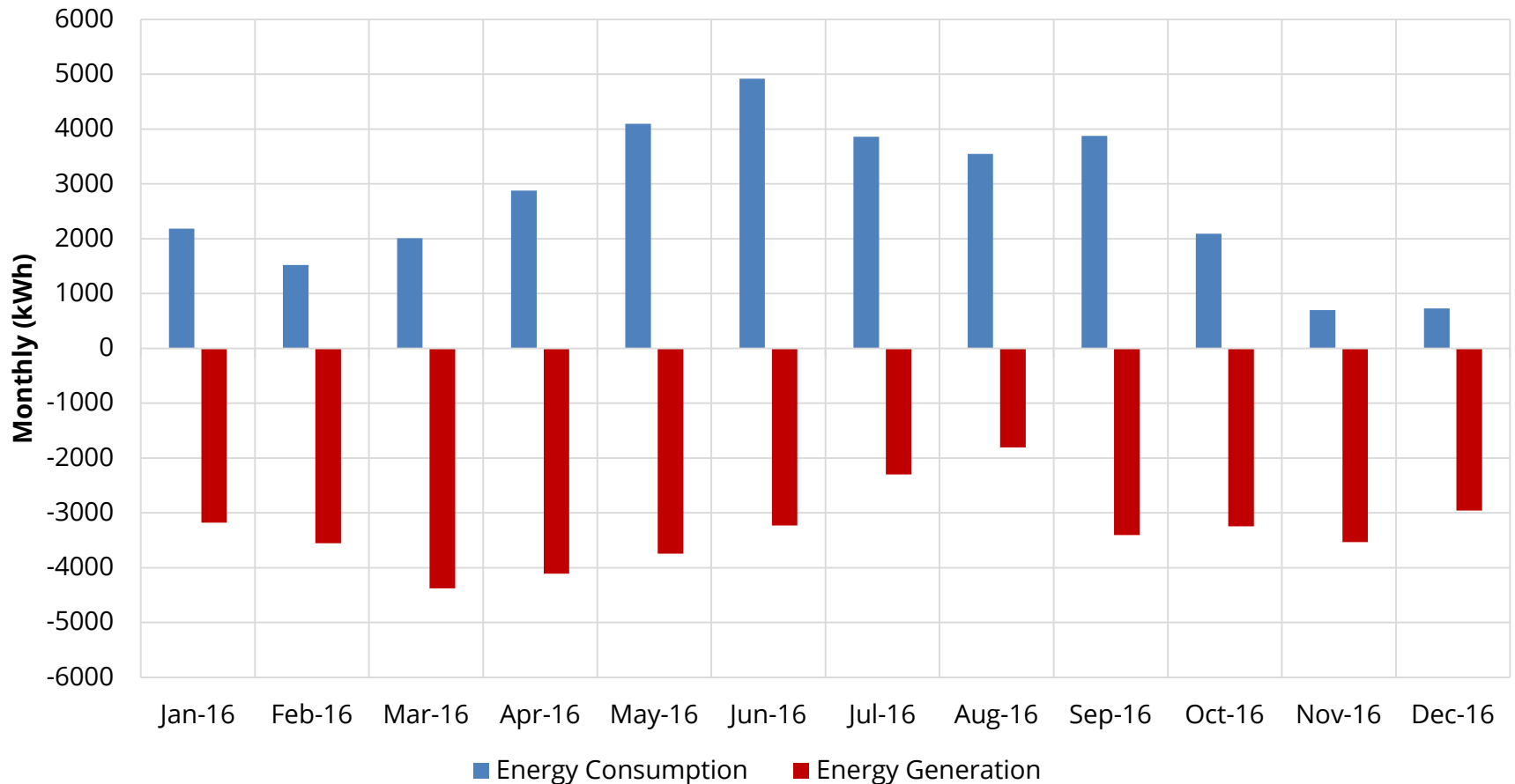
Thermal Comfort Surveys and Occupant Feedback

Are you comfortable?



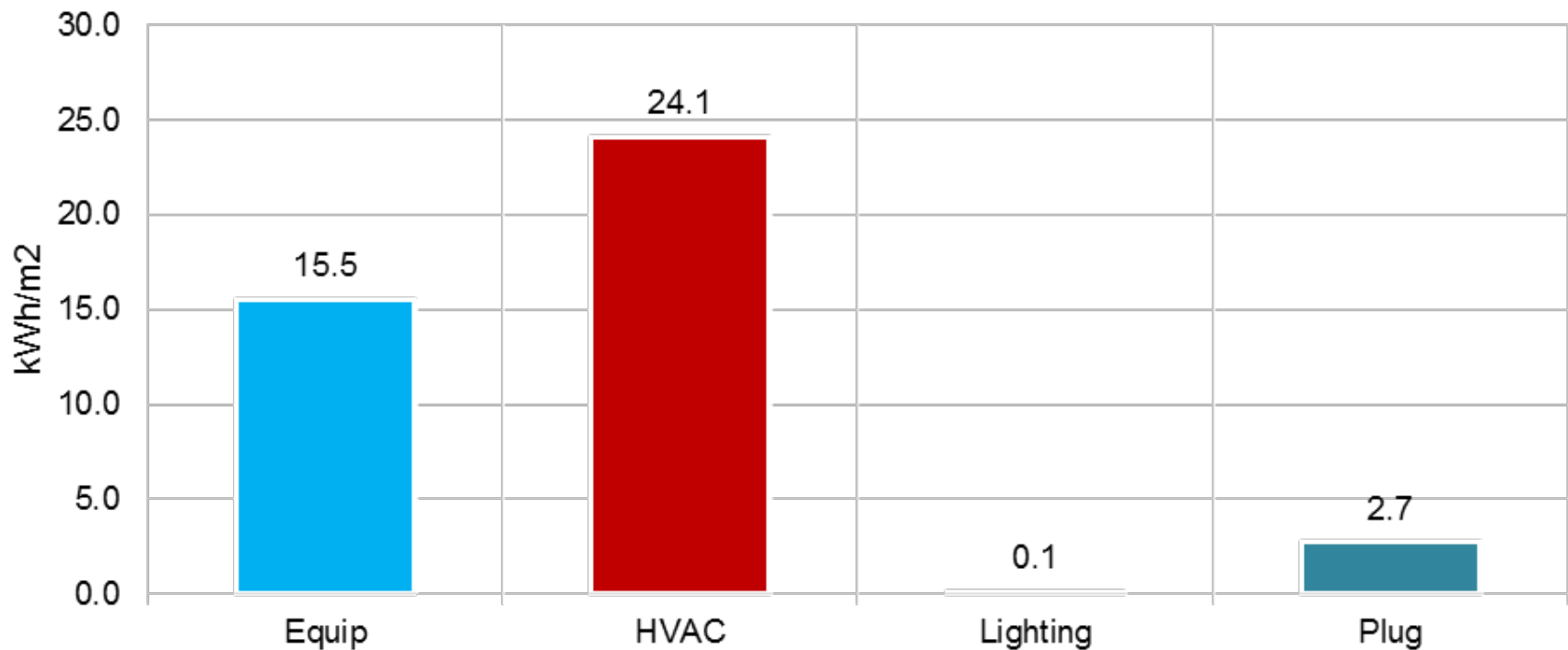
Energy Consumption Summary

Monthly Consumption and Generation



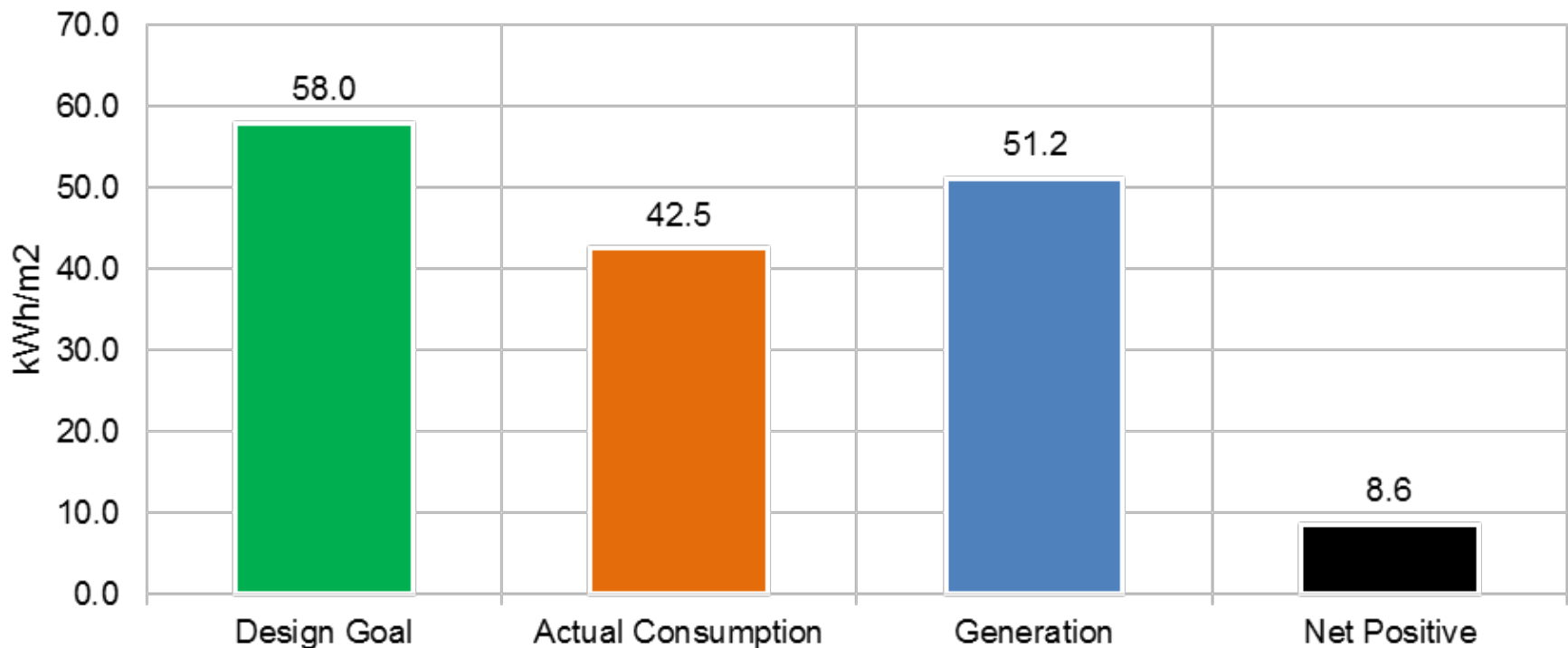
End Use Energy Consumption

End Use Energy Performance Index (EPI) in 2016



Comparison with Design Goals

Energy Performance Index (EPI) in 2016



**Do we have all
ingredients to
build NZEBs in
India?**

**“Buying the right computer
and getting it to work
properly is no more
complicated than building a
nuclear reactor from
wristwatch parts in a
darkened room using only
your teeth”**

- Dave Barry

Thermal Characterization



- Thermal Conductivity
- Thermal Diffusivity
- Specific heat



Thermal Characterization : Wall



- Guarded Hot Box
- Non-homogenous Materials
- ASTM C 1363
ISO 12567



Optical Property Characterization



- Solar Reflectance
- Solar Transmittance
- ASTM / ISO / EN



Fenestration Characterization



- Solar Calorimeter
- Air leakage Chamber
- NFRC & ASTM



Construction Database



- Indian Materials
- Glazing Systems
- ISO / ASTM

U-factor Calculator

HOME
ABOUT
SUBJECT AREAS
A LIVING LABORATORY
PERSONNEL
RESOURCE
NETWORKS
CONTACT US

Wall and Roof Assembly U-value Calculator

Location : State : City :

Assembly Type :

Select no. of layers :

Select Material : Thickness : Outside

Thickness :

Thickness : Inside

Thermal Properties						
	Material Name	Conductivity (W/m-k)	Specific heat (J/kg-k)	Density (kg/m ³)	Sample Source	Material Information
Layer 1	Gypsum	0.40	1.34	50	ISO 10456	More
Layer 2	Modular brick	0.72	0.77	60	CIBSE Guide	More
Layer 3	Cement	0.40	1.23	72	CIBSE Guide	More

Assembly	Heat Capacity (kJ/m ² -k)	Surface to Surface U-value (w/m ² -k)	Overall U-value	Calculation Method	Internal Heat Transfer Coefficient (w/m ² -k)	External Heat Transfer Coefficient (w/m ² -k)
Layer 1+2+3	100	5.9	5.9	ASHRAE	0.2	0.2
Layer 1+2+3	100	5.9	5.7	CEPT	0.1	0.2

▶ [Go to the Tools main page](#)

Hygrothermal Characterization



- Sorption Isotherm
- Vapor Transmission
- Water uptake



SPSS and Mirror Box

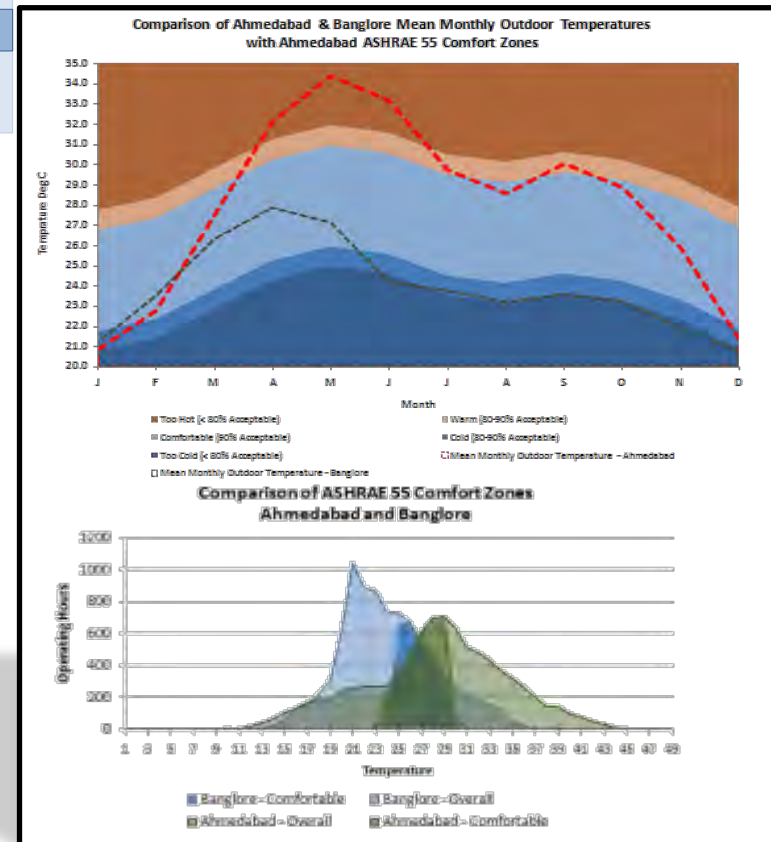
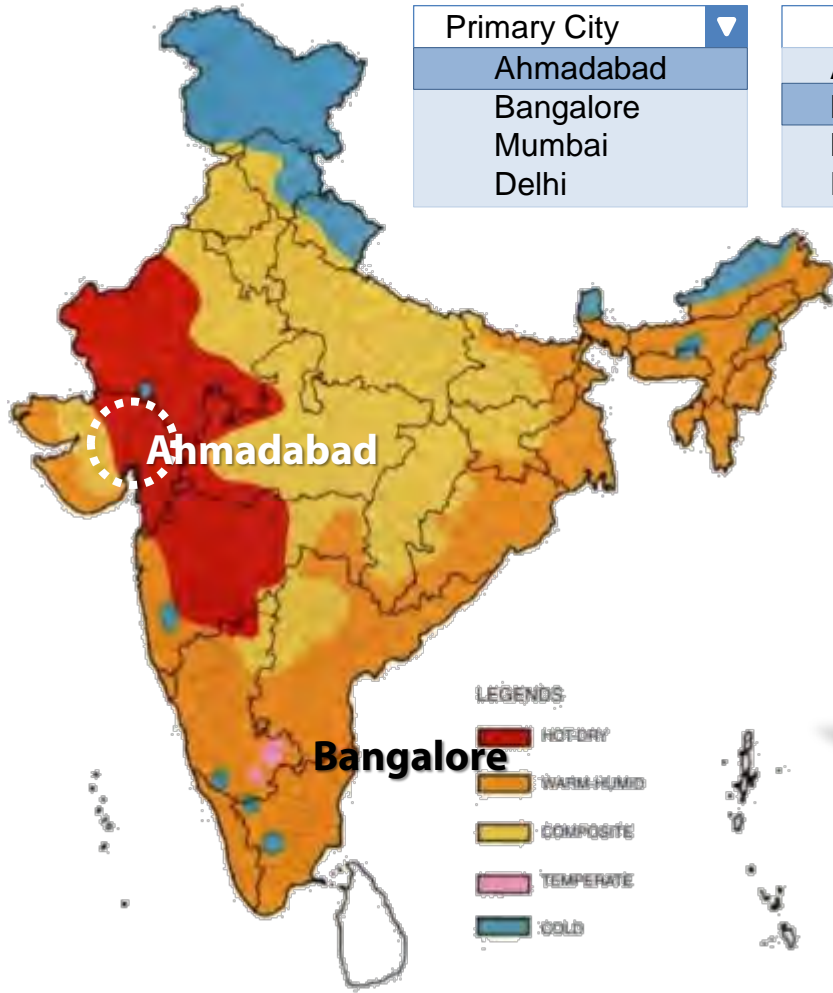


- Daylight Simulation
- Mirror Box
 - Cloudy Sky Simulation
- Single Patch Sky Simulator
 - Clear Sky Simulation

Climate Comparison

Primary City
Ahmadabad
Bangalore
Mumbai
Delhi

Secondary City
Ahmadabad
Bangalore
Mumbai
Delhi



NZEB Partners

- Antech Consultants
- Clanton & Associates
- Deep Electricals
- Gujarat Energy Development Agency, Govt of Gujarat
- Infinity Technologies
- Owens Corning
- Pankaj Dharkar Associates
- Pidilite Industries
- SGL Carbon
- Shashwat Cleantech
- The Weidt Group
- Tripur Builders
- US Agency for International Development ECOIII Project
- VMS Consultants
- Volpak Systems
- Yogi Engineers

Thank You

yash.shukla@cept.ac.in