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

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

GLOBAL HOUSING TECHNOLOGY CHALLENGE INDIA

RACHNA

RESILIENT, AFFORDABLE AND COMFORTABLE HOUSING THROUGH NATIONAL ACTION

Improving Thermal Comfort and Sustainability in Low-Income Housing

School of Architecture, Reva University

16/05/2022

Presented by South Cluster CSB Cell

Introduction - GIZ

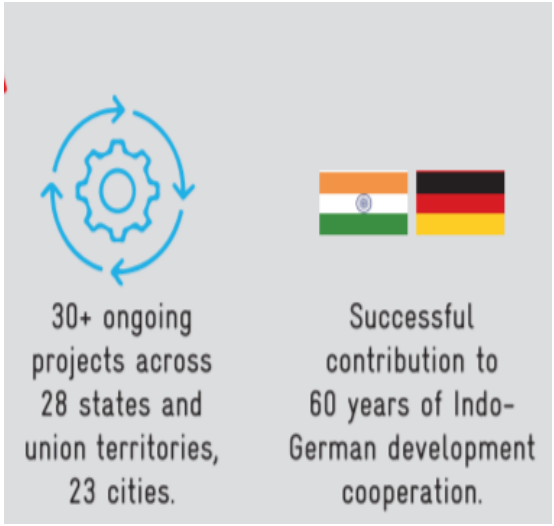
GIZ

GIZ is an international cooperation enterprise for sustainable development which operates worldwide, on a public benefit basis. GIZ is fully owned by the **German Federal Government**, GIZ implement development programs in partner country on behalf of the German Government in achieving its development policy objectives.

german cooperation
DEUTSCHE ZUSAMMENARBEIT

The focal areas of Indo-German cooperation currently are:

- ❑ Energy
- ❑ Environment, Preservation, and Sustainable Use of Natural Resources
- ❑ Sustainable Urban & Industrial Development
- ❑ Sustainable Economic Development



GIZ

Energy

We support our partners in developing framework conditions for the promotion of renewable energy, improved energy efficiency and rural energy access.

- Indo-German Energy Forum – Support Office
- Indo-German Energy Programme – Access to Energy in Rural Areas
- Integration of Renewable Energies into the Indian Electricity System
- Indo-German Solar Partnership – PVRT
- Promotion of Solar Water Pumps
- Indo-German Energy Programme – Green Energy Corridors
- Energy Efficiency in Buildings Programme
- Indo-German Energy Programme – Energy Efficiency

Sustainable Urban and Industrial Development

We support the development of urban and industrial areas to become cleaner, more liveable, inclusive, climate-friendly and resilient.

- Land Use Planning and Management
- Sustainable and Environment-friendly Industrial Production
- Support to Ganga Rejuvenation
- Integrated and Sustainable Urban Transport Systems for Smart Cities in India
- Sustainable Urban Development – Smart Cities
- Climate Smart Cities

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MoHUA + GIZ

MoHUA
(Ministry of Housing & Urban Affairs)

Government of India

+

GIZ
(Deutsche Gesellschaft für Internationale Zusammenarbeit)

Government of Germany

Indo-German Energy Program (IGEN)

IGEN Program: Climate Smart Buildings

- **Thermal Comfort Action Plan**
- **Standard / Guidelines**

- **Implementation of GHTC India**
- **Establishment of Cluster Cells**

Introduction - GHTC

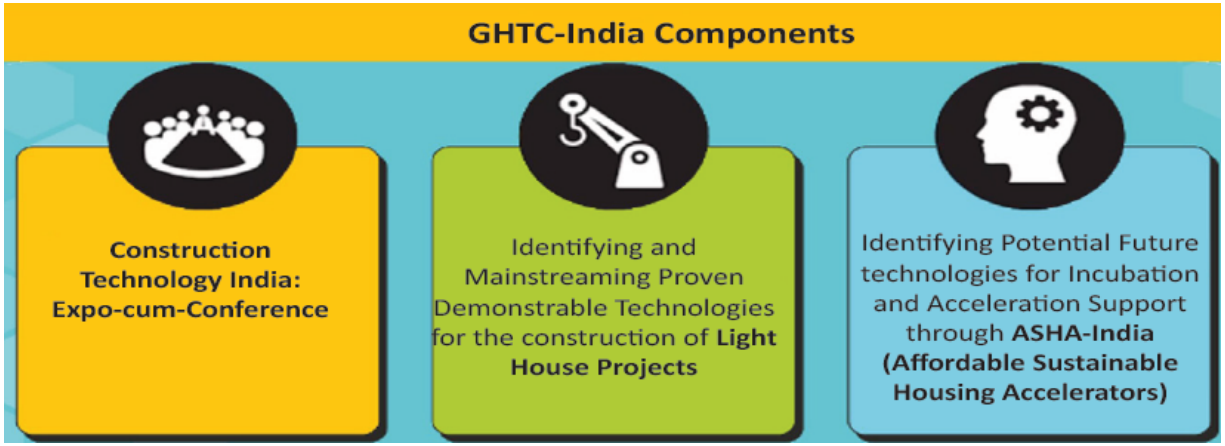
Global Housing Technology Challenge - India

MoHUA has initiated the **Global Housing Technology Challenge-India (GHTC-India)** which aims to identify and mainstream a basket of innovative construction technologies from across the globe for housing construction sector that are sustainable, eco-friendly and disaster-resilient.

They are to be cost effective and speedier while enabling the quality construction of houses, meeting diverse geo-climatic conditions and desired functional needs.

MoHUA, through a **Technical Evaluation Committee (TEC)**, shortlisted **54 innovative** proven technologies suiting different geo-climatic conditions that could be considered for demonstration through actual ground implementation of six Light House Projects (LHP) in six different States/UTs of PMAY(U) regions across the country.

Hon'ble Prime Minister Shri Narendra Modi laid the foundation stone of these LHPs on January 1, 2021



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Light House Project

- **Model housing projects with approximately 1,000 houses built with shortlisted alternate technology suitable to the geo-climatic and hazard conditions of the region.**
- Demonstrate and deliver ready to live houses with speed, economy and with better quality of construction in a sustainable manner.
- **Period of construction is maximum 12 months from the date of handing over of sites to the construction agency after all statutory approvals.**
- LHPs shall serve as LIVE Laboratories for planning, design, production of components, construction practices, testing etc.
- **Site infrastructure development such as internal roads, pathways, common green area, boundary wall, water supply, sewerage, drainage, rain water harvesting, solar lighting, external electrification, etc.**
- Cluster design may include innovative systems of water supply, drainage and rainwater harvesting, renewable energy sources with special focus on solar energy.
- **Incentives for early completion.**

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Light House Project

Six Technology providers have been selected through a rigorous online bidding process for construction of Light House Projects (LHPs) at six different locations in six states.

1. Precast Concrete Construction System - 3D Precast volumetric

2.Precast Concrete Construction System - Precast components assembled at site

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

4.Prefabricated Sandwich Panel System

5.Monolithic Concrete Construction

6.Stay In Place Formwork System

Introduction – Climate Smart Buildings Cell

GIZ Climate Smart Buildings Cell (CSB cell)

Light House Project – Implementation Monitoring & Evaluation

Technical Assistance to DHPs & AHRCs

GIZ Climate Smart Building Cell (CSB)

Inclusion of Thermal Comfort requirements in Bye-laws

Capacity Building of Stakeholders

South Cluster Cell covers

- ❑ ***Tamilnadu***
- ❑ ***Karnataka***
- ❑ ***Kerala***
- ❑ ***Andhra Pradesh***
- ❑ ***Telangana***
- ❑ ***Puducherry***
- ❑ ***Andaman & Nicobar***
- ❑ ***Lakshadweep***

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Light House Project : CHENNAI

TECHNOLOGY SELECTED:

Precast Concrete Construction System – Precast Components Assembled at Site

AGENCY: **M/s B.G. Shirke Construction Technology Pvt. Ltd.**

No. of Towers: 12 **No. of Houses: 1128** **No. of Floors: 6**

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Light House Project : CHENNAI

Project Brief

Location of Project : Nukkampalayam Road, Chennai, Tamil Nadu

No. of DUs : 1,128 (G+5) **Plot area :** 29,222 sq.mt.

Carpet area of each DU : 26.78 sq.mt. **Total built up area :** 43439.76 sq.m

Technology being used : Precast Concrete Construction System - 3S System

Other provisions : Anganwadi, shops, milk booth, library and ration shop.

Broad Specifications:

- Foundation RCC isolated footing
- Structural Frame RCC precast beam/columns
- Walling AAC Blocks Floor Slabs/Roofing RCC precast

Door Frame/ Shutters:

- Pressed steel door frame with flush shutters
- PVC door frame with PVC Shutters in toilets.
- Window Frame/ Shutter:
- uPVC frame with glazed panel and wire mesh shutters.

Flooring:

- Vitrified tile flooring in Rooms & Kitchen
- Anti-skid ceramic tiles in bath & WC
- Kota stone Flooring in the Common area.
- Kota stone on Staircase steps.

Light House Project : CHENNAI

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

Light House Project : CHENNAI

Precast concrete construction

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

Light House Project : CHENNAI

Special Features

- Nearly all components of building work are manufactured in plant/casting yard & the jointing of components is done In-situ leading to reduction in construction time.
- The controlled factory environment brings resource optimization, improved quality, precision & finish.
- The concrete can be designed as industrial by-products such as Fly Ash, Ground granulated blast furnace slag (GGBFS), Micro silica etc. resulting in improved workability & durability, while also conserving natural resources.
- Helps in keeping a neat & clean construction site and dust free environment.
- Optimum use of water through recycling.
- Use of shuttering & scaffolding materials is minimal.
- All weather construction & better site organization.

Demonstration Housing Project (DHPs)

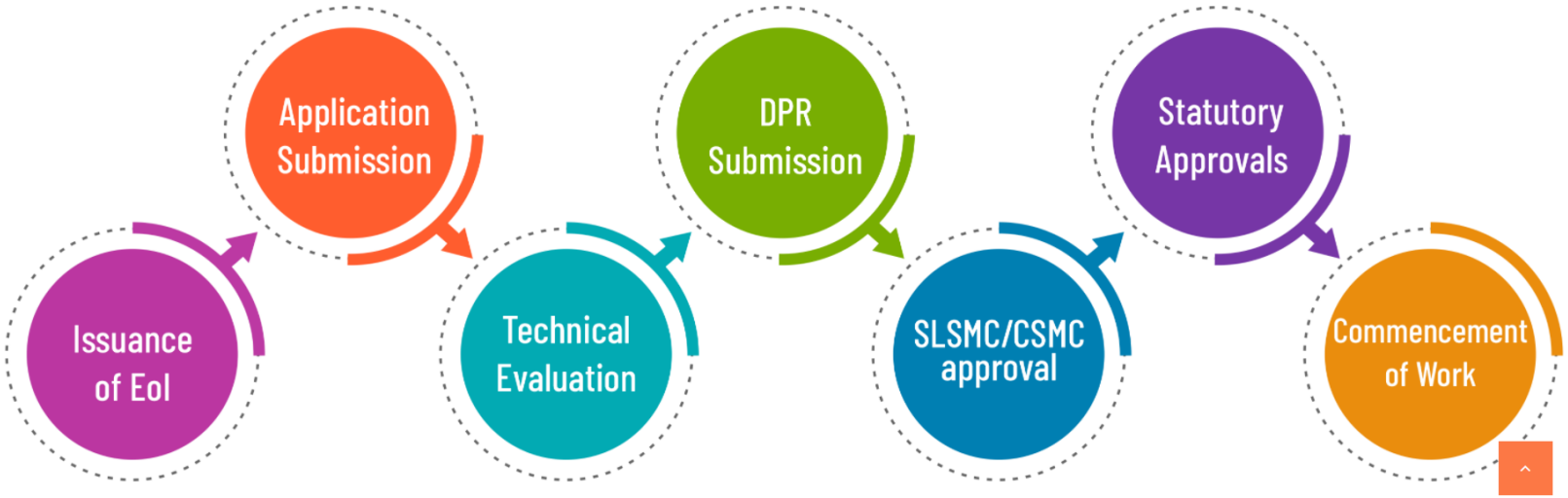
To showcase the field level application of new / alternate technologies, **MoHUA** has taken an initiative to construct Demonstration Housing Project (DHP) through **Building Materials & Technology Promotion Council (BMTPC)** as a part of Technology Sub-Mission under **PMAY(U)**.

Collection of drawings and other inputs at the Design Stage → **Technical Commercial feasibility analysis** → **Outputs & Recommendations through ENS and Simulations (softwares)** → **Specifications of Proposed strategies** → **Techno-Economic Feasibility Report** → **Acceptance & Implementation of recommendations** → **Monitoring & Verification of Thermal Comfort during & post construction**

ARHCs

- COVID-19 pandemic has resulted in **reverse migration** of urban migrants/ poor in the country. They need **decent rental housing** at affordable rate at their work sites.
- In order to address this need, **Ministry of Housing & Urban Affairs** has initiated **Affordable Rental Housing Complexes (ARHCs),** a sub-scheme under Pradhan Mantri AWAS Yojana- Urban (**PMAY-U**).
- Scheme will be implemented in 2 models: **Model 1** (Utilizing vacant Gov. houses)

MODEL-2



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RACHNA

Trainings & Workshops on Innovative Construction Technologies & Thermal Comfort for Affordable Housing

RACHNA

Resilient, Affordable and Comfortable Housing through National Action

TRAININGS:

The Climate Smart Buildings Project in partnership with Ministry of Housing & Urban Affairs is hosting **75** trainings under the following categories:

- 30 Trainings for Built-environment professionals & Govt. Departments
- 10 Vocational Trainings
- 20 Trainings for Senior Govt. Officials & Policy makers
- 6 Trainings for Future trainers
- 8 Awareness sessions for students
- 22 Additional Capacity Building Workshops
- 2 International knowledge exchange programs

IMPACT:

- Capacity Building – **2500 stakeholders**
- More than **1000 architects & developers** trained to design & deliver Thermally comfortable affordable housing
- More than **450 govt officials and policy makers** trained for incorporating thermal comfort provisions in Byelaws
- More than **300 contractors, masons and field workers** trained in working with new technologies
- Students in 8 architectural colleges across the country targeted for awareness at ground roots level.

March-August 2022

Thermal comfort

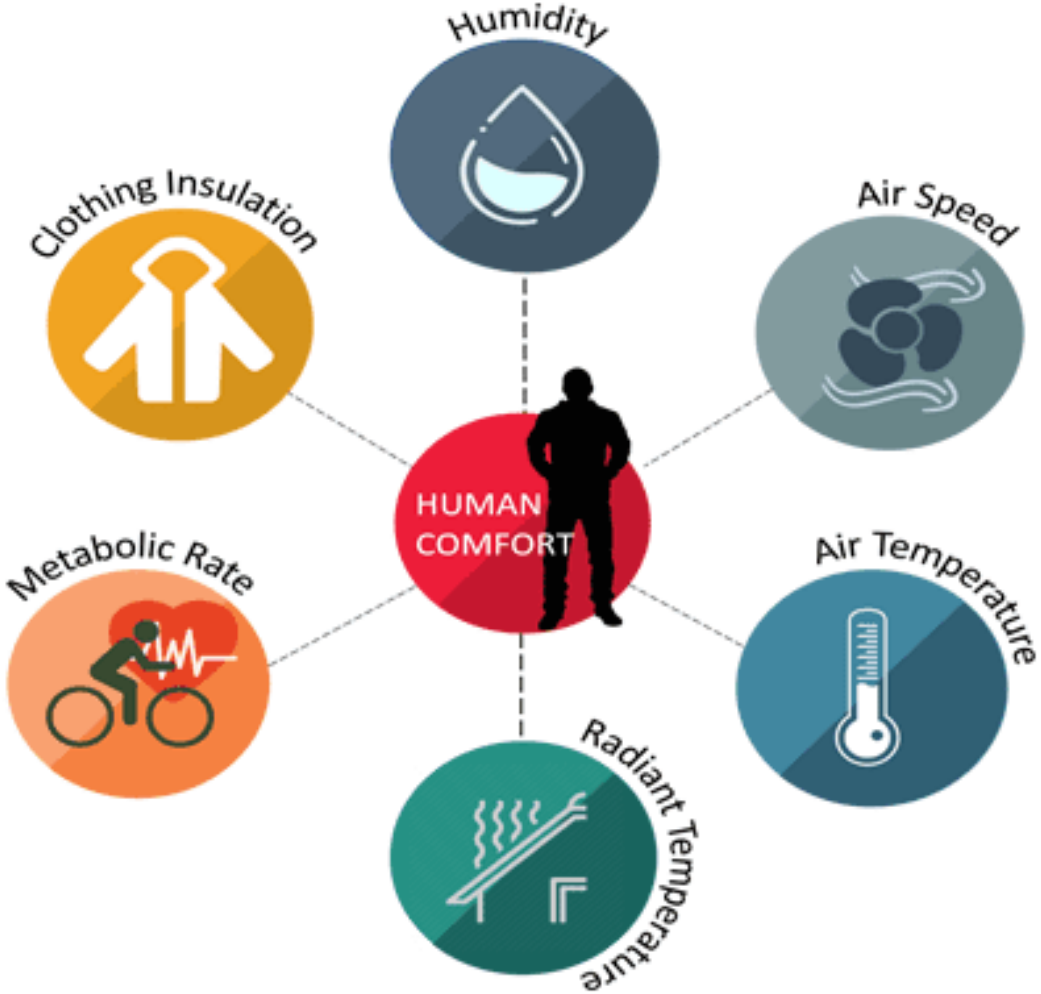
Thermal Comfort – Definition

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/

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"

- 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 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

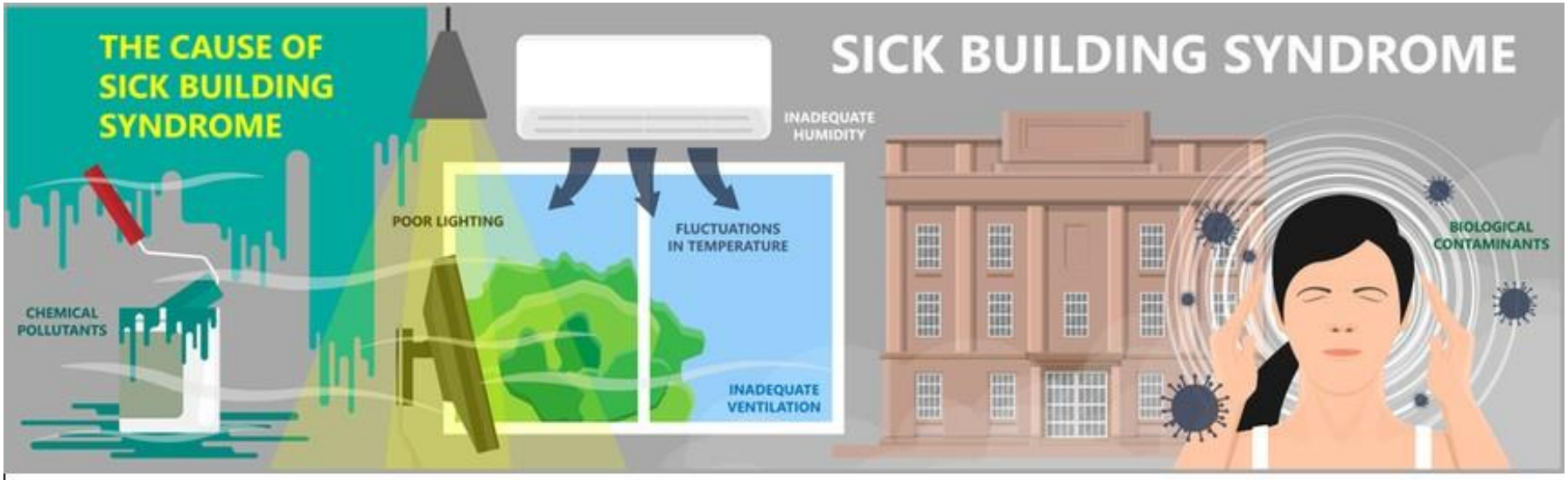
Problems due to Low Humid Conditions

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

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

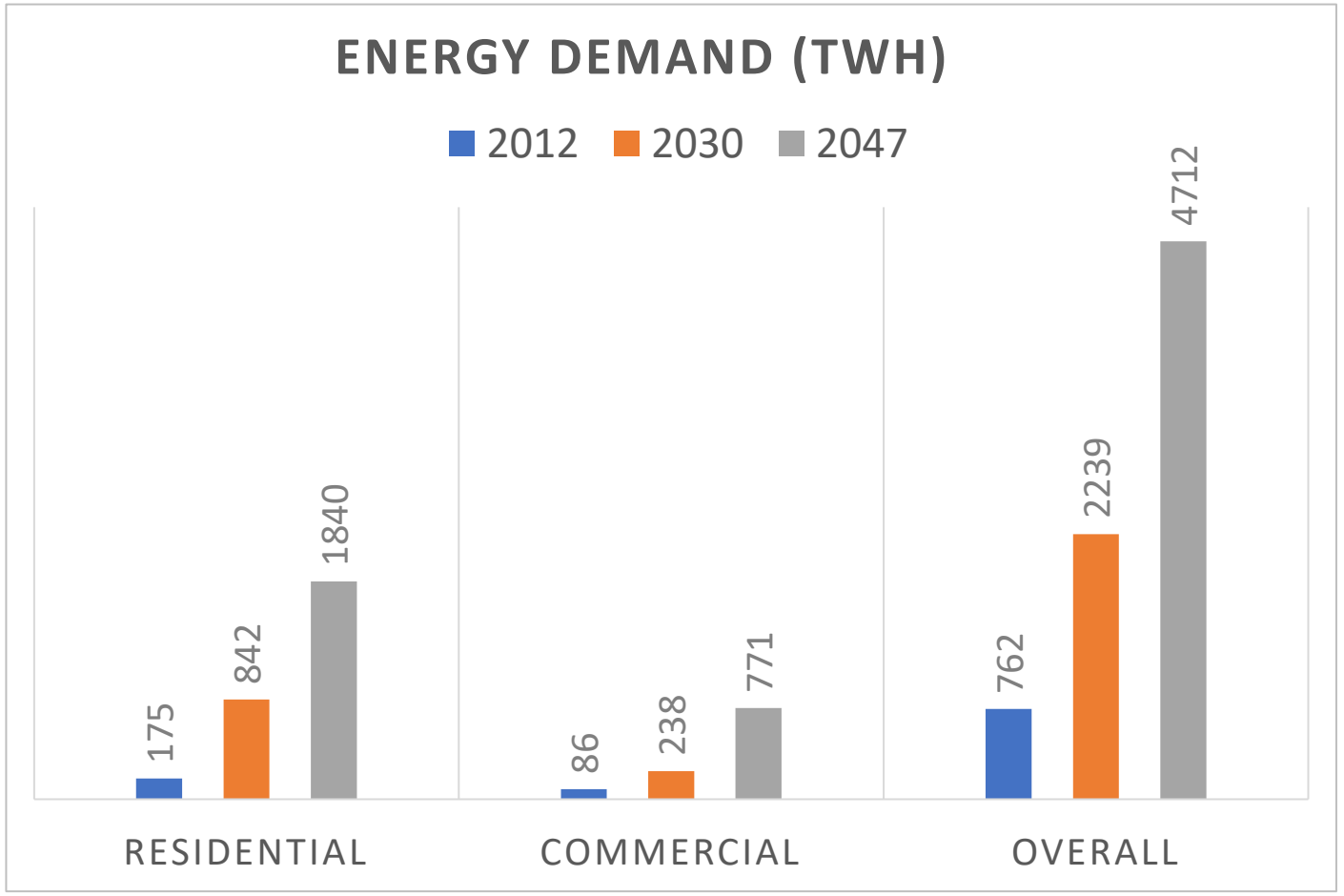


Necessity of Thermal comfort in Affordable Housing

Affordable Housing Demand

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

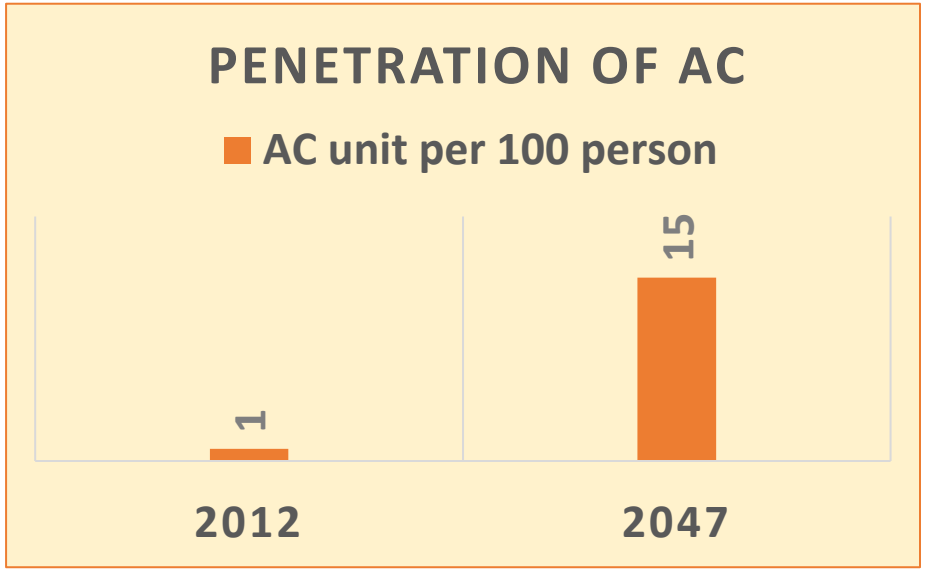
Source: India 2020 Energy Review Policy

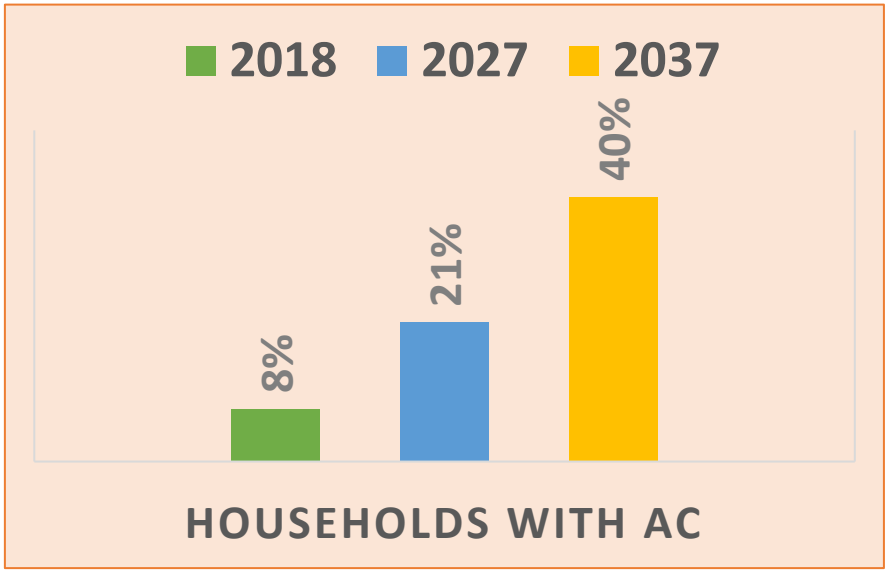


Source: NITI Aayog 2015

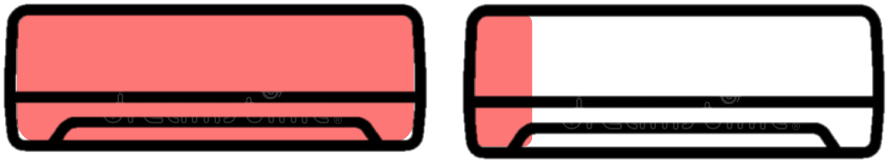
Increase in AC demand in the Residential Sector

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



1.2 ACs (Average) for all households that have AC

National Sample Survey Office,2011

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
- Off-grid micro-systems for cooling
- Localized heat-action plans could be provided.

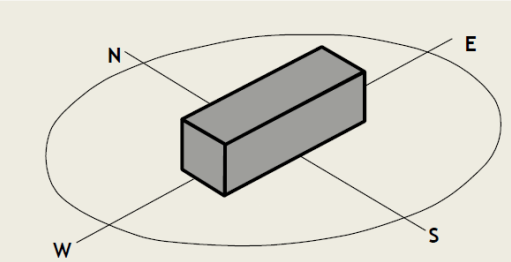
Implementation & Enforcement measures

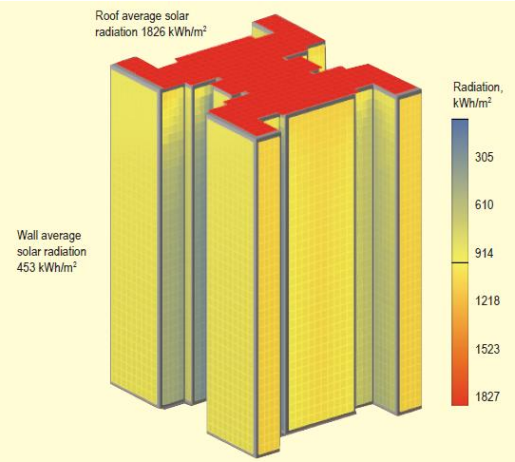
- Regulatory and policy actions in the adoption of energy efficient building practices Promoting capacity building and fostering market awareness

Thermal Comfort Improvement through Design

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





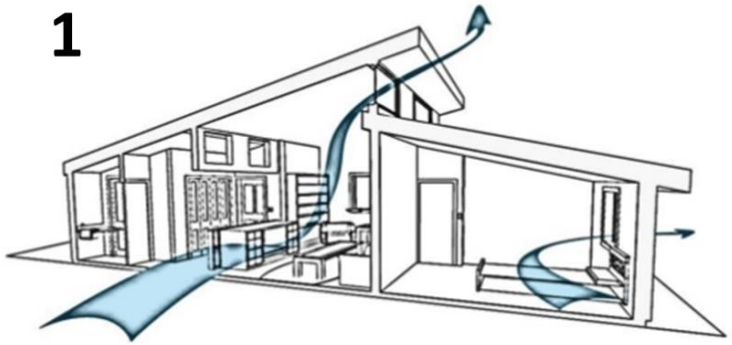
Active Strategies

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

Thermal Comfort Improvement through Passive Measures

Minimum Building Envelope design standards are developed to improve Energy Efficiency in Residential Buildings

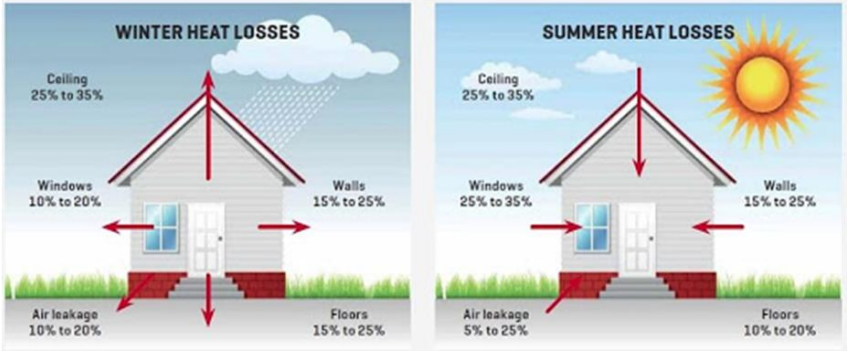
1



1. For Adequate natural ventilation potential for thermal comfort

2. For adequate day light for visual comfort

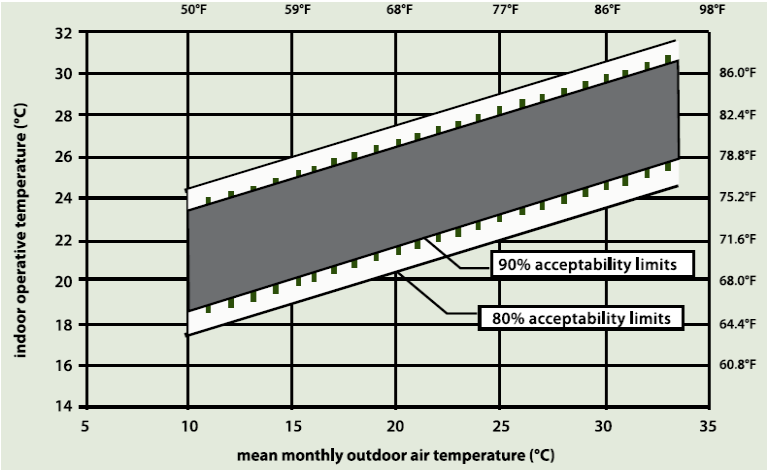
3



3. Limit heat gains / heat loss for energy efficiency

Thermal Comfort Standard – IMAC

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



Select city: Chennai

Months	Acceptibility Range	Naturally ventilated	Mix Mode buildings	Air.cond. Based on air temp.	Air.cond. Based on std. effective. Temp
January	90%	28.78	28.36	26.71	25.88
		24.02	21.44	23.71	23.88
February	90%	29.41	28.69	26.80	25.90
		24.65	21.44	23.80	23.90
March	90%	30.26	29.13	26.92	25.92
		25.50	22.21	23.92	23.92
April	90%	31.33	29.69	27.08	25.95
		26.57	22.77	24.08	23.95
May	90%	32.52	30.31	27.25	25.98
		27.76	23.39	24.25	23.98
June	90%	32.95	30.53	27.31	25.99
		28.19	23.61	24.31	23.99
July	90%	31.93	30.00	27.17	25.96
		27.17	23.08	24.17	23.96
August	90%	31.45	29.75	27.10	25.95
		26.69	22.83	24.10	23.95
September	90%	31.27	29.66	27.07	25.95
		26.51	22.74	24.07	23.95
October	90%	30.79	29.41	27.00	25.93
		26.03	22.49	24.00	23.93
November	90%	30.02	29.01	26.89	25.91
		25.26	22.09	23.89	23.91
December	90%	29.30	28.63	26.78	25.90
		24.54	21.71	23.78	23.90

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.

Eco Niwas Samhita (ENS)

BEE
(BUREAU OF ENERGY EFFICIENCY)

Government of India

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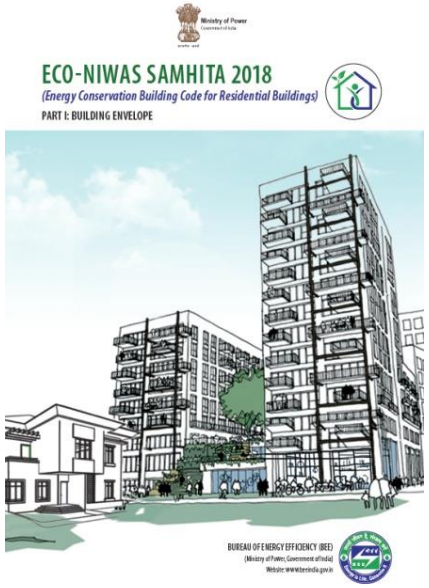
(Deutsche Gesellschaft für Internationale Zusammenarbeit)

Government of Germany



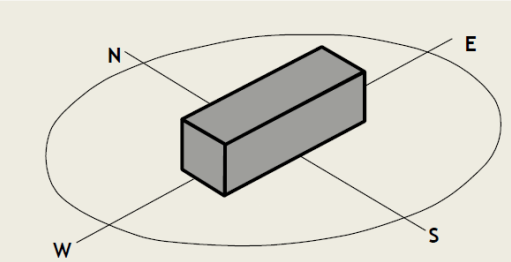
Eco Niwas Samhita Part 1

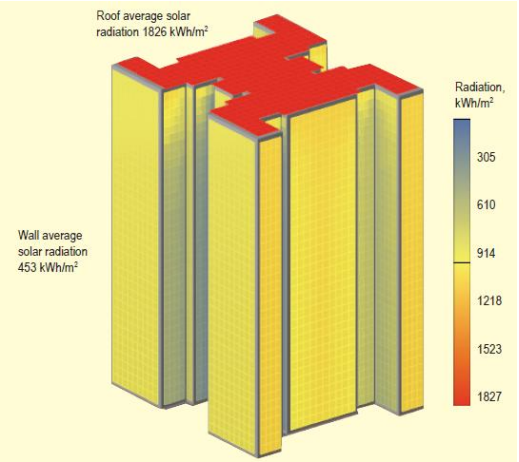
Launch of Eco Niwas Samhita in December 2018

Thermal comfort Design for Affordable Housing

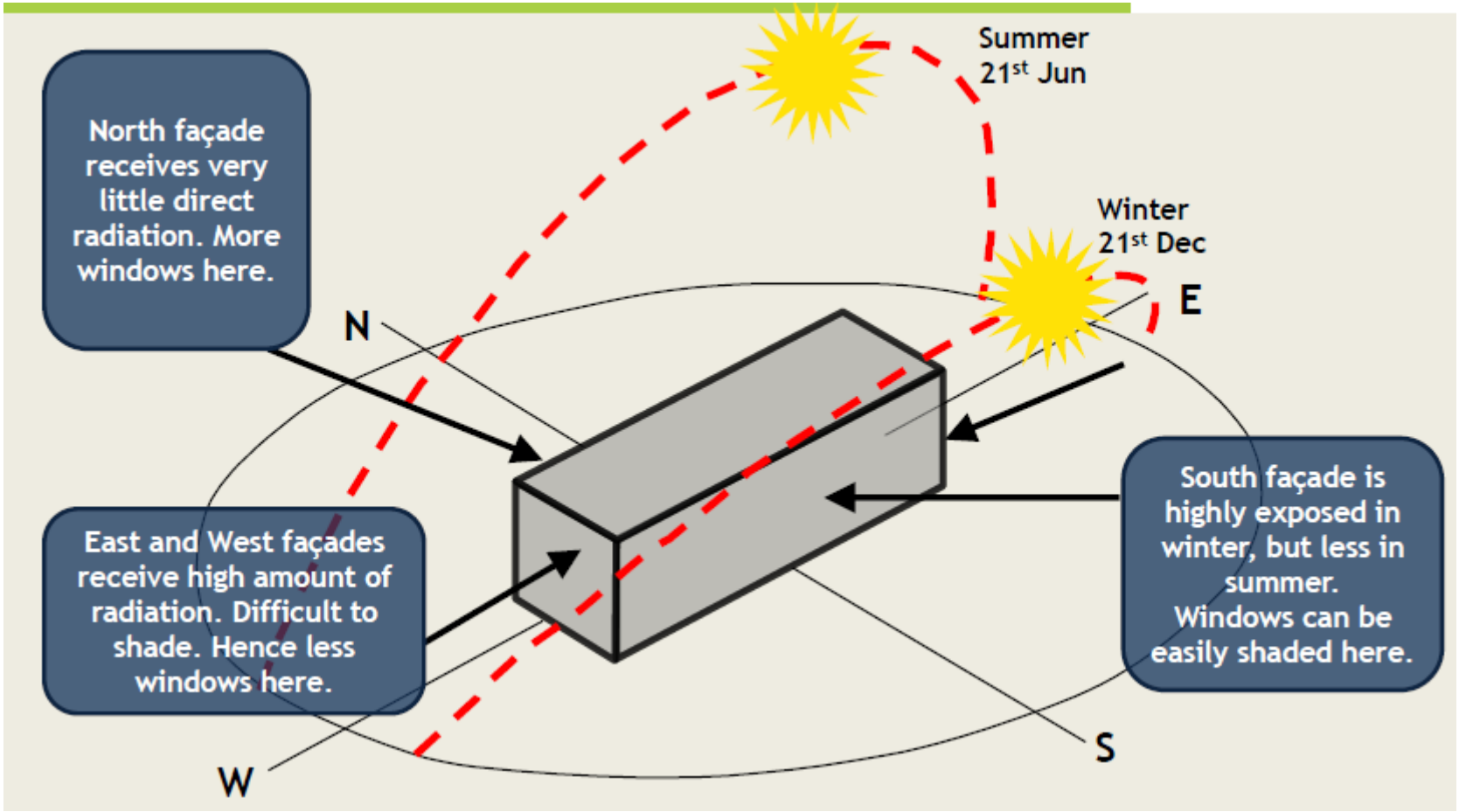
Thermal Comfort Improvement through Passive Measures

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

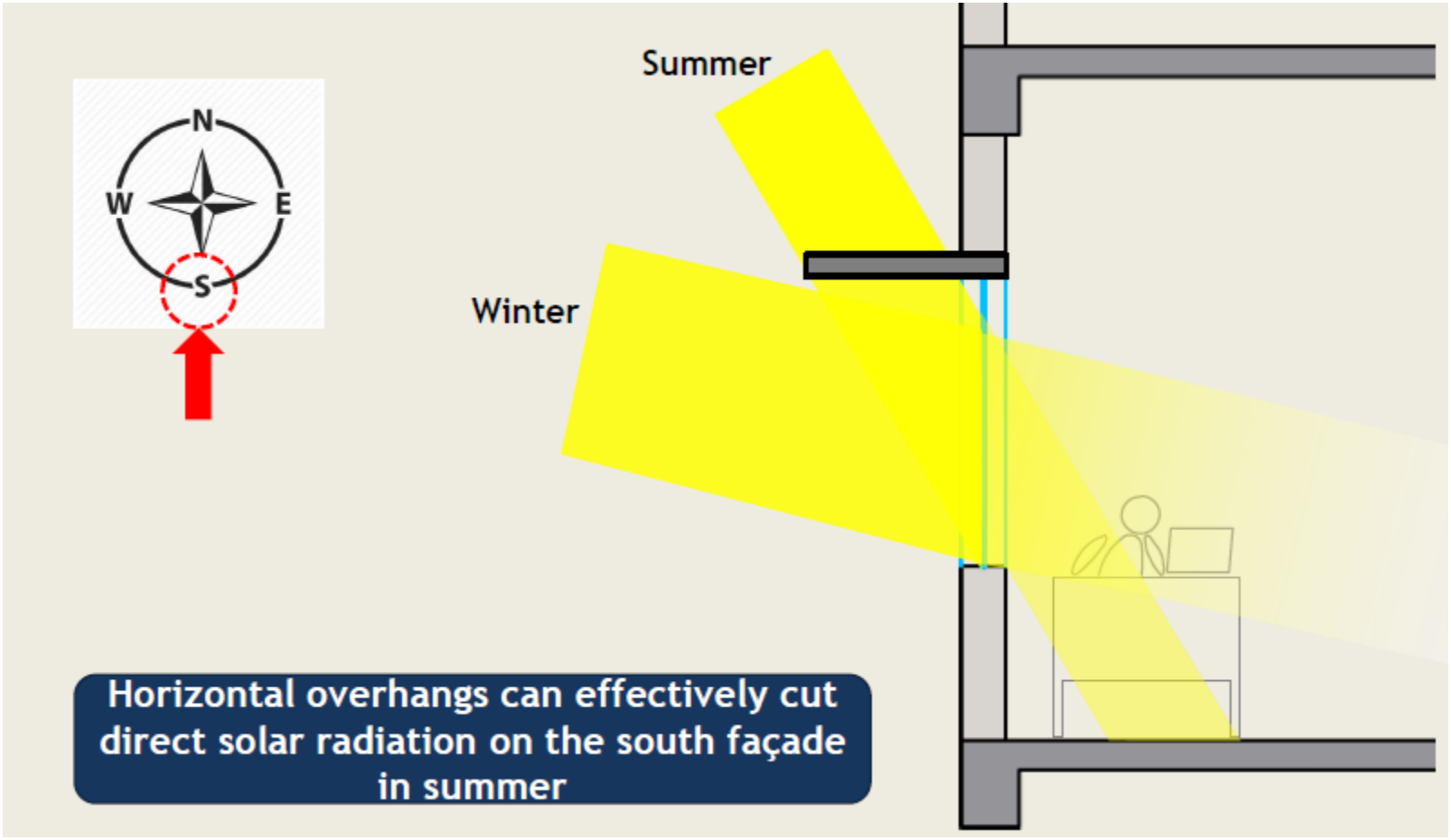




Passive Measures - Orientation



Passive Measures - Shading

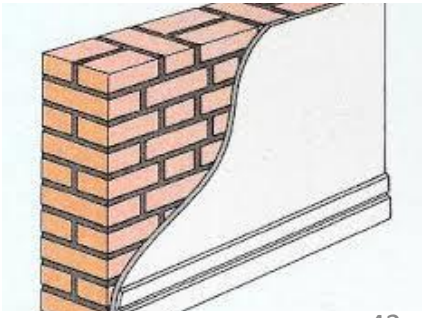


Effects of Materials on Thermal comfort

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

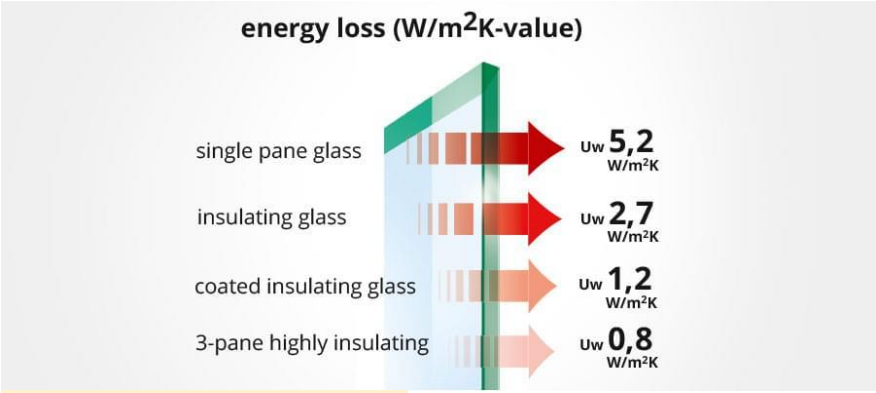


Thermal Comfort Improvement through Materials

EPS Insulation

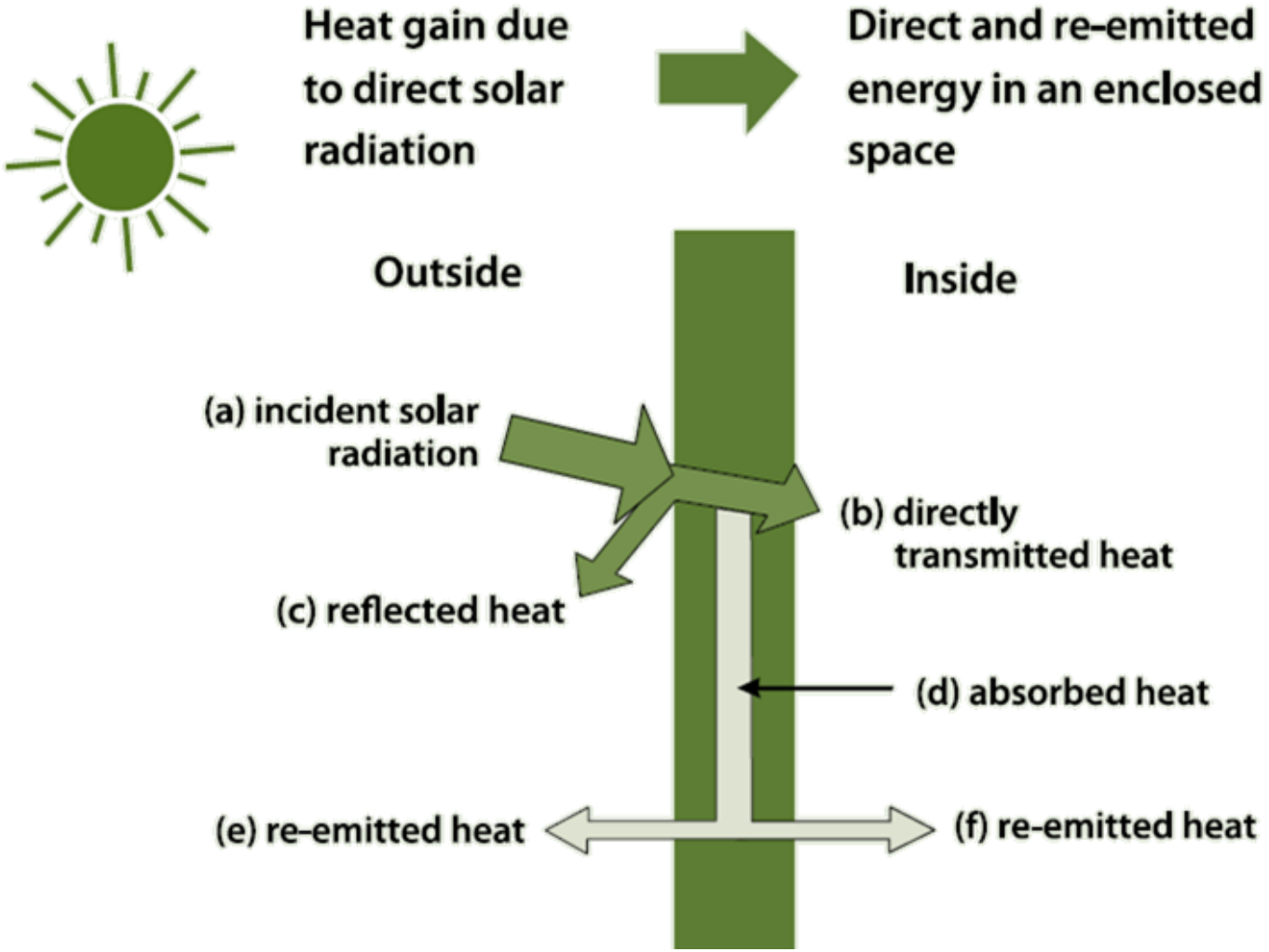
XPS Insulation

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

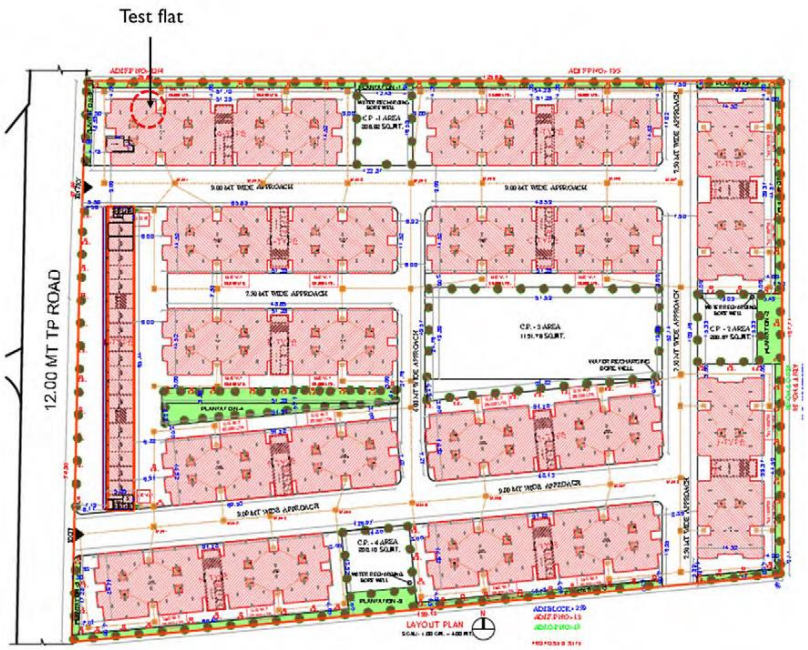
Case Study : Smart Ghar, Rajkot

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

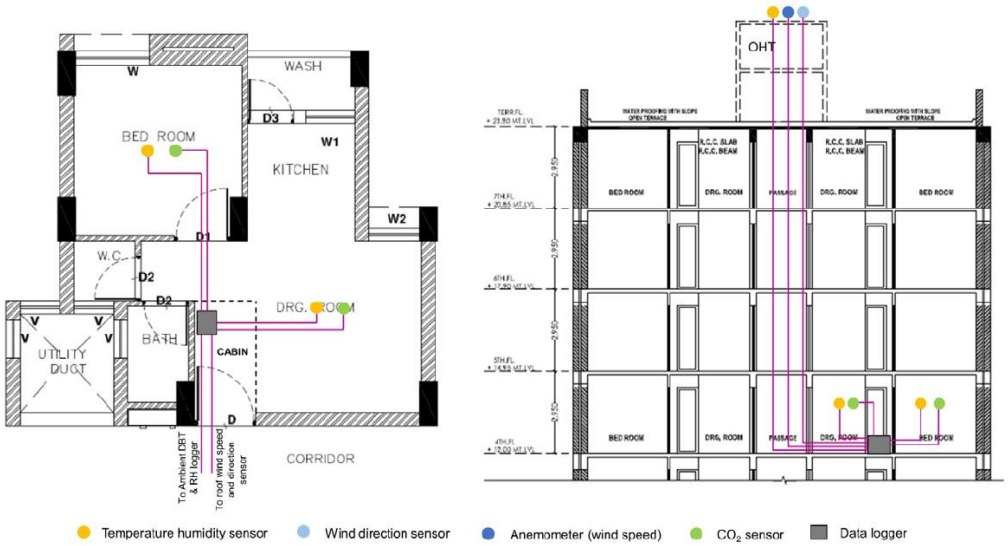
- Project Type - *PMAY Housing*
- Location - *Rajkot*
- Dwelling Units - *1176*
- DU Area - *33.6 m^2*
- Ext Wall – *200mm AAC (E&N) & Cavity Wall (200mm AAC + 40mm air gap + 200mm AAC) (W&S Side)*
- Casement windows – for ventilation improvement
- Window shading – *Overhang & Side fins*
- *Glazed window*



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)

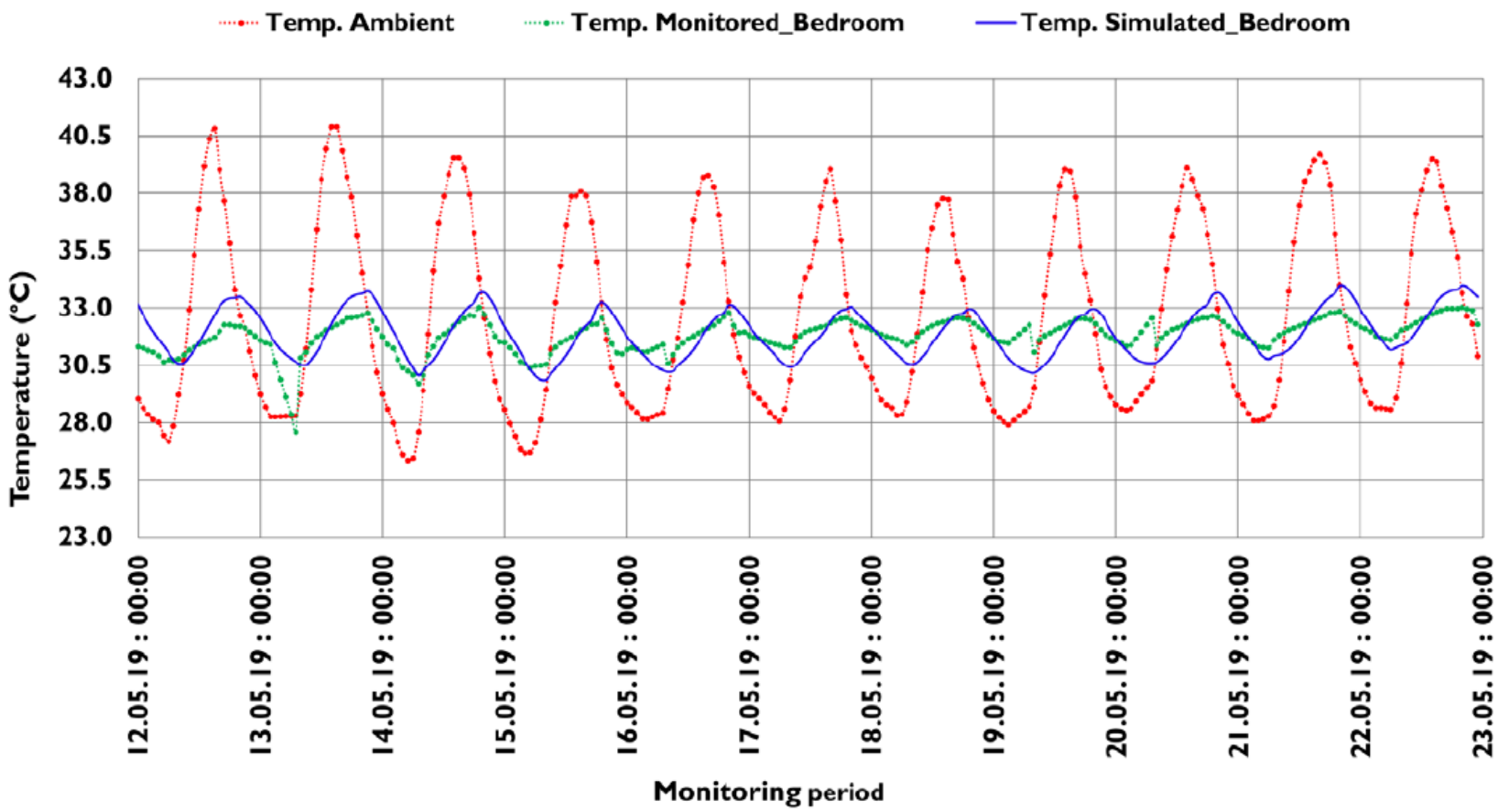


Results

- 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)

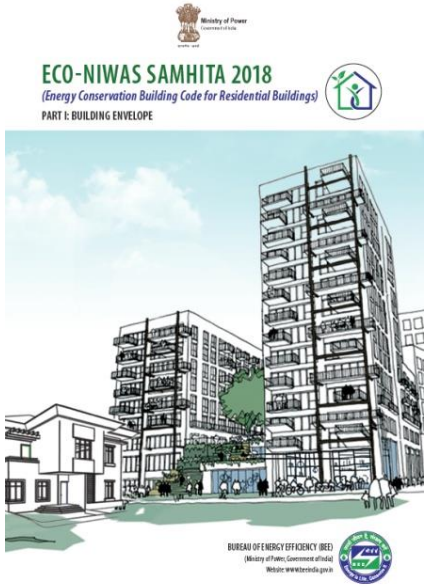
BEE
(BUREAU OF ENERGY EFFICIENCY)

Government of India

+

GIZ
(Deutsche Gesellschaft für Internationale Zusammenarbeit)

Government of Germany



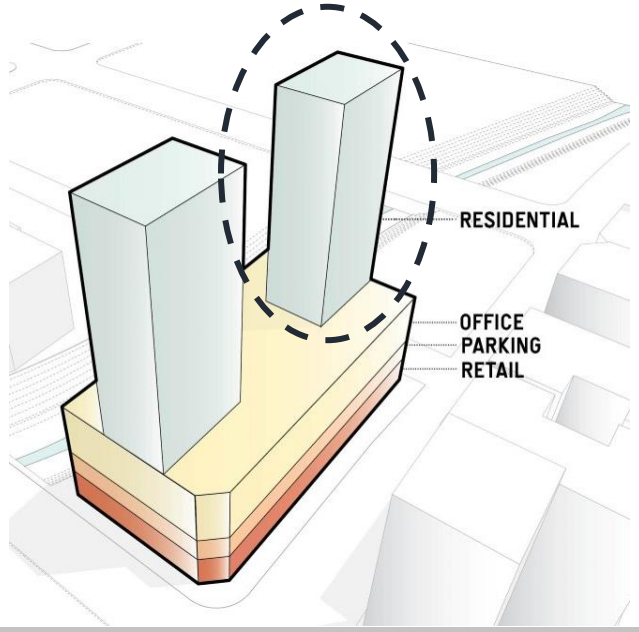
Eco Niwas Samhita Part 1

Launch of Eco Niwas Samhita in December 2018

Eco Niwas Samhita (ENS)

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

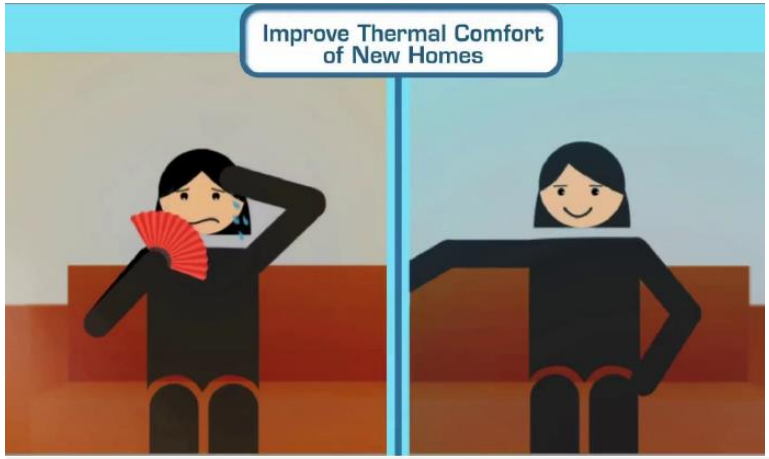
Dormitories

Hotels

Lodging Rooms

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

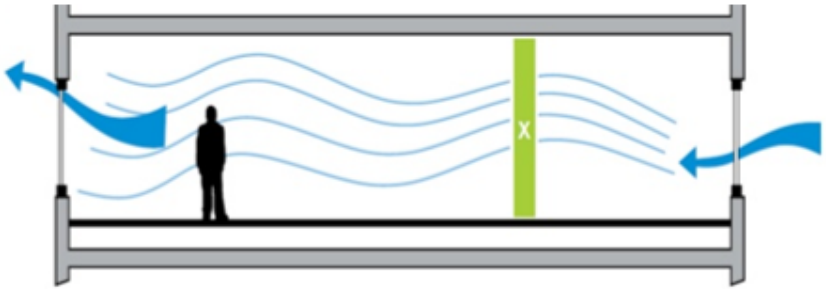
- 3.1 Openable Window to Floor Area Ratio (WFR_{op}) → For Natural Ventilation
- 3.2 Visible Light Transmittance (VLT)- Derived from WWR → For Day Light Potential
- 3.3 Thermal Transmittance of Roof (U_{roof}) → For Thermal Transmission
- 3.4 Residential Envelope Transmittance Value (RETV) → For Thermal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

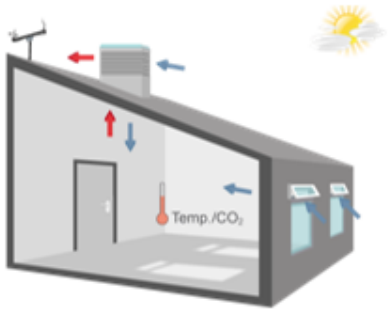
ENS – Part 1 – Building Envelope

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

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

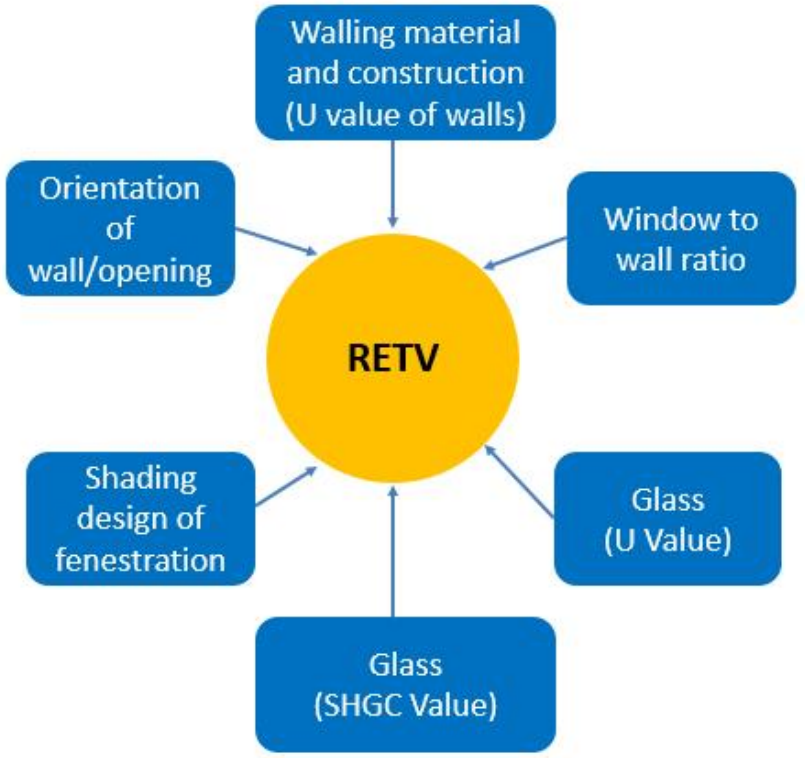
ENS – Part 1 – Building Envelope

3.4 Residential Envelope Transmittance (RETV)

Solar Radiation through non-opaque surfaces

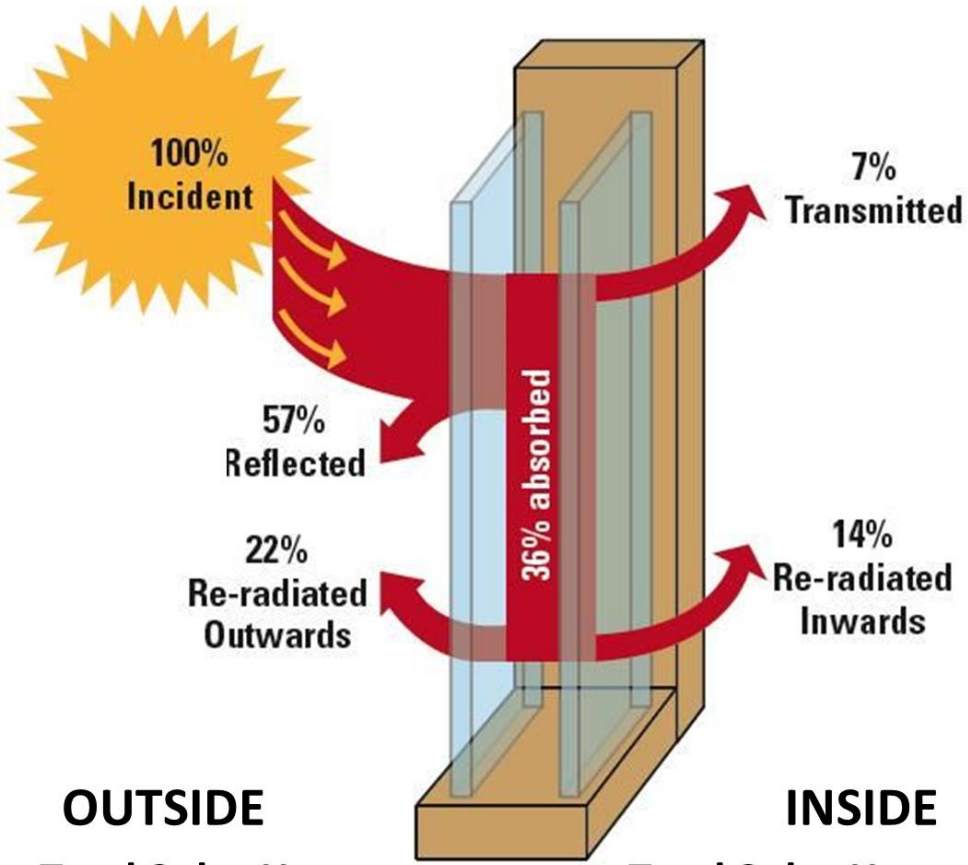
Conduction through opaque surfaces

Conduction through non-opaque surfaces



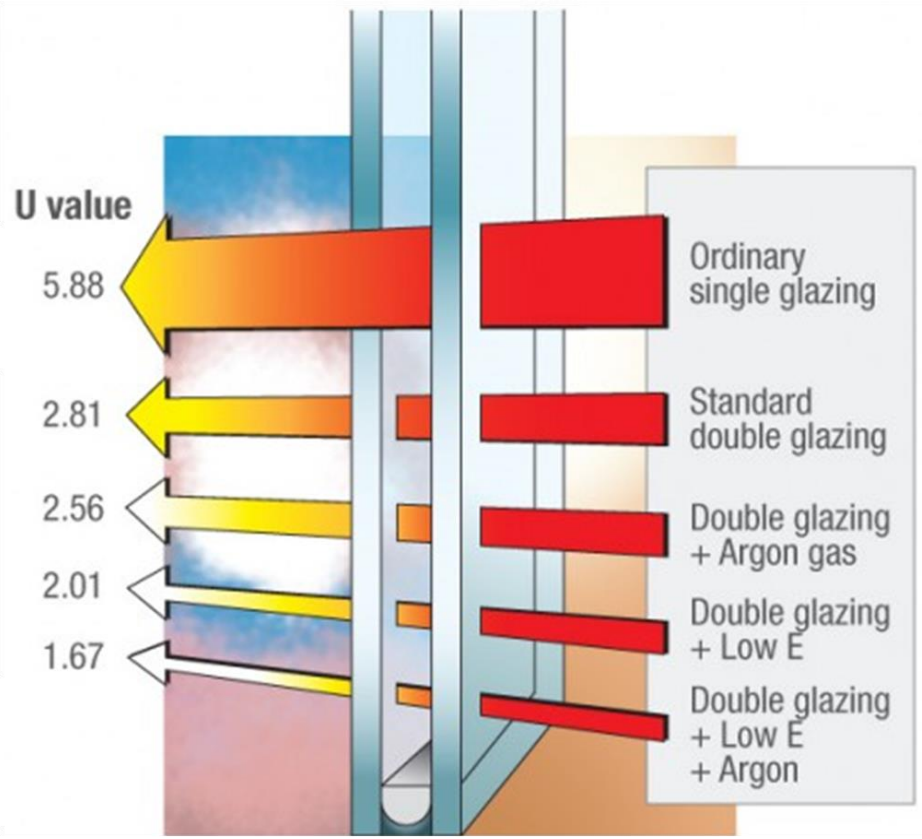
ENS – Part 1 – Building Envelope

3.4 Thermal Transmittance Value (U-Value) Non Opaque



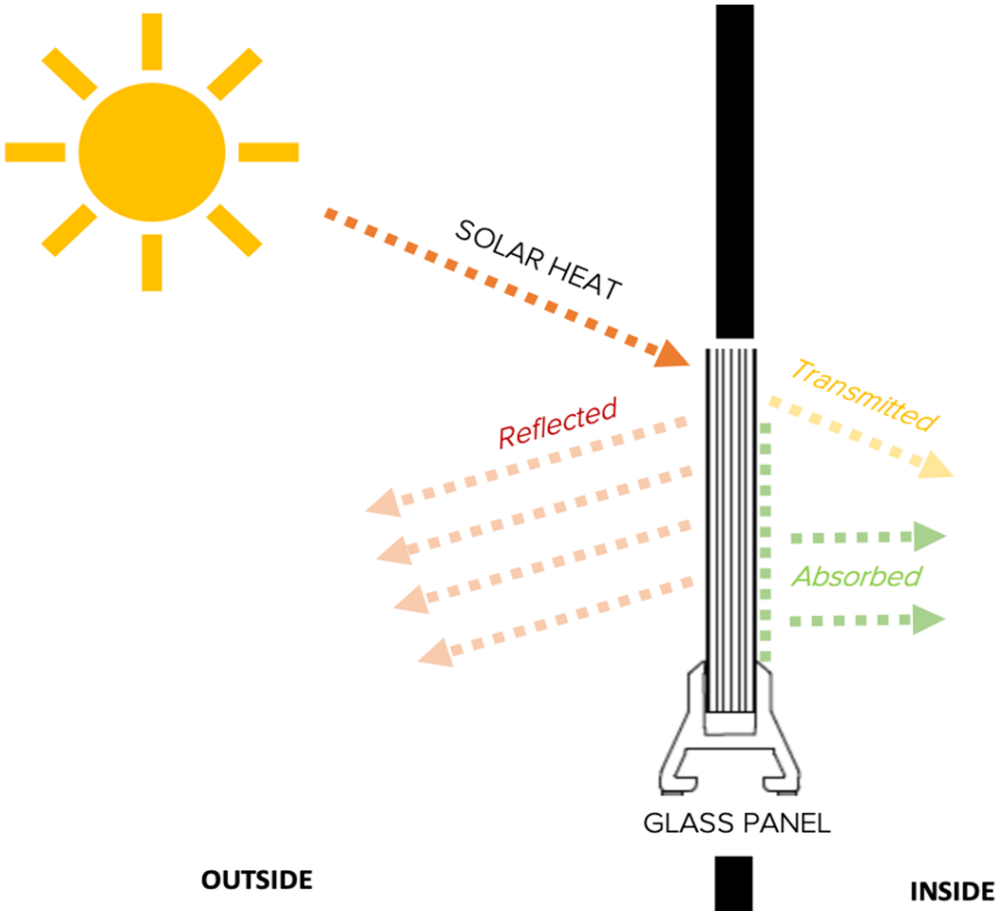
Total Solar Heat
Elimination : 79%

Total Solar Heat
Transmission : 21%



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 $\propto$ lesser Heat Transfer

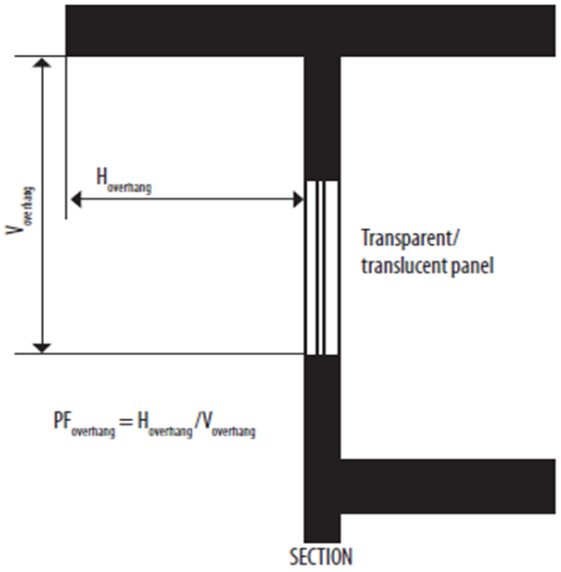
Solar Radiation is subsequently released inward through conduction, convection and radiation.

ENS – Part 1 – Building Envelope

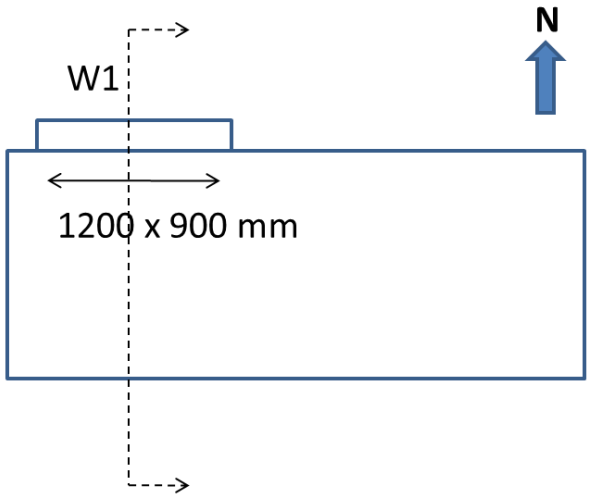
3.4 Projection Factor (PF)

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.

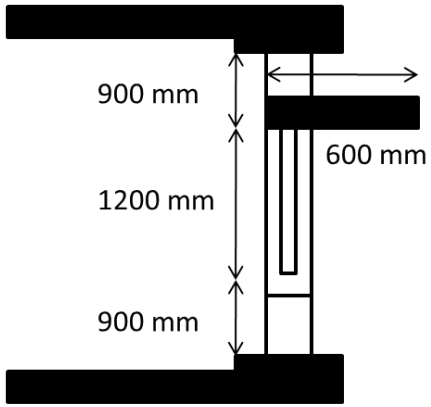
$$PF_{overhang} = \frac{H_{overhang}}{V_{overhang}}$$



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

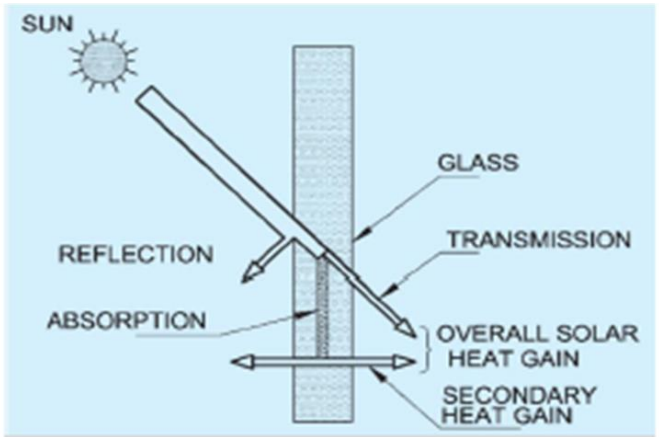


PF = 600/1200 = 0.5

Section

ENS – Part 1 – Building Envelope

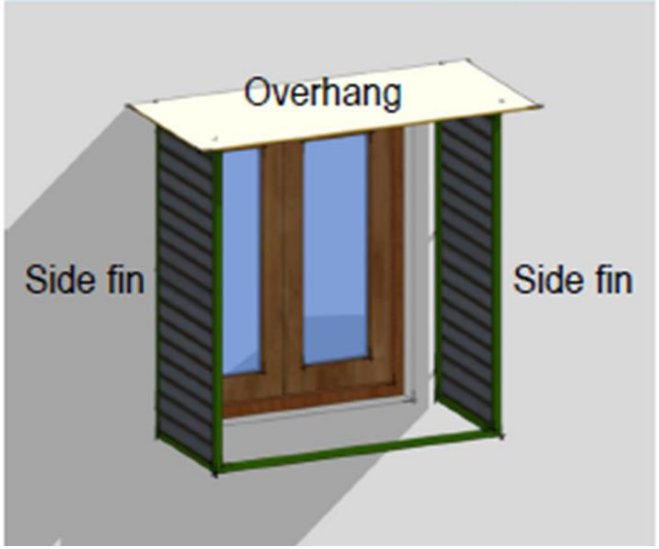
3.4 Equivalent SHGC



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

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

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



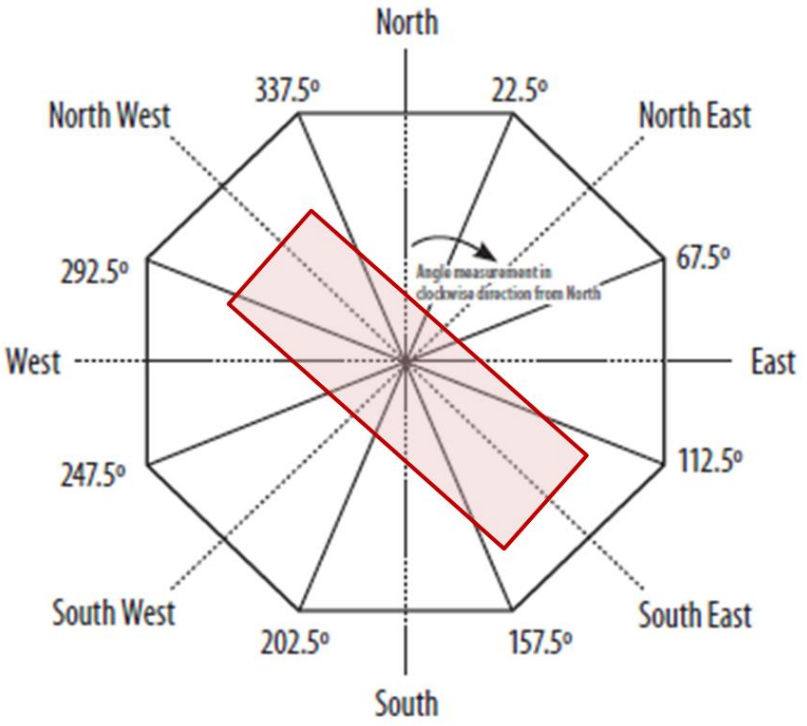
$$\mathbf{SHGC_{eq} = SHGC_{unshaded} \; X \; ESF_{total}}$$

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/m².K			

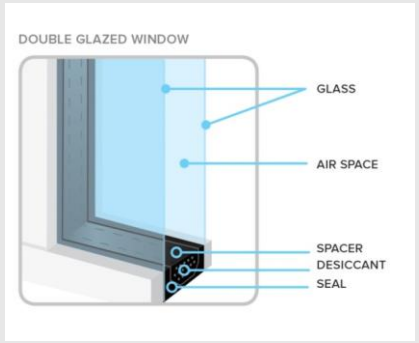
ENS – Part 1 – Building Envelope

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			

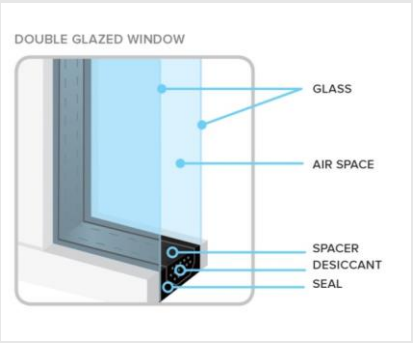
ENS – Part 1 – Building Envelope

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/m².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

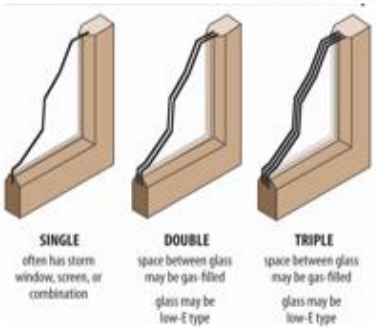
Building Design Flexibility by ENS

Material wall Assembly

Design of Window Panel

Shading of external Windows

Type of glazing



ENS – Part 2 – Building Services

- Lighting (Exterior & Interior)
- Elevators
- Pumps
- Comfort Systems
- Electrical Systems
- Solar Hot Water
- Solar Photo Voltaic

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

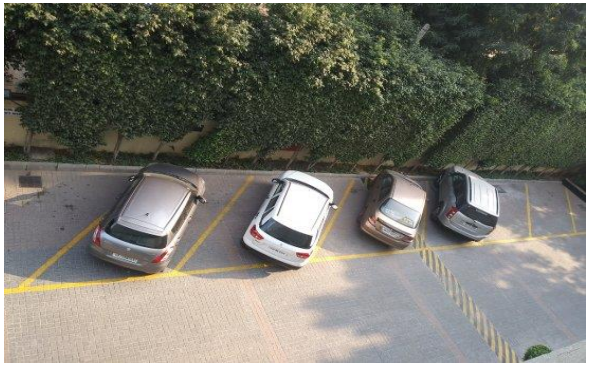
Corridor Lighting

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)

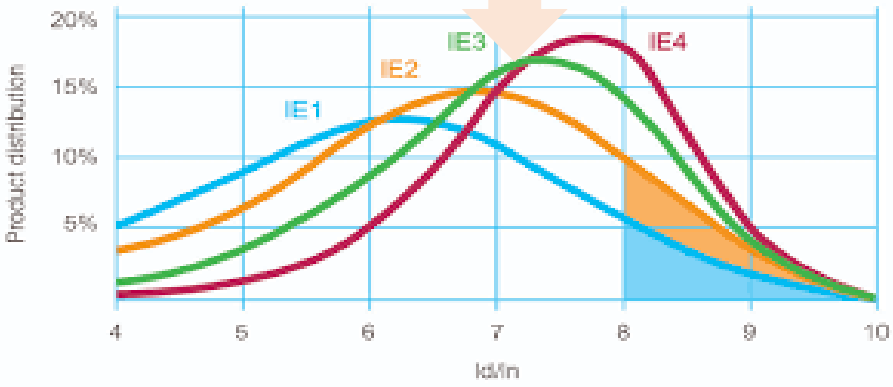
ENS – Part 2 – Services

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

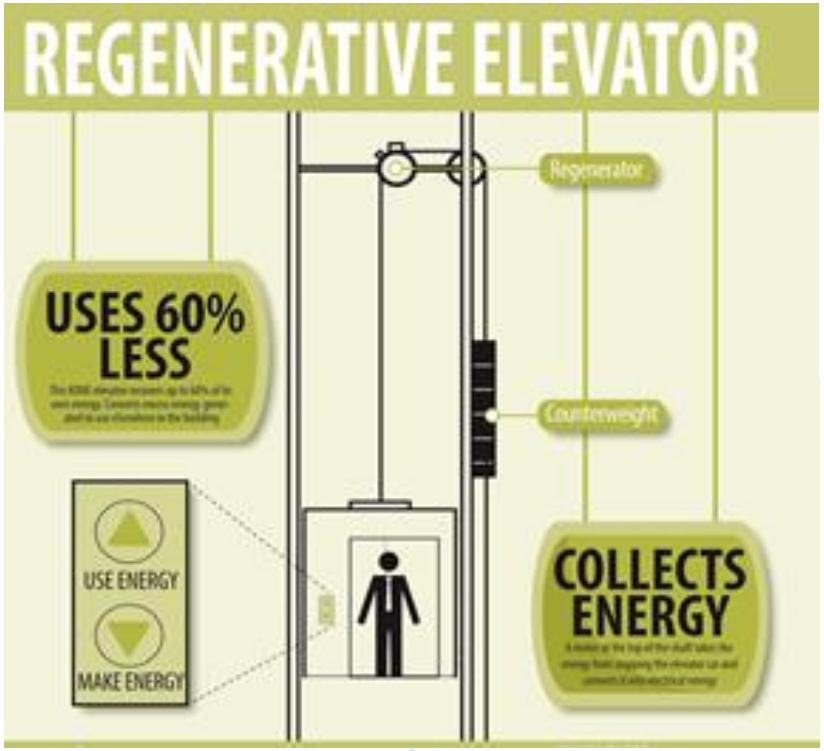


Group Automatic with Supervision

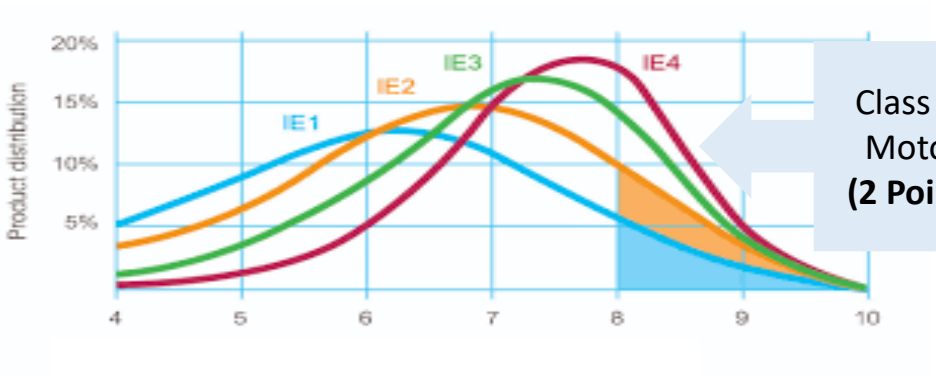
13 POINTS

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

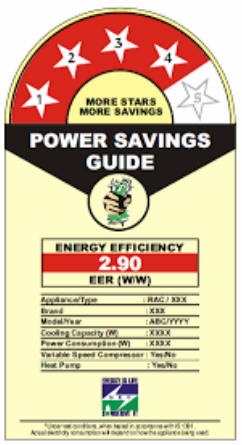
Pumps – Maximum 14 points

HYDRO-PNEUMATIC PUMPS

Mechanical Efficiency

60%

OR



6 POINTS

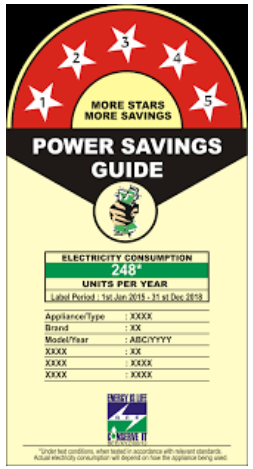
Installation of Hydro-Pneumatic Pumps or BEE Star rated pumps.

Mechanical Efficiency

70%

3 POINTS

+



8 POINTS

5 POINTS

ENS – Part 2 – Services

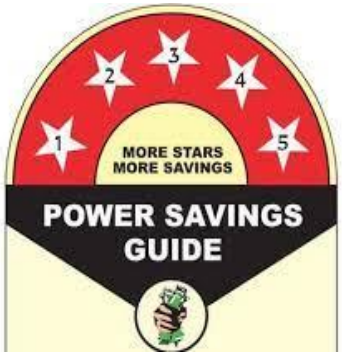
Electrical Systems – Maximum 6 points

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

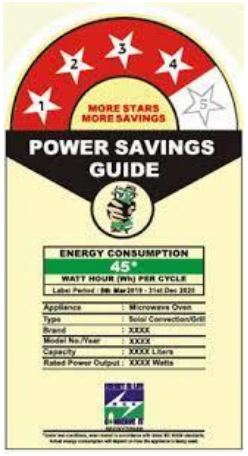
ENS – Part 2 – Services

Comfort Systems– Maximum 50 points

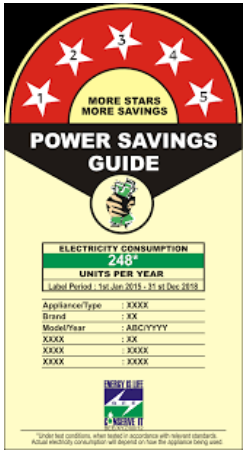
Ceiling Fans: Points for ceiling fans will be only applicable and could be achieved if all the bedrooms and hall in all the dwelling units are having ceiling fans

- 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

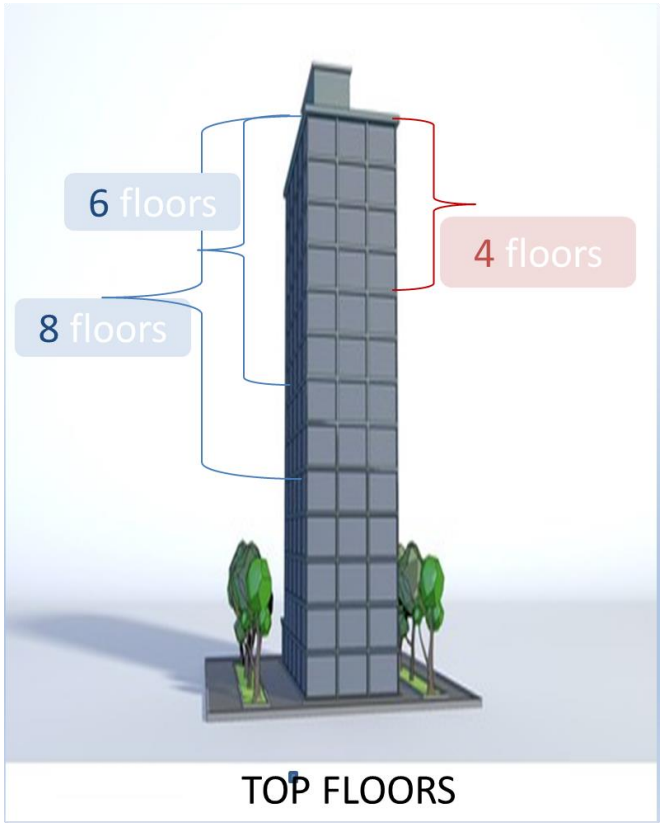
- SWH of **minimum BEE 3 Star label** and meeting 100% of Top 4 floors

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)**



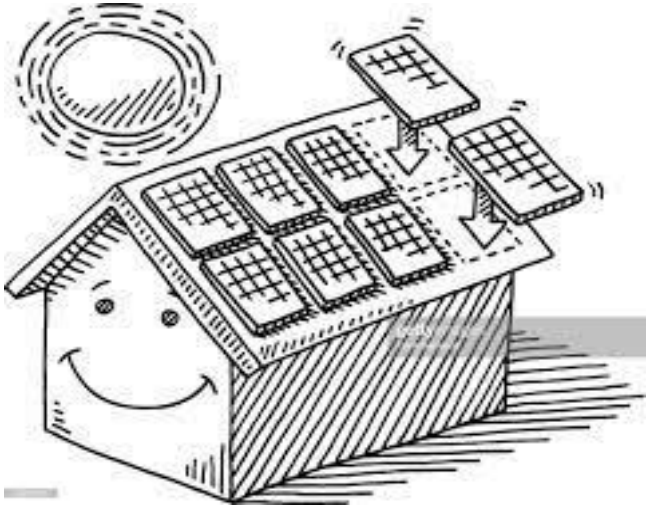
ENS – Part 2 – Services

Solar Photovoltaic

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

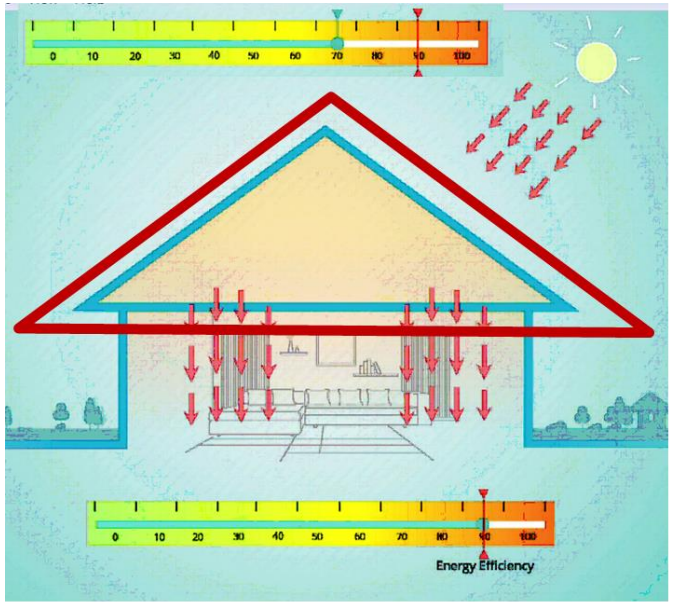
- At least 20% of roof area
- Free of any obstructions and shadows

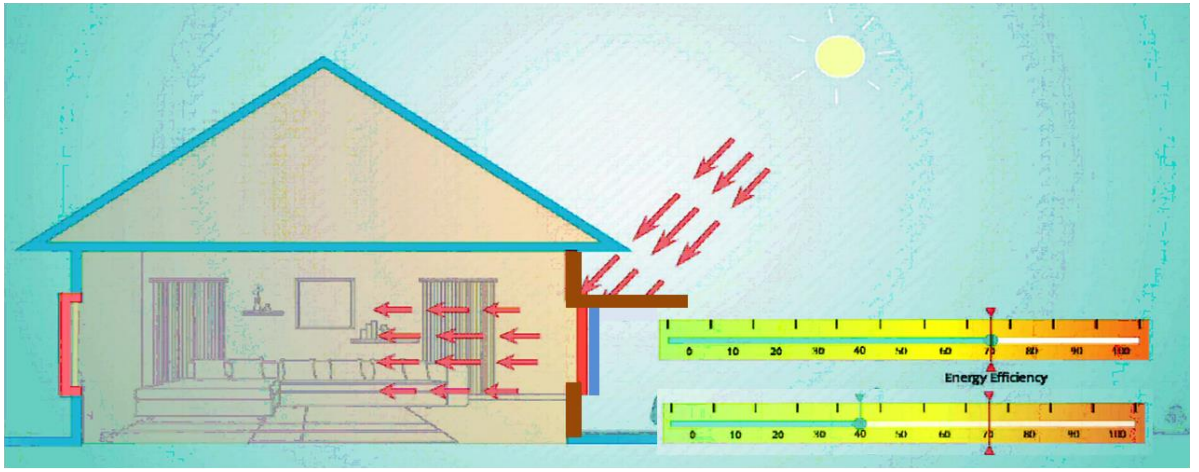
5 Points



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

Conventional Building Vs ENS Building



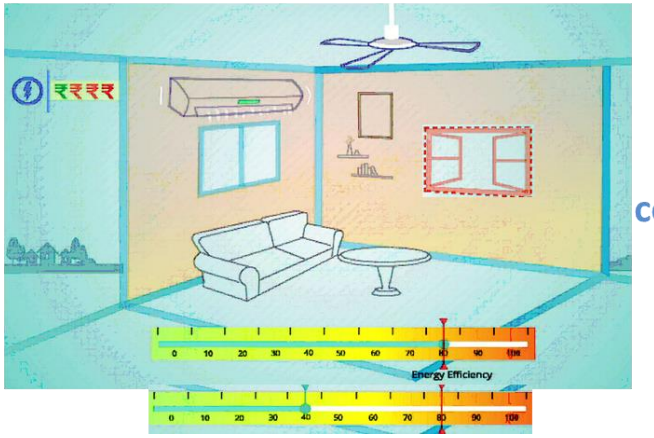


Conventional Brick wall, roof and single glazed windows, traps heat

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



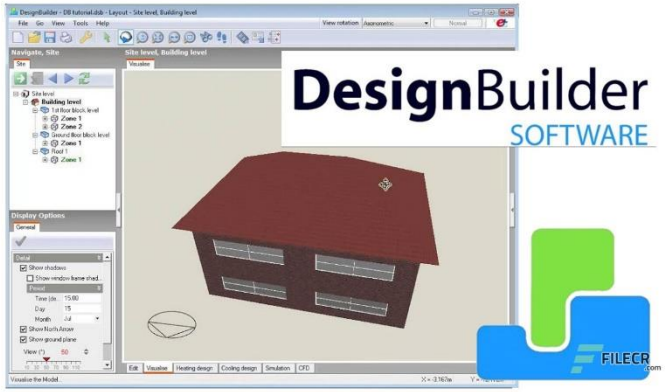
Increases in cross-ventilation reduces dependency on Air conditioners & coolers, thereby reduces electricity bills

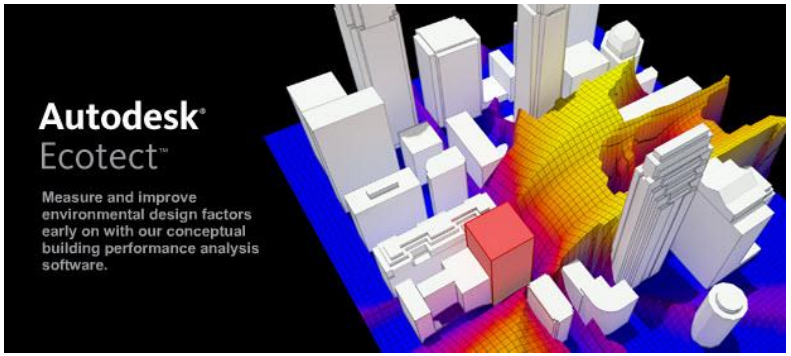
Simulation Tools

eQuest
Quick Energy Simulation Tool

eQUEST

EnergyPlus





ENS & Thermal Comfort analysis for the LHP

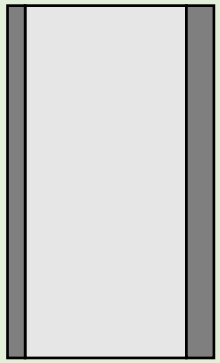
Case Study : Light House Project (LHP), Chennai

- Project Type - *PMAY Housing*
- Location - *Chennai*
- Dwelling Units - *1152*
- DU Area - *26.58 m^2*
- Precast Concrete Construction System Precast Components Assembled at Site

LHP Site - Thermal Features

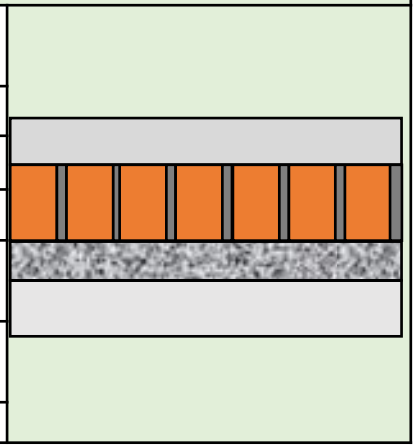
- 150mm AAC block is used for Masonry work & 100mm AAC block is used for internal partitions

20mm Plaster + 150mm AAC block + 12mm Plaster

External Wall Assembly								
Layer no.	*Material*	*Density (kg/m3)*	*Specific Heat (kJ/kg.K)*	*Thickness (m)*	*Conductivity (W/m-K)*	*R value m^2K/W*	*Source*	*Wall section*
1	Interior surface film resisitance	-	-	-	7.700	0.130	ENS 2018	
2	Internal cement Plaster	1762	0.840	0.012	0.721	0.017	ENS 2018	
3	AAC Block	642	1.240	0.150	0.184	0.815	ENS 2018	
4	External cement Plaster	1762	0.840	0.020	0.721	0.028	ENS 2018	
5	Exterior surface film resisitance	-	-	-	25.000	0.040	ENS 2018	
U value of assembly (W/m2K)						**0.97**		

LHP Site Thermal Features

- 305mm RCC wall is used for Roof. Brick bat koba is used as weathering course.

Roof Assembly								
Layer no.	*Material*	*Density (kg/m3)*	*Specific Heat (kJ/kg.K)*	*Thickness (m)*	*Conductivity (W/m-K)*	*R value m^2K/W*	*Source*	*Roof section*
1	Interior Surface film resisitance	-	-	-	5.900	0.169	ENS 2018	
2	Precast slab (RCC)	2288	NA	0.075	1.580	0.047	ENS 2018	
3	Screeding (RCC)	2288	0.920	0.055	1.580	0.035	ENS 2018	
4	BrickBat	1440	NA	0.100	0.620	0.161	ENS 2018	
5	External cement mortar	1648	0.840	0.075	0.719	0.104	ENS 2018	
6	Exterior Surface film resisitance	-	-	-	25.000	0.040	ENS 2018	
U value of assembly (W/m2K)						**1.79**		

- According to ENS code, U value of roof should be within **1.2 W/sqmK**

LHP Site Thermal Improvements

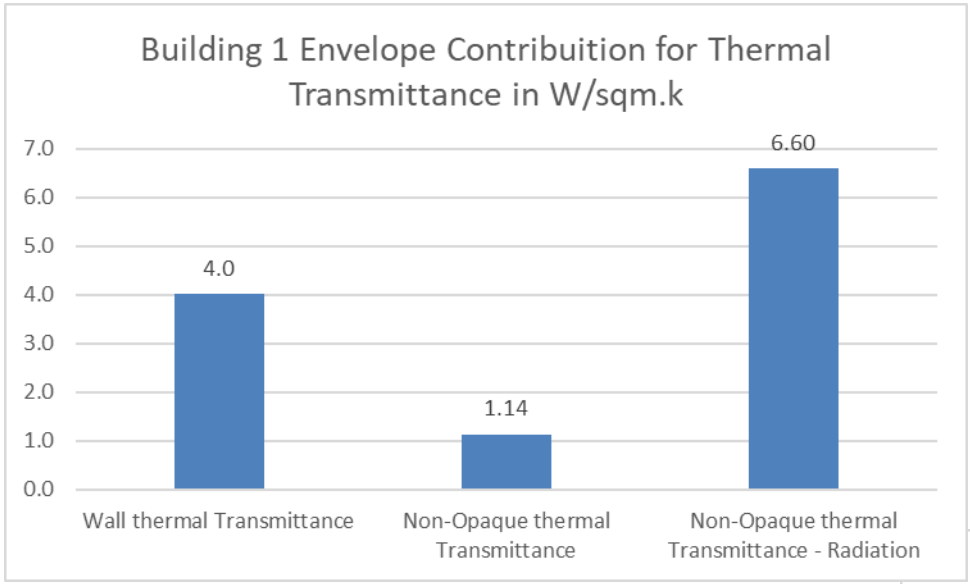
- Inclusion of 25 mm EPS overdeck insulation would make the roof comply with ENS codes

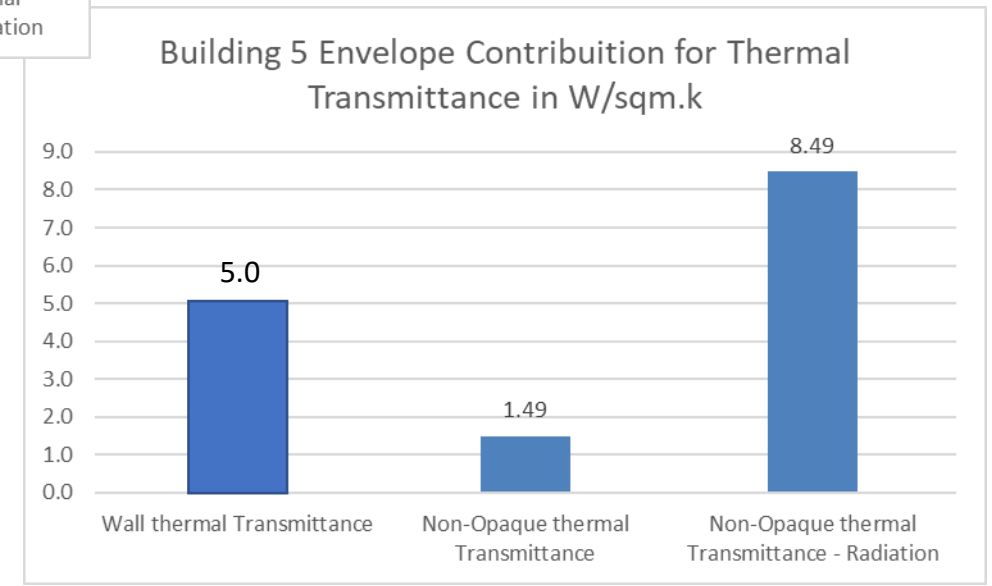
Roof Assembly								
Layer no.	*Material*	*Density (kg/m3)*	*Specific Heat (kJ/kg.K)*	*Thickness (m)*	*Conductivity (W/m-K)*	*R value m^2K/W*	*Source*	*Roof section*
1	Interior Surface film resisitance	-	-	-	5.900	0.169	ENS 2018	
2	Precast slab (RCC)	2288	NA	0.075	1.580	0.047	ENS 2018	
3	Screeding (RCC)	2288	0.920	0.055	1.580	0.035	ENS 2018	
4	Insulation	20	NA	0.100	1.47	0.68	ENS 2018	
5	External cement mortar	1648	0.840	0.075	0.719	0.104	ENS 2018	
6	Exterior Surface film resisitance	-	-	-	25.000	0.040	ENS 2018	
U value of assembly (W/m2K)						**1.07**		

LHP Site Analysis

ENS Compliance Parameters	Achieved		ENS Requirement	Compliance Status
	Building 1	Building 5		
Openable Window to Floor Area Ratio (WFR_{op})	**26.59**	**26.59**	≥ 16.66 %	Complied
Visible Light Transmittance (VLT)	**0.89**	**0.89**	≥ 0.27	Complied
Thermal Transmittance of Roof (U_{roof})	**1.8**	**1.8**	≤ 1.2 W/m^2. K	Not Complied
Residential Envelope Transmittance Value (RETV)	**11.8**	**14.1**	≤ 15 W/m^2.K	Complied

LHP Site Analysis





Case Study : Light House Project (LHP), Chennai

Discomfort Hour Percentage

LHP Project Building 1 (North - South)

Building 1									
	Ground floor			Middle floor			Top floor		
	Bedroom	Living	Kitchen	Bedroom	Living	Kitchen	Bedroom	Living	Kitchen
Jan	87%	87%	52%	100%	92%	69%	100%	98%	69%
Feb	57%	84%	51%	94%	91%	68%	96%	96%	69%
Mar	51%	68%	51%	80%	89%	63%	85%	90%	67%
Apr	97%	90%	77%	100%	100%	89%	100%	100%	91%
May	94%	91%	92%	99%	96%	94%	100%	98%	95%
Jun	85%	67%	70%	94%	88%	78%	96%	91%	80%
Jul	80%	60%	67%	93%	82%	71%	94%	88%	71%
Aug	98%	78%	72%	100%	97%	74%	100%	98%	75%
Sep	92%	80%	66%	99%	94%	80%	99%	95%	81%
Oct	55%	60%	40%	74%	69%	46%	81%	71%	52%
Nov	54%	63%	44%	84%	75%	49%	89%	78%	58%
Dec	63%	67%	33%	95%	82%	48%	97%	90%	53%

GLOBAL HOUSING TECHNOLOGY CHALLENGE INDIA

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Pradhan Mantri Awas Yojana-Urban

Ministry of Housing and Urban Affairs
Government of India

Azadi Ka Amrit Mahotsav

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Case Study : Light House Project (LHP), Chennai

Discomfort Hour Percentage

LHP Project Building 5 (East - West)

Building 5									
	Ground floor			Middle floor			Top floor		
	Bedroom	Living	Kitchen	Bedroom	Living	Kitchen	Bedroom	Living	Kitchen
Jan	99%	98%	66%	100%	100%	72%	100%	100%	72%
Feb	87%	92%	62%	100%	100%	77%	100%	100%	79%
Mar	60%	95%	61%	99%	99%	72%	100%	100%	76%
Apr	100%	100%	84%	100%	100%	96%	100%	100%	96%
May	100%	100%	92%	100%	100%	94%	100%	100%	96%
Jun	98%	92%	74%	100%	99%	82%	100%	100%	86%
Jul	99%	92%	69%	100%	96%	73%	100%	97%	76%
Aug	100%	100%	74%	100%	100%	81%	100%	100%	82%
Sep	99%	99%	72%	100%	100%	87%	100%	100%	88%
Oct	76%	75%	42%	88%	88%	53%	92%	89%	57%
Nov	86%	82%	47%	92%	91%	58%	97%	94%	60%
Dec	94%	86%	46%	100%	96%	55%	100%	99%	62%

Case Study : Light House Project (LHP), Chennai

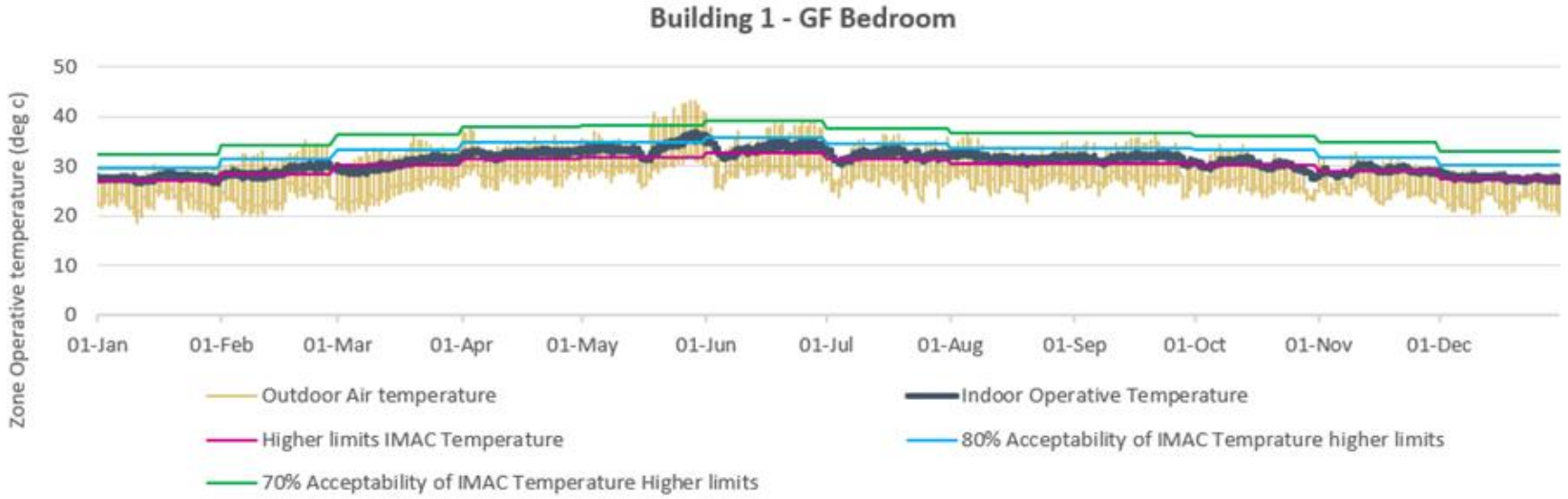
Percentage of occupied hours that meets IMAC Adaptive thermal comfort Range

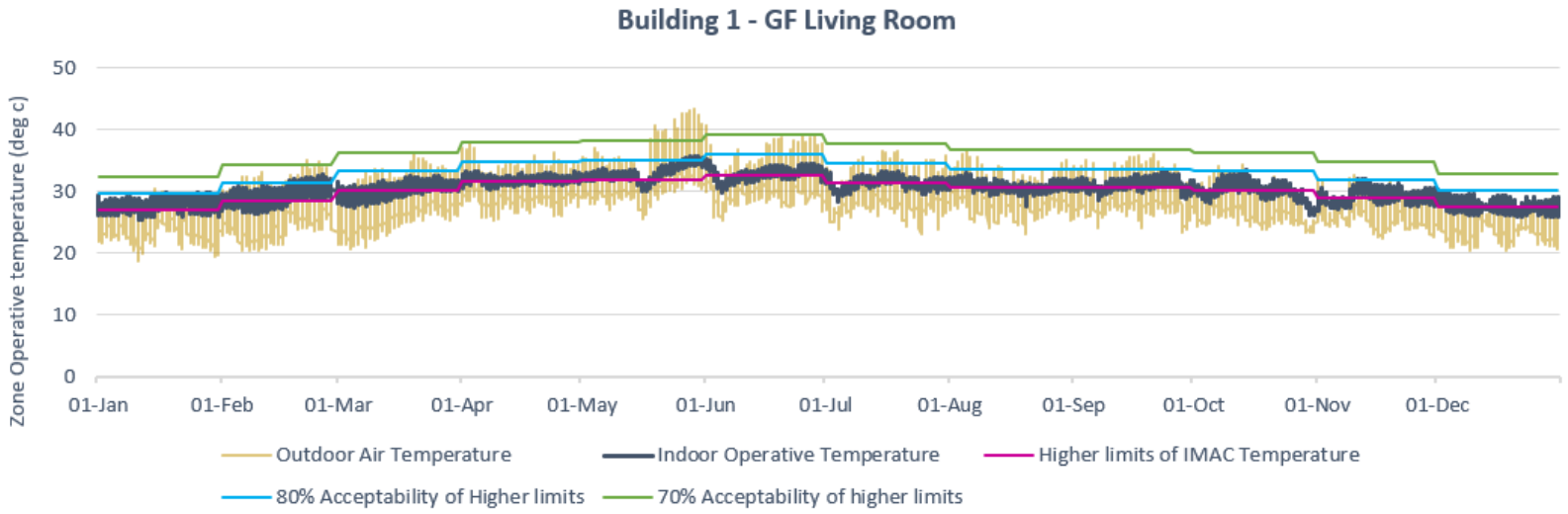
IMAC Temperature		
Month	Min	Max
January	22.31	27.07
February	23.75	28.51
March	25.52	30.28
April	26.8	31.56
May	27.06	31.82
June	27.89	32.65
July	26.67	31.43
August	25.86	30.62
September	25.82	30.58
October	25.44	30.2
November	24.17	28.93
December	22.7	27.46

Zone name	Building 5			Building 1		
	Ground floor	Middle floor	Top Floor	Ground floor	Middle floor	Top Floor
Percentage of Occupied hours within 90% acceptability limits						
Bedroom	8%	2%	1%	24%	7%	5%
Living	7%	2%	2%	25%	12%	9%
Kitchen	34%	25%	23%	40%	31%	28%
Percentage of Occupied hours within 80% acceptability limits						
Bedroom	97%	57%	34%	99%	84%	72%
Living	92%	41%	26%	98%	84%	66%
Kitchen	88%	77%	62%	88%	82%	71%
Percentage of Occupied hours within 70% acceptability limits						
Bedroom	100%	97%	92%	100%	99%	97%
Living	100%	95%	82%	100%	99%	98%
Kitchen	99%	98%	96%	99%	98%	97%

Case Study : Light House Project (LHP), Chennai

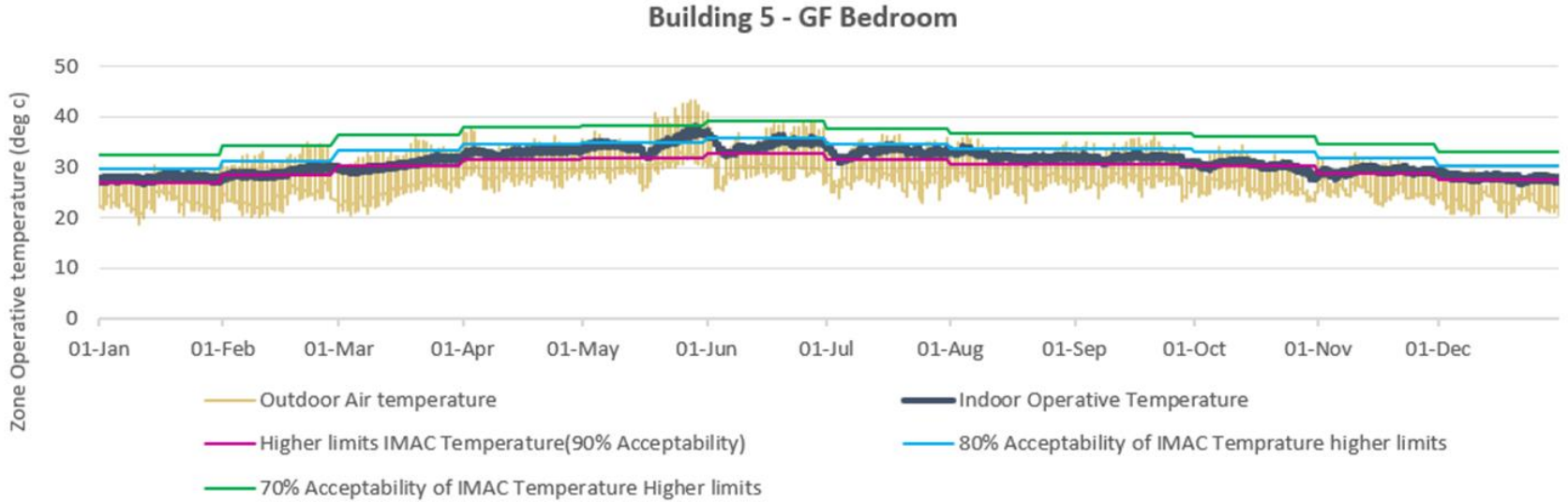
LHP Project Building 1 (North - South)

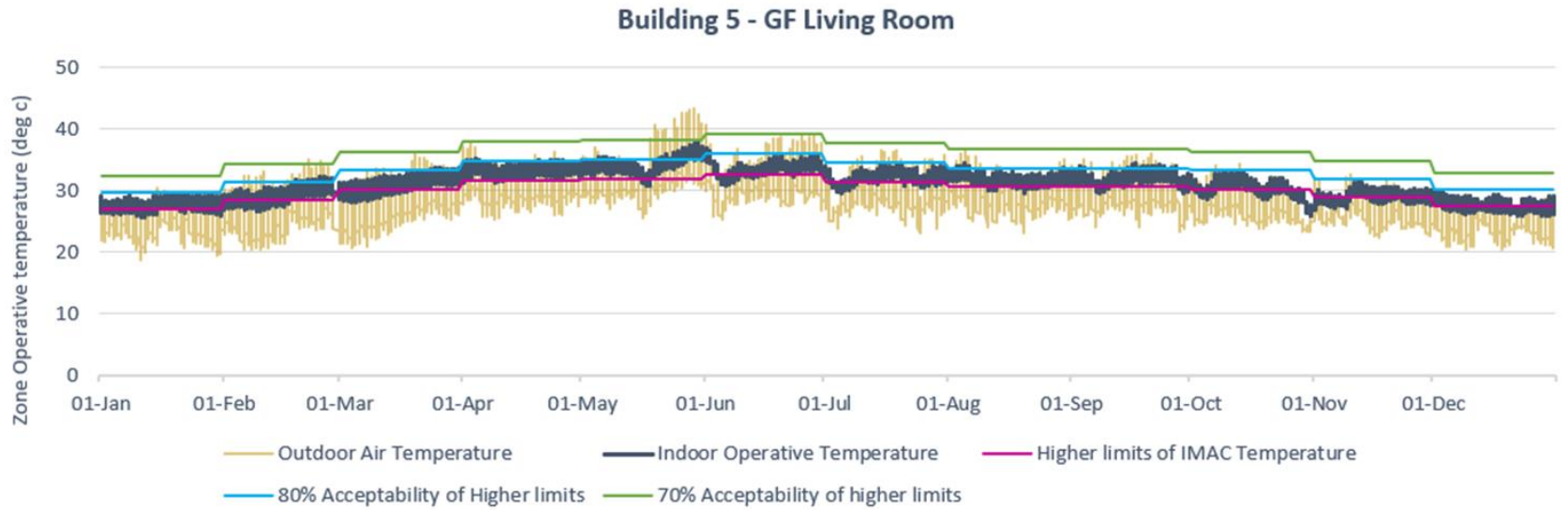




Case Study : Light House Project (LHP), Chennai

LHP Project Building 5 (East - West)





Thermal Comfort Improvement through Passive Measures

1. Large Window opening size
2. Cross ventilation
3. Shading for windows
4. Ventilator above Main door
5. EPS insulation – Under deck (At least 25 mm Thick)

LHP Site Thermal Improvements

- Dwelling units have two panel sliding window system for Living, Bedroom & kitchen openings
- Sliding windows open up only to 50% of Openable area

- Instead of using Sliding windows**, Casement windows** can provide opening up to 90% of Openable area
- This increase the quantity of fresh natural air comes into the space & aids to thermal comfort of occupants

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Azadi Ka Amrit Mahotsav

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Thank you !

Presented by:

GIZ and South Cluster Cell