Eco Niwas Samhita - Karnataka

Energy Conservation Building Code for Residential Building

Power Sector- A Snapshot

GENERATION

Wind

Nuclear

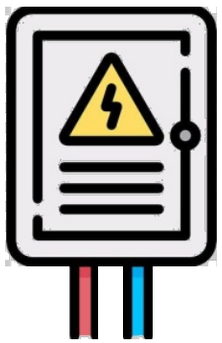
Hydro

Thermal

Solar

TRANSMISSION

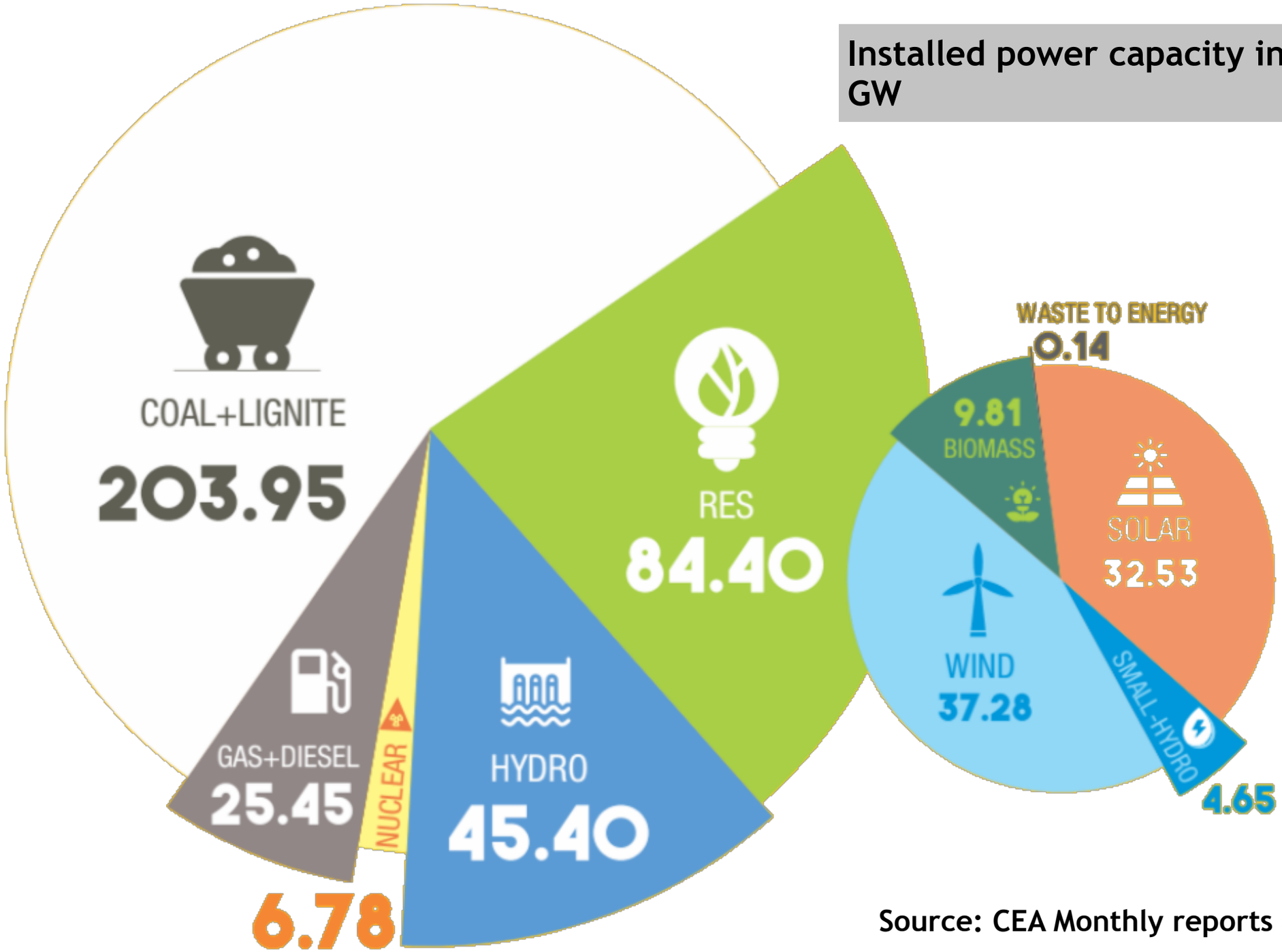
DISTRIBUTION



CONSUMPTION

Power Consumption

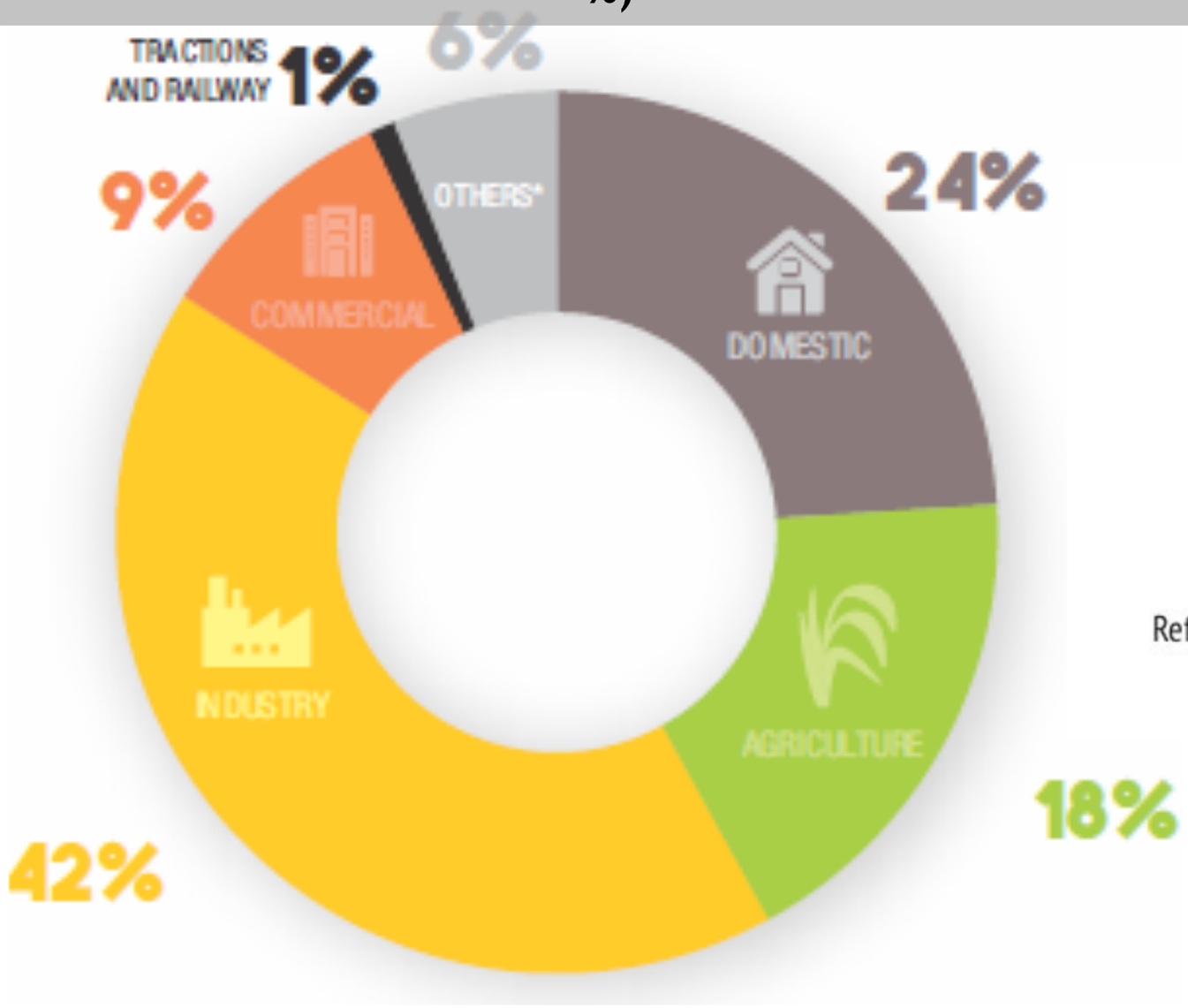
Installed power capacity in GW

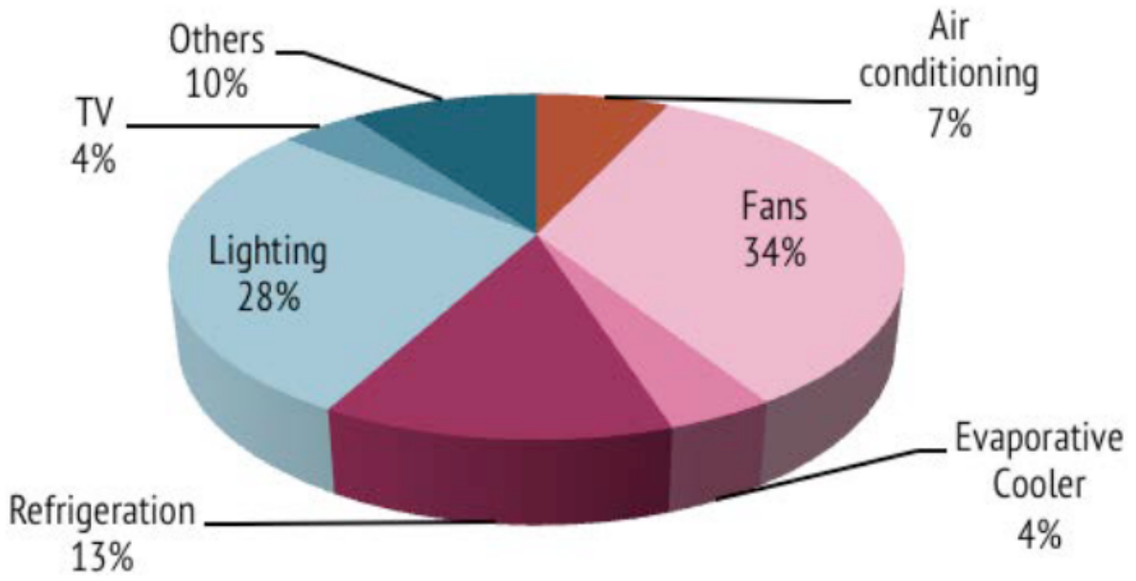


Source: CEA Monthly reports on installed capac

Source wise Energy Consumption

Domestic has the second highest energy consumption rate (24 %)





Energy consumption in Residential Buildings

Planning Commission, 201

Source : Climate Works, Foundation, 2010

Introduction to Eco Niwas Samhita (ENS)

BEE
(BUREAU OF ENERGY EFFICIENCY)

+

GIZ
(Deutsche Gesellschaft für Internationale Zusammenarbeit)

Government of India

Government of Germany

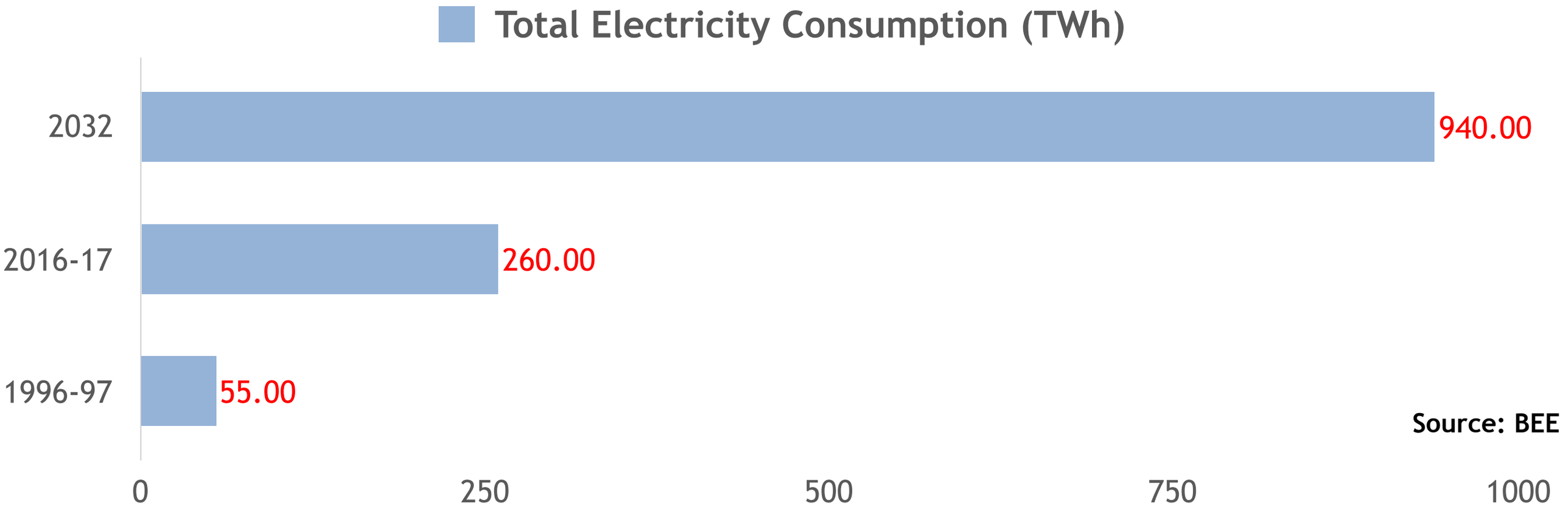
Eco Niwas Samhita

Launch of Eco Niwas Samhita in December 2018

Need for ENS

With respect to **BUILT-UP AREA** , approximately **3 Billion sq-m** of Residential Built-up area will be added by **2030** with an exponential land use increase from **24% to 60%** by **2047.**

ENERGY DEMAND increase is as indicated below



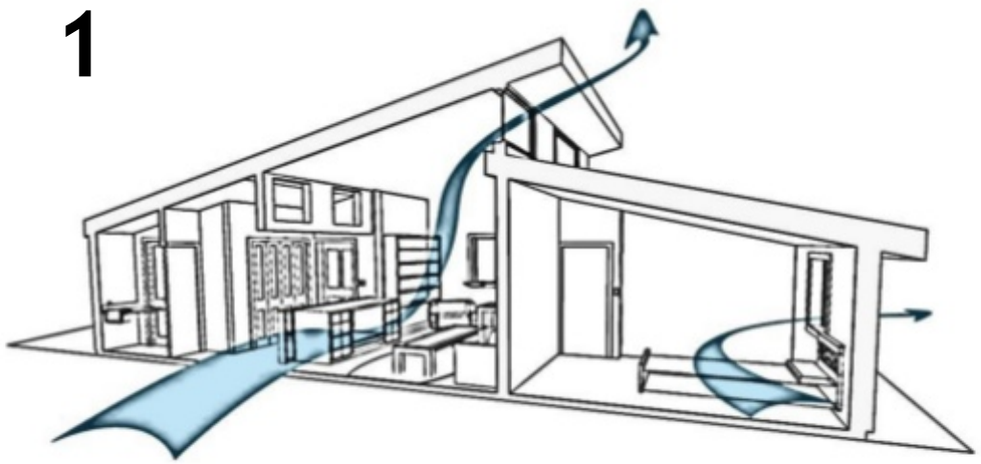
Source: BEE

Bureau of Energy Efficiency, Ministry of Power, Government of India

Eco Niwas Samhita (ENS) - Part 1

Eco Niwas Samhita – Part 1 is designed to define minimum Building Envelope design standards to improve Energy Efficiency in Residential Buildings

1



1. For Adequate natural ventilation potential

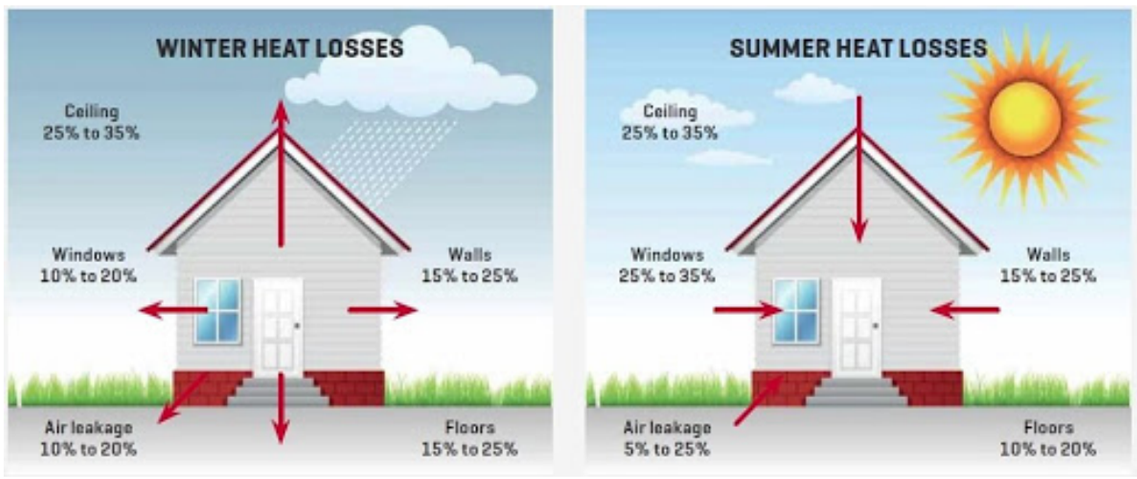
(WFR – Window to Floor Area Ratio)

2. For adequate day light

(WWR- Window to Wall area Ratio)

2

3



3. Limit heat gains / heat loss (U Value – Thermal Transmittance, RETV- Residential Envelope Transmittance Value)

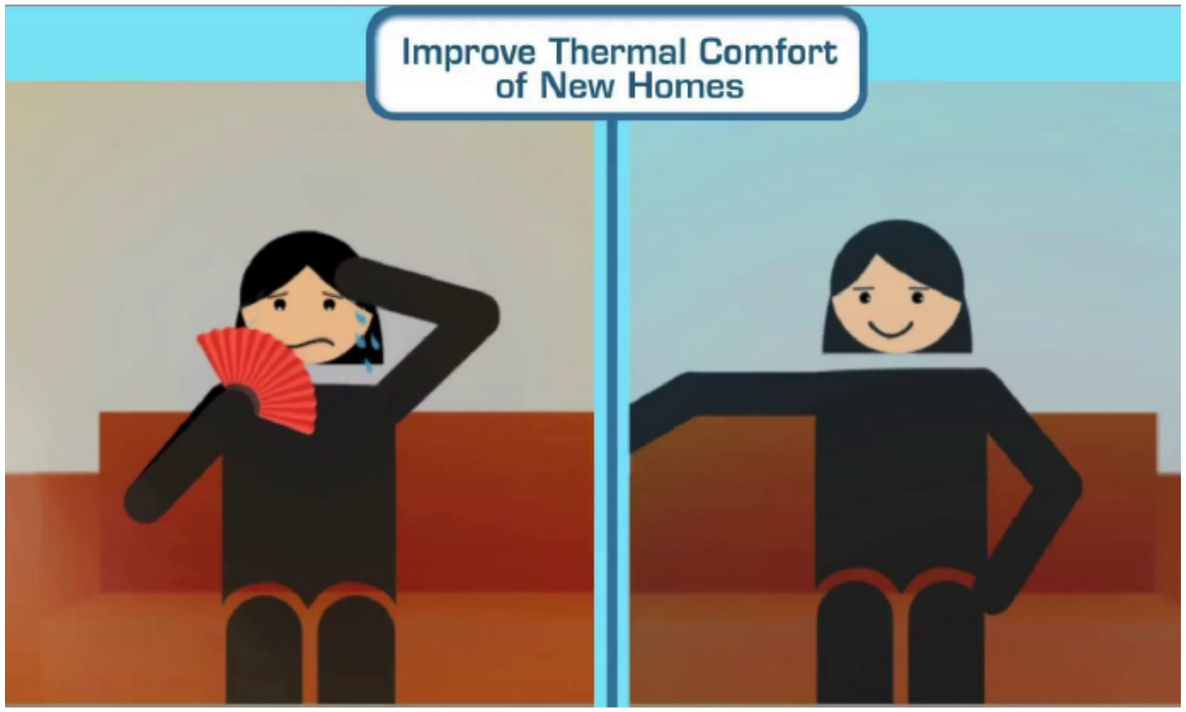
Salient Features of ENS

- ❑ Simple-to-apply format **(Prescriptive Compliance Approach)**
- ❑ Simple calculations based on inputs from the architectural design drawings of buildings.
- ❑ Will **not require any simulation software**.
- ❑ Code to be readily **adopted in the building bye-laws.**
- ❑ A **compliance tool** is also available on BEE website to aid in the calculations and compliance check.

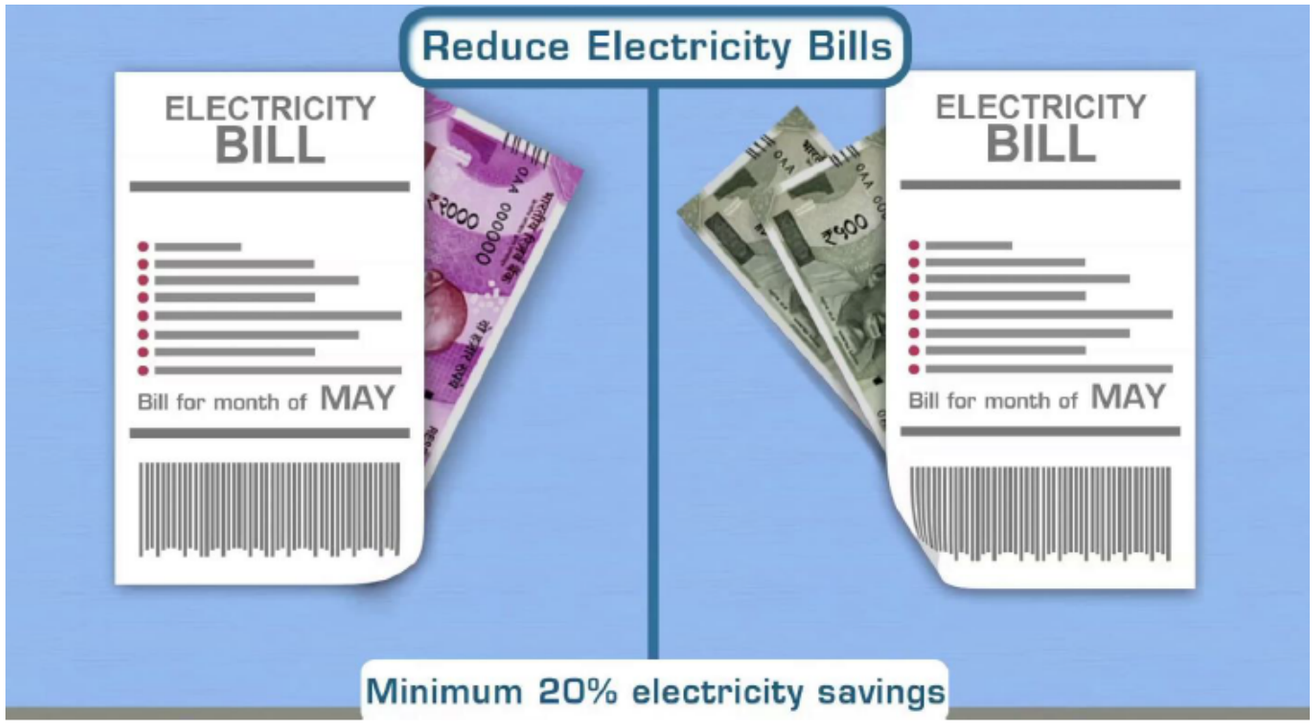
http://www.econiwas.com/

Benefits of ENS

Improve Thermal Comforts



Reduce Electricity Bills



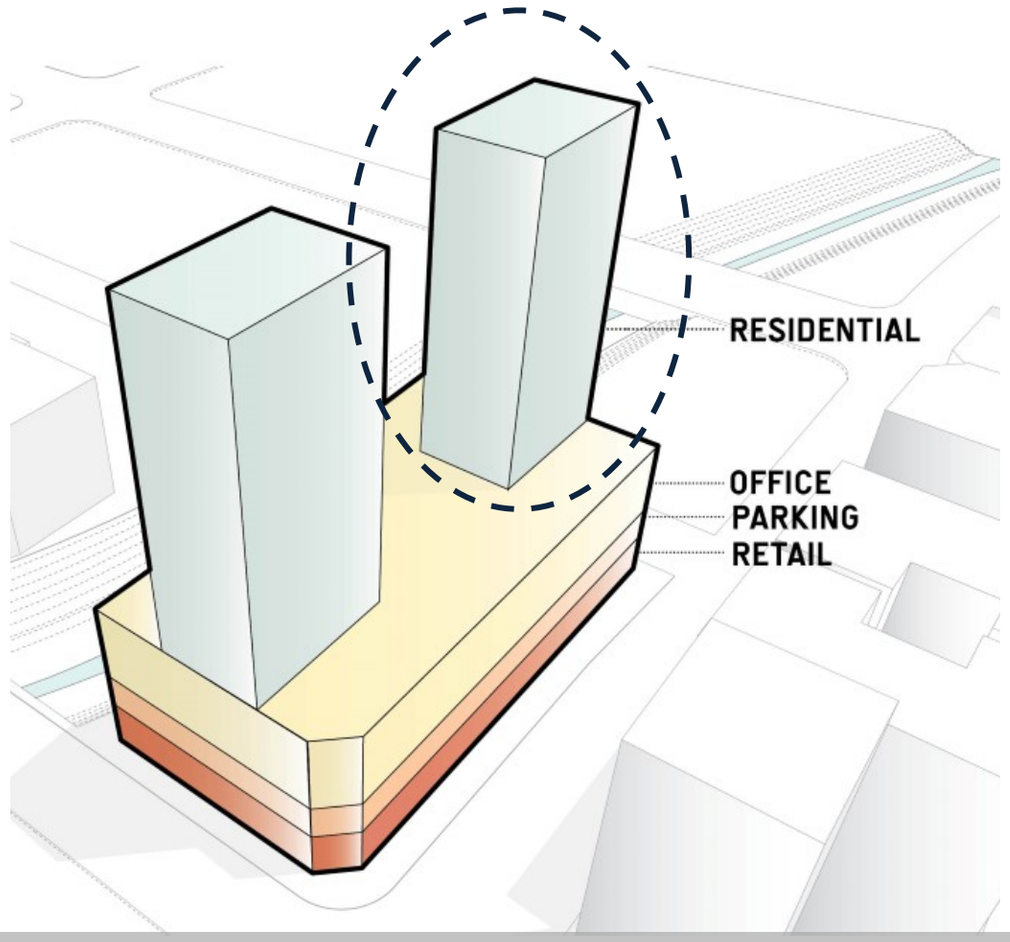
Estimated Impact Of Implementing Eco Niwas Samhita

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

Scope of 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.**

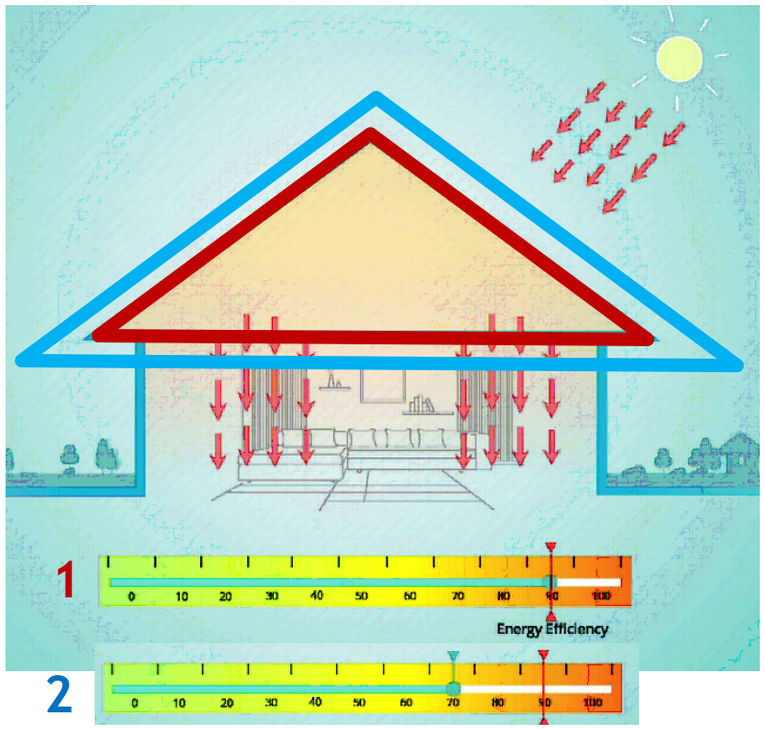
Excluded from the code

Dormitories

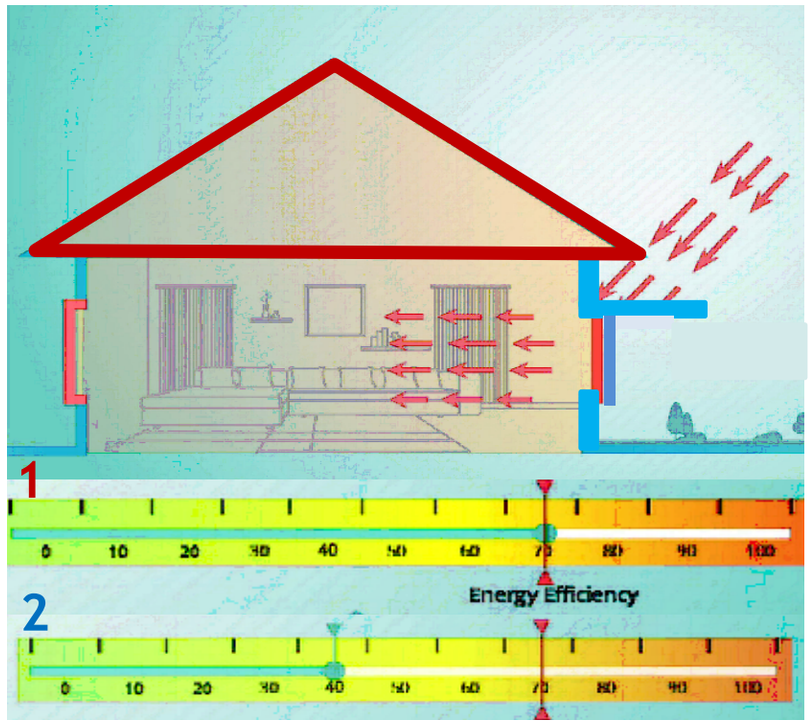
Hotels

Lodging Rooms

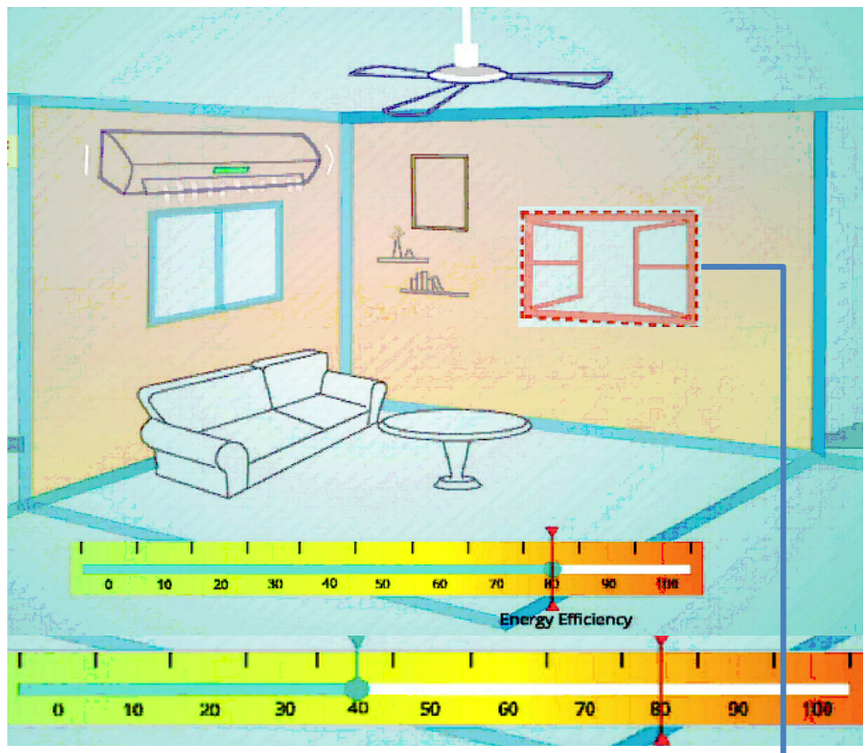
Conventional Building VS ENS Compliant Building



1. Non-insulated roof absorbs more heat and radiates inside the building ; 90 EPI (approx.)
2. Proper Insulating materials can reduced heat gain ; 70 EPI (approx.)



1. Conventional Brick wall, roof and single glazed windows, traps heat ; 70 EPI (approx.)
2. Proper shading, glazing, Wall & Roof insulation reduces impact of heat ; 40 EPI (approx.)



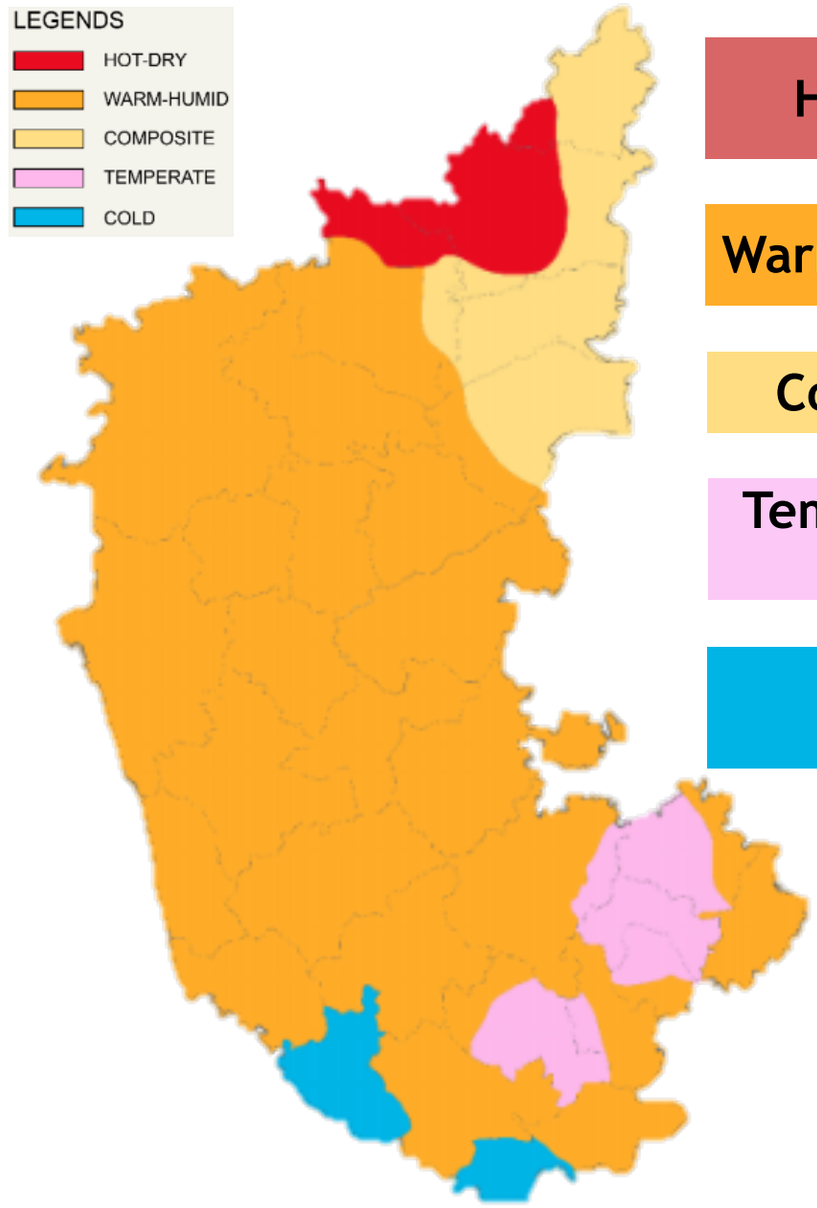
Increases in cross-ventilation reduces dependency on Air conditioners & coolers, thereby reduces electricity bills

Karnataka ENS Code

SCOPE: The Karnataka ENS code is applicable to Residential Buildings with **plot area ≥ 500m²** and Residential part of **"Mixed Land-use building projects" built on plot area of ≥ 500m².**

APPLICABILITY: The Karnataka ENS code is applicable to **all 5 climatic zones** (Composite, Hot & Dry, Warm & Humid, Temperate & Cold), that all districts fall under. **Latitude below 23.5 ° N**

Climate Map -Karnataka



Hot -Dry : Tumkuru

Warm-Humid : Mangaluru

Composite : Belagavi

Temperate : Bengaluru, Mysuru

Cold : Coorg

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})
- 3.4 Residential Envelope Transmittance Value (RETV)
- 3.5 Thermal Transmittance for Cold Climate ($U_{envelope,cold}$)

3.3, 3.4, 3.5 — For Thermal Transmission

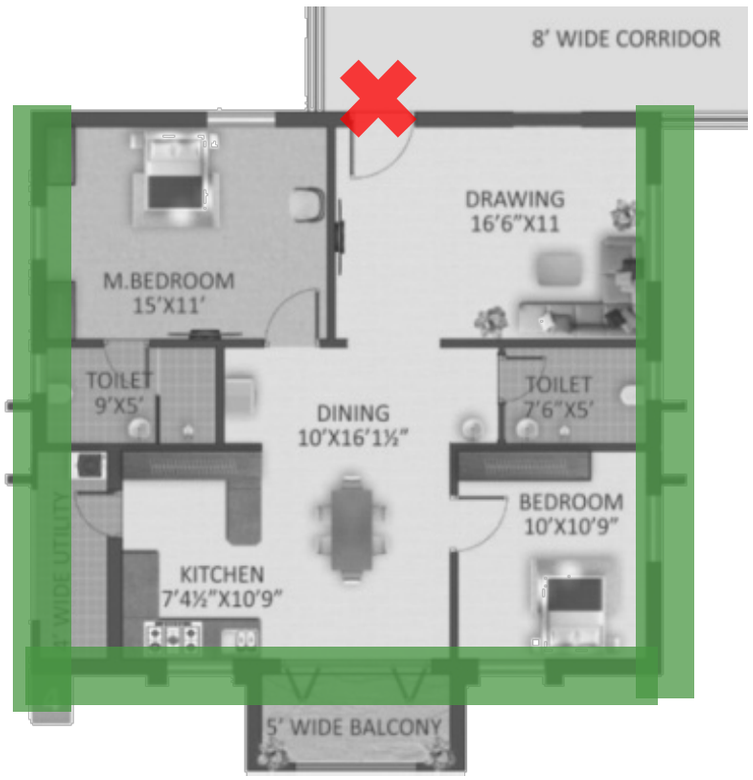
Source: Eco Niwas Samhita 2018

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

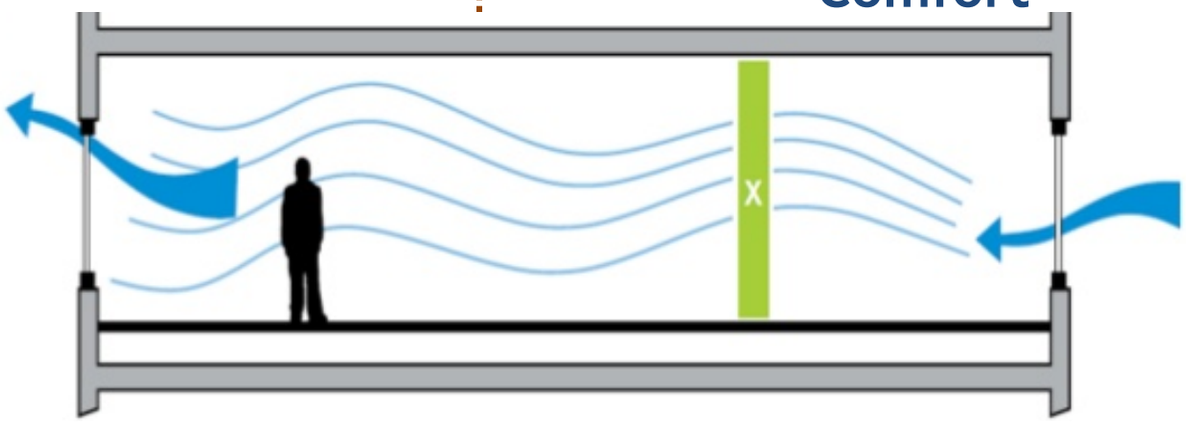
Carpet Area

- Total Internal Area of the habitable space Balconies - Excluded

3.1 Openable Window to Floor Area Ratio (WFR_op)

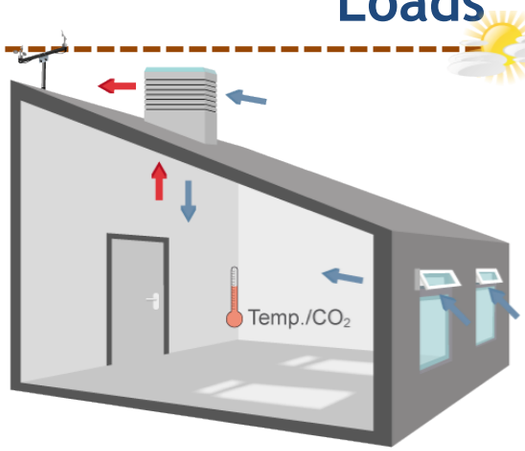
Minimum WFRop helps in

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%

3.2 Window to Wall Area Ratio (To arrive at Optimum VLT)

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

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

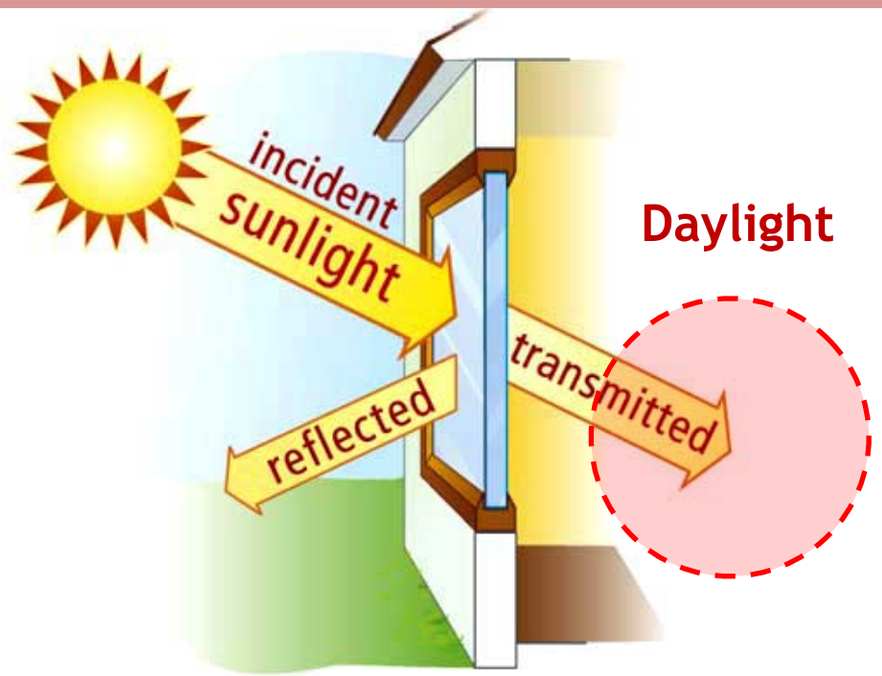
*** Note for WWR ≤ 0.15 , VLT - 40%**

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

3.2 Window to Wall Area Ratio (To arrive at Optimum VLT)

Total light transmitted in any area through Glass.

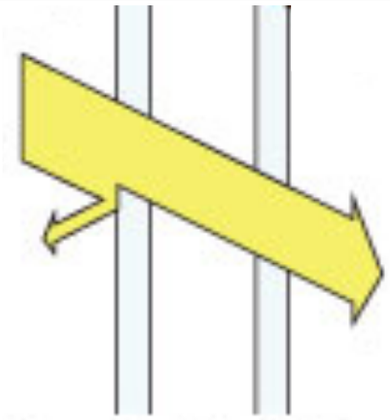


- Factors affecting VLT
  - Glazing type,
  - No. of panes in an area,
  - Coating on the glass

Reduced energy usage for artificial lighting

Daylight savings

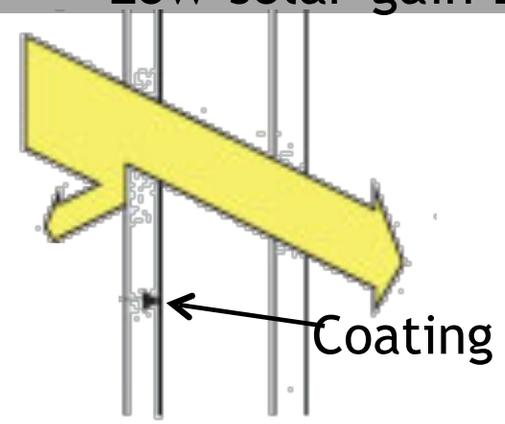
Clear Double Glazing



VLT = .79

79% of visible light transmitted

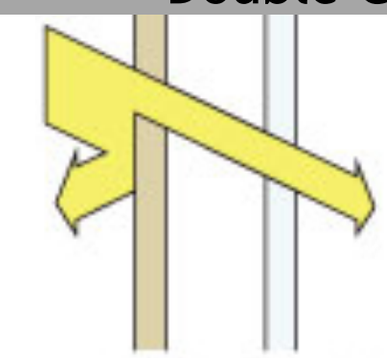
Low-solar-gain Low-E double Glazing



VLT = .69

69% of visible light transmitted

Double Glazing with Bronze Tint



VLT = .48

48% of visible light transmitted

3.2 Window to Wall Area Ratio (To arrive at Optimum VLT)

From where can we obtain the VLT of the Glass ?

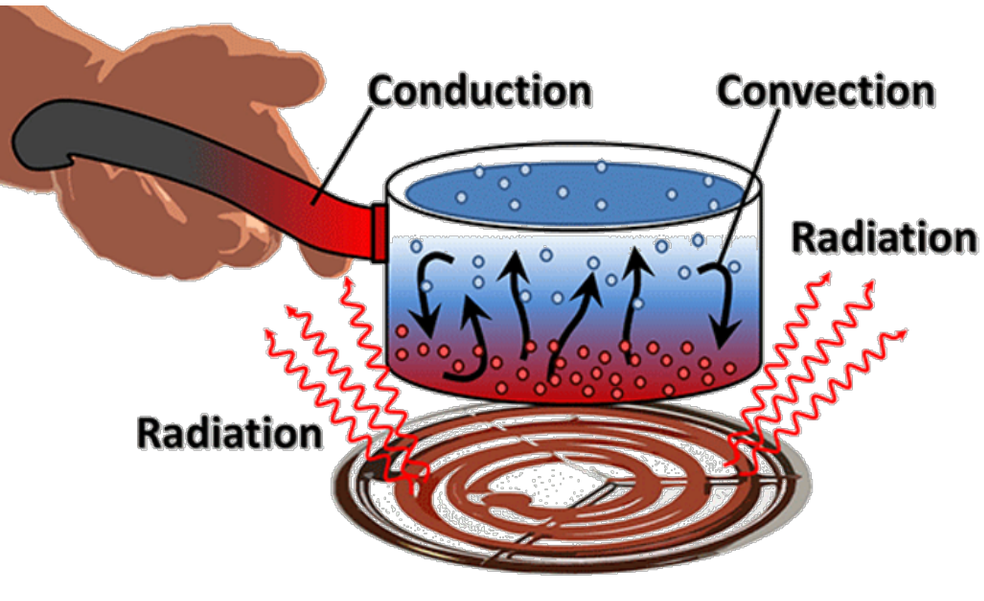
Colour / Performance	Thickness (mm)	Light Transmittance LT	Light Reflectance LR	Total Solar Radiant Heat Transmittance	Total Shading Coefficient	U Value (W/m^2K)	R_w Value (dB)
Clear	10	0.77	0.14	0.67	0.77	2.7	38
Clear	12	0.76	0.14	0.64	0.74	2.7	38
Clear	15	0.74	0.13	0.60	0.69	2.6	40
73/42	10	0.69	0.10	0.40	0.46	1.4	38
70/39	10	0.67	0.12	0.37	0.43	1.3	38
69/37	10	0.66	0.11	0.35	0.40	1.3	38
62/29	10	0.58	0.09	0.29	0.33	1.3	38
50/27	10	0.48	0.10	0.26	0.30	1.3	38
30/17	10	0.29	0.24	0.19	0.22	1.3	38

VLT of a Glass can be obtained from the Glass cut sheet available with any Glass manufacturer

BUILDING PHYSICS PRINCIPLES TO UNDERSTAND THERMAL TRANSMITTANCE

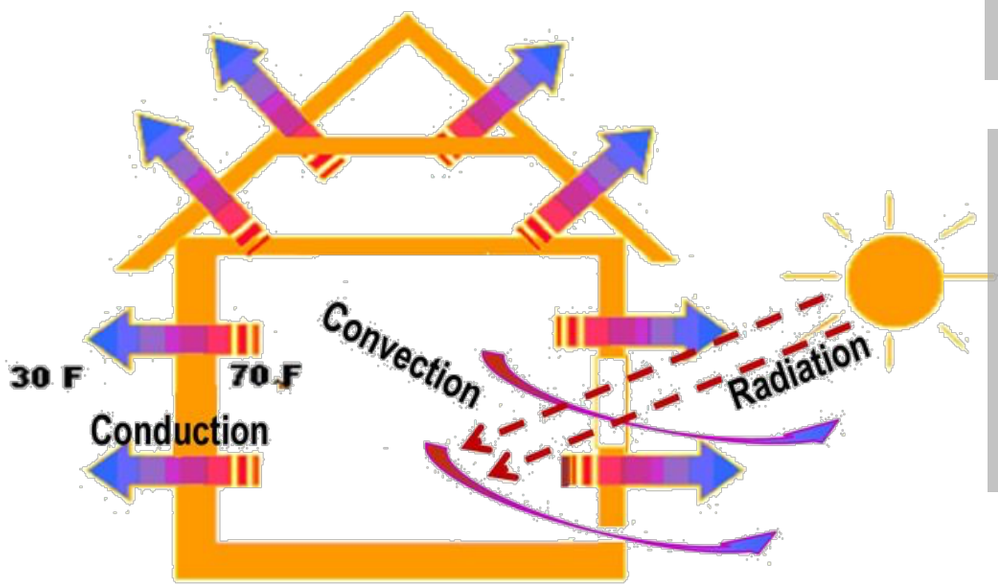
- Modes of Heat Transfer
- **Opaque Envelope (Walls & Roof)**
  - Thermal Conductivity – K Value
  - Thermal Resistance – R Value
  - Thermal Transmittance – U Value
- **Non - Opaque Envelope (Glazing & Windows)**
  - Thermal Transmittance – U Value
  - Solar Heat Gain Coefficient (SHGC)
  - Visible Light Transmittance (VLT)
- **Residential Envelope Transmittance Value (RETV)** – Walls (Opaque + Non – Opaque Elements)

HEAT TRANSFER MEDIUMS



Conduction
Heat transfer occurring, whenever there is a temperature gradient/ difference between two surfaces through direct contact.

Convection
Convection heat transfer takes place between a surface and a moving fluid/air medium, when they are at different temperatures

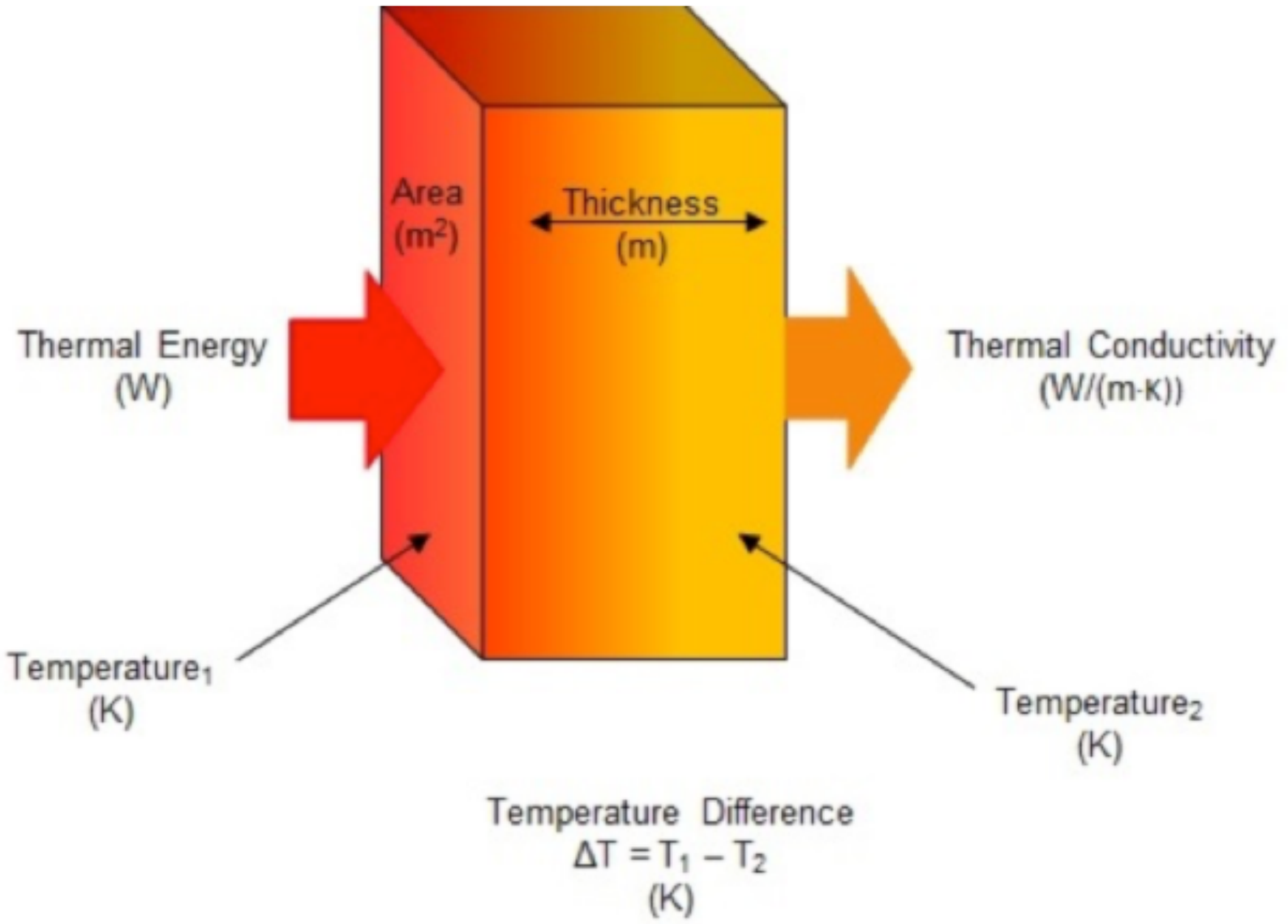


Radiation
Radiation heat transfer does not require any medium for transmission and transfer of heat is through electro magnetic waves

K-VALUE,R-VALUE –THERMAL RESISTANCE

K-value (k) -
The rate at which heat passes through a specified material, expressed as the amount of heat that flows per unit time through a unit area with a temperature gradient of one degree per unit distance. (W/m K)

R-value -
Thermal resistance is a heat property and a measurement of a temperature difference by which an object or material resists a heat flow, through unit thickness of material. (m^2K/W)



R -Value = Thickness of material (t)/ K

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

Source: Eco niwas Samhita -2018, Annexure -

3.3 Thermal Transmittance - U_{roof}

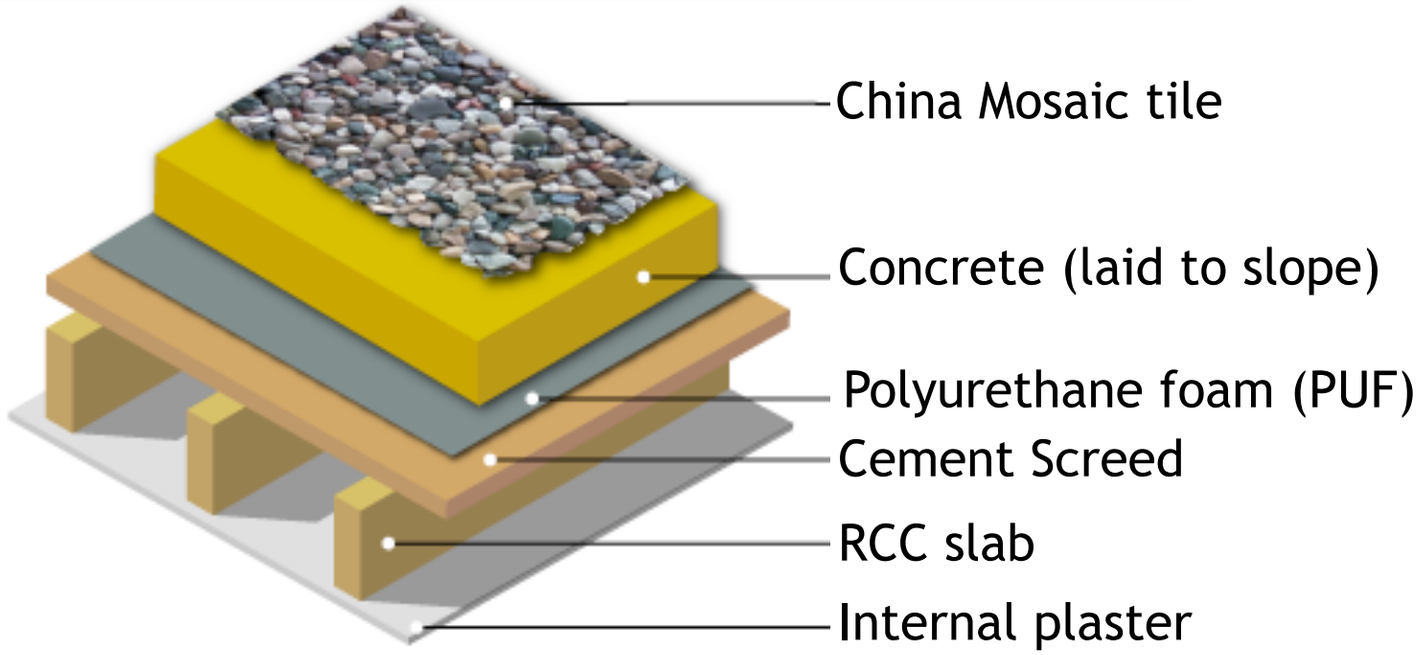
Total thermal Resistance -

$R_t = R_{si} + R_{se} + R1 + R2 + R3 \ldots\ldots$

$= 0.17 + 0.04 + 1.917 = 2.127\ m^2.K/w$

Total Thermal Transmittance (Roof)-

$U_{roof} = 1/RT = 0.47\ W/m^2.K$



Material Layer	Thickness,(t)	Thermal Conductivity- k (W/m.K)	Thermal Resistance , R=t/k(m^2.K/w)
China mosaic tile	0.007	1.500	0.005
Concrete (laid to slope)	0.050	1.740	0.029
Polyurethane foam (PUF)	0.040	0.023	1.739
Cement screed	0.020	0.720	0.028
RCC slab	0.150	1.580	0.095
Internal plaster	0.015	0.720	0.021
Sum of all material thermal resistance			1.917

Source: Eco niwas Samhita -2018, Annexure -

3.4 Residential Envelope Transmittance Value (RETV)

The net heat gain rate through building Envelope

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

RETV accounts for -

➢ heat conduction through opaque and non-opaque building envelope components and **does not include ROOFS.**

➢ Solar radiation through non-opaque building envelope components

SHGC –Solar heat gain coefficient

A_{opaque} , $A_{non\text{-}opaque}$ - area of opaque and non-opaque areas in the building envelope

W_i - Orientation Factor

U_{opaque}, $U_{non\text{-}opaque}$ - Thermal transmittance of opaque and non-opaque building envelope components.

a,b,c – Coefficients for different climatic zones

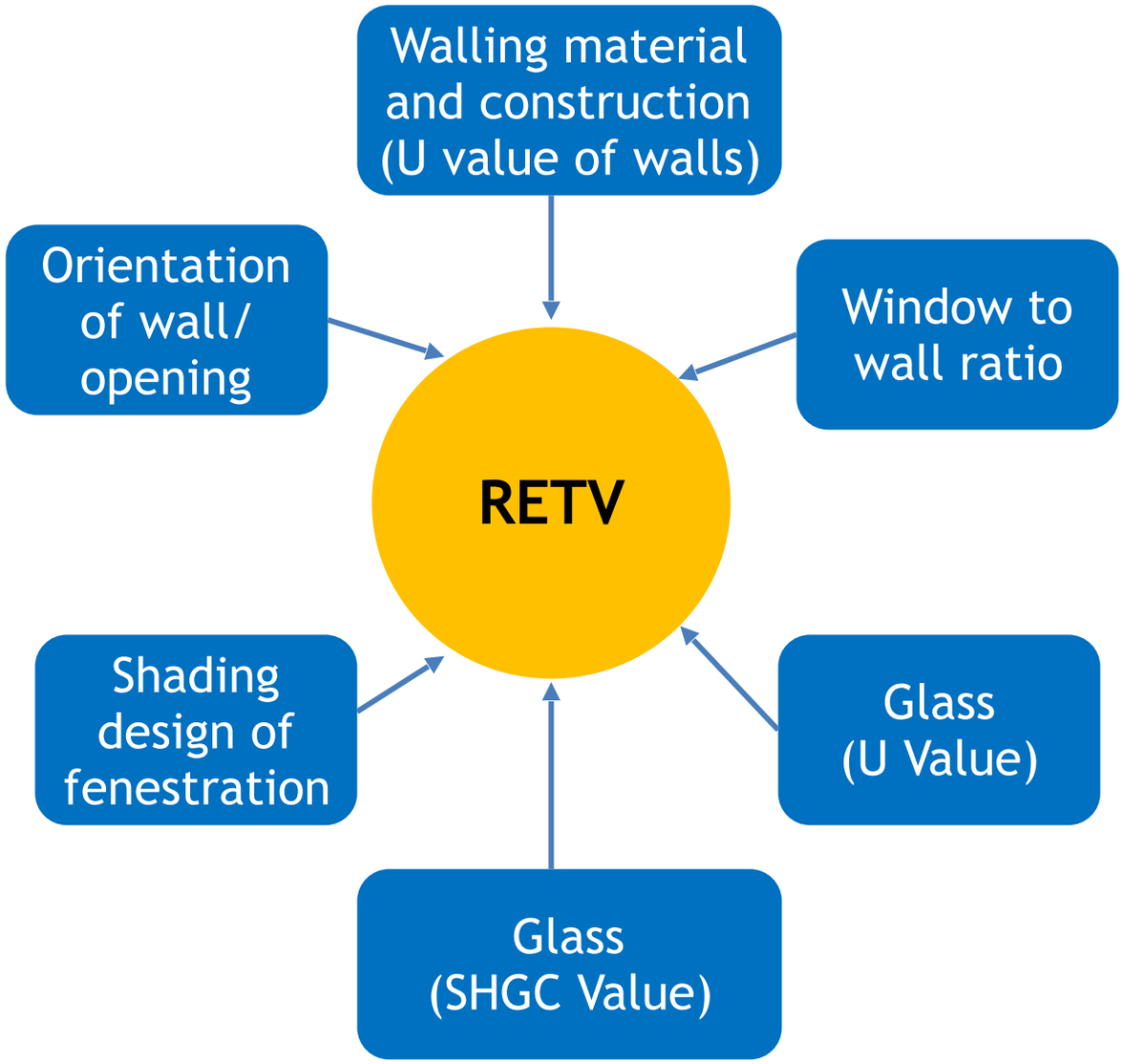
$A_{envelope}$ – Envelope area of dwelling units, **except roof area.**

3.4 Residential Envelope Transmittance Value (RETV)

Solar Radiation through non-opaque surfaces

Conduction through opaque surfaces

Conduction through non-opaque surfaces



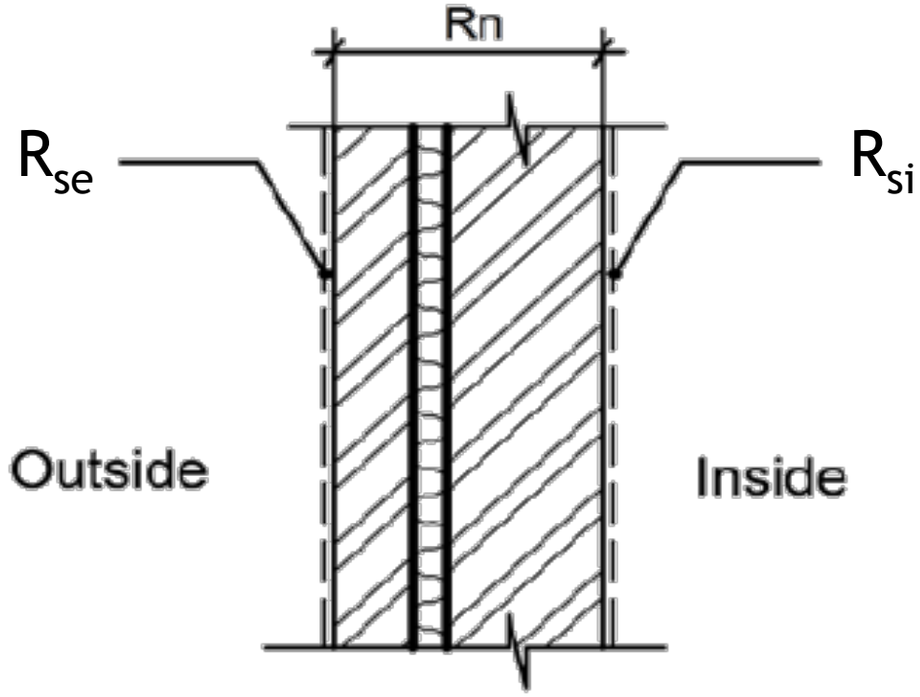
3.4 U- Value - Thermal Transmittance - Wall

U-value - Rate of transfer of heat through a structure (which can be a single material or an assembly), divided by the difference in temperature across that structure. **(W/m^2K)**

$$U = 1 / R_t$$

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

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



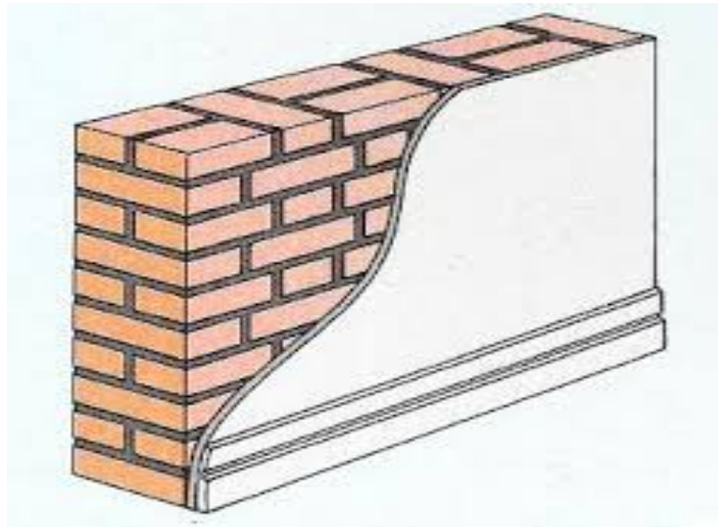
	Wall	Roof	
	All climatic Zones	Composite , Hot-Dry, Warm-humid, and Temperate climate	Cold climate
Rsi (m2.K/W)	0.13	0.17	0.10
Rse (m2.K/W)	0.04	0.04	0.04

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

3.4 Types of wall and their U-value

150 mm RCC (No plaster)
U Value - 3.77 W/m²K

200 mm Solid Concrete Block with 15 mm plaster on both sides
U Value- 2.8 W/m²K

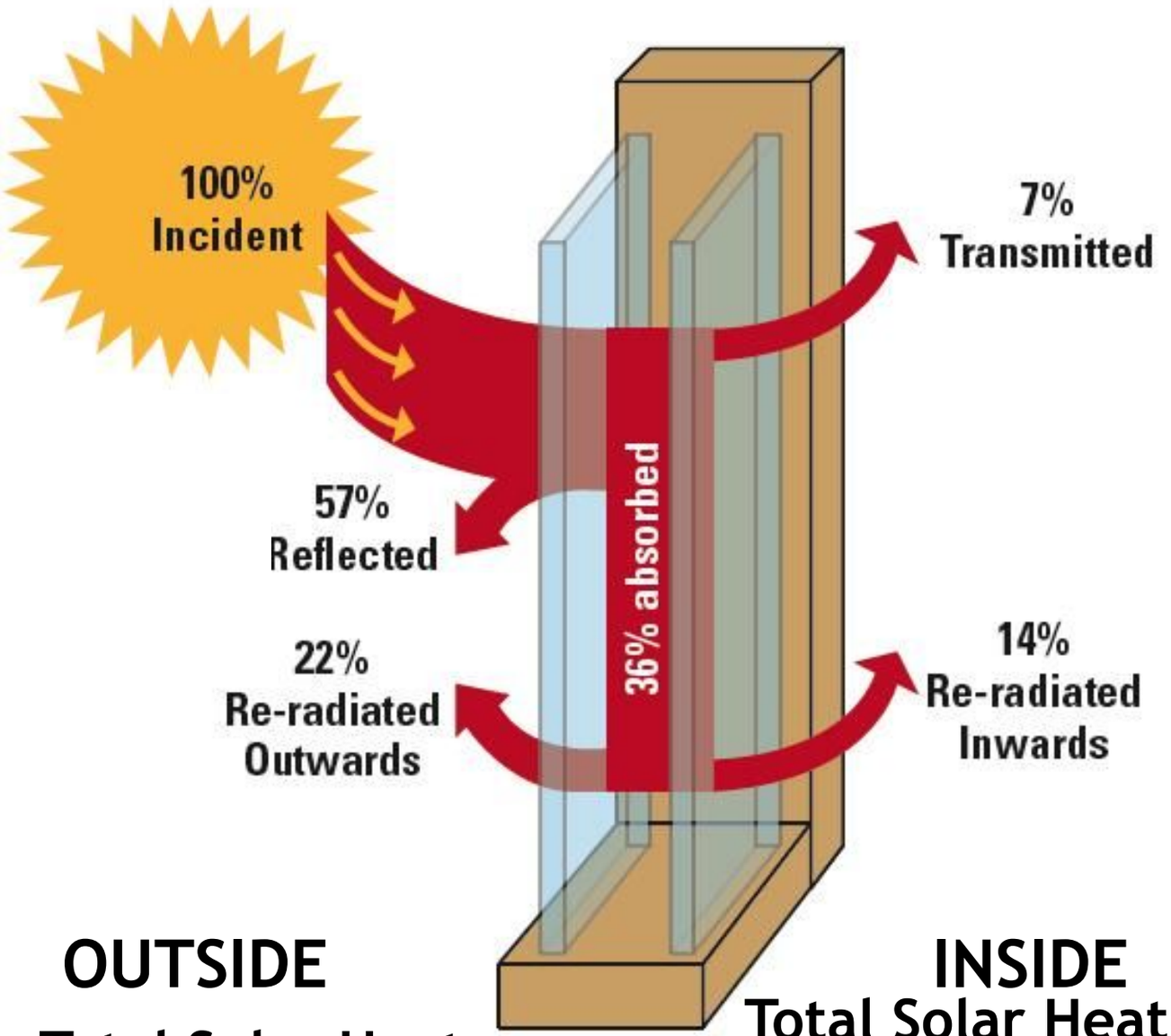


230 mm Brick with 15 mm plaster on both sides
U Value 1.72 - 2.24 W/m²K

200 mm Autoclaved Aerated Concrete (AAC) with 15 mm plaster on both side
U Value- 0.77 W/m²K

300 mm Autoclaved Aerated Concrete (AAC) with 15 mm plaster on both sides
U Value - 0.54 W/ m²K

3.4 U- Value - Thermal Transmittance - Non-Opaque



OUTSIDE

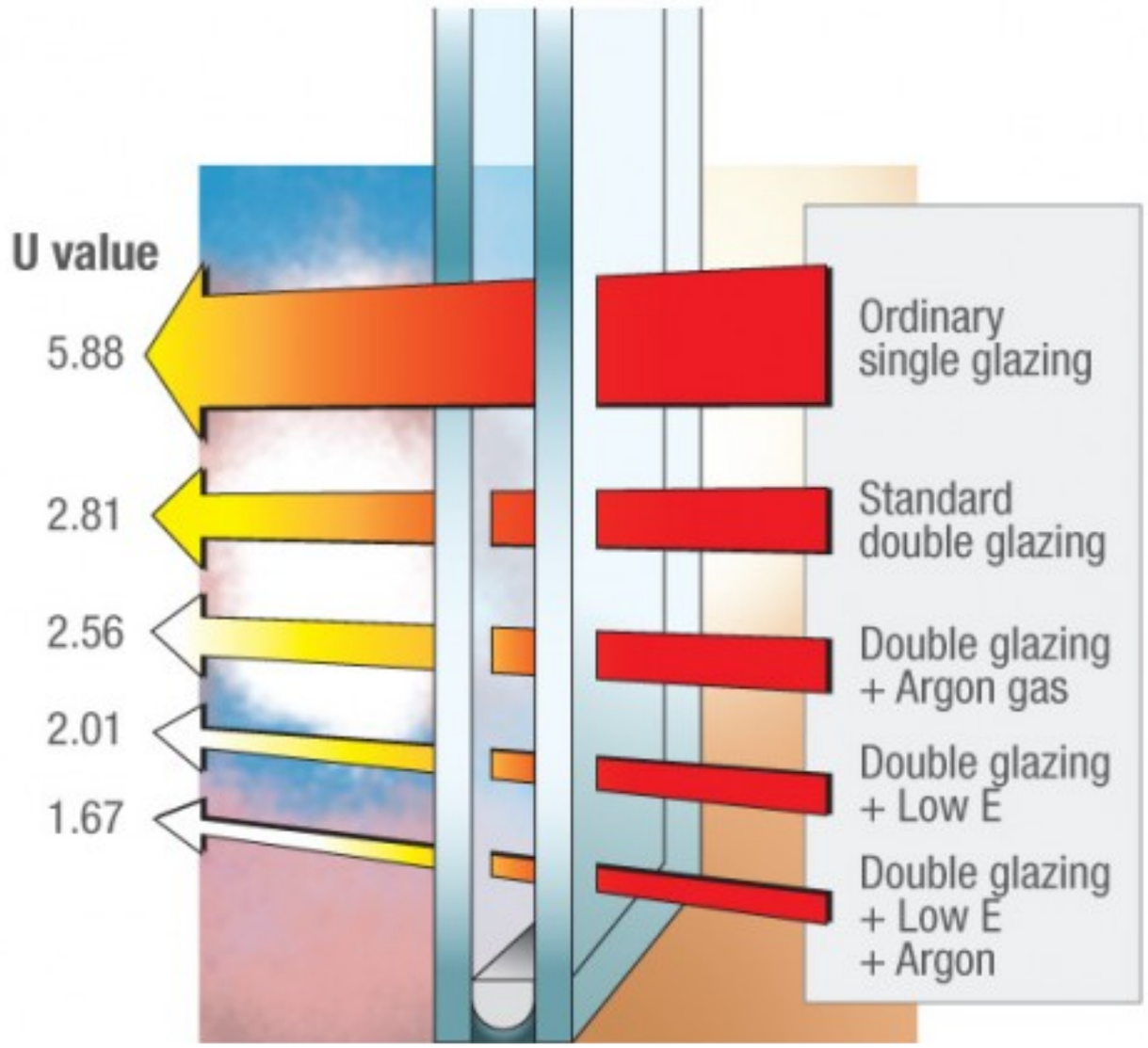
Total Solar Heat

Elimination : 79%

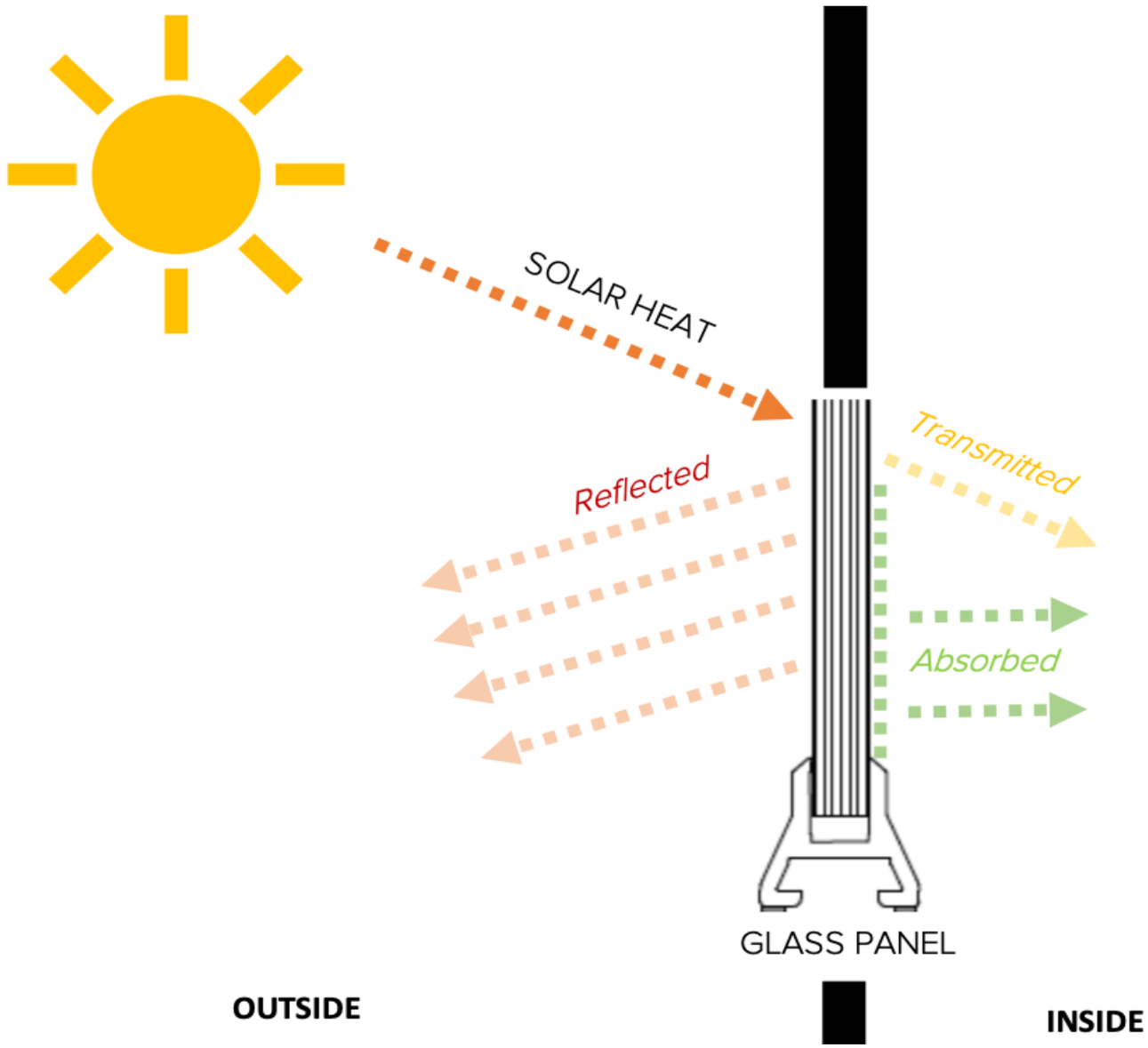
INSIDE

Total Solar Heat

Transmission : 21%



3.4 Solar Heat Gain Coefficient (SHGC) - Non-Opaque



Solar heat gain coefficient is the measure of solar heat –

- Absorbed
- Transmitted

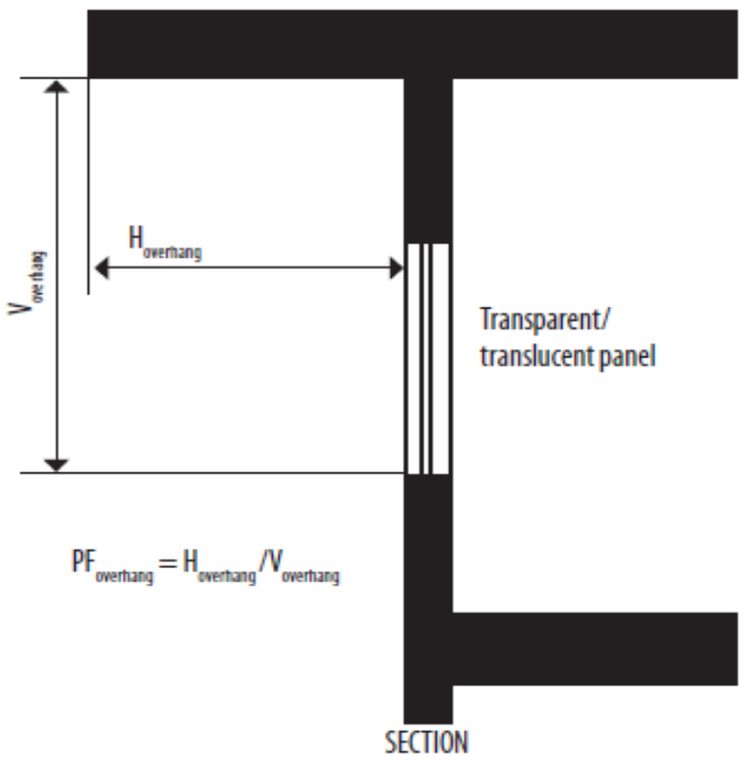
Lower SHGC ∝ lesser Heat Transfer

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

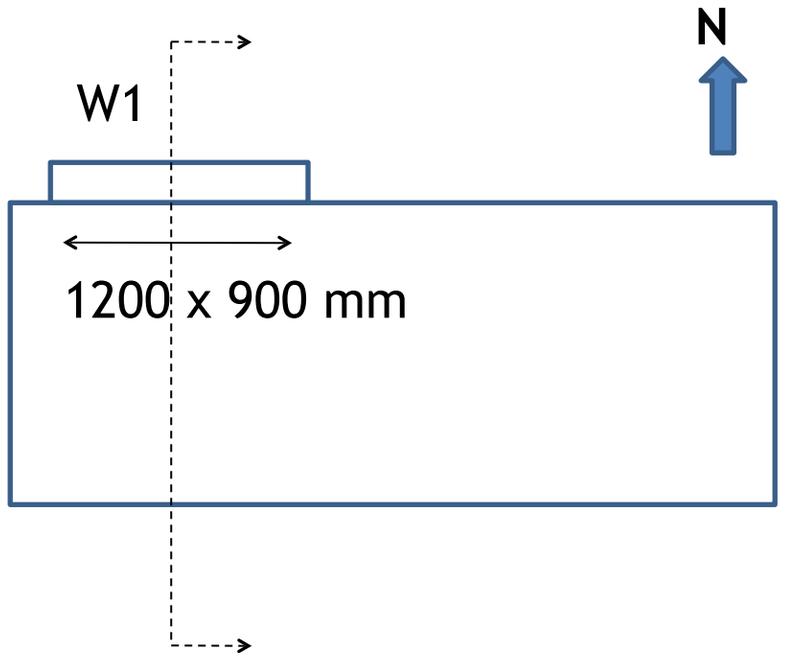
3.4 Projection factor (PF)

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.

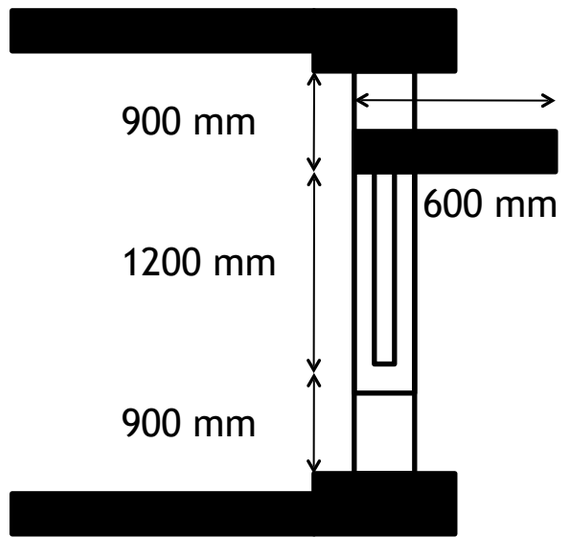
$$PF_{overhang} = \frac{H_{overhang}}{V_{overhang}}$$



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

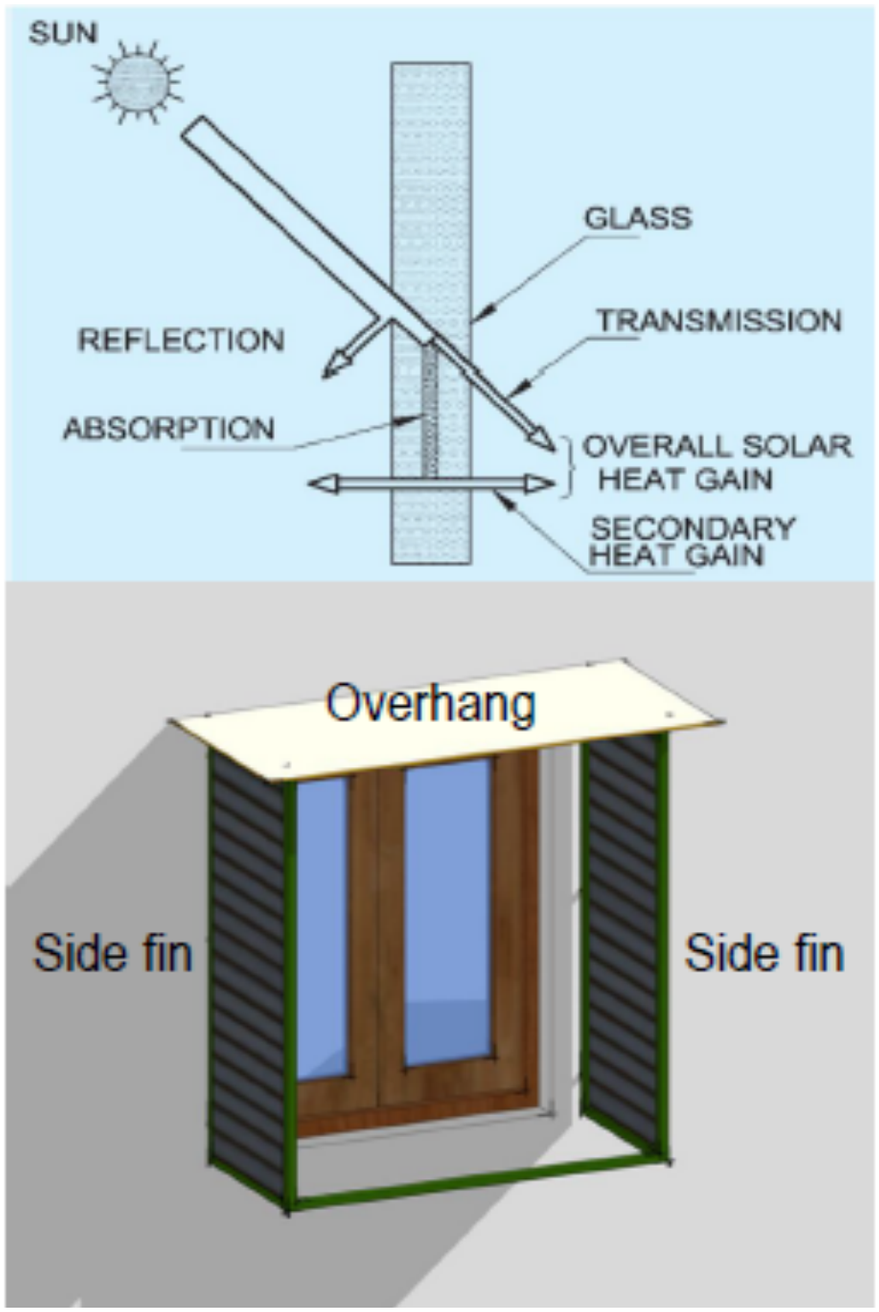


Plan



Section

3.4 Equivalent SHGC



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

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

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

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

$SHGC_{eq}$ - Equivalent SHGC

$SHGC_{unshaded}$ - Unshaded SHGC

ESF_{total} - Total External Shading Factor

3.4 Equivalent SHGC

Orientation / $PF_{overhang}$	External Shading Factor for Overhang ($ESF_{overhang}$) for LAT < 23.5°N							
	North (337.6°–22.5°)	North-east (22.6°–67.5°)	East (67.6°–112.5°)	South-east (112.6°–157.5°)	South (157.6°–202.5°)	South-west (202.6°–247.5°)	West (247.6°–292.5°)	North-west (292.6°–337.5°)
<0.10	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
0.10-0.19	0.931	0.924	0.922	0.910	0.896	0.910	0.922	0.924
0.20-0.29	0.888	0.864	0.855	0.834	0.816	0.834	0.854	0.864
0.30-0.39	0.860	0.818	0.797	0.771	0.754	0.771	0.796	0.818
0.40-0.49	0.838	0.782	0.747	0.721	0.708	0.720	0.746	0.782
0.50-0.59	0.820	0.755	0.705	0.682	0.675	0.681	0.705	0.755
0.60-0.69	0.806	0.734	0.670	0.651	0.653	0.651	0.670	0.734
0.70-0.79	0.793	0.718	0.641	0.628	0.638	0.627	0.640	0.717
0.80-0.89	0.783	0.706	0.616	0.610	0.628	0.609	0.615	0.705
0.90-0.99	0.775	0.696	0.596	0.596	0.621	0.596	0.595	0.695
≥1	0.768	0.688	0.579	0.585	0.616	0.585	0.578	0.688

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

$$= 0.6 * 0.820$$

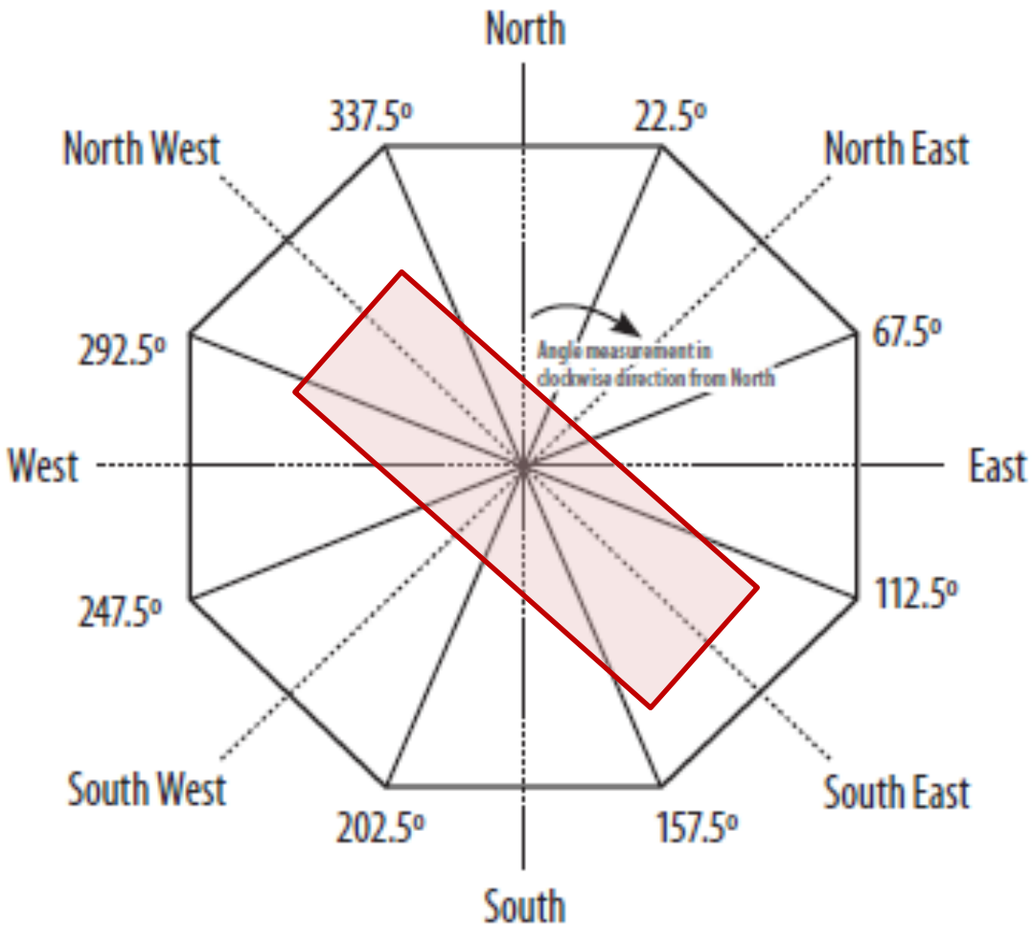
$$= 0.492$$

Source: Eco Niwas Samhita -2018, Table 11, Annexure - 7

3.4 Orientation factor (ω)

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



The building is oriented at 45 ° N, then the corresponding Orientation factor = 0.906

3.4 Residential Envelope Transmittance Value (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)		

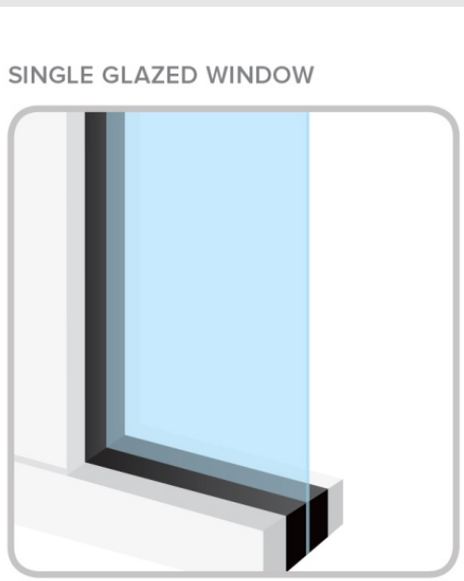
RETV for the building envelope (except roof) for four climate zones, namely, Composite Climate, Hot-Dry Climate, Warm-Humid Climate and Temperate

Climate shall comply with the maximum RETV of **15 W/m²**

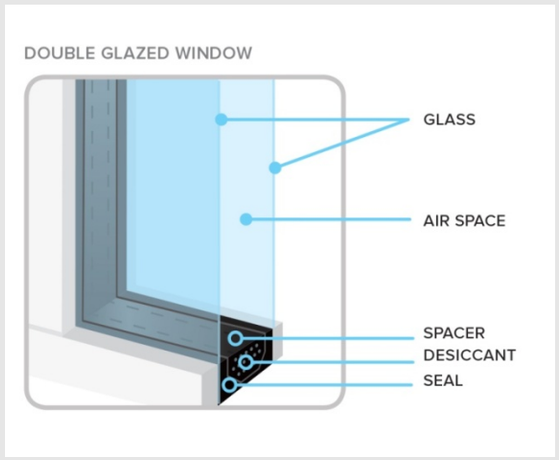
3.4 RETV Case - 1 ; Belagavi, Karnataka (Composite)

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/m².K			

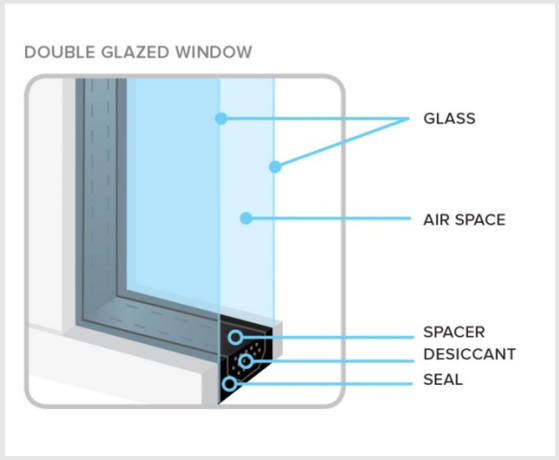
3.4 RETV Case - 2 ; Belagavi, Karnataka (Composite)

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			

3.4 RETV Case - 3 ; Belagavi, Karnataka (Composite)

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/m².K			

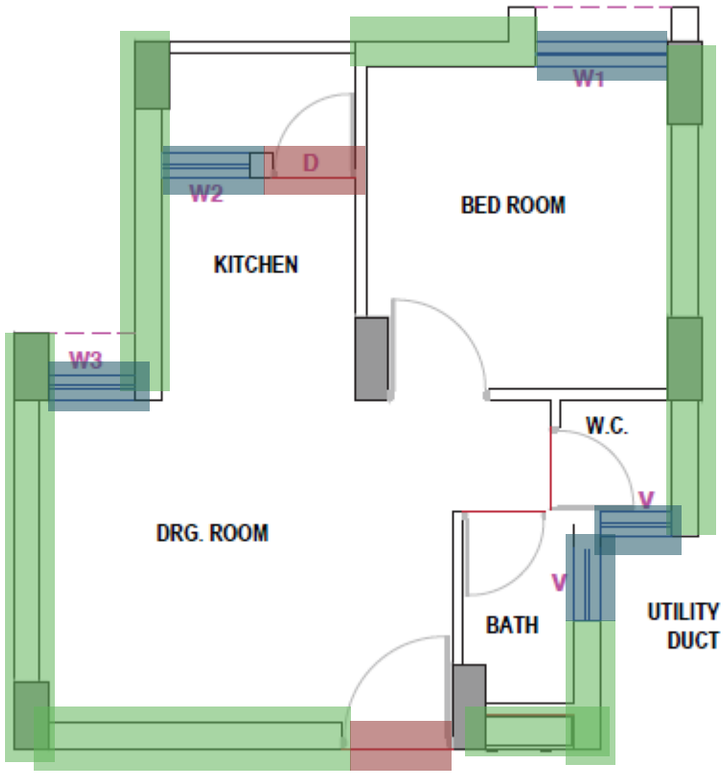
3.4 RETV Case - 4 ; Belagavi, Karnataka (Composite)

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			

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

$$U_{envelope,cold} = \frac{(2793.38 \times 0.78) + (210.00 \times 5.23) + (474.88 \times 5.80)}{2793.38 + 210.00 + 474.88} = 1.73 \ \mathbf{W/m^2.K}$$

Case Study Analysis

Project Description and Details

Building Type	High Rise Residential
Location	Bengaluru
Climate Condition	Temperate
Residential Segment	Luxury Segment Project
Site Area	14,999 m^2
Total Built-up Area	35,525 m^2
Total No of Residential Units	214
Type of Units	3 BHK, 2 BHK
Orientation of Building	North with tilt of 5˚

Project Description and Details

3 BHK - Block - A

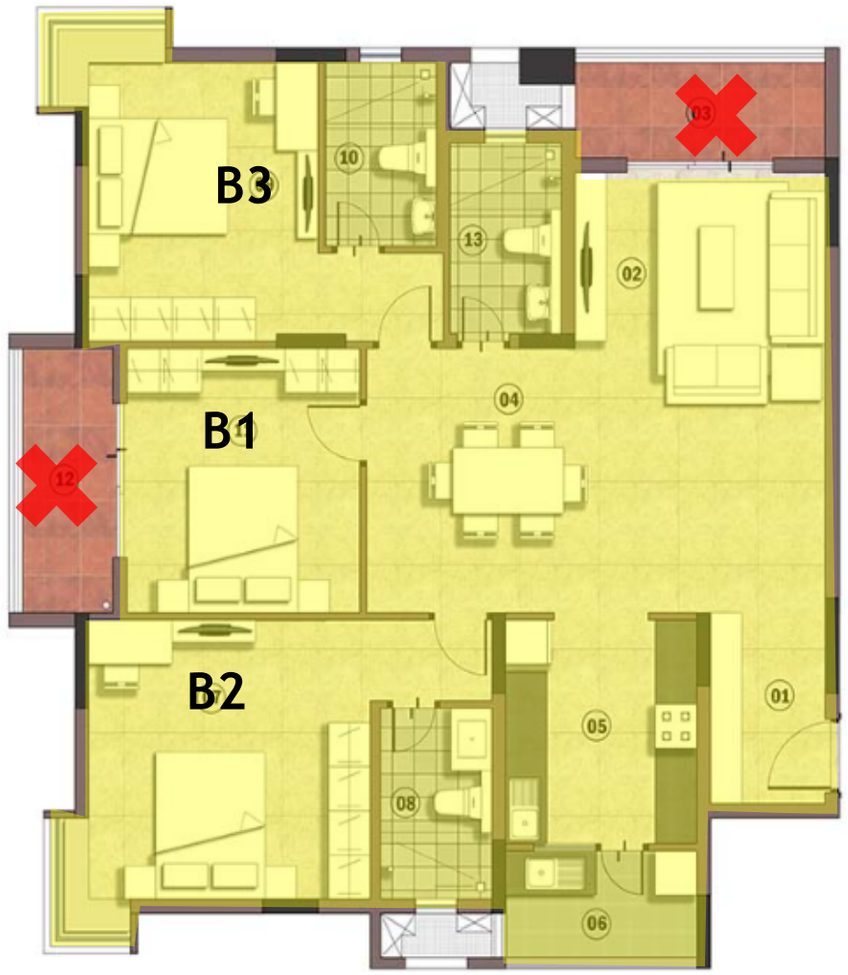
2 BHK - Block - B

Total Blocks	5 Blocks (A-E)
3 BHK	40 units (each block)
Floor area (3 BHK)	70.7 to 98.5 sqm
2 BHK	3 units (each block)
Floor area (2 BHK)	92.4 to 98.5 sqm
Other Amenities	Gymnasium, Indoor Games, Swimming Pool, Badminton Court

Envelope Type	Construction Configuration
Wall	External Cement Mortar (15mm) + Concrete Wall (200mm) + Internal Cement Mortar (12mm)
Roof	SRI Paint + Internal Cement Mortar (15mm) + BBC (150mm) + Expanded Poly Styrene (EPS) (50mm) + RCC Slab (200mm)
Fenestration & Glazing	UPVC frame SGU with 6mm clear glass, SHGC = 0.84, VLT = 0.82

Openable Window to Floor Area Ratio (WFR_{op}) - 3 BHK

BLOCK C (3-BHK Unit)								
Area	Floor Area			Openable Window/Door Area				
	Width (m)	Length (m)	Area (m2)	Type	Qty	Width (m)	Length (m)	Area (m2)
Bedroom-1	3.35	3.8	**12.73**	SD	1	0.925	1.8	**1.665**
Bedroom-2	3.15	3.8	**11.97**	W/W1	1	0.625	1.374	**0.86**
Bedroom-3	3.15	3.8	**11.97**	W/W2	1	0.625	1.374	**0.86**
Living/ Dining Room/ Foyer	3.45	6.4	**22.08**	SD	1	0.925	1.8	**1.66**
Kitchen	2.8	2.8	**7.84**	KW	1	0.6	0.78	**0.47**
				KD	1	0.59	1.8	**1.1**
Bathroom-1	2.6	1.7	**4.42**	V	1	0.9	0.6	**0.54**
Bathroom-2	1.75	2.8	**4.9**	V	1	0.9	0.6	**0.54**



WFR_{op} = 10.9

Openable Window to Floor Area Ratio (WFR_{op}) - 2 BHK

BLOCK C (2-BHK Unit)								
Area	Floor Area			Openable Window/Door Area				
	Width (m)	Length (m)	Area (m2)	Type	Qty	Width (m)	Length (m)	Area (m2)
Bedroom-1	3.35	3.7	12.395	W/ W1	1	0.925	1.8	1.665
Bedroom-2	3.6	3.35	12.06	W/ W2	1	0.925	1.8	1.665
Living/ Dining Room	7.2	3.45	24.975	SD	1	0.925	1.8	**1.66**
Kitchen	2.6	3.45	8.97	KW	1	0.6	0.78	0.468
				KD	1	0.59	1.8	1.062
Bathroom-1	1.6	2.5	4	V	1	0.9	0.6	0.54
Bathroom-2	1.6	2.5	4	V	1	0.9	0.6	0.54

WFR_{op} = 11.4

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

Climate Zone	Minimum WFRop (%)
Composite	12.5
Hot-Dry	10
Warm-Humid	16.66
Temperate	12.5
Cold	8.33

3 BHK

$$WFRop = \frac{A_{openable}}{A_{carpet}} = \frac{8.3}{75.91} = 10.9\%$$

2 BHK

$$WFRop = \frac{A_{openable}}{A_{carpet}} = \frac{7.59}{66.4} = 11.4\%$$

Bengaluru is in the temperate climate.

As per Table, the minimum WFRop for this climate is 12.5%.

Thus, this project does not complies with this requirement.

Window to Wall Area Ratio (To arrive at Optimum VLT)

Wall area calculations

Orientation	Areas			WWR
	Opaque Wall Area (m^2)	Non-Opaque Area (m^2)	Total Envelope Area (m^2)	
North	2842.82	1578.88	4421.7	0.30
South	3028.92	1393.38	4422.3	
East	922.26	137.34	1059.6	
West	678.17	107.68	785.85	

Building Envelope Details of the Project

Envelope Type	Construction Configuration	Thermal Transmittance (W/ m^2. K)
Fenestration & Glazing	UPVC frame SGU(Single Glazed Unit) with 6mm clear glass, SHGC = 0.84, **VLT = 0.82**	5.68

WWR to arrive at optimum VLT - As per Code

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

In this project and Single Glazed Unit with UPVC frame having a **VLT of 0.82** is used for construction.
Therefore, it is seen that the project **is meeting the compliance requirement for VLT.**

Thermal Transmittance - U_{roof}

Roof Construction Details of the Project

Building Envelope Type	Construction Configuration	Thickness (m)	Thermal Conductivity, "K" (W/m. K)	Thermal Resistance Total, "R"(m^2.K/W)	Thermal Transmittance, "U" (W/m^2. K)
Roof	Internal Cement Mortar	0.012	0.719	0.764 (including Rs_i = 0.17 m^2. K/W and Rs_e = 0.04 m^2. K/W)	**1.31**
	RCC Slab	0.2	1.58		
	Brick Bat Coba	0.15	0.62		
	Expanded Poly Styrene Insulation (EPS)	0.05	0.35		
	External Cement Mortar	0.015	0.719		
	SRI Paint	0.0005	0.09		

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

	Roof	
	Composite climate, hot-Dry climate, warm-humid climate, and temperate climate	Cold Climate
Rsi(m2.K/W)	0.17	0.10
Rse(m2.K/W)	0.04	0.04

The project has **U-value of 1.31 W/m^2. K.**
Hence the building's roof configuration **does not complies with this requirement.**

Source- Adapted from Bureau of Energy Efficiency (BEE), 2009. *Energy Conservation Building Code User Guide*, New Delhi

Residential Envelope Transmittance Value (RETV)

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

Climate Co-efficient	a	b	c
Temperate	3.38	0.37	63.69

Orientation Factor for Building oriented at 5°N; Latitude < 23.5°N			
N	S	E	W
0.659	0.966	1.155	1.156

Wall and Glazing Details of the Project

Envelope Type	Construction Configuration	Thickness (m)	Thermal Conductivity, "K" (W/m. K)	Thermal Resistance Total, "R"(m^2.K/W)	Thermal Transmittance, "U" (W/m^2. K)
Wall	Internal Cement Mortar	0.015	0.719	0.49	2.06
	Concrete wall	0.2	0.73		
	Exterior Cement Mortar	0.015	0.719		
Glazing	Single Glazed Unit with UPVC Frame; SHGC = 0.84	0.006			5.68

Residential Envelope Transmittance Value (RETV)

Wall													
Envelope	Property	Gross Area (m^2)				Net Area (m^2)							
	U value (W/m^2. K)	North	East	South	West	North	East	South	West				
Concrete Wall	2.06	4421.70	1059.60	4422.30	785.85	2842.82	922.26	3028.92	678.17				
Glazing												RETV (W/m^2)	
		SHGC EQ					Window Area (m^2)						
SHGC	Type	North	East	South	West	U value (W/m^2. K)	North	East	South	West	Total	Standard	Achieved
0.84	W/W1	0.72	0.74	0.70	0.74	5.70	461.25	67.50	380.25	18.00	927.00	15.00	13.04
	W2	0.72	0.74	0.70	0.74		17.55	0.00	20.40	28.80	66.75		
	KW	0.54	0.00	0.43	0.43		21.06	0.00	23.40	9.36	53.82		
	SD	0.55	0.43	0.46	0.00		905.52	46.20	803.88	0.00	1755.60		
	SDs	0.50	0.00	0.39	0.00		26.40	0.00	33.00	0.00	59.40		

The above table describes the suitable values considered for calculating thermal transmittance based on the orientation of the building

The project has **RETV value as 13.04 W/m^2.**
Hence the building's RETV configuration **complies with this requirement.**

Code Compliance Report

Compliance Parameters	Achieved	Requirement	Compliance Status
Openable Window to Floor Area Ratio (WFR_{op})	8.95 % to 10.09 %	≥ 12.5 %	**NOT COMPLIANT**
Visible Light Transmittance (VLT)	0.87	≥ 0.27	**COMPLIANT**
Thermal Transmittance of Roof (U_{roof})	1.31	≤ 1.2 W/m². K	**NOT COMPLIANT**
Residential Envelope Transmittance Value (RETV)	13.04	≤ 15 W/m²	**COMPLIANT**

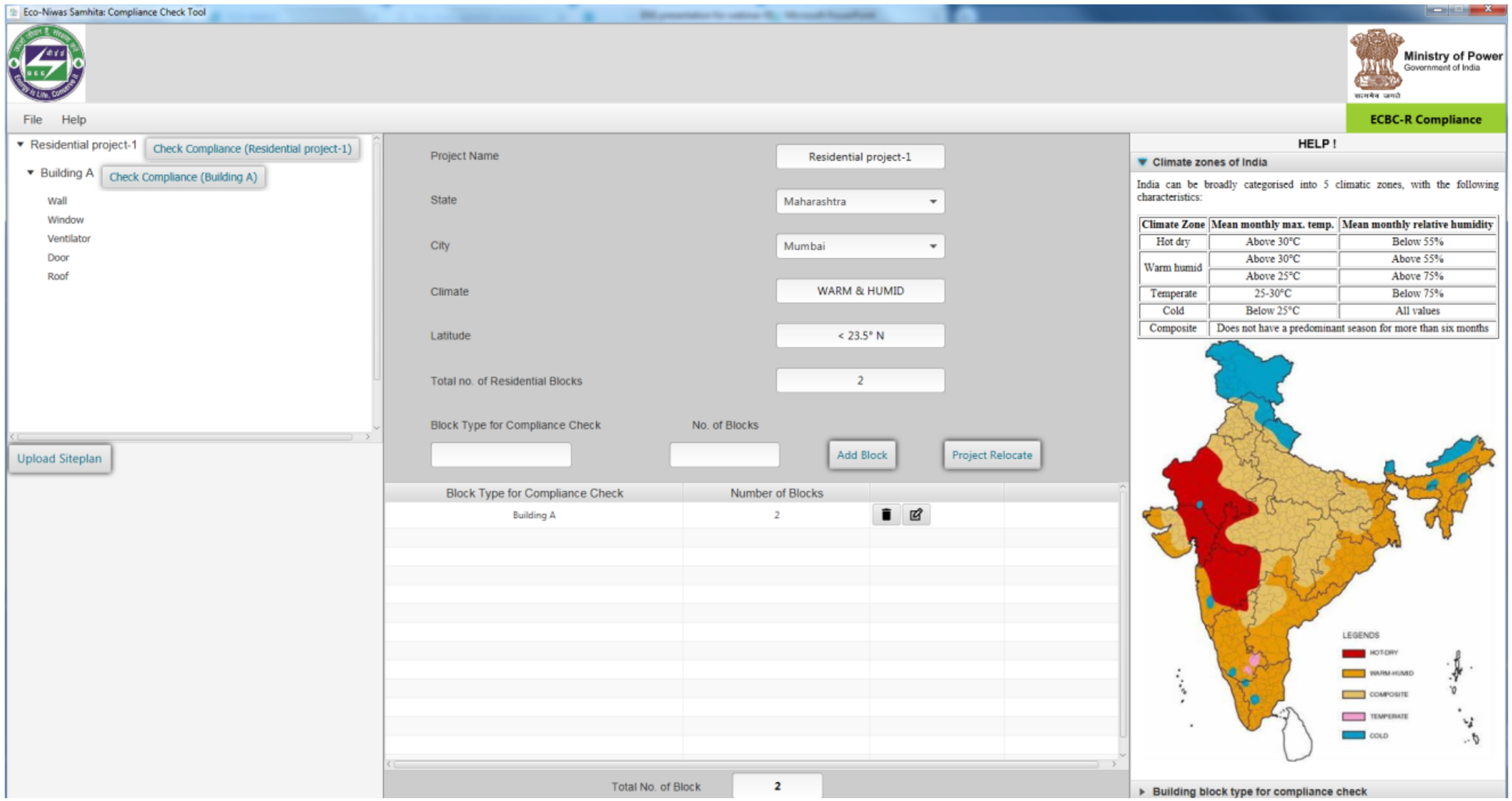
There is scope for improvement in the design aspects to glazing components of the building.

Reducing these values will limit the amount of heat gained inside the dwelling units and will provide thermal comfort to occupants at a lower cost of energy.

Eco-Niwas Samhita Compliance Approach Tool

Eco Niwas Samhita – Compliance Tool

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

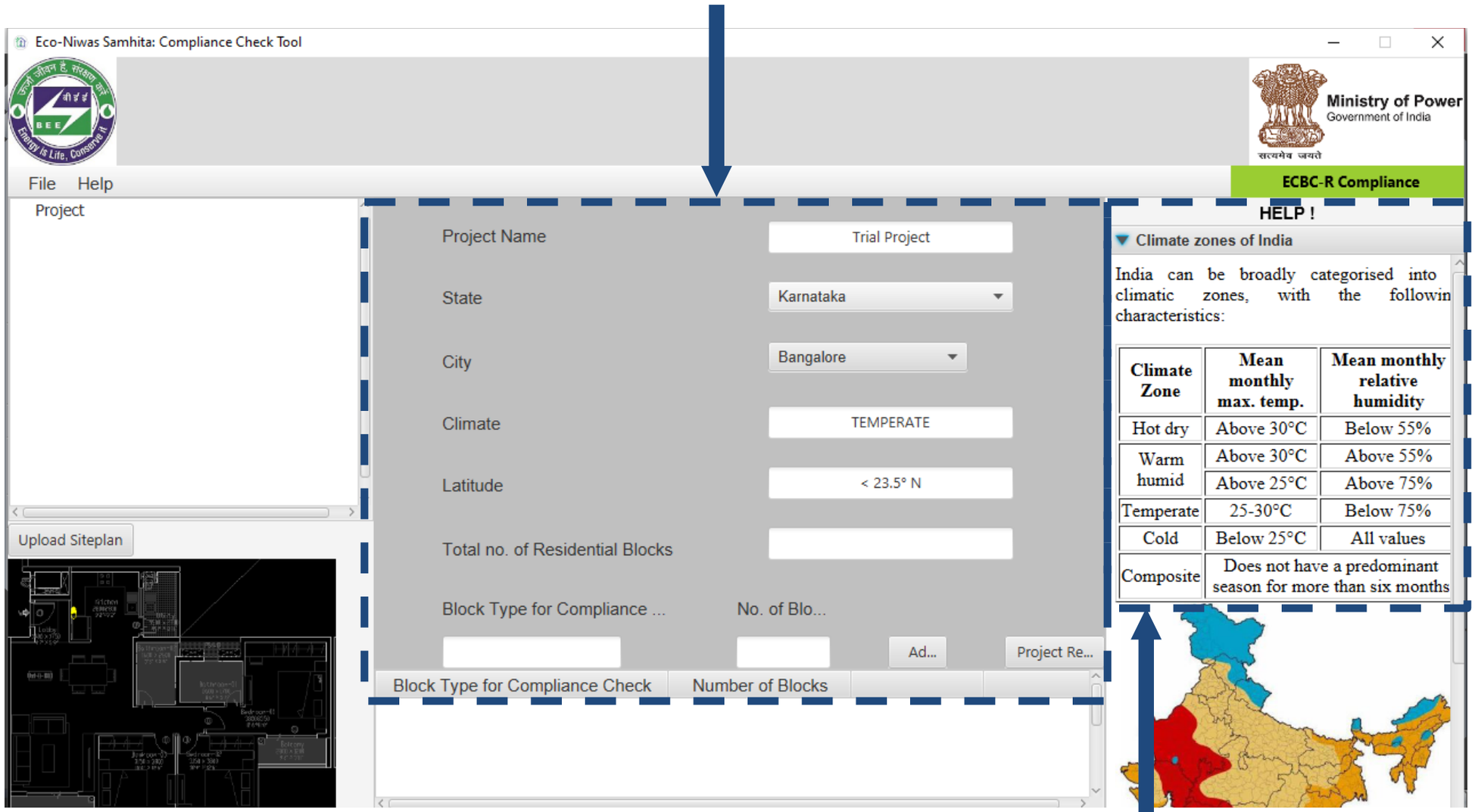


Available on Bureau of Energy Efficiency's website for download.

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

Eco Niwas Samhita – Compliance Tool

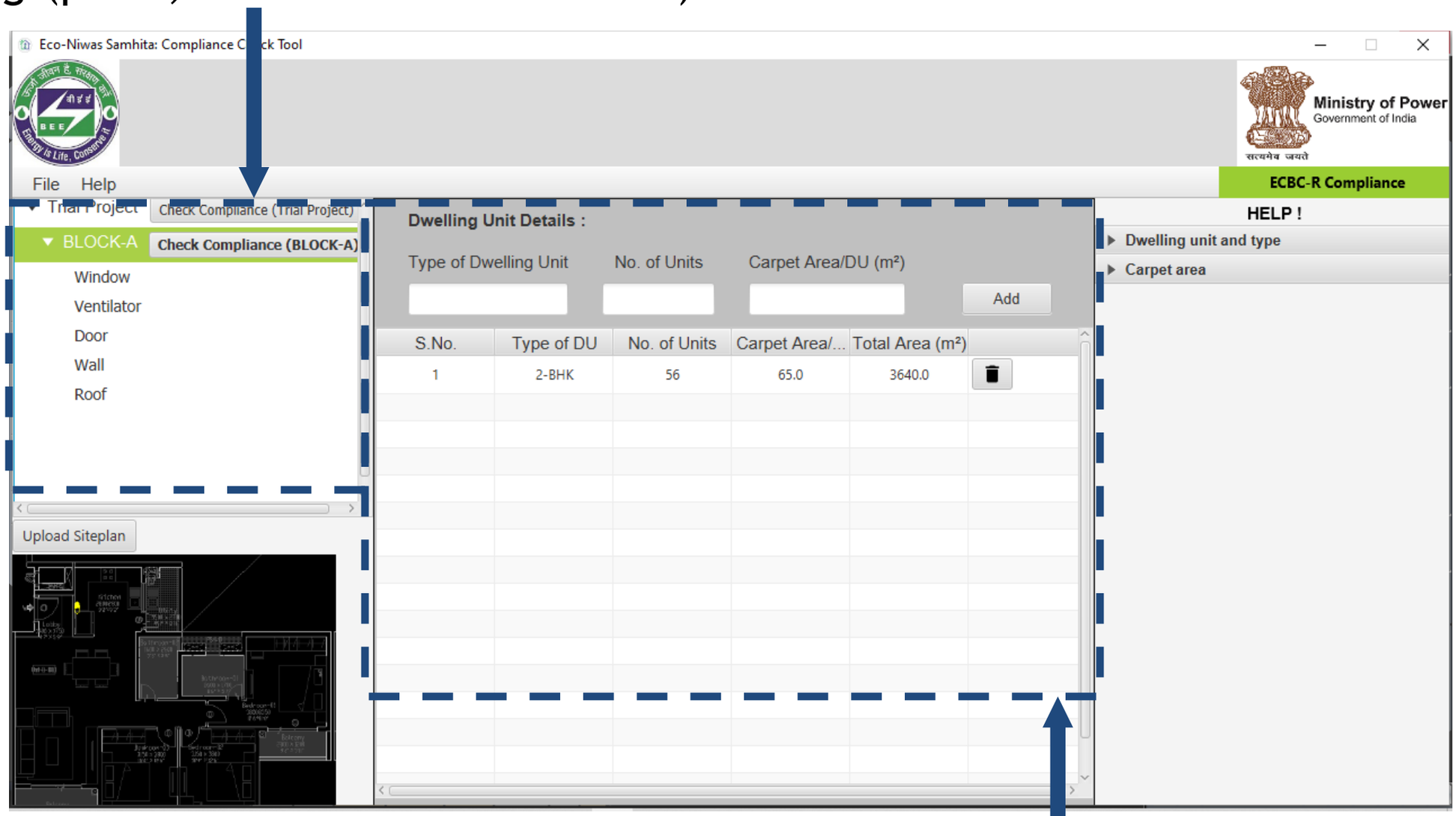
Project related details are entered in the tool for compliance check



Climate data after entering the project location details

Eco Niwas Samhita – Compliance Tool

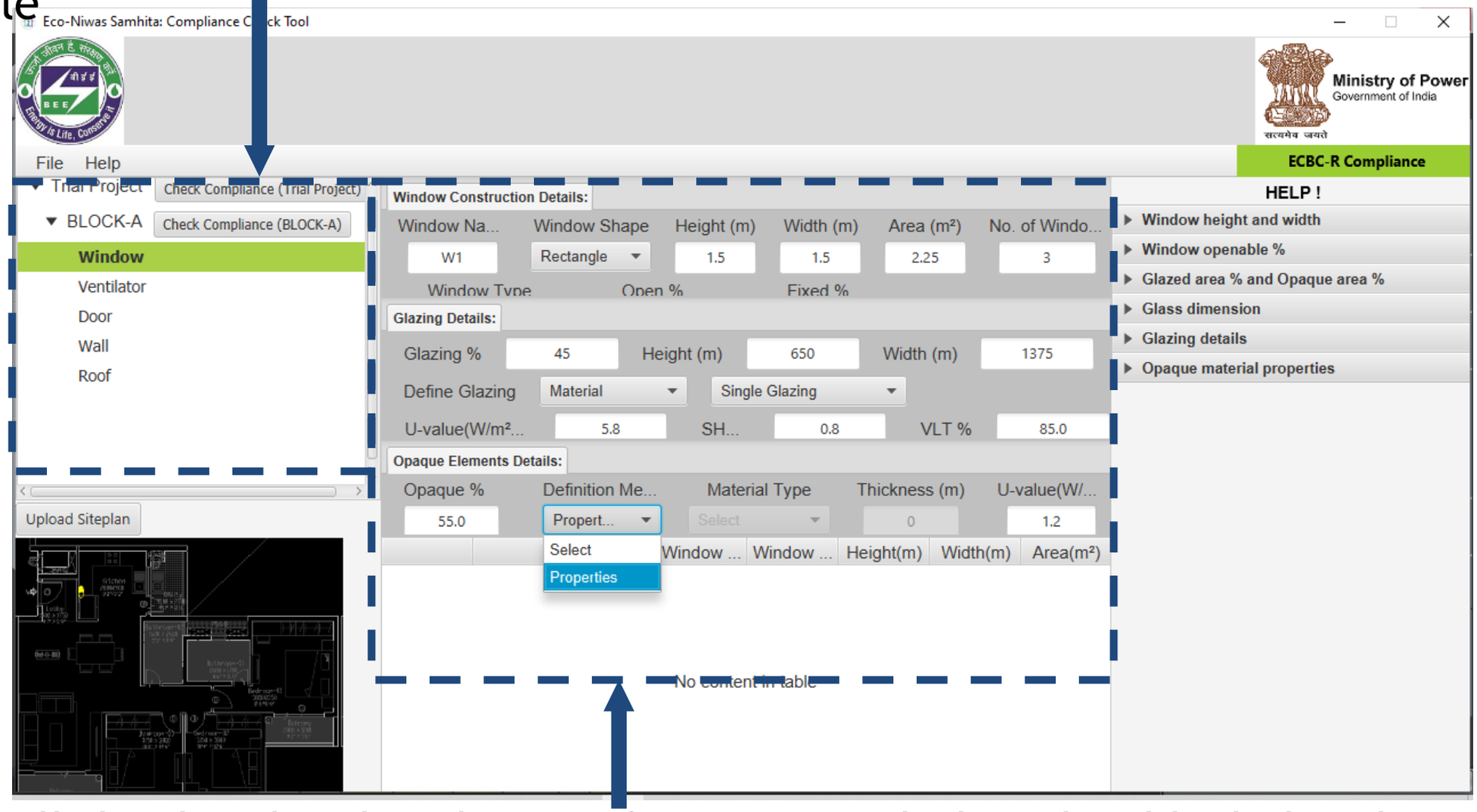
Details of various building components will be added for Compliance check- Architectural drawings(plans, sections and elevations)



Details of the blocks are submitted and can be seen here

Eco Niwas Samhita – Compliance Tool

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

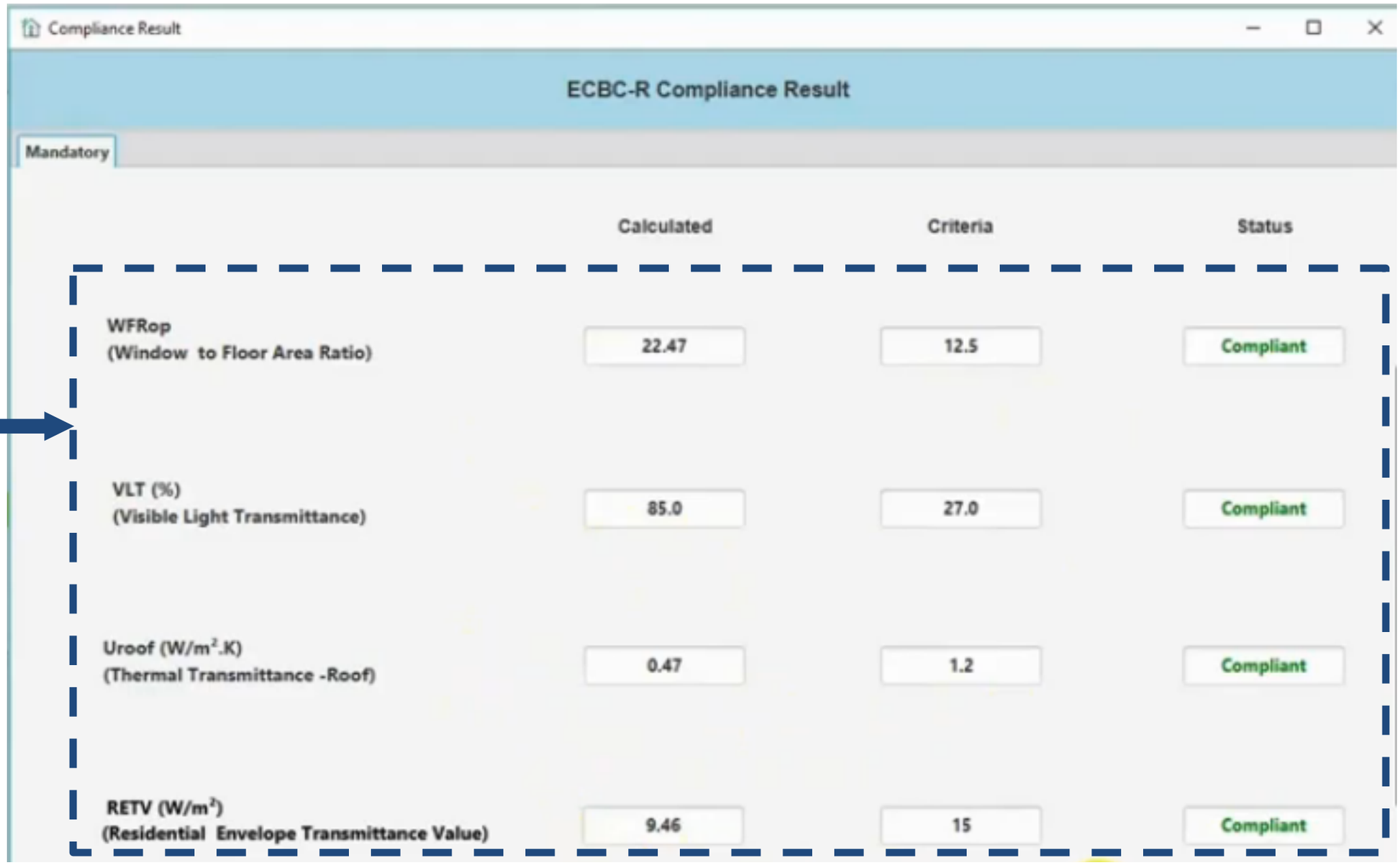


All the details related to window are submitted for the compliance

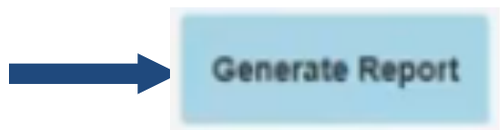
Similarly, other block details are added in the table for checking different design alternatives

Eco Niwas Samhita – Compliance Tool

Result of the compliance of code provisions shown



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



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