



GLOBAL
HOUSING
TECHNOLOGY
CHALLENGE INDIA



Ministry of Housing and Urban Affairs
Government of India

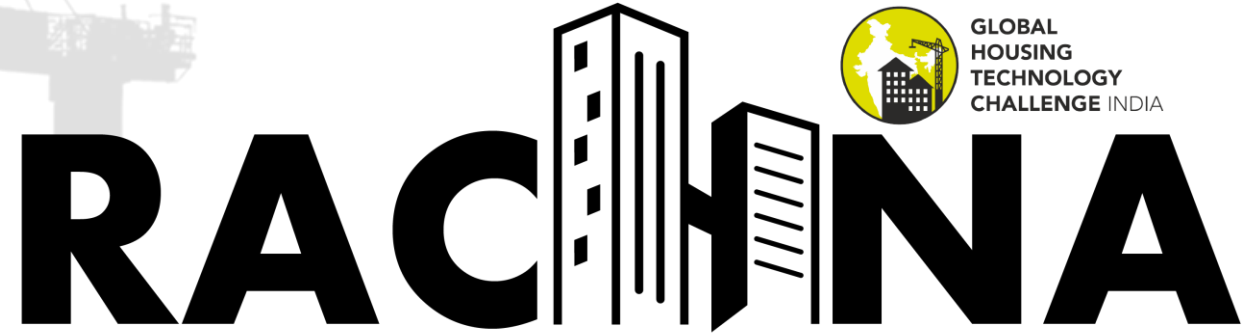


giz Deutsche Gesellschaft
für Internationale
Zusammenarbeit (GIZ) GmbH

Two-day Training: Professionals

| Location: Bhubaneswar, Odisha |

| Date: 9th-10th June, 2022 |



RACHINA

RESILIENT, AFFORDABLE AND COMFORTABLE HOUSING THROUGH NATIONAL ACTION

“ Innovative Construction Technologies & Thermal Comfort for Affordable Housing ”



Ministry of Housing
and Urban Affairs
Government of India

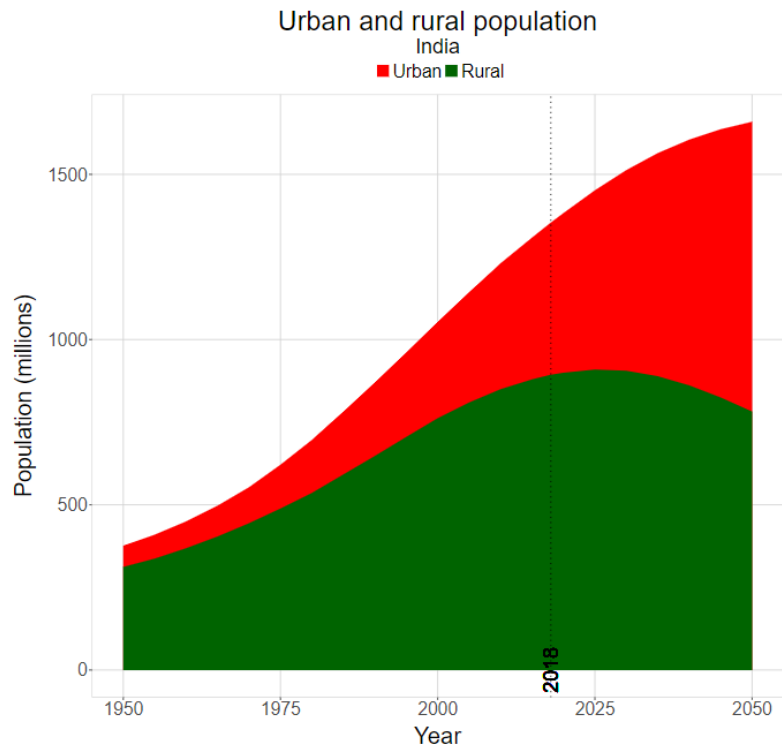


DAY 1



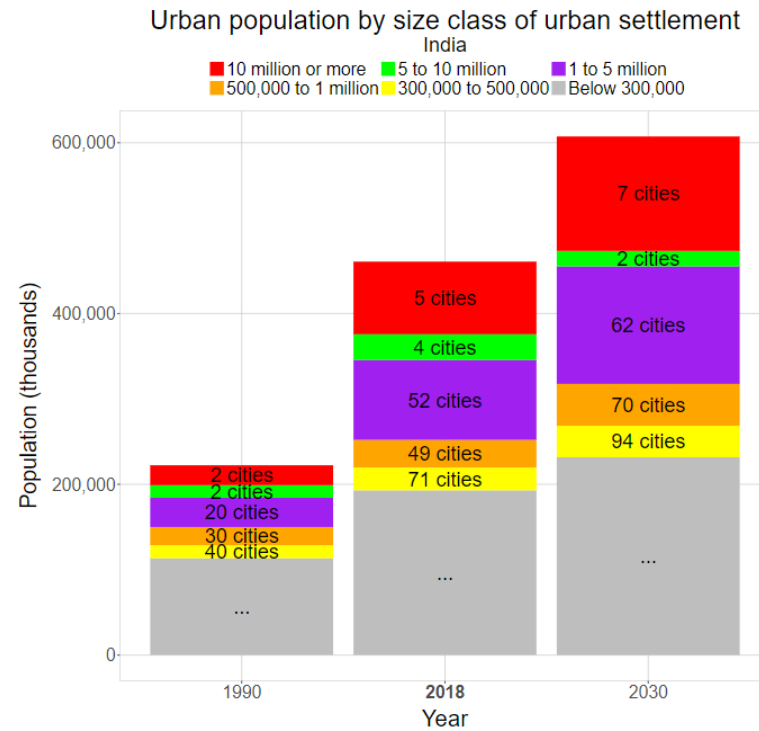
INTRODUCTION

Growing Opportunities with Rapid Urbanization



© 2018 United Nations, DESA, Population Division. Licensed under Creative Commons license CC BY 3.0 IGO.

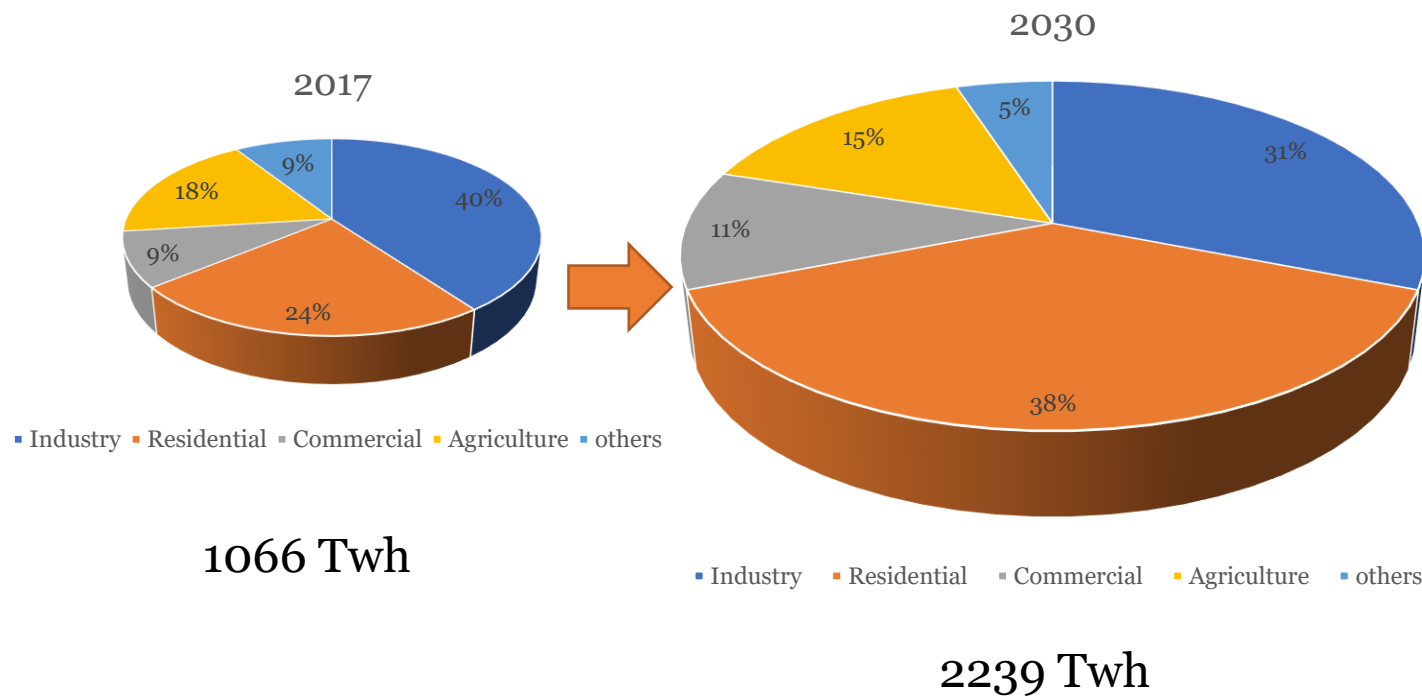
Note: Urban and rural population in the current country.



© 2018 United Nations, DESA, Population Division. Licensed under Creative Commons license CC BY 3.0 IGO.

Cities, which will contribute over 80% to GDP by 2050, need to be Receptive, Innovative, and Productive to foster sustainable growth and ensure a better quality of living

Energy demand with Rapid Urbanization



Residential Buildings: Fast Growth in Electricity Consumption.

*IESS, NITI Aayog

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

MoHUA Initiates for Urban Transformation

- 1 SMU (U)
- 2 PMY (U)
- 3 DAY-NULM
- 4 HRIDAY
- 5 AMRUT

- 6 Smart City
- 7 Urban Transport

Flagship Missions under the Ministry of Housing & Urban Affairs (MoHUA) aim to achieve Transformative, Inclusive and Sustainable development through planning, development and reforms for achieving Urban Transformation.

Global Housing Technology Challenge- India (GHTC-India)

MoHUA has initiated the GHTC-India to identify and mainstream a basket of innovative construction technologies from across the globe for the housing construction sector that is sustainable, eco-friendly, and disaster-resilient.



AGARTALA, TRIPURA
Light Gauge Steel Structural System & Pre-Engineered Steel Structural System

CHENNAI, TAMIL NADU
Precast Concrete Construction System- Precast Components Assembled at Site

INDORE, MADHYA PRADESH
Prefabricated Sandwich Panel System

LUCKNOW, UTTAR PRADESH
Stay in-place Formwork System

RAJKOT, GUJARAT
Monolithic Concrete Construction System

RANCHI, JHARKHAND
Precast Concrete Construction System-3D Pre-Cast Volumetric

Components of GHTC India



Affordable Housing in India

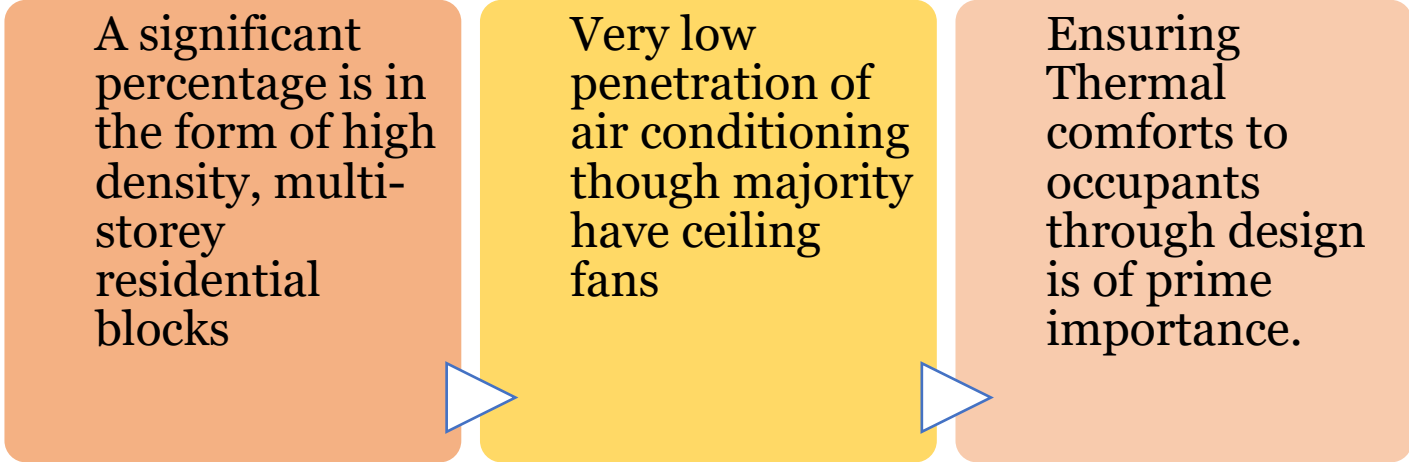
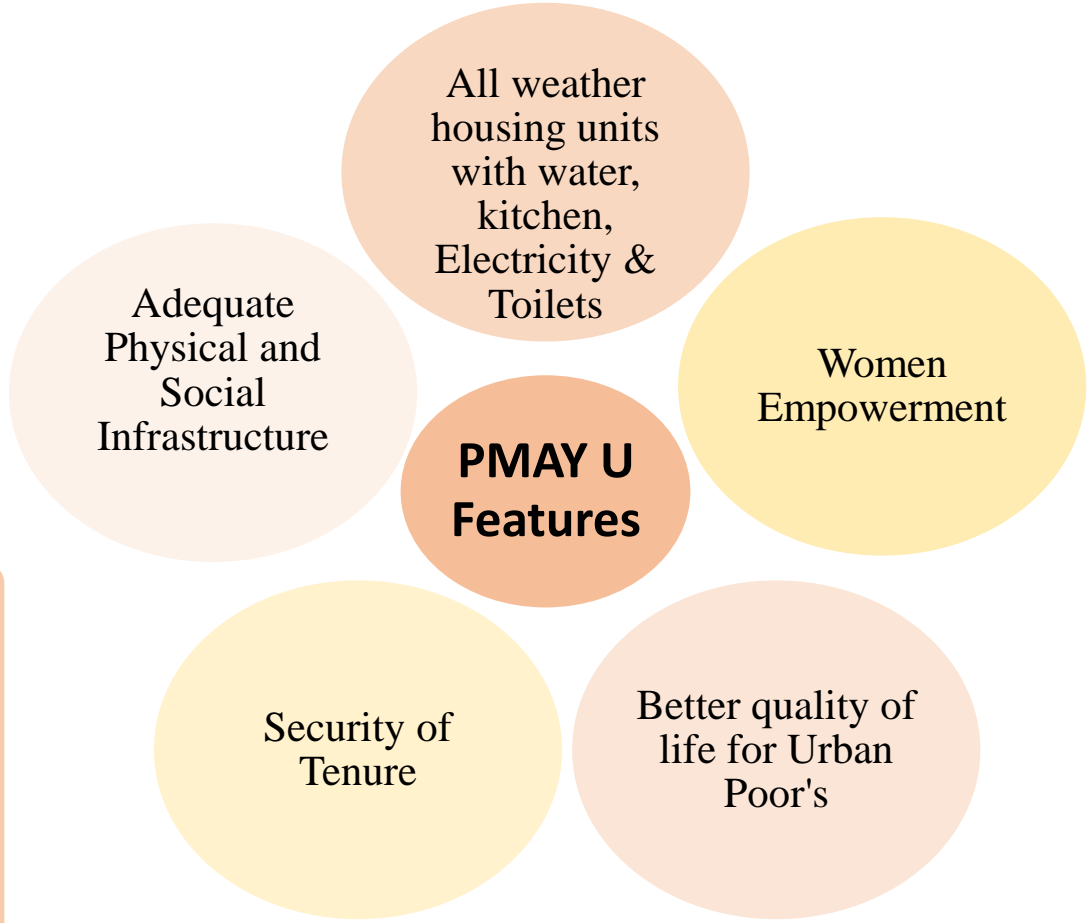
Affordable housing, as defined by the National Planning Policy Framework, is housing for sale or rent for those whose needs are not met by the market.



The provision of affordable housing is a key element of the Government's plan to end the housing crisis, tackle homelessness and provide aspiring homeowners with a step onto the housing ladder

Pradhan Mantri Awas Yojna – Urban

- PMAY-U, launched in 2015, aims to provide houses for homeless. The Government is offering this scheme to all UT's and states. It also offers interest subsidy for Home loans for first time buyers in urban areas
- The residential buildings expected to increase by 2 times in terms of floor area by 2030
- 12 million new affordable homes in Urban areas under PMAY by 2022.



Pradhan Mantri Awas Yojna – Urban

The mission is addressing the affordable housing requirement in Urban areas through following program verticals:

Subsidiary for beneficiary led individual house construction/enhancement. In-Situ Slum Redevelopment (ISSR) for Slums

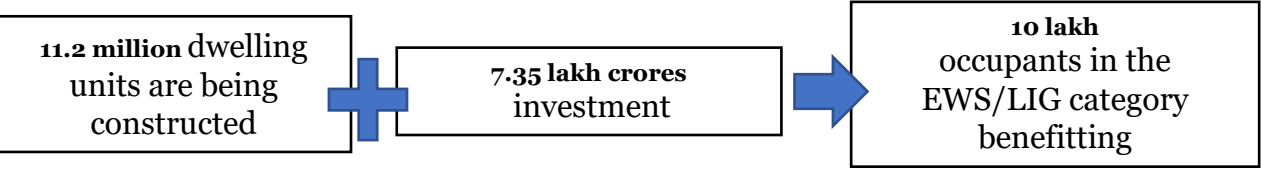
Affordable housing in partnership with Public & Private Sectors

Promotion of Affordable Housing through Credit linked subsidy

Slum rehabilitation of Slum dwellers with participation of private developers using Land as a resource

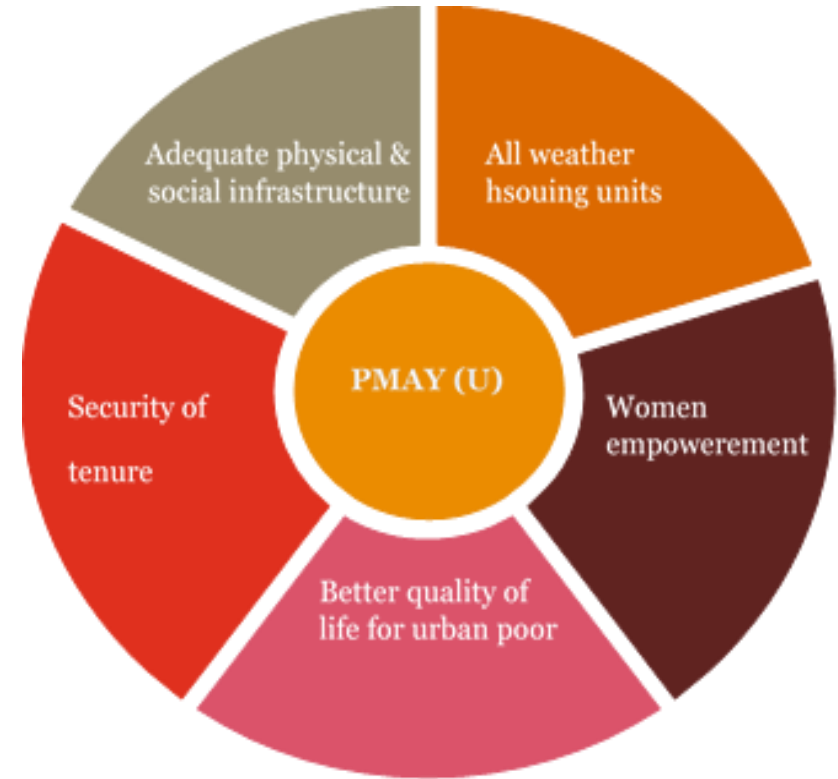
Project Objectives

Pradhan Mantri Awas Yojana - Urban



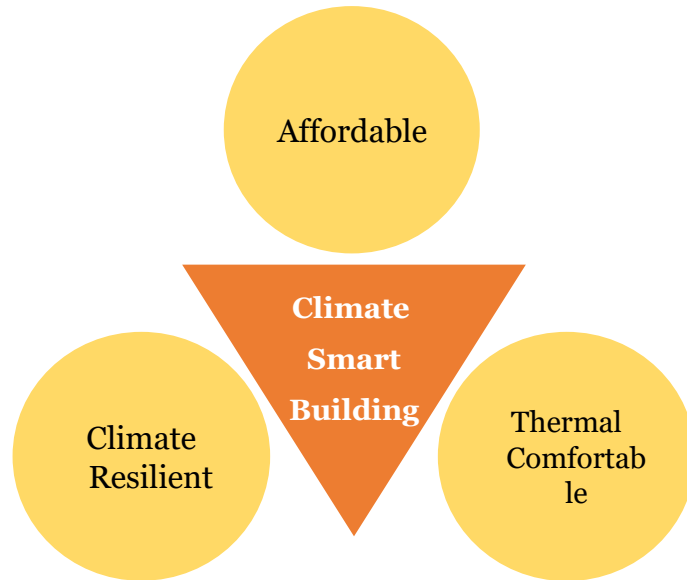
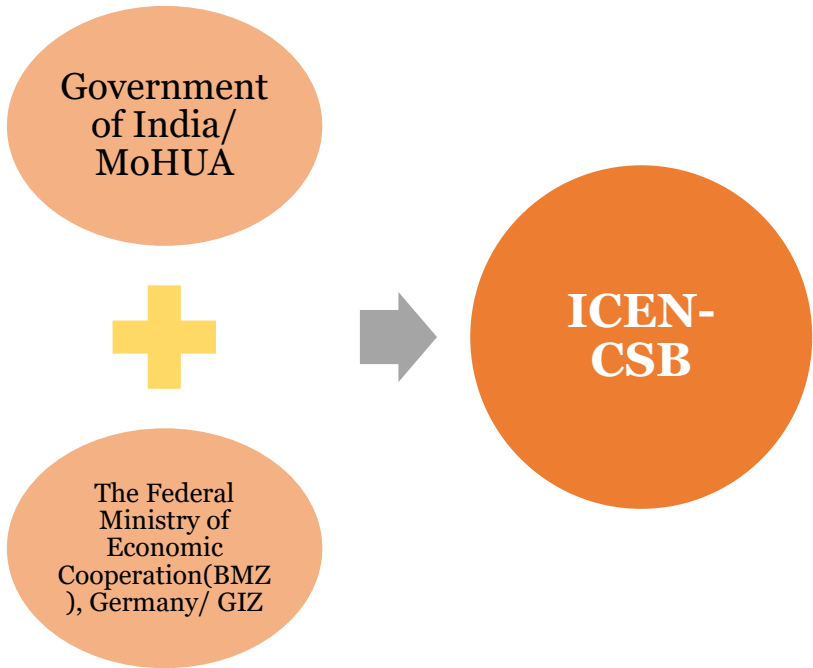
- Construction of affordable housing in Partnership with Public & Private Sectors
- Promotion of affordable Housing through Credit Linked Subsidy
- Slum rehabilitation with private developers using land as a resource
- Subsidy for beneficiary-led individual house construction/enhancement. (ISSR)

Problems addressed through cafeteria approach by mission

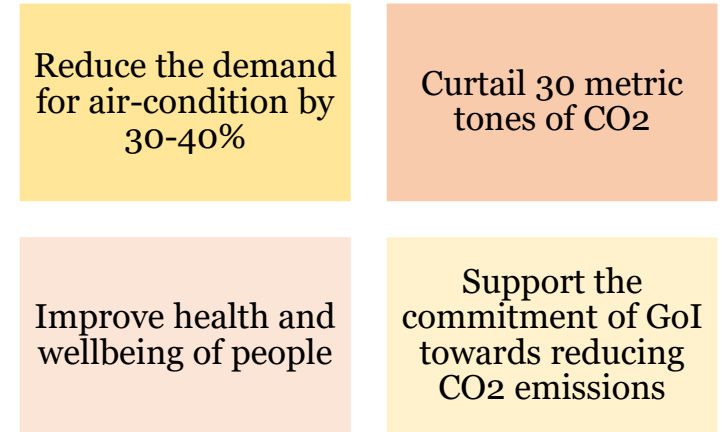


Key features of PMAY-U projects

Climate Smart Buildings Programme (ICEN-CSB)



Key features of a CSB



Results of a Climate responsive building design

About the project-“Climate Smart Buildings (CSB): Establishment of the Cluster Cell in Rajkot, Gujarat under Global Housing Technology Challenge-India (GHTC-India)”

Chandigarh	Dadar & Nagar Haveli, Daman & Diu	Gujarat	Haryana	Punjab	Rajasthan
-------------------	--	----------------	----------------	---------------	------------------

The climate smart building project intends to address the majority of gaps identified in the affordable housing sector

- By introducing of thermal comfort & climate resilience in the Local Government framework through Byelaws as an overarching objective.
- In order to achieve this objective, activities like documentation of LHP construction process from a sustainability perspective, knowledge transfer & capacity building through LHPs, performance monitoring & demonstration of thermal comfort in selected housing projects among others.

Project Objectives



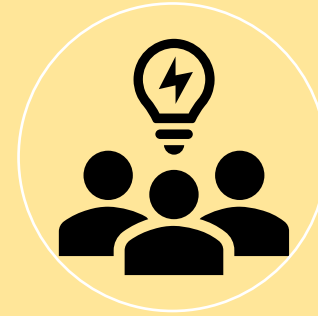
WP1: Facilitate implementation and monitoring of Light House Projects (LHPs)



WP 2: Technical assistance to enhance thermal comfort in upcoming Demonstration Housing Projects (DHPs) and ARHCs (Affordable rental housing complexes) and other Public/Private housing projects in West Cluster



WP 3: Inclusion of climate resilience and thermal comfort requirements in building byelaws and Local Government framework in West Cluster



WP 4: Capacity development of Govt officials and private stakeholders on thermal comfort in the West Cluster





LHP INTRODUCTION

Light House Projects

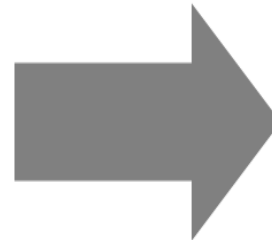
- The aim of the assignment is to introduce thermal comfort into the foray of affordable housing, a critical design & thus usability aspect which unfortunately has been missing from the current nature of affordable housing in India.
- Although studies & policies like the greening guidelines for PMAY projects, Eco-Niwas Samhita Part-1, Star Labelling of energy efficient homes etc have been around but what the sector really needs is specific, easy to comprehend provisions which can be mandated & enforced in a steadfast way which is exactly what this project intends to do



Light House Projects

Strategic Intent

- Seamless implementation of LHPs
- Assist in knowledge transfer through documentation of technologies used & implementation of LHPs
- Technical assistance to achieve thermal comfort in demonstration projects
- Support the implementation of thermal comfort provision in state legislature
- Capacity buildings around thermal comfort & sustainable construction



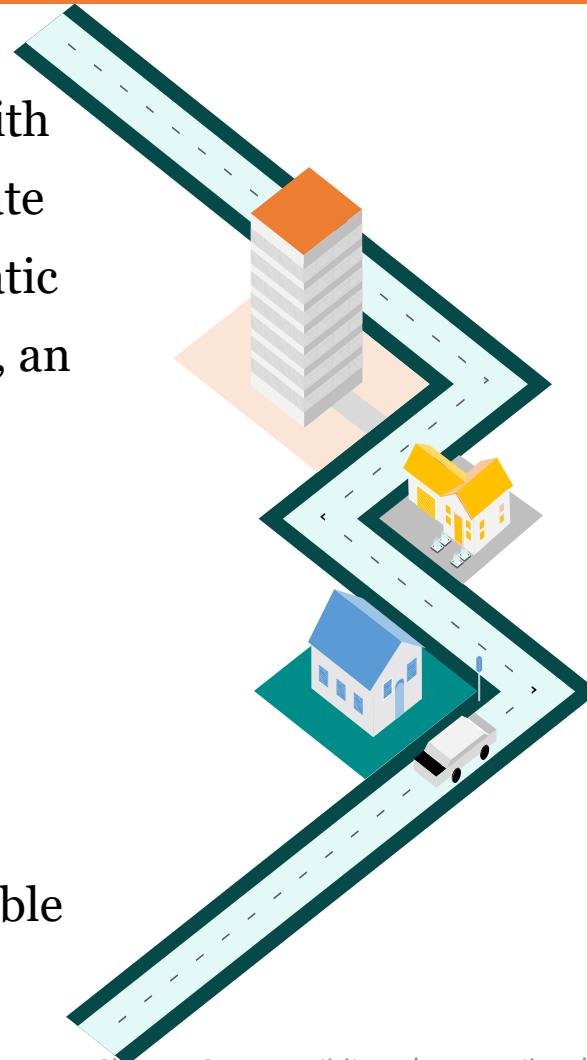
Outcome

- Successful model for the implementation & documentation of LHPs
- Databank of technologies , relevant materials in the state analyzed around various relevant parameters
- Replicable models for thermally comfortable affordable houses in Gujarat (climate sensitive to 3 climatic conditions in the state)
- Thermal comfort provisions mandated by the law
- Better grasp of thermal comfort & sustainability in general among the concerned stakeholders & general public too

What are we working on?

LHPs are model housing projects with houses built with shortlisted alternate technology suitable to the geo-climatic and hazard conditions of the region, an initiative under the Climate Smart Building Programme.

These projects demonstrate and deliver ready to live houses with speed, economy and with better quality of construction in a sustainable manner.



Currently the LHPs' are being implemented in six states (Uttar Pradesh, Gujarat, Madhya Pradesh, Gujarat, Jharkhand, and Tripura) of India under Global Housing Technology Challenge (GHTC) – India. These projects will be made up of modern technology and innovative processes and reduce the construction time and make a more resilient, affordable, and comfortable house for the poor.

Details of LHP Projects along with construction Technology Used

LHP Location	TECHNOLOGY SELECTED	NUMBER OF HOUSES TO BE CONSTRUCTED
Rajkot, Gujarat	Monolithic Concrete Construction using Tunnel Formwork	1144
Indore, Madhya Pradesh	Prefabricated Sandwich Panel System	1024
Chennai, Tamilnadu	Precast Concrete Construction System – Precast Components Assembled at Site	1152
Ranchi, Jharkhand	Precast Concrete Construction System – 3D Volumetric	1008
Agartala, Tripura	Light Gauge Steel Structural System & Pre-engineered Steel Structural System	1000
Lucknow, Uttar Pradesh	PVC Stay in Place Formwork System	1040

Features of LHP

Definition

A model housing project with approximate 1,000 houses built with shortlisted Construction technology under GHTC Challenge, demonstrating speed, economy and better quality of construction in a sustainable manner

Minimum Size of houses

A model housing project with approximate 1,000 houses built with shortlisted Construction technology under GHTC Challenge, demonstrating speed, economy and better quality of construction in a sustainable manner

Available on-site facilities

A model housing project with approximate 1,000 houses built with shortlisted Construction technology under GHTC Challenge, demonstrating speed, economy and better quality of construction in a sustainable manner

Design

- Designed as per the dimensional requirements mandated in the National Building Code (NBC) 2016.
- Design in concurrence with existing centrally sponsored schemes and Missions such as Smart Cities, AMRUT, Swachh Bharat (U), National Urban Livelihood Mission (NULM), Ujjwala, Ujala, Make in India, etc.
- Structural details designed considering durability and safety requirements of applicable loads including earthquakes and cyclone and flood as applicable confirming to applicable Indian/International standards.
- Design of Cluster involves the possibility of innovative system of water supply, drainage and rainwater harvesting, renewable energy sources with special focus on solar energy.

Construction Period

A model housing project with approximate 1,000 houses built with shortlisted Construction technology under GHTC Challenge, demonstrating speed, economy and better quality of construction in a sustainable manner

Construction Methodology of LHP Rajkot

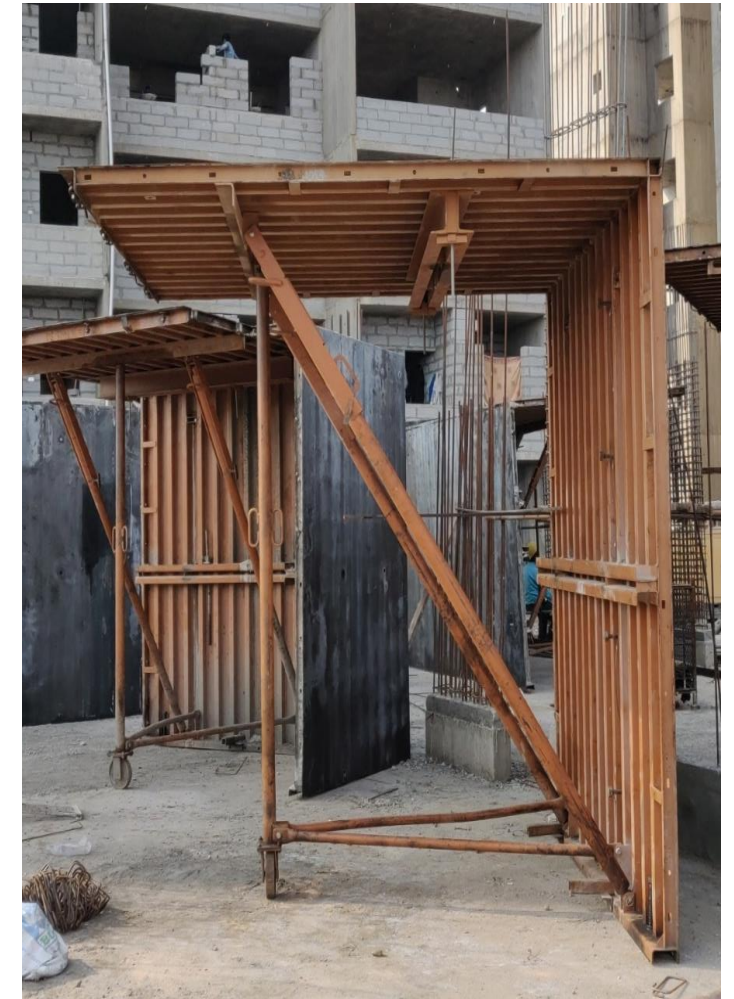
Monolithic Concrete Construction using Tunnel Formwork

Tunnel formwork is a mechanised cellular structure construction system. It is made up of two half shells that are joined to make a room or a cell. An apartment is made up of several cells.

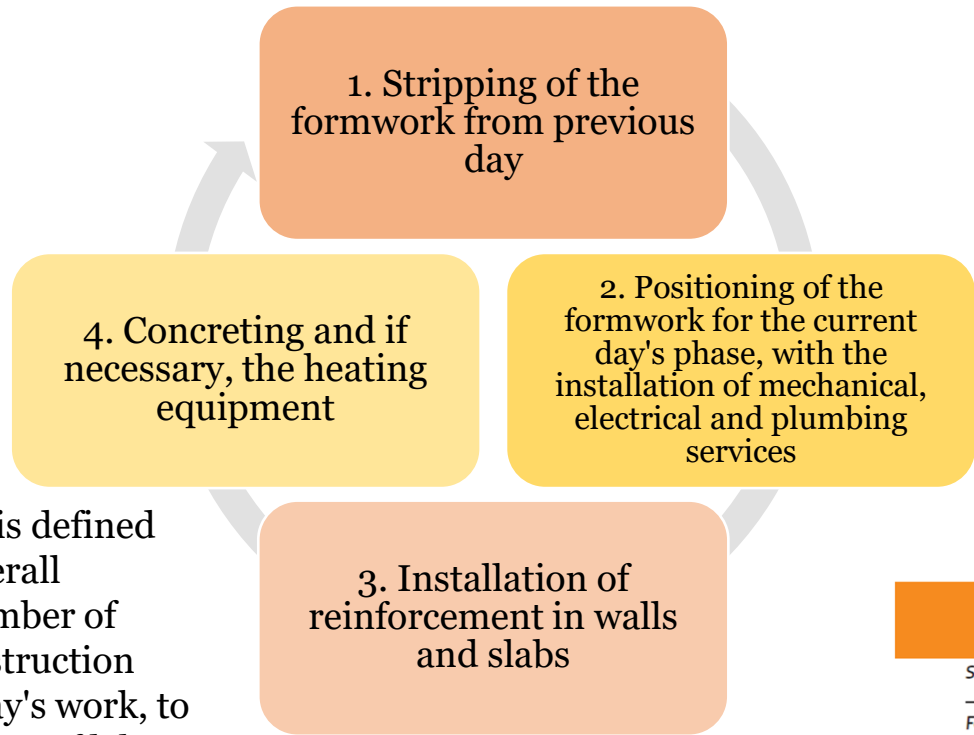
Tunnel forms allow walls and slabs to be cast in one day through several phases to the structure. The programme and the amount of floor area that can be poured in one day define the phasing. The task to be done each day is defined by the 24-Hour cycle. In the morning, the formwork is set up for the day's pour. In the afternoon, the reinforcement and services are installed, and concrete is poured. Concrete for walls and slabs must be poured in one operation once reinforcing has been installed. Early in the morning, the formwork is removed and positioned for the next phase.

The assembly-line approach of the system to construction provides developers and contractors with benefits relating to the certainty of their site schedule, efficient time management and an overall reduction in cost. This enables companies to develop a better quality, monolithic structure that is more acoustically and thermally efficient. The repetitive nature of tunnel form tasks ensures high productivity, and optimum use of labour and these are of considerable benefit to the project manager.

This formwork is manufactured in a completely automated facility in France and there is no manufacturing plant in India.

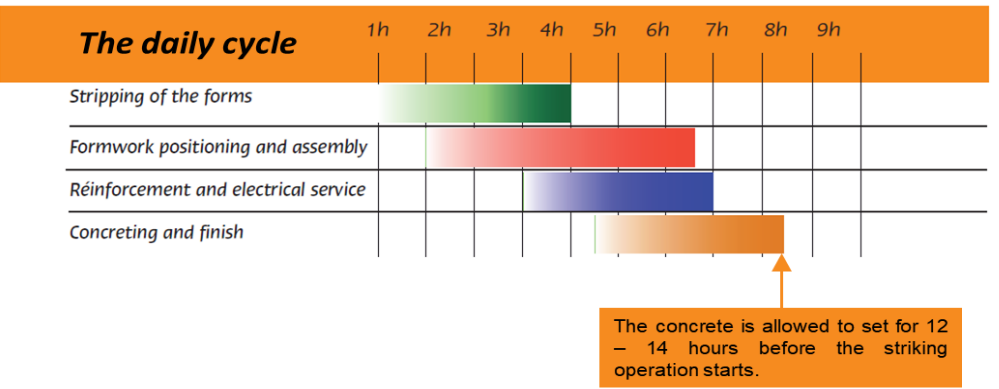


Construction Methodology – 24 Hour Cycle



The implementation of 24-Hour Cycle shall be in accordance with IS 456:2000 – Code of practice for plain and reinforced concrete. However, the structural engineer shall furnish details about the actual process of removal of formwork after casting of concrete

The task to be done each day is defined by the 24-Hour cycle. The overall structure is divided into a number of more or less comparable construction phases, each matching to a day's work, to establish this cycle. The amount of labour and equipment required is then calculated based on the magnitude of these phases. Every day, the phases are similar to achieve optimal efficiency.



DAY 1

Tea Break

DAY 1

Session 1



01

THERMAL COMFORT

Thermal comfort is a mental state that reflects happiness with the thermal environment and is measured by subjective assessment.



Importance of Thermal Comfort

2

People adjust their behavior to cope with their thermal environment, such as by adding or removing clothing, changing their posture unconsciously, selecting a heating source, moving closer to or farther away from cooling/heating sources, and so on.

3

When this option (removing a jacket or moving away from a heat source) is gone, issues develop since people are no longer able to adjust. People are unable to adapt to their environment in some cases because the environment in which they work is a product of the processes of the task they are doing.

1. You can increase morale and productivity while also enhancing health and safety by regulating thermal comfort. Because their capacity to make decisions and/or do manual tasks deteriorates in excessively hot and cold conditions, people are more prone to behave unsafely



THERMAL ENVIRONMENTS CAN BE DIVIDED LOOSELY INTO THREE BROAD CATEGORIES:

THERMAL COMFORT

Broad satisfaction with the Thermal Environment i.e. most people are neither too hot nor too cold.

THERMAL COMFORT

People start to feel uncomfortable i.e. they are too hot or too cold, but are not made unwell by the conditions.

THERMAL COMFORT

Heat stress or cold stress, is where the thermal environment will cause clearly defined harmful medical conditions, such as dehydration or frost bite

THERMAL DISCOMFORT

Thermal Discomfort can be induced



by a generalized warm or cool discomfort of the body



by an unpleasant chilling or heating of a specific region of the body.

Factors affecting Thermal Comfort



PHYSIOLOGICAL FACTORS

When trying to maintain maximum thermal comfort in a building, are individualized in nature and impossible to manage



PHYSICAL FACTORS

Venus has a beautiful name and is the second planet from the Sun



PHYSICAL FACTORS

+

•01

•Air Temperature

+

•02

•Mean Radiant Temperature

+

•03

•Radiant Temperature Asymmetry

+

•04

Floor Surface Temperature

+

•05

•Relative Humidity

+

•06

•Air Speed

AIR TEMPERATURE – the temperature of the air surrounding a body

The ideal temperature for sedentary work is usually between 20°C and 26°C

Workers who conduct strenuous labor frequently prefer a cooler environment.

When deciding on an indoor temperature, keep the outside temperature in mind.

The temperature within a workplace that is considered "comfortable" is determined by the outside temperature.

RADIANT TEMPERATURE – the heat that radiates from a warm object

Heat can be generated by equipment, which raises the temperature in a specific region.

Heat lamps, spot lighting, skylights, and other heat-producing sources are examples of heat-producing sources.

Even a tiny room with a few workers can see a temperature spike.

PHYSICAL FACTORS

AIR VELOCITY – the speed of air moving across the worker

Because people are sensitive to air movement, air velocity is a major determinant in thermal comfort assessments.

It's best if the air flow rate is between 0.1 and 0.2 m/s.

Little air movement or air that is still or stagnant in indoor environments may cause feelings of fatigue.

It may help to cool workers in a hot setting if the air is colder than the environment, but it may bring further pain to workers in a cool atmosphere.

HUMIDITY – the amount of evaporated water in the air

Humidity in interior spaces varies widely and is influenced by the type of plant utilized, such as those that produce steam.

Air-conditioning can easily attain ideal relative humidity values of 40 percent to 70 percent. On warm or hot humid days, relative humidity in non-air-conditioned workplaces, or where outdoor climatic conditions influence the internal thermal environment, can be more than 70%.

When the humidity is excessively high, it causes discomfort (heavy sweating, weariness, and a sense of 'airlessness,' for example).

PHYSIOLOGICAL FACTORS

CLOTHING LEVEL

Because it affects heat loss and, as a result, the thermal balance, the amount of thermal insulation worn by a person has a significant impact on thermal comfort. Layers of insulating clothing keep a person warm or cause overheating by preventing heat loss. The better the insulating ability of a garment, the thicker it is in general. Air movement and relative humidity can reduce the insulating effectiveness of clothing, depending on the type of material it is constructed of.



METABOLIC RATE

The rate at which chemical energy is converted into heat and mechanical effort by metabolic activities within an organism, commonly measured in units of total body surface area. People have different metabolic rates that can fluctuate due to activity level and environmental conditions.



CLOTHING	Clo
T-shirts, shorts, Light socks, Sandals	0.30
Shirt, Trousers socks, Shoes	0.70
Jacket, Blouse, Long skirt, stockings	1.00
Trousers, Vest, Jacket Coat, Socks Shoes	1.50

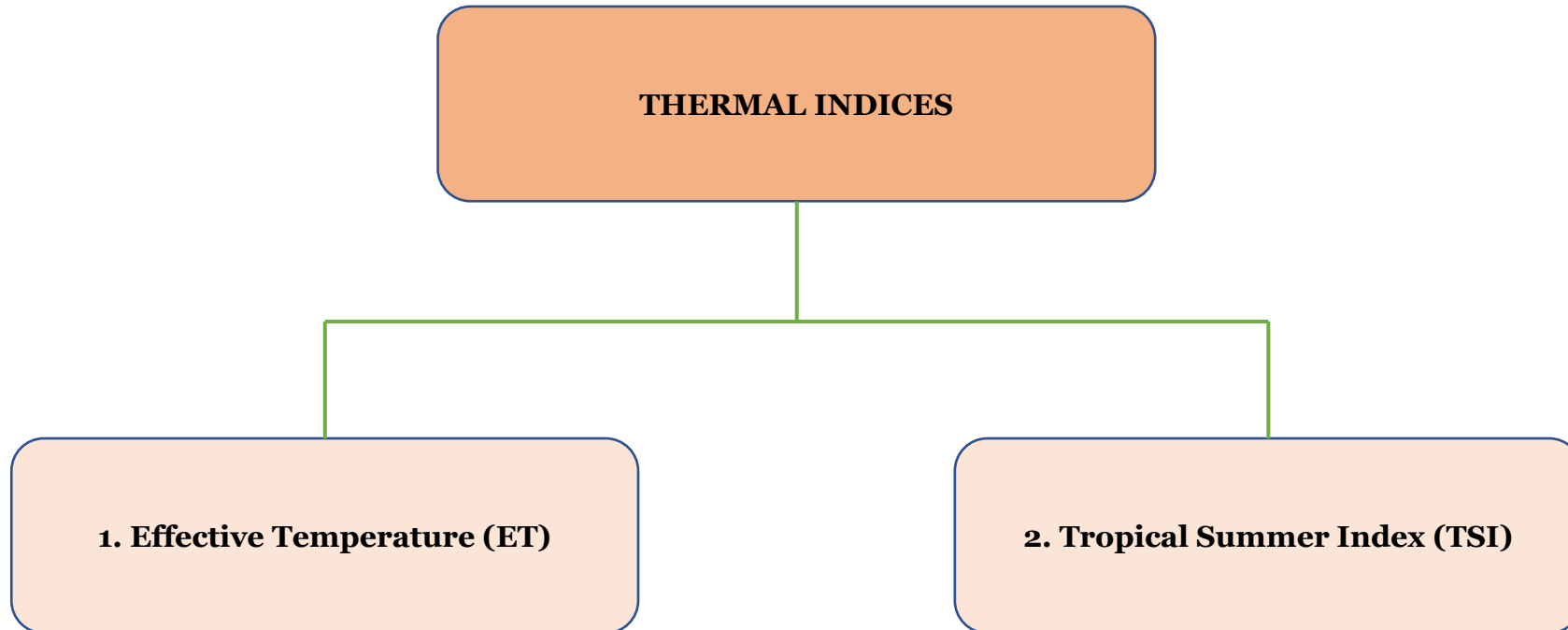
CLOTHING LEVELS & INSULATION

ACTIVITY	Met
Seated, Relaxed	1.0
Sedentary Activity (office, dwelling, school, laboratory)	1.2
Standing, Light Activity (shopping, laboratory, light industry)	1.6
Standing, Medium activity (shop assistant, domestic work, machine work)	2.0

METABOLIC RATE

Thermal Comfort Indices

Two of the thermal indices which find applications for hot environments are described as follows.



• 1 - Effective Temperature

- The temperature of still, saturated air at which the same amount of heat is released is known as the effective temperature. as well as a general influence on comfort the atmosphere is being investigated.
- Temperature, humidity, and other factors the same thermal output is produced by the same wind velocity. A person's sensations are assumed to have a temperature that is effective.

Initially two scales were developed

Basic Scale

one of which referred to men stripped to the waist and called the basic scale.

Normal Scale of Effective Temperature

The other applies to men fully clad in indoor clothing and called the normal scale of effective temperature. B

The same effective temperature is defined as a combination of temperature, humidity, and wind velocity that produces the same thermal experience in an individual.

The use of globe temperature reading instead of the air temperature reading to make allowance for the radiant heat.

The scale was compiled only for men either seated or engaged in light activity.



**CORRECTED EFFECTIVE
TEMPERATURE (CET)**

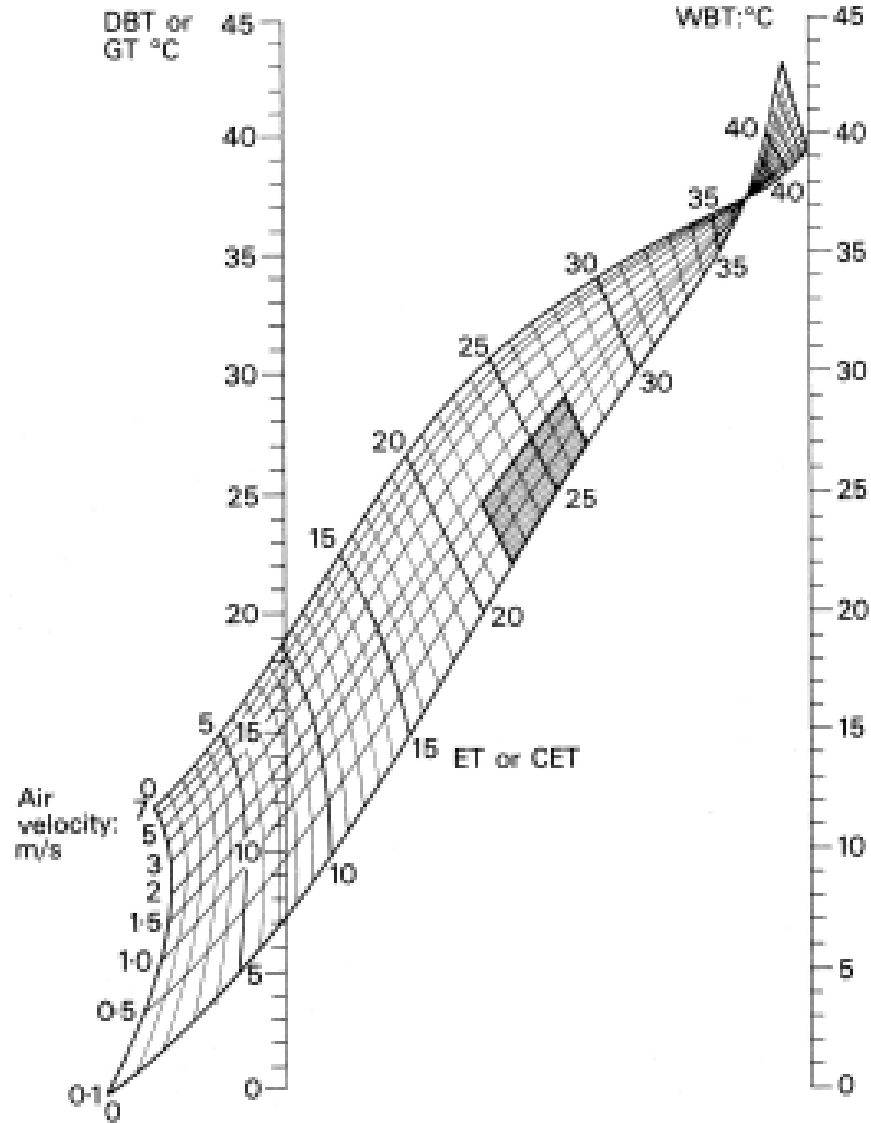


Figure represents the Corrected Effective Temperature (CET) Nomogram

• 2 - Tropical Summer Index

The TSI is defined as the temperature of calm air at 50% relative humidity which imparts the same thermal sensation as the given environment .The 50% level of relative humidity is chosen for this index as it is a reasonable intermediate value for the prevailing humidity conditions.

Mathematically, TSI (°C) is expressed as

$$\text{TSI} = 0.308t_w + 0.745t_g - 2.06\sqrt{V} + 0.841$$

Where,

Tw	Wet bulb temperature in °C
Tg	Globe temperature in °C
V	Air speed in m/s

The ranges of environmental conditions and TSI covered in this study are:

Globe Temperature	20-42 °C
Wet Bulb Temperature	18-30 °C
Air Speed	0-2.5 m/s
TSI	15-40 °C

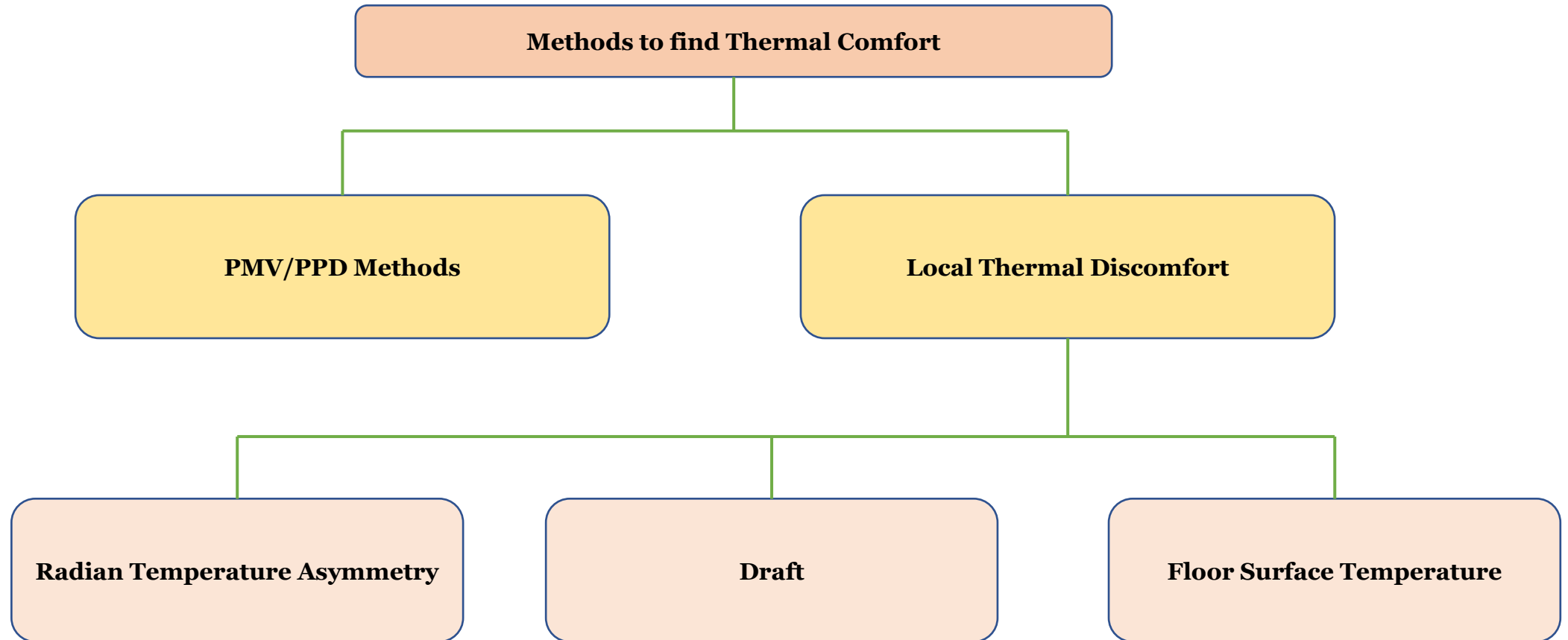
The thermal comfort of subjects was found to lie between TSI values of 25 and 30°C with optimum conditions at 27.5°C.

REDUCTION IN TSI VALUE FOR VARIOUS WIND SPEED

Air Speed (m/s)	Decrease in TSI (°C)
0.5	1.4
1.0	2.0
1.5	2.5
2.0	2.8
2.5	3.2

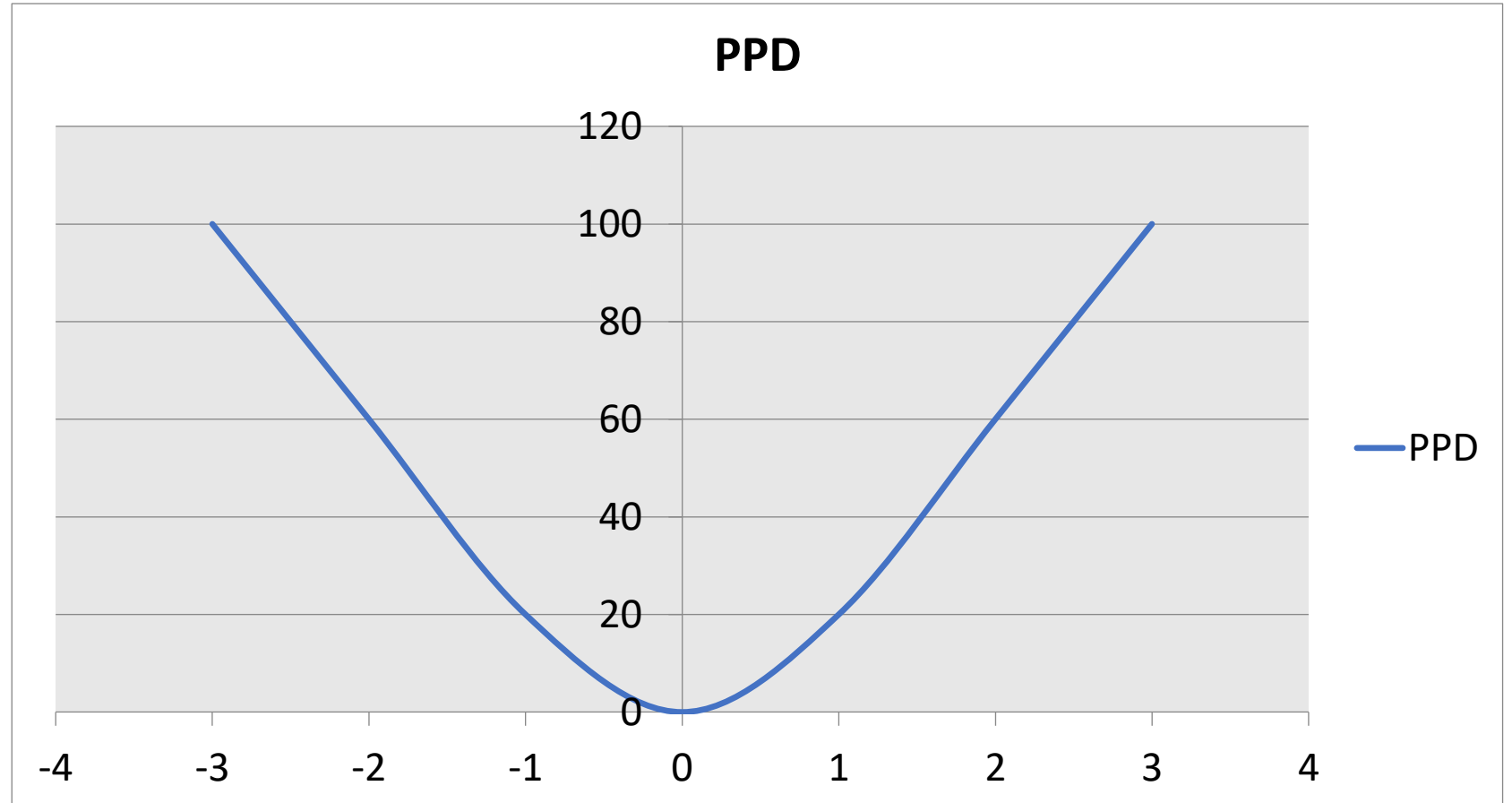
The warmth of the environment was found tolerable between 30 and 34°C (TSI), and too hot above this limit. On the lower side, the coolness of the environment was found tolerable between 19 and 25°C (TSI) and below 19°C (TSI), it was found too cold.

Methods to find Thermal Comfort

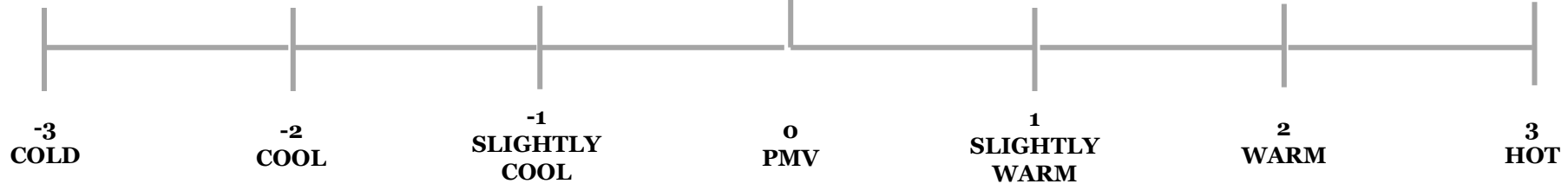


• 1 - PMV/PPD Methods

To describe comfort, the PMV/PPD model was constructed utilizing heat-balance equations and empirical investigations on skin temperature. Subjects are asked to rate their thermal comfort on a seven-point scale ranging from cold (-3) to hot (+3) in standard thermal comfort surveys.



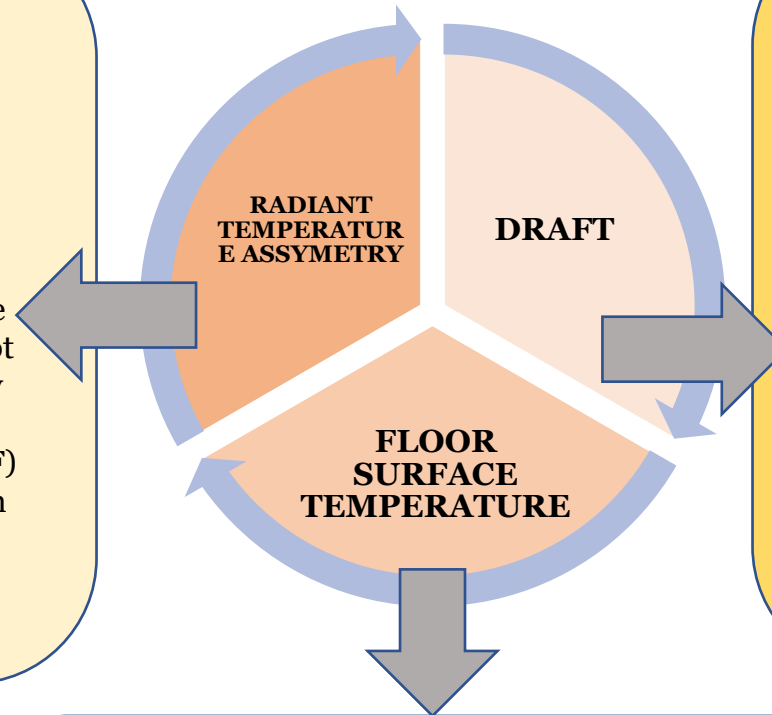
The comfort zone is determined by the combinations of the six parameters for which the PMV is within the recommended range (-0.5PMV+0.5), with the PMV equal to zero denoting thermal neutrality. While anticipating a population's thermal feeling is a crucial step in determining what conditions are pleasant, it is more vital to assess whether or not individuals will be satisfied.



It is critical to avoid local thermal discomfort, whether it is produced by a vertical air temperature difference between the feet and the head, an asymmetric radiant field, local convective cooling (draught), or contact with a hot or cold floor. When a person's thermal sensitivity is cooler than neutral, they are more sensitive to local discomfort, and when their body is warmer than neutral, they are less sensitive.



- Large variances in the heat radiation of the surfaces that surround a person might create local discomfort or impair acceptance of the temperature circumstances.
- The temperature disparities across diverse surfaces are limited by ASHRAE Standard 55. Because some asymmetries are more sensitive than others, such as a warm ceiling against hot and cold vertical surfaces, the limitations vary depending on which surfaces are involved.
- The ceiling cannot be more than +5 °C (9.0 °F) warmer than the other surfaces, but a wall can be up to +23 °C (41 °F) warmer.



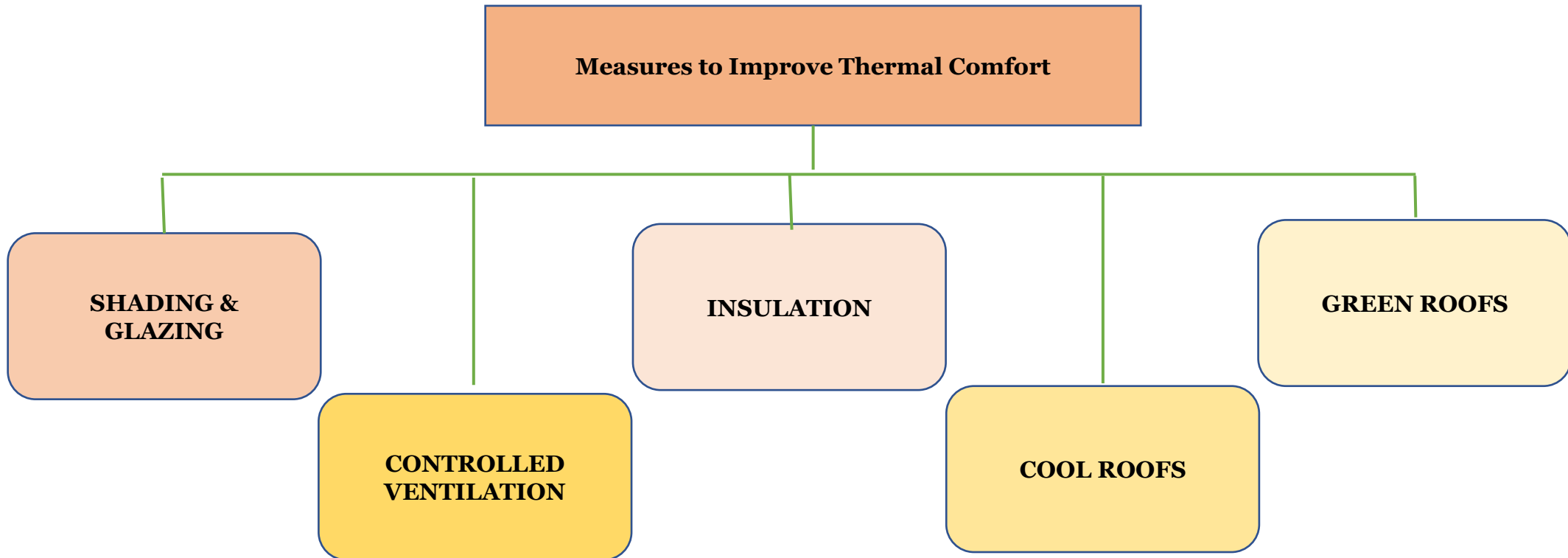
- While air movement can be enjoyable and give pleasure in some situations, it can also be unwelcomed and cause discomfort in others.
- The undesired air movement is known as "draught," and it is most noticeable when the complete body's thermal sense is cool.
- A draught is most likely to be felt on exposed body regions such as the head, neck, shoulders, ankles, feet, and legs, although the sensation is also affected by air speed, air temperature, activity, and clothing.

Depending on the footwear, too hot or too cold floors might be uncomfortable. In rooms where users will be wearing lightweight shoes, ASHRAE 55 advises keeping floor temperatures between 19–29 °C (66–84 °F).

There will always be a percentage dissatisfied occupants.
Often it will be the same person, therefore the values should not be added

CATEGORY	PPD (PREDICTED PERCENTAGE DISSATISFIED)	PMV (PREDICTED MEAN VOTE)	DR (DRAUGHT RISK)
	%	-	%
A	< 6	-0.2 < PMV < +0.2	< 10
B	< 10	-0.5 < PMV < +0.5	< 20
C	<15	-0.7 < PMV < +0.7	< 30

Measures to Improve Thermal Comfort



Shading & Glazing

Shading reduces internal heat gain through coincident radiation.

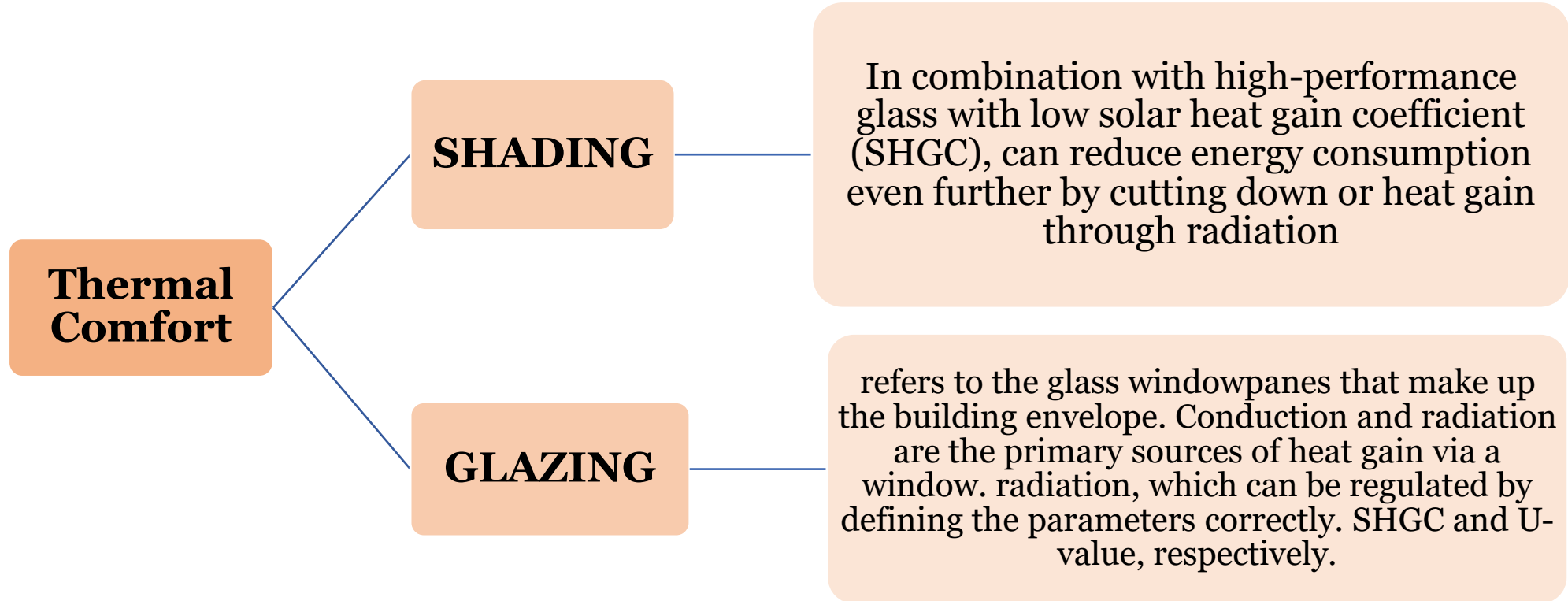
VARIOUS METHODS TO SHADE WINDOWS					
Overhangs	Awnings	Louvers	Vertical Fins	Light Shelves	Natural Vegetation

These can reduce cooling energy consumption by 10-20%

The shading mechanism can be fixed or movable (manually or automatically) for allowing varying levels of shading based on

- 1. the sun's position and**
- 2. movement in the sky**

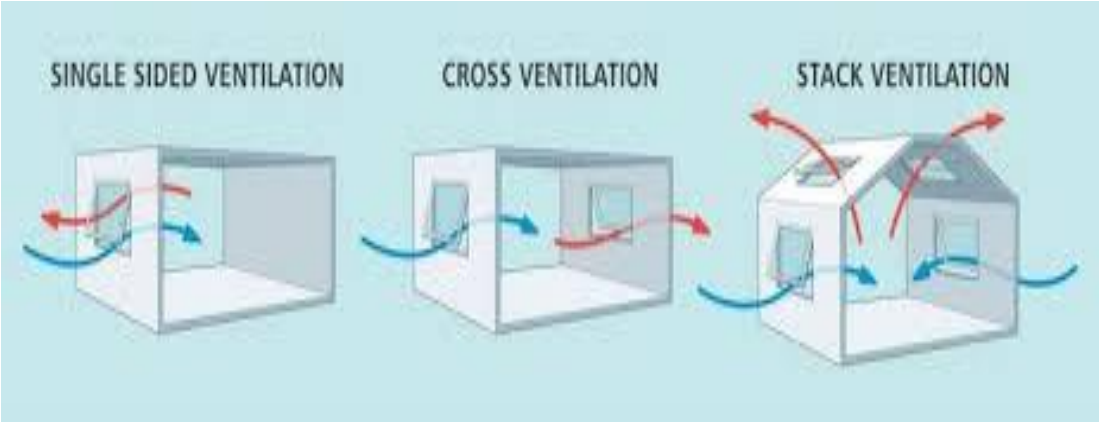
Shading & Glazing



Controlled Ventilation

BUILDING CAN BE DESIGNED AS

- CROSS VENTILATION
- STACK VENTILATION
- SINGLE-SIDED VENTILATION



Controlled Ventilation

Designing windows and vents to dissipate warm air and allow the ingress of cool air can reduce cooling energy consumption by 10-30%

Air Velocity range between 0.5 to 1 m/s Drops temperature at about 3 °C at 50% relative Humidity

AIR VELOCITY OF 1 m/s	
Office Environment	Too High
Home Environment	Acceptable (Especially if there is no resource to active air conditioning.)



Controlled Ventilation

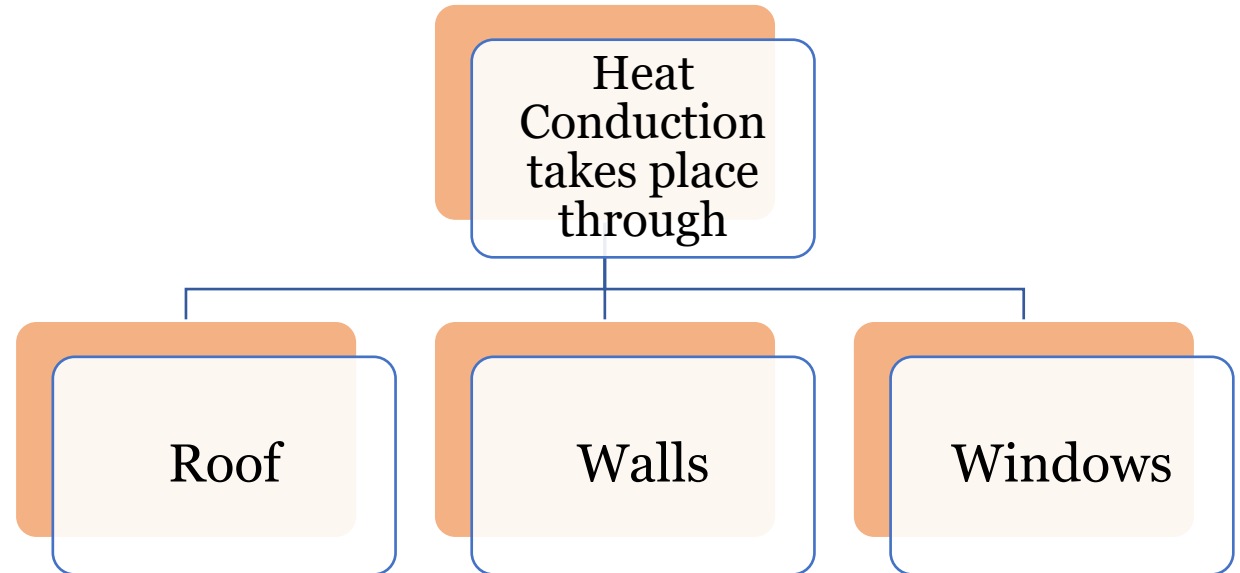
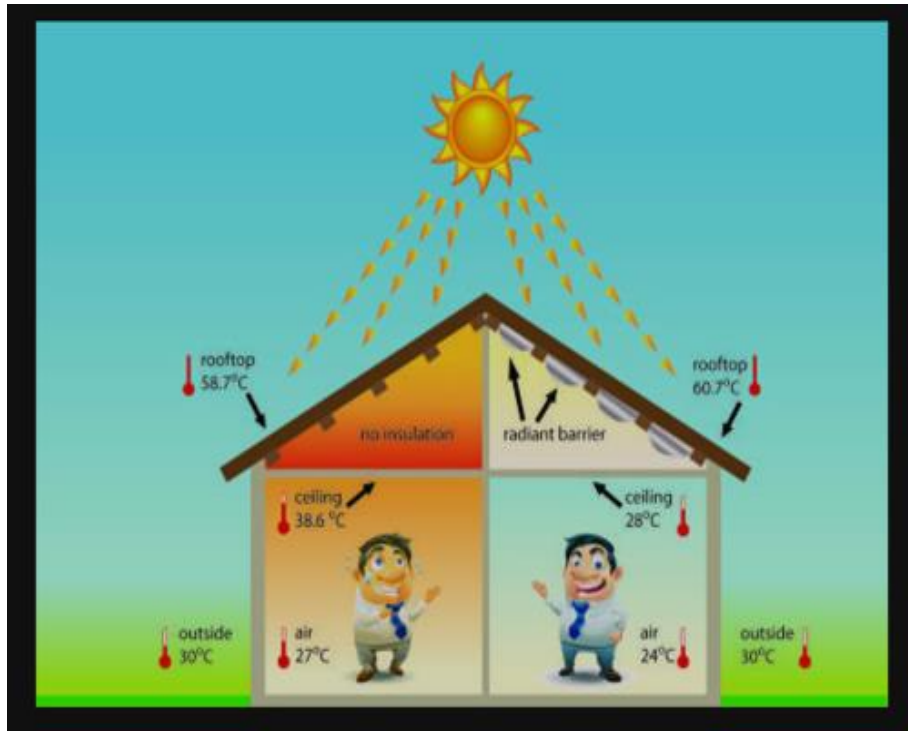
Natural ventilation takes advantage of the differences in air pressure between warm air and cool air, as well as convection currents, to remove warm air from an indoor space and allow fresh cooler air in.

This also has the added advantage of cooling the walls and roofs of the buildings that hold significant thermal mass, further enhancing the thermal comfort of the occupants

NATURAL VENTILATION	
With Breeze Air	Works Best
Absence of natural breeze	Fans can be used to improve the flow of cool air
Natural ventilation promotes the occupants' adaptation to external temperature, called adaptive thermal comfort	

Even in hot-dry and warm-humid climate zones where some air-conditioning may be required during peak Thermal Comfort for All summer, buildings can be designed to operate in a mixed mode to enable **night ventilation** and **natural ventilation** during cooler seasons

Insulation

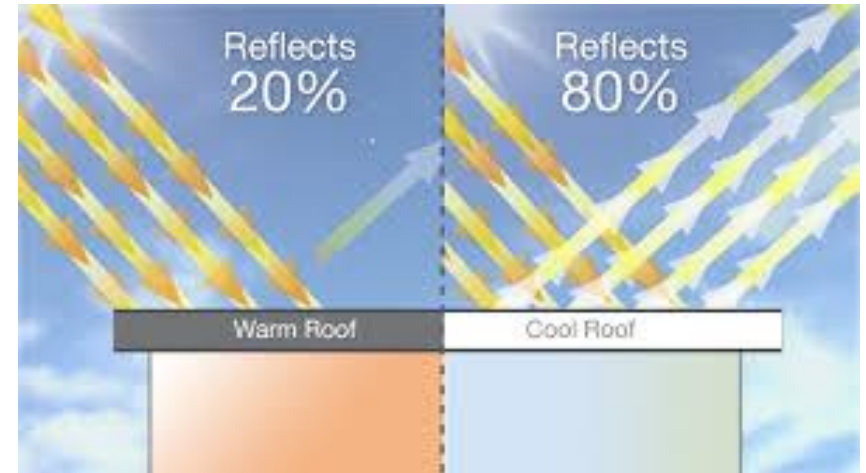


An insulating material can resist heat transfer due to its low thermal conductivity. Insulating walls and the roof can reduce cooling energy loads by up to 8%

Cool Roofs

Cool roofs are one of the passive design options for reducing cooling loads in buildings. Cool roofs reflect most of the sunlight (about 80% on a clear day)

When sunlight is incident on a dark roof	When Sunlight is incident on a cool roof
38% heats the atmosphere	10% heats the environment
52% heats the city air	8% heats the city air
5% is reflected	80% is reflected
	1.5% heats the building



Cool Roofs

In the summer, a typical cool roof surface temperature keeps 25-35°C cooler than a conventional roof, lowering the internal air temperature by roughly 3-5°C and improving the thermal performance.

The comfort of the inhabitants is improved, and the roof's lifespan is extended.

Cool roofs increase the durability of the roof itself by reducing thermal expansion and contraction.

Apart from helping enhance the thermal comfort in the top floor and helping reduce air-conditioning load, cool or white roof or pavements also offer significant reduction in urban heat island effect



The cities of Jodhpur and Jaipur is the extremely hot state of Rajasthan, where most of the city homes are painted in light blue and light pink colours, are examples of practical application of this age-old traditional design style.

Green Roofs

A green roof is a roof of a building that is partially or completely covered with vegetation

GREEN ROOFS PURPOSE

Absorbing Rain Water

Providing Insulation

Helping lower urban air temperatures

Mitigating the urban heat island effect



Green Roofs

Reduction in Energy use is an important feature of Green Roofing

GREEN ROOFS IN BUILDINGS ALLOWS

During cooler Winter Months

Retain their heat

During hotter Summer Months

Reflecting and absorbing solar radiations

Thermal Comfort in Affordable Housing

70% of the buildings needed in India by 2030 have yet to be constructed. Maintaining the status quo is pointless, and there is a huge opportunity to properly incorporate passive design strategies across our built environment.

Passive solutions for thermal comfort in buildings can greatly reduce cooling, ventilation, and lighting requirements

Less reliance on mechanical cooling/heating approaches reduces the generation of surface ozone, resulting in better air quality

Building techniques that are more sensitive will tend to reduce disparities in thermal comfort between different income classes as more people become aware of the benefits of sustainable building design.

Thermal Comfort in Affordable Housing

Impact of Thermally Comfortable Affordable Housing

Thermal comfort in housing is one of the key pillars to achieve India's National Cooling Action Plan target of reducing cooling energy need by 20-40 per cent by 2037-38.

Overview of affordable housing sector

80 million households in India are estimated to be living in slums

20 million current housing shortage in Urban areas

40 million current housing shortage in Rural areas

70% housing shortage in Rural areas is mainly in affordable segment

Thermal comfort housing can have numerous positive impacts

Lower operational costs for the economically weaker sections

Broader market & outreach for the sustainable material & technology market

Social benefits rising from better comfort conditions like boost in academic performance of kids, improvement in quality of life of the women

Boost to meet the targets of Paris Agreement & achievement of sustainable development goal specially number 3, 11 & 13

Better health and well being of the occupants

Passive Strategies & Building Physics

Passive Measures

Climatic Zone Level

Temperature, rainfall, wind direction, sun radiation, humidity, and other environmental factors are taken into consideration when designing.

Site Level

To take advantage of the positive aspects of the site and its microclimatic features while minimising the negative aspects.

Level of Response

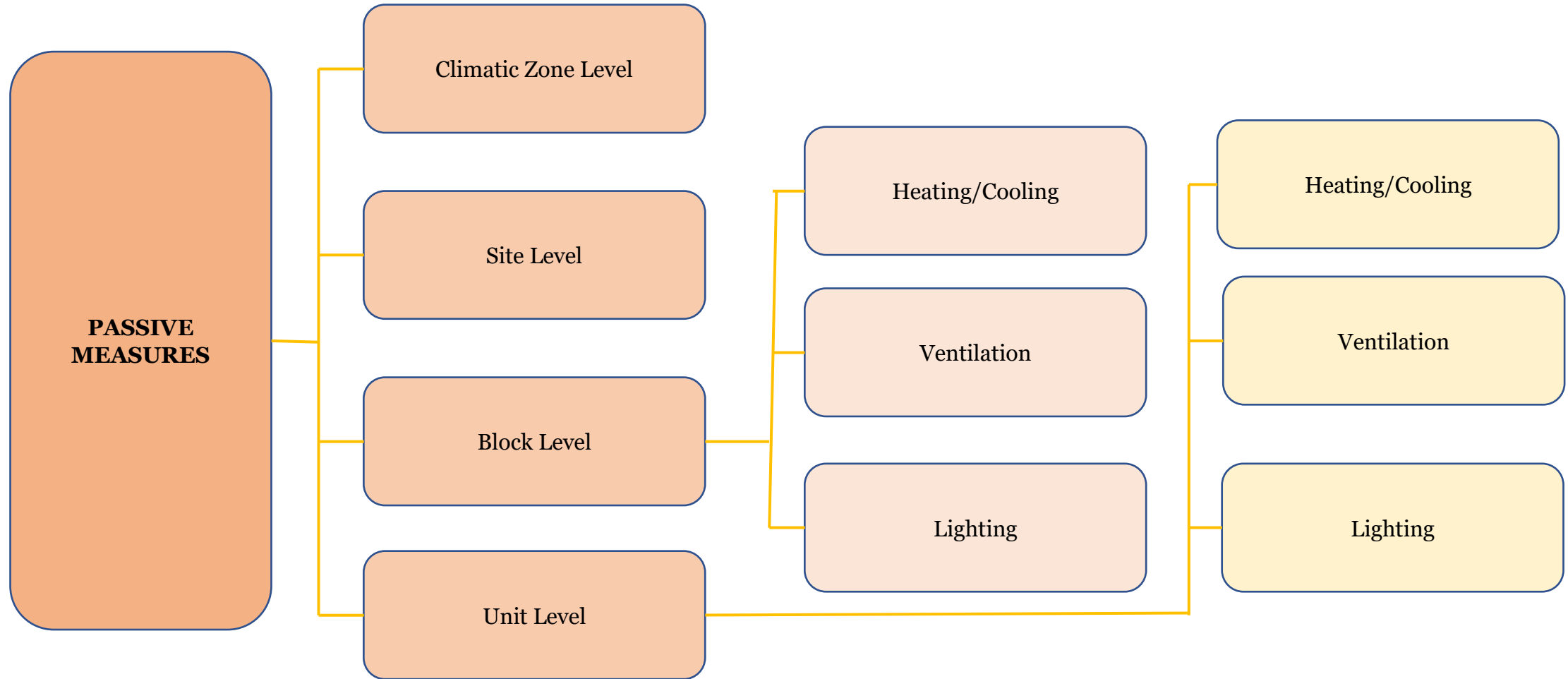
Block Level

Interaction of the block with its surroundings and plants to ensure that it has adequate heating, ventilation, and lighting.

Unit Level

Design solutions that influence heat, light, and ventilation based on climatic variables at the unit level.

Passive Strategies & Building Physics



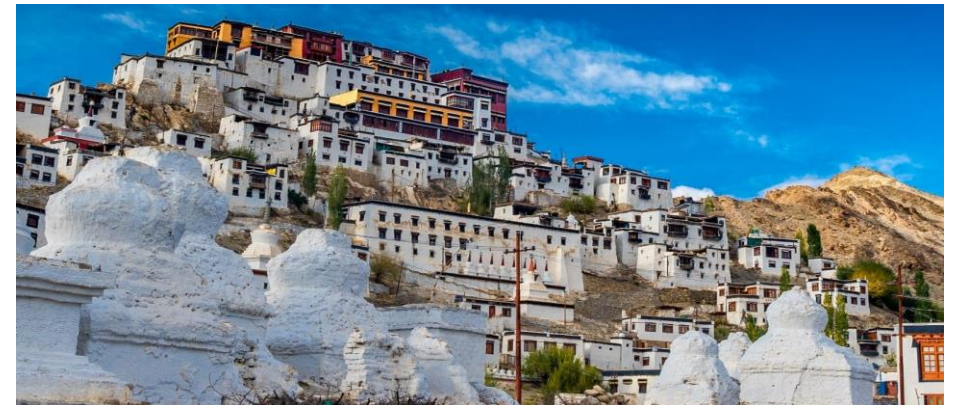
Passive Strategies & Building Physics

Passive Measures – Climatic Zone Level

Vernacular / traditional architectural typologies that respond to the region's distinct environment are best exemplified.

Example

- In Ladakh, earth architecture with thick walls and limited windows provides optimal insulation.
- In Rajasthan, courtyard havelis take advantage of pressure differences and reciprocal shading to provide natural cooling and ventilation.
- In Kerala, sloping roofs are used to guard against severe rains.



Passive Strategies & Building Physics

Passive Measures – Site Level

Reducing the 'heat island' effect with approaches like:

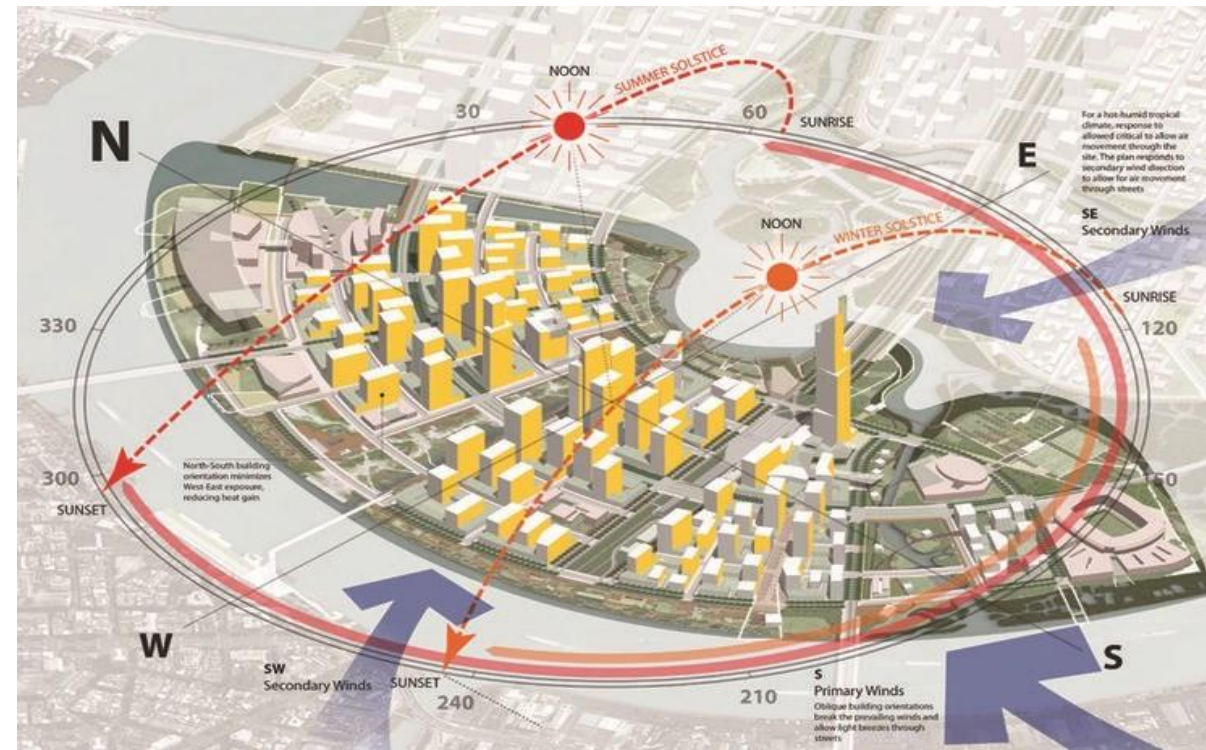
Courtyards / open courts are often surrounded by construction.

Taking advantage of block mutual shading

Using site massing to create wind passageways

lowering the amount of hard paving to allow for water absorption

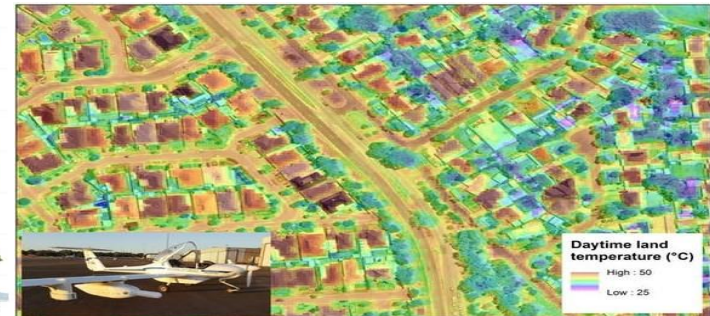
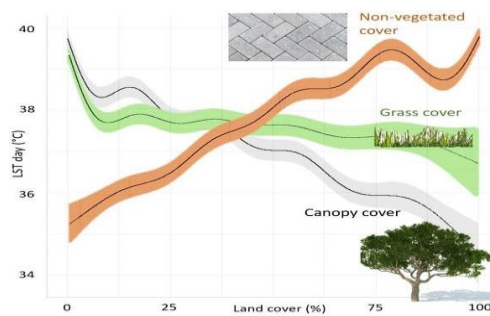
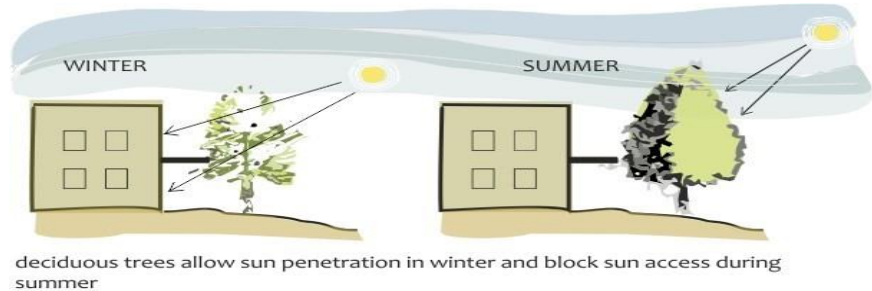
Using complementary vegetation to manage the amount of sunlight that gets through as the seasons change



Passive Strategies & Building Physics

Passive Measures – Leveraging Plantation

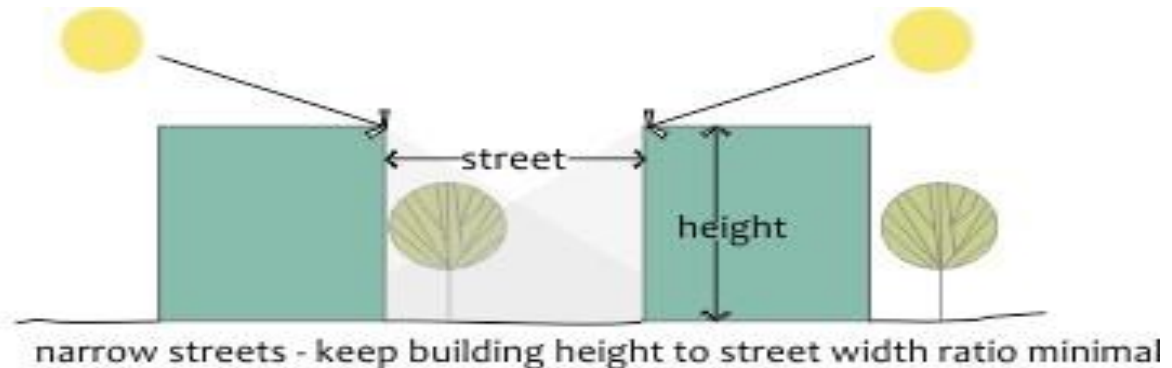
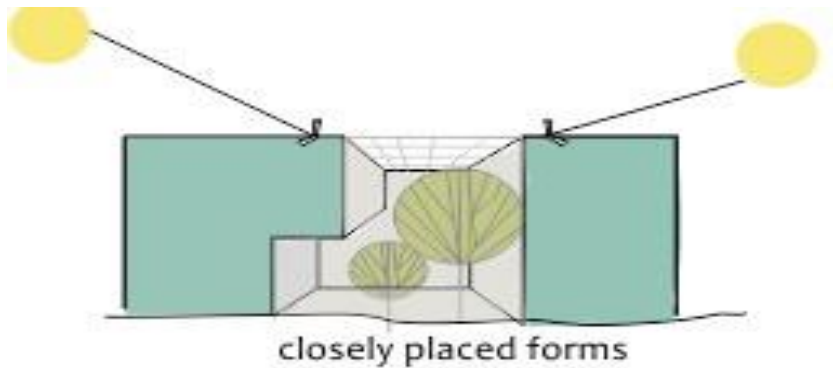
Planting trees in the right places to provide shade and ventilation can significantly reduce the severity of intense weather. During heatwaves in Adelaide, a research found that districts with more vegetation cover remained cooler by up to 6°C.



Passive Strategies & Building Physics

Block Level

Arrange the blocks so that mutual shade is obtained, avoiding solar heat buildup throughout the summer.



HEATING/
COOLING

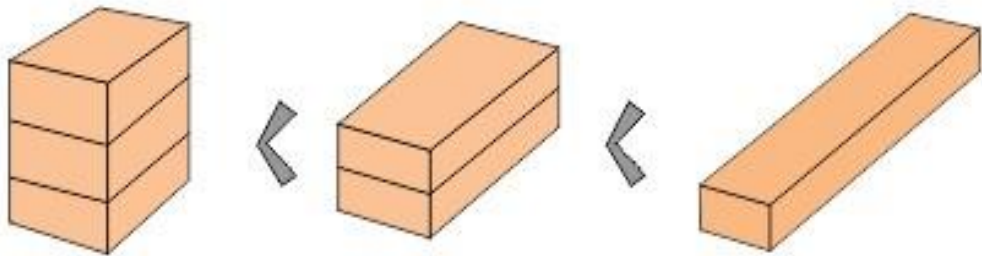


Passive Strategies & Building Physics

Block Level

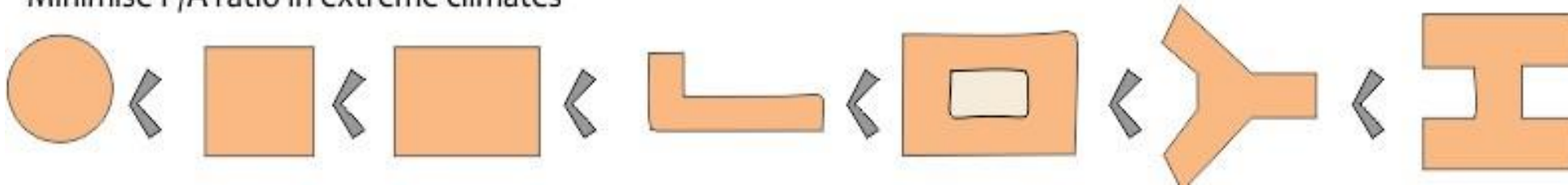
In harsh climate zones, reduce the surface area to building volume and perimeter to area ratios to reduce solar radiation exposure.

Minimise S/V ratio in extreme climates



increase compactness by reducing surface area for the same volume

Minimise P/A ratio in extreme climates

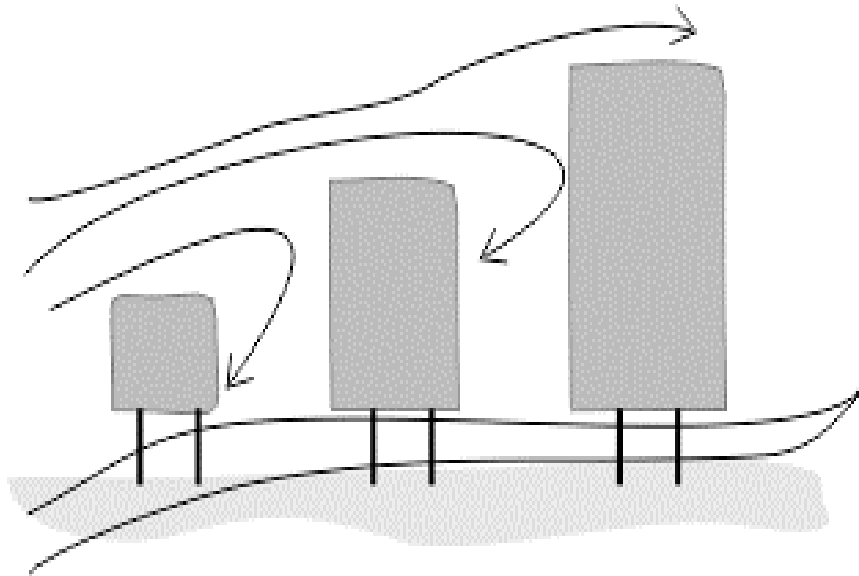


**HEATING/
COOLING**

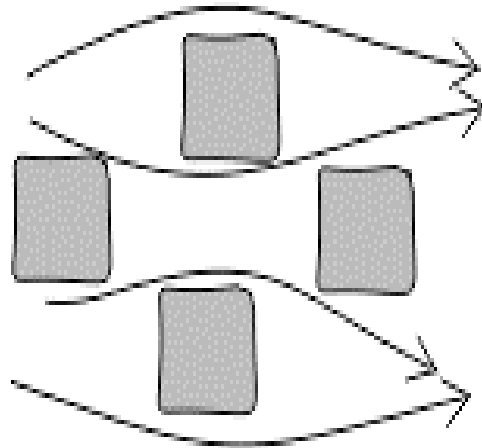
Passive Strategies & Building Physics

Block Level

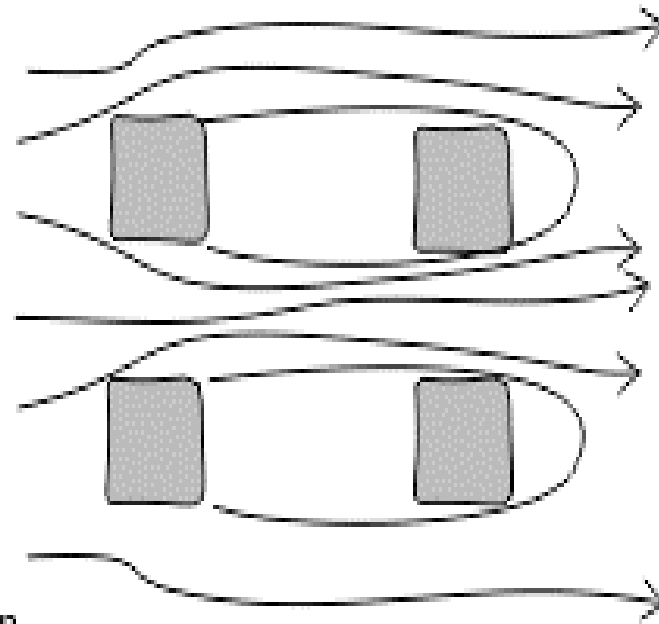
Wind shadows should be avoided by building orientation.



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



staggered layout helps in accentuating wind movement

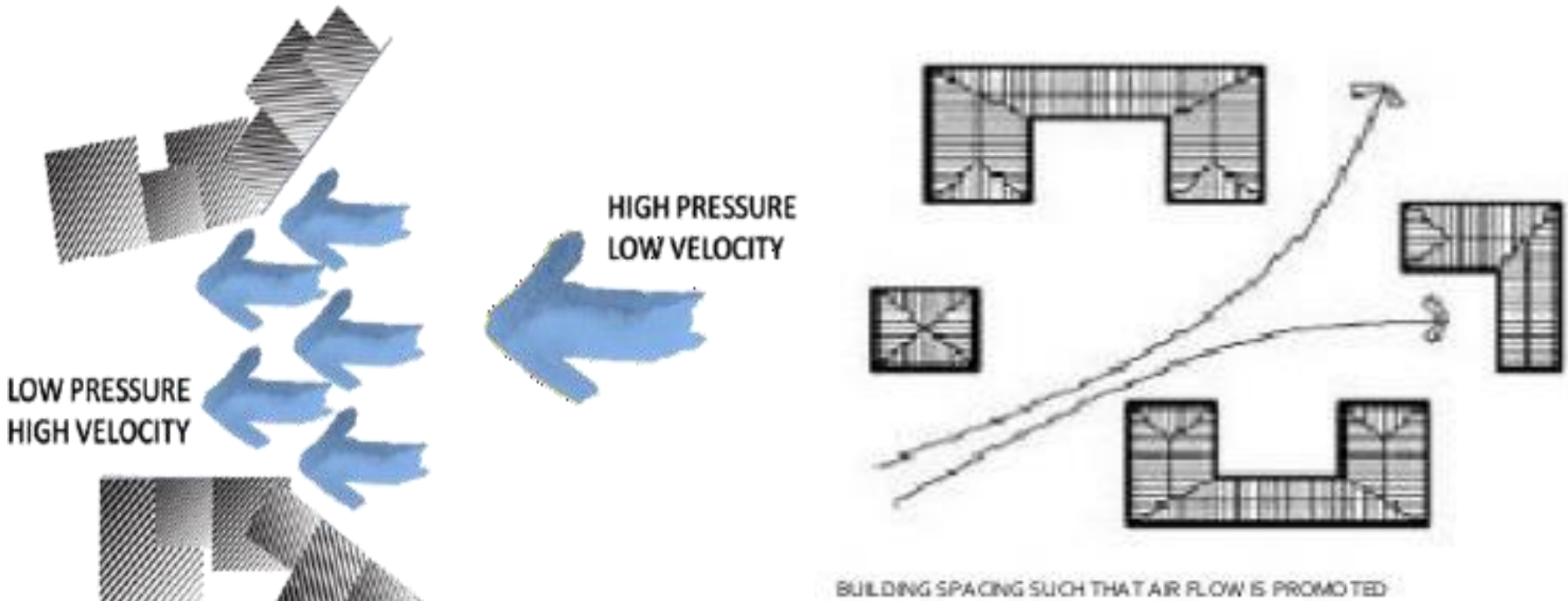


VENTILATION

Passive Strategies & Building Physics

Block Level

Wind flows can be harvested by constructing courts and catchment zones of various sizes. This can help to improve airflow and provide a cooling effect for the blocks.



Passive Strategies & Building Physics

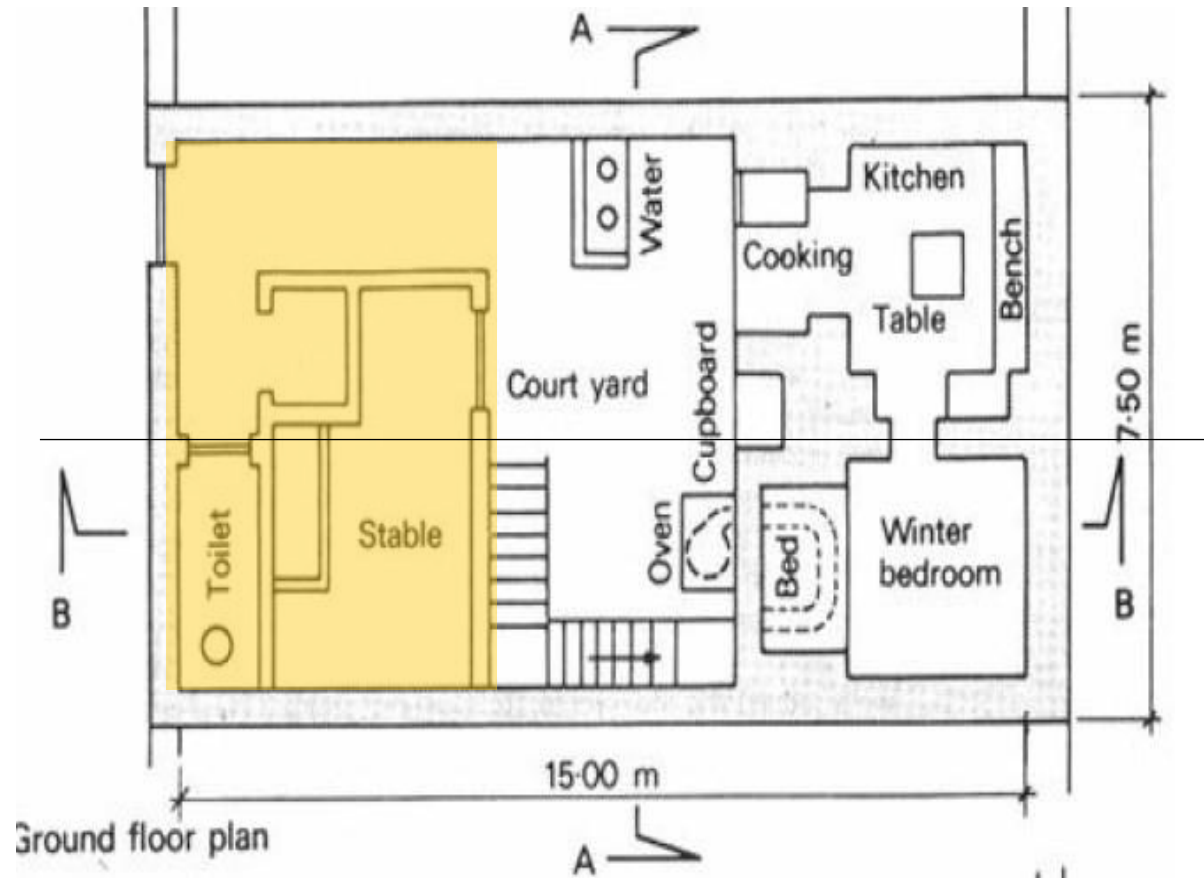
Unit Level

FORMS AND ORIENTATION:

Sun radiation penetration patterns and, as a result, heat uptake and loss in a building are affected by changes in solar route during different seasons.

Internal layout is of the courtyard type, which is rather compact. Reduced sun exposure on East-West external walls to reduce heat gain.

If planned and situated on the east and, especially, the west end of the structure, non-habitable rooms (stores, bathrooms, etc.) can be efficient thermal barriers.



**HEATING/
COOLING**

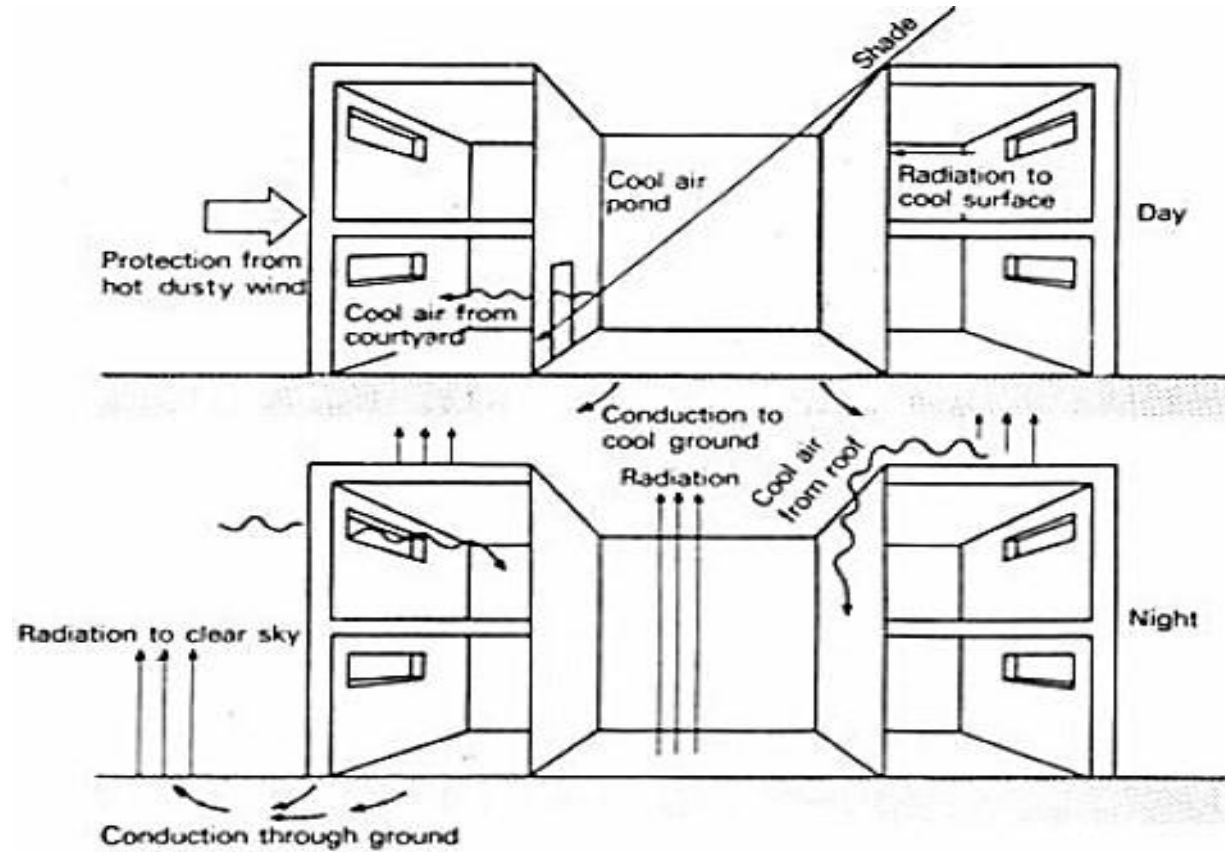
Passive Strategies & Building Physics

Unit Level

FORMS AND ORIENTATION:

High walls block the sun, resulting in significant portions of the inner surfaces and courtyard floor being shaded during the day.

The dirt beneath the courtyard will extract heat from the surrounding places and remit it to the open sky during the night, resulting in cooler air and surfaces.



HEATING/
COOLING

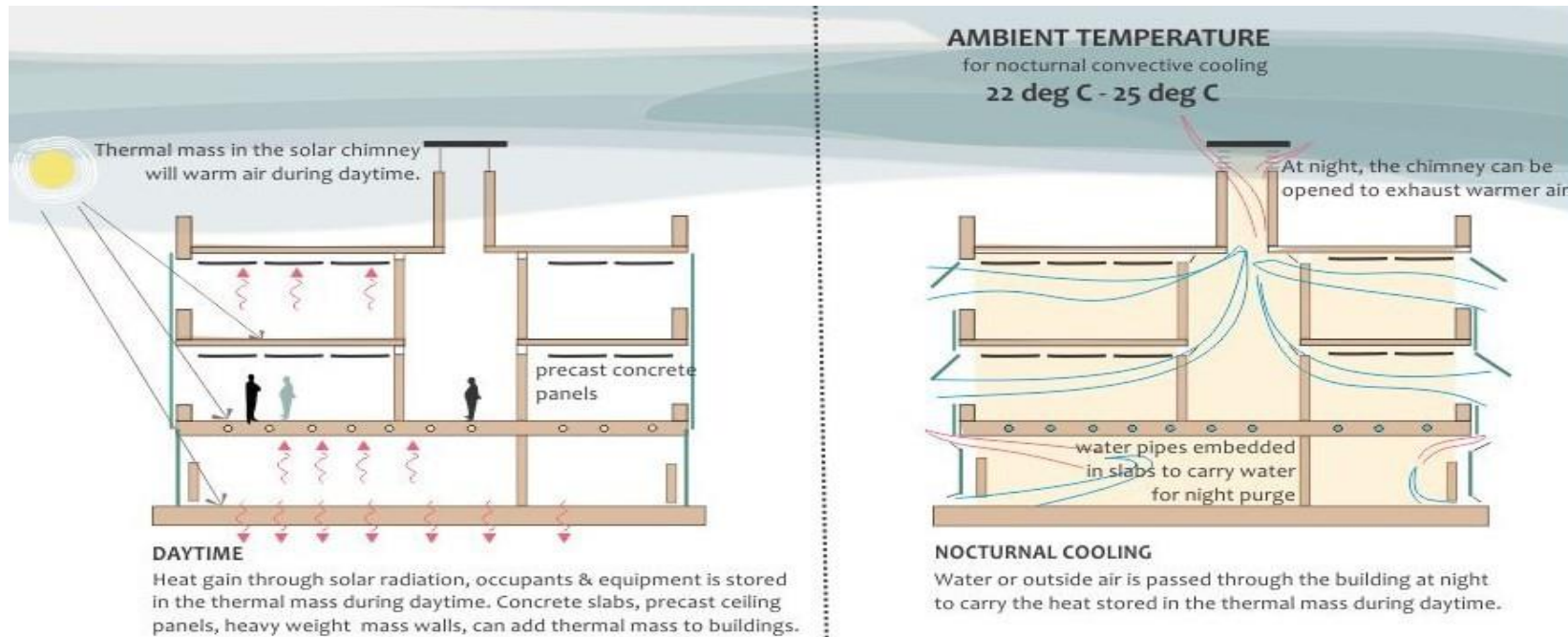
Passive Strategies & Building Physics

Unit Level

THERMAL MASS:

Thermal mass can be combined with night-time convective cooling, sometimes known as "night cooling," to passively cool buildings.

Thermal mass as a passive cooling and heating approach requires a large diurnal swing.



HEATING/
COOLING

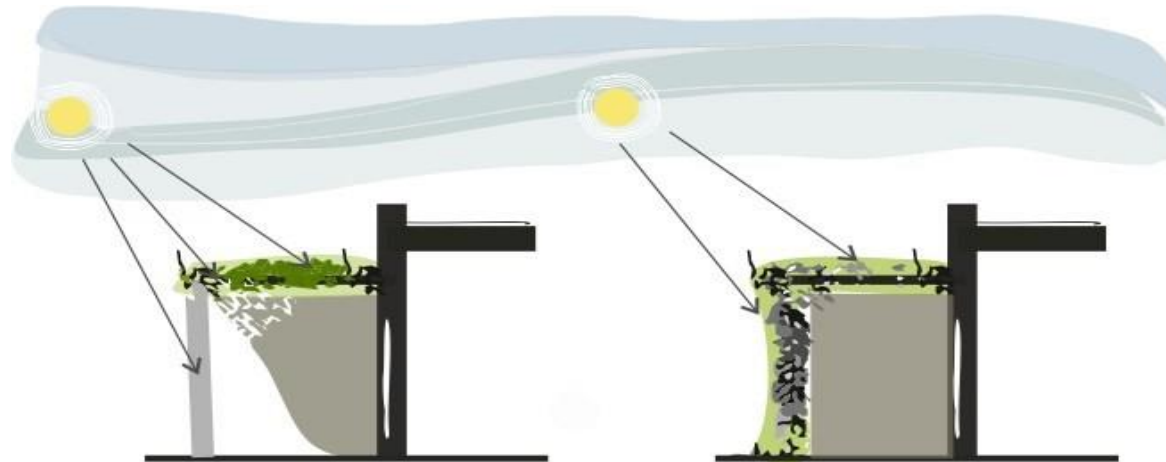
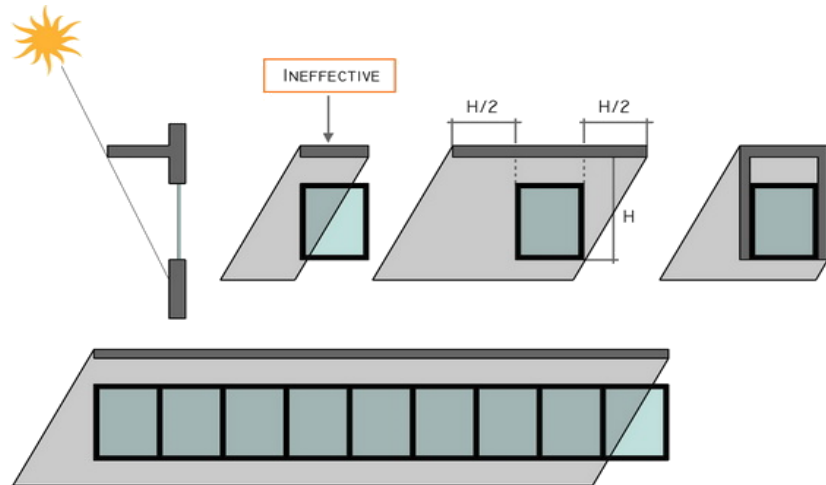
Passive Strategies & Building Physics

Unit Level

SHADING:

Shade-producing plants, such as creepers, can be used.

Fenestrations and shades/chajjas can be built to maximise solar radiation depending on the environment.



HEATING/
COOLING

Passive Strategies & Building Physics

Unit Level

ORIENTATION:

Buildings can be orientated in relation to the prevailing wind direction at angles ranging from 0° to 30° .

In buildings with a courtyard, positioning the courtyard 45 degrees from the prevailing wind maximises wind flow into the courtyard and improves cross ventilation in the building (in climates where cooling is required).

CREATING PRESSURE DIFFERENCES:

A 'squeeze point' occurs when wind enters through a smaller opening and escapes through a larger opening. This generates a natural vacuum, which speeds up the wind.

The total area of apertures should be at least 30% of the total floor space.

The window-to-wall-ratio (WWR) should not exceed 60%.

VENTILATION

CASE STUDIES

INFOSYS – POCHARAM CAMPUS

LOCATION	HYDERABAD, TELANGANA
COORDINATES	17° N, 78° E
OCCUPANCY TYPE	OFFICE
TYPOLOGY	NEW CONSTRUCTION
CLIMATE TYPE	HOT AND DRY
PROJECT AREA	27,870 m ²



Given the high-standards in terms of building design achieved at the SDB1 in Hyderabad, it has now been showcased in the 'Best Practices Guide for High Performance Indian Office Buildings' by Lawrence Berkeley National Lab, a U.S. Department of Energy (DoE) National Laboratory.

- The Indian Green Building Council (IGBC) has given Infosys, a worldwide consulting and technology firm, the LEED (Leadership in Energy and Environmental Design) India 'Platinum' designation for its Software Development Block 1 (SDB 1) at its Pocharam site in Hyderabad, India.
- The SDB 1 is the first commercial building in India to deploy unique Radiant-cooling technology, setting new norms for energy efficiency in building systems design.

It has been built keeping in mind a holistic approach to sustainability in five key areas

SUSTAINABLE SITE
DEVELOPMENT

WATER
SAVINGS

ENERGY
EFFICIENCY

MATERIALS
SELECTION

INDOOR
ENVIRONMEN
T QUALITY

EPI –
75kWh/m²/yr

GODREJ PLANT 13 ANNEXE

LOCATION	MUMBAI, MAHARASHTRA
COORDINATES	19° N, 73° E
OCCUPANCY TYPE	OFFICE – PRIVATE
TPOLOGY	NEW CONSTRUCTION
CLIMATE TYPE	WARM AND HUMID
PROJECT AREA	24,443 m ²



GODREJ PLANT 13 ANNEXE

The Plant 13 Annexe Building at Godrej & Boyce (G&B) in Mumbai has been designated as India's first CII-IGBC accredited Net Zero Energy Building. The structure is a mixed-use office/convention center (with office spaces, conference and meeting rooms, auditoriums (90 to 250 seats), banquet hall, 300-person eating facilities, and an industrial kitchen), making certification extremely difficult.

In 2015, the building received an IGBC Platinum grade in the EB (Existing Building) category, which was recertified in 2019. In 2016, it was also awarded the BEE 5 Star Rating. In 2019, he received the 'Energy Performance Award' for meticulous energy measuring and monitoring. At the CII National Energy Management Award event in 2020, it was named "Excellent Energy Efficient Unit."

**EPI –
75kWh/m²/yr**

INDIRA PARYAVARAN BHAWAN, MoEF

LOCATION	NEW DELHI
COORDINATES	29° N, 77° E
OCCUPANCY TYPE	OFFICE & EDUCATIONAL
TYPOLOGY	NEW CONSTRUCTION
CLIMATE TYPE	COMPOSITE
PROJECT AREA	9565 m ²



The Indira Paryavaran Bhawan is now India's most environmentally friendly structure. GRIHA 5 Star and LEED Platinum certifications were awarded to the project. The structure has already received accolades, including the MNRE's Adarsh/GRIHA Award for Outstanding Integration of Renewable Energy Technologies.

The new office building for the Ministry of Environment and Forest (MoEF), Indira Paryavaran Bhawan, is a significant departure from traditional architectural design

To reach net zero criterion, several energy saving measures were implemented to lower the building's energy loads, with the residual demand being satisfied by producing energy from on-site installed high efficiency solar panels.

The project team focused on measures for lowering energy demand, such as ample natural light, shade, landscape to reduce ambient temperature, and energy-efficient active building technologies

When compared to a conventional building, Indira Paryavaran Bhawan utilizes 70% less energy. The project used green building principles, such as water conservation and optimization through site waste water recycling.

EPI –
44kWh/m²/yr

Renewable Energy Integration 930 kW PV panels with a total area of 4650m² for on-site generation, tilted at 23° facing south to generate equivalent to 70kWh/m²/yr

JAQUAR HEADQUARTERS

LOCATION	MANESAR HARYANA
COORDINATES	28° N, 77° E
OCCUPANCY TYPE	CORPORATE AND MANUFACTURING
TPOLOGY	NEW CONSTRUCTION
CLIMATE TYPE	COMPOSITE
PROJECT AREA	48000 m ²



JAQUAR HEADQUARTERS

The building is a perfect blend of modern design sensibilities, biophilic inspiration, and a brand ambition of soaring high.

The Jaguar Headquarters in Manesar is not only a stunning structure, but also a painstakingly constructed complex with cutting-edge technology that has resulted in a net zero campus with a LEED Platinum (USGBC) rating. This project is known for its complex organic design and space arrangement, making it a visual pleasure.

Through its characteristic wing-shaped architecture, the design redefines a business workplace by giving it a memorable experience. The spreading wings of a symbolic eagle, poised to take flight, are atop the horizontal glass edifice, suggesting a firm with worldwide ambitions.

ST. ANDREWS BOYS HOSTEL BLOCK, GURUGRAM

LOCATION	GURUGRAM HARYANA
COORDINATES	28° N, 76° E
OCCUPANCY TYPE	HOSTEL
TYOLOGY	NEW CONSTRUCTION
CLIMATE TYPE	HOT AND DRY
PROJECT AREA	5574 m ²



ST. ANDREWS BOYS HOSTEL BLOCK, GURUGRAM

The goal of the design process was to increase student interaction within the indoor areas, which then spilled outdoors and interacted with the surrounding landscape.

On the south and north facades, the linear block was twisted to create a shaded entry (summer court) and an open terrace (winter court), respectively, to stimulate activities at all times of the day and season. The ramp serves as a buffer between the hot outdoors and the cooler interior, preventing kids from experiencing heat shock.

ST. ANDREWS GIRLS HOSTEL BLOCK, GURUGRAM

LOCATION

GURUGRAM HARYANA

COORDINATES

28° N, 76° E

OCCUPANCY TYPE

HOSTEL

TPOLOGY

NEW CONSTRUCTION

CLIMATE TYPE

HOT AND DRY

PROJECT AREA

2322 m²



ST. ANDREWS GIRLS HOSTEL BLOCK, GURUGRAM

Indoor and outdoor spaces that connect physically and aesthetically at different levels to encourage interactions and social activities are incorporated into the building's plan.

The entrance foyer and lobby were planned as outdoor spaces facing west and connected to the pantry so that students can enjoy their nights outside with a spill-out into the green landscape.

AKSHAY URJA BHAWAN HAREDA

LOCATION

PANCHKULA HARYANA

COORDINATES

30° N, 76° E

OCCUPANCY TYPE

OFFICE - PUBLIC

TPOLOGY

NEW CONSTRUCTION

CLIMATE TYPE

COMPOSITE

PROJECT AREA

5100 m²



AKSHAY URJA BHAWAN HAREDA

Mechanical air conditioning is used to guarantee thermal comfort in apical zones at all times.

Zones are created based on the intended temperature set points. 25.1 °C for apex offices, 25.3 °C for regulated office and public areas, and 25.5 °C for passive zones.

In the summer, controlled zones are cooled, and in the monsoon, they are chilled. In the summer, passive zones are cooled, while in the monsoon, they are aired. The centre atrium has a mist system for cooling the controlled and passive zones. Water that has been chilled to a temperature of 15°C.

SUN CARRIER OMEGA

LOCATION

BHOPAL M.P.

COORDINATES

23° N, 77° E

OCCUPANCY TYPE

OFFICE – PRIVATE

TPOLOGY

NEW CONSTRUCTION

CLIMATE TYPE

HOT AND DRY

PROJECT AREA

9888 ft²



GRIDCO BHUBANESWAR

LOCATION

BHUBANESWAR.

COORDINATES

20° N, 85° E

OCCUPANCY TYPE

OFFICE

TYOLOGY

NEW CONSTRUCTION

CLIMATE TYPE

WARM AND HUMID

PROJECT AREA

15,793.5 m²



GRIDCO BHUBANESWAR

The structure was created using computer simulation to determine how long direct sunshine or radiation was tolerable for human habitat based on the sun-path of Bhubaneswar.

The structure encourages natural light and screen radiation. It would feature photovoltaic glass panels and geothermal cooling systems strategically placed, as well as indigenous solar producing technologies, to ensure that it is self-sustaining.

Rainwater can be collected, purified, and utilised as drinkable water. Grey water that has been treated can be reused for flushing and landscape irrigation.

Live Exercise

DAY 1

Lunch Break

DAY 1

Session 2



02-A

THERMAL COMFORT STANDARDS

Thermal Comfort Standards



ASHRAE - 55



National Building Code - 2016



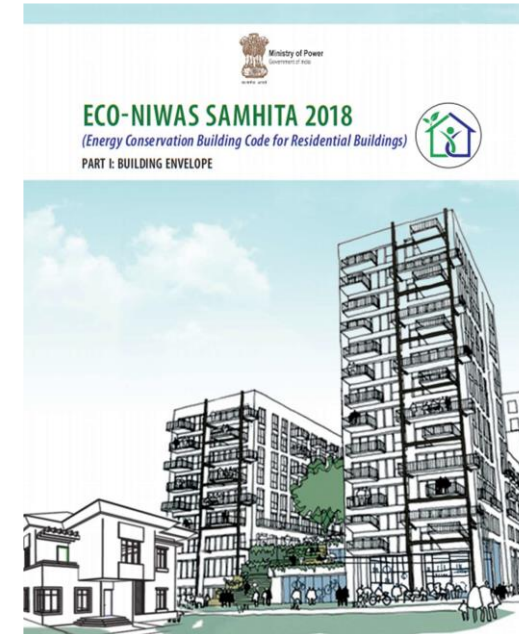
Handbook of Functional Requirements of Buildings
1987 by BIS



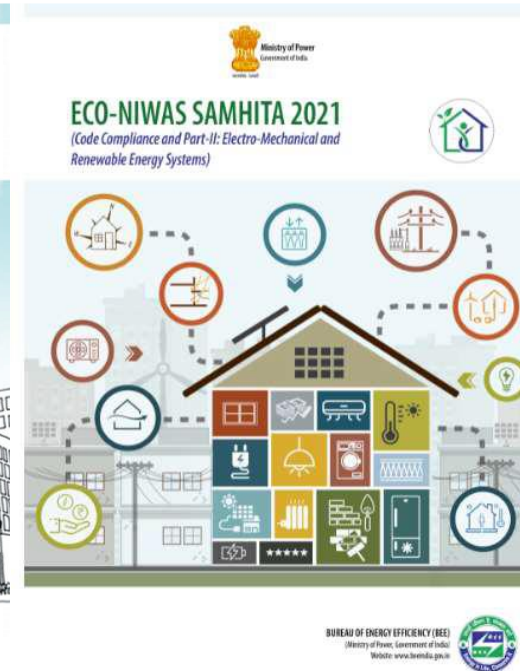
Eco Niwas Samhita Part 1 and Part 2



ISHRAE – Indoor Environmental Quality Standards
2018-19



EcoNiwas Samhita 2018
Part 1: Building Envelope



EcoNiwas Samhita 2021
Code Compliance and Part 2

ASHRAE 55

Meeting the standards for Thermal Comfort

ASHRAE standard 55, Thermal Environmental condition for Human Occupancy

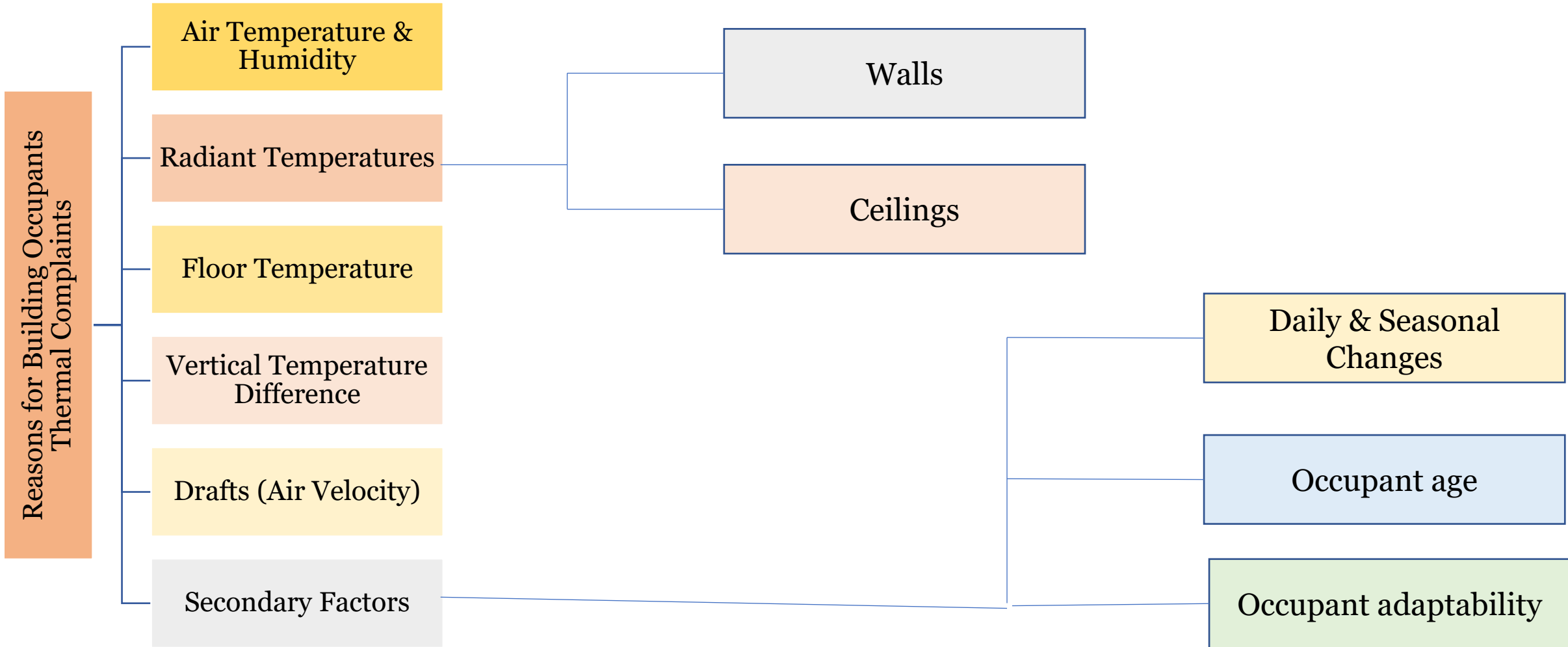
ISO 7726:1998

Ergonomics of the Thermal Environment – Instruments for measuring Physical quantities

ISO 7730:1994

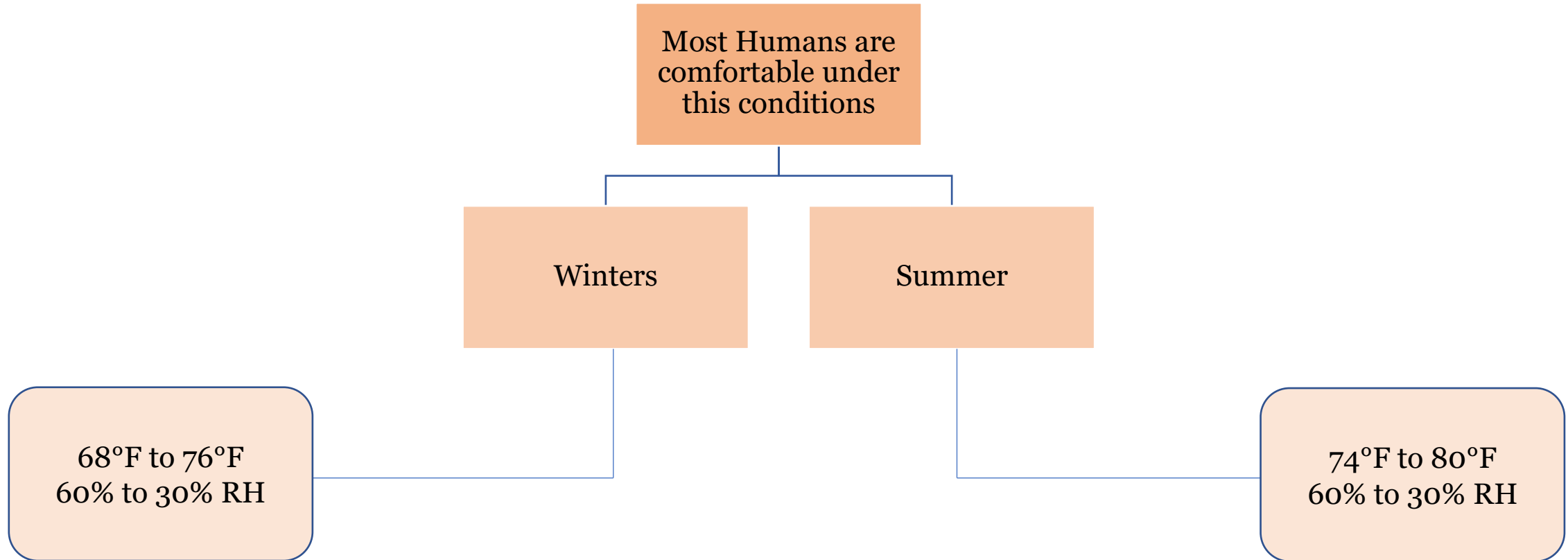
Moderate Thermal Environments – Determination of the PMV and PPD Indices and specification of the conditions for Thermal Comfort

ASHRAE 55



ASHRAE 55

Human Comfort Range



Body Regularity Mechanism

The Thermal balance of the body can be shown by following equation, if the heat gain and lost factors are

	Met = Metabolism (basel and muscular)
Gain	Cnd = Conduction (contact with warm bodies)
	Cnv = Convection (if the air is warmer than skin)
	Red -= Radiation (from the sun, the sky and hot bodies)
Loss	Cnd = Conduction (contact with cold bodies)
	Cnv = Convection (if the air is cooler than the skin)
	Red = Radiation (to night sky and cold surface)
	Evp = Evaporation (of moisture and sweat)

Then Thermal Balance exist when:

$$\text{Met} - \text{Evp} + \text{Cnd} + \text{Cnv} + \text{Red} = 0$$

Body Thermal Balance

The body generates heat on a constant basis. The majority of the metabolic processes involved, such as tissue formation, energy conversion, and muscular effort, are all exothermic. Food ingestion and digestion provide the energy required, and metabolism refers to the process of converting food into living matter and usable energy.

METABOLIC HEAT PRODUCTION

**BASEL
METABOLISM**

Heat Production of Vegetative, automatic
process

**MUSCULAR
METABOLISM**

Heat Production due to consciously controlled
work

Body Thermal Balance

- Only 20% of the heat generated in the body is used, thus any excess heat must be evacuated.
- The mechanism by which the human body maintains its core internal temperature is known as thermoregulation.
- Homeostasis is the state of having a constant internal temperature. All thermoregulation systems aim to bring the body back to a state of homeostasis.
- The temperature range for a healthy safe temperature is between 98.6° F (37°C) and 100° F (37.8°C). The temperature on your skin is between 31° and 34°.

HUMAN BODY RELEASES HEAT TO THE ENVIRONMENT BY

EVAPORATION

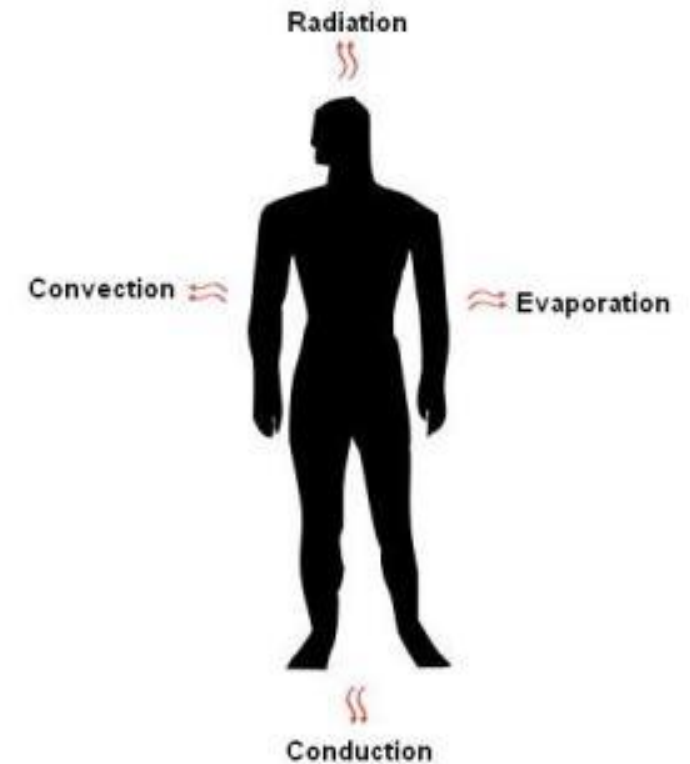
RADIATION

CONVECTION

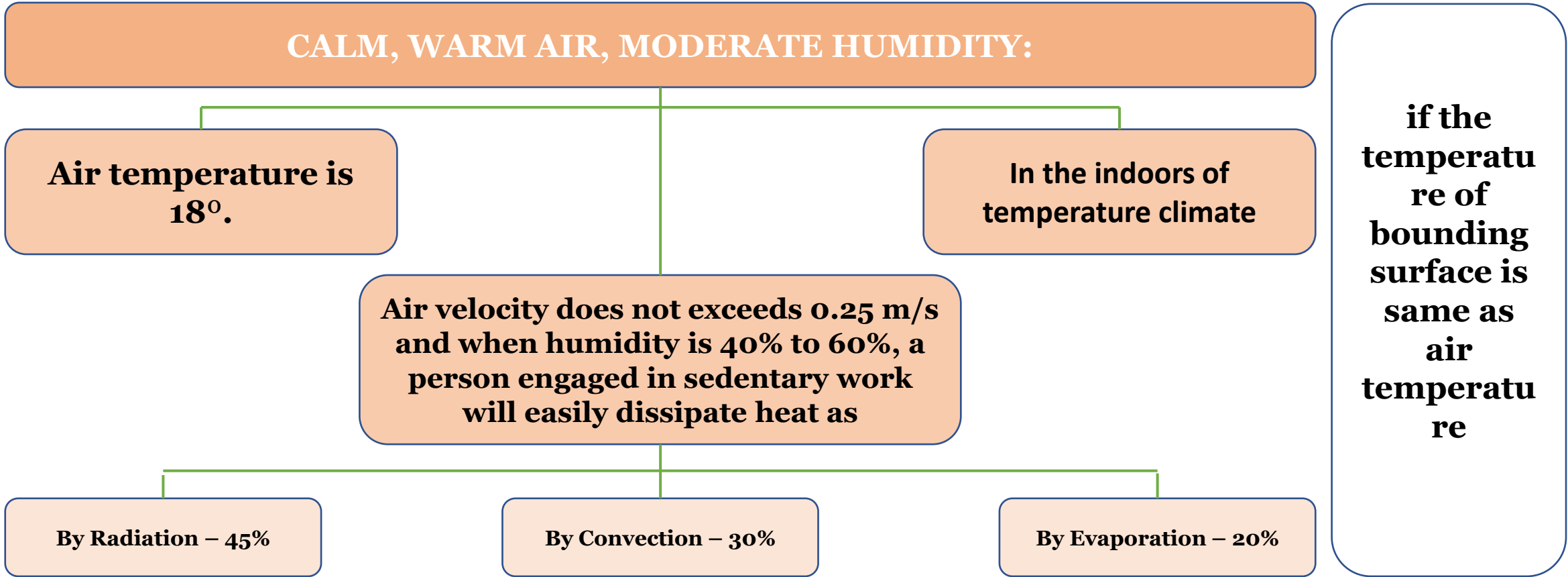
CONDUCTION

Body Thermal Balance – Heat Loss by Human Body

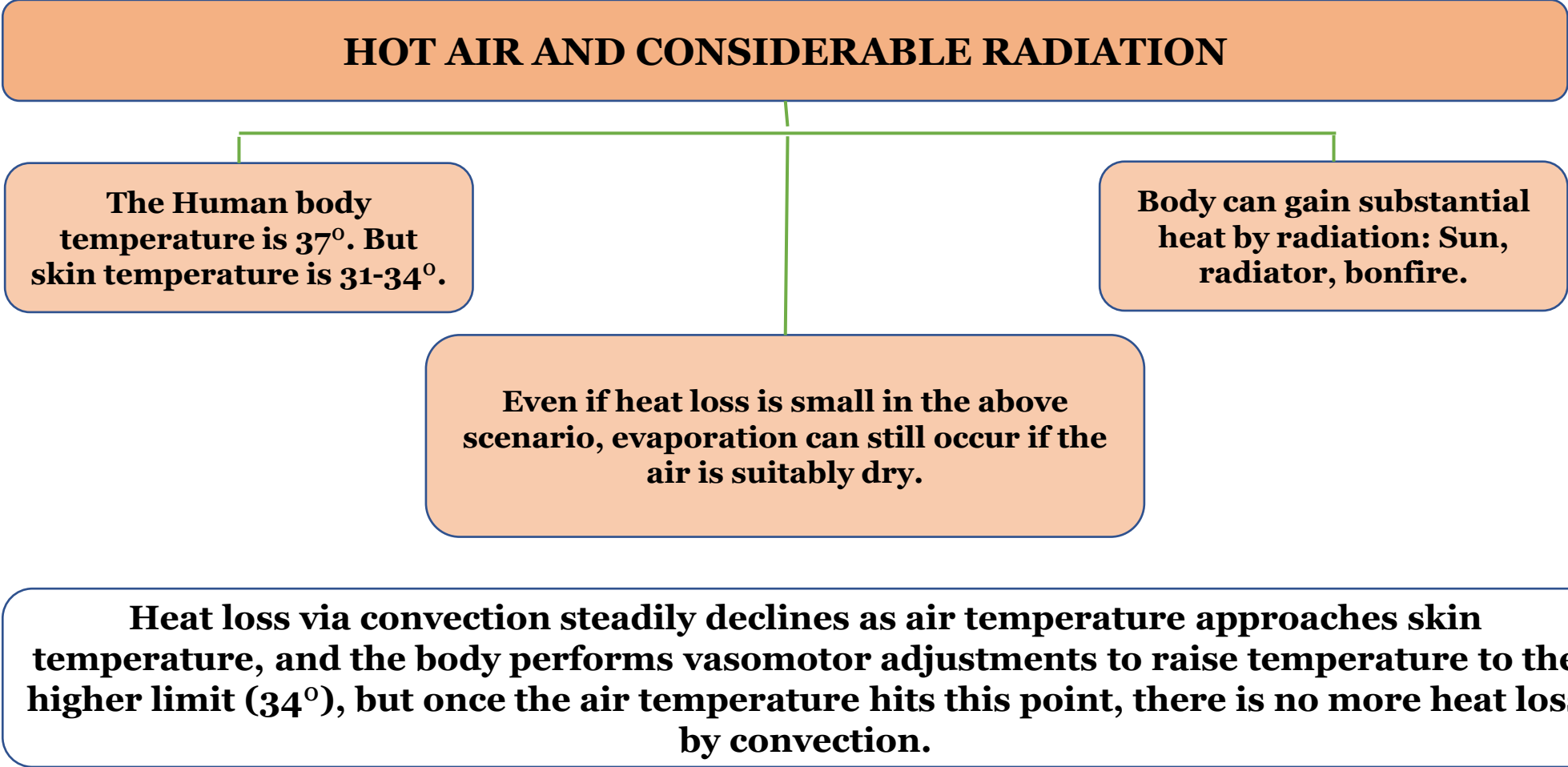
CONVECTION	<ul style="list-style-type: none"> • The heat from the body is transferred to the air in contact with the skin or clothing, which rises and is replaced by cooler air. • Faster air movement, lower temperature, and a higher skin temperature all enhance the rate of convective heat loss.
RADIATION	<ul style="list-style-type: none"> • The temperature of the body surface and the temperature of the opposing surface affects radiant heat loss.
CONDUCTION	<ul style="list-style-type: none"> • It is determined by the temperature difference between the body surface and the object with which the body is in direct touch.
EVAPORATION	<ul style="list-style-type: none"> • Is determined by evaporation rate, which is influenced by air humidity (the dryer the air, the faster the evaporation) and the amount of moisture available for evaporation. • Perspiration and sweating cause evaporation, as does breathing in the lungs.



Body Thermal Balance – Heat Loss in Various Thermal Environment



Body Thermal Balance – Heat Loss in Various Thermal Environment



Body Thermal Balance – Heat Loss in Various Thermal Environment

HOT AIR, RADIATION AND APPRECIABLE AIR MOVEMENT

When the air is hot (equal to or above skin temperature), the surrounding objects are hot (no heat loss by radiation), and when the air is humid (less than 100% RH), air movement will speed up evaporation, even though the air temperature is higher than skin temperature. Moving air constantly replaces saturated air in the surrounding area.

Inadequately planned houses can generate a lethal condition in which the air is entirely saturated, there is no air flow, and the air is warmer than the skin, resulting in heat stroke.

Body Thermal Balance – Heat Loss in Various Thermal Environment

SATURATED STILL AIR, ABOVE BODY TEMPERATURE

Air is hot (over 34°.)

Unappreciable air movement (≤ 0.25 m/s)

Humidity is near 100%

This leads to profuse sweating and no evaporation and body temperature begins to rise.

At 45°, death is unavoidable.

At 41°, coma sets in and death is imminent

A body temperature of 40° will cause heat stroke. (Failure in circulation system, followed by rapid increase in body temperature)

When the situation is adverse such as

Measurements of Thermal Comfort

- Developed in parallel with ASHRAE 55
- Evaluate and measure the moderate Thermal Environment
- Extreme Environments
 - ✓ ISO 7243:2017
 - ✓ ISO 7933: 2004
 - ✓ ISO/TR 11079:1993

BS EN ISO 7730

Ergonomics of the Thermal Environment – Analytical determination and interpretation of thermal comfort using calculation of the PMV and PPD indices and local Thermal comfort criteria

BS EN ISO 7726

Ergonomics of the Thermal Environment – Instruments for measuring Physical quantities

General Requirements & Standard Conditions of ASHRAE 55

The standards and conditions that must be completed in order to comply with ASHRAE 55 are defined in sections 4 and 5. The criterion must be applied to the specific space being evaluated, the inhabitants who will be inhabiting the area, locations within that space if not the entire space, and any outlier occupants, according to general requirements (i.e., children, disabled persons, elderly persons, etc.).

Because satisfying everyone in a given place is impossible owing to unknown differences, the mandatory requirements that must be met to comply with ASHRAE standard 55 exist in a range of values (physiologically and psychologically). As a result, ASHRAE 55 specifies a certain percentage of occupants as acceptable, as well as the thermal environment values associated with that number.

Compliance with ASHRAE Standard 55

The comfort zone is regarded sufficient if at least 80% of its occupants are unlikely to object to the ambient state, implying that the majority are between -0.5 and 0.5 on the PMV scale.

Design conditions must maintain the spatial conditions within the acceptable range using one of the methodologies outlined in section 5 of the standard for building systems to comply with ASHRAE, including

natural ventilation
systems

mechanical
ventilation systems

combinations of
these systems

control systems

thermal envelopes

They must also account for all expected conditions (summer and winter, although barring extremes), external and internal environmental elements, and any essential documents.

Needed Thermal Comfort Compliance Documentation

Except in the case of naturally ventilated areas, all of the following documentation is required to comply with ASHRAE:

1

The operative temperature, humidity, and total interior loads are all specified in the design.

2

The hours of each seasonal exceedance associated with the outdoor weather percent design conditions

3

The values assumed for comfort parameters (clothing insulation, metabolic rate, indoor airspeed, etc.) at the different assumed conditions (i.e., seasonal).

4

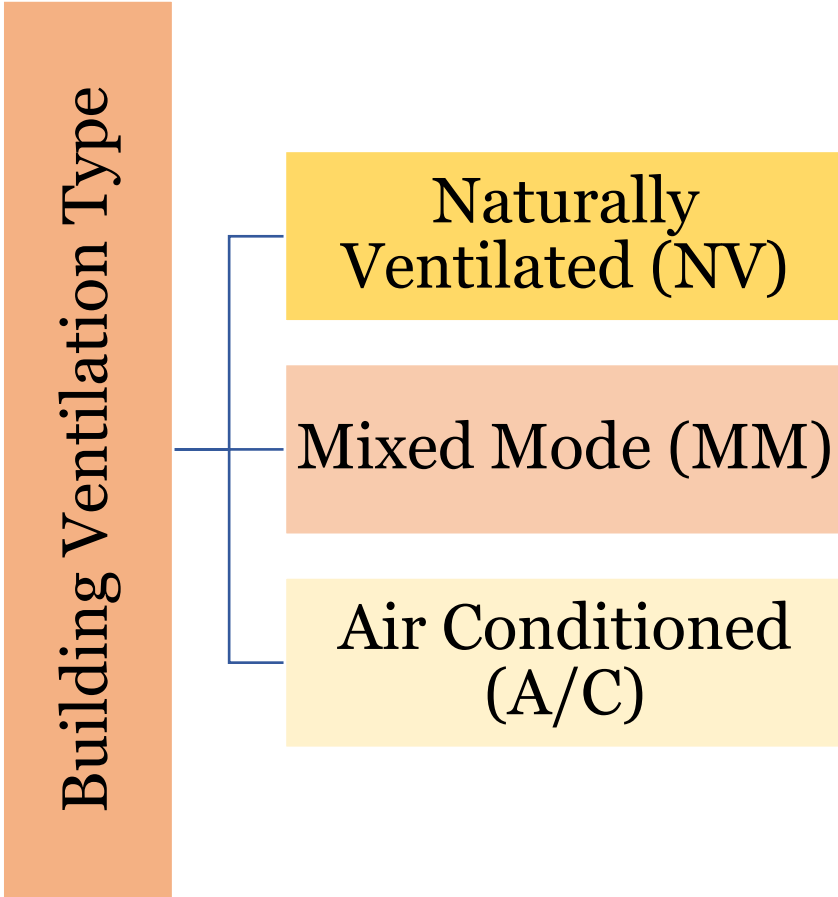
Local discomfort effects (i.e., if someone sits next to a radiator or right below a cooling vent this can lead to local discomfort although the entire space overall is in thermal equilibrium. These effects can easily be determined using thermal modeling tools)

5

The system input or output capacity needed to attain the design operative thermal conditions.

IMAC – Indian Model for Adaptive Comfort

- The adaptive thermal comfort model saves more energy in buildings that are naturally ventilated when compared to air-conditioned buildings as residents adjust to wider indoor temperatures than the peripheral thermal comfort zones determined by the PMV model.
- IMAC Classifies the Building Ventilation into three types based on their HVAC system ranging from naturally ventilated to complete Air Conditioning



IMAC – Indian Model for Adaptive Comfort

- The Standard Classification is based on the ADAPTIVE Thermal Comfort model which differentiate the thermal tolerance of occupants accustomed to monotonic temperature (such as air conditioned places) and people habituated to variation in internal temperatures (such as naturally ventilated structures)

- The Indoor operative temperature values for different building types (NV, MM & A/C) are Pre – Calculated for most Indian cities

IMAC – Indian Model for Adaptive Comfort

Naturally Ventilated Buildings

- The Occupants in NV buildings are Thermally adapted to the outdoor temperature of their location.
- The Indoor Operative Temperature of the occupants to stay thermally comfortable is given by the below equation.

$$\text{Indoor Operative Temperature (}^{\circ}\text{C)} = 0.54 \times \text{Mean Monthly Outdoor DBT} + 12.83$$

Acceptability range for naturally ventilated buildings is $\pm 2.38^{\circ}\text{C}$

IMAC – Indian Model for Adaptive Comfort

Mixed Mode Ventilated Buildings

- The MM Ventilated buildings takes into consideration the combination of natural ventilation and the availability of air-conditioning when necessary.
- The Occupants in MMV Buildings thermally adapt to the outdoor temperature more than the A/C buildings & somewhat less adaptive to NV building
- The Indoor Operative temperature for the occupants to stay thermally comfortable is given by the below equation.

$$\text{Indoor Operative Temperature (}^{\circ}\text{C)} = 0.28 \times \text{Mean Monthly Outdoor DBT} + 17.87$$

Acceptability range for Mixed Mode ventilated buildings is $\pm 3.46^{\circ}\text{C}$

IMAC – Indian Model for Adaptive Comfort

AC Buildings – Air Temperature based Approach

Indoor Operative Temperature (°C) = $0.078 \times \text{Mean Monthly Outdoor DBT} + 23.25$

Acceptability range for Air-Conditioned buildings is $\pm 1.5^\circ\text{C}$



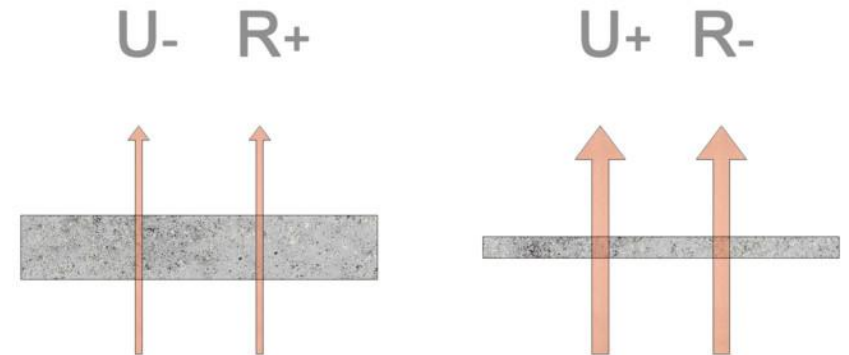
02-B

EFFECTS OF MATERIALS ON THERMAL COMFORT

U-Value or Thermal Transmittance

U-Value or Thermal Transmittance (Reciprocal of R-Value)

Thermal performance is quantified in terms of heat loss and is often represented as a U-value or R-value in the building sector. When developing construction strategies, U-value calculations will almost always be required. The rate of heat transfer through a structure (which can be a single material or a composite) divided by the temperature differential across that structure is known as thermal transmittance, also known as U-value.



- W/m^2K is the unit of measurement.
- The lower the U-value, the better insulated the structure is.
- Workmanship and installation standards can have a significant impact on thermal transmission.
- The thermal transmittance can be much higher than desirable if insulation is installed improperly, with gaps and cold bridges.
- Thermal transmittance accounts for heat loss by conduction, convection, and radiation

U-Value Calculation

U-Value or Thermal Transmittance (Reciprocal of R-Value)

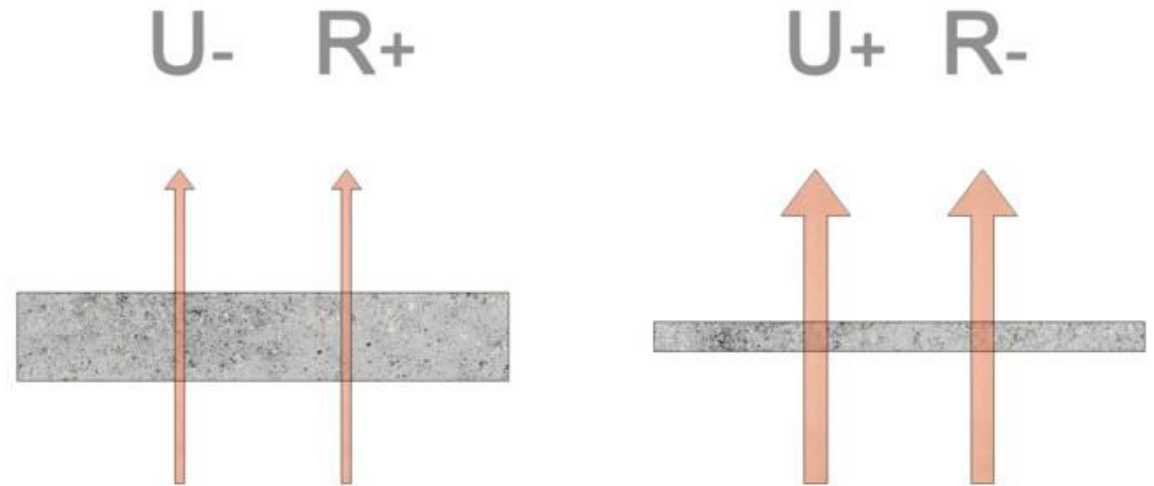
Thermal transmittance is the rate of heat transfer through materials

Unit of U value is $W/(m^2K)$

$$U = \frac{1}{\text{Thermal Resistance of a material (R)}}$$

Where $R = \frac{\text{Thickness of material (t)}}{\text{Conductivity (k)}}$

Conductivity (k) is the rate at which heat is transferred by conduction through material



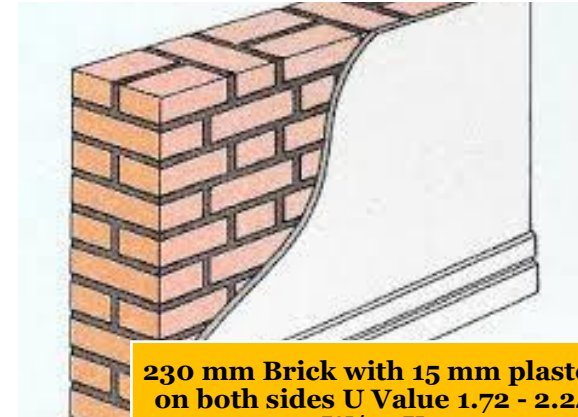
Comparative in terms of U-Value



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

Conventional Materials vs Local Materials vs Materials used at LHP

Sr. No.	CONVENTIONAL MATERIALS		LOCAL MATERIALS		MATERIALS USED AT LHP	
	MATERIALS	U-VALUE	MATERILAS	U-VALUE	MATERIALS	U-VALUE
1	Red Bricks (230mm)	2.8 W/m ² K	Concrete Block (200mm)	2.8 W/m ² K	RCC Wall (150mm)	10.53 W/m ² K
2	Fly Ash Bricks (200mm)	4.28 W/m ² K	Sand Stone Blocks (200mm)	2.6 W/m ² K	AAC Blocks (200mm)	0.77 W/m ² K

DAY 1

Session 3



03

NEW AGE

INNOVATIVE TECHNOLOGY

Light House Projects

LHPs are model housing projects with houses built with shortlisted alternate technology suitable to the geo-climatic and hazard conditions of the region, an initiative under the Climate Smart Building Programme. These projects demonstrate and deliver ready to live houses with speed, economy and with better quality of construction in a sustainable manner.

Through the LHPs, it is envisaged to demonstrate innovative construction technologies which are cost-effective, green, and sustainable. These LHPs shall serve as LIVE Laboratories for different aspects of Transfer of technologies to field application, such as planning, design, production of components, construction practices, testing etc. for both faculty and students, Builders, Professionals of Private and Public sectors, and other stakeholders involved in such construction.

Currently the LHPs' are being implemented in six states (Uttar Pradesh, Gujarat, Madhya Pradesh, Gujarat, Jharkhand, and Tripura) of India under Global Housing Technology Challenge (GHTC) – India. These projects will be made up of modern technology and innovative processes and reduce the construction time and make a more resilient, affordable, and comfortable house for the poor.

Light House Projects

Following are the details of Construction Technologies being employed at the Light House Projects selected under the Global Housing Technology Challenge (GHTC) – India



Monolithic Concrete Construction using Tunnel Formwork

- LHP Location: Rajkot, Gujarat
- No. of Houses: 1144



Prefabricated Sandwich Panel System

- LHP Location: Indore, Madhya Pradesh
- No. of Houses: 1024



Precast Concrete Construction System – Precast Components Assembled at Site

- LHP Location: Chennai, Tamilnadu
- No. of Houses: 1152



Precast Concrete Construction System – 3D Volumetric

- LHP Location: Ranchi, Jharkhand
- No of Houses: 1008



Light Gauge Steel Structural System & Pre-engineered Steel Structural System Agartala, Tripura

- LHP Location: Agartala, Tripura
- No of Houses: 1000



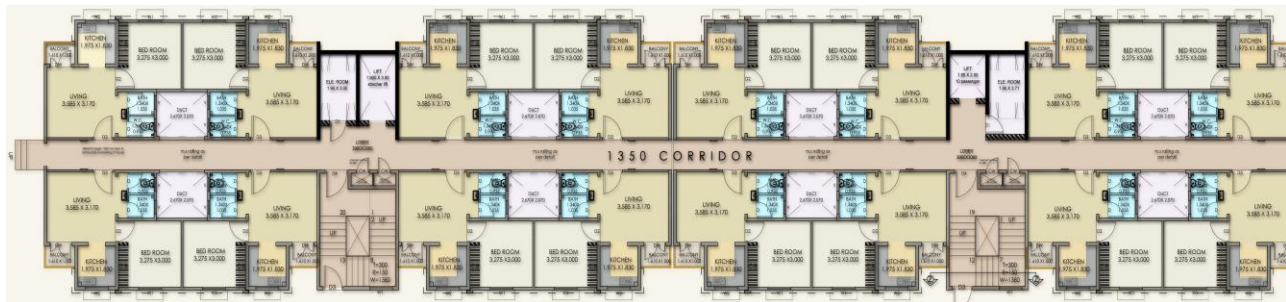
PVC Stay in Place Formwork System

- LHP Location: Lucknow, Uttar Pradesh
- No of Houses: 1040

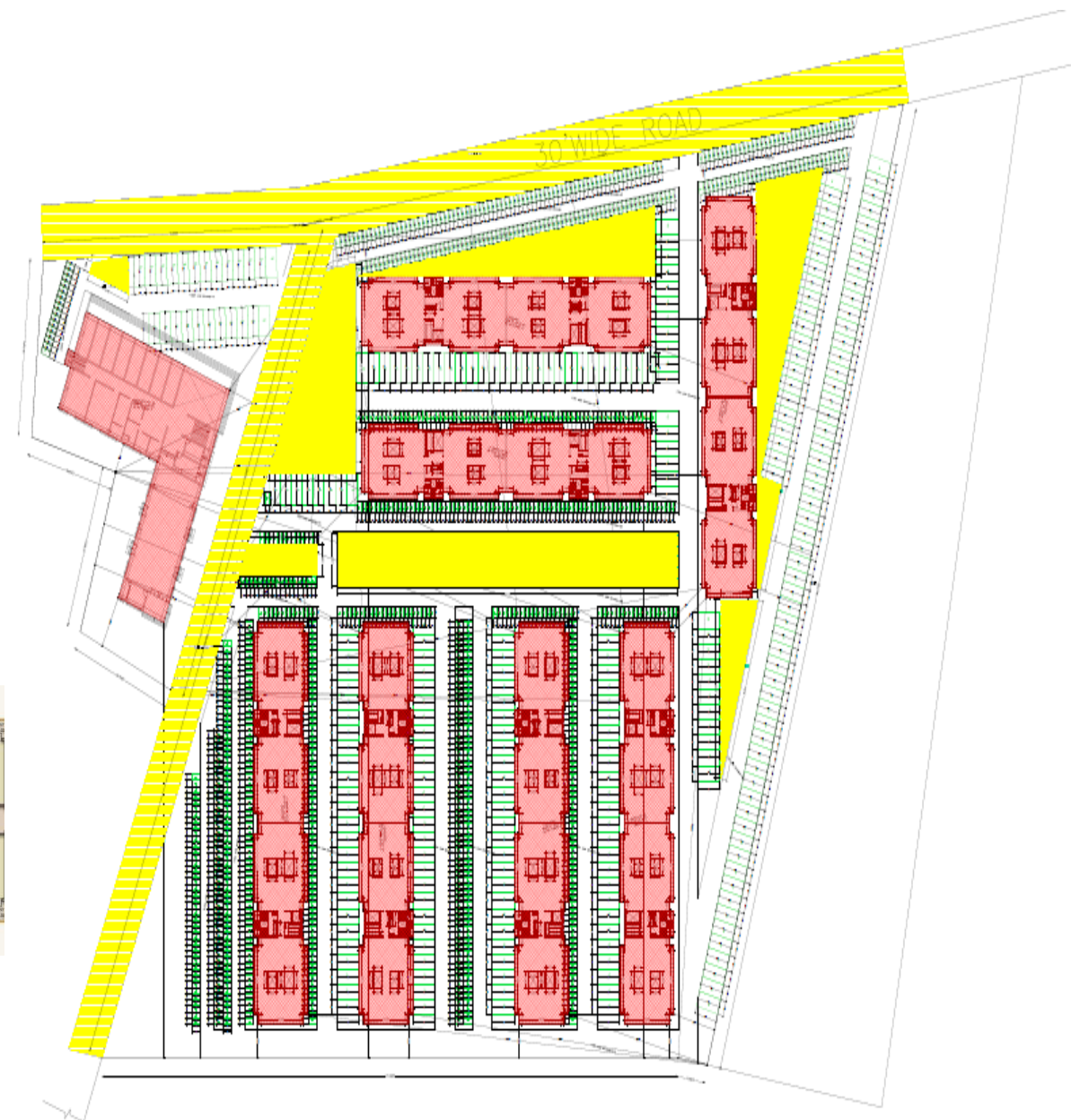
Summary of Six Light House Projects (LHPs)

LHP Location			Chennai (Tamil Nadu)	Rajkot (Gujarat)	Indore (Madhya Pradesh)	Ranchi (Jharkhand)	Agartala (Tripura)	Lucknow (Uttar Pradesh)
Sl. No	Particulars	Units						
1	Name of Technology	Name	Precast Concrete Construction System- Precast Components	Monolithic Concrete Construction using Tunnel Formwork	Prefabricated Sandwich Panel System	Precast Concrete Construction System – 3D Volumetric	Light Gauge Steel Frame System (LGSF) with Pre-Engineered Steel Structural System	Stay in Place Formwork System
2	No. of Houses	No.	1,152	1,144	1,024	1,008	1,000	1,040
3	No. of Floors	No.	G+5	S+13	S+8	G+8	G+6	S+13
4	Plot Area	Sqm	33,596	39,599	41,920	31,160	24,000	20,000
5	Per House Carpet Area	Sqm	26.58	39.77	29.04	29.85	30.00	34.50
6	Project Cost	INR (in Cr)	116.27	118.90	128.00	134.00	162.50	130.90
7	Per House cost (with infrastructure)	INR (in Lakh)	10.09	10.39	12.50	13.29	16.25	12.58

- There are 7 blocks in Ground + 8 configuration with 1008 houses along with basic and social infrastructure.
- Ground coverage of the project is 29.3% and FAR is 2.21.
- Green space is 20%.



Typical floor plan

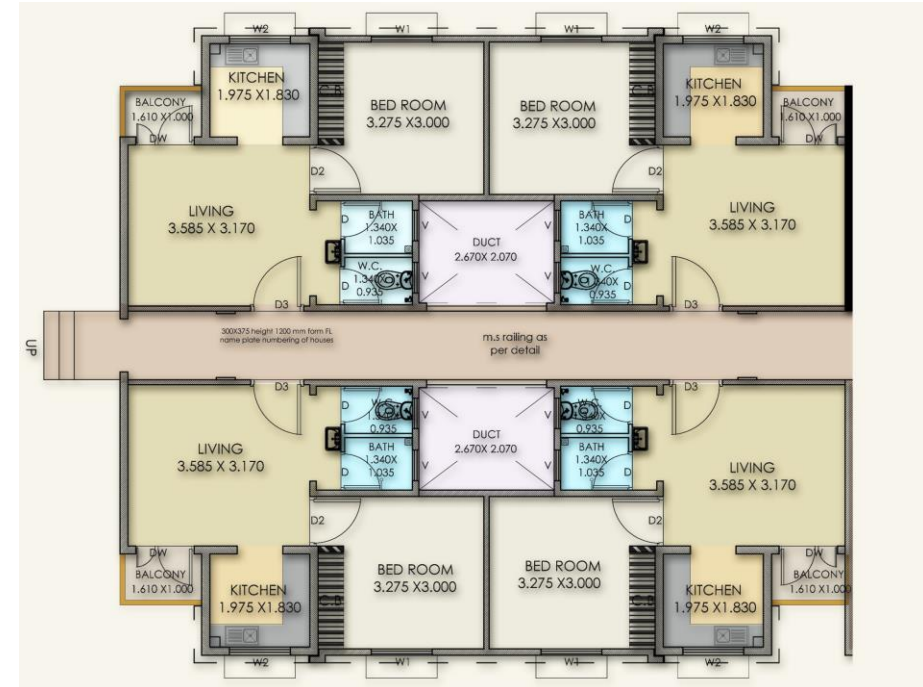


16 dwelling units at each floor of building block with provision of lifts and staircases.

Typical Dwelling Unit plan



Each dwelling unit consists of one hall, one bed room, a kitchen, WC, Bath and a balcony. The carpet area of each unit is 29.85 Sq.mt. The sizes of individual rooms & service areas conform to NBC norms.



Other special features:

- Green rating as per GRIHA
- Use of renewable resources:
 - Rain water harvesting
 - Solar lighting
- Solid waste management
- STP with recycling of waste water
- Fire Fighting System conforming to NBC

Conventional Construction Systems

The prevalent construction systems in India are:

Load bearing Structure

In this system, walls are constructed using bricks/stone/block masonry and floor/roof slabs are of RCC/stone/composite or truss. It is cast in-situ system and called load bearing system as load of structure is transferred to foundation and then to ground through walls.

RCC Framed Structure

In this cast in-situ system, the skeleton of a structure is of RCC column and beam with RCC slab. The infill walls can be of bricks/blocks/stone /panels. The load of the structure is transferred through beam and column to the foundation.



Prevalent Construction Systems

Load bearing Structure

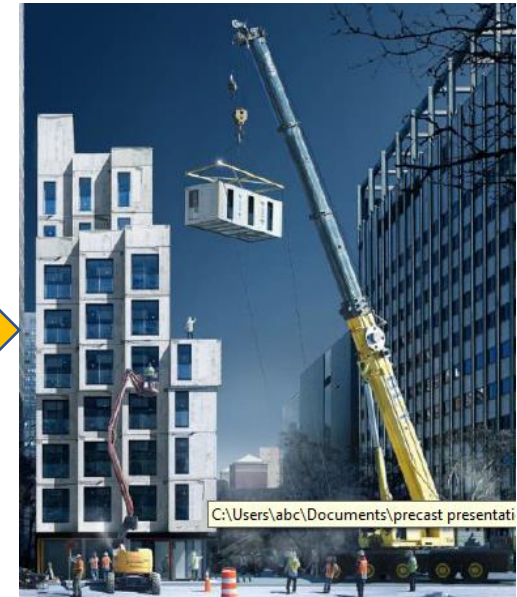


RCC Framed Structure



Technology being Used

Precast Concrete Construction - 3D Volumetric



It is the modern method of building by which precast concrete structural modules like room, toilet, kitchen, bathroom, stairs etc. & any combination of these are cast monolithically in Plant or Casting yard in a controlled condition.

These Modules transported, erected & installed using cranes and are integrated together in the form of complete building unit.

Conventional Construction Systems

Slow
Maximum Use of Natural Resources
Waste Generation
Air/Land/Water Pollution
Labor Intensive
Prescriptive Design
Unhealthy Indoor Quality
Regular Maintenance
Energy Intensive
Cast-in-situ Poor Quality
High GHG Emissions
Unsustainable



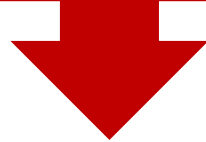
Alternate Construction Systems

Fast
Optimum use of Resources
Minimum Waste
Minimum Pollution
Industrialized System
Cost-effective Design
Better health & Productivity
Low Life Cycle Cost
Energy Efficient
Factory Made Quality Products
Low GHG Emissions
Sustainable

MAP SHOWING SIX DIFFERENT LHP LOCATIONS



Establishment of the Cluster Cell in Ranchi, Jharkhand under Global Housing Technology Challenge-India (GHTC-India)”



- Jharkhand
- Bihar
- Odisha
- West Bengal

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

Sustainable Buildings

- ❖ **30%-50% reduction in energy use**
- ❖ **40% reduction in water use**
- ❖ **35% reduction in GHG emission**
- ❖ **75% reduction in waste**

3D Precast Volumetric Construction

- Replacing cast in situ RCC structural frame with factory made structural components – 3D
- Customized factory-made volumetric construction i.e. the entire module (room)



LHP-RANCHI (Precast Concrete Construction System – 3D Volumetric)

Advantages

- Upto 90% of the building work including finishing is complete in plant/casting yard leading to significant reduction in construction & occupancy time
- The controlled factory environment brings resource optimization, improved quality, precision & finish
- The required concrete can be designed using industrial by-products such as Fly Ash, Ground granulated blast furnace slag (GGBS), Micro silica etc. resulting in improved workability & durability, while also conserving natural resources. In this project Ground granulated blast furnace slag & silica fume is proposed in concrete.
- With smooth surface it eliminates use of plaster
- The monolithic casting of walls & floor of a building module reduces the chances of leakage
- The system has minimal material wastage (saving in material cost), helps in keeping neat & clean construction site and dust free environment
- Use of optimum quantity of water through recycling
- Use of shuttering & scaffolding materials is minimal
- All weather construction & better site organization

Light House Project (LHP) at Chennai, Tamil Nadu

(Technology: Precast Concrete Construction System-Precast Components)

2



No. of Dwelling Units : 1152 Nos. (G+5)
No. of Block / Tower : 12 Blocks
Units in each Block / Tower : 96 Nos.



2D Precast Concrete Construction

- Replacing cast in situ RCC structural frame with factory made structural components – 2D planar elements
- Customized Factory-made beams, columns, wall panels, slab/floors, staircases etc.



Concrete components prefabricated in precast yard or site and installed in the building during construction



LHP-CHENNAI (Precast Concrete Construction System-Precast Components Assembled at Site)

Advantages

- Quality of construction is enhanced significantly due to pre-casting of components by using sophisticated moulds and machineries in factory like environment, assured curing, assured specified cover to reinforcement, proper compaction of concrete results in to dense and impermeable concrete etc. Thus lesser maintenance cost during lifetime of project.
- Inbuilt eco-friendly method of construction in terms of more off-site works in controlled factory like environment results in to significant reduction in wastage of water, natural resources, air pollution and noise pollution.
- Safety of workforce achieved automatically as most of the works are carried out at ground floor in factory like environment, which ultimately enhances the work efficiency and quality.
- Wooden shuttering material is completely avoided and wastage of other construction materials reduced significantly; which results in to conservation of scarce natural resources like soil, sand, aggregate, wood etc.
- Advance procurement of major construction materials, advance pre-casting of structural components and assured completion of work within stipulated completion period will save cost towards escalation & early returns on investments, thus Substantial cost benefit to the client.

Light House Project (LHP) at Agartala, Tripura

(Technology: Light Gauge Steel Structural System & Pre-Engineered Steel Structural System)

No. of Dwelling Units : 1000 Nos. (G+6)
No. of Block / Tower : 7 Blocks
Units in each Block / Tower : A(112), B(154), C(118),
D(168), E(168), F(168) & G(112)



PRE-ENGINEERED STEEL STRUCTURAL SYSTEM

- Replacing cast in situ RCC structural frame with factory made steel (hot rolled) structural system





Steel skeleton with Aerocon panel infills

LIGHT GAUGE STEEL STRUCTURAL SYSTEMS

- Replacing cast in situ RCC structural frame with factory made light gauge steel (cold rolled) structural system



LHP-AGARTALA (Light Gauge Steel Structural System & Pre-engineered Steel Structural System)

Advantages

- Due to light weight, significant reduction in design earthquake forces is achieved. Making it safer compared to other structures.
- Fully integrated computerised manufacturing of LGSF sections provide very high precision & accuracy.
- Speedier
- Structure being light, does not require heavy foundation
- Structural elements can be transported to any place including hilly areas/ remote places easily
- Structure can be shifted from one location to other with minimum wastage of materials.
- Steel used can be recycled multiple times
- The system is very useful for post disaster rehabilitation work.

Light House Project (LHP) at Indore, M.P.

(Technology: Prefabricated Sandwich Panel System & Pre-Engineered Steel Structural System)

4

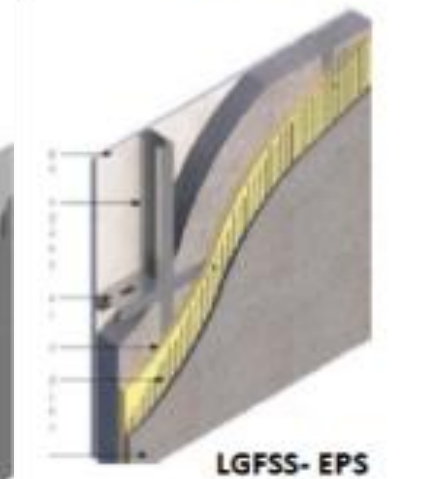
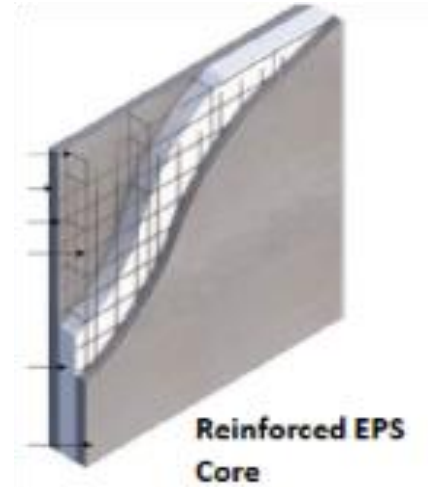
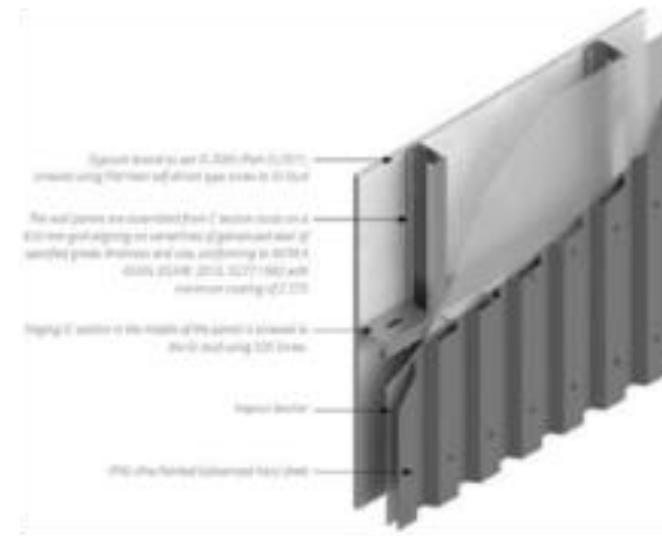
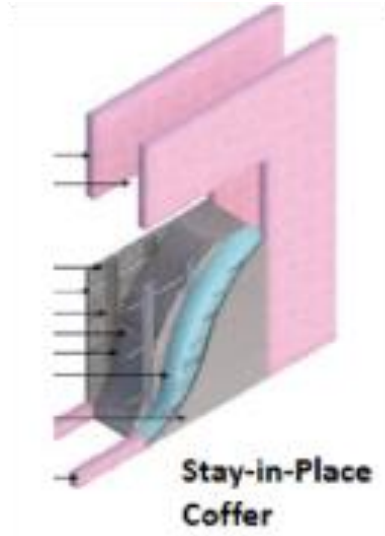
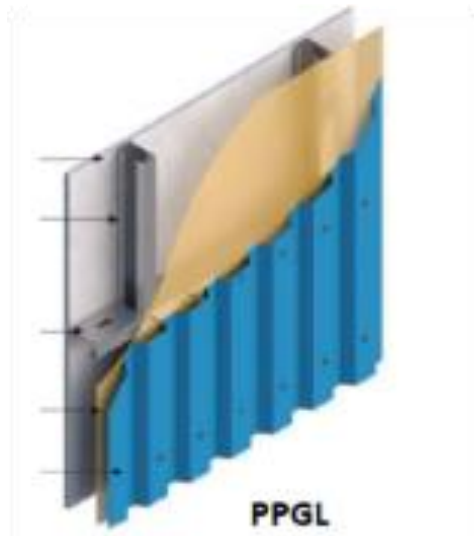
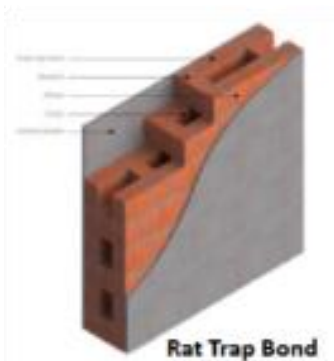


No. of Dwelling Units : 1024 Nos. (S+8)
No. of Block / Tower : 8 Blocks
Units in each Block / Tower : 128 Nos.



PREFABRICATED SANDWICH PANEL SYSTEMS

- EPS Core Panel Systems
- Other Sandwich Panel Systems
 - Fibre cement board
 - MgO Board
 - AAC panels



- **Replacing brick and mortar walls with dry customized walls made in factory**



LHP-INDORE (Prefabricated Sandwich Panel System)

Advantages

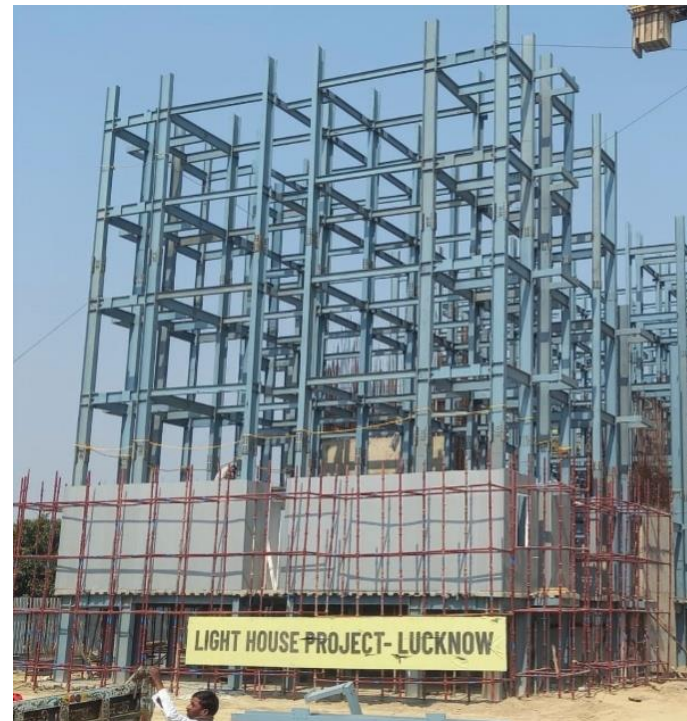
- The system is dry walling system, brings speed in construction, water conservation (no use of water for curing of walling components at site).
- The sandwich panels have light weight material as core material, which brings resource efficiency, better thermal insulation, acoustics & energy efficiency
- Being light in weight, results in lower dead load of building & foundation size.

Light House Project (LHP) at Lucknow, U.P.

(Technology: Stay in-place Formwork System & Pre-Engineered Steel Structural System)

5

No. of Dwelling Units : 1040 Nos. (S+13)
No. of Block / Tower : 4 Blocks
Units in each Block / Tower : A(494),
B(130), C(208) & D(208)



Modular Tunnel form



- Tunnel formwork is a mechanized system for cellular structures. It is based on two half shells which are placed together to form a room or cell. Several cells make an apartment. With tunnel forms, walls and slab are cast in a single day.
- The formwork is set up for the day's pour in the morning. The reinforcement and services are positioned and concrete is poured in the afternoon. Once reinforcement is placed, concrete for walls and Slabs shall be poured in one single operation. The formwork is stripped the early morning and positioned for the subsequent phase.
- Here the walls and slabs are cast in a form of a tunnel leaving two sides open whereas in monolithic concrete construction the entire room is cast in a single pour..



STAY-IN-PLACE FORMWORK SYSTEM

- **Replacing cast-in-situ Formwork with factory made formwork systems**
- **It is sacrificial formwork or lost formwork means formwork is left in the structural system to later act as insulation or reinforcement cage**



Stay-In-Place PVC Wall Forms

- This is a prefinished wall formwork from M/s Novel Assembler Pvt. Ltd. comprising of rigid Poly-Vinyl Chloride (PVC) based polymer components that serve as a permanent stay-in-place durable finished form-work for concrete walls.
- The extruded components slide and interlock together to create continuous formwork with the two faces of the wall connected together by continuous web members forming hollow rectangular components. The web members are punched with oval-shaped cores to allow easy flow of the poured concrete between the components.
- The hollow Novel Wall components are erected and filled with concrete, in situ, to provide a monolithic concrete wall.



LHP-LUCKNOW (Stay in Place PVC formwork System)

Advantages

- Having formwork already as part of system, the construction of building is faster as compared to conventional buildings. The formwork needs some support only for alignment purpose.
- The formwork consists of rigid PVC components, which do not corrode, chip or stain & resistant to UV, bacteria, fungi etc., thus ensuring long life of the structure.
- The polymer content used in manufacturing of formwork is up to 55% recycled content and are further recyclable, making it an eco-friendly material.
- The form work system has specific advantage for use in coastal areas as due to polymer encasement it offers higher durability.
- With concrete as filling material, the curing requirement of concrete is significantly reduced, thus saving in precious water resources.
- The formwork system does not have plastering requirement & gives a aesthetic finished surface in different color options.
- The system provides advantages in terms of structural strength, durability enhancement, weather resistance, flexural strength, thermal insulation and ease of construction.

Light House Project (LHP) at Rajkot, Gujarat

(Technology: Monolithic Concrete Construction System)

6



No. of Dwelling Units : 1144 Nos. (S+13)
No. of Block / Tower : 11 Blocks
Units in each Block / Tower : 104 Nos.



MONOLITHIC CONCRETE CONSTRUCTION

- **Replacing cast-in-situ Formwork with factory made customized formwork systems**
- **Formwork material is Aluminium / composites / steel having 100 to 500 repetitions**
- **Assembly line construction i.e. placing the formwork, pouring the concrete, moving the formwork to upper level**



LHP-RAJKOT (Monolithic Concrete Construction using Tunnel Formwork)

Advantages

- Facilitates rapid construction of multiple/ mass modular units (similar units)
- Results in durable structure with low maintenance requirement
- The precise finishing can be ensured with no plastering requirement
- The concrete can use 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 resource
- Being Box type structure, highly suitable against horizontal forces (earthquake, cyclone etc.)
- The large number of modular units bring economy in construction.

DAY 1

Tea Break

DAY 1

Session 4



04

GREEN BUILDINGS

What is Green Building?

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



The Benefits

Environmental Benefits

- Protect Biodiversity & ecosystems
- Improve air and water quality
- Reduce Water streams
- Conserve natural resources

Economic Benefits

- Reduce operating cost
- Tax incentives and subsidies for green buildings and renewable energy concepts
- Create, expand and shape markets for green product and services
- Improve Occupant Productivity

Social Benefits

- Enhance occupant comfort & health
- Heighten aesthetic qualities
- Minimize strain on local infrastructure
- Improve overall quality of life



Green buildings & the Sustainable Development Goals

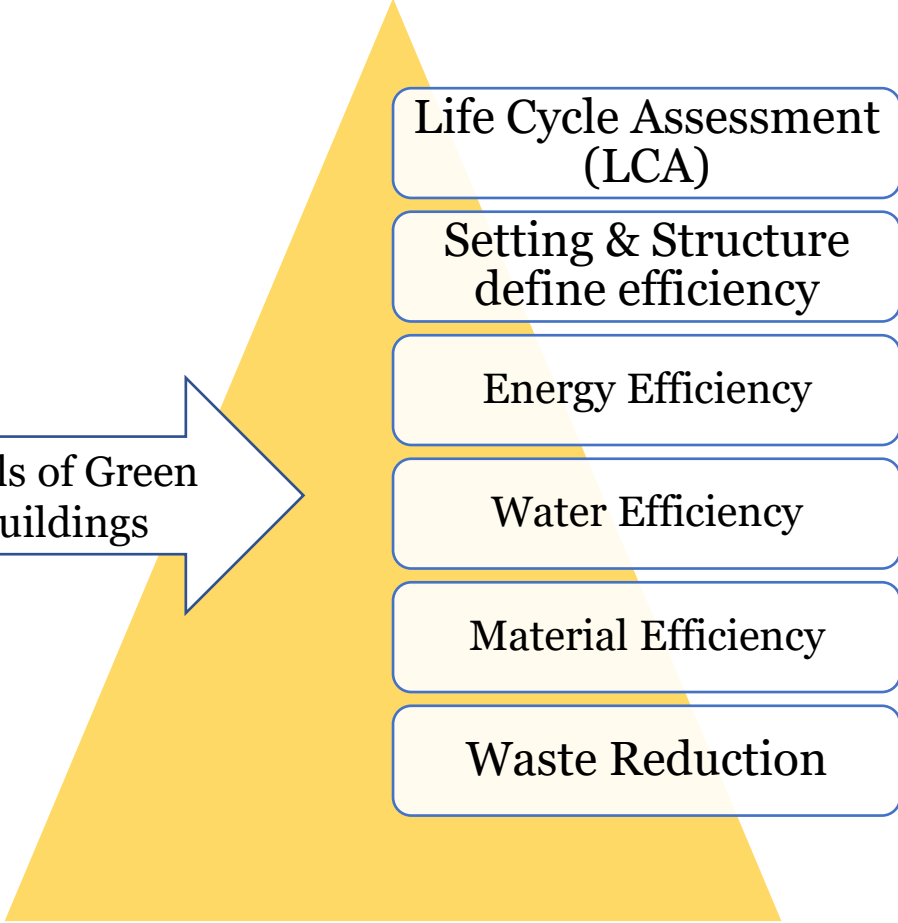


Goals of Green Buildings

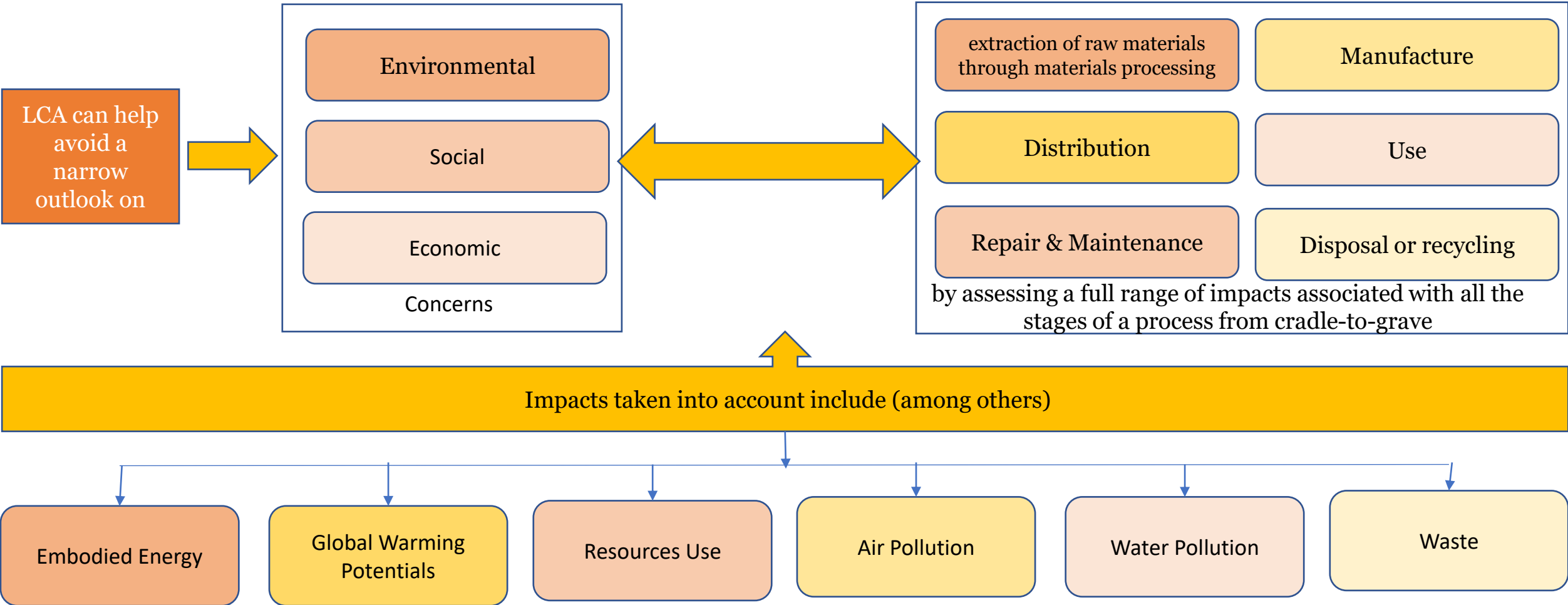
Green building brings together a vast array of practices and techniques to reduce and ultimately eliminate the impacts of buildings on the environment and human health.

It often emphasizes taking advantage of renewable resources, e.g., using sunlight through passive solar, active solar, and photovoltaic techniques and using plants and trees through green roofs, rain gardens, and for reduction of rainwater run-off.

Many other techniques, such as using packed gravel or permeable concrete instead of conventional concrete or asphalt to enhance replenishment of ground water, are used as well. While the practices, or technologies, employed in green building are constantly evolving and may differ from region to region, there are fundamental principles that persist from which the method is derived:



Life Cycle Assessment (LCA)



Setting & Structure Design Efficiency

The foundation of any construction project is rooted in

Concept Stage

The concept stage, in fact, is one of the major steps in a project life cycle, as it has the largest impact on cost and performance. In designing environmentally optimal buildings, the objective is to minimize the total environmental impact associated with all life-cycle stages of the building project. However, building as a process is not as streamlined as an industrial process, and varies from one building to the other, never repeating itself identically

Design Stage

In addition, buildings are much more complex products, composed of a multitude of materials and components each constituting various design variables to be decided at the design stage. A variation of every design variable may affect the environment during all the building's relevant life-cycle stages.

Energy Efficiency

Green buildings often include measures to reduce energy consumption – both the embodied energy required to extract, process, transport and install building materials and operating energy to provide services such as heating and power for equipment

To reduce operating energy use, high-efficiency windows and insulation in walls, ceilings, and floors increase the efficiency of the building envelope, (the barrier between conditioned and unconditioned space). Another strategy, passive solar building design, is often implemented in low-energy homes

Designers orient windows and walls and place awnings, porches, and trees to shade windows and roofs during the summer while maximizing solar gain in the winter

In addition, effective window placement (day lighting) can provide more natural light and lessen the need for electric lighting during the day. Solar water heating further reduces energy costs.

Water Efficiency

Reducing water consumption and protecting water quality are key objectives in sustainable building. One critical issue of water consumption is that in many areas, the demands on the supplying aquifer exceed its ability to replenish itself.

To the maximum extent feasible, facilities should increase their dependence on water that is collected, used, purified, and reused on-site.

The protection and conservation of water throughout the life of a building may be accomplished by designing for dual plumbing that recycles water in toilet flushing.

Point of use water treatment and heating improves both water quality and energy efficiency while reducing the amount of water in circulation.

Waste-water may be minimized

by utilizing water conserving fixtures such as

ultra-low flush toilets

low-flow shower heads.

Bidets help eliminate the use of

toilet paper

Reducing Sewer Traffic

increasing possibilities of re-using water on-site

The use of non-sewage and greywater for on-site use such as site-irrigation will minimize demands on the local aquifer.

Material Efficiency

Building materials

typically considered to be 'green' include

lumber from forests that have been certified to a third-party forest standard, rapidly renewable plant materials like

- bamboo and straw
- insulating concrete forms
- dimension stone,
- recycled stone
- recycled metal

and other products that are

Non Toxic

reusable

renewable, and/or recyclable

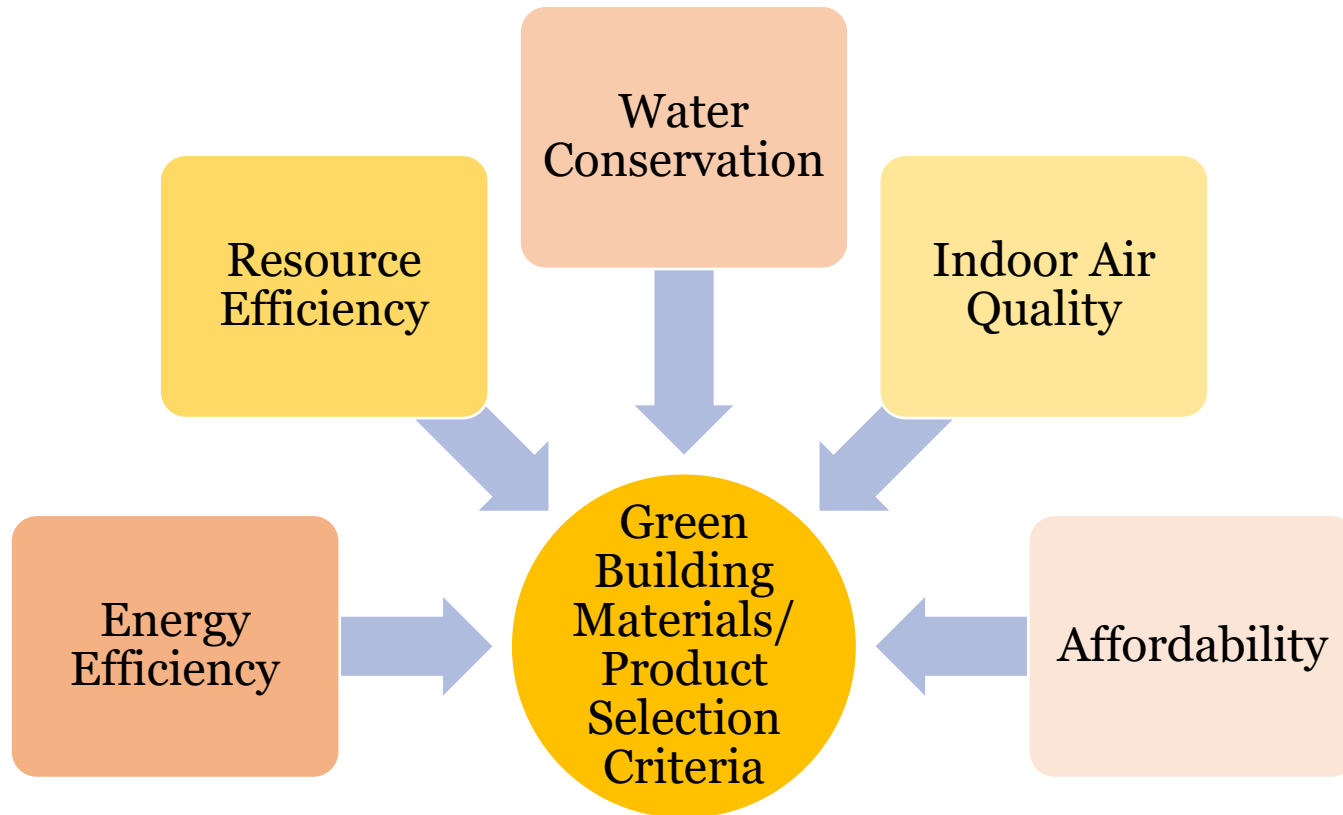
The EPA (Environmental Protection Agency) also suggests using recycled industrial goods, such as coal combustion products, foundry sand, and demolition debris in construction projects Building materials should be extracted and manufactured locally to the building site to minimize the energy embedded in their transportation

Where possible, building elements should be manufactured off-site and delivered to site, to maximize benefits of off-site manufacture including minimizing waste, maximizing recycling (because manufacture is in one location), high quality elements, better OHS management, less noise and dust.

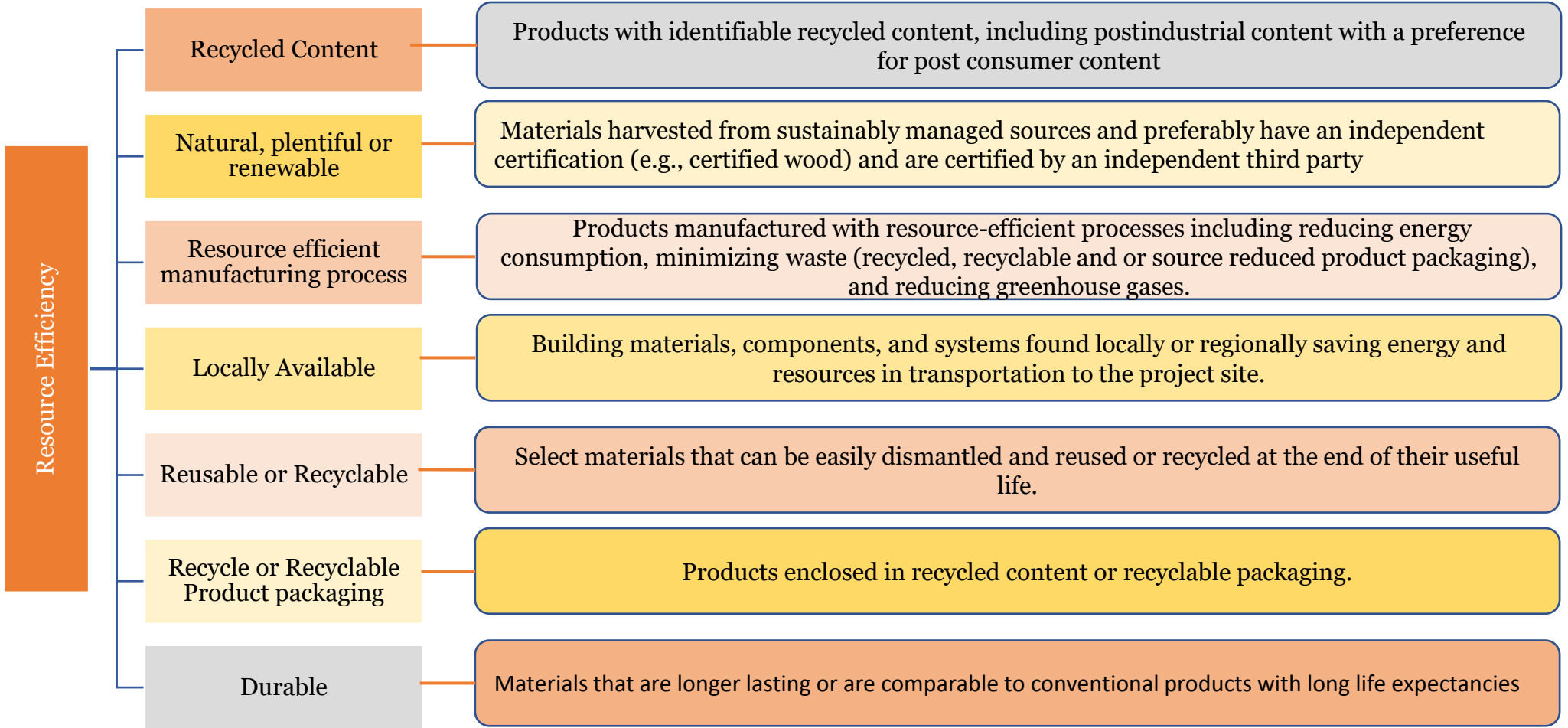
Waste Reduction

Green Building Materials

Selection criteria like what is presented below was also used for the East End Project as identified in the Review of Construction Projects Using Sustainable Materials.

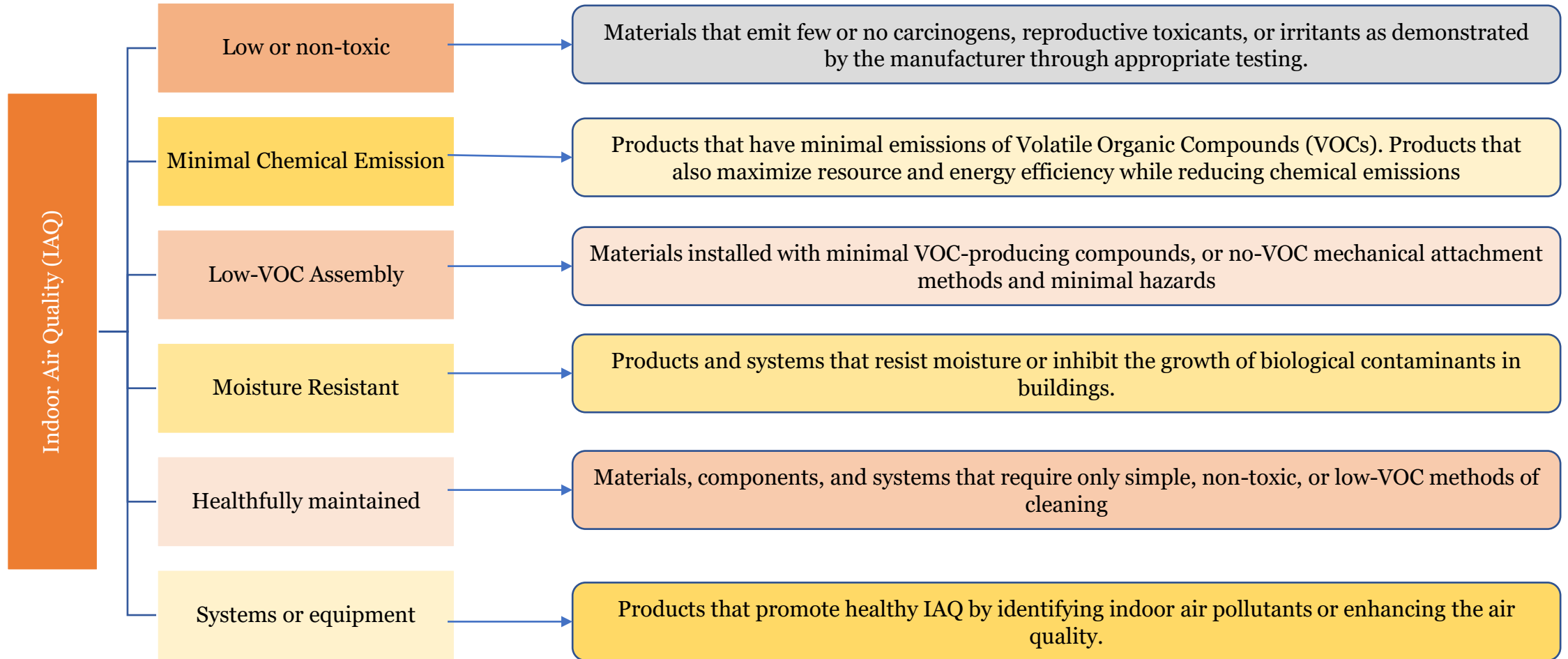


Green Building Materials - Resource Efficiency



Salvaged, refurbished, or remanufactured: Includes saving a material from disposal and renovating, repairing, restoring, or generally improving the appearance, performance, quality, functionality, or value of a product

Green Building Materials - Indoor Air Quality (IAQ)



Green Building Materials - Indoor Air Quality (IAQ)

Materials, components, and systems that help reduce energy consumption in buildings and facilities

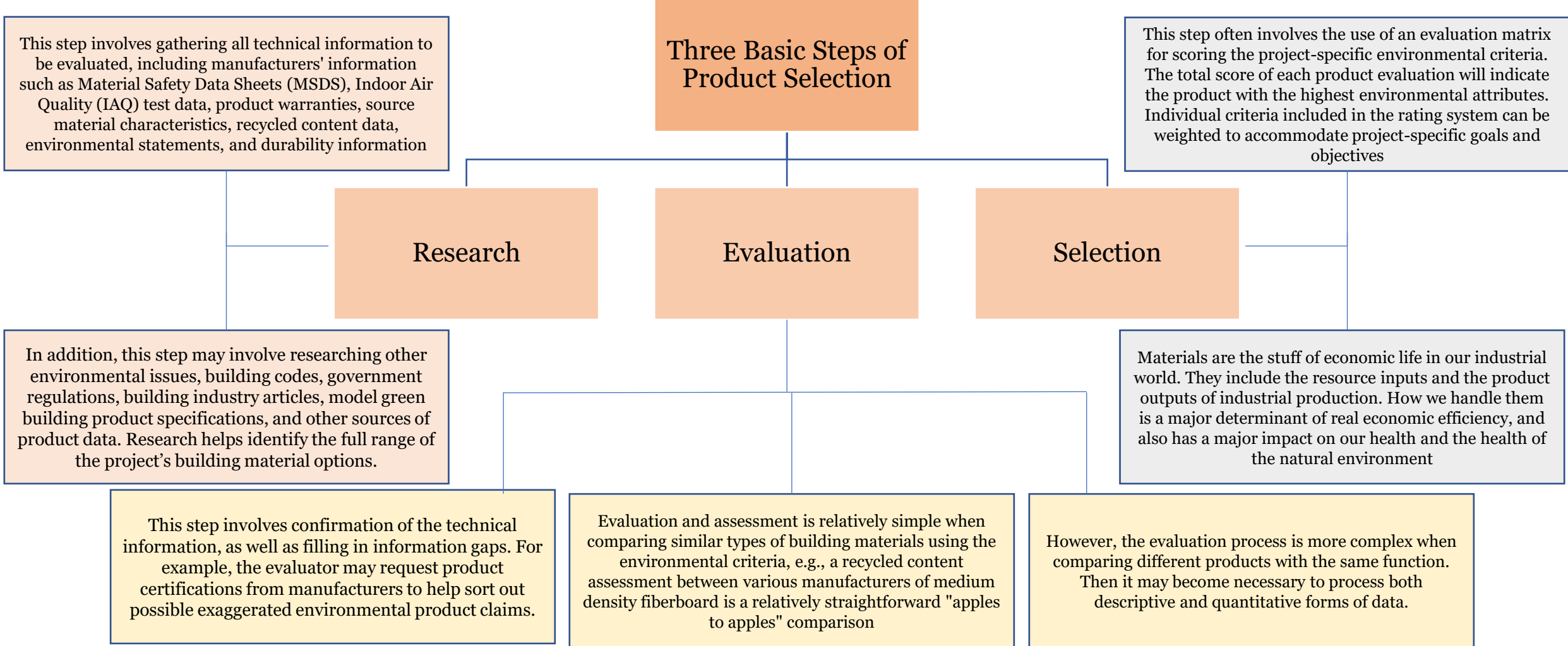
Energy Efficiency can be maximized by utilizing materials and systems that meet the following criteria:

Water Conservation can be obtained by utilizing materials and systems that meet the following criteria:

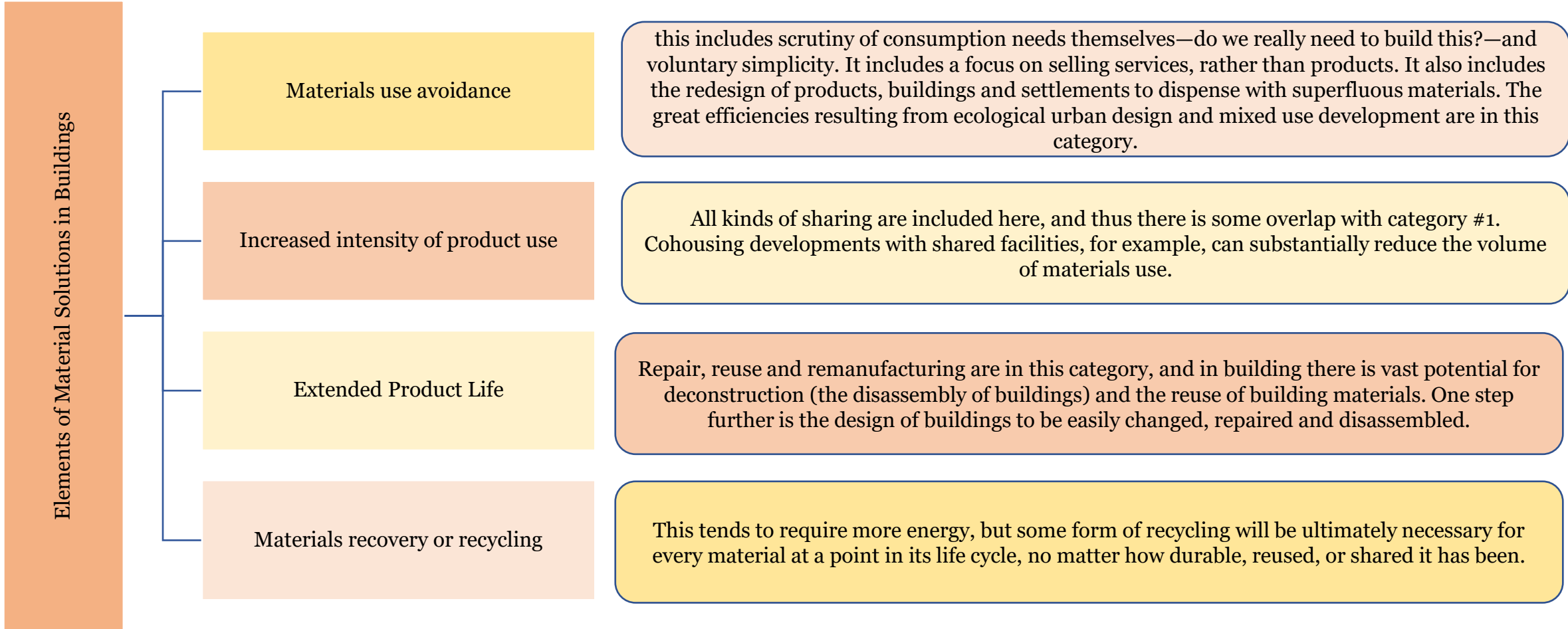
Products and systems that help reduce water consumption in buildings and conserve water in landscaped areas

Affordability can be considered when building product life-cycle costs are comparable to conventional materials or, are within a project-defined percentage of the overall budget.

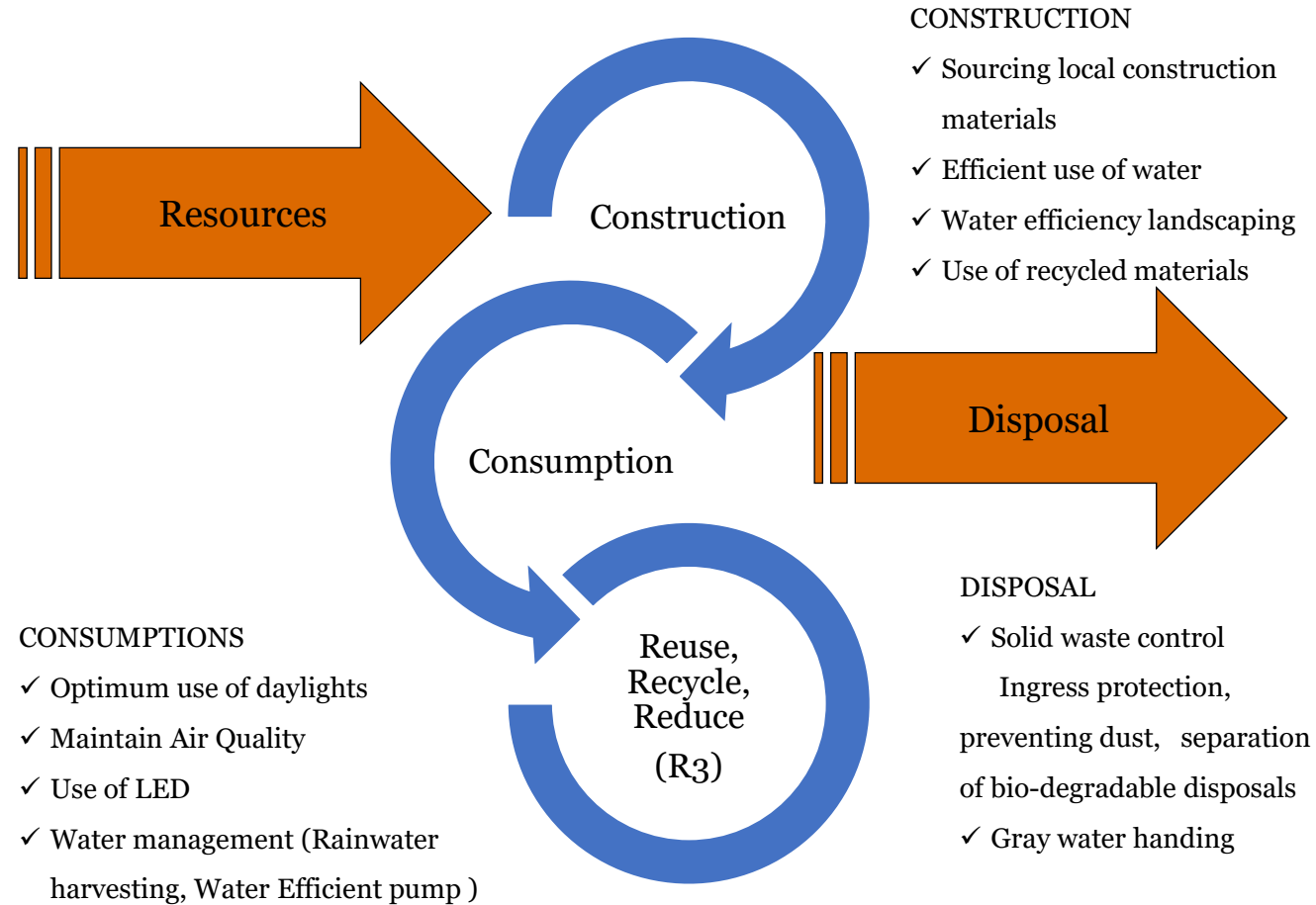
Green Building Materials – Three Basic Steps of Product Selection



Green Building Materials – Elements of Material Solutions in Building



Life Cycle of Green Building



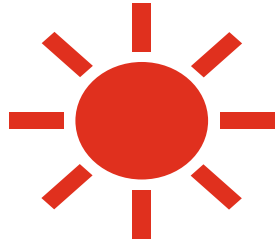
GREEN RATING SYSTEMS



Features that can make an Affordable building 'GREEN'



Site Planning



Energy and Occupant Comfort



Water Saving



Waste Management

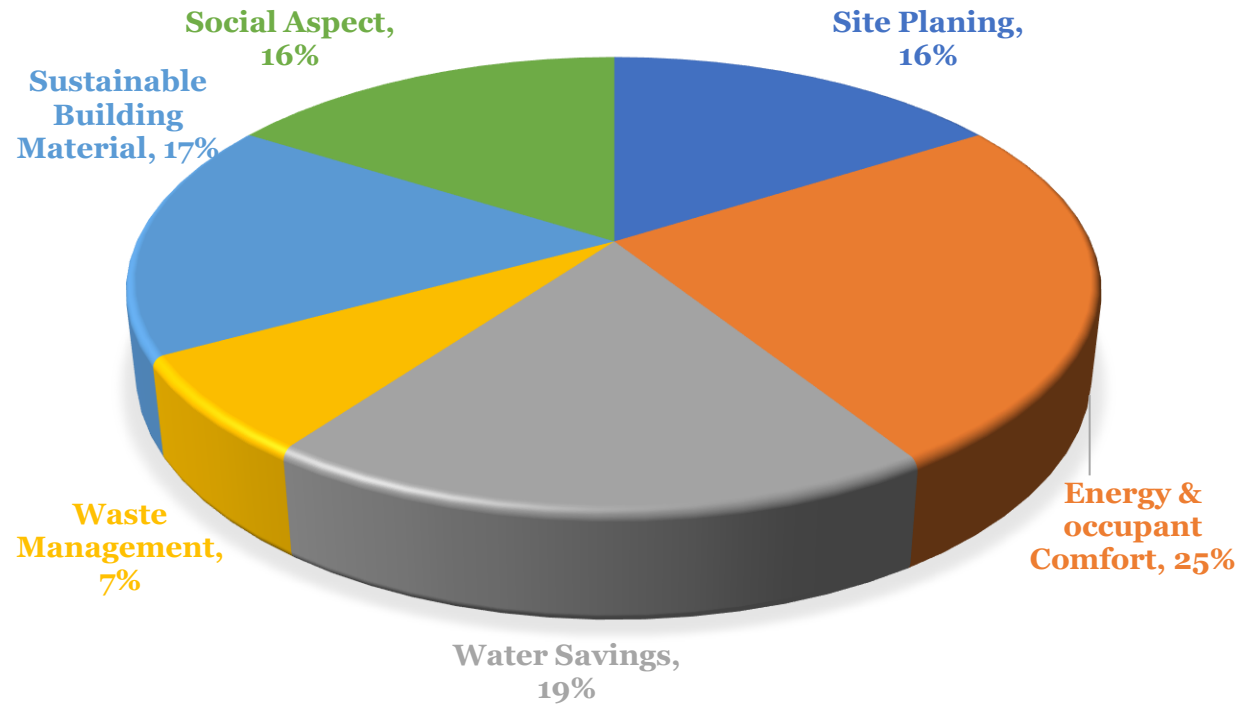


Sustainable Building Material



Social Aspect

GRIHA Rating System: AFFORDABLE HOUSING



POINT WEIGHTAGES

Rating Thresholds	Rating
86 and above	5 Star
71-85	4 Star
56-70	3 Star
41-55	2 Star
25-40	1 Star

Site Planning

1

Climate Type	Passive Design Strategies
	Solar Chimney/ Wind Tower
	Courtyards
	Roof Pond for Evaporative Cooling
	Reduce Solar Access
	Building/ Site planning to increase cross ventilation (layout of windows in the rooms and building for wind flow)
	Cavity Walls/ Thermal mass to reduce heat gain/loss
	Dense vegetarian cover to moderate micro-climate
	Design accordingly site slope
	Light Shelves
	Internal distribution of spaces to be carried out such that buffer spaces like store rooms, staircases , toilets etc are located on the eastern and western facades
	Cool roofs in the form of vegetated roof/ terrace gardens/ roof ponds



Site Planning

1



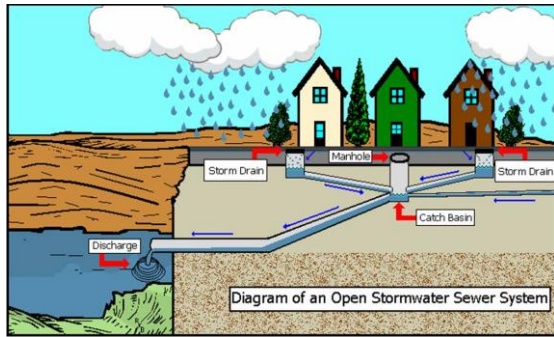
Vegetated Roof



SRI Coating



Grass pavers (<https://greenroutesolutions.com/>)



Storm water management
(<https://www.thewater treatments.com>)



Light Shelves
(<https://www.designingbuildings.co.uk/>)



Mosaic tiles
(<https://www.dreamstime.com/>)

Design to mitigate -UHIE

- SRI Coating, Grass pavers

Landscape preservation

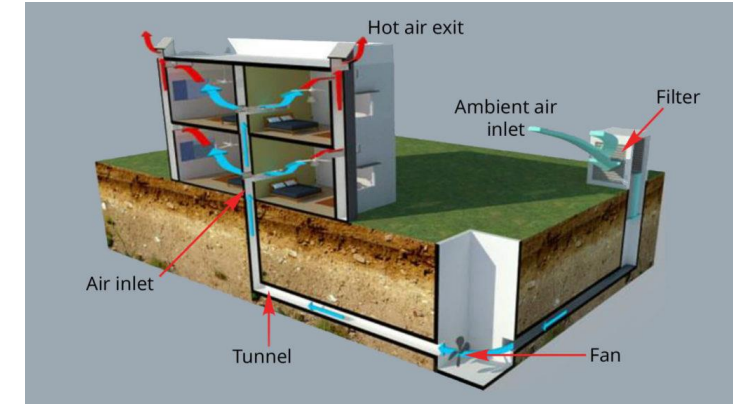
- Protection mature trees

Storm Water management

Reduction in air and soil pollution

Energy & Occupant Comfort

Envelope Thermal Performance	<ul style="list-style-type: none"> • Peak Heat Gai Factor (W/Sq.m) • Peak Cooling Load (W/Sq.m)
Occupants visual comfort (Daylight)	<ul style="list-style-type: none"> • UDI • Daylight Extent factor as per ECBC
Efficient Lighting	<ul style="list-style-type: none"> • Minimum luminous efficacy 75 lumen/Watt • 100% outdoor lighting
Energy Efficient Equipments	<ul style="list-style-type: none"> • At least BEE 3 Star Motor & Transformers
Renewable Energy	<ul style="list-style-type: none"> • 1kWp per 500 sq.m
Energy Metering	<ul style="list-style-type: none"> • Dedicated energy meter in each DUs



Earth Air System
<https://>



BEE Star ratings

Water Savings

Efficient use of water during construction

- Gunny Bag/hessian cloth and ponding for curing
- Additives
- Use of treated wastewater/ captured rainwater

Optimizing the Building & Landscape water demand

- **20% reduction w.r.t base case**
- Reduce the total landscape water requirement (Sprinkler Irrigation, Drip irrigation)

Water Reuse

- Sewage Treatment Plant
- Reuse of treated and rain water

Water Metering

- **Installation of the water meter**
- Sub-water meter in each DUs



GUNNY Bags
(<https://blog.fabricuk.c>)



Water meter
(<https://www.nobroker.in/>)



Sprinkler

Waste Management

4

Construction Waste Management

- Waste management plan as per 'Construction and Demolition Waste Management Rules, 2016

Post Construction Waste Management

- Compliance with Solid Waste Management Rules, 2016
- Collection & Segregation (multi-coloured bins)
- Safe & hygienic storage
- Safe recycling
- Treating organic waste (biogas/manure) (>100kg/day)



<https://www.nbmcw.com/>

150 million tonnes of construction and demolition (C&D) waste every year. (2019)
Recycling capacity is a about 6,500 tonnes per day (TPD) -- just about 1 per cent.*

*<https://www.cseindia.org/>

Sustainable Building Materials

- Reduction in environmental impact of construction (Building Structure)**
 - Use of BIS recommended waste materials (OPC, aggregate, sand)
 - Use of recycled materials (Steel frame, polystyrene components, Gypsum panels)
 - Embodied energy calculation
- Use of low environmental impact materials in building interiors**
 - Stones from India
 - Composite wood based product
 - FSC Chain of custody certified products
 - Products with 5% recycled content
- Use of recycled content in roads and pavements**
 - 8% (min) as per CPRI and IRC Guidelines
- Low VOC paints, adhesives, sealants and composite wood products**
 - VOC limit (g /litre) specified
- Zero ODP materials**
 - CFC, HCFCs free from Building insulation , HVAC & refrigeration equipment and fire fighting system

Portland Slag Cement, commonly known as PSC
Up to 45- 50% slag, 45% – 50% clinker, and 3-5% gypsum



Compacted EPS Blocks



Gypsum Board
(<https://www.boardandwall.com/>)

Social Aspects

5

- Facilities for construction workers**
 - Compliance with NBC 2016 Safety norms
 - Drinking water, hygienic working & living condition
- Universal Accessibility**
 - Measure to provide barrier free facilities for Specially abled persons and elderly persons
- Proximity of Transport and basic Services**
 - With in 500 metre transportation facilities
 - Health Care, Education, Socio culture, market, sports, recreation, Bank (ATM) – 800 metre preferred
- Environmental Awareness**
 - Awareness tools (Brochure, poster etc.)
- Tobacco Smoke Control**
 - Zero exposure of non-smoking occupants
- Water Quality**
 - Conform to IS 10500-1991
- Provision to access clean sources of Cooking Fuel**
 - Basic infrastructure for PNG & LPG connection



Ramp for physically handicapped



DAY 1

Q & A Session

DAY 1

Vote of Thanks

DAY 2

DAY 2

Session 5

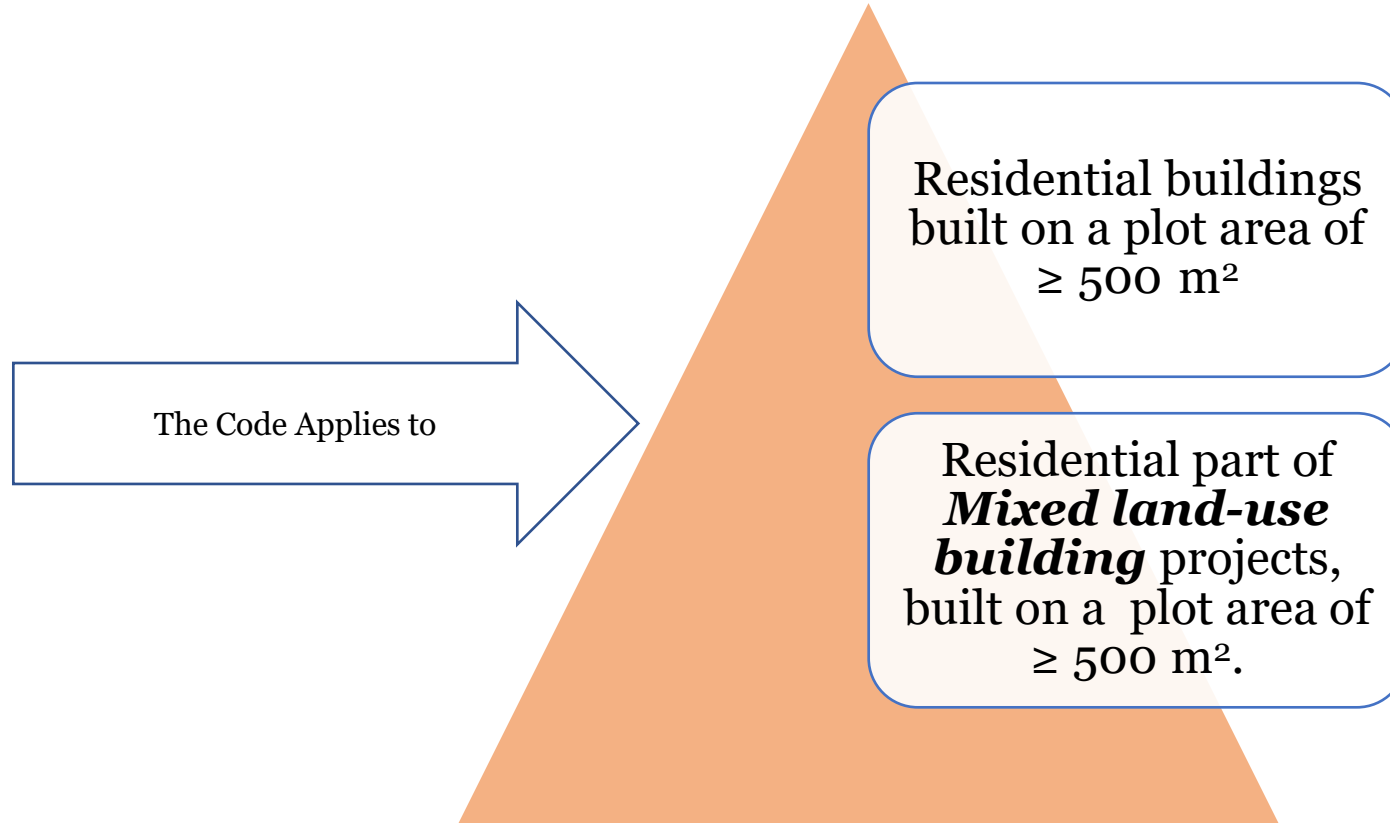


05

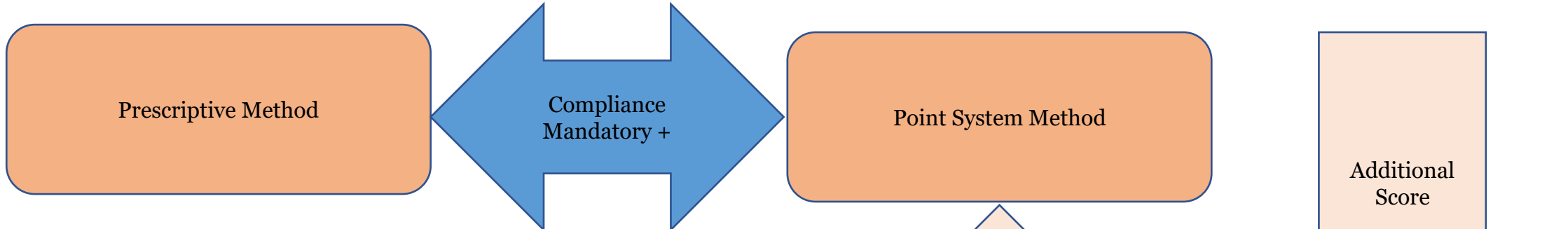
ENS

2021

Eco – Niwas Samhita 2021 Scope



ECO – NIWAS SAMHITA 2021 CODE COMPLIANCE



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

- Minimum Points
- Additional Points
- Maximum Points

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

ECO – NIWAS SAMHITA 2021 CODE COMPLIANCE

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

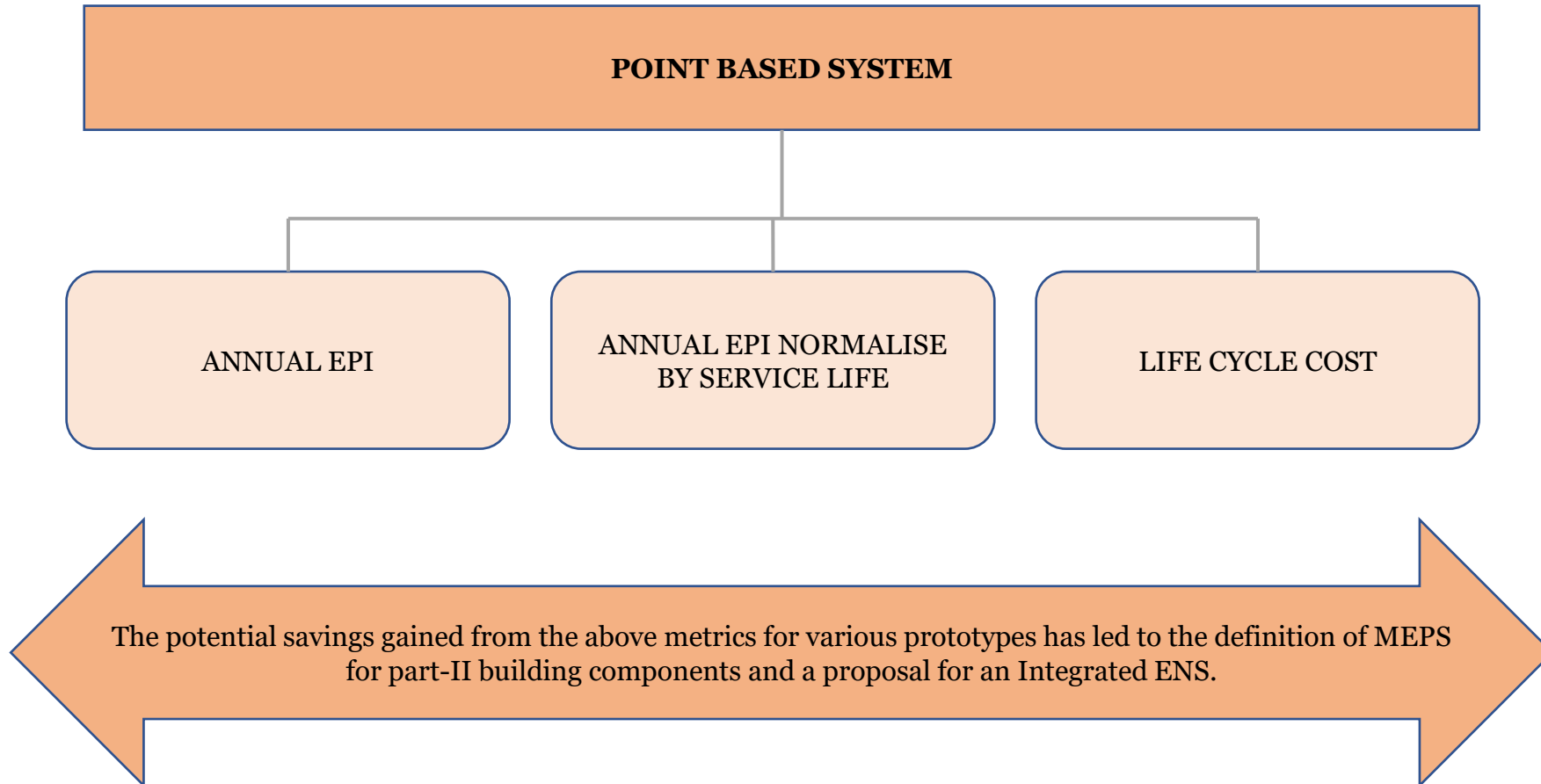
Low Rise Buildings: A structure of four stories or less, and/or a structure of up to 15 metres in height (without stilts) and up to 17.5 metres in height (including stilt).

Affordable Housing Projects:

- for Affordable houses are Dwelling Units (DUs)
- for Economically Weaker Section (EWS) category
- For Lower Income Group (LIG) category

High Rise Buildings: A structure with more than four stories and/or a height of more than 15 metres (without stilts) and 17.5 metres (including stilt).

Point Based System



Advantages of Point Based System

- A point system is a less complicated way of assigning weight to building components that are relevant in terms of energy efficiency and compliance. Each dot does not always imply a percentage reduction in energy consumption.
- Singapore began with prescriptive compliance, but as the code grew, the point-based model was adopted as a means of compliance, combining trade-off and prescriptive criteria.

Ease of comprehending by the citizens	• Easy to comprehend by citizens for both overall energy performance of a residential building and incorporated component level energy efficiency
Trade-off	<ul style="list-style-type: none"> • Trade-off among components is possible but on a stepped EE improvements giving limited flexibility to owner to show compliance • Easy to deter possibility of gaming
Compliance	<ul style="list-style-type: none"> • Low expertise is required for doing and checking the compliance • Require simpler tool for showing compliance • Will have only one compliance approach
Future revision	<ul style="list-style-type: none"> • Easy to accommodate additions and removal of components from code. • Easier for states to make any revisions/amendments

Mandatory Requirements

1. **Building Envelope:** All of the ENS Part I requirements must be met.
2. **Power Factor Correction:** In all three phases, 0.97 at the point of connection or the state requirement, whichever is more strict.
3. **Energy Monitoring:** Common area lighting (Outdoor lighting, corridor lighting and basement lighting)
 - Elevators
 - Water pumps
 - Basement car parking ventilation system
 - Electricity generated from power back-up
 - Electricity generated through renewable energy systems
 - Lift pressurization system
4. **Electrical Vehicle Charging Station:** If it is installed, it must follow the new criteria for Charging Infrastructure established by the Ministry of Power.
5. **Electrical Systems:** Distribution losses in the ENS building must not exceed 3% of total power demand. At design load, the voltage drop for feeders is less than 2%. At design load, the voltage drop for the branch circuit is less than 3%.

Prescriptive Method

1. **Building Envelope:**
 - VLT and WFR – as per ENS Part 1
 - RETV (for all climate except cold) – max 12 W/m²
 - Thermal Transmittance for cold – max 1.3W/m²K
 - Roof – 1.2W/m²K
2. **Common Area & Exterior Lighting: Either LPD or Efficacy and use of PhotoSensor**

Common Areas	Maximum LPD (W/m ²)	Minimum luminous efficacy (lm/W)
Corridor lighting & Stilt Parking	3.0	All the permanently installed lighting fixtures shall use lamps with an efficacy of at least 105 lumens per Watt
Basement Lighting	1.0	All the permanently installed lighting fixtures shall use lamps with an efficacy of at least 105 lumens per Watt

Exterior Lighting Areas	Maximum LPD (in W/m ²)
Driveways and parking (open/ external)	1.6
Pedestrian walkways	2.0
Stairways	10.0
Landscaping	0.5
Outdoor sales area	9.0

Prescriptive Method

3. Elevators, if applicable:
 - Lamps: 85l/W
 - Automatic switch off control
 - IE4 motors
 - VFDs
 - Regenerative drives
 - Group Automatic operation
4. Pumps, if applicable: Min Eff -70% or BEE 5 Star
5. Electrical System, if applicable:
 - Distribution loss less than 3%
 - Dry Type Transformer - as mentioned in table
 - Oil Type Transformer – BEE 5 Star

Point System Method

Point System Method

Minimum Points - are a set of points that must be obtained for each component in order to demonstrate ENS compliance

Additional Points - These are the points provided for implementing additional or improved energy efficiency measures in a component. These points can be combined with others to get the total score for ENS compliance described in section 3.1.2.

The total points available for each component are the **maximum points**.

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

Point System Method

1 - Building Envelope (87 Max Points out of which 47 are essential)

- Thermal Transmittance of Roof (7 Points)
- RETV (80 Points)

Thermal Transmittance of Roof	
<p>Minimum: Thermal transmittance of roof shall comply with the maximum Uroof value of 1.2 W/m²·K.</p>	Up to 4 Points
<p>Additional: 1 Point for every reduction of 0.23 W/m²·K in thermal transmittance of roof from the Minimum requirement prescribed under §6.1(a).</p>	Maximum 3Points

RETV	
<p>The 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.</p>	44 Points
<p>For RETV less than 15 and upto 12 W/m², score will be calculated by following equation:</p> $74 - 2 \times (\text{RETV})$ <p>(@2 points per RETV reduction)</p>	Up to 50 Points
<p>Additional: For RETV less than 12 and upto 6 W/m², score will be calculated by following equation:</p> $110 - 5 \times (\text{RETV})$ <p>(@ 5 points per RETV reduction)</p>	Up to 80 points
<p>Additional: For RETV less than 6 W/m²</p>	80 Points

Point System Method

2 – Common Area and Exterior Lighting (9 Points)

Common Areas	Maximum LPD (W/m ²)	Minimum luminous efficacy (lm/W)
Corridor lighting & Stilt Parking	3.0	All the permanently installed lighting fixtures shall use lamps with an efficacy of at least 85 lumens per Watt
Basement Lighting	1.0	All the permanently installed lighting fixtures shall use lamps with an efficacy of at least 85 lumens per Watt

Exterior Lighting Areas - at least 85 lm/W and maximum LPD requirements given in Table	Maximum LPD (in W/m ²)
Driveways and parking (open/ external)	1.6
Pedestrian walkways	2.0
Stairways	10.0
Landscaping	0.5
Outdoor sales area	9.0

Additional Points (6 points)	
Corridor lighting & Stilt Parking	1 Point for installing 95 lm/W Or 2 Point for installing 105 lm/W
Basement Lighting	1 Point for installing 95 lm/W Or 2 Point for installing 105 lm/W
Exterior Lighting Areas	2Points for Installing photo sensor or astronomical time switch

Point System Method

3 – ELEVATORS (22 Points)

Minimum:

Elevators installed in the ENS building shall meet all the following requirements:

- i. **Install high efficacy lamps for lift car lighting having minimum luminous efficacy of 85 lm/W**
- ii. **Install automatic switch-off controls for lighting and fan inside the lift car when are not occupied**
- iii. **Install minimum class IE 3 high efficiency motors** **13 Points**
- iv. **Group automatic operation of two or more elevators coordinated by supervisory control**

Additional:

- i. Additional points can be obtained by meeting the following requirements:
- ii. Installing the variable voltage and variable frequency drives. (4 points)
- iii. Installing regenerative drives. (3 points) **9 Points**
- iv. Installing class IE4 motors. (2 points)

Point System Method

4 – Pumps (14 Points)

Minimum:

Either hydro-pneumatic pumps having minimum mechanical efficiency of 60% or BEE 4 star rated

6 Points

Pumps shall be installed in the ENS building.

Additional:

Additional points can be obtained by meeting the following requirements:

- i. Installation of BEE 5 star rated pumps (5 Points)
- ii. Installation of hydro-pneumatic system for water pumping having minimum mechanical efficiency of 70% (3 Points)

8 Points

Point System Method

5 – Electrical Systems (6 Points)

Minimum:

- i. Power transformers of the proper ratings and design must be selected to satisfy the minimum acceptable efficiency at 50% and full load rating. The permissible loss shall not exceed the values listed in Table 8 for dry type transformers and BEE 4-star rating in Table 9 for oil type transformers.**

1 Points

Additional:

Additional points can be obtained by providing all oil type transformers with BEE 5 star rating.

5 Points

Point System Method

6 – Indoor Lightings (12 Points)

Minimum:

All the lighting fixtures shall have lamps with luminous efficacy of minimum 85 lm/W installed in all bedrooms, hall and kitchen.

4 Points

Additional:

Additional points for indoor lighting by installing all lighting fixtures in all bedrooms, hall and kitchen shall have lamps luminous efficacy as per following:

- i. 95 lm/w (3 Points)
- ii. 105 lm/W (8 Points)

Upto 8 Points

Point System Method

7 – Comfort Systems (50 Points) – Ceiling Fans

Minimum:

- i. All ceiling fans installed in all the bedrooms and hall in all the dwelling units shall have a service value as given below:
 - For sweep size <1200 mm: equal or greater than 4 m³/minute·Watt
 - For sweep size >1200 mm: equal or greater than 5 m³/minute·Watt
- i. BEE Standards and Labeling requirements for ceiling fans shall take precedence over the current minimum requirement, as and when it is notified as mandatory. 6 Points

Additional:

Additional points for ceiling fans by installing in all the bedrooms and hall in all the dwelling units as per following:

- i. 4 Star 1 Points
- ii. 5 Star 3 Points

Point System Method

Weighted Average of different Comfort Systems installed in a building allowed for better flexibility (Points Achieved for AC)

Minimum:

- | | |
|---------------------------------|------------------|
| i. Unitary Type: 5 Star | |
| ii. Split AC: 3 Star | |
| iii. VRF: 3.28 EER | 20 Points |
| iv. Chiller: Minimum ECBC Level | |

Additional 9 points for :

- | | |
|--|-----------------|
| i. Split AC: 4 Star | |
| ii. VRF: Not Applicable as on date, however, whenever Star labelling of BEE is launched, Star 4 will be applicable | 9 Points |
| iii. Chiller: Minimum ECBC+ Level as mentioned in ECBC 2017 | |

Additional 21 points for :

- | | |
|--|------------------|
| i. Split AC: 5 Star | |
| ii. VRF: Not Applicable as on date, however, whenever Star labelling of BEE is launched, Star 5 will be applicable | 21 Points |
| iii. Chiller: Minimum SuperECBC Level as mentioned in ECBC 2017 | |

Point System Method

8 – Solar Water Heating (10 Points)

Minimum:

The ENS compliant building shall provide a solar water heating system (SWH) of minimum BEE 3Star label and is capable of meeting 100% of the annual hot water demand of top 4 floors of the residential building.

or

100% of the annual hot water demand of top 4 floors of the residential building is met by the system using heat recovery

5 Points

Additional:

Additional points can be obtained by installing SWH system as per as per following:

- i. 100% of the annual hot water demand of top 6 floors of the residential building (2 points)
- ii. 100% of the annual hot water demand of top 8 floors of the residential building (5 points)

Upto 5 Points

Point System Method

9 – Solar Photo Voltaic (10 Points)

Minimum:

The ENS compliant building shall provide a dedicated Renewable Energy Generation Zone (REGZ) –

- Equivalent to a minimum of 2 kWh/m².year of electricity; or
- Equivalent to at least 20% of roof area.

5 Points

The REGZ shall be free of any obstructions within its boundaries and from shadows cast by objects adjacent to the zone.

Additional:

Additional points can be obtained by installing solar photo voltaic as per following:

- i. Equivalent to a minimum of 3 kWh/m².year of electricity or Equivalent to at least 30% of roof area (2 points)
- ii. Equivalent to a minimum of 4 kWh/m².year of electricity or Equivalent to at least 40% of roof area (5 points)

Upto 5 Points



Ministry of Housing
and Urban Affairs
Government of India



Group Exercise

DAY 2

Tea Break

DAY 2

Session 6



6-A

ENS

COMPLIANCE TOOLS

Introduction

- Quick design and compliance checks benchmarks of ECONIWAS SAMHITA.
- 5 key features in consideration:
 1. User friendliness
 2. Responsiveness
 3. Adaptability
 4. Dynamism
 5. Resourcefulness.
- Compliance for Both Prescriptive and Points Based Systems.
- Categories included:
 1. High rise
 2. Low Rise
 3. Affordable
 4. Mixed Use

ECO-NIWAS SAMHITA COMPLIANCE TOOL

Ministry of Power, Government of India

File Help

▼ Demo Building TEST (Demo Building)

- ▶ Affordable High-Rise TEST (Affordable High-Rise)
- ▶ Low Rise TEST (Low Rise)
- ▶ High Rise TEST (High Rise)

Project Name: Demo Building State: Chandigarh

City: Chandigarh Climate: COMPOSITE

Latitude: >= 23.5° N

Project Construction Type: New Building Housing Category: High Rise

Plot Area (m²): 1500.0 Total no. of Residential Blocks: 5

Compliance Method Used: Points System Prescriptive System

Buttons: Add Category, Project Relocate

S.No.	Housing Category	Plot Area (m²)	Total Residential ...
1	Affordable High-Rise	10000	10
2	Low Rise	1000	1
3	High Rise	1500	5

Upload Siteplan

Legend: HOTDRY, WARM HUMID, COMPOSITE, TEMPERATE, COLD

Climate zones of India: Composite Does not have a predominant season for more than six months

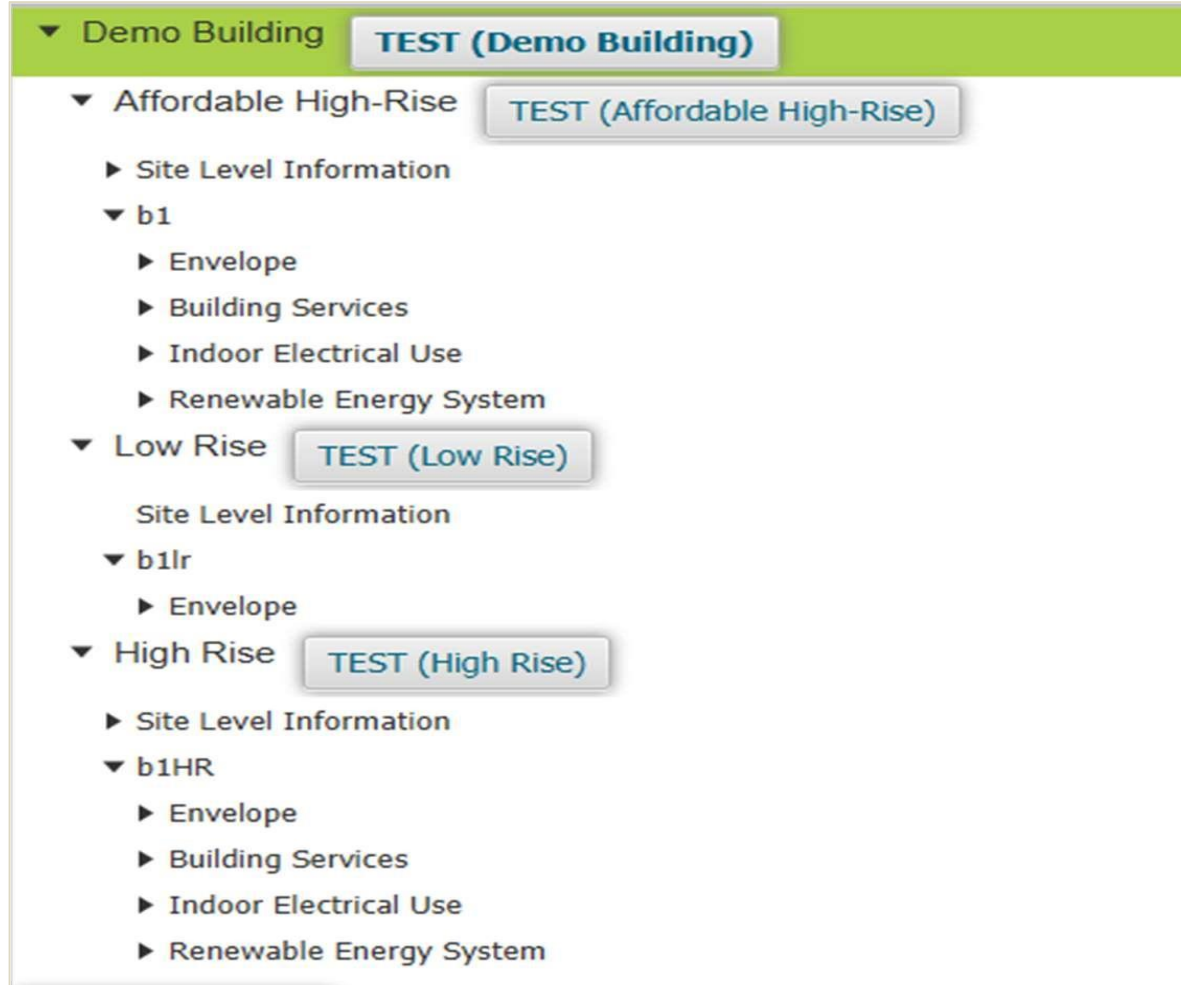
HELP!

- ▶ Project Construction type for compliance check
- ▶ ENS Code Purpose & Applicability
- ▶ Project Construction Type
- ▶ ENS Compliance Criteria
- ▶ Plot Area
- ▶ Housing Category
- ▶ Total no. of Residential Blocks

Total No. of Block: 16

ENS Compliance Tools Key Features

- Easy to navigate tree-view structure



ENS Compliance Tools Key Features

- Project relocation feature for multiple domain use

Project Name	Demo Building	State	New Delhi
City	New Delhi	Climate	COMPOSITE
Latitude	>= 23.5° N		
Project Construction Type	New Building	Housing Category	Affordable ...
Plot Area (m ²)	10000	Total no. of Residential Blocks	10
Compliance Method Used	<input type="radio"/> Points System	<input type="radio"/> Prescriptive System	
		Add Category	Project Relocate

ENS Compliance Tools Key Features

- Segregated site level & block level inputs for ease in information flow

The screenshot shows a hierarchical menu for a 'Demo Building' project. The main category is 'TEST (Demo Building)'. Underneath, there are several sub-categories, each with its own 'TEST' button:

- Affordable High-Rise (TEST (Affordable High-Rise))
 - Site Level Information
 - Basement Lighting
 - Exterior Lighting
 - Pumps
 - Diesel Generator Set
 - Power Factor
 - Energy Monitoring
 - EV Supply Equipment
 - Transformer
 - Power Distribution Loss
 - Solar Photovoltaic System
 - b1
 - Envelope
 - Building Services
 - Indoor Electrical Use
 - Renewable Energy System
 - Low Rise (TEST (Low Rise))
 - High Rise (TEST (High Rise))

- Comprehensive help panel on each form for easy user referencing

The 'HELP!' panel provides information on climate zones and project construction types. It includes a table for orientation ranges and a compass diagram for angle measurement.

Orientation	Range (0° being north and 90° being east)
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°

The diagram below the table shows a compass rose with angles measured clockwise from North. The angles are: North (0°), North East (67.5°), East (112.5°), South East (157.5°), South (202.5°), South West (247.5°), West (292.5°), and North West (337.5°). A note indicates: 'Angle measurement in clockwise direction from North'.

Below the diagram, there is a list of help topics:

- ENS Code Purpose & Applicability
- Project Construction Type
- ENS Compliance Criteria
- Plot Area
- Housing Category
- Total no. of Residential Blocks

ENS Compliance Tools Key Features

- Component level display for mandatory provisions and points achieved

The screenshot displays the 'Energy Monitoring' configuration page in the ENS Compliance Tools. The left sidebar shows a tree view with 'Energy Monitoring' selected. The main panel includes sections for 'Energy Monitoring' (Availability: Yes, Energy MeteringType: Select), 'Meter Segregted Recording For:' (radio buttons for Basement Lighting, Corridor Lighting, Outdoor Lighting, Power Backup Generation, Elevators, RE Generation, Lift System, Car Park Vent System, Water Pumps), 'Reporting Frequency:' (radio buttons for Hourly, Daily, Monthly, Annually), and 'Data Retaining Capability of DCS/EMIS (Year/s)'. Below these is a table with columns for S.No., Energy Metering, Basement Li..., Corridor Li..., Power BackUp Gen..., Outdoor Light, Elevator, Car Park..., and Wa. The first row shows S.No. 1, Energy Metering Smart, and checkmarks for Basement Li..., Corridor Li..., Power BackUp Gen..., Outdoor Light, Elevator, and Car Park... At the bottom, a red box highlights the 'Mandatory Compliance' status, which is 'Achieved'.

S.No.	Energy Metering ...	Basement Li...	Corridor Li...	Power BackUp Gen...	Outdoor Light	Elevator	Car Park...	Wa
1	Smart	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	

ENS Compliance Tools Key Features

Eco-Niwas Samhita Compliance Result

Affordable High-Rise | Low Rise | High Rise

Envelope | Building Services | Indoor Electrical Use | Renewable Energy | Final Result

	Point Achieved	Total Points
Building Envelope	50	87
Building Services	47	51
Indoor Electric Use	47	62
Renewable Energy System	12	20

Total Points Achieved: 156
Total Maximum Points: 220

Compliant

Generate Report

- Consolidated result display for individual housing category at project level & housing category level including compliance status

ENS Compliance Tools Key Features

- Provisions for PDF output reporting for each input and corresponding output

The screenshot shows a window with the following summary statistics:

- Total Points Achieved: 156
- Total Maximum Points: 220
- Compliant

A red box highlights the **Generate Report** button at the bottom right of the interface.

Eco-Niwas Samhita: Compliance Check Report

ECO-NIWAS SAMHITA (ENS) COMPLIANCE EVALUATION REPORT

Project Information

Project Name	Demo Building
State	Chandigarh
City	Chandigarh
Climate	COMPOSITE
Latitude	>= 23.5° N
Building Construction Type	New Building
Compliance Method Used	Point System

Housing Category Information

Housing Category	Plot Area(m ²)	Total No. of Residential Blocks	Total Basement Area(m ²)	Total Exterior Light Area(m ²)	Total Roof Area(m ²)
Affordable High-Rise	10000	10	1000.0	1000.0	1000.0
Low Rise	1000	1	1000.0	1000.0	1000.0
High Rise	1500	5	100.0	100.0	100.0

Eco-Niwas Samhita: Compliance Check Report

Consolidated Compliance Status of the Project:

S.No.	Housing Categories	Total Points	Maximum Points	Minimum Points	Compliance Status
1	Affordable High-Rise	156	220	70	Compliant
2	Low Rise	53	87	47	Compliant
3	High Rise	82	220	100	Non Compliant

Eco-Niwas Samhita: Compliance Check Report

1. Affordable High-Rise : Compliance Result

1.1. Building Envelope:

S.No.	Component	Mandatory Requirements	Calculated value	Points Achieved	Maximum Points
1	RET(V/W/m ² K)	NA	14.59	44	80
2	U-Value Roof(W/m ² K)	NA	0.53	6	7
3	WFRop	Achieved	32.0	NA	NA
4	VLT %	Achieved	60.0	NA	NA

1.2. Building Services:

S.No.	Component	Mandatory Requirements	Calculated value	Points Achieved	Maximum Points
1	Exterior Lighting	NA	--	3	3
2	Basement Lighting	NA	--	2	3
3	Corridor Lighting	NA	--	3	3
4	Lift	NA	--	22	22
5	Pump	NA	--	11	14
6	Diesel Generator Sets	Achieved	--	NA	NA
7	Power Factor Correction	Achieved	--	NA	NA
8	Energy Monitoring System	Achieved	--	NA	NA
9	Electric Vehicle Supply Equipment	Achieved	--	NA	NA
10	Transformer	NA	--	6	6
11	Power Distribution Loss	Achieved	--	NA	NA
12	Car Parking Basement Ventilation	Achieved	--	NA	NA

1.3. Indoor Electrical End Use:

S.No.	Component	Mandatory Requirements	Calculated value	Points Achieved	Maximum Points
1	Indoor Lighting	NA	--	12	12
2	Ceiling Fan	NA	--	7	9
3	Cooling Equipment	NA	--	28	41

1.4. Renewable Energy System:

S.No.	Component	Mandatory Requirements	Calculated value	Points Achieved	Maximum Points
1	Solar Hot Water Requirements	NA	--	7	10
2	Solar Photovoltaic System	NA	--	5	10



6-B

THERMAL COMFORT
ANALYSIS

Thermal Comfort Analysis



12

AFFORDABLE HOUSING PROJECT RECOMMENDATIONS

Recommendations

Proper orientation of Buildings, this reduce the impact of unfavorable weather conditions like solar radiation, driving rain and thunderstorm

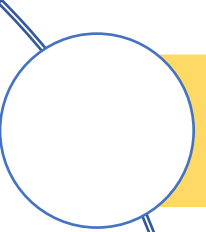
Proper Ventilation – Proper positioning the windows and opening them create air movement in the house. Walls and vegetation should not be too close to the building in order to avoid diversion of wind away from the openings, thereby reducing air flow within the building. If possible, the rooms should be cross ventilated.

Using Shading Device – use of overhangs or horizontal projections over windows. Double pane windows with tinted glass and glass coated with reflective film should be used for windows instead of steels, wood and zincs.

Creation of Microclimate – trees can be planted to create micro – climate that is, small-scale climatic condition at a spot or area or site

Preventing Infiltration – Infiltration can be prevented by sealing the sites of air leaks. This can be achieved by caulking, weatherizing, good workmanship, and replacing some aged parts of buildings, etc.

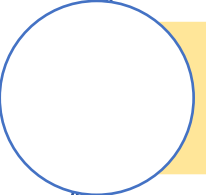
Recommendations



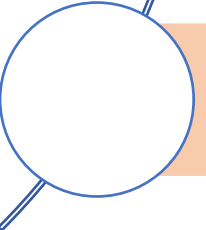
To align with GHG reduction targets and other government activities, make "Thermal Comfort for All" a government priority, and relate it to India's ambition to give a better quality of life to all of its residents.



Create market momentum for smart cooling through public awareness campaigns, information access, and technical support.



Consistent testing and rating processes, as well as market communication initiatives, can help to mainstream the use of energy efficient building materials and equipment.



Take significant steps to phase out HFCs and encourage the industry to switch to renewable refrigerants.

DAY 2

Lunch Break

DAY 2

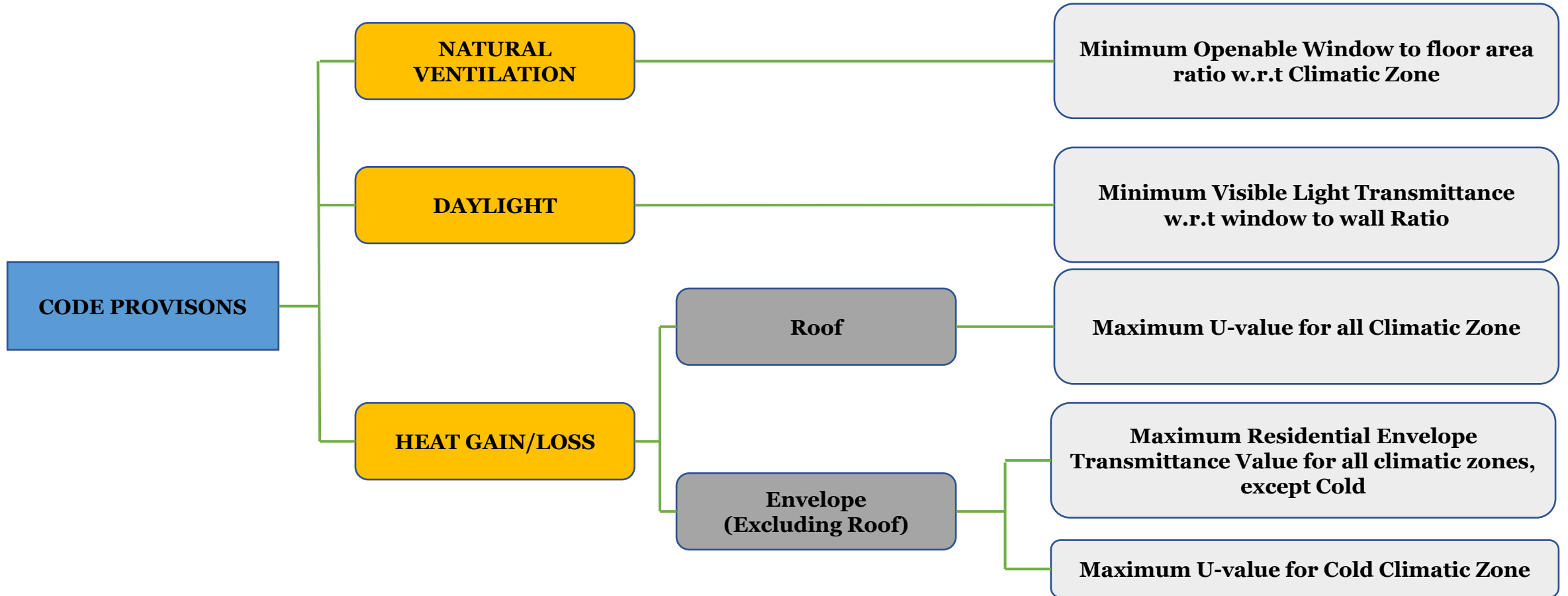
Session 7



7

ENS
2018

Code Provisions by Eco Niwas Samitha for Thermal Comfort in Affordable Housing



SR.NO.	CODE PROVISIONS
1	Openable Window to Floor Area Ratio
2	Visible Light Transmission
3	Thermal Transmittance of Roof
4	Residential Envelope Transmittance Value for Building Envelope (Except Roof) for four Climate Zones, namely, Composite Climate, Hot-Dry Climate, Warm-Humid Climate, and Temperature Climate
5	Thermal Transmittance of Building Envelop (Except Roof) for Cold Climate

Openable window to floor area ratio (wfr):

Openable window-to-floor area ratio (WFR) indicates the potential of using external air for ventilation. Ensuring minimum WFR helps in ventilation, improvement in thermal comfort, and reduction in cooling energy

The openable window-to-floor area ratio (WFR) shall not be less than the values given in Table. (Source Adapted from Bureau of Indian Standards (BIS). 2016. National Building Code of India 2016. New Delhi: BIS.)

Climatic Zone	Minimum WFR
Composite	12.50
Hot-Dry	10.00
Warm-Humid	16.66
Temperature	12.50
Cold	8.33

Openable window to floor area ratio (wfr):

EQUATION FOR WFR

$$WFR = \frac{A_{openable}}{A_{carpet}}$$

Where,

WFR	Openable Window to Floor Area Ratio
$A_{Openable}$	Openable area (m ²); it includes the openable area of all windows and ventilators, opening directly to the external air, an open balcony, ‘verandah’, corridor or shaft; and the openable area of the doors opening directly into an open balcony. Exclusions: All doors opening into corridors. External doors on ground floor, for example, ground-floor entrance doors or back-yard doors.
A_{Carpet}	carpet area of dwelling units; it is the net usable floor area of a dwelling unit, excluding the area covered by the external walls, areas under services shafts, exclusive balcony or verandah area and exclusive open terrace area, but includes the area covered by the internal partition walls of the dwelling unit

VISIBLE LIGHT TRANSMITTANCE (VLT):

Visible light transmittance (VLT) of non-opaque building envelope components (transparent/translucent panels in windows, doors, ventilators, etc.), indicates the potential of using daylight. Ensuring minimum VLT helps in improving day lighting, thereby reducing the energy required for artificial lighting

The VLT requirement is applicable as per the window-to-wall ratio (WWR) of the building. WWR is the ratio of the area of non-opaque building envelope components of dwelling units to the envelope area (excluding roof) of dwelling units.

EQUATION FOR VLT

$$WWR = \frac{A_{non_opaque}}{A_{envelope}}$$

VISIBLE LIGHT TRANSMITTANCE (VLT):

MINIMUM VISIBLE LIGHT TRANSMITTANCE (VLT) REQUIREMENT:

The glass used in non-opaque building envelope components (transparent/translucent panels in windows, doors, etc.) shall comply with the requirements given in Table .(Source Bureau of Indian Standards (BIS). 2016. National Building Code of India 2016. New Delhi: BIS)

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

THERMAL TRANSMITTANCE OF ROOF - U_{roof} :

Thermal transmittance (U_{roof}) characterizes the thermal performance of the roof of a building. Limiting the U_{roof} helps in reducing heat gains or losses from the roof, thereby improving the thermal comfort and reducing the energy required for cooling or heating.

Thermal transmittance of roof shall comply with the maximum U_{roof} value of 1.2 W/m² K.

THERMAL TRANSMITTANCE OF ROOF - U_{roof} :

EQUATION FOR U_{roof} :

$$U_{\text{roof}} = \frac{1}{A_{\text{roof}}} \sum_{i=0}^n (U_i \times A_i)$$

U_{roof}

Thermal Transmittance of Roof (W/M².K)

A_{roof}

Total Area of the Roof (m²)

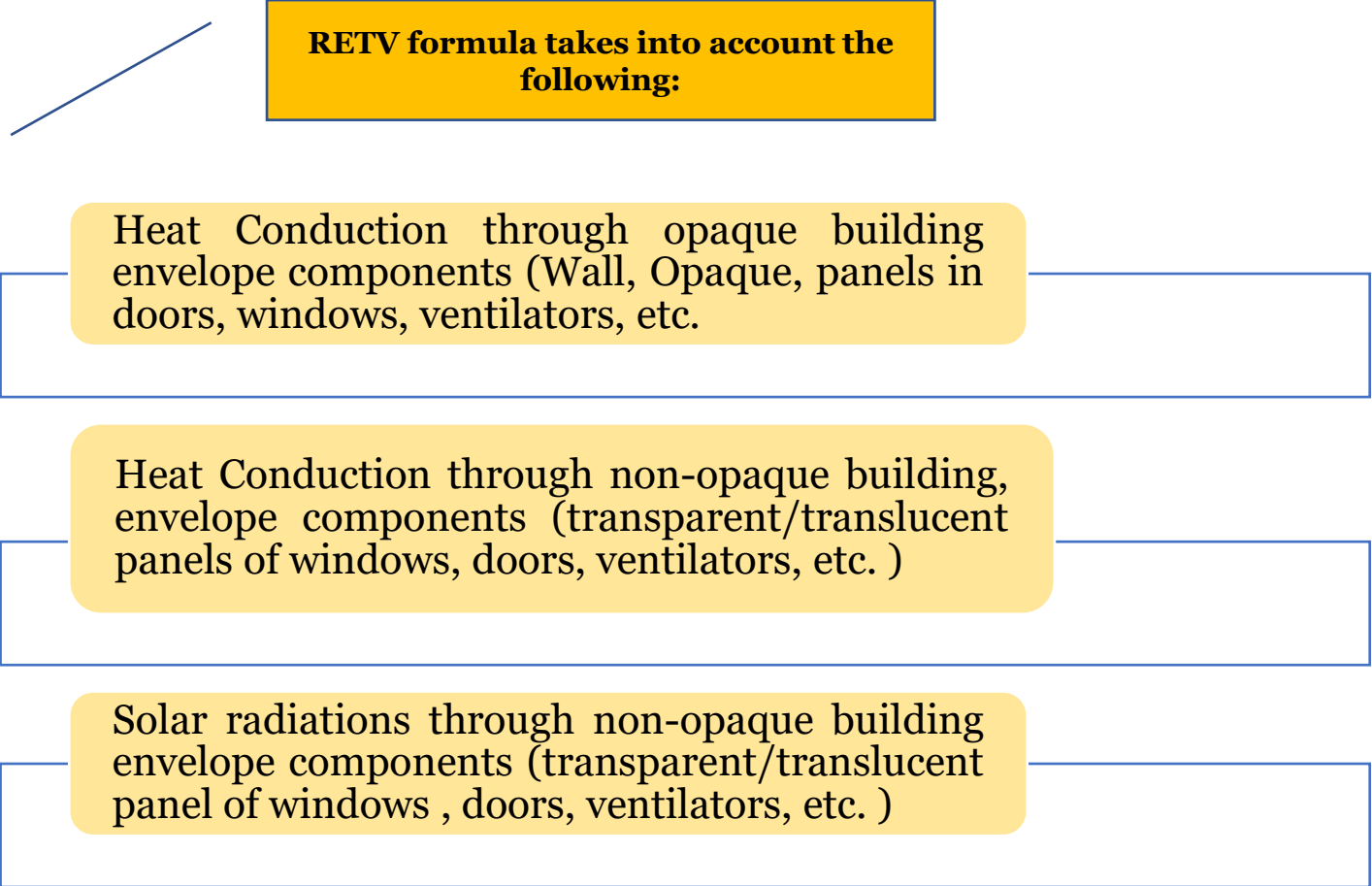
U_i

Thermal Transmittance values of different roof constructions (W/m² .K)

A_i

Areas of different Roof Constructions (m²)

RESIDENTIAL ENVELOPE TRANSMITTANCE VALUE FOR BUILDING ENVELOPE (EXCEPT ROOF):



Residential envelope heat transmittance (RETV) is the net heat gain rate (over the cooling period) through the building envelope (excluding roof) of the dwelling units divided by the area of the building envelope (excluding roof) of the dwelling units. Its unit is W/m^2 .

RESIDENTIAL ENVELOPE TRANSMITTANCE VALUE FOR BUILDING ENVELOPE (EXCEPT ROOF):

$$RET_{TV} = \frac{1}{A_{envelope}} \times \left[\{a \times \sum_{i=1}^n (A_{opaque} \times U_{opaque} \times \omega_i)\} + \{b \times \sum_{i=1}^n (A_{non_opaque} \times U_{non_opaque} \times \omega_i)\} + \{c \times \sum_{i=1}^n A_{non_opaque} \times SHGC_{eq} \times \omega_i\} \right]$$

RESIDENTIAL ENVELOPE TRANSMITTANCE VALUE FOR BUILDING ENVELOPE (EXCEPT ROOF):

RETV EQUATIONS TERMS

A_{envelope}	envelope area (excluding roof) of dwelling units (m^2). It is the gross external wall area (includes the area of the walls and the openings such as windows and doors).
A_{opaque}	areas of different opaque building envelope components (m^2)
U_{opaque}	thermal transmittance values of different opaque building envelope components ($\text{W}/\text{m}^2 \cdot \text{K}$)
$A_{\text{non-opaque}}$	areas of different non-opaque building envelope components (m^2)
$U_{\text{non-opaque}}$	thermal transmittance values of different non-opaque building envelope components ($\text{W}/\text{m}^2 \cdot \text{K}$)
SHGC_{eq}	equivalent solar heat gain coefficient values of different non-opaque building envelope components
ω_1	orientation factor of respective opaque and non-opaque building envelope components; it is a measure of the amount of direct and diffused solar radiation that is received on the vertical surface in a specific orientation

RESIDENTIAL ENVELOPE TRANSMITTANCE VALUE FOR BUILDING ENVELOPE (EXCEPT ROOF):

The coefficients of RETV formula, for different climate zones, are given in Table

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
Temperature	3.38	0.37	63.69
Cold	Not Applicable for RETV		

THERMAL TRANSMITTANCE OF BUILDING ENVELOPE:

$U_{\text{envelope,cold}}$ takes into account the following

Thermal transmittance $U_{\text{envelope,cold}}$ characterizes the thermal performance of the building envelope (except roof). Limiting the $U_{\text{envelope,cold}}$ helps in reducing heat losses from the building envelope, thereby improving the thermal comfort and reducing the energy required for heating

Heat Conduction through opaque building envelope components (Wall, Opaque, panels in doors, windows, ventilators, etc.

Heat Conduction through non-opaque building, envelope components (transparent/translucent panels of windows, doors, ventilators, etc.)

THERMAL TRANSMITTANCE OF BUILDING ENVELOPE:

The Thermal transmittance of the building envelope (except roof) for cold climate shall comply with the maximum of 1.8 W/m² .K

U_{envelope,cold} thermal transmittance of building envelope (except roof) for cold climate (W/m² .K)

EQUATION FOR
U_{envelope,cold}:

$$\frac{1}{A_{envelope}} \sum_{i=1}^n (U_i \times A_i)$$

A _{envelope}	envelope area (excluding roof) of dwelling units (m ²). It is the gross external wall area (includes the area of the walls and the openings such as windows and doors)
U _i	thermal transmittance of different opaque and non-opaque building envelope components (W/m ² .K)
A _i	area of different opaque and non-opaque opaque building envelope components (m ²)

DAY 2

Tea Break

DAY 2

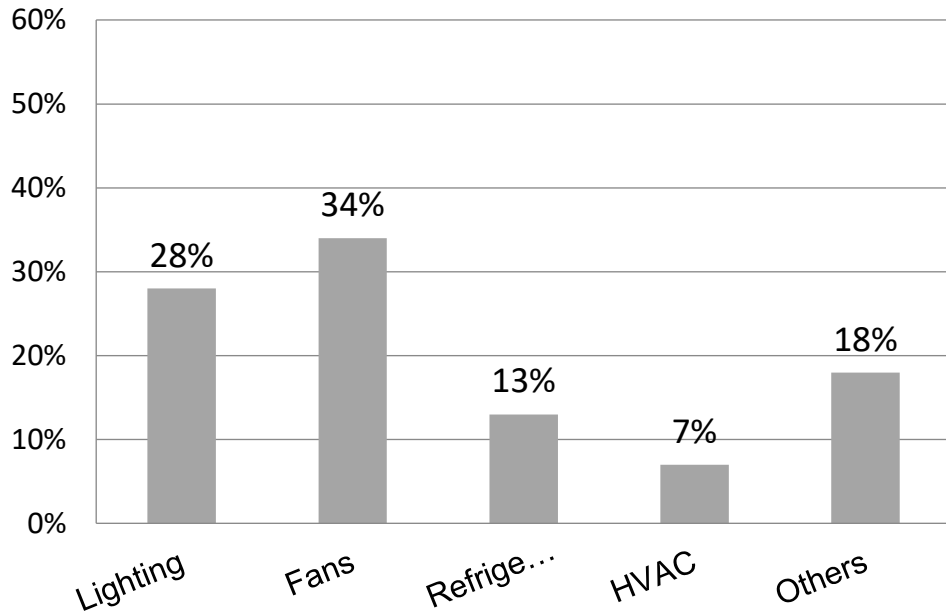
Session 8



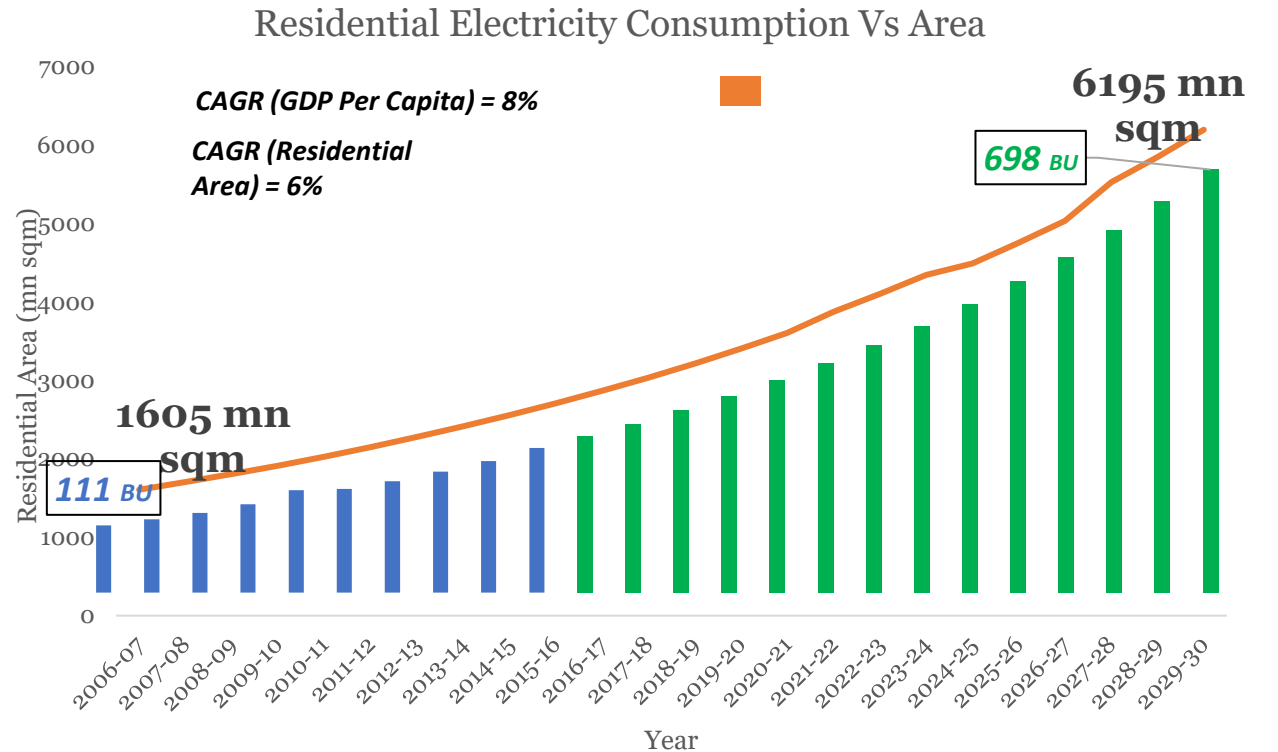
8-A

ENERGY EFFICIENCY LABEL FOR RESIDENTIAL BUILDINGS

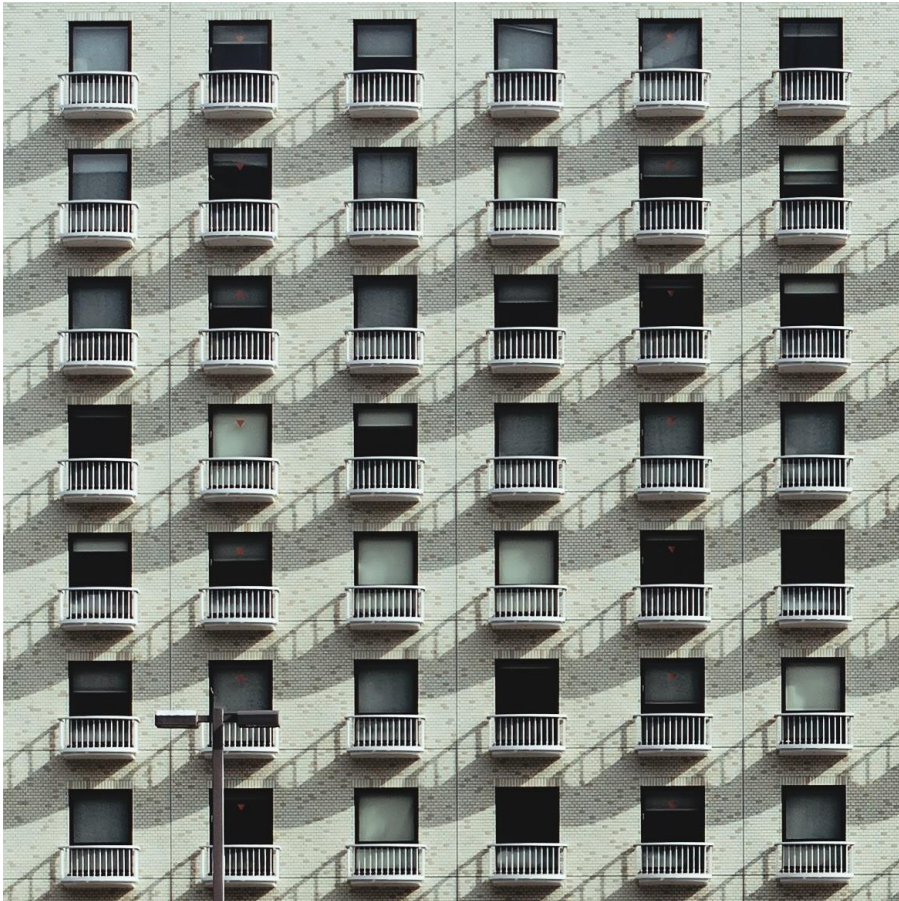
ELECTRICITY CONSUMPTION IN RESIDENTIAL BUILDINGS



Source: Energy Statistics 2018



Estimated Savings in Residential Buildings



Energy savings in BU (considering 2018-19 as base year)		
Year	Savings (BU)	CO2 million tonnes
2019-20	4.9	4.0
2020-21	3.1	2.5
2021-22	7.6	6.2
2022-23	12.1	9.9
2023-24	19.5	16.0
2024-25	28.8	23.6
2025-26	43.3	35.5
2026-27	45.8	37.6
2027-28	55.8	45.8
2028-29	69.6	57.1
2029-30	82.0	67.2
TOTAL	372.5	305.5

Scope & type of labelling Program

Energy Efficiency Label for Residential Buildings

'Applied For' Label

'Final' Label



New Residences

Existing Residences

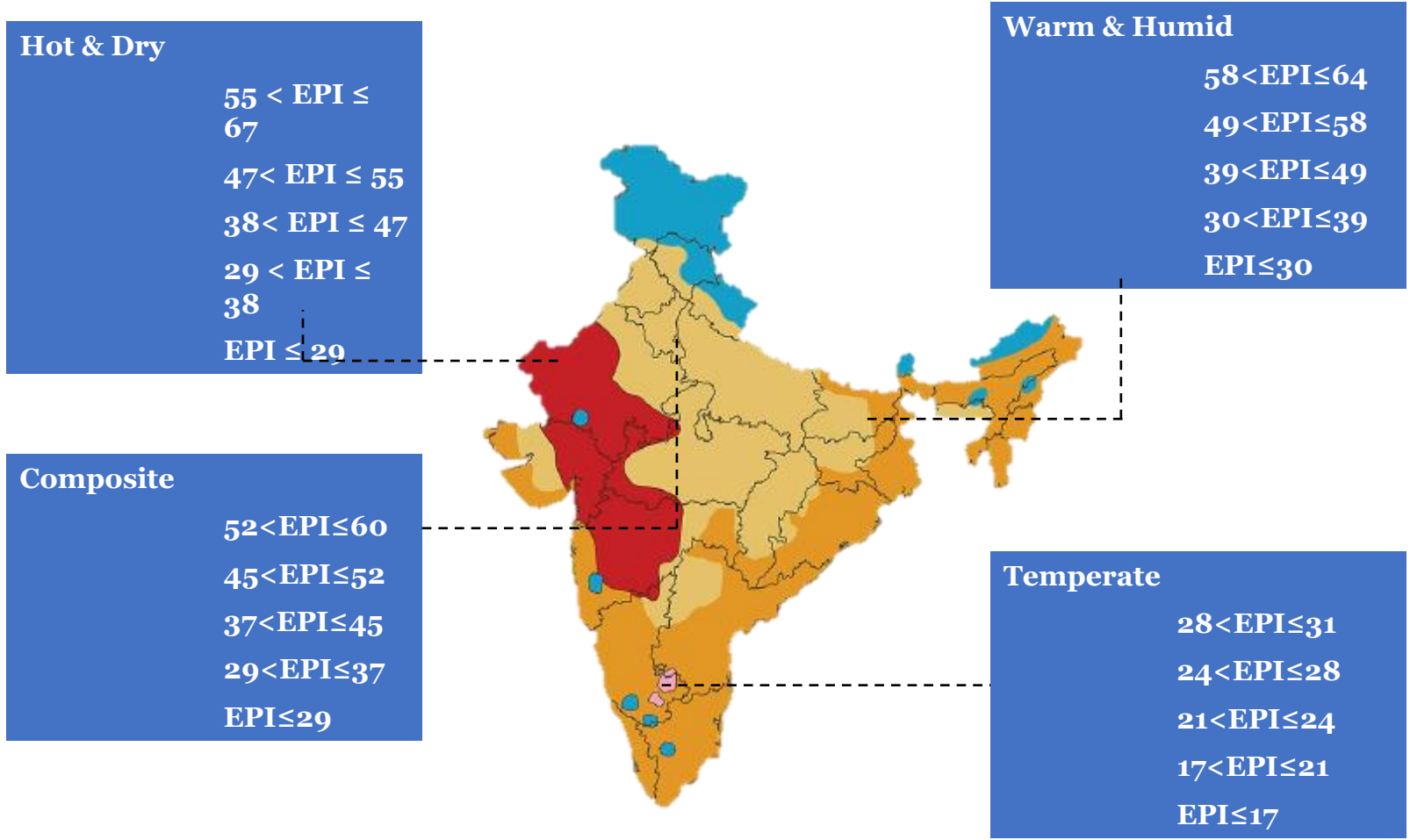
EE Label for Res Buildings

Label Criteria

There is **no minimum requirement** with respect to Area or Connected load (kW) for a dwelling unit to be covered under this labeling program.

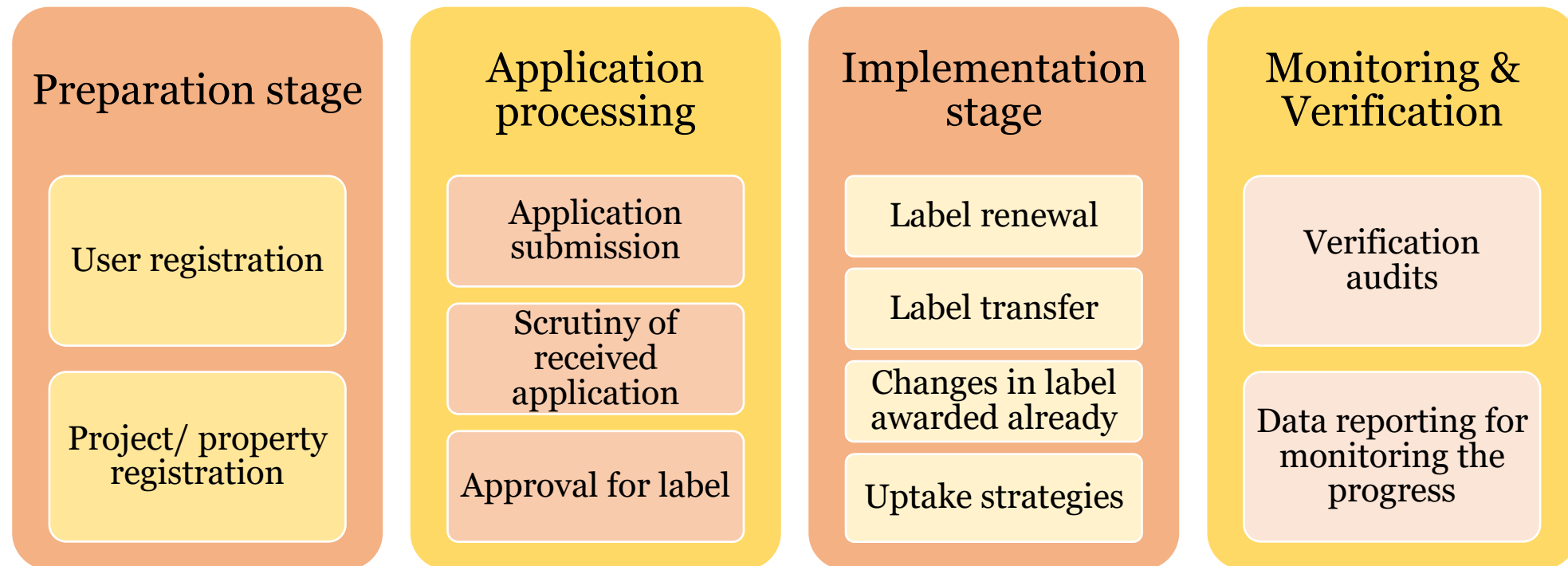
- ✓ Star Rating awarded in the basis on EPI (**Energy Performance Index**)
- ✓ Energy Performance Index = Annual Energy Consumption (kWh)/Built up area (m²)
- ✓ BEE has prepared an **online platform** for the User of Label to apply for seeking an award of label under this program
- ✓ The online platform consists of a **Simulation-Based Tool** that will calculate the EPI of respective dwelling unit

Residential Building Star Rating Plan



Outline of the process for awarding BEE Star Label

- BEE Star Label for Residential Building:
- Applied For Label (specifically for developers or under construction residential buildings – Voluntary)
- Final Asset Label



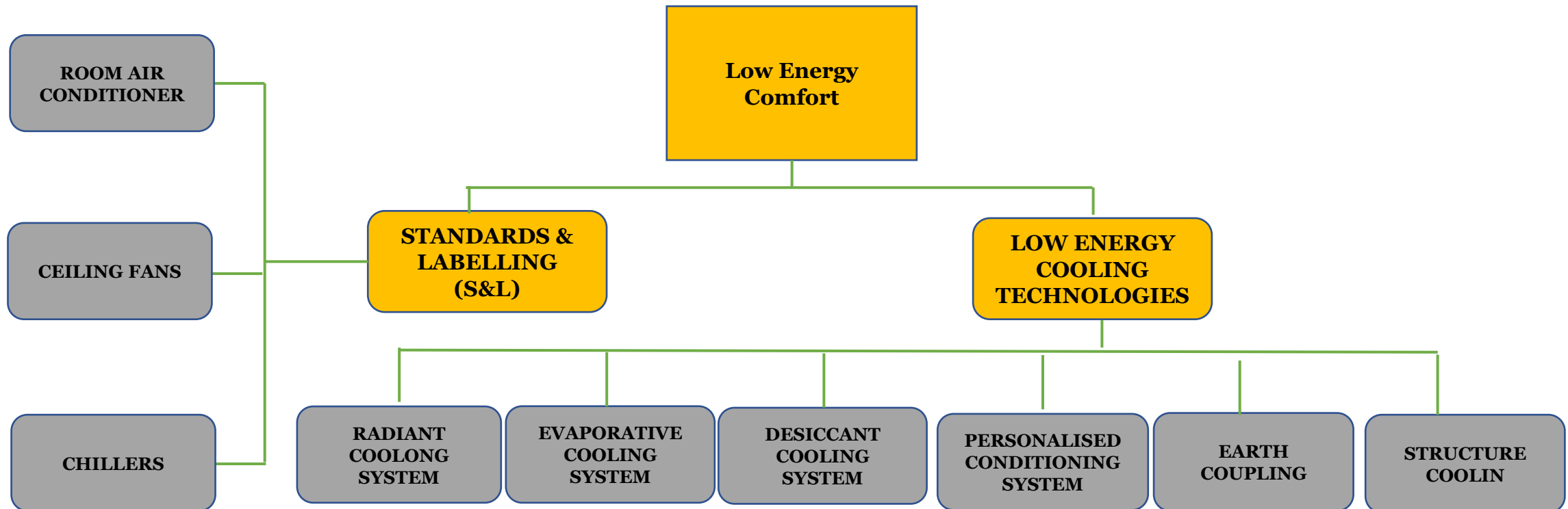


15

LOW ENERGY COMFORT SYSTEM IN

HOUSING

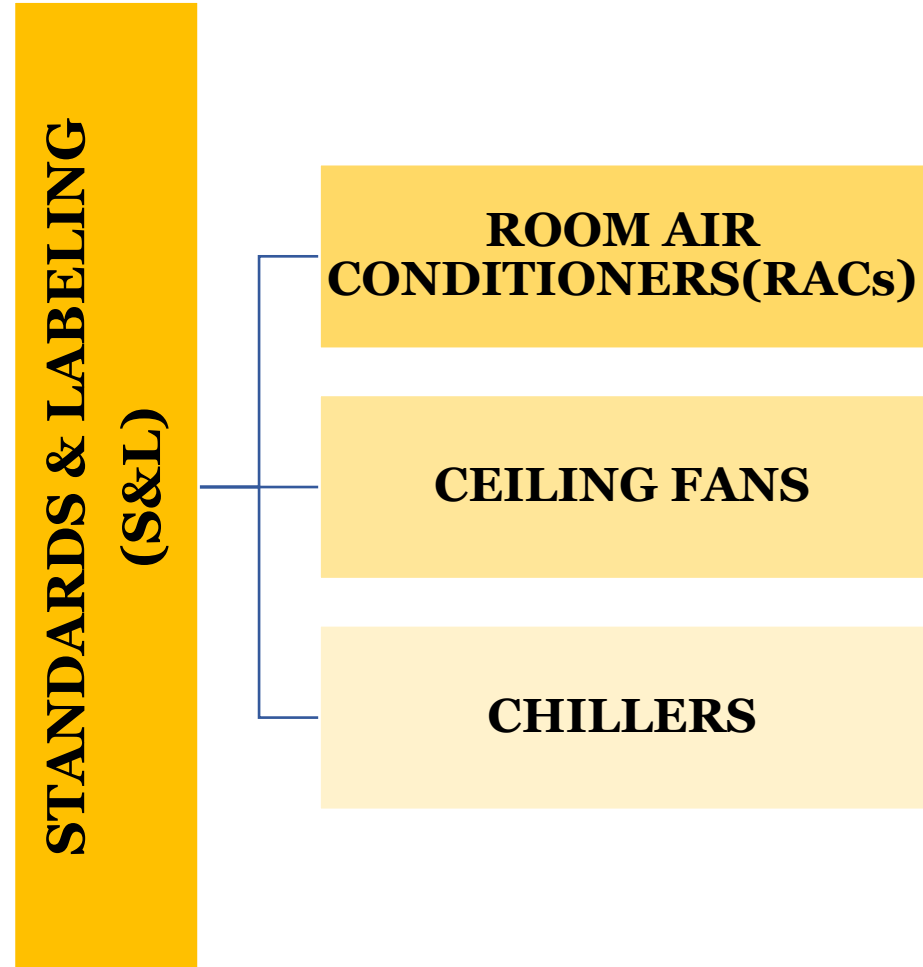
Low Energy Comfort System in Housing



Standards & Labeling (S&L)

S&L assists consumers in making educated decisions about appliance energy usage and promotes the market penetration of energy efficient appliances and equipment. BEE established the S&L program in 2006.

RACs are the only space cooling appliance under the mandatory labeling scheme. Ceiling fans and variable speed ACs are under the voluntary labeling scheme.



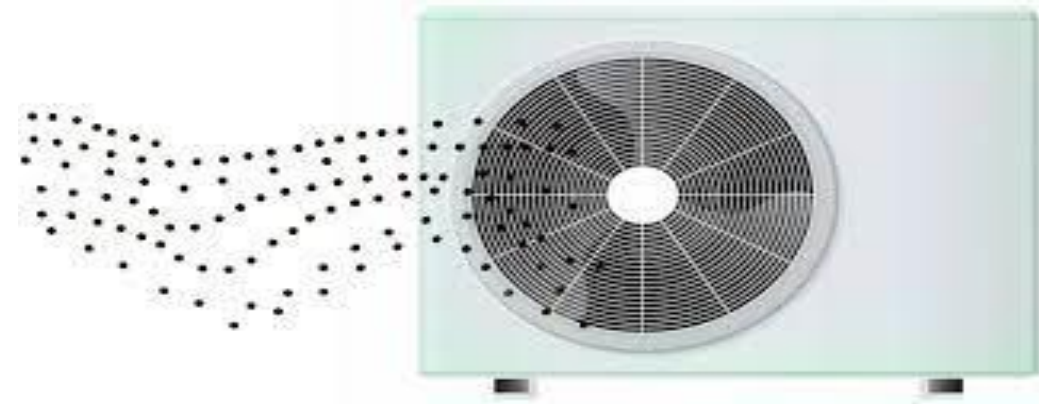
Standards & Labeling (S&L)

1 - ROOM AIR CONDITIONERS (RACs):

For variable capacity (inverter type) ACs, BEE established a new star grading technique called the Indian Seasonal Energy Efficiency Ratio (ISEER) in 2015.

This metric, which is based on the ISO-16358 standard with revisions to account for India's higher outdoor temperature ranges, will be used instead of the Energy Efficiency Ratio (EER).

ISEER takes into account the range of temperatures in Indian climate zones throughout the year to produce a more realistic estimate of cooling efficiency for the full year.



Standards & Labeling (S&L)

BEE star rating levels for inverter ACs effective from June 2015 through December 2019 (BEE, 2015)

STAR RATING	MINIMUM ISEER	MAXIMUM ISEER
1 – Star	3.10	3.29
2 – Star	3.30	3.49
3 – Star	3.50	3.99
4 – Star	4.00	4.49
5 – Star	4.50	-

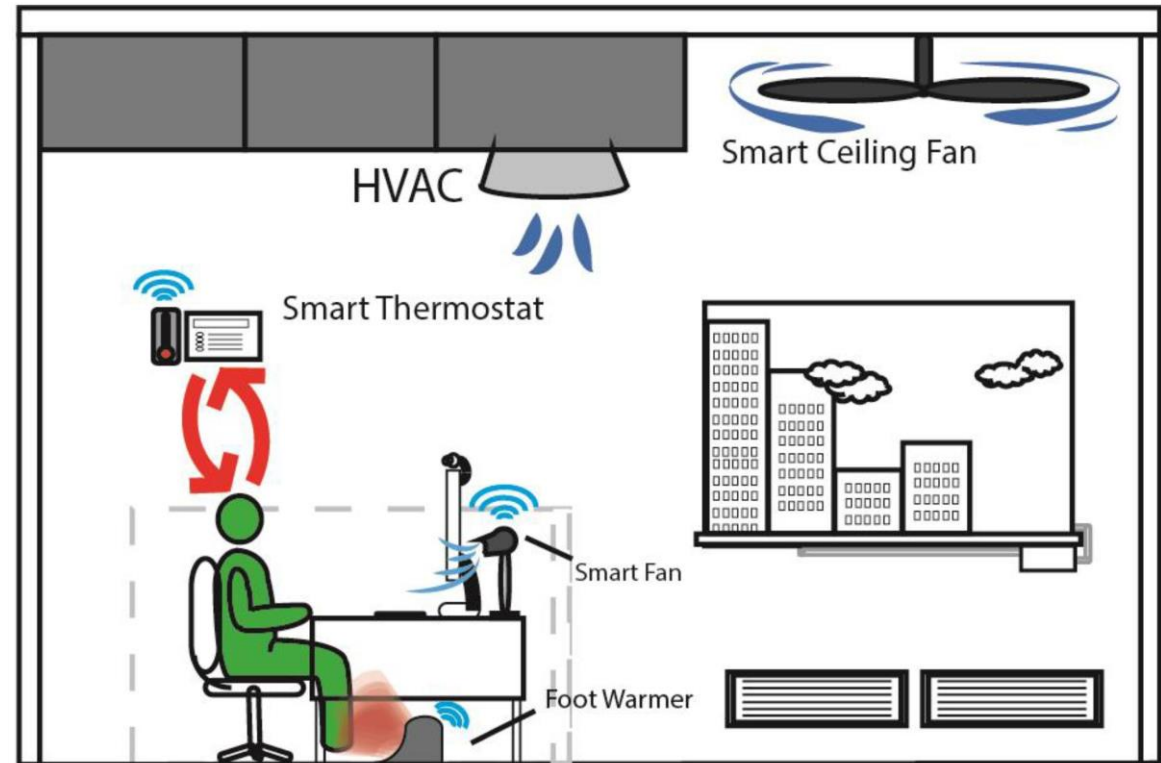
Standards & Labeling (S&L)

2 - CELING FANS:

Ceiling fans consumed 6% of the energy consumed by residential buildings in 2000, and are predicted to consume 9% by 2020 due to an increase in the number of ceiling fans installed.

Fan effectiveness, rather than efficiency, is a phrase used to describe the volume of air provided per minute per unit of power ($m^3 / \text{minute}/W$) delivered by a ceiling fan.

Both the BIS and the BEE give ratings to fans.



Standards & Labeling (S&L)

3 - CHILLERS:

ECBC (version 2) sets minimum chiller performance efficiency based on Air-conditioning, Heating, and Refrigeration Institute (AHRI) standards that provide test circumstances more reflective of climate in the United States and Europe.

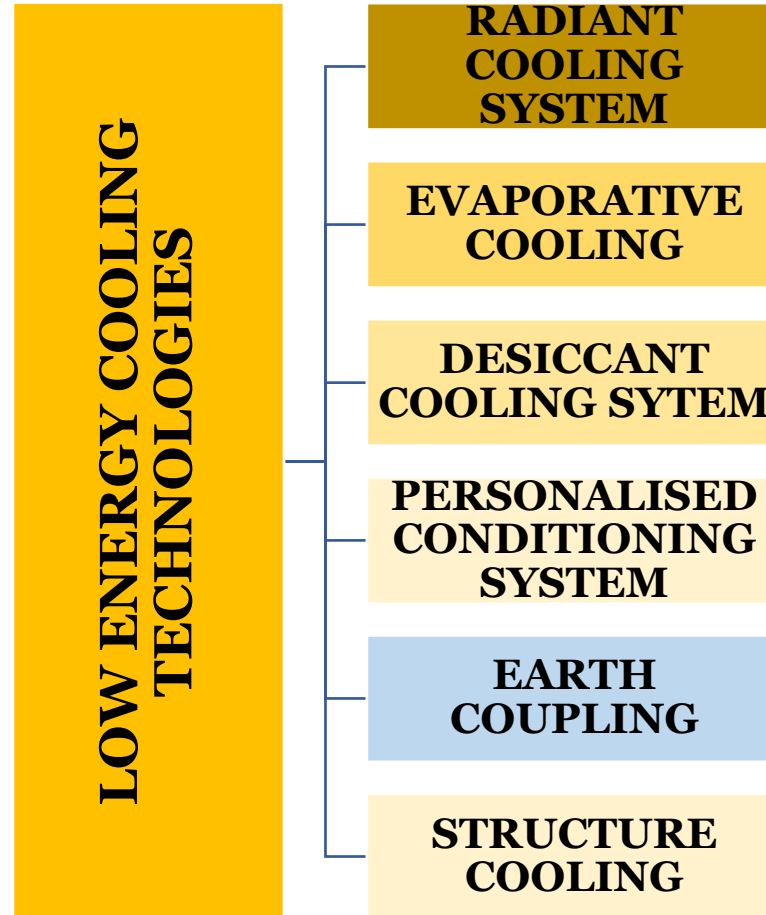
Recognizing the significance of the chiller standard, the ISHRAE has undertaken the responsibility of designing chiller test conditions. The standard, created collaboratively by ISHRAE and the RAMA, establishes a new set of rating and performance testing parameters (temperature, part load weightages, and fouling conditions) for both air and water cooled chillers.

ISHRAE has also created a standard for evaluating and testing variable refrigerant flow (VRF) systems.



Low Energy Cooling Technologies

These are energy-efficient cooling systems that are not commonly used. These can be utilized as stand-alone cooling systems or in conjunction with traditional air conditioning systems.



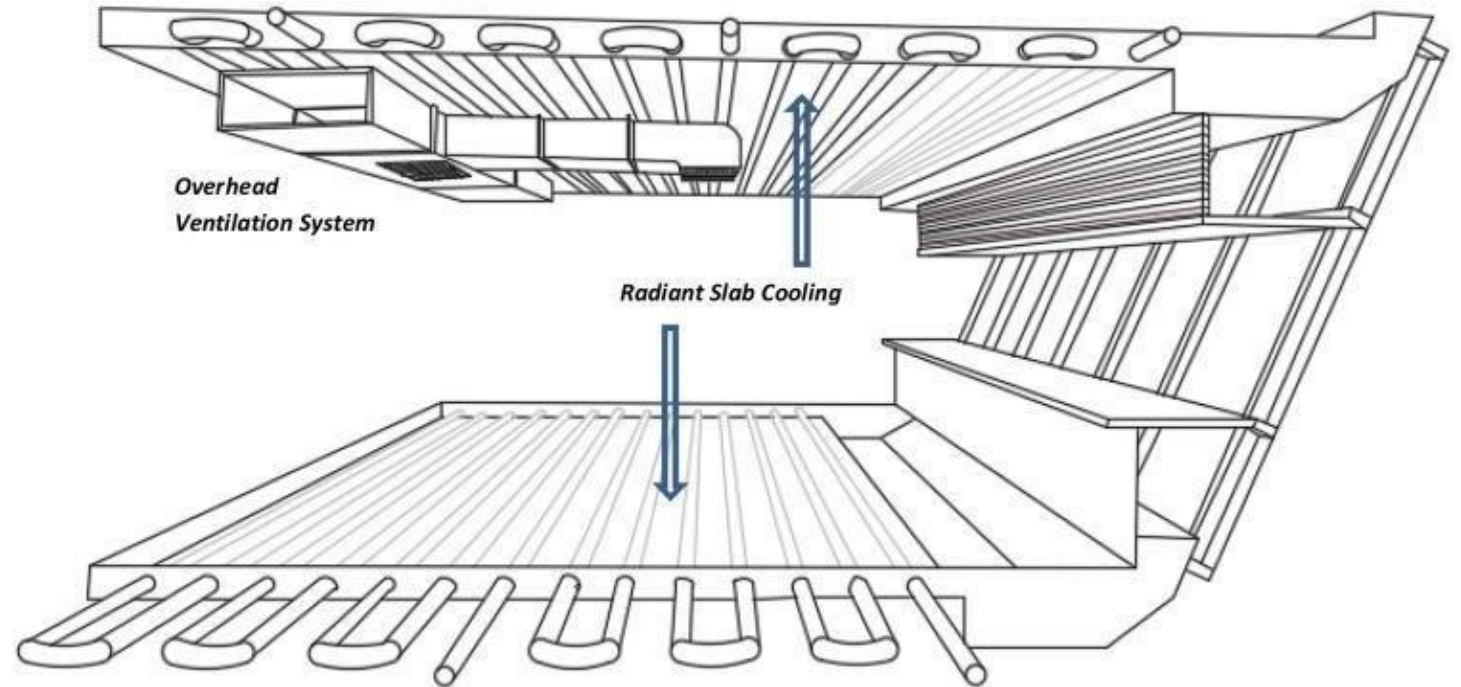
Low Energy Cooling Technologies

1 - RADIANT COOLING SYSTEM:

Radiant cooling makes use of actively cooled surfaces to enhance thermal comfort by transferring heat from the human body to the cooled surface via radioactive heat transfer.

Radiant-based HVAC systems absorb heat from the room, which is then removed by chilled water flowing through pipes installed in the floors, walls, or ceilings, or through externally fixed wall and ceiling panels.

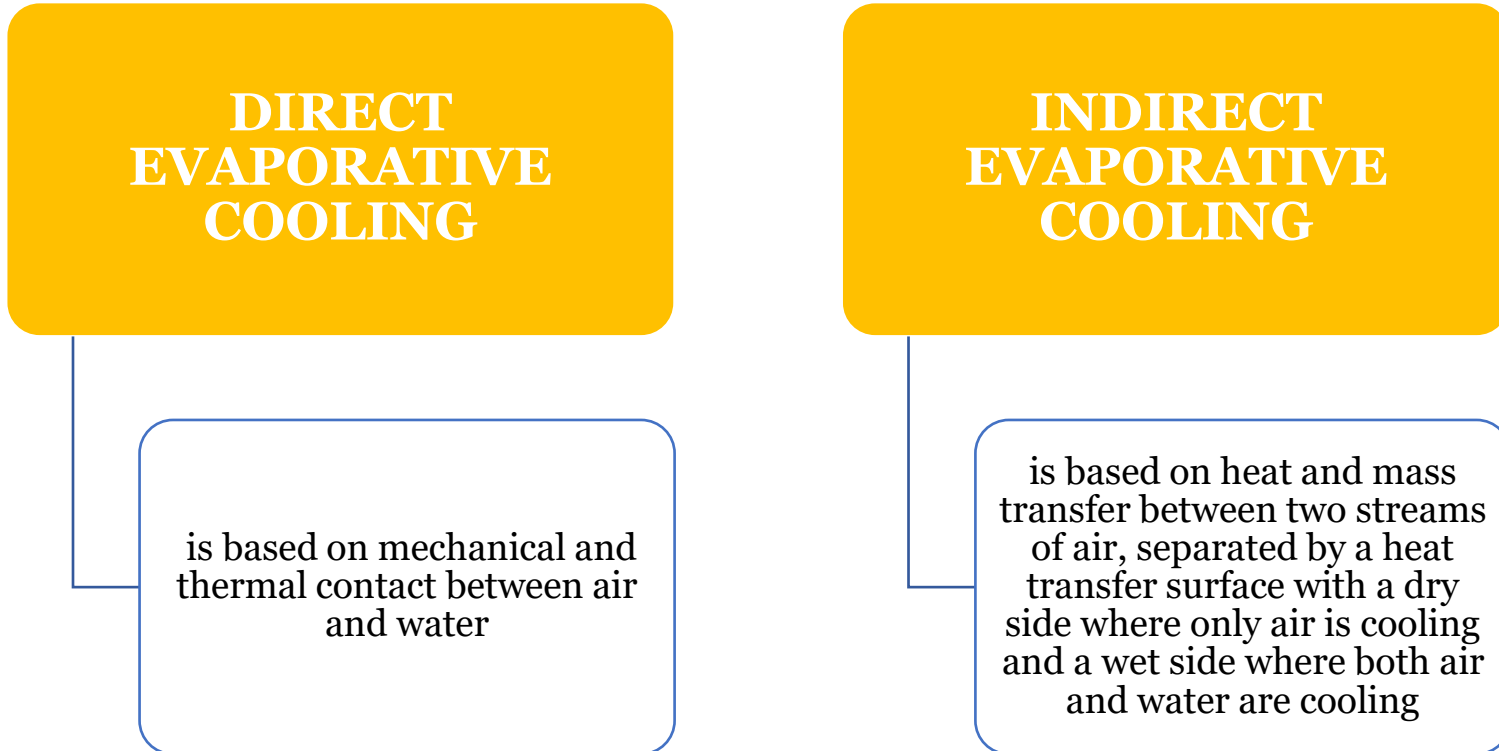
The technique makes advantage of water's far higher thermal capacity than air.



Low Energy Cooling Technologies

2 - EVAPORATIVE COOLING:

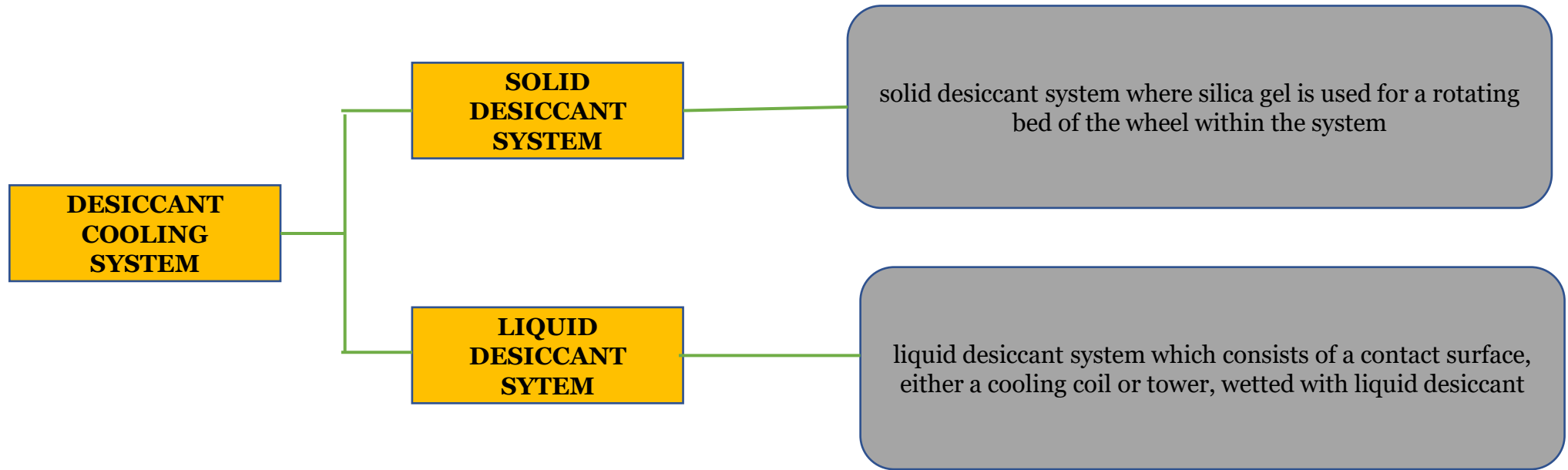
The evaporative cooling technology is based on heat and mass transfer between air and cooling water



Low Energy Cooling Technologies

3 - DESICCANT COOLING SYSTEM:

A desiccant is a substance, either liquid or solid, which absorbs water molecules from the air and dehumidifies it.



The desiccant system also improves the quality of indoor air. Integration with traditional HVAC systems to remove latent heat can reduce cooling and heating energy usage by up to 30% and 5%, respectively.

Low Energy Cooling Technologies

PERSONALISED CONDITIONING SYSTEM

- A customized air-conditioning system at the office produces a microclimatic zone around a single occupant, ensuring that energy is only used where it is required.
- Because of its excellent localized energy utilization, this technology serves to improve thermal comfort for occupants while also reducing energy consumption.

EARTH COUPLING

- Due to the great thermal inertia of soil, the Earth maintains a relatively constant temperature just a few meters below the surface, which is less than the outside temperature in summer and higher in winter.
- By pumping or exchanging heat with the earth, geothermal technologies such as the Earth Air Tunnel Heat Exchanger (EATHE) and Ground Source Heat Pump (GSHP) utilize the earth's temperature stabilizing property to deliver central heating or cooling to a structure.

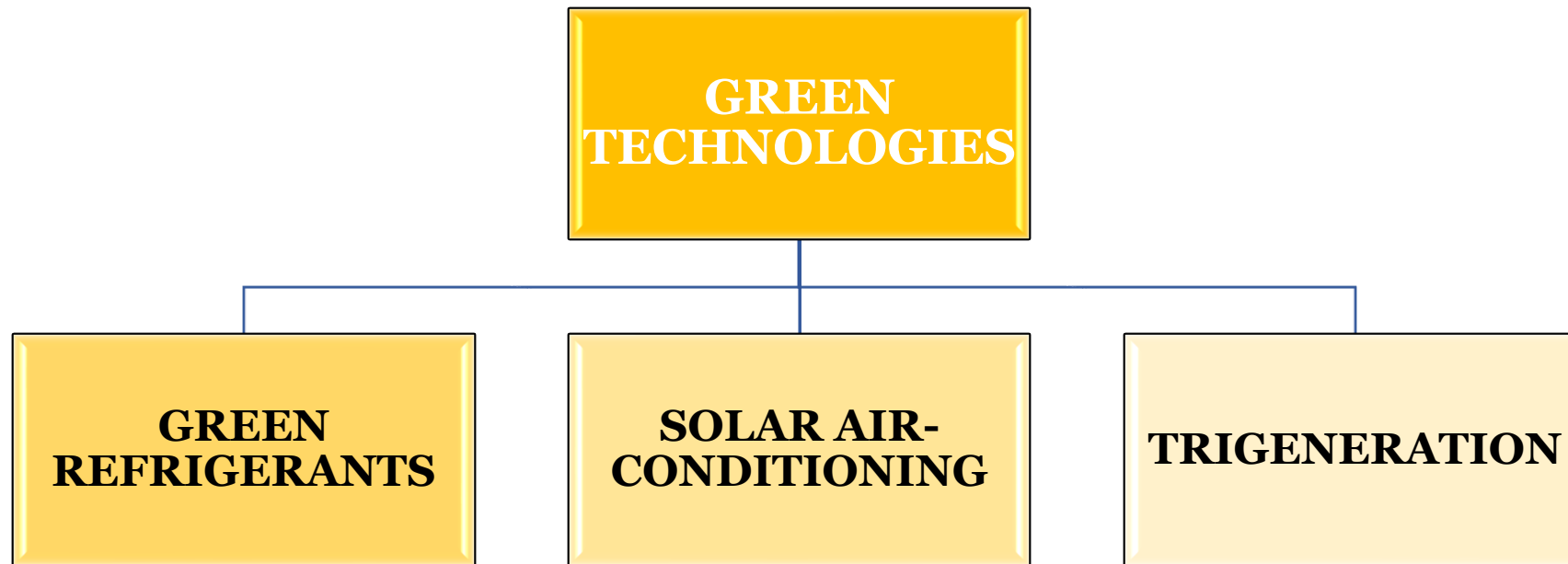
Low Energy Cooling Technologies

STRUCTURE COOLING

- By removing heat from the structure, structure cooling tries to lower the mean radiant temperature. This is accomplished by circulating water at room temperature through pipes implanted in slabs to drain heat from the building and prevent it from overheating. The larger thermal mass of water slows the transport of heat from the environment to the structure's innards.
- The heated water runs to the radiator, where it gives away the heat obtained and returns to the tank for recirculation, while the circulated water drains heat from the structure. Because it is a closed loop system, there is only one water requirement. There is no need to cold the water or use refrigerants; just the pump consumes energy.

Green Technologies

Green technology, such as RACs with green refrigerants, solar air-conditioning, and trigeneration, will have a significant influence on the environment if used wherever practical. India's energy security and contribution to minimizing climate change Changes in the climate.



Green Technologies

1 - GREEN REFRIGERANTS:

A green refrigerant would have the benefits of natural refrigerants and also be energy efficient

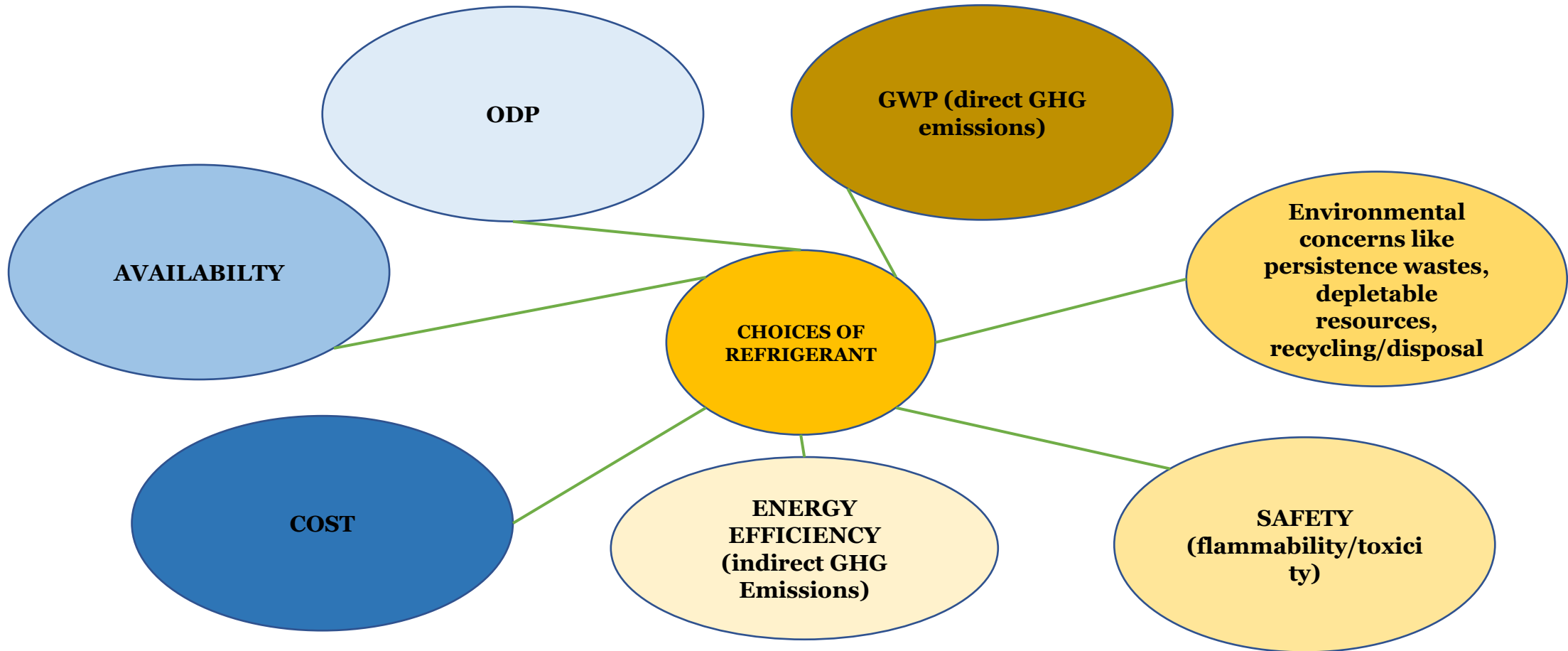
Natural refrigerants have numerous advantages, including 0% ODP, a low GWP, participation in natural biogeochemical cycles, and the absence of permanent chemicals in the atmosphere, water, or biosphere. Carbon dioxide, ammonia, and hydrocarbons like propane, propene, and isobutene are among them. Natural refrigerants, like as isobutene in residential freezers and ammonia in big cooling systems, are commonly employed in various RAC applications.

One of the most significant issues with hydrocarbon-based natural refrigerants is the flammability, which can be mitigated by steps such as the use of appropriate materials, the selection of safe components, and operator training. CO₂, a natural refrigerant, is inefficient in terms of energy use. When choosing a refrigerant, keep these considerations in mind. (2017, Green-cooling-initiative.org)

A good refrigerant should be non-flammable, non-toxic, and odorless, with a very low GWP and no risk for ozone depletion.

Many next-generation refrigeration options are non-flammable and have an ultra-low GWP, making them suited for chiller applications with bigger refrigerant charge sizes, or non-flammable refrigerant mixes with a moderate GWP of less than 750.

The quickest way to accomplish environmental goals is to use non-flammable, low-GWP refrigerants in high-performance products.



Green Technologies

TYPES OF REFRIGERANTS AND THEIR GWP (ASSIMILATED FROM AEEE's SECONDARY RESEARCH)

REFRIGERANT	GWP	ENERGY EFFICIENCY	COMPANIES	MARKET STATUS	COST
HCFC-22	High (1800)	High	All Phasing Out	GHG, scheduled for phase out under Montreal protocol	High
HFC-410a	High (1923)	Low	LG, Samsung, GE, Carrier	GHG, Ozone Safe	High
HFC-32	Medium (675)	High	Daikin, Fujitsu, Hitachi, Mitsubishi, Panasonic, Toshiba	Ozone Safe, Mildly flammable	Low
HC-290	Very Low (<5)	High	Godrej	Low GWP, best available for ozone safe in small room AC, highly flammable	Low
HFC BLENDS (DR7, L41, L20)	Medium (300-450)	Medium	DuPont, Honeywell	Low GWP, Low Flammable	Medium
HFOs	Very Low (<4)	Very High	In Research Phase	Environmental friendliness, cost-effectiveness	Low

Green Technologies

2 - SOLAR AIR-CONDITIONING:

Solar air-conditioning refers to any air-conditioning system that uses solar power

The vapor absorption method is used to provide cooling in thermally operated chillers. Instead of employing compressors, desorption is used to enhance the refrigerant's vapor pressure and temperature. Chilled water is produced by thermally driven chillers, which is subsequently utilized to cool hot or warm areas of a building.

Solar absorption chillers have very cheap operating and maintenance expenses, and they use very little electricity. Solar air-conditioning has a current market potential of over 0.7 million TR and is growing at a pace of around 17% per year.

SOLAR AIR-CONDITIONING CAN BE DONE THROUGH

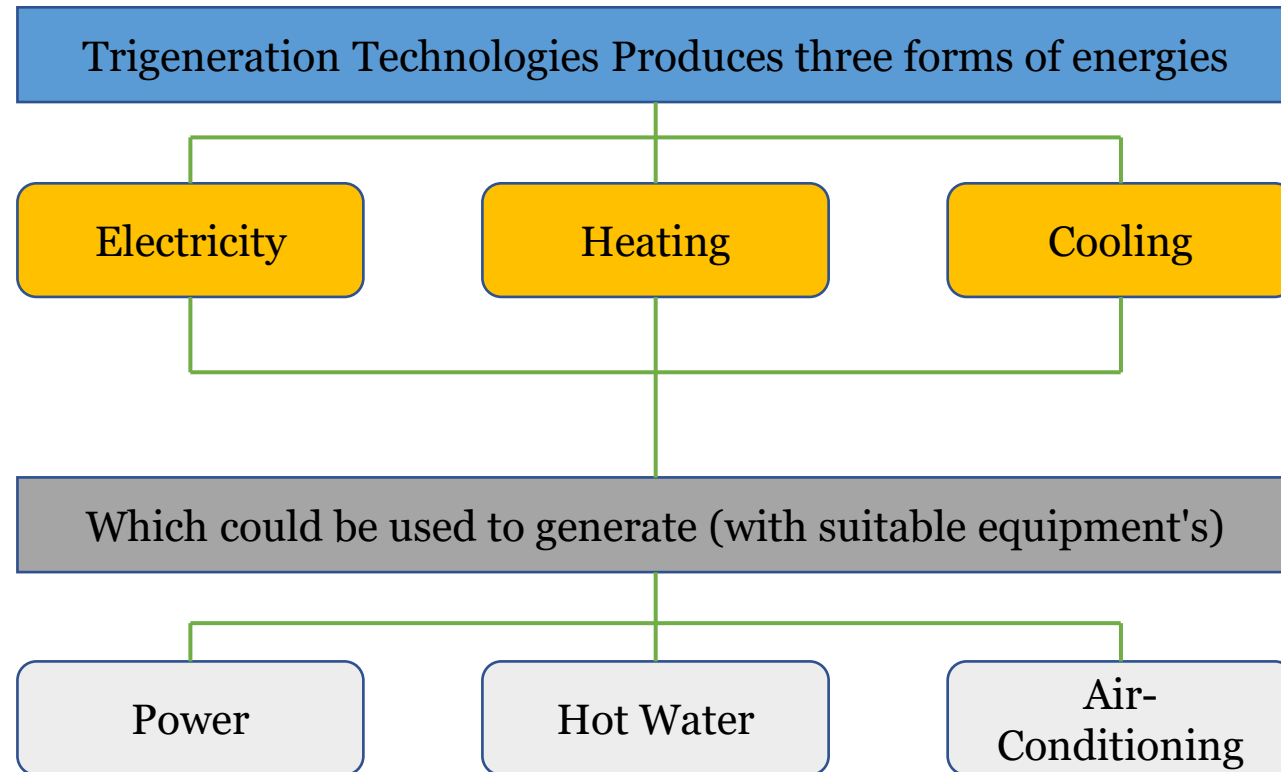
PASSIVE SOLAR

SOLAR THERMAL ENERGY CONVERSION

PHOTOVOLTAIC CONVERSION

Green Technologies

3 -TRIGENERATION:

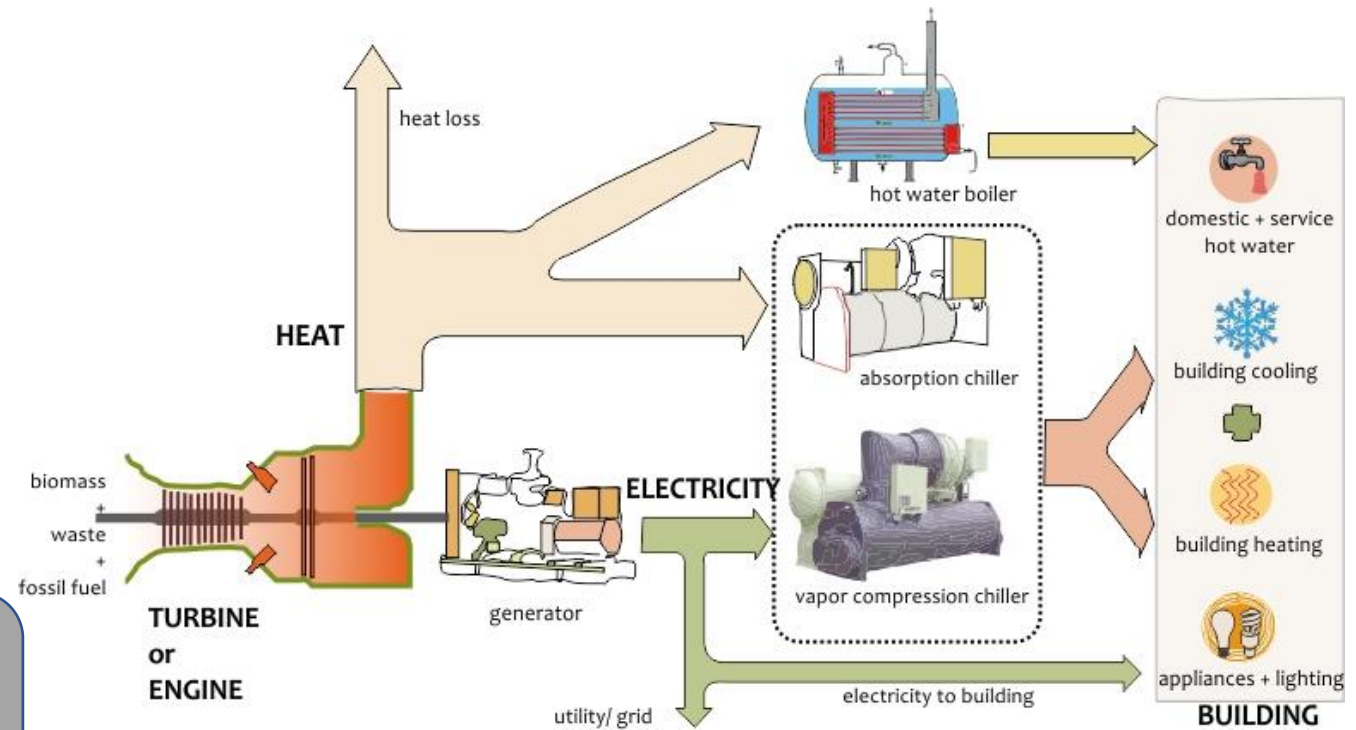


Green Technologies

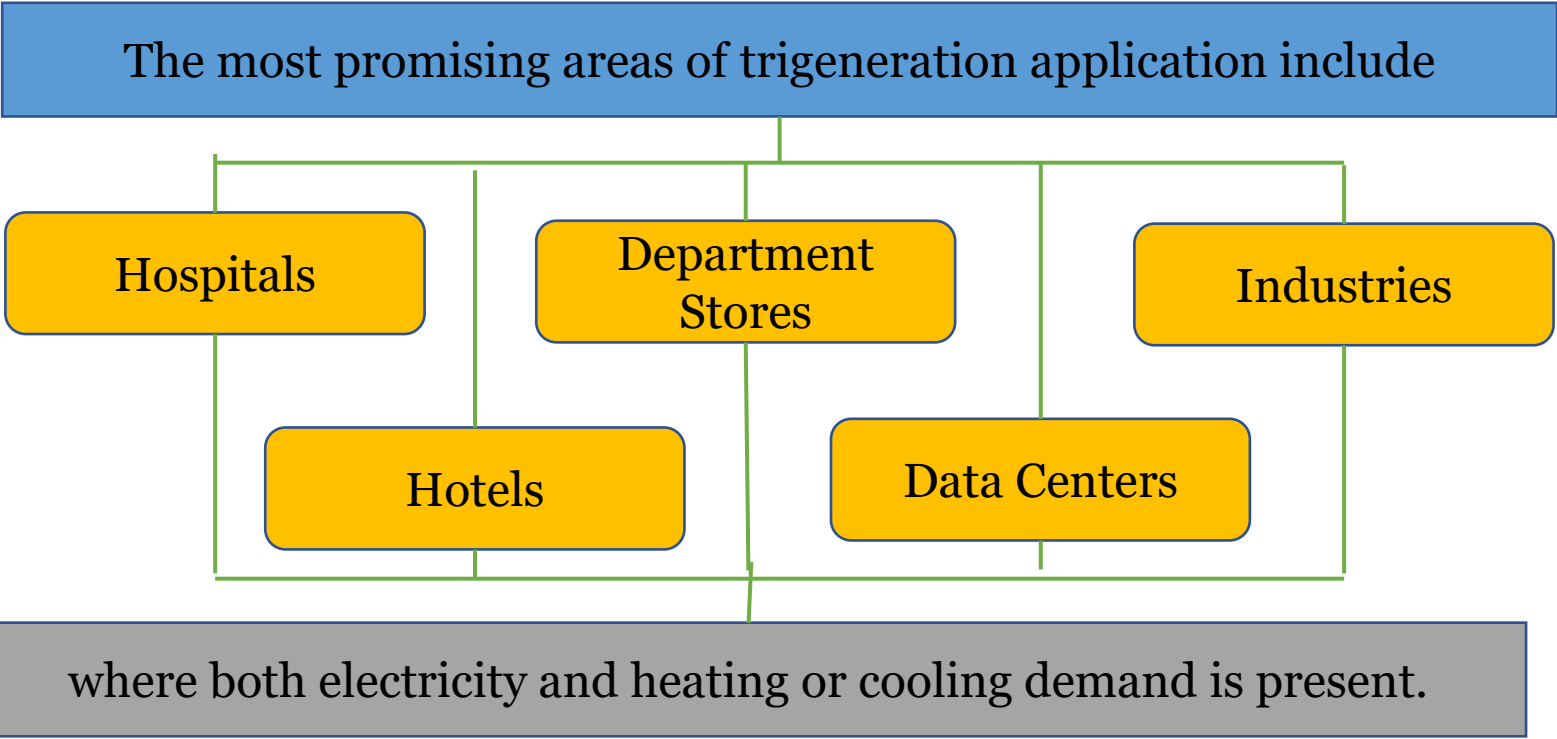
Absorption chillers can employ heat absorbed from waste burning, power generation with generators, or heat generated by solar panels to generate chilled water.

By utilizing a waste heat recovery system at the end user site, trigeneration systems can achieve great efficiency with no transmission losses.

If they can sell to the grid, they could potentially help India meet peak power demand and avoid harmful power outages.



Green Technologies





8-B

INDIAN & INTERNATIONAL
BEST PRACTICES

Indian & International Best Practices

SIERRA's eFACiLiTY® Green Office Building, Coimbatore

- Location Coimbatore, Tamil Nadu
- Coordinates 11° N, 77° E
- Occupancy Type Office
- Typology New Construction
- Climate Type Warm and Humid
- Project Area 2,322 m²
- Grid Connectivity Grid Connected
- EPI 56 KWh/m²/



Indian & International Best Practices



Climate Responsive Design

- Long facades face towards east and west- Window Wall Ratio (WWR) is less than 40%
- External shading devices and high-performance reflective glazing-harvest 86% daylight

Landscaping and Water Efficiency

- Ensuring 100% rainwater harvesting and 100% wastewater treatment to tertiary standards- Zero discharge
- Use of native drought-tolerant species- Landscape water demand reduce 40%

Air-Conditioning

- Variable Refrigerant Flow system- Energy Efficiency Ratio (EER) of 13.85
- Smart Sensors - intelligently maintain temperature and fresh air supply

Indoor Air Quality

- Triple filtering & Demand Controlled Ventilation aided by CO2 sensors
- Real-time IoT sensors- levels of volatile organic compounds, humidity, and particulate matter 2.5 & 10

Artificial Lighting and Controls

- 100% LED lights- 0.26 W per sq ft
- Sensor-activated passage lights, occupancy sensors, and lux sensors

Water Efficiency

89% water savings are achieved using waterless urinals, high efficiency sensor faucets, reuse of treated water for flushing and reuse of stored rainwater for domestic use.

Sequencing Batch Reactor (SBR) based STP System, rainwater filtration, Raw water treatment UV treatment etc.

Energy Monitoring

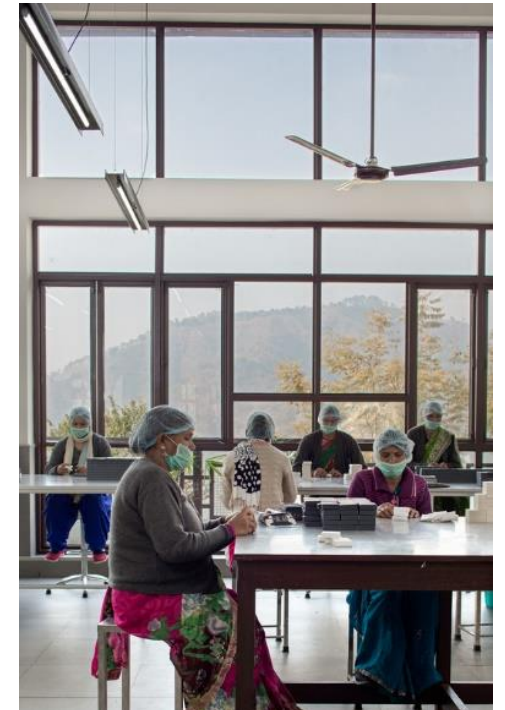
Renewable Energy

60 KW rooftop solar PV with the automatic sprinkler cooling system- meets 80% of the energy demand and about 33% of the energy use further reducing the EPI to 18.8 KWh/m²/year

Indian & International Best Practices

Industrial building

- Location: Lodsi, India
- Year :2019
- Area: 1000 Sqft
- Architects: Morphogenesis
- Purpose: manufacturing facility for a modern skincare company
- EPI (energy performance index) of 35kWh/m²/year
- <https://www.archdaily.com/>



Indian & International Best Practices



Climate Responsive Design

- The built form draws inspiration from the traditional Garwahli 'kholi' (house).
- A rectilinear volume-oriented along the East-West axis has been planned with a central entry that divides the facility into two parts.
- The functions that require a cooler environment (herb grinding, packaging, and storage) are located on the ground floor, whereas the preparatory functions with high internal heat gain are located on the upper floor.
- The North-South-oriented butterfly roof form, reminiscent of the traditional roof not only provides a modern aesthetic but also permits the use of large openable windows that take advantage of the prevailing Northeast and Southeast winds for ventilation further providing 80% naturally daylight spaces.

Renewable Energy

Solar roof generating 50kWp

Indian & International Best Practices



Climate Responsive Design

- The built form draws inspiration from the traditional Garwahli 'kholi' (house).
- A rectilinear volume-oriented along the East-West axis has been planned with a central entry that divides the facility into two parts.
- The functions that require a cooler environment (herb grinding, packaging, and storage) are located on the ground floor, whereas the preparatory functions with high internal heat gain are located on the upper floor.
- The North-South-oriented butterfly roof form, reminiscent of the traditional roof not only provides a modern aesthetic but also permits the use of large openable windows that take advantage of the prevailing Northeast and Southeast winds for ventilation further providing 80% naturally daylight spaces.

Renewable Energy

Solar roof generating 50kWp

Indian & International Best Practices

Unnati Office

- Location Greater Noida, Uttar Pradesh
- Coordinates 29° N, 78° E
- Occupancy Type: Office, Private
- Typology New Construction
- Climate Type Composite
- Project Area 3,740 m²
- Date of Completion- 2018
- Grid Connectivity- Grid-connected
- EPI 60 kWh/m²/yr.
- <https://www.archdaily.com/>



Ground Floor Plan – Office layout



It is the first building in India to be certified Platinum under LEED v4 BD+C : NC rating in 2018. The building performs 59% better than a conventional office building in the region, and 40% of the building energy consumption is met through on site renewable energy generation.

Indian & International Best Practices

OFFICE – Active cooling system



Orientation

The three-storey building is a cuboid with a central courtyard. It is oriented northeast-southwest, with the core areas distributed in the east and the west orientations

Landscaping

The landscape is a mix of existing and new vegetation. 30% of the site is un-built, of which 25% is covered with shrubs and trees.

Daylighting

90% of the office spaces, including the core and service areas, receive uniformly distributed daylight. This can be attributed to the form, central courtyard, shallow floor plates, appropriate sizing and distribution of openings. All the windows have box shading that prevents glare.

Building Envelope and Fenestration

Truss reinforced insulated concrete panels (TRIC) used for the exterior walls are 25 mm concrete (AAC), 60 mm expanded polystyrene (EPS), and 25 mm concrete (AAC), and 10 mm plaster.

The green roof insulation materials are 13 mm extruded polystyrene insulation and a 300 mm layer of green roof soil substrate.

Optimized Energy Systems / HVAC system

The building has a hybrid HVAC system which is a combination of water-cooled air handling units and ceiling-embedded radiant cooling system.

Cooling load distribution of the system is such that 55% of the load is met by the radiant cooling system and 45% by AHUs.

Renewable Energy

The building draws 40% of its energy from the roof-top PV plant.

The installed 100 kW solar PV generates 146 MWh/yr.

Indian & International Best Practices

Shenzhen Institute of Building Research (IBR) Headquarters

- Location Shenzhen, China
- Coordinates 39° N, 116° E
- Occupancy Type Office + research labs
- Typology New Construction
- Climate Type Humid subtropical
- Project Area 18,169 m²
- Grid Connectivity Grid Connected
- EPI 63 kWh/m²/yr
- <https://www.hpbmagazine.org/>



Indian & International Best Practices



Roof

Type Roof garden (green roof) shaded with a PV canopy
Walls Type Insulated concrete panel with aluminum cladding
Glazing Percentage Varies by orientation from 30% to 70%
Windows-Effective U-factor for Assembly 0.35 Btu/h·ft²°F
Solar Heat Gain Coefficient (SHGC) 0.4
Visual Transmittance 0.45
Acoustic Isolation Performance 60 dbA

Wind:

Natural ventilation in all the office spaces allows for direct contact with nature, and uses 30% less air conditioning

Light:

Daylight for all the office spaces means no artificial lighting is needed during the day and provides views of the surrounding mountains from all of the workstations

Land:

A vertical landscape distributed throughout the building doubles the area available for greenery compared to the building's original footprint. The roof garden, "sky garden," and patio garden all help restore the ecological balance of the building site.

Materials

Concrete with high-percent recycled material, wood products with 10% recycled materials. Construction materials sorted and collected for recycling. Use of local and native materials. Low-emission interior finishes.

HVAC.

Water-loop heat pump, water-source heat pump, temperature and humidity are independently controlled, and high-efficiency and energy-saving air conditioning.

Indian & International Best Practices

Bayalpata Hospital

- Location: Achham Nepal
- Coordinates: 29° N, 81° E
- Occupancy Type: Medical Complex
- Climate Type- Subtropical (due to elevation)
- Project Area: 4,225 m²
- Date of Completion 2019
- Grid Connectivity: Grid-connected
- EPI- 10 kWh/m²/yr



Indian & International Best Practices



Climate Responsive Architecture and Strategies:

The architecture maintains a vernacular scale through setbacks, gabled roofs, and low-cost heat-storing materials.

The complex includes low-rise one- and two-story structures organized around landscaped courtyards. The structures are heated and cooled passively (with the exception of the operating theatre and laboratories that are mechanically conditioned).

Heating, Cooling and Ventilation Design

The structures comprises of massive rammed earth walls with insulated roofs. Material with thermal mass retains daytime heat gain in winter, while keeping the interiors cool by preventing overheating during summer.

The cross-breezes through courtyards, aided by clerestory ventilation and ceiling fans, promote natural ventilation and improve comfort conditions.

Daylighting

Inside the buildings, tall narrow windows and south-facing series of glazed clerestories brings in natural daylight reducing the need for artificial lighting.

Material Palette

Soil from the site was mixed with 6% cement content to stabilize the earth for better durability and seismic resistance. Reusable, plastic lock-in-place formwork facilitated faster construction, while local stone was used for foundations, pathways, and retaining walls.

Indian & International Best Practices

Nowon Energy Zero House (EZ House)

- Location: Seoul, South Korea
- Coordinates 37° N, 127° E
- Occupancy Type- Multi-unit housing complex
- Climate Type Continental
- Project Area 17,652 m²
- Grid Connectivity Grid Connected
- <https://www.schoeck.com/en/case-studies/nowon-energy-zero-house-ez-house>



Indian & International Best Practices



- Nowon EZ House, Korea's first **zero-energy multi-unit housing complex**, is the result of the project “Zero Energy Housing Activation Optimization Model Development and Demonstration Complex Development”
- Nowon EZ House was built using the highest level of passive technology and materials in Korea, some of which were the first to be used in the country.
- **Structural thermal break solutions** Schöck Isokorb® XT type K and XT type Z have been applied to prevent the thermal bridges in the balcony area. Thanks to the new technologies, EZ House is aimed to maintain a temperature of 20°C to 22°C in winter and 26°C to 28°C in summer – without any heating or cooling

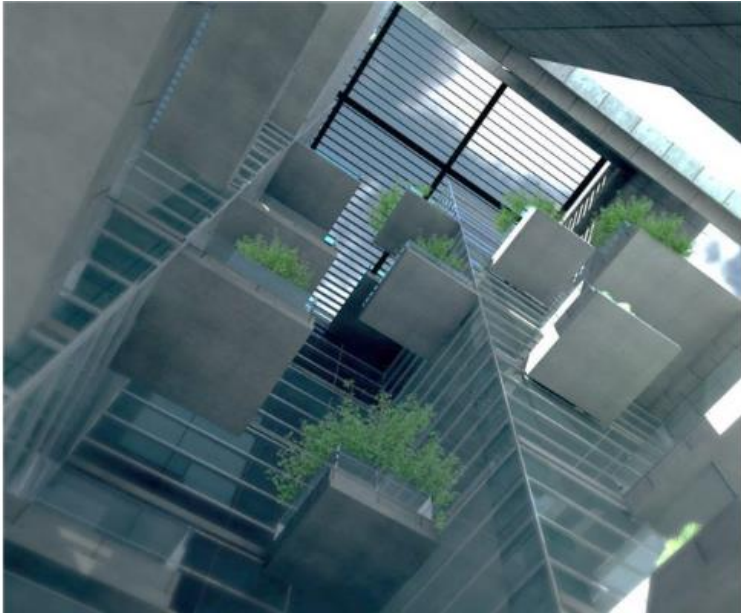
Indian & International Best Practices

Mobil House

- Location Dhaka
- Coordinates 23.8° N, 90.4° E
- Occupancy Type: Office
- Climate Type Tropical wet and dry climate
- Project Area 6,673 m²
- Date of Completion Oct 2019
- Grid Connectivity Grid-connected
- EPI (kWh/m²/yr)- 58 kWh/m²/yr



Indian & International Best Practices



Site Layout & Planning

Due to size constraints of the site, the green cover on site is minimal. However, significant foliage has been incorporated within the large terraces distributed throughout the building. Potted plants and vertical gardens compensate for the lack of surface green cover.

Climate Responsive Design

The most striking feature of the building includes the landscaped and shaded terraces. These act as thermal buffers for the interior spaces.

Form and Massing

The building mass has been oriented such that circulation elements like lift core and staircases are situated along the West façade. This shields the regularly occupied spaces like offices and reception from the solar gains from the west façade. The northeast façade, with less solar gain potential, incorporates large windows to allow daylight and outdoor views.

Facade and Envelope

The envelope is made of 300 mm thick concrete walls, leading to high thermal mass which shields the buildings from heat gain during the daytime. The deep building terraces and courtyards enhance biophilia and create shaded outdoor breakout spaces that remain cool throughout the day. In addition to the walls, the windows – double-glazed panels with low emissivity and a U-value 1.1 W/m²k – also reduce heat gain. The glazing has a shading coefficient of less than 0.25, leading to further reduction in solar heat gain.

Daylight Design

The building form is optimized to let in daylight, blocking solar heat gain. This is done through the deep terraces of the building which provide shading to the north-east façade. This façade, with its row of large windows, also lets in plenty of daylight. A significant number of occupants have access to daylight and views to the outside

DAY 2

Q & A Session

DAY 2

Vote of Thanks



**THANK
YOU**