Ministry of Housing and Urban Affairs
Government of India

Climate Smart Buildings (CSB)

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

RACHNA

RESILIENT, AFFORDABLE AND COMFORTABLE HOUSING THROUGH NATIONAL ACTION

THERMAL COMFORT IN AFFORDABLE HOUSING

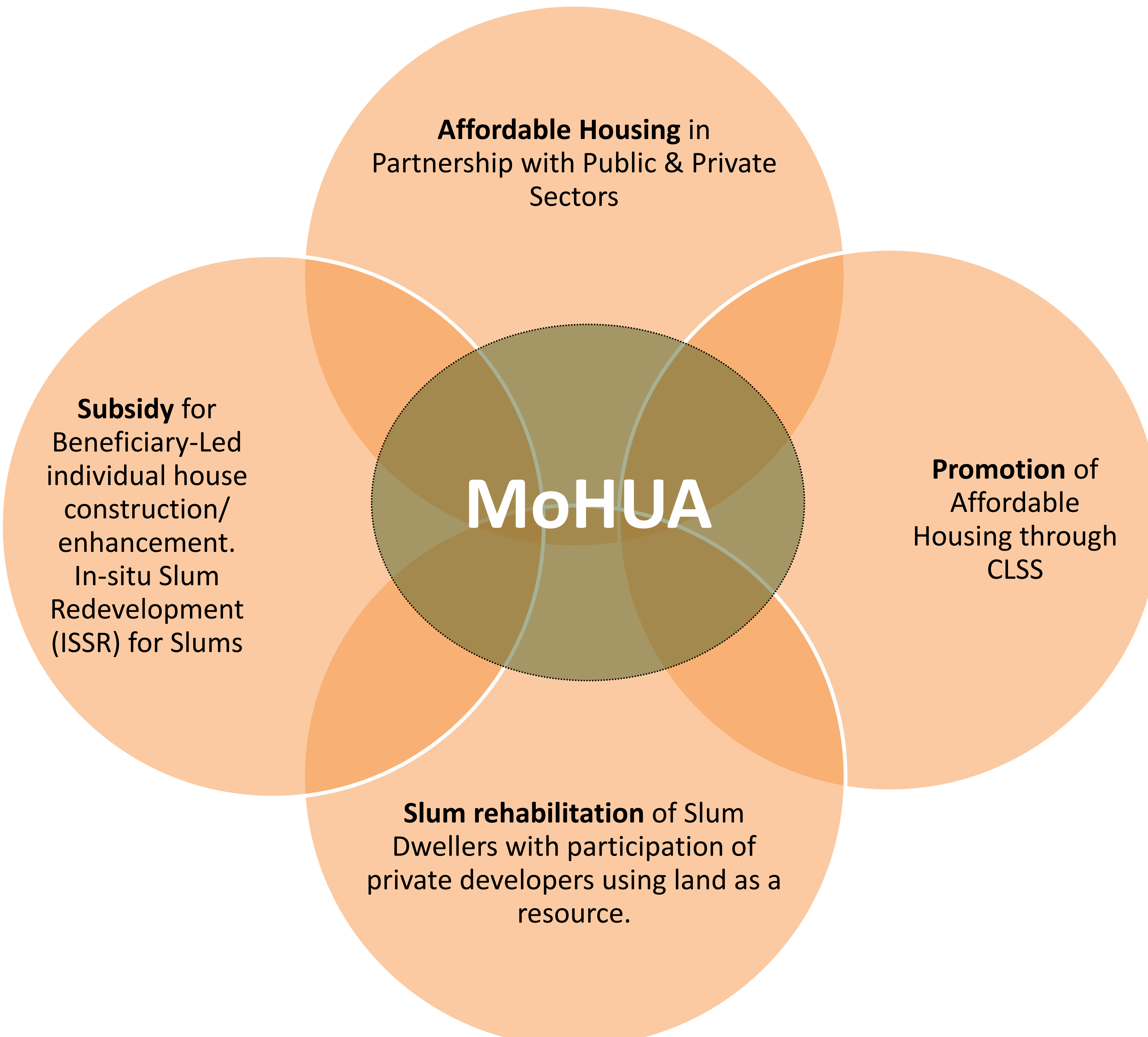
Training D at Bhopal – 22nd July 2022

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:

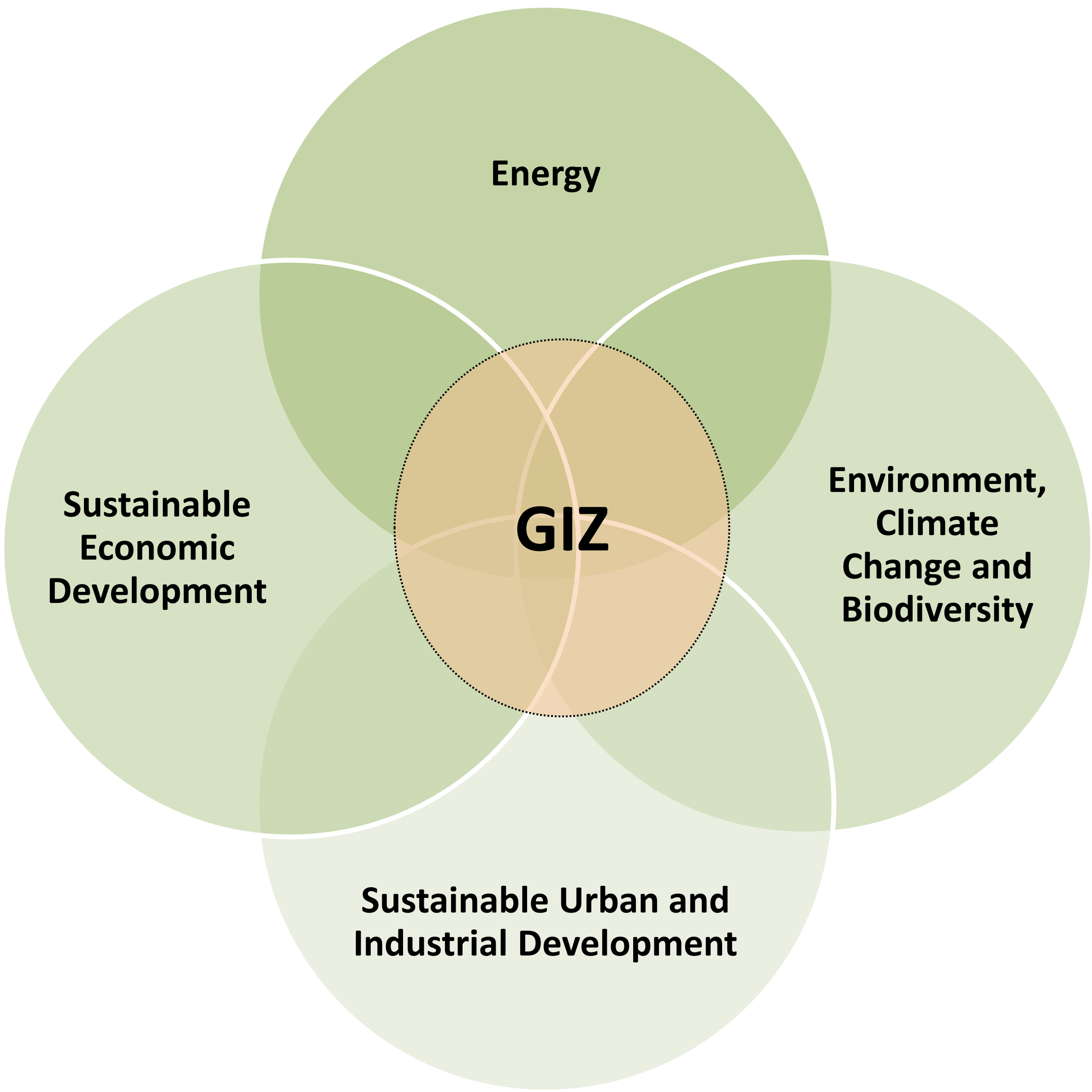


INTRODUCTION - GIZ

- 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

CLIMATE SMART BUILDINGS

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

Indo-German Energy programme (IGEN's Programme), Climate Smart Buildings (CSB) proposes to extend technical assistance and cooperation for the followings:

- Developing action plan for Thermal Comfort to build Climate Resilient Buildings for mass scale application
- Implementation of Global Housing Technology Challenge-India (GHTC-India)

HEAD OFFICE of CENTRAL CLUSTER
Indore, Madhya Pradesh
known as 'Central Cluster Building Cell' (alias **CSB Cell**)

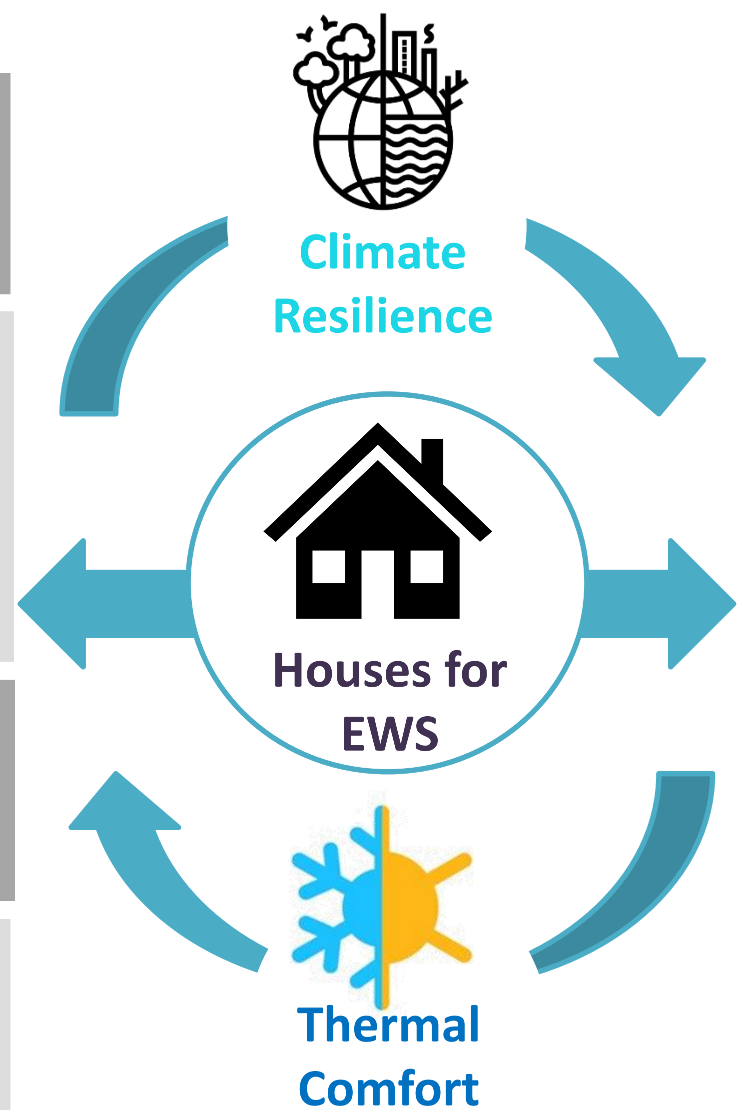
AIM & CONCEPT

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

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

New age innovative technologies along with the 6 LHP construction technologies focusing on - efficiency in construction, mainstreaming & replication of technologies.

LHP INTRODUCTION

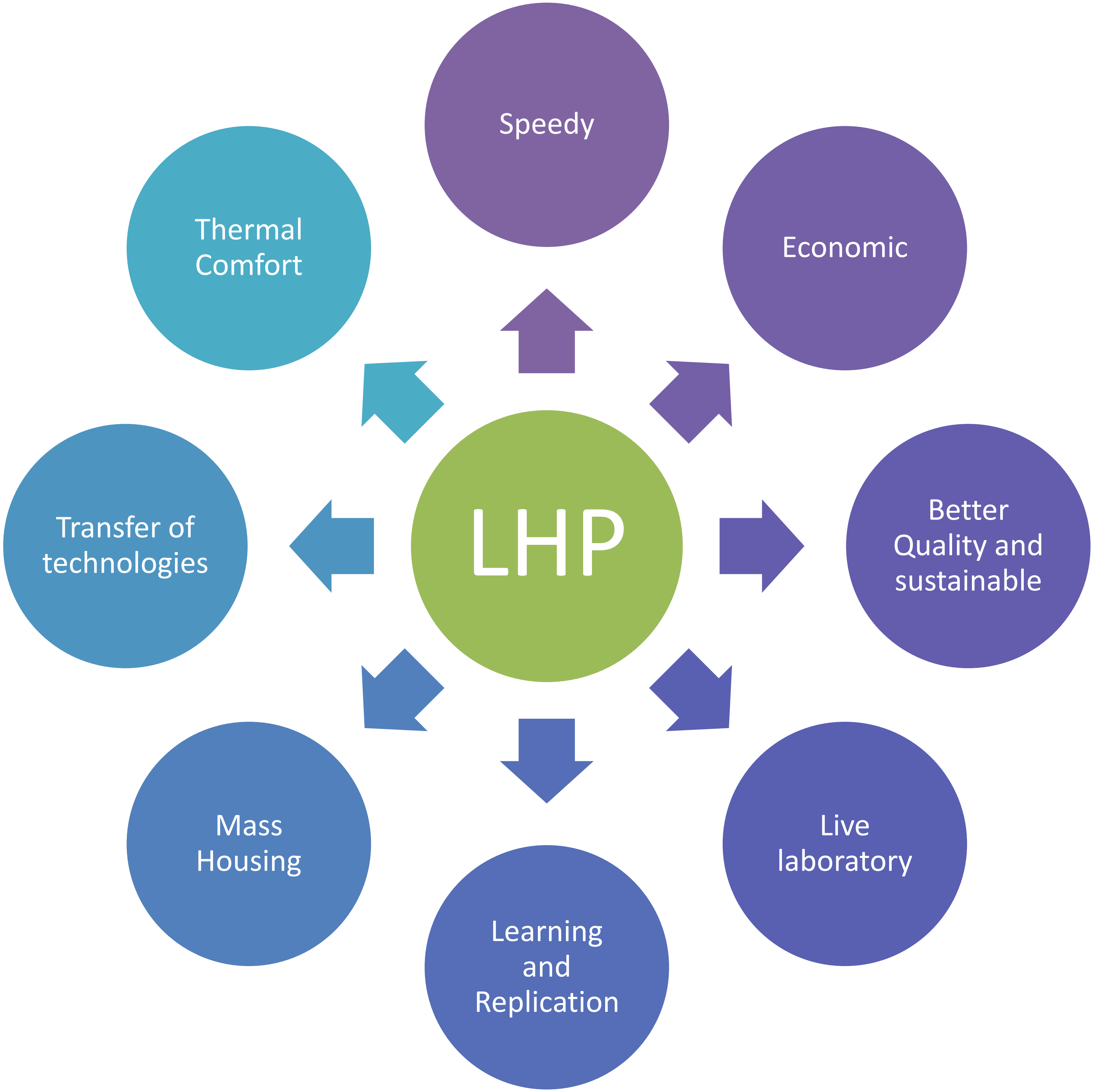
6 LHP ACROSS INDIA

Map showing six different LHP Locations

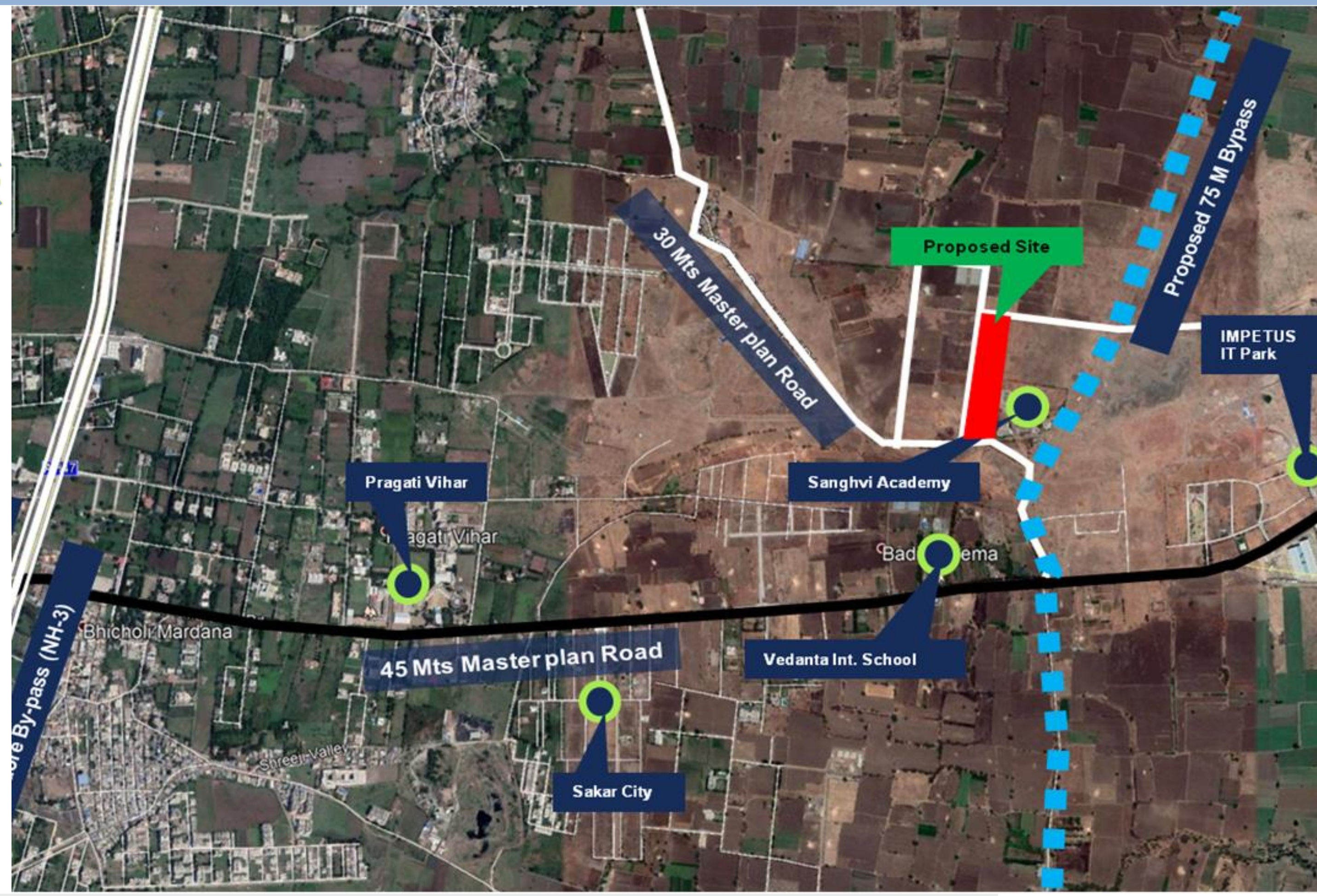
LHPs shall serve **as LIVE Laboratories** for different aspects of **Transfer of technologies**

6 LHPs Explained Via Video

6 LHPS – FOCUSES ON



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 - 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

PEB ERRECTION

PEB ERRECTION Explained Via Video

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

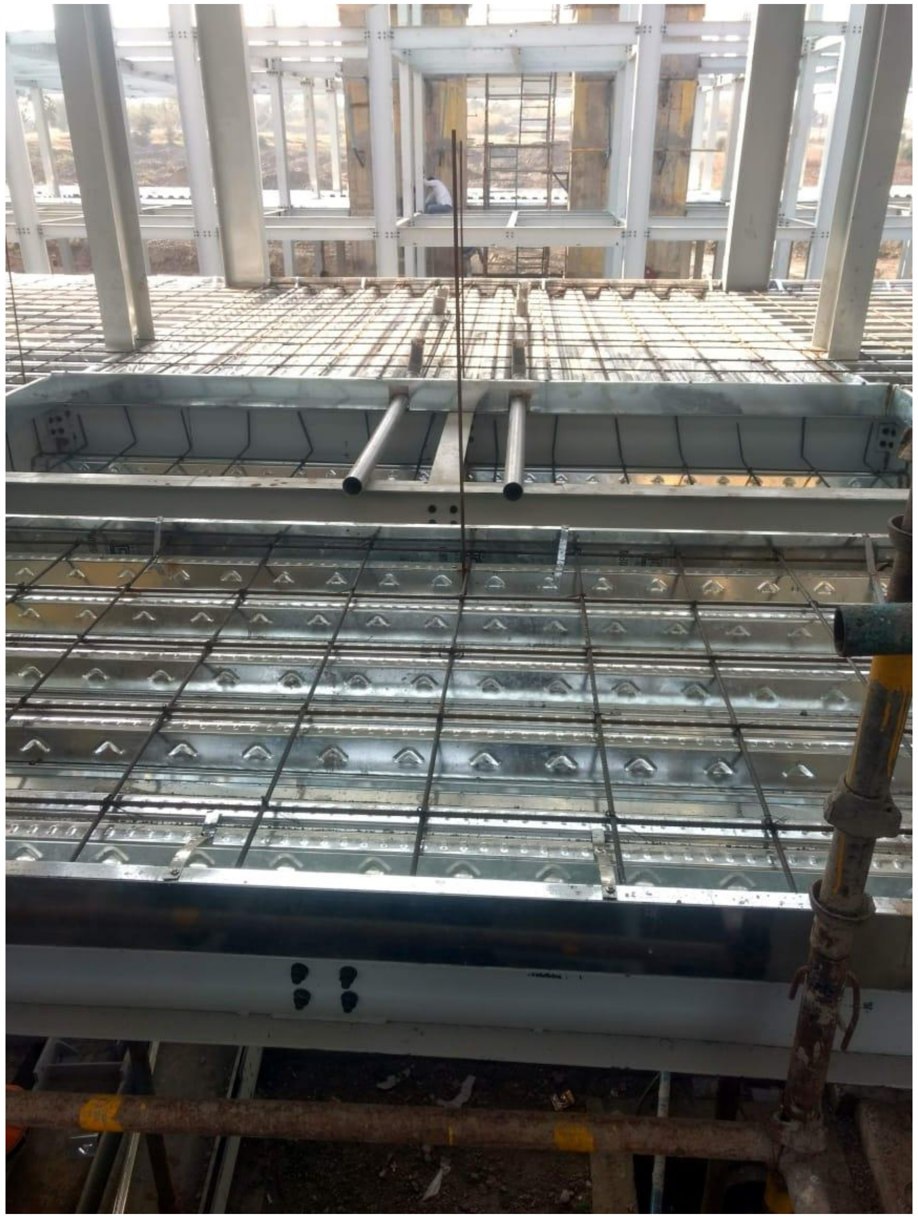
LHP INDORE - TECHNOLOGY

DECK SLAB

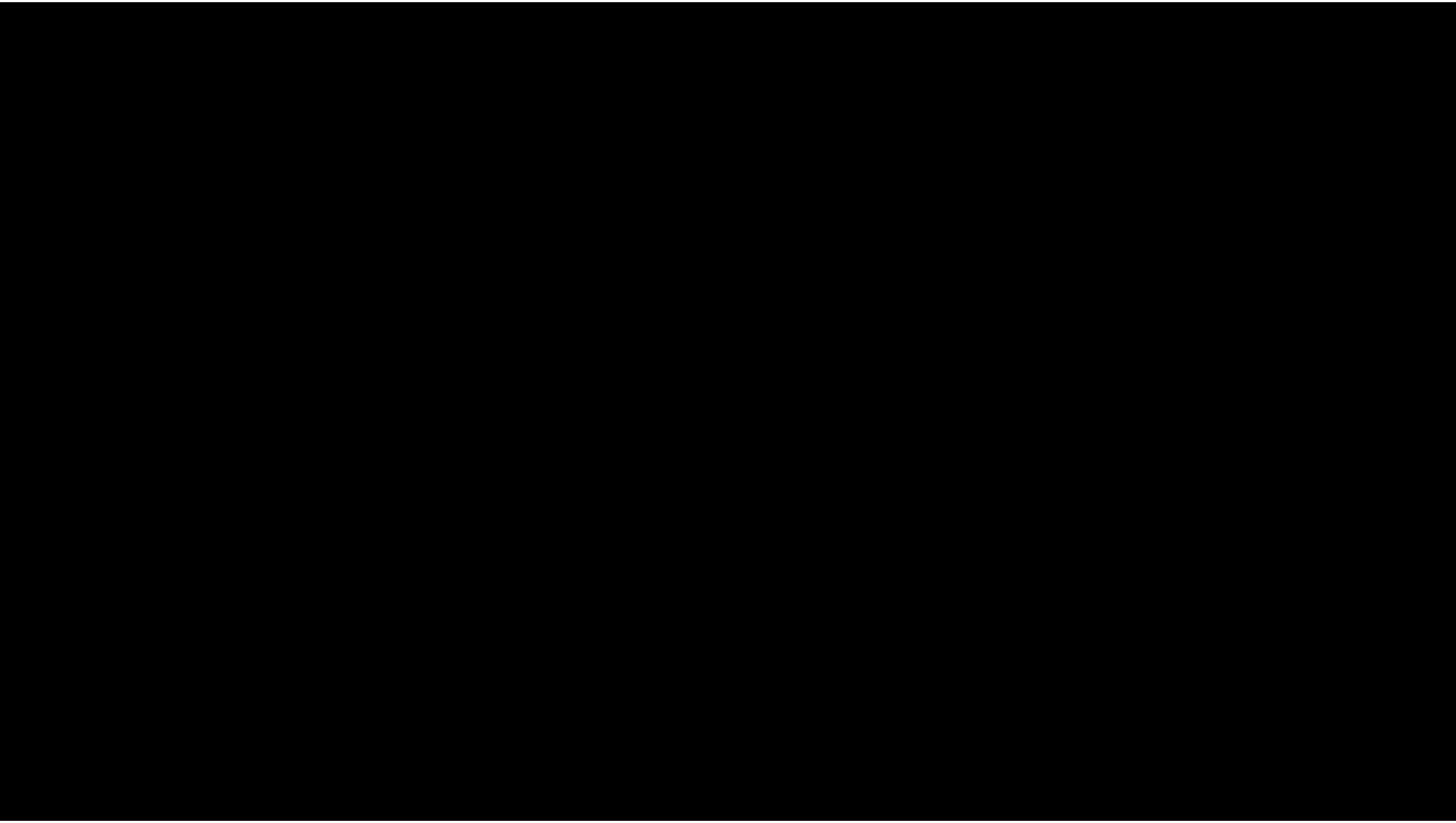
Deck sheet laying

Services & reinforcement laying

Concreting

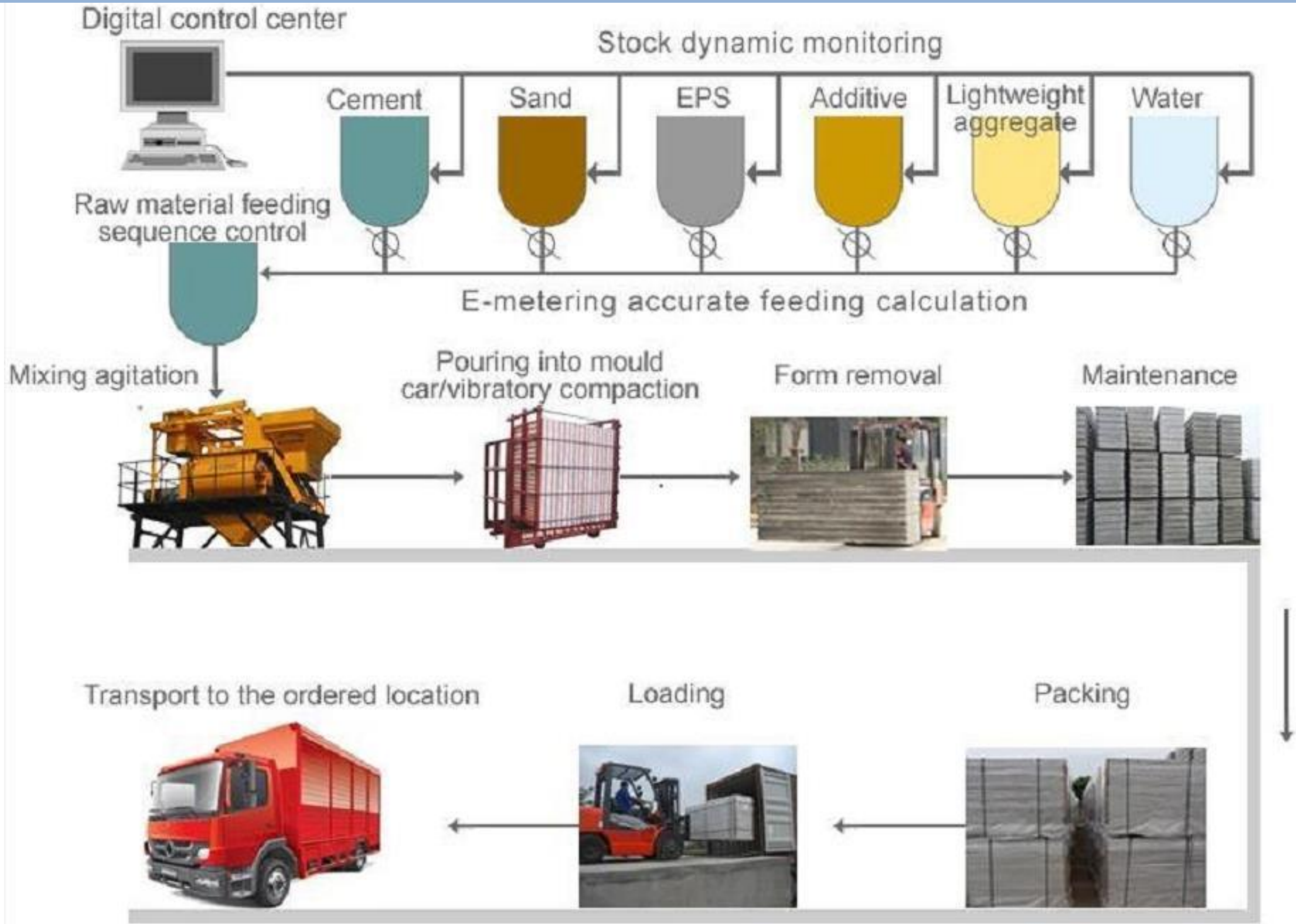


LHP INDORE - TECHNOLOGY

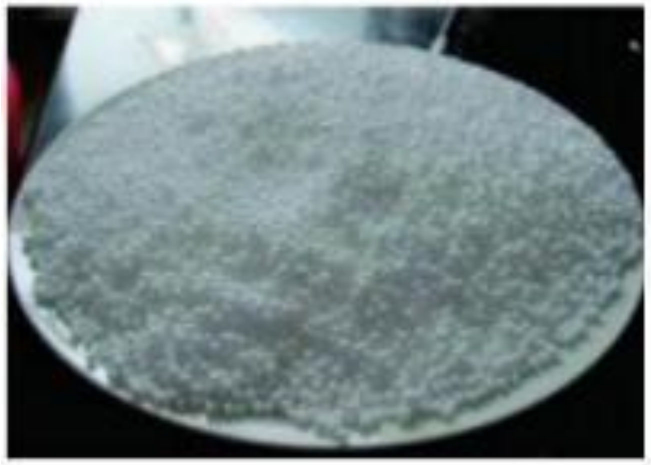


Technology information being explained via Video

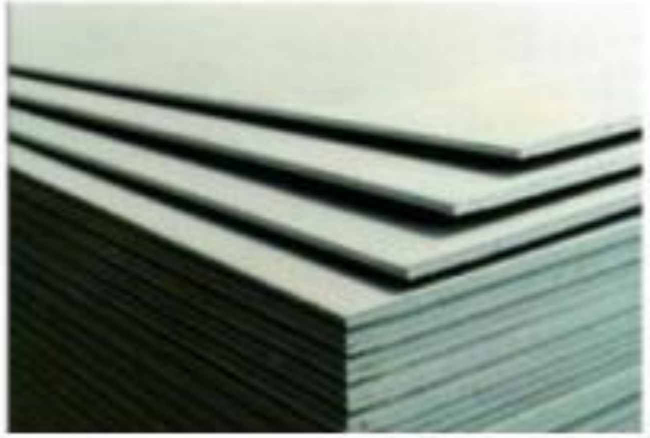
EPS SANDWICH PANEL MANUFACTORING PROCESS



EPS SANDWICH PANEL RAW MATERIALS



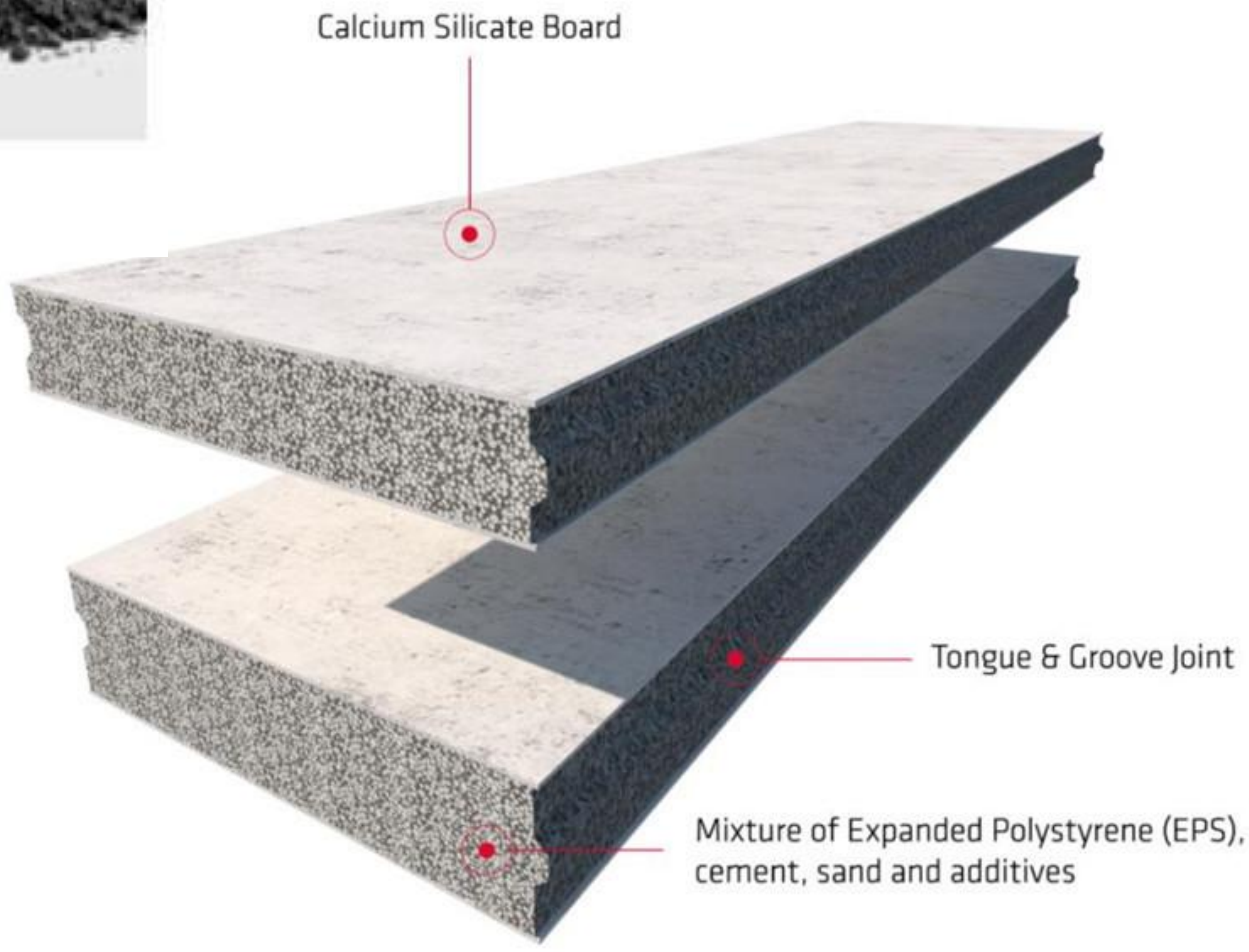
EPS



Calcium silicate board

Fly ash

Cement



EPS SANDWICH PANEL- FIXING TOOLS

No.	Name	Picture	Function	Picture
1	Cement adhesive		Special cement adhesive for EPS cement sandwich panel connection	
2	Triangle wood		Support, ensure the panel be sticked firmly	
3	Steel bar		Reinforce the connection of the EPS cement sandwich panels	
4	PU foam		Filling the gaps between panel and structure, door, window.	
Decoration remark: if you choose painting for the decoration, you need to put fiber mesh cloth on the wall or fiber mesh tape at the joint before painting, if you decorate the wall by wallpaper, wall tile or other covered materials, no need for the following materials, can put the wallpaper, wall tile on the wall directly.				
5	Fiber mesh cloth		For whole wall anti-crack	
6	Fiber mesh tape		Between panels connection for anti-crack	
7	Anti-crack mortar		Stick (cover) the fiber mesh cloth/fiber mesh tape on the panel	

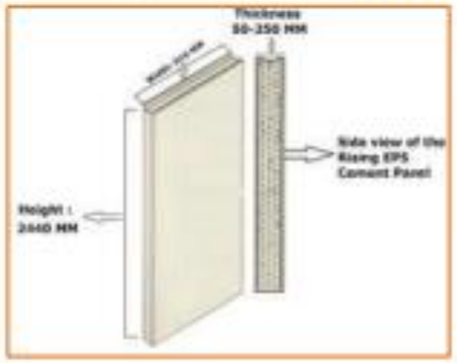
EPS PANEL PERFORMANCE APPRAISAL CERTIFICATE

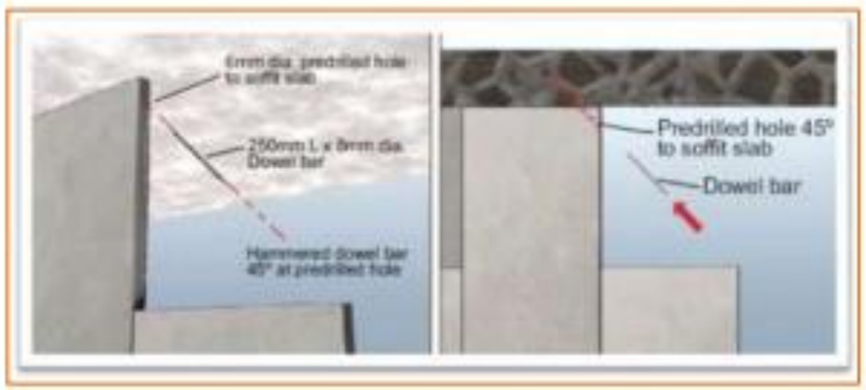
BMTPC
PACS
PERFORMANCE APPRAISAL CERTIFICATION

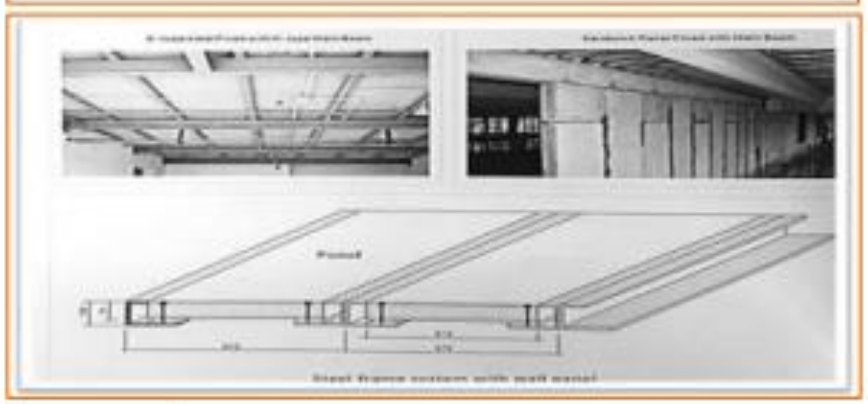
Rising EPS (Beads) Cement Panels

User should check the validity of the Certificate by contacting Member Secretary, BMBA at BMTPC or the Holder of this Certificate.

Name and Address of Certificate Holder:	Performance Appraisal Certificate No.
M/s Rising Japan Infra Pvt. Ltd., **I-203,Som Vihar, R K Puram** **New Delhi -- 110022** **Tel: 08826195032** **E-mail:rpg@rijapaninfra.com**	PAC No.:**1032-S/2017** Issue No. **01** Date of Issue: **04.07.2017**







bmtpc

Building Materials & Technology Promotion Council
Ministry of Housing & Urban Poverty Alleviation
Government of India
Core 5A, First Floor, India Habitat Centre,
Lodhi Road, New Delhi – 110 003

Tel: +91-11-2463 8096, 2463 8097; Fax: +91-11-2464 2849
E-mail: bmtpc@del2.vsnl.net.in Web Site: http://www.bmtpc.org

Rising EPS Cement Panels

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Race Course Road, Gwalior (M.P.) 474 005
Phone: +91-751-2409300 Fax: +91-751-2664684 Email: infomitsgwl@gmail.com website: www.mitsgwl.ac.in

Ref: Civil/AT/Material Testing /886 Date: 04/04/17

To
The Director
Rising Japan Infra Private Limited
I-203, Som Vihar, R K Puram
New Delhi-110022

Subject: Testing of Rising EPS Cement Sandwich Panels of 90mm Thickness samples
Ref: ***Your letter No. NIL dated 28.02.2017***

Dear Sir,

Please find herewith a consolidated test report of 90mm thickness Rising EPS Cement sandwich panels samples sent by you vide above mentioned reference and subject: This table of results is a summary of the detailed individual tests conducted on the panel samples as per listed tests.

Report of the results of the Tests

Sl No.	Test conducted	Standards Applied	Lab Results	Remarks
1.	Density & Flammability of EPS	ASTM 7309–07	780 kgs/ M³ (Flammability)	Qualified
2.	Axial compression	EN520:2004+ A1:2009	4.27 MPa	Qualified
3.	Resistance to continuous heating	ASTM F 1939	80°c	Qualified
4.	Flexural Strength	ASTM 293	1.53 MPa	Qualified
5.	Acoustic Performance	IS 9901-1981	40 dB	Qualified
6.	Thermal conductivity	IS 3346 1980	0.22 W/ mk	Qualified
7.	Thermal Resistance	IS 3346 1980	0.42 mk/W	Qualified
8.	Water penetration	EN1609	No dampness or leakage	Pass
9.	Fire rating of the panels	BS 478 part 20/ 22	Grade –1 / 3 Hrs.	Pass
10.	Resistance to structural damage from a large light body	BS5234: Part2: 1992, Annex E	No collapse or dislocation	Pass
11.	Anti-bending damage load	BS 5234: Part 2	3 Times of its weight	Qualified
12.	Non-combustibility	GB8624-1994	A Level	Qualified
13.	Water tightness	ASTM C1185	No droplets observed behind panels after 24 Hrs.at 250mm Water head	Qualified
14.	Drying Shrinkage value	IS 2185 Part 1-0C	0.083 %	Pass
15.	Single point hanging strength	BS 5234: Part 2	1300 N	Pass

Remarks: "Qualified" with regards to relevant tests.
The above tests results are only for the information to the referred agency / client. The institute does not take any responsibility of these tests results for any other purpose, legal or otherwise.

Forwarded by:

Prof I/C Material Testing — H.C.E.D 04/04/17 — DIRECTOR 4.4.17

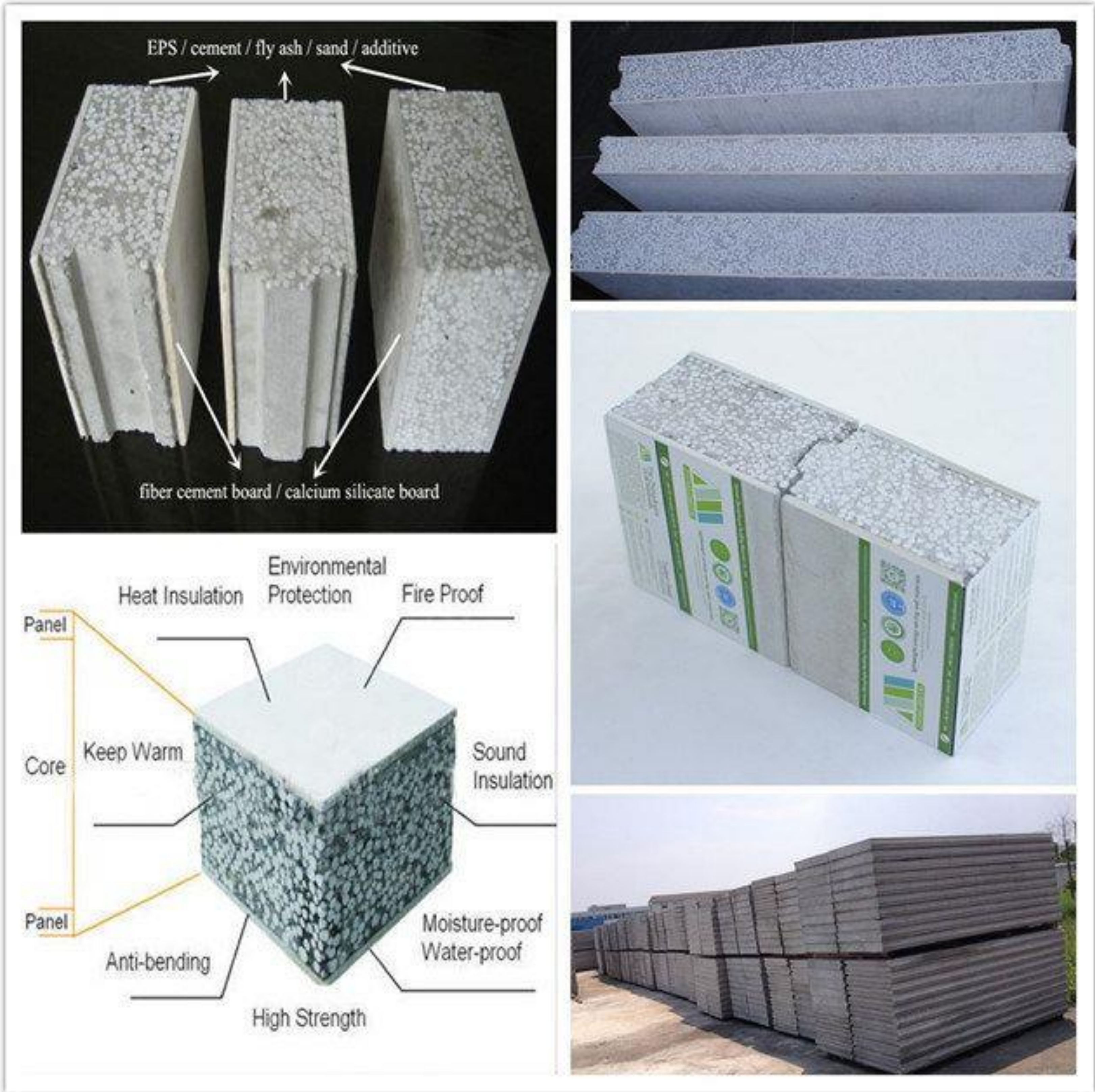
Council of Architecture — IITBombayX — acm Chapter — IEEE — IET The Institution of Engineering and Technology — ASCE

EPS SANDWICH PANEL- PANEL SIZES

EPS Cement Sandwich Panel			
Specification L*W*T (mm)	Weight (kg/m2)	Packing (pcs/m2 per 20′ GP / 40′ HQ)	Application
2270 / 2440 x 610 x 60	45-48	315pcs*436m2/ 384pcs*572m2	Interior wall/ Roof system
2270 / 2440 x 610 x 75	50-53 / 55-58	252pcs*349m2/ 312pcs*464m2	Interior wall
2270 / 2440 x 610 x 90	55-58 / 69-72	207pcs*287m2/ 251pcs*375m2	Interior/ Exterior wall
2270 / 2440 x 610 x 100	60-65 / 72-75	189pcs*262m2/ 240pcs*357m2	Interior/ Exterior wall
2270 / 2440 x 610 x 120	65-75 / 90-93	153pcs*212m2/ 192pcs*286m2	Exterior wall
2270 / 2440 x 610 x 150	80-90 / 111-114	126pcs*175m2/ 156pcs*232m2	Exterior wall

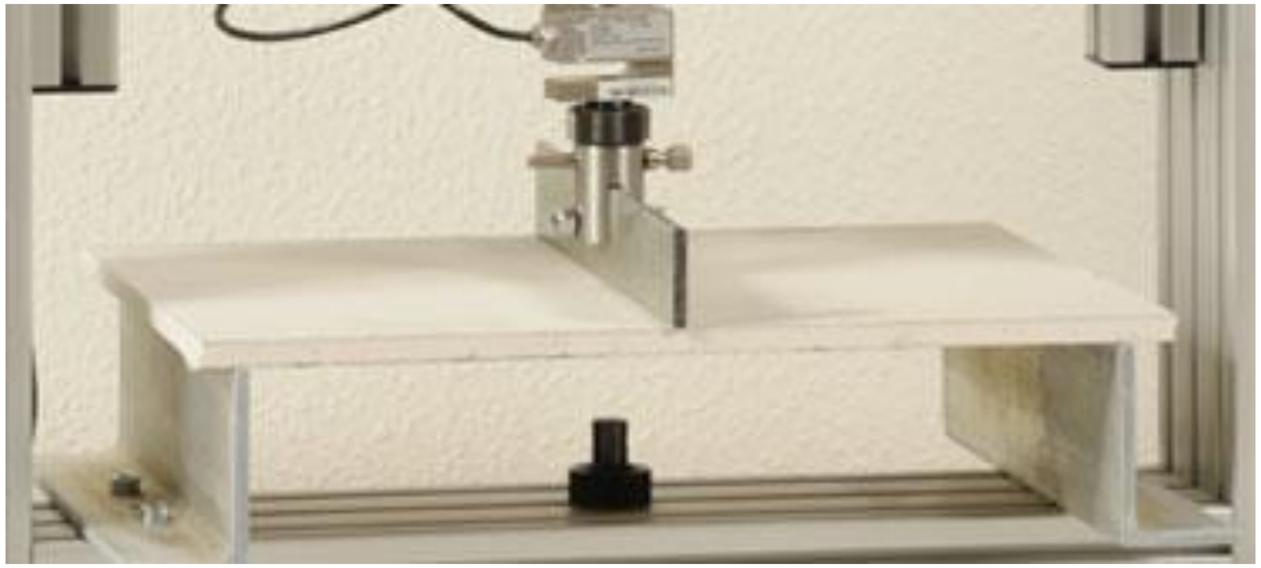
EPS PANEL INSTALLATION Via Video

LHP INDORE – TECHNOLOGY ADVANTAGES



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

LHP INDORE – TECHNOLOGY ADVANTAGES



Strength Test

Fast and Easy Construction

Fire Resistance Test

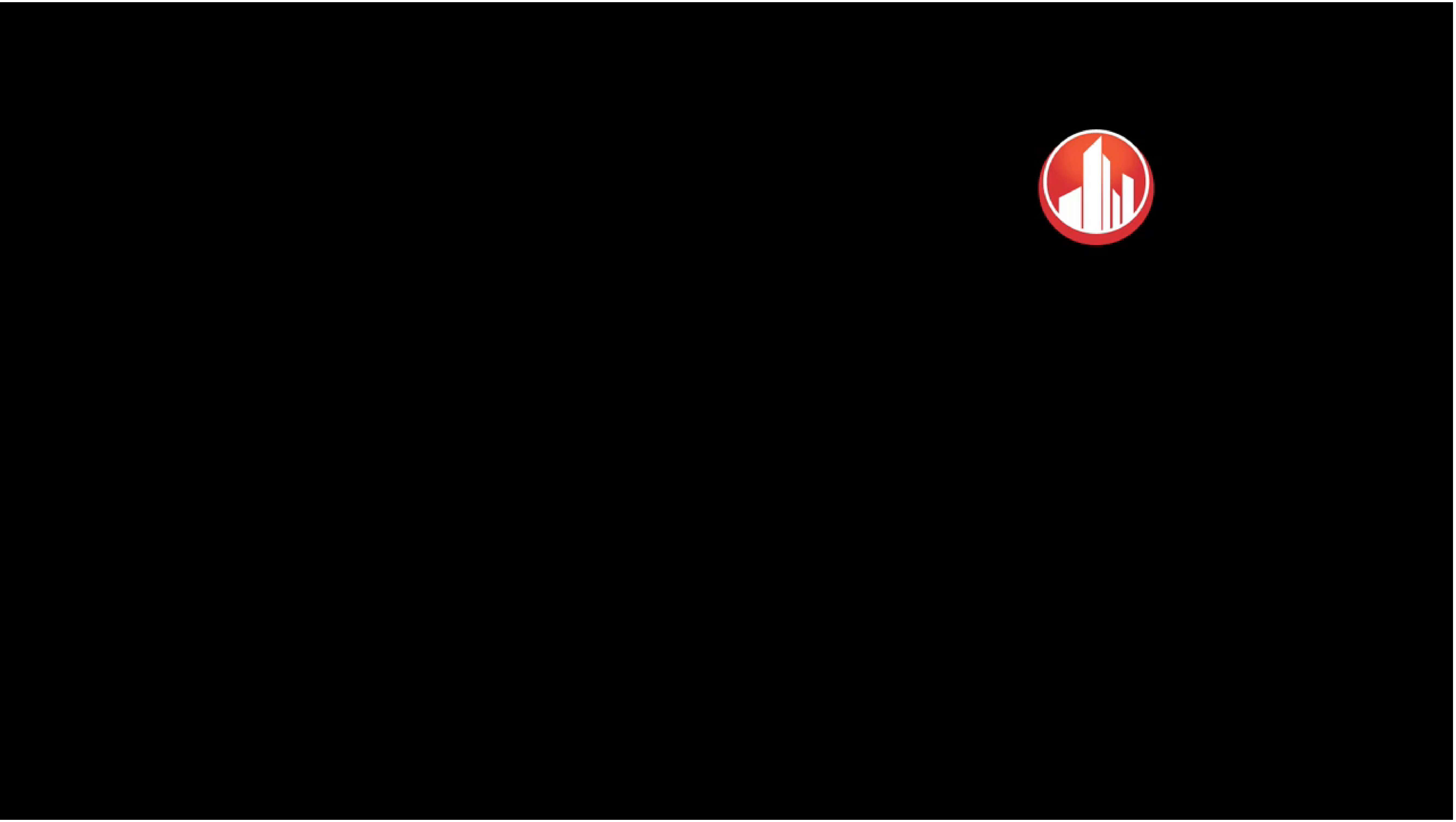
Energy saving by thermal resistance

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

LHP INDORE



SESSION :1 THERMAL COMFORT

Introduction: Thermal Comfort for Affordable Housing

Session 1**:** ***Thermal Comfort***

a)Need and Impact
b)Thermal comfort in Affordable Housing
c)Passive strategies & Building Physics
d)Case Studies

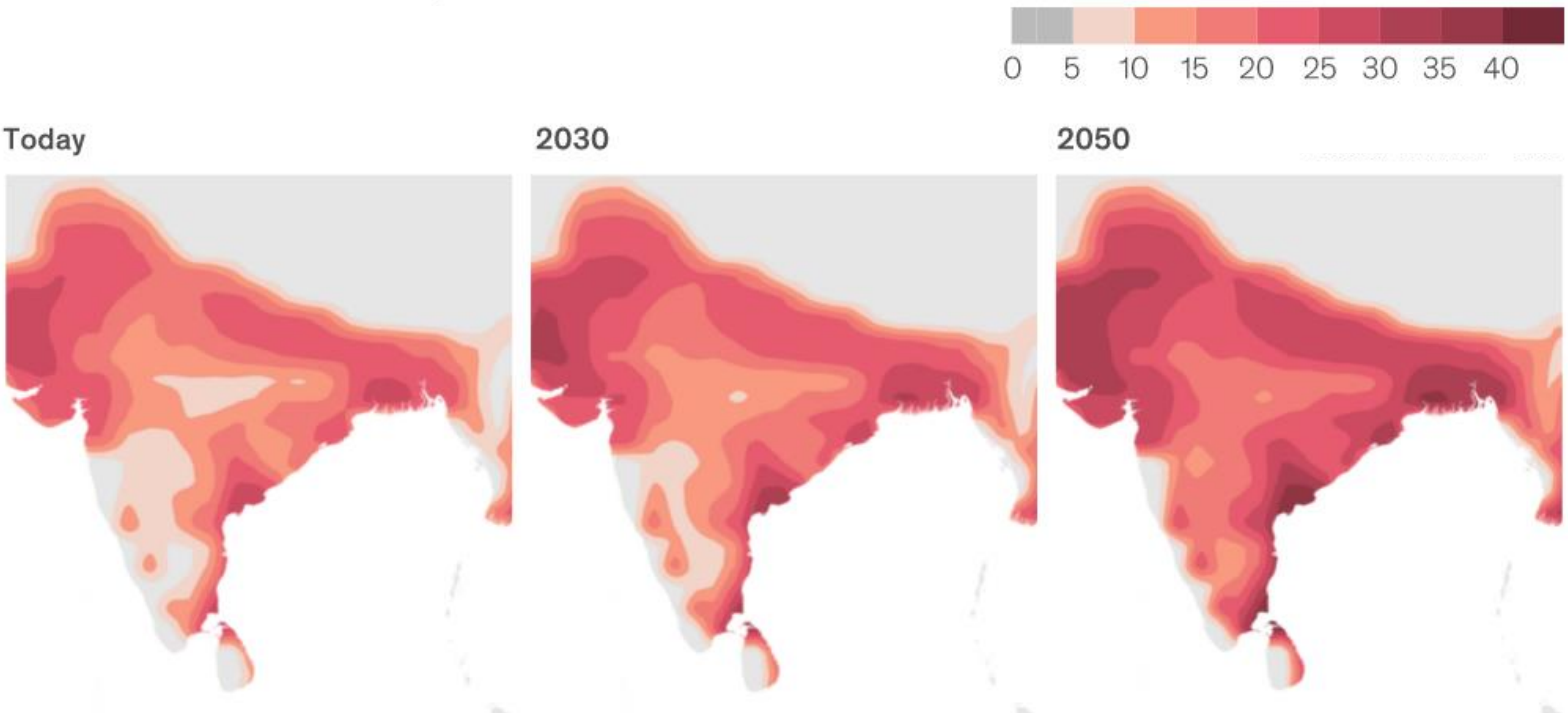
THERMAL COMFORT

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.

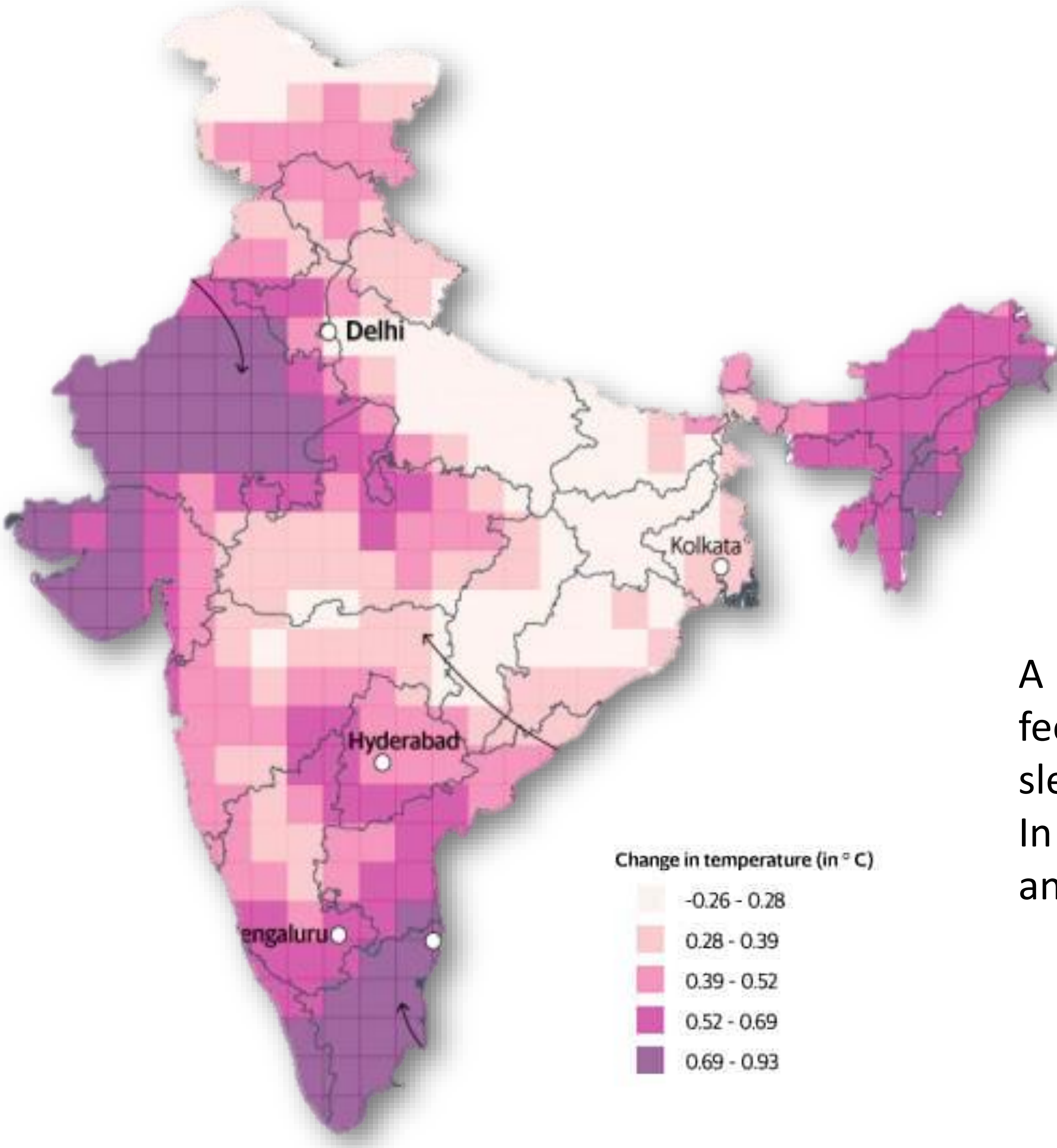
NEED FOR THERMAL COMFORT AND HOW IT IMPACT US – QUALITATIVE AND QUANTITATIVE

Impact of Heat-wave
Impact on working hours



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

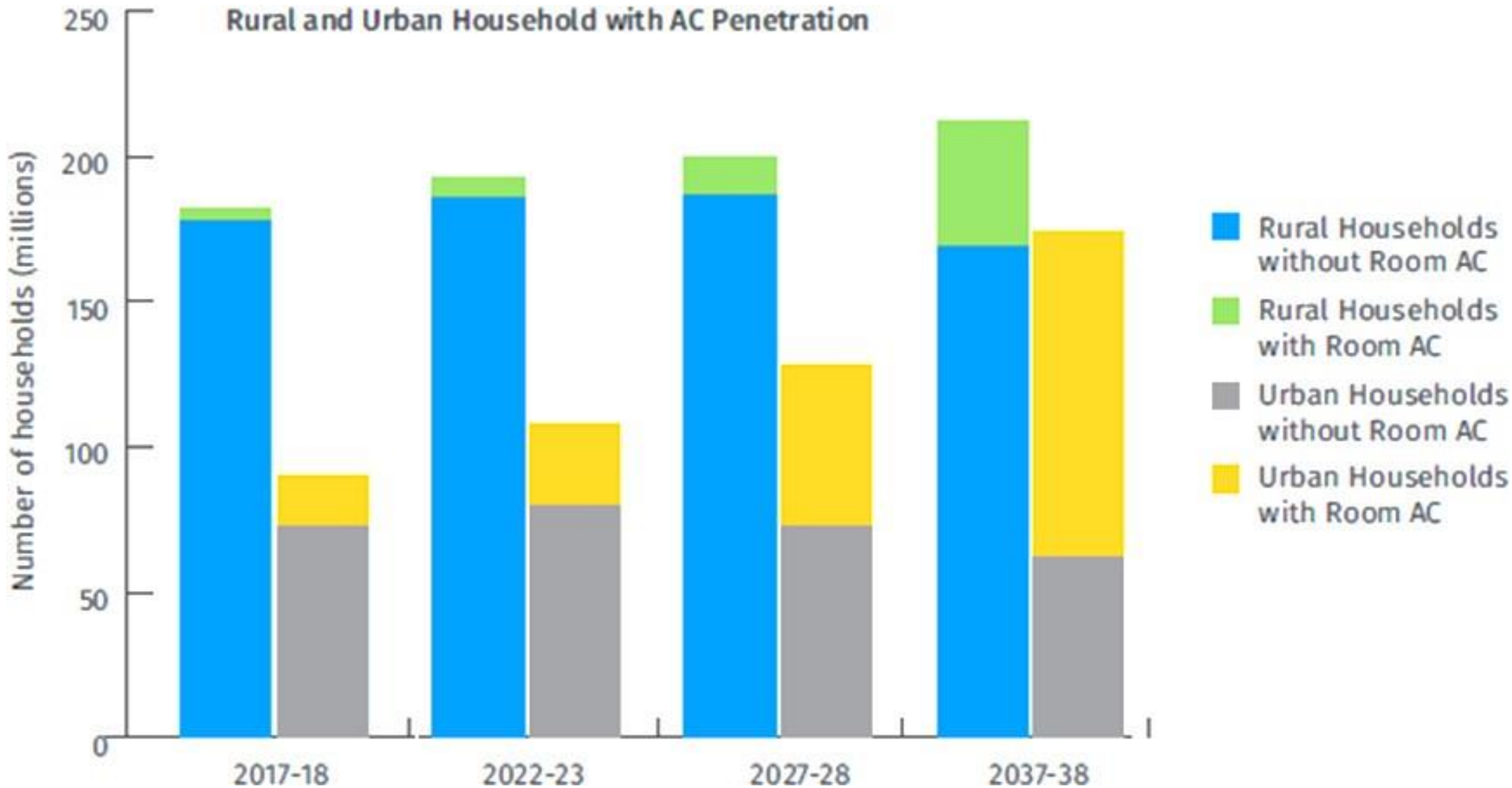
NEED FOR THERMAL COMFORT AND HOW IT IMPACT US – QUALITATIVE AND QUANTITATIVE



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

India Cooling Action Plan



India Cooling Action Plan: Residential Building recommendations

- Nation-wide adoption and enforcement of ECBC for both commercial and residential sectors
- Adoption at the municipal and urban and local body level and through development of city level action plans
- Aggressive market awareness campaigns to sensitize both the construction community as well as the users towards the multiple benefits of efficient buildings

MEASURES TO IMPROVE THERMAL COMFORT VIA DESIGN

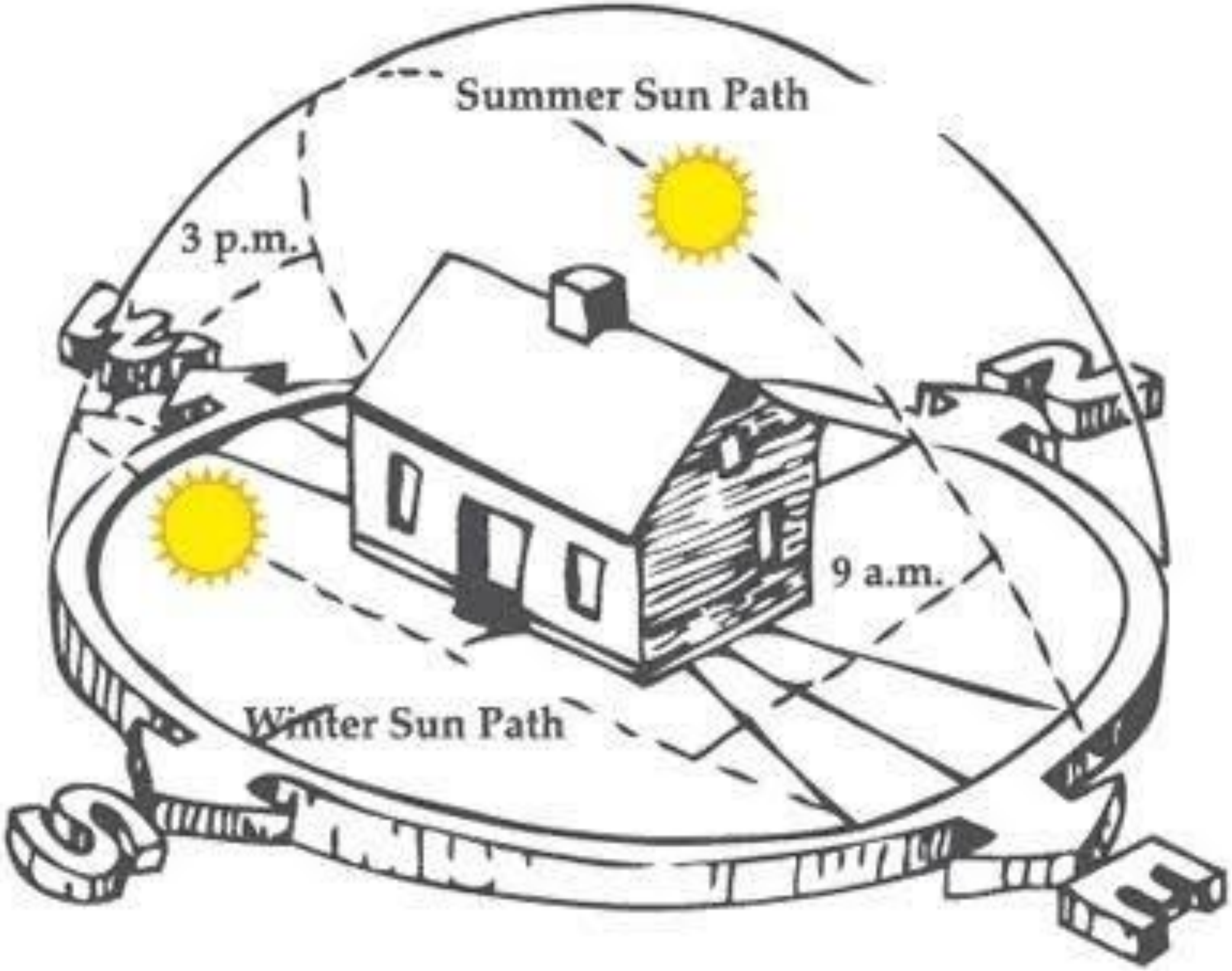
Passive Design
Design that leverages climatologically responsive design to encourage natural heating/cooling, ventilation, and lighting.

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

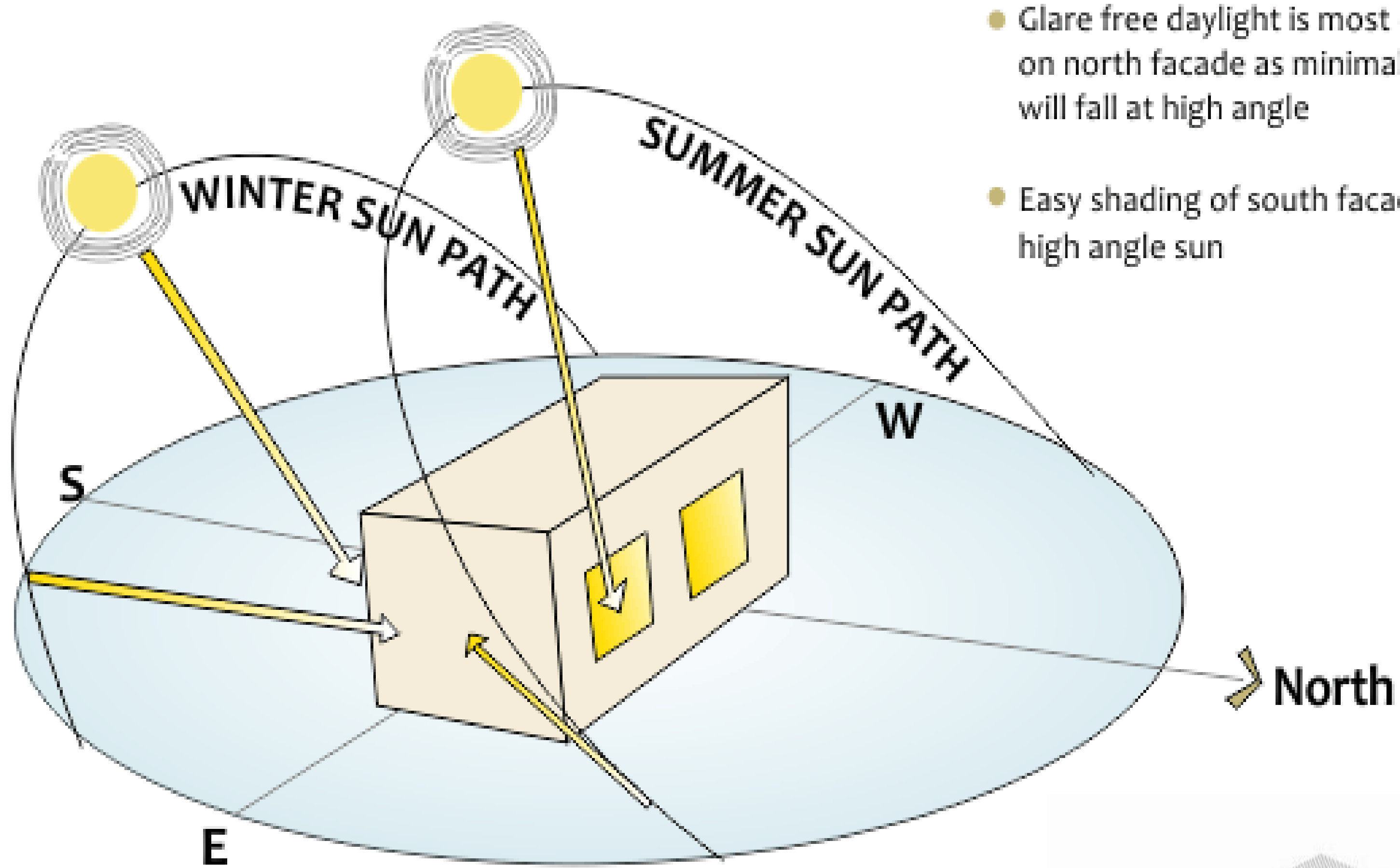
ORIENTATION OF BUILDING BLOCKS:

WINTER SUN

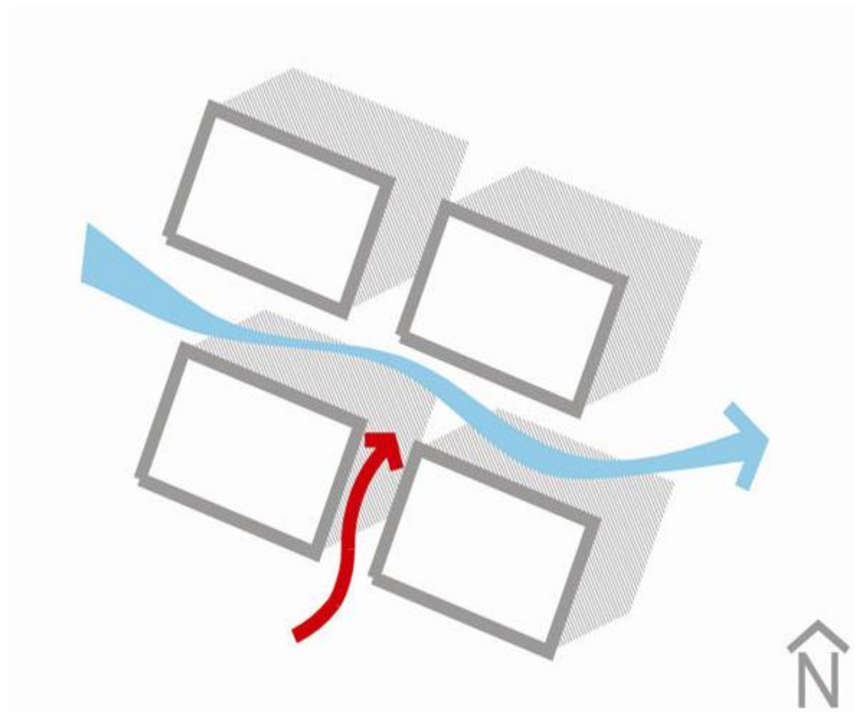
- Sun path at a low angle , south to E-W axis
- Solar radiation will penetrate south facing facades at a low angle during winter

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 radation will fall at high angle
- Easy shading of south facade from high angle sun



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

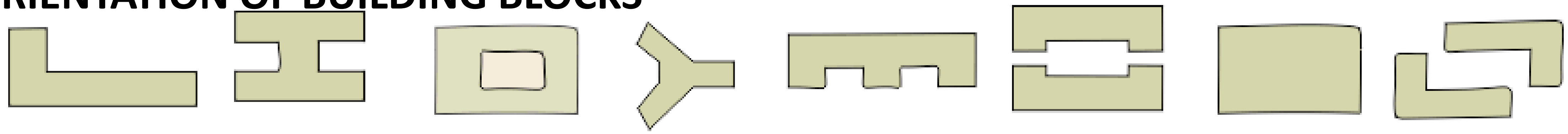


Source: NZEB

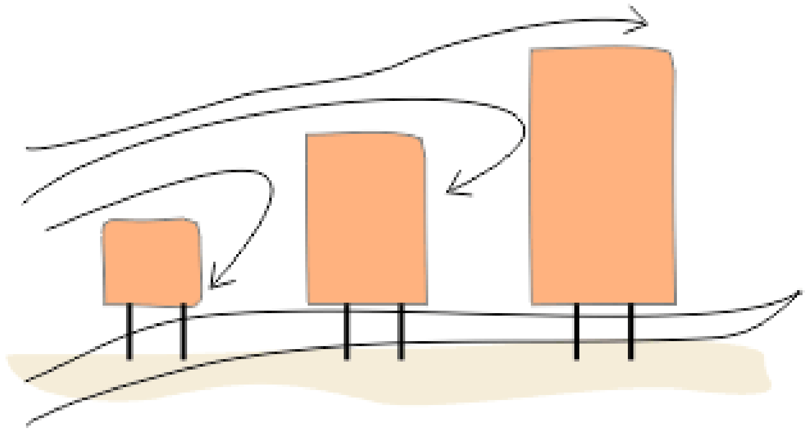
MEASURES TO IMPROVE THERMAL COMFORT

passive design strategies for affordable housing

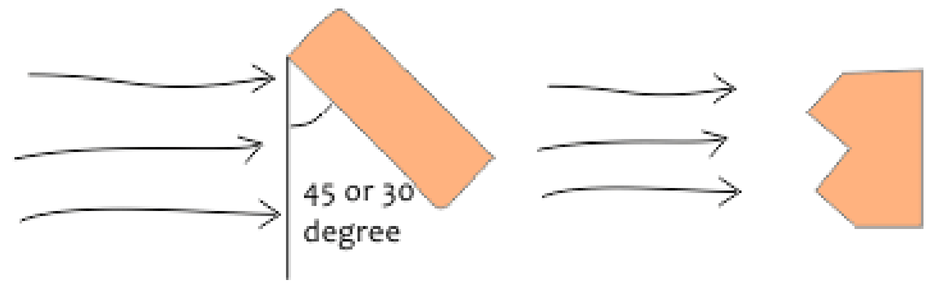
ORIENTATION OF BUILDING BLOCKS



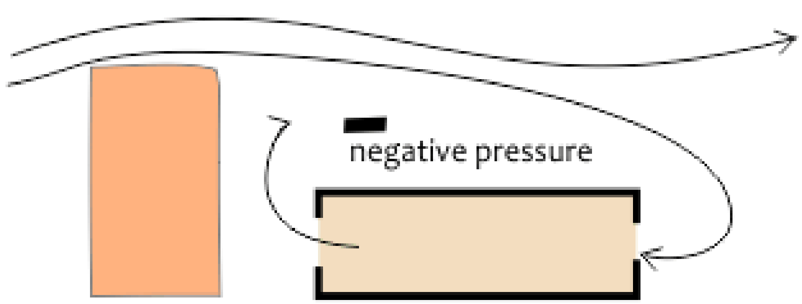
Orient longer facades along the north. This will provide glare free light in summer from north without shading and winter sun penetration from the south.



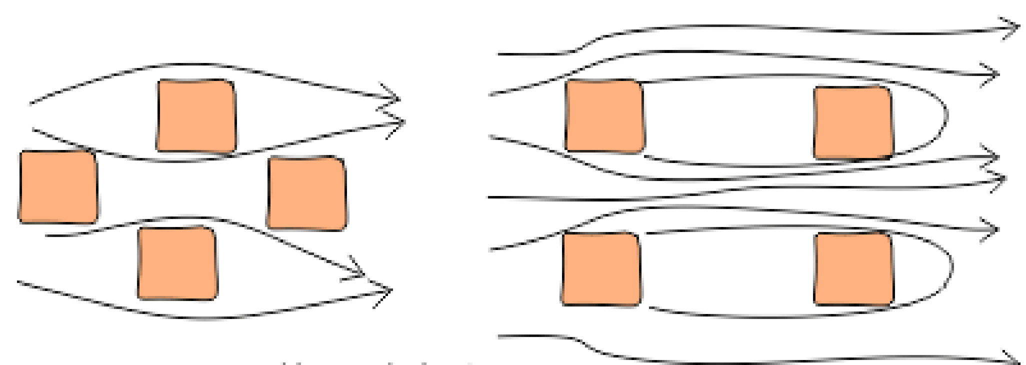
if a site has multiple buildings, they should be arranged in ascending order of their heights and be built on stilts to allow ventilation



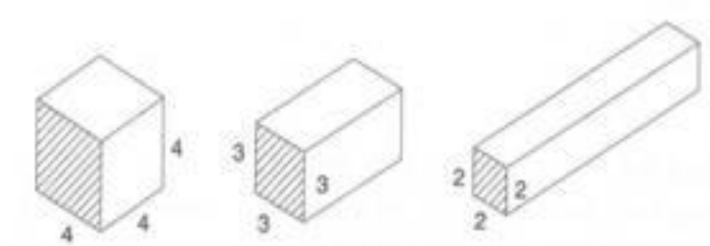
Place buildings at a 30 or 45 degree angle to the direction of wind for enhanced ventilation. Form can be staggered in the wind facing direction also to achieve the same result.



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

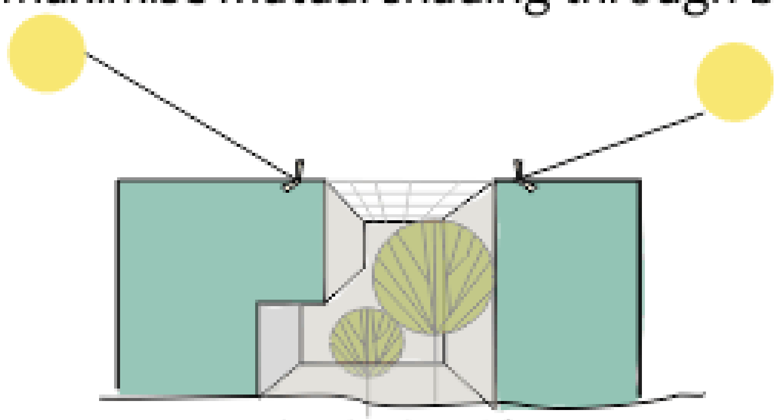
Source: NZEB

MEASURES TO IMPROVE THERMAL COMFORT

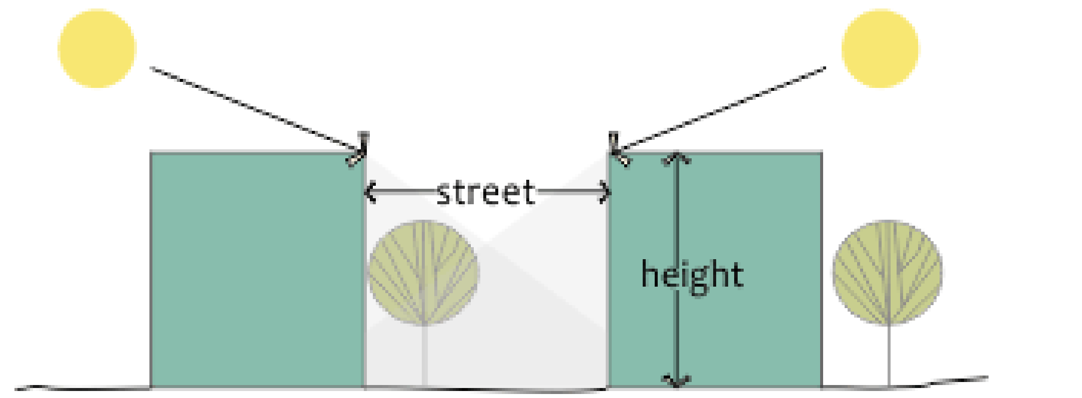
passive design strategies for affordable housing

FORM OF BUILDING BLOCKS:

1 Maximise mutual shading through built forms

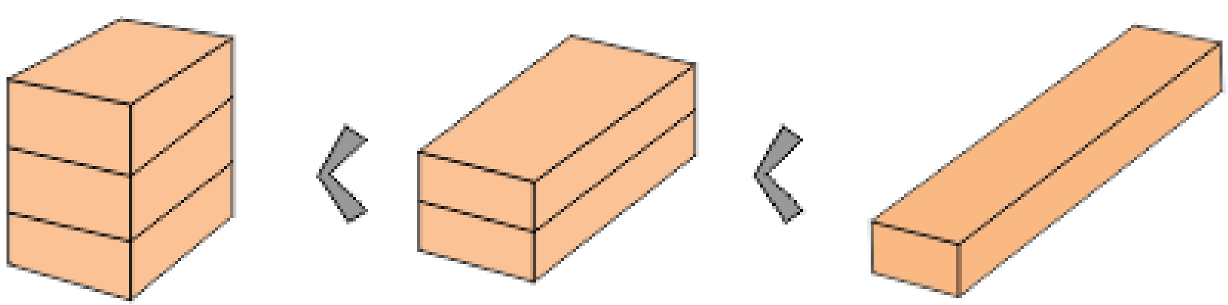


closely placed forms



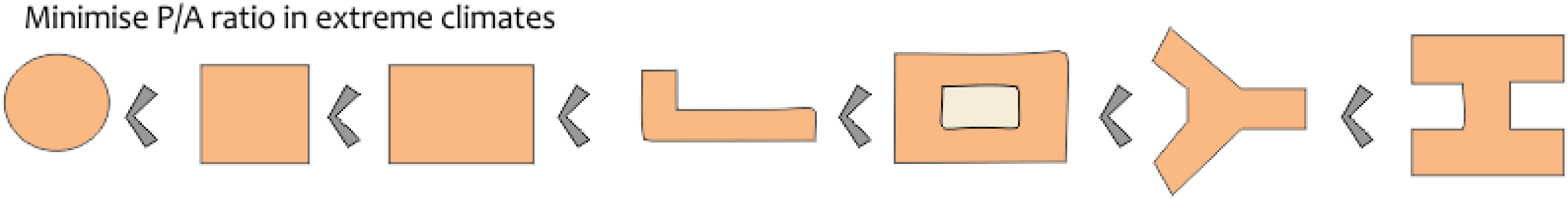
narrow streets - keep building height to street width ratio minimal

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

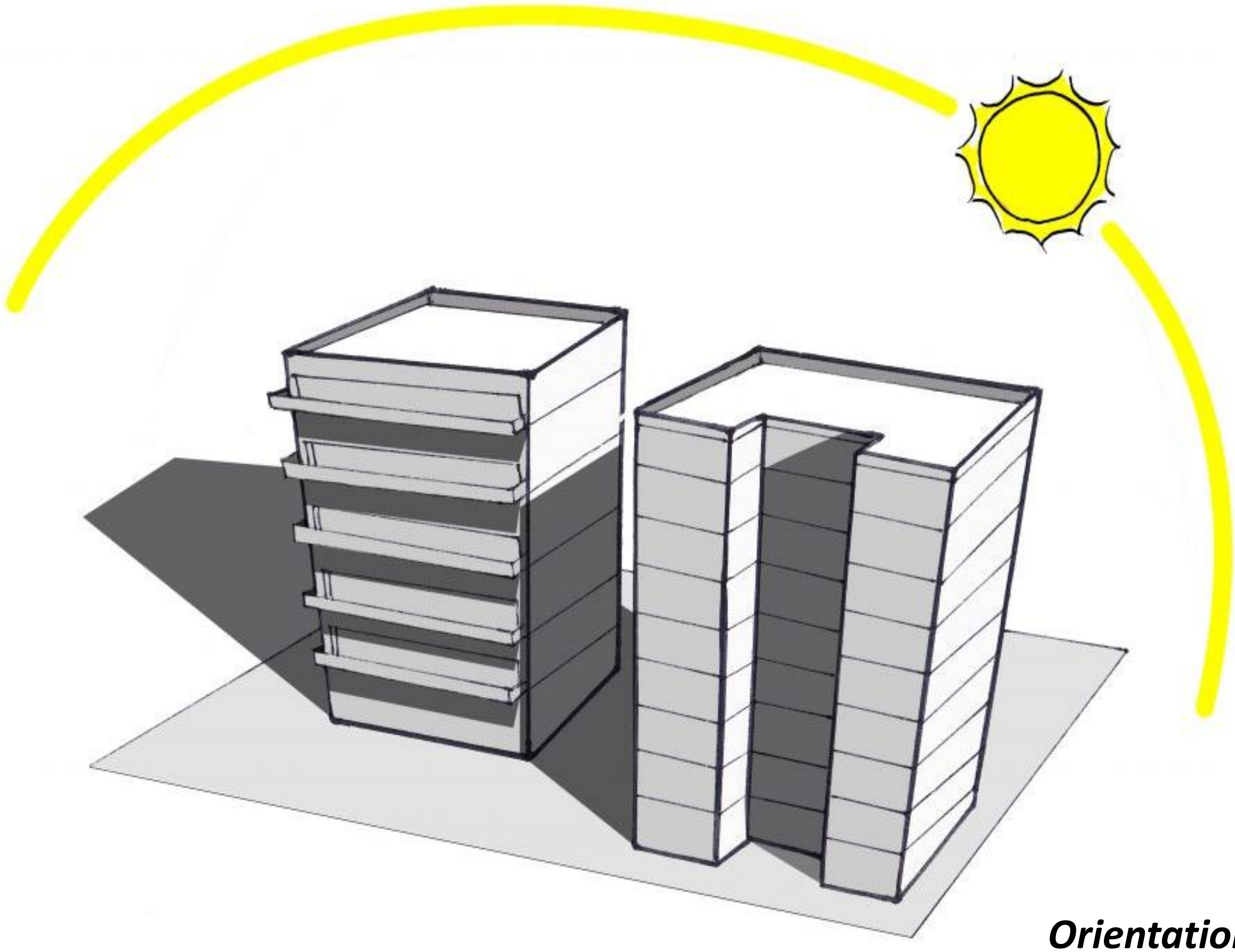
- Maximum daylight
- Proper ventilation

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

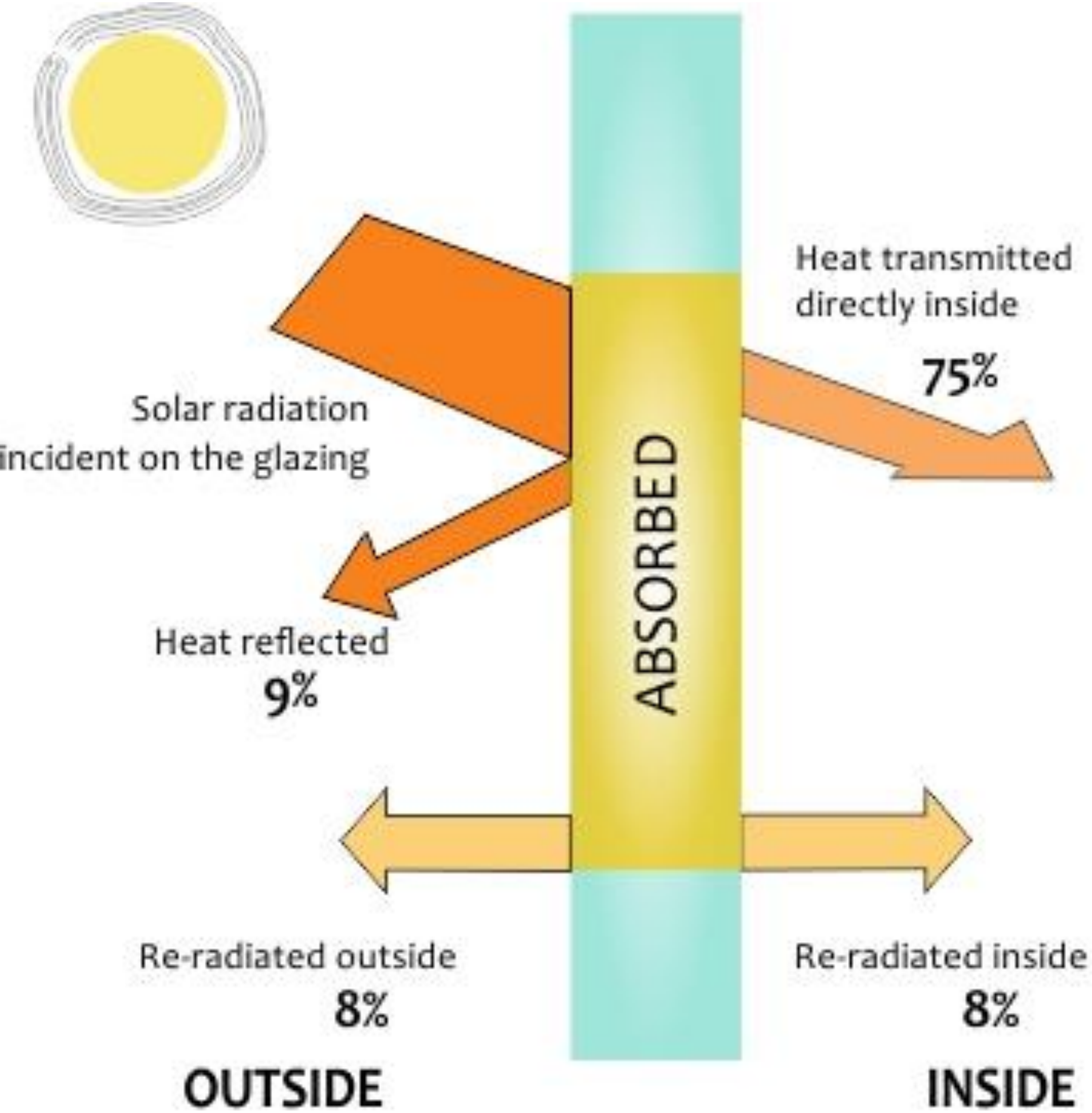
Minimizing the surface area to volume ratio minimizes heat transfer.

MEASURES TO IMPROVE THERMAL COMFORT

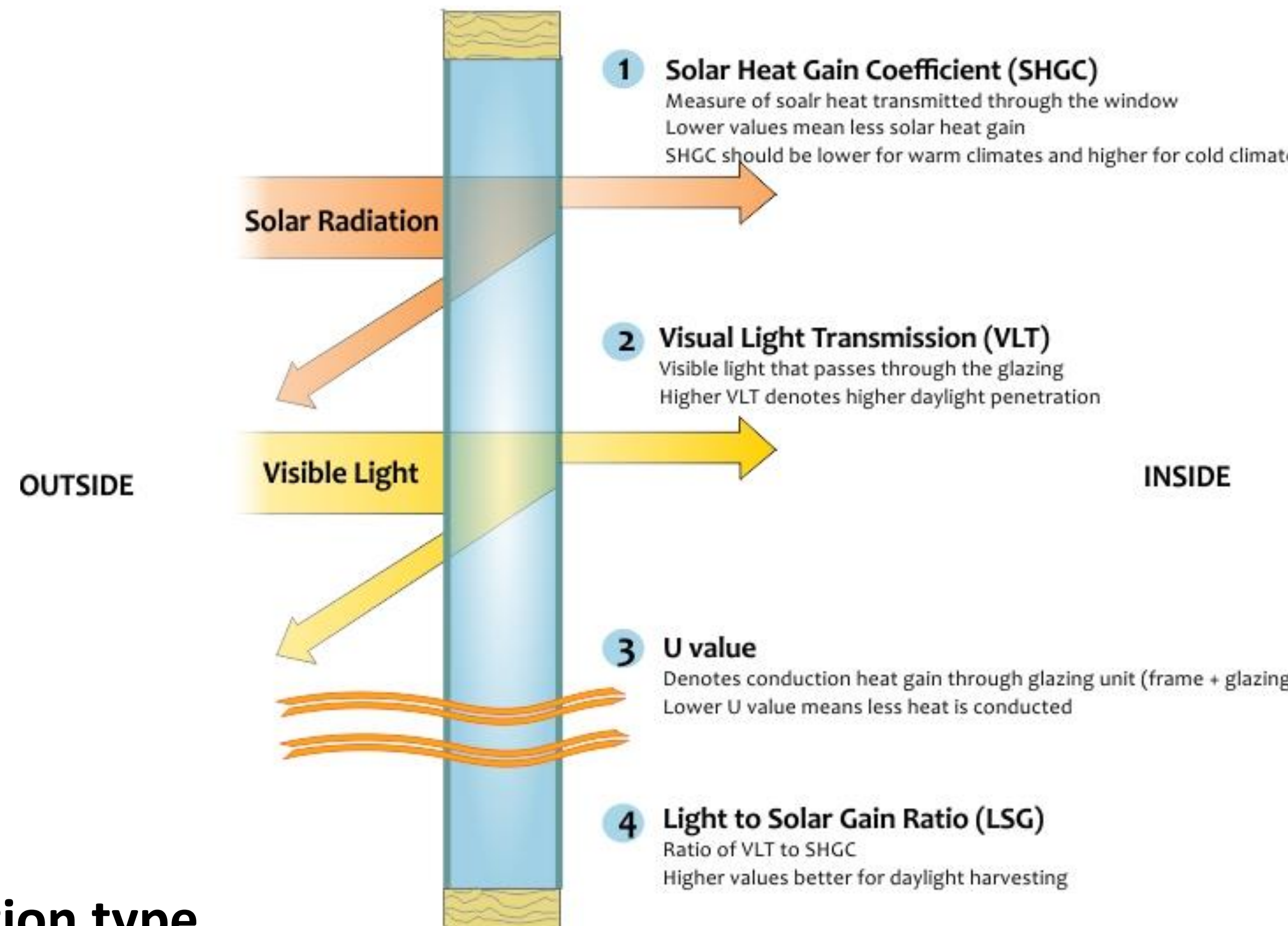
passive design strategies for affordable housing

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



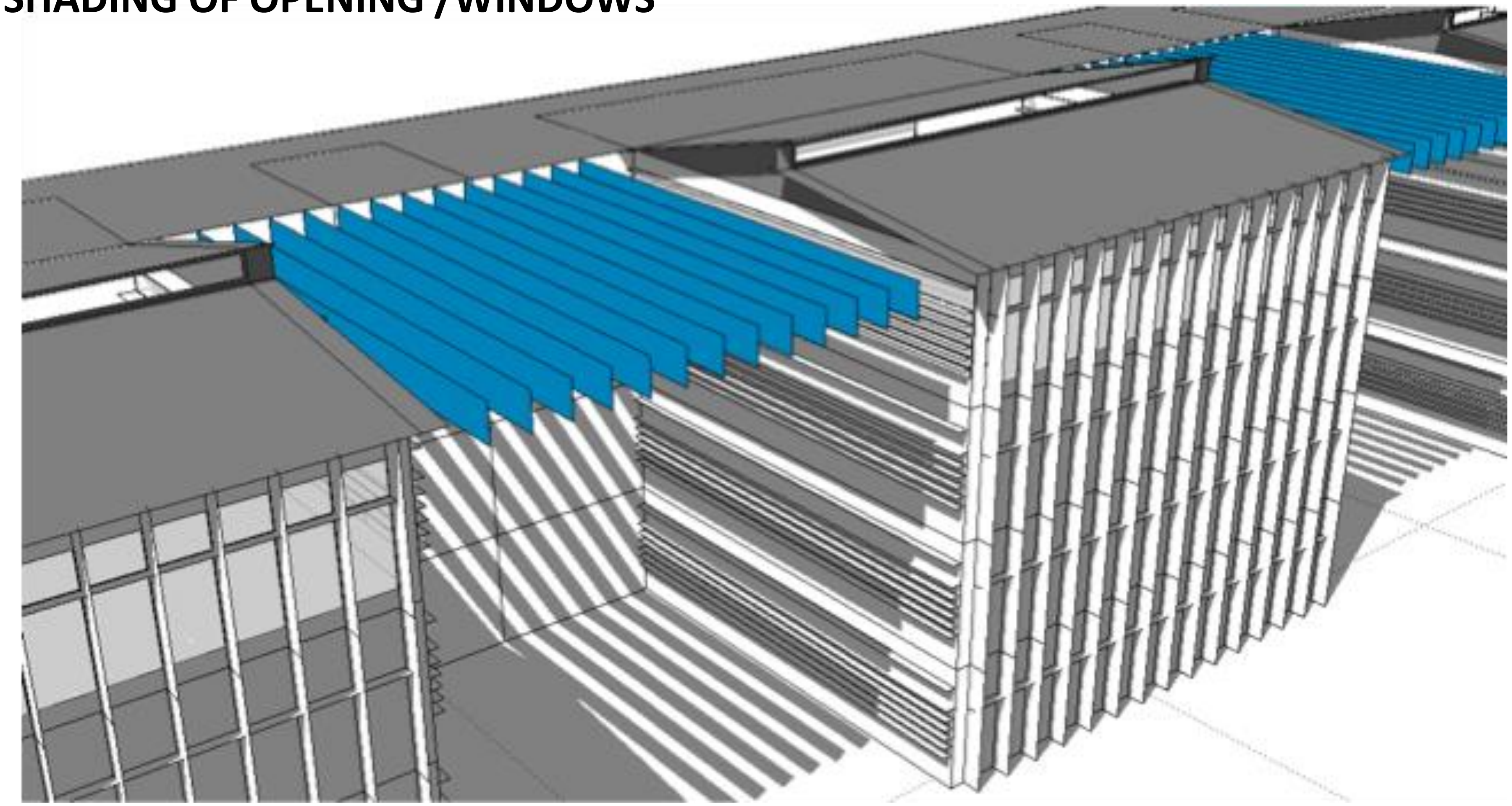
Fenestration type

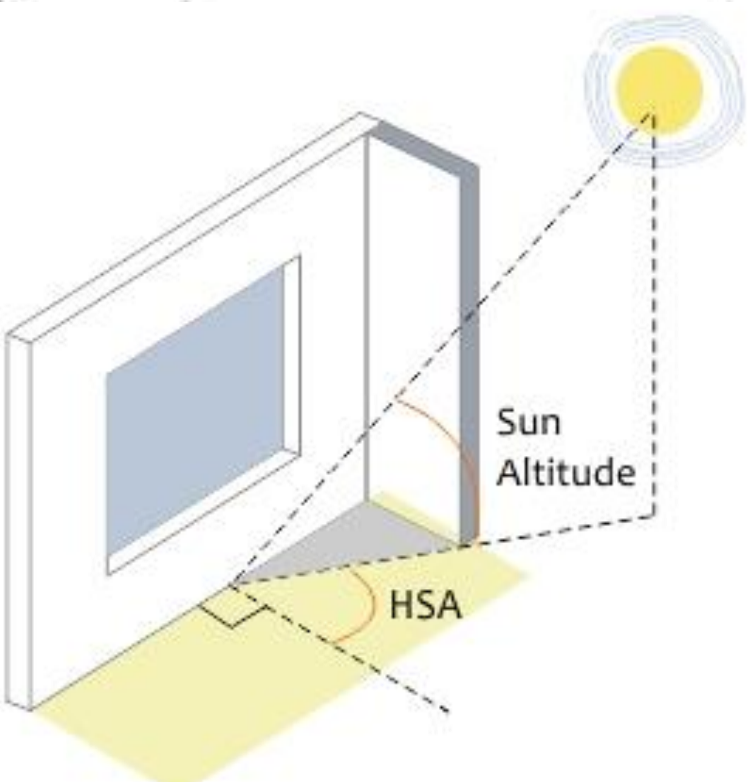
Source: NZEB

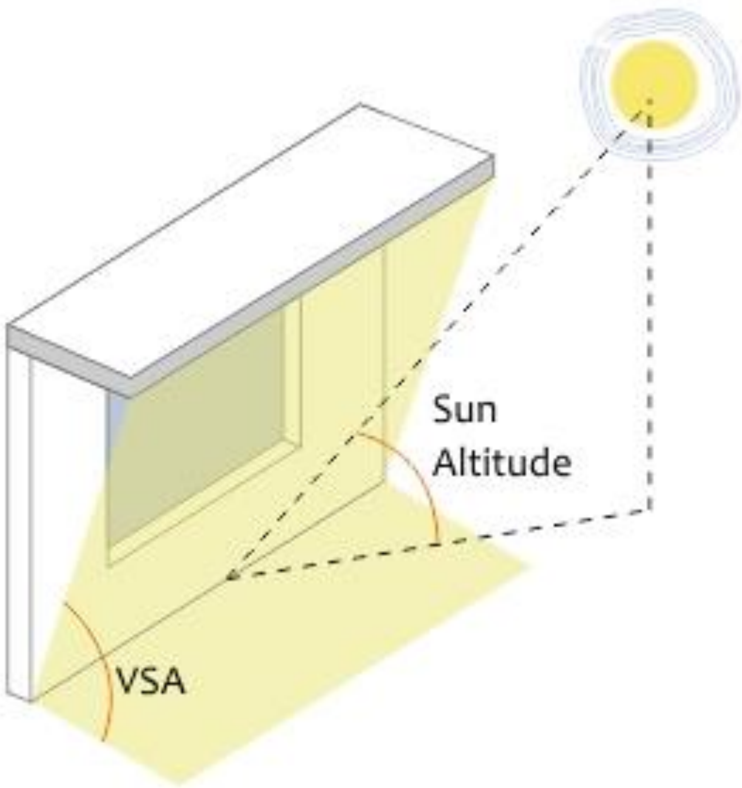
MEASURES TO IMPROVE THERMAL COMFORT

passive design strategies for affordable housing

SHADING OF OPENING /WINDOWS



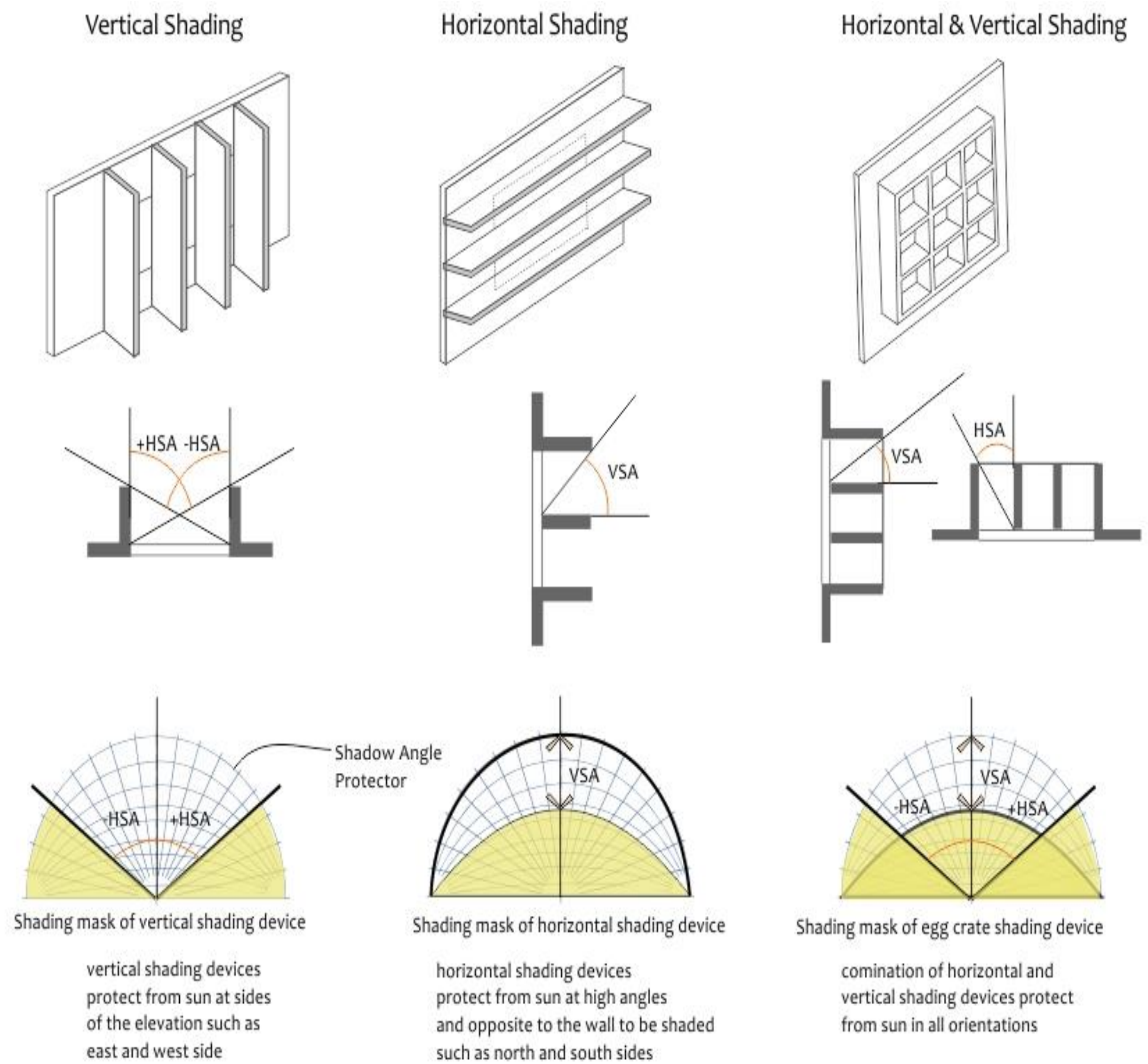




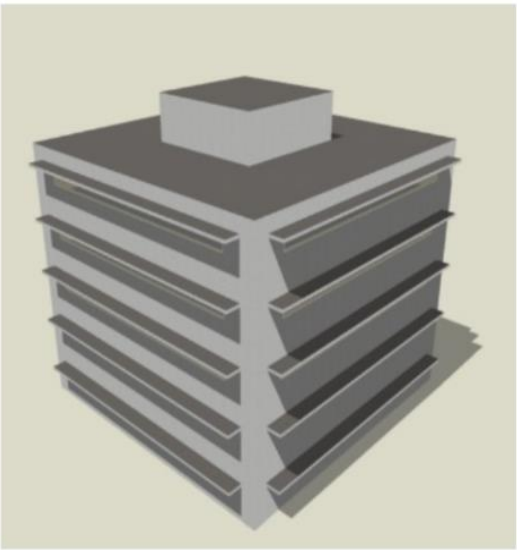
MEASURES TO IMPROVE THERMAL COMFORT

passive design strategies for affordable housing

SHADING OF OPENING /WINDOWS

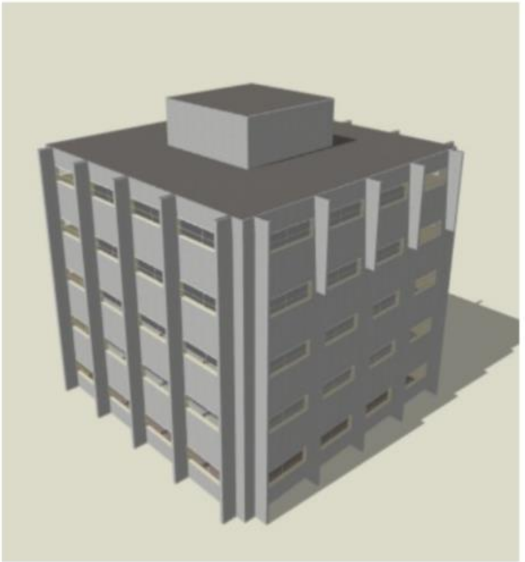


Horizontal BIPV Shading Devices Cases



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

Vertical BIPV Shading Devices 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

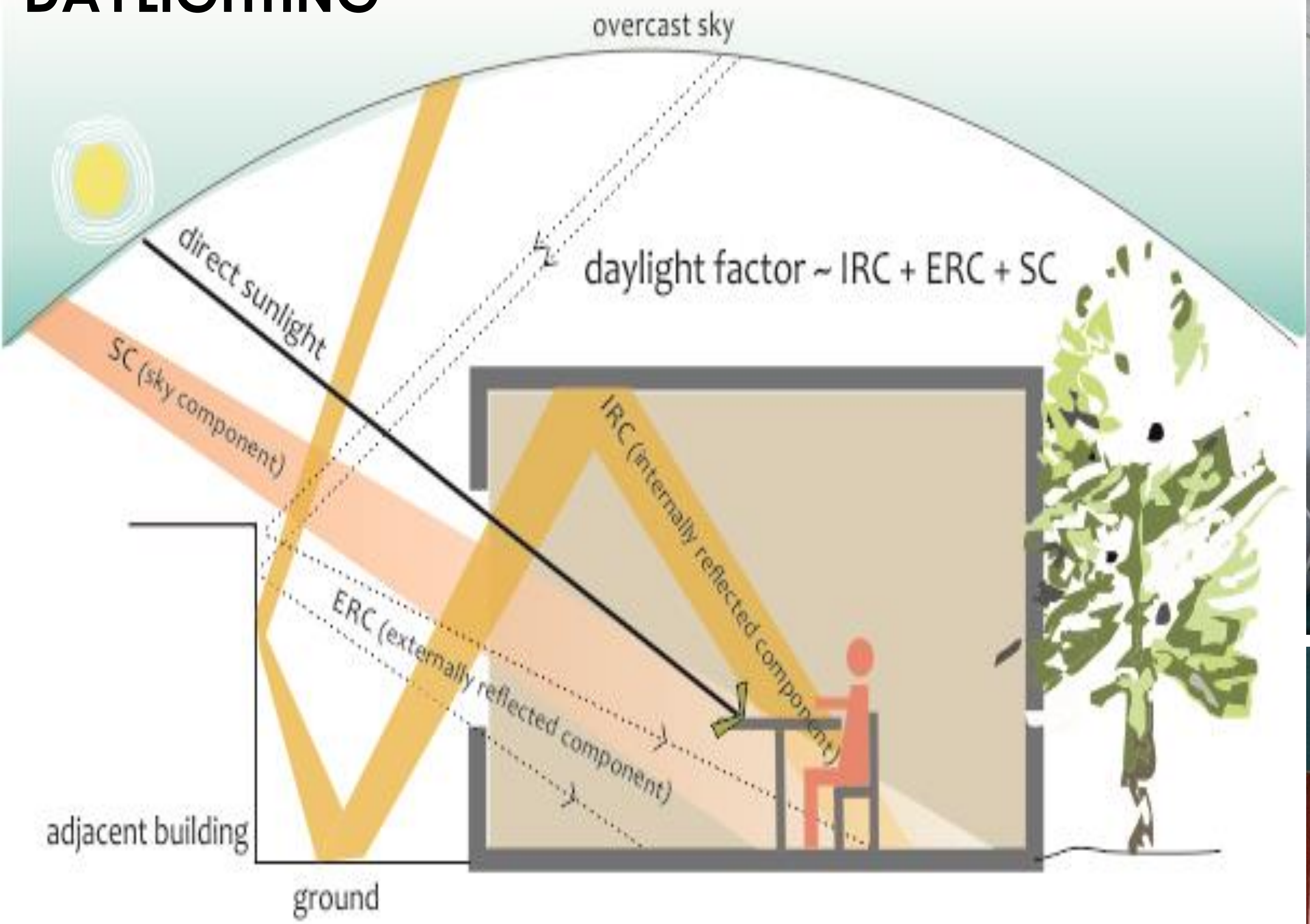
Use of shading device at Palace of Assembly, Chandigarh

Source: NZEB

MEASURES TO IMPROVE THERMAL COMFORT

passive design strategies for affordable housing

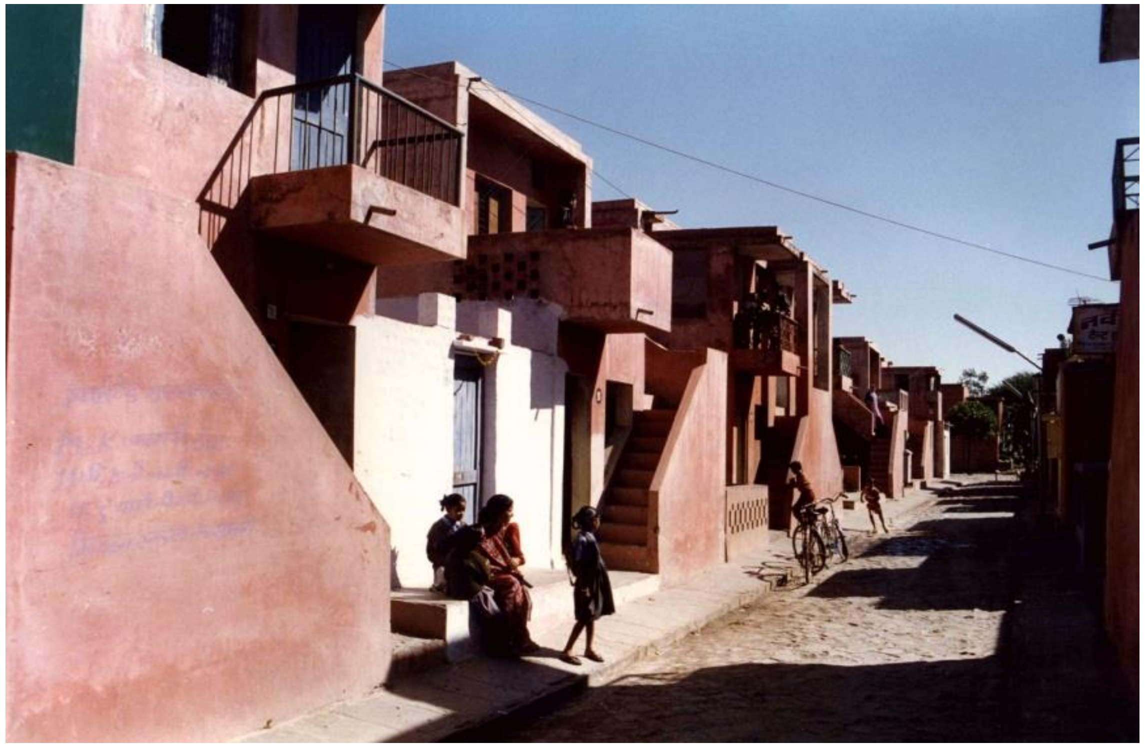
DAYLIGHTING



- 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

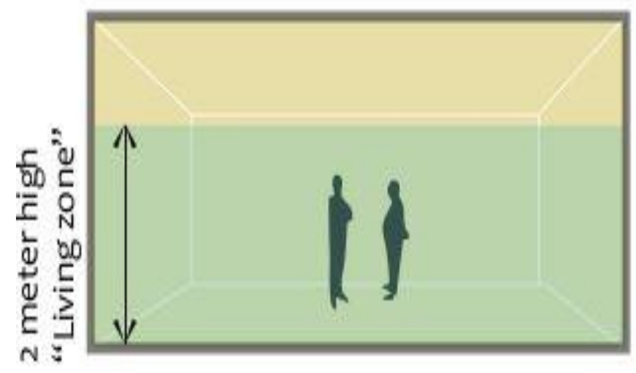
Source: NZEB

MEASURES TO IMPROVE THERMAL COMFORT

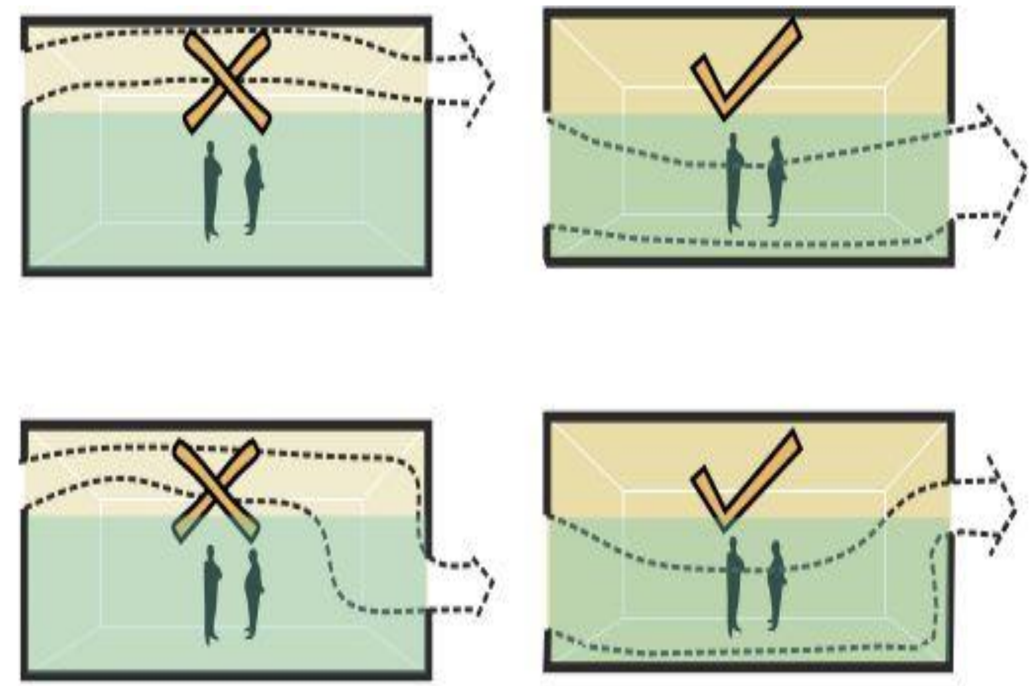
passive design strategies for affordable housing

NATURAL VENTILATION

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

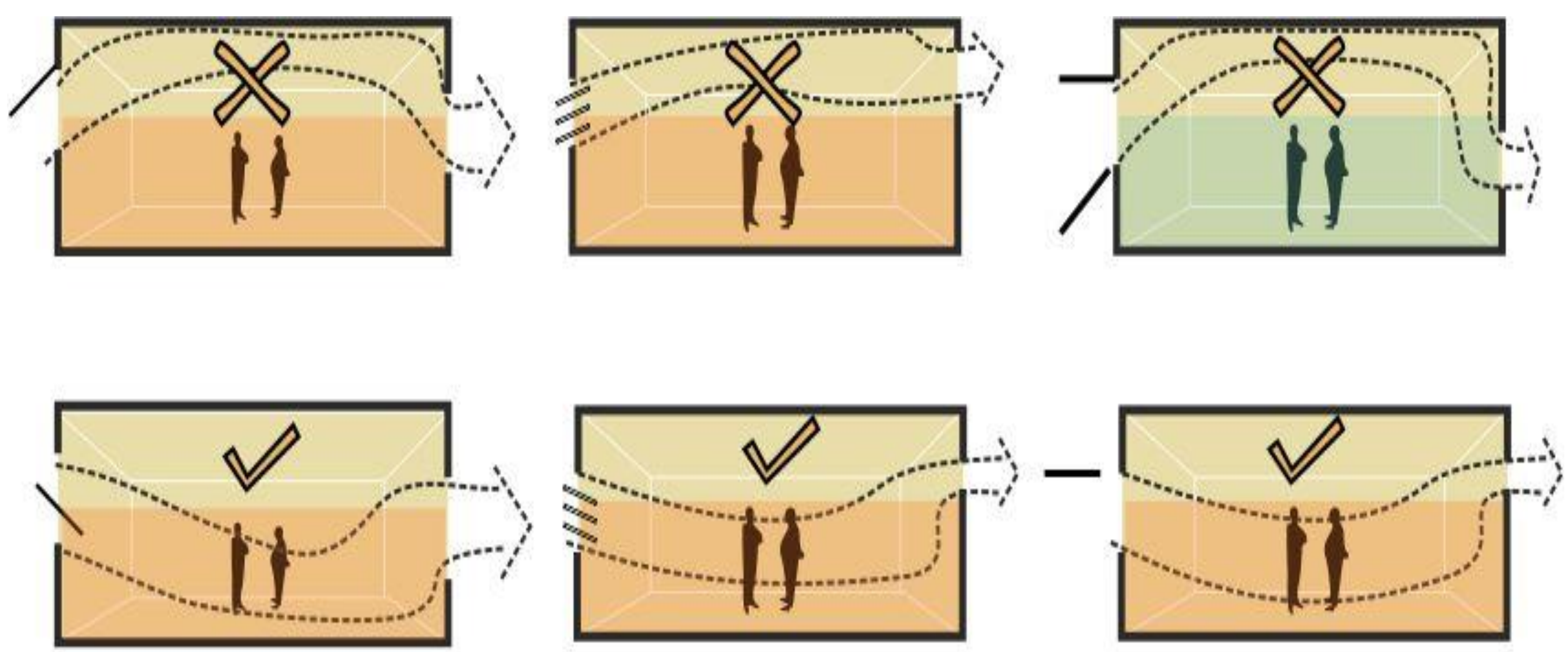


Living zone is the space commonly used by occupants. Air movement should be directed through this space.



inlet openings placed at high level deviate air flow away from the living zone irrespective of outlet position

Types of opening and their location



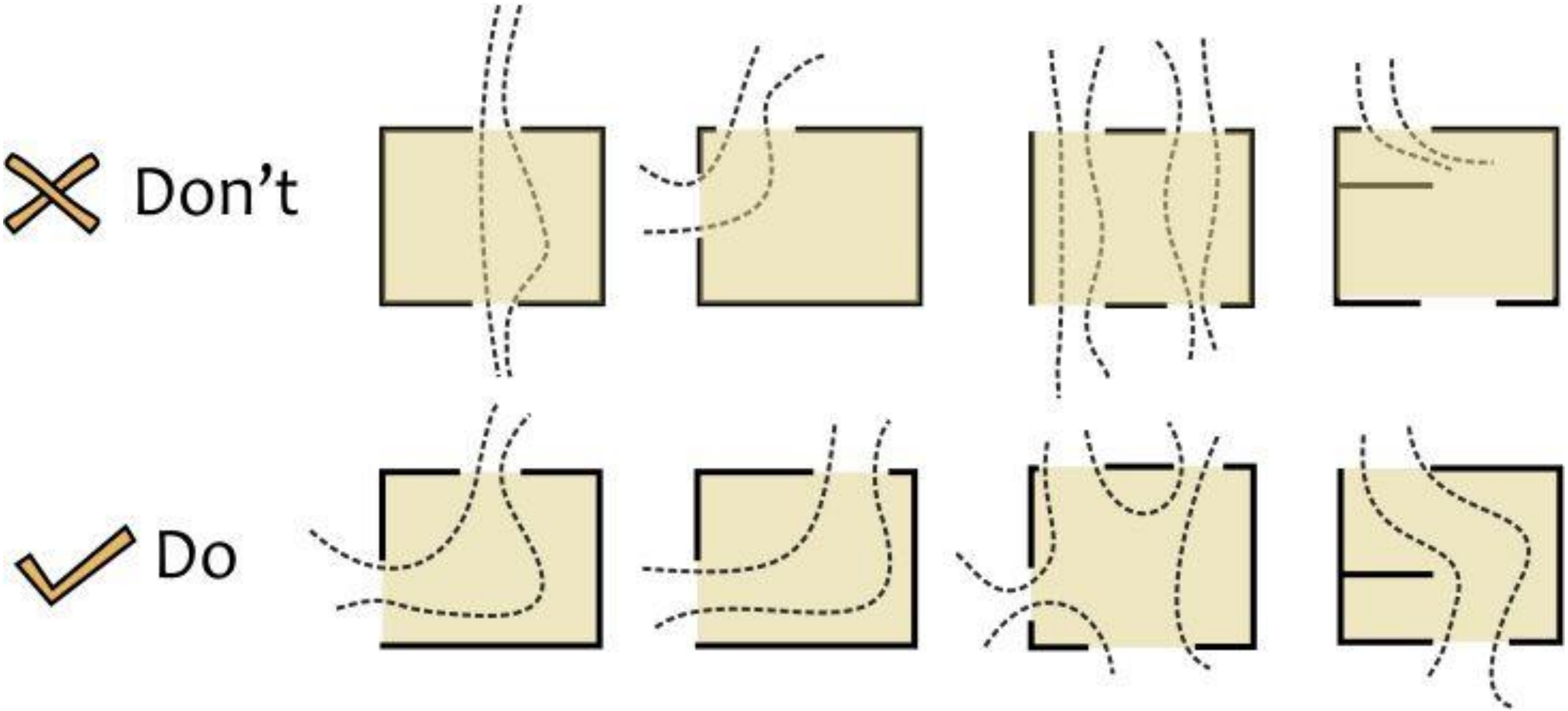
Natural ventilation helps in reducing mechanical cooling load of the building

Source: NZEB

MEASURES TO IMPROVE THERMAL COMFORT

passive design strategies for affordable housing

NATURAL VENTILATION



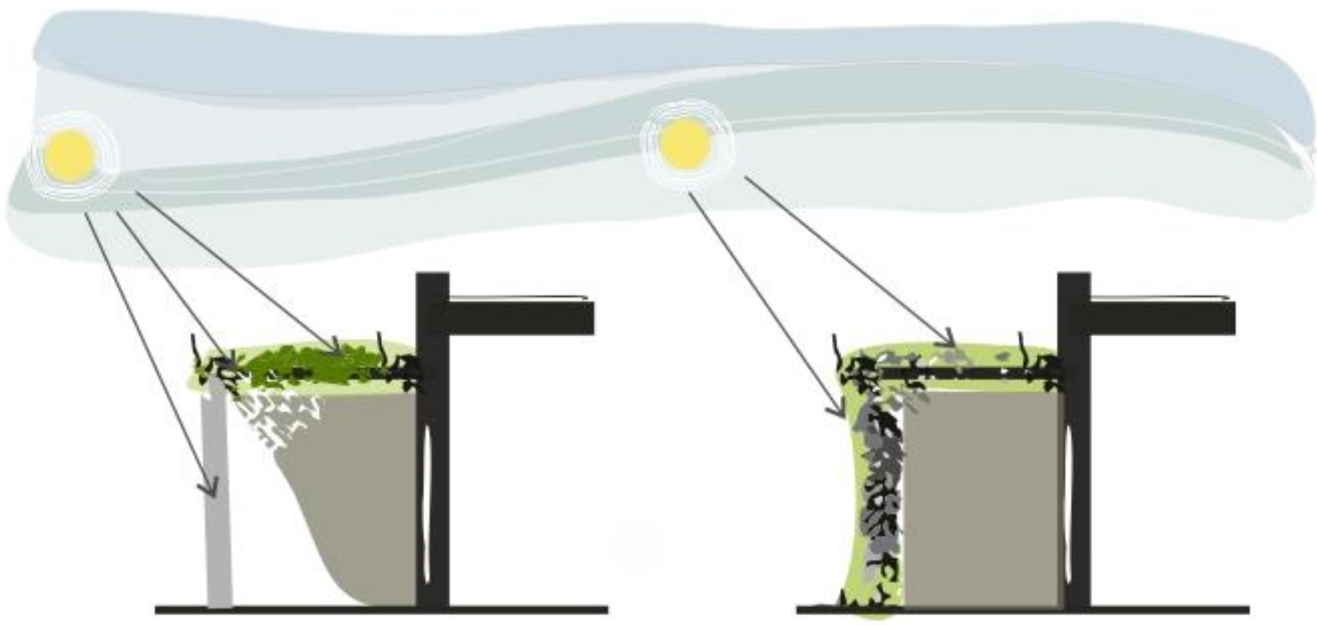
Horizontal placing of openings and internal partitions can alter the direction and spread of air stream

MEASURES TO IMPROVE THERMAL COMFORT
passive design strategies for affordable housing

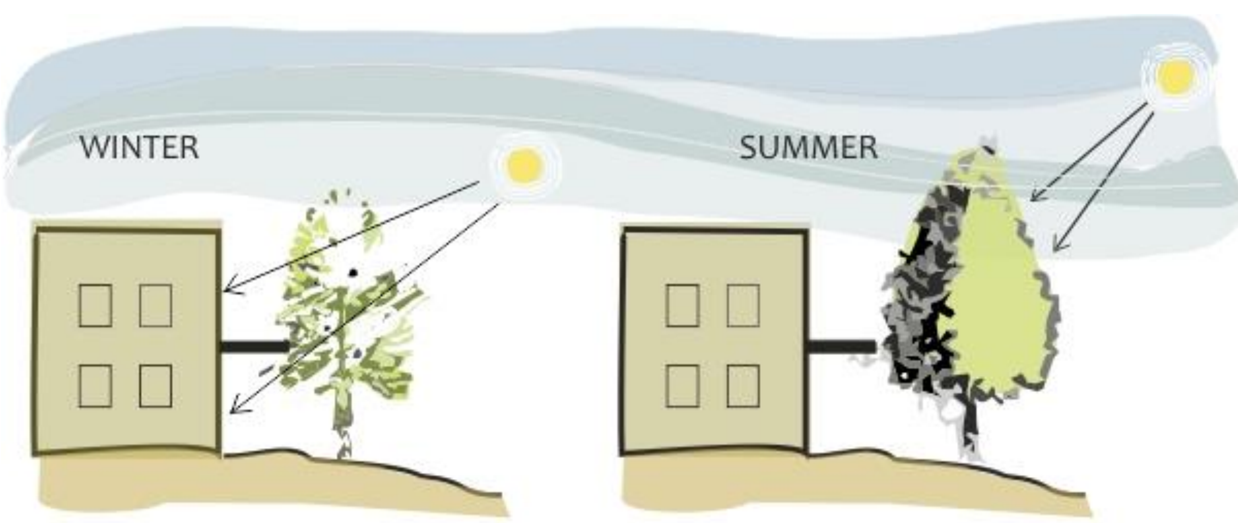
VEGETATION

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

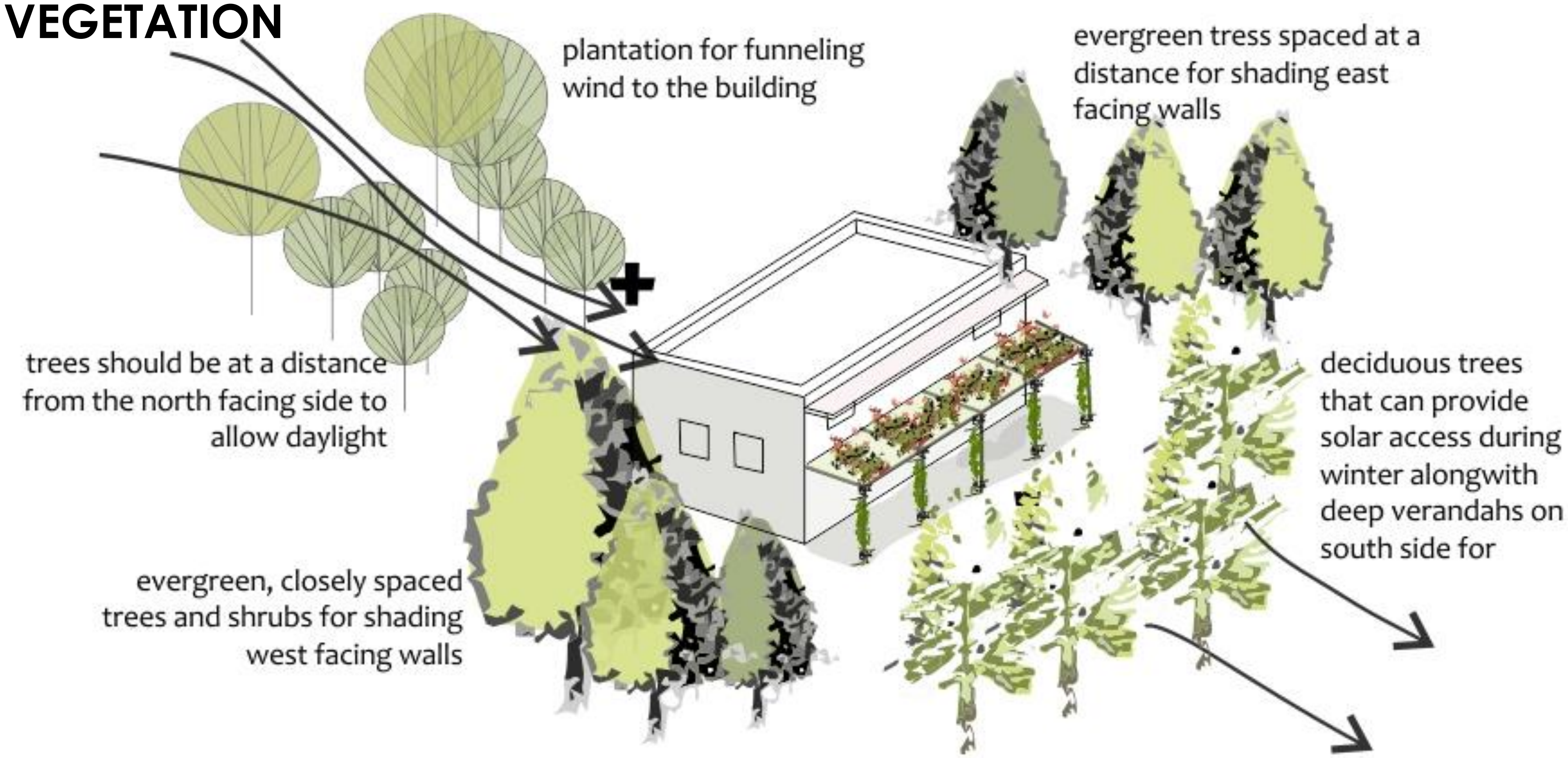


deciduous trees allow sun penetration in winter and block sun access during summer

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.**

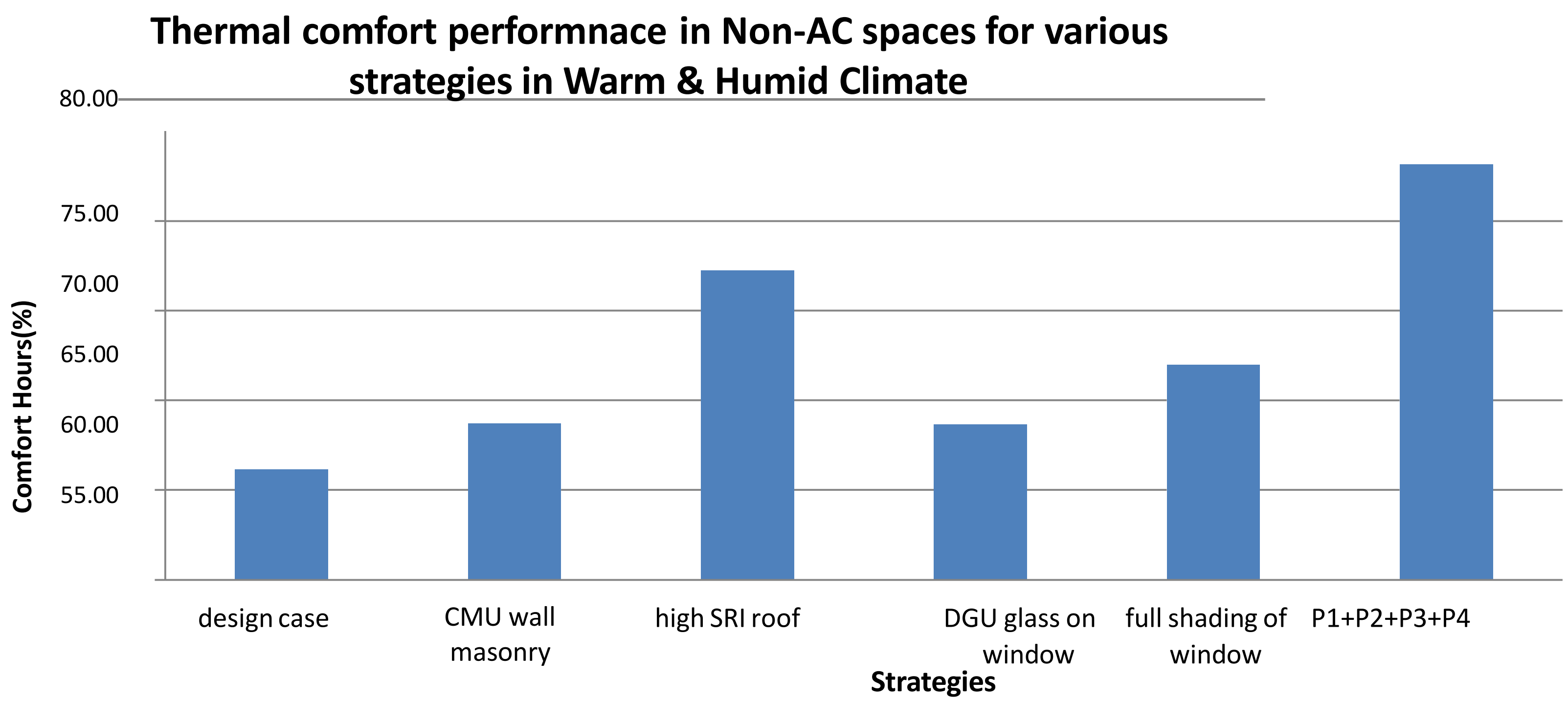
Trees also reduce ambient air temperature due to evapo-transpiration.

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

THERMAL COMFORT IN AFFORDABLE HOUSING



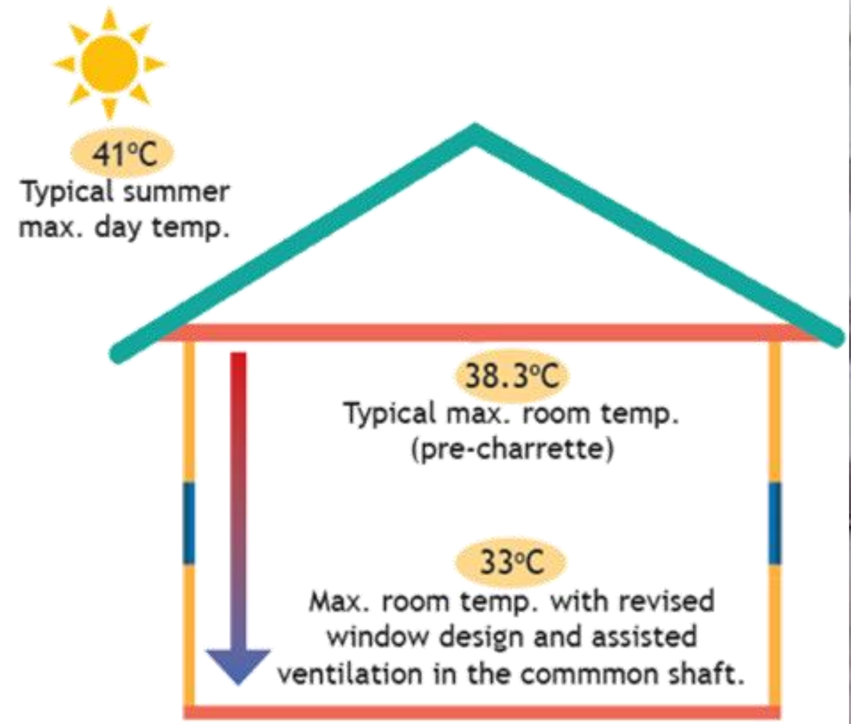
Parametric	simulation Parametric	Thermal comfort (%)	Increment in thermal comfort(%)
P0	design case	61.15	0.00
P1	CMU wall masonry	63.70	2.55
P2	high SRI roof	72.25	11.10
P3	DGU glass on window	63.65	2.50
P4	full shading of window	66.99	5.83
P5	P1+P2+P3+P4	78.14	16.99

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

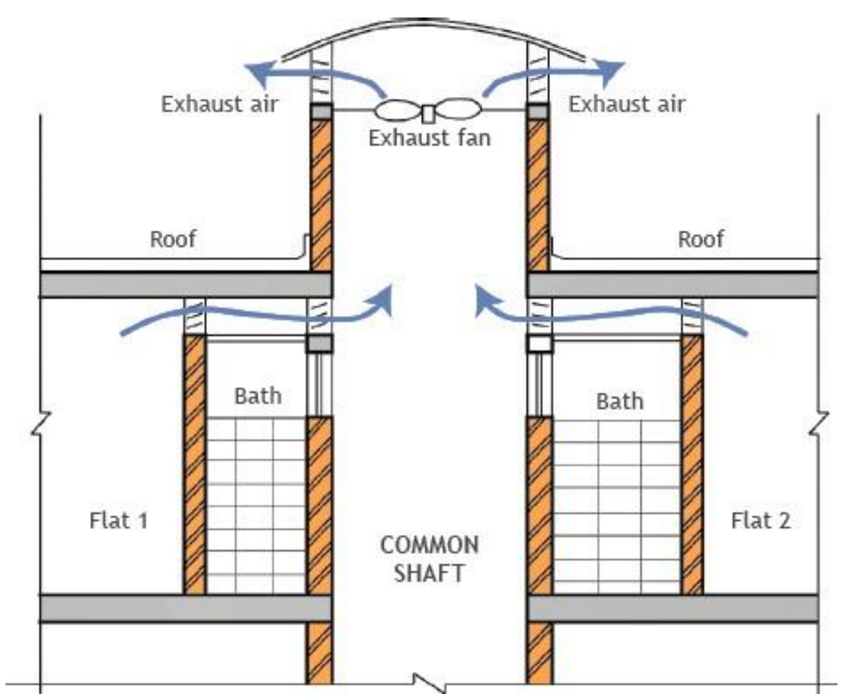


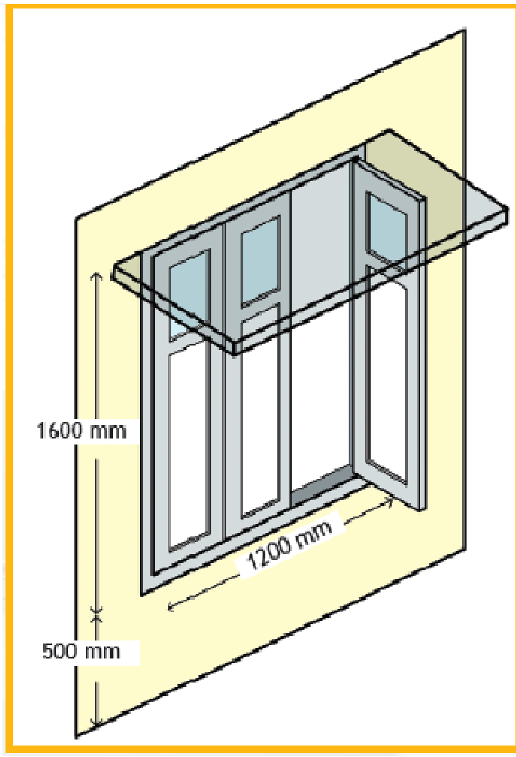
Key Features

- 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.

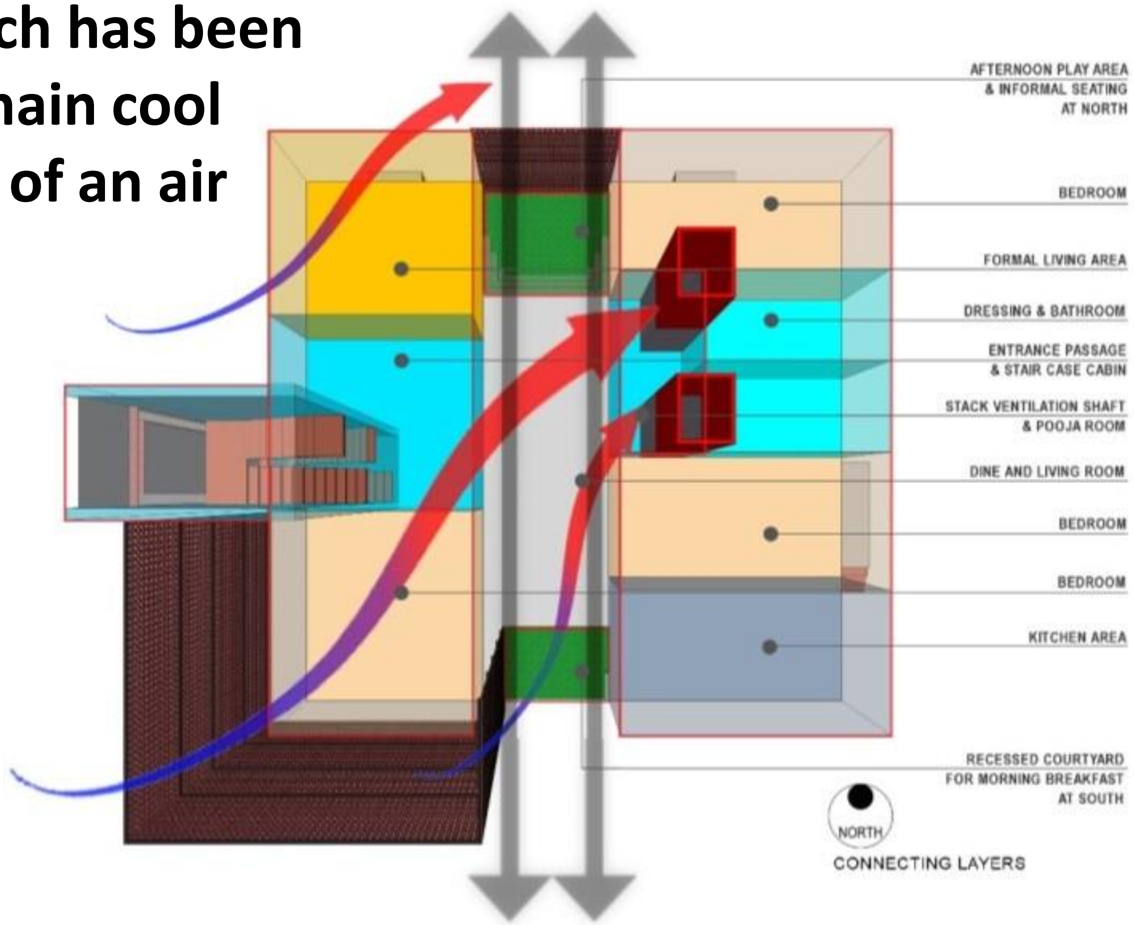




Source: BEEP

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

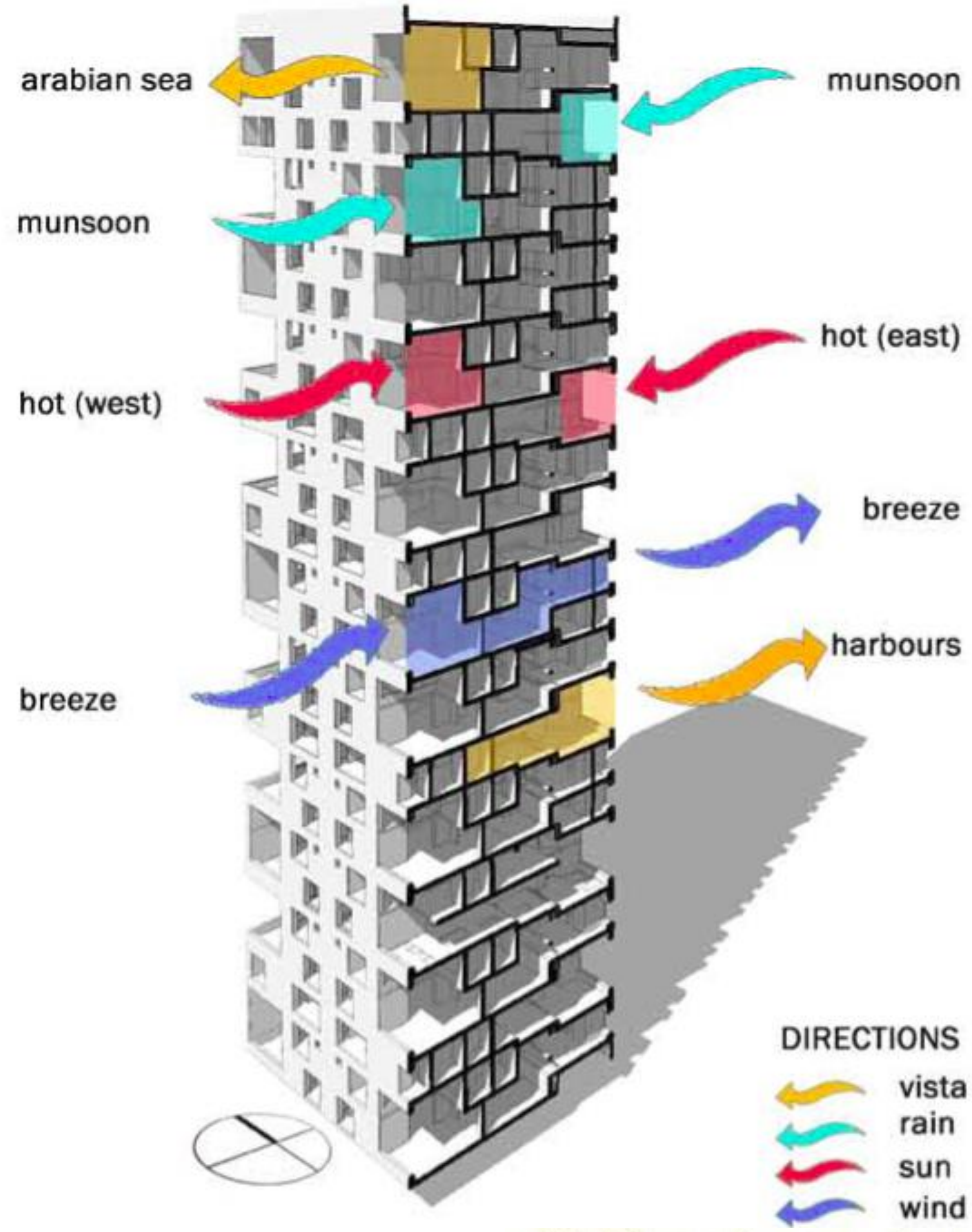
Source: Parekh Collaborative

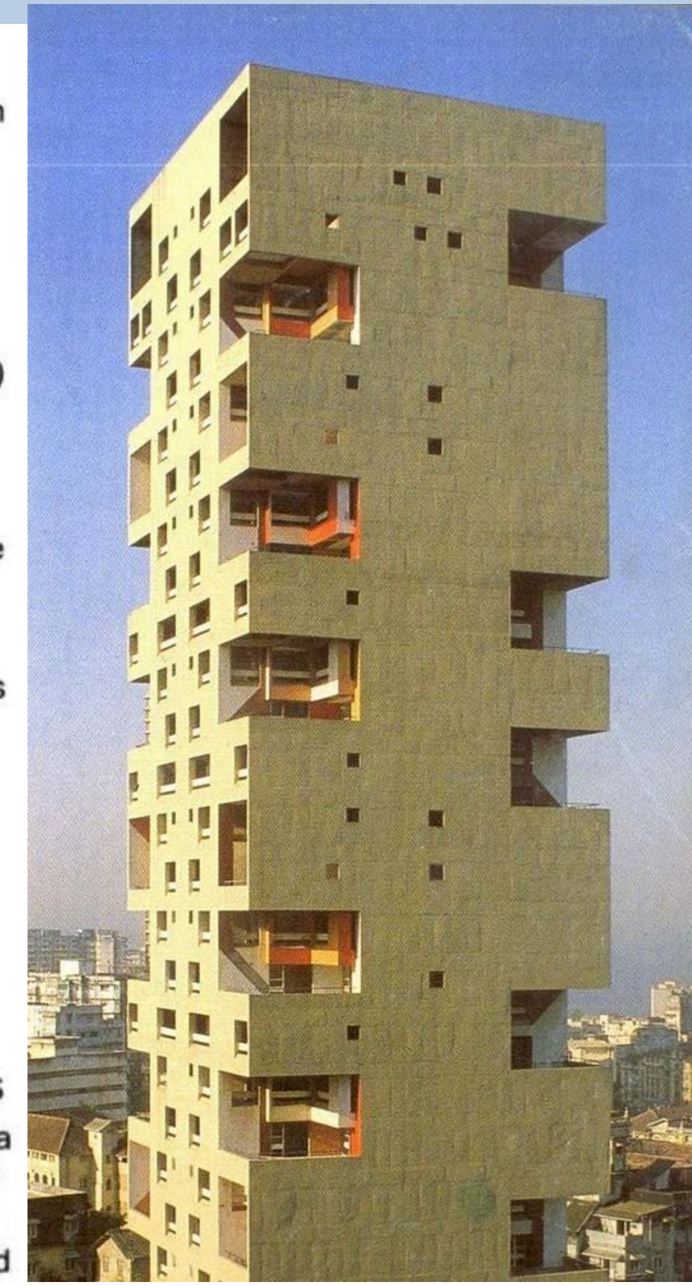
CASE STUDY - KANCHANJUNGA APARTMENTS

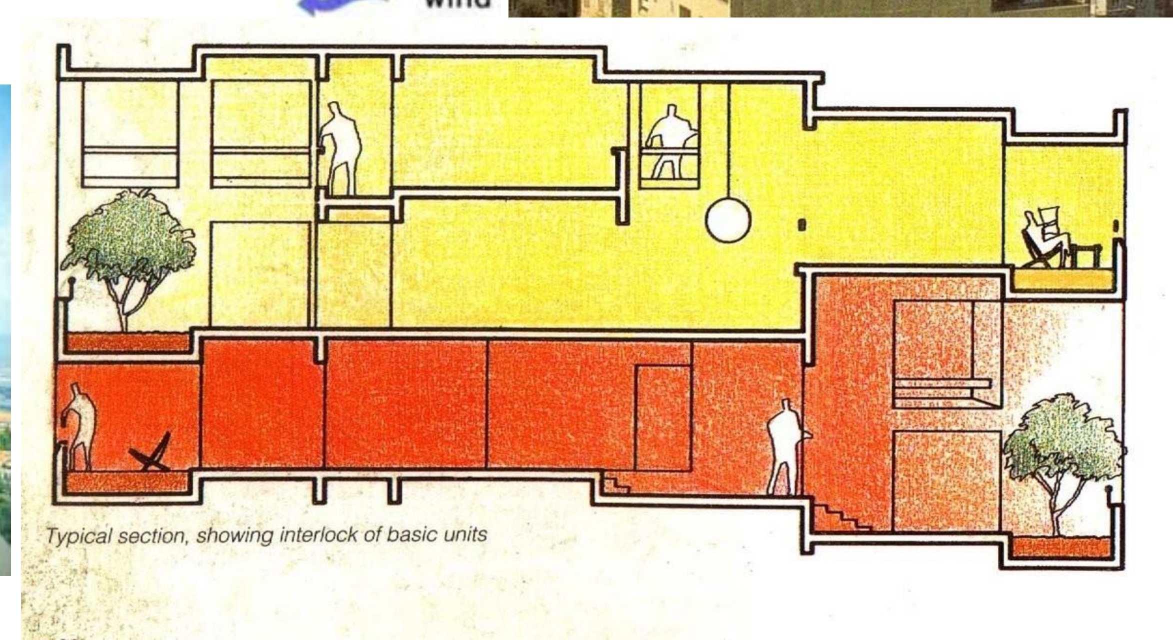
- **Architect:** Charles Correa
- **Location:** Bombay, India
- **Completed on:** 1983
- **Building Type:** Skyscraper multi-family housing
- **Construction System:** Concrete
- **Floors:** 32

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

Thermal Comfort Models

Session 2: Thermal Comfort models

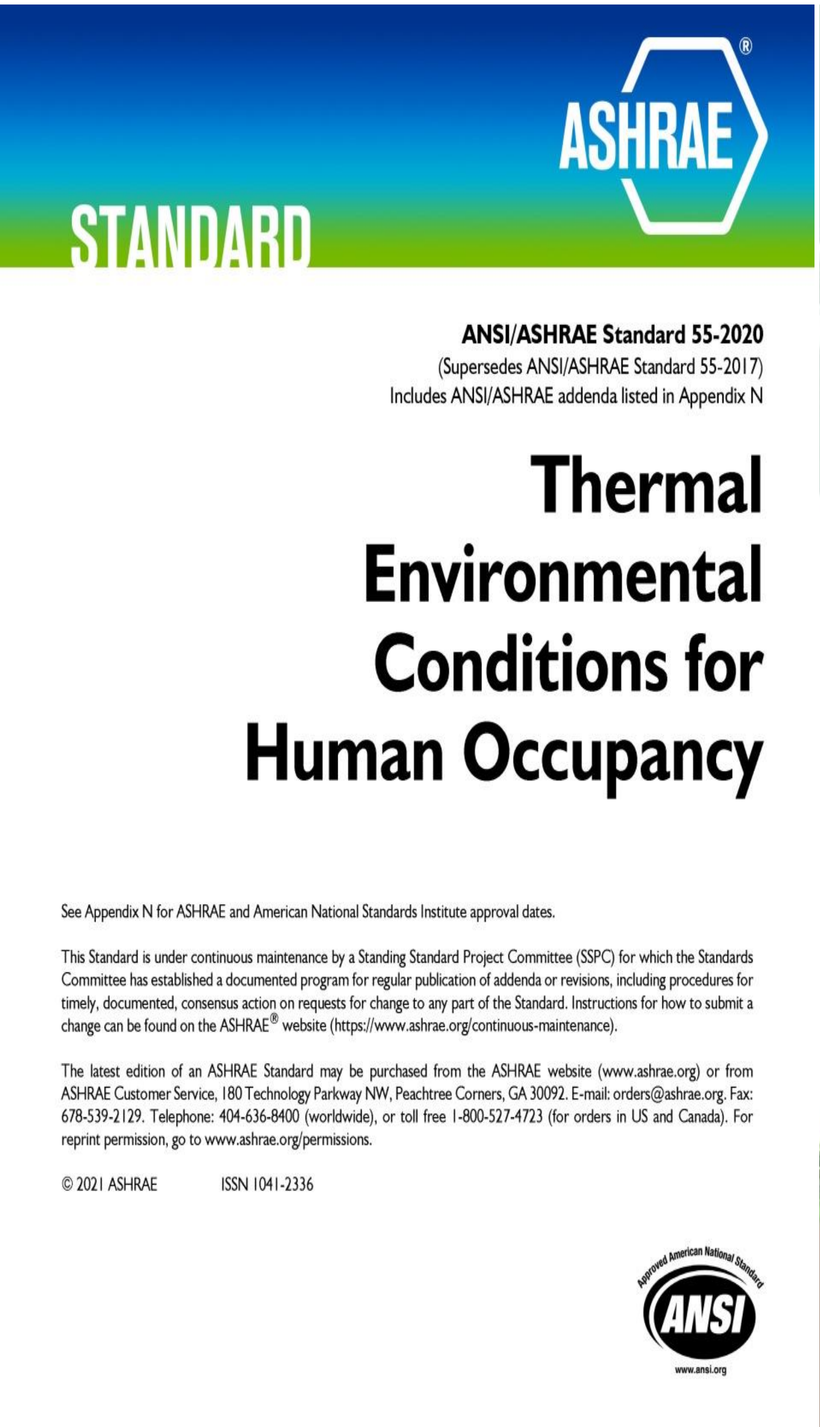
a)Thermal Comfort standards

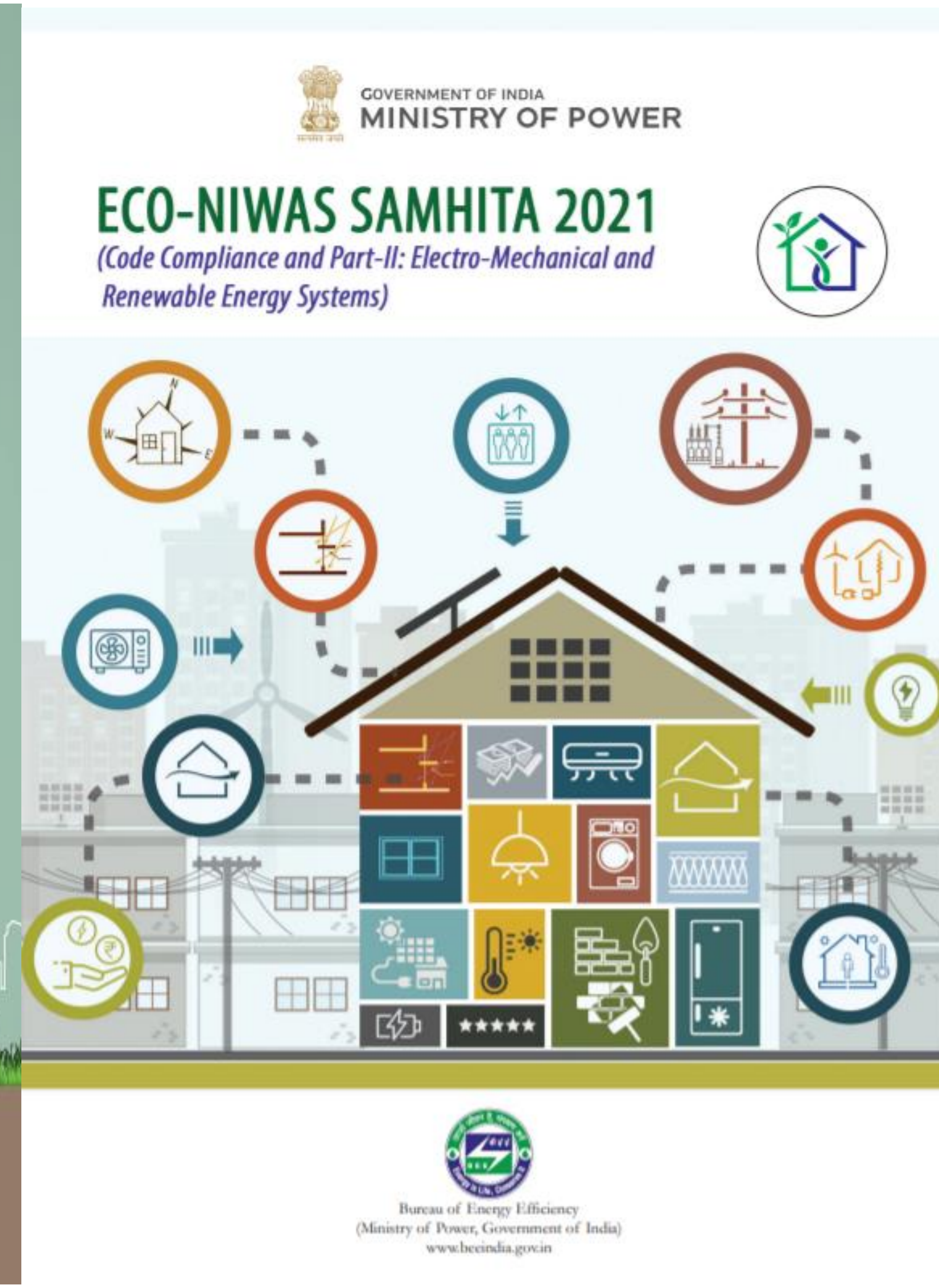
1.IMAC

2.ASHRAE

b)Effect of materials on thermal comfort

EXISTING STANDARDS FOR IMPROVING THERMAL COMFORT





THERMAL COMFORT IN AFFORDABLE HOUSING

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 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.

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

CBE CENTER FOR THE BUILT ENVIRONMENT

CBE Thermal Comfort Tool

Help | Other CBE tools

ASHRAE-55 | EN-16798 | Compare | Ranges | Upload | Fans & Heat | PHS

Inputs

Select method: PMV method

Operative temperature: 25 °C

Air speed: 0.1 m/s — No local control

Relative humidity: 50 % — Relative humidity

Metabolic rate: 1 met — Seated, quiet: 1.0

Clothing level: 0.61 clo — Trousers, long-sleeve shi

Create custom ensemble

Dynamic predictive clothing

Solar gain on occupants

Set pressure | SI/IP

Local discomfort | Globe temp

Reset | Save | Reload | Share

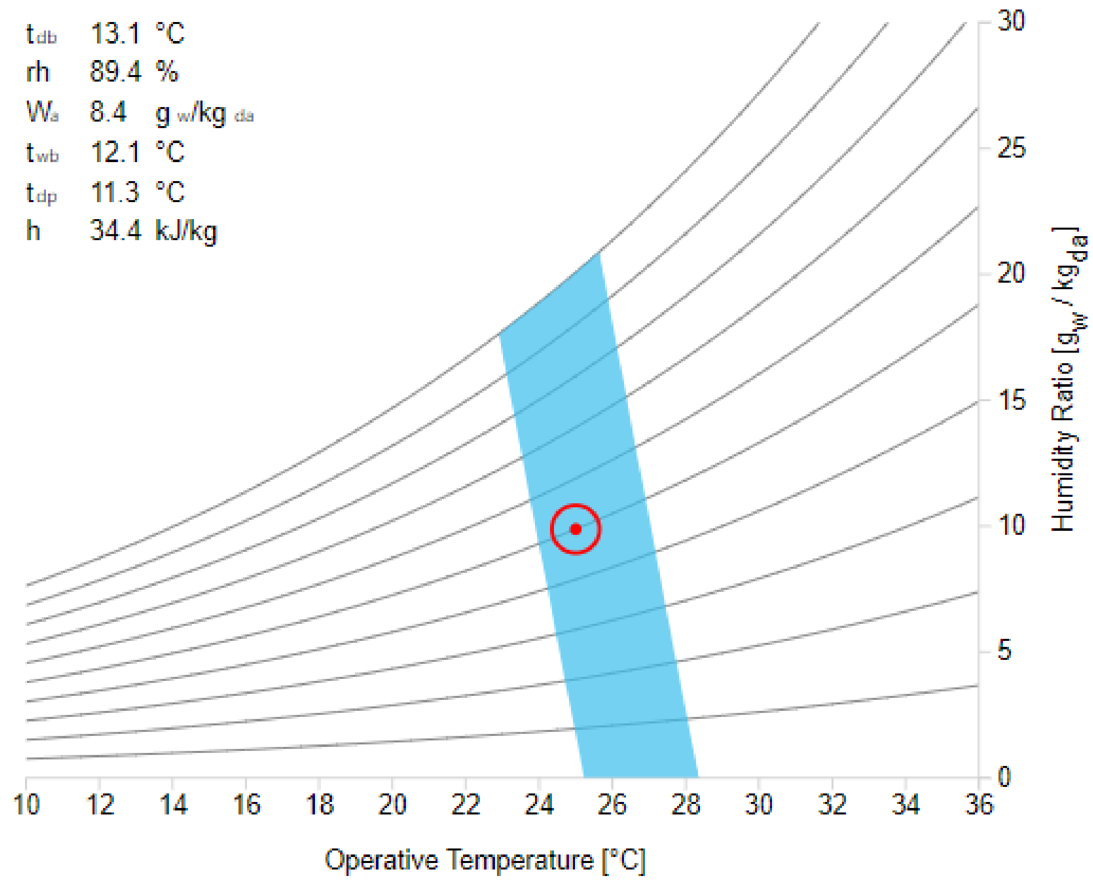
Documentation

✔ Complies with ASHRAE Standard 55-2020

PMV = -0.16 PPD = 6 %

Sensation = Neutral SET = 24.8 °C

Psychrometric (operative temperature)



NOTE: In this psychrometric chart the abscissa is the operative temperature and for each point dry-bulb temperature equals mean radiant temperature (DBT = MRT). The comfort zone represents the combination of conditions with the same DBT and MRT for which the PMV is between -0.5 and +0.5, according to the standard.

Limits of Applicability: This standard is only applicable to healthy individuals. This standard does not apply to occupants: a) whose clothing insulation exceed 1.5 clo; b) whose clothing is highly impermeable; or c) who are sleeping, reclining in contact with bedding, or able to adjust blankets or bedding.

The CBE comfort tools automatically calculates the relative air speed and the dynamic clothing insulation .

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

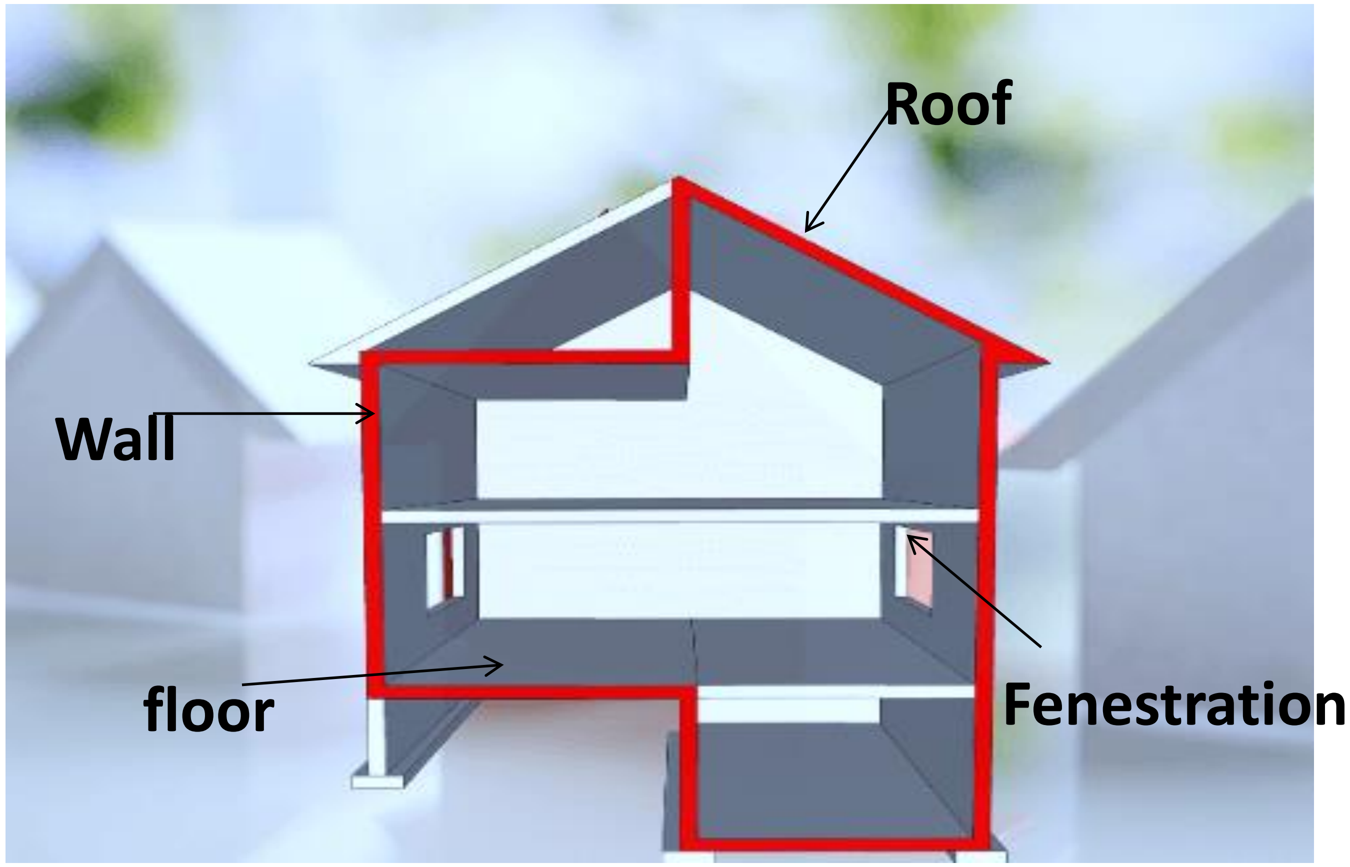
a. Minimum openable window-to-floor area ratio with respect to the climatic zone

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

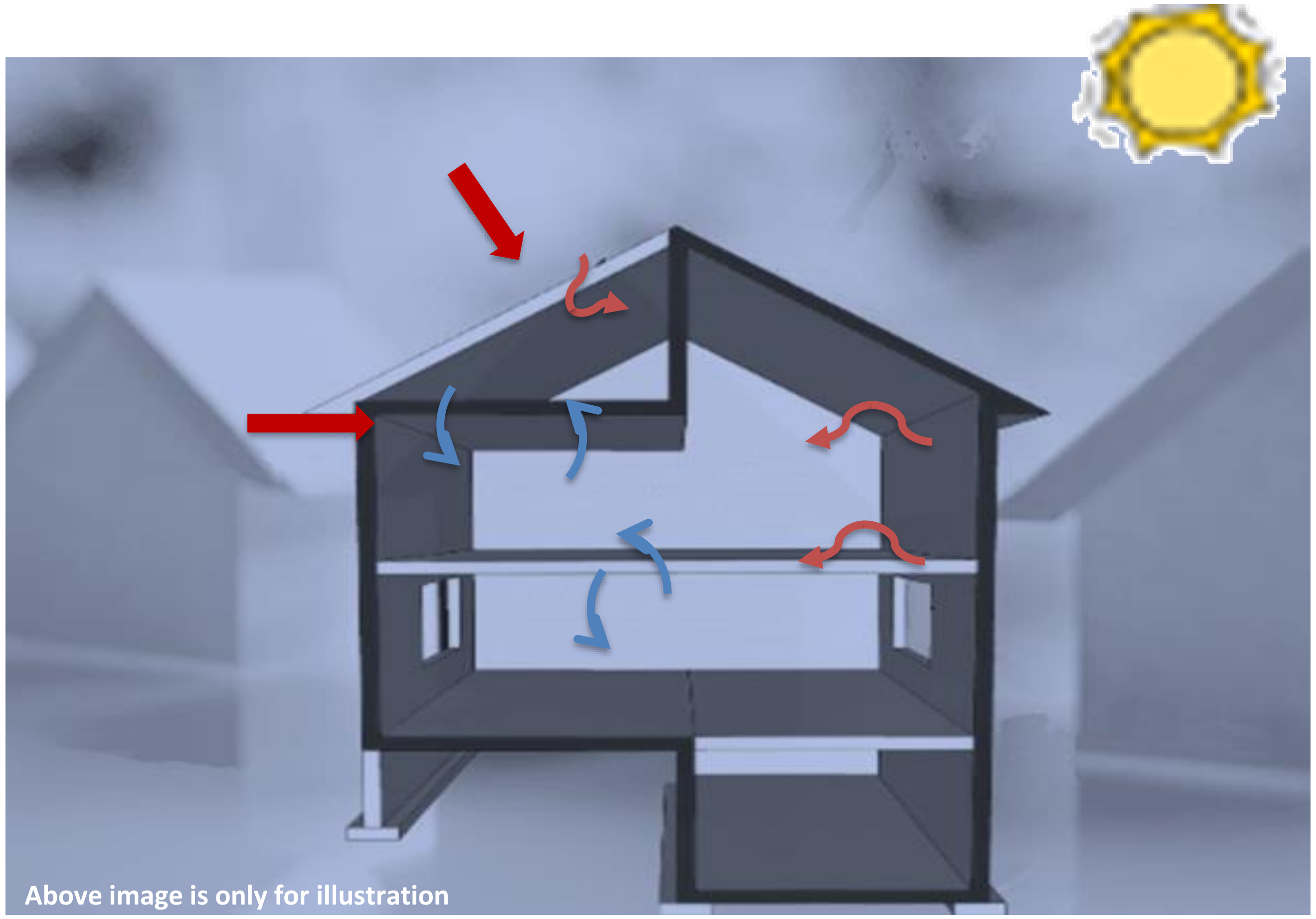
Transfer of heat from one material to another, through direct contact

CONVECTION

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

RADIATION

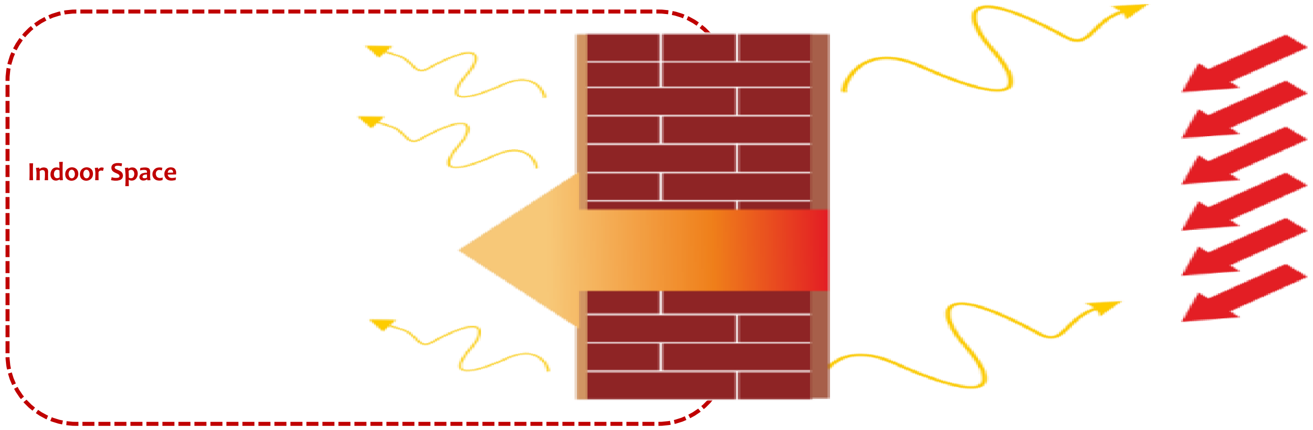
Energy that is radiated in form of rays/ waves



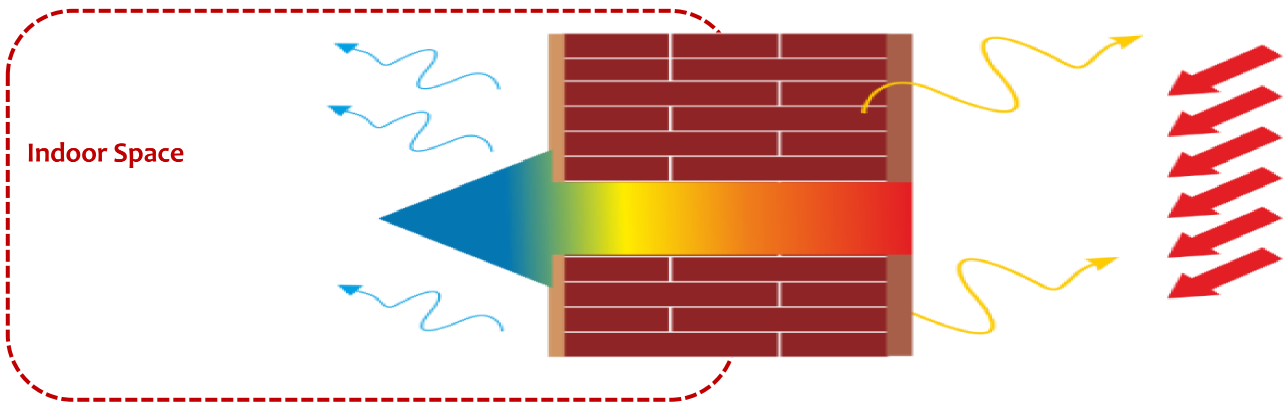
Building consist of wall, roof, fenestration, floor, sky light, columns, beams, doors

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



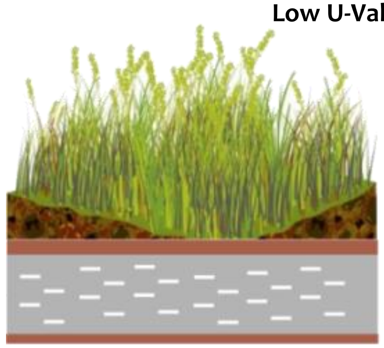
High U-Value



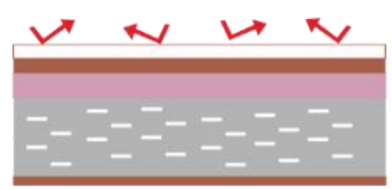
Low U-Value

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**.



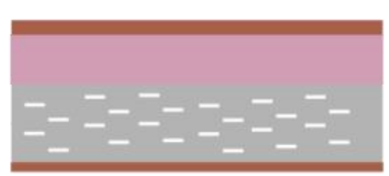
Above Deck Insulation



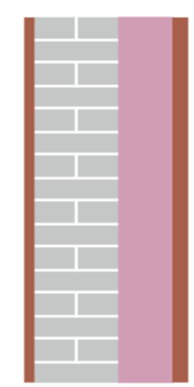
Reflective Tiles with above deck insulation of low thickness

For Roof

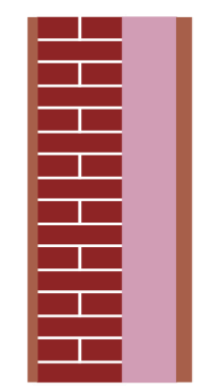
- Reflective paints
- Roof garden
- Insulation
- Reflective tiles- China Mosaic



Above Deck Insulation



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

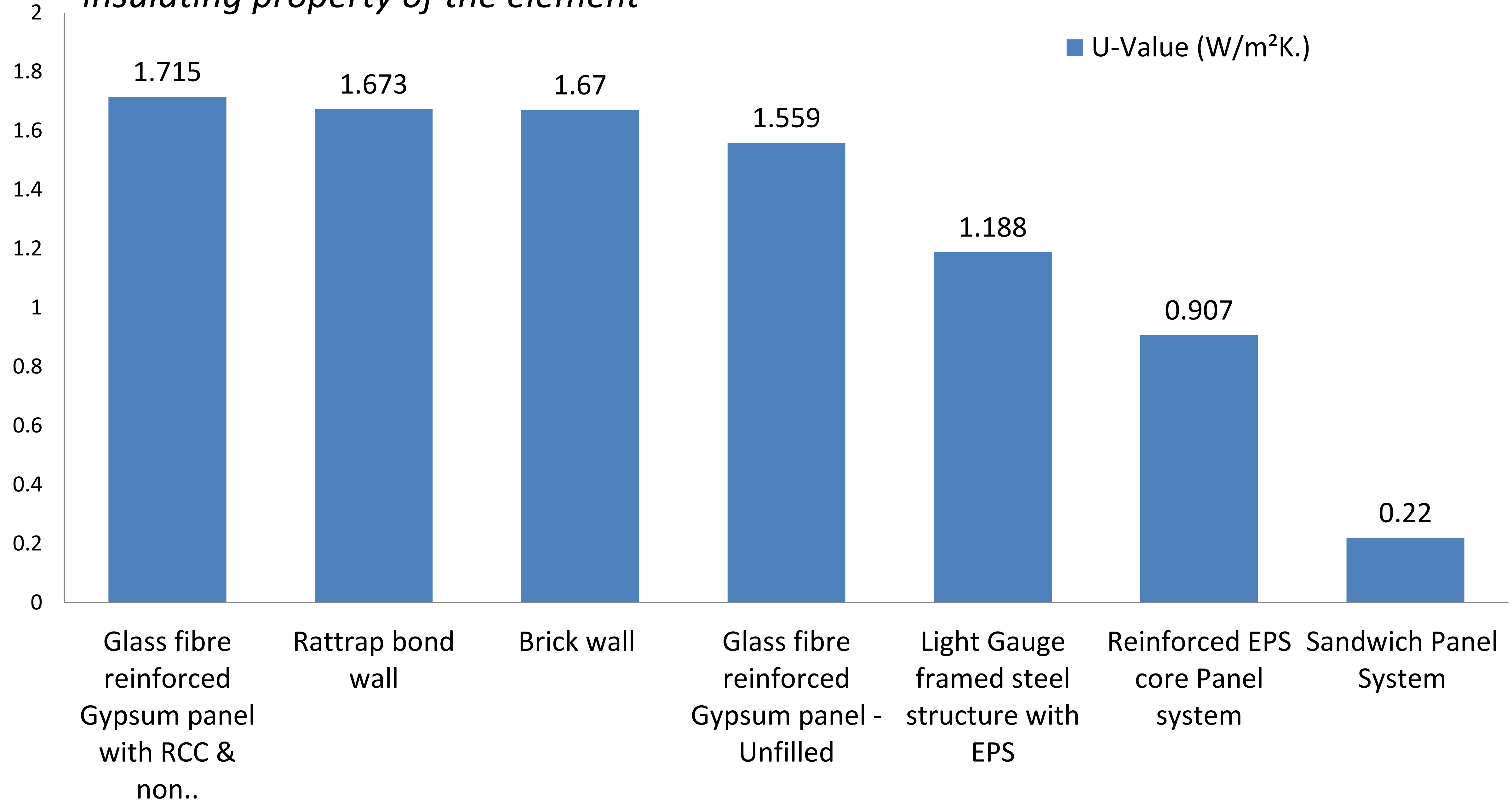
Characteristic of insulating materials	Insulating Power	Density	Fire Resistance	Water vapor diffusion	Resistance to water	Compression Strength	Traction Strength	Heat Resistance	Absorption of vibrations	Absorption of aerial noise	Cost at given insulation	Embodied Energy
Light mineral Wool	+	_._	++	-	O	_._	_._	+		++	+	_._
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



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Session 3: Eco Niwas Samhita

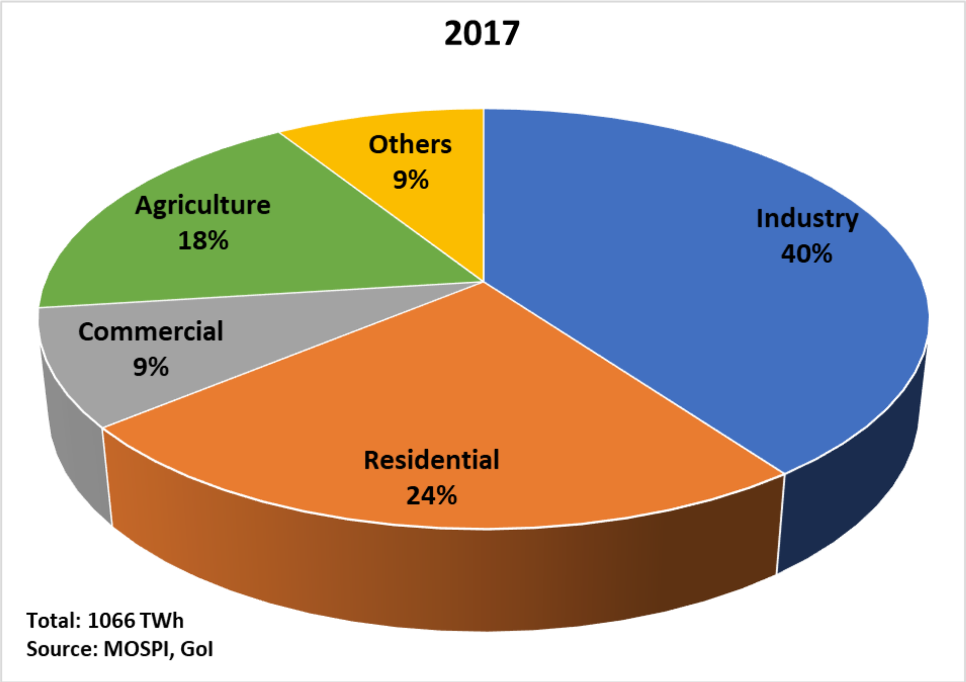
EcoNiwas Samhita Part 1 & 2, Overview and its role in Thermal Comfort and Energy Efficiency in affordable housing

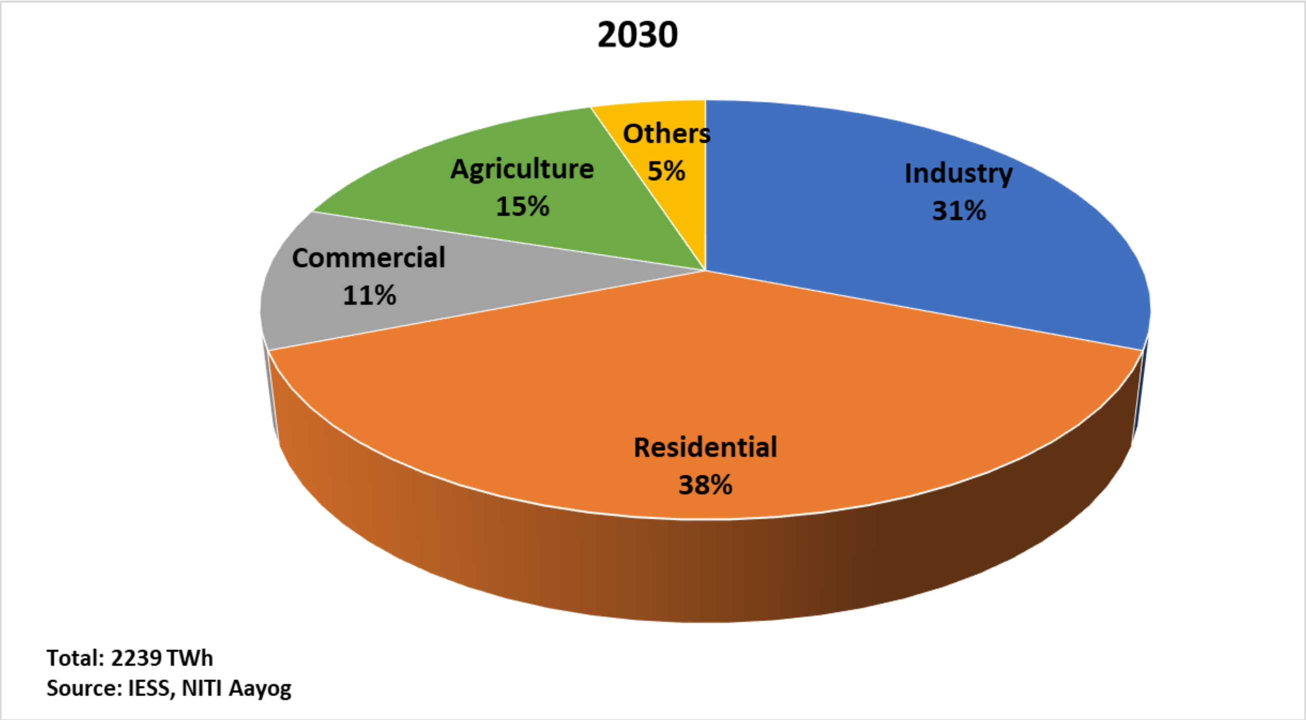
Thermal Comfort - Health & Socio- Economic Impacts

- Majority (~90%) of the households does not have access to air-conditioning
- The maximum air temperature limit for thermal comfort (with fan) is around 32-34^{o}C [NBC]
- As room air temperature and the wall surface temperatures approach 35^{o}C, then the ability of the human body to loose heat reduces drastically.
- Thermal discomfort results in
  - Loss of concentration, nausea or irritability, muscle cramps or weakness, headache, fatigue, etc.
  - Negative impact on health of the occupants, children unable to study, loss of income due to poor productivity

Thus while designing houses care should be taken that the peak indoor operative temperatures does not exceed comfort band during peak summer period. This is the basic strategy for curtailing the growing use of air conditioning to alleviate discomfort.

Residential Buildings: Fast Growth in Electricity Consumption





- Residential buildings consumes around **255 TWh electricity in 2017**, the electricity consumption in residential buildings is expected to multiply by more than **3X and reach around 850 TWh by 2030**. **Increased penetration of air-conditioning** in residential building is the key reason for this growth.
- Residential buildings will become the **largest end-user of electricity** in the country accounting for **38% of the total electricity consumption**.

Building Energy Efficiency - Overview

- The Bureau of Energy Efficiency (BEE) has adopted a multi-pronged approach to conserve energy in building sector:
  - Energy Conservation Building Code (ECBC) for commercial buildings (2007 & 2017).
  - Star rating system for various types of commercial buildings
  - Star rating for appliances, which cover air conditioners, fans, lighting, etc.

- BEE now plans to aggressively push for energy efficiency in new housing through the **Energy Conservation Building Code for Residential Buildings (Parts 1 & 2)** and through the Residential Building Labelling Programme.

Eco-Niwas Samhita 2018

- Eco-Niwas Samhita 2018 (Part I: Building Envelope) is the new Energy Conservation Building Code for Residential Buildings; launched by Ministry of Power (MoP) on 14 December 2018.

Building envelope provisions to improve thermal comfort and reduce energy consumption

Thermal Comfort - Health & Socio-Economic Impacts

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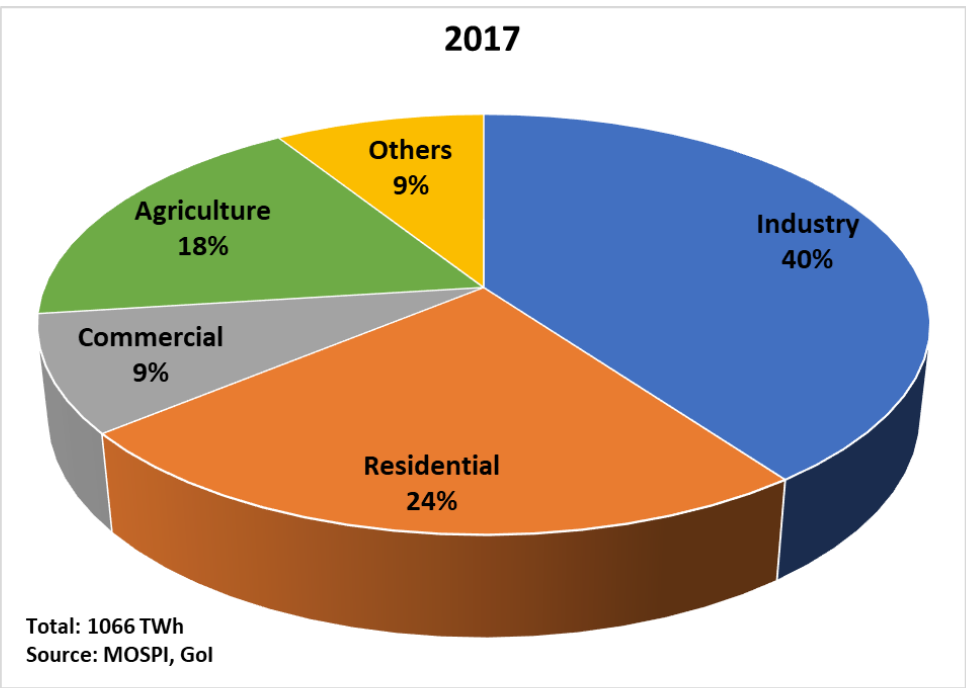

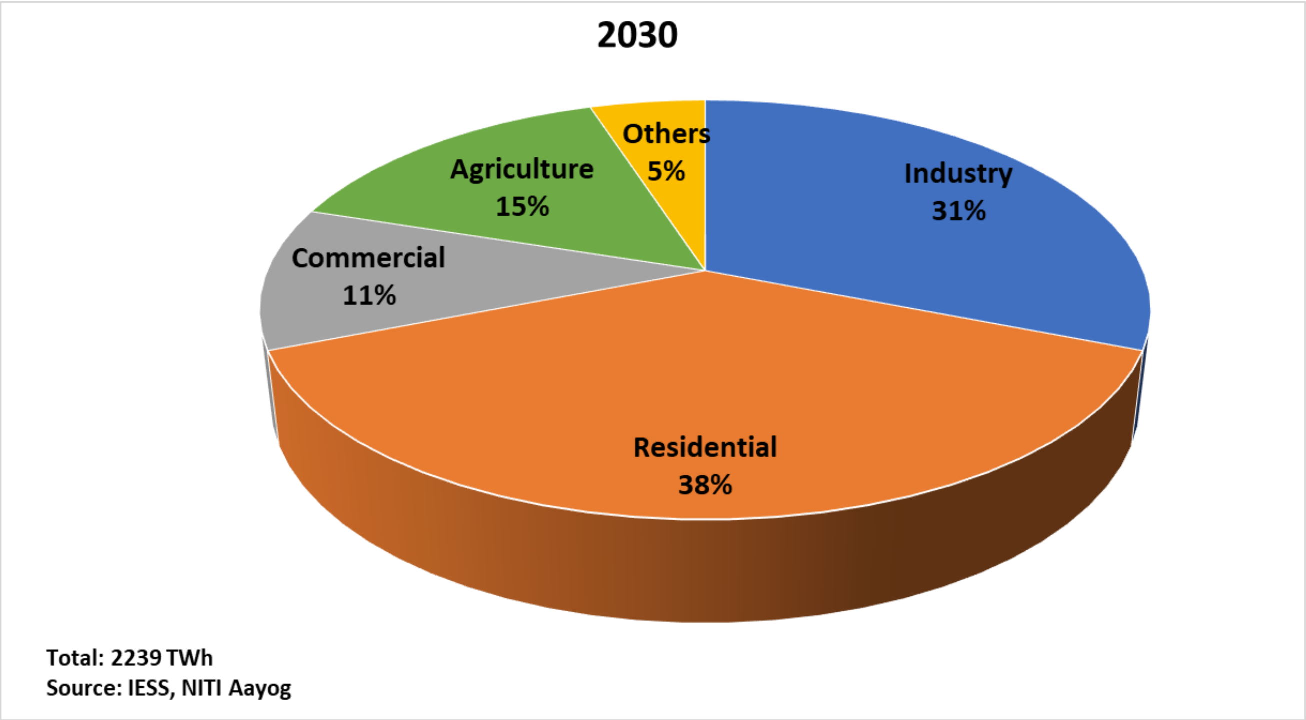

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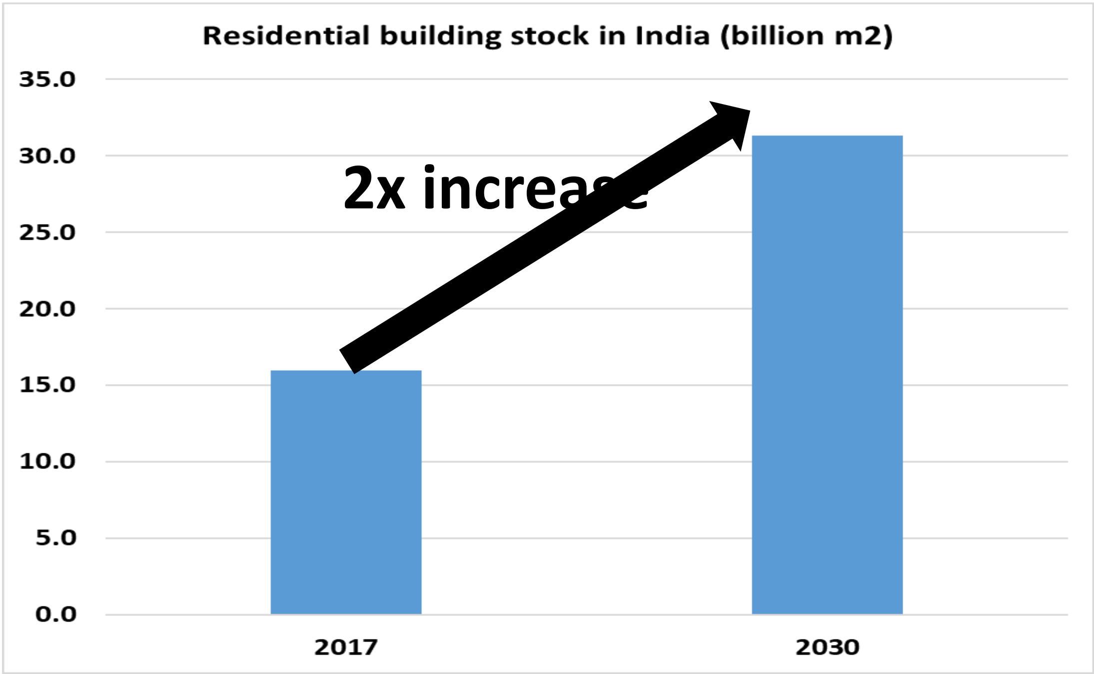
- Residential buildings will become the **largest end-user of electricity** in the country accounting for **38% of the total electricity consumption**.

Residential Buildings Construction

- The residential buildings expected to increase 2 times in terms of floor area by 2030.

- 12 million new affordable homes in urban areas under PMAY by 2022.
  - A significant percentage is in the form of high density, multi-storey residential blocks.
  - Very low penetration of air conditioning, though majority have ceiling fans.
  - Ensuring thermal comfort to occupants through design is of prime importance



12 Million New Affordable Houses in Urban Areas

Adaptive Comfort

India

Model for

Adaptive

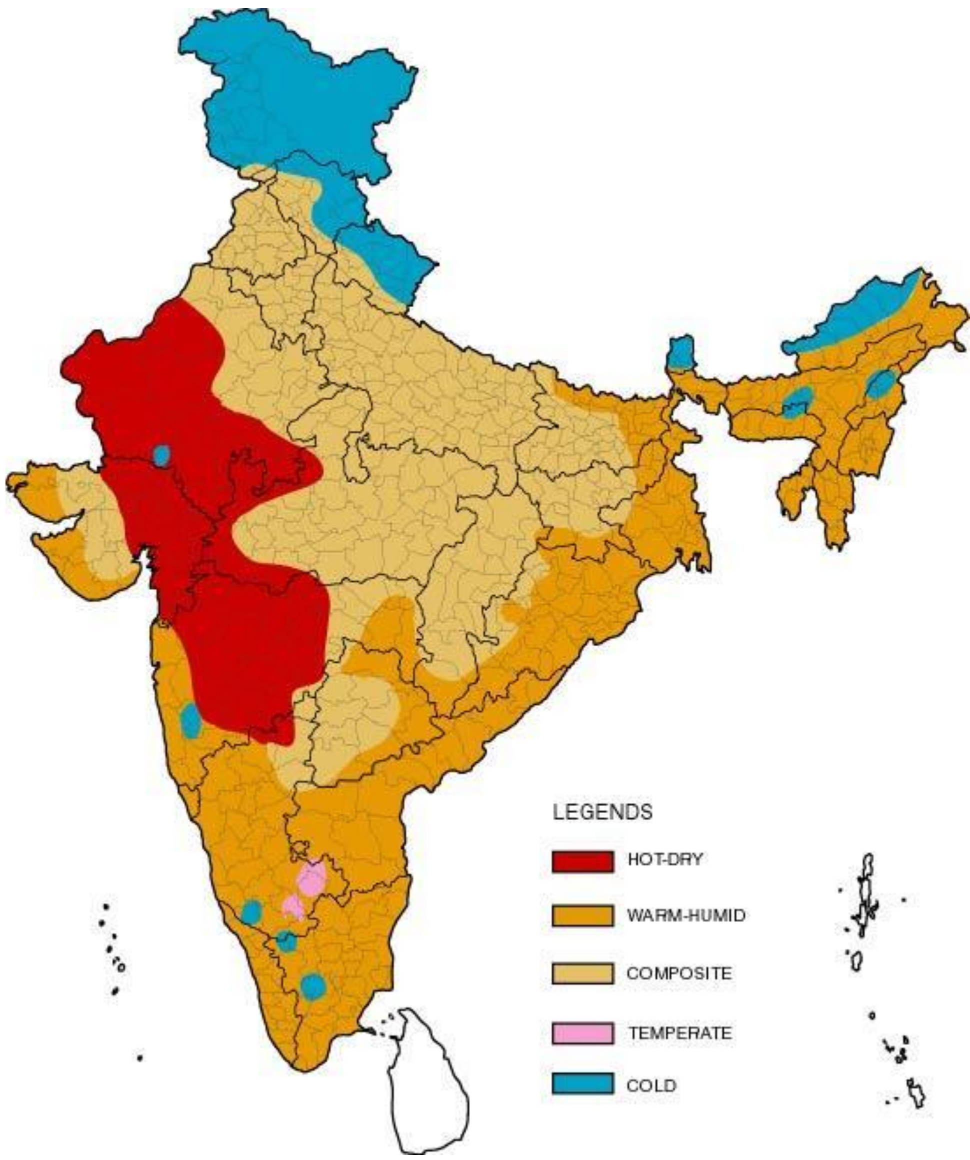
Comfort

Standard of adaptive thermal comfort based on Indian specific model guideline (currently for office / commercial buildings)

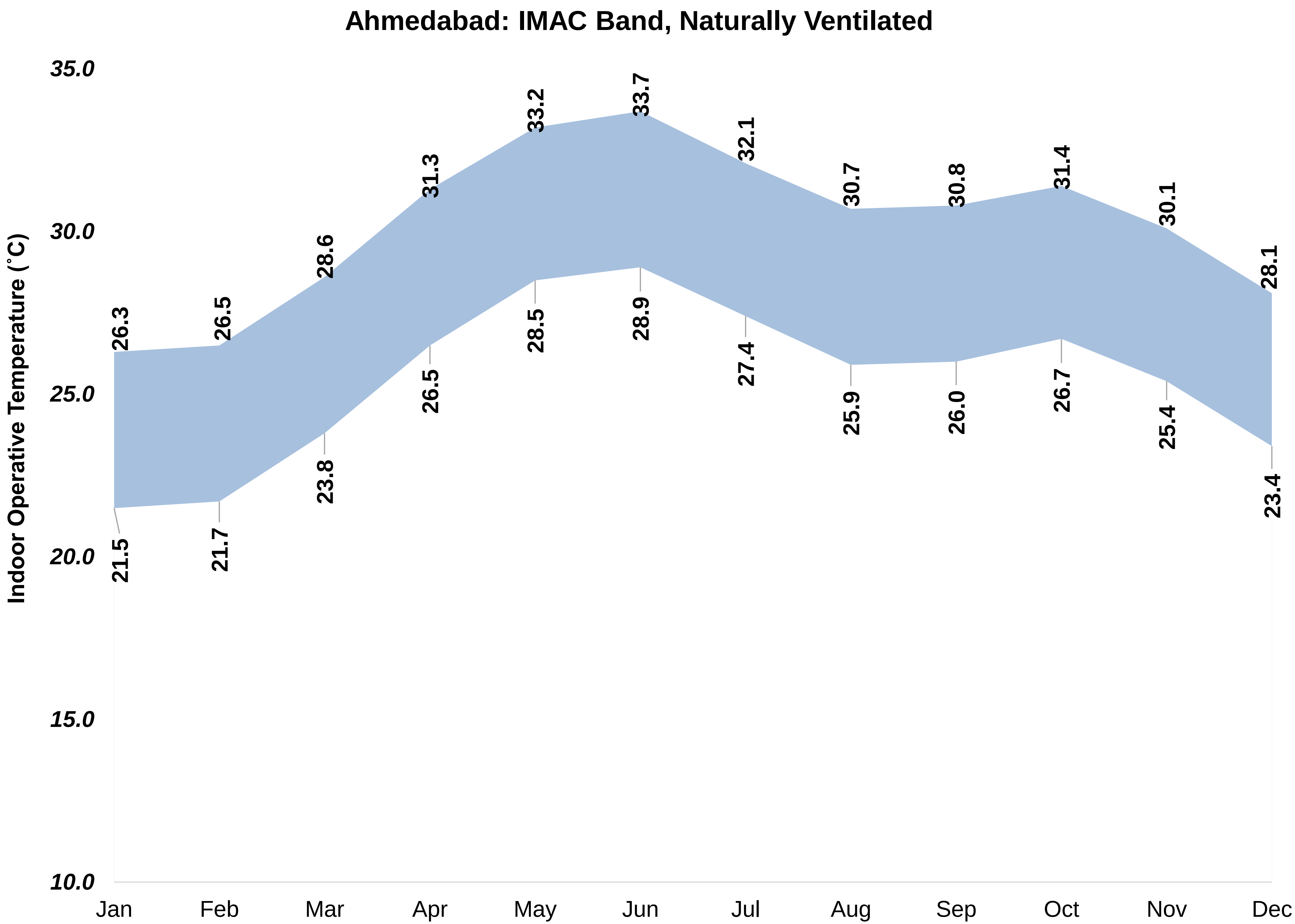
Applicable for air conditioned, naturally ventilated and mixed-mode buildings

Includes the wide temperature ranges in all Indian climate zones

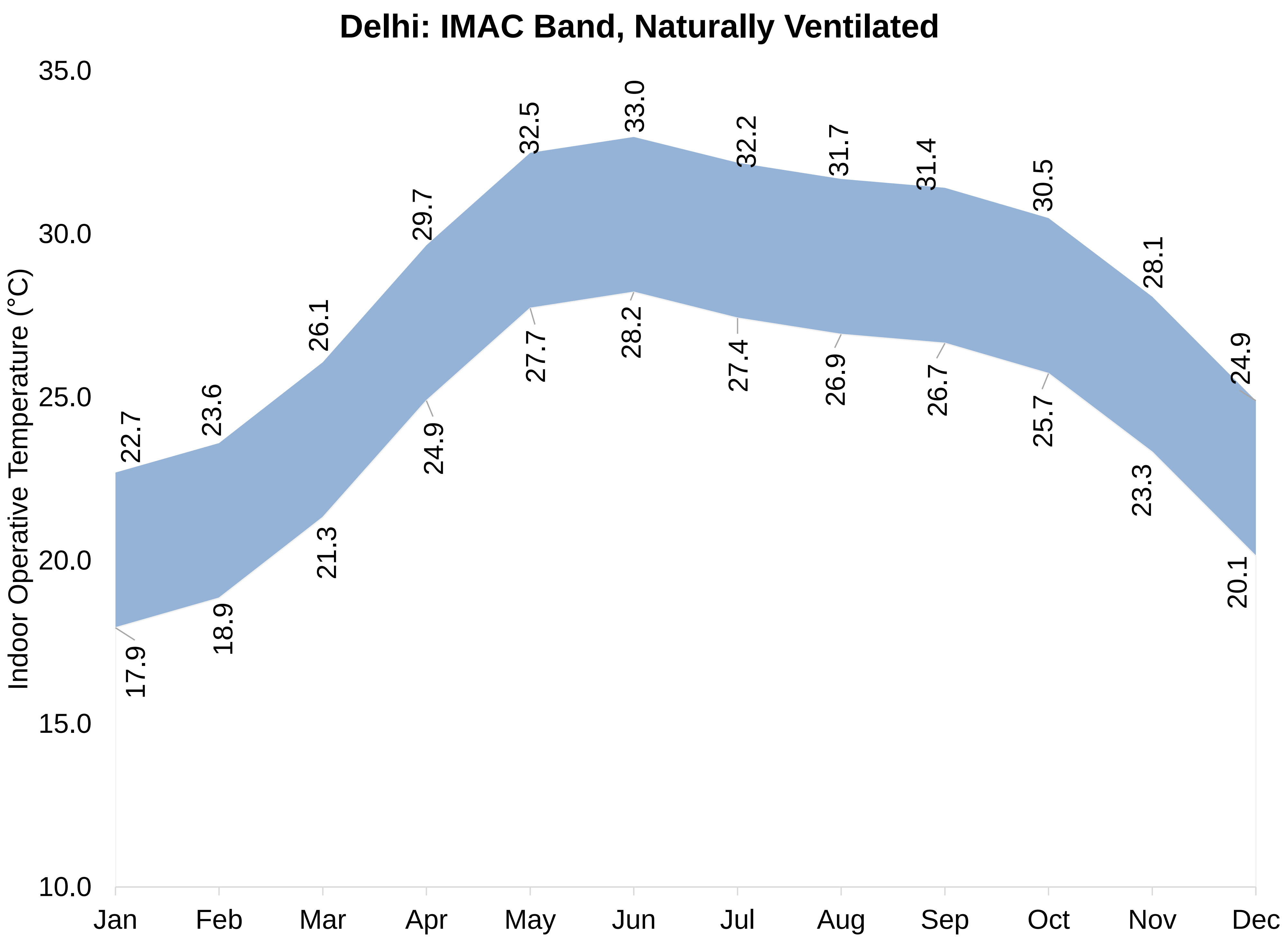
Shows 90% and 80% acceptability bands



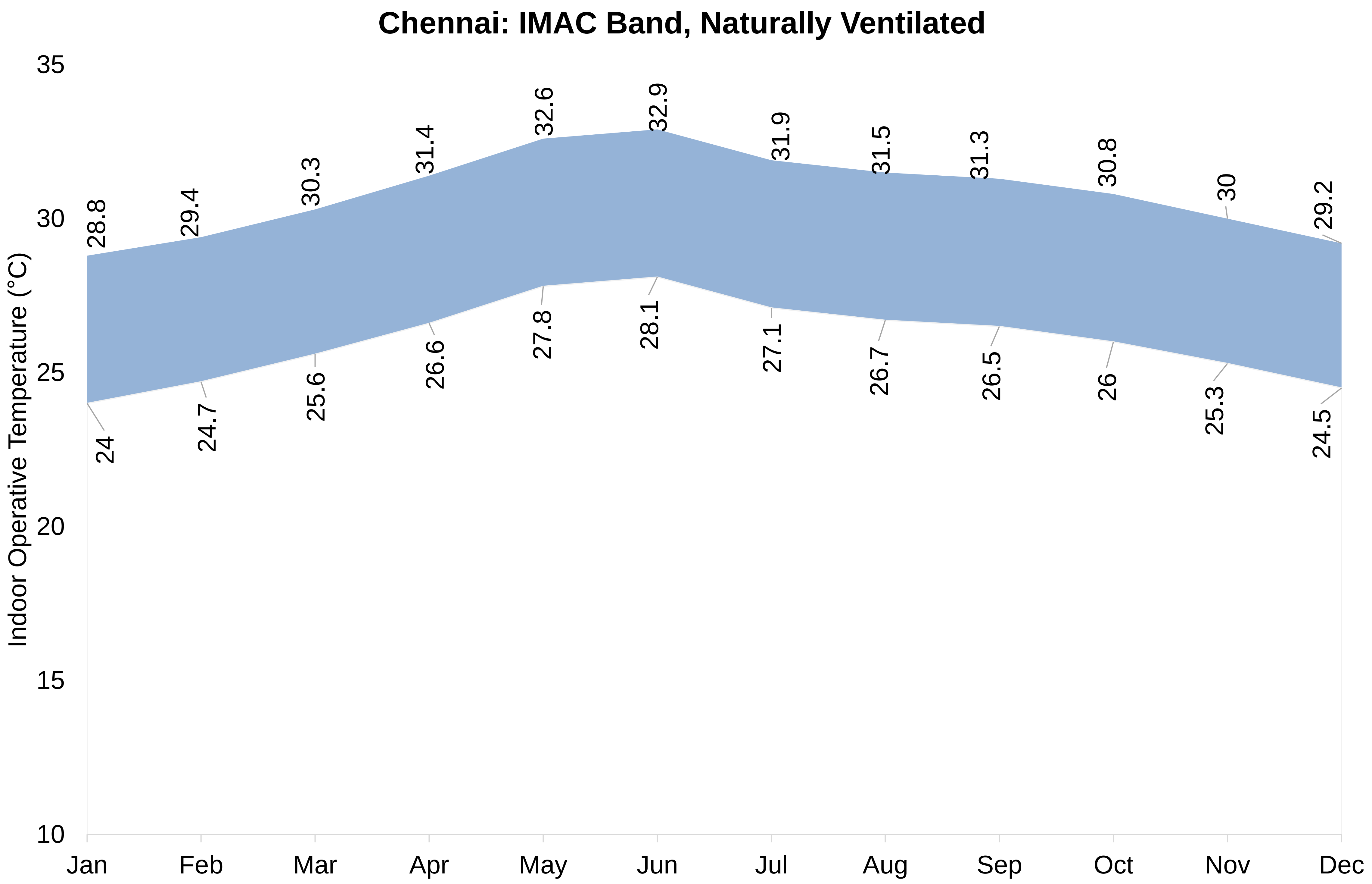
Hot & Dry Climate



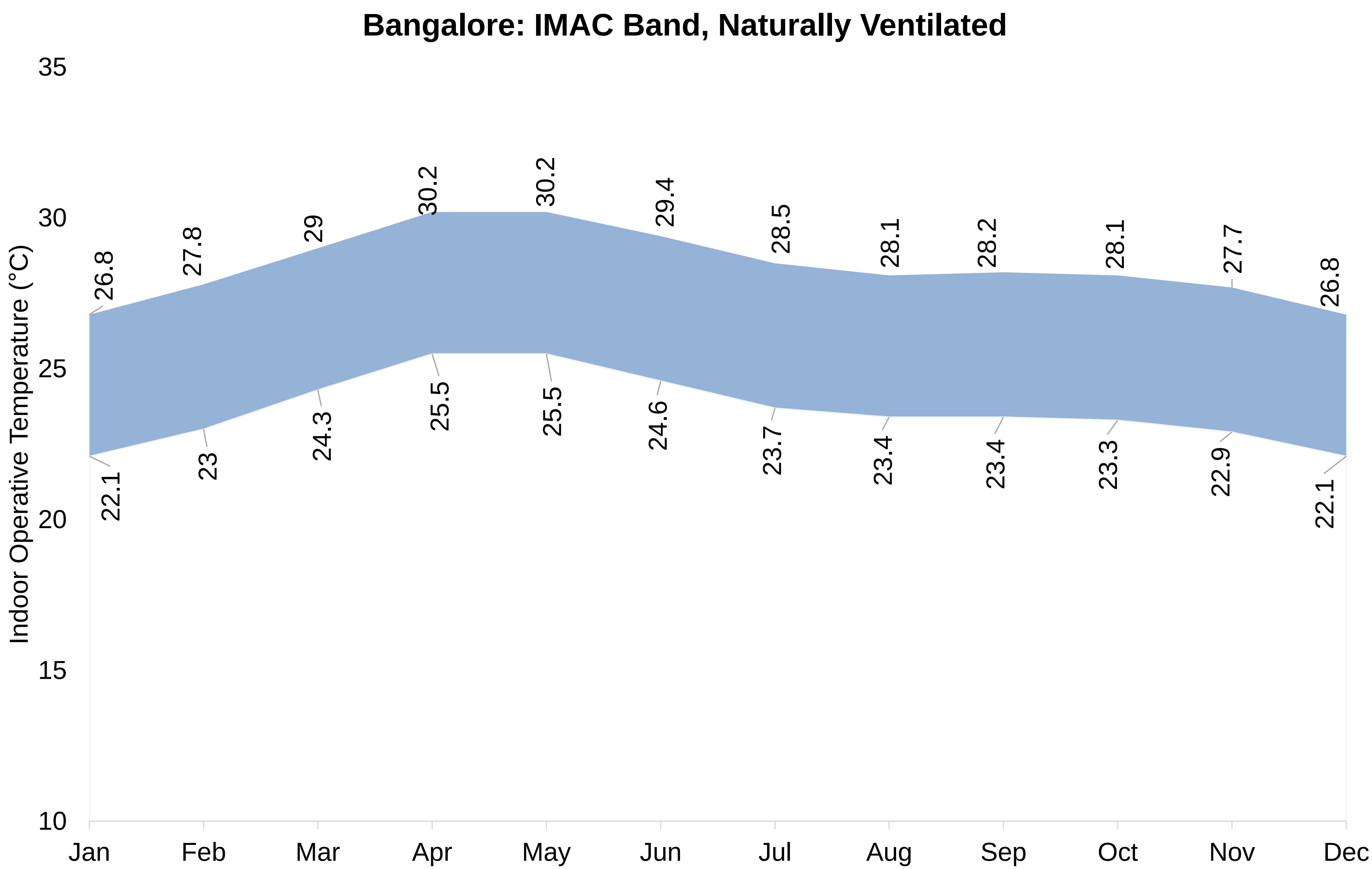
Composite Climate



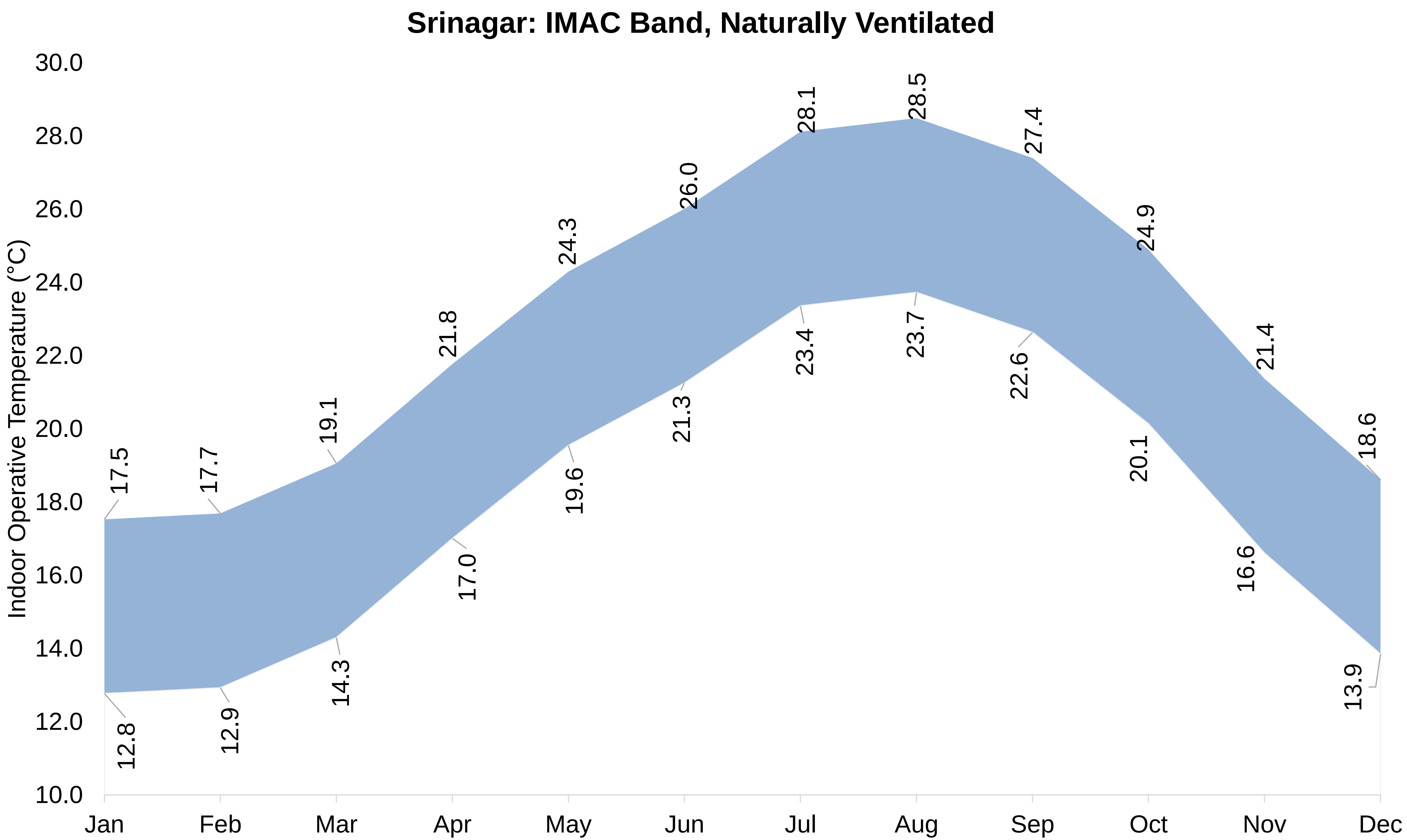
Warm and Humid Climate



Temperate Climate



Cold Climate



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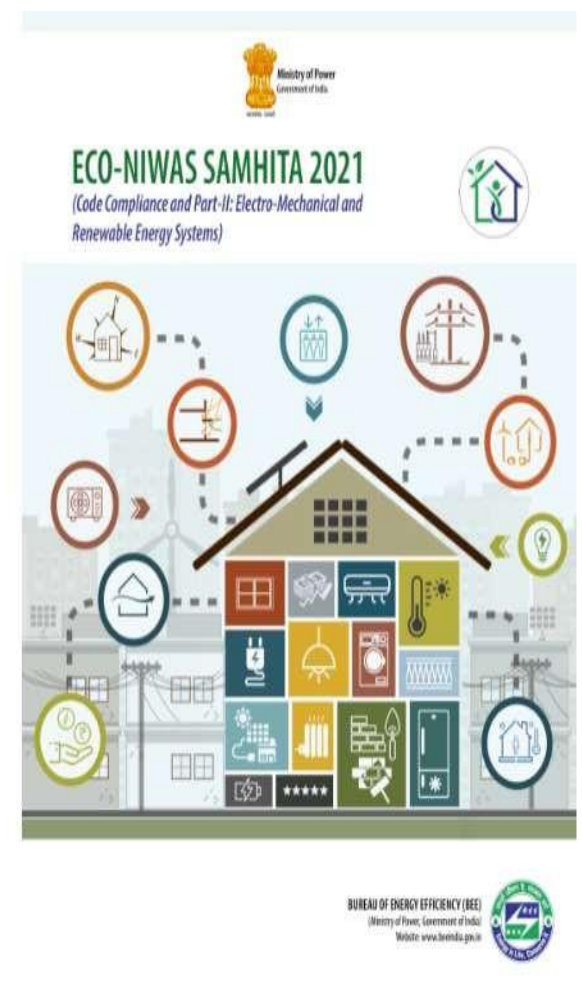
ECO NIWAS SAMHITA TOOL Via Video

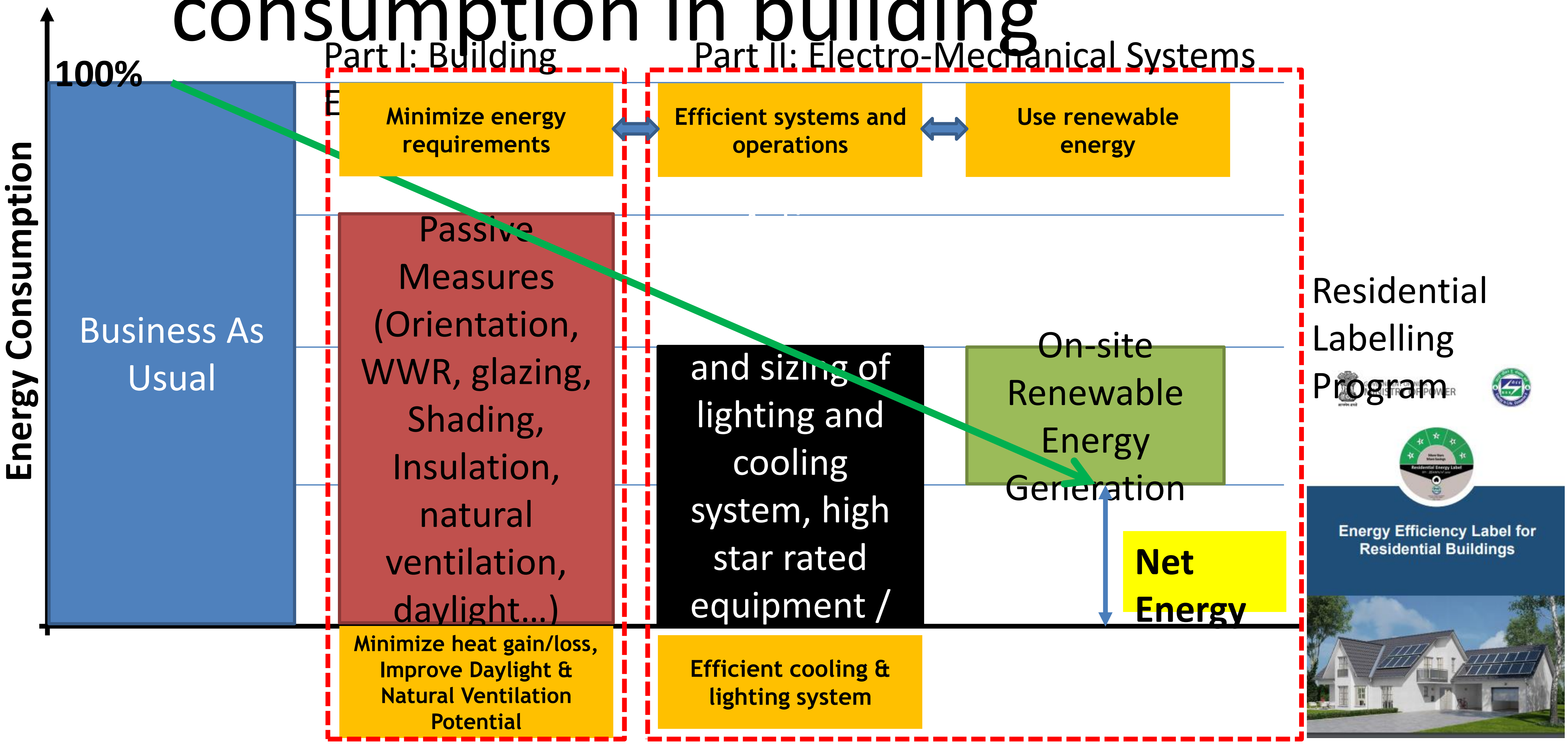
PART One & Two Parts of ENS: Envelope & Active Measures

EcoNiwas Samhita 2018
Part 1: Building Envelope

EcoNiwas Samhita 2021
Code Compliance and Part 2



Approach for reducing energy consumption in building



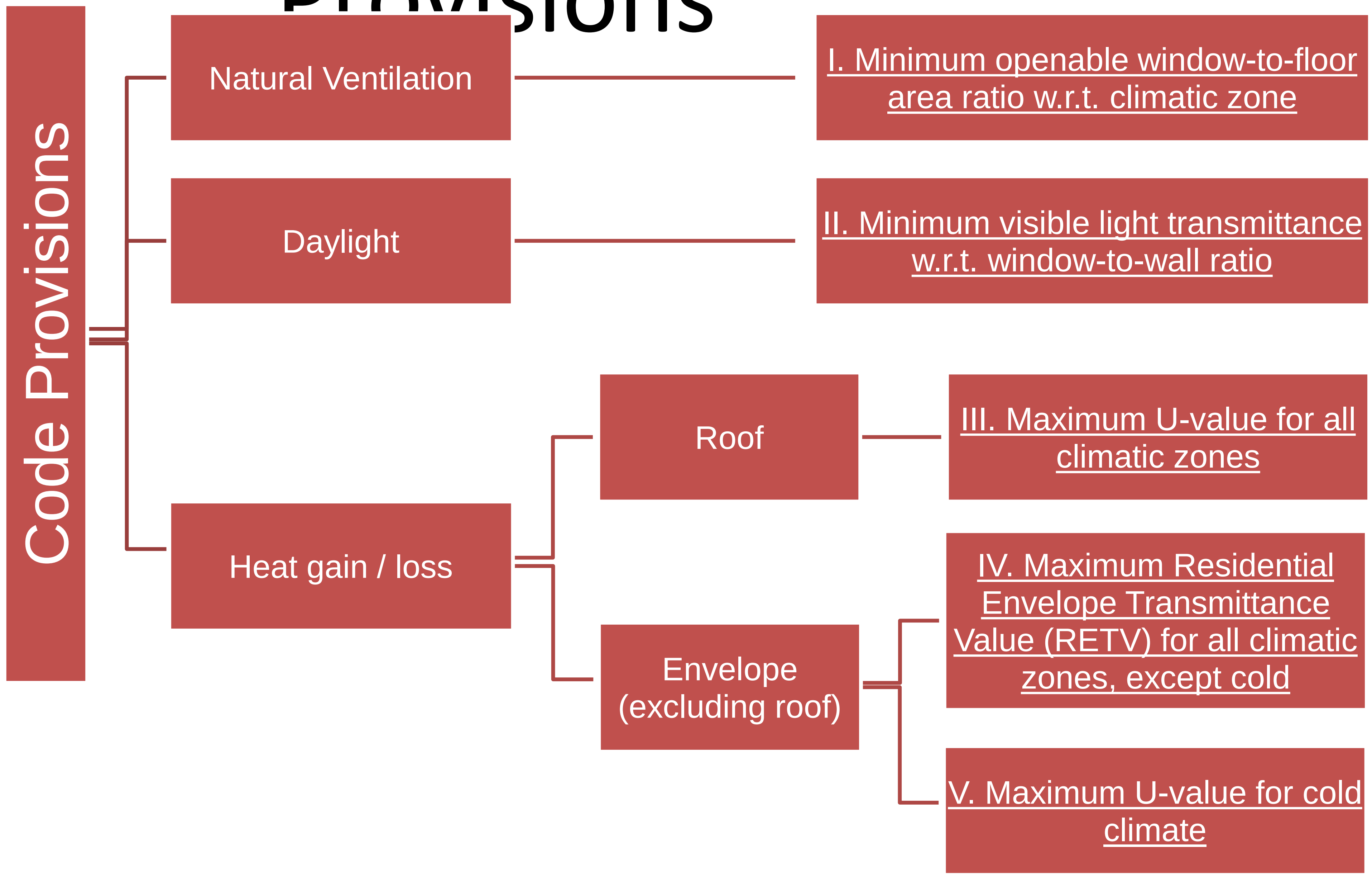
Energy Conservation Building Code-Residential: Objective

PROVISIONS FOR BUILDING ENVELOPE

- Reduces Heat Gains/Loss
- Improve Natural Ventilation & Daylighting Potential

Improved thermal comfort & reduced energy consumption

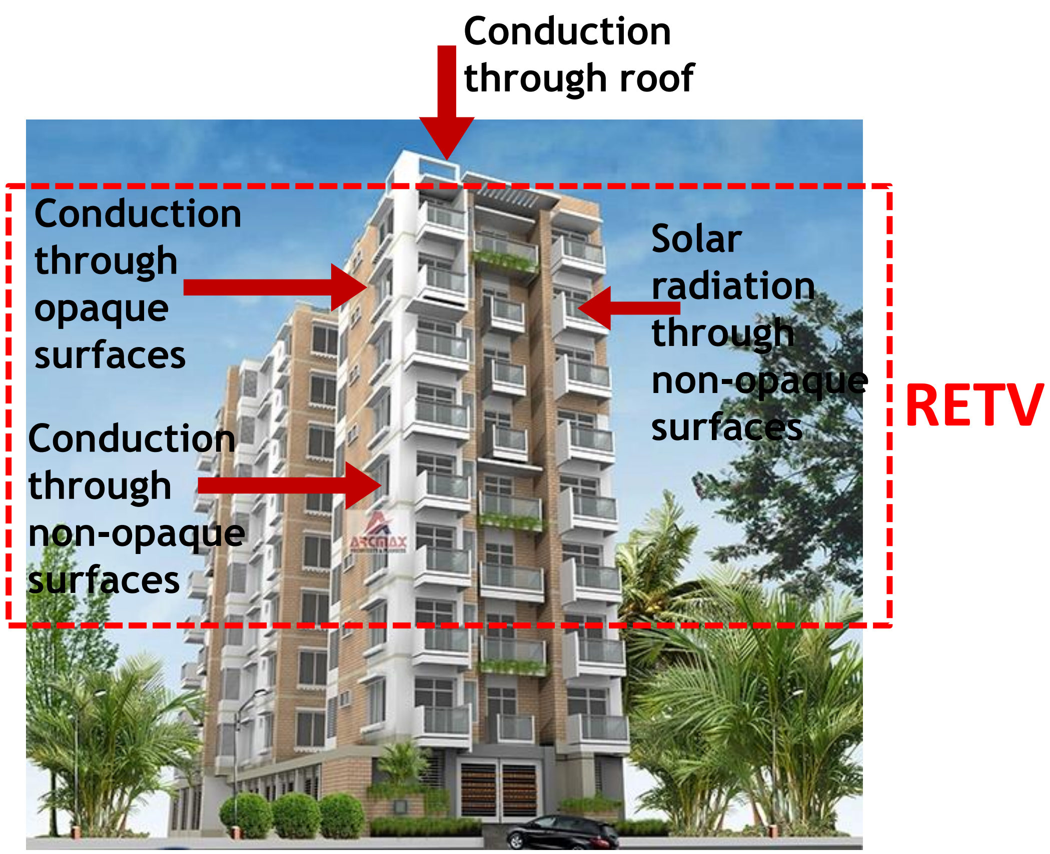
Eco-Niwas Samhita 2018: Code Provisions

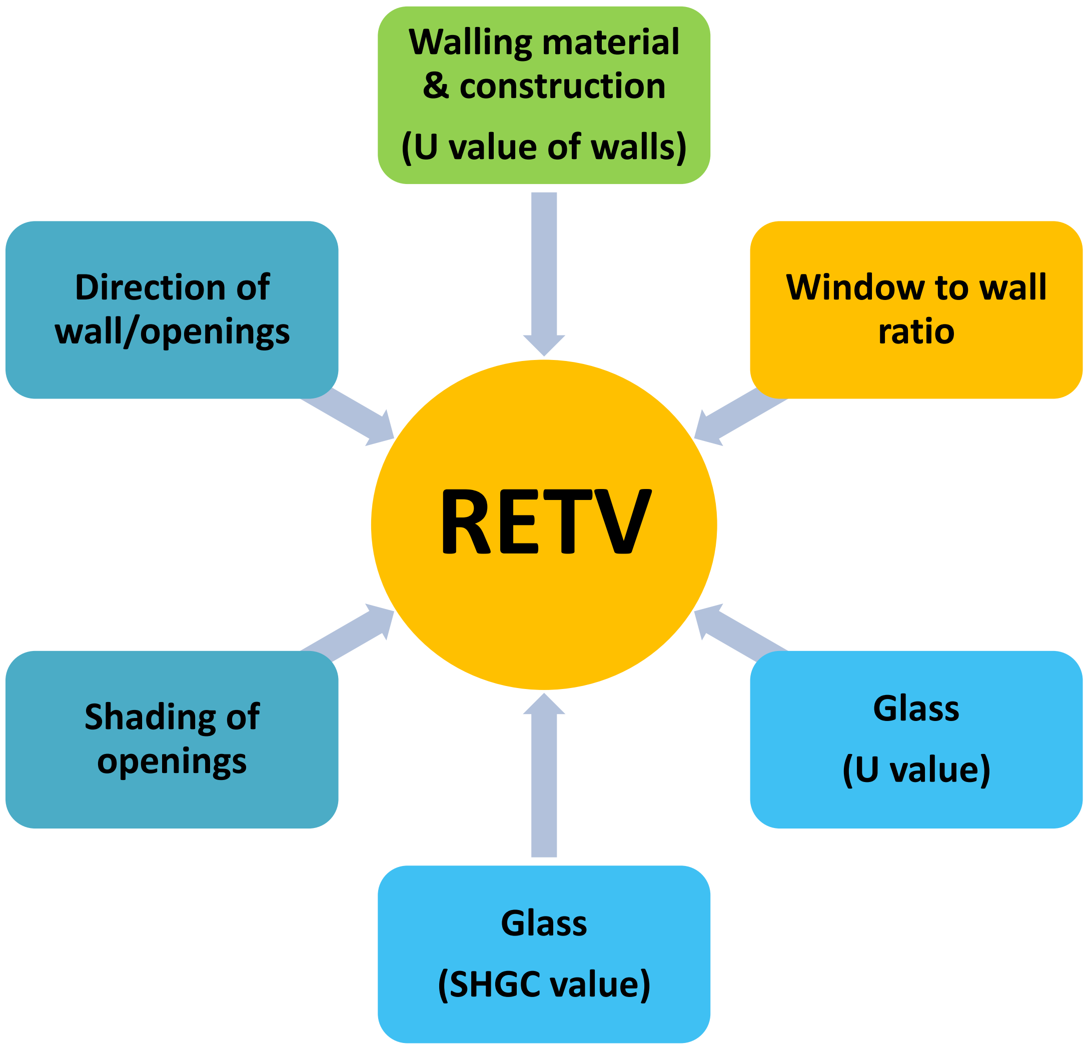


Resources

- Code document: https://www.beepindia.org/wp-content/uploads/2013/12/ECBC_BOOK_Web.pdf
- https://beeindia.gov.in/content/ecbc-residential
- Brochure: https://www.beepindia.org/wp-content/uploads/2013/12/Brochure.pdf
- Compliance check tool: https://www.beepindia.org/wp-content/uploads/2013/12/EcoNiwasSamhita_ComplianceCheckTool.zip
- Film: English short version (https://www.youtube.com/watch?v=zg515mlU0dc)
- Film: English long version (https://www.youtube.com/watch?v=EG44gdSuWNE)
- Film: Hindi short version (https://www.youtube.com/watch?v=nyweHmqAPxw)
- Film: Hindi long version (https://www.youtube.com/watch?v=LEAb-iviwRc)
- ECBC-R Compliance tool video tutorial: https://www.youtube.com/watch?v=2SQyKekxpiM
- Support email: pmtu@beepindia.org, saswati@gkspl.in, anandh@gkspl.in

Combined heat gains from the building envelope (except roof)





RETV: Residential Envelope Transmittance Value

IV. Residential envelope transmittance value (RETV) for building envelope (except roof) for four climate zones, except cold

- Provision: **RETV ≤ 15 W/m²**. (Composite Climate, Hot-Dry Climate, Warm-Humid Climate, and Temperate Climate)
- RETV is the net heat gain rate (over the cooling period) through the building envelope (excluding roof) of the dwelling units divided by the area of the building envelope (excluding roof) of the dwelling units.

$$RETV = \frac{1}{A_{envelope}} \times \left[\begin{array}{l} \left\{ a \times \sum_{i=1}^{n} \left(A_{opaque_i} \times U_{opaque_i} \times \omega_i \right) \right\} \\ + \left\{ b \times \sum_{i=1}^{n} \left(A_{non-opaque_i} \times U_{non-opaque_i} \times \omega_i \right) \right\} \\ + \left\{ c \times \sum_{i=1}^{n} \left(A_{non-opaque_i} \times SHGC_{eq_i} \times \omega_i \right) \right\} \end{array} \right]$$

Dependent on wall properties

Dependent on window properties

Dependent on window properties & shading

a, b, c: coefficients, based on climatic zone

$A_{envelope}$: envelope area (excluding roof) of dwelling units (m²)

A_{opaque_i}: areas of wall / opaque part (m²)

$A_{non-opaque_i}$: areas of glass / non-opaque part (m²)

U_{opaque_i}: thermal transmittance values of wall / opaque part (W/m².K)

$U_{non-opaque_i}$: thermal transmittance values of glass / non-opaque part (W/m².K)

$SHGC_{eq_i}$: equivalent solar heat

Coefficients of RETV Formula

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)		

Non-opaque Area & Envelope Area (Excluding Roof)

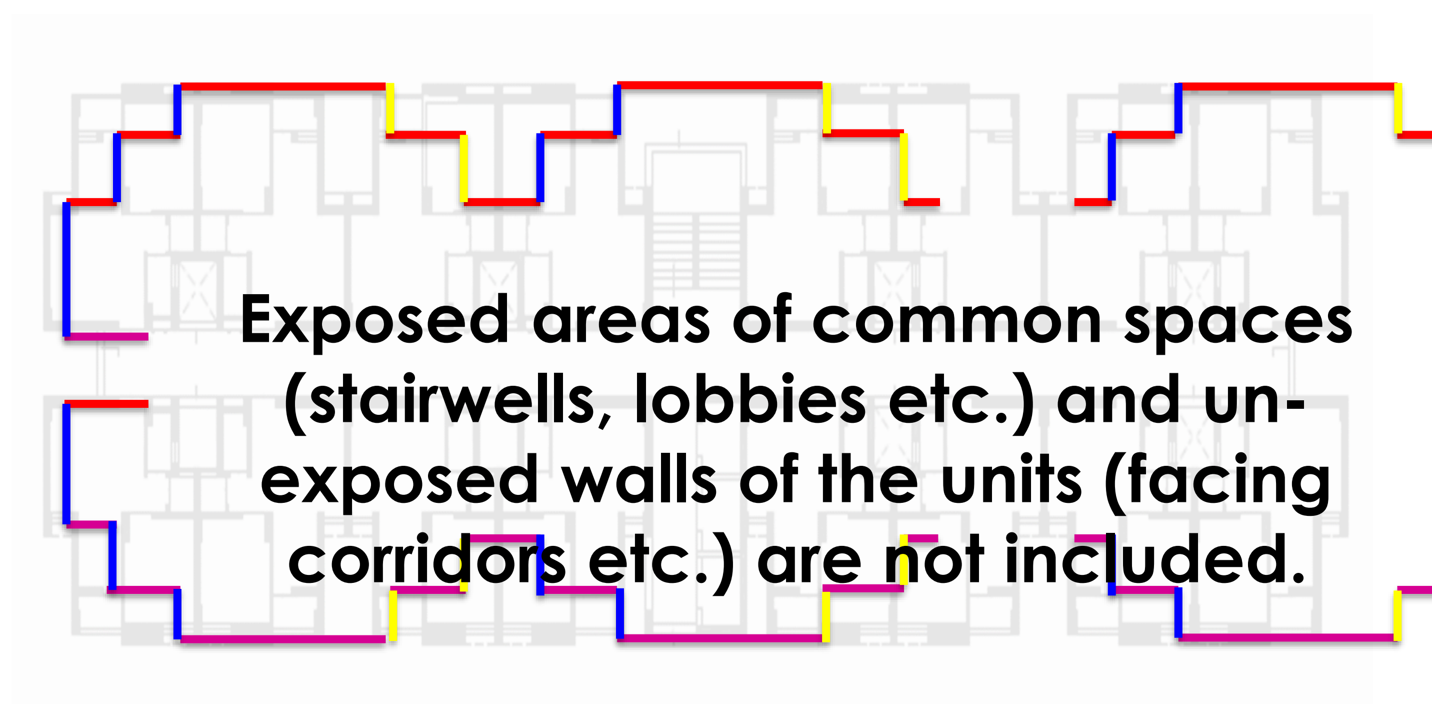
Non-opaque Area

*Frame area is not taken in calculation

Non-opaque area:
100% opening area

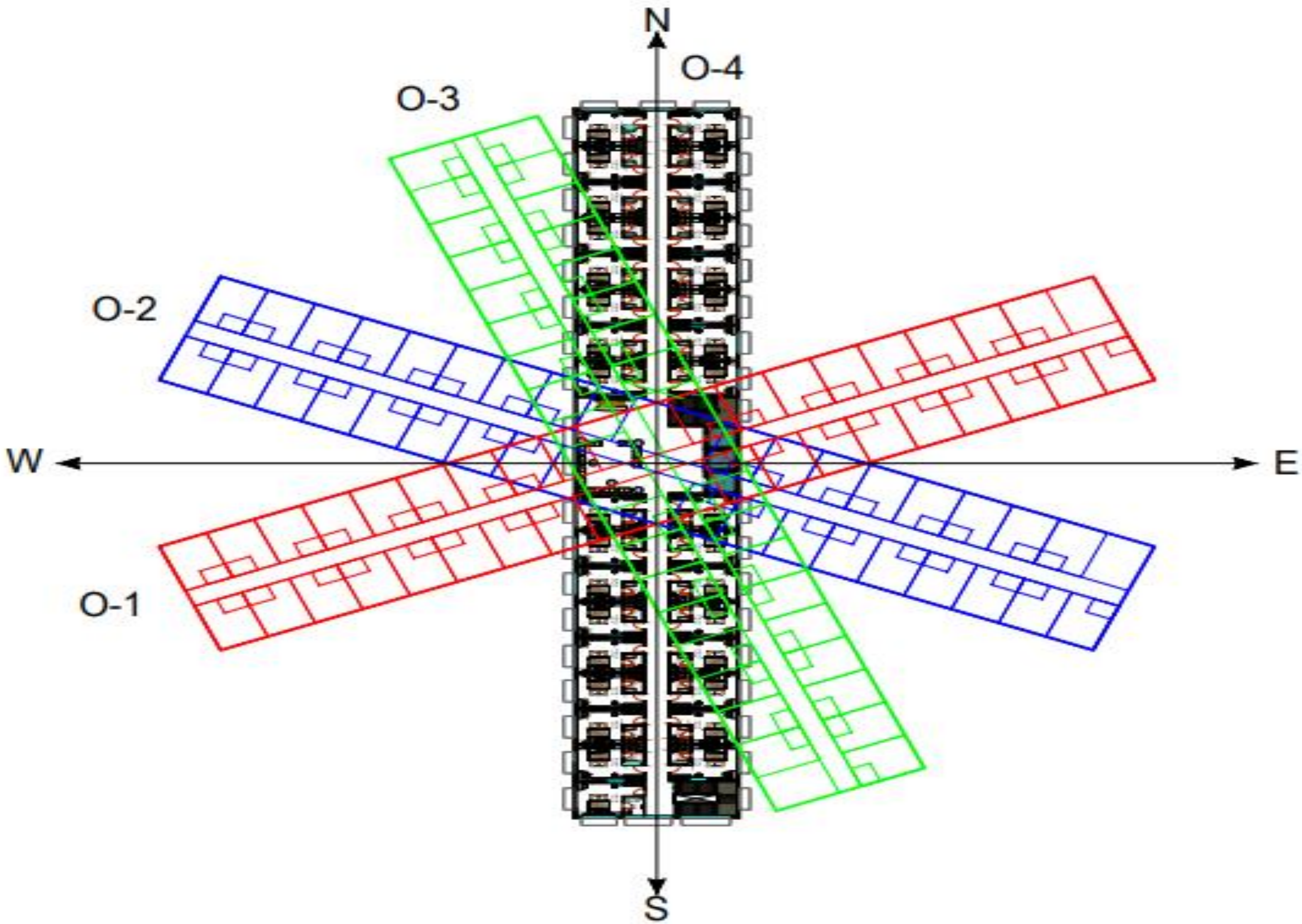
Non-opaque area:
33.3% opening area

Envelope Area (Excluding Ro

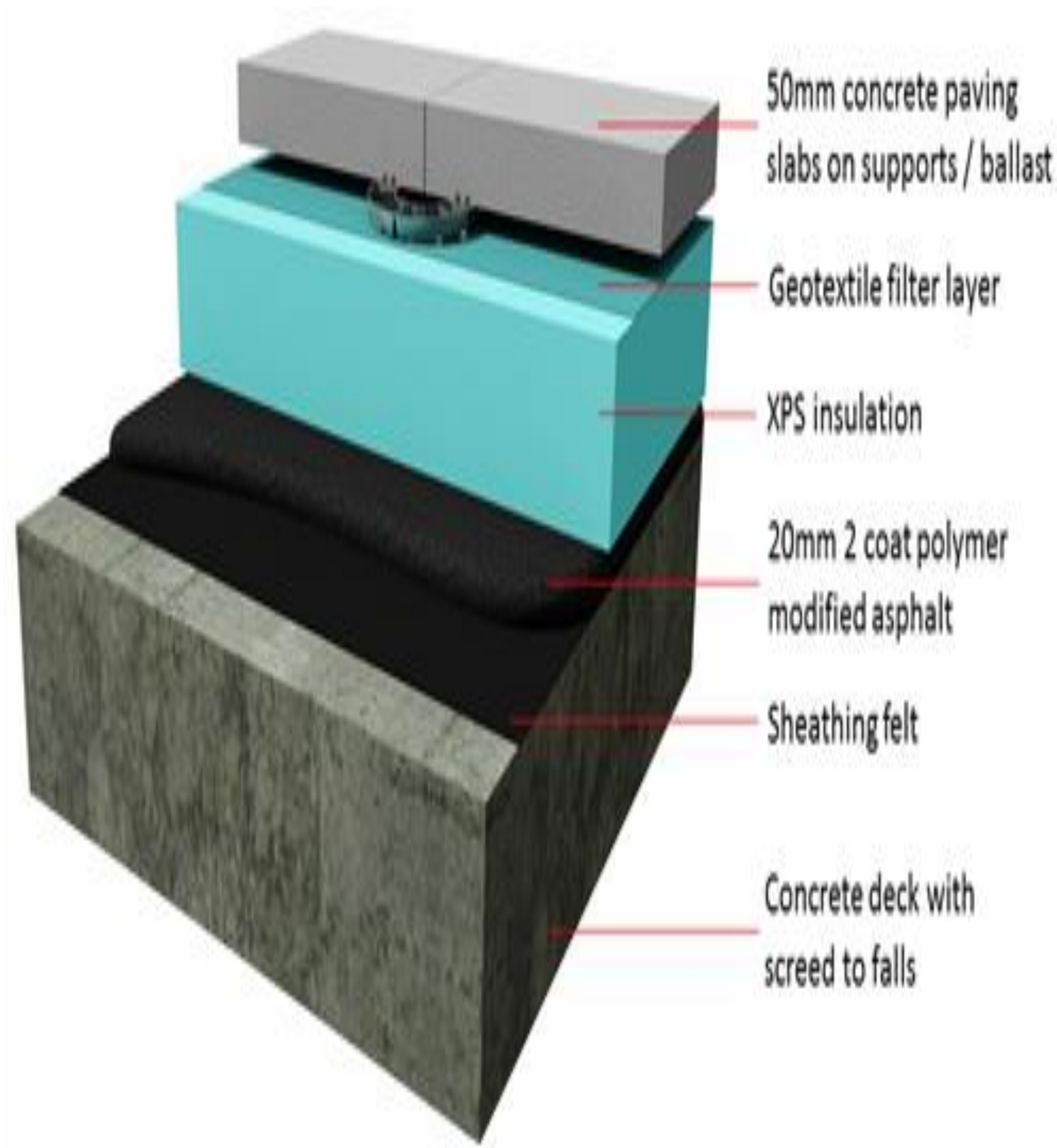


Envelope area =
Total wall length (m), exposed to ambient x
Total wall height (m), exposed to ambient

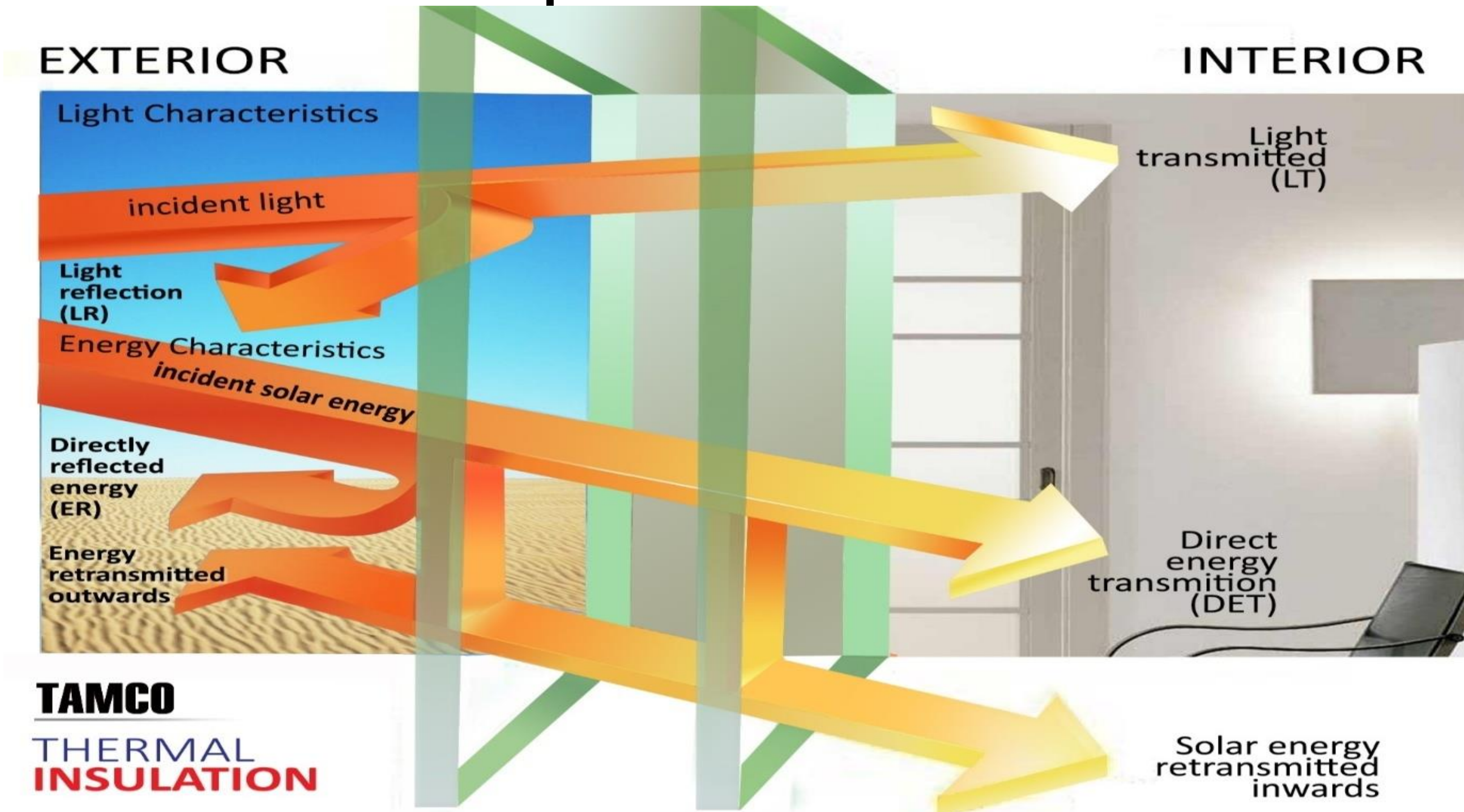




N
O-4
O-3
O-2
W
E
O-1
S

The schematic diagram and



The figure shown below depicts the schematic



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

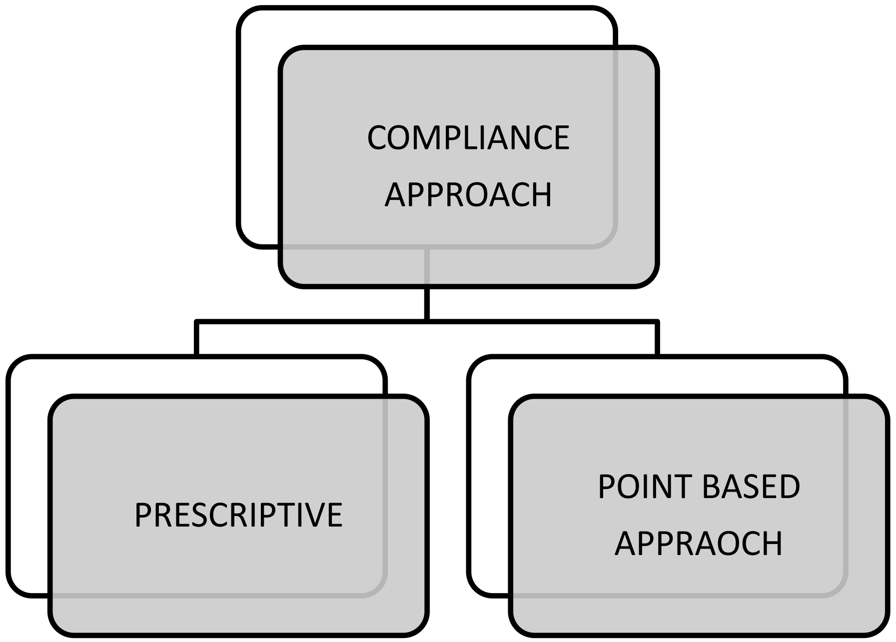
Table 9: Score for Renewable Energy System Components

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 .



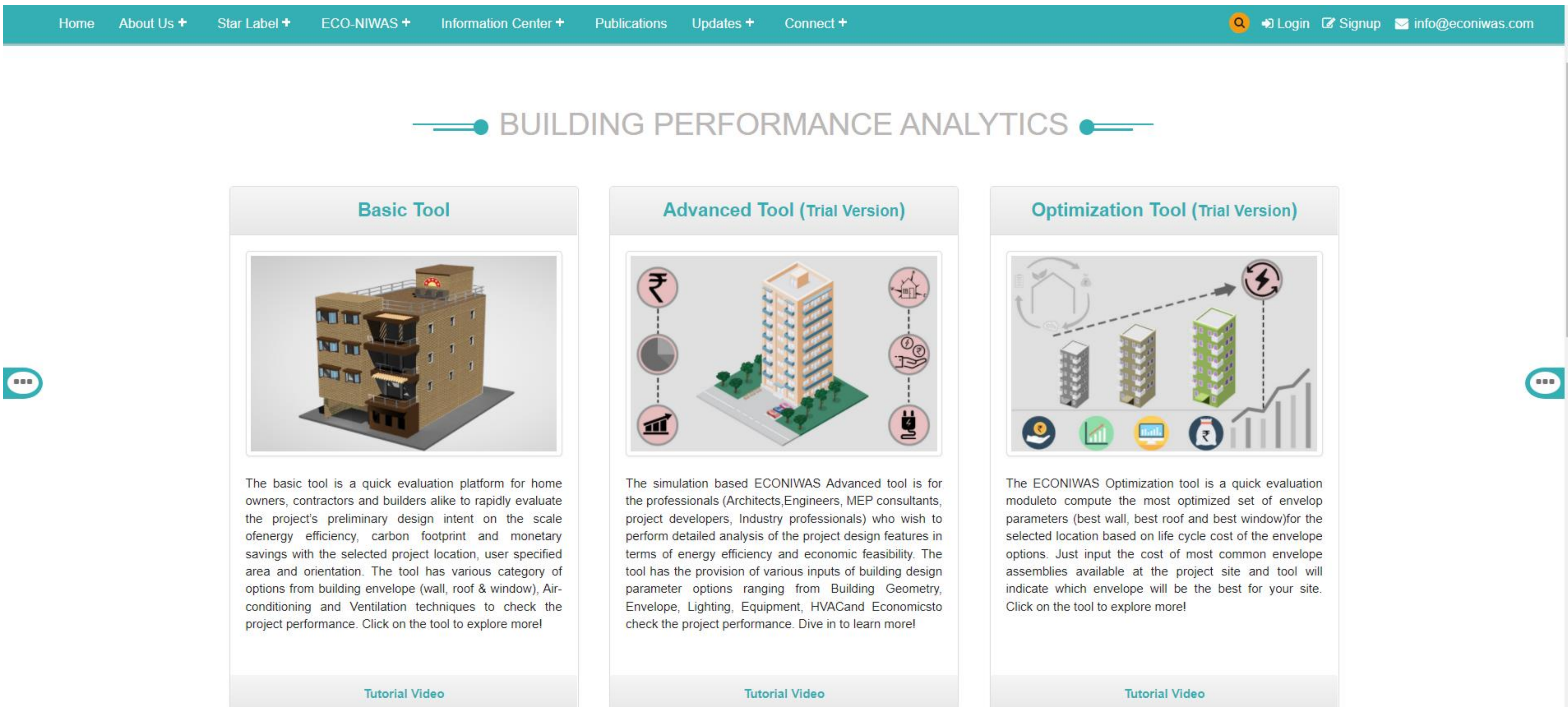
Compliance Approaches

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



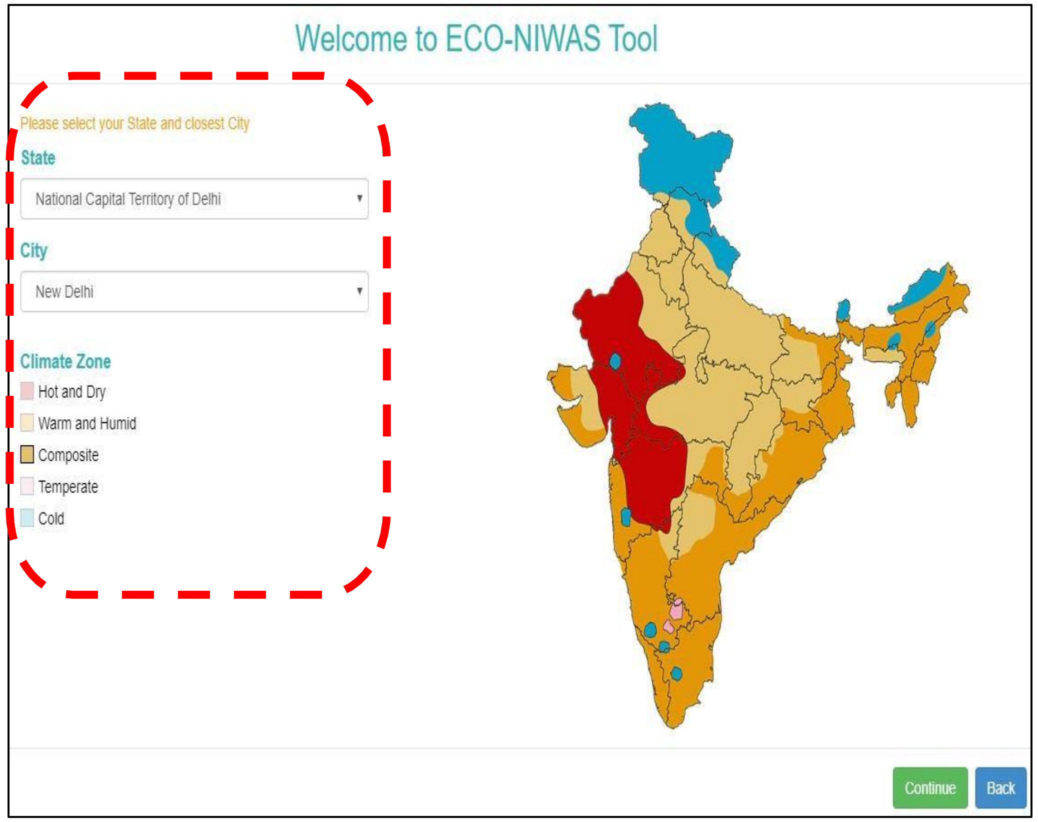
ECONIWAS 2.0 - MODULES

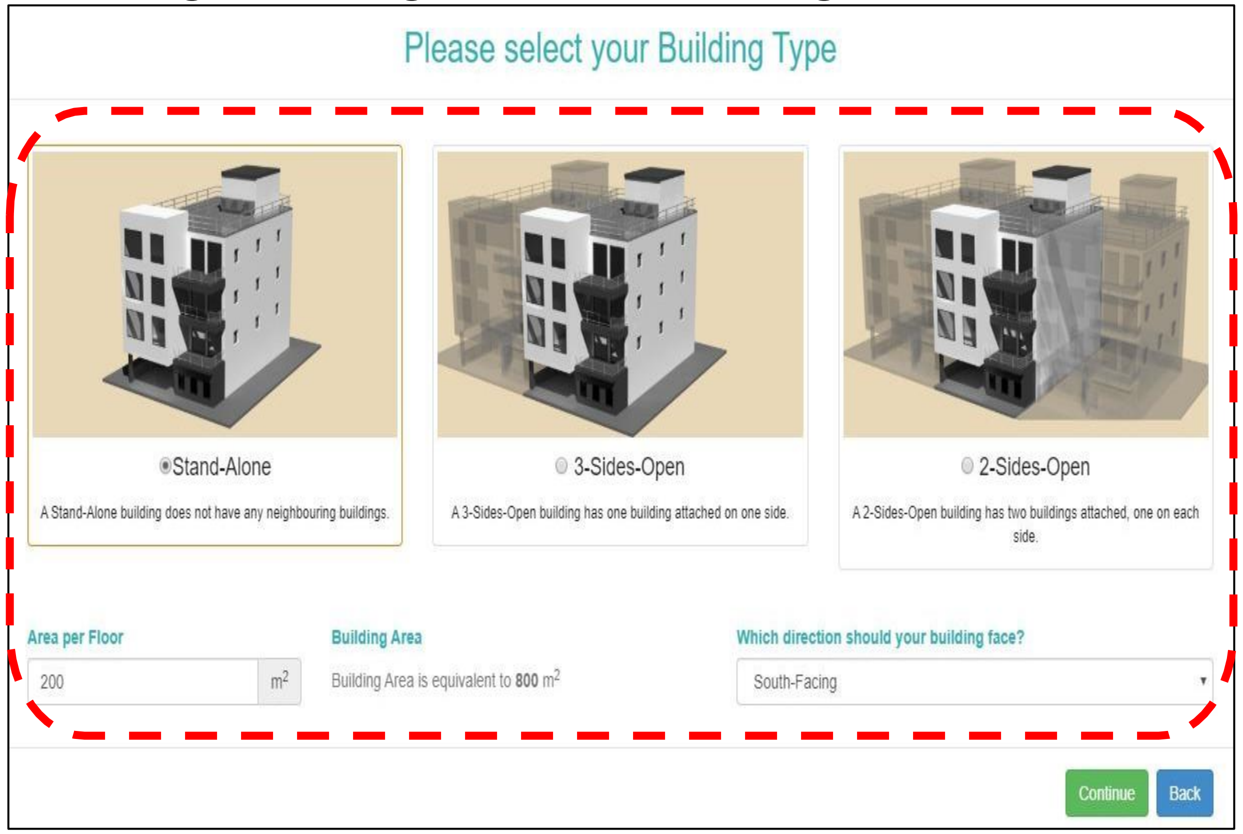
Basic Tool:

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.

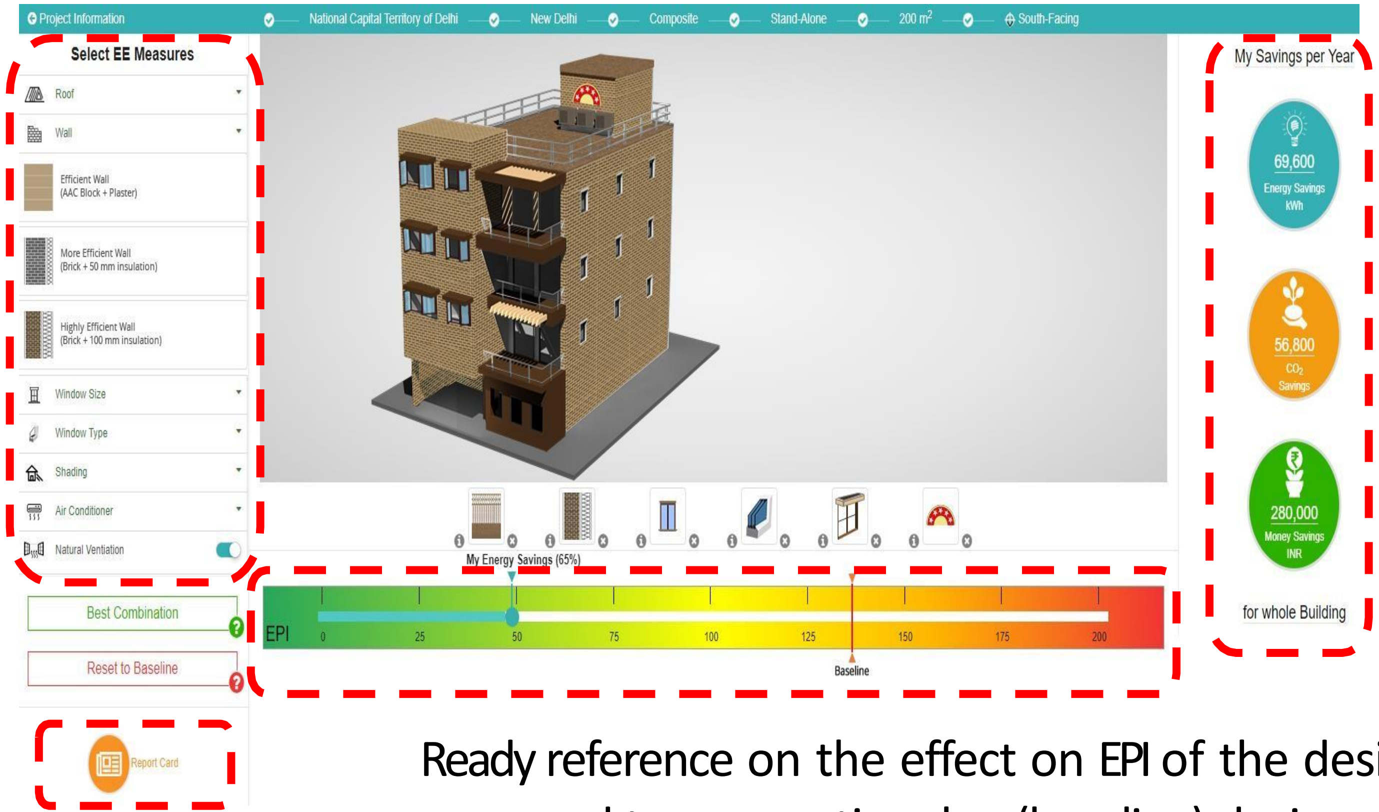
ECONIWAS 2.0 – BASIC TOOLS

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



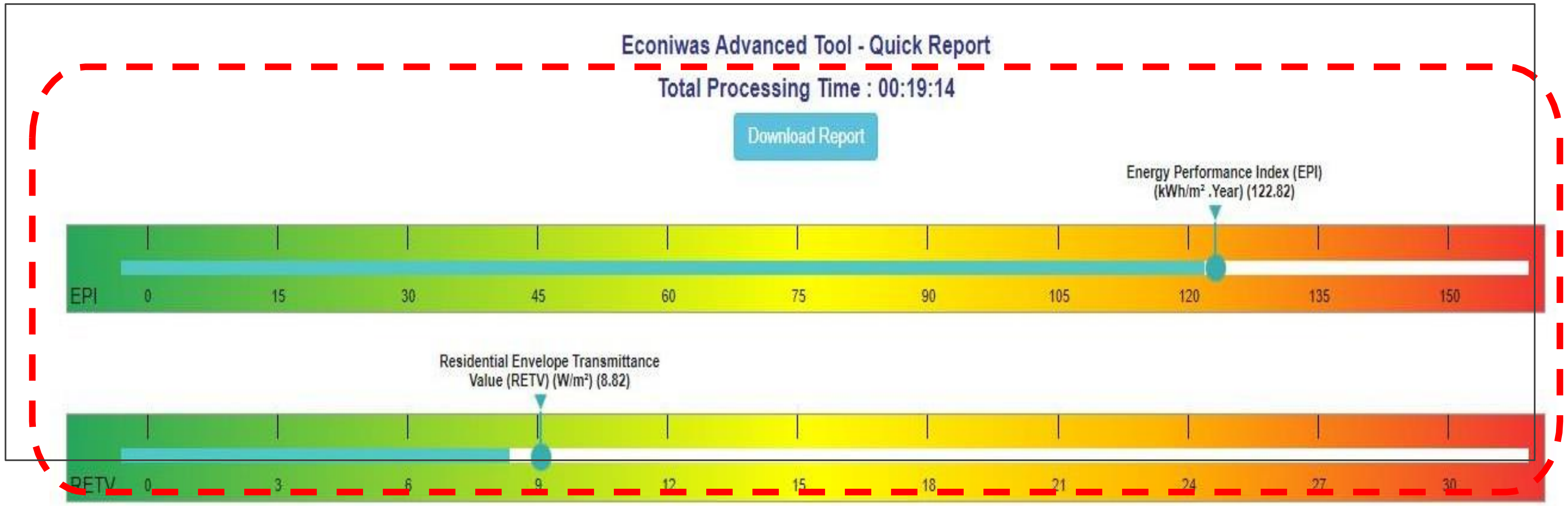
Quick inference on the impact of selected design features on the energy, environment and monetary level.

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 – ADVANCED 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.

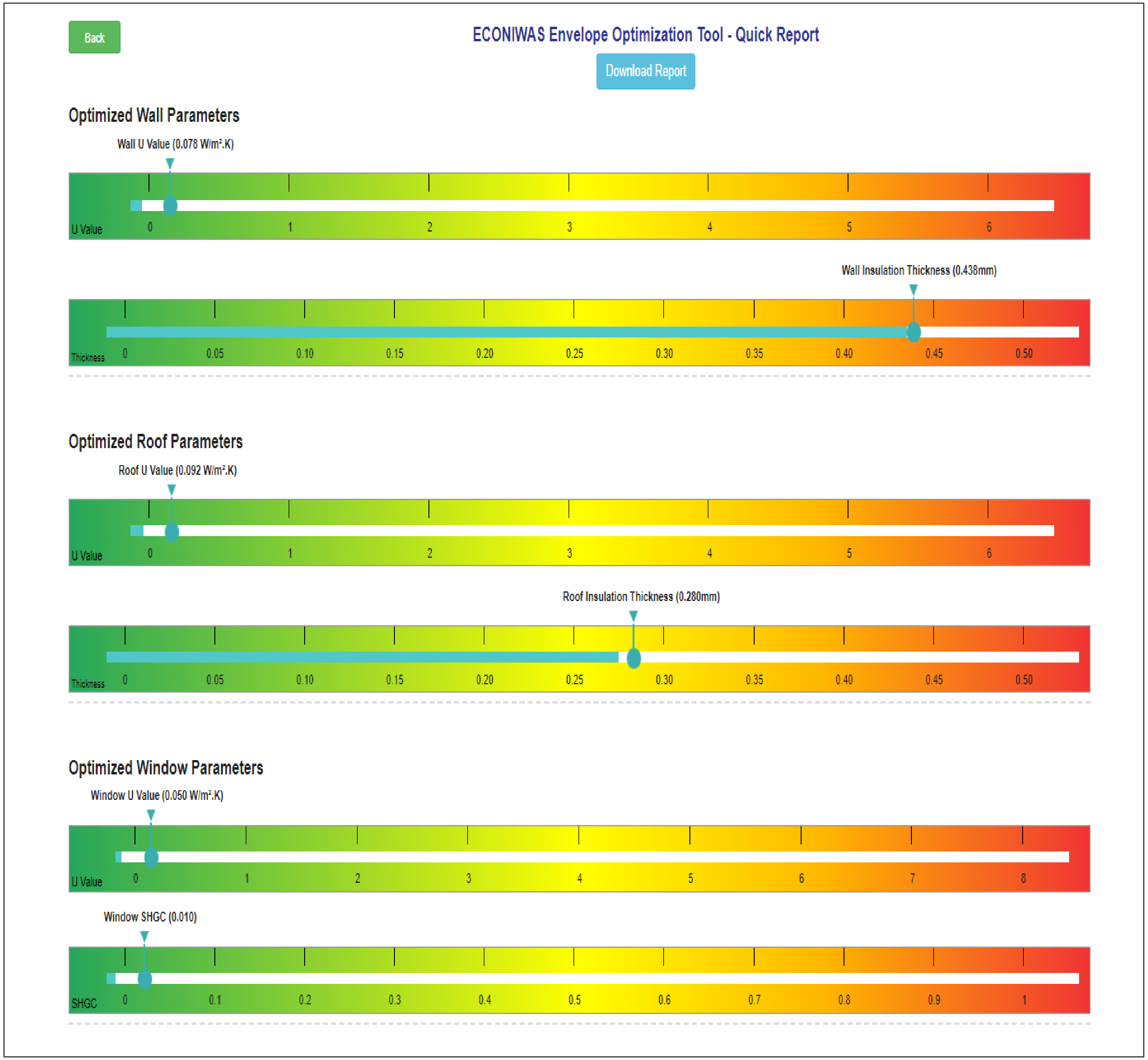


The user has the option to export the results in PDF format for later use, using the "Download Report" button on the results page.

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

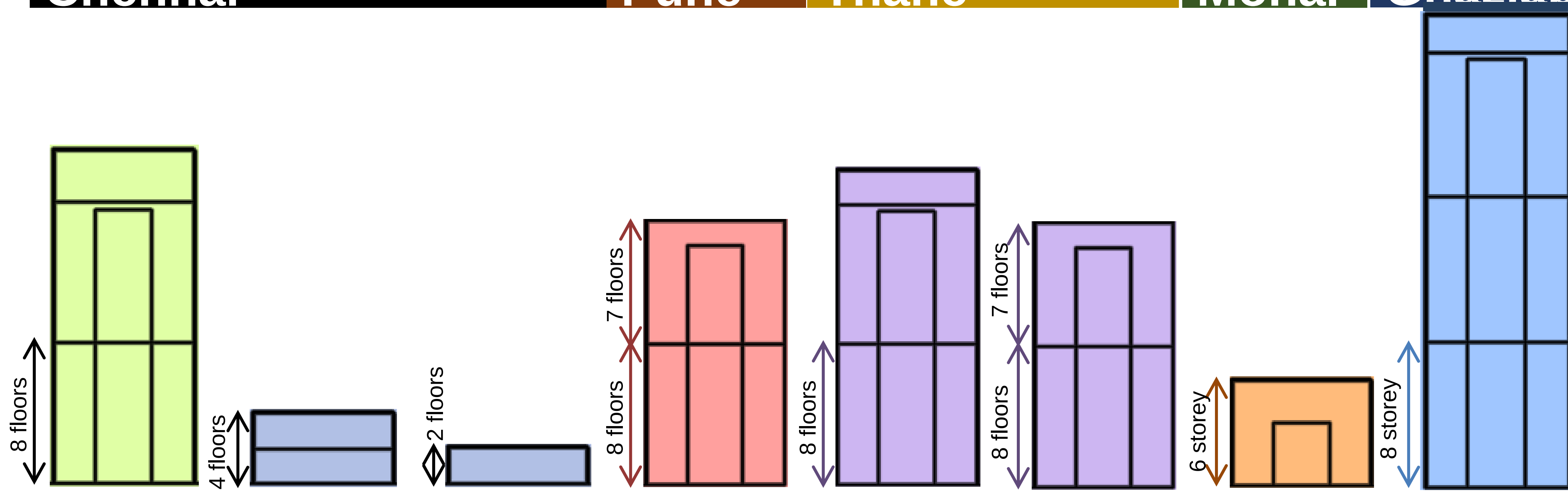
ECONIWAS 2.0 – ENVELOPE OPTIMIZATION TOOL – RESULTS

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.



Project Details

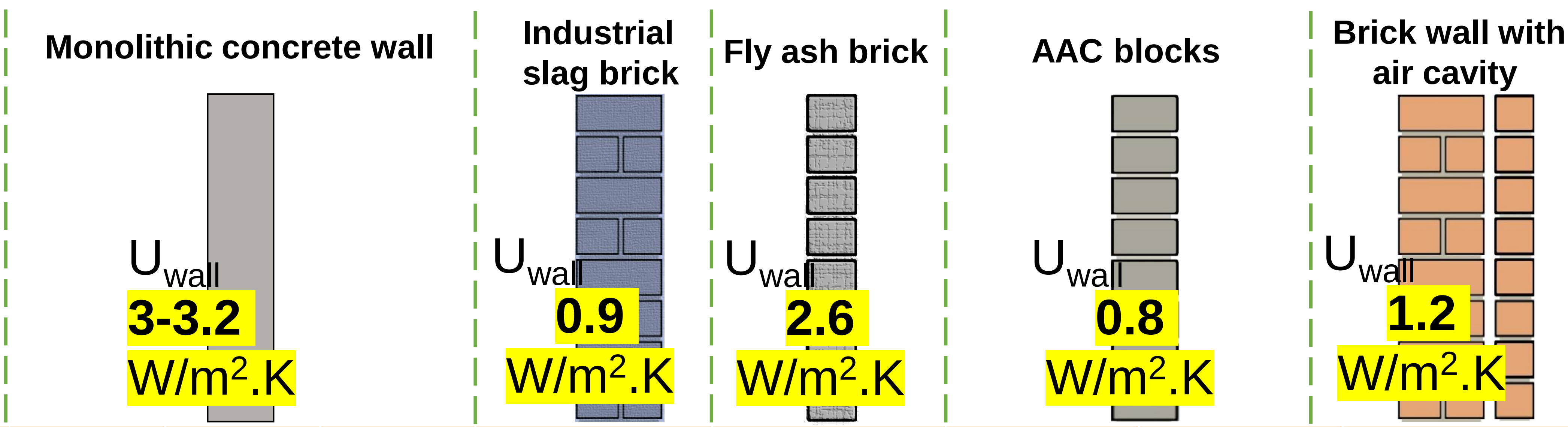
Warm and Humid Climate						Composite Climate	
Chennai			Pune	Thane		Mohal	Ghaziab



	P1	P2	P3	P4	P5	P6	P7	P8
Number of storey	19 storey	4 storey	2 storey	15 storey	18 storey	15 storey	6 storey	26 storey
Orientation*	E-W	N-S	NW-SE	NW-SE	N-S	N-S	E-W	E-W

* Longer sides facing

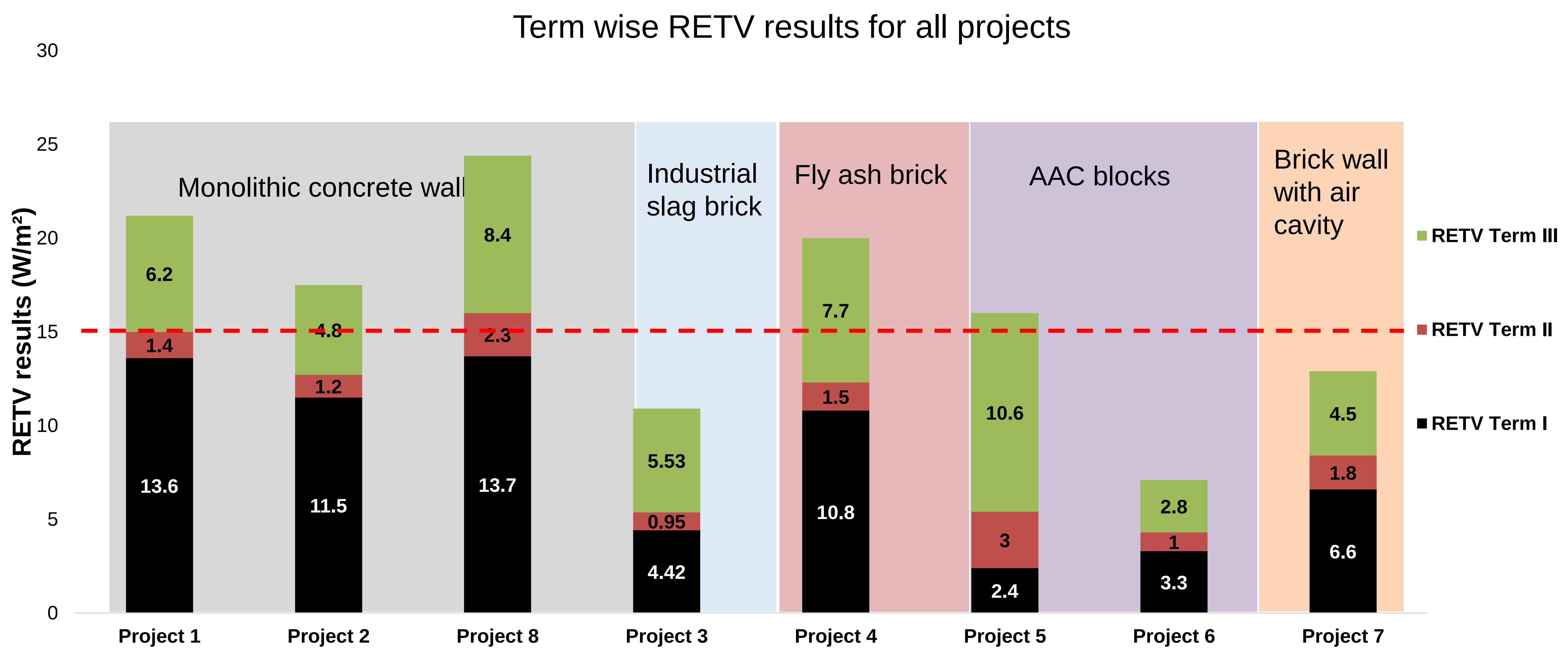
Key Building Envelope Construction Details



	P1	P2	P8	P3	P4	P5	P6	P7
Thickness (mm)	170	200	200	230	150	200	200	400
Plaster (mm) External | Internal	15 | 10	20 | 15	20 | 15	15 | 10	20 | 15	20 | 15	20 | 10	20 | 10
WWR (%) Window to wall ratio	17	19.3	20.1	12.6	20	41.3	16.1	16.6
Glazing type*	SC	SR	SC	SC	SC	SR	SR	SR

*SC-Single clear
*SR-Single reflective

Discussion and Analysis



Case-Study in Chennai

- Location: Chennai.
- The longer sides of the project are facing E-W orientation.

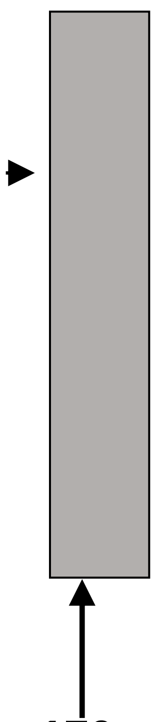
- **Climate type: Warm & Humid climate**
- **No. of blocks: 3, Block A,B &C**
- **20 storeys**
- **Unit type: 2/3 BHK apartments**
- **Number of units: 596**

Construction details

U= 5.8 W/m2.K
SHGC = 0.8

	Details
External Wall	170 mm monolithic concrete
Glazing	6 mm thick single clear glass
WWR	~17%

U= 3.60 W/m2.K



170 mm monolithic concrete wall;

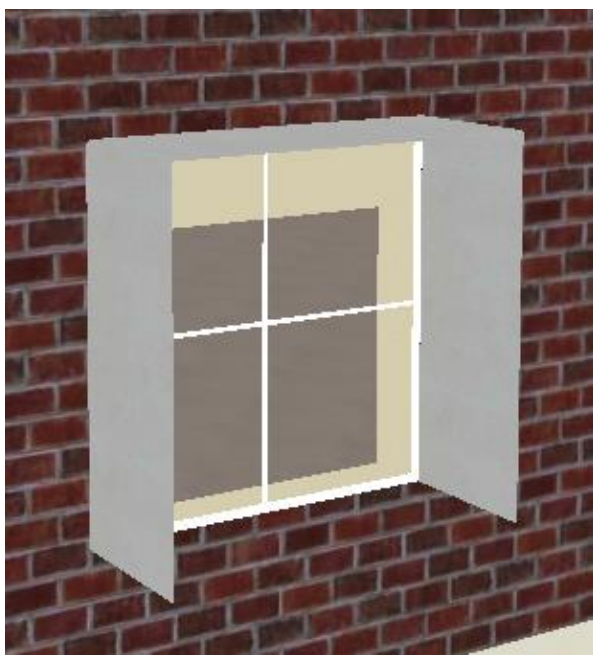
Case I: 170 mm concrete wall + Single Clear Glazing + No Shading

	RETV (I^{st} Term)	RETV (II^{nd} Term)	RETV (III^{rd} Term)	RETV (TOTAL)
Case.1 - No shading - Monolithic concrete	15.3	1.4	9.4	**26.1**

RETV ~ 26, (high compared to cut-off of 15 W/m^2 as per ECBC-R);

- **Excess heat gain from wall conduction due to East-West facing orientation and walling made of monolithic concrete.**
- **Heat gain due to window transmittance is also high because of inadequate shading**

Case II: (Final design constructed)
Case I + Proper Shading of Windows



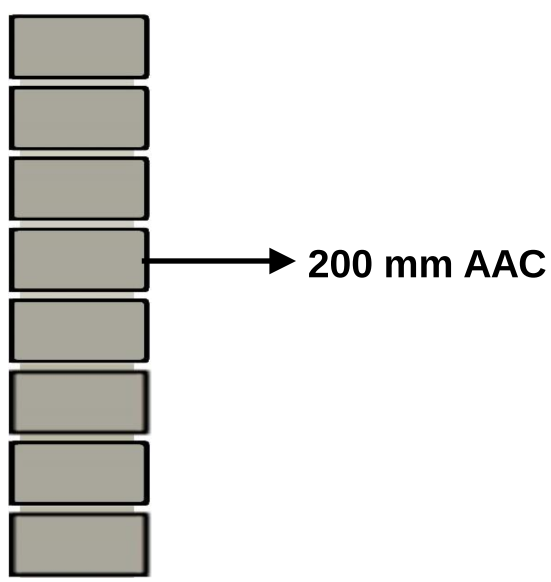
	RETV (Ist Term)	RETV (IInd Term)	RETV (IIIrd Term)	RETV (TOTAL)
Case.II - Box type Shading - Monolithic concrete	15.3	1.4	**6.2**	22.9

RETV ~23 W/m^2
Shading helps in reducing heat gains from windows

Annexure 7: Calculation of Effective SHGC

Case III: Case II+ AAC block wall (Proposed measure)

U= 0.77 W/m².K



	RETV (Ist Term)	RETV (IInd Term)	RETV (IIIrd Term)	RETV (TOTAL)
Case.III - Box type Shading - AAC Blocks	**3.3**	1.4	6.2	10.9

RETV ~ 11, significantly lower than 15 W/m^2

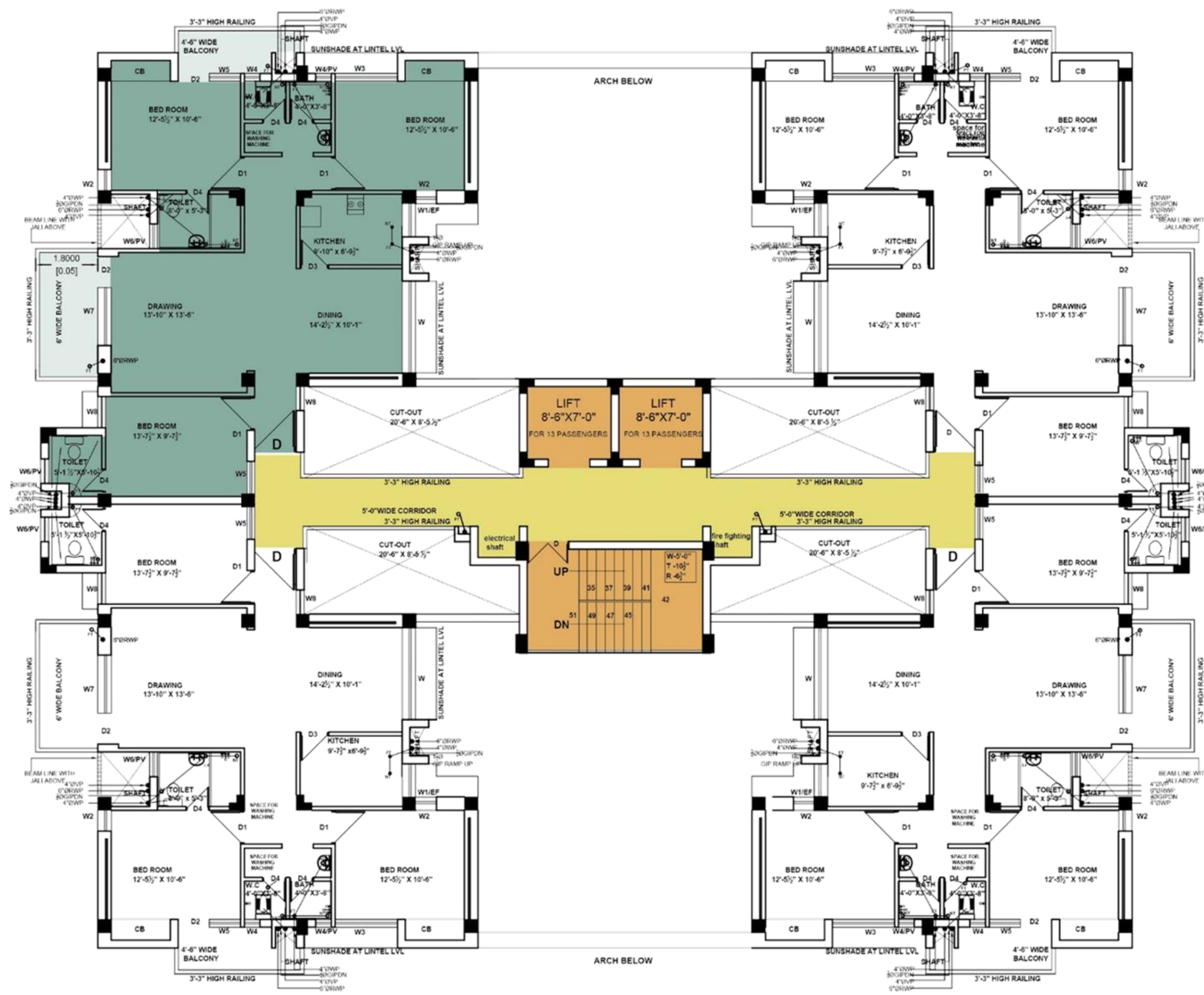
Reduced thermal conduction from walls

Key Envelope Parameters and it's impact on RETV

	RETV (Ist Term)	RETV (IInd Term)	RETV (IIIrd Term)	RETV (TOTAL)
Case I: 170 mm concrete wall + Single Clear Glazing + No Shading of Windows	15.3	1.4	9.4	**26.1**
Case II: (Final design constructed) Case I + Proper Shading of Windows	15.3	1.4	**6.2**	**22.9**
Case III: Case II+ AAC block wall (Proposed measure)	**3.3**	1.4	6.2	**10.9**

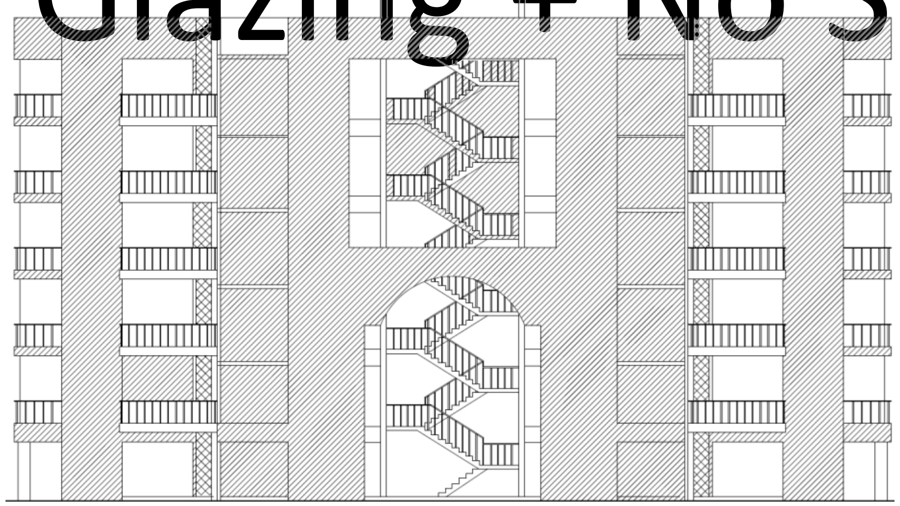
Case-Study of NABARD Project, Mohali

- This project is a residential quarters (only block II) build for the NABARD *(National bank for agriculture and rural development)* staff at Mohali.
- The climate type is composite.

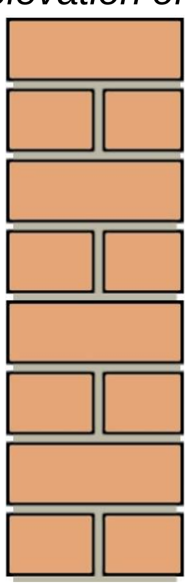


- **No. of dwelling units in Block II (DU): 20 (all 2 BHK)**
- **Stilt + 5 storeys**

Case I: 230 mm brick wall + Normal WWR + Single Clear Glazing + No Sl



Front elevation of the block II



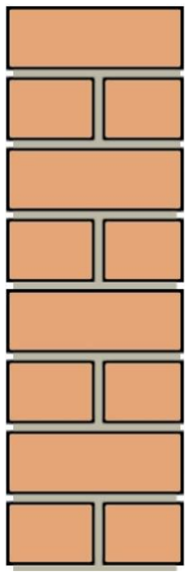
U-Value **2.0** W/m².K

	RETV (Ist Term) Wall conduction	RETV (IInd Term) Window conduction	RETV (IIIrd Term) Window transmittance	RETV (TOTAL)
Case.1 - Brick Wall - No Shading - Single clear glazing - WWR: ~14%	10.1	1.8	9.6	21.5

RETV ~ 22, (high compared to cut-off of 15 W/m² as per ECBC-R)

Heat conduction through wall is high and high heat gains from windows with no shading

Case II: Case I + Proper Shading of Windows



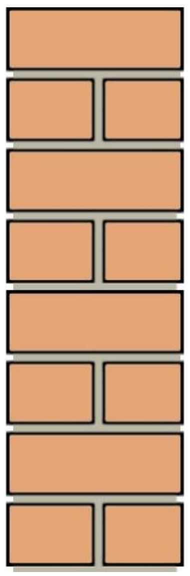
U-Value **2.0** W/m^2.K

	RETV (I^{st} Term) Wall conduction	RETV (II^{nd} Term) Window conduction	RETV (III^{rd} Term) Window transmittance	RETV (TOTAL)
Case.2 (Brick Wall, Shading: Overhang + Side fin WWR: ~14%	10.1	1.8	**6.7**	**18.6**

RETV ~19 W/m^2
Shading helps in reducing heat gains from windows

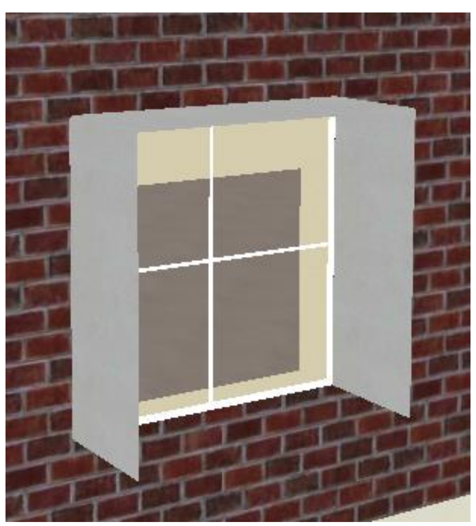
Annexure 7: Calculation of Effective SHGC

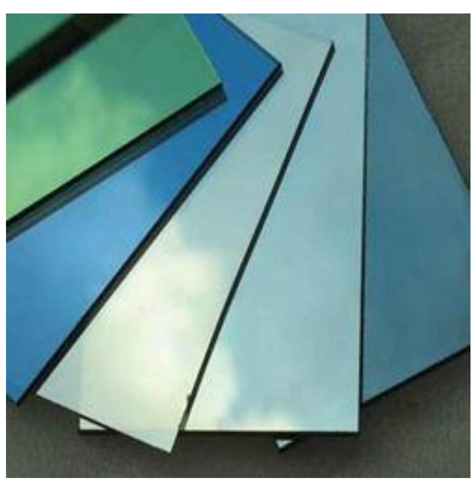
Case III: Case II+ Single reflective glass



U-Value **2.0** W/m^2.K

	RETV (Ist Term) Wall conduction	RETV (IInd Term) Window conduction	RETV (IIIrd Term) Window transmittance	RETV (TOTAL)
Case.3 (Brick Wall, Shading: Overhang + Side fin+ Single reflective glass	10.1	1.8	**4.5**	**16.3**

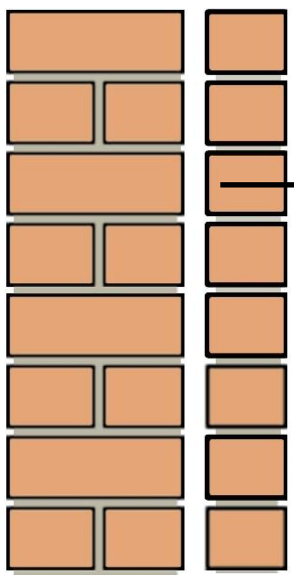




RETV ~16 W/m^2
Using single reflective glass instead of single clear glass reduces heat gain due to window transmittance

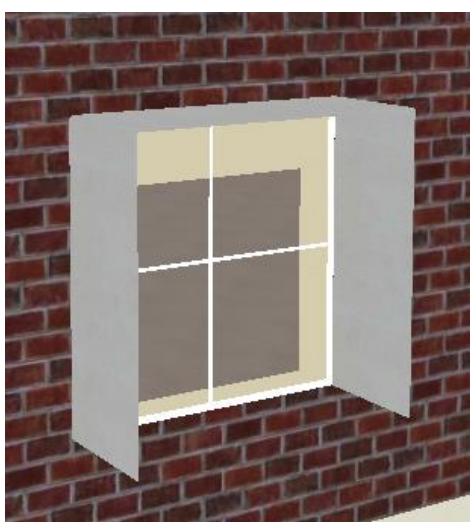
Annexure 7: Calculation of Effective SHGC

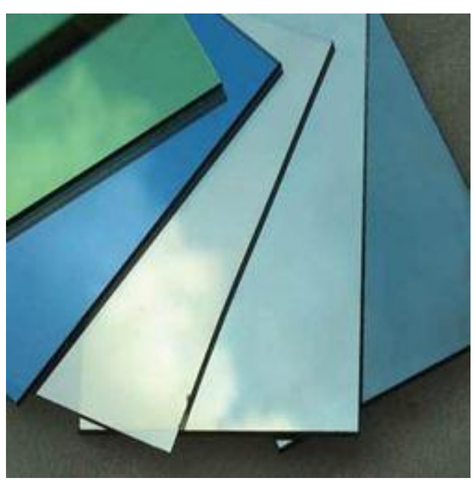
Case IV: (Final Design Constructed) Brick cavity wall+ Shading+ Single refle



U-Value **1.1** W/m².K

	RETV (I^{st} Term) Wall conduction	RETV (II^{nd} Term) Window conduction	RETV (III^{rd} Term) Window transmittance	RETV (TOTAL)
Case.4 (Brick Cavity, Shading: Overhang + Side fin+ Single reflective glass	**6.6**	1.8	4.5	**12.8**



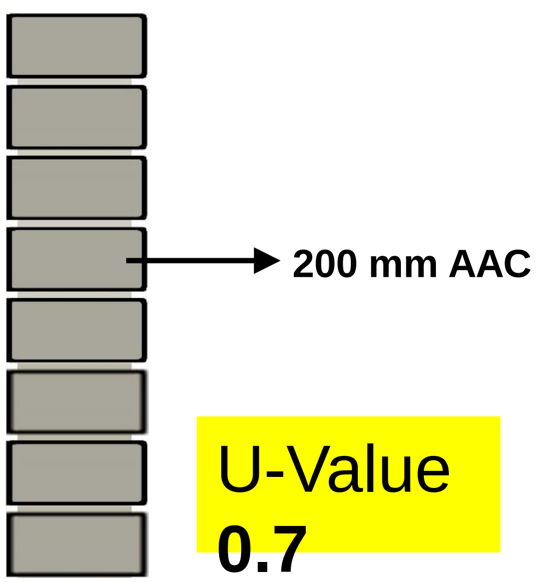


RETV ~13 W/m²
Using Brick cavity wall with 40mm air gap reduces the heat gained due to wall conduction

Annexure 7: Calculation of Effective SHGC

Case V: Extra measure: AAC block wall + Shading of Windows+ re

	RETV (Ist Term)	RETV (IInd Term)	RETV (IIIrd Term)	RETV (TOTAL)
Case.3 - AAC Block Wall - Shading - Single reflective glass	**4.7**	**1.8**	**4.5**	**10.9**



U-Value **0.7** W/m^2.K

RETV ~ 11 significantly lower than 15 W/m^2
Reduced thermal conduction from walls; use of single reflective glass and shading helps in reducing heat gains from windows

Key Envelope Parameters and it's impact on RETV

	RETV (I^{st} Term)	RETV (II^{nd} Term)	RETV (III^{rd} Term)	RETV (TOTAL)
Case.1 (Brick Wall, No Shading, Single clear glass-SC)	10.1	1.8	9.6	21.5
Case.2 (Brick Wall, Shading: Overhang + Side fins, SC)	10.1	1.8	$\boxed{6.7}$	18.6
Case.3 (Brick Wall, Shading: Overhang + Side fins, Single reflective glass-SR)	10.1	1.8	$\boxed{4.5}$	16.3
Case.4 FINAL DESIGN (Brick cavity wall, Shading: Overhang + Side fins, Single reflective glass-SR)	$\boxed{6.6}$	1.8	4.5	12.8
Case.4 Extra measure (AAC Block Wall, Shading and SR glass)	$\boxed{4.7}$	**1.8**	**4.5**	10.9

Session 4: Star Labelling

a)Low Energy Comfort Systems and BEE Star Labelling
b)Indian & International Best Practices

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.

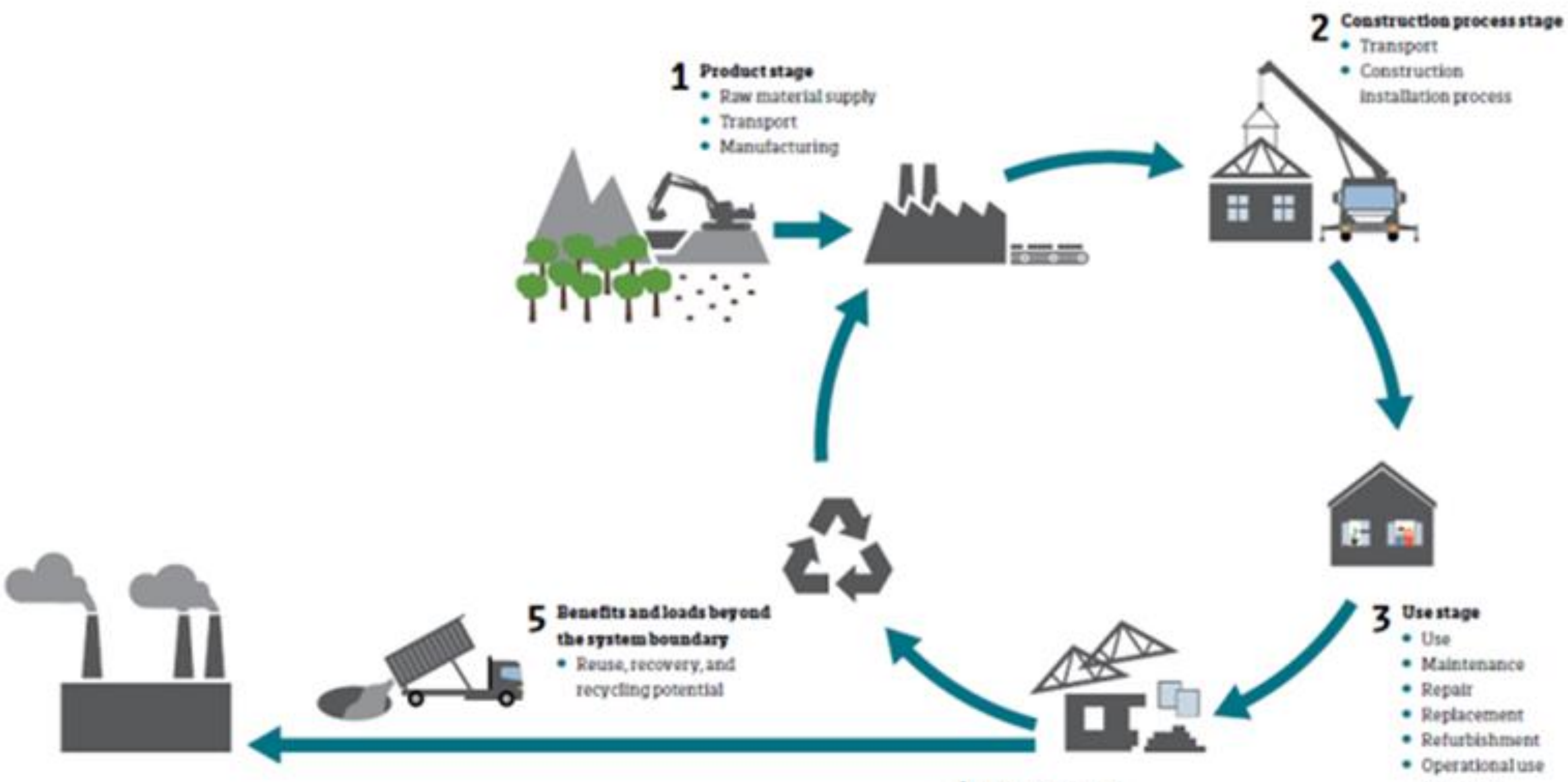
- Efficient use of energy, water and other resources
- Use of renewable energy, such as solar energy
- Pollution and waste reduction measures, and the enabling of re-use and recycling
- Good indoor environmental air quality
- Use of materials that are non-toxic, ethical and sustainable
- Consideration 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

INDIGENOUS AND LOW-EMBODIED MATERIALS

MATERIALS WITH

LEAST CARBON FOOTPRINT

LOW CARBON EMISSION



POTENTIAL FOR RECYCLING & REUSE

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

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

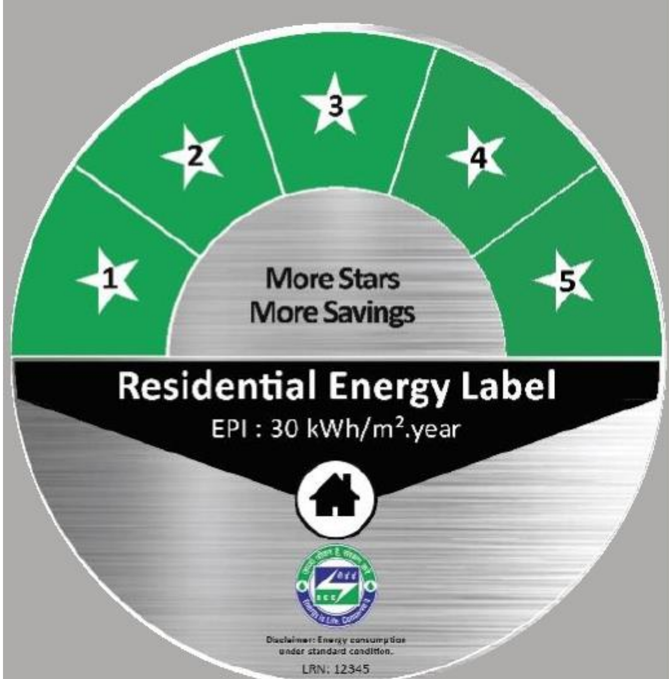
Program Scope

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

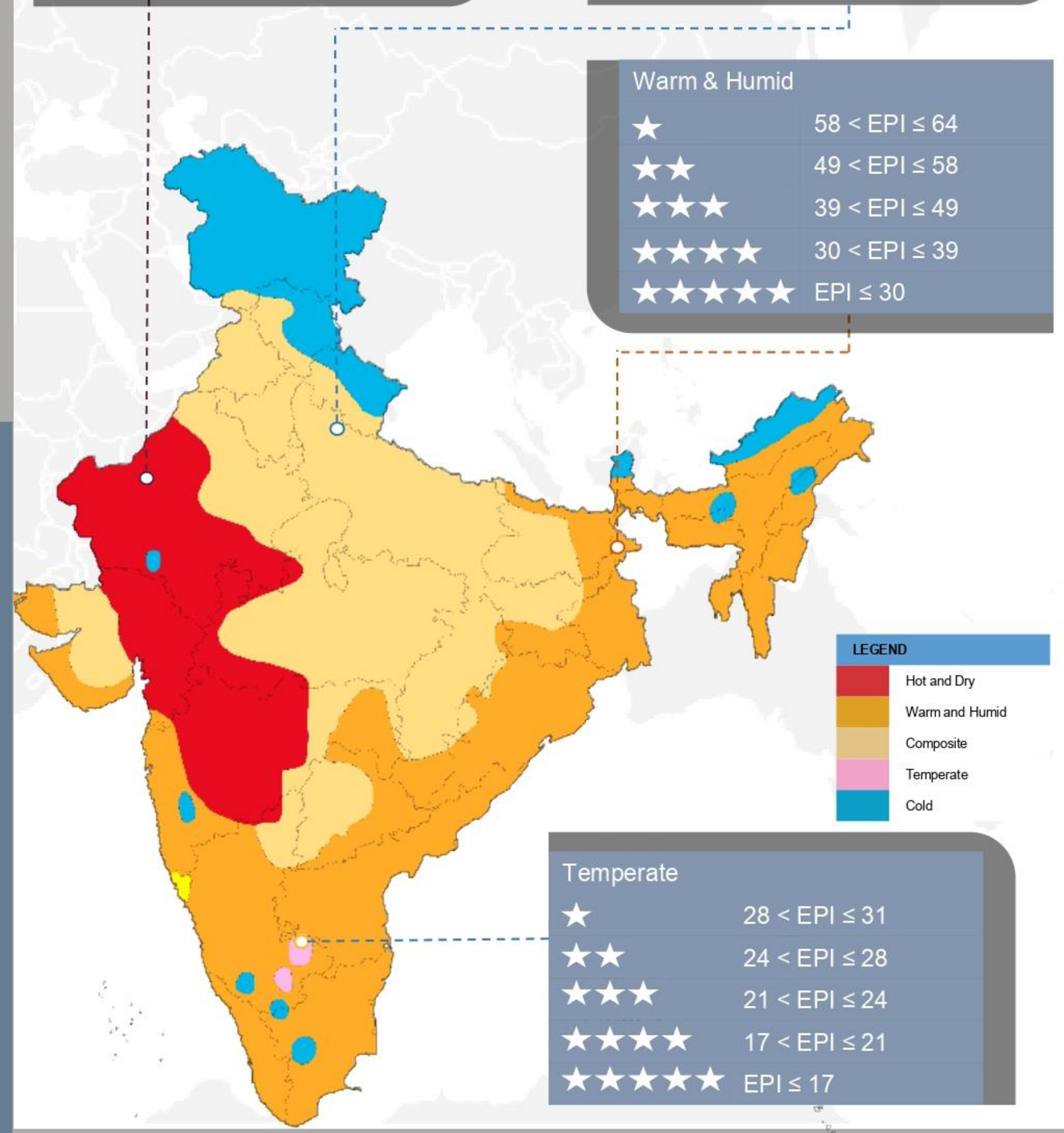
- Cumulative saving of 388 billion units of electricity by 2030
- Reduction of carbon emission by 3 billion tones by 2030
- Increased uptake of energy efficient construction in India
- Facilitate energy efficient materials and technologies market supporting the "Make in India" initiative
- Improve environmental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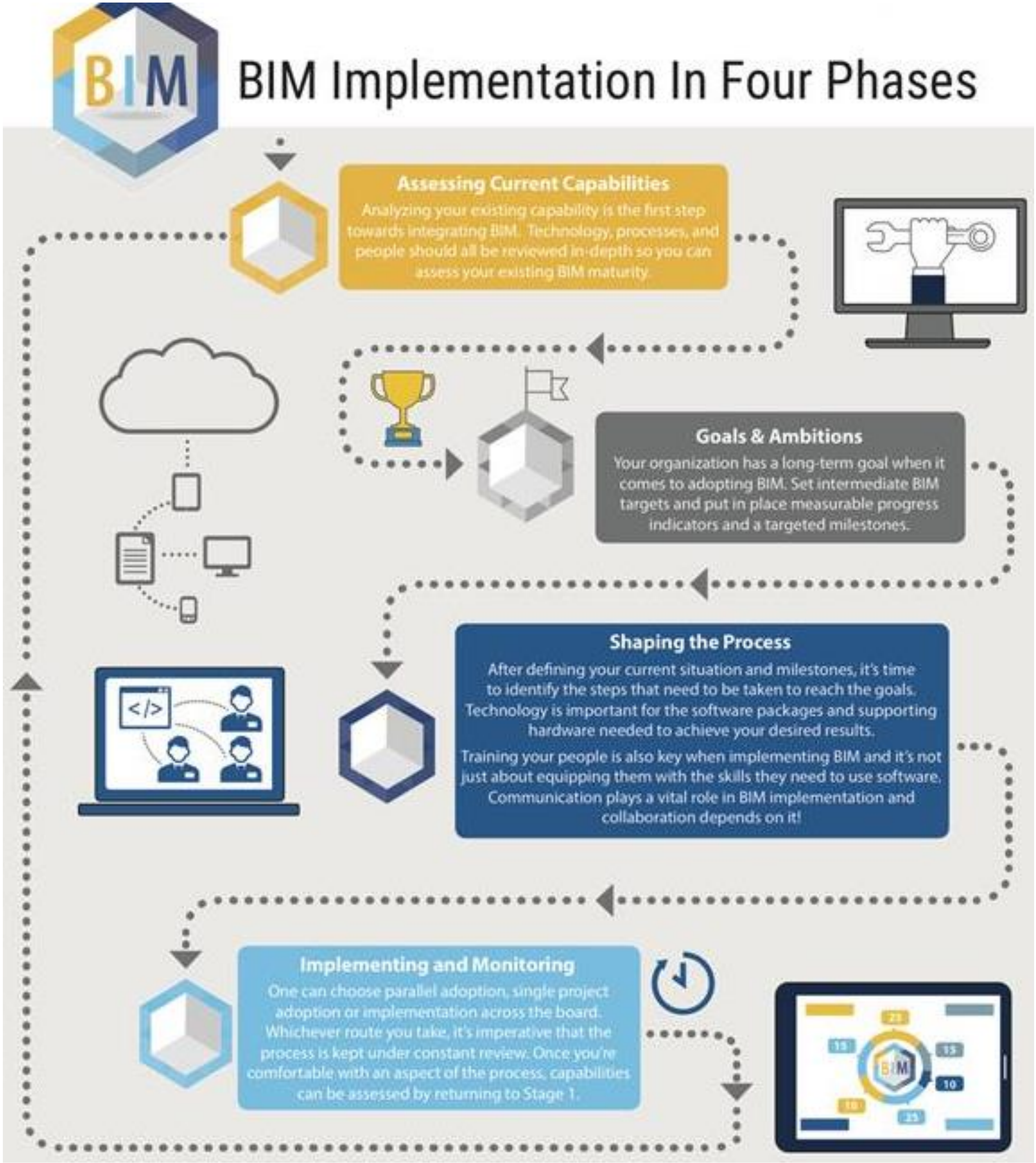

INTERNATIONAL BEST PRACTICES

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.**

Thank you.

Source: McKinsey