प्रधान मंत्री आवास योजना
Pradhan Mantri Awaas Yojana

GLOBAL HOUSING TECHNOLOGY CHALLENGE INDIA

Ministry of Housing and Urban Affairs
Government of India

Azadi Ka Amrit Mahotsav

bmtpc

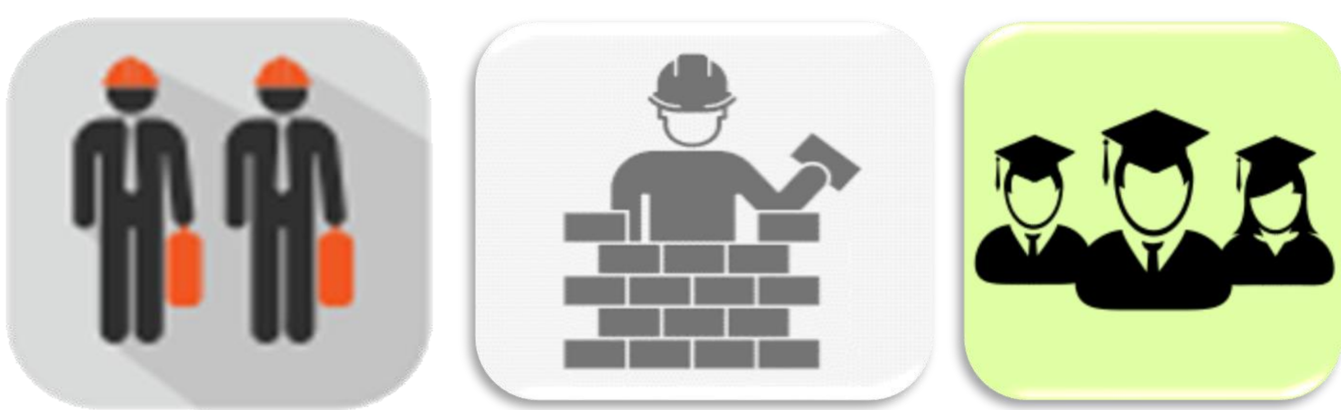
giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Climate Smart Buildings (CSB)

Cluster cell Indore, Madhya Pradesh under Global Housing Technology Challenge - India (GHTC-India)

THERMAL COMFORT IN AFFORDABLE HOUSING

Training B



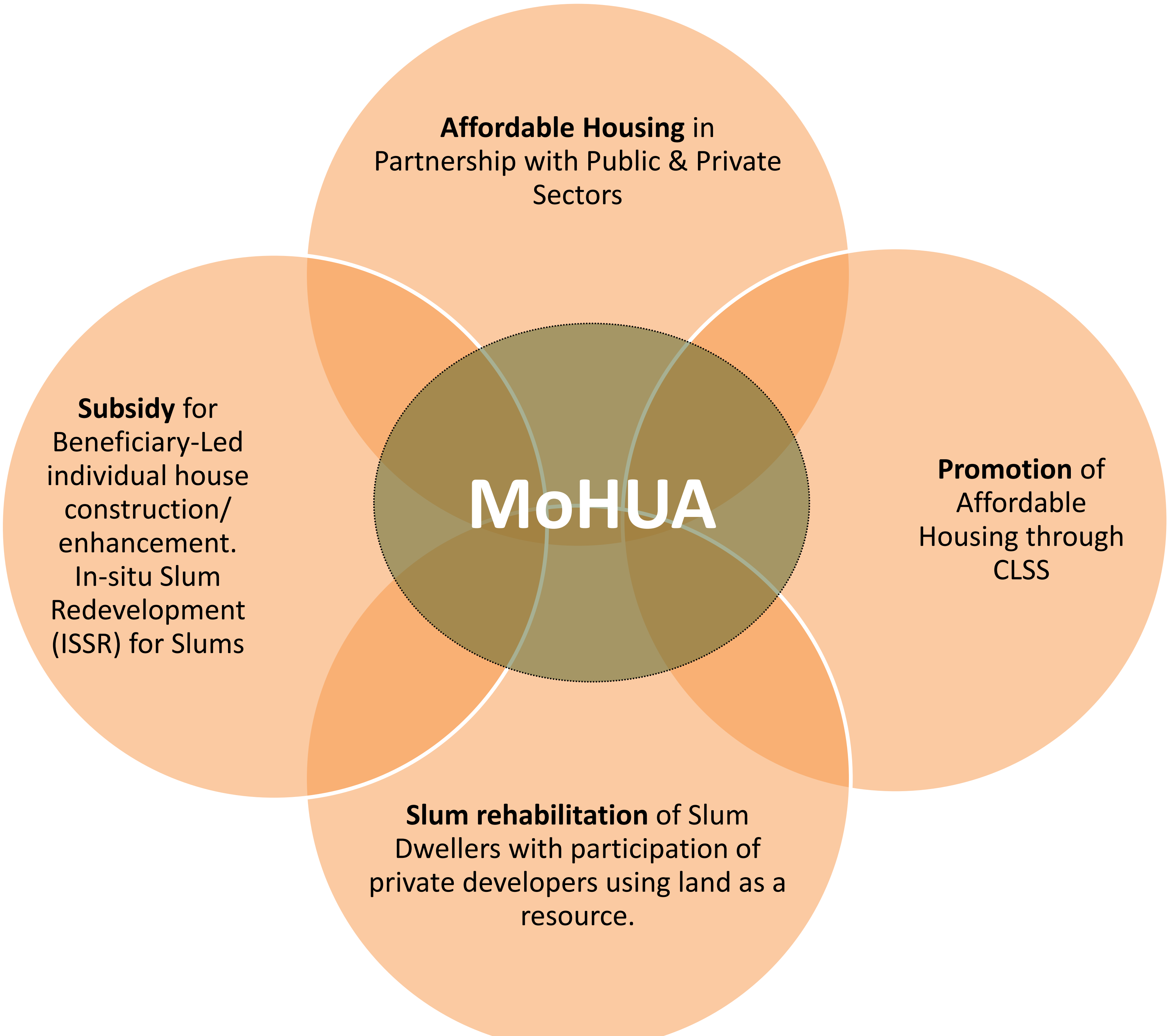
DAY 1

INTRODUCTION - MoHUA

'Housing for All' by 2022.

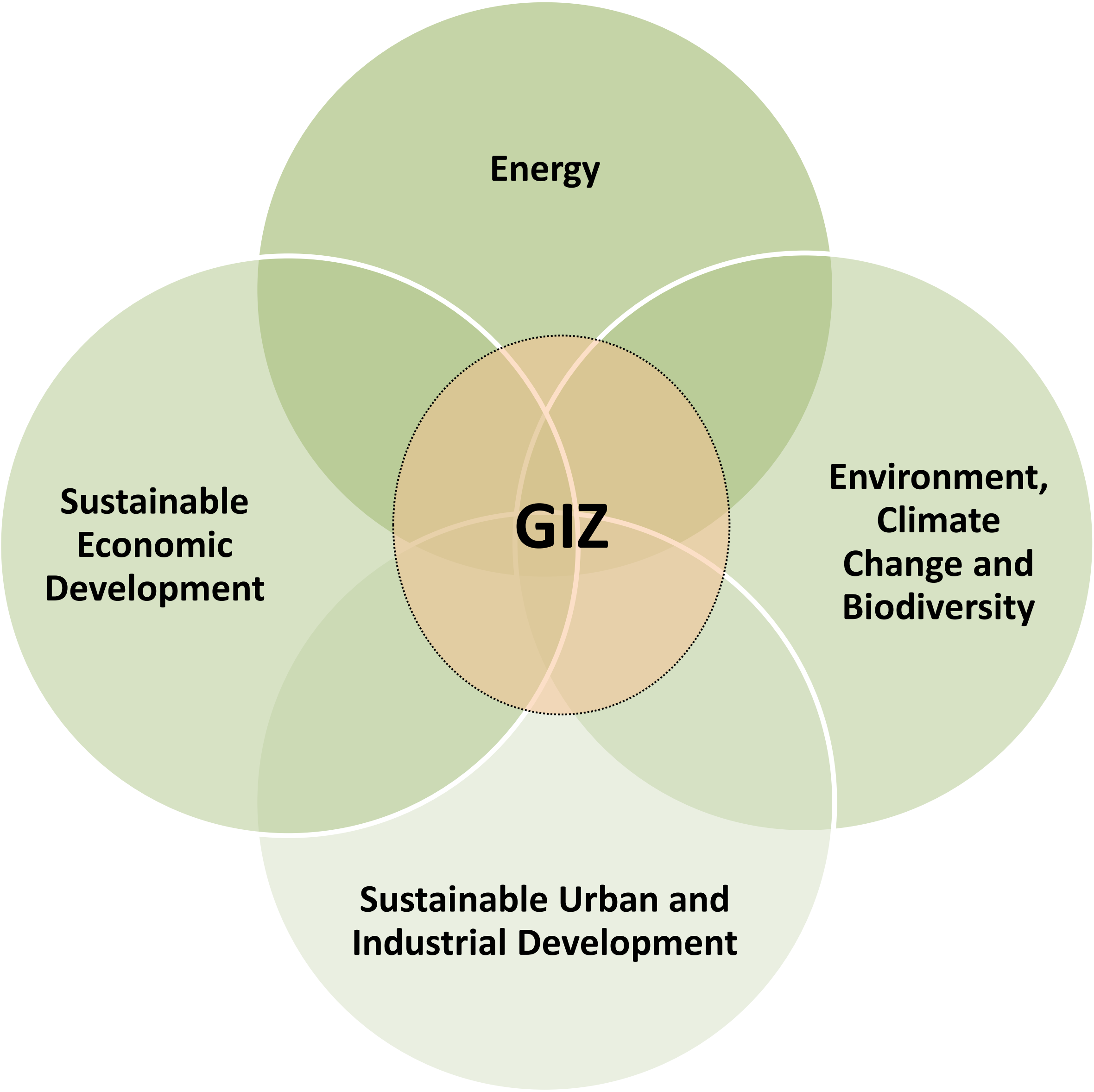
Under the Mission, Ministry of Housing and Urban Affairs (MoHUA), provides Central Assistance to implementing agencies through States and Union Territories for providing houses to all eligible families/beneficiaries by 2022.

Addressing the affordable housing requirement in urban areas through:



INTRODUCTION - GIZ

- GIZ is an international cooperation enterprise for sustainable development which operates worldwide, on a public benefit basis.
- GIZ is fully owned by the German Federal Government, GIZ implement development programs in partner country on behalf of the German Government in achieving its development policy objectives.
- For over **60 years**, the GIZ has been working jointly with partners in India for **sustainable economic, ecological, and social development.**



TASKS PLANNED WITH MoHUA

The Climate Smart Buildings (CSB) programme is aligned with the commitments made by the Indian Government to meet its objectives submitted under SDG 11.

IGEN's programme, Climate Smart Buildings (CSB) proposes to extend technical assistance and cooperation for the following:

- Technical assistance in developing thermal comfort action plan for climate resilience building for mass scale application in selected states for Affordable Housing
- Technical support in implementation of Global Housing Technology Challenge-India (GHTC-India)

CLIMATE SMART BUILDING

Map showing states under central cluster cell

States and UT's under central cluster cell established at Indore

- Madhya Pradesh
- Maharashtra
- Goa
- Telangana
- Chhattisgarh

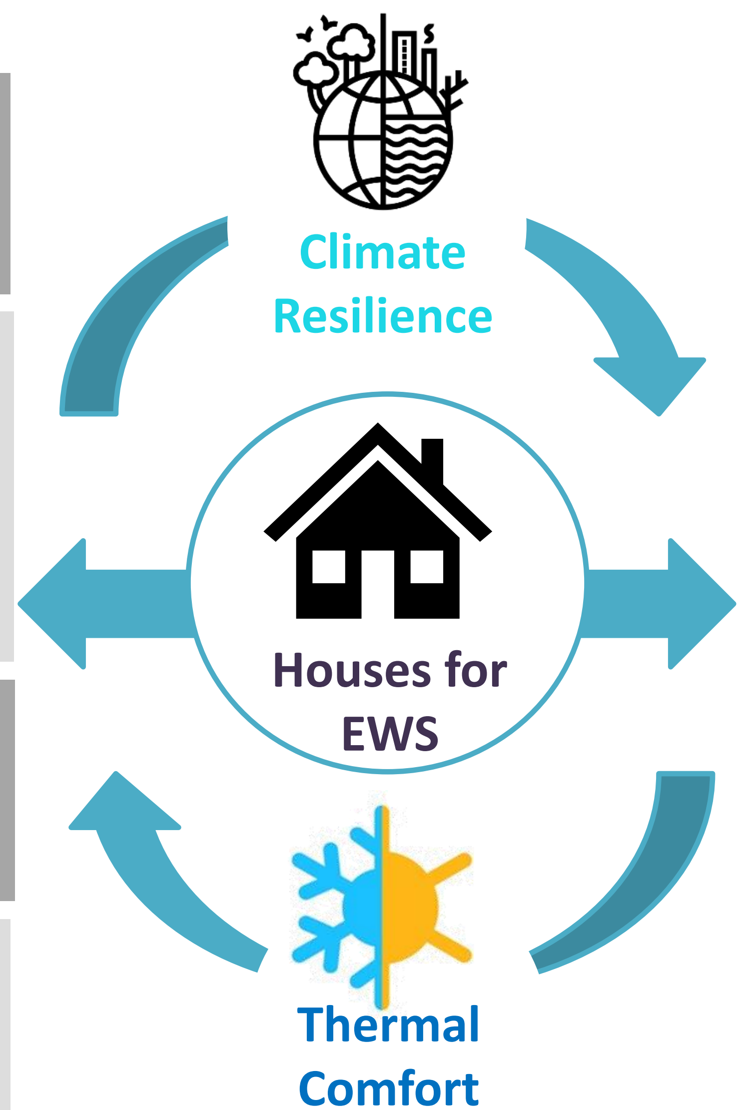
AIM & CONCEPT

7 AFFORDABLE AND CLEAN ENERGY
Ensure access to affordable, reliable, sustainable, and modern energy for all

9.INDUSTRY, INNOVATION AND INFRASTRUCTURE
Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation

11.SUSTAINABLE CITIES AND COMMUNITIES
Make cities and human settlements inclusive, safe, resilient, and sustainable

13. PROTECT THE PLANET
Take urgent action to combat climate change and its impacts



DESIGN
↓
CONSTRUCTION
↓
POST OCCUPANCY (O & M)

INTEGRATION IN BY-LAWS

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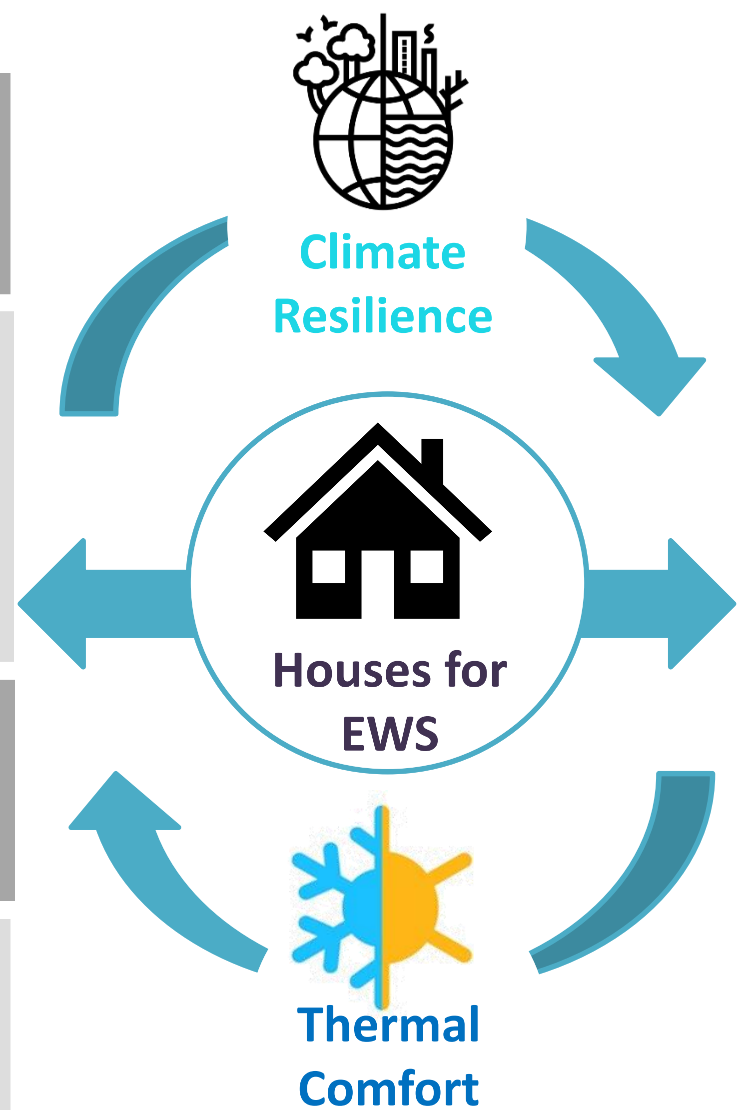

DESIGN

↓

CONSTRUCTION

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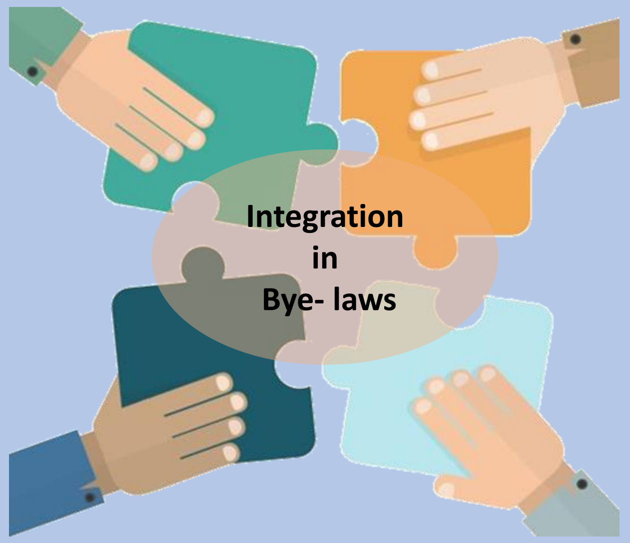
POST OCCUPANCY (O & M)

INTEGRATION IN BY-LAWS

CSB CELL - WORK PACKAGES

0-3MONTHS

3-6 MONTHS



6-18 MONTHS

Work Package 1:

Facilitate implementation and monitoring of Light House Projects (LHPs)

Work Package 2:

Technical assistance to enhance thermal comfort in upcoming Demonstration Housing Projects (DHPs) and ARHCs (Affordable rental housing complexes) and other Public/Private housing projects in the Central Cluster

Work Package 3:

Inclusion of climate resilience and thermal comfort requirements in building byelaws and Local Government framework in Central Cluster

Work Package 4:

Capacity development of Govt officials and private stakeholders on thermal comfort in the Central Cluster

SESSION :1 THERMAL COMFORT

Session 1: Thermal Comfort

a) **Indices**
b) **Thermal comfort in Affordable Housing**
c) **Passive strategies & Building Physics**
d) **Case studies**
e) **Live exercise**

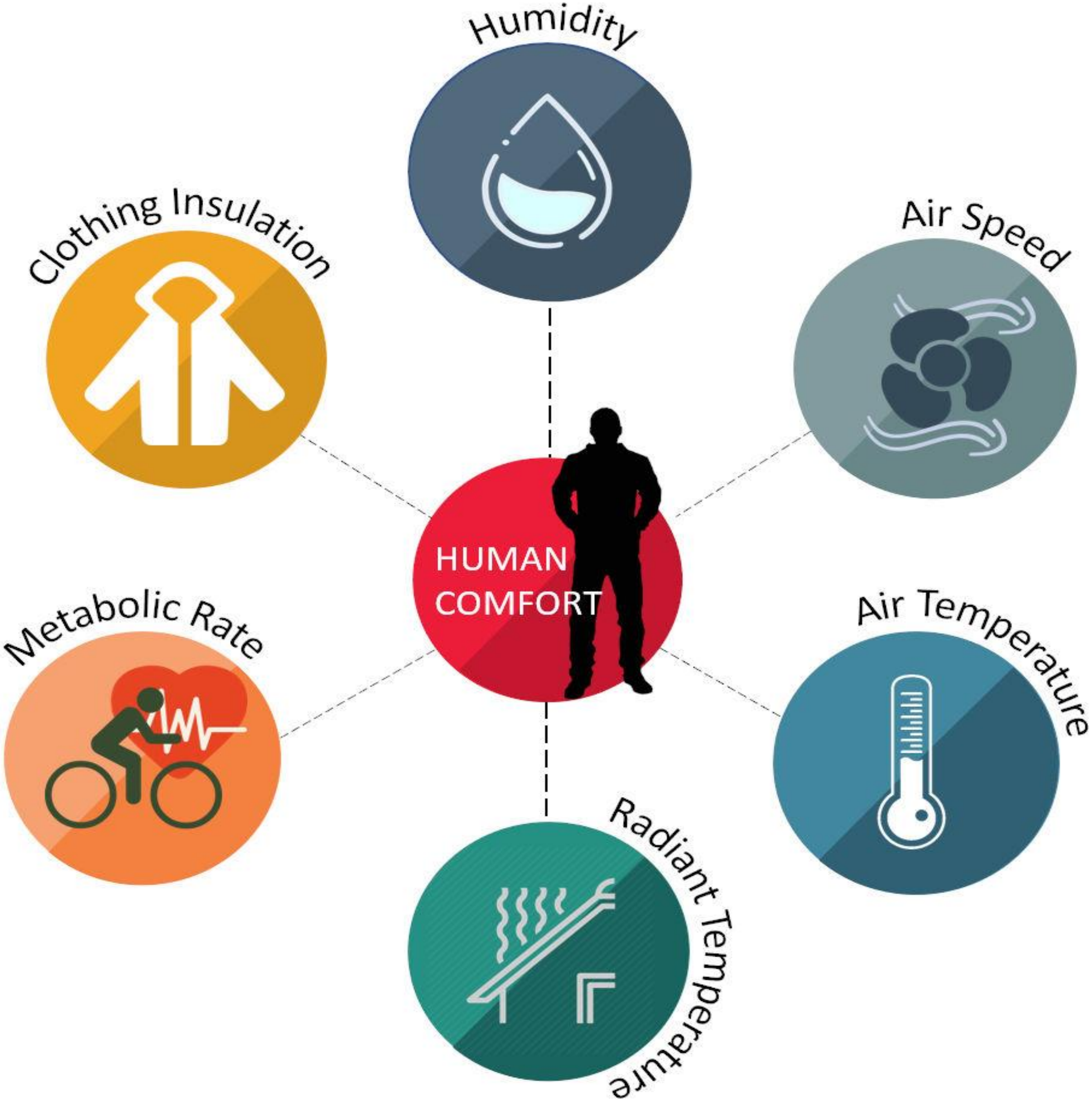
i. **Passive Architectural Design Strategies**
ii. **Building Construction material**
iii. **No cost solutions**

THERMAL COMFORT

Thermal comfort is the condition of mind that expresses satisfaction with the thermal environment and is assessed by subjective evaluation (ANSI/ASHRAE Standard 55)

Thermal comfort is difficult to measure because it is highly subjective. It depends on the air temperature, humidity, radiant temperature, air velocity, metabolic rates, and clothing levels.

FACTORS AFFECTING THERMAL COMFORT



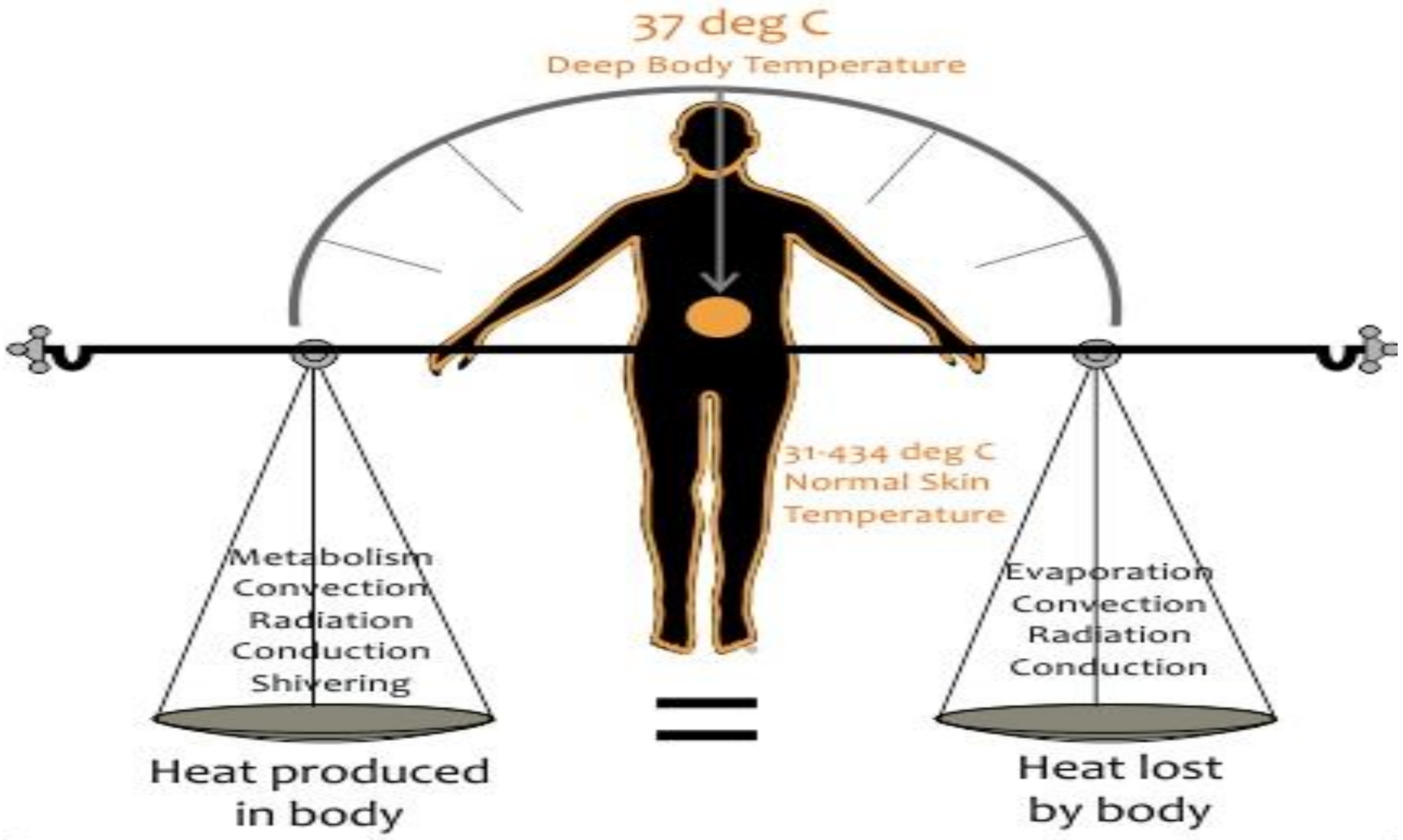
Personal factor

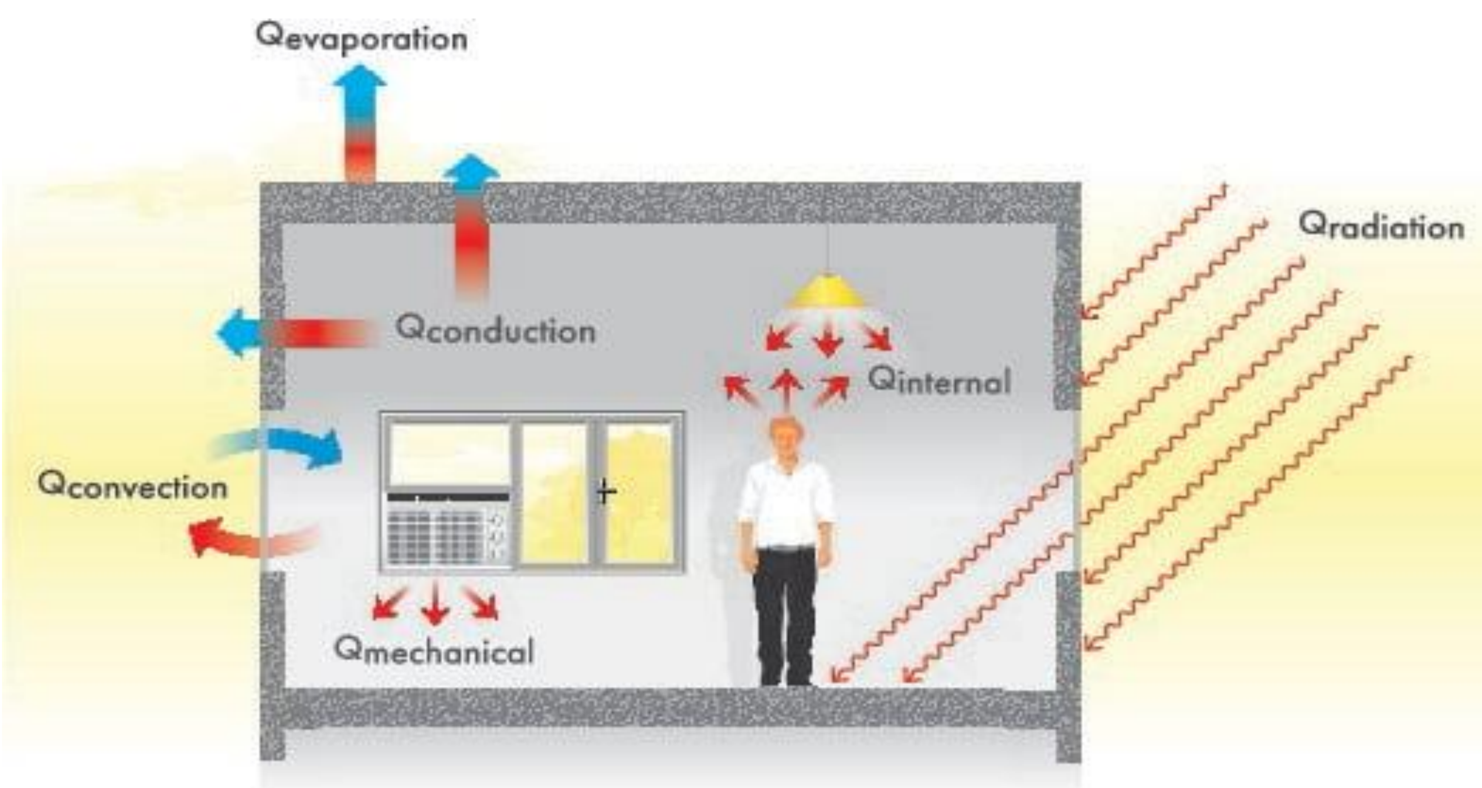
- ✓ **Clothing insulation**
- ✓ **Metabolic Rate(met)**

Environmental factor

- ✓ **Humidity**
- ✓ **Air Speed**
- ✓ **Air Temperature**
- ✓ **Radiant Temperature**

FACTORS AFFECTING THERMAL COMFORT - INDOOR ENVIRONMENT





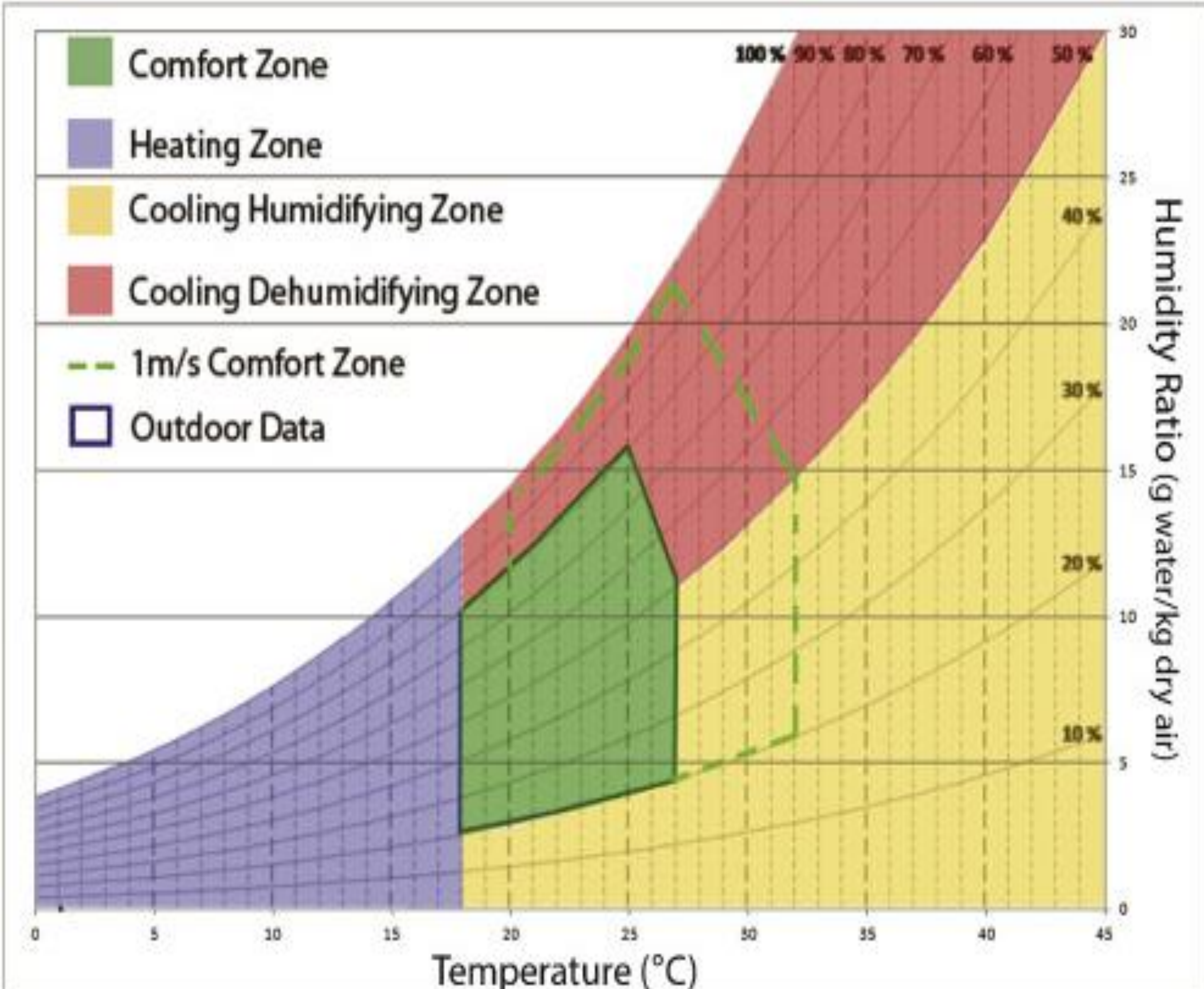
Thermal comfort refers to the perceived feeling on the human body as the result of the effect of heat and cold sources in the environment.

Heat exchange between the human body and its environment via

- **Radiation**
- **Convection**
- **Evaporation**

THERMAL COMFORT INDICES

Thermal comfort indices describe how the human body experiences atmospheric conditions, specifically air temperature, humidity, wind and radiation.



Direct Indices

- Dry Bulb Temperature
- Dew Point Temperature
- Wet Bulb Temperature
- Relative Humidity
- Air Movement

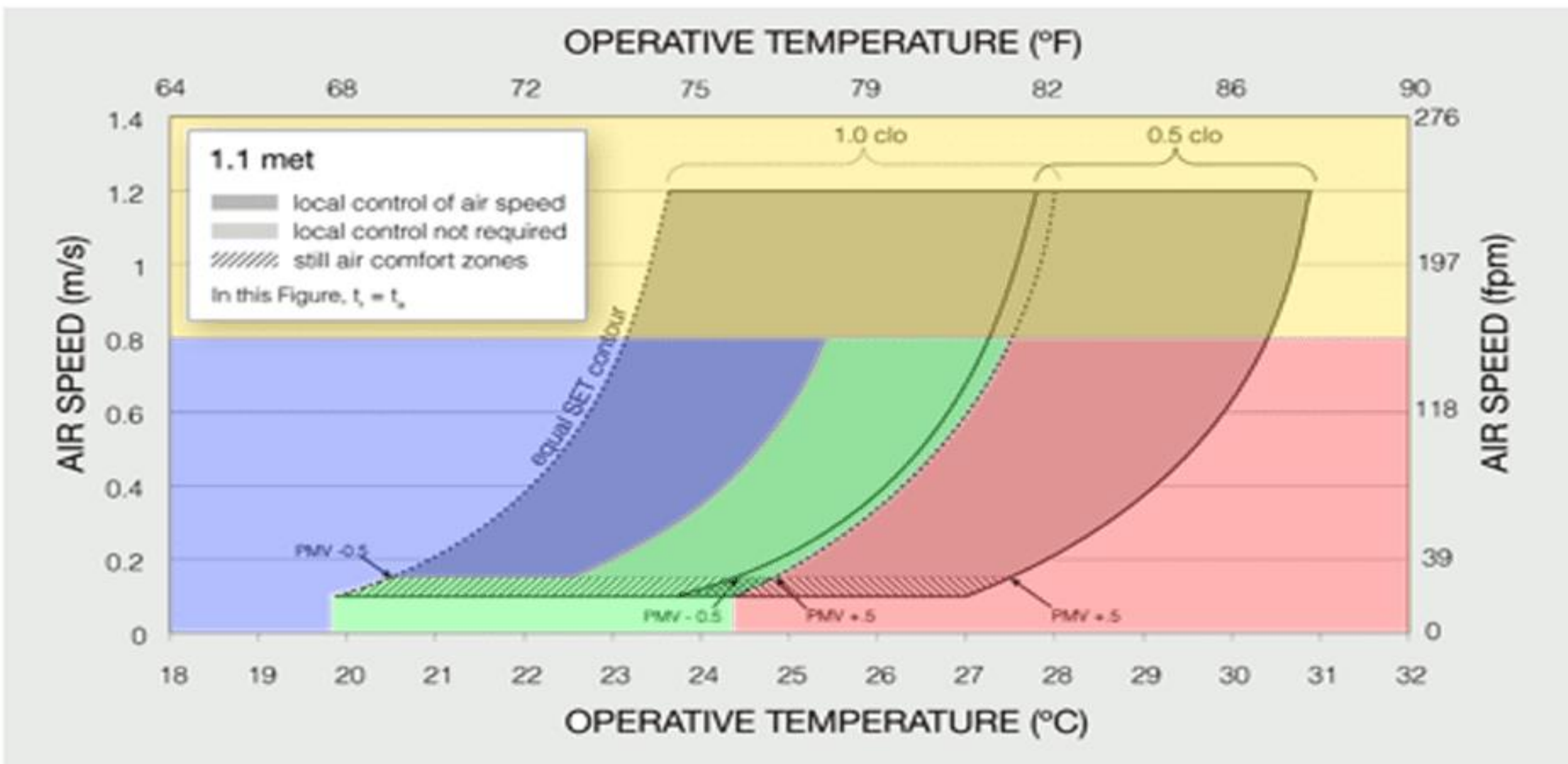
Rationally Derived Indices

- Mean Radiant temp
- Operative Temperature
- Heat Stress
- Thermal Stress

Operative temperature is defined as a uniform temperature of an imaginary black enclosure in which an occupant would exchange the same amount of heat by radiation plus convection as in the actual non uniform environment

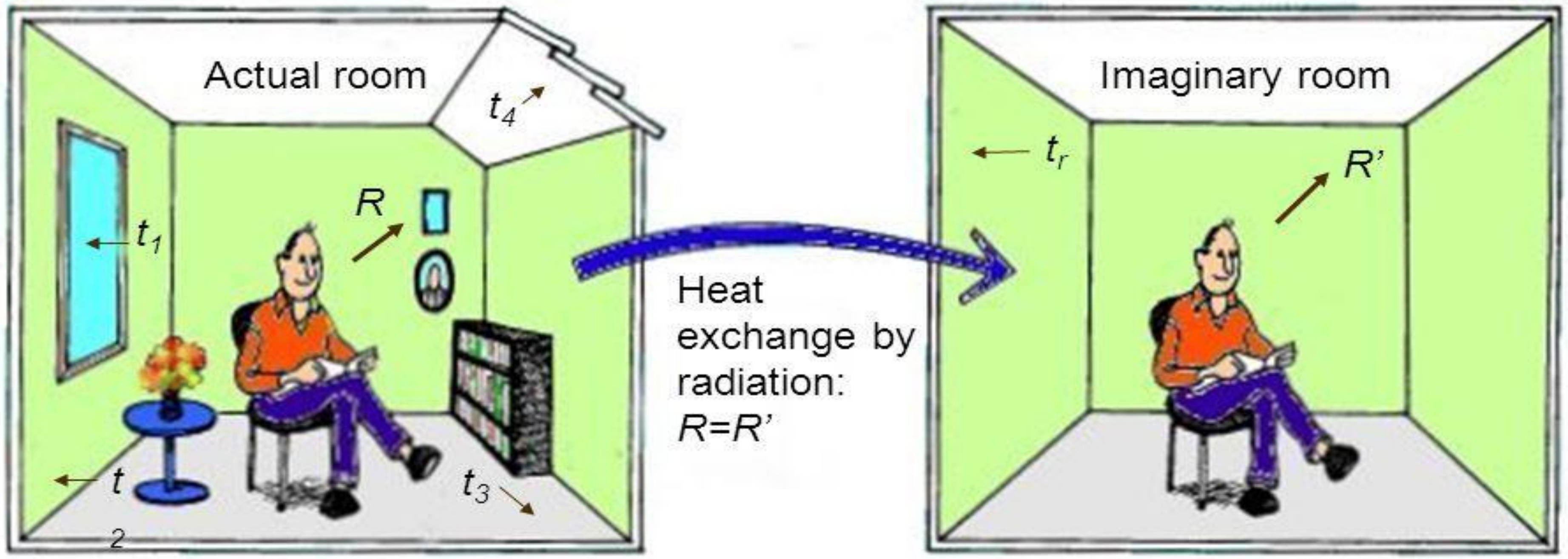
Naturally Ventilated Buildings

Indoor Operative Temperature = (0.54 x outdoor temperature) + 12.83



Comfortable | Too Hot | Too Cold | Too Drafty

Mean Radiant Temperature

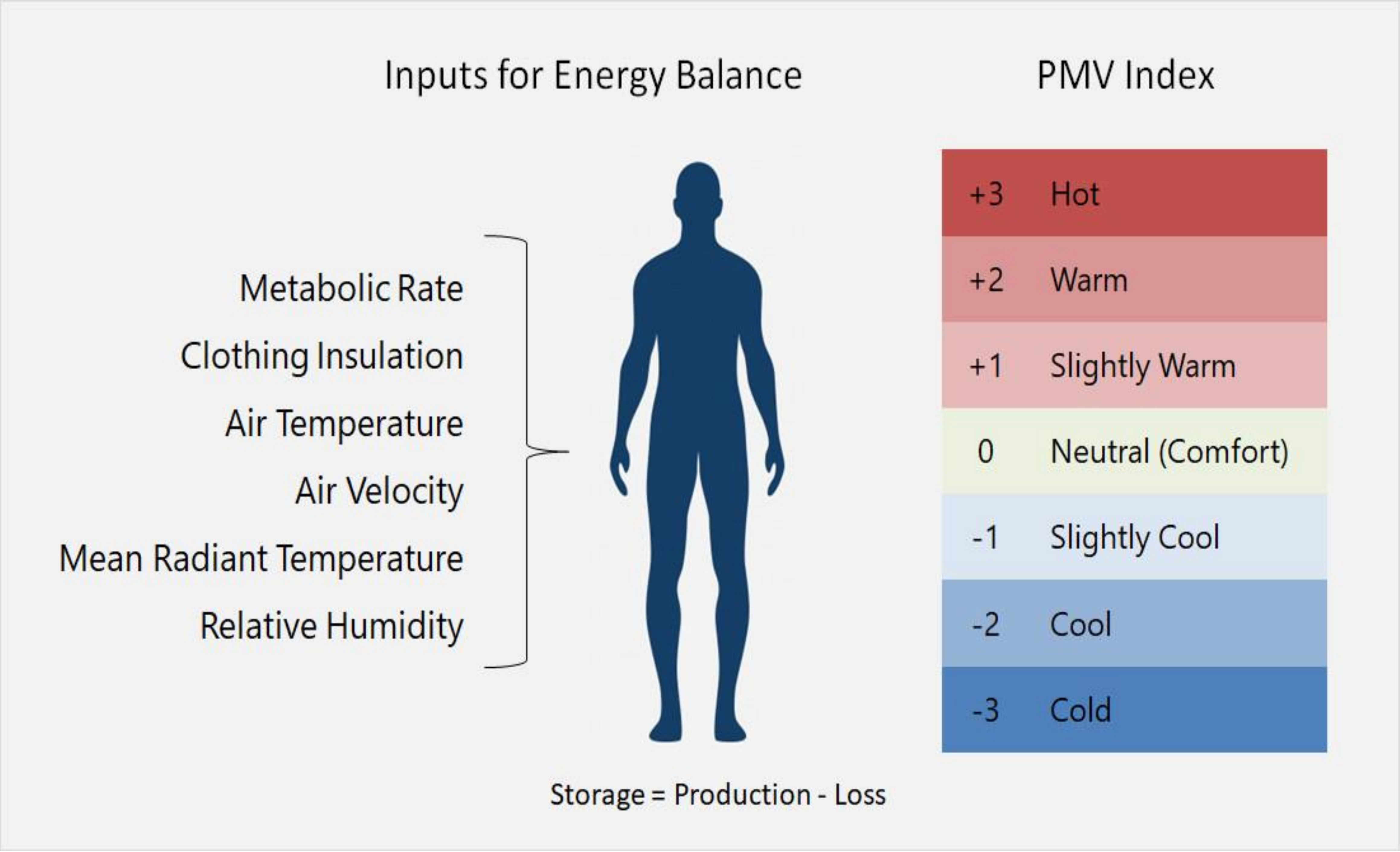


- The Mean Radiant Temperature is that uniform temperature of an imaginary black enclosure resulting in same heat loss by radiation from the person, as the actual enclosure.
- Measuring all surface temperatures and calculation of angle factors is time consuming. Therefore use of Mean Radiant Temperature is avoided when possible.

$$MRT = T_1 F_{p-1} + T_2 F_{p-2} + \ldots + T_n F_{p-n}$$

THE PREDICTED MEAN VOTE (PMV)

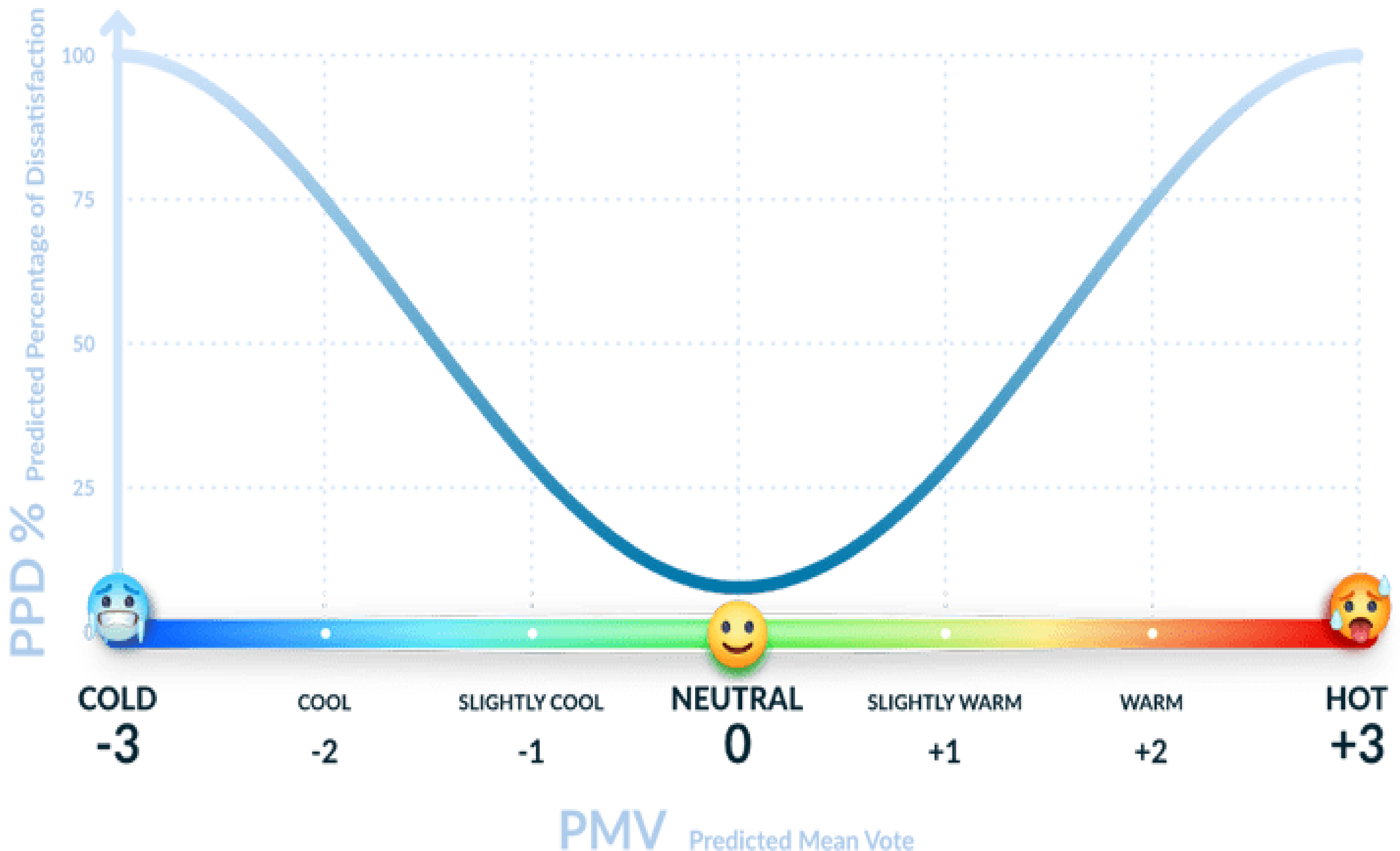
- PMV refers to a thermal scale that runs from Cold (-3) to Hot (+3).
- PMV range for thermal comfort = **-0.5 and +0.5** for an interior space.**(ASHARE 55)**



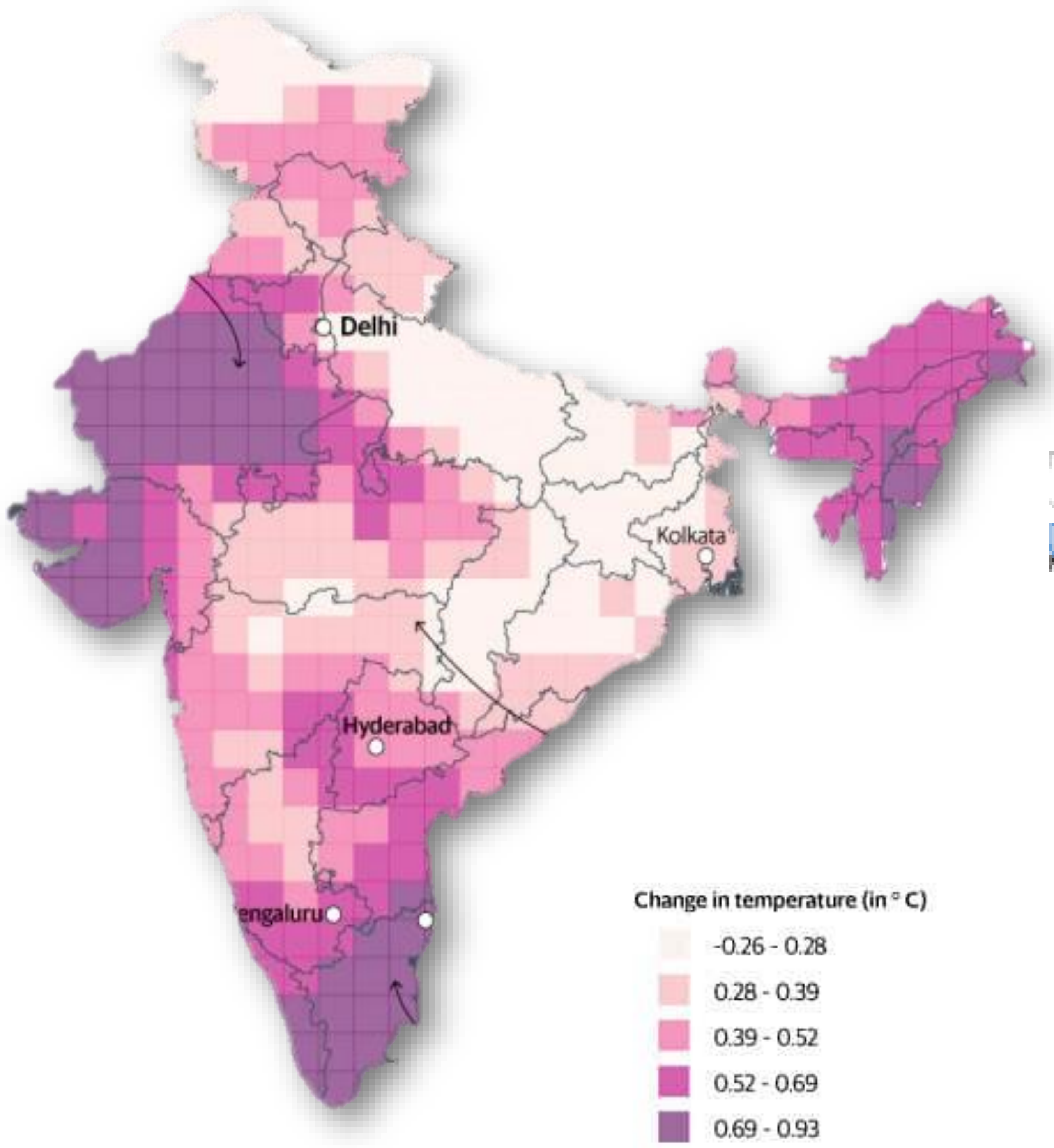
THERMAL COMFORT INDICES

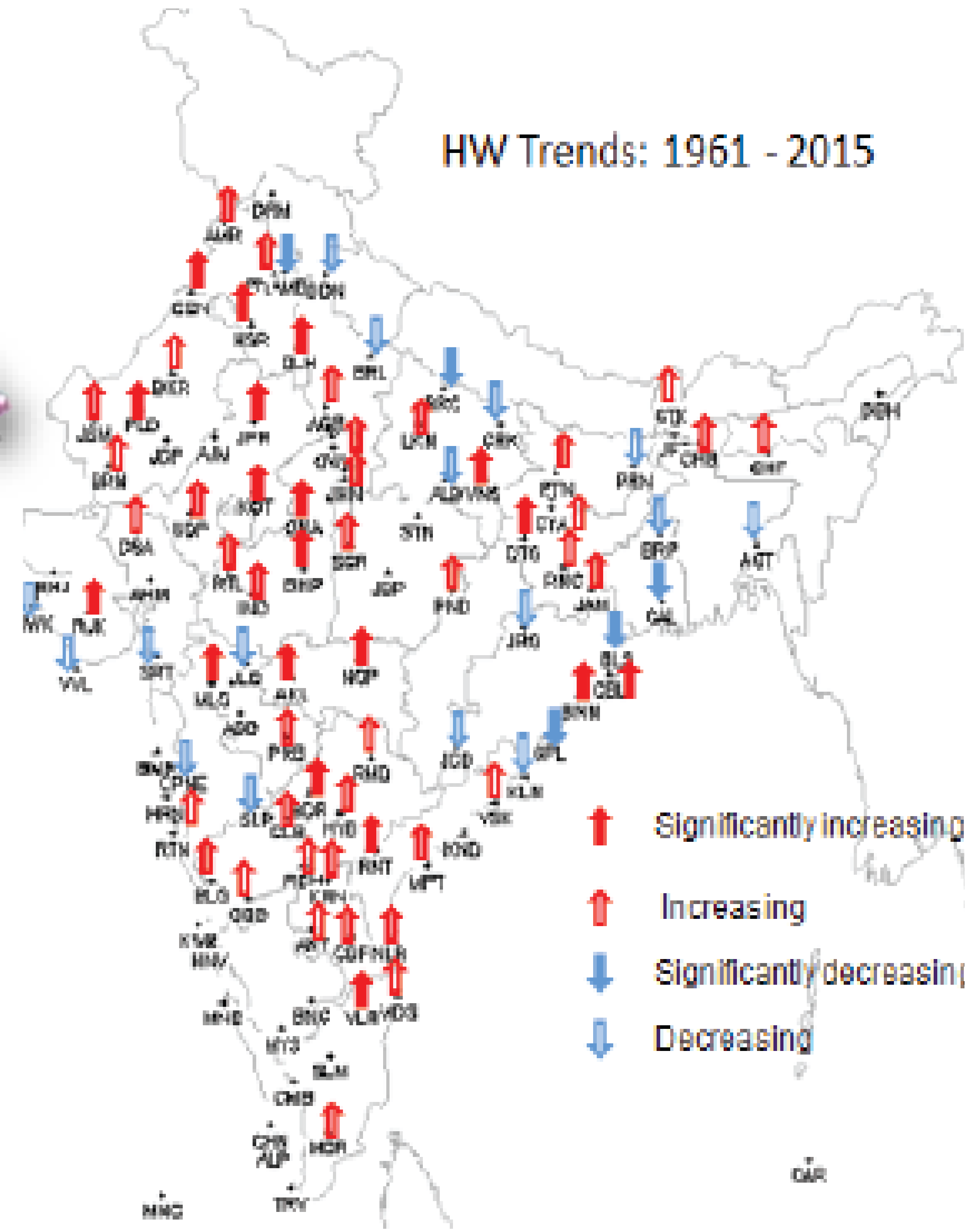
PREDICTED PERCENTAGE OF DISCOMFORT

PPD, or index that establishes a quantitative prediction of the percentage of thermally dissatisfied occupants (i.e. too warm or too cold)



NEED FOR THERMAL COMFORT AND HOW IT IMPACT US – QUALITATIVE AND QUANTITATIVE





India could lose the equivalent of 34 million jobs in 2030 due to global warming, says ILO

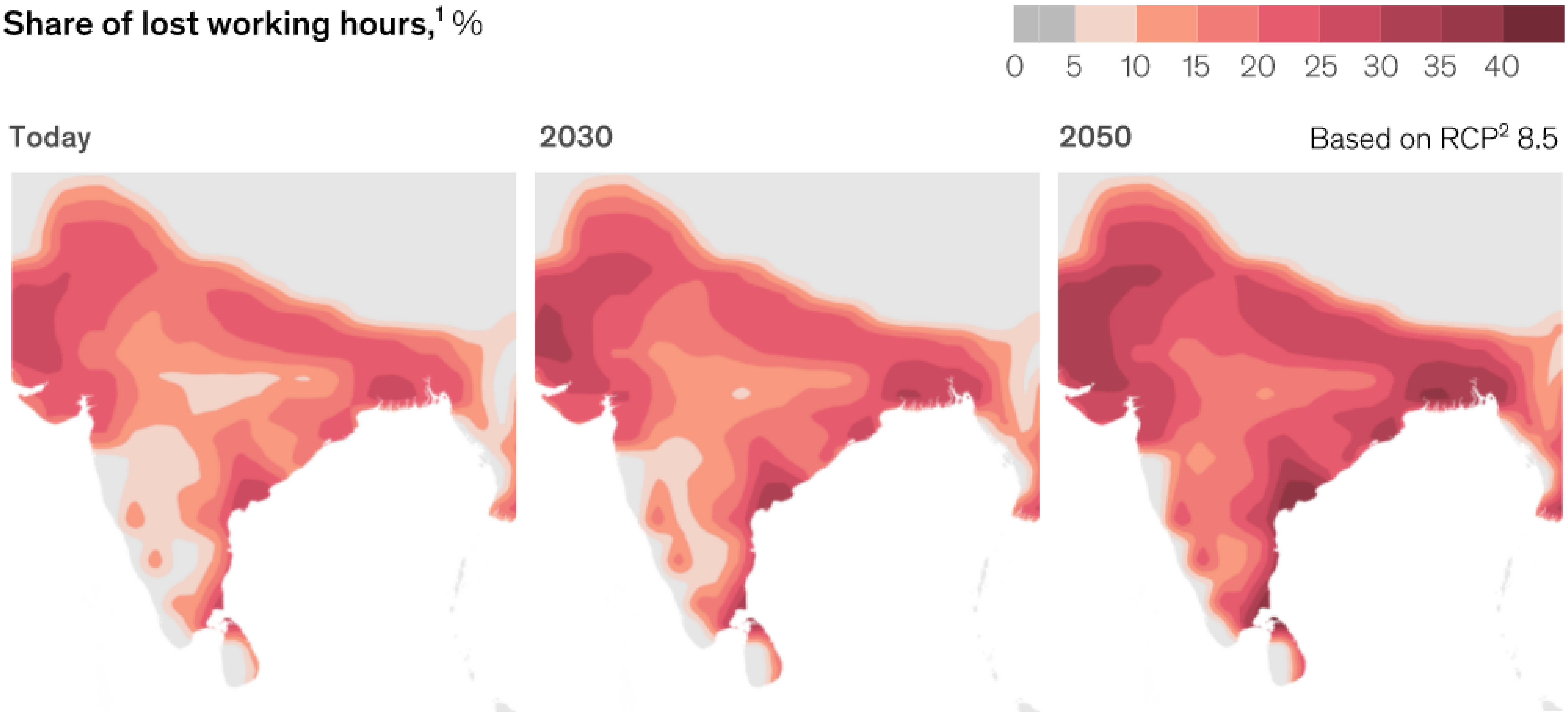
A lack of thermal comfort makes us feel **stressed**, annoyed, distracted, feel sleepy, tired and lacking concentration.

In turn, thermal comfort inevitably has an impact on well-being, productivity

Source Biannial update report India

NEED FOR THERMAL COMFORT AND HOW IT IMPACT US – QUALITATIVE AND QUANTITATIVE

The affected area and intensity of extreme heat and humidity is projected to increase, leading to a higher expected share of lost working hours in India.



Note: See the technical appendix to the report for why we chose Representative Concentration Pathway (RCP) 8.5. All projections are based on the RCP 8.5 and Coupled Model Intercomparison Project 5 multimodel ensemble. Corrected for heat-data bias. Following standard practice, future (ie, 2030 and 2050) states as the average climatic behavior over multidecade periods. Climate for today is the average between 1998 and 2017; for 2030, the average between 2021 and 2040; and for 2050, the average between 2041 and 2060.

[1]Lost working hours include loss in worker productivity as well as breaks, based on an average year that is an ensemble average of climate models.

[2]Representative Concentration Pathway.

Source: Woods Hole Research Center

McKinsey & Company

- https://www.mckinsey.com/business-functions/sustainability/our-insights/climate-risk-and-response-physical-hazards-and-socioeconomic-impacts

MEASURES TO IMPROVE THERMAL COMFORT VIA DESIGN

Passive Design

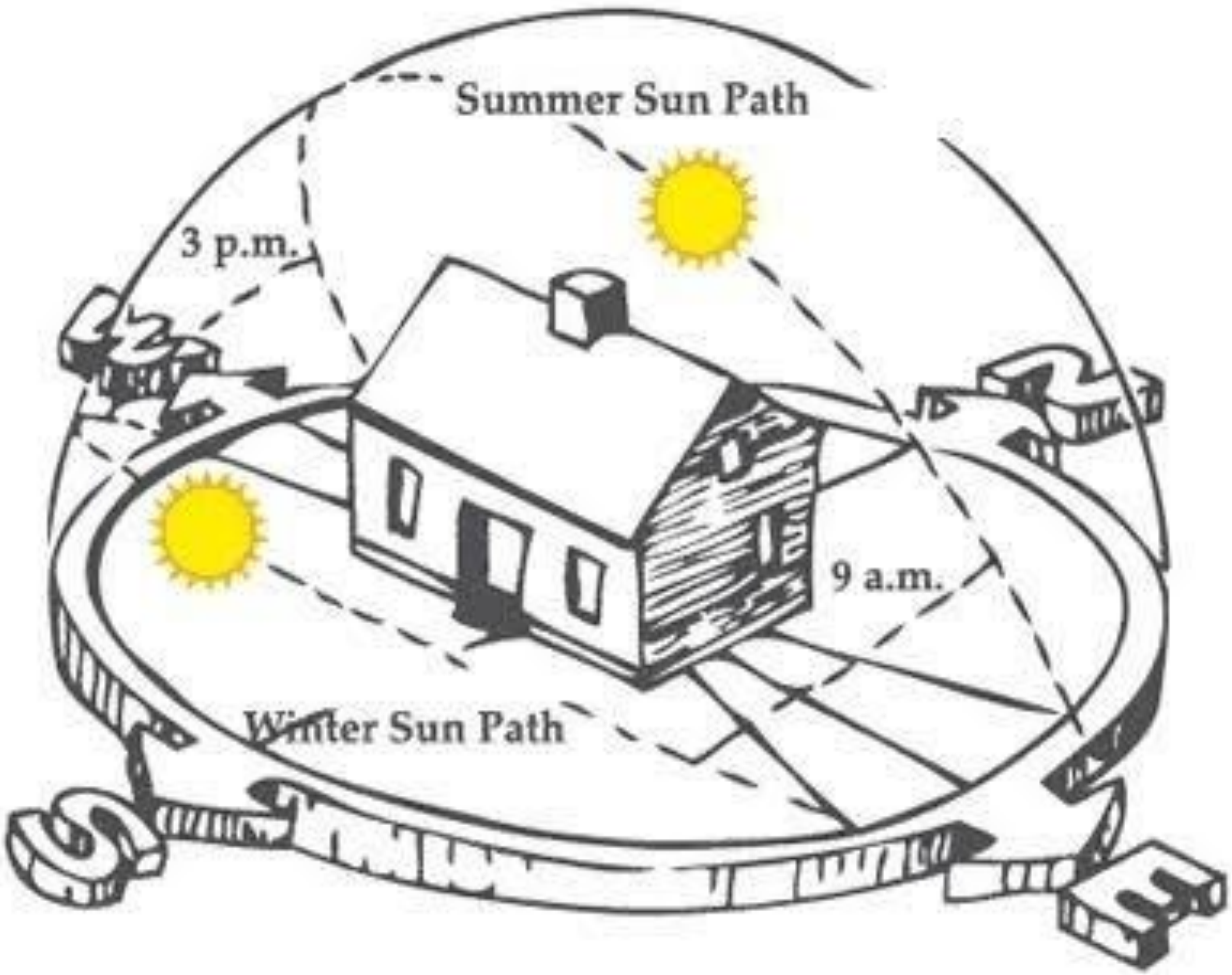
Design that leverages climatologically responsive design to encourage natural heating/cooling, ventilation, and lighting.

Active Design

Design that relies largely on mechanical / electrical sources of heating / cooling, ventilation, and lighting.

Passive design needs **active users.**

Active design needs **passive users.**



MEASURES TO IMPROVE THERMAL COMFORT
passive design strategies for affordable housing

Building Ventilation Types

- Naturally Ventilated (NV) ✓
- Mixed Mode (MM)
- Air Conditioned (AC)

- **FORM & ORIENTATION OF BUILDING BLOCKS**
- **FENESTRATION**
- **SHADING OF OPENING /WINDOWS**
- **DAYLIGHTING**
- **NATURAL VENTILATION**
- **VEGETATION**

MEASURES TO IMPROVE THERMAL COMFORT

passive design strategies for affordable housing

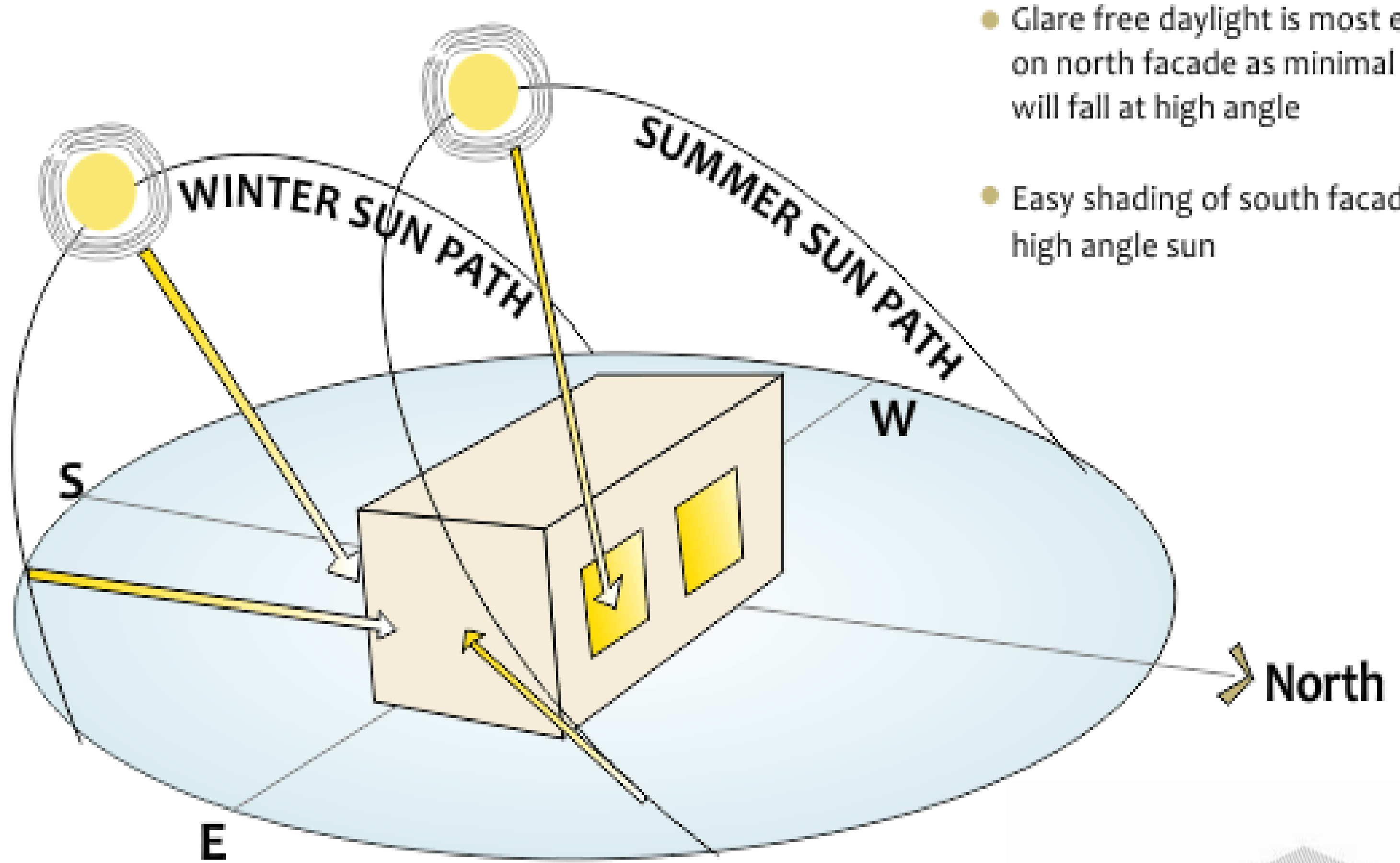
ORIENTATION OF BUILDING BLOCKS:

SUMMER SUN

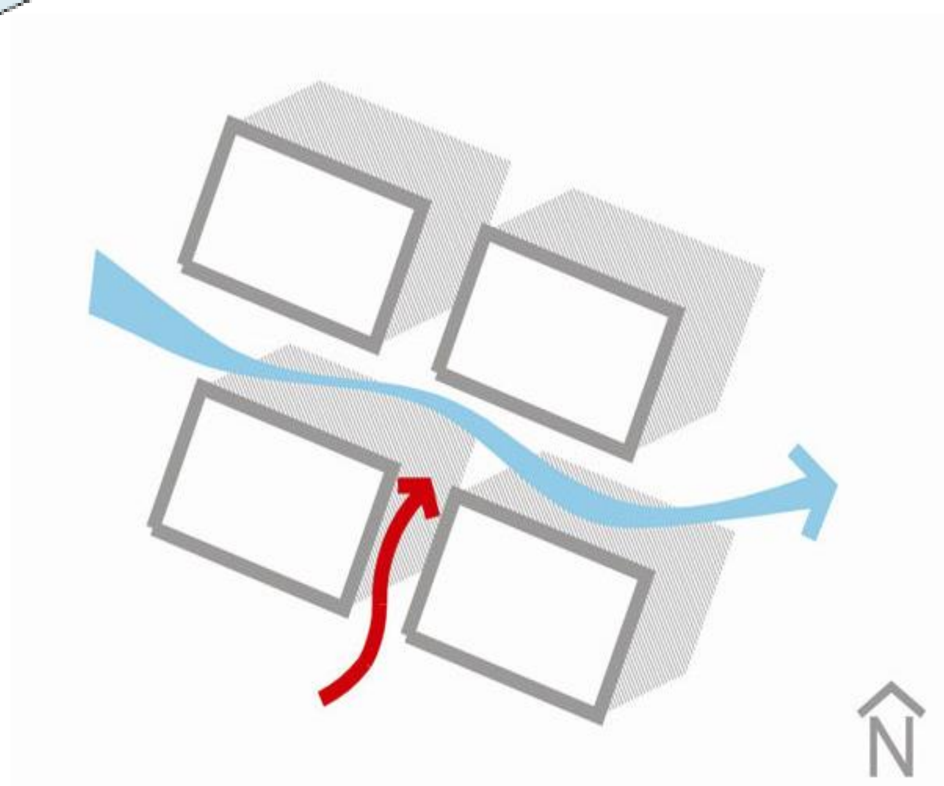
- Sun path at a high angle sun, north to E-W axis
- Glare free daylight is most easily available on north facade as minimal solar radiation will fall at high angle
- Easy shading of south facade from high angle sun

WINTER SUN

- Sun path at a low angle , south to E-W axis
- Solar radiation will penetrate south facing facades at a low angle during winter



East and west facades continue to receive uniform, strong solar radiation at a low angle through the year.

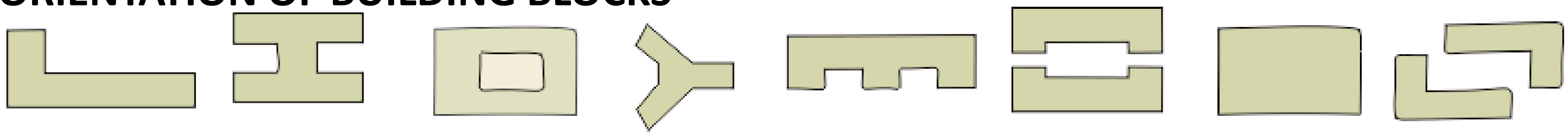


Source: NZEB

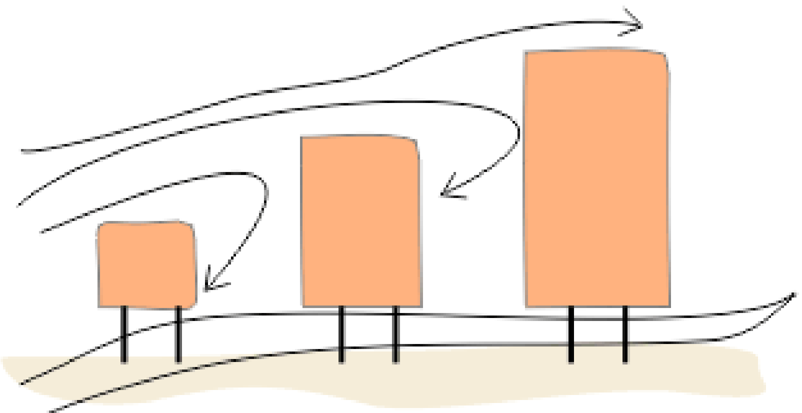
MEASURES TO IMPROVE THERMAL COMFORT

passive design strategies for affordable housing

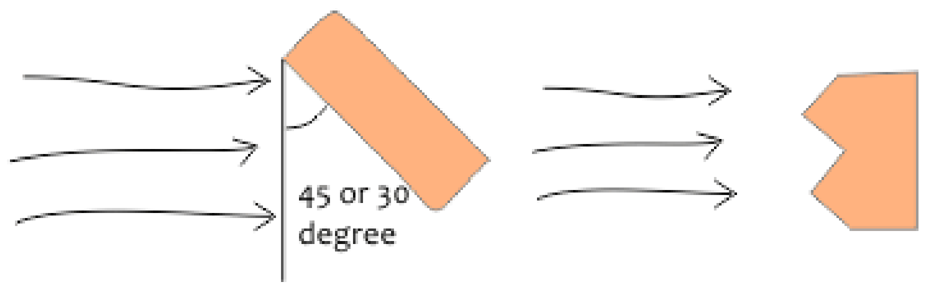
ORIENTATION OF BUILDING BLOCKS



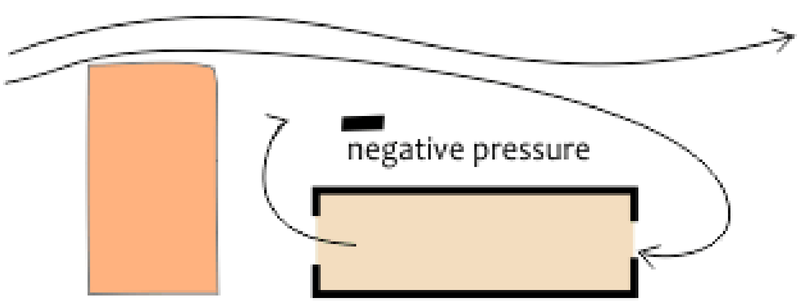
Orient longer facades along the north. This will provide glare free light in summer from north without shading and winter sun penetration from the south.



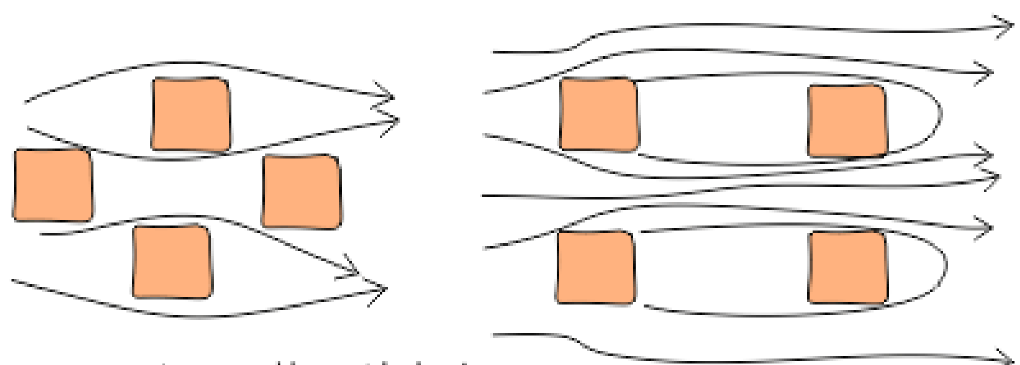
if a site has multiple buildings, they should be arranged in ascending order of their heights and be built on stilts to allow ventilation



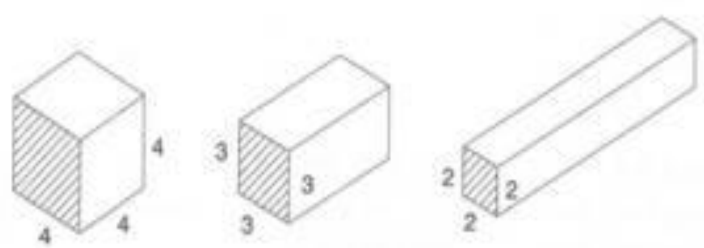
Place buildings at a 30 or 45 degree angle to the direction of wind for enhanced ventilation. Form can be staggered in the wind facing direction also to achieve the same result.



Taller forms in the wind direction of prevailing wind can alter the wind movement pattern for low lying buildings behind them



staggered layout helps in accentuating wind movement



Solid shape type	Surface area (S)	Volume (V)	Ratio (S/V)
a	96	64	1.5
b	103.2	64	1.61
c	136	64	2.13

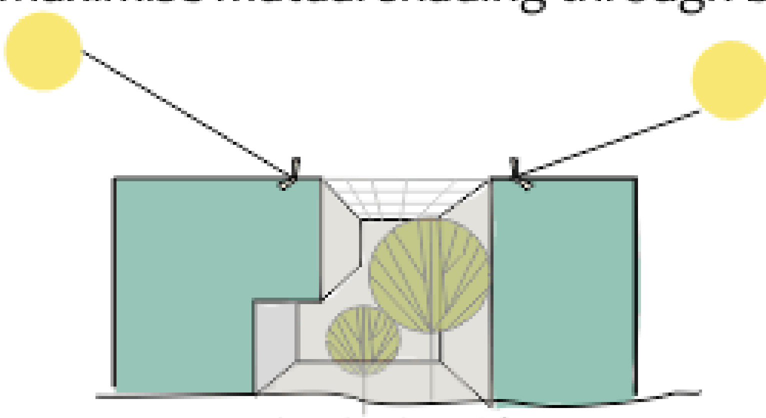
Source: NZEB

MEASURES TO IMPROVE THERMAL COMFORT

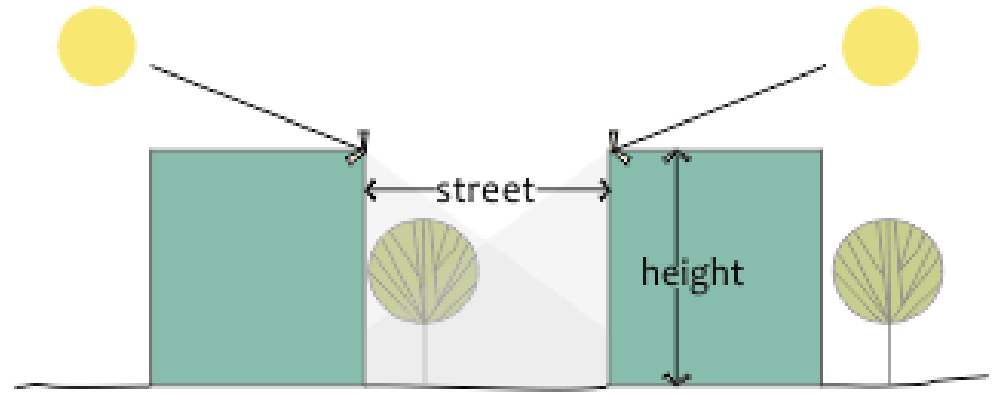
passive design strategies for affordable housing

FORM OF BUILDING BLOCKS:

1 Maximise mutual shading through built forms

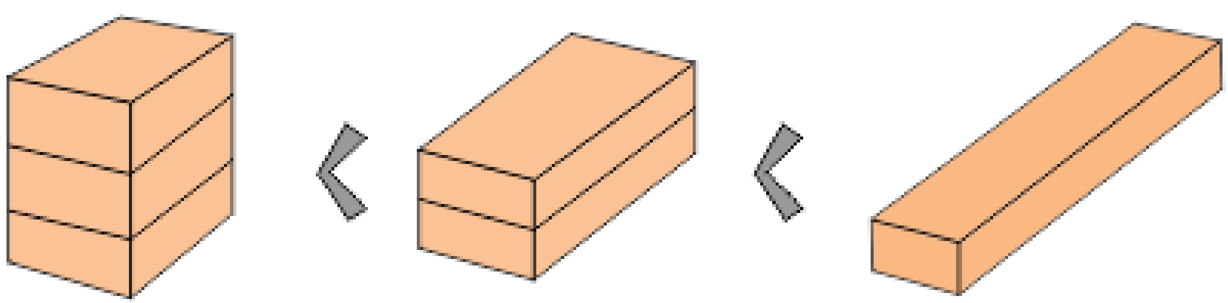


closely placed forms



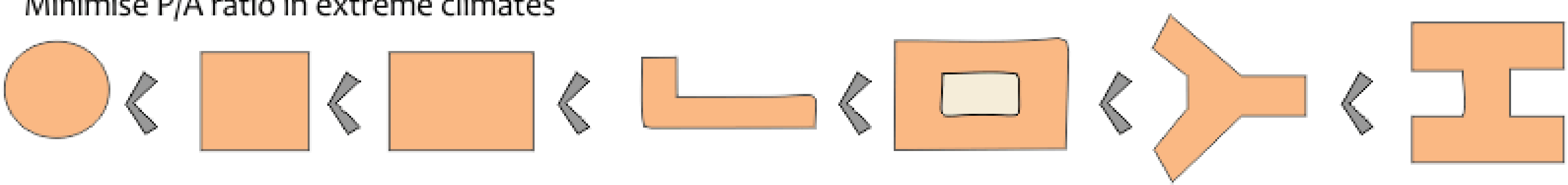
narrow streets - keep building height to street width ratio minimal

2 Minimise S/V ratio in extreme climates



increase compactness by reducing
surface area for the same volume

3 Minimise P/A ratio in extreme climates



MEASURES TO IMPROVE THERMAL COMFORT
passive design strategies for affordable housing

ORIENTATION OF BUILDING BLOCKS:

UDAAN, low cost mass housing project at Mumbai

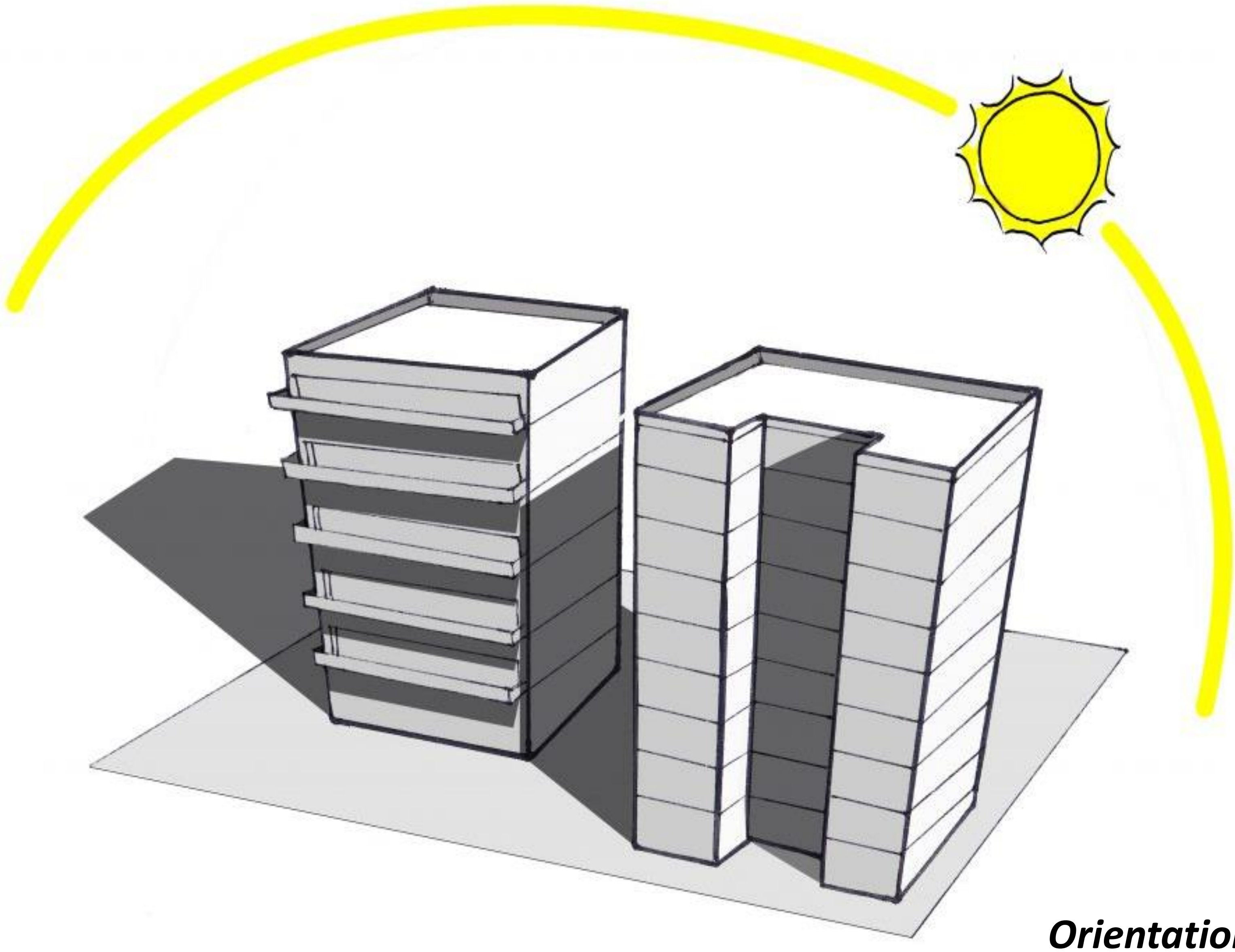
- Maximum daylight
- Proper ventilation

The Orientation can alter the thermal comfort up to – 9 % as the area of the wind facing wall varies with the orientation

Source: NZEB

MEASURES TO IMPROVE THERMAL COMFORT

passive design strategies for affordable housing



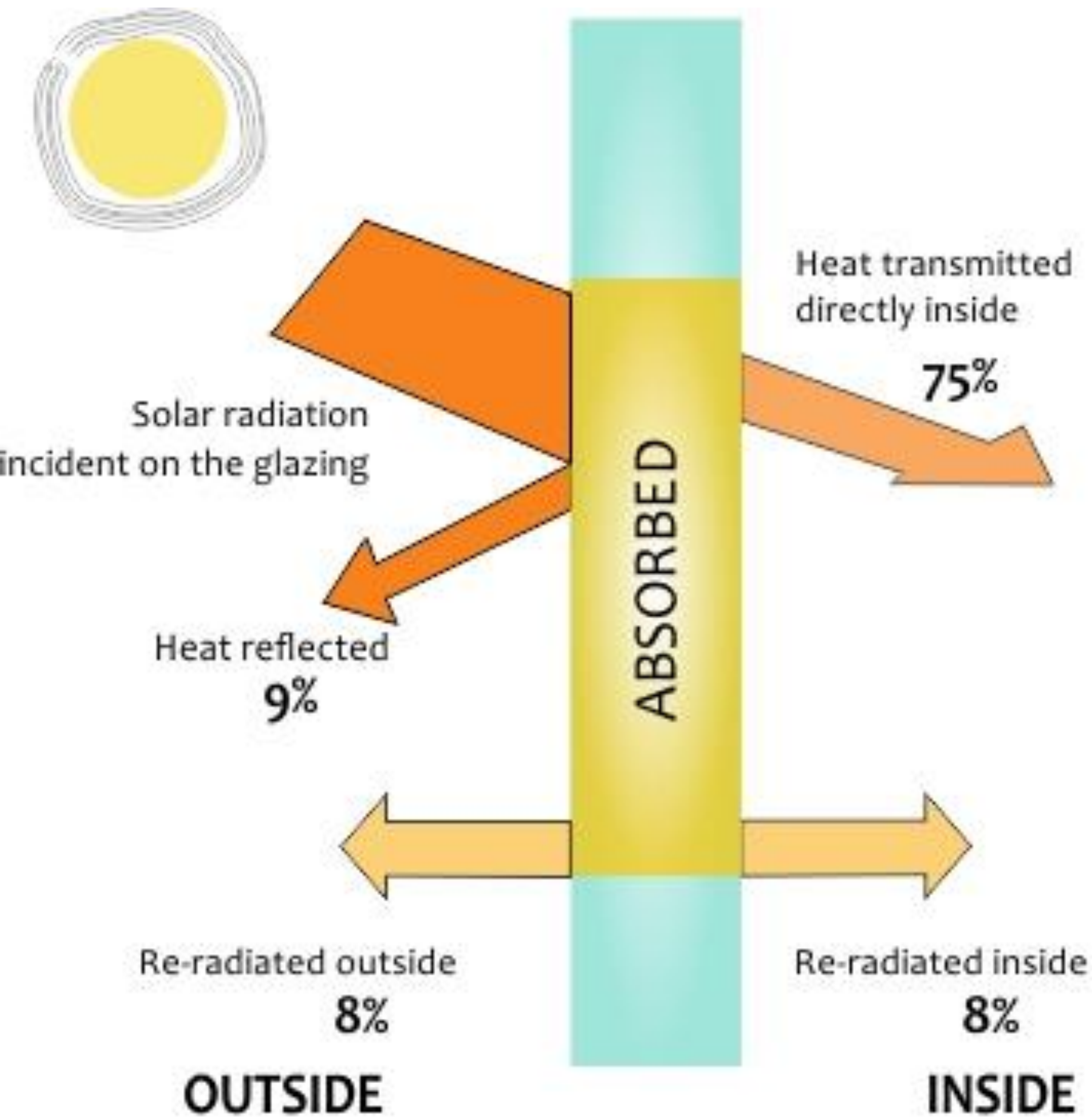
Orientation and form

- In extreme climatic condition *compact planning* is more preferable
- Minimising the perimeter to area ratio of building form, building performs better in terms of thermal comfort
- *Compact forms* gain less heat at day time and loss heat during night time

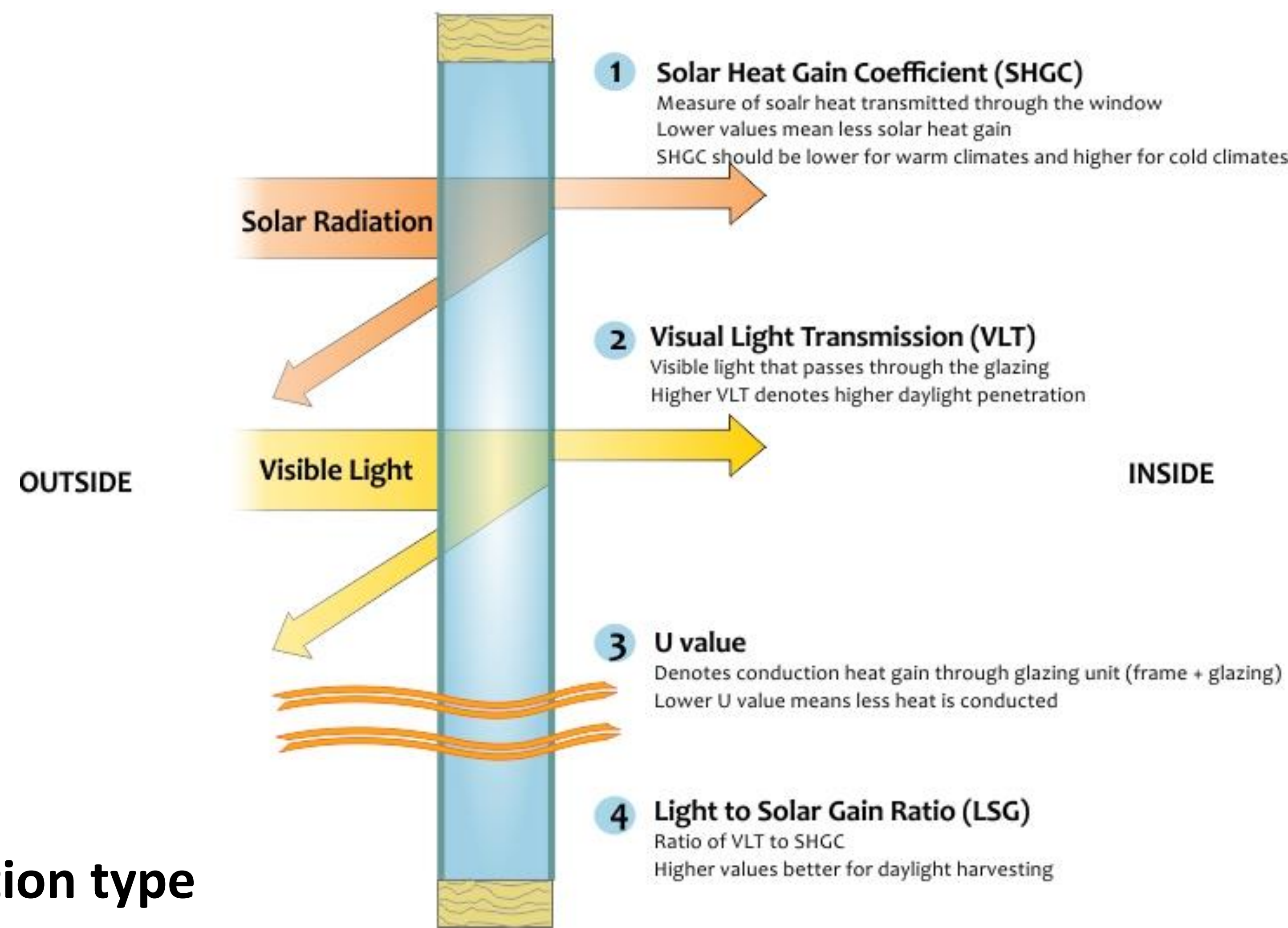
Minimizing the surface area to volume ratio minimizes heat transfer.

Fenestration

A fenestration system with low U-value and low effective SHGC can result in ***reduction of heating and cooling demand*** by 6-11% in moderate climate and between 8-16% in hot humid, hot dry, and composite climates.



Heat transmission in a single glazing clear glass



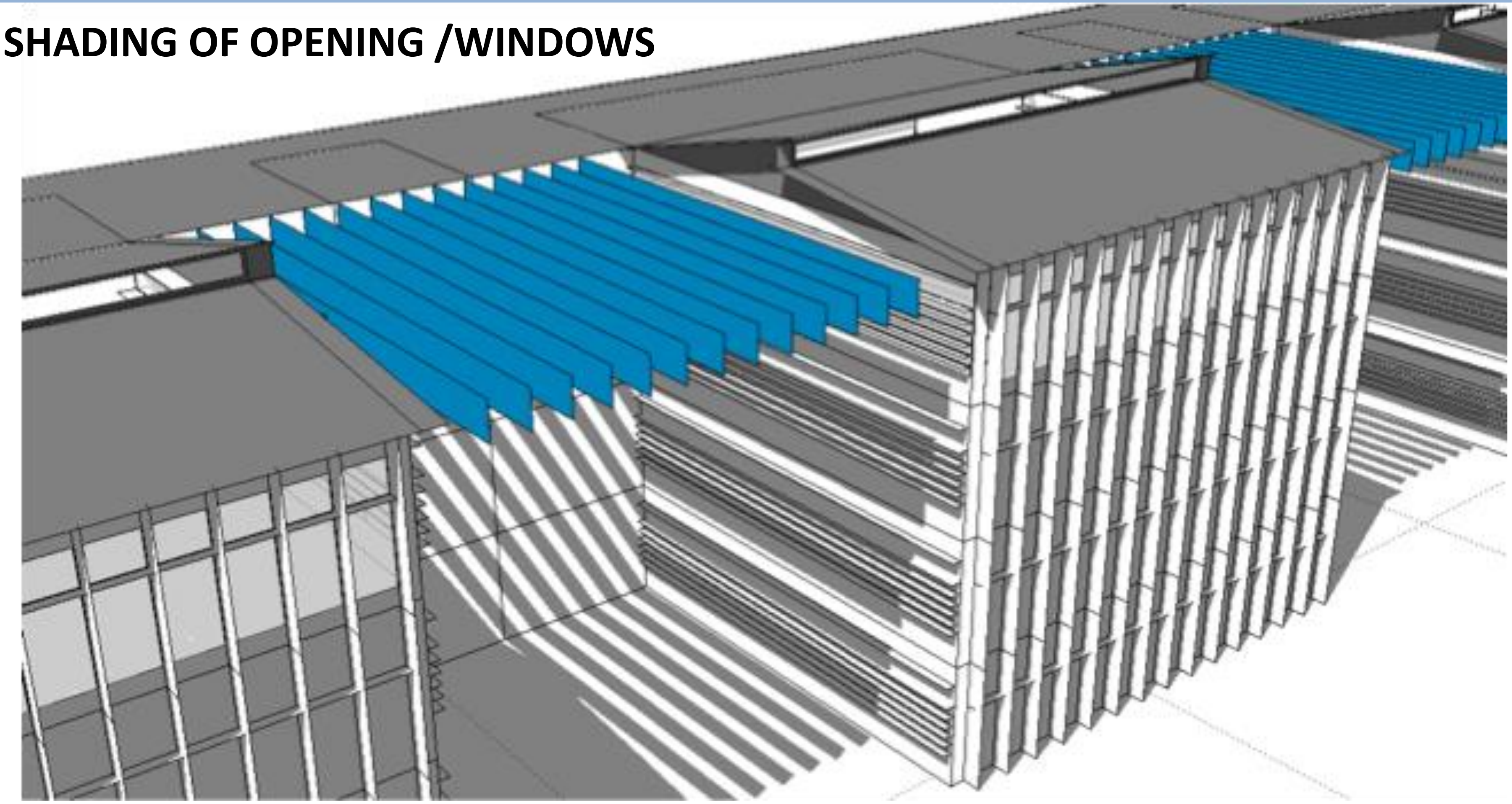
Fenestration type

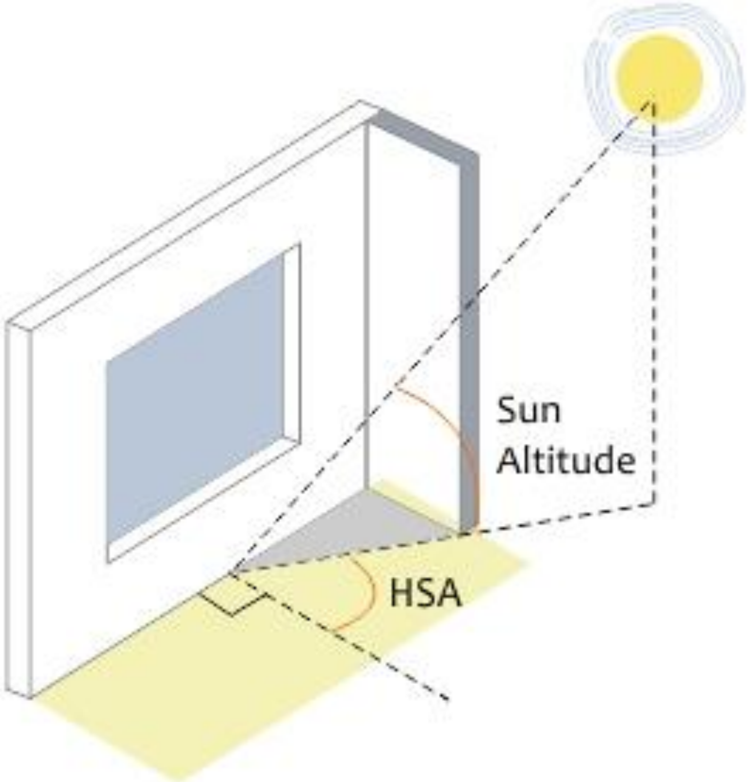
Source: NZEB

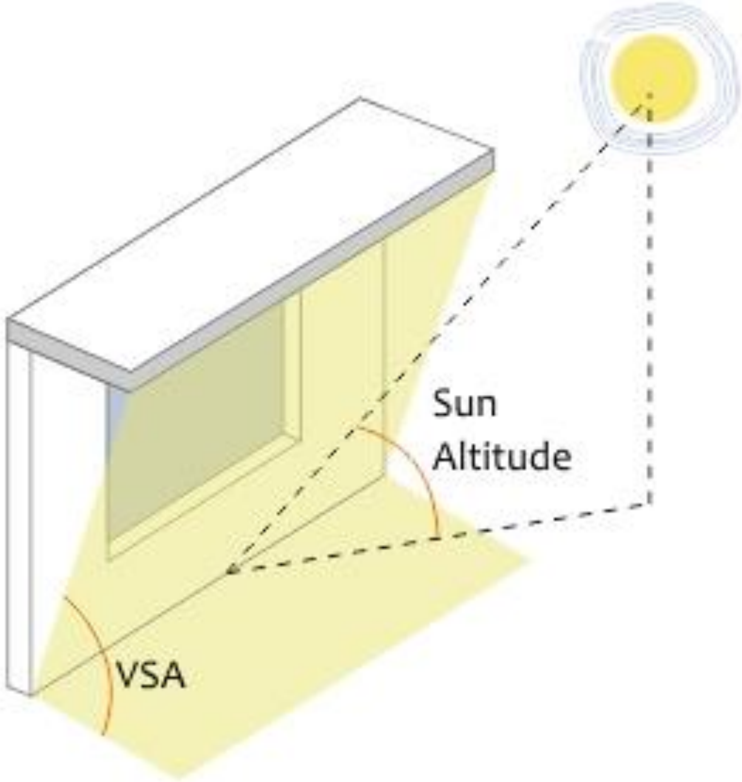
MEASURES TO IMPROVE THERMAL COMFORT

passive design strategies for affordable housing

SHADING OF OPENING /WINDOWS







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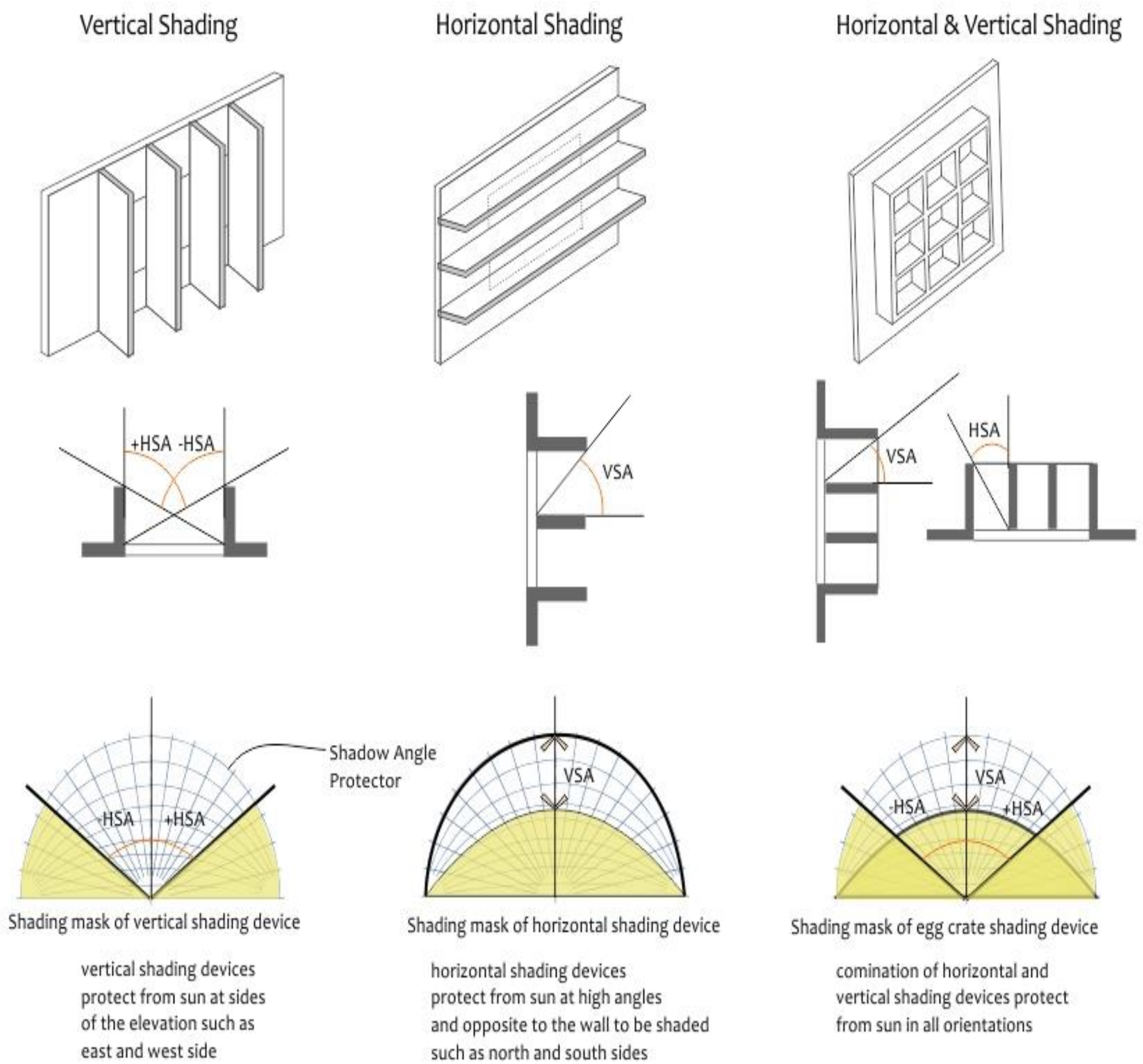
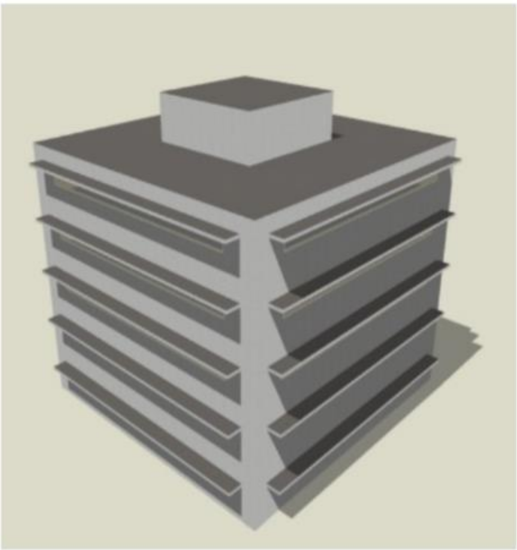
SHADING OF OPENING /WINDOWS

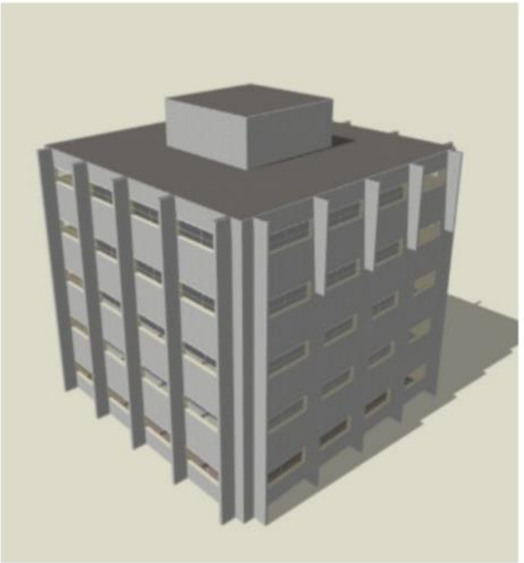


Cases



H-SD-0 (no inclination)
H-SD-30 (inclined at 30°)
H-SD-45 (inclined at 45°)
H-SD-60 (inclined at 60°)

Cases



V-SD-0 (no inclination)
V-SD-30 (inclined at 30°)
V-SD-45 (inclined at 45°)
V-SD-60 (inclined at 60°)

Solar shading devices helps

- Diffusing light
- Control heat
- Improving daylight

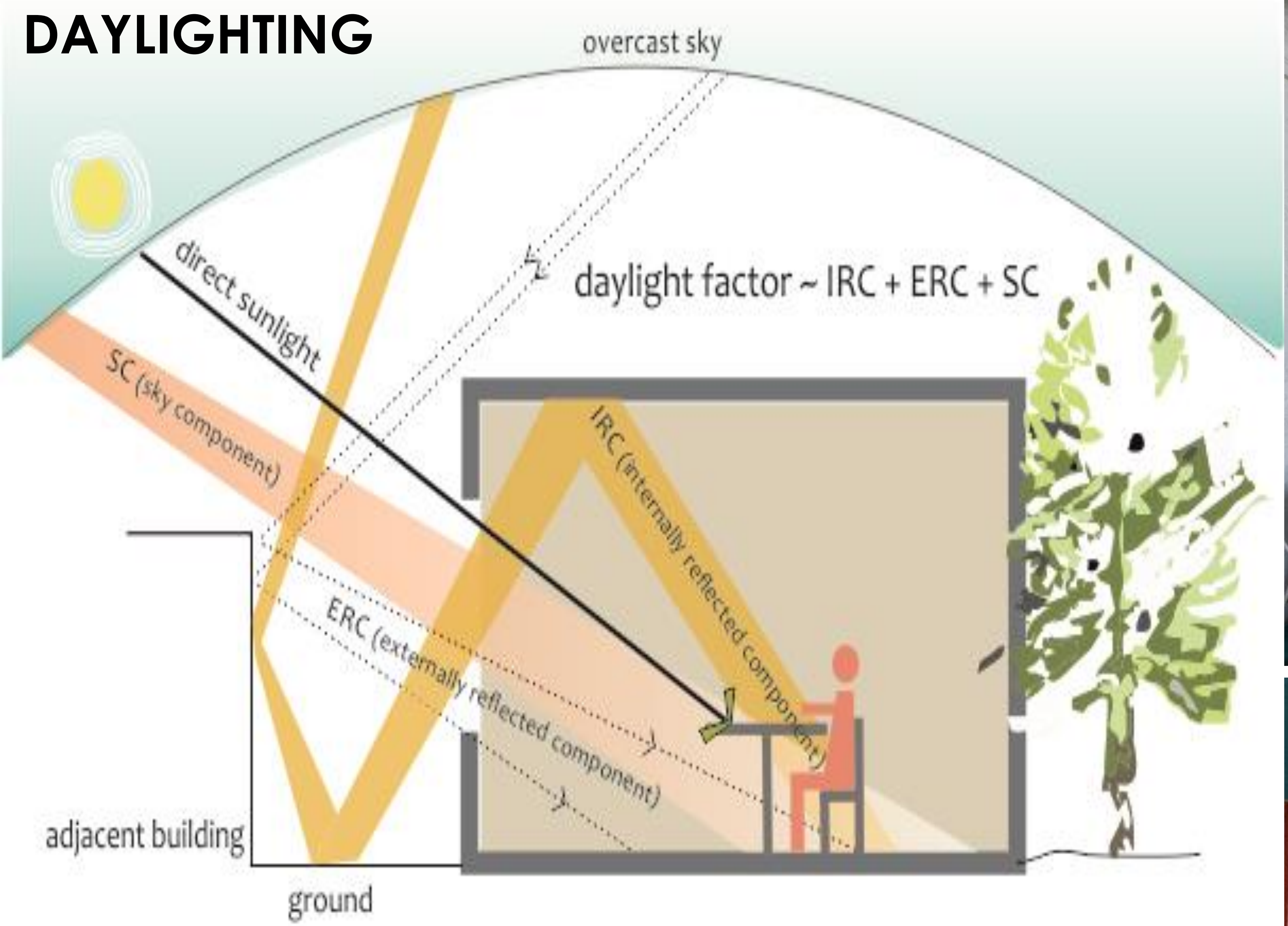
Comfortable living

Use of shading device at Palace of Assembly, Chandigarh

Source: NZEB

MEASURES TO IMPROVE THERMAL COMFORT
passive design strategies for affordable housing

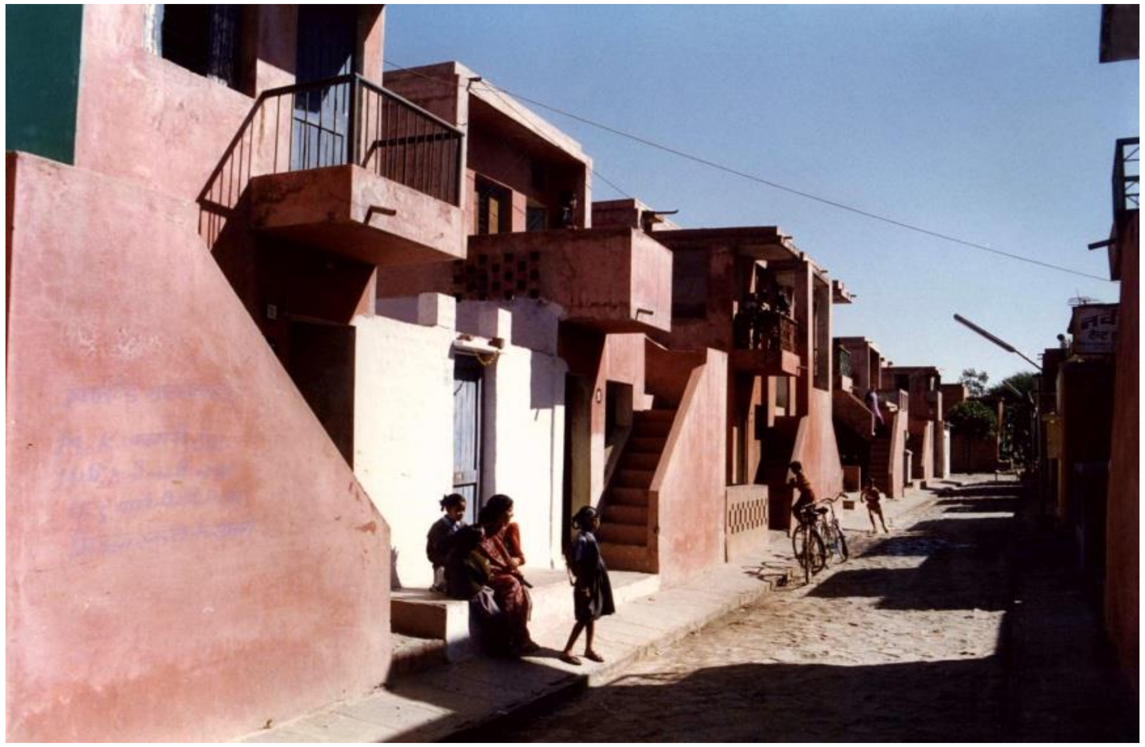
DAYLIGHTING



- Designed daylighting features enhance

1. Indoor environmental quality,
2. Building occupant performance

Daylighting can impact the energy use by **reducing** the lighting energy demand up to **20-30%.**



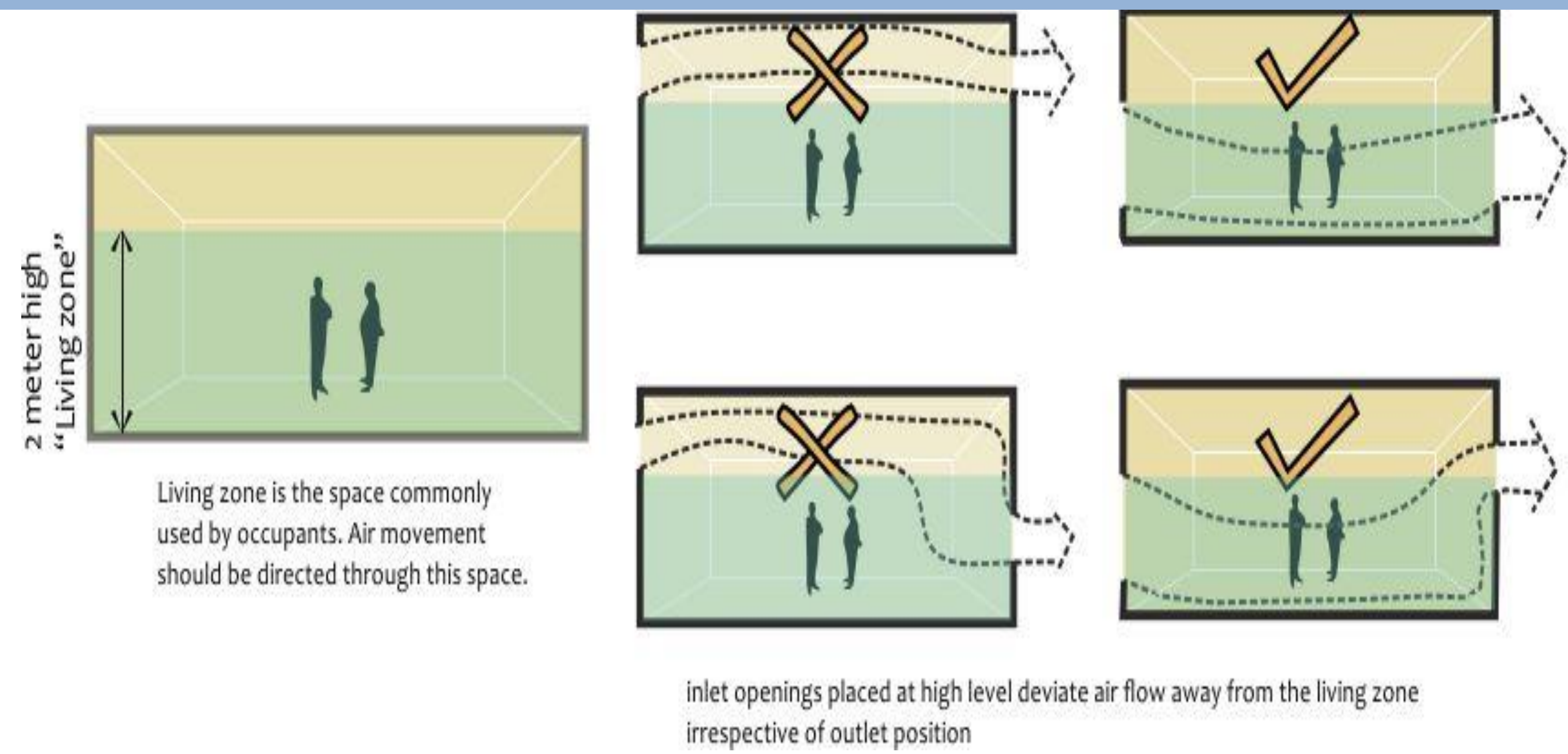
Day lighting and Shading at Aranya Housing, Indore

Source: NZEB

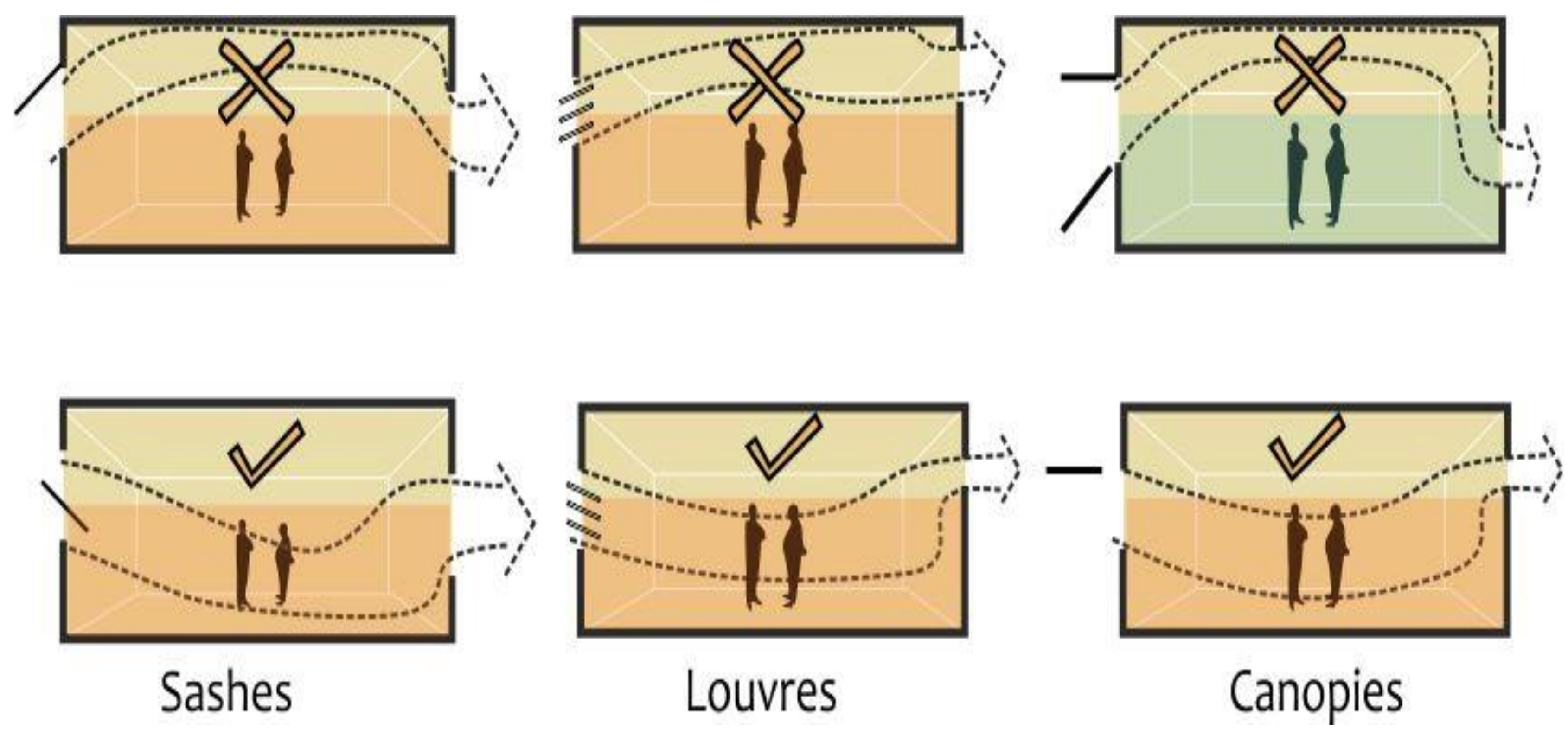
MEASURES TO IMPROVE THERMAL COMFORT
passive design strategies for affordable housing

NATURAL VENTILATION

Cross ventilation
to allow ***maximum air flow*** inside the space



Types of opening and their location



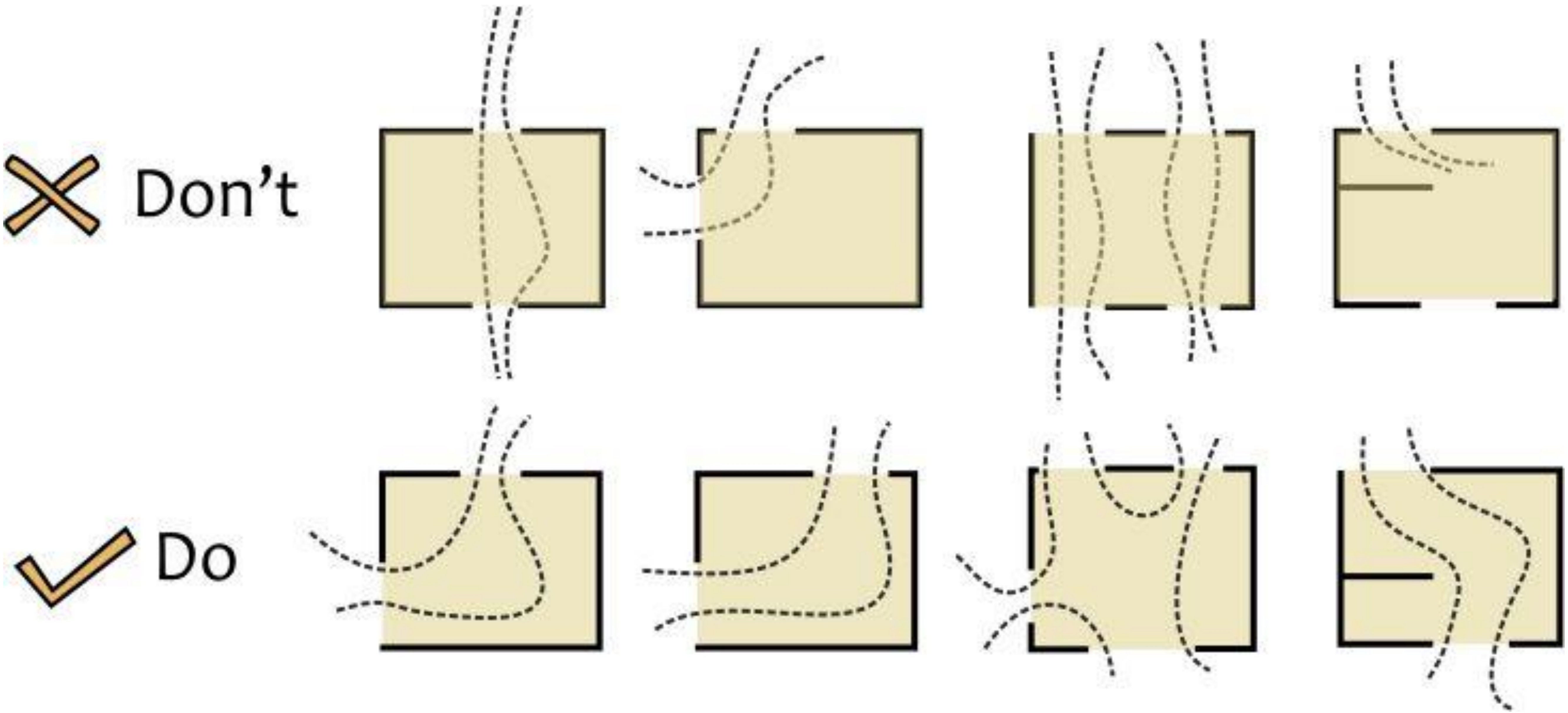
Natural ventilation helps in reducing mechanical cooling load of the building

Source: NZEB

MEASURES TO IMPROVE THERMAL COMFORT

passive design strategies for affordable housing

NATURAL VENTILATION



Horizontal placing of openings and internal partitions can alter the direction and spread of air stream

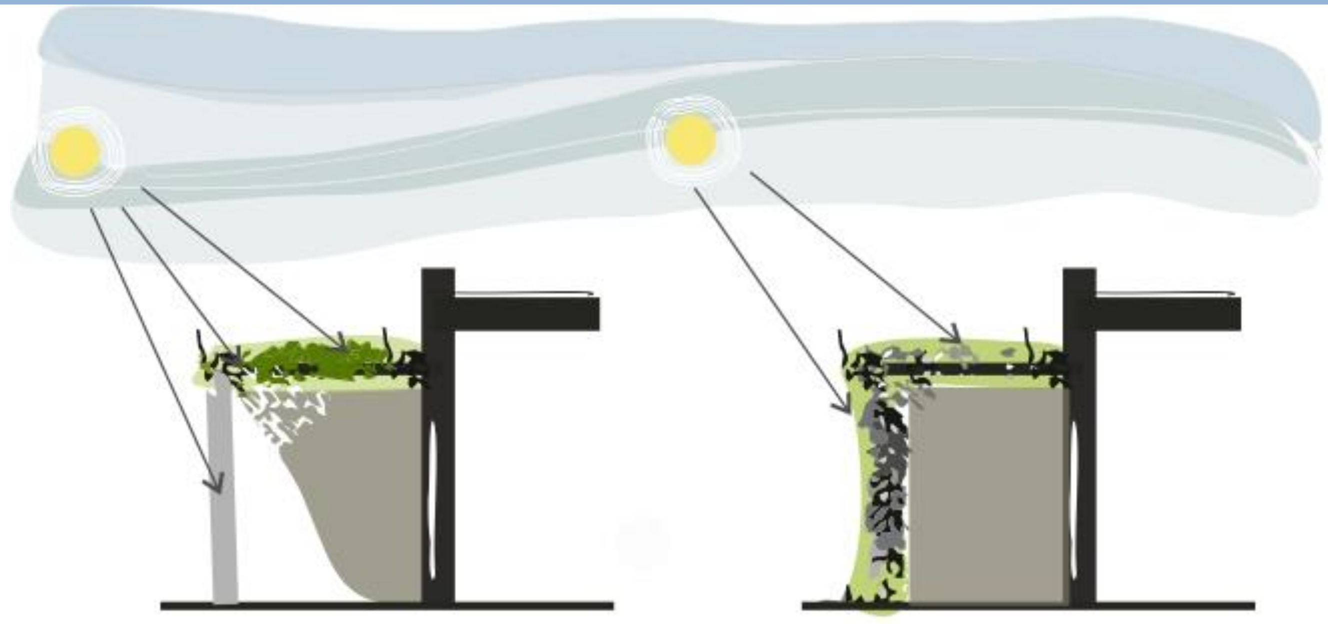
MEASURES TO IMPROVE THERMAL COMFORT

passive design strategies for affordable housing

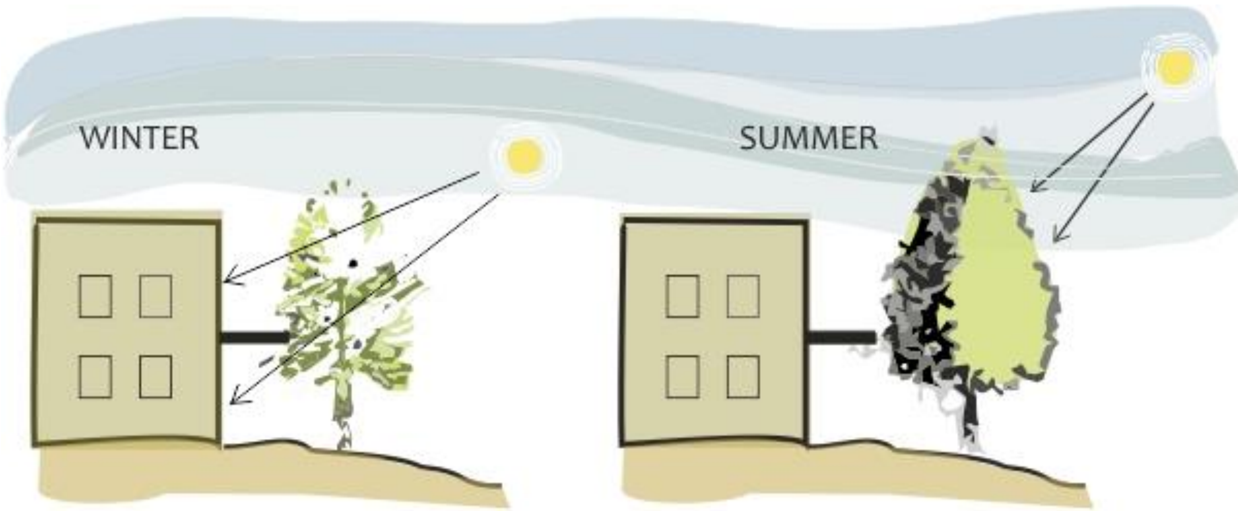
VEGETATION

Trees and shrubs create different air flow patterns, provide shading and keep the surroundings cooler in warm weather. Vegetation can be used for energy conservation in buildings in the following ways:

•Shading of buildings and open spaces through landscaping
•Roof gardens (or green roofs)
•Shading of vertical and horizontal surfaces (green walls)
•Buffer against cold and hot winds
•Changing direction of wind



creepers are flexible shading devices for shading verandahs and interior spaces as per the season

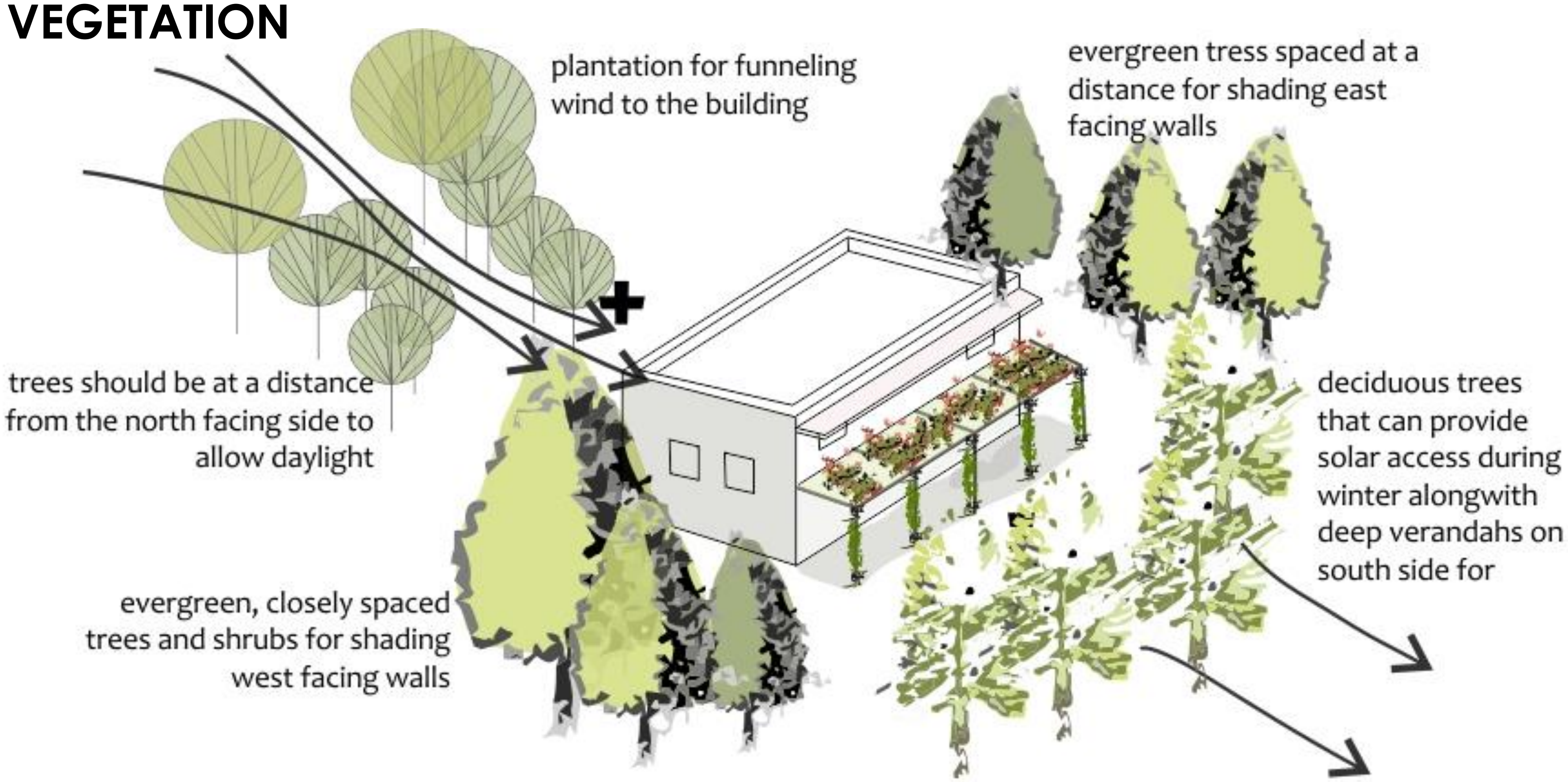


deciduous trees allow sun penetration in winter and block sun access during summer

MEASURES TO IMPROVE THERMAL COMFORT

passive design strategies for affordable housing

VEGETATION



An increase in urban **vegetation** to reduce urban heat and improve outdoor **thermal comfort.**

Trees also reduce ambient air temperature due to evapo-transpiration.

Study shows that ambient air under a tree adjacent to the wall is about 2 – 2.5°C lower than that for unshaded areas.

Community, Gary Horton, Landscape Development

Source: NZEB

CASE STUDY

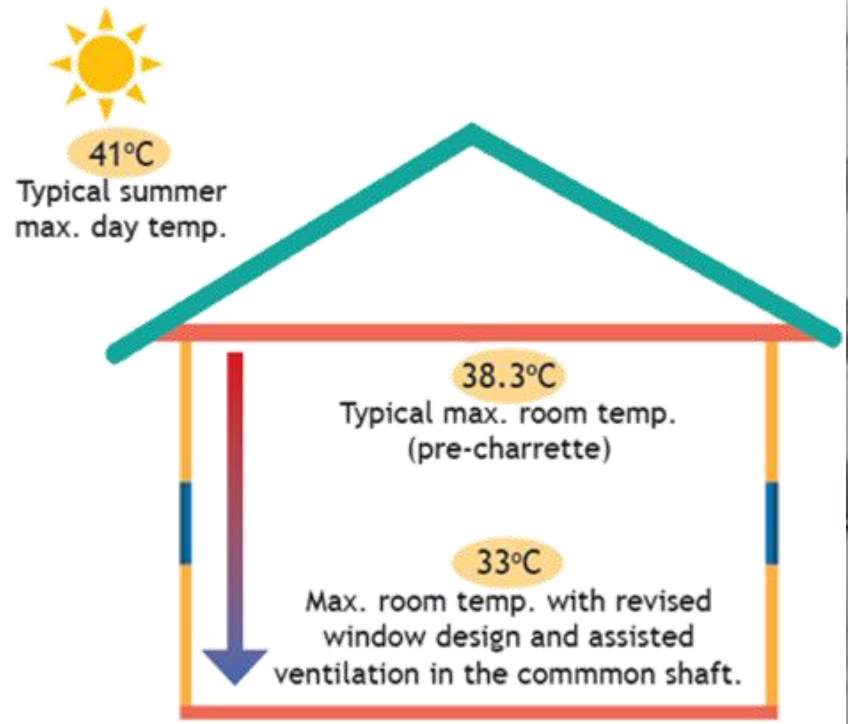
CASE STUDY - SMART GHAR III, RAJKOT

Project: Affordable housing in Rajkot under PMAY Untenable Slum Redevelopment.

- Site area: 17,593 m2
- Built-up area: 57,408 m2
- Number of dwelling units (DU): 1176 (All 1 BHK)
- 11 residential towers : Stilt + 7

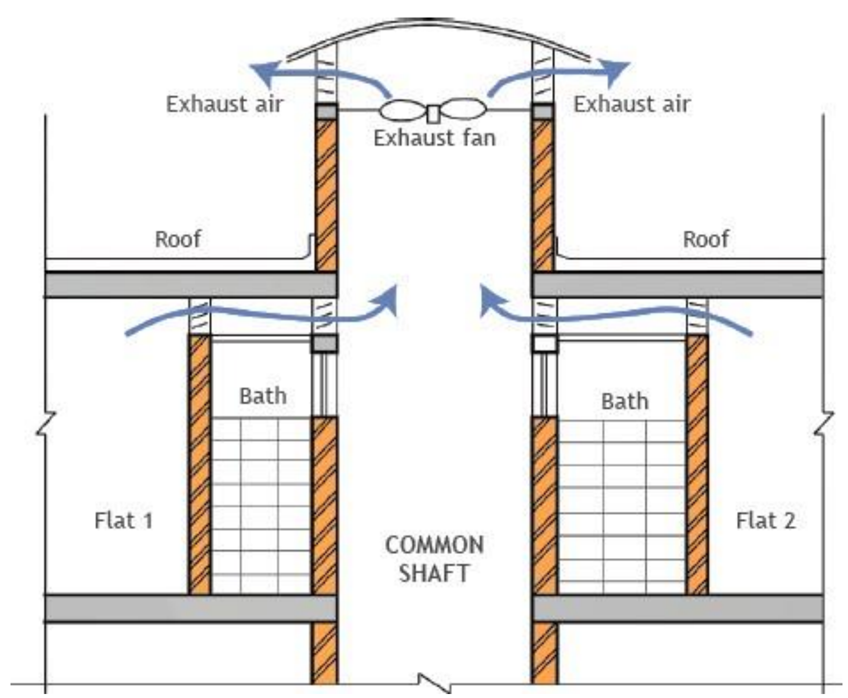
Key Features

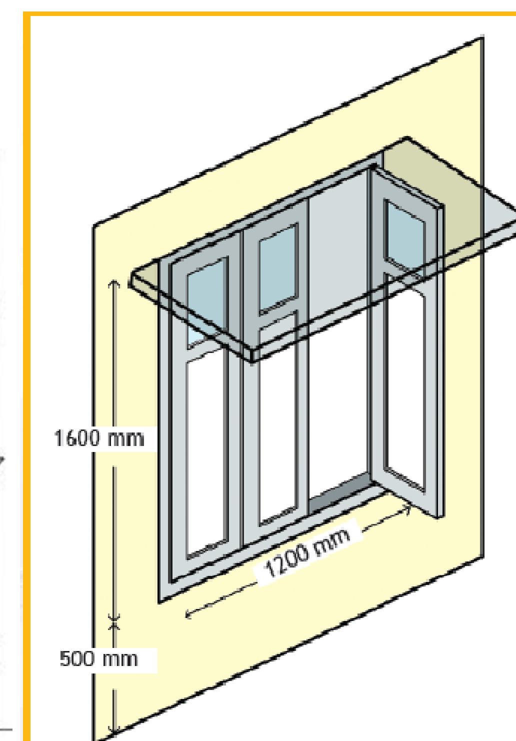
- Sensitively designed window shades to reduce heat gains while improving day light.
- Use of a fan-serviced ventilation shaft to improve air quality inside.



Outcomes

- Reduced peak summer room temperature by >5°C
- Increased number of comfortable hours from ~2600 hours to ~6300 hours.



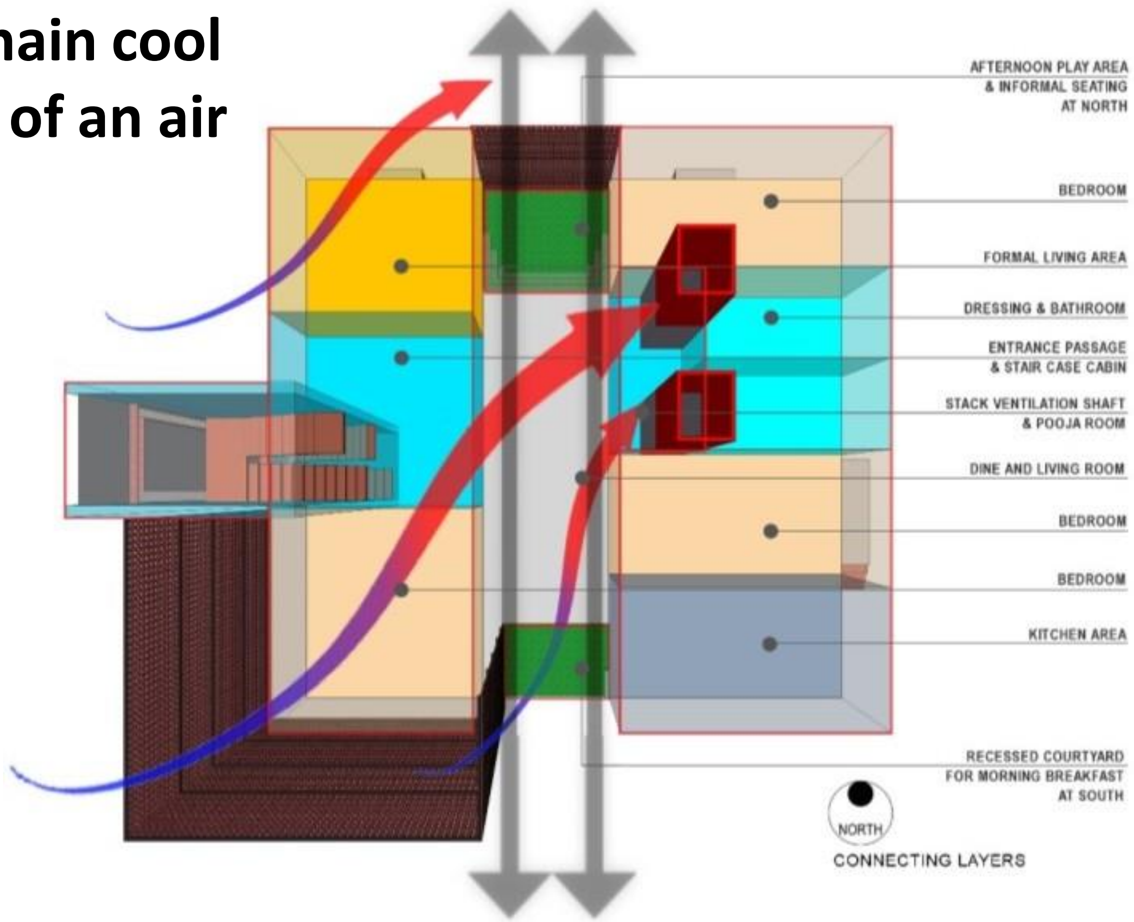


After charrette: Taller, partially glazed casement windows. Casement windows provide better natural ventilation as they are 90% openable. The window shutters are 2/3rd opaque, which prevents heat gains from entering. Glazing is reduced to 1/3rd, which provides adequate daylight.

Source: BEEP

CASE STUDY - RAM BAUGH, BURHANPUR

A residence which has been designed to remain cool without the use of an air conditioner.



Key Features

- mutual shading
- optimal building orientation

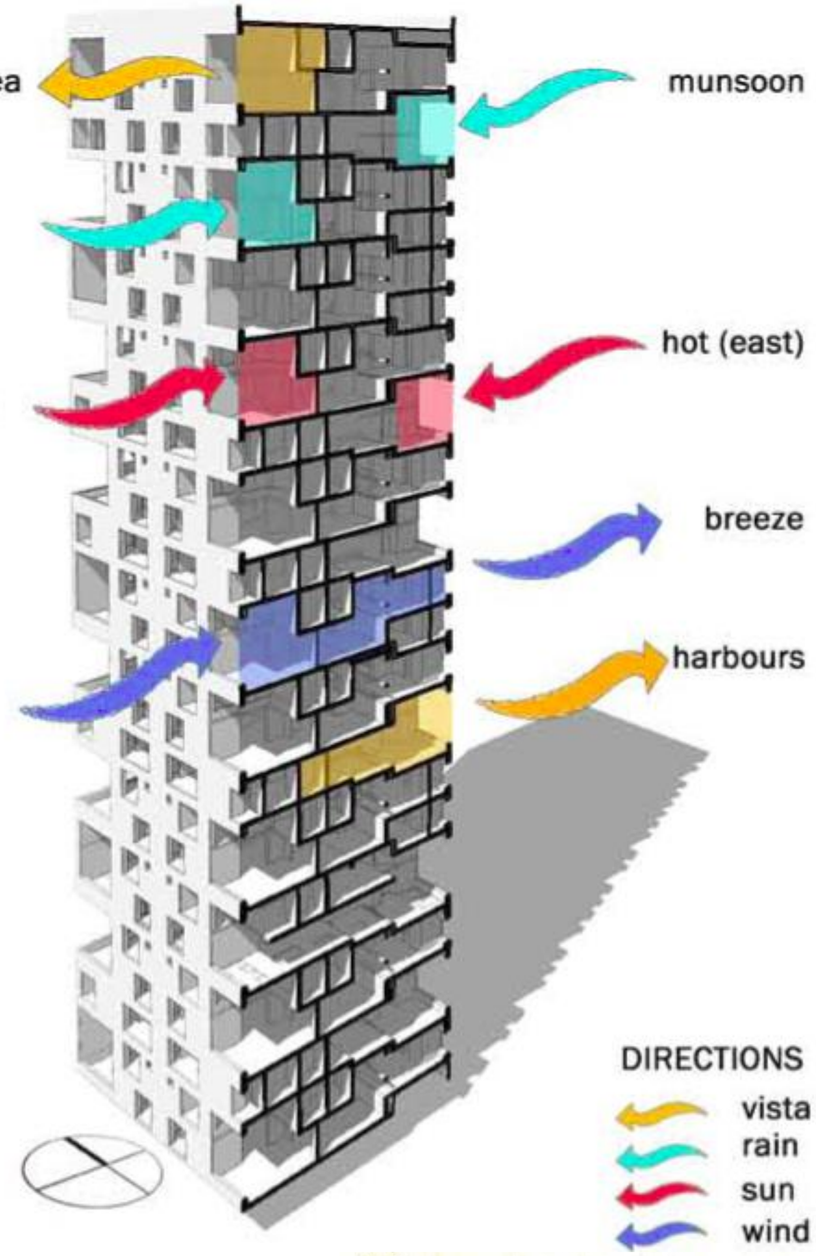
Source: Parekh Collaborative

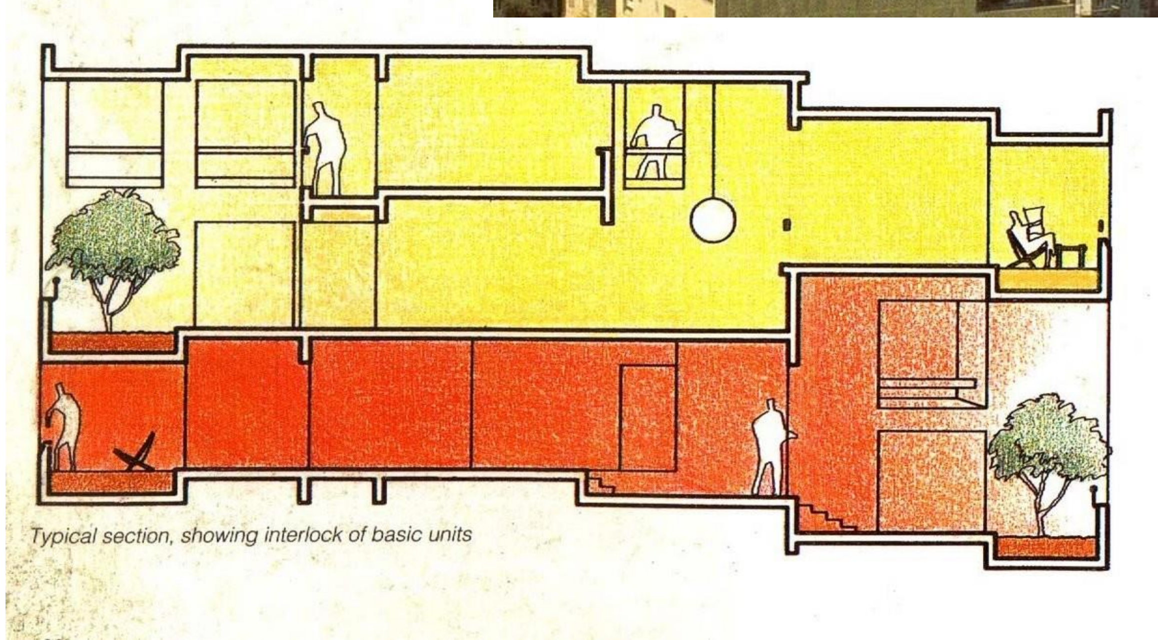
CASE STUDY - KANCHANJUNGA APARTMENTS

- **Architect:** Charles Correa
- **Location:** Bombay, India
- **Completed on:** 1983
- **Building Type:** Skyscraper multi-family housing
- **Construction System:** Concrete
- **Floors:** 32

Key Features

The main living spaces with an enclosed verandah whilst turning that buffer zone into a garden, thriving on the problem. Because of climatic considerations with existing views, the massing settled upon a configuration facing east and west





Typical section, showing interlock of basic units

Live exercise

a) Live exercise

i. Passive Architectural Design Strategies

ii. Building Construction material

iii. No cost solutions

BRIEF

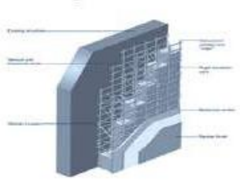
Climate

Thermal Comfort & Daylight system : Resist heat gain / Promote heat loss

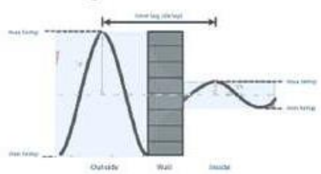
Common Building Design Strategies

Hot & Dry Climate

Increase thermal resistance
High Insulation



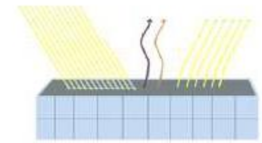
Increase thermal capacity (time-lag)
High Thermal Mass



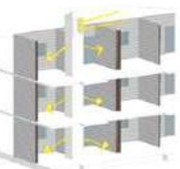
Increase buffer spaces
Air locks / Balconies etc.

Compact internal planning
Openings for cross ventilation

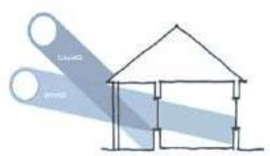
Increase surface reflectivity
High SRI paints, Cool roofs, China mosaic tiles etc.



Increase air exchange rate (Ventilation during night-time)
Provide windows / Exhausts / Courtyards/ wind towers



Roof overhangs
Roof overhangs can shade from summer sun while letting in winter rays.

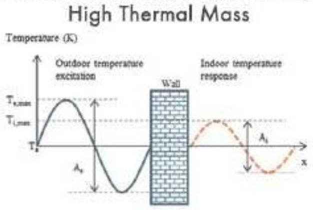


Increase humidity levels
Trees, water ponds, evaporative cooling, Potential heatsink, night cooling

Composite Climate

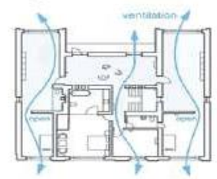
Increase thermal resistance
Moderate to High Insulation

Increase thermal capacity (time-lag)
High Thermal Mass



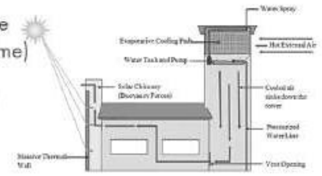
Increase buffer spaces
Balconies, courtyards etc.

Compact internal planning
Openings for cross ventilation



Increase surface reflectivity
High SRI paints, Cool roofs, China mosaic tiles etc.

Increase air exchange rate (Ventilation during night-time)
Provide windows / Exhausts / Courtyards/ wind towers / solar chimney



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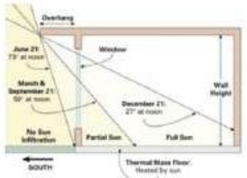
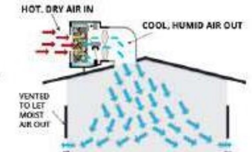
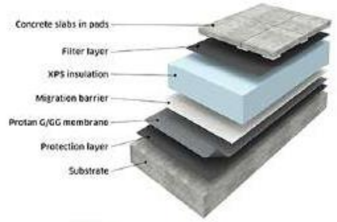


Increase humidity levels
Trees, water ponds, evaporative cooling, Potential heatsink



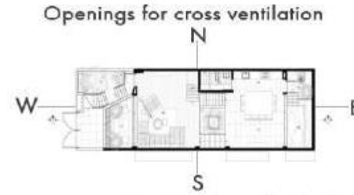
Warm & Humid Climate

Increase thermal resistance and thermal capacity (time-lag)
High Insulation & High thermal mass with water proofing

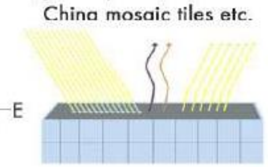


Increase buffer spaces
Balconies, verandahs etc.

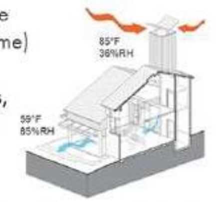
Elongated free plan can be evolved, if shaded well
Openings for cross ventilation



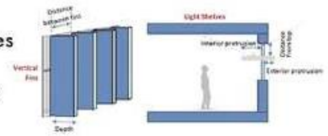
Increase surface reflectivity
High SRI paints, Cool roofs, China mosaic tiles etc.



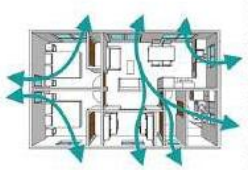
Increase air exchange rate (Ventilation during night-time)
Ventilated roof construction, Courtyards, wind towers (axial fans) and arrangement of openings



Shading
Walls, glass surfaces protected by overhangs, fins and trees

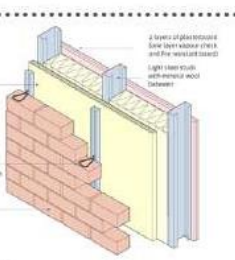


Decrease humidity levels
Dehumidifier/ desiccant cooling, Potential heatsink, Create Air pressure difference / Cross Ventilation enhancement



Moderate Climate

Increase thermal resistance and thermal capacity (time-lag)
High Insulation & low / moderate thermal mass

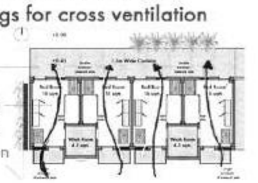


Increase buffer spaces
Balconies, verandahs, lobbies etc.

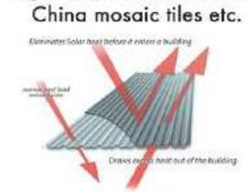
Elongated free plan can be evolved with single loaded corridor
Openings for cross ventilation

corridor

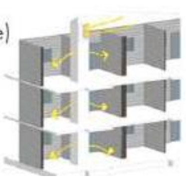
opposite side windows for cross ventilation



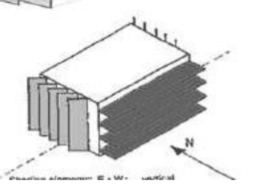
Increase surface reflectivity
High SRI paints, Cool roofs, China mosaic tiles etc.



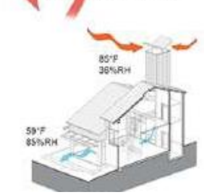
Increase air exchange rate (Ventilation during night-time)
Ventilated roof construction, Courtyards, wind towers (axial fans) and arrangement of openings



Shading
Walls, glass surfaces protected by overhangs, fins and trees



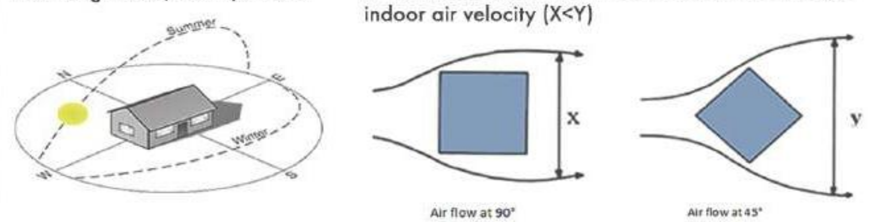
Decrease humidity levels
Dehumidifier/ desiccant cooling, Potential heatsink, Create Air pressure difference / Cross Ventilation enhancement



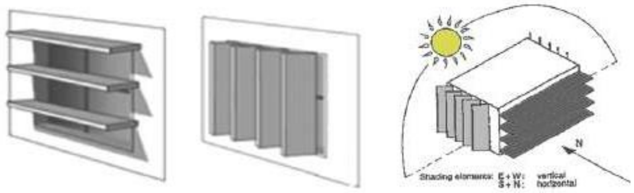
Common Building Design Strategies

Decrease exposed surface Area
E-W longer axis; Low S/V ratio

Building orientation w.r.t Wind
A wind incidence at 45 would increase the average indoor air velocity (X<Y)



Increase Shading
Adjustable vertical shading on E-W facade & Deep horizontal shading / overhangs & trees on South & SW facade



Dense planting as wind breaks

Deciduous trees & shurbs shade the east and west wall & windows

Placement of Trees

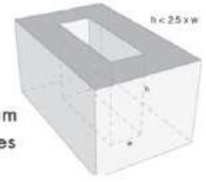
South facing courtyard with moist, cool fernery

Deciduous trees & vines to the north

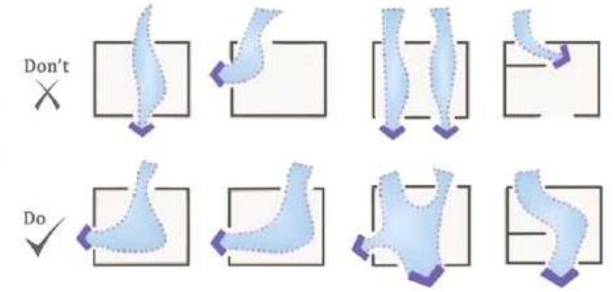
Keep evergreen trees well back from the

Window type
Taller windows give greater penetrations & broader windows give better distribution of light.

Atrium thumb Rule
To daylit all spaces bordering an interior atrium with diffuse daylight, the max. atrium height is about 2.5 times it's width.



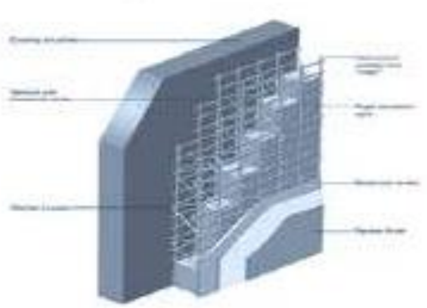
Placement of windows
Larger windows on the windward side & smaller openings on leeward side. Air movement must be ensured through the space mostly used by the occupants i.e. through the 'living zone' (up to 2 m high).



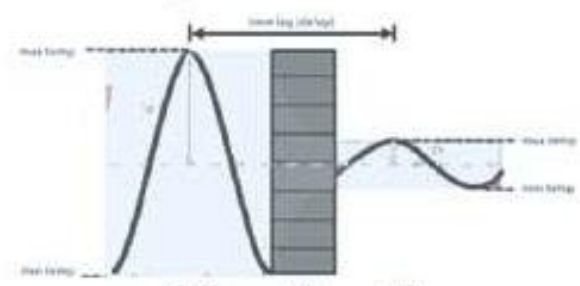
CLIMATE ZONE	Building Envelope Component					Minimum Openable Window to Floor Area ratio (WFR_{op})
	Wall	Roof	Glazing			
	U value (W/m²K)	U value (W/m²K)	U value (W/m²K)	SHGC (W/m²K) WWR<20%	SHGC (W/m²K) WWR>20%	
Hot & Dry	≤ 2.5	≤1.2	≤ 5.7	≤0.5	≤ 0.42	10%
Warm & Humid	≤ 2.5	≤1.8	≤ 5.7	≤0.5	≤ 0.42	16.66%
Composite	≤ 2.5	≤1.2	≤ 5.7	≤0.5	≤ 0.42	12.5%
Temperate	≤ 1.1	≤1.2	≤ 5.7	≤0.6	≤ 0.48	12.5%
Cold	≤ 2.5	≤1.2	≤ 5.7	≤0.8	≤ 0.80	8.33%

HOT & DRY CLIMATE

Increase thermal resistance
High Insulation



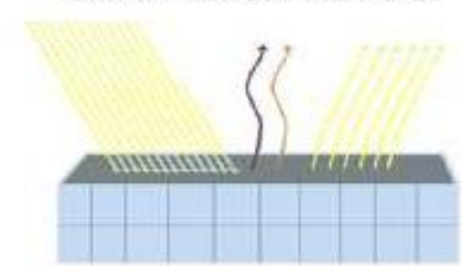
Increase thermal capacity (time-lag)
High Thermal Mass



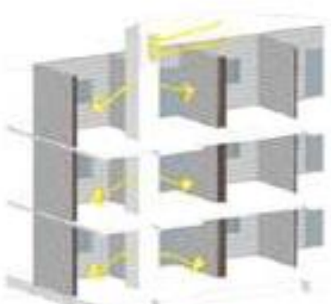
Increase buffer spaces
Air locks / Balconies etc.

Compact internal planning
Openings for cross ventilation

Increase surface reflectivity
High SRI paints, Cool roofs, China mosaic tiles etc.



Increase air exchange rate (Ventilation during night-time)
Provide windows / Exhausts / Courtyards/ wind towers

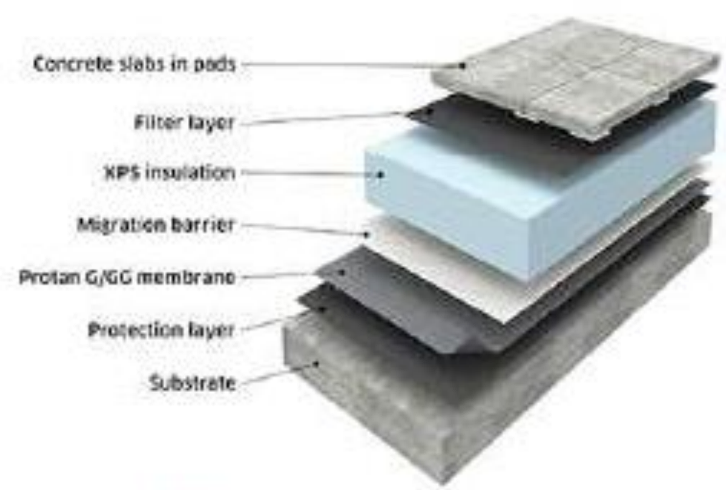


Roof overhangs
Roof overhangs can shade from summer sun while letting in winter rays.

Increase humidity levels
Trees, water ponds, evaporative cooling, Potential heatsink, night cooling

WARM AND HUMID CLIMATE

- Increase thermal Resistance and thermal Capacity(Time- lag) High Insulation & High Thermal mass with water proofing
- Increase air exchange rate (Ventilation during night- time)
- Ventilated roof construction, courtyards, wind towers (Axial Fans) and arrangement of openings



Increase buffer spaces
Balconies, verandahs etc.

Elongated free plan can be evolved, if shaded well
Openings for cross ventilation

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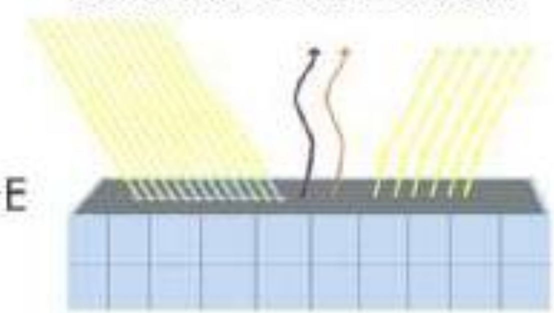
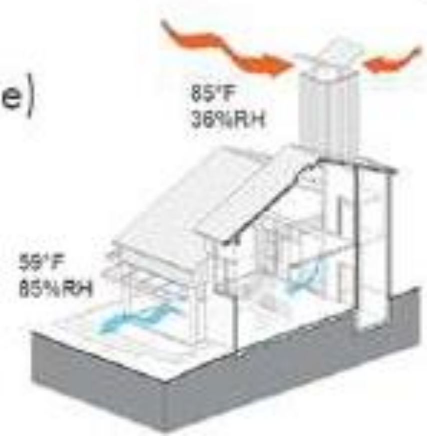
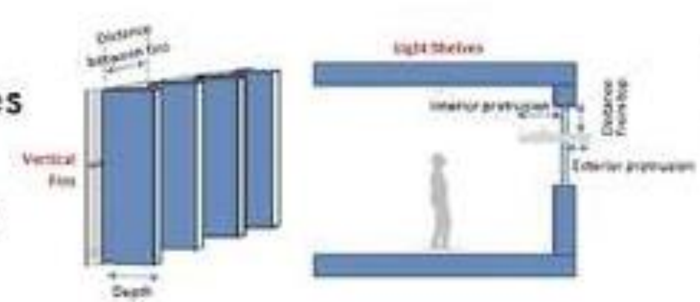
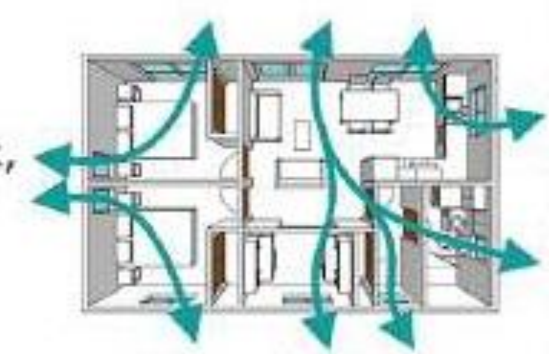




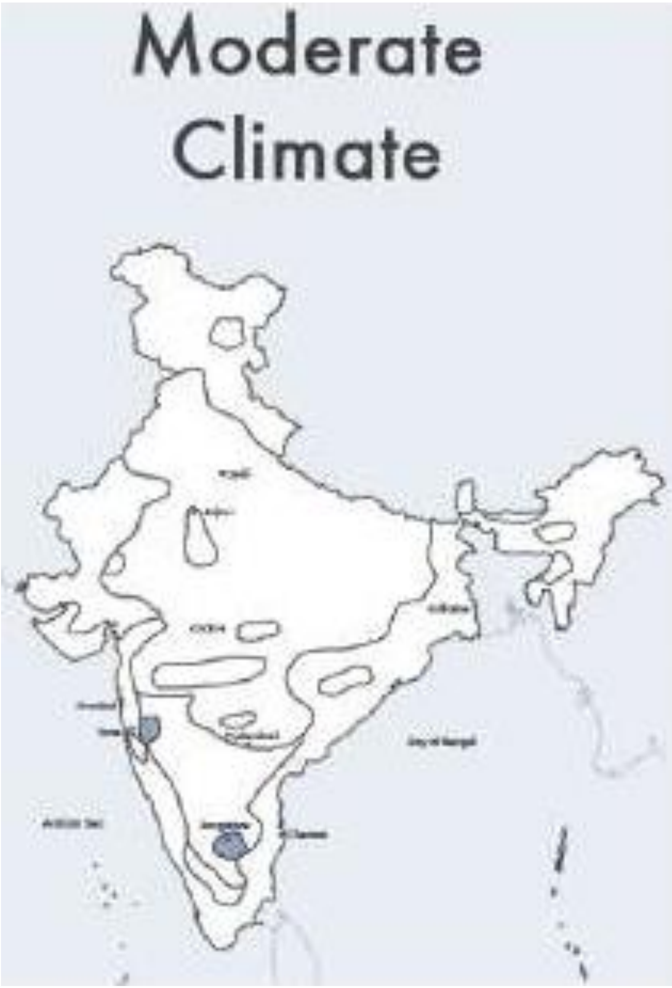
Shading
Walls, glass surfaces protected by overhangs, fins and trees



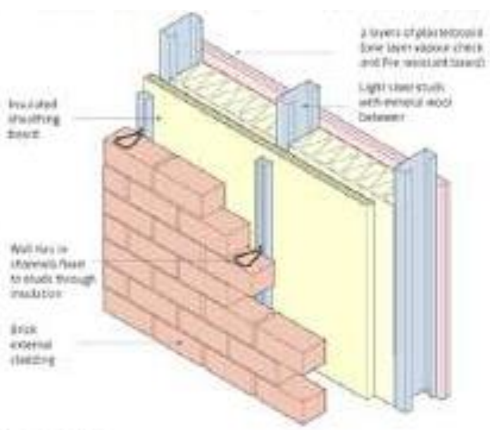
Decrease humidity levels
Dehumidifier/ desiccant cooling, Potential heatsink, Create Air pressure difference / Cross Ventilation enhancement



MODERATE CLIMATE

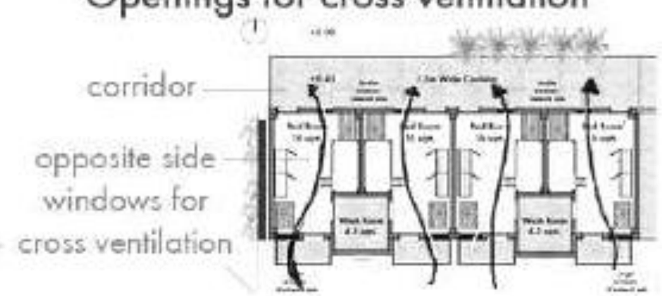


Increase thermal resistance and thermal capacity (time-lag)
High Insulation & low / moderate thermal mass



Increase buffer spaces
Balconies, verandahs, lobbies etc.

Elongated free plan can be evolved with single loaded corridor
Openings for cross ventilation



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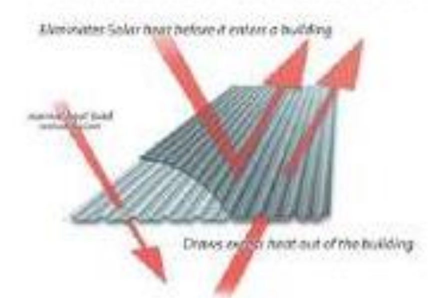
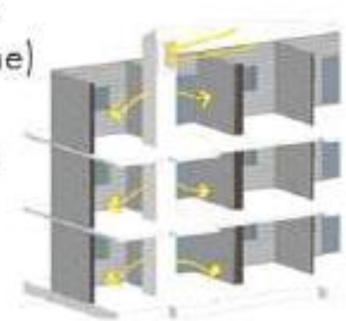


Increase air exchange rate (Ventilation during night-time)
Ventilated roof construction, Courtyards, wind towers (axial fans) and arrangement of openings



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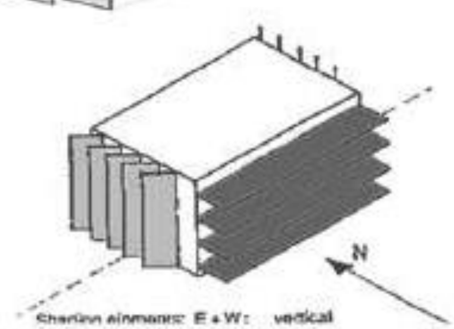
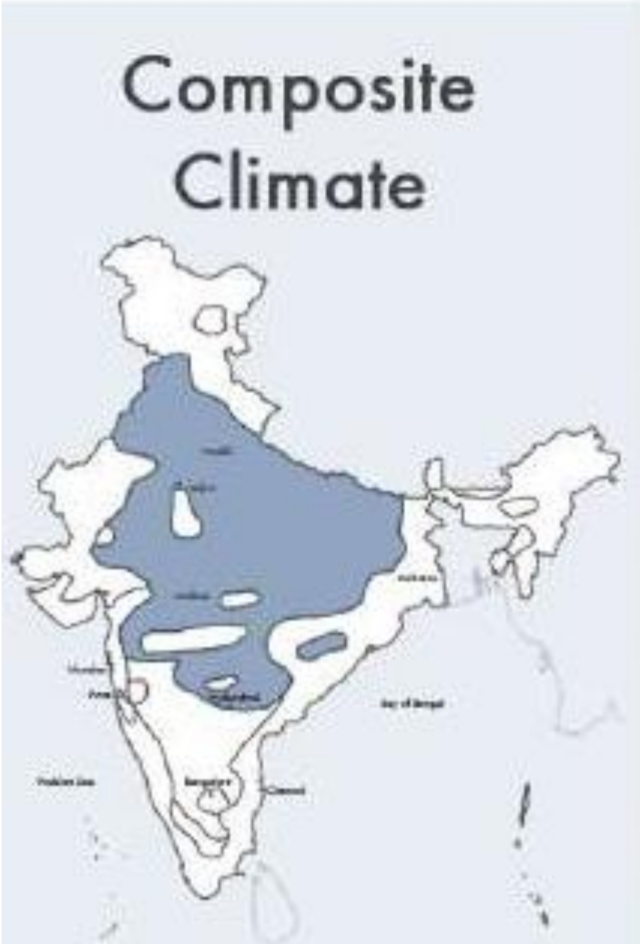


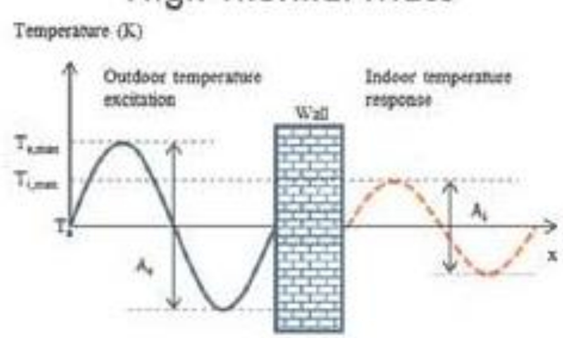
Decrease humidity levels
Dehumidifier/ desiccant cooling, Potential heatsink, Create Air pressure difference / Cross Ventilation enhancement

COMPOSITE CLIMATE



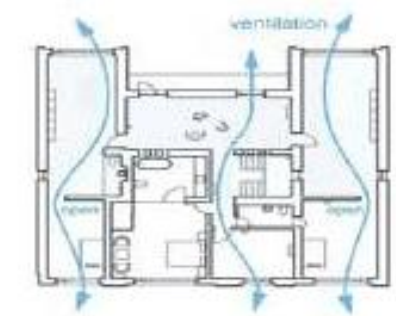
Increase thermal resistance
Moderate to High Insulation

Increase thermal capacity (time-lag)
High Thermal Mass

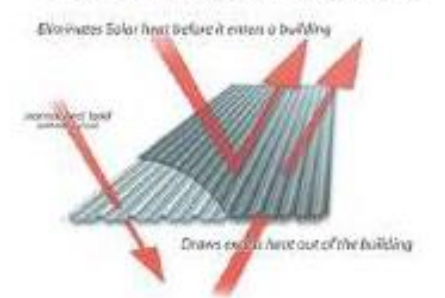


Increase buffer spaces
Balconies, courtyards etc.

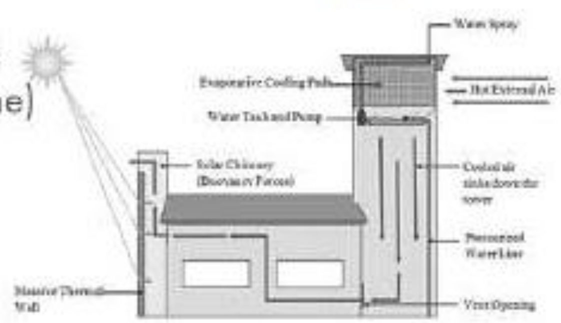
Compact internal planning
Openings for cross ventilation



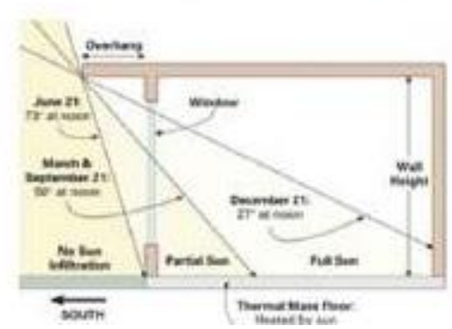
Increase surface reflectivity
High SRI paints, Cool roofs, China mosaic tiles etc.



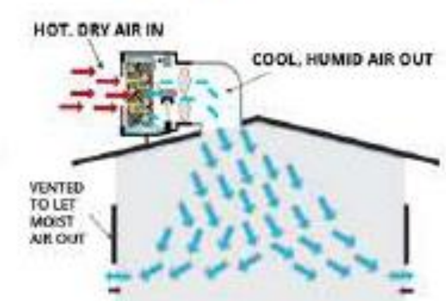
Increase air exchange rate
(Ventilation during night-time)
Provide windows / Exhausts / Courtyards/ wind towers / solar chimney

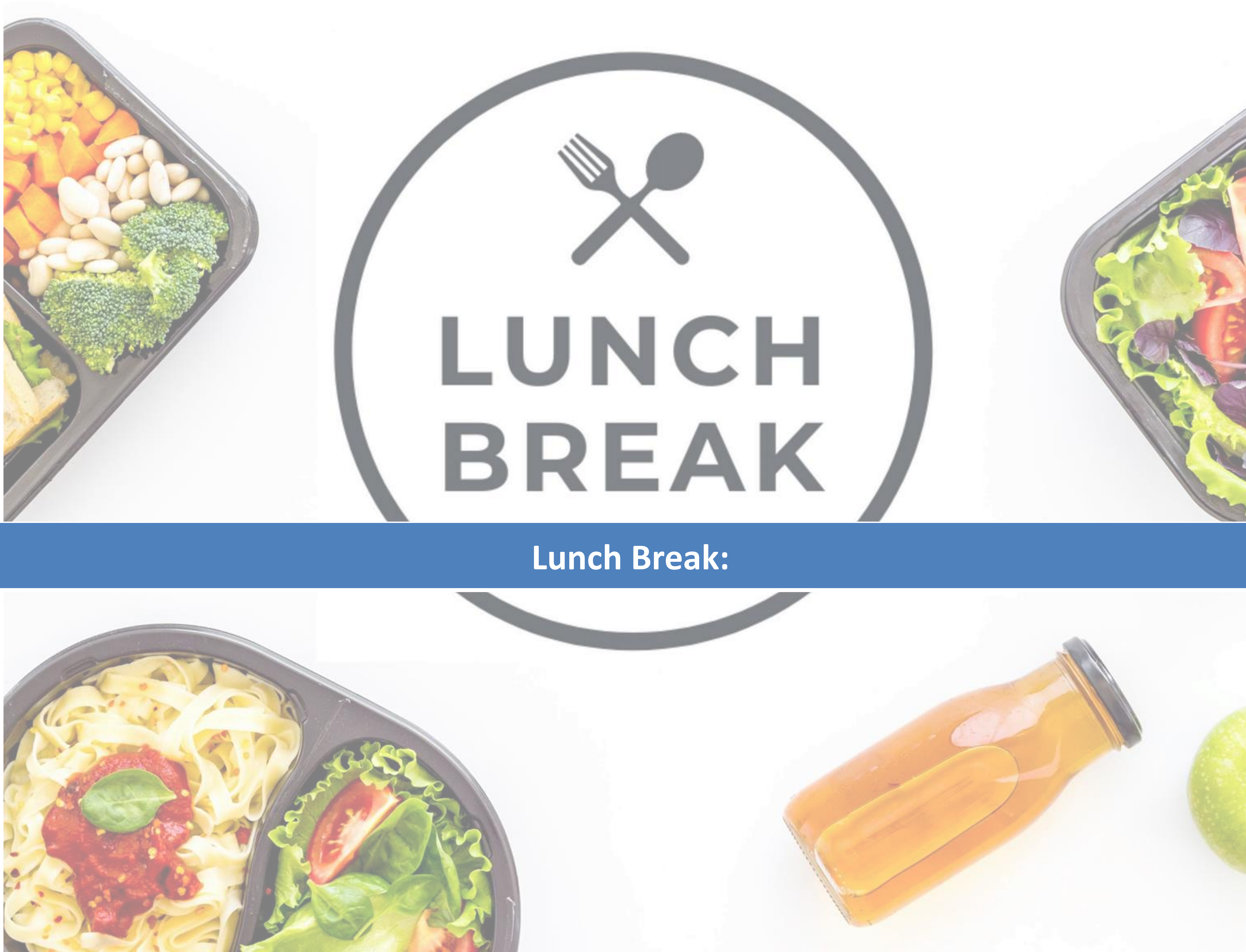


Roof overhangs
Roof overhangs can shade from summer sun while letting in winter rays.



Increase humidity levels
Trees, water ponds, evaporative cooling, Potential heatsink





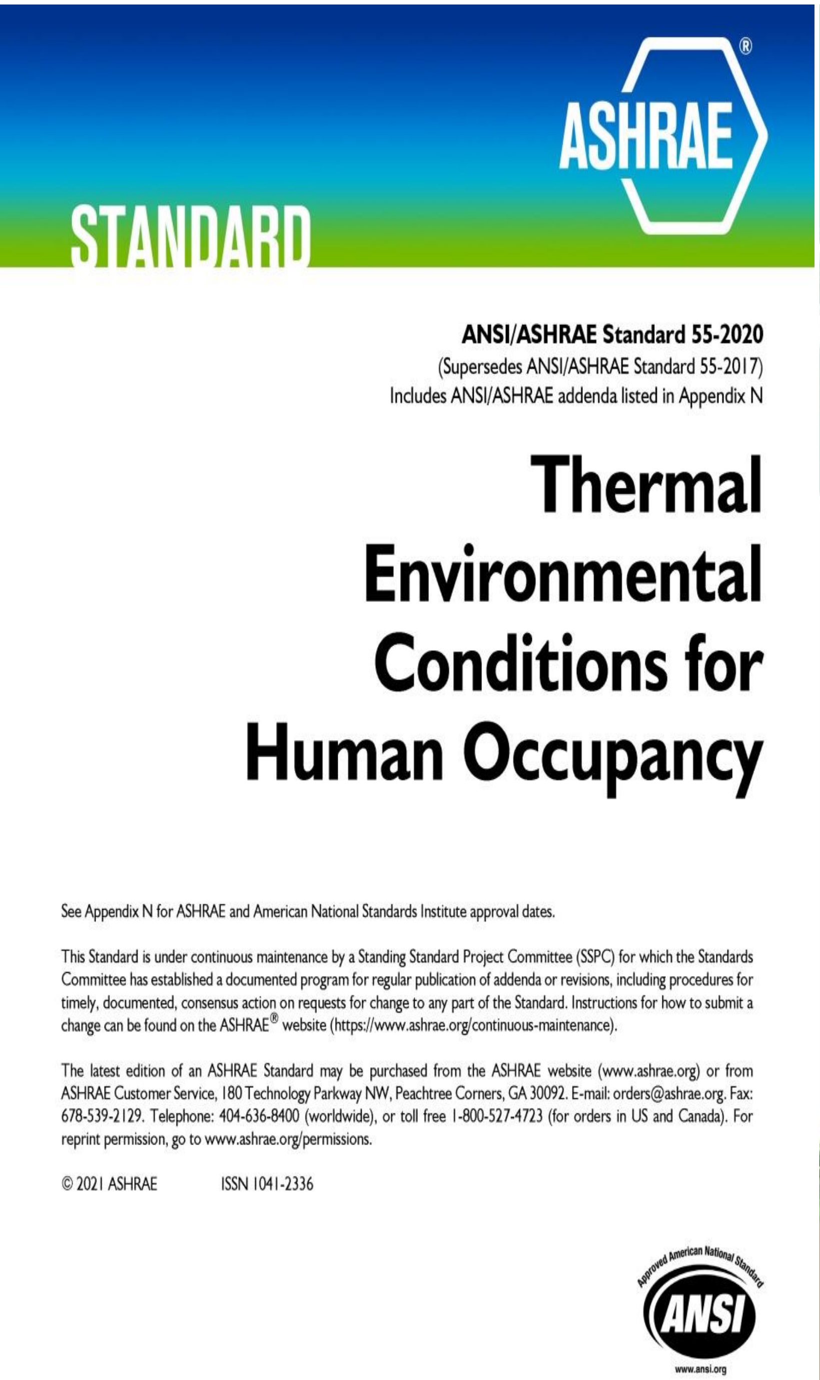
Lunch Break:

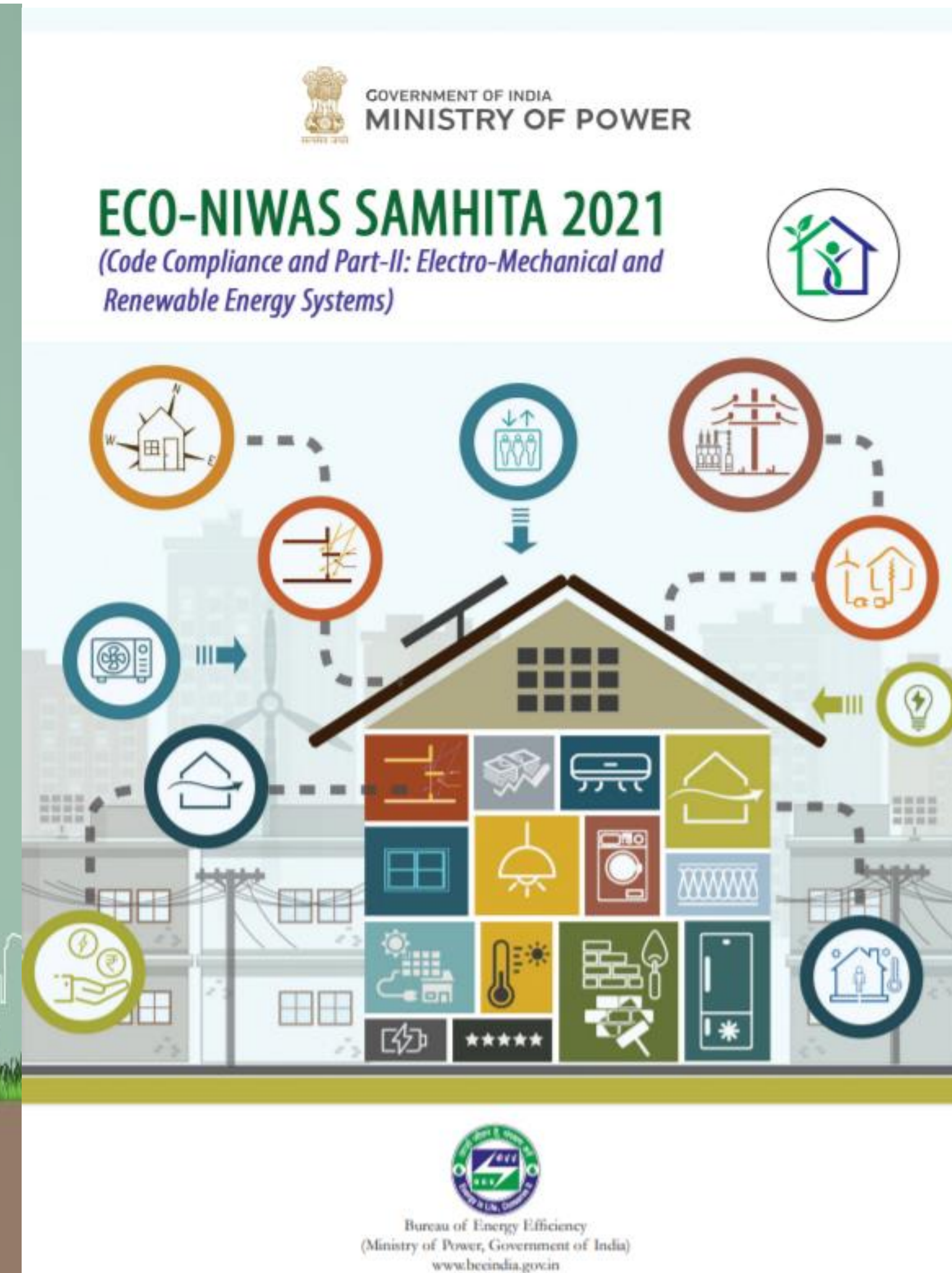
Thermal comfort

Session 2: Thermal Comfort

a) **Thermal Comfort standards**
b) **IMAC**
c) **ASHRAE**
d) **Effect of materials on thermal comfort**

EXISTING STANDARDS FOR IMPROVING THERMAL COMFORT





EXISTING STANDARDS FOR IMPROVING THERMAL COMFORT

According to the IMAC model, **neutral temperature in naturally ventilated buildings varies from 19.6 to 28.5 °C for 30-day outdoor running mean air temperatures ranging from 12.5 to 31 °C**.

An Introduction to the India Model for Adaptive (Thermal) Comfort

IMAC 2014

Principal investigators

Sanyogita Manu, Yash Shukla and Rajan Rawal

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

Lead experts and Co-investigators

Richard de Dear, *University of Sydney*

Leena Thomas, *University of Technology, Sydney*

Funding bodies

Ministry of New and Renewable Energy, Govt. of India and Shakti Sustainable Energy Foundation

Introduction

Buildings represent around 40% of world's primary energy consumption. They are, therefore, directly responsible for increase in greenhouse gases and can play a key role in climate change adaptation. To achieve an energy efficient building regime, governments, businesses and individuals must transform the way buildings are designed, built and operated. Energy consumption in new and existing buildings can be reduced through design interventions, low-energy systems and behavioural changes.

In India, electricity demand already exceeds supply. The largest and most significant end use of electricity in commercial buildings is air-conditioning. The rapid growth in new floor space combined with an increase in thermal comfort expectations and aspirations, will lead to a surge in demand for air conditioning. If permitted unchecked, the growth in building air-conditioning will add immense pressure on electricity infrastructure and exacerbate the already extreme peak-demand problem in the country.

In order to prevent an increase in energy use associated with space cooling, the deployment of low energy adaptive strategies in building operation is critical. This could also help increase our resilience to the effects of climate change. When the occupants are allowed to adapt to a building's environment by means of adjusting their clothing, cooling or heating set points, operation of windows, or any other measures, they are able to tolerate a wider range of environmental conditions, which, in turn, helps save energy. At present, the predominant trend in India is to design air-conditioned office buildings that operate at 22.5 ± 1°C all year round to meet the stringent specifications outlined by ISO 2005 and ASHRAE 55. These buildings are designed as sealed and fully controlled environments, and do not take advantage of favourable outdoor conditions whenever available. This conventional approach to design and

EXISTING STANDARDS FOR IMPROVING THERMAL COMFORT

ASHRAE-55

EXISTING STANDARDS FOR IMPROVING THERMAL COMFORT

National Building Code of India (NBC 2016)

National Building Code (NBC) of India is a standard which unifies the building regulations all over the country.

Type	Adaptive comfort model as per NBC 2016
Naturally ventilated building	T_{in}=0.54T_{rm} +12.83 90% acceptability range: ±2.38 °C
Mixed mode building	T_{in}=0.28T_{rm} +17.87 90% acceptability range: ±3.48 °C
Air-conditioned building	Air temperature-based approach: T_{in}=0.078T_{rm} +23.25 90% acceptability range: ±1.5 °C
	Standard Effective Temperature based approach: SET_{in}=0.014T_{rm} +24.53 90% acceptability range: ±1.0 °C

Tin: Indoor operative temperature (in °C) is neutral temperature

Trm: 30-days running mean outdoor temperature

SETin: Standard effective temperature (in °C) is neutral temperature

Adaptive Thermal Comfort Equation for determining acceptable indoor conditions as per NBC 2016

EXISTING STANDARDS FOR IMPROVING THERMAL COMFORT

Table 9 Desirable Wind Speeds (m/s) for Thermal Comfort Conditions

(*Clause* 5.2.3.1.2)

Sl. No.	Dry Bulb Temperature °C	Relative Humidity Percent						
		30	40	50	60	70	80	90
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
i)	28	[1]	[1]	[1]	[1]	[1]	[1]	[1]
ii)	29	[1]	[1]	[1]	[1]	[1]	0.06	0.19
iii)	30	[1]	[1]	[1]	0.06	0.24	0.53	0.85
iv)	31	[1]	0.06	0.24	0.53	1.04	1.47	2.10
v)	32	0.20	0.46	0.94	1.59	2.26	3.04	[2]
vi)	33	0.77	1.36	2.12	3.00	[2]	[2]	[2]
vii)	34	1.85	2.72	[2]	[2]	[2]	[2]	[2]
viii)	35	3.20	[2]	[2]	[2]	[2]	[2]	[2]

[1] None.
[2] Higher than those acceptable in practice.

Table 10 Minimum Wind Speeds (m/s) for Just Acceptable Warm Conditions

(*Clause* 5.2.3.1.2)

Sl No.	Dry Bulb Temperature °C	Relative Humidity Percent						
		30	40	50	60	70	80	90
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
i)	28	[1]	[1]	[1]	[1]	[1]	[1]	[1]
ii)	29	[1]	[1]	[1]	[1]	[1]	[1]	[1]
iii)	30	[1]	[1]	[1]	[1]	[1]	[1]	[1]
iv)	31	[1]	[1]	[1]	[1]	[1]	0.06	0.23
v)	32	[1]	[1]	[1]	0.09	0.29	0.60	0.94
vi)	33	[1]	0.04	0.24	0.60	1.04	1.85	2.10
vii)	34	0.15	0.46	0.94	1.60	2.26	3.05	[2]
viii)	35	0.68	1.36	2.10	3.05	[2]	[2]	[2]
ix)	36	1.72	2.70	[2]	[2]	[2]	[2]	[2]

[1] None.
[2] Higher than those acceptable in practice.

Table 11 Maximum Permissible Wet Bulb Temperatures for Given Dry Bulb Temperatures

(*Clause* 5.2.3.2)

Sl No.	Dry Bulb Temperature °C	Maximum Wet-Bulb Temperature °C
(1)	(2)	(3)
i)	30	29.0
ii)	35	28.5
iii)	40	28.0
iv)	45	27.5
v)	50	27.0

NOTES

1 These are limits beyond which the industry should not allow the thermal conditions to go for more than 1h continuously. The limits are based on a series of studies conducted on Indian subjects in psychrometric chamber and on other data on heat casualties in earlier studies conducted in Kolar Gold Fields and elsewhere.

2 Figures given in this table are not intended to convey that human efficiency at 50°C will remain the same as at 30°C, provided appropriate wet bulb temperatures are maintained. Efficiency decreases with rise in the dry bulb temperature as well, as much as possible. Long exposures to temperature of 50°C dry bulb/27°C wet bulb may prove dangerous.

3 Refrigeration or some other method of cooling is recommended in all cases where conditions would be worse than those shown in this table.

National Building Code of India (NBC 2016)

EXISTING STANDARDS FOR IMPROVING THERMAL COMFORT

Eco-Niwas Samhita (Energy Conservation Building Code for Residential Buildings)

Eco-Niwas Samhita 2018 (BEE, 2018) is the new Energy Conservation Building Code for Residential Buildings (ECBC-R) which has following provisions:

1. To minimize the heat gain in cooling dominated climate or heat loss in heating dominated climate,

a. Through the building envelope (excluding roof):

  i. Maximum RETV for cooling dominated climate (Composite Climate, Hot-Dry Climate, Warm-Humid Climate, and Temperate Climate)

  ii. Maximum U-value for the cold climate

b. Through the Roof: Maximum U-value for Roof

2. For natural ventilation potential

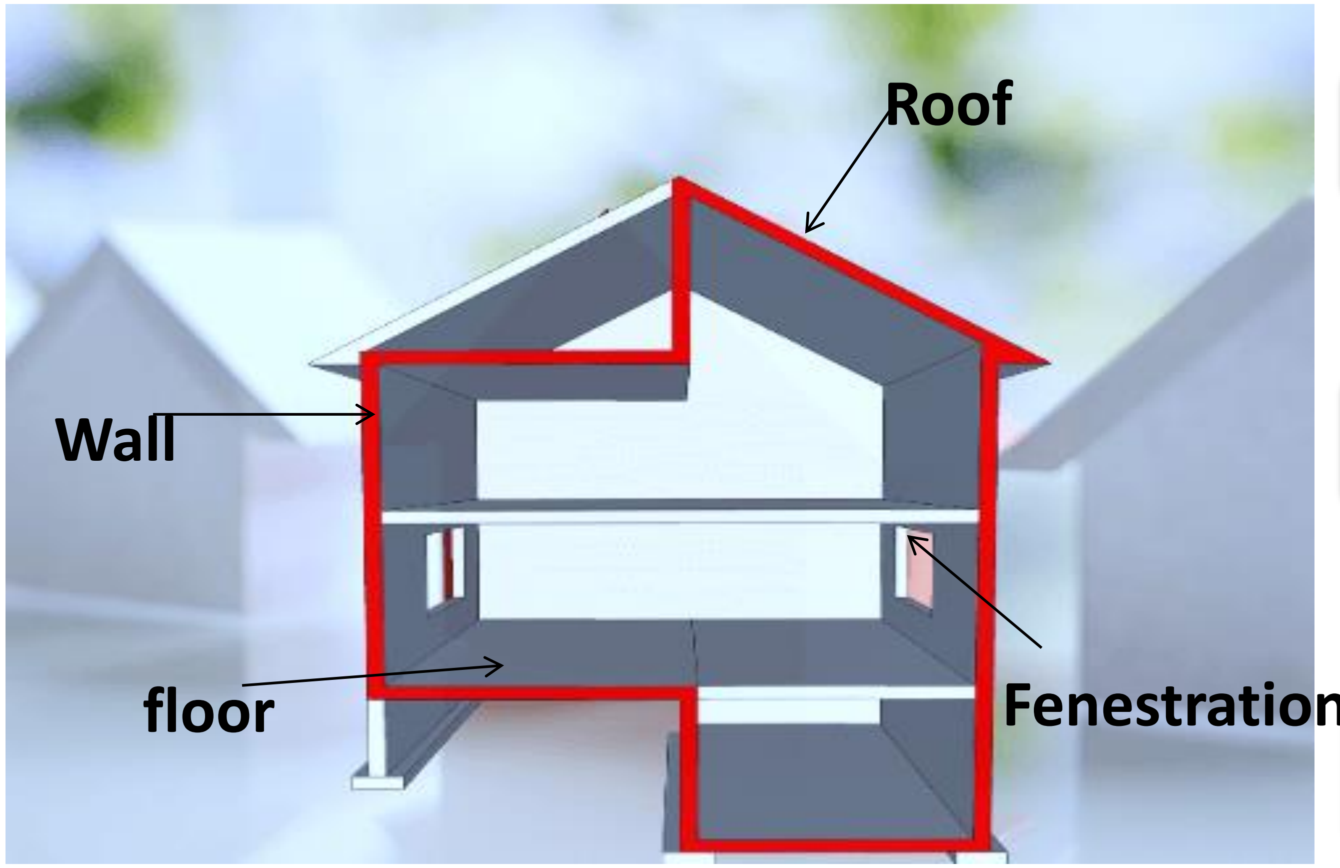
a. Minimum openable window-to-floor area ratio with respect to the climatic zone

3. For daylight potential

a. Minimum visible light transmittance with respect to window-to-wall ratio

This code focuses on building envelope and aims to improve the thermal comfort and reduce the energy required for cooling and lighting in Residential buildings.

EFFECT OF MATERIALS ON THERMAL COMFORT



CONDUCTION

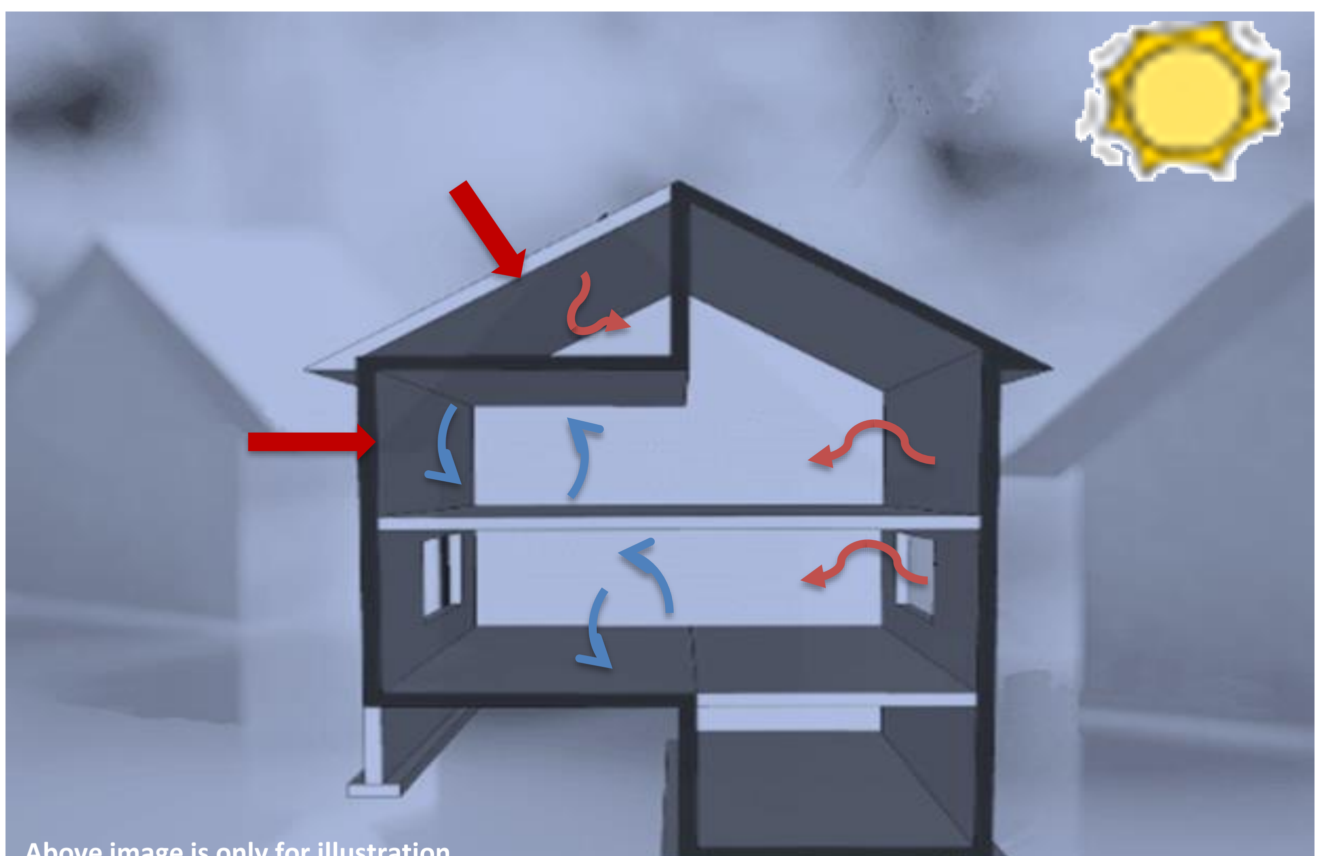
Transfer of heat from one material to another, through direct contact

CONVECTION

Transfer of heat through a medium, in case of buildings it is mostly air

RADIATION

Energy that is radiated in form of rays/ waves



Above image is only for illustration

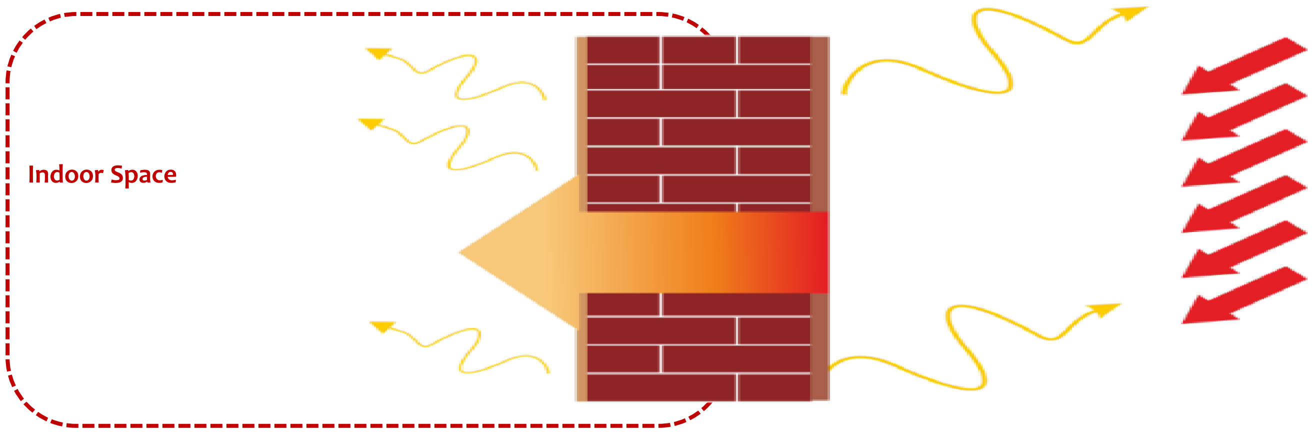
Building consist of wall, roof, fenestration, floor, sky light, columns, beams, doors

For the same we do require different materials to fulfil the user requirements such as aesthetics, safety, visibility, etc.

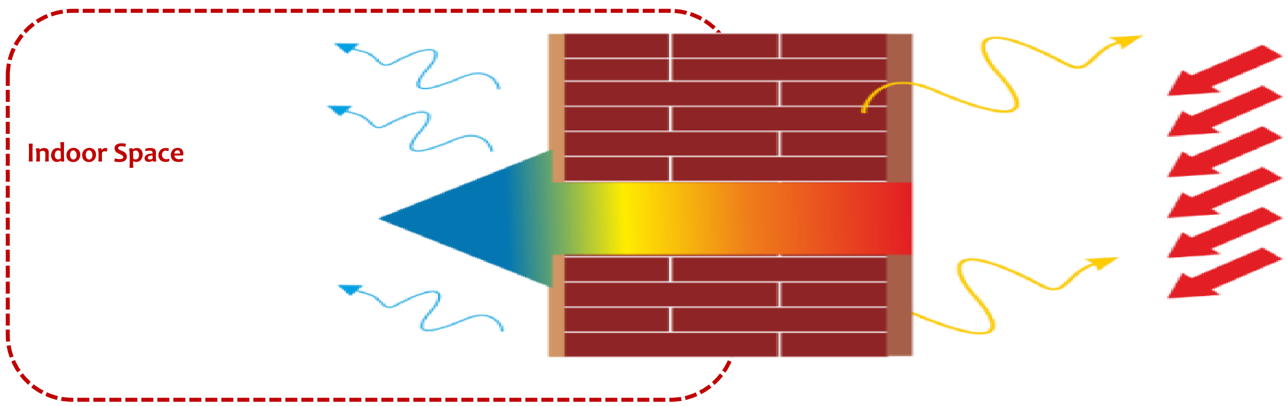
EFFECT OF MATERIALS ON THERMAL COMFORT

Thermal transmittance U-value

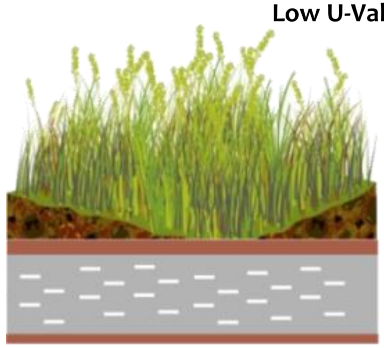
- Heat transfer due to temperature difference, inside & outside
- Heat transmission in unit time through unit area of a material or construction and the boundary air films, induced by unit temperature difference between the environments on each side
- Unit of U value is **W/m²k**.



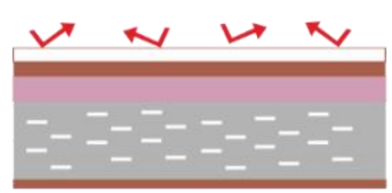
High U-Value



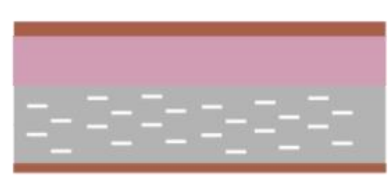
Low U-Value



Above Deck Insulation



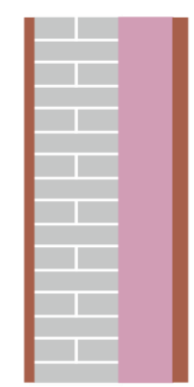
Reflective Tiles with above deck insulation of low thickness



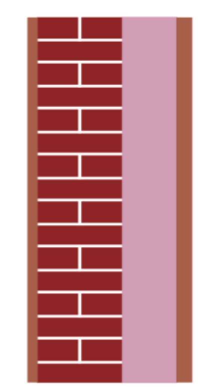
Above Deck Insulation

For Roof

- Reflective paints
- Roof garden
- Insulation
- Reflective tiles- China Mosaic



External Insulation with AAC Block



Externally Insulated Wall

For External Wall

- Increase wall thickness
- Insulations over walls
- Cavity

EFFECT OF MATERIALS ON THERMAL COMFORT

Before selecting insulation material for a building, the following factors need to be considered:

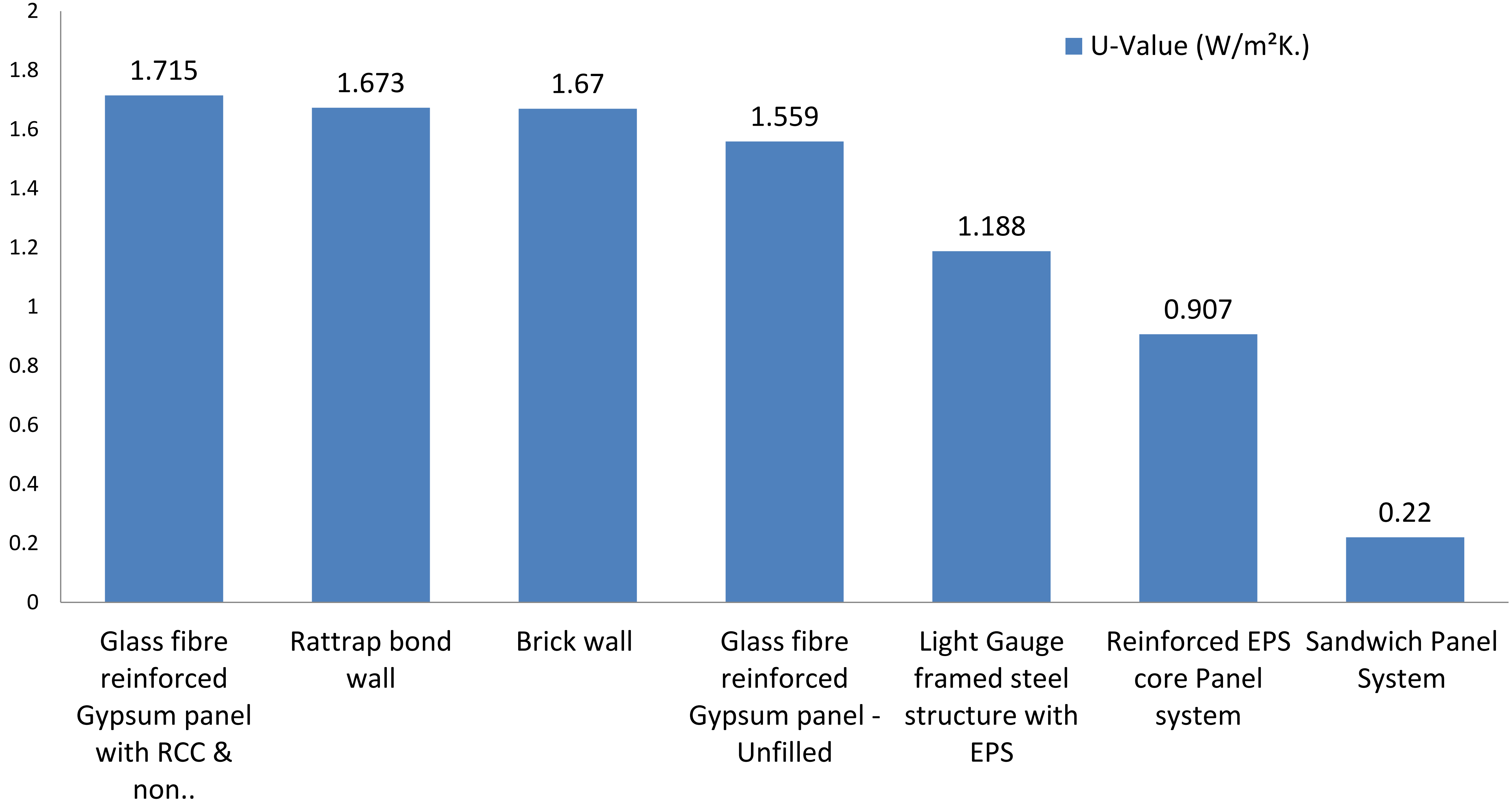
- ✓ The climatic conditions of the region
- ✓ The material flammability in case of an accident
- ✓ Material toxicity
- ✓ Ease of replacement of the material
- ✓ Material affordability
- ✓ Material durability
- ✓ Ease of installation

Characteristic of insulating materials	Insulating Power	Density	Fire Resistance	Water vapor diffusion	Resistance to water	Compression Strength	Traction Strength	Heat Resistance	Absorption of vibrations	Absorption of aerial noise	Cost at given insulation	Embodied Energy
Light mineral Wool	+	_-_	++	-	O	_-_	_-_	+		++	+	_-_
Dense Mineral Wool	++	+	++	_-_	O	O	_	++	++	+	+	O
Glass foam	+	+	++	++	++	++	++	++	_-_	_	+++	O
PUR	++	-	O	-	O	+	+	++	_	_-_	+	++
EPS	++	_-_	+	+	O	+	+	O	_	_-_	+++	_
XPS	++	O	+	++	+	+	++	O	-	_-_	+	+
++ Very high; + High; O Average; - Low; _-_ Very low												

Comparison of commonly used insulation material

MATERIAL CHARACTERISTICS FOR BETTER THERMAL COMFORT

Thus, the lower the U-value, the lower the rate of heat transfer, and the better the insulating property of the element



@source :CRDF Document of CEPT

SESSION 3: INNOVATIVE TECHNOLOGIES

Session 3: New age innovative technologies along with the 6 LHP construction technologies focusing on - efficiency in construction, mainstreaming & replication of technologies, and sustainable cum thermal comfort aspects.

LHP INTRODUCTION

6 LHP ACROSS INDIA

Map showing six different LHP Locations

LHPs shall serve **as LIVE Laboratories** for different aspects of **Transfer of technologies**

6 LHPs

1.Indore,Madhya Pradesh

- Prefabricated Sandwich Panel System

2.Rajkot,Gujarat

- Monolithic Concrete Construction using Tunnel Formwork

3.Chennai,Tamil Nadu

- Precast Concrete Construction System – Precast Components Assembled at Site

4.Ranchi,Jharkhand

- Precast Concrete Construction System – 3D Volumetric

5.Agartala,Tripura

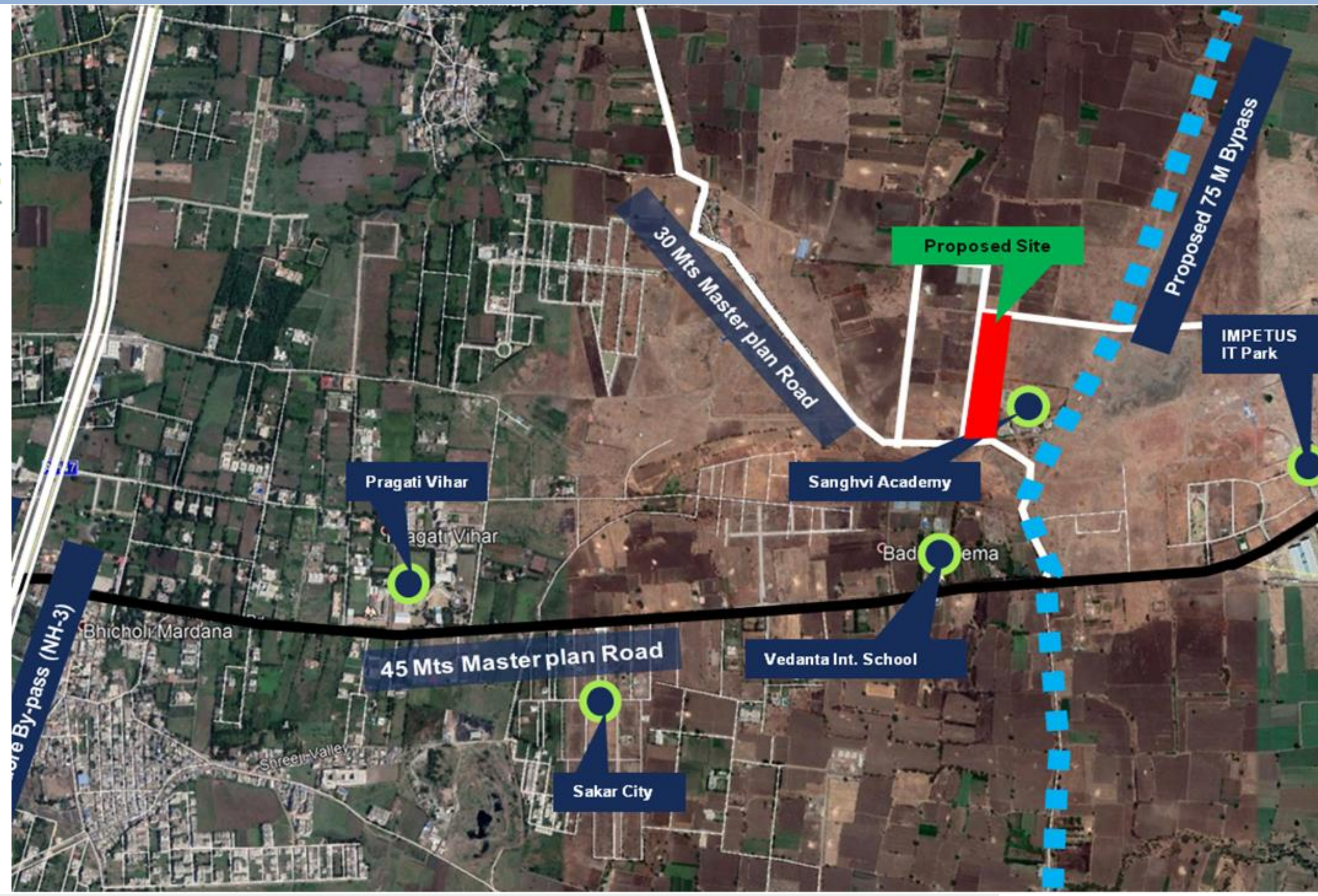
- Light Gauge Steel Structural System & Pre-engineered Steel Structural System

6.Lucknow,Uttar Pradesh

- PVC Stay In Place Formwork System

6 LHPs Explained Via Video

LHP INDORE



Description	Unit	Length	Width	Area
Living Room	Sqmt	3.12	3.08	9.61
Bed Room	Sqmt	3.12	2.99	9.33
Kitchen	Sqmt	2.1	1.81	3.80
Toilet	Sqmt	2.1	1.2	2.52
Balcony	Sqmt	2.07	1.06	2.19
Circulation Area	Sqmt	2.19	0.9	1.97
Thresold Area	Sqmt			0.50
Total Carpet Area	Sqmt			29.92

LHP INDORE

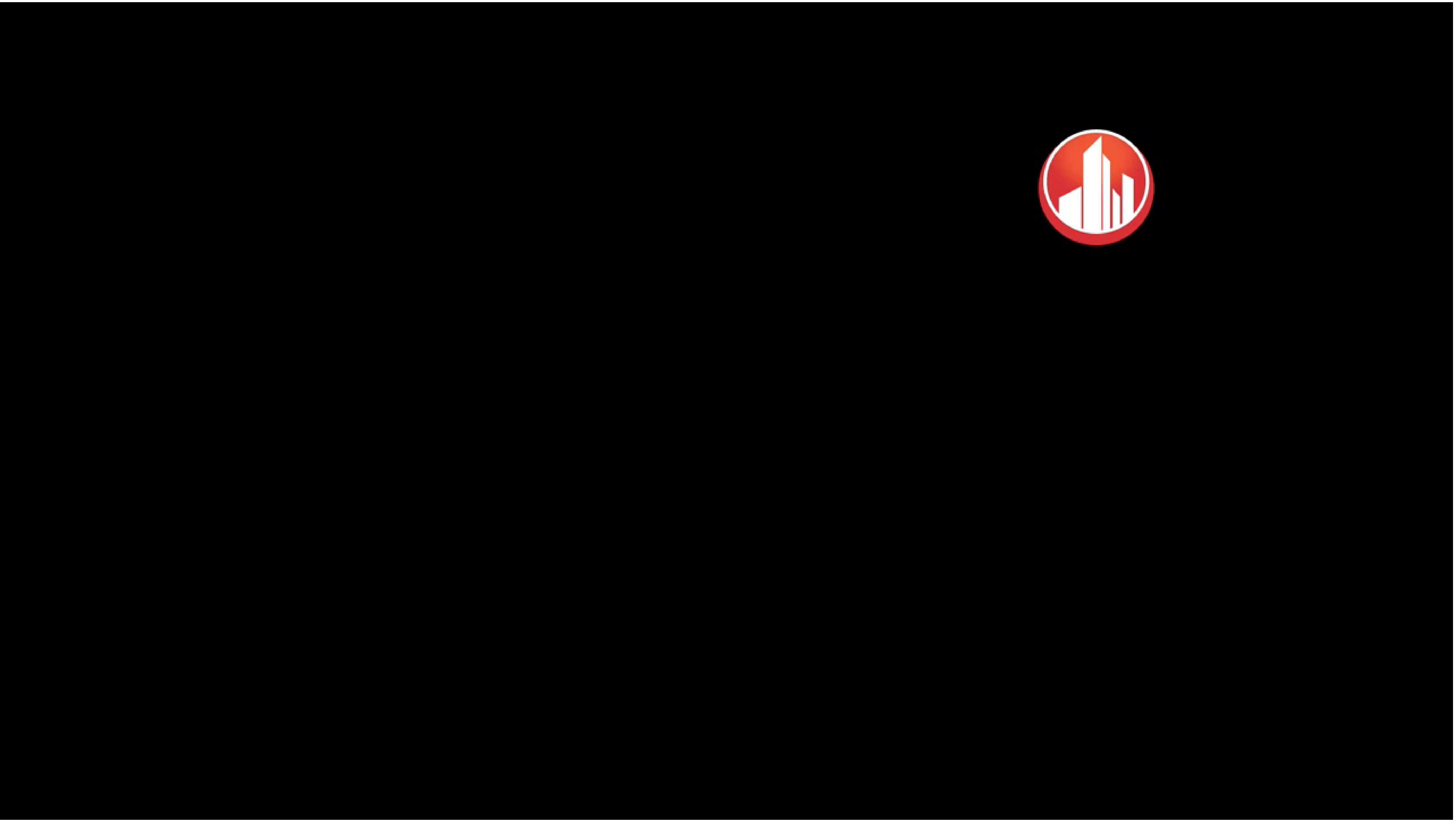
Project Details

Land Area – 41920 sqm
Net Plot Area – 34276 sqm
No's of Dwelling Unit – 1024
No's of Tower – 08
No's of Floor – *SF* + 08
No's of DU / Tower – 128
Community Hall – 169.5 sqm

Key Highlights

Technology – Pre-Fabricated Sandwich Panel & PEB Structure
Project Start Date – 01-01-2021
Project Expected End Date – 31-03-2022
Amenities –
Rain Water Harvesting
Rooftop Solar Power System
Fire Equipment (s)
Elevator / Lift
Emergency Power Back-up
Sewage Treatment Plant
Central Waste Collection Plant

LHP INDORE



LHP INDORE - TECHNOLOGY

Structural System – *Pre Engineering Building*
Slab- *Deck Sheet Slab*
Walling System - *Pre fabricated sandwich panel system*

PEB STRUCTURE

DECK SHEET SLAB

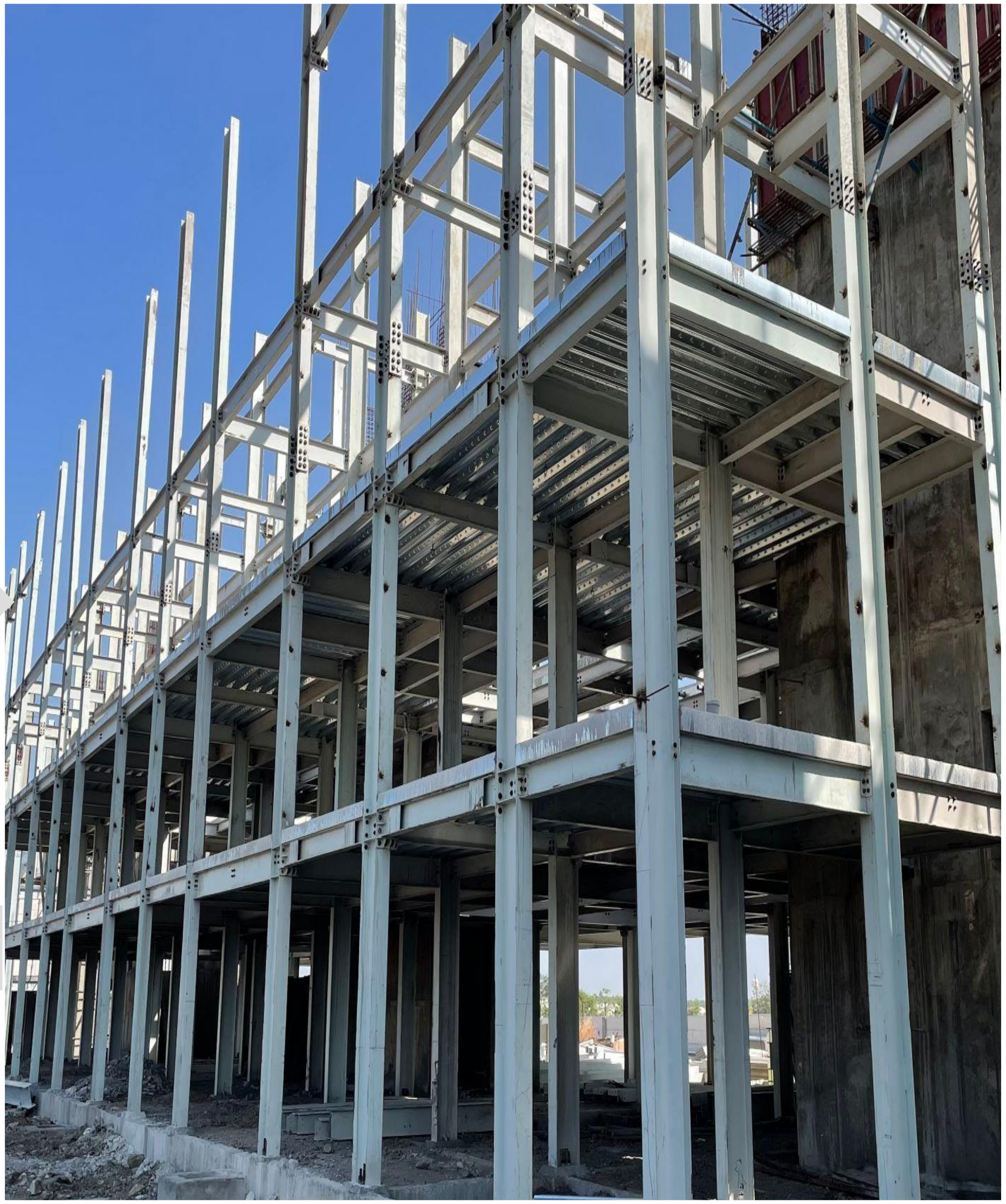
PREFABRICATED SANDWICH PANEL WALLING

LHP INDORE - TECHNOLOGY

PEB STRUCTURE

- With **Pre-engineered steel building** systems, multi-stories can now be scripted in the shortest "set-up" time
- Speed in Construction

Lifting



Assembled Structure

Bolting

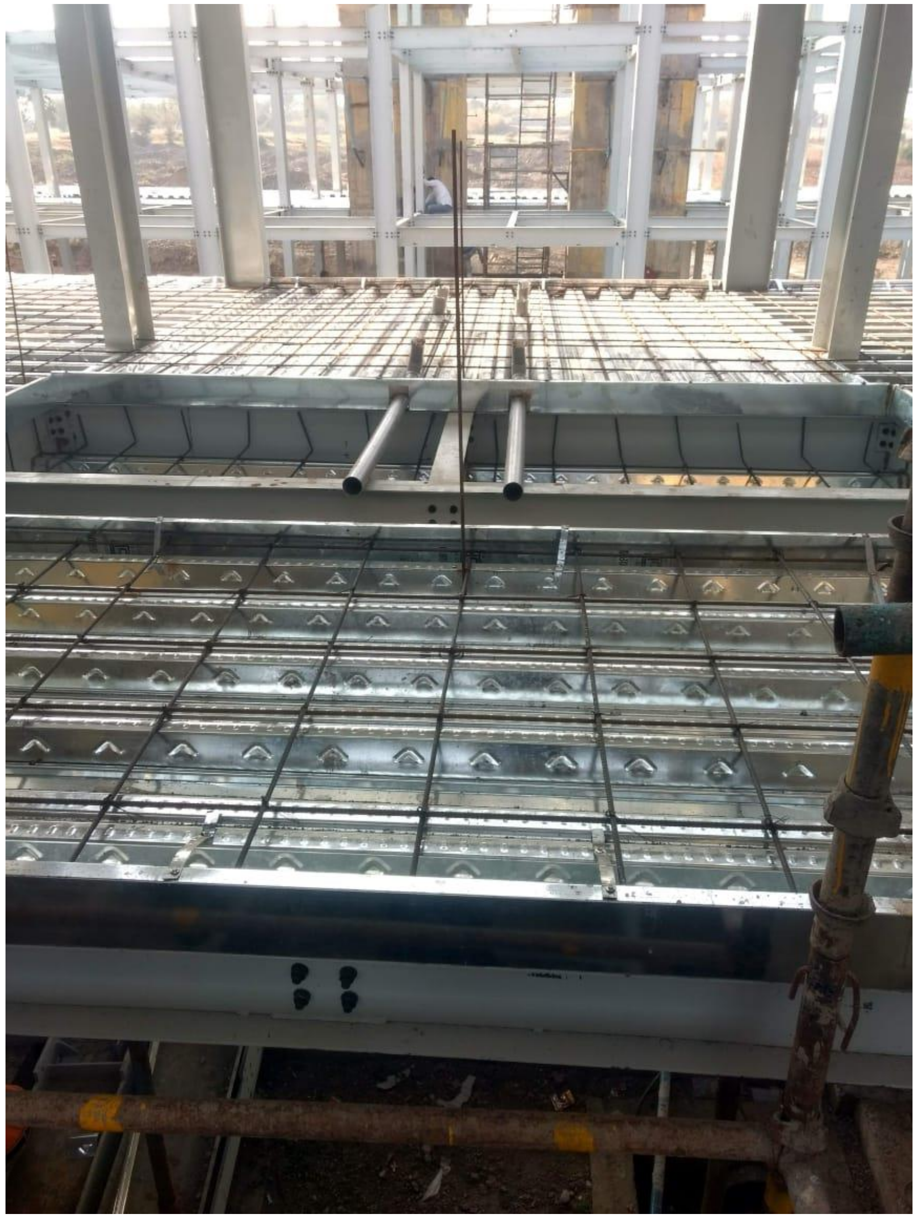
LHP INDORE - TECHNOLOGY

DECK SLAB

Deck sheet laying

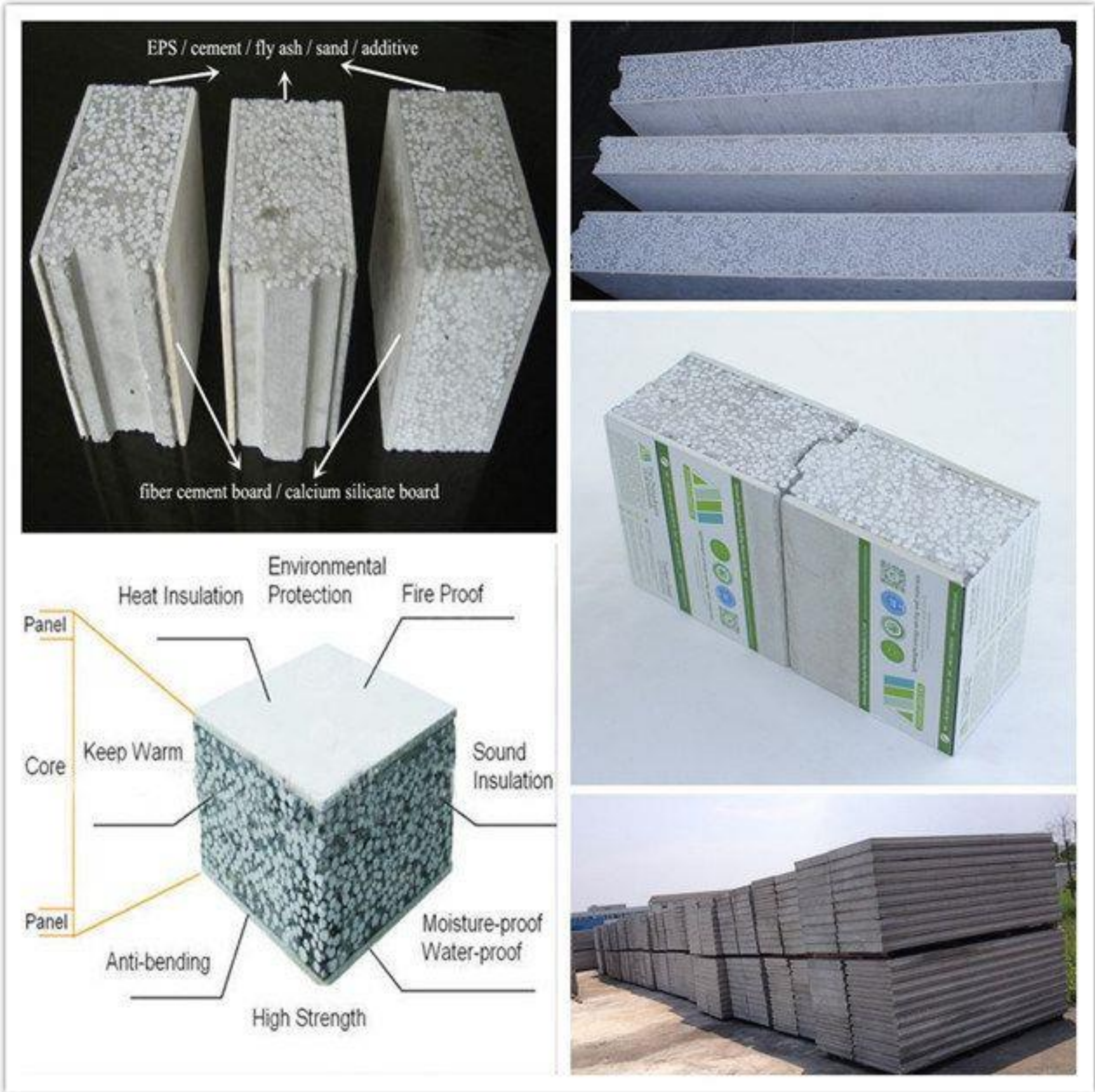
Services & reinforcement laying

Concreting



LHP INDORE - TECHNOLOGY

PRE FABRICATED SANDWICH PANEL SYSTEM



- Speed in Construction
- No use of water in curing
- Panels bring resource efficiency, better thermal insulation, acoustics & energy efficiency.

CONSTRUCTION METHDOLOGY

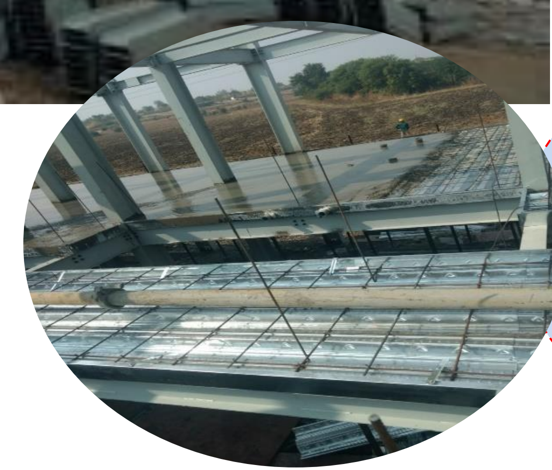
6. Staircase –
Fabricated MS sections are being welded at site for staircase frame preparation

5. Lift Wall –
RCC structure is being prepared for lift walls. Onsite RMC plant for RCC material preparation

4. Walling System
Factory made Prefabricated sandwich panels are being used for wall preparation

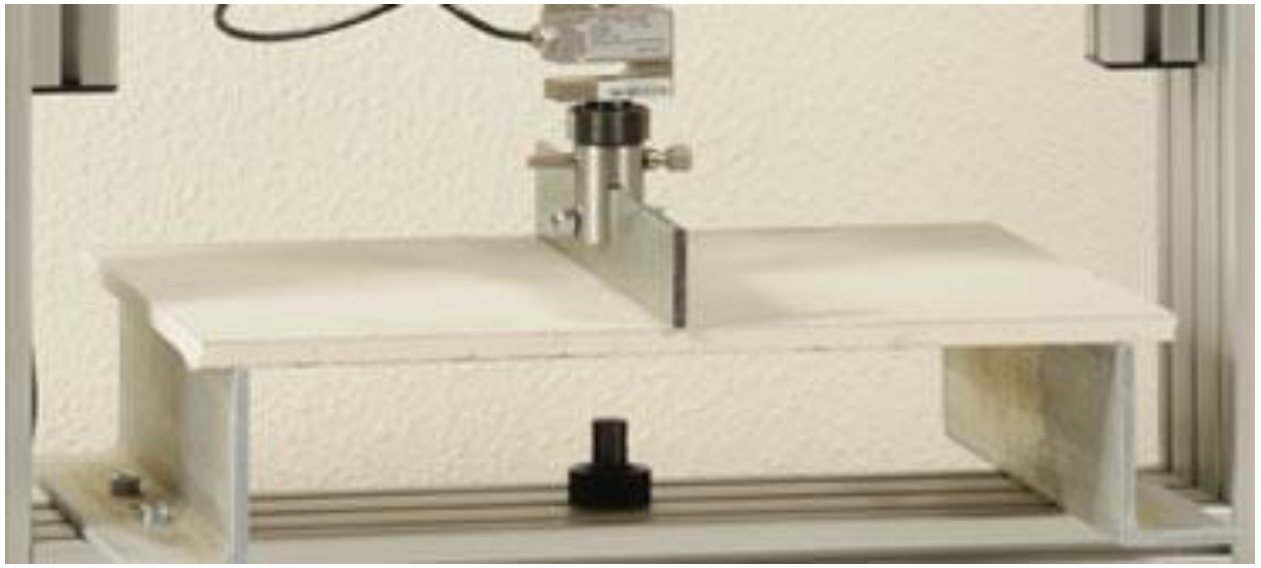
1.Substructure
RCC Isolated column footing

2.Structural System
Pre Engineered structure consists of factory manufactured steel column and beam erected on site.



3. Slab –
Deck sheet is placed on structure. over it, slab casting is done

LHP INDORE – TECHNOLOGY ADVANTAGES



Strength Test

Fast and Easy Construction

Fire Resistance Test

Energy saving by thermal resistance

Recyclable

Eco friendly dry construction

1. Light weight and cost effective
2. Easy and faster construction
3. Fireproof
4. Water proof and damp proof
5. Non-toxic & environment-friendly
6. Energy saving & environment-friendly
7. Water saving due to dry construction
8. Smooth and flat surface, thus no plastering needed
9. High sound insulation
10. Cost effective
11. Ground staff optimization
12. Increase in carpet area up to 15% which saves money

https://youtu.be/3ENcie5HUqk

LIGHT HOUSE PROJECTS - RAJKOT, GUJARAT

Monolithic Concrete Construction using Tunnel Formwork

In 'Tunnel Form' technology, concrete walls and slabs are cast in one go at site giving monolithic structure using high-precision, re-usable, room-sized, Steel forms or moulds called 'Tunnel Form'. An already established System for building construction in many countries, this system intends to replace the conventional RCC Beam-Column structure which uses steel/plywood shuttering. 'Tunnel Form' system uses customized engineered steel formwork consisting of two half shells which are placed together and then concreting is done to form a room size module. Several such modules make an apartment.

LIGHT HOUSE PROJECTS - RAJKOT, GUJARAT

Monolithic Concrete Construction using Tunnel Formwork

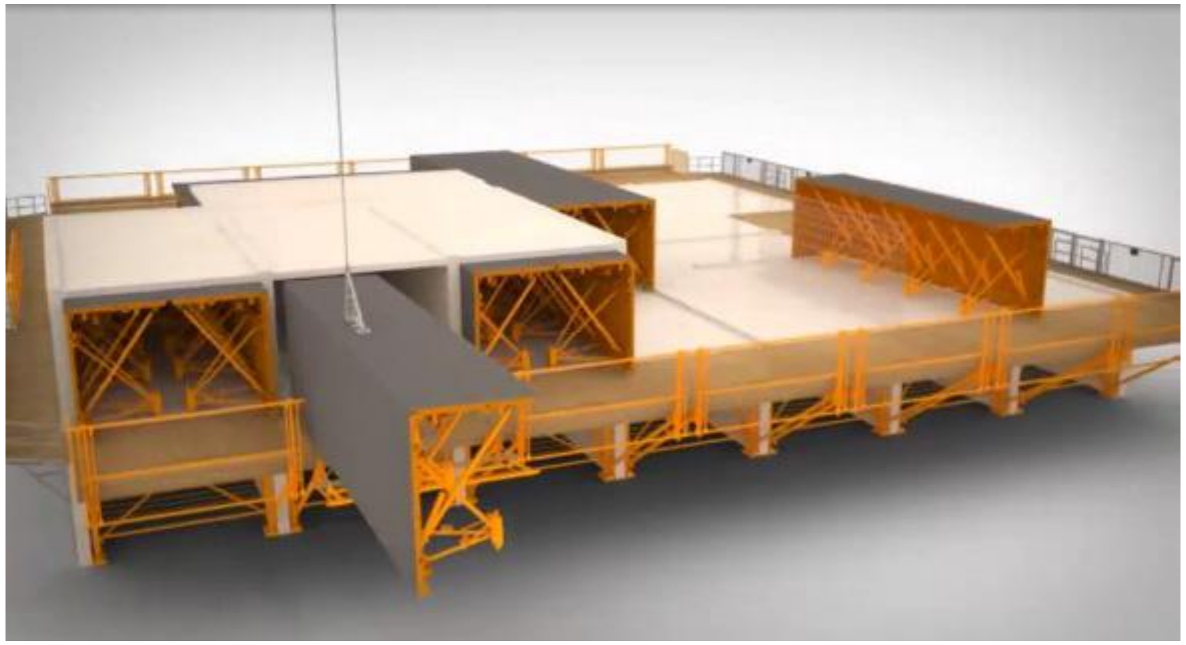
Description	Unit	Length	Width	Area
Living Room	Sqmt	3.59	3.28	11.67
Toilet	Sqmt	1.705	1	1.71
Kitchen	Sqmt	2.59	1.77	4.58
Wash	Sqmt	2.59	1	2.59
Bed Room	Sqmt	2.89	3.04	8.79
Toilet	Sqmt	1.81	1.02	1.85
Study Room	Sqmt	2.705	2.85	7.76
Main Door	Sqmt	1	0.16	0.16
Study Room Door	Sqmt	0.9	0.1	0.09
Bed Room Door	Sqmt	0.9	0.16	0.14
Toilet Door	Sqmt	0.8	0.1	0.16
Kitchen to Wash Door	Sqmt	0.9	0.2	0.148
Living Room to kitchen Gap	Sqmt	0.9	0.1	0.09
Total Carpet Area				39.77

Special Features:

- Facilitating rapid construction of multiple/ mass modular units (similar units).
- Making structure durable with low maintenance requirement.
- The precise finishing can be ensured with no plastering requirement.
- The concrete can be designed to use industrial by-products such as Fly Ash, Ground granulated blast furnace slag (GGBS), Micro silica etc. resulting in improved workability & durability, while also conserving natural resource
- Being Box type monolithic structure, it is safe against horizontal forces (earthquake, cyclone etc.)
- The large number of modular units bring economy in construction.

LIGHT HOUSE PROJECTS - RAJKOT, GUJARAT

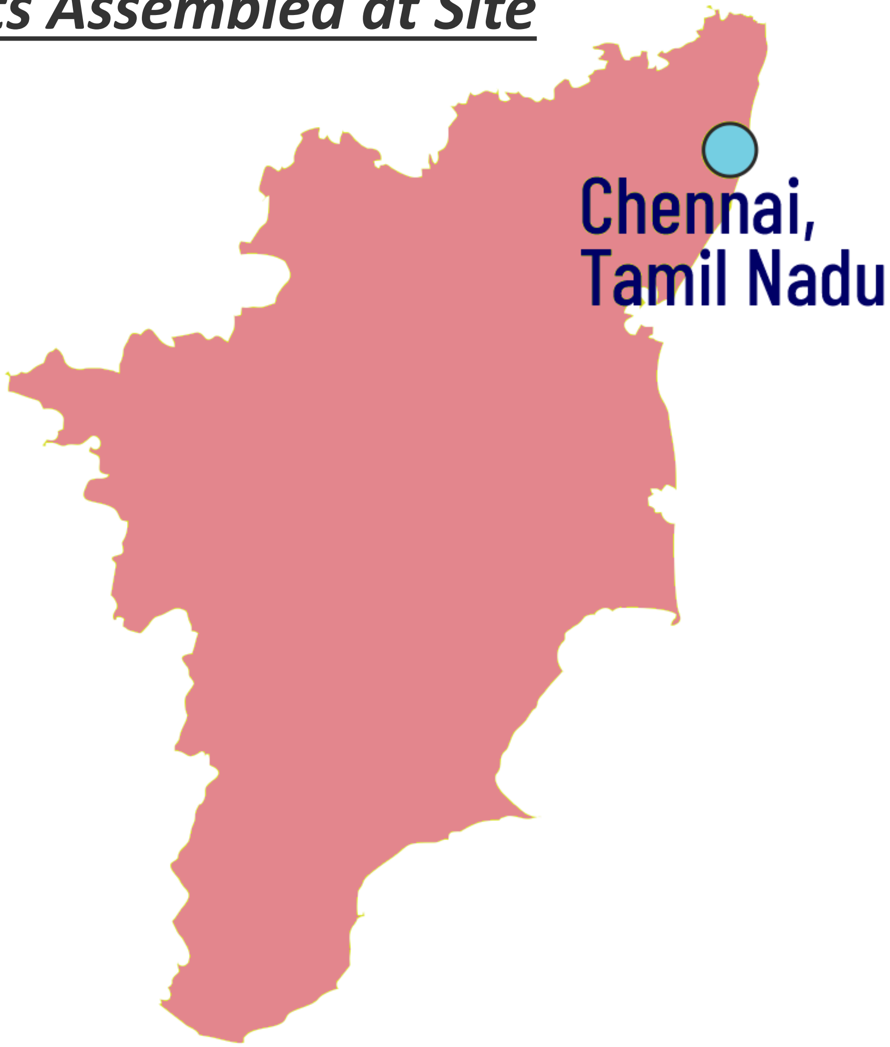
Monolithic Concrete Construction using Tunnel Formwork



•**Construction Process:**
•Stripping of the formwork from the previous day.
•Positioning of the formwork for the current day’s phase, with the installation of mechanical, electrical and plumbing services.
•Installation of reinforcement in the walls and slabs.
•Concreting

LIGHT HOUSE PROJECTS - CHENNAI, TAMIL NADU

Precast Concrete Construction System – Precast Components Assembled at Site



An already established technology for building construction, Precast concrete construction is a system where the individual precast components such as walls, slabs, stairs, column, beam etc, of building are manufactured in plant or casting yard in controlled conditions. The finished components are then transported to site, erected & installed.

The technology provides solution for low rise to high rise buildings, especially for residential and commercial buildings

LIGHT HOUSE PROJECTS - CHENNAI, TAMIL NADU

Precast Concrete Construction System – Precast Components Assembled at Site

Unit Plan

Description	Unit	Length	Width	Area
Hall	Sqmt	3.175	3.025	9.60
Kitchen	Sqmt	1.8	2.8	5.04
Bed Room	Sqmt	2.725	2.528	7.70
Bed Room Offset	Sqmt	0.9	0.2	0.18
Bath Room	Sqmt	1	1.4	1.4
W.C	Sqmt	0.9	1.55	1.395
Passage	Sqmt	1	1.2	1.2
Kitchen Opening	Sqmt	0.9	0.1	0.09
Door 1	Sqmt	1	0.15	0.15
Door 2	Sqmt	0.9	0.1	0.09
Door 3	Sqmt	0.75	0.1	0.075
Column Deduction	Sqmt			0.22
Total Carpet Area				26.78

•Special Features:

•Nearly all components of building work are manufactured in plant/casting yard & the jointing of components is done In-situ leading to reduction in construction time.

•The controlled factory environment brings resource optimization, improved quality, precision & finish.

•The concrete can be designed industrial by-products such as Fly Ash, Ground granulated blast furnace slag (GGBFS), Micro silica etc. resulting in improved workability & durability, while also conserving natural resources.

•Eliminates use of plaster.

•Helps in keeping neat & clean construction site and dust free environment.

•Optimum use of water through recycling.

•Use of shuttering & scaffolding materials is minimal.

•All weather construction & better site organization.

LIGHT HOUSE PROJECTS - CHENNAI, TAMIL NADU

Precast Concrete Construction System – Precast Components Assembled at Site

Construction Process:

The construction process comprises of manufacturing of precast concrete Columns, Beams and Slabs in steel moulds. The reinforcement cages are placed at the required position in the moulds. Concrete is poured and compaction of concrete is done by shutter/ needle vibrator. Casted components are then moved to stacking yard where curing is done for requited time and then these components are ready for transportation and erection at site.

These precast components are installed at site by crane and assembled together through in-situ jointing and/or grouting etc.

LIGHT HOUSE PROJECTS - RANCHI, JHARKHAND

Technology : Precast Concrete Construction System – 3D Volumetric

An already established System for building construction in Europe, Singapore, Japan & Australia, this 3D Volumetric concrete construction is the modern method of building by which solid precast concrete structural modules like room, toilet, kitchen, bathroom, stairs etc. & any combination of these are cast monolithically in Plant or Casting yard in a controlled condition. These Modules are transported, erected & installed using cranes and push-pull jacks and are integrated together in the form of complete building unit. Subject to the hoisting capacity, building of any height can be constructed using the technology.

LIGHT HOUSE PROJECTS - RANCHI, JHARKHAND

Unit Plan

Description	Unit	Length	Width	Area
Living Area	Sqmt	3.585	3.170	11.364
Toilet Area				
Lobby	Sqmt	2.045	0.485	0.212
W.C	Sqmt	1.340	0.935	1.253
Bath	Sqmt	1.340	1.035	1.387
Kitchen	Sqmt	1.975	1.830	3.614
Bedroom	Sqmt	3.275	3.000	9.825
Door				
D	Sqmt	0.750	0.750	0.056
D	Sqmt	0.750	0.750	0.056
D.W	Sqmt	1.150	0.160	0.184
Kitchen Door	Sqmt	0.900	0.160	0.144
D2	Sqmt	0.975	0.160	0.156
D3	Sqmt	1.050	0.100	0.105
Total Carpet Area				29.349 Sqmt

•**Special Features:**

•About 90% of the building work including finishing is complete in plant/casting yard leading to significant reduction in construction & occupancy time.

•The controlled factory environment brings resource optimization, improved quality, precision & finish.

•The required concrete can be designed using industrial by-products such as Fly Ash, Ground granulated blast furnace slag (GGBS), Micro silica etc. resulting in improved workability & durability, while also conserving natural resources. In this project Ground granulated blast furnace slag & silica fume is being used in concrete.

•With smooth surface it eliminates use of plaster.

•The monolithic casting of walls & floor of a building module reduces the chances of leakage.

•The system has minimal material wastage (saving in material cost), helps in keeping neat & clean construction site and dust free environment.

•Use of Optimum quantity of water through recycling.

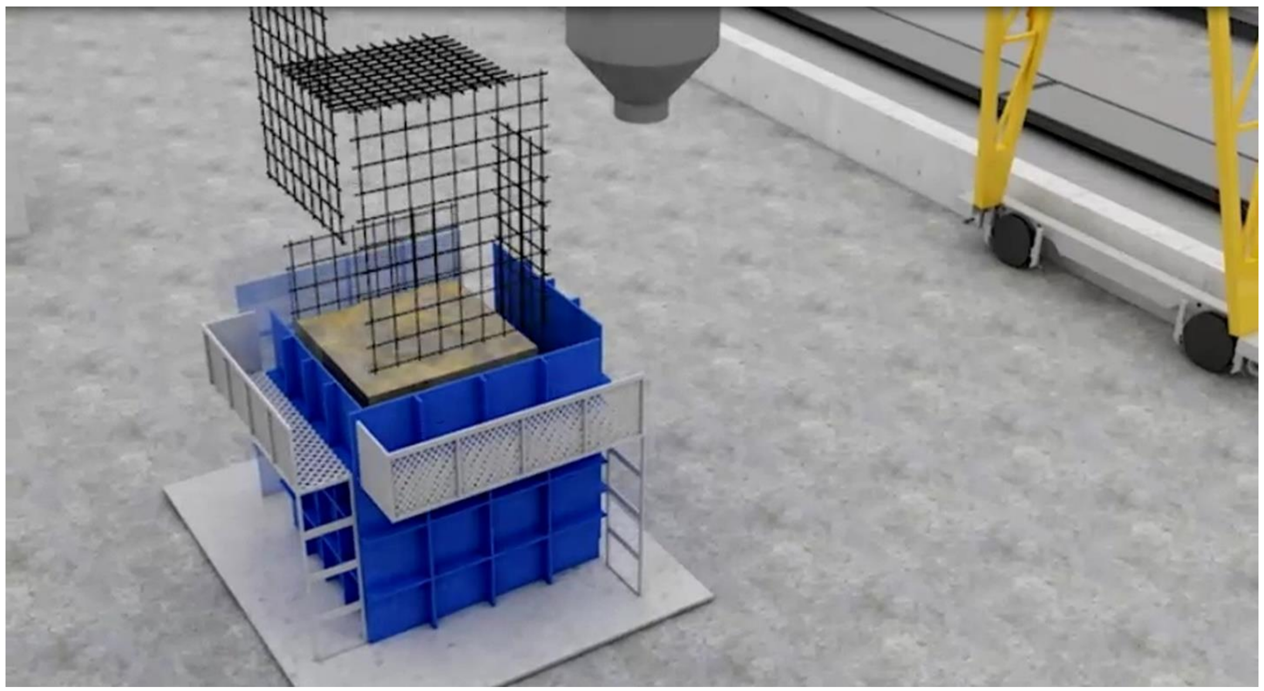
•Use of shuttering & scaffolding materials is minimal.

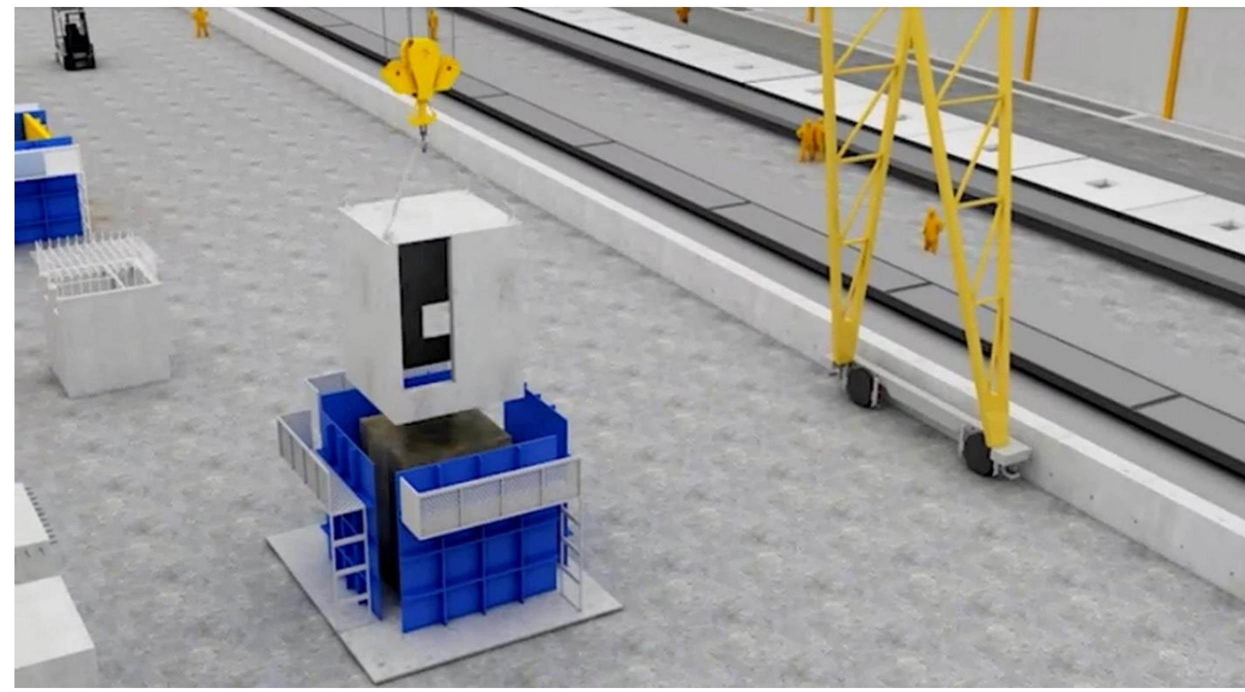
•All weather construction & better site organization.

LIGHT HOUSE PROJECTS - RANCHI, JHARKHAND

Construction Process:

Sequential construction in the project here begins with keeping the designed foundation of the building ready, while manufacturing of precast concrete structural modules are taking place at the factory. Factory finished building units/modules are then installed at the site with the help of tower cranes. Gable end walls are positioned to terminate the sides of building. Pre stressed slabs are then installed as flooring elements. Rebar mesh is finally placed for structural screed thereby connecting all the elements together. Consecutive floors are built in similar manner to complete the structure.





LIGHT HOUSE PROJECTS - AGARTALA, TRIPURA

TECHNOLOGY : Light Gauge Steel Structural System & Pre-engineered Steel Structural System

An already established System for building construction in Japan, Australia & North America; Light Gauge Steel Frame (LGSF) System uses factory made galvanized light gauge steel components. The components/sections are produced by cold forming method and assembled as panels at site forming structural steel framework upto G+3 building. LGSF is used in combination with pre-engineered steel structural system for buildings above G+3 for longevity, speedier construction, strength and resource efficiency. Under this Light House Project, houses are being constructed using Light Gauge Steel Frame System (LGSF) with Pre-Engineered Steel Structural System.

LIGHT HOUSE PROJECTS - AGARTALA, TRIPURA

Unit Plan

Description	Unit	Length	Width	Area
Living Room	Sqmt	3.12	3.08	9.61
Bed Room	Sqmt	3.12	2.99	9.33
Kitchen	Sqmt	2.1	1.81	3.80
Toilet	Sqmt	2.1	1.2	2.52
Balcony	Sqmt	2.07	1.06	2.19
Circulation Area	Sqmt	2.19	0.9	1.97
Thresold Area	Sqmt			**0.50**
Total Carpet Area	Sqmt			**29.92**

•**Special Features:**

•High strength to weight ratio. Due to light weight, significant reduction in design earthquake forces is achieved. Making it safer compared to other structures.

•Fully integrated computerised system with Centrally Numerical Control (CNC) machine primarily employed for manufacturing of LGSF sections provide very high Precision & accuracy.

•Construction being very fast, a typical four storeyed building can be constructed within one month.

•Structure being light, does not require heavy foundation

•Structural element can be transported to any place including hilly areas to remote places easily making it suitable for far flung regions including difficult terrains.

•Structure can be shifted from one location to other without wastage of materials.

•Steel used can be recycled multiple times

•The system is very useful for post disaster rehabilitation work.

LIGHT HOUSE PROJECTS - AGARTALA, TRIPURA

Construction Process:

The sequence of construction comprises of foundation laying, fixing of Pre-Engineered Steel Structural System, fixing of tracks, fixing of wall panels with bracings as required, fixing of floor panels, decking sheet, fixing of electrical & plumbing services and finally fixing of concrete walling panels with light weight concrete as infill. The other options of dry walling components such as sandwich panels with insulation material in between can also be used. Similarly, the floors can either by composite slab/deck slabs/precast hollow core slabs as per the need & requirements.

LIGHT HOUSE PROJECTS - LUCKNOW, UTTAR PRADESH

TECHNOLOGY : PVC Stay In Place Formwork System

Already in use in Canada & Australia, the plant manufactured rigid poly-vinyl chloride (PVC) based polymer components serve as a permanent stay-in-place finished form-work for concrete walls. The formwork System being used acts as pre-finished walls requiring no plaster and can be constructed instantly.

This System is suitable for residential and commercial buildings of any height from low rise to high rise. In order to achieve speedier construction, strength and resource efficiency, the composite structure with Pre-Engineered Steel Structural System as structural members is being used in the present project.

LIGHT HOUSE PROJECTS - LUCKNOW, UTTAR PRADESH

TECHNOLOGY : PVC Stay In Place Formwork System

Unit Plan

Description	Unit	Length	Width	Area
Living Room	Sqmt	3.91	3.07	11.98
Kitchen	Sqmt	2.17	1.80	3.91
Bed Room	Sqmt	3.62	3.06	11.04
Passage	Sqmt	1.68	1.20	2.02
Balcony	Sqmt	1.39	1.27	1.77
Toilet Passage	Sqmt	1.09	0.55	0.60
Bathroom	Sqmt	1.59	1.28	**2.03**
Toilet	Sqmt	1.10	1.09	**1.20**
Total Carpet Area	Sqmt			**34.54**

Special Features:

•Having formwork already as part of system, the construction of building is faster as compared to conventional buildings. The formwork needs some support only for alignment purpose.

•In case of concrete as filling material, the curing requirement of concrete is significantly reduced, thus saving in precious water resources.

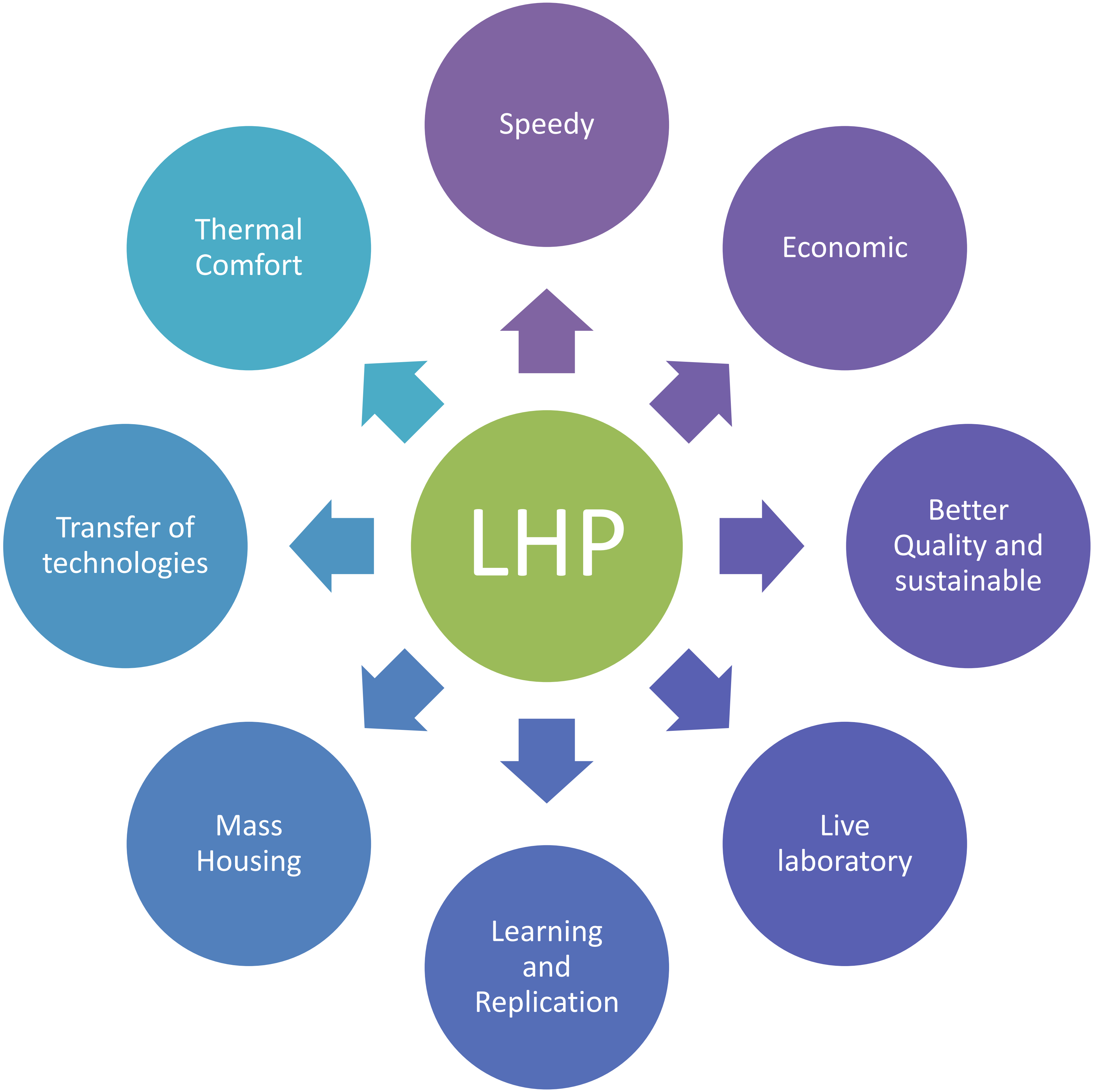
•The formwork system does not have plastering requirement & gives a very aesthetic look.

LIGHT HOUSE PROJECTS - LUCKNOW, UTTAR PRADESH

Construction Process:

Construction is done in a sequential manner where at first, the Prefabricated PVC Wall panels and Pre-Engineered Steel Structural Sections as per the design are transported to the Site. Then, these Sections are erected on the prepared foundation using cranes and required connections. Floor is installed using decking sheet. Once the structural frame and floor is installed and aligned, wall panels are fixed on decking floor. The pre-fabricated walling panels having provisions of holes for services conduits, are fixed along with the reinforcement & cavities inside the wall panels are filled with concrete. Upon installment of wall panels, flooring and ceiling, the finishing work is executed.

6 LHPS – FOCUSES ON



SESSION 4: GREEN BUILDINGS

Session 4: **Green Buildings**

a) Brief

b) Green Measures

c) Indigenous and low-embodied materials

d) Best Practices

GREEN BUILDING

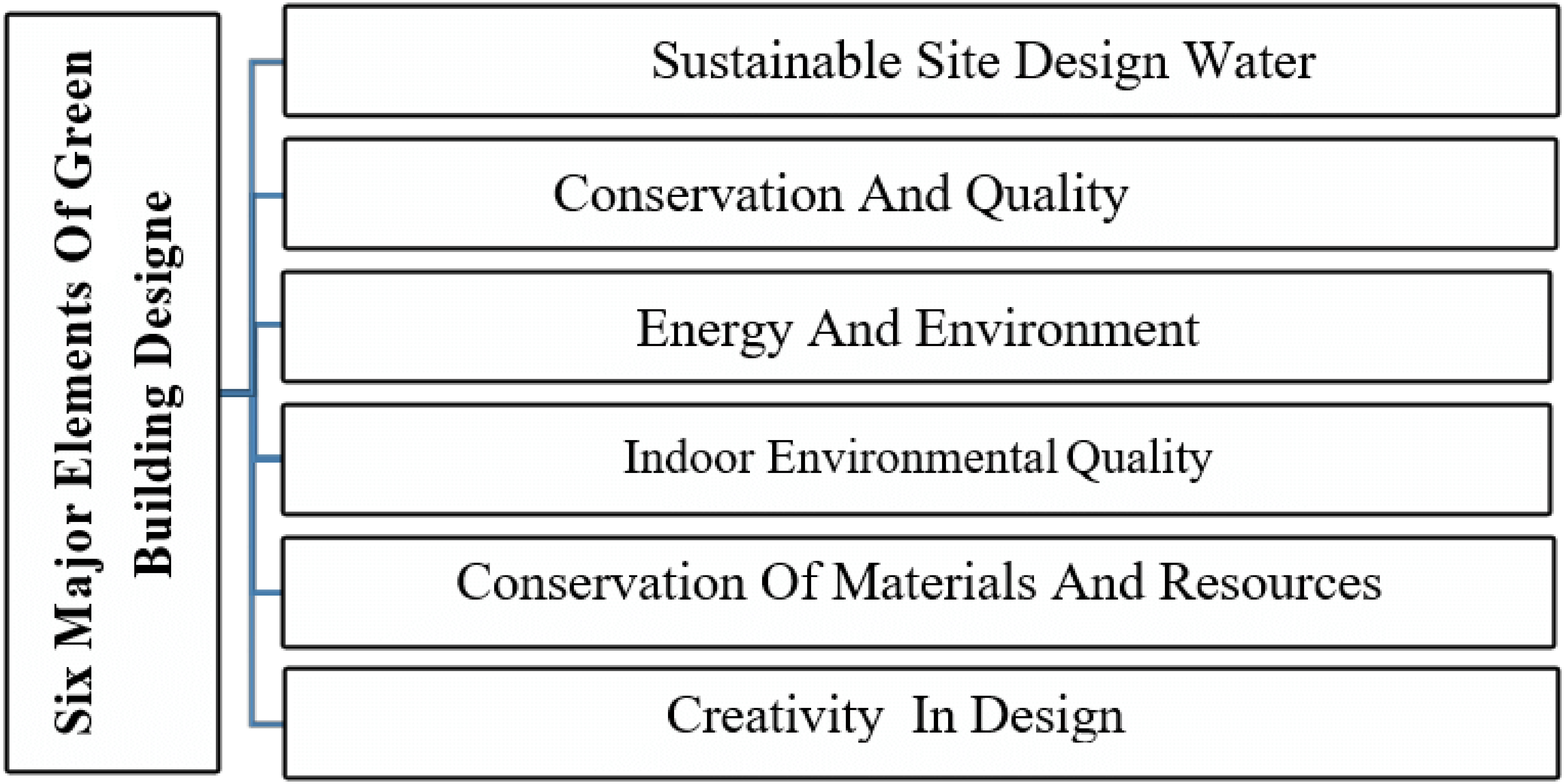
GREEN BUILDING

What is green building?

A ‘green’ building is a building that, in its design, construction or operation, reduces or eliminates negative impacts, and can create positive impacts, on our climate and natural environment. Green buildings preserve precious natural resources and improve our quality of life.

- Efficient use of energy, water and other resources
- Use of renewable energy, such as solar energy
- Pollution and waste reduction measures, and the enabling of re-use and recycling
- Good indoor environmental air quality
- Use of materials that are non-toxic, ethical and sustainable
- Consideration of the environment in design, construction and operation
- Consideration of the quality of life of occupants in design, construction and operation
- A design that enables adaptation to a changing environment

GREEN MEASURES

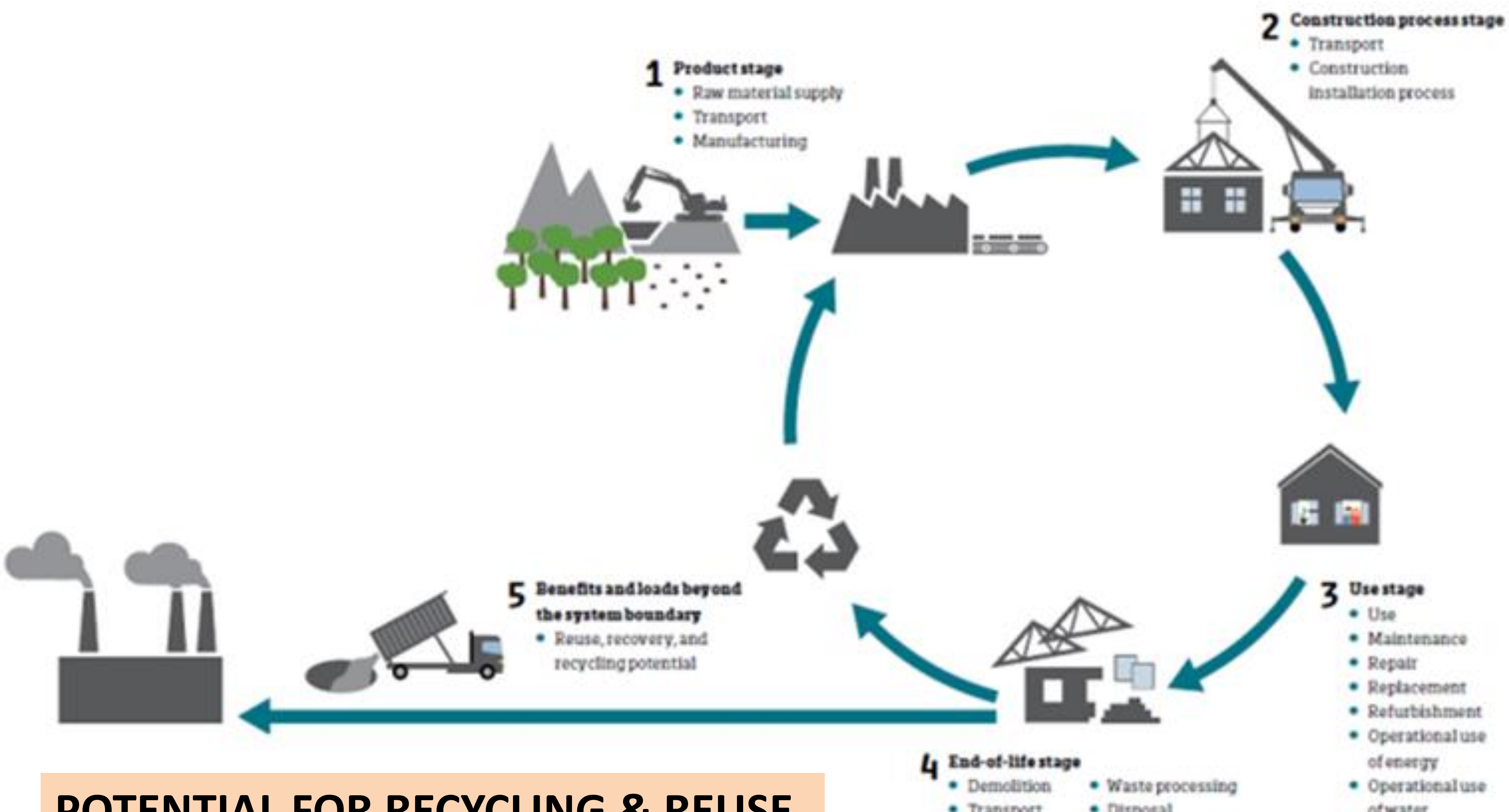


INDIGENOUS AND LOW-EMBODIED MATERIALS

MATERIALS WITH

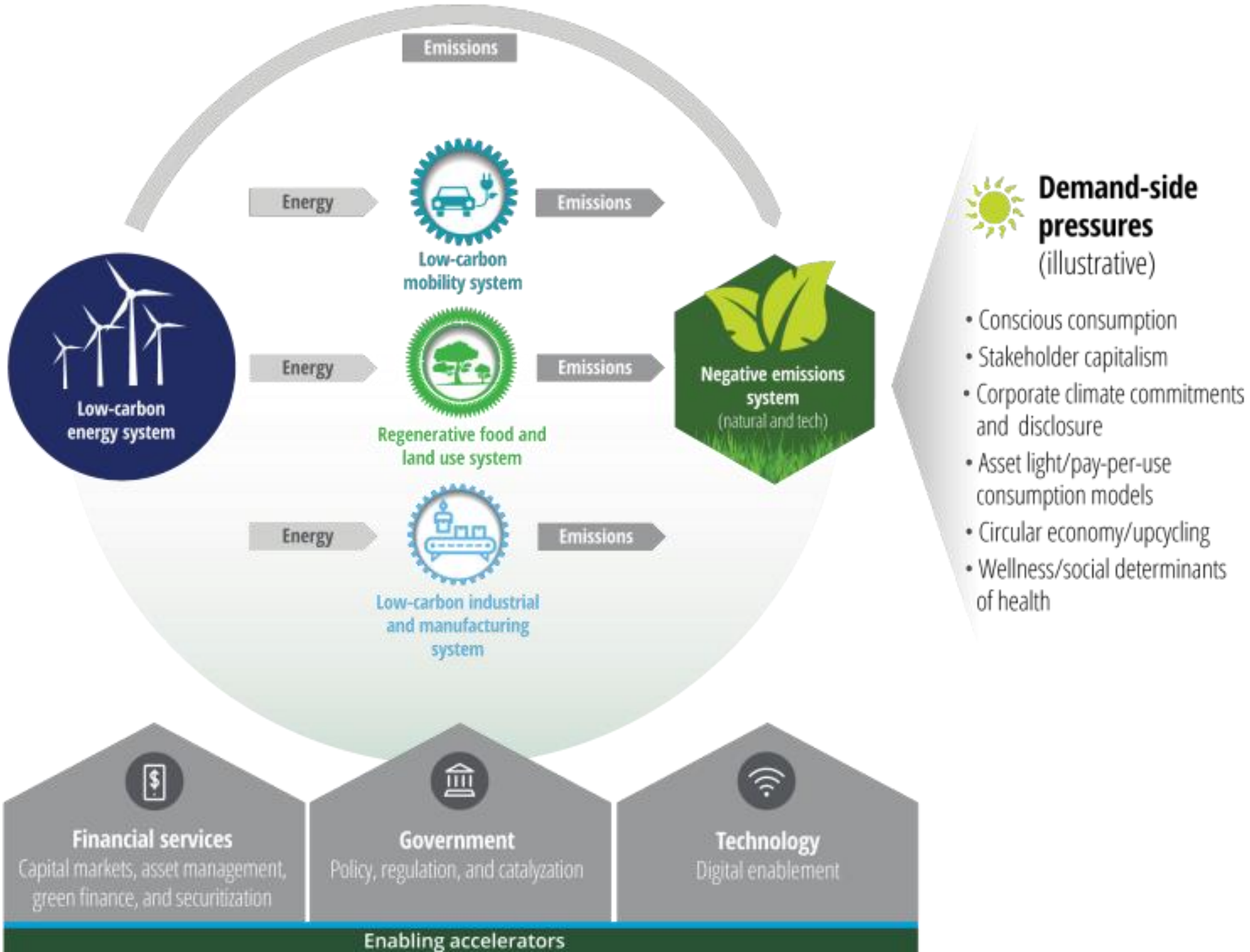
LEAST CARBON FOOTPRINT

LOW CARBON EMISSION



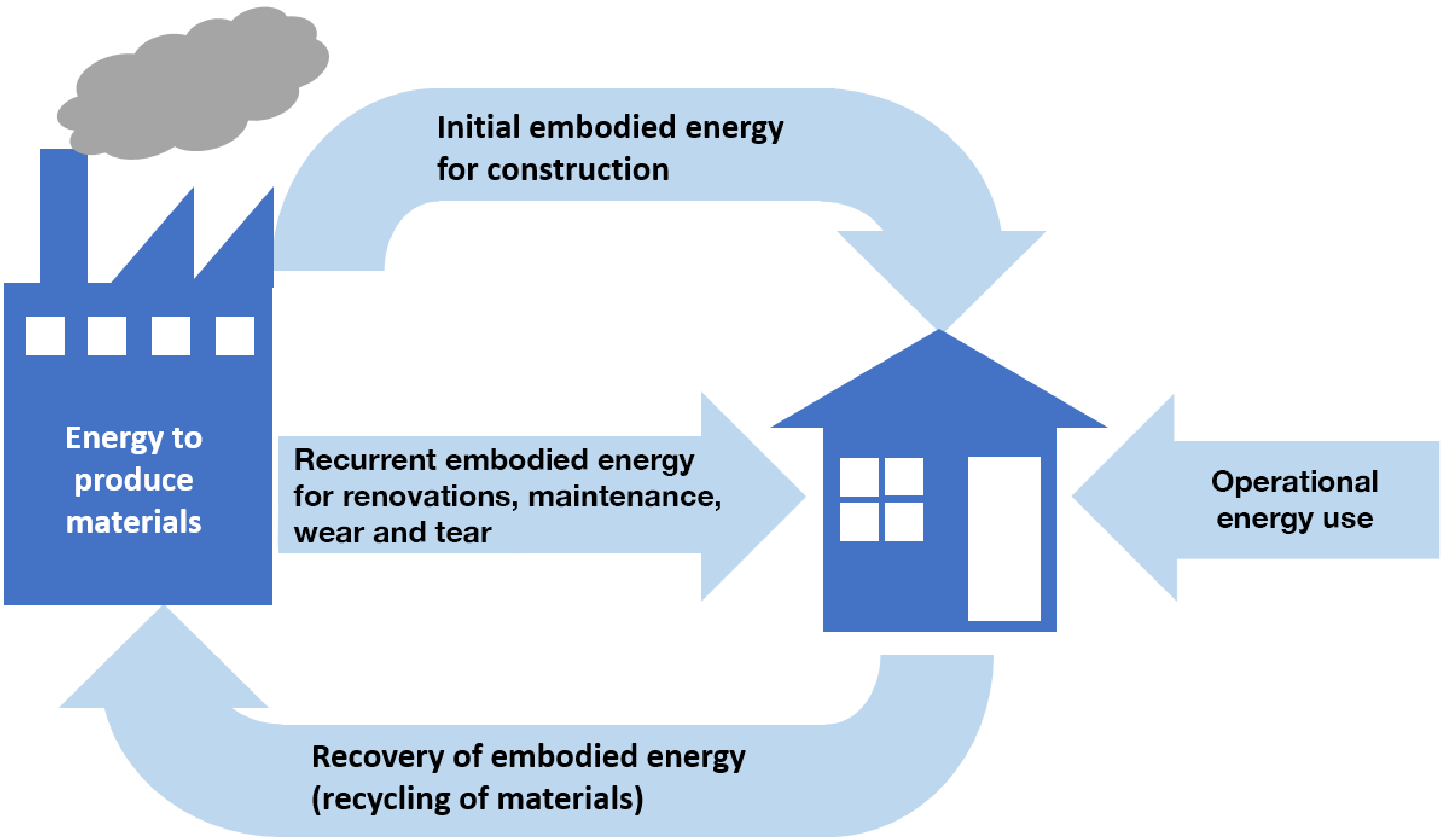
POTENTIAL FOR RECYCLING & REUSE

INDIGENOUS AND LOW-EMBODIED MATERIALS



EMBODIED ENEGY

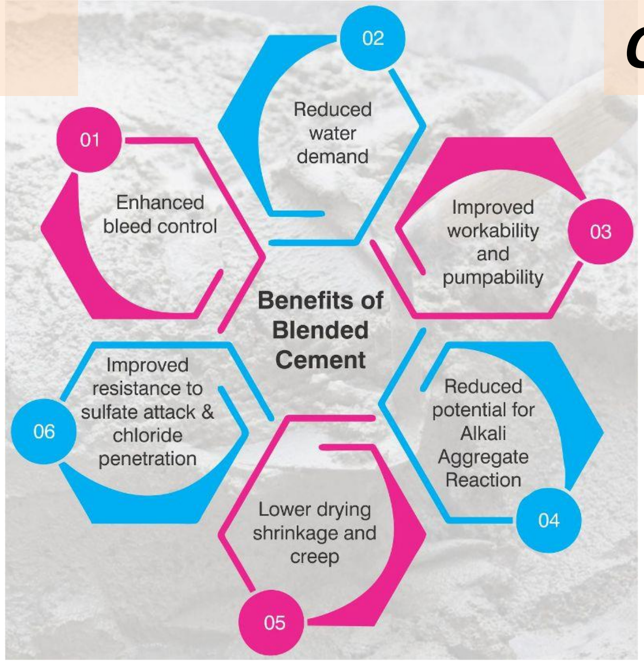
Embodied energy is the energy consumed by all of the processes associated with the production of a building, from the mining and processing of natural resources to manufacturing, transport and product delivery. Embodied energy does not include the operation and disposal of the building material. This would be considered in a life cycle approach. Embodied energy is the ‘upstream’ or ‘front-end’ component of the lifecycle impact of a home.



INDIGENOUS AND LOW-EMBODIED MATERIALS

BLENDED CEMENTS

Blended cement can be defined as **uniform mix of ordinary Portland cement (OPC) and blending materials such as silica fumes, fly ash, limestone and slag to enhance its properties for different uses**. Blended cement can improve workability, strength, durability and chemical resistance of concrete.

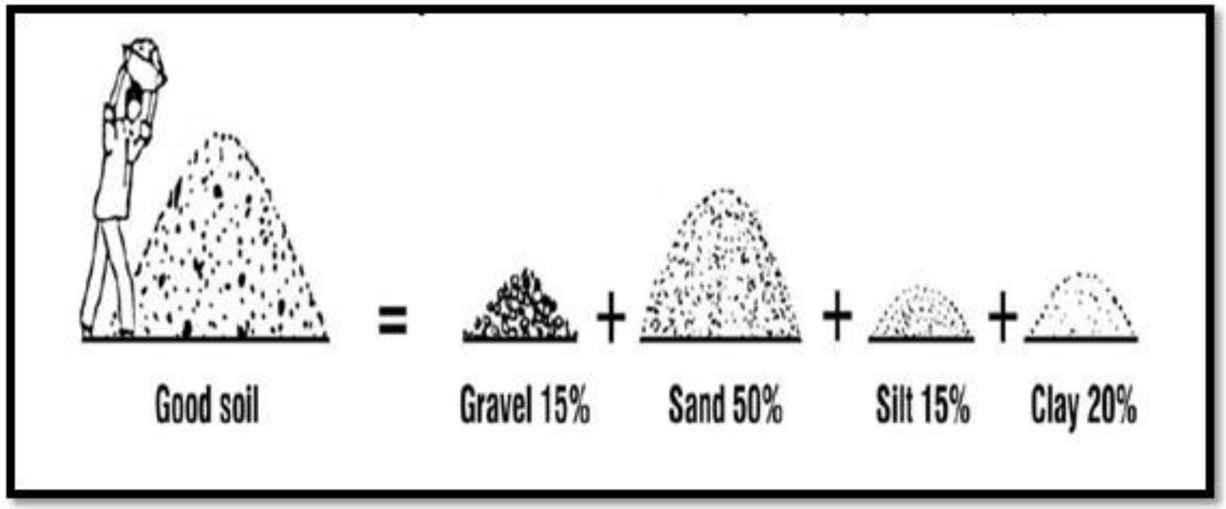


COMPACTED FLY ASH BLOCKS

containing class C or class F fly ash and water. Compressed at 28 MPa (272 atm) and cured for 24 hours in a 66 °C steam bath, then toughened with an air entrainment agent, the bricks can last for more than 100 freeze-thaw cycles.

STABILIZED MUD BLOCKS FOR MASONRY

Stabilized mud blocks (SMBs) are **manufactured by compacting a wetted mixture of soil, sand, and stabilizer in a machine into a high-density block**. Such blocks are used for the construction of load-bearing masonry. Cement soil mortar is commonly used for SMB masonry.



LOW ENERGY INTENSITY FLOOR AND ROOFING SYSTEMS

RAMMED EARTH WALLS

Rammed earth walls are constructed by ramming a mixture of selected aggregates, including gravel, sand, silt, and a small amount of clay, into place between flat panels called formwork. Traditional technology repeatedly rammed the end of a wooden pole into the earth mixture to compress it.

Table 4. *Embodied energy in various walling and floor/roofing systems.*

Type of building element	Energy per unit (GJ)
Burnt clay brick masonry (m^3)	2.00–3.40
SMB masonry (m^3)	0.50–0.60
Fly ash block masonry (m^3)	1.00–1.35
Stabilized rammed earth wall (m^3)	0.45–0.60
Unstabilized rammed earth wall (m^3)	0.00–0.18
Reinforced concrete slab (m^2)	0.80–0.85
Composite SMB masonry jack-arch (m^2)	0.45–0.55
SMB filler slab (m^2)	0.60–0.70
Unreinforced masonry vault roof (m^2)	0.45–0.60

GREEN BUILDING – BEST PRACTICES

1 Increased water preservation efforts

- Rain water harvesting
- Using building material, which requires less curing or water after
- Use of native species in landscape

2 Improved Environmental product market

- Use of low VOC content material
- High SRI paints
- Fly ash bricks
- EPS Panel

3 Fewer Wastewater Treatment Plants

- Use of water efficient fixtures
- Monitoring and optimization of overflow of water

GREEN BUILDING – BEST PRACTICES

4	Fewer Power Plants & Power lines	• Use of energy efficient appliances and systems
5	Equitable access to transportation infrastructure	• Encourage use of public transport / encourage to use vehicle with low emission
6	Better comfort and productivity	• Thermal comfort will lead to better productivity

time for a little

question & answer

session

DAY 2

SESSION 5 - ECO-NIWAS SAMHITA 2021

ECO NIWAS SAMHITA TOOL Via Video

ENS CODE COMPLIANCE

Table 1: Minimum ENS Score Requirement

Project Category	Minimum ENS Score
Low rise buildings	47
Affordable Housing	70
High rise buildings	100

Table 2: Component wise Distribution of ENS Score

Section	Components	Minimum points	Additional Points	Maximum Points
6.4	Building Envelope			
	Building Envelope	47	40	87
6.5	Building Services			
	Common area and exterior lighting	3	6	9
	Elevators	13	9	22
	Pumps	6	8	14
	Electrical Systems	1	5	6
6.6	Indoor Electrical End-Use			
	Indoor Lighting		12	12
	Comfort Systems		50	50
	ENS Score	70	130	200

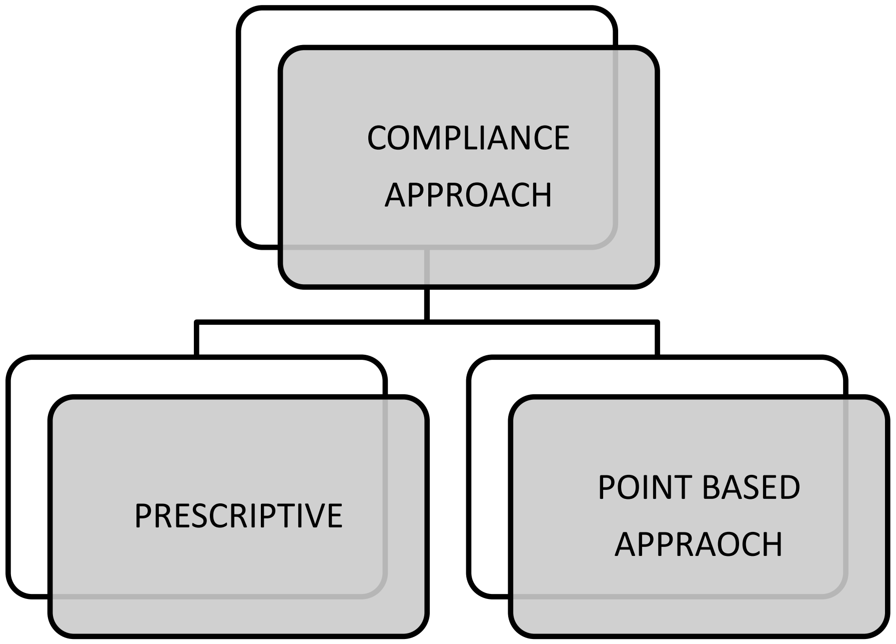
Table 9: Score for Renewable Energy System Components

Renewable Energy Systems Components	Minimum Points	Additional Points	Maximum Points
Solar Hot Water Systems		10	10
Solar Photo Voltaic		10	10
Additional ENS Score		20	20

The purpose of Eco Niwas Samhita 2021

The code applies to –

- Residential buildings built on a plot area of ≥ 500 m2
- Residential part of Mixed land-use building projects, built on a plot area of ≥ 500 m2 .



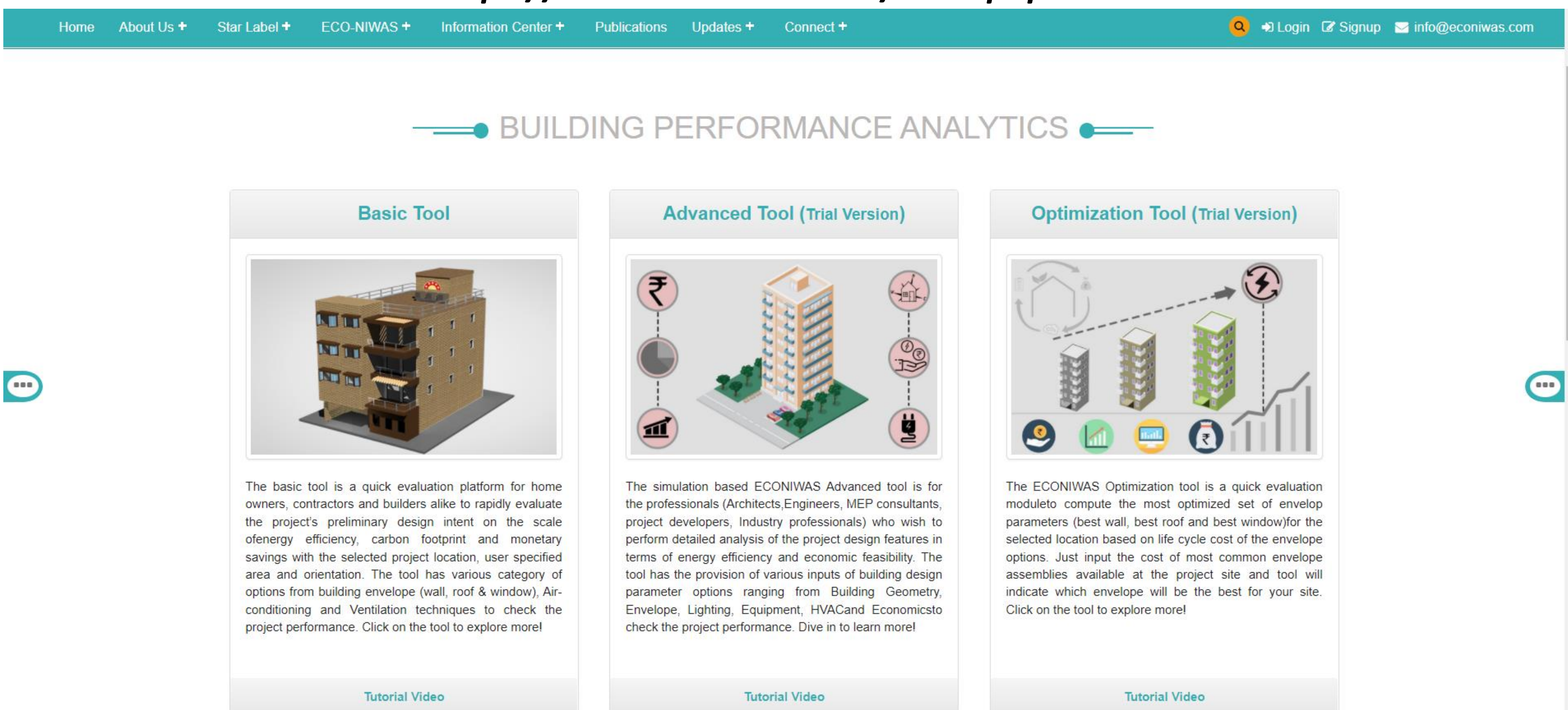
Compliance Approaches

ENS SIMULATION TOOLS

ENS TOOLS ECONIWAS 2.0 - INTRODUCTION

- Building simulation allows engineers and architects to address key aspects of building performance throughout the whole building life cycle from early design stages through construction and even for major energy retrofitting.
- Building simulation is a way to test how elements of building design will perform under real-world conditions
- **Basic Tool**
- **Advanced Tool**
- **Envelope Optimization Tool**

https://www.econiwas.com/tools.php



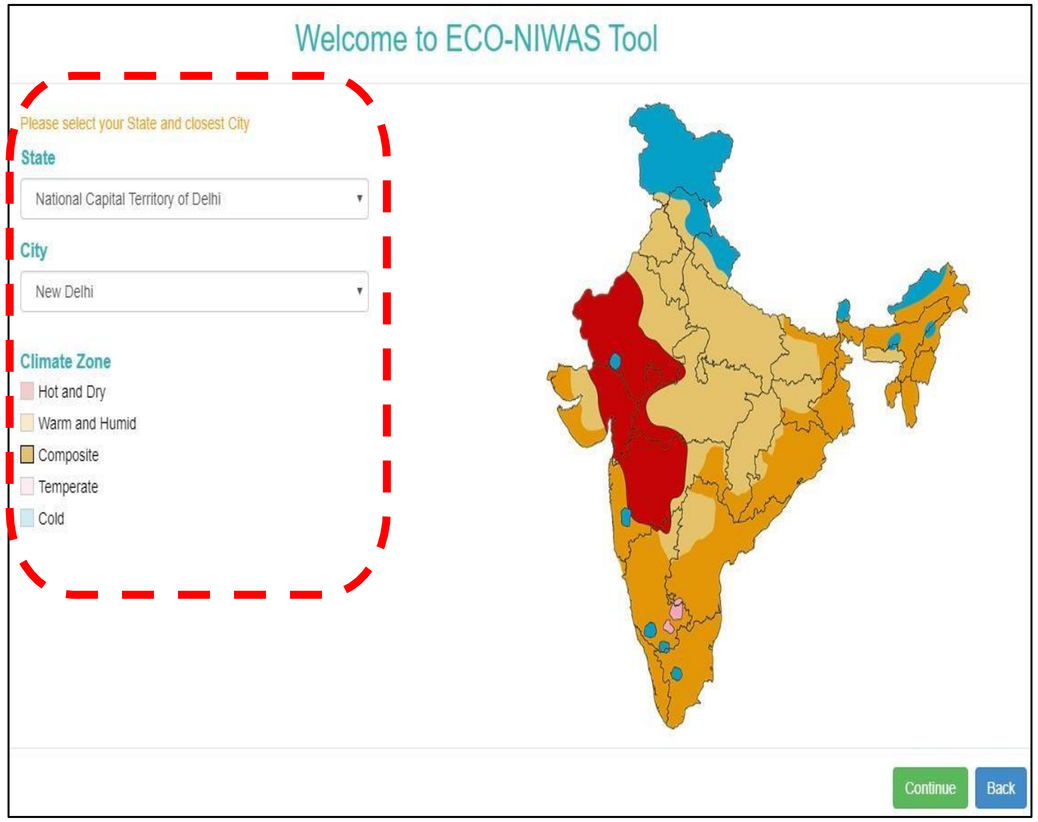
ECONIWAS 2.0 - MODULES

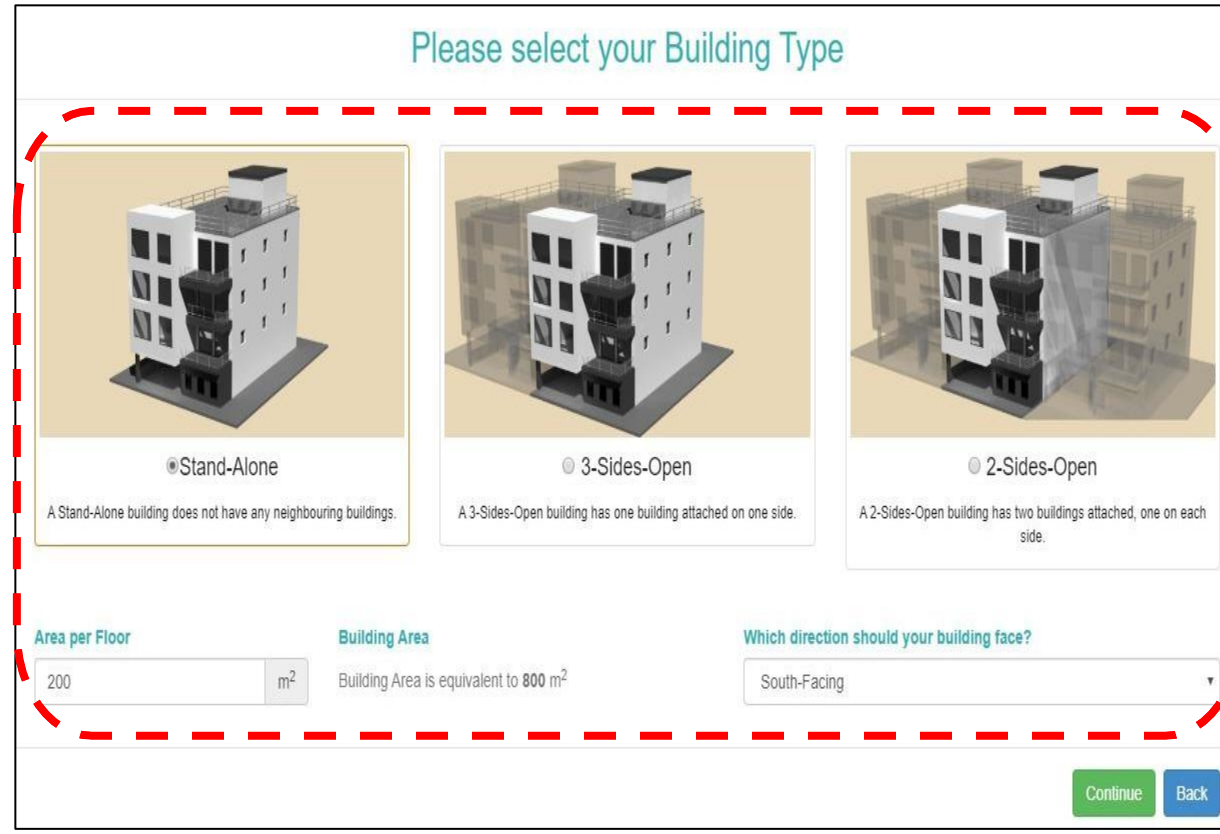
Basic Tool:

Quick evaluation platform for homeowners, contractors and builders alike to rapidly evaluate the project's preliminary design intent on the scale of energy efficiency, carbon footprint and monetary savings with the selected project location, user specified area and orientation, building envelope (wall, roof & window), Air-conditioning and Ventilation techniques.

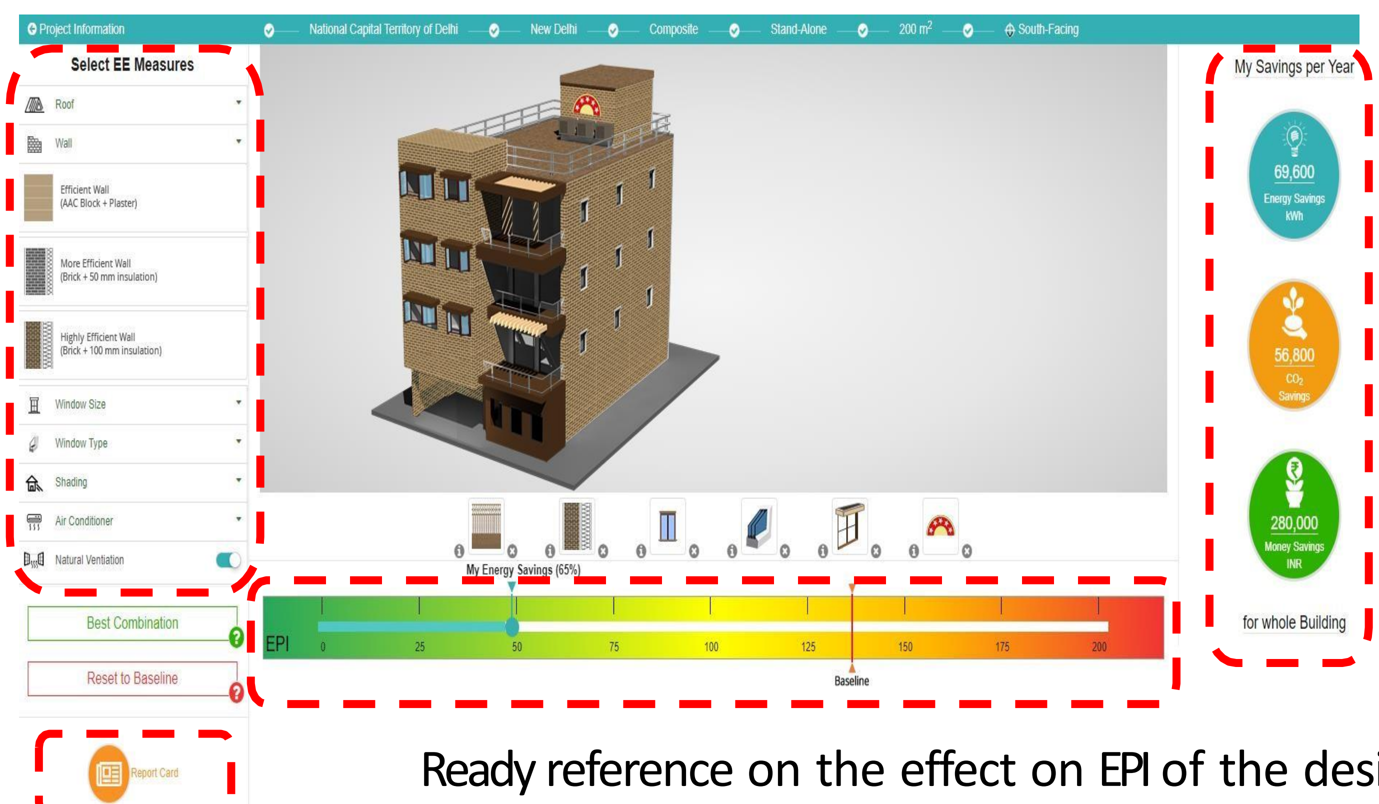
ECONIWAS 2.0 – BASIC TOOLS

Quick and Easy Inputs for defining primary information of Building including location, shading, area and orientation.





Most interactive drag and drop features to select and install energy efficient parameters in building design



Quick inference on the impact of selected design features on the energy, environment and monetary level.

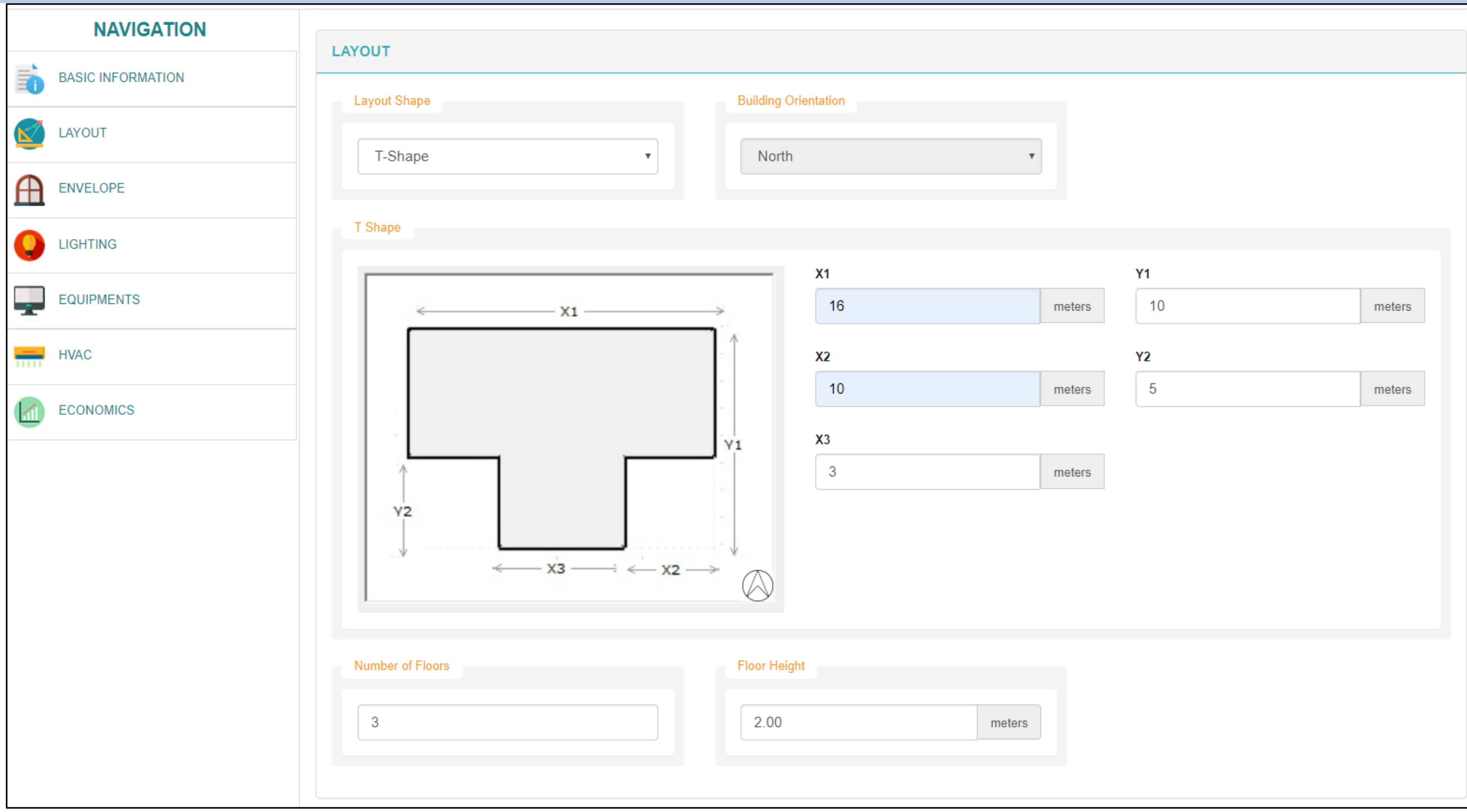
Ready reference on the effect on EPI of the design as compared to conventional (baseline) design

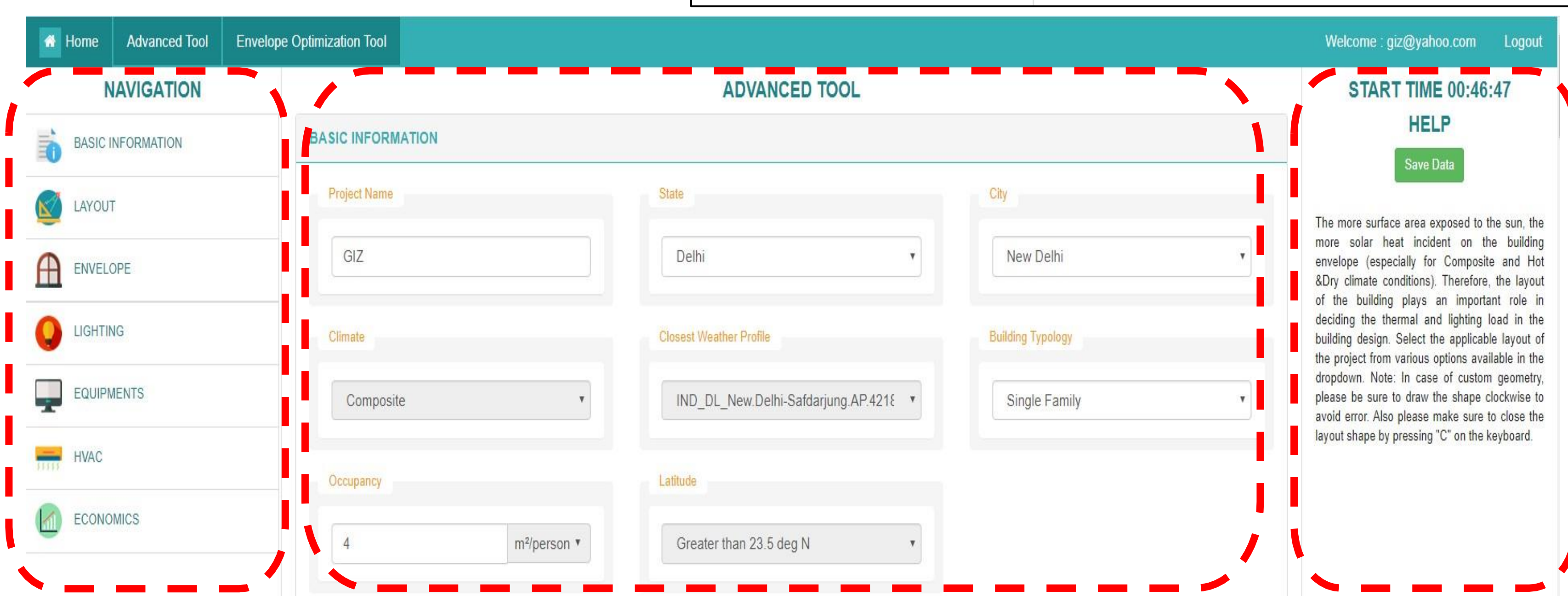
One click export of results to PDF file

ECONIWAS 2.0 – MODULES AND BASIC INFORMATION

ADVANCED TOOL

Simulation based tool for the professionals (Architects, Engineers, MEP consultants, project developers, Industry professionals) who wish to perform detailed analysis of the project design features in terms of energy efficiency, economic feasibility and environmental impact.





Effective and responsible user form that takes essential inputs from the user to generate desired results

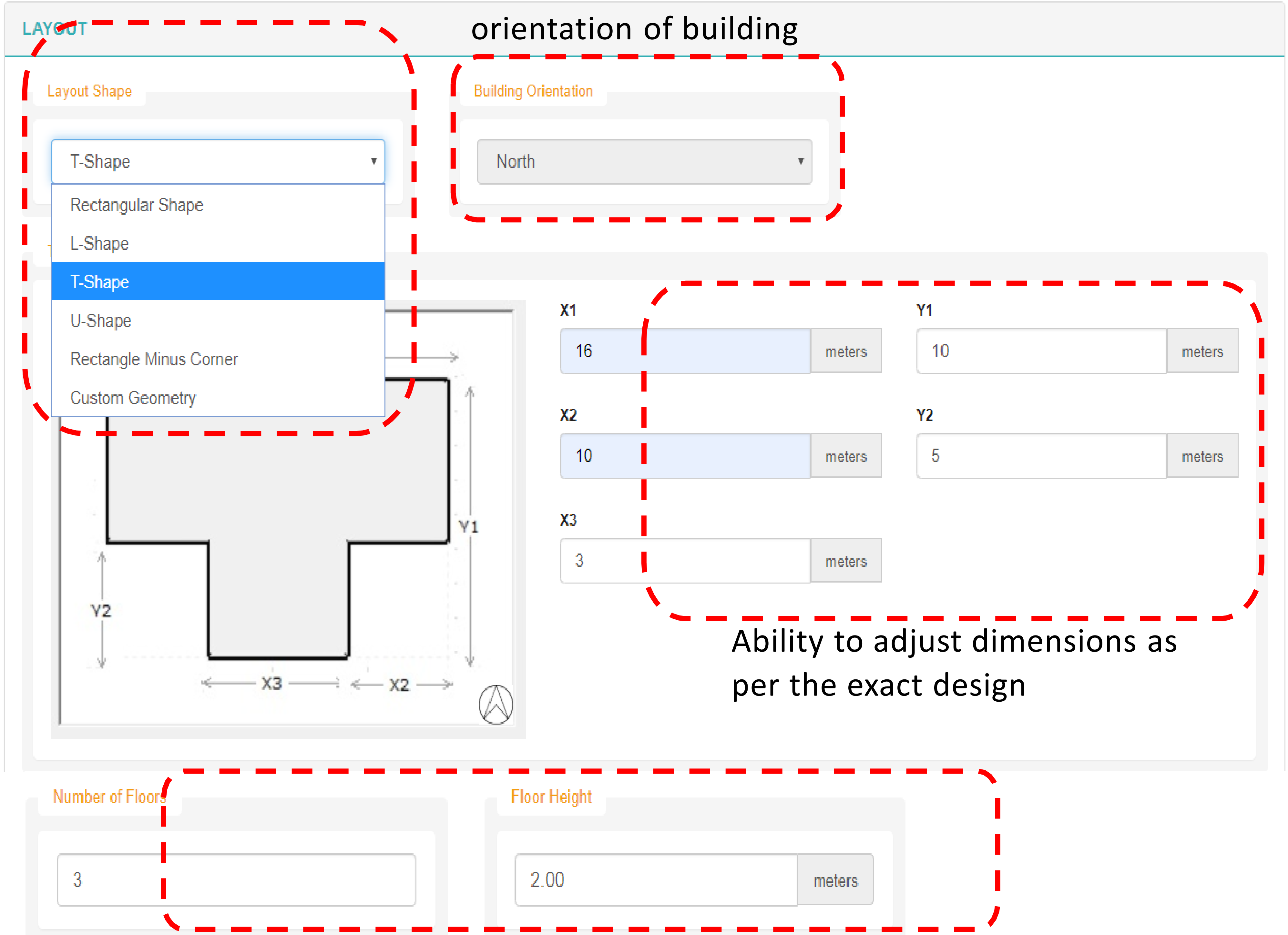
Easy to Navigate, tree view layout for quick navigations between various building parameters.

Self explanatory help panel for easy understanding of inputs for the users

ECONIWAS 2.0 – ADVANCECD TOOL – LAYOUT INFORMATION

Various layout options for the user to choose from, to match exact shape of the building design.

User can select desired orientation of building



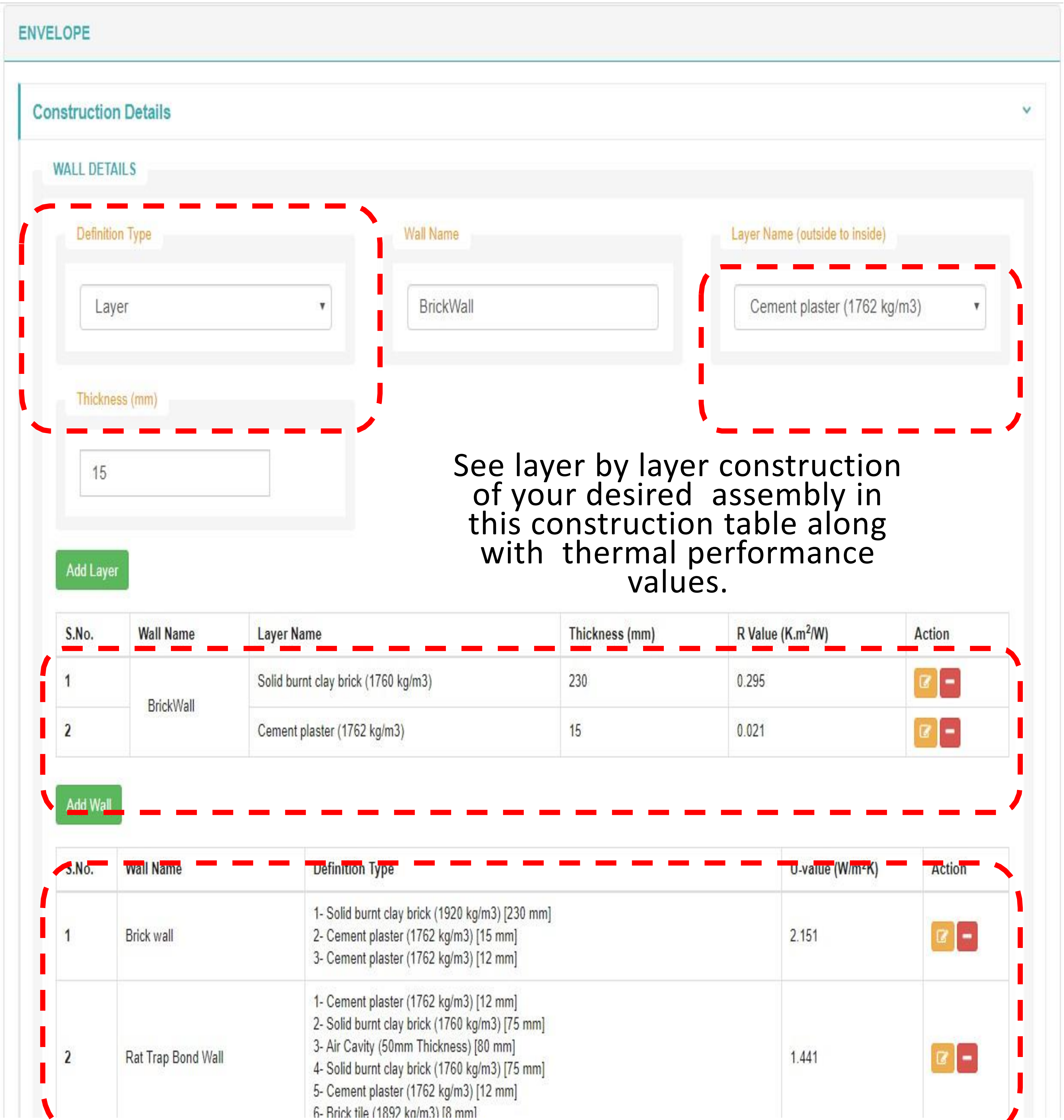
Ability to adjust dimensions as per the exact design

Accessibility to design multiple floors with user specified floor height

ECONIWAS 2.0 – ADVANCECD TOOL – ENVELOPE CONSTRUCTION INFORMATION

For Wall & Roof Construction Assembly Definition

Define Wall/Roof constructions through property (U-value) or layer definition method. The construction once created can be used multiple times.



See layer by layer construction of your desired assembly in this construction table along with thermal performance values.

Large number of construction Materials as per ENS are available in the list

All the assembled constructions are listed in this table for later use.

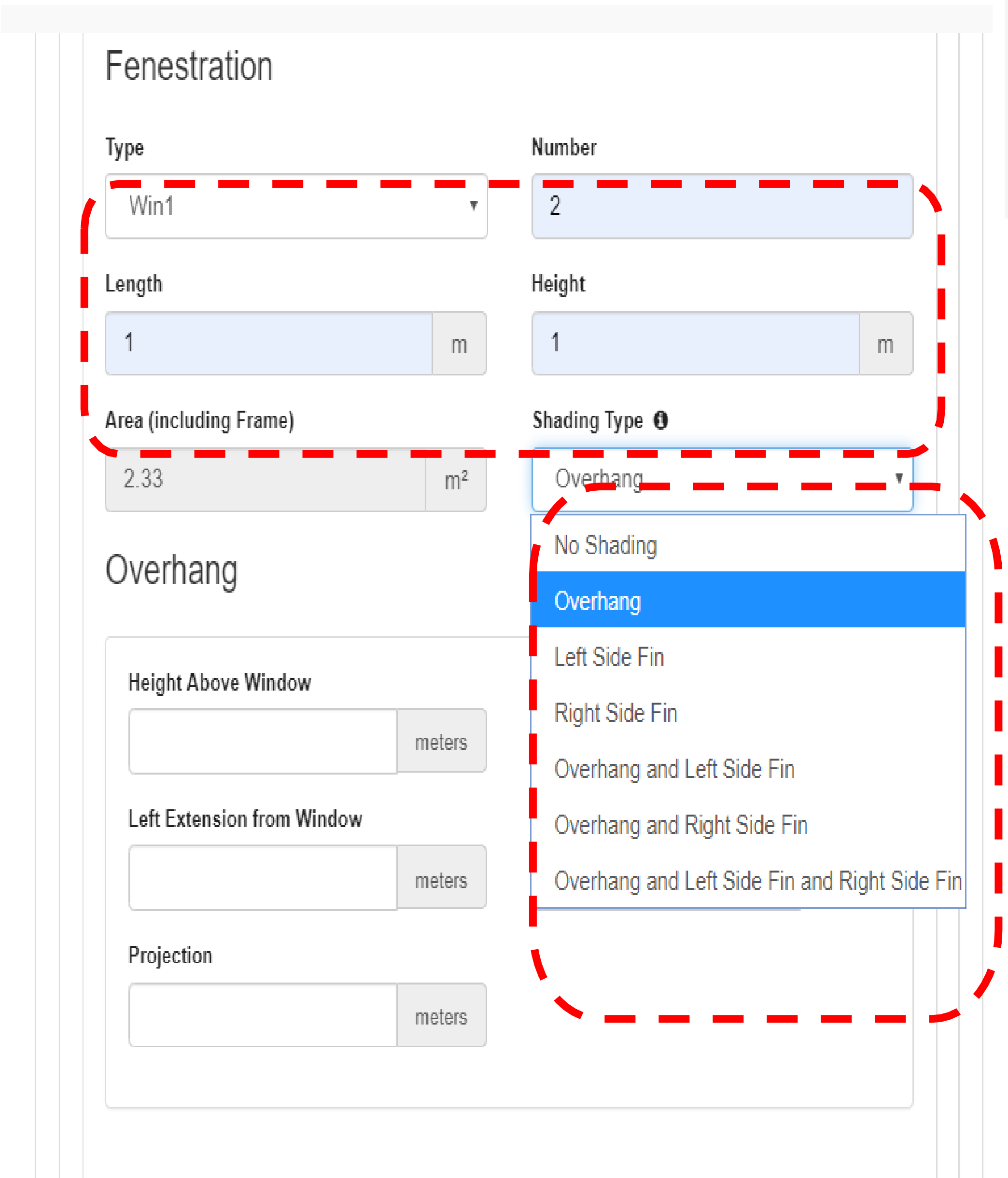
ECONIWAS 2.0 – ADVANCECD TOOL – ENVELOPE CONSTRUCTION INFORMATION

For Fenestration Definition

Define fenestration constructions through property U-value, SHGC & VLT, glazing area and opaque frame selection. The construction once created can be used multiple times.

S.No.	Fenestration Type	Name of the window	Fenestration Opening Type	U-value (W/m²K)	SHGC	VLT	Glazing (%)	Opaque Frame U-Value (W/m².K)	Action
1	Window	wind_1	Casement	1.4	0.4	0.47	50	1.90	
2	Window	wind_2	Casement	0.4	0.4	0.44	40	0.40	

All the window constructions are listed in this table for later use.



For Fenestration & Shading Dimension Definition

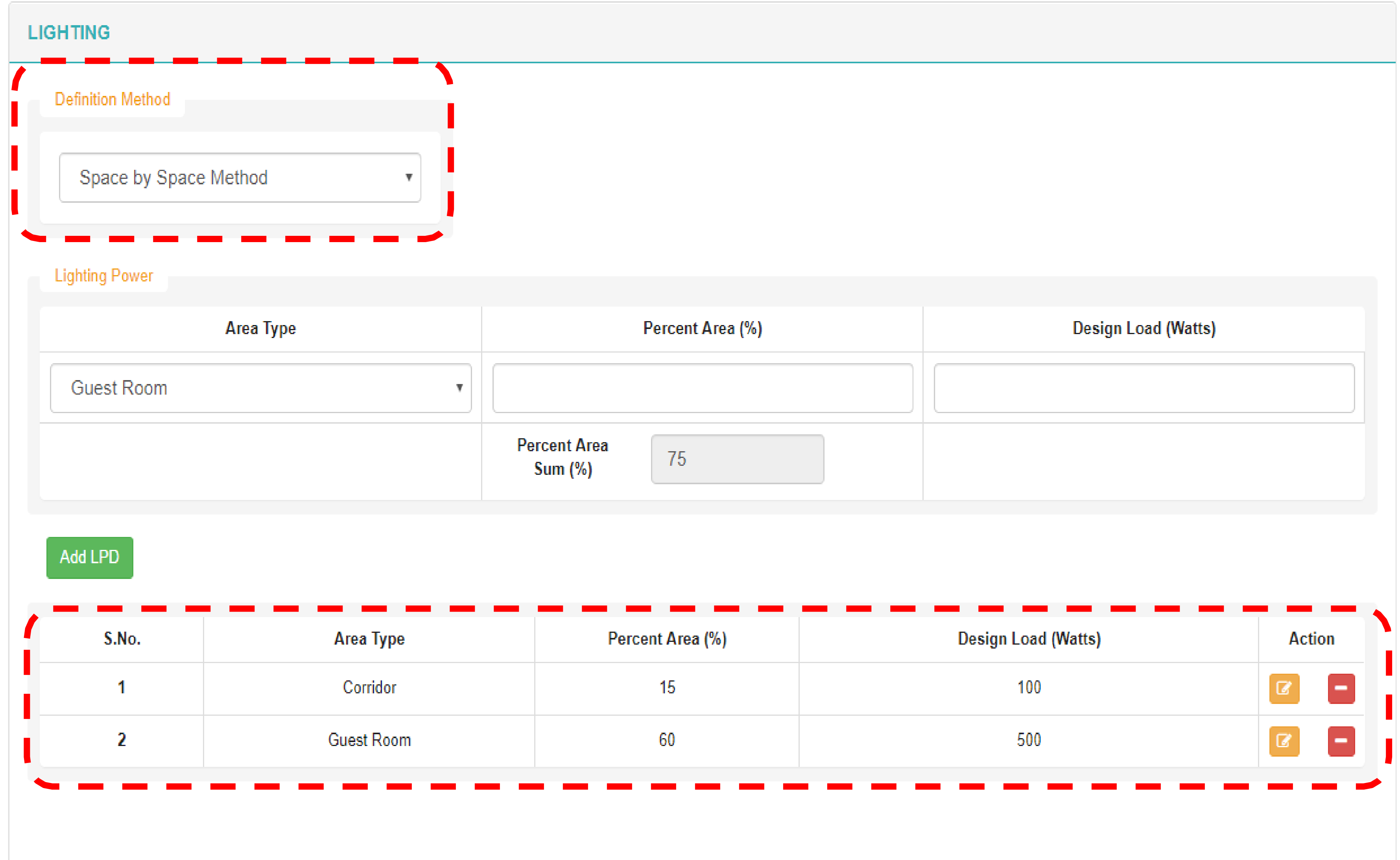
Select window type from predefined window constructions types to be installed on the selected wall of the building. Define dimension of windows and numbers

Options to install shading elements on the selected window. Select one and input dimensions.

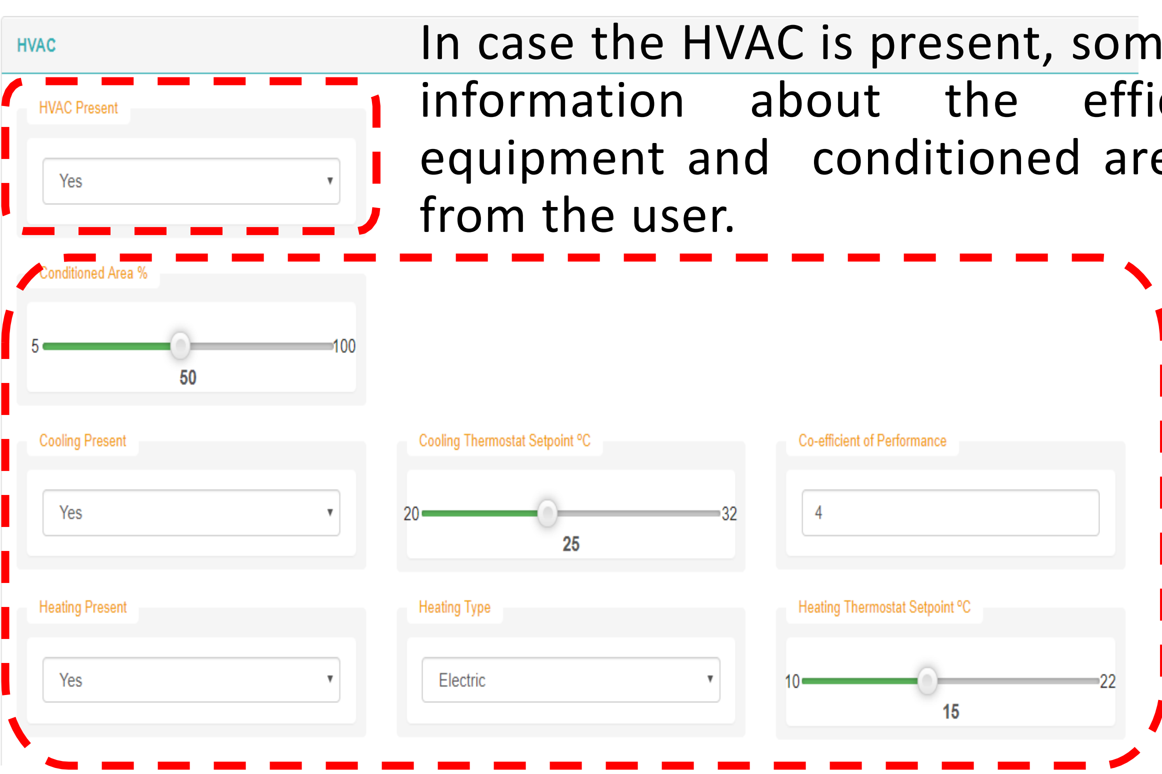
ECONIWAS 2.0 – ADVANCECD TOOL – LIGHTING/EQUIPMENT & HVAC INFORMATION

User can define the lighting/equipment power density using Building Area Method or Space Function Method as per ECBC

This table represents the design lighting/equipment load in different areas of the building.



In case the HVAC is present, some essential information about the efficiency of equipment and conditioned area is asked from the user.

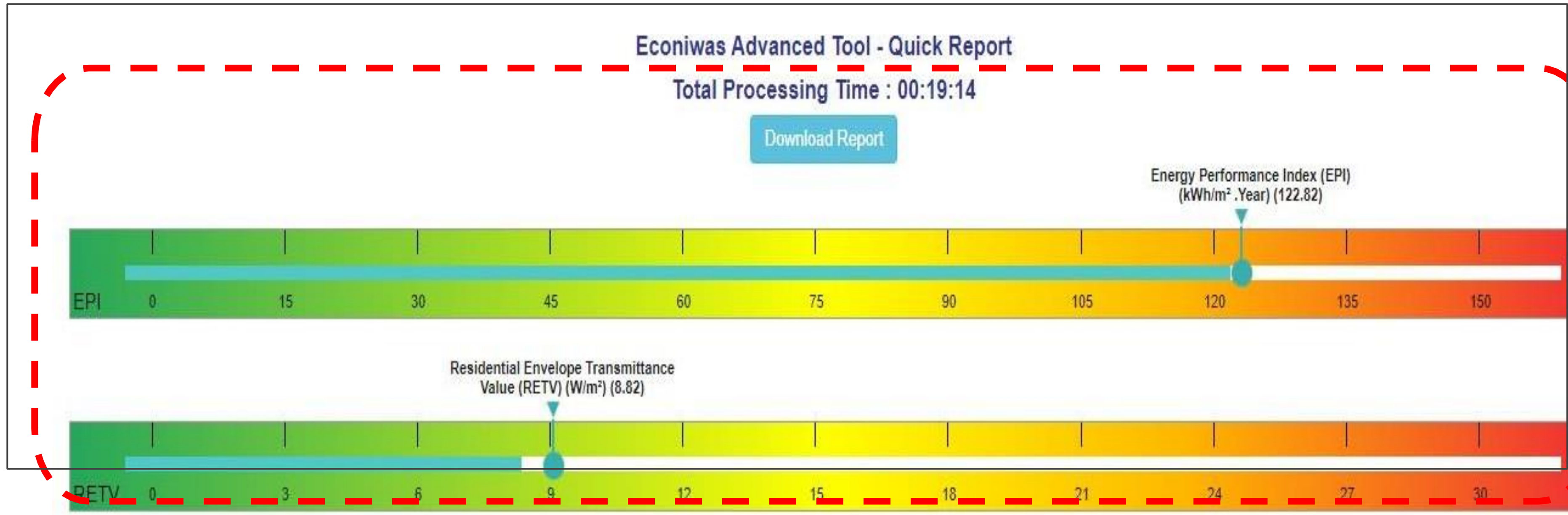


User has the option to choose whether the building is conditioned or naturally ventilated.

ECONIWAS 2.0 – ADVANCECD TOOL – RESULTS

On the submission of the form, the tool performs the energy simulation using energy plus server-side simulation platform to predict the EPI and RETV values of the designed building.

The user has the option to export the results in PDF format for later use, using the "Download Report" button on the results page.

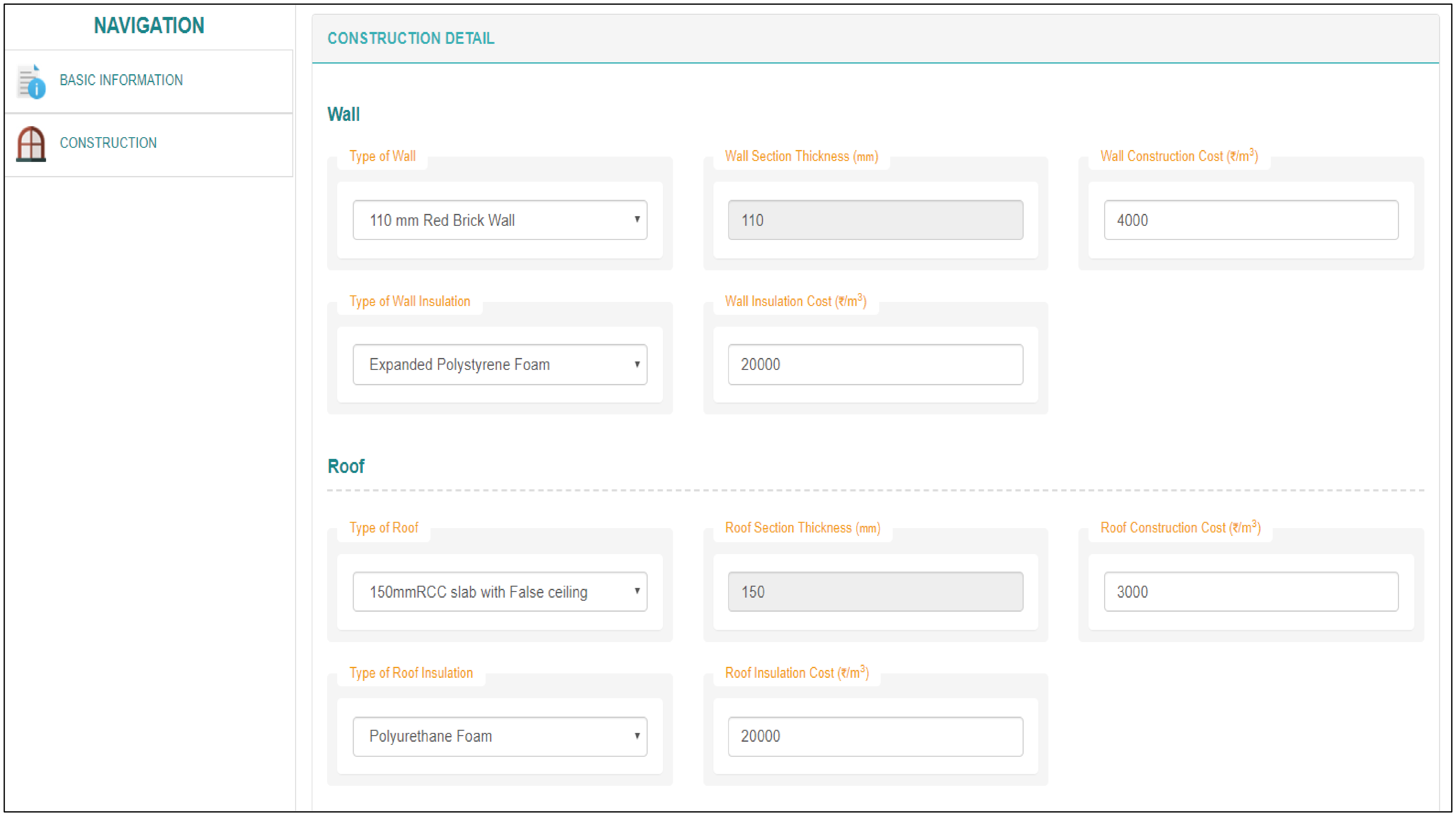


The tool also predicts the Annual CO2 generation, Annual Operational cost of the design and Annual life cycle cost of the project based on the inputs given by the user

ECONIWAS 2.0

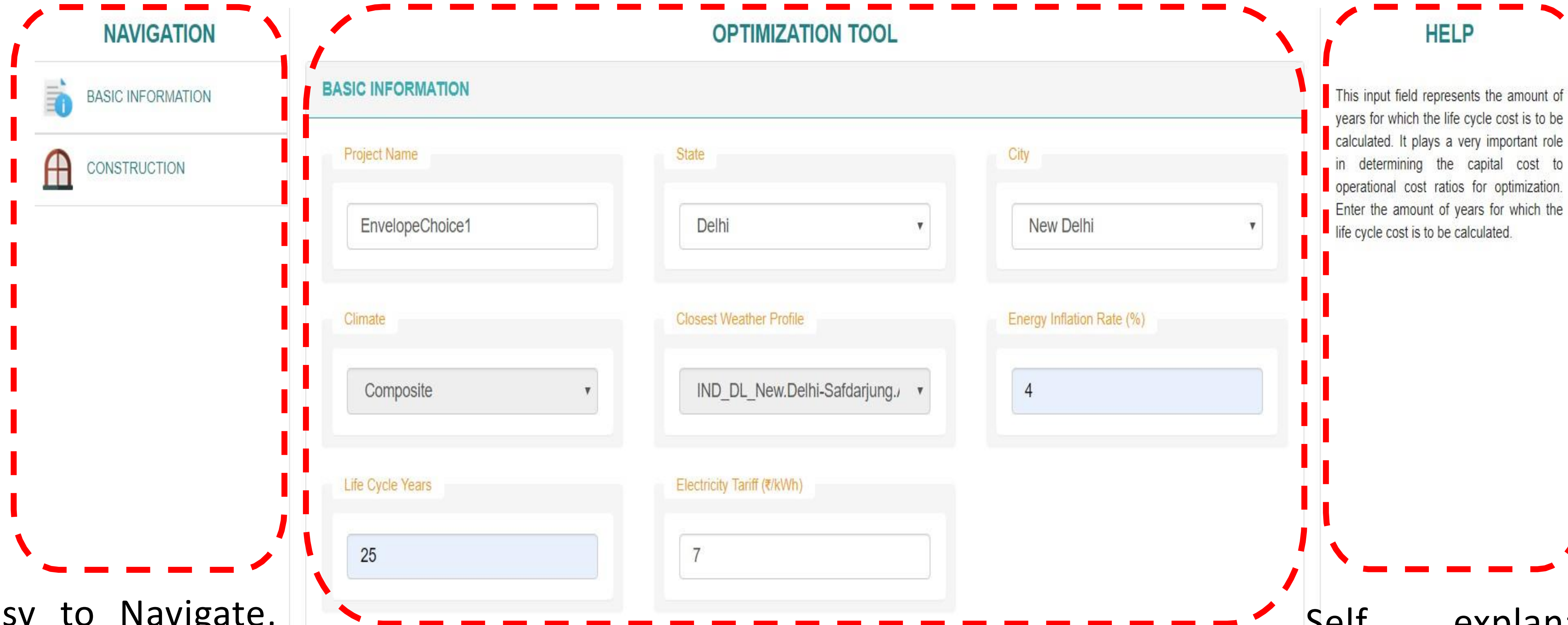
Envelope Optimization Tool

A quick envelope evaluation module to compute the most optimized set of U-values & SHGC for best wall, best roof and best window including thickness of selected insulation required on the selected base assemblies of wall and roof for the selected location based on life cycle cost of the building envelope.



ECONIWAS 2.0 – ENVELOPE OPTIMIZATION TOOL – BASIC INFORMATION

Effective and responsible user form that takes essential inputs from the user to generate desired results. Project location, energy inflation rate, tariff rate and life cycle years are few basic inputs which are required by the user.

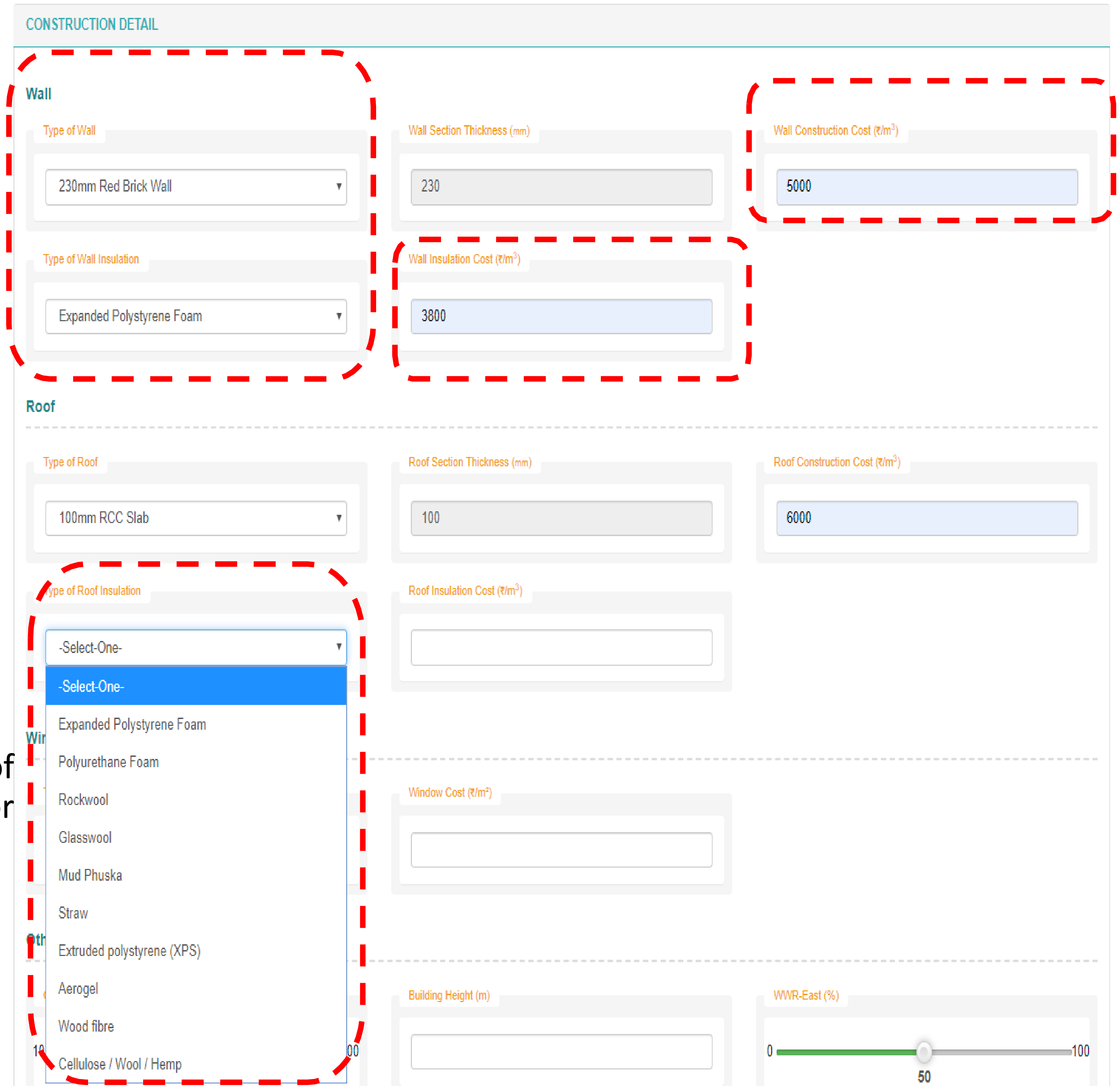


Easy to Navigate, tree view layout for quick navigations between various building parameters.

Self explanatory help panel for easy understanding of inputs for the users

ECONIWAS 2.0 – ENVELOPE OPTIMIZATION TOOL – BASIC INFORMATION

User is required to select the choice of base wall/roof assembly on which insulation of optimized thickness shall be installed. Similarly, selection of insulation material is required as input.

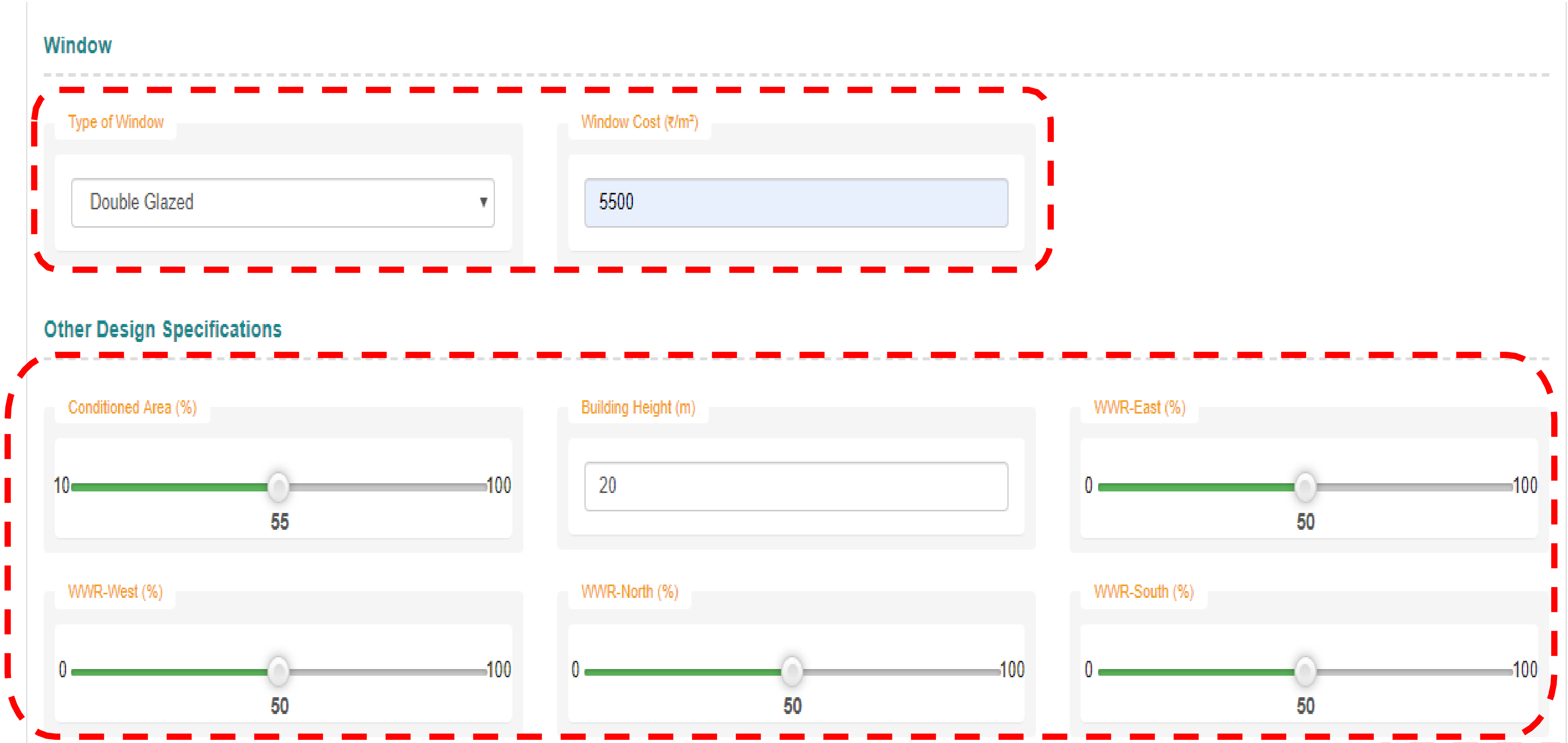


User is required to define the cost per cubic meter for base wall roof assembly and the selected insulation.

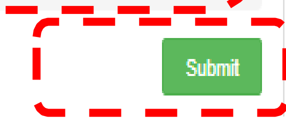
Large number of insulation options for user to choose from.

Similarly, selection of Window type and corresponding cost is required as input. Based on the window type, the optimization tool shall limit the U-value output.

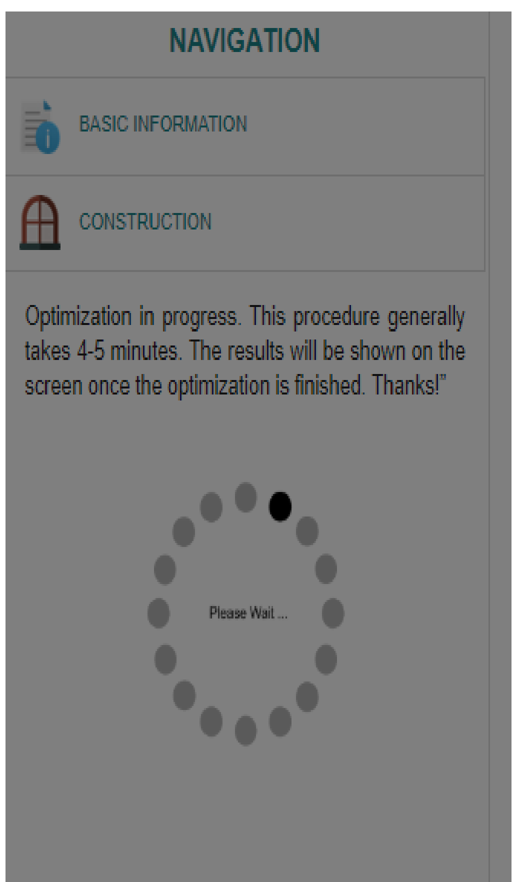
For example, if user selects SGU, the tool can predict U values close to 7 W/m2.K, whereas if user selects DGU, the tool will limit the prediction of U-value upto 4 W/m2.K



Apart from this, a few other relevant information on the envelope such as Building Height, Conditioned Area and WWR of each façade is required as input from the user



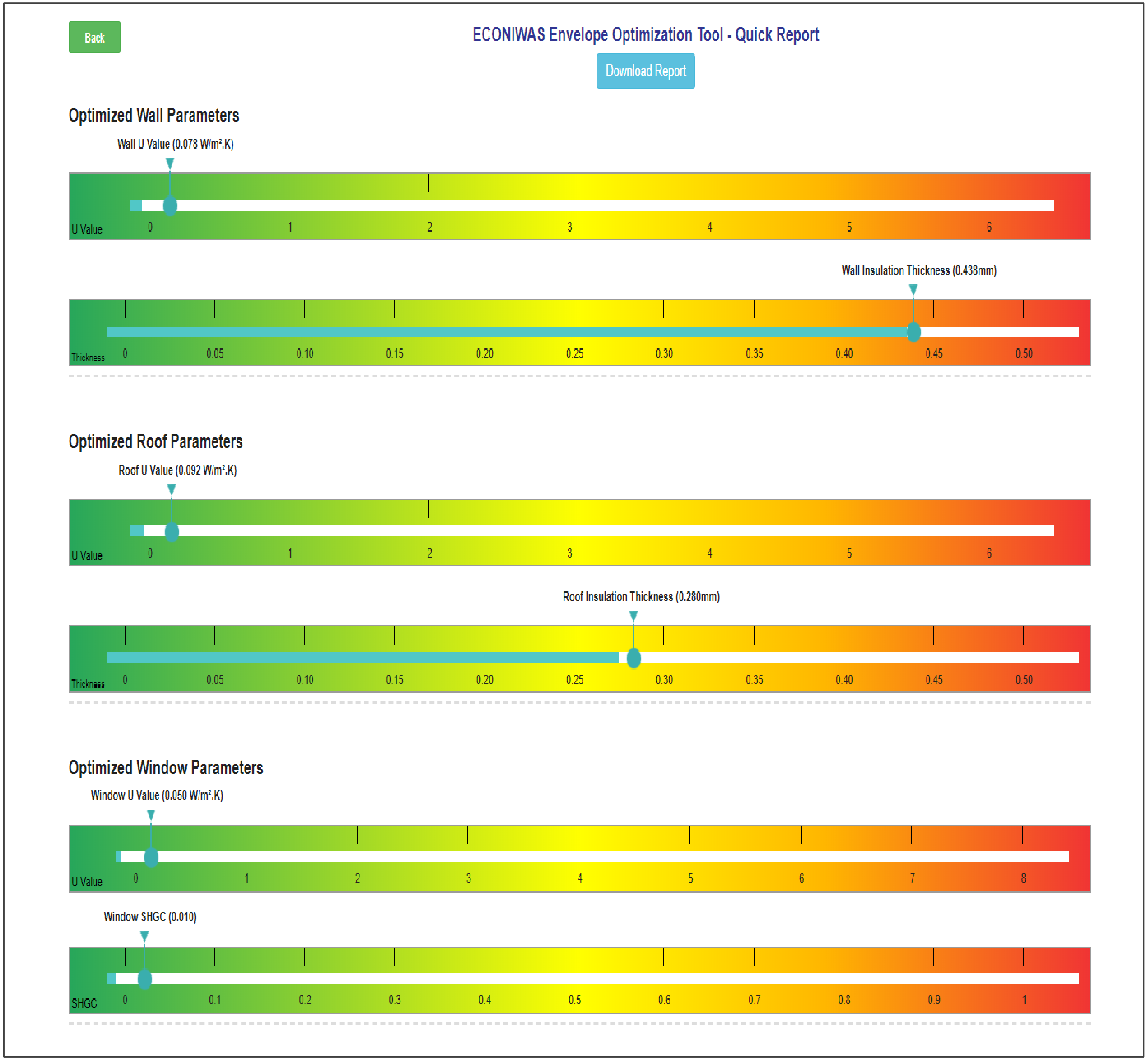
After filling all the required information, the user is required to click on the Submit button to start the optimization engine.



Generally, the optimization process takes 4-5 minutes to complete. The following message is shown in the tool during execution of optimization.

ECONIWAS 2.0 – ENVELOPE OPTIMIZATION TOOL – RESULTS

On the submission of the form, the tool performs the optimization using energy plus server-side simulation platform to predict the optimized U-value, SHGC for envelope components (wall, roof windows) as well as thickness of insulation for wall and roof assemblies. The user also has the option to export the results in PDF format for later use, using the "Download Report" button on the results page.



Lunch Break:

SESSION 7- ENS CODE *ANALYSIS WITH LHP,INDORE*

CODE PROVISIONS

1. Openable Window-to-Floor Area Ratio (WFRop)
2. Visible Light Transmittance (VLT)
3. Thermal Transmittance of Roof (Uroof)
4. Residential envelope transmittance value (RETV) for building envelope (except roof) for four climate zones, namely, Composite Climate, Hot-Dry Climate, Warm-Humid Climate, and Temperate Climate
5. Thermal transmittance of building envelope (except roof) for cold climate (Uenvelope,cold)

CODE COMPLIANCE

ENS CODE COMPLIANCE

Table 1: Minimum ENS Score Requirement

Project Category	Minimum ENS Score
Low rise buildings	47
Affordable Housing	70
High rise buildings	100

Table 2: Component wise Distribution of ENS Score

Section	Components	Minimum points	Additional Points	Maximum Points
6.4	Building Envelope			
	Building Envelope	47	40	87
6.5	Building Services			
	Common area and exterior lighting	3	6	9
	Elevators	13	9	22
	Pumps	6	8	14
	Electrical Systems	1	5	6
6.6	Indoor Electrical End-Use			
	Indoor Lighting		12	12
	Comfort Systems		50	50
	ENS Score	70	130	200

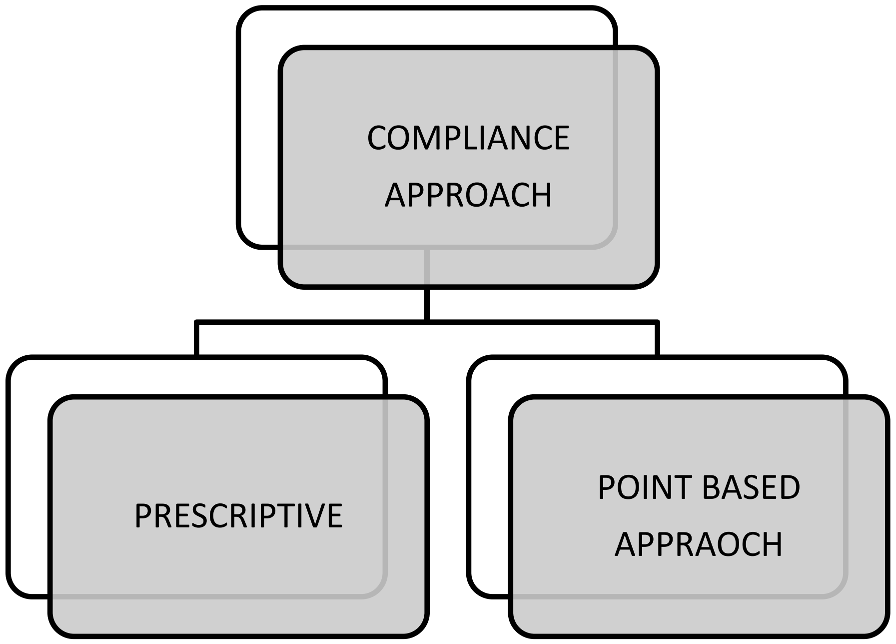
Table 9: Score for Renewable Energy System Components

Renewable Energy Systems Components	Minimum Points	Additional Points	Maximum Points
Solar Hot Water Systems		10	10
Solar Photo Voltaic		10	10
Additional ENS Score		20	20

The purpose of Eco Niwas Samhita 2021

The code applies to –

- Residential buildings built on a plot area of ≥ 500 m2
- Residential part of Mixed land-use building projects, built on a plot area of ≥ 500 m2 .

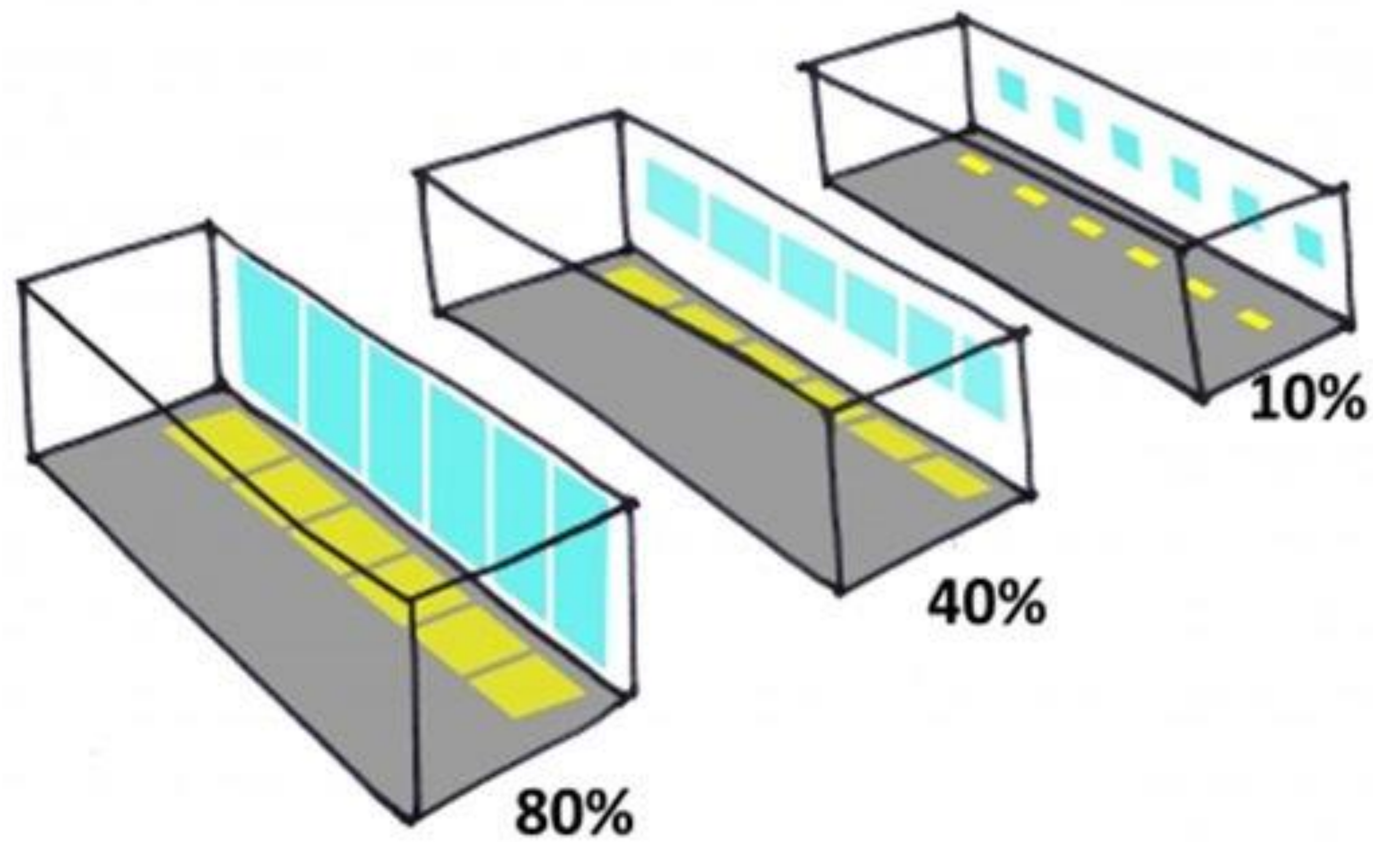


Compliance Approaches

CODE PROVISIONS

- ***Openable Window-to-Floor Area Ratio (WFRop)*** - it indicates the potential of using external air for ventilation.
- Ensuring minimum WFRop helps in ventilation, improvement in thermal comfort, and reduction in cooling energy
- It is the ratio of openable area to the carpet area of dwelling units.

$WFR_{OP} = A_{openable} / A_{carpet}$



3.1.3 The openable window-to-floor area ratio (WFR_{op}) shall not be less than the values[14] given in Table 1.

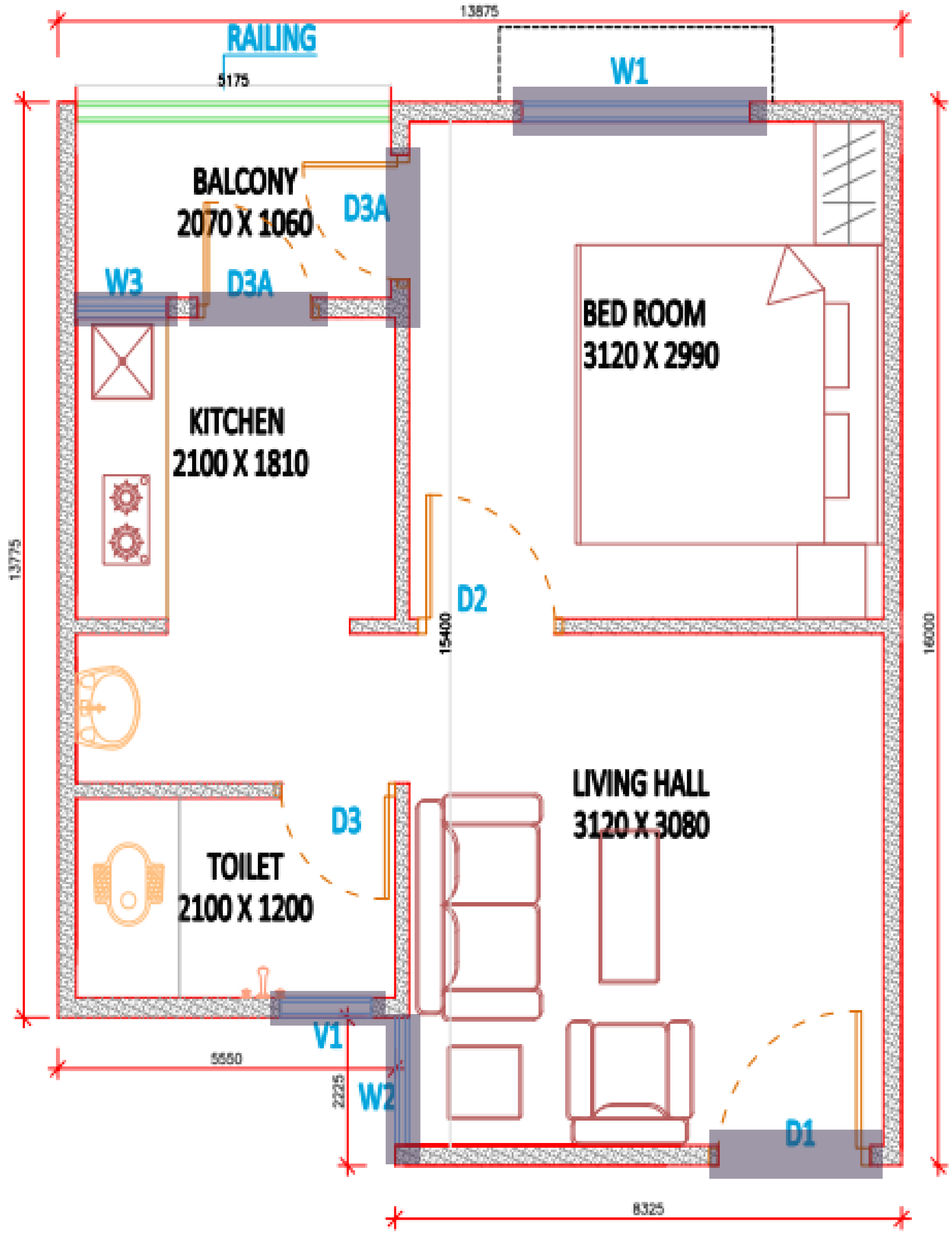
TABLE 1 Minimum requirement of window-to-floor area ratio (WFR_{op})

Climatic zone	Minimum WFR_{op} (%)
Composite	12.50
Hot-Dry	10.00
Warm-Humid	16.66
Temperate	12.50
Cold	8.33

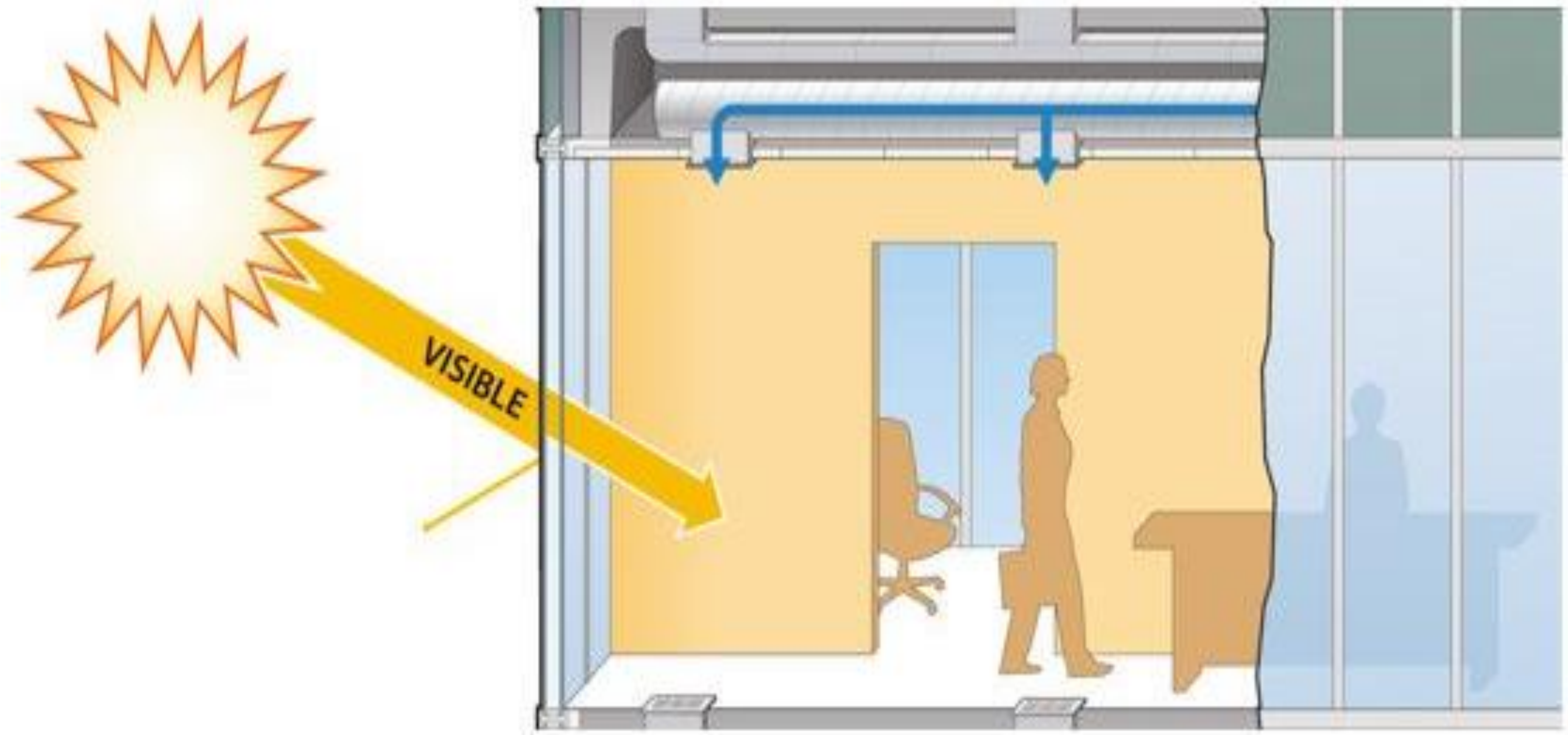
SOURCE Adapted from Bureau of Indian Standards (BIS). 2016. National Building Code of India 2016. New Delhi: BIS.

LHP INDORE

Opening Name	Opening Area, m2	Openable Area, m2	No	Effective Openable area m2
W1	2.40	1.20	1.00	1.20
W2	1.20	0.60	1.00	0.60
W3	0.90	0.81	1.00	0.81
V1	0.27	0.24	1.00	0.24
GD	1.58	1.42	2.00	2.84
openable area for 1 flat				5.69
openable area for 128 flat				728.06
$A_{\text{unit carpet area}}$		128	29.92	3829.76
WFR	$A_{\text{openable}} / A_{\text{carpet}}$			**19.01**
For Composite minimum 12.5%				



Visible Light Transmittance (VLT)



VLT of non-opaque building envelope indicates the potential of using daylight. Ensuring minimum VLT helps in improving day lighting, thereby reducing the energy required for artificial lighting

$$WWR = A_{(Non-Opaque)} / A_{(envelope)}$$

TABLE 2 Minimum visible light transmittance (VLT) requirement[15]

Window-to-wall ratio (WWR)[16]	Minimum VLT [17]
0–0.30	0.27
0.31–0.40	0.20
0.41–0.50	0.16
0.51–0.60	0.13
0.61–0.70	0.11

SOURCE Bureau of Indian Standards (BIS). 2016. National Building Code of India 2016. New Delhi: BIS.

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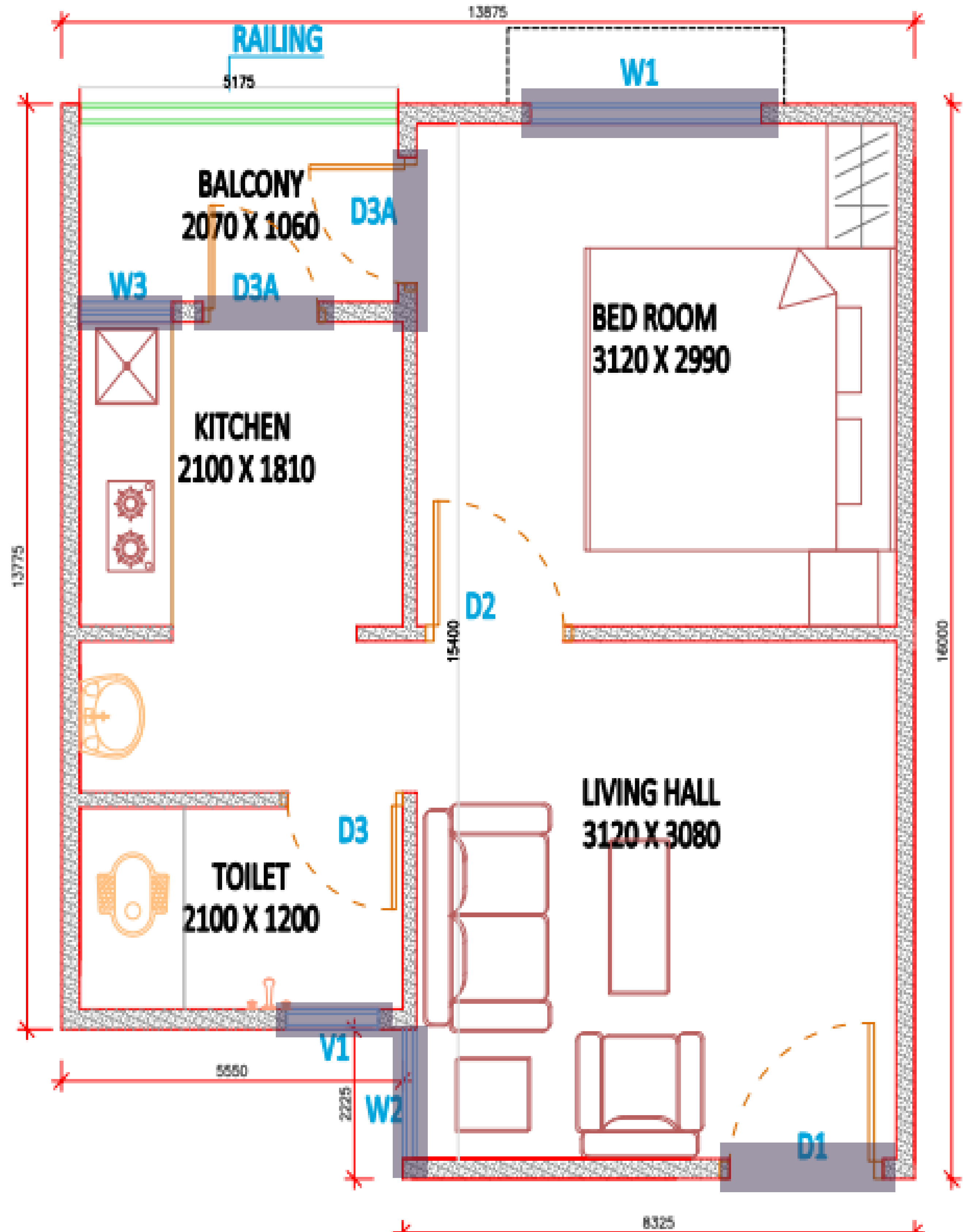
Calculation of Window to Wall Ratio

Orientation	Opening Name	Opening Area, m2	Non - opaque (Glass) Area in Opening, m2	No of openings	Total Opening Are, m2	Total Non-opaque (Glass) Area, m2	Total opaque (PVC, Frame) Area, m2
North	W2	1.2	0.77	16	19.2	12.29	6.91
South	W2	1.2	0.77	16	19.2	12.29	6.91
East	W1	2.4	1.54	64	153.6	98.30	55.30
East	W3	0.9	0.58	64	57.6	36.86	20.74
West	W1	2.4	1.54	64	153.6	98.30	55.30
West	W3	0.9	0.58	64	57.6	36.86	20.74
East	V1	0.27	0.15	16	4.32	2.42	1.90
West	V1	0.27	0.15	16	4.32	2.42	1.90
East	GD	1.58	0	128	201.6	0	0
West	GD	1.58	0	128	201.6	0	0
					872.64	299.75	169.69
					WWR	**0.11**	

Window-to-wall ratio (WWR)	Minimum VLT
0–0.30	0.27

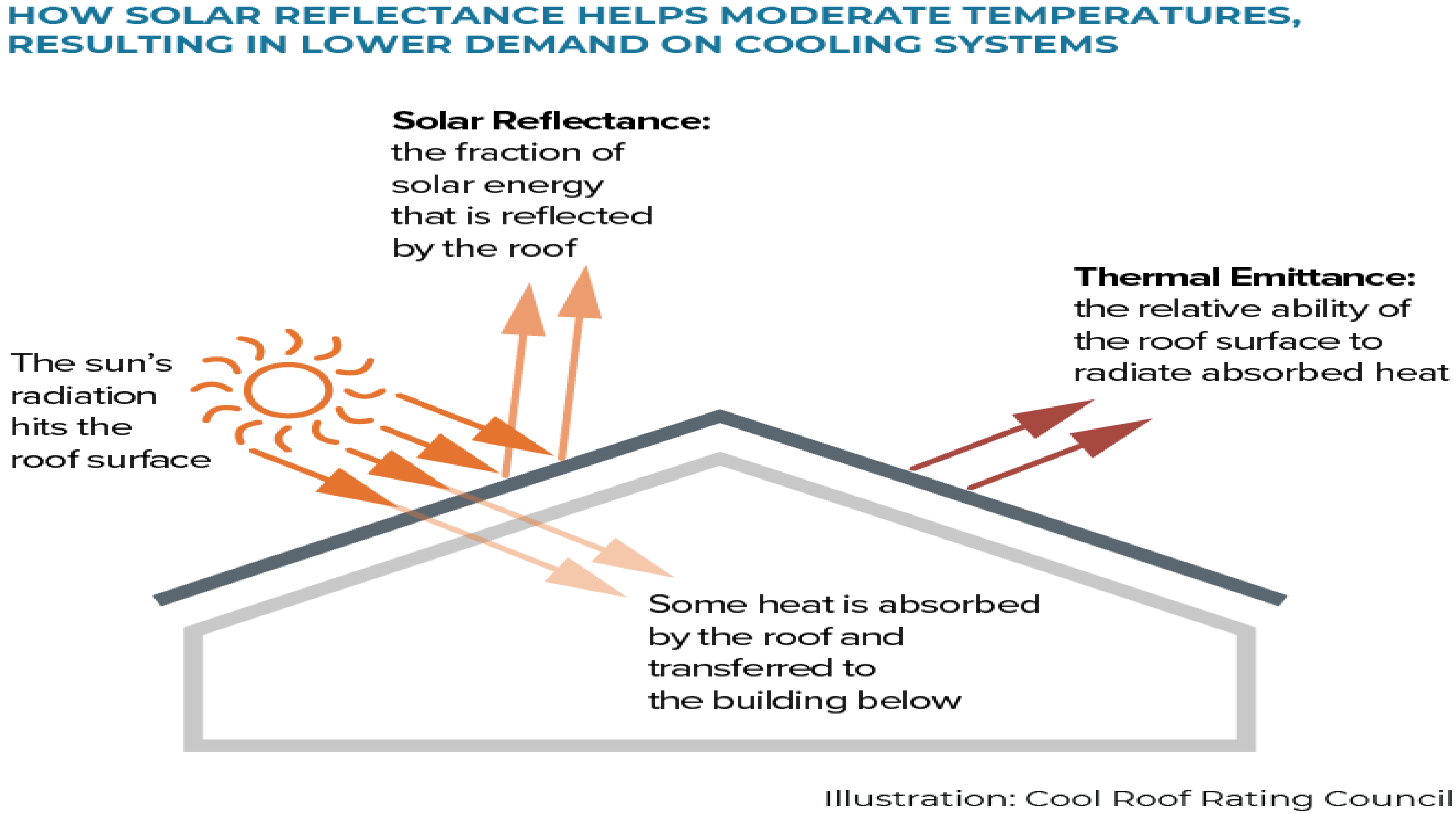
MINIMUM IS 27% while IN LHP INDORE IT IS 90%



As per Table 2, for WWR of 0.21 (range 0–0.30), the minimum required VLT is 27%. The glass used in this project has a VLT of 90% (as per certified specification for the product). Thus, this project complies with this requirement. Also, it complies with the recommended value.

Thermal transmittance

(U_{roof}) characterizes the thermal performance of the roof of a building. *Thermal transmittance of roof shall comply with the maximum* U_{roof} *value of 1.2 W/m2 .K.*



3.3.3 The calculation[18] shall be carried out, using Equation 3 as shown below.

$$U_{roof} = \frac{1}{A_{roof}}\left[\sum_{i=1}^{n}(U_i \times A_i)\right] \quad \ldots(3)$$

where,

U_{roof} : thermal transmittance of roof (W/m².K)

A_{roof} : total area of the roof (m²)

U_i : thermal transmittance values of different roof constructions (W/m².K)

A_i : areas of different roof constructions (m²)

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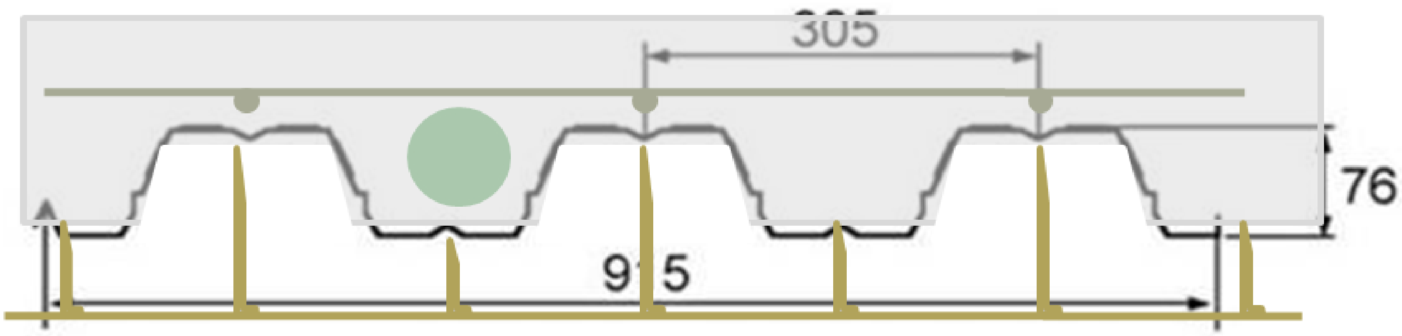


Roof Assembly					
Layer no.	***Material***	***Thickness (m)***	***Conductivity (W/m-K)***	***R value m^2K/W***	***Source***
1	Rsi	0.003	-	0.170	As per ENS guidelines 2018 (roof section), Composite climate
2	Gypsum Board (False Ceiling)	12.500	0.160	0.078	From Manufacturer (Gyproc) Technical Data Sheet
3	Air Gap, 100 mm	0.100	0.500	0.200	As per ENS guidelines 2018, Composite climate
4	Deck Sheet (GI sheet)	0.001	61.060	0.000	As per ENS guidelines 2018, Composite climate
5	RCC Slab	0.098	1.580	0.062	Density Value - from Site team Others (Spc heat, R & K Values) - as per ENS guidelines 2018
6	Brick Bat Coba (Solid Burnt Black Clay Bricks)	0.090	0.620	0.145	As per ENS guidelines 2018, Composite climate
7	Rse	0.003	-	0.04	As per ENS guidelines 2018 (roof section), Composite climate
8	**R Total**			**0.695**	
U value of assembly				**1.439**	

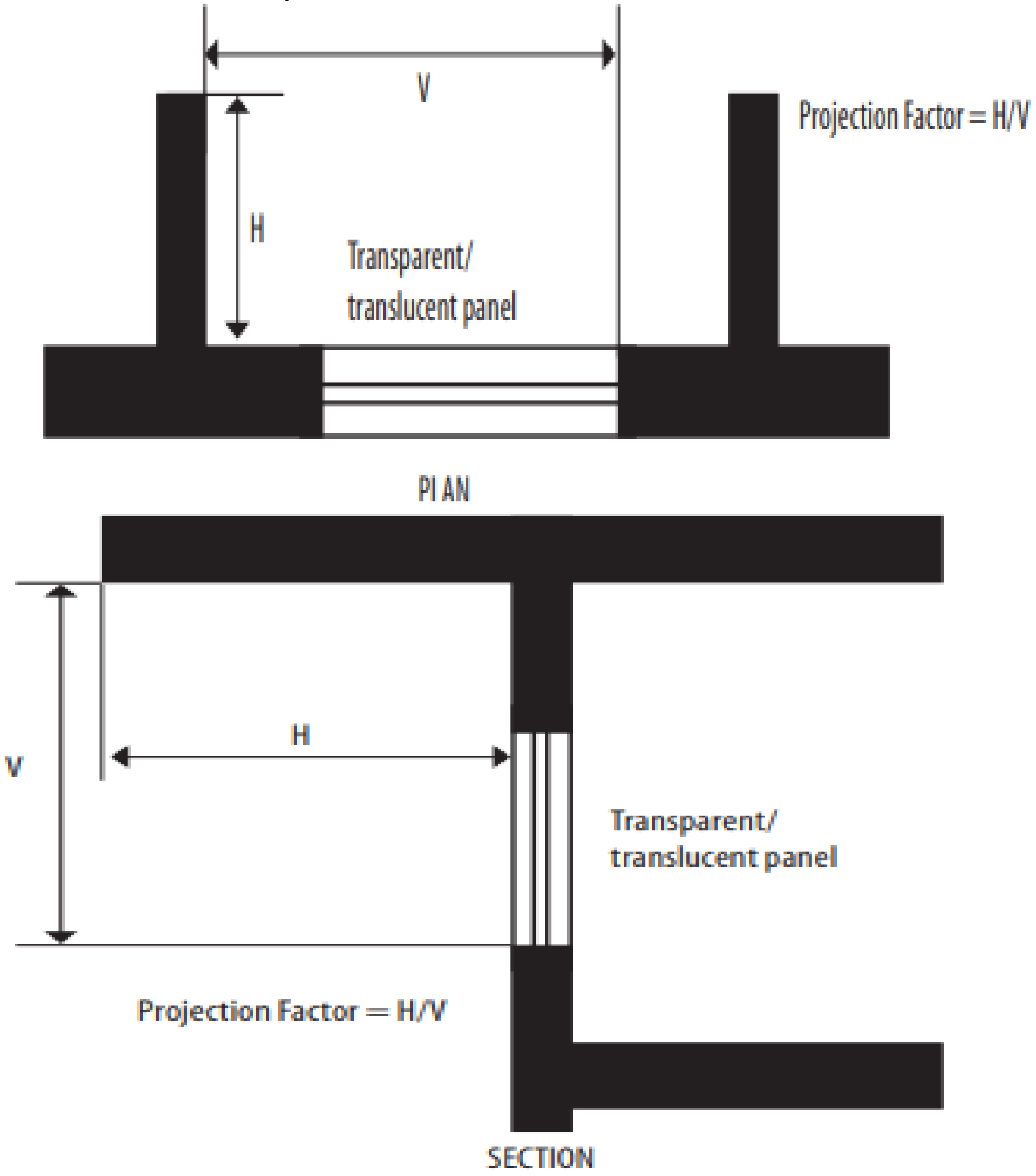
This is greater than the maximum Uroof value of 1.2 W/m2 .K.

Roof U value is 1.44, it can be reduced to 0.4 W/m2.k via adding PUF insulation.

Solar Heat Gain Coefficient (SHGC): SHGC is the fraction of incident solar radiation admitted through non-opaque components, both directly transmitted, and absorbed and subsequently released inward through conduction, convection, and radiation

Projection factor, overhang: the ratio of the horizontal depth of the external shading projection (Hoverhang) to the sum of the height of a non-opaque component and the distance from the top of the same component to the bottom of the farthest point of the external shading projection (Voverhang), in consistent units.

$PF_{overhang} = H_{overhang} / V_{overhang}$



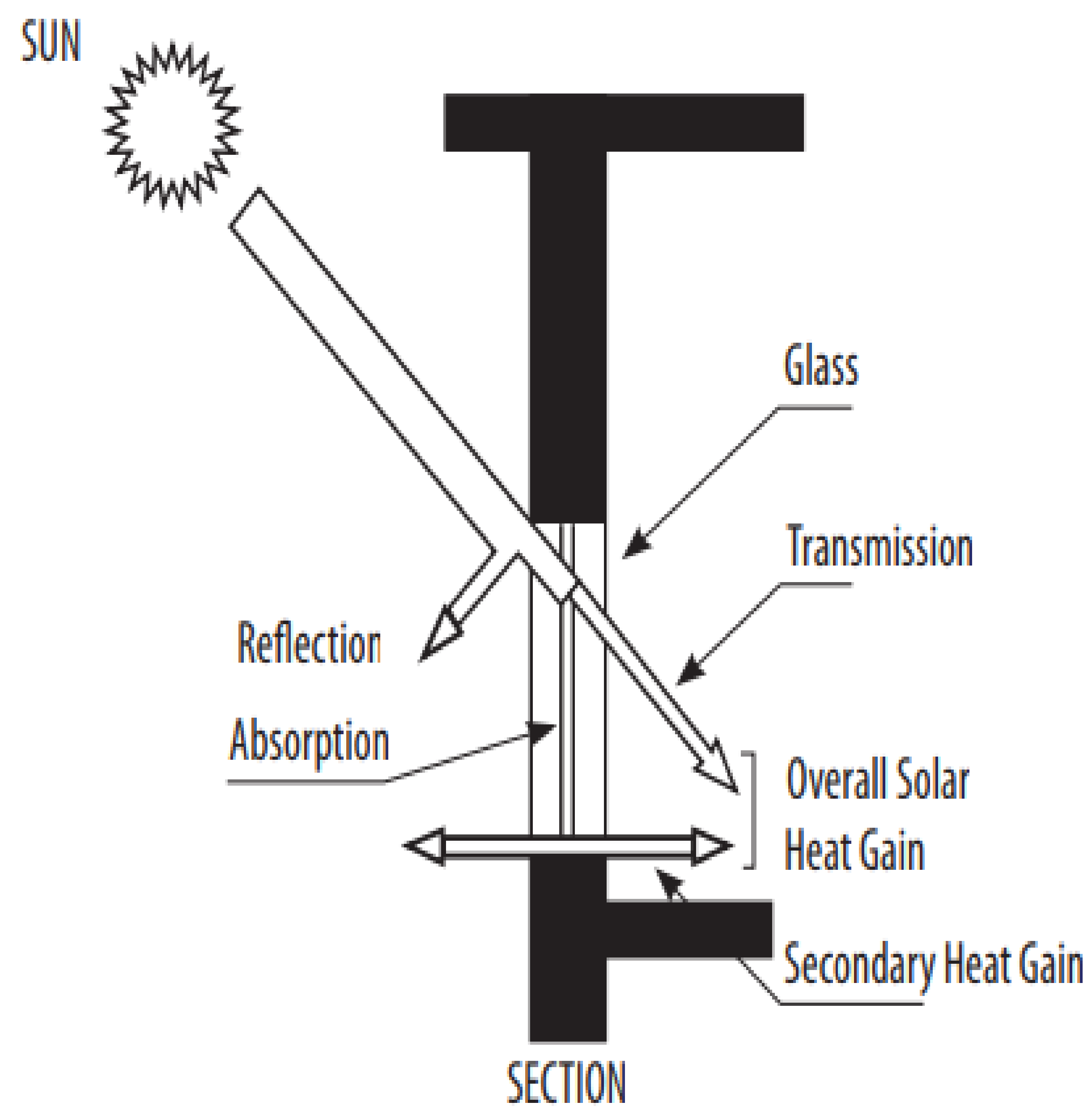


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TABLE 11 External Shading Factor for Overhang ($ESF_{overhang}$) for LAT<23.5°N

Orientation	External Shading Factor for Overhang ($ESF_{overhang}$) for LAT < 23.5°N							
$PF_{overhang}$	North (337.6°–22.5°)	North-east (22.6°–67.5°)	East (67.6°–112.5°)	South-east (112.6°–157.5°)	South (157.6°–202.5°)	South-west (202.6°–247.5°)	West (247.6°–292.5°)	North-west (292.6°–337.5°)
<0.10	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
0.10-0.19	0.931	0.924	0.922	0.910	0.896	0.910	0.922	0.924
0.20-0.29	0.888	0.864	0.855	0.834	0.816	0.834	0.854	0.864
0.30-0.39	0.860	0.818	0.797	0.771	0.754	0.771	0.796	0.818
0.40-0.49	0.838	0.782	0.747	0.721	0.708	0.720	0.746	0.782
0.50-0.59	0.820	0.755	0.705	0.682	0.675	0.681	0.705	0.755

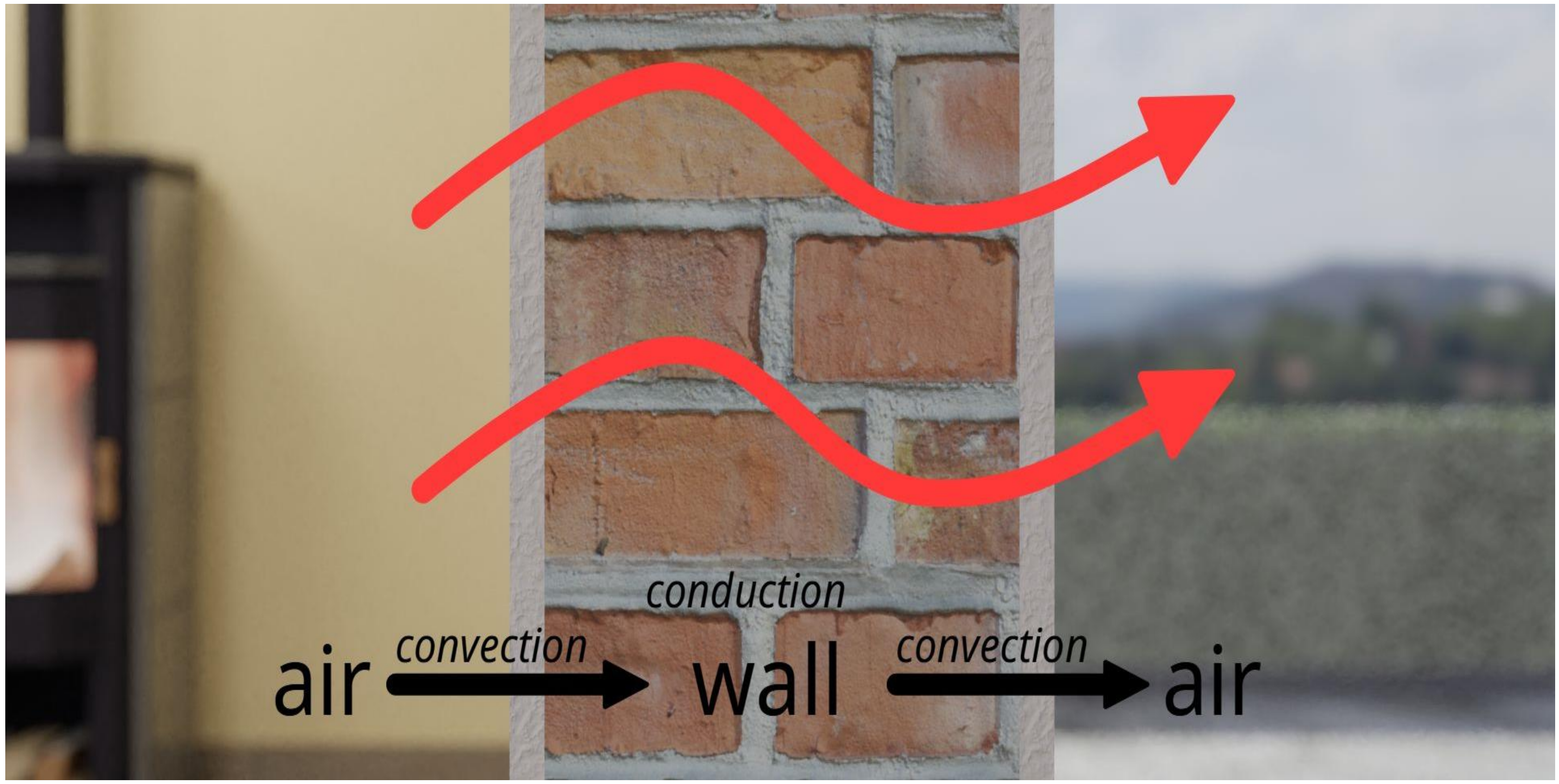
$$SHGC_{eq} = SHGC_{Unshaded} \times ESF_{total}$$

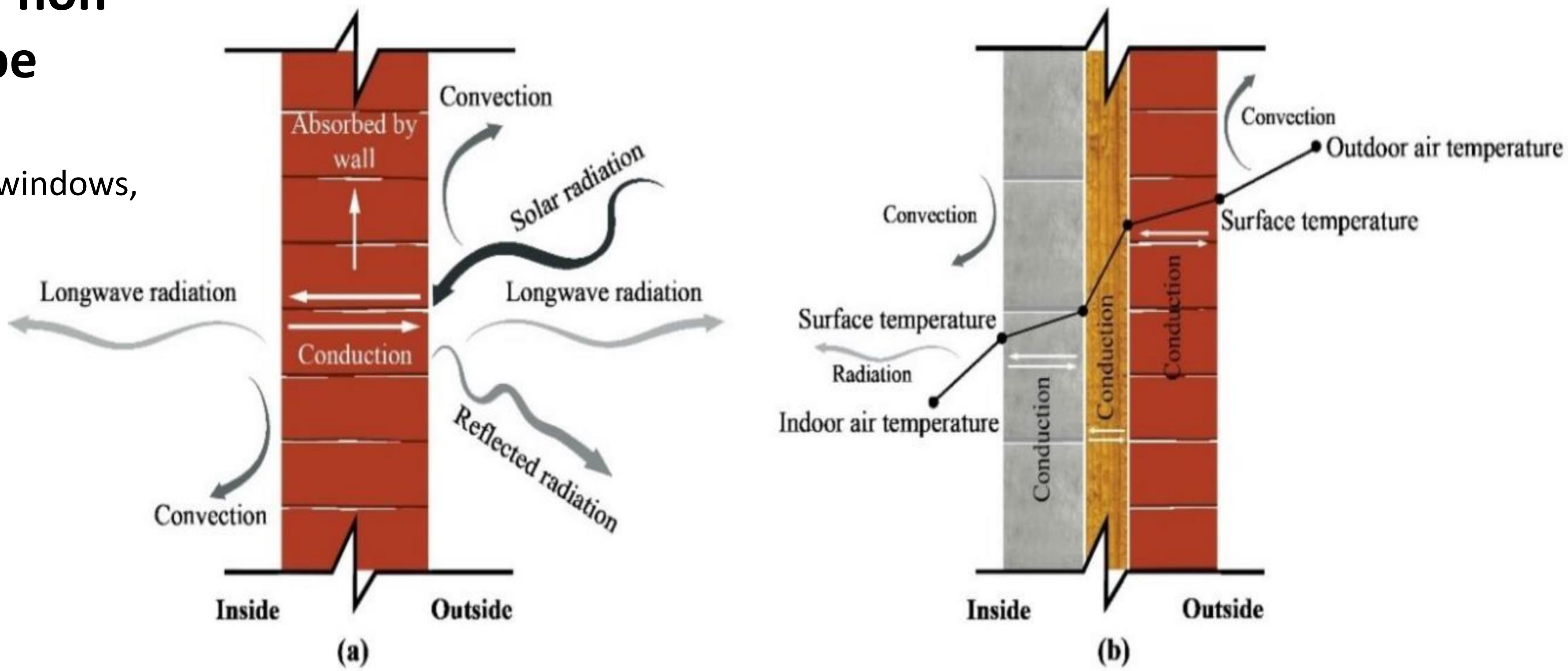
Calculation on equivalent SHGC of Non Opaque Opening for each Orientation

Orientation	Name	Width of Glass, m	Height of Glass, m	Nos of Windows	Glas Area, m2	H, overhabg	V, overhang	PF, overhang	H, right, m	V, right, m	PF, right	H, left, m	V, left, m	PF, left	ESF, overhang	ESF, right	ESF, left	ESFsidefin	ESF, total	SHGCunshaded	SHGC Eq
North	W2	0.64	1.2	16	12.29	0	0	0.00	2.2	0.8	2.75	2.2	0.8	2.75	1	0.86	0.85	0.71	0.71	0.86	**0.61**
South	W2	0.64	1.2	16	12.29	0	0	0.00	2.2	0.8	2.75	2.2	0.8	2.75	1	0.86	0.86	0.72	0.72	0.86	**0.62**
East	W1	1.2	1.28	64	98.30	0.45	1.6	0.28	0	0	0	0	0	0	0.86	1	1	1	0.86	0.86	**0.74**
East	W3	0.48	1.2	64	36.86	1.1	1.6	0.69	1.1	0.6	1.83	1.1	2.1	0.52	0.67	0.88	0.94	0.82	0.55	0.86	**0.47**
West	W1	1.2	1.28	64	98.30	0.45	1.6	0.28	0	0	0	0	0	0	0.85	1	1	1	0.85	0.86	**0.73**
West	W3	0	1.2	64	0	1.1	1.6	0.69	1.1	0.6	1.83	1.1	2.1	0.52	0.67	0.91	0.91	0.83	0.55	0.86	**0.48**

Thermal transmittance of building envelope (except roof)

- Thermal transmittance characterizes the thermal performance of the building envelope (except roof).
- U value takes into account the following:
  - Heat conduction through ***opaque building envelope components*** (wall, opaque panels in door, window, ventilators, etc.)
  - Heat conduction through **non-opaque building envelope components** (transparent/translucent panels in windows, doors, ventilators, etc.).





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External Wall Assembly, 120 mm

Layer no.	Material	Density	Specific Heat	Thickness	Conductivity	R value	Source
		(kg/m3)	(kJ/kg.K)	(m)	(W/m-K)	m^2K/W	
1	Rsi	-	-	0.003	-	0.130	As per ENS guidelines 2018, Composite climate
2	sandwich panel 120mm	780.0	-	0.120	0.220	0.560	
3	Rse	-	-	0.003	-	0.040	As per ENS guidelines 2018, Composite climate
4	R Total					0.730	
U value of assembly						**1.370**	

Internal Wall Assembly, 90 mm

Layer no.	Material	Density	Specific Heat	Thickness	Conductivity	R value	Source
		(kg/m3)	(kJ/kg.K)	(m)	(W/m-K)	m^2K/W	
1	Rsi	-	-	0.003	-	0.130	As per ENS guidelines 2018, Composite climate
2	sandwich panel 90mm	780.000	-	0.090	0.220	0.420	Test Certificate - Rising Japan Infra Mumbai Rising HONGFA (R90 value provided by Manufacturer)
3	Rse	-	-	0.003	-	0.040	As per ENS guidelines 2018, Composite climate
4	R Total					0.590	
U value of assembly						**1.695**	

Internal Wall Assembly, 60 mm

Layer no.	Material	Density	Specific Heat	Thickness	Conductivity	R value	Source
		(kg/m3)	(kJ/kg.K)	(m)	(W/m-K)	m^2K/W	
1	Rsi	-	-	0.003	-	0.130	As per ENS guidelines 2018, Composite climate
2	sandwich panel 60mm	780.0	-	0.060	0.220	0.280	
3	Rse	-	-	0.003	-	0.040	As per ENS guidelines 2018, Composite climate
4	R Total					0.450	
U value of assembly						**2.222**	

Residential Envelope Transmittance Value

RETV characterizes the thermal performance of the building envelope ***(except roof).*** Limiting the RETV value helps in reducing heat gains from the building envelope, thereby improving the thermal comfort and reducing the electricity required for cooling.

Its unit is W/m2 .

$$RETV = \frac{1}{A_{envelope}} \times \left[\begin{array}{l} \left\{ 6.06 \times \sum_{i=1}^{n} \left(A_{opaque_i} \times U_{opaque_i} \times \omega_i \right) \right\} \\ + \left\{ 1.85 \times \sum_{i=1}^{n} \left(A_{non-opaque_i} \times U_{non-opaque_i} \times \omega_i \right) \right\} \\ + \left\{ 68.99 \times \sum_{i=1}^{n} \left(A_{non-opaque_i} \times SHGC_{eq_i} \times \omega_i \right) \right\} \end{array} \right] \begin{array}{l} Term\text{-}I \\ Term\text{-}II \\ Term\text{-}III \end{array}$$

TABLE 3 Coefficients (a, b, and c) for RETV formula

Climate zone	a	b	c
Composite	6.06	1.85	68.99
Hot-Dry	6.06	1.85	68.99
Warm-Humid	5.15	1.31	65.21
Temperate	3.38	0.37	63.69
Cold	Not applicable (Refer Section 3.5)		

LHP INDORE

Orientation	Description	Area, m2	U Value, W/m2.k	Orientation Factor, w	TERM-I a*b*c	TERM-II a*b*c
NORTH	Non-opaque (glass) area	12.29	5.35	0.66	0.00	43.32
NORTH	Opaque area 1 (Sandwich Panel)	297.56	1.37	0.66	268.62	
NORTH	Opaque area 2 (PVC FRAME)	6.91	4.80	0.66	21.86	
NORTH	Opaque area 3 (Wooden doors)	0.00	0.17	0.66	0.00	
SOUTH	Non-opaque (glass) area	12.29	5.35	0.97	0.00	63.51
SOUTH	Opaque area 1 (Sandwich Panel)	297.56	1.37	0.97	393.76	
SOUTH	Opaque area 2 (PVC FRAME)	6.91	4.80	0.97	32.05	
SOUTH	Opaque area 3 (Wooden doors)	0.00	0.17	0.97	0.00	
EAST	Non-opaque (glass) area	137.59	5.35	1.16	0.00	850.19
EAST	Opaque area 1 (Sandwich Panel)	676.99	1.37	1.16	1071.13	
EAST	Opaque area 2 (PVC FRAME)	77.93	4.80	1.16	432.06	
EAST	Opaque area 3 (Wooden doors)	201.60	0.17	1.16	40.52	
WEST	Non-opaque (glass) area	137.59	5.35	1.16	0.00	850.92
WEST	Opaque area 1 (Sandwich Panel)	676.99	1.37	1.16	1072.05	
WEST	Opaque area 2 (PVC FRAME)	77.93	4.80	1.16	432.43	
WEST	Opaque area 3 (Wooden doors)	201.60	0.17	1.16	40.55	
					3805.03	**1807.94**

Orientation	Name	Total Opening Are, m2	Orientation Factor, w	TERM-III a*b*c
North	W2	19.2	0.66	7.71
South	W2	19.2	0.97	11.45
East	W1	153.6	1.16	130.45
East	W3	57.6	1.16	31.40
West	W1	153.6	1.16	130.41
West	W3	57.6	1.16	31.69
				343.11

RETV – 17.75

RETV is >15 W/m2 where clear glass SHGC is 0.86. RETV can be achieved <15, with Clear Glass of SHGC of 0.55.

ENS CODE COMPLIANCE

LHP INDORE Component wise Distribution of ENS Score

ENS Score	80	210	100
Components	**Minimum Points**	**Maximum Points**	**LHP Indore (Proposed)**
Building Envelope	47	87	51
Building Services			
Common area & exterior lighting	3	9	6
Elevators	13	22	17
Pumps	6	14	6
Electrical Systems	1	6	0
Indoor Electrical End-Use			
Indoor Lighting	-	12	9
Comfort Systems	-	50	6
Renewable	10	10	5

Common Area and exterior Lighting

- Light installation will be done in a way where W/m2 will meet the criteria
- Fixture Lm/W, Lumens will se selected in a way where Lm/W will be more than 95

Elevators

- Proposal from Elevator OEM meeting all the requirement / criteria. It is proposed to go for same proposal / BOQ line items
- Choose VVVF technology based elevator. (part of proposal). This will help in achieving extra points

Pumps

Expected that PMC team will go for BEE 4 star rated pumps as Hydro-Pneumatic is expensive technology. Project can achieve 06 points

Renewable Energy Systems

As per drawings provided, Installation of 79 Panels need approx. 132 sqm area which is approx. to 24% of tower roof area occupied by Panels. Hence project can achieve 5 points.

SESSION 8: Low Energy Comfort System & BEE Star labelling

BEE STAR LABELLING FOR RESIDENTIAL BUILDINGS

Labeling Types

"Applied For" label	Applicable for new buildings with construction permit issued by the authorities having jurisdiction
"Final" Label	Applicable for existing and new buildings. For new building, this label can only be awarded after the occupancy certificate is issued by the authorities having jurisdiction

Labeling Process

Outline of process for awarding BEE Star Label for Residential Buildings

Preparation Stage
- Pre-requisites for applying
- Evaluation for eligibility requirements

Application processing
- Registration
- Online application
- Scrutiny of application
- Approval for label

Implementation
- Transfer from "Applied for" to "Final" label
- Ownership transfer
- Changes in label, already awarded

M&V
- Verification audits
- Data reporting

For more information: www.econiwas.com and www.beeindia.gov.in

About the Program

The program aims to develop national energy efficiency label for residential buildings to enhance energy efficiency in the residential sector.

A residential building label is a benchmark to compare a home over the other on the energy efficiency standards

Need of Residential Building Labeling Program

- Real estate market is expected to climb up to US$ 180 billion by 2020
- Residential sector is expected to contribute 11% to India's GDP by 2020.
- More than 3 billion square meters of new residential buildings will be added by 2030
- Electricity demand due to residential sector is expected to reach 698 billion units by 2030 from 2018 value of 250 billion units

BEE STAR LABELLING FOR RESIDENTIAL BUILDINGS

Program Objectives

The objective of the program is to provide:-

- information to consumers on the energy efficiency standard of the Homes
- Facilitation in the implementation of EcoNiwas Samhita 2018
- a consumer driven market transformation business model solution for Energy Efficiency in housing sector
- steering the construction activities of India towards international best practices norms

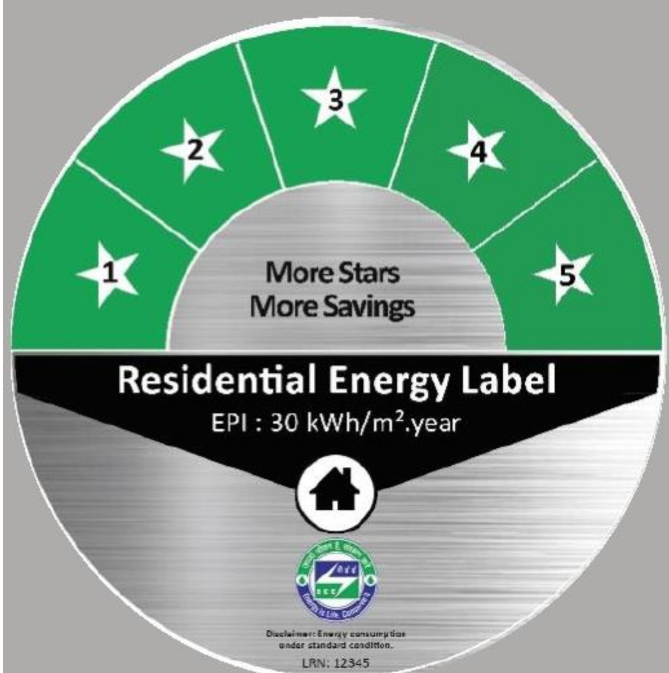
Program Scope

The program is applicable for all single and multiple dwelling unit in the country for residential purpose

5 star rated home is **40%** more energy efficient than 1 star rated home

Energy Savings

Annual saving of 90 Billion Units in the year of 2030



Benefits from the labeling program

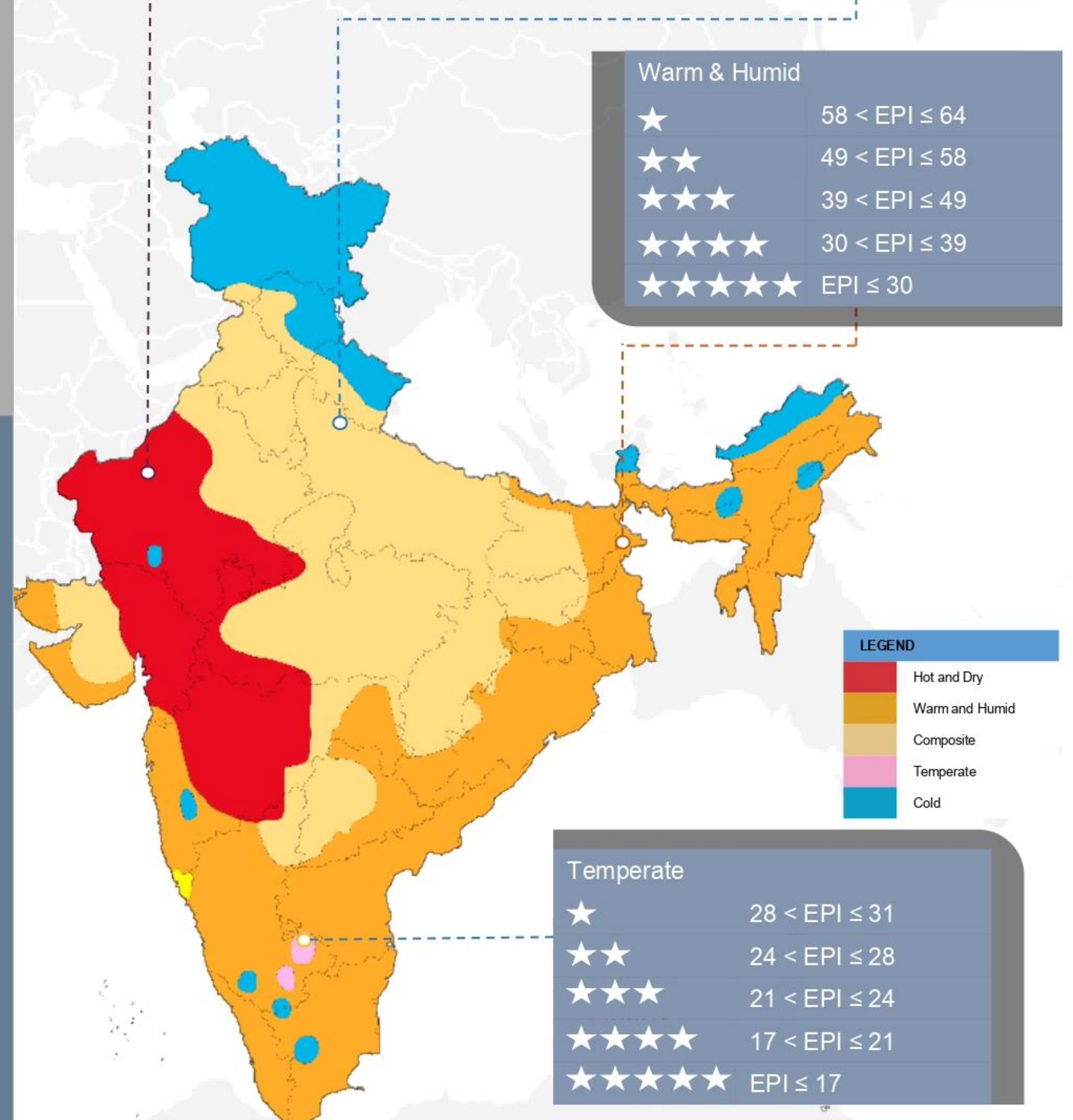
- Cumulative saving of 388 billion units of electricity by 2030
- Reduction of carbon emission by 3 billion tones by 2030
- Increased uptake of energy efficient construction in India
- Facilitate energy efficient materials and technologies market supporting the "Make in India" initiative
- Improve environmental resilience and energy security
- Sustainable living standards

Residential Building Star Rating Plan

Hot & Dry	
★	55 < EPI ≤ 67
★★	47 < EPI ≤ 55
★★★	38 < EPI ≤ 47
★★★★	29 < EPI ≤ 38
★★★★★	EPI ≤ 29

Composite	
★	52 < EPI ≤ 60
★★	45 < EPI ≤ 52
★★★	37 < EPI ≤ 45
★★★★	29 < EPI ≤ 37
★★★★★	EPI ≤ 29

Warm & Humid	
★	58 < EPI ≤ 64
★★	49 < EPI ≤ 58
★★★	39 < EPI ≤ 49
★★★★	30 < EPI ≤ 39
★★★★★	EPI ≤ 30



Temperate	
★	28 < EPI ≤ 31
★★	24 < EPI ≤ 28
★★★	21 < EPI ≤ 24
★★★★	17 < EPI ≤ 21
★★★★★	EPI ≤ 17

BIM Technology

- A single coherent system of computer based
- 3D models rather than separate design drawings
- BIM incorporates people and technology to streamline time and cost, and improve efficiency in builds including skyscrapers, hospitals, office and residential buildings.
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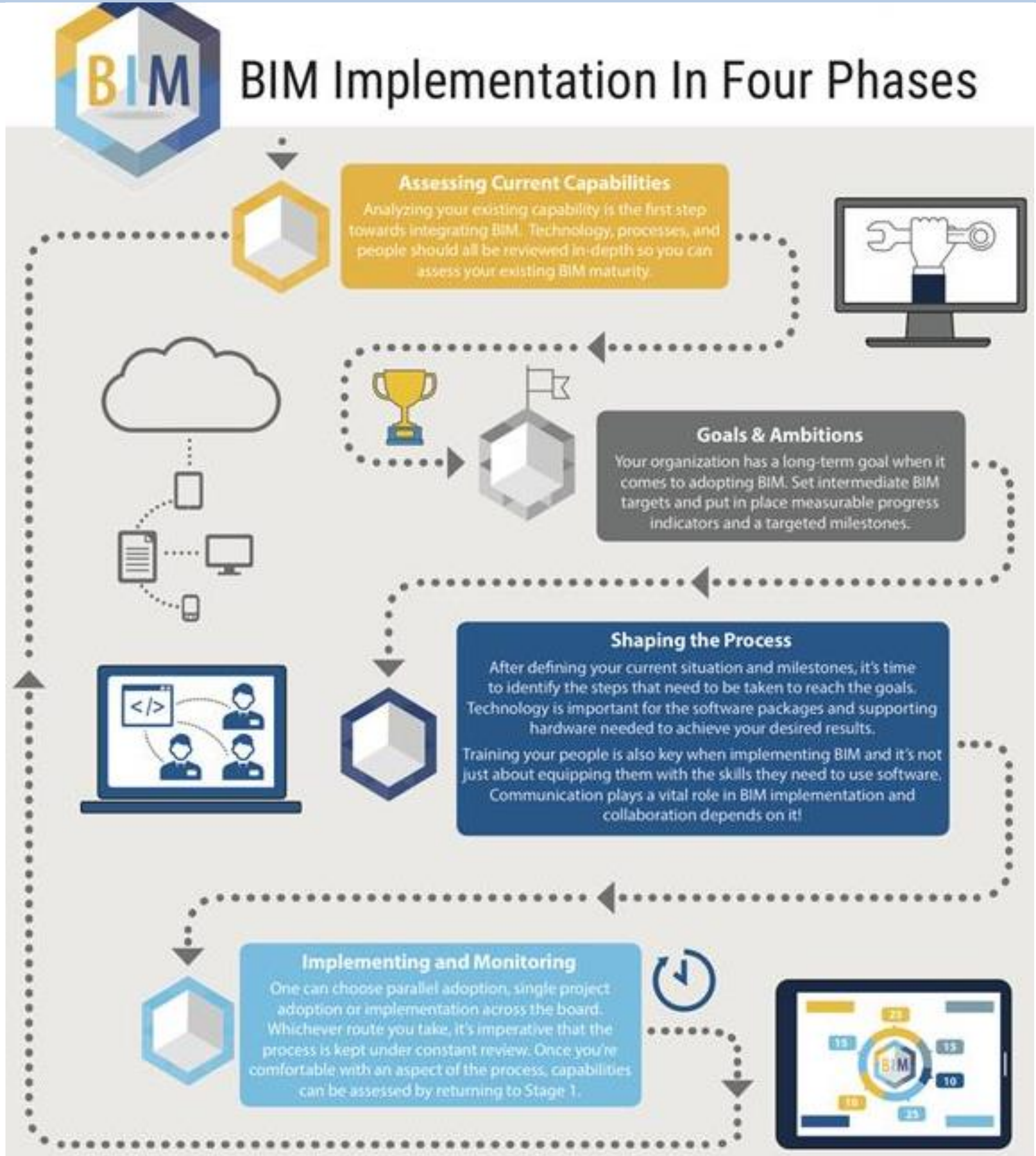

INTERNATIONAL BEST PRACTICES

BIM Technology

LEARNINGS

- Mainstreaming passive strategies in buildings for thermal comfort can significantly reduce cooling, ventilation and lighting requirements in buildings;
- Lesser dependency on mechanical cooling/ heating approaches will decrease formation of surface ozone, hence better air quality.
- Greater awareness of the benefits of sustainable building design will spur greater demand from all strata of society
- Sensitivity in building practices will tend to decrease disparity in thermal comfort of different economic classes.
- **Make active strategies passive, and passive strategies active.**
- **70% of the buildings required in India by 2030 are yet to be built. Maintaining status quo is irrelevant, and there is a great opportunity for incorporating passive design strategies successfully across our built environment.**

Source: McKinsey

Thank you.

time for a little

question & answer

session