GLOBAL HOUSING TECHNOLOGY CHALLENGE INDIA

प्रधान मंत्री आवास योजना-शहरी
Pradhan Mantri Awas Yojana-Urban

Ministry of Housing and Urban Affairs
Government of India

Azadi Ka Amrit Mahotsav

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GLOBAL HOUSING TECHNOLOGY CHALLENGE INDIA

RACHNA

RESILIENT, AFFORDABLE AND COMFORTABLE HOUSING THROUGH NATIONAL ACTION

Innovative Construction Technologies & Thermal Comfort for Affordable Housing

Training 69
29th July 2022
Hyderabad

Presented by CSB Cell - South

Thermal comfort

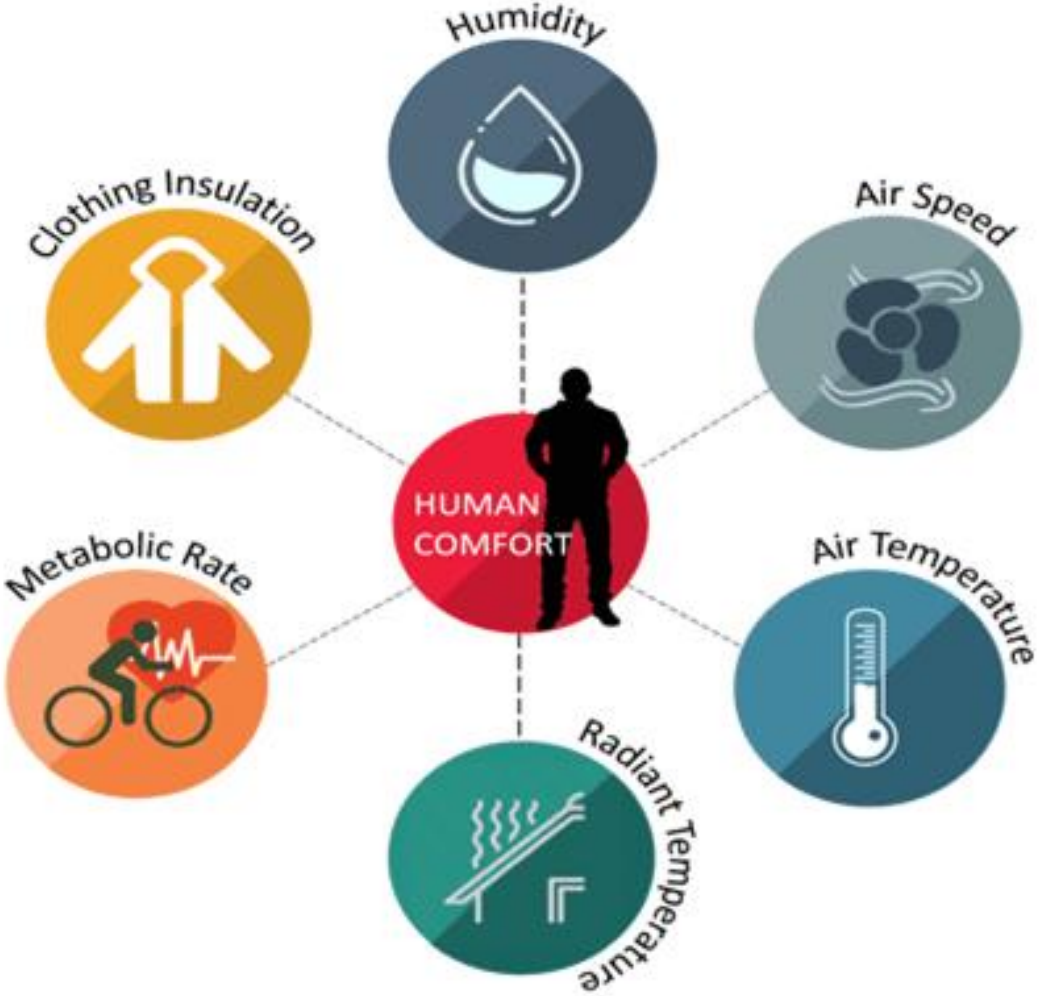
Thermal Comfort – Definition

It is defined as "that condition of mind which expresses satisfaction with the thermal environment." This condition is also some times called as "neutral condition", though in a strict sense, they are not necessarily same for everyone.

Internationally Engineers & designers look up to following standards for thermal comfort conditions:

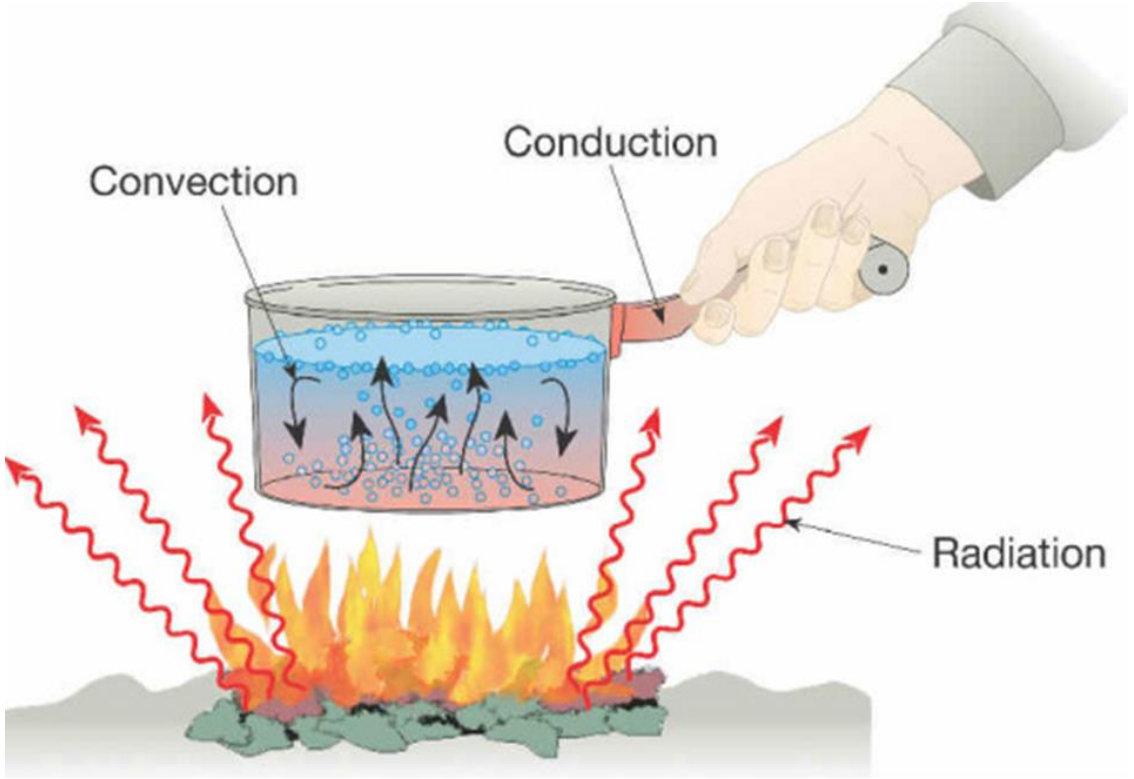
- **ASHRAE 55** (American Society of Heating, Refrigerating, and Air Conditioning Engineers)
- **ISHRAE** (Indian Society of Heating, Refrigerating, and Air Conditioning Engineers)
- **IMAC** (Indian Model for Adaptive Thermal Comfort)

Thermal Comfort – Indices



Source: https://www.simscale.com/blog/2019/08/what-is-ashrae-55-thermal-comfort/

Mode of Heat Transfer – Influencing Thermal comfort



Thermal Comfort Indices – Metabolic Rate

Source: https://www.simscale.com/blog/2019/08/what-is-ashrae-55-thermal-comfort/

Thermal Comfort Indices – Clothing Insulation

- The clothing factor used to represent the thermal insulation from clothing
- The unit for measuring the resistance offered by clothes is called as "clo"

  - Radiation heat loss/gain
  - Convection heat loss/gain
  - Surface area exposed

  - 1 clo : 0.155 m^2K/W
  - Winter clothing : 1.0 clo
  - Summer clothing : 0.5 clo

Trouser+ Half Sleeves	Jeans + Blazer	Woollen Clothes
		
0.6 clo	1.0 clo	1.5 clo

Thermal Comfort – Impact of Radiant Temperature

- Uniform Temperature of an imaginary Enclosure
- Measure of the effect of Radiant interchanges at a point in space
- Depends on the surrounding environment & envelope

Thermal Comfort Indices – Environmental Factors

Indices	Air Speed	Humidity	Air Temperature
Definitions	Rate of Air Movement	Percentage of the amount of moisture the air could possibly hold	Average temperature of air surrounding an occupant
Controls	Fan Speed Wind speed Window Opening	Humidifier Dehumidifier	Insulated Envelope Heat Ingress/Egress
Heat Influence	Convective Evaporative	Evaporation	Convective Evaporative

Thermal Comfort Indices – Environmental Factors

Problems due to High Humid Conditions

- ❑ Stuffy air
- ❑ Condensation on windows and walls
- ❑ Mold spots or water stains
- ❑ Musty smells
- ❑ Allergies
- ❑ Skin problems
- ❑ Swollen woods
- ❑ Moist fabrics

Problems due to Low Humid Conditions

- ❑ Dry air
- ❑ Allergies
- ❑ Vulnerable to Cold
- ❑ Infections
- ❑ Itchy & Dry Skin
- ❑ Damage to wood furniture & paints
- ❑ Increased static electricity
- ❑ Electronics damage

Building Physics - Air Changes per Hour (ACH)

Air changes per hour (ACH) is a measure of how many times the air within a defined space is replaced in a hour

$$N = \frac{60Q}{Vol}$$

N = number of air changes per hour

Q = Volumetric flow rate of air in cubic feet per minute (cfm)

Vol = Space volume L × W × H, in cubic feet

Thermal Discomfort due to Building factors

Local Thermal Discomfort

- The local thermal discomfort is **unwanted cooling or heating** on a particular part of an occupant's body

Asymmetric radiant field (Cold floor, warm wall, equipment & sunlight)

Too warm or too cold Flooring

Local convective cooling (draught)

Vertical Air temperature difference (Warm air near head & Cold air near feet)

• Draught

• Radiation Asymmetry

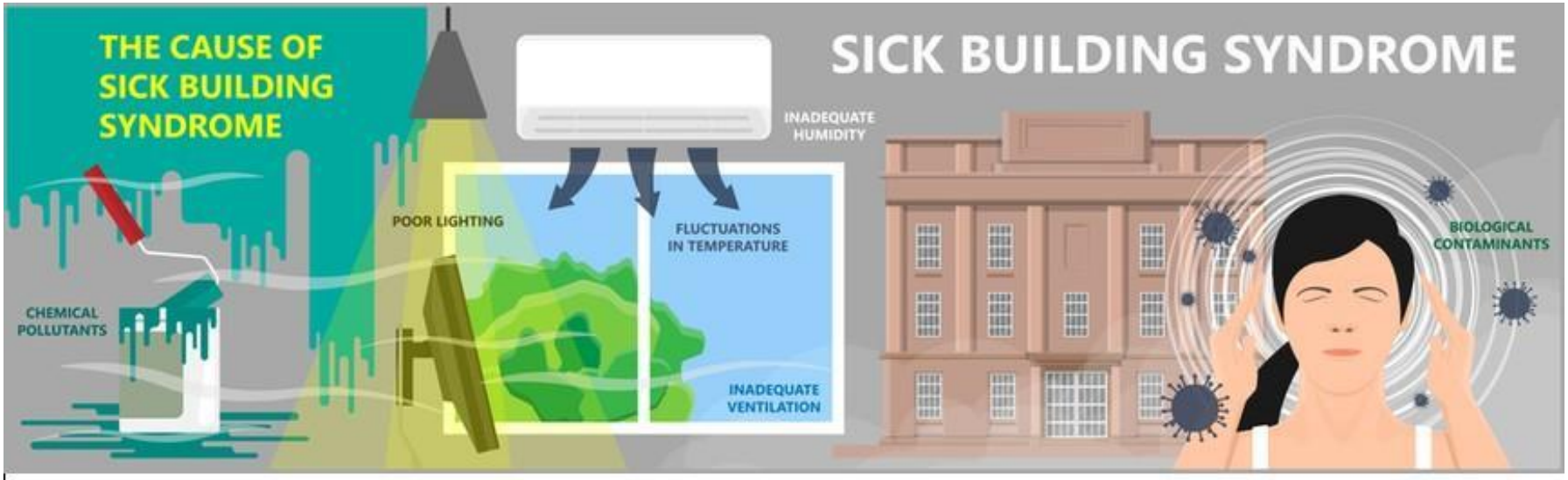
• Vertical Air Temperature Differences.

• Floor temperature

Thermal Discomfort – Sick Building Syndrome

SICK BUILDING SYNDROME

- Sick building syndrome (SBS) is used to describe situations in which building occupants experience acute health and comfort effects that appear to be linked to time spent in a building

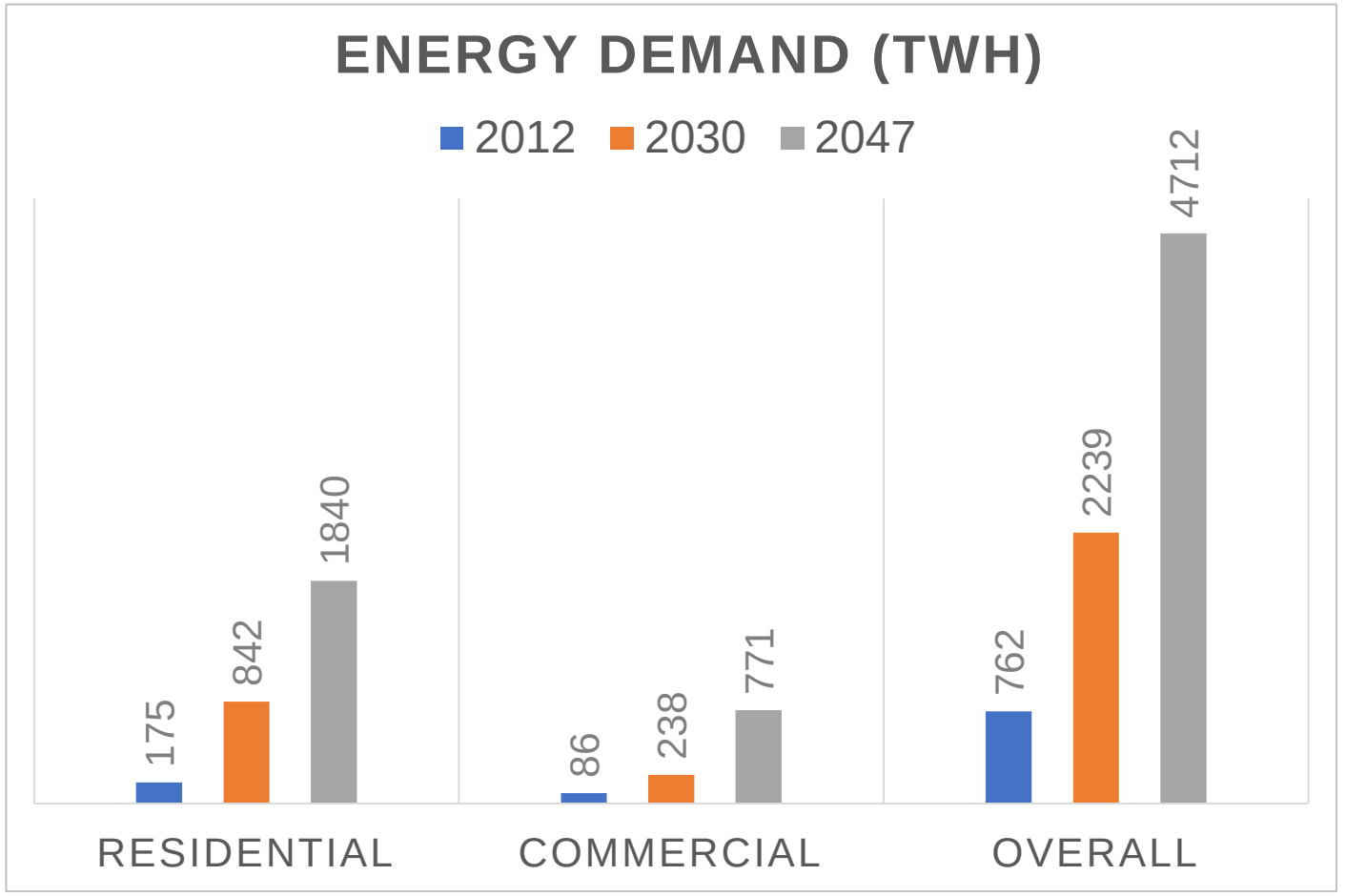


Necessity of Thermal comfort in Affordable Housing

Affordable Housing Demand

India is projected to double its energy demand and have the largest increase in energy consumption worldwide between 2020 and 2040.

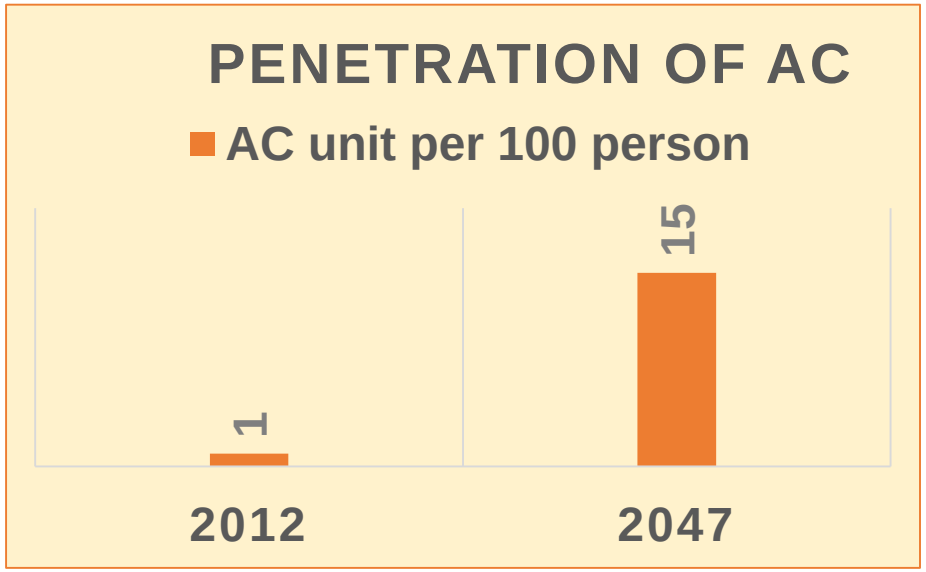
Source: India 2020 Energy Review Policy

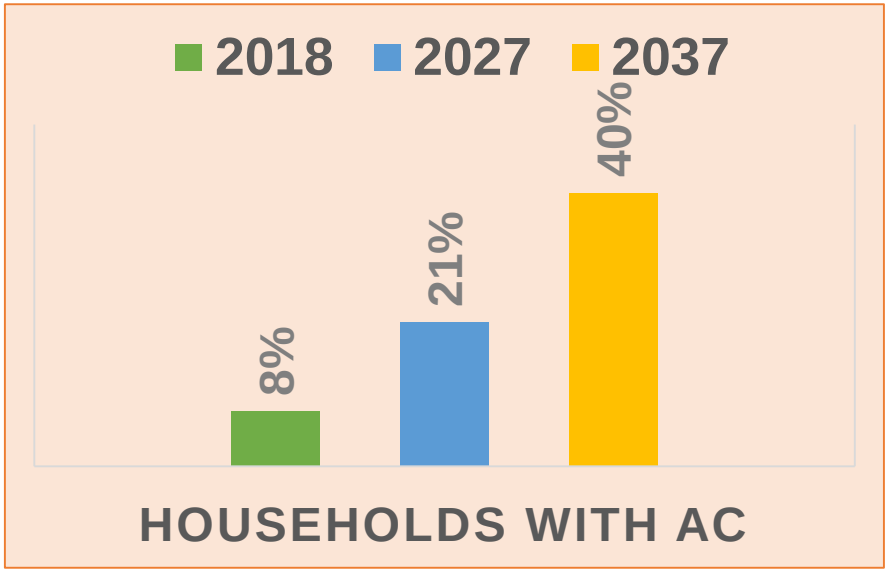


Source: NITI Aayog 2015

Increase in AC demand in the Residential Sector

In 2017, approximately 272 million households were estimated in India which will increase to 328 and 386 million in 2027 and 2037 respectively.





Source: Ministry of Environment, Forest & Climate Change. (2019). India Cooling Action Plan & NITI Aayog 2015

Impetus of Thermal Comfort in Affordable Housing

11.2 Million houses under the PMAY scheme, with a lifespan of 50 to 60 years

LIG and EWS segment will not have access to active air-conditioning.

Climate appropriate and energy efficient building design for EWS and LIG segments. Climate Smart Buildings (CSB)

Passive strategies to achieve thermal comfort in Affordable housing

- Eco Niwas Samhita (ENS) – Part 1 (Building Envelope)

Active strategies to achieve thermal comfort in Affordable housing

- Cool-roof programs

Implementation & Enforcement measures

- Regulatory and policy actions in the adoption of energy efficient building practices Promoting capacity building and fostering market awareness

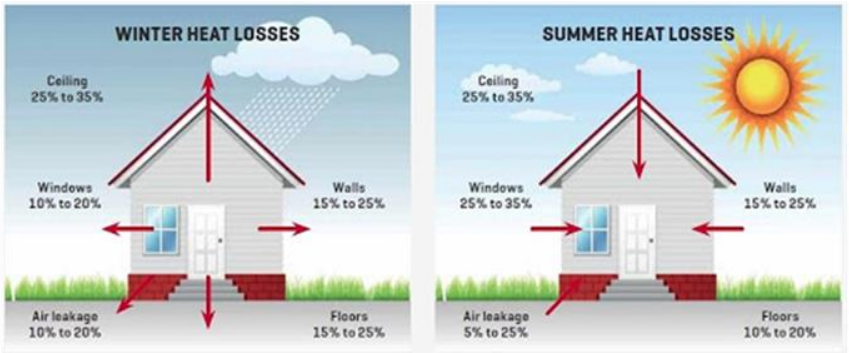
Thermal Comfort Improvement in a Building

1

1. For Adequate natural ventilation potential for thermal comfort

2. For adequate day light for visual comfort

3

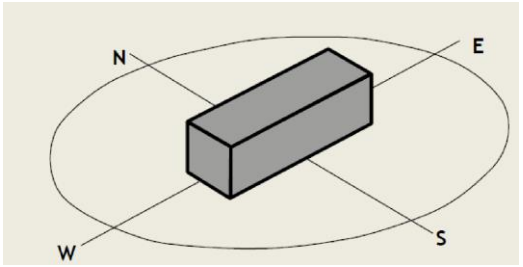


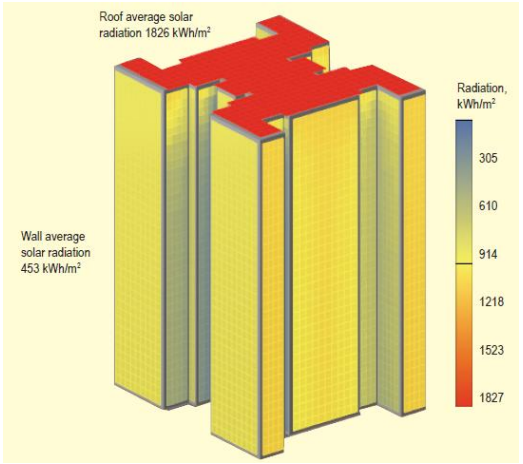
3. Limit heat gains / heat loss for energy efficiency

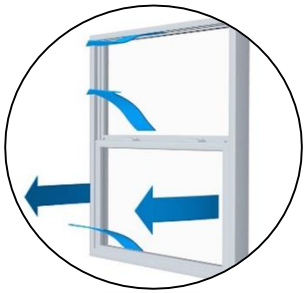
Thermal Comfort Improvement Strategies

Passive Strategies

1. Orientation
2. Thermal Mass
3. Roof and Wall Materials
4. Non Opaque material properties
5. Appropriate Shading Design
6. Minimize Infiltration losses
7. Climate specific design interventions
8. Mutual / Tree Shading



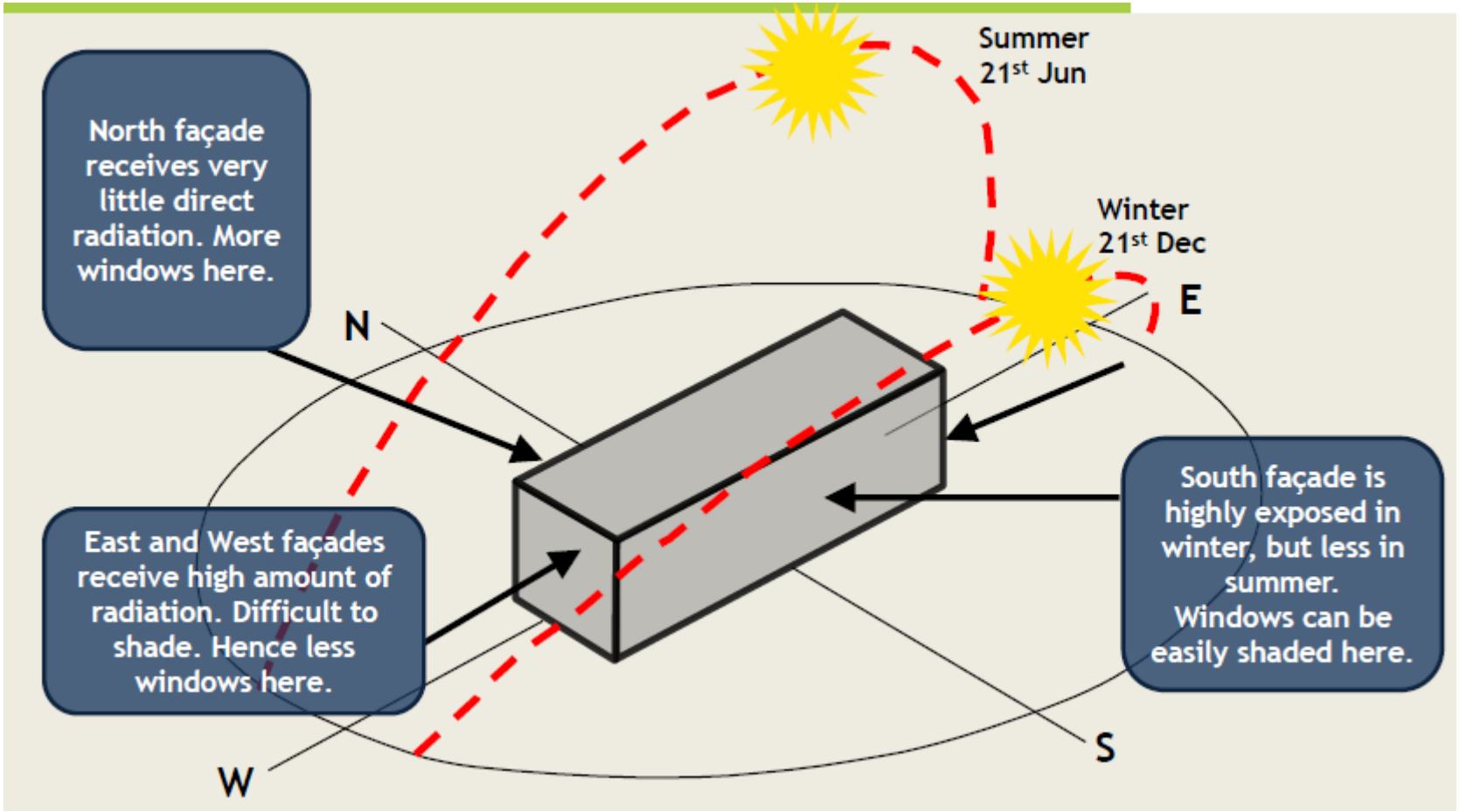




Active Strategies

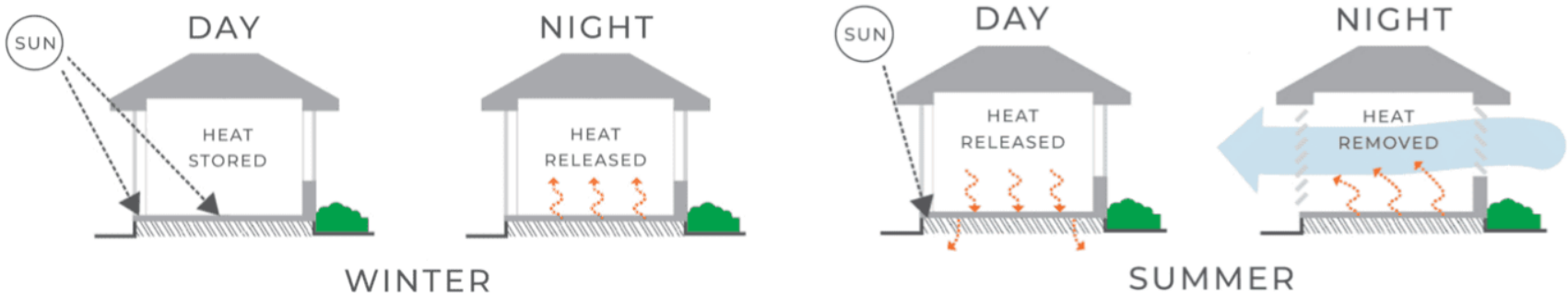
1. Renewable Energy
2. Direct / Indirect Evaporative Cooling
3. Cool roofs

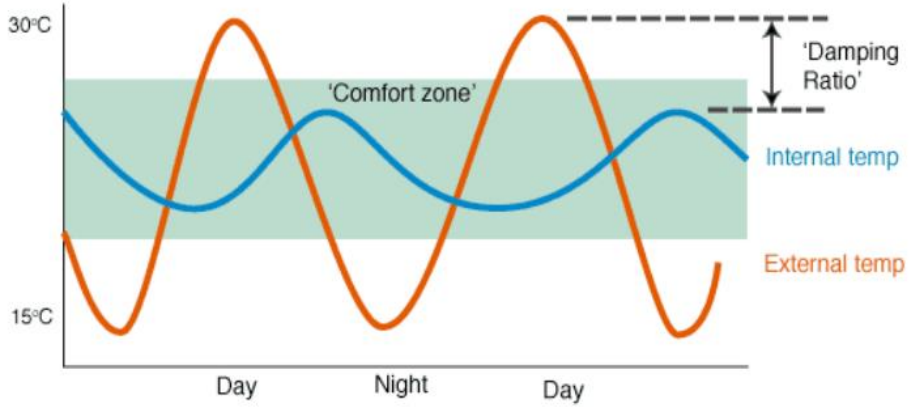
Passive Measures - Orientation



Passive Measures - Thermal Mass

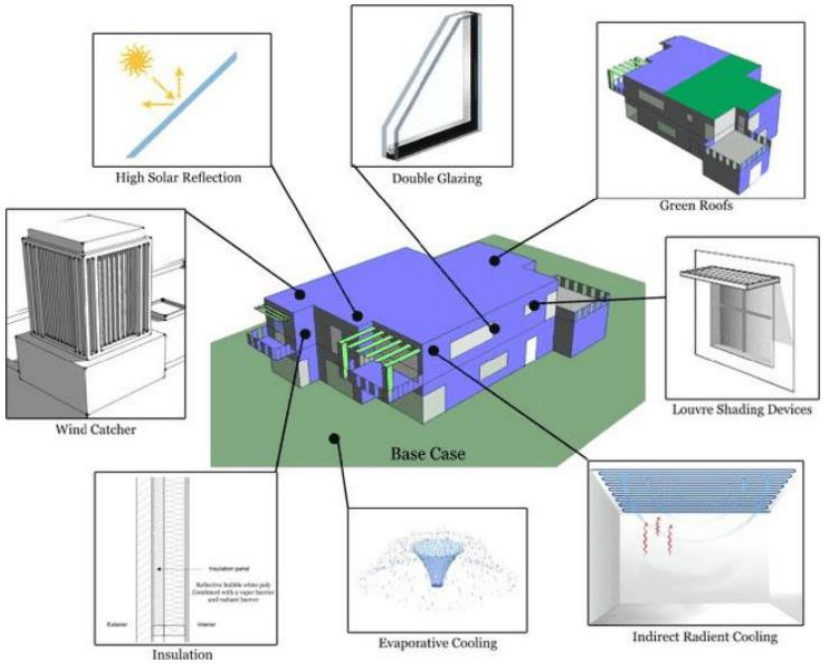
- Denser thermal mass materials are more effective passive solar materials. Thus, denser the material the better it stores and releases heat.
- Integrate thermal mass with an efficient passive solar design, by considering the placement of added mass.
- Do not substitute thermal mass for insulation. It should be used in conjunction with insulation





Passive Measures - Roof and Wall Materials

The properties of building materials act as building envelopes by resisting the external temperature and humidity, mostly influenced by indoor thermal comfort. The materials having lower thermal conductivity, thermal diffusivity, and absorptivity has the properties of less temperature swing on the inside surface of the walls compared to the materials with high thermal conductivity

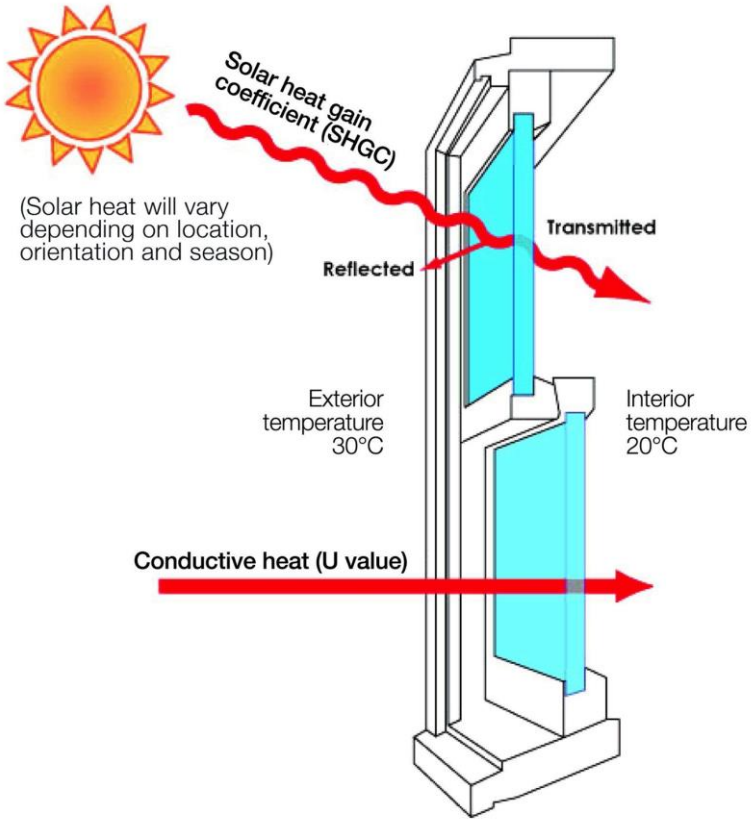


- Green roofs.
- Louvre and shading devices.
- Insulation
- Low energy cooling techniques
- Wind catchment and ventilation
- High solar reflective surface.

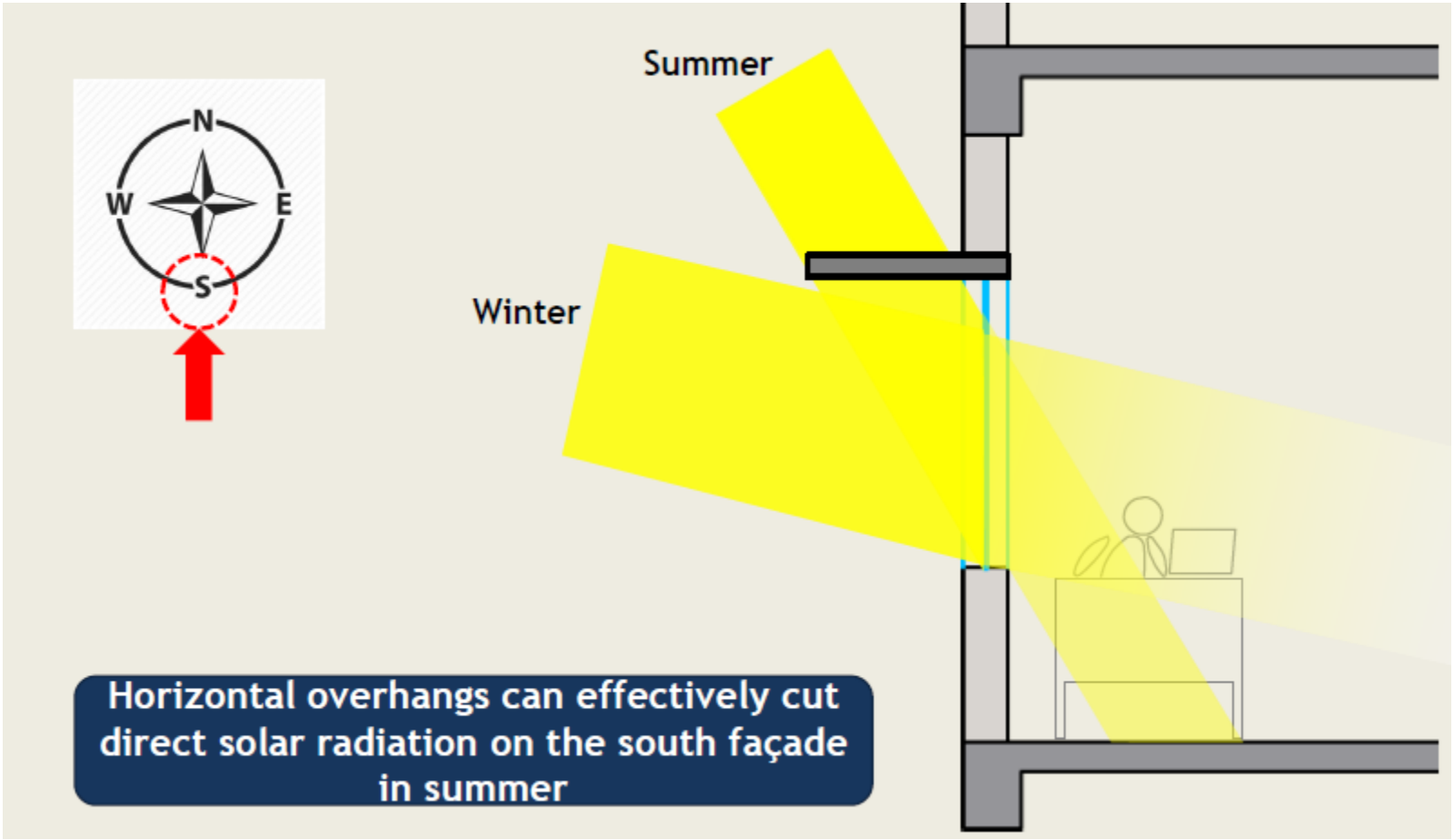
Passive Measures - Non Opaque Material Properties

- Three of the most important properties of the materials, coatings, and constructions that make up windows, skylights, translucent panels, or other products used to let sunlight into a building include:
  - *Thermal conductance (U-value)*
  - *Solar Heat Gain Coefficient (SHGC)*
  - *Visible Light Transmittance (VT)*

- Appropriate values for glazing properties vary by climate, size, and placement of the aperture.

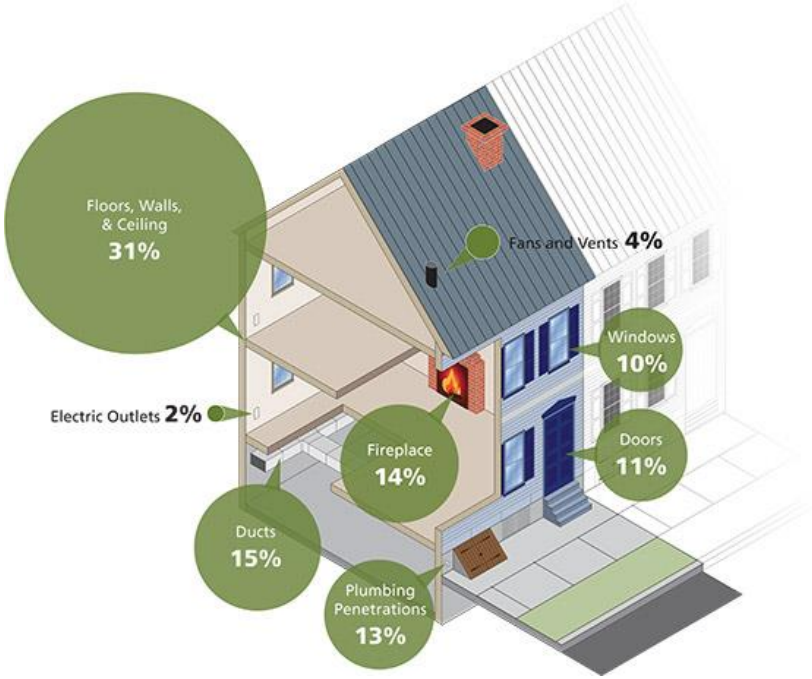


Passive Measures - Shading



Passive Measures - Minimal Infiltration Losses

- Infiltration is **the unintentional or accidental introduction of outside air into a building, typically through cracks in the building envelope and through use of doors for passage**. Infiltration is sometimes called air leakage.
- Reducing air infiltration is often the first action item of a weatherization plan. Caulking cracks, sealing an unused fireplace, and adding weatherstripping are simple, low-cost improvements that can reduce air infiltration.



Typical places to check for air infiltration include:

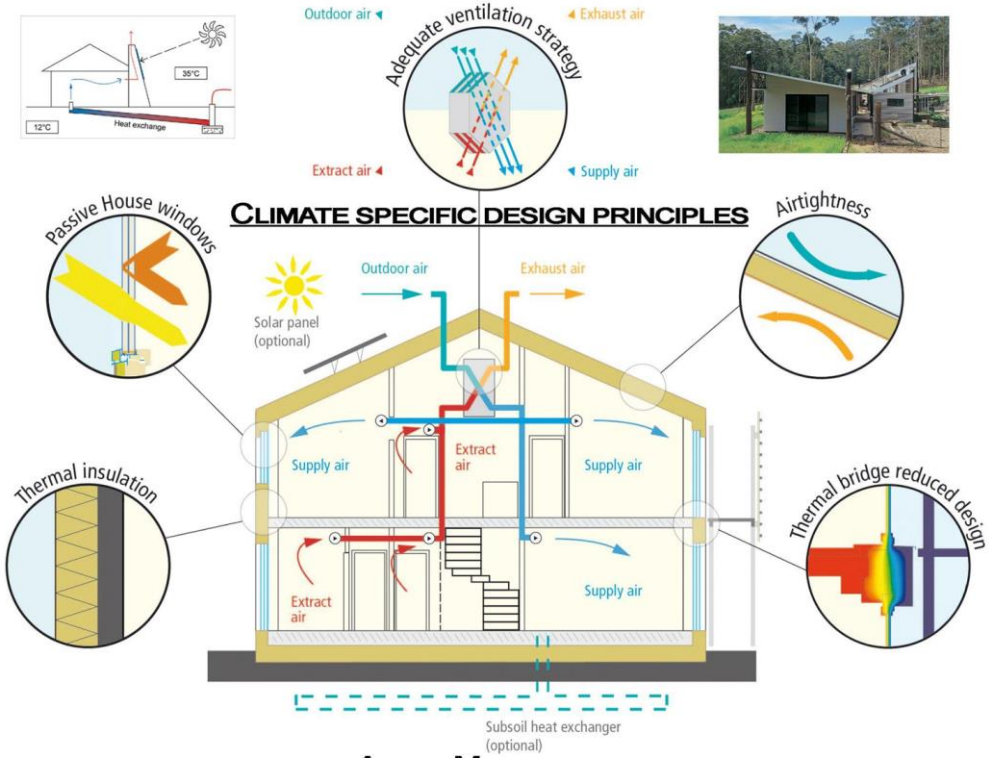
- Electrical outlets, switches, and ceiling fixtures
- Operable features of windows and doors – check for a loose fit
- Window and door frames where they meet the wall
- Wall or window-mounted air conditioners
- Plumbing, electrical, cable, and telephone penetrations
- Ducts in unconditioned spaces.

Passive Measures - Climate Specific Design Interventions

The climate responsive design refers to **the architecture that reflects the particular region-specific weather conditions of the peculiar area**. It uses data of weather patterns and factors like sun, wind, rainfall, and humidity. The building structure is built according to the same.

Factors Affecting Climatic Design:

- **Topography - elevation, slopes, hills and valleys, ground surface conditions.**
- Vegetation - height, mass, silhouette, texture, location, growth patterns.
- Built forms - nearby buildings, surface conditions. and ventilation heat flow.

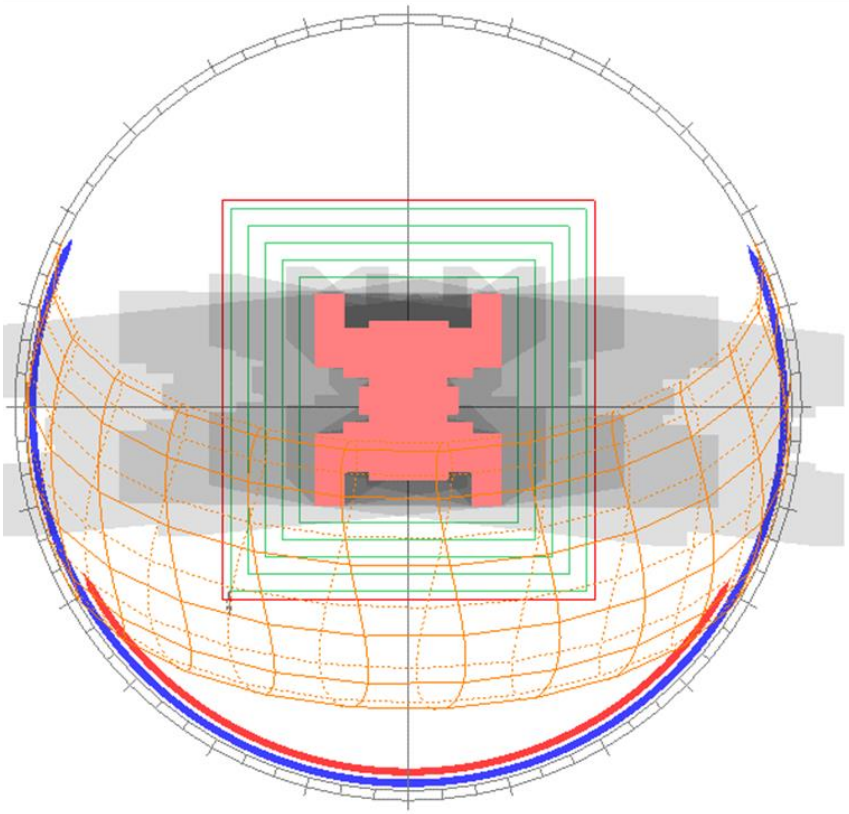


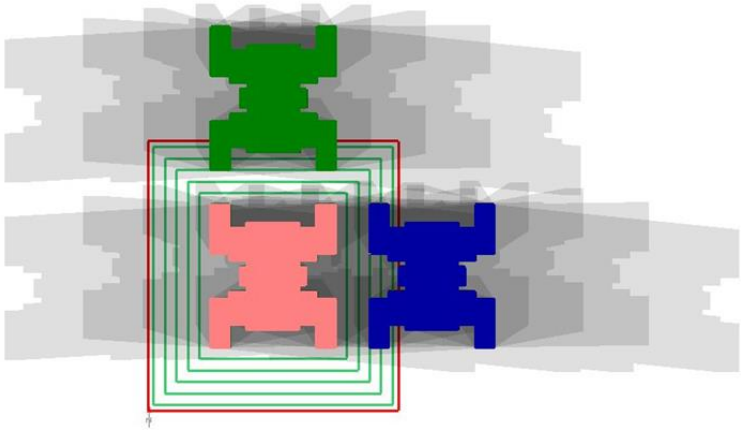
Passive Measures - Mutual Shading

Mutual Shading: June 21st

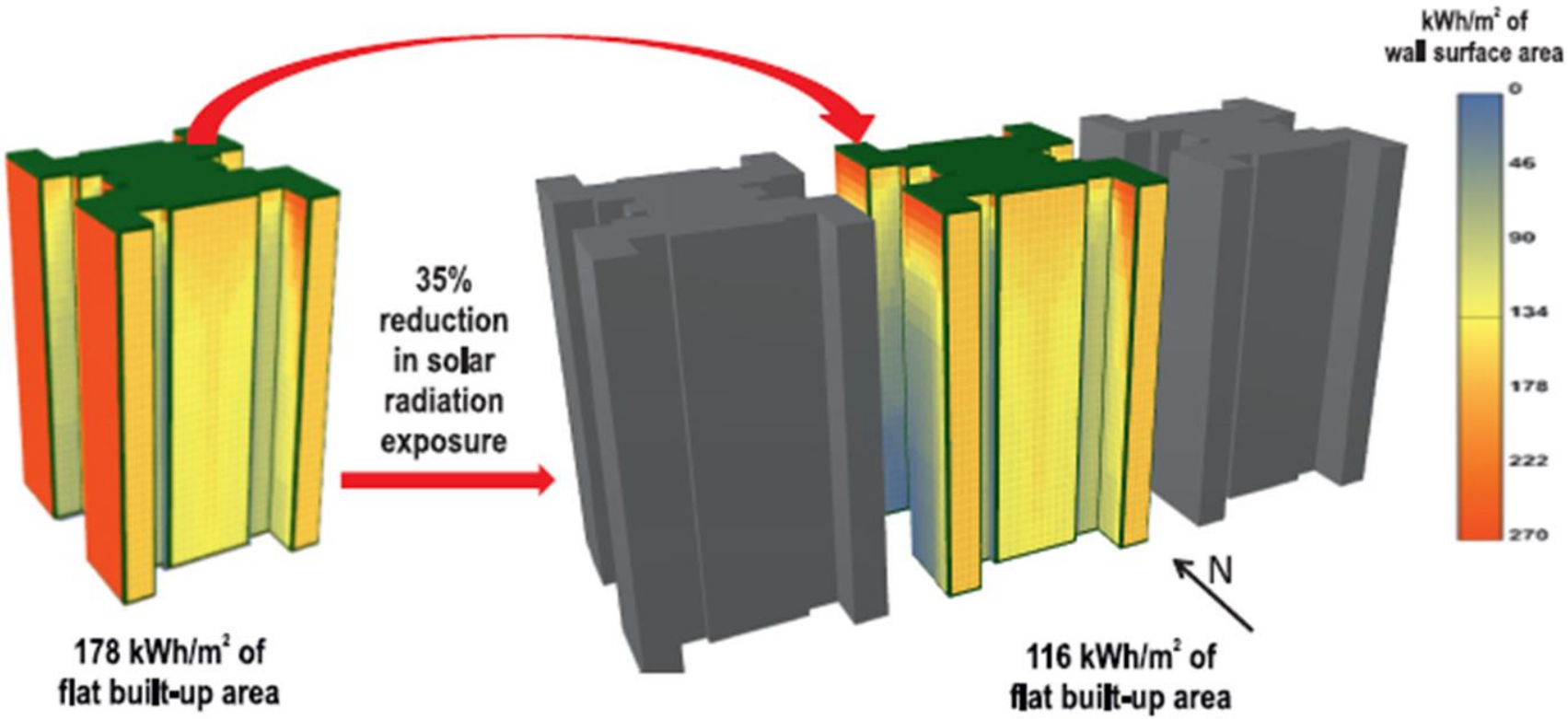
12 storey tower typology residential building

LATITUDE: 28.6°
LONGITUDE: 77.2





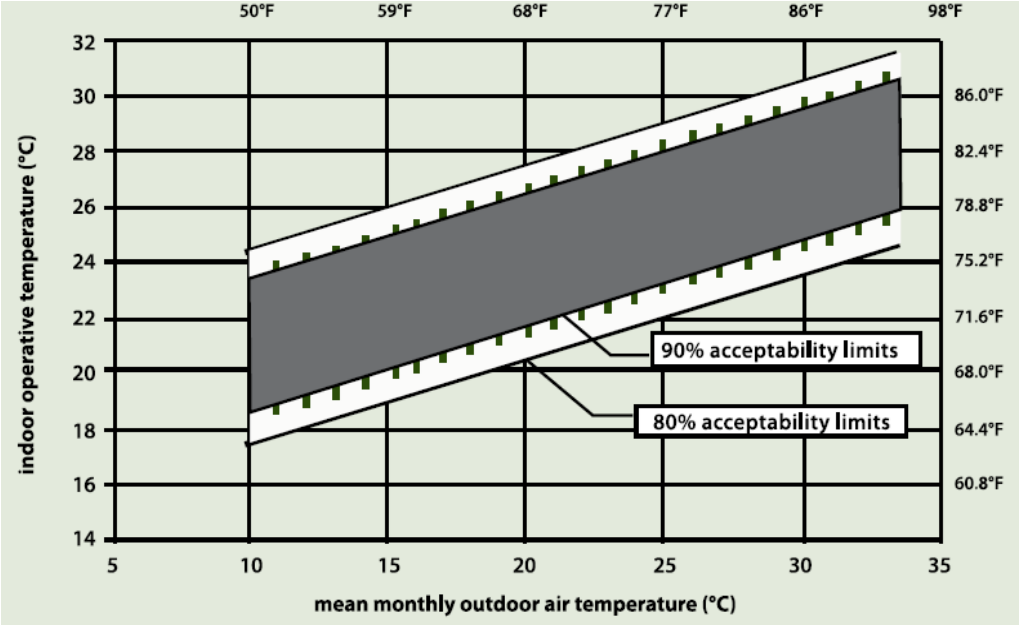
Passive Measures - Quantitative Impact of Mutual Shading



Thermal Comfort Models

Thermal Comfort Standard – IMAC R

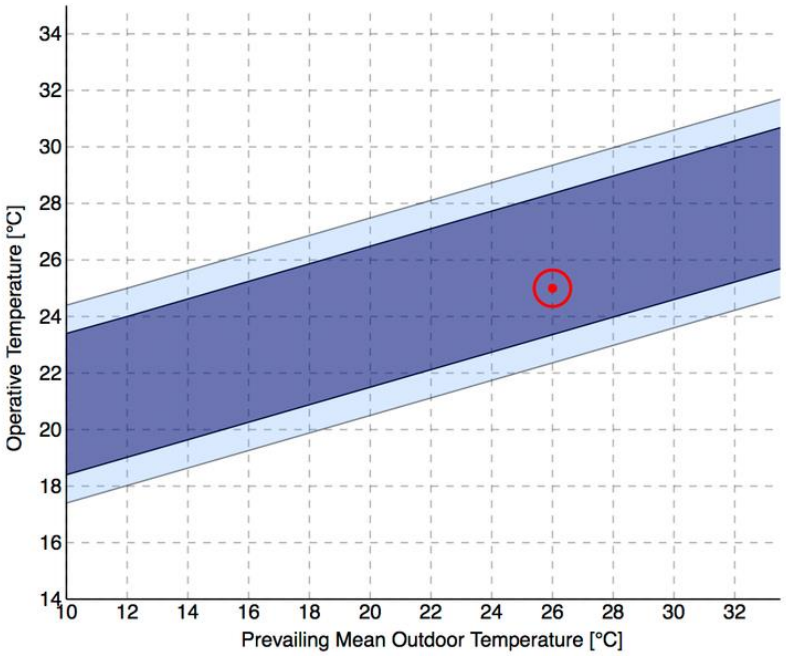
Indian Model for Adaptive Thermal Comfort (IMAC) models for neutral temperature and acceptability limits for naturally ventilated residential buildings through an empirical field study specific to the Indian context. It offers an energy-efficient pathway for the building sector without compromising occupant comfort.



Composite Location: Rajkot			
Months	Description	90% Acceptability Temperature (degC.)	80% Acceptability Temperature (degC.)
Jan	Minimum	24.13	22.68
	T nuet	26.28	26.28
	Maximum	28.43	29.88
Feb	Minimum	25.52	24.07
	T nuet	27.67	27.67
	Maximum	29.82	31.27
Mar	Minimum	26.87	25.42
	T nuet	29.02	29.02
	Maximum	31.17	32.62
Apr	Minimum	28.48	27.03
	T nuet	30.63	30.63
	Maximum	32.78	34.23
May	Minimum	28.78	27.33
	T nuet	30.93	30.93
	Maximum	33.08	34.53
Jun	Minimum	28.58	27.13
	T nuet	30.73	30.73
	Maximum	32.88	34.33
Jul	Minimum	27.38	25.93
	T nuet	29.53	29.53
	Maximum	31.68	33.13
Aug	Minimum	27.04	25.59
	T nuet	29.19	29.19
	Maximum	31.34	32.79
Sep	Minimum	27.09	25.64
	T nuet	29.24	29.24
	Maximum	31.39	32.84
Oct	Minimum	27.83	26.38
	T nuet	29.98	29.98
	Maximum	32.13	33.58
Nov	Minimum	26.56	25.11
	T nuet	28.71	28.71
	Maximum	30.86	32.31
Dec	Minimum	25.11	23.66
	T nuet	27.26	27.26
	Maximum	29.41	30.86

Thermal Comfort Standard – ASHRAE 55

- The adaptive model is based on the idea that outdoor climate influences indoor comfort because humans can adapt to different temperatures during different times of the year.
- These results were incorporated in the ASHRAE 55-2004 standard as the adaptive comfort model. The adaptive chart relates indoor comfort temperature to prevailing outdoor temperature and defines zones of 80% and 90% satisfaction.
- This model applies especially to occupant-controlled, natural-conditioned spaces, where the outdoor climate can actually affect the indoor conditions and so the comfort zone.
- Adaptive models of thermal comfort are implemented in other standards, such as European EN 15251 and ISO 7730 standard.
- There are basically three categories of thermal adaptation, namely: behavioral, physiological, and psychological.



Thermal Comfort Standard – ASHRAE 55

Summer design conditions: 22.5 to 26.1 ^{0}C RH 60%

Winter design conditions: 20.0 to 23.9 ^{0}C RH 60%

- The comfort zone is considered to be sufficiently comfortable if at least **80%** of its occupants can be expected to not object to the ambient condition, meaning that the majority are between **-0.5 and 0.5** on the PMV scale.

E1. THERMAL ENVIRONMENT POINT-IN-TIME SURVEY

1. **Record the approximate outside-air temperature _____ and seasonal conditions:**

☐ Winter ☐ Spring ☐ Summer ☐ Fall

2. **What is your general thermal sensation? (Check the one that is most appropriate)**

(Note to survey designer: This scale must be used as-is to keep the survey consistent with ASHRAE Standard 55.)

☐ Hot
☐ Warm
☐ Slightly Warm
☐ Neutral
☐ Slightly Cool
☐ Cool
☐ Cold

5. **Are you near an exterior wall (within 15 ft)?**

☐ Yes
☐ No

6. **Are you near a window (within 15 ft)?**

☐ Yes
☐ No

7. **Using the list below, please check each item of clothing that you are wearing right now. (Check all that apply):**

(Note to survey designer: This list can be modified at your discretion.)

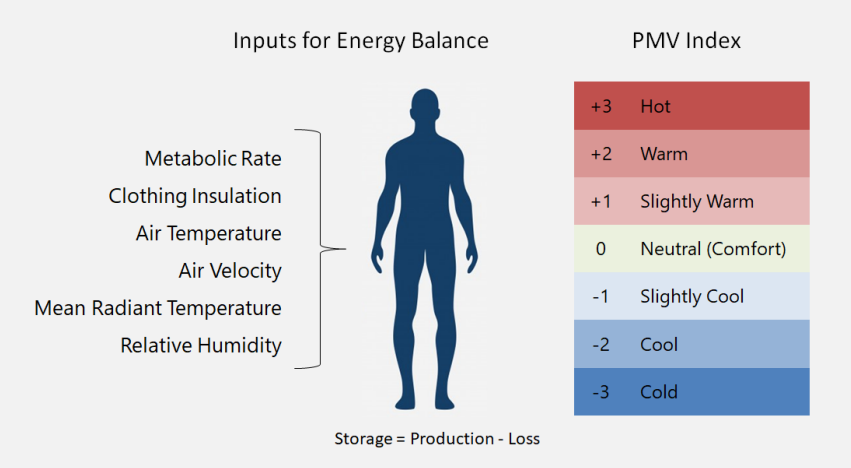
☐ Short-Sleeve Shirt	☐ Dress	☐ Nylons
☐ Long-Sleeve Shirt	☐ Shorts	☐ Socks
☐ T-shirt	☐ Athletic Sweatpants	☐ Boots

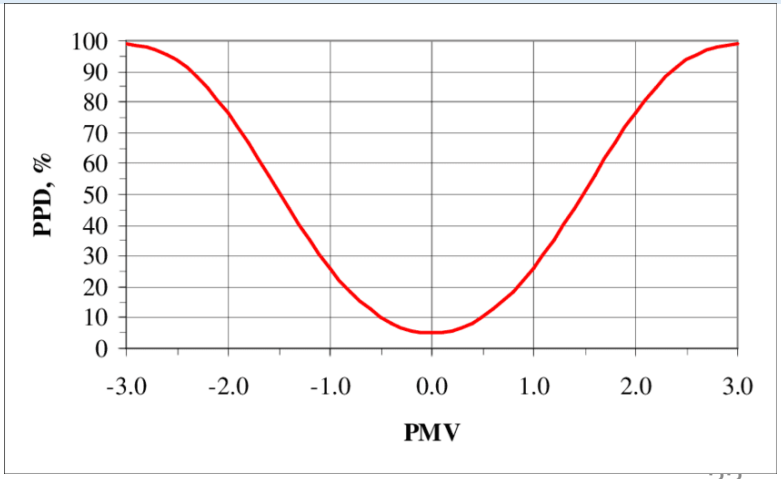
ANSI/ASHRAE Standard 55-2020
(Supersedes ANSI/ASHRAE Standard 55-2017)
Includes ANSI/ASHRAE addenda listed in Appendix N

Thermal Environmental Conditions for Human Occupancy

Thermal Comfort Standard – ASHRAE 55

- **Predicted mean vote (PMV)** is an index that predicts the mean value of the thermal sensation votes (self-reported perceptions) of a large group of persons on a sensation scale expressed from –3 to +3 corresponding to the categories
- **Predicted percentage of dissatisfied (PPD)** is an index that establishes a quantitative prediction of the percentage of thermally dissatisfied people





Effects of Materials on Thermal comfort

Thermal Comfort Improvement through Materials

Materials without Insulation

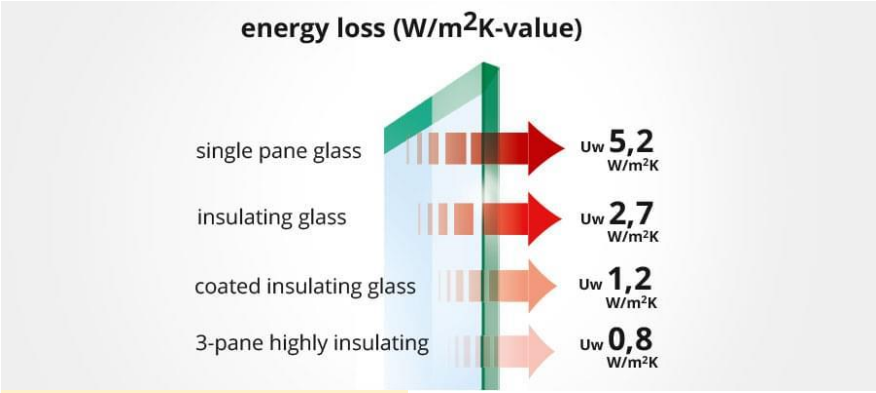
Wall materials	U Value (W/sqmK)
150 mm RCC (No plaster)	3.77
200 mm Solid Concrete Block with plaster on both sides	2.8
230 mm Brick with plaster on both sides	1.72-2.24
200 mm Autoclaved Aerated Concrete (AAC) with plaster on both side	0.77
300 mm Autoclaved Aerated Concrete (AAC) with plaster on both side	0.54

Thermal Comfort Improvement through Materials

EPS Insulation

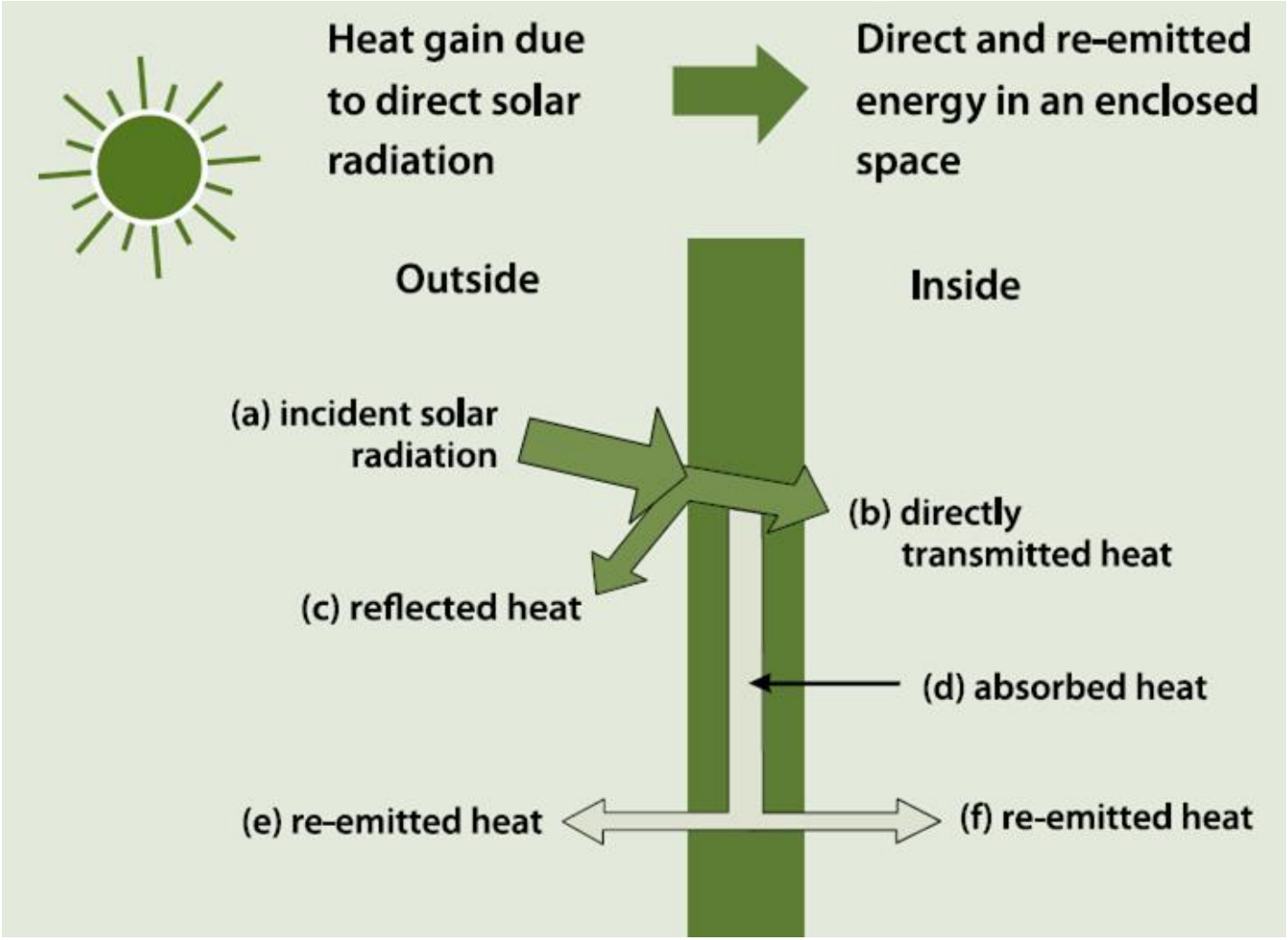
XPS Insulation

Glass Mineral Wool



Glazing Options

Thermal Comfort Improvement through Materials



Thermal Comfort Improvement through Materials

Glazing Selection

U-value / U-factor

- Conductive Heat Transfer
- Thermal conductivity (W/sqmK)
- Glass & Frame
- Lower the better??

VLT – Visual Light Transmission

- Light passing through the glass
- Ratio
- Useful light vs Glare
- Higher the better??

SHGC – Solar Heat Gain Coefficient

- Radiation Transmission
- Amount of Heat passes through the glass
- Lower the better??

Selectivity

- VLT / Solar Factor
- Ratio
- Higher the better??

Case Study

Case Study : Smart Ghar, Rajkot

A CASE STUDY ON DESIGN OF THERMALLY COMFORTABLE AFFORDABLE HOUSING IN COMPOSITE CLIMATE: SIMULATION RESULTS & MONITORED PERFORMANCE

by

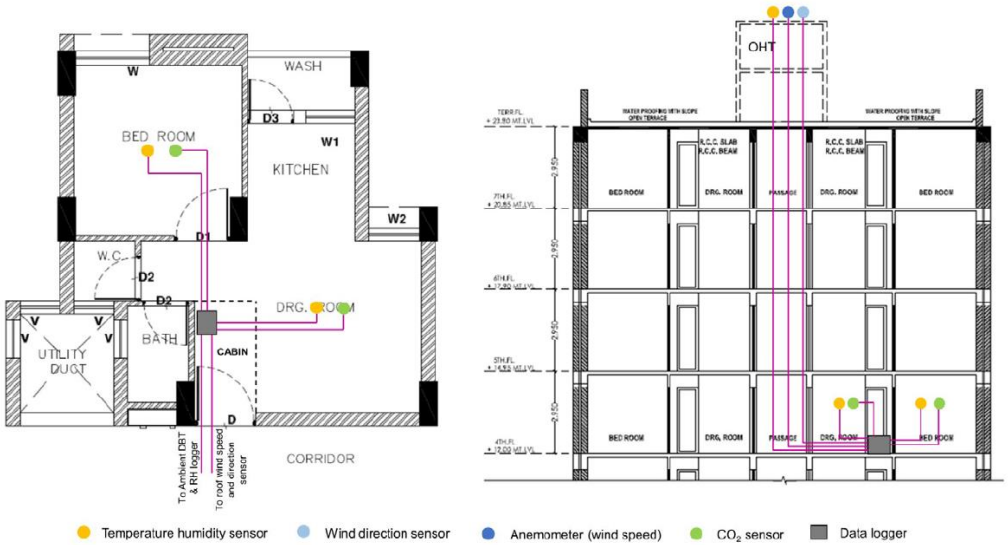
Saswati Chetia, Sameer Maithel, Pierre Jaboyedoff, Ashok Lall, Prashant Bhanware, Akshat Gupta

- Project Type - *PMAY Housing*
- Location - *Rajkot*
- Dwelling Units - *1176*
- DU Area - *33.6 m^2*
- Ext Wall – *200mm AAC (E&N) & Cavity Wall (200mm AAC + 40mm air gap + 200mm AAC) (W&S Side)*
- Casement windows – for ventilation improvement
- Window shading – *Overhang & Side fins*
- *Glazed window*

Case Study : Smart Ghar, Rajkot

Validation by Software

- Simulated period - May 12, 2019 to May 22, 2019
- Software used - DesignBuilder 4.7 (EnergyPlus 8.3 simulation engine)

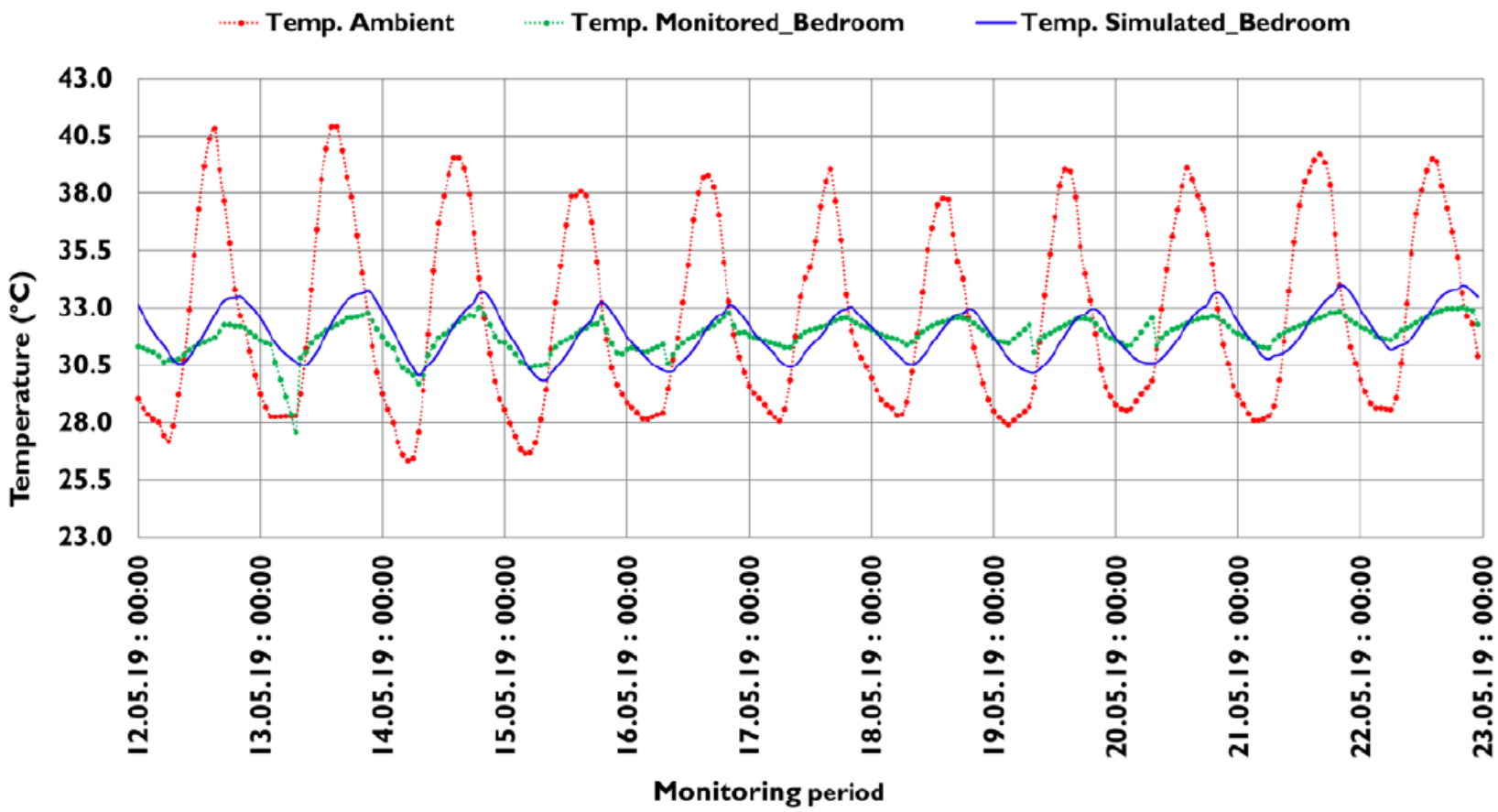


Results

- Indoor temperature for the bedroom goes up to a **maximum average of 32.7°C during the day** and minimum average of 30.6°C early morning. The maximum average ambient temperature was 39.3°C, while the average minimum ambient temperature was 27.8 °C.
- Thus compared to the diurnal variation of 11.5 °C in the ambient temperatures, the diurnal variation in indoor temperature was only 2.1 °C.

Case Study : Smart Ghar, Rajkot

Observations



Case Study : Smart Ghar, Rajkot

Results

- For the present study, the Indian Model for Adaptive Comfort (IMAC) is chosen as the thermal comfort model. It is observed that all hours of the monitored period falls within the 80% acceptability limits whereas 87% of the monitored period falls within the 90% acceptability limits.

Conclusion

- *The results of the monitoring show a **quantifiable impact of building envelope** (both construction material and openings for ventilation) on internal temperatures.*
- *It shows that with building envelope interventions it is possible to get maximum average temperature of 32°C in summer when the average maximum ambient temperature is 39°C, thus, increasing comfortable hours and reducing the need for air-conditioning.*

Eco Niwas Samhita

Eco Niwas Samhita (ENS)

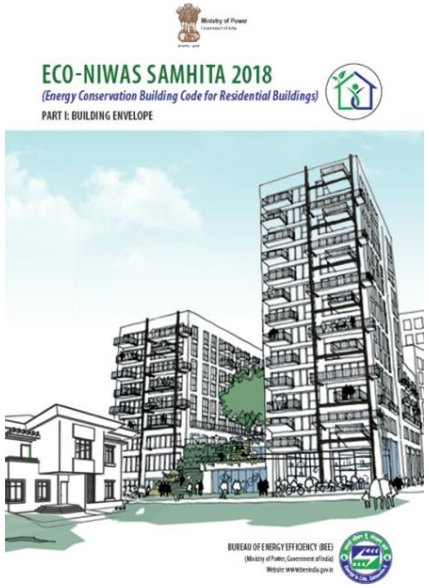
BEE
(BUREAU OF ENERGY EFFICIENCY)

Government of India

+

GIZ
(Deutsche Gesellschaft für Internationale Zusammenarbeit)

Government of Germany



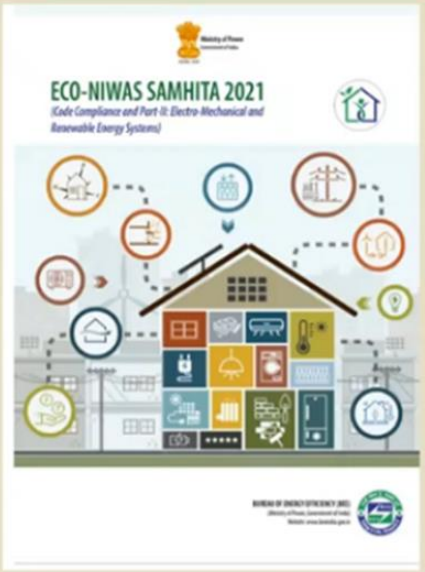
Eco Niwas Samhita Part 1

Launch of Eco Niwas Samhita in December 2018

Eco Niwas Samhita (ENS)

EcoNiwas Samhita 2018
Part 1: Building Envelope

EcoNiwas Samhita 2021
Code Compliance and Part 2



ECO Niwas Samhita – The EE code for residential buildings is now comprised of 2 parts

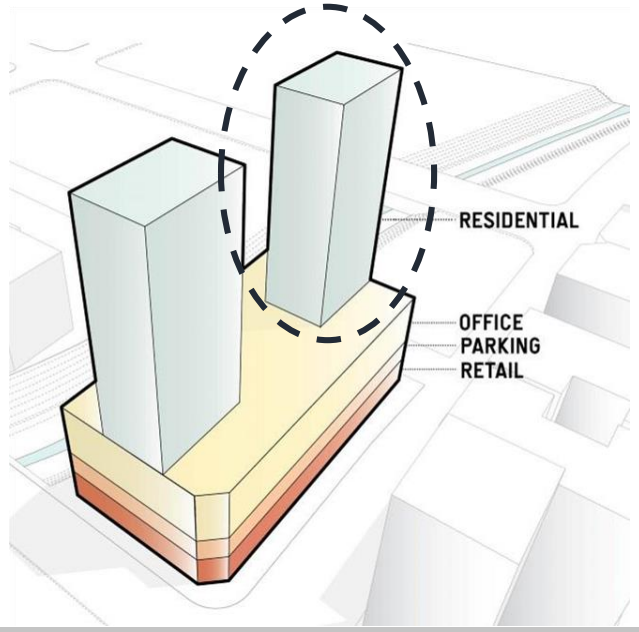
Scope of ENS

New building	• Residential Buildings with (Plot area ≥ 500Sqm) built up area of 800 sqm/ Connected load ≥ 35kW
Mixed Land Use	• Residential part of "Mixed Land-use building projects" with (Plot area ≥ 500Sqm) built up area of 800 sqm/ Connected load ≥ 35kW
Additions	• All additions made to existing residential buildings with (Plot area ≥ 500Sqm) built up area of 800 sqm/ Connected load ≥ 35kW
Alterations	• Alterations made to existing residential buildings with (Plot area ≥ 500Sqm) built up area of 800 sqm/ Connected load ≥ 35kW

Eco Niwas Samhita (ENS)

The code is applicable to

(a)Residential Buildings with **plot area ≥ 500m²**



(b) Residential part of **"Mixed Land-use building projects" built on plot area of ≥ 500m².**

Excluded from the code

Dormitories

Hotels

Lodging Rooms

Scope of ENS (Setting Minimum Requirement)

Building Envelope
- Opaque Construction Materials
- Fenestration U-factors
- Solar Heat Gain Coefficients (SHGC)
- Visible Light Transmittance (VLT)
- Overhangs +Fins
- Operable Window Area

+

Building Services
- Common Area Lighting
- Pump Efficiencies
- Elevator Technologies
- Transformer Losses
- Power Factor Correction
- Basement Ventilation
- Charging Infrastructure
- Electrical Metering & Monitoring

+

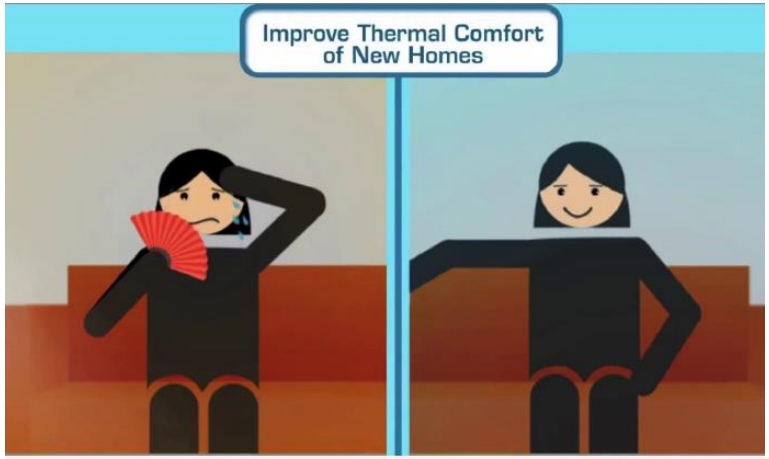
Indoor Electrical End Use
- Indoor Lighting
- Automatic Lighting Shutoff
- Occupancy Sensors
- Ceiling Fan Star Labelling
- Service Hot Water
- Air Conditioner system, sizes, efficiencies and controls

+

Renewable Energy Systems
- System Peak Generation Capacity
- Solar Water Heating System
- Technical Specifications
- Renewable Energy Zone Area

Eco Niwas Samhita (ENS) Benefits

Improve Thermal Comforts



Reduce Electricity Bills

Estimated Impact Of Implementing Eco Niwas Samhita

- Minimum **20% energy saving** as compared to a typical Building
- **125 billion KWH** of electricity Saving
- **100 million tonnes of CO_2** equivalent abatement

ENS – Part 1 – Building Envelope

Performance Standards for Building Envelope

- 3.1 Openable Window to Floor Area Ratio (WFR_{op}) → For Natural Ventilation
- 3.2 Visible Light Transmittance (VLT)- Derived from WWR → For Day Light Potential
- 3.3 Thermal Transmittance of Roof (U_{roof}) → For Thermal Transmission
- 3.4 Residential Envelope Transmittance Value (RETV) → For Thermal Transmission
- 3.5 Thermal Transmittance for Cold Climate ($U_{envelope,cold}$) → For Thermal Transmission

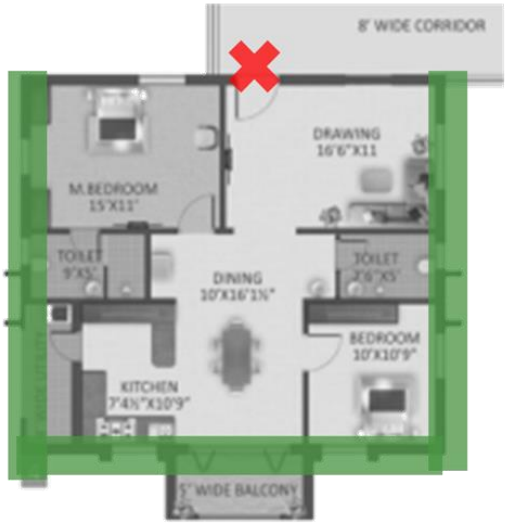
ENS – Part 1 – Building Envelope

3.1 Openable Window to Floor Area Ratio (WFR_{op})

$$WFR_{op} = \frac{A_{openable}}{A_{carpet}}$$

Window to floor area ratio is the ratio of Openable area to the carpet area of the dwelling Units.

Openable Area



Windows, Ventilators, opening directly to
- External air,
- Open balcony,
- Corridor,
- Shaft

Doors opening directly into
- Open balcony

Carpet Area

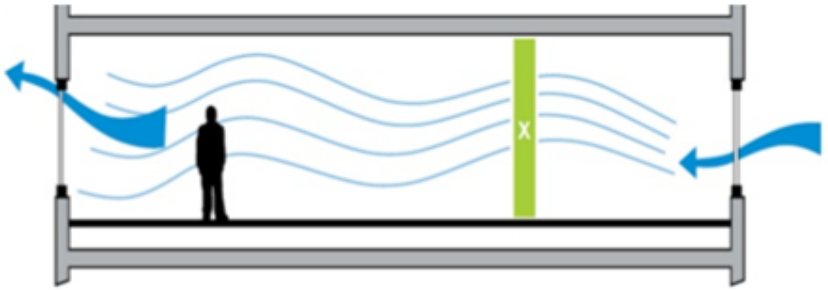
- Total Internal Area of the habitable space Balconies - Excluded

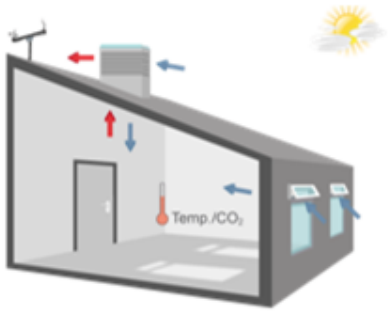
ENS – Part 1 – Building Envelope

3.1 Openable Window to Floor Area Ratio (WFR_{op})

Minimum WFRop helps in

- Natural Ventilation
- Improvement in Thermal Comfort
- Reduction in Cooling Energy Loads





Minimum requirement of window-to-floor area Ratio

Climate Zone	Minimum WFRop
Composite	12.50
Hot-Dry	10.00
Warm-Humid	16.66
Temperate	12.50
Cold	8.33

Openable Area Percentages (In case the exact Openable is not known)

Type of Window/Door/ Ventilator	Percentage Openable Area
Casement	90%
Sliding (2 Panes)	50%
Sliding (3 Panes)	67%

ENS – Part 1 – Building Envelope

3.2 Window to Wall Area Ratio (WWR)

$$WWR = \frac{A_{non-opaque}}{A_{envelope}}$$

WWR – Window to wall area ratio
Area (non-opaque) –
Total glass area in the opening .
Excluded - Opaque part of the total opening size.
Area(Envelope) –
Total envelope area of all facades.
Included – opaque and non-opaque

*** Note for WWR ≤ 0.15 , VLT – 40%**

Relation between WWR and Visual Light Transmittance

Window to Wall Ratio (WWR)	Minimum VLT
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

ENS – Part 1 – Building Envelope

3.3 Thermal Transmittance (U_{roof})

Thermal Transmittance of roof U_{roof} - Is the rate of transfer of heat through the roof structure (which can be a single material or an assembly), divided by the difference in temperature across that structure.

Limiting U_{roof} by helps in reducing heat gains or losses from the roof. Ex : Insulation, Cool Roofs, Green Roofs

Thermal transmittance of roof shall comply with U_{roof} value – 1.2 W/m^2.k

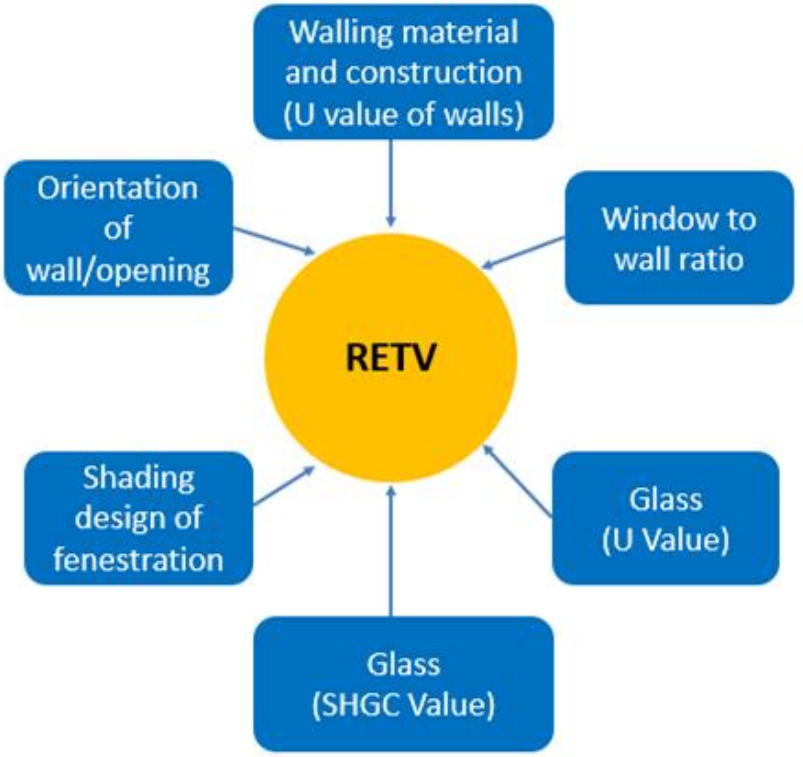
ENS – Part 1 – Building Envelope

3.4 Residential Envelope Transmittance (RETV)

Solar Radiation through non-opaque surfaces

Conduction through opaque surfaces

Conduction through non-opaque surfaces



ENS – Part 1 – Building Envelope

3.4 Residential Envelope Transmittance (RETV)

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)		

RETV for the building envelope (except roof) for four climate zones, namely, Composite Climate, Hot-Dry Climate, Warm-Humid Climate and Temperate Climate shall comply with the maximum RETV of **15 W/m²**

ENS – Part 1 – Building Envelope

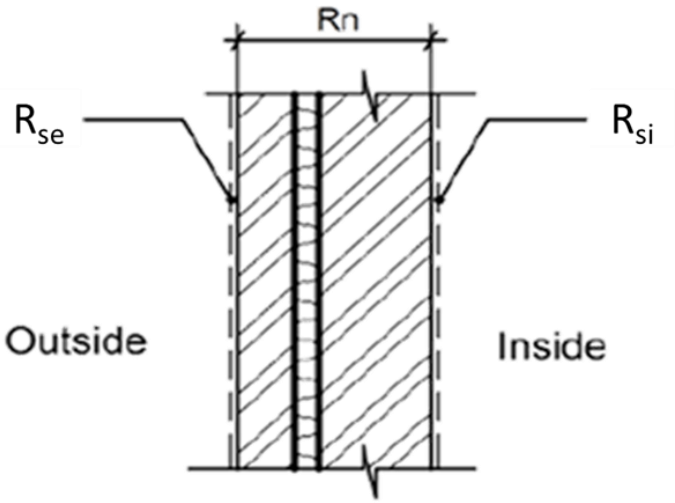
3.4 Thermal Transmittance Value (U-Value) Non Opaque

$$U = 1 / R_t$$

$$U = 1/ (R_{so} + \sum R_n + R_{si})$$

U-value is the reciprocal of Thermal Resistance (R)

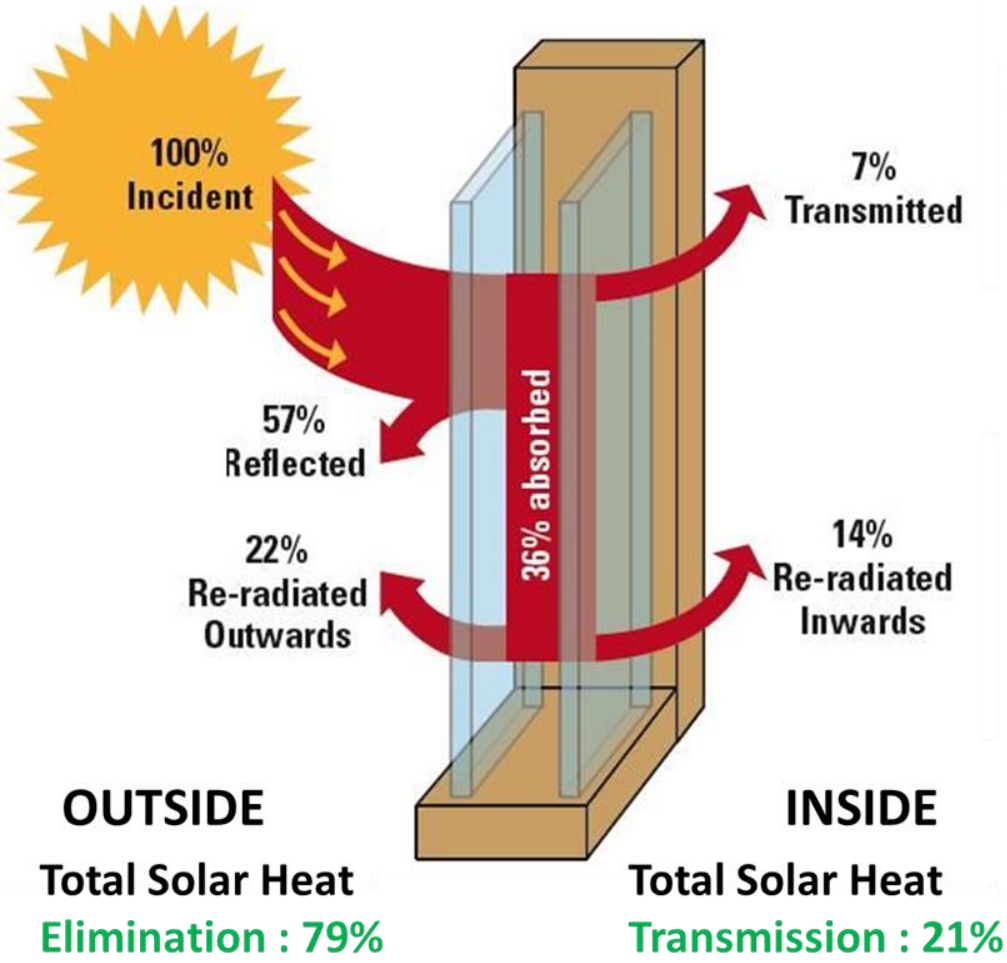
	Wall	Roof	
	All climatic Zones	Composite , Hot-Dry, Warm-humid, and Temperate climate	Cold climate
Rsi (m2.K/W)	0.13	0.17	0.10
Rse (m2.K/W)	0.04	0.04	0.04

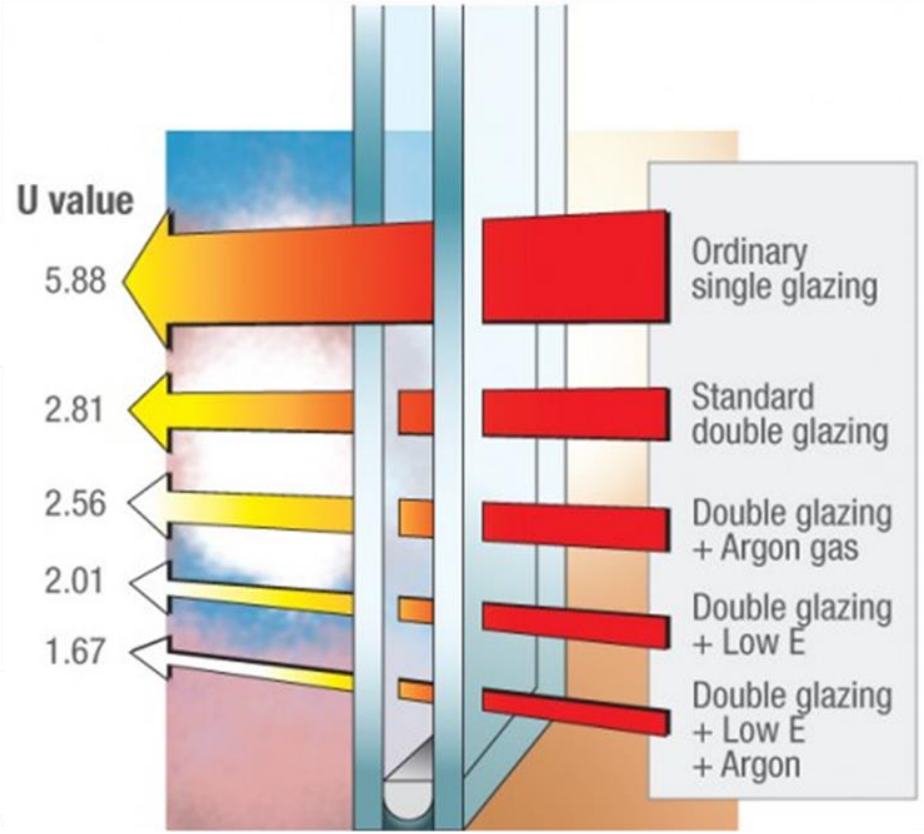


Source: Eco Niwas Samhita -2018, Table 6, Annexure - 5

ENS – Part 1 – Building Envelope

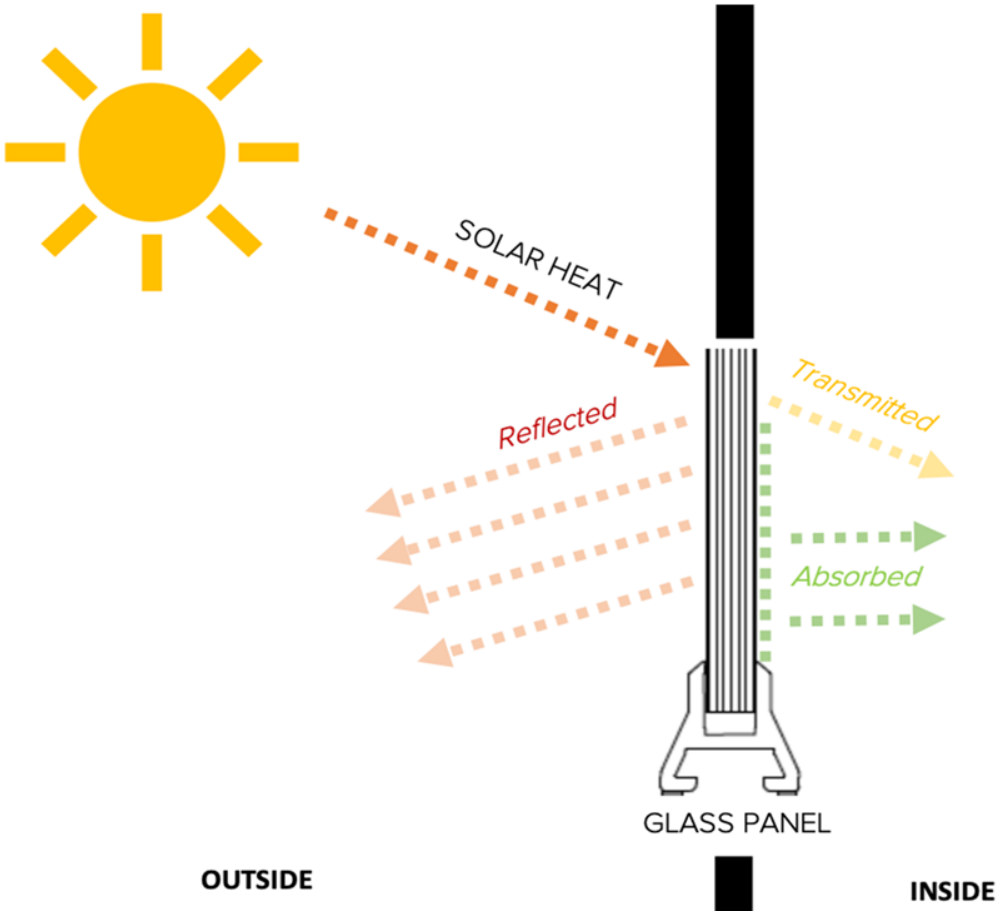
3.4 Thermal Transmittance Value (U-Value) Non Opaque





ENS – Part 1 – Building Envelope

3.4 Solar Heat Gain Coefficient (SHGC) Non Opaque



Solar heat gain coefficient is the measure of solar heat –

- Absorbed
- Transmitted

Lower SHGC ∝ lesser Heat Transfer

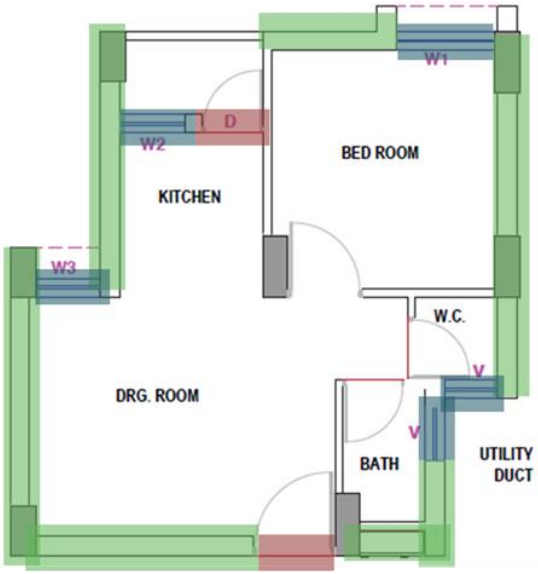
Solar Radiation is subsequently released inward through conduction, convection and radiation.

ENS – Part 1 – Building Envelope

3.5 Thermal Transmittance – Wall (Except roof) for Cold Climate (U envelope, cold)

$$U_{envelope,cold} = \frac{1}{A_{envelope}}\left[\sum_{i=1}^{n}(U_i \times A_i)\right]$$

➢The thermal transmittance of the building envelope (except roof) for cold climate shall comply with the maximum of **1.8 w/M²K**



	Area (sq mt)	U- value (w/m²k)
Wall (opaque)	2793.38	0.78
Door (opaque)	210	5.23
Window (non-opaque)	475.88	5.80

AAC Wall
Wooden Door
Glass Window

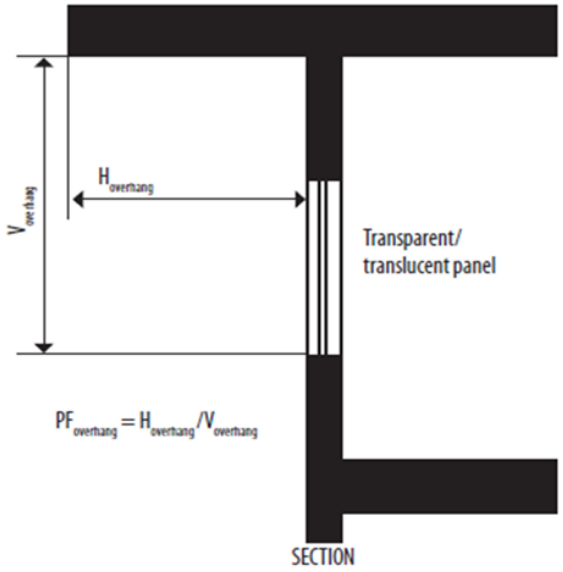
$$U_{envelope,cold} = \frac{(2793.38\times0.78)+(210.00\times5.23)+(474.88\times5.80)}{2793.38+210.00+474.88} = 1.73 \ W/m^2.K$$

ENS – Part 1 – Building Envelope

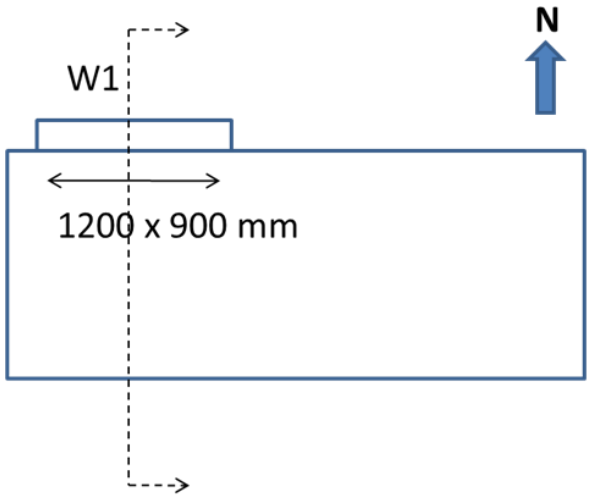
3.4 Projection Factor (PF)

Projection Factor (PF) is the ratio of the horizontal depth of the external shading projection ($H_{overhang}$) to the bottom of the farthest point of the external shading projection ($V_{overhang}$), in consistent units.

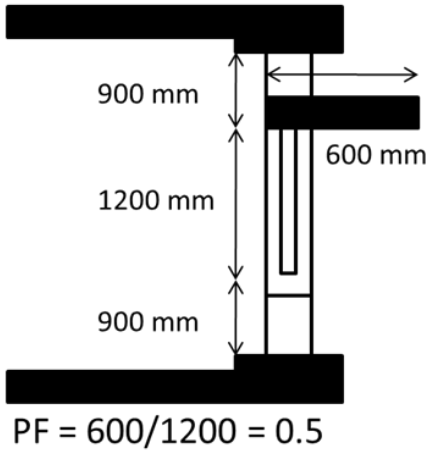
$$PF_{overhang} = \frac{H_{overhang}}{V_{overhang}}$$



Solved exercise: Considering a room size of 3m * 5m, with a window W1 shown in plan and section. The projection factor for the same is calculated, to arrive at the ESF (Effective Shading Factor). Glass parameters; Single Glazing Unit (SGU), U value = 5.6 W/m2 K, SHGC = 0.6, VLT = 0.7



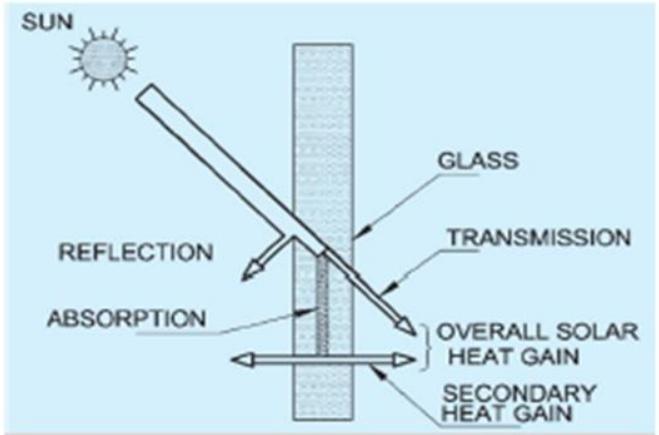
Plan



Section

ENS – Part 1 – Building Envelope

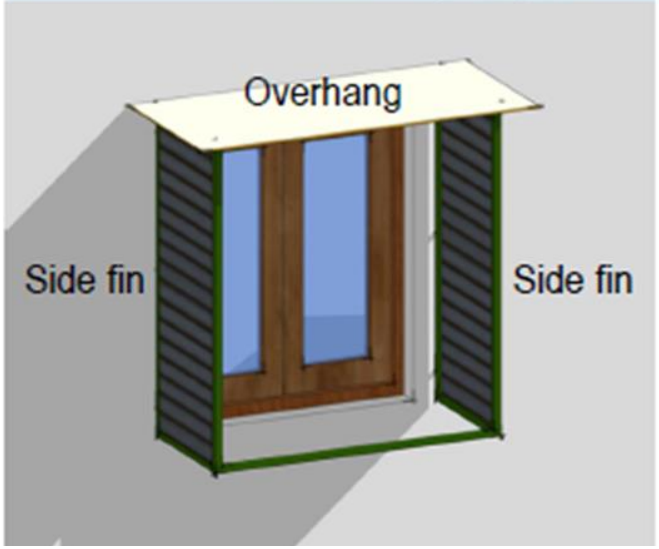
3.4 Equivalent SHGC



$$SHGC_{unshaded} = \frac{\text{Transmission + Secondary heat gain}}{\text{Incident Solar radiation}}$$

External Shading (overhang,side fins)cut the solar radiation

External Shading Factor ($ESF_{total} \leq 1$) accounts the impact of shading.



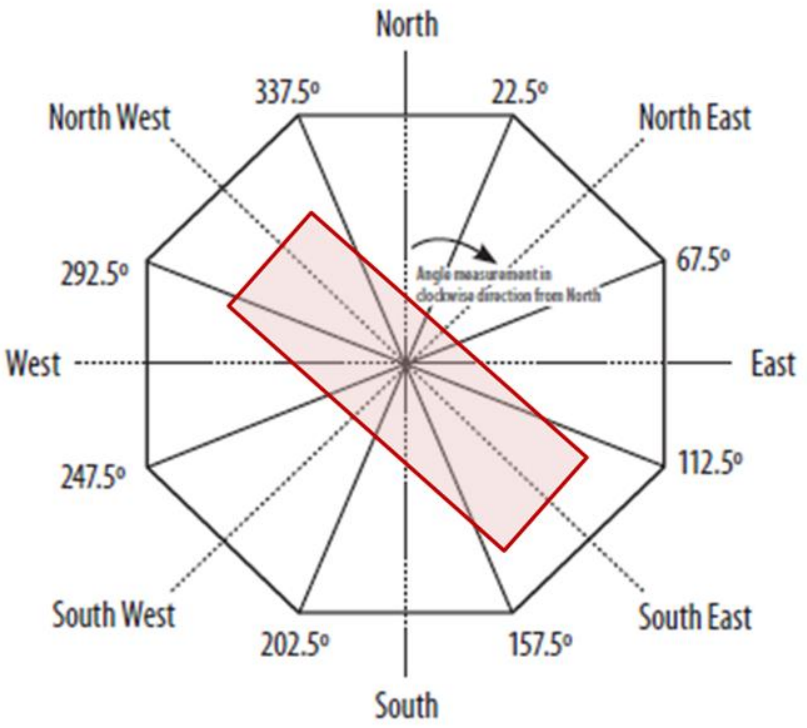
$$SHGC_{eq} = SHGC_{unshaded} \times ESF_{total}$$

ENS – Part 1 – Building Envelope

3.4 Orientation Factor

The orientation factor (ω) is a measure of the amount of direct and diffused solar radiation that is received on the vertical surface in a specific orientation

Orientation	Orientation factor (ω) Latitudes <23.5°N
North (337.6°–22.5°)	0.659
North-east (22.6°–67.5°)	0.906
East (67.6°–112.5°)	1.155
South-east (112.6°–157.5°)	1.125
South (157.6°–202.5°)	0.966
South-west (202.6°–247.5°)	1.124
West (247.6°–292.5°)	1.156
North-west (292.6°–337.5°)	0.908



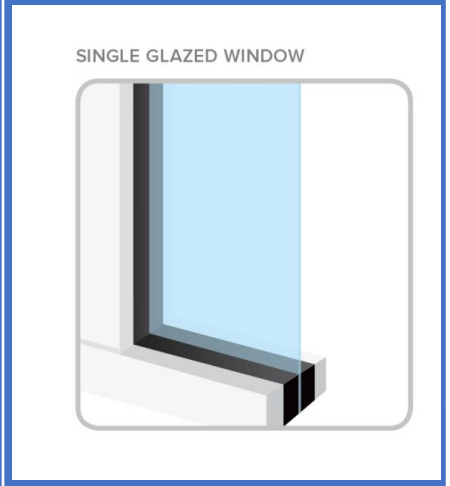
ENS – Part 1 – Building Envelope

3.4 RETV – Case 1

Case 1	External wall	Roof Construction	Glazing	Window to wall Ratio
 	230mm thick Solid Burnt Clay Brick	150 mm thick RCC slab + 50mm thick EPS	50 mm Steel Frame; Single glazed Unit U Value = 5.7 W/m2k, SHGC = 0.56, VLT=0.51	22.55%
	RETV – 14.92 W/m^2.K			

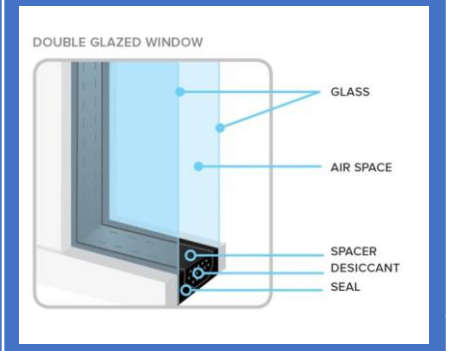
ENS – Part 1 – Building Envelope

3.4 RETV – Case 2

Case 2	External wall	Roof Construction	Glazing	Window to wall Ratio
 	200mm thick AAC Block wall	150 mm thick RCC slab + 50mm thick EPS	50 mm Steel Frame; Single glazed Unit U Value = 5.7 W/m2k, SHGC = 0.56, VLT=0.51	22.55%
	RETV – 9.71 W/m².K			

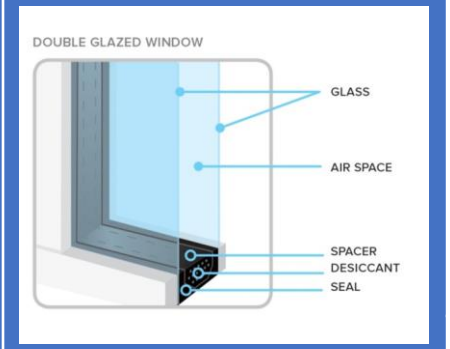
ENS – Part 1 – Building Envelope

3.4 RETV – Case 3

Case 3	External wall	Roof Construction	Glazing	Window to wall Ratio
 	200mm thick AAC Block wall	150 mm thick RCC slab + 50mm thick EPS	Double glazed Unit - Asahi LC 54/37 U Value = 1.64 W/m2k, SHGC = 0.36, VLT=0.52	22.55%
	RETV – 6.62 W/m^2.K			

ENS – Part 1 – Building Envelope

3.4 RETV – Case 4

Case 4	External wall	Roof Construction	Glazing	Window to wall Ratio
 	200mm thick AAC wall, 50 mm EPS, high SRI paint	150 mm thick RCC slab + 50mm thick EPS	Double glazed Unit - Asahi LC 54/37 U Value = 1.64 W/m2k, SHGC = 0.36, VLT=0.52	22.55%
	RETV – 5.13 W/m².K			

ENS – Part 1 – Building Envelope

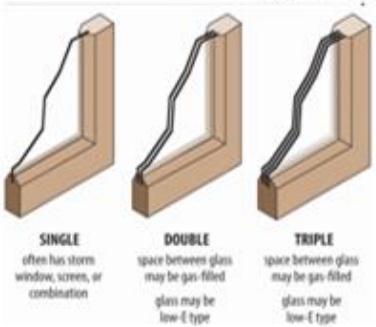
Building Design Flexibility by ENS

Material wall Assembly

Design of Window Panel

Shading of external Windows

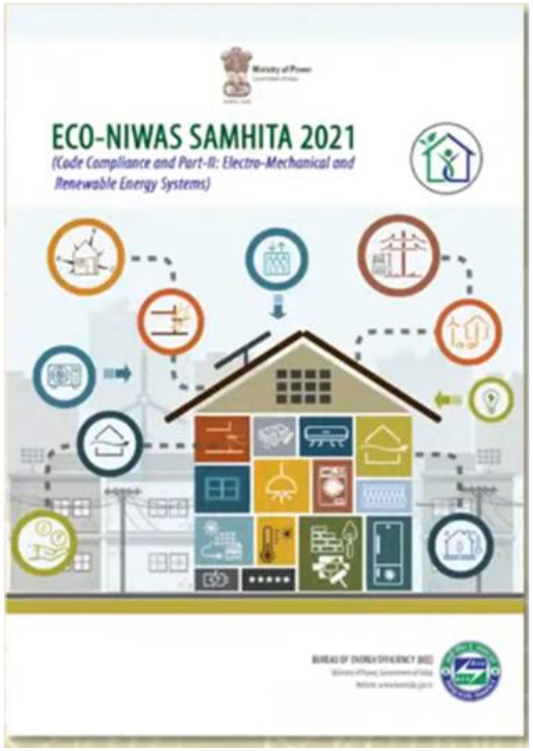
Type of glazing



ENS Part 2

ENS – Part 2 – Services

CODE PROVISIONS



- **Building Services**
  - Common Area & Exterior Lighting
  - Elevators
  - Electrical Systems
  - Pumps
- **Indoor End Electrical Use**
  - Indoor Lighting
  - Comfort Systems
- **Renewable Energy Systems**
  - Solar Water Heating
  - Solar Photo-Voltic

ENS – Part 2 - Code Compliance

Low Rise Buildings:

A building equal or below 4 stories, and/or a building **up to 15 meters in height** (without stilt) and up to 17.5 meters (including stilt).

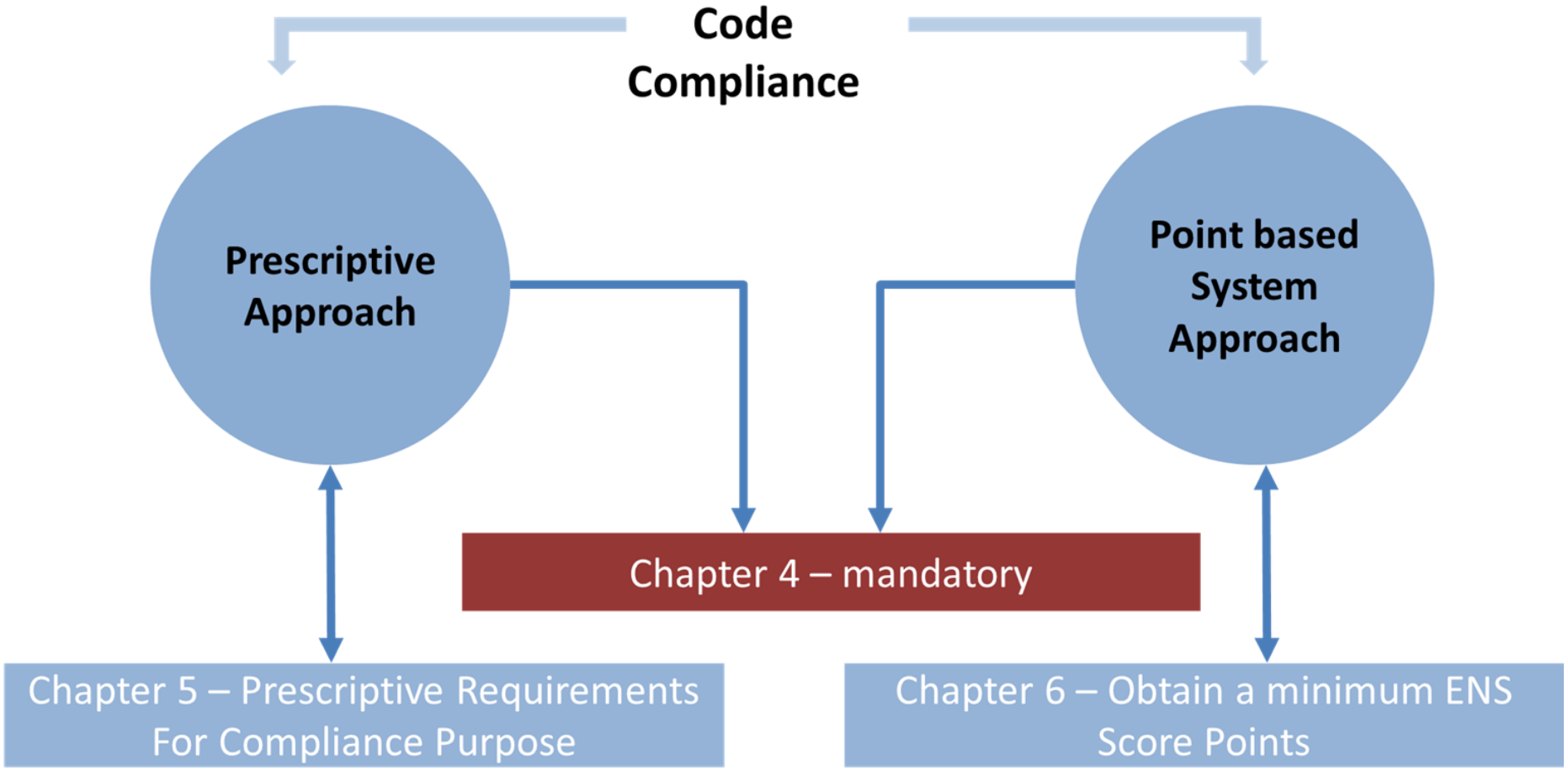
Affordable Housing Projects:

Affordable houses are Dwelling Units (DUs) with **Carpet Area less than 60 sqm**. It also includes **Economically Weaker Section (EWS) category and Lower Income Group (LIG)** category **(LIG-A: 28-40 sq. m. and LIG-B 41-60 Sq.m.)**.

High Rise Buildings:

A building above 4 stories, and/or a building **exceeding 15 meters** or more in height (without stilt) and 17.5 meters (including stilt).

ENS – Part 2 - Code Compliance



ENS – Part 2 - Documentation

Building Envelope
- Opaque Construction Materials
- Fenestration U-factors
- Solar Heat Gain Coefficients (SHGC)
- Visible Light Transmittance (VLT)
- Overhangs +Fins
- Operable Window Area

+

Building Services
- Common Area Lighting
- Pump Efficiencies
- Elevator Technologies
- Transformer Losses
- Power Factor Correction
- Basement Ventilation
- Charging Infrastructure
- Electrical Metering & Monitoring

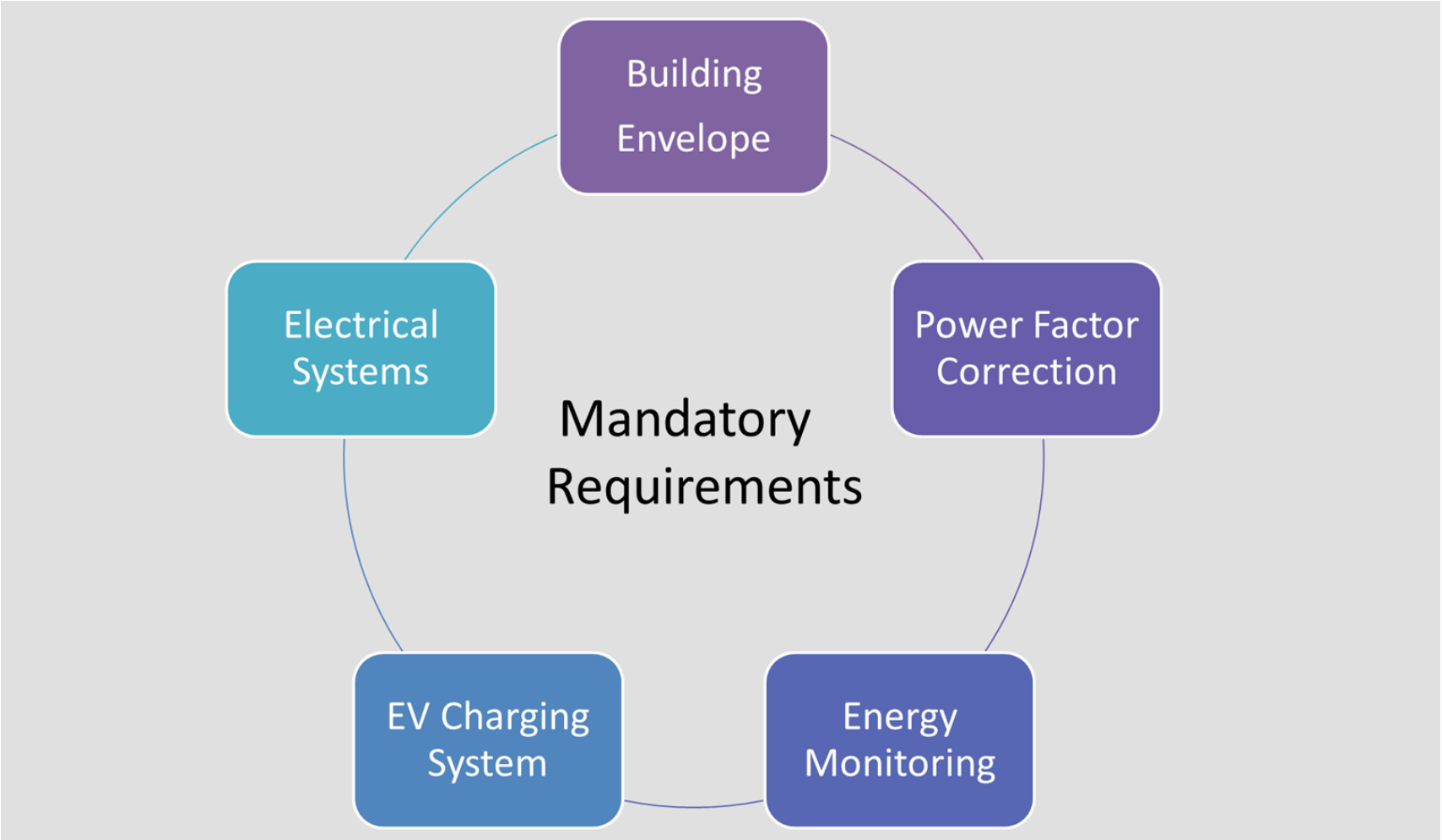
+

Indoor Electrical End Use
- Indoor Lighting
- Automatic Lighting Shutoff
- Occupancy Sensors
- Ceiling Fan Star Labelling
- Service Hot Water
- Air Conditioner system, sizes, efficiencies and controls

+

Renewable Energy Systems
- System Peak Generation Capacity
- Solar Water Heating System
- Technical Specifications
- Renewable Energy Zone Area

ENS – Part 2 - Mandatory Requirements



ENS – Part 2 - Mandatory Requirements

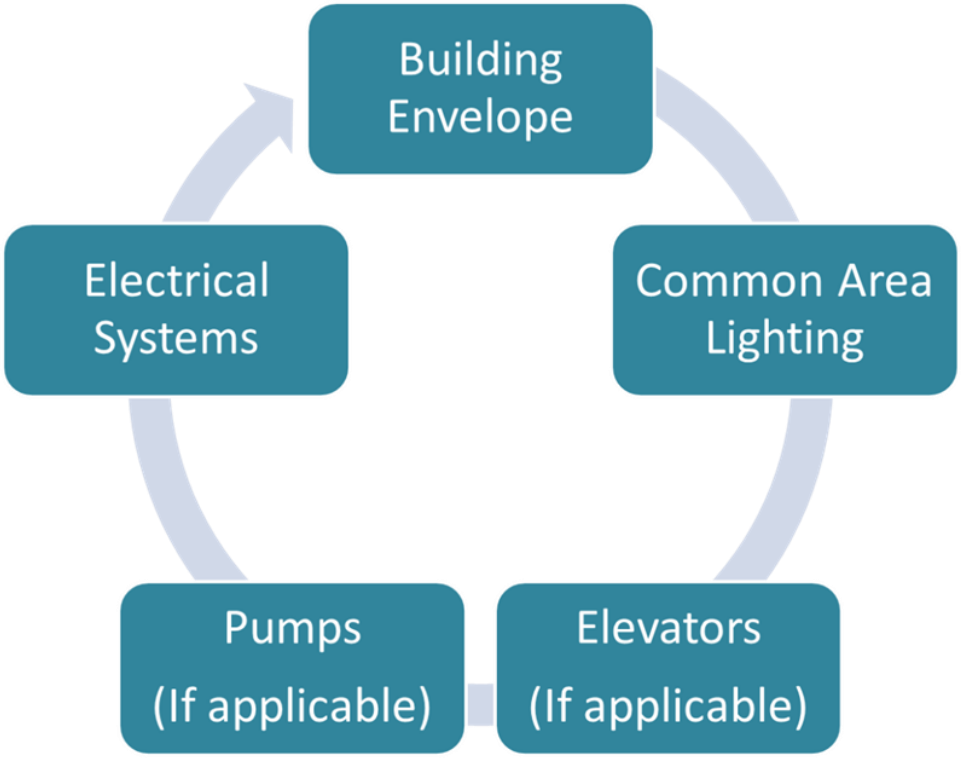
Chapter 4 of ENS Part I	Building Envelope
All 3 phase shall maintain the power factor of 0.97 at the point of connection	Power Factor Correction
Total Electrical Energy	Energy Monitoring
Electrical Consumption of Applicable End Use Systems	
Guidelines issued by Ministry of Power for EV Charging on Oct 1st 2019	EV Charging Systems
Electrical Consumption of Applicable End Use Systems	Electrical Systems

ENS – Part 2 - Prescription Requirements

Prescriptive Method:

To demonstrate compliance with ENS Code through Prescriptive method, ENS building shall meet the following:

- **Chapter 4** – Mandatory Requirements
- **Chapter 5** – Prescriptive Requirements



ENS – Part 2 - Prescription Requirements

Building Envelope:

ENS Code Prescriptive Method (Building Envelope)

- All requirements of Building Envelope including **Openable Window-to-Floor area ratio, Visible Light Transmittance** as per Chapter 4 of ENS Part 1
- **RETV for Building Envelope (except roof) for all climatic zones (except cold)** shall comply with the **Maximum RETV of 15W/m2.** Thermal Transmittance of Building Envelope for cold climate shall comply with **max U value of 1.3w/m2.K**
- **Thermal transmittance of roof** shall comply with the **maximum Uroof value of 1.2W/m2.K**

ENS – Part 2 - Code Compliance- Point Based System

Point based System Approach

Obtain a minimum ENS Score Points as in 6.1

Project Category	Minimum ENS Score
Low Rise Buildings	47
Affordable Housing	70
High Rise Buildings	100

Get Additional Points By

Additional Points
Additional Points of **Building Envelope** under section 6.4 and/or
Requirements labelled additional of **Building Services and Indoor Electrical End Use** under Section 6.5 /6.6 and/or
Requirement labelled additional of **Renewable Energy Systems** under 6.7

ENS – Part 2 - Code Compliance- Point Based System

Maximum Points are TOTAL Points available for each component

Minimum Points

- **Minimum Points** are set of points which are compulsory to achieve for each component to show compliance for ENS

Additional Points

- **Additional Points** are the set of points which are awarded for adopting additional or better energy efficiency measures in a respective component. These points are trade able with other components to achieve the total score mentioned in section 3.1.2 for ENS compliance

ENS – Part 2 - Code Compliance- Point Based System

Components	Minimum Points	Additional Points	Maximum Points
Building Envelope			
Building Envelope	47 Points	40 Points	87 Points
Building Services			
Common area & Exterior Lighting	3 Points	6 Points	9 Points
Elevators	13 Points	9 Points	22Points
Pumps	6 Points	8 Points	14 Points
Electrical Systems	1 Point	5 Points	6 Points
Indoor Electrical End Use			
Indoor Lighting		12 Points	12 Points
Comfort Systems		50 Points	50 Points
ENS SCORE	**70 Points**	**130 Points**	**200 Points**

ENS – Part 2 – Services

Common Area and Exterior Lighting

Common Areas	Maximum LPD (W/m2)	Minimum Luminous Efficacy (lm/W)
Corridor Lighting & Stilt Parking	3.0	All permanently installed lighting fixtures shall use lamps with an efficacy of at least 85 lumens per Watt
Basement Lighting	1.0	All permanently installed lighting fixtures shall use lamps with efficacy of at least 85 lumens per Watt

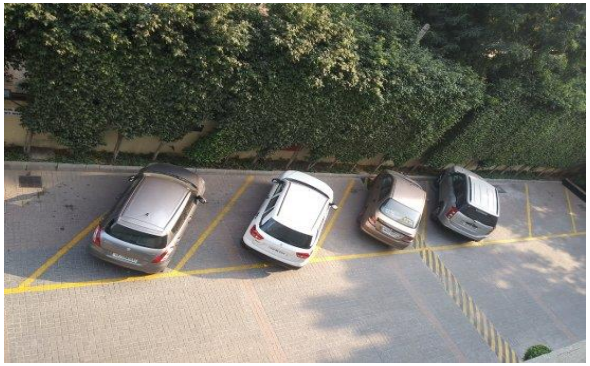

Corridor Lighting

85 LUMENS/WATT

ENS – Part 2 – Services

Common Area and Exterior Lighting

Exterior Lighting Areas/Zones	Maximum LPD (in W/m2)
Driveways and Parking	1.6
Pedestrian Walkways	2.0
Stairways	10.0
Landscaping	0.5
Outdoor Sales Areas	9.0



Parking (open/external)

Stairways

ENS – Part 2 – Services

Common Area and Exterior Lighting

Areas/Zones	Points 95lm/W	Points 105lm/W + Photo
Corridor Lighting and Stilt Parking	1	2
Basement Lighting	1	2
Exterior Lighting Areas	1	2

Basement Lighting

Exterior Lighting

Lighting Power Density (LPD)

Luminous Efficacy (LE)

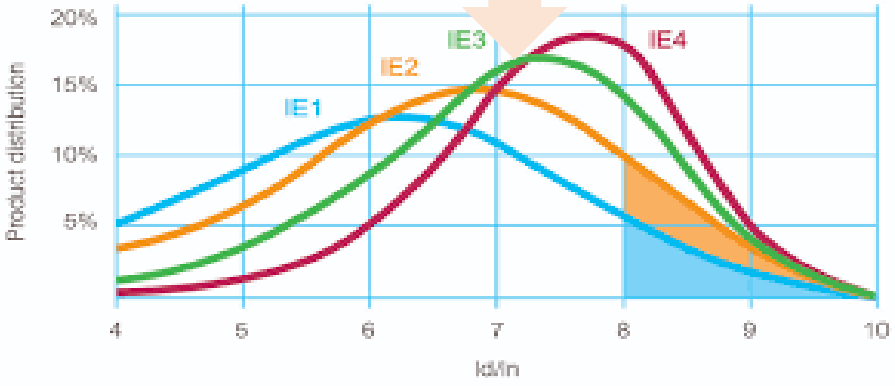
ENS – Part 2 – Services

Elevators – Maximum 22 points

High Efficacy lamps with Luminous Efficacy of 85lm/w

Auto Switch off for Light & Fan when not in use.

Min IE3 High Efficiency Motors

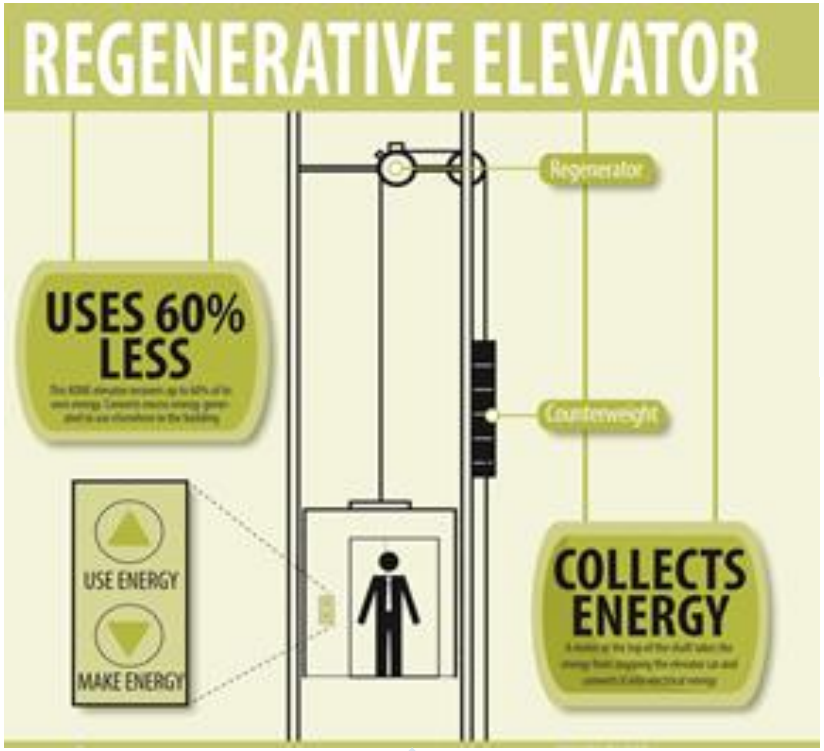


Group Automatic with Supervision

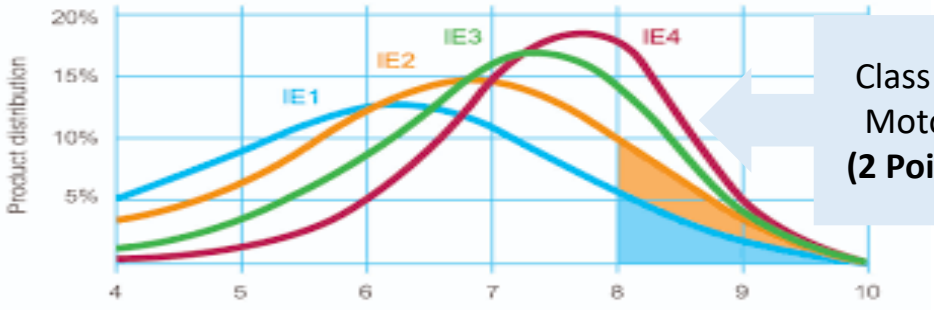
13 POINTS

ENS – Part 2 – Services

Elevators – Maximum 22 points



Regenerative Drives
(3 Points)



Class IE4 Motors
(2 Points)

Variable Voltage & Variable Frequency Drives
(4 Points)

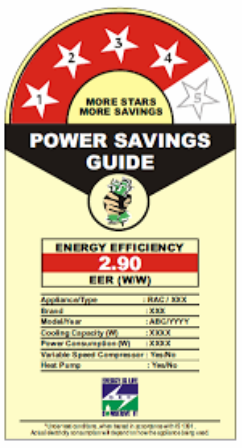
ENS – Part 2 – Services

Pumps – Maximum 14 points

Mechanical Efficiency

60%

OR



6 POINTS

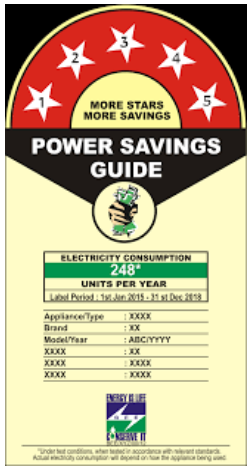
HYDRO-PNEUMATIC PUMPS

Installation of Hydro-Pneumatic Pumps or BEE Star rated pumps.

Mechanical Efficiency

70%

3 POINTS



5 POINTS

8 POINTS

ENS – Part 2 – Services

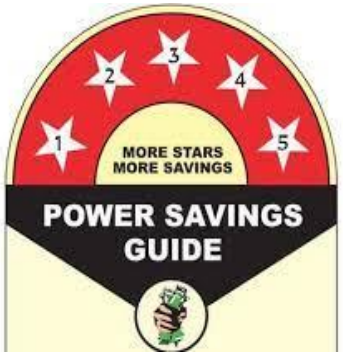
Electrical Systems – Maximum 6 points

POWER TRANFORMERS

- Power transformers to satisfy minimum acceptable efficiency at 50%
- Permissible loss as per Table 8 for dry type and Table 9 for Oil Type transformers

(13 POINTS)

OIL TYPE TRANFORMERS



Oil Type Transformers With BEE 5 STAR

(5 POINTS)

ENS – Part 2 – Services

Indoor Lighting– Maximum 12 points

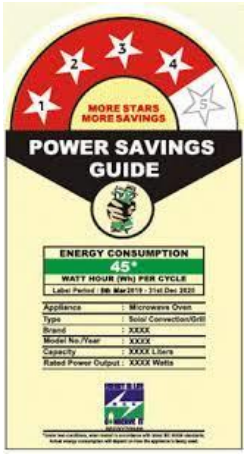
LIVING ROOM	BED ROOM	KITCHEN
		
 85lm/W ← 4 POINTS	 95lm/W ← 3 POINTS	 105lm/W ← 8 POINTS

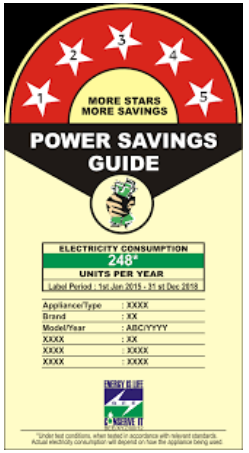
ENS – Part 2 – Services

Comfort Systems– Maximum 50 points

Ceiling Fans: Points for ceiling fans will be only applicable and could be achieved if all the bedrooms and hall in all the dwelling units are having ceiling fans

- Sweep Size < 1200mm: equal or greater than 4m^3/min.Watt
- Sweep size > 1200mm: equal or greater than 5m^3/min.Watt





6 POINTS

1 POINT

3 POINTS

BEE Standards and Labelling requirements for ceiling shall take precedence over current requirements

ENS – Part 2 – Services

Comfort Systems– Maximum 50 points

Air Conditioners:

Points for air conditioners will be only applicable and could be achieved if all the bedrooms in all the dwelling units are having air conditioners (either unitary, split, VRF or centralized plant)

20 POINTS

UNITARY TYP : 5 STAR

SPLIT AC : 3 STAR

CHILLER : ECBC 2017

VRF : 3.28

ENS – Part 2 – Services

Comfort Systems– Maximum 50 points

9 POINTS

SPLIT AC 4 STAR

CHILLER : ECBC+

** VRF not applicable as on Date. Whenever BEE Star rating is launched, it will be applicable.*

21 POINTS

SPLIT AC 5 STAR

CHILLER : SUPER ECBC

ENS – Part 2 – Services

Solar Water Heating

Solar Water Heating

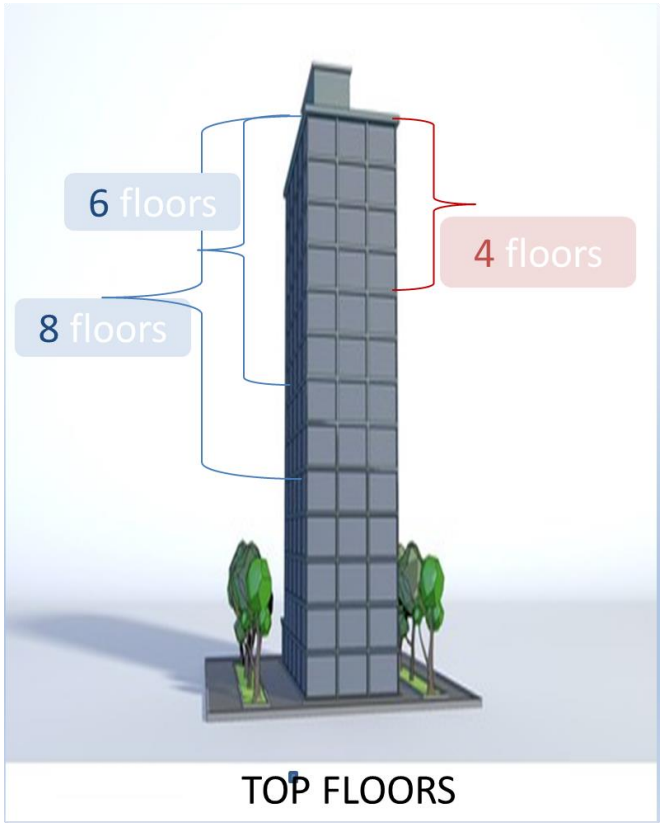
- SWH of **minimum BEE 3 Star label** and meeting 100% of Top 4 floors

OR

- 100% of Annual Hot Water demand of Top 4Floors is met by using heat recovery

6 POINTS

- 100% of Annual water demand for Top 6 floors **(2points)**
- 100% of Annual water demand for Top 8 floors **(5 points)**

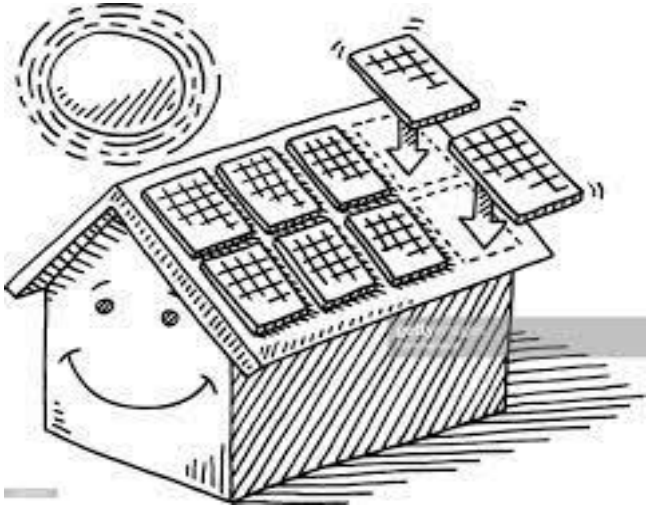


ENS – Part 2 – Services

Solar Photovoltaic

- Dedicated Renewable Energy Zone (REGZ)
- Minimum of 2kWh/m2 year of electricity

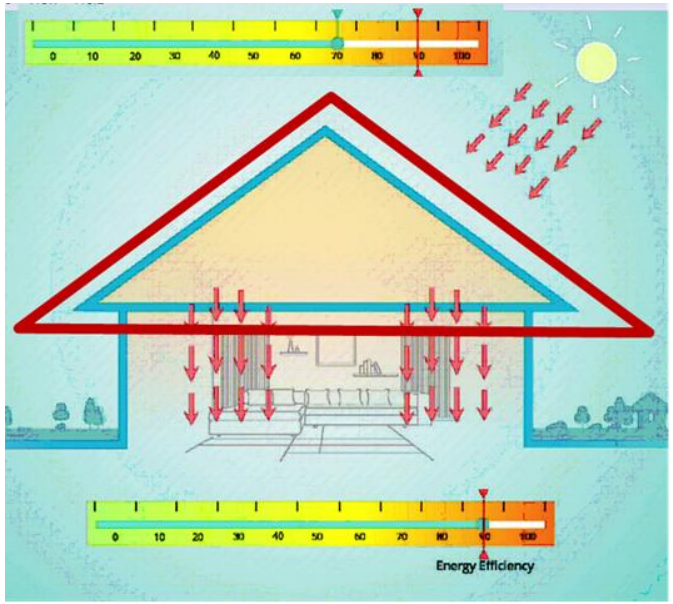
- At least 20% of roof area
- Free of any obstructions and shadows

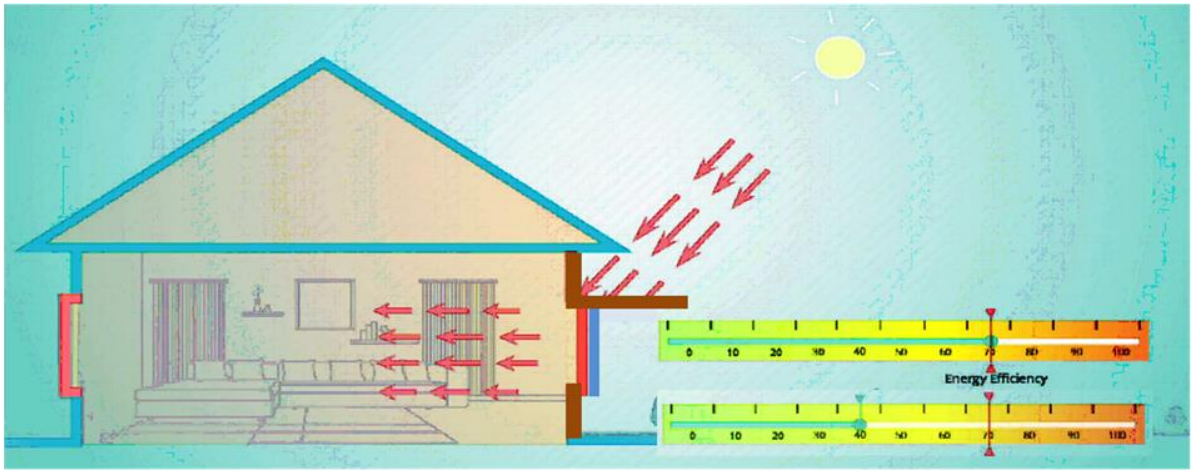


- Min. of 3kWh/m2 of Electricity / 30% of roof area **(2 points)**
- Min. of 4kWh/m2 of electricity /40% roof area **(5 points)**

5 Points

Conventional Building Vs ENS Building



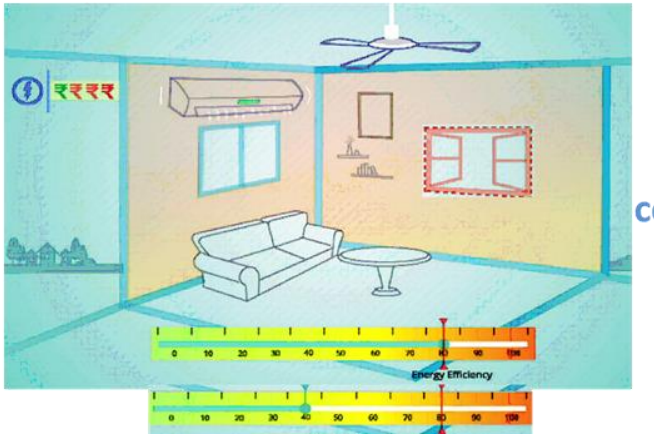


Conventional Brick wall, roof and single glazed windows, traps heat

Proper shading, glazing, Wall & Roof insulation reduces impact of heat

Non-insulated roof absorbs more heat and radiates inside the building

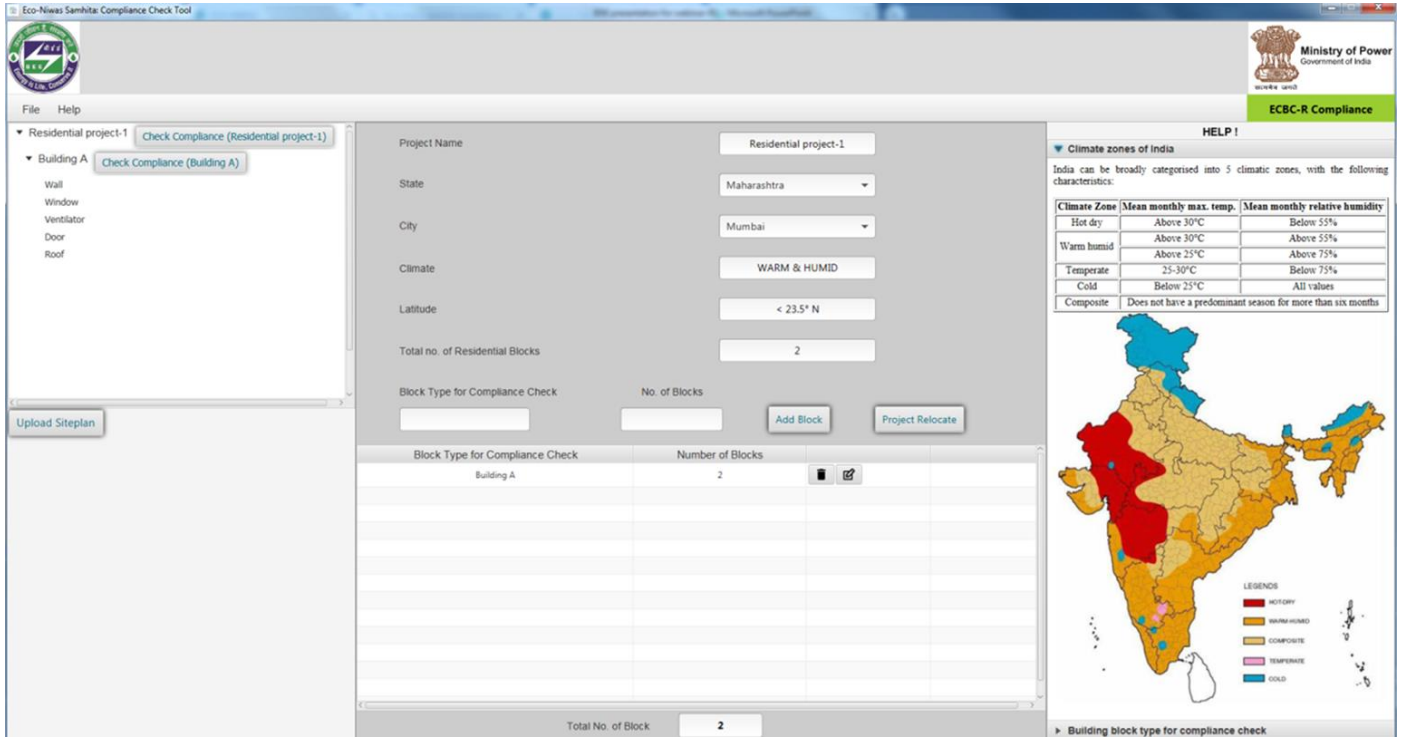
Proper Insulating materials can reduced heat gain



Increases in cross-ventilation reduces dependency on Air conditioners & coolers, thereby reduces electricity bills

Compliance Tool

Java based ENS compliance check tool has been developed to check compliance for residential project.

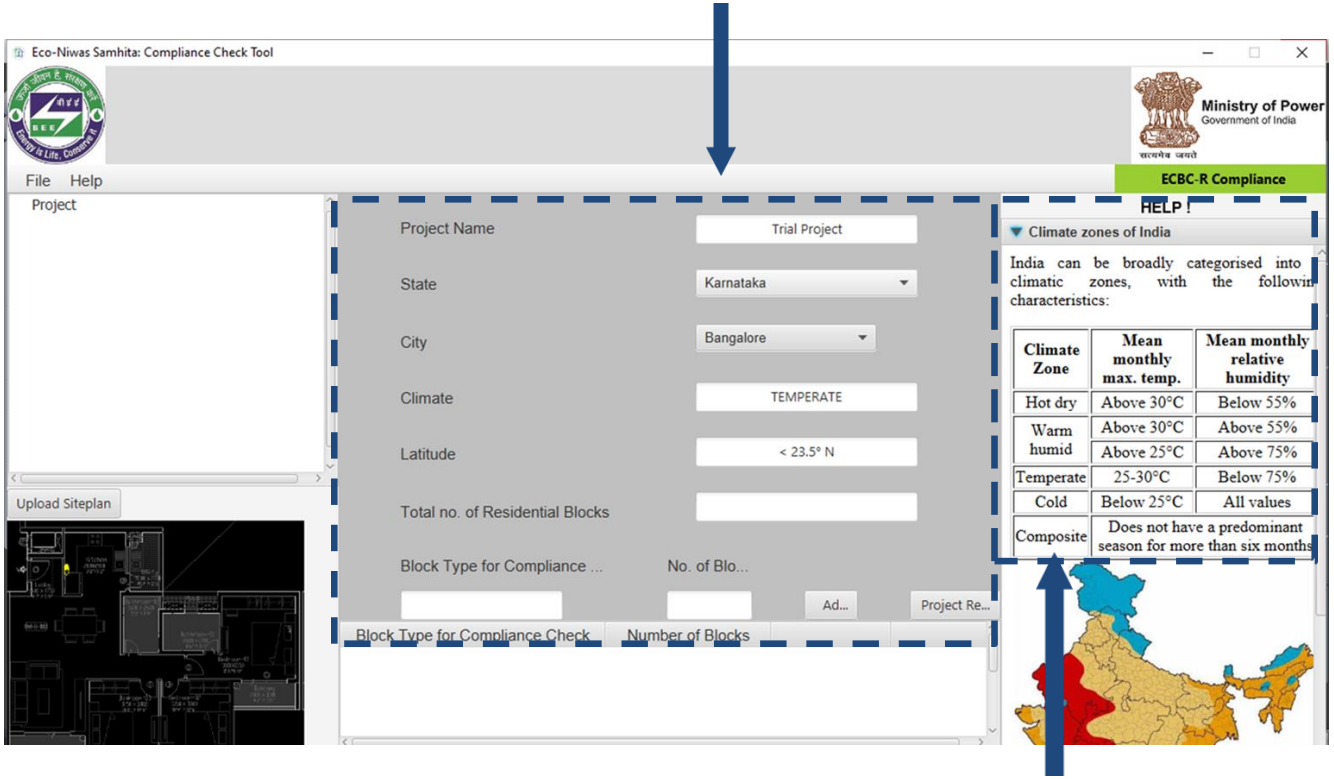


Available on Bureau of Energy Efficiency's website for download.

Link - https://beeindia.gov.in/content/ecbc-residential

Compliance Tool

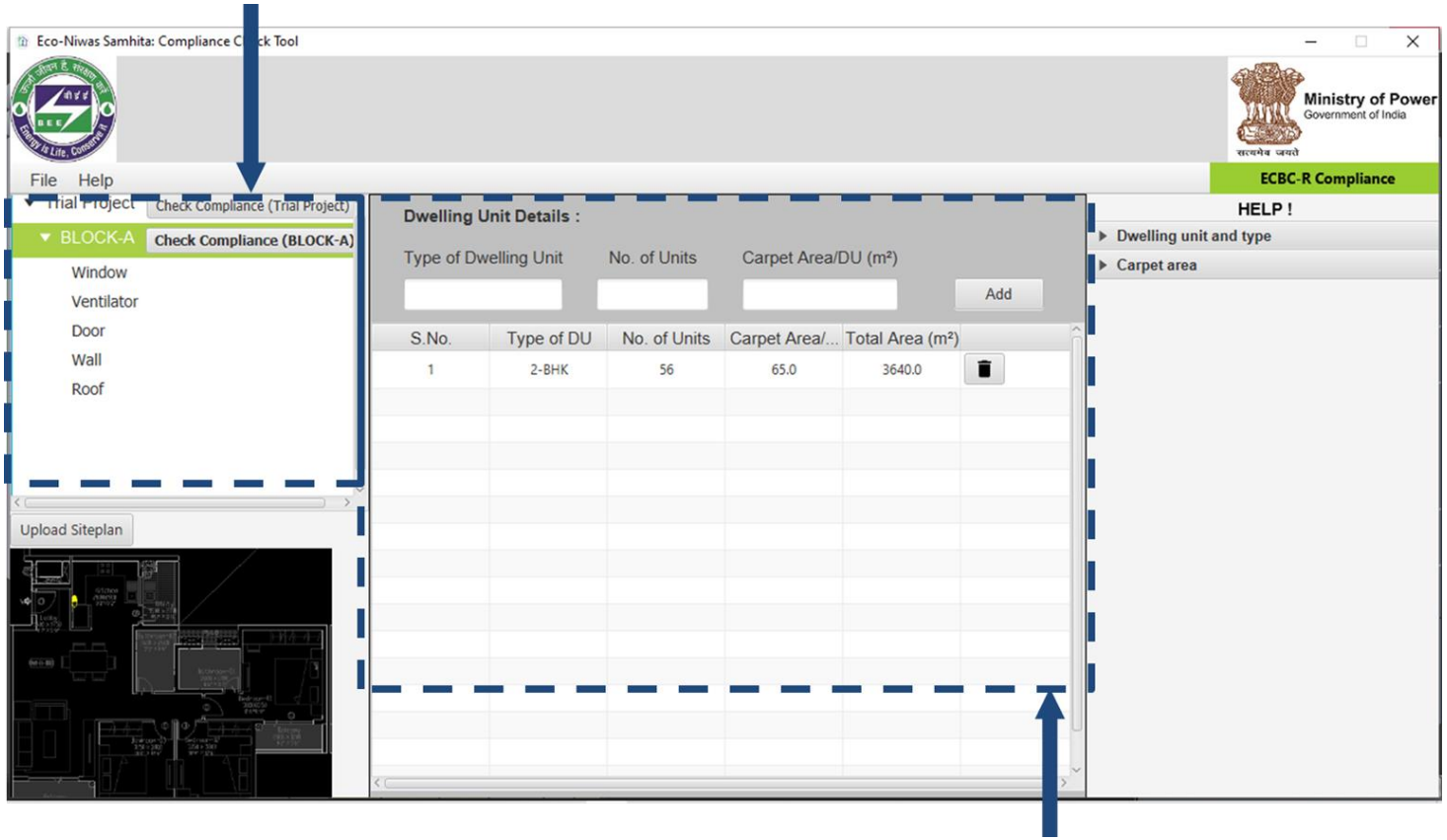
Project related details are entered in the tool for compliance check



Climate data after entering the project location details

Compliance Tool

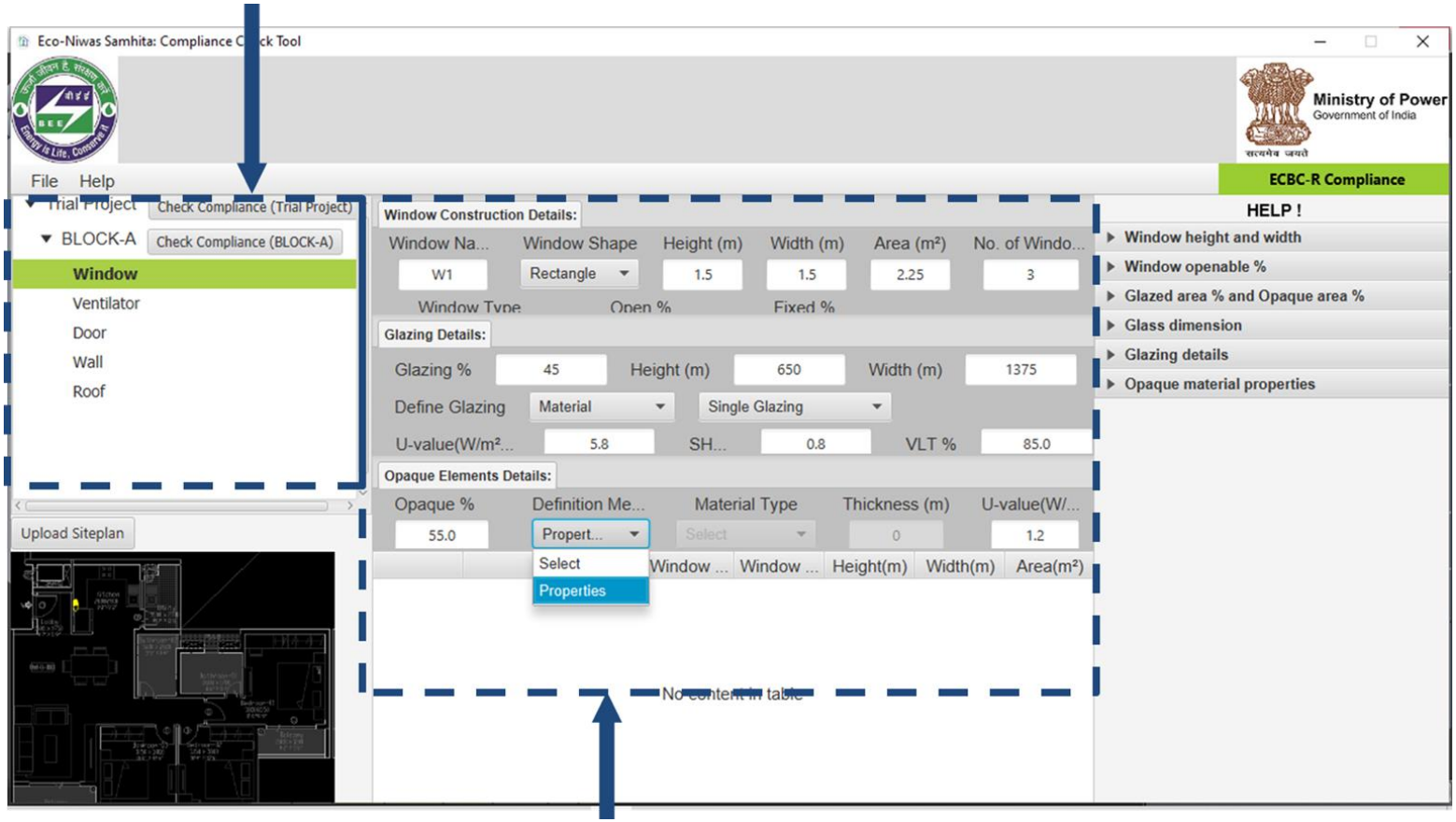
Details of various building components will be added for Compliance check- Architectural drawings(plans, sections and elevations)



Details of the blocks are submitted and can be seen here

Compliance Tool

Construction material details are entered in the tool. Window details are shown here for example

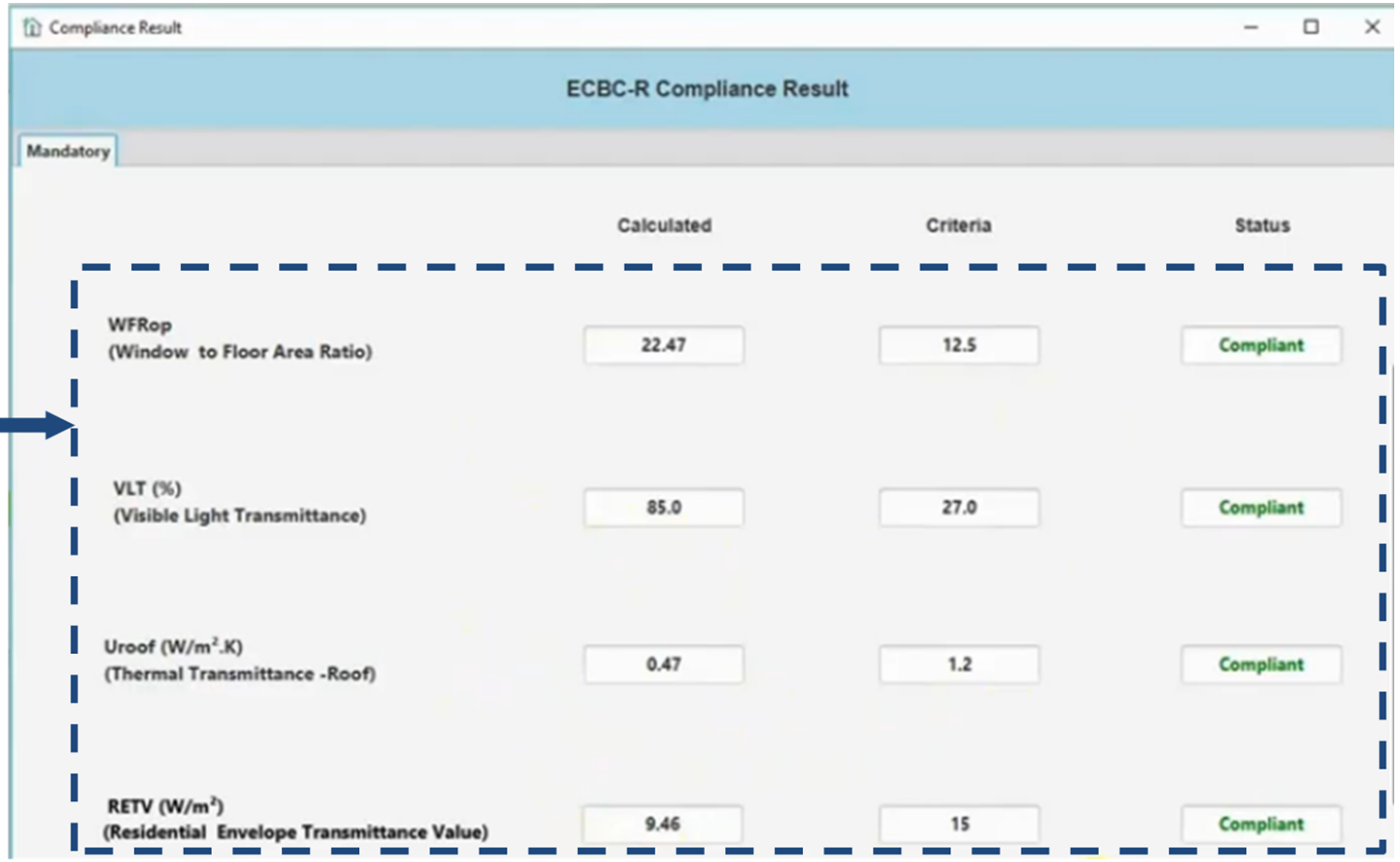


All the details related to window are submitted for the compliance

Similarly, other block details are added in the table for checking different design alternatives

Compliance Tool

Result of the compliance of code provisions shown



A report is generated once all the design provisions are complaint to the code

Generate Report

BEE Star Labelling for Residential Buildings

BEE – STAR LABELLING

Table for Building Energy Star Rating Programme More than 50 % air conditioned built up area

Climatic Zone- Composite

EPI(Kwh/sqm/year)	Star Label
190-165	1 Star
165-140	2 Star
140-115	3 Star
115-90	4 Star
Below 90	5 Star

Climatic Zone - Warm and Humid

EPI(Kwh/sqm/year)	Star Label
200-175	1 Star
175-150	2 Star
150-125	3 Star
125-100	4 Star
Below 100	5 Star

Climatic Zone - Hot and Dry

EPI(Kwh/sqm/year)	Star Label
180-155	1 Star
155-130	2 Star
130-105	3 Star
105-80	4 Star
Below 80	5 Star

Table for Building Energy Star Rating Programme Less than 50 % air conditioned built up area

Climatic Zone- Composite

EPI(Kwh/sqm/year)	Star Label
80-70	1 Star
70-60	2 Star
60-50	3 Star
50-40	4 Star
Below 40	5 Star

Climatic Zone - Warm and Humid

EPI(Kwh/sqm/year)	Star Label
85-75	1 Star
75-65	2 Star
65-55	3 Star
55-45	4 Star
Below 45	5 Star

Climatic Zone - Hot and Dry

EPI(Kwh/sqm/year)	Star Label
75-65	1 Star
65-55	2 Star
55-45	3 Star
45-35	4 Star
Below 35	5 Star

The program would rate office buildings on a 1-5 Star scale with 5 Star labeled buildings being the most efficient. Five categories of buildings - **office buildings, hotels, hospitals, retail malls, and IT Parks** in five climate zones in the country have been identified for this programme.

Those buildings having a **connected load of 100 kW** and above would be considered for BEE star rating scheme.

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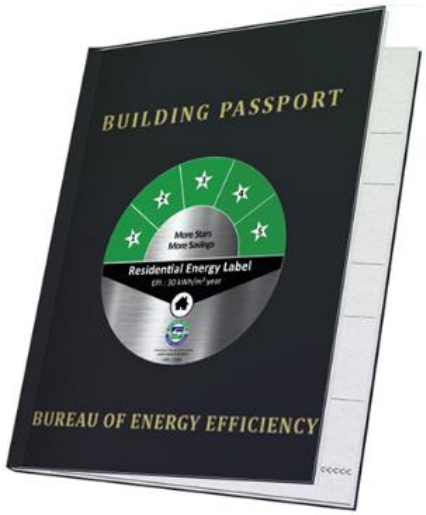

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Type of Applicant

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Name

Identity Number

Email
This will be username.

Mobile Number

Address for correspondence

Property Number

Line 1

Line 2

Locality

State
Choose State

City/Town
Choose City

District

Pincode

Password

Create Password

Re-enter Password

I confirm that all details are true and correct.

Register

Enter all the credentials and register as either Individual or a Firm.

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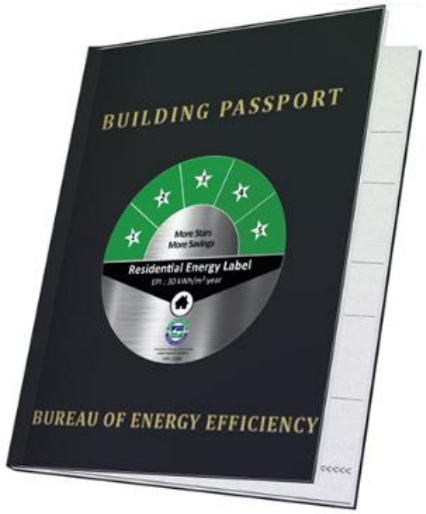

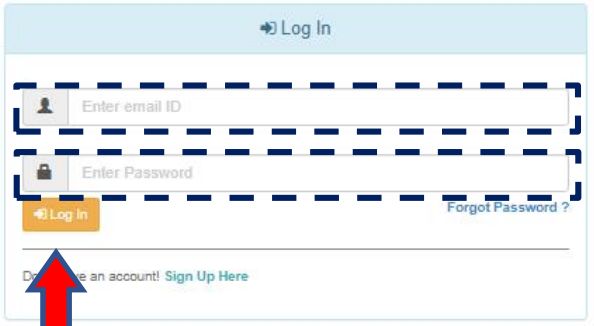

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Thank you !

Presented by:

GIZ and South Cluster Cell

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