NZEB at CEPT University: A Living Laboratory

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Adaptive Comfort and Retro commissioning

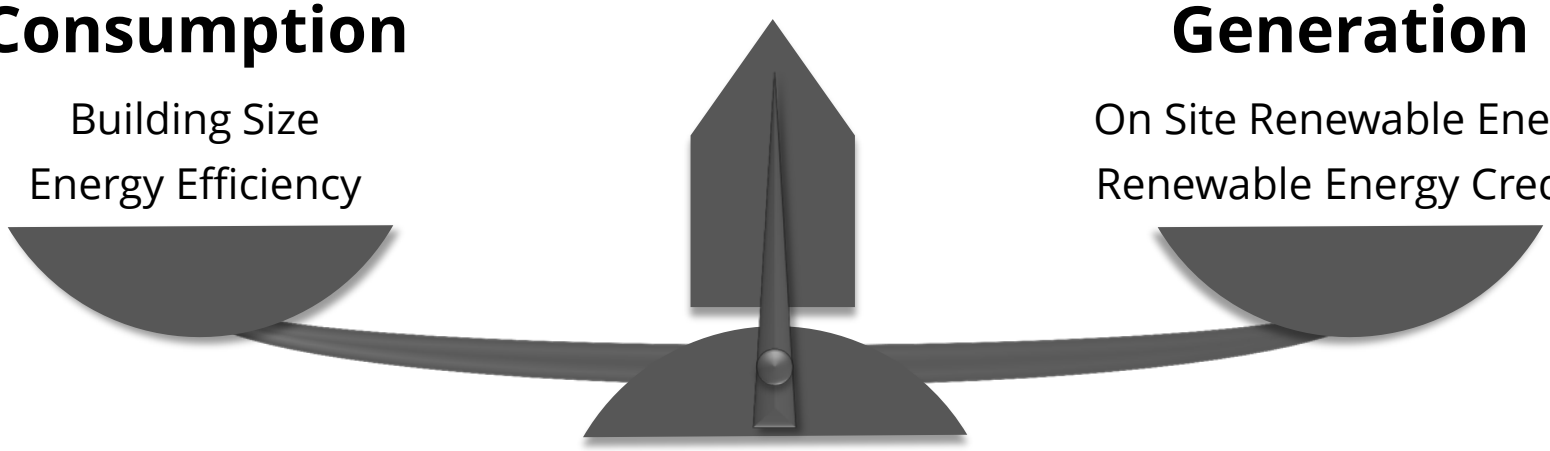
EDGE 2017, ASHRAE Region-at-large, Sub region II, 8th December 2017, Mumbai

What is a Net Zero Energy Building?

Consumption

Building Size

Energy Efficiency



Generation

On Site Renewable Energy

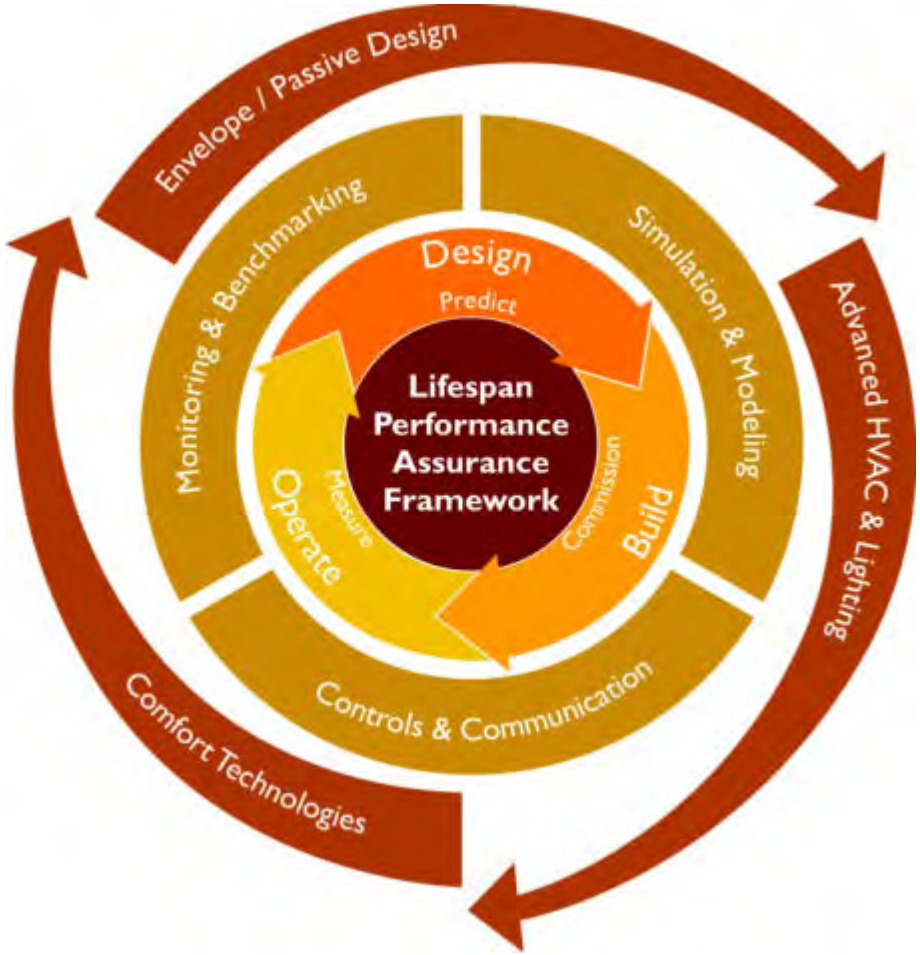
Renewable Energy Credits

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

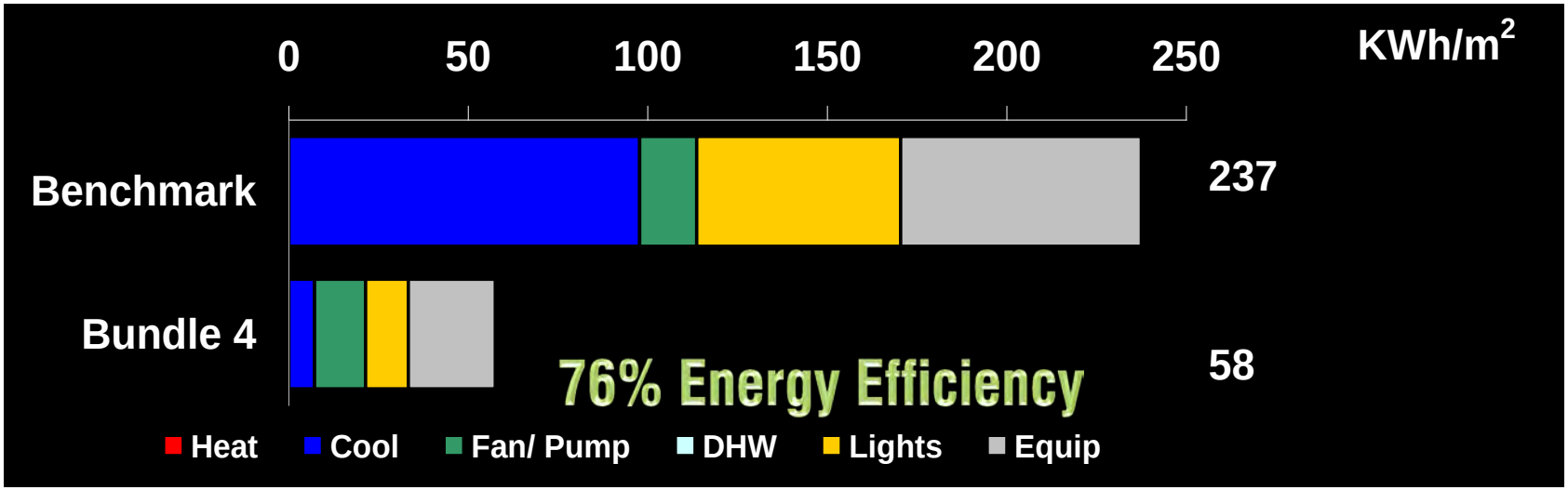
- Predesign
- Conceptual Design
- System Development
- Systems Optimization

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

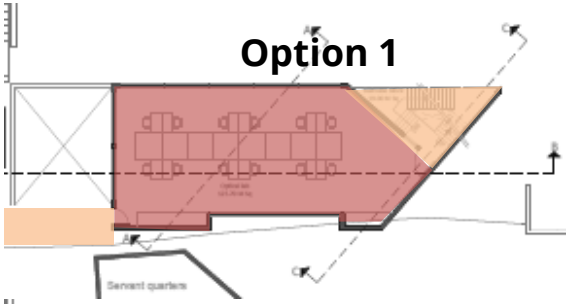
Predesign Goals

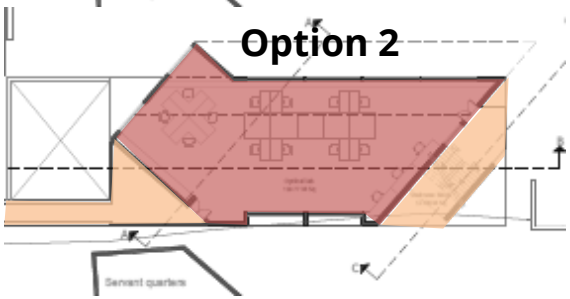
Pre-design energy simulations of a benchmark building

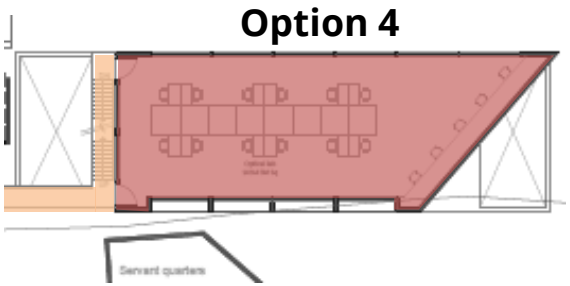
Investigated 80 energy conservation measures (ECMs) in the Ahmedabad climate

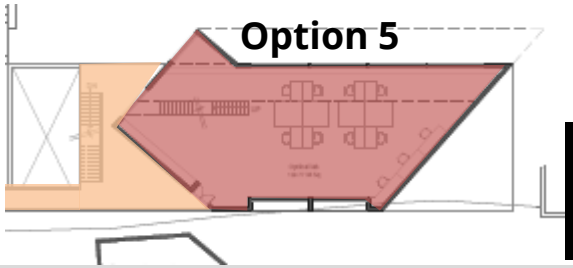


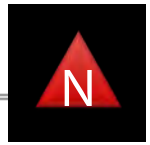
Building Massing Analysis





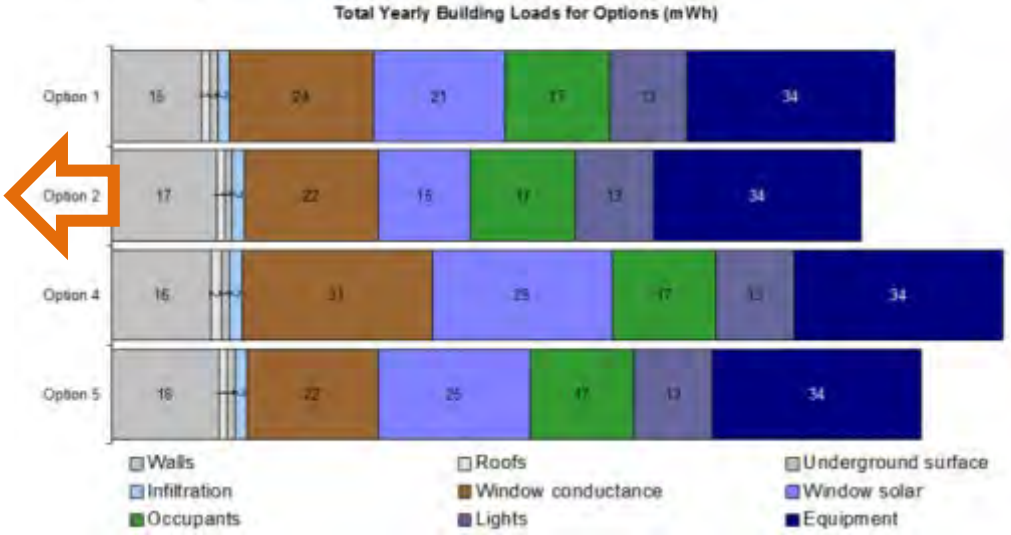






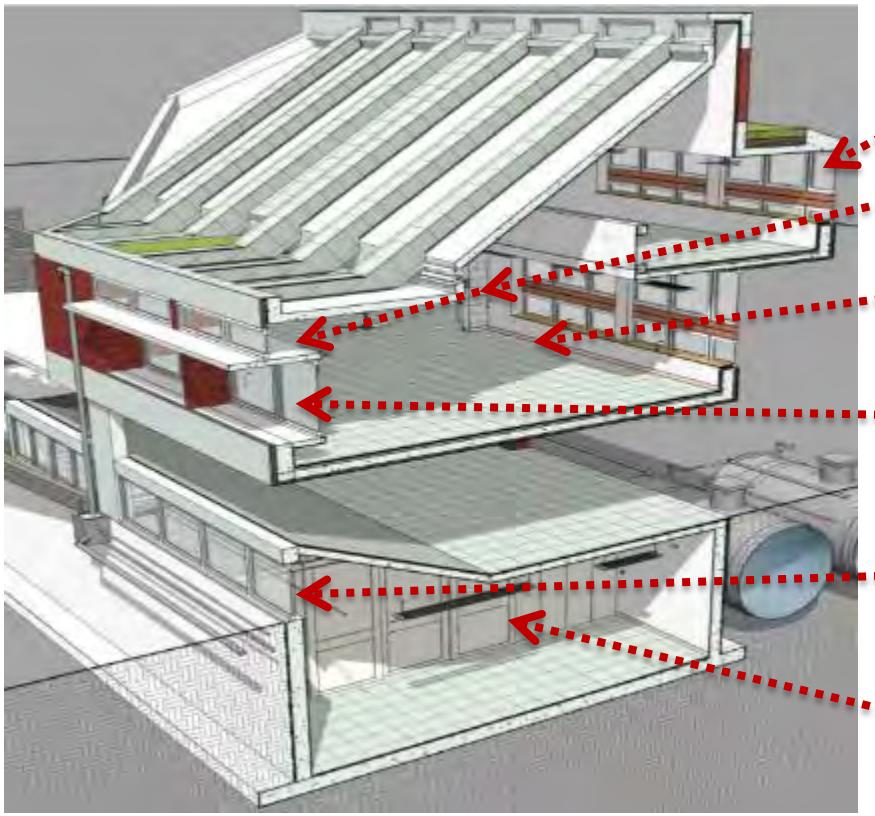
Building Cooling Loads

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

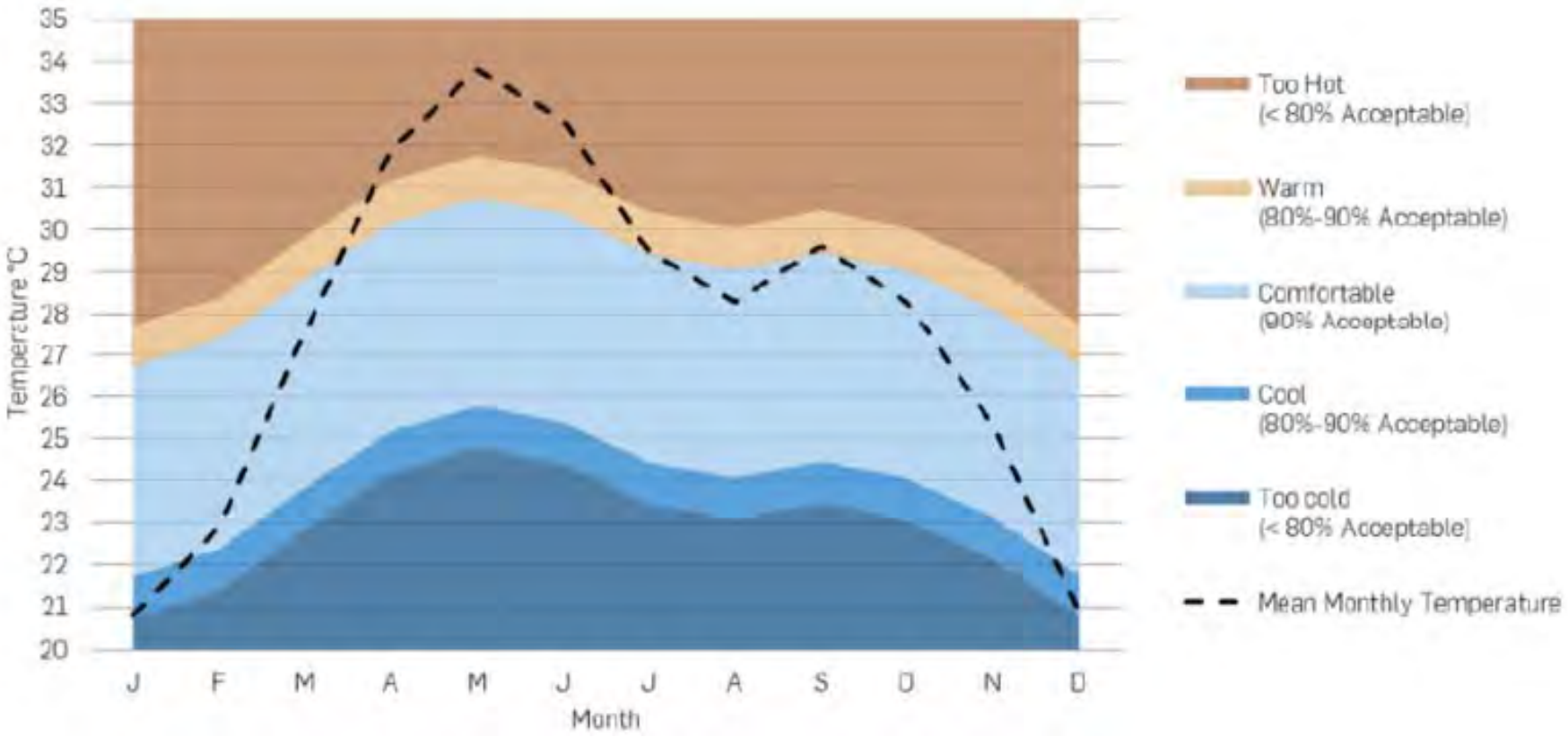
Interior wall finishes

Sizing of South Vision Windows

Sizing Basement Light Monitor

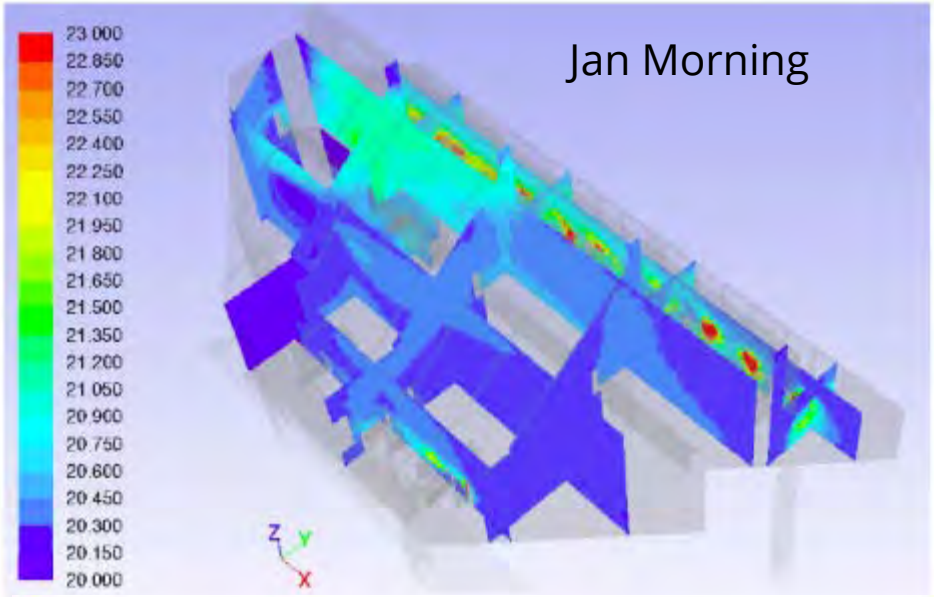
Sizing of Basement Courtyard Windows

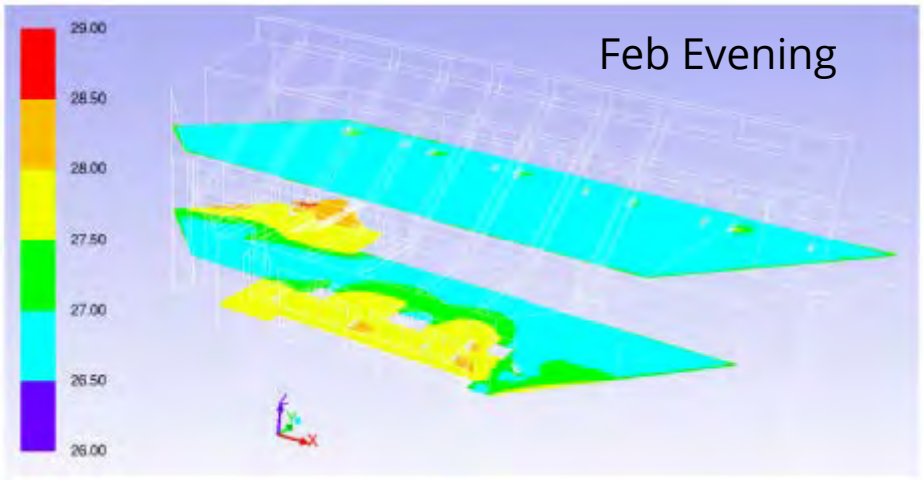
Adaptive Thermal Comfort



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

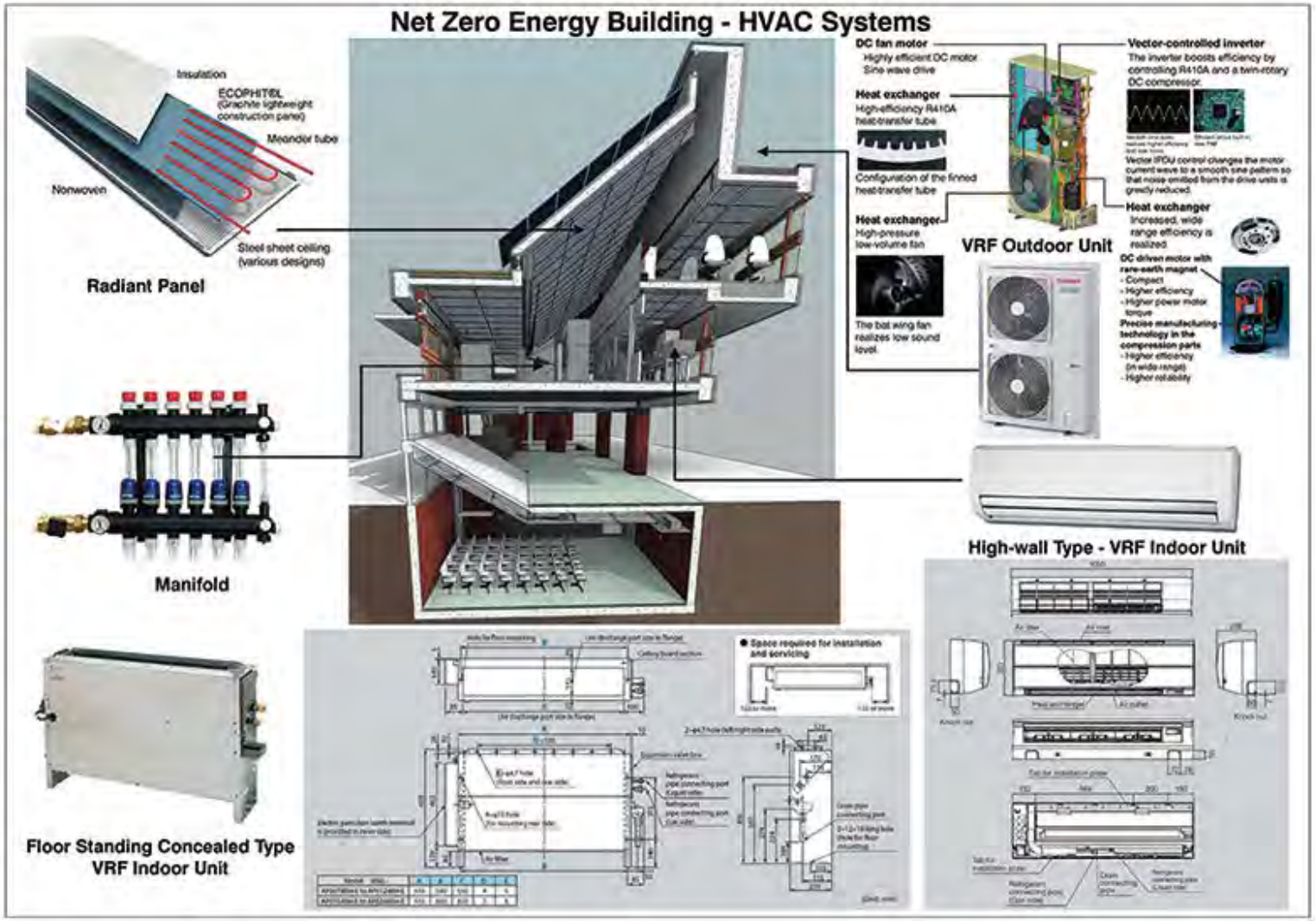
Comfortable Outdoor Environment

Hot Outdoor Environment

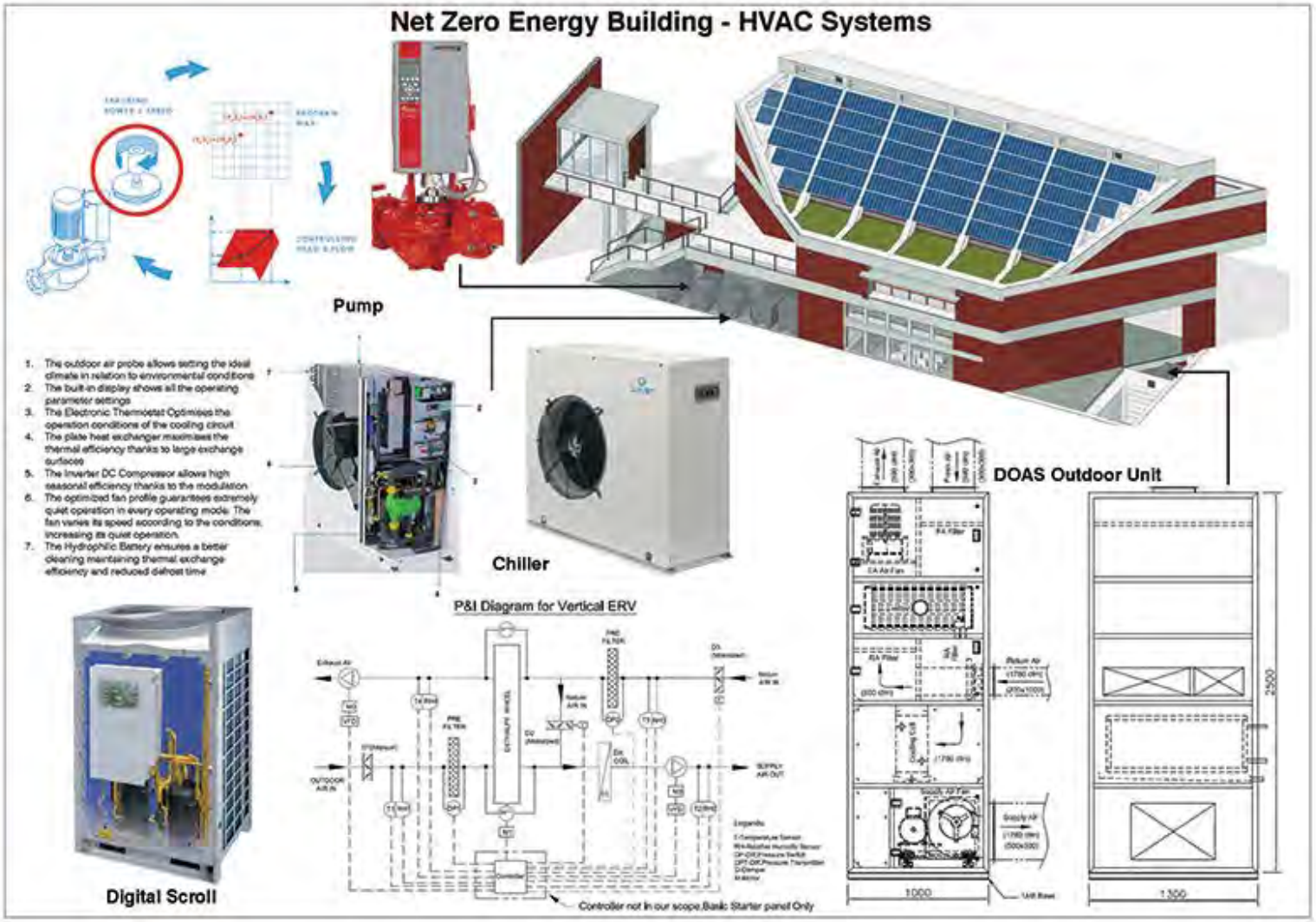
HVAC Systems

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

HVAC Systems

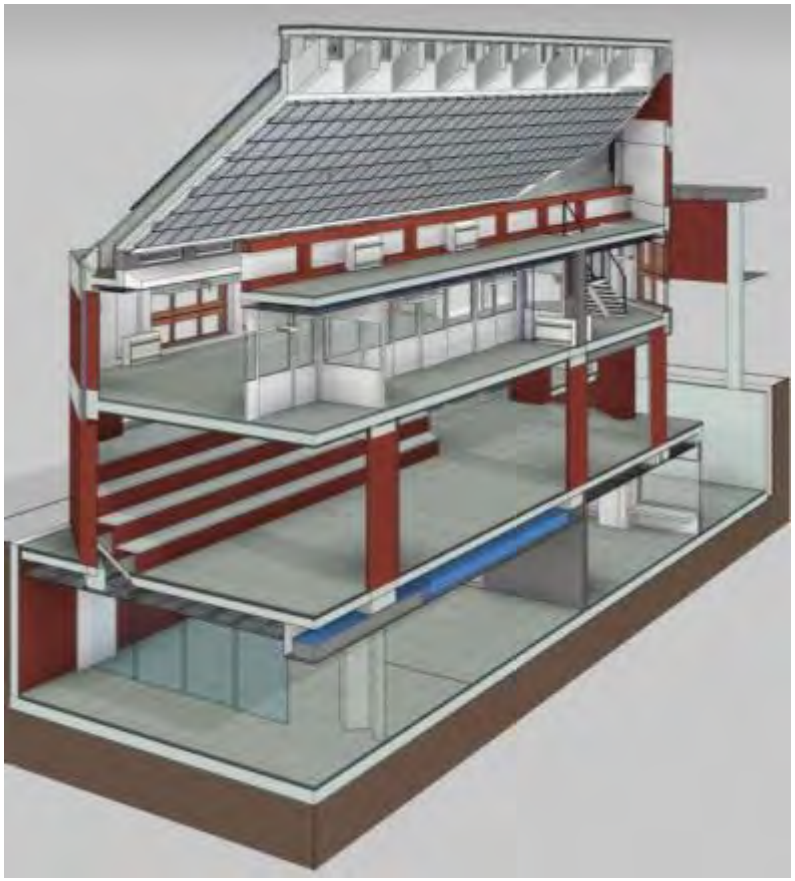


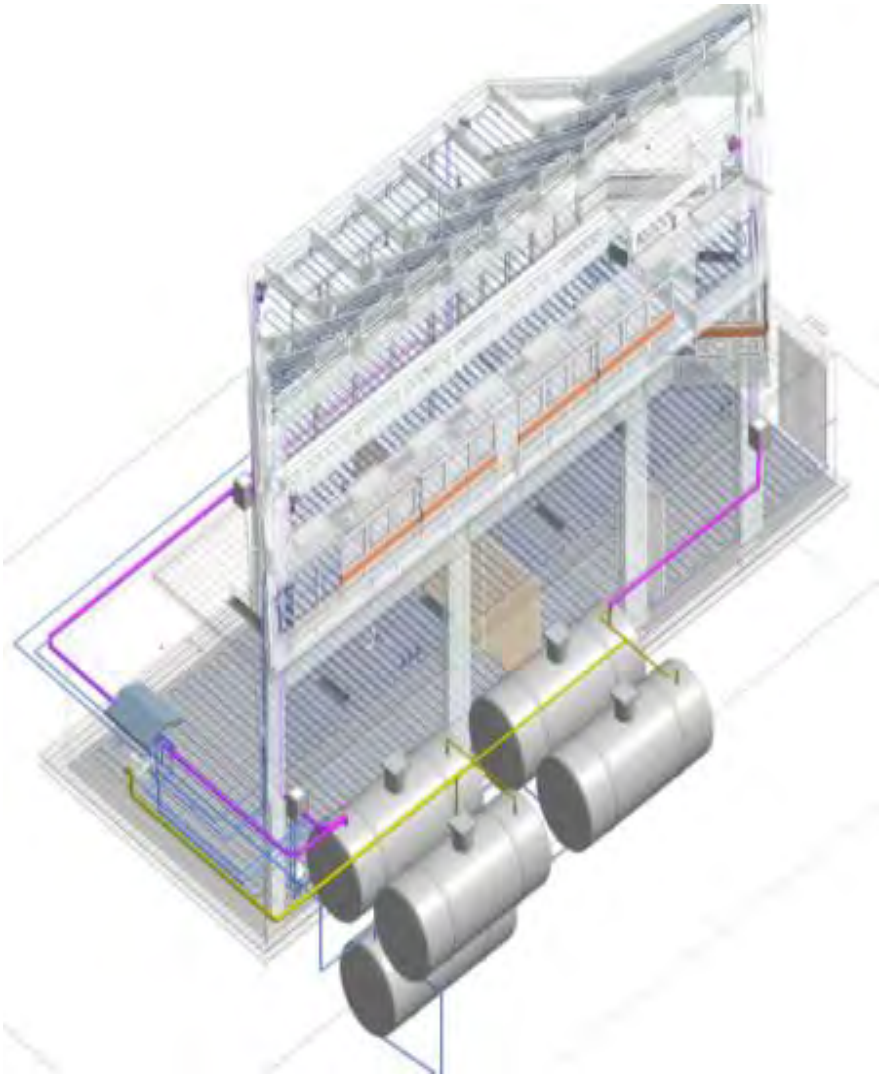
HVAC Systems



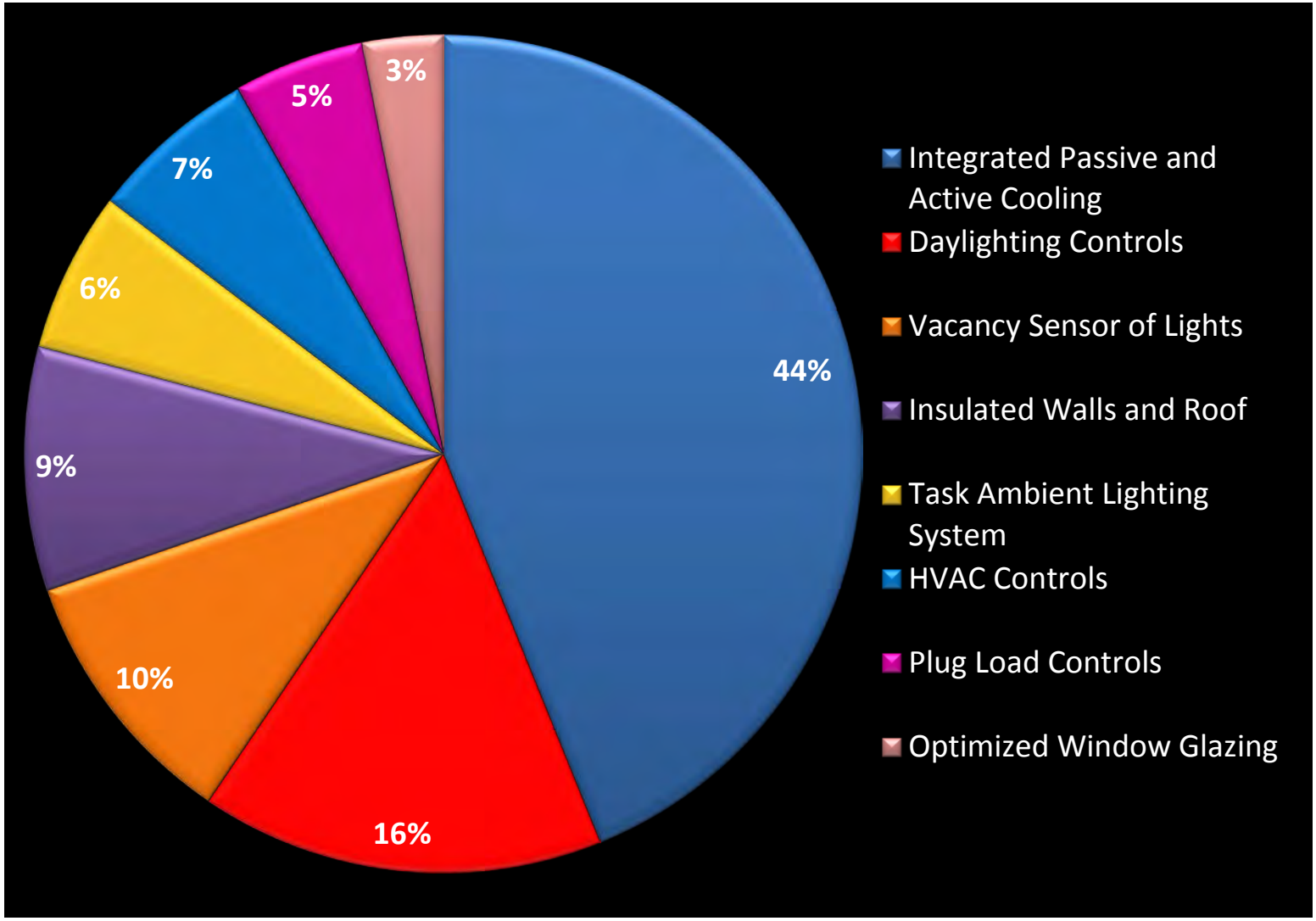
Building Integrated PV

BIM System Integration

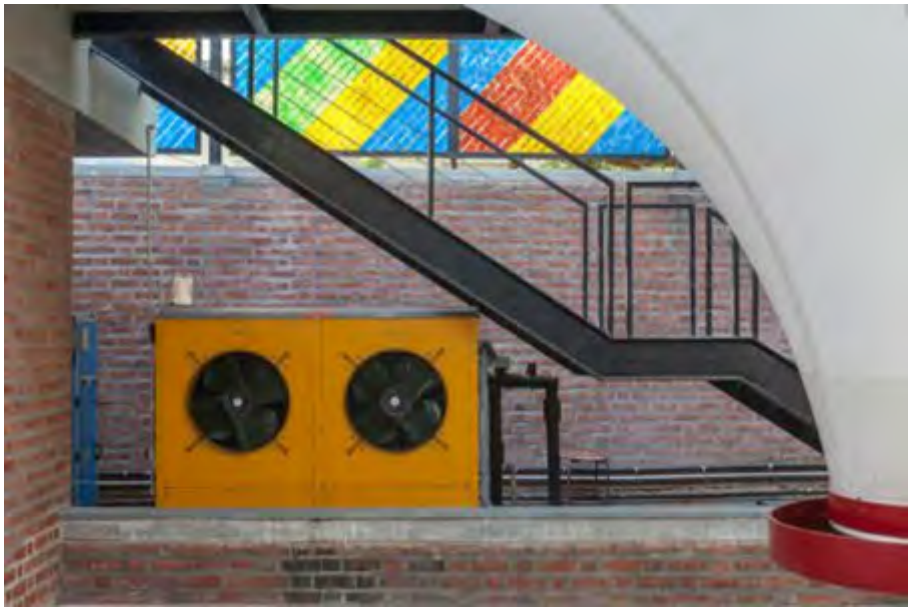




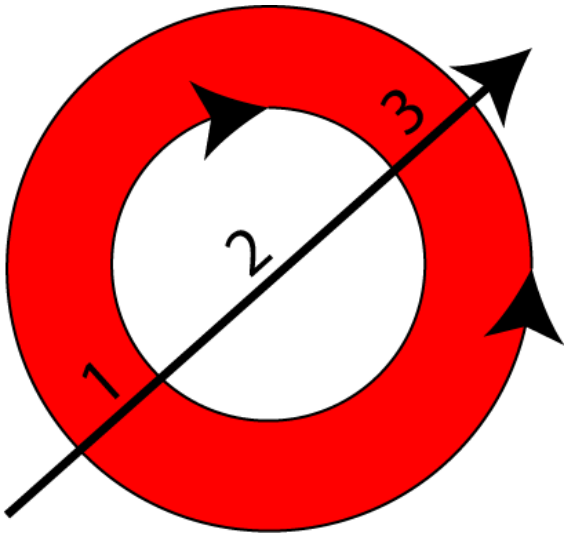
Savings by Measure Type



Building External Views



Building Internal Views



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

-Marty Rubin

Monitoring and Control - NZEB

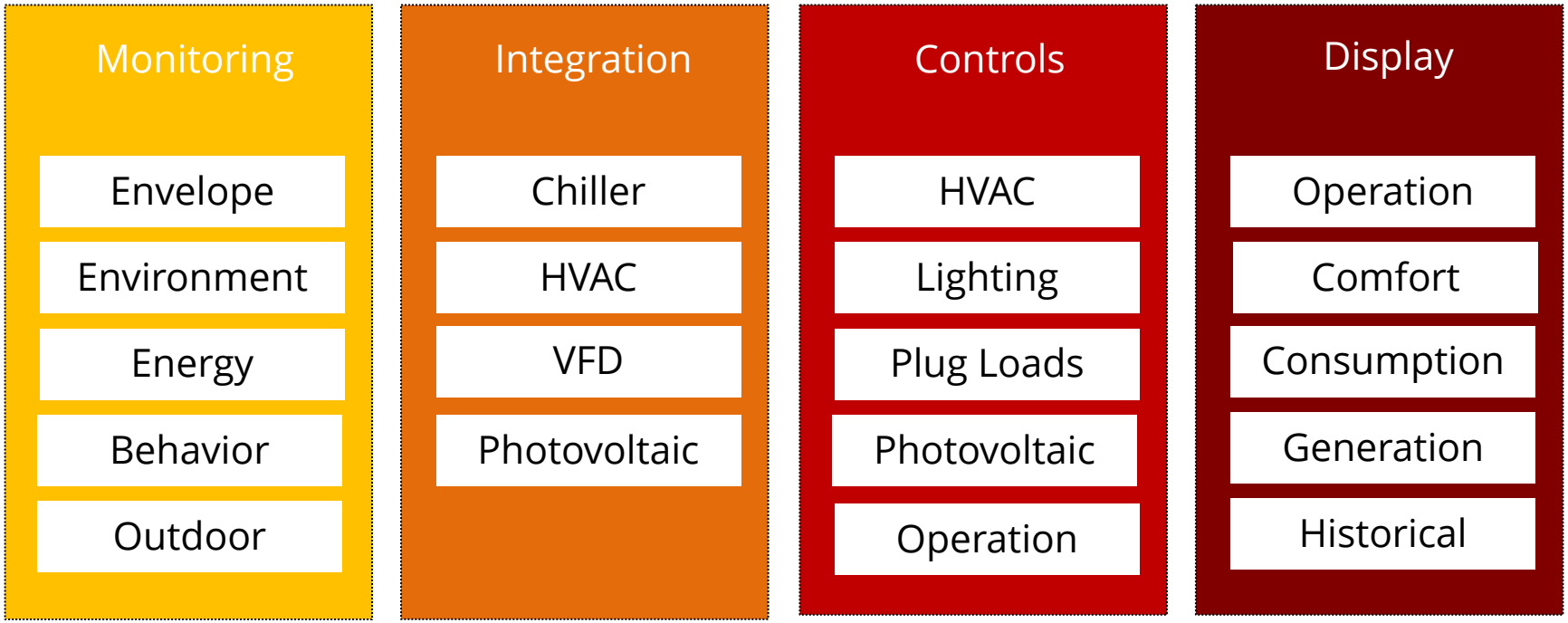
Building Information Systems

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

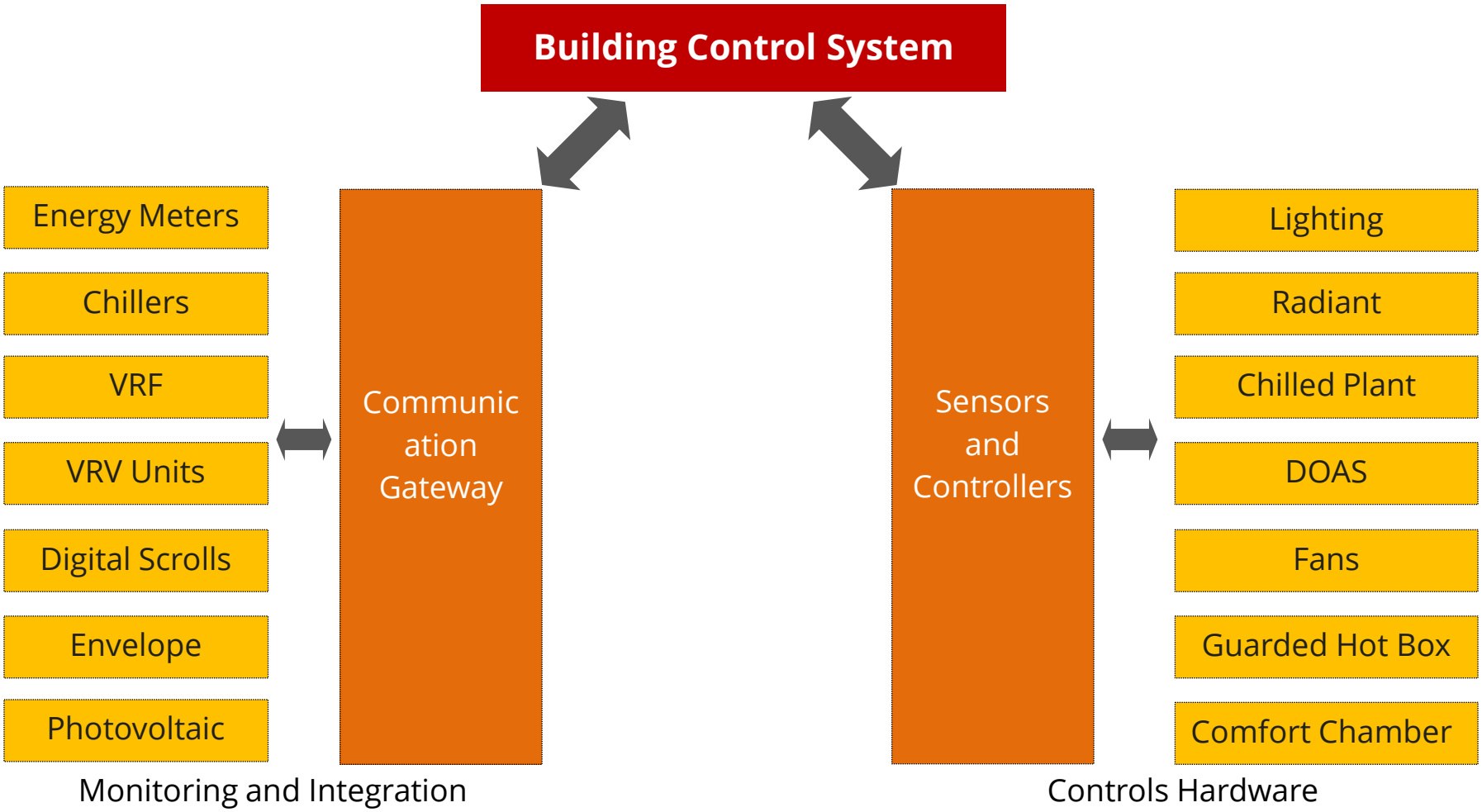
Building Management Systems

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

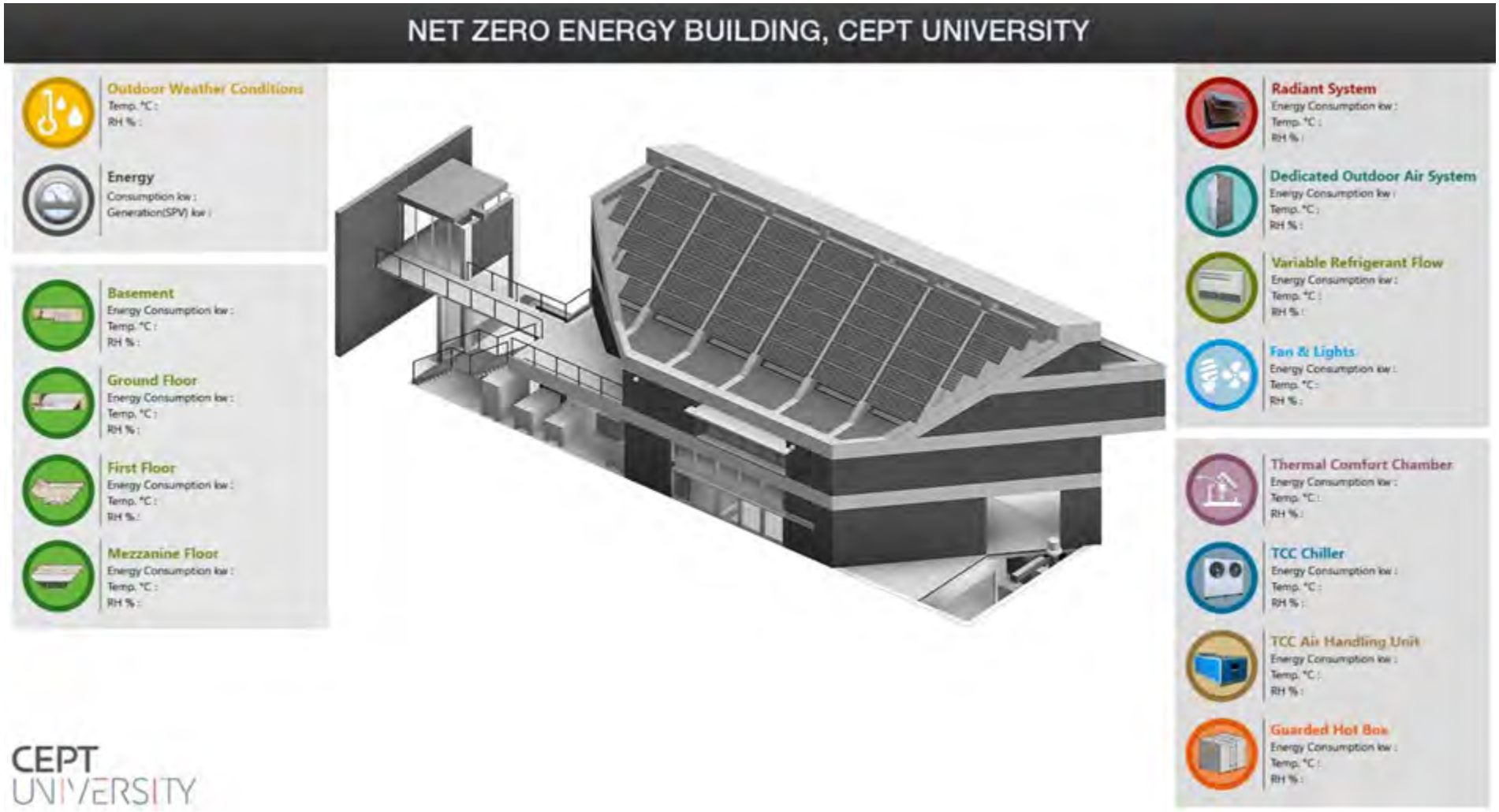
Monitoring and control system



Details of Monitoring, Integration and Controls Philosophy

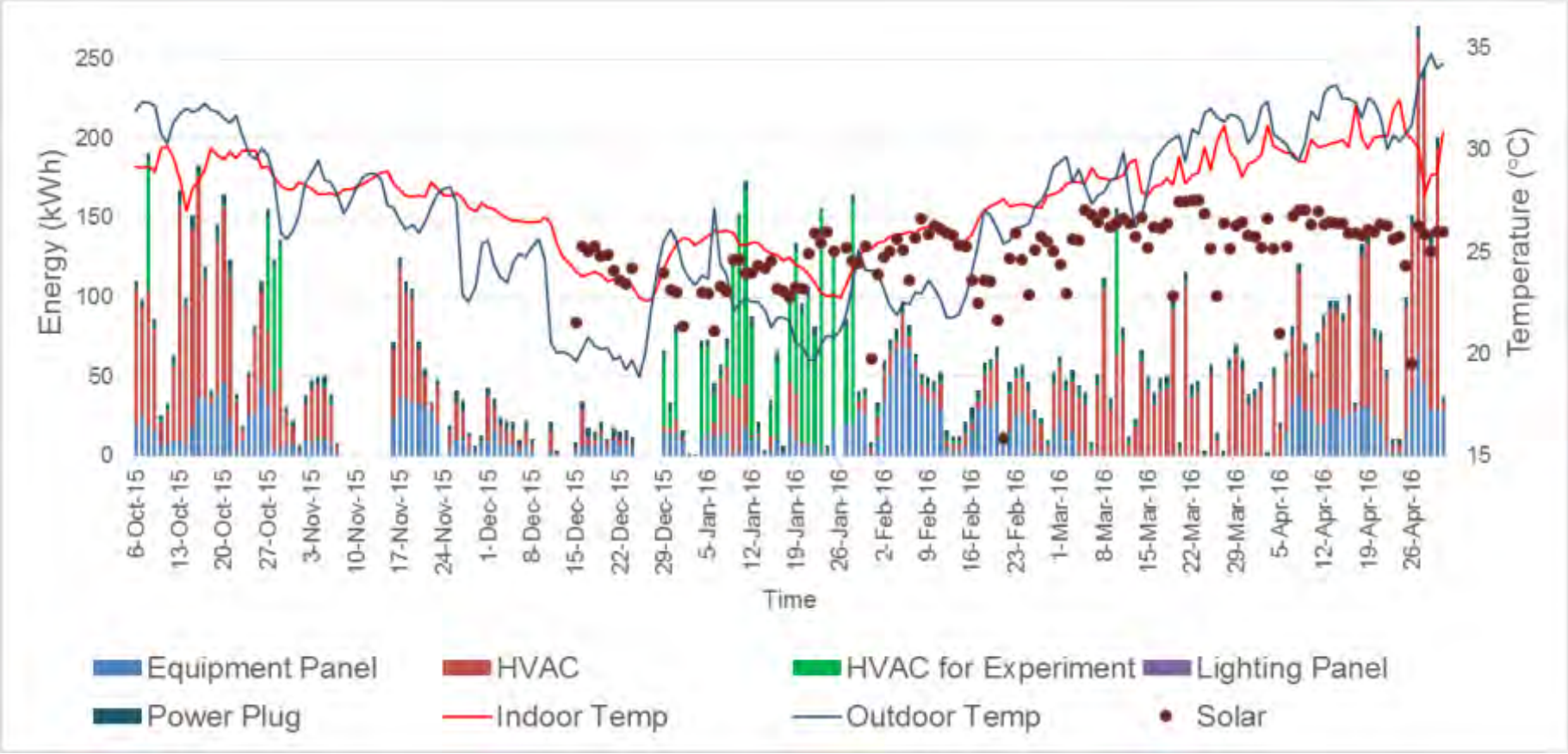


Building Energy Monitoring System

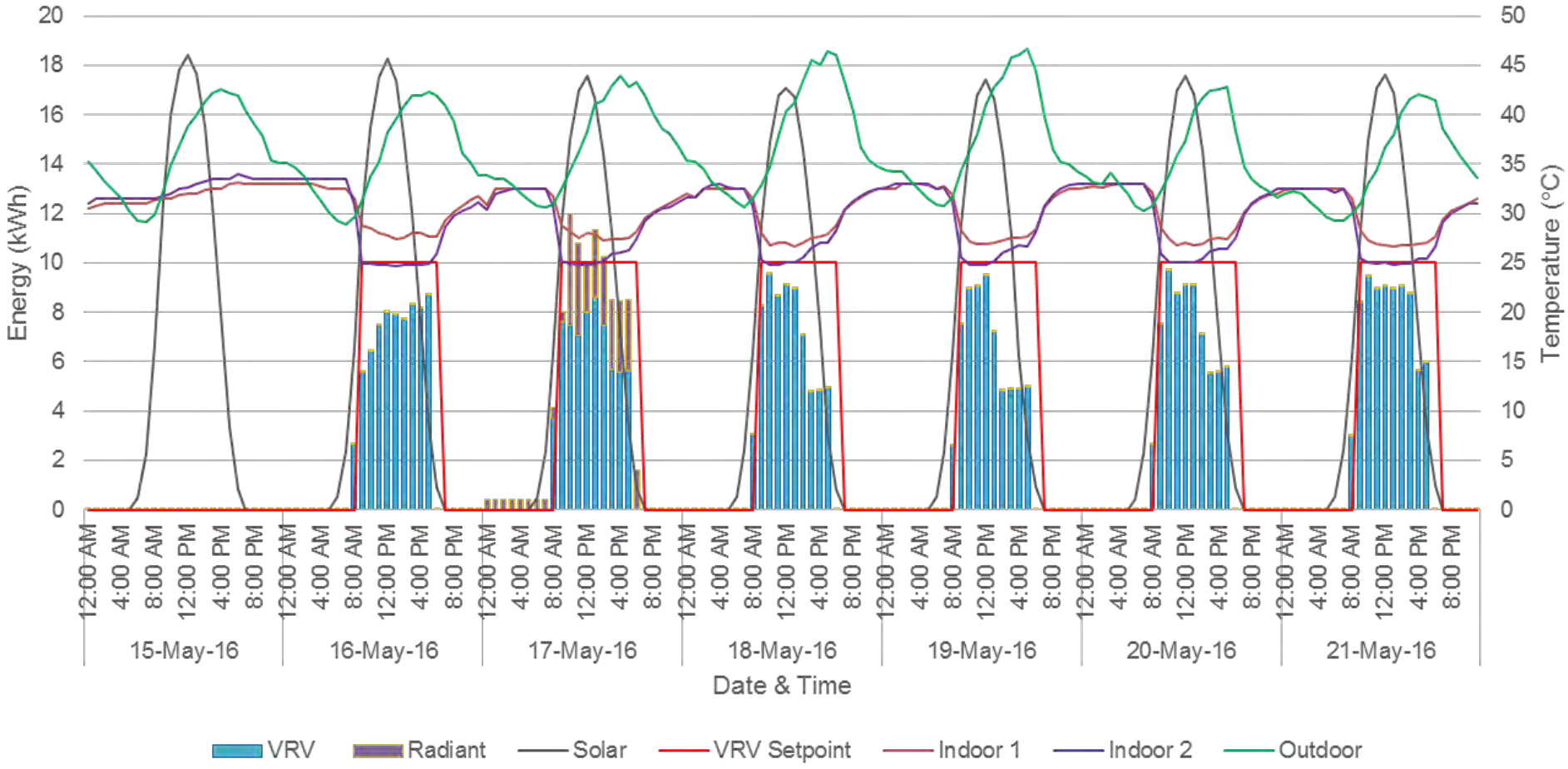


Building Energy Monitoring System

Environment and Energy

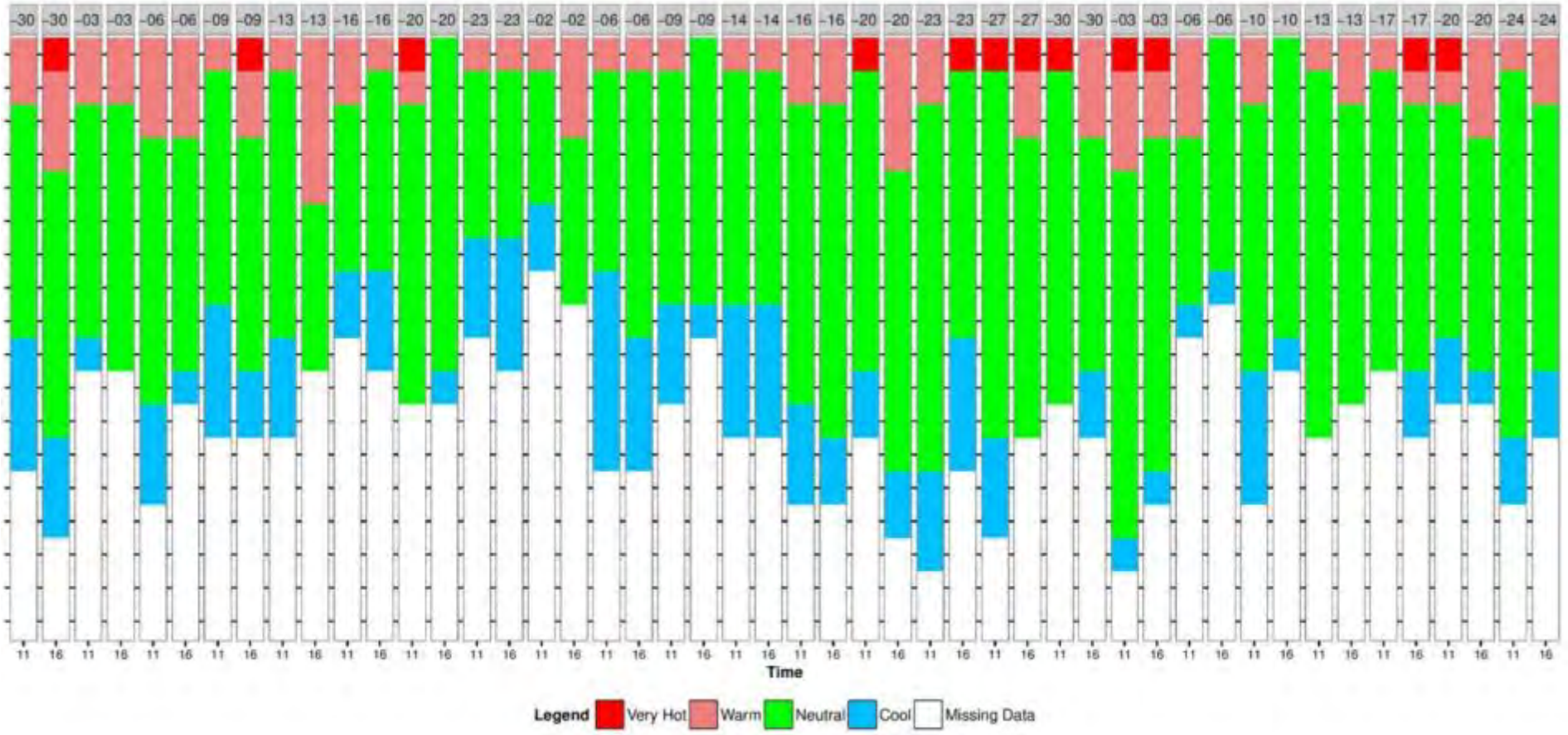


Environment and Energy



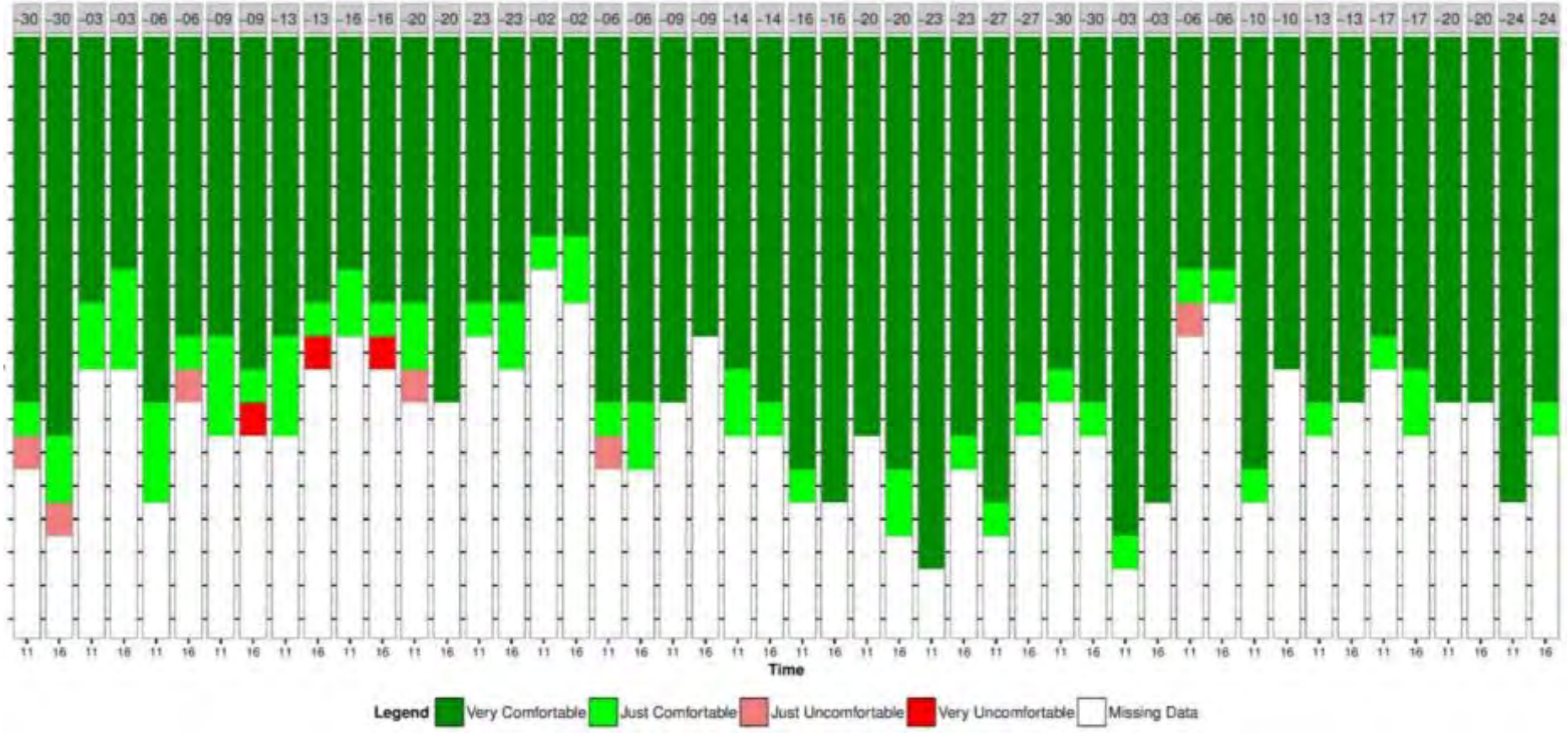
Thermal Comfort Surveys and Occupant Feedback

How do you describe your current thermal sensation?

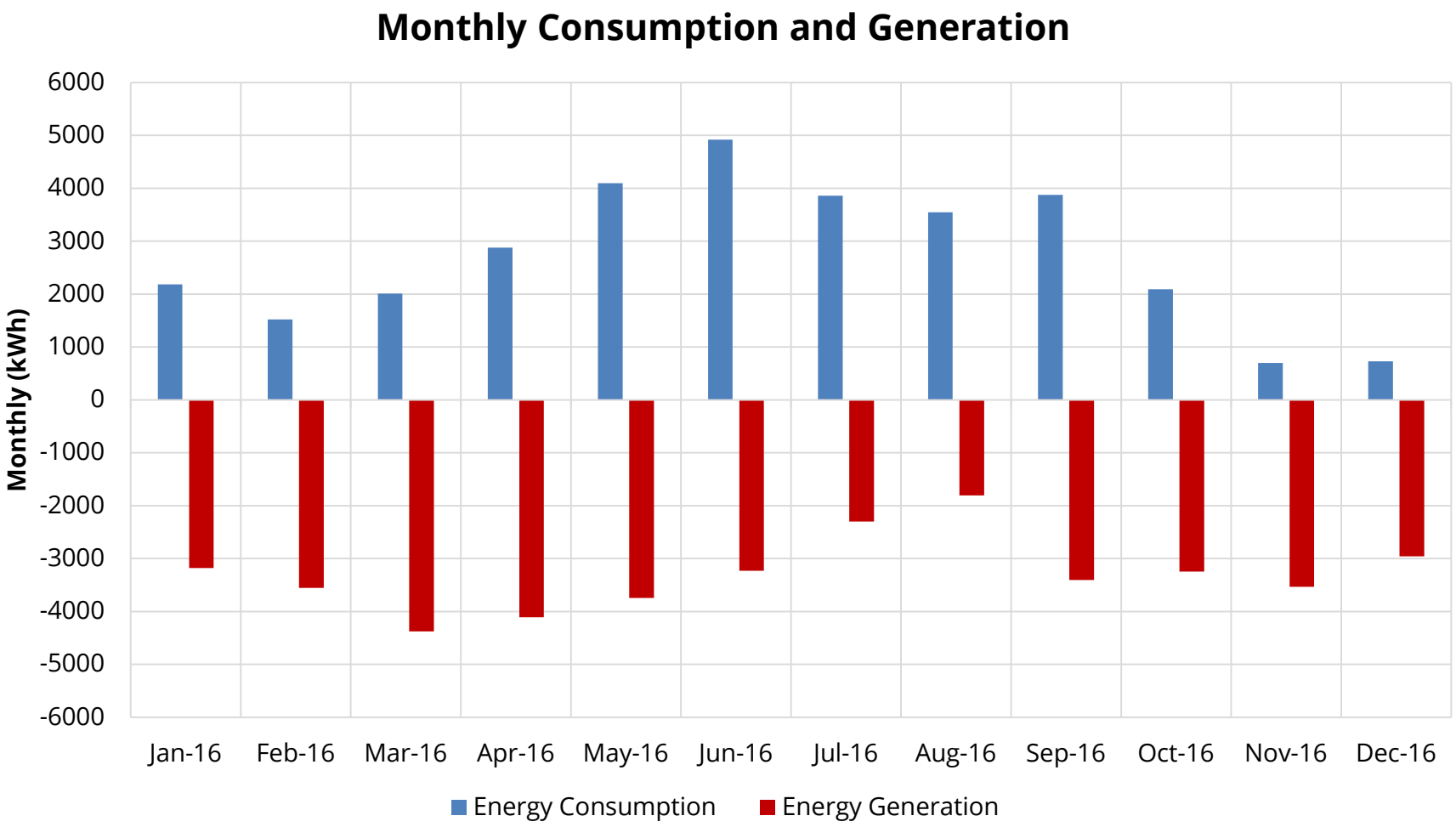


Thermal Comfort Surveys and Occupant Feedback

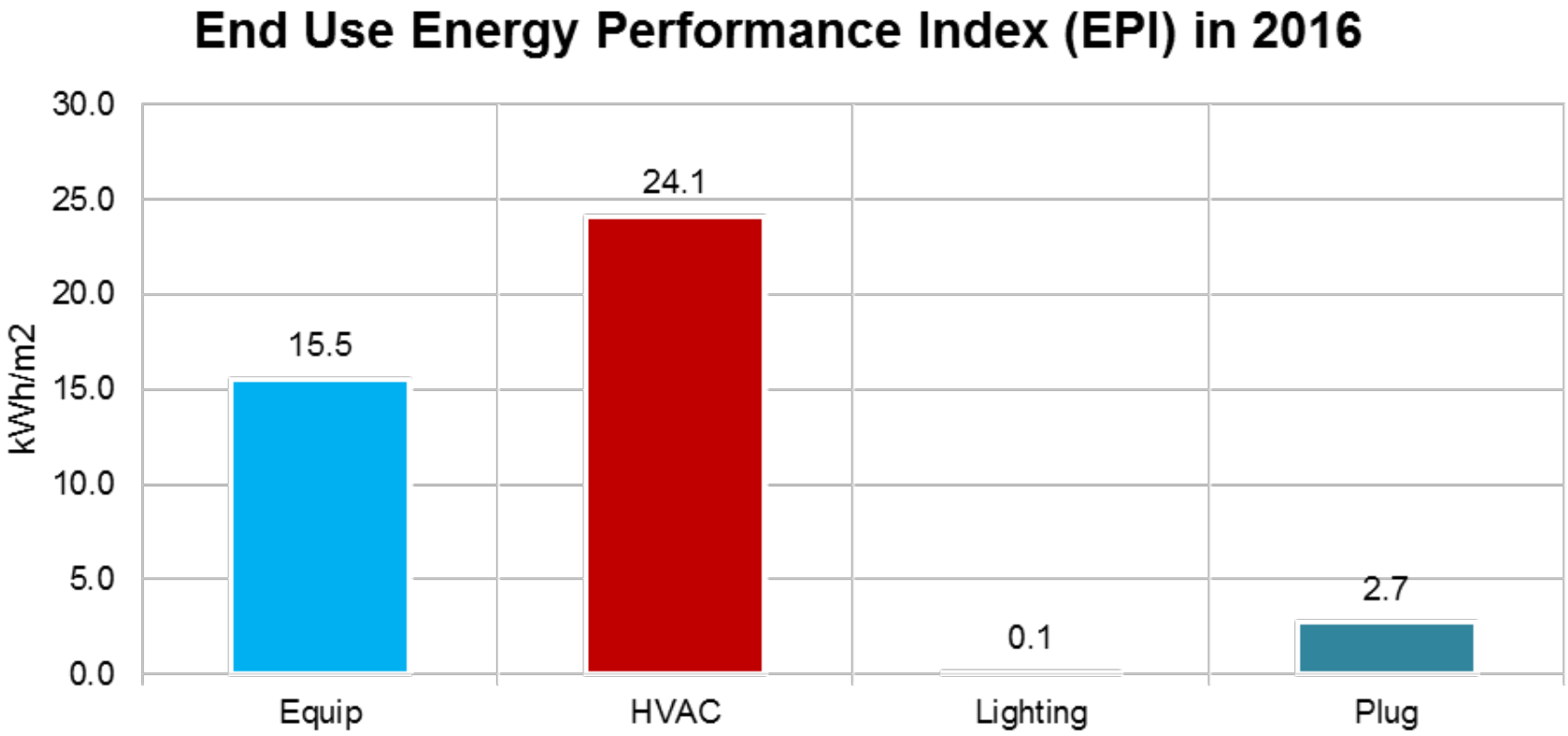
Are you comfortable?



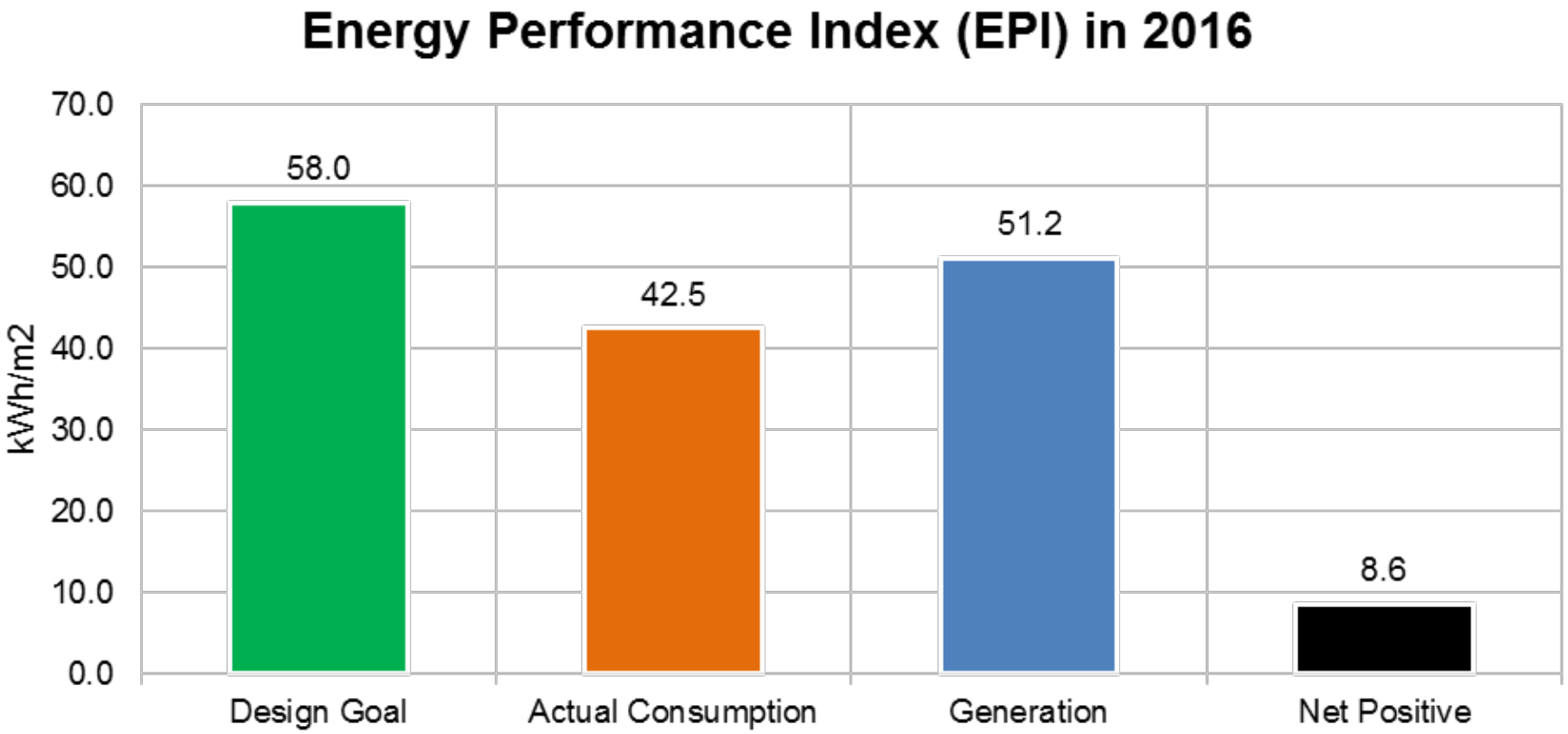
Energy Consumption Summary



End Use Energy Consumption



Comparison with Design Goals



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

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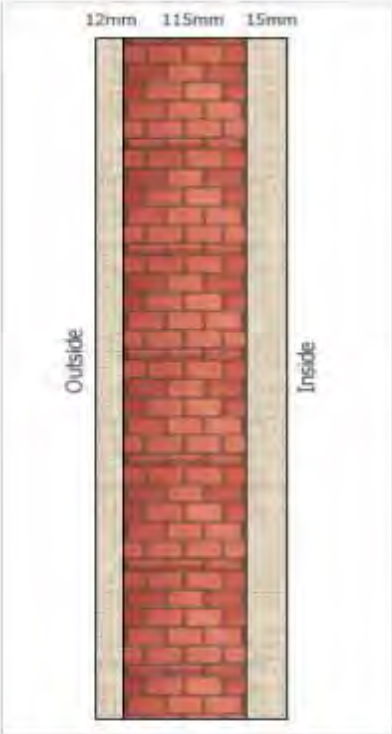
Wall and Roof Assembly U-value Calculator



Location : State : City :

Assembly Type :

Select no. of layers :

Select Material : Thickness : Outside

Thickness :

Thickness : Inside

Calculate | Save my assembly

Thermal Properties

	Material Name	Conductivity (W/m-k)	Specific heat (J/kg-k)	Density (kg/m³)	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/m²-k)	Surface to Surface U-value (w/m²-k)	Overall U-value	Calculation Method	Internal Heat Transfer Coefficient (w/m²-k)	External Heat Transfer Coefficient (w/m²-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

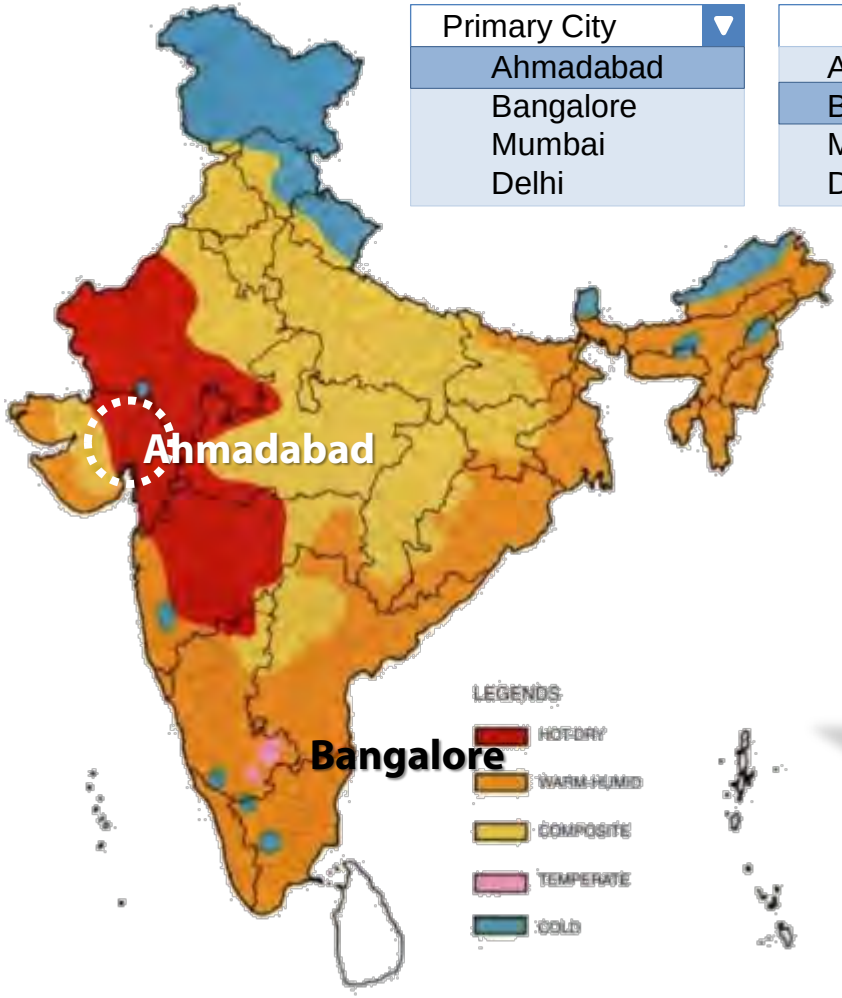
SPSS and Mirror Box

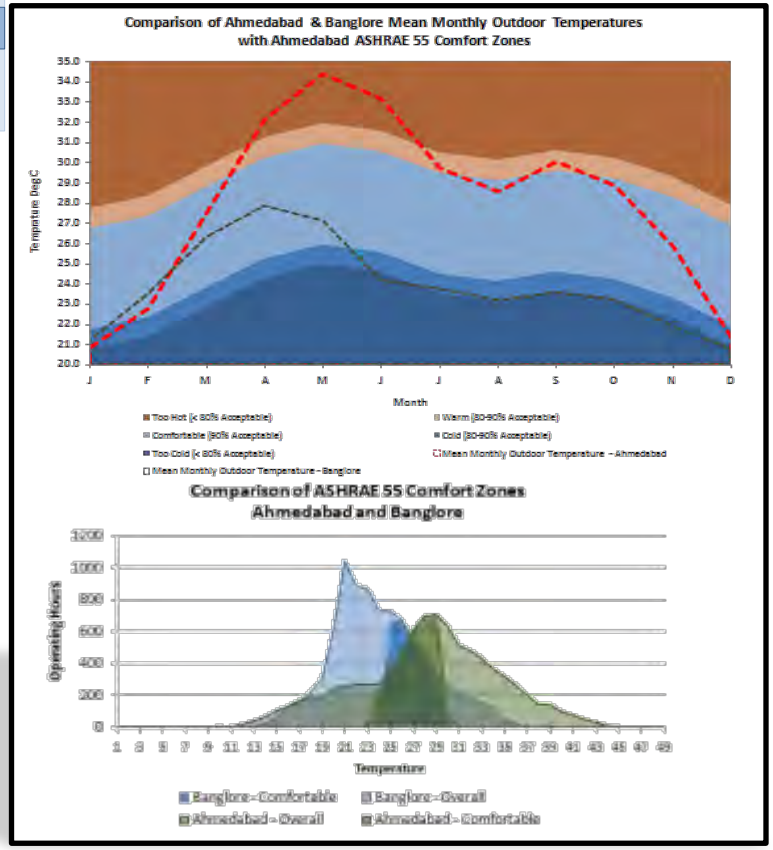
- Daylight Simulation
- Mirror Box
  - Cloudy Sky Simulation
- Single Patch Sky Simulator
  - Clear Sky Simulation

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

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