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

GLOBAL HOUSING TECHNOLOGY CHALLENGE INDIA

Ministry of Housing and Urban Affairs
Government of India

आज़ादी का अमृत महोत्सव

bmtpc

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Replicable designs for Thermally Comfortable Affordable housing

First stakeholder meeting | **11 April 2022**

Knowledge Partners:

Ashok B Lall Architects

LEAD Consultancy

Greentech Knowledge Solutions

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Type design overview of Thermal Performance and Carbon Footprint of Construction

- **Key indicators:** Thermal Performance and carbon footprint of construction
- **Thermal performance :** *Methodology for simulation*
- **Thermal Performance variants** –DU location, orientation and walling/roofing material
- **Embodied Energy Intensity (EEI)** and carbon footprint of construction

GOIs flagship program under implementation since 2015 to provide **'Housing for all' by 2022**

Provides **Central Assistance to implementing agencies through States and Union Territories** for providing houses to all eligible families/beneficiaries by 2022.

The Mission **will be implemented through four verticals** (as shown in the image)

Urban

More than 12 million houses

are being constructed within the Mission period

"In situ" Slum Redevelopment

Affordable Housing through Credit Linked Subsidy

Affordable Housing in Partnership

Multi-family homes in cities

Subsidy for Beneficiary-Led Individual house construction or enhancement

Single-family homes on independent plots

Potential challenges

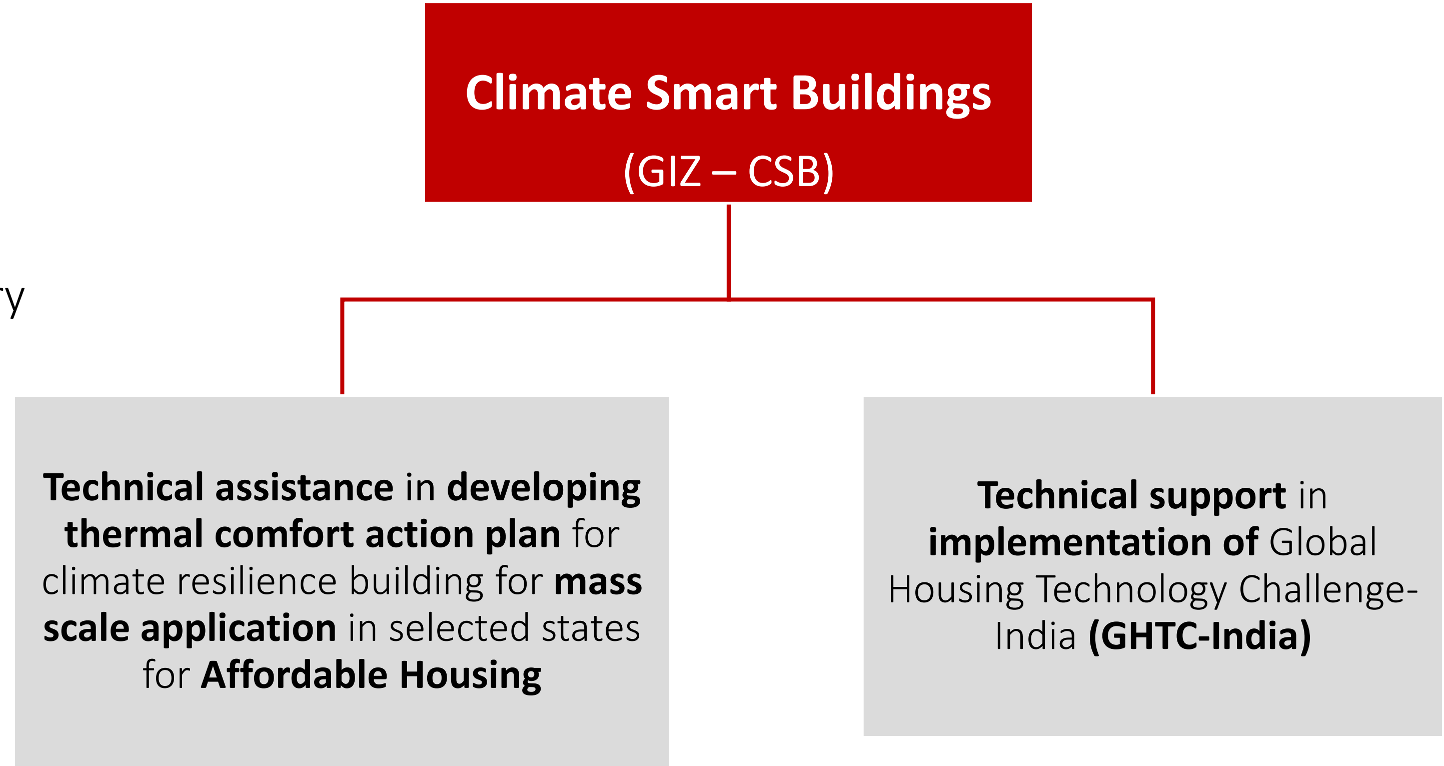
- Homes built today will last at least **50-60 years**
- They will **impact resource usage during their life span**.
- The **design and construction** of these homes will have an impact on the **level of comfort** that these dwellings provide to its occupants, thus impacting their **energy use and costs to achieve environmental comfort** and **associated carbon emissions** over their lifetime.
- The **expected increase in cooling needs** due to higher aspirations arising from enhanced access to housing will also **significantly increase the projected electricity demand.**
- With **climate change temperature rise compounded by increasing UHI** in urban areas will also **add to this demand.**

Optimizing thermal comfort by passive design means

Is imperative while designing and building homes affordable housing.

GIZ has supported GOI for :

- The development of Eco-Niwas Samhita
- Labelling mechanism for residential building
- Energy Efficient Building Material Directory
- Replicable designs for energy efficient residential buildings
- Smart Home program.



1.2. Project objective

To **enhance climate resilience and thermal comfort** in buildings by adopting **appropriate passive measures, locally available and low embodied energy materials** coupled with **appropriate available technologies of construction for affordable housing.**

The main objective is **developing a Catalogue of Replicable Design options for Thermally Comfortable Affordable Housing** by **minimizing discomfort hours in homes** through use of passive design measures.

1.3. Project team and roles

TEAM LEAD
Environmentally sustainable and affordable architecture expert,
ASHOK B LALL ABLA

EXPERTS		
Building Performance Analysis Expert	**International Expert**	**BIM Expert**
M SELVARASU LEAD	**Dr. RAJAT GUPTA** Oxford Brookes University	**RAMNEET KAUR** ASP Associates

Building Energy Analysis Expert	Building Construction Expert	Building Material Expert	Structural Systems Expert
RATHNASHREE LEAD	**RAKESH DAYAL** ABLA	**PRASHANT BHANWARE** GKSPL	**KALHAN MITRA** PCPL

Architectural Design Expert	Passive Strategies Expert	Webtool designer	Project management
ROOPA NAIR ABLA	**SASWATI CHETIA** GKSPL	**SADDAM HUSSAIN** IWL	**GAUTAM NAGAR** Optimus Energy Consultants

1.4. Our interpretation and approach

Develop a practical solution-set responding to the policy objectives of 'Housing for All', SDGs, and the Climate Change mitigation commitments of the GOI.

Focus on urban house types that are suitable for EWS and LIG categories since 80% of the current unmet need for homes are in these categories

Consider the emergent future of affordable housing while also addressing the present need of affordable housing today.

Develop the replicable design set as a response to the modes of housing provision under PMAY(U) such as cooperative/local authority/institutional group housing, to developer built mass housing, to self-build beneficiary led mode.

Evaluate the designs using a techno-commercial matrix vis-à-vis the SDGs, affordability/economy, Climate mitigation potential considering embodied energy and potential operational energy, and thermal comfort.

Prioritize economy and simplicity of construction while optimizing thermal comfort is to be prioritized.

Introduce potential new materials and innovative methods of construction that enhance comfort and reduce Co2 emissions of construction.

1.5. Key project stakeholders

1. Government and quasi-government organizations

POTENTIAL VALUE TO STAKEHOLDER :

- Support the fulfillment of the GOI commitments under 'Housing for all 'and the SDG
- Technical inputs on developing the thermal comfort action plan for climate resilience building

INPUT REQUESTED:

- Inputs on assumptions and parameters for the project based on current research and policy

2. Independent bodies

[Academic researchers, certification bodies]

POTENTIAL VALUE TO STAKEHOLDER :

- Support on the development of innovative technologies and sustainable construction materials through technical inputs.
- Provide a standard for thermal comfort in affordable housing.

INPUT REQUESTED :

- Inputs on methodologies and design strategies proposed for the projects
- Inputs on new materials and technologies based on research

3. Implementing agencies

POTENTIAL VALUE TO STAKEHOLDER:

- Support on effective implementation of affordable housing schemes through a better understanding on 'affordability'.

INPUT REQUESTED :

- Inputs on gaps in the present scenario and any foreseen challenges in the implementation of the project outputs

4. End users

[Professional, architects, builders and home owners]

POTENTIAL VALUE TO STAKEHOLDER:

- Access to the replicable design drawing set, BOQ and simulation packages.

INPUT REQUESTED:

- Inputs on gaps in the present scenario and any foreseen challenges in the interpretation and implementation of the project outputs

SESSION I

Overview of existing design and construction practices to identify gaps in achieving optimal Thermal comfort

SESSION I: Objectives and deliverables

OBJECTIVE

Documentation of architectural typology, construction technology and materials used for affordable housing under PMAY-(U)

PMAY(U) AFFORDABLE HOUSING DOCUMENTATION

PART A
General trends of affordable housing construction

To understand the current housing typologies, construction technologies , associated costs, thermal performance and the possible correlation to their specific climate zones

- Observed trends in building plan types
- Observed trends in construction technologies
- Identification of plan types and construction technologies for thermal comfort

PART B
Prevalent gaps in design / construction practices in adopting strategies for thermal comfort

- Draw attention to gaps in adoption of passive design strategies
- Draw attention to embodied energy intensity of construction technologies and materials
- Show analytically, building types, construction technologies that are low carbon and economically suitable for affordable housing.

DELIVERABLES

- **Report on documentation** of typologies of affordable housing projects
- **Gap analysis document** w.r.t thermal comfort and sustainability

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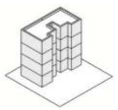
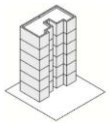
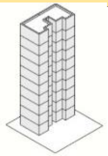
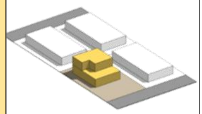
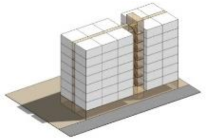
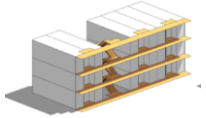
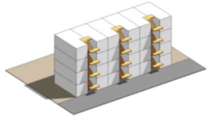
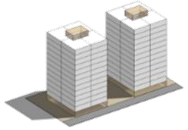
SESSION I : Criteria for project selection for survey -

Criteria for project selection to be representative of the sets and categories shown below :

A) PROJECT TYPE	
	EWS Carpet area equal to and less than 60Sqm
	LIG Carpet area equal to and less than 60Sqm

B) CLIMATIC RANGE
Cold
Composite
Warm and Humid
Hot and Dry
Temperate

C) BUILDING HEIGHT		
Low –rise	Mid - rise	High – rise
		

D) BUILDING PLAN TYPE RANGE					
Plotted	Singly Loaded corridor(SLC)	Doubly Loaded corridor (DLC)	Row House (RH)	Tower Stand Alone (TSA)	Tower Connected (TC)
					

E) CONSTRUCTION TECHNOLOGY RANGE			
RCC Structure with AAC block	RCC Structure with burnt clay / flyash masonry	Monolithic concrete	RCC Structure with concrete blockwork
			

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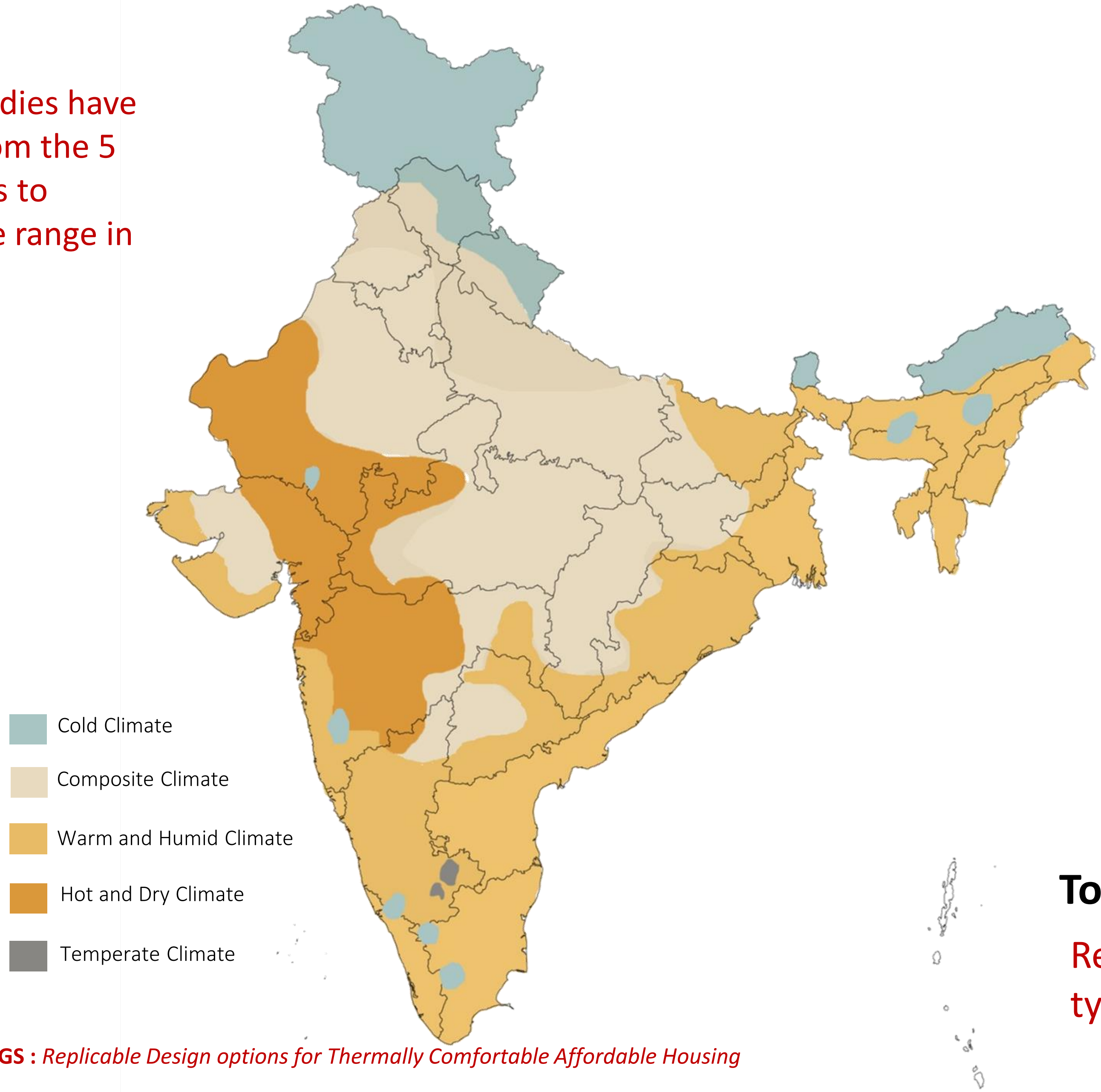
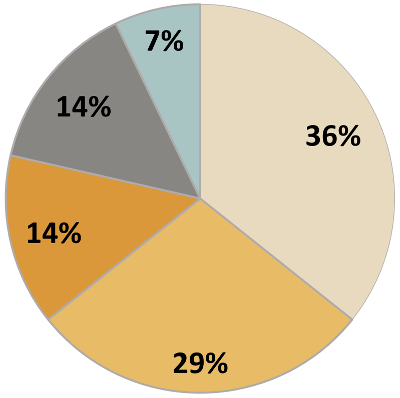
NAME	LHP, Agartala, Tripura	LHP, Chennai, Tamil Nadu	LHP, Indore, Madhya Pradesh	LHP, Lucknow, Uttar Pradesh	LHP, Rajkot, Gujarat	LHP, Ranchi, Jharkhand
						
Building Plan Type	DOUBLY LOADED CORRIDOR	TOWER STAND ALONE	TOWER CONNECTED	DOUBLY LOADED CORRIDOR	TOWER STAND ALONE	DOUBLY LOADED CORRIDOR
Building Height	G+6	G+5	Stilt+8	Stilt+13	Stilt+13	G+8
Construction Technology	Light gauge steel structural system	Pre-cast concrete construction system	Prefabricated sandwich panel system	PVC Stay in place formwork system	Monolithic concrete construction using tunnel formwork	Pre-cast concrete construction system - 3D Volumetric

The survey case studies have been shortlisted from the 5 major climate zones to ensure an adequate range in project types.



Projects surveyed :

Affordable housing schemes	**65**
Lighthouse Projects	**6**
	71



GRAPH 1 : % of affordable housing projects in each climate zone

Total survey case studies : 113 + 6

Representing different building plan types and dwelling unit sizes.

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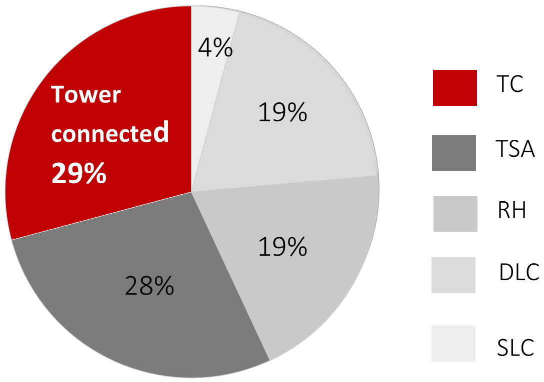
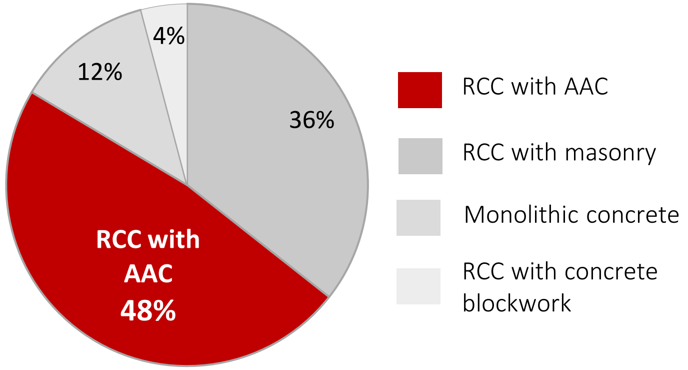
1. BUILDING PLAN TYPE



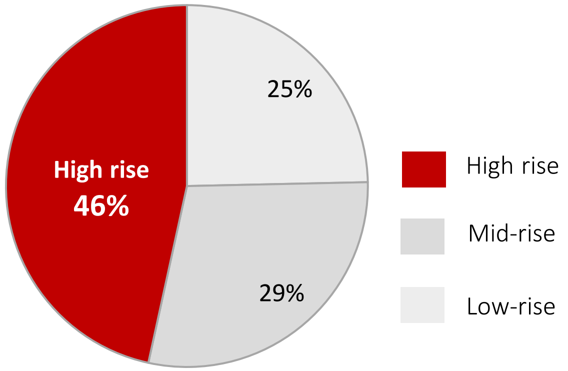
GRAPH 1 : Identified building plan types

2. CONSTRUCTION TECHNOLOGY



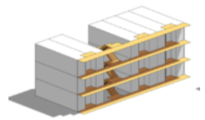
GRAPH 2 : Identified construction technologies

3. BUILDING HEIGHTS



GRAPH 3 : Identified building height range

4. CLIMATE

Singly Loaded Corridor (SLC)				
				
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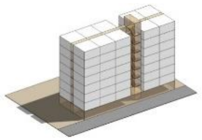
	✓		✓	

Doubly Loaded Corridor (DLC)				
				
C	W&H	H&D	T	CO
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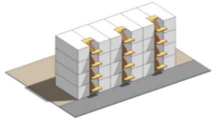
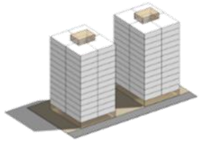
Row House (RH)				
				
C	W&H	H&D	T	CO
✓	✓	✓	✓	✓

Tower Stand Alone (TSA)				
				
C	W&H	H&D	T	CO
✓	✓		✓	✓

Tower Connected (TC)				
				
C	W&H	H&D	T	CO
✓	✓	✓	✓	✓

SESSION I: Inferences – *General trends of affordable housing construction under PMAY(U)*

- **No correlation between climate zone and building plan type**. All building plan types are found in every climatic zone.
- General trend indicates **tendency towards high rise typologies** .These are **high on EE intensity and CO_2 emissions on account of construction.**
- However, **the adoption of low/mid-rise buildings is also common**. These have lower EE intensity and CO_2 emissions on account of construction.
- General trend indicates **increasing adoption of lightweight AAC blocks in RCC frame.** Most preferred for mid and high-rise construction.
- The building plan type , building height and construction materials and technology are **determined primarily by project economics and permissible F.A.R according to development control regulations**.

GAP ANALYSIS

A) APPLICATION OF PASSIVE DESIGN STRATEGIES

- Compactness
- RETV

- **To understand the existing gaps in the designing of thermally comfortable Affordable homes**

B) SIMULATING FOR THERMAL PERFORMANCE

- Degree discomfort hours (IMAC-R)
- Daylight

- ECBC-R Compliance
  - WFr
  - VLT
  - U-Value (roof)

For selected projects only

Similar data to be received for Light House Projects from other consultants

C) COMPARING EMBODIED ENERGY INTENSITY

Steel Intensity (Kg/Sqm of Carpet Area)

Concrete intensity (cum/ Sqm of Carpet area)

Walling system(Building shell) intensity

- **To understand the impact of the construction system and material on thermal performance**

D) UNDERSTANDING COST TRENDS

Cost of Steel per Sqm of carpet area

Cost of Concrete per Sqm of carpet

Cost of Walling material per Sqm of carpet area

- **To understand implications of building plan type, building height and building EEI on affordable cost**

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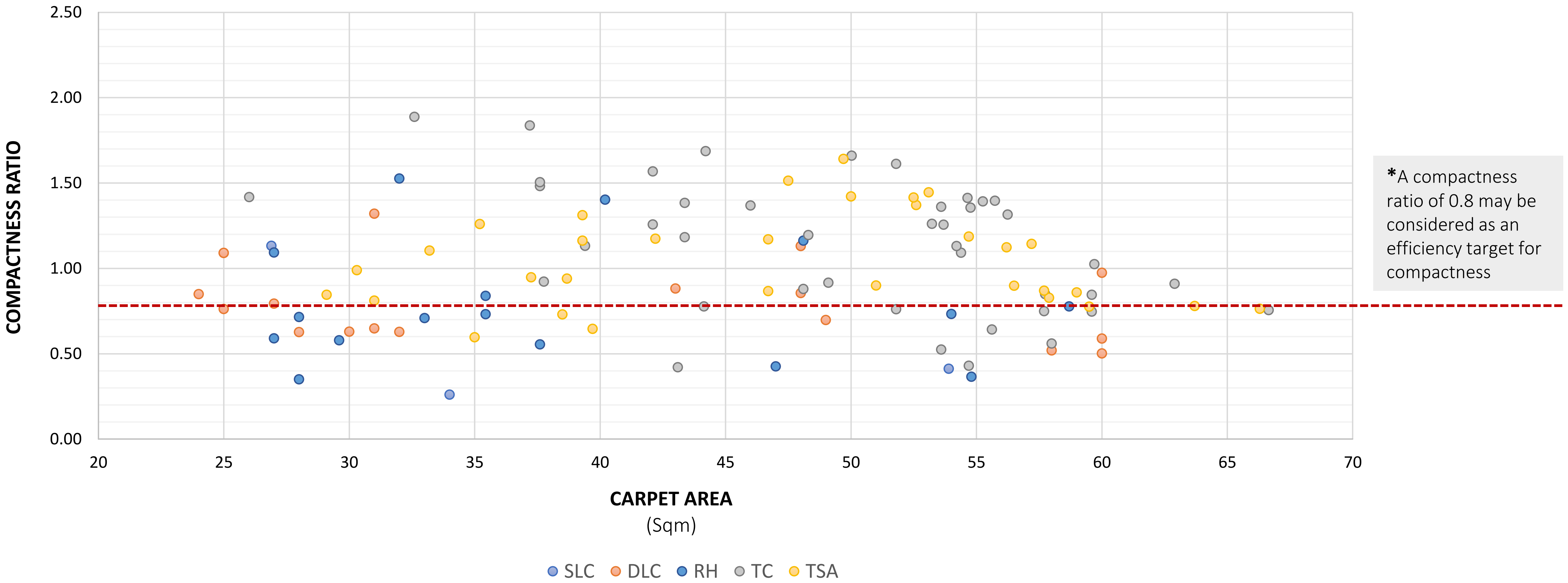
Compactness ratio

- Compactness of plan is desirable for reduction of heat transfer across the building envelop and for energy conservation

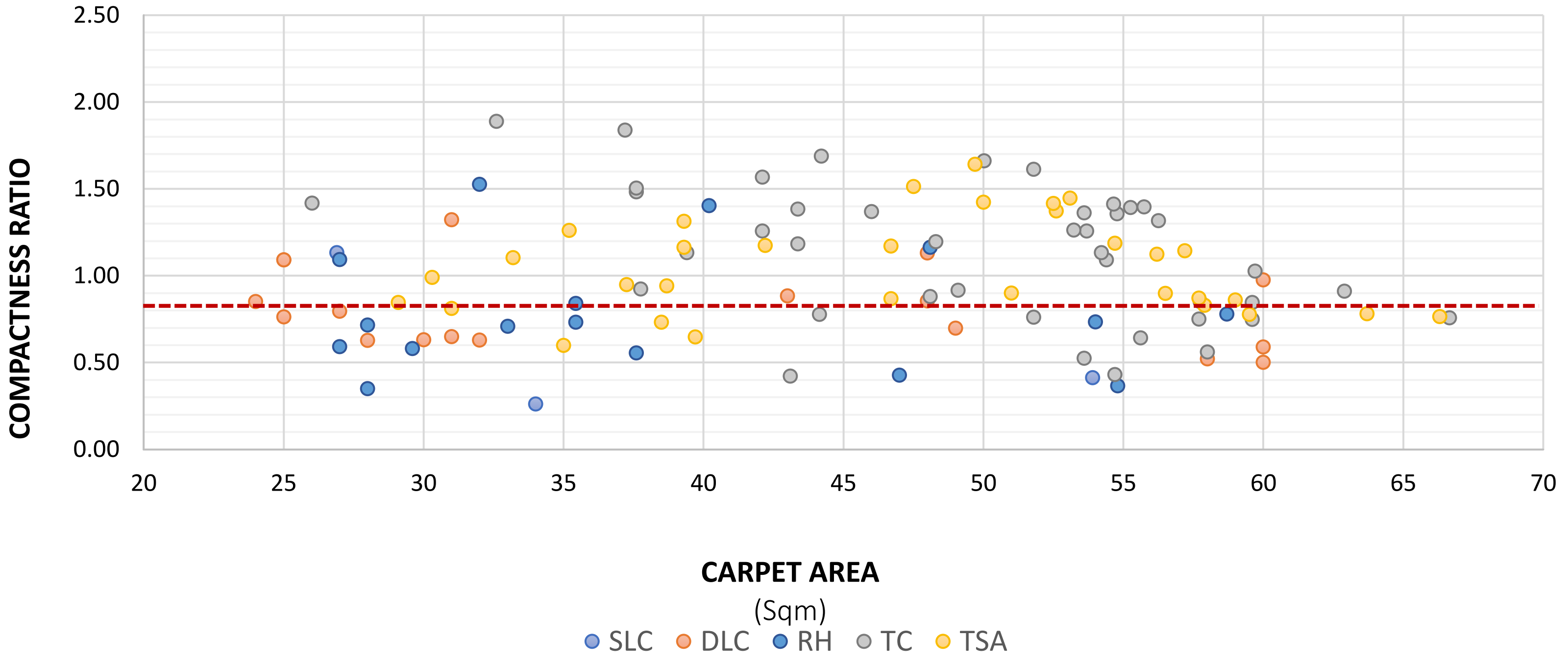
- Compactness is the ratio of the DU external wall area to the DU carpet area

- Higher the value of the ratio, lesser is the compactness of the DU.



*A compactness ratio of 0.8 may be considered as an efficiency target for compactness

Compactness ratio - Inferences

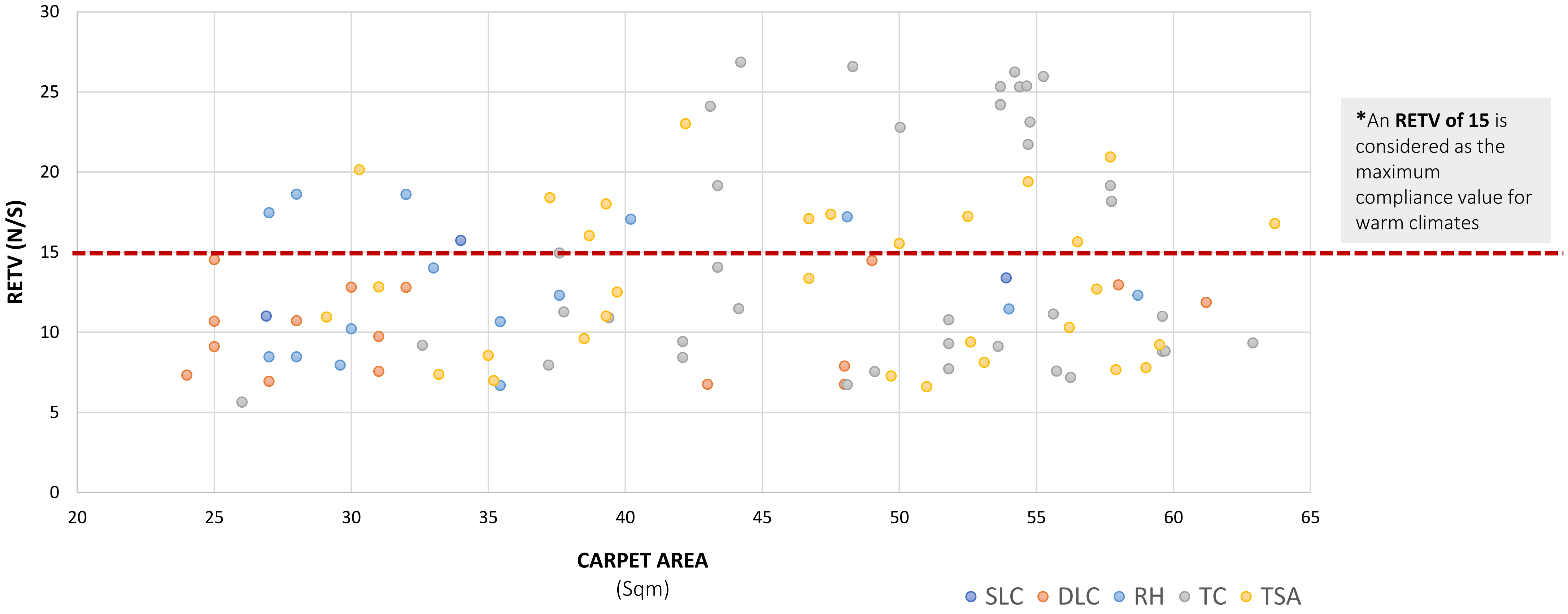


- In **SLC and DLC** building plan types **compactness is achieved** irrespective of DU size.
- In **Tower Connected (TC)** building plan type it is seen that **compactness is poor in small DUs** and **improves for** DU size between **50-60Sqm.**
- However, in **Tower Stand Alone (TSA)** it appears that **reasonable compactness** can be achieved at **all DU sizes**.

RETV (Best case) **– North/South**

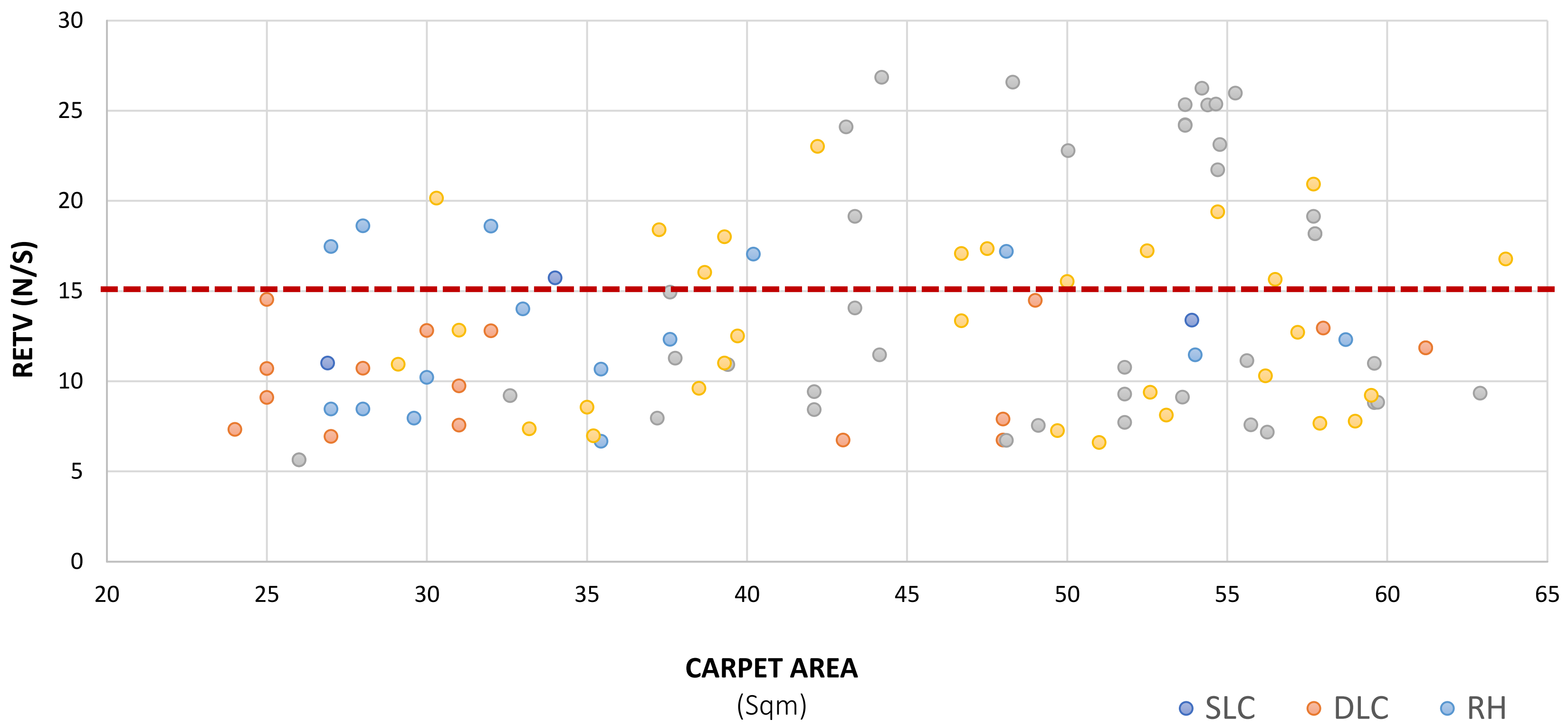
•RETV (Residential Envelope Transmittance Value) is a measure of heat transfer through the building envelope

•RETV has been adopted as an energy efficiency measure for the Eco Niwas Samhita-R (ENS) code for residential building design.



***An RETV of 15** is considered as the maximum compliance value for warm climates

RETV (N/S) - Inferences



- It is observed that if ideal orientation of the longer **facade facing N/S** is considered, **RETV performance shows good results in most cases.**
- However, it is seen that in the case **of TC and TSA** building plan types **RETV of 15 is not met by approximately half the projects**

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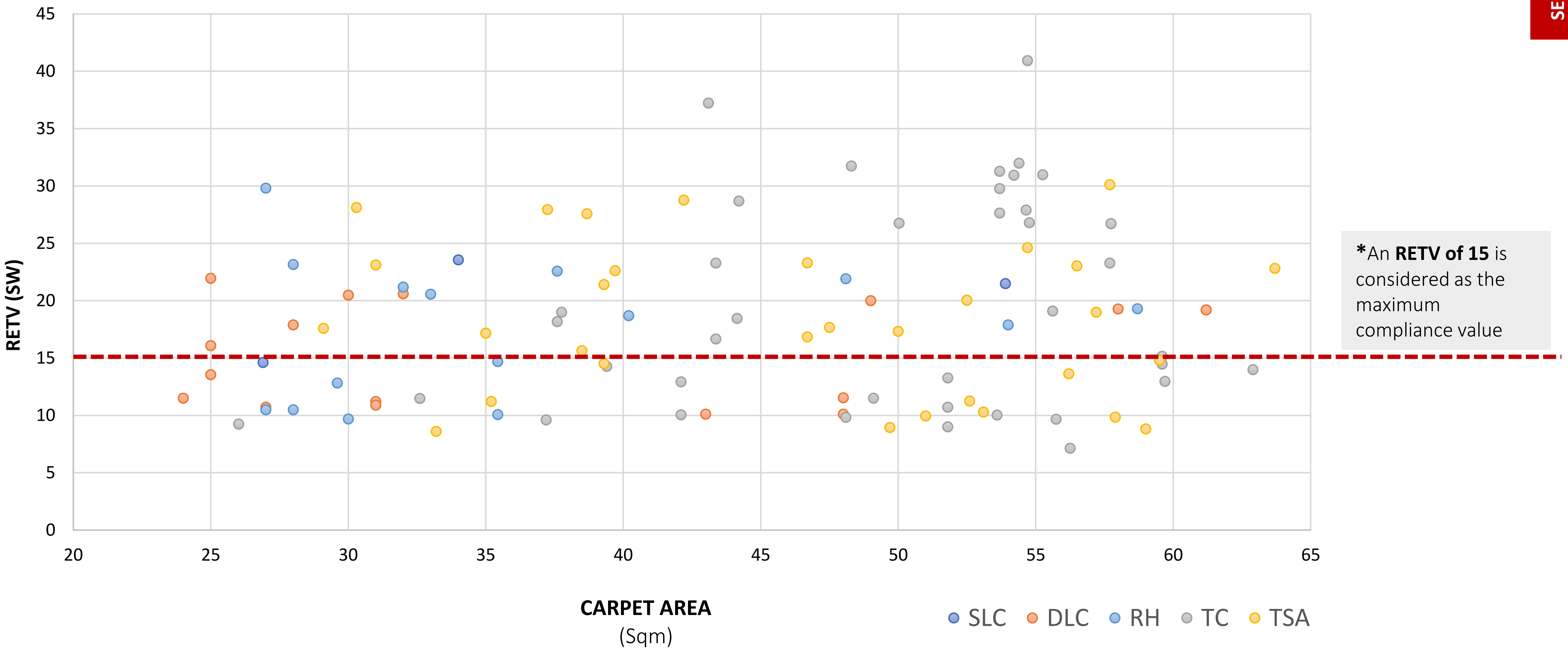
RETV (Worst case) – **South West**



*An **RETV of 15** is considered as the maximum compliance value

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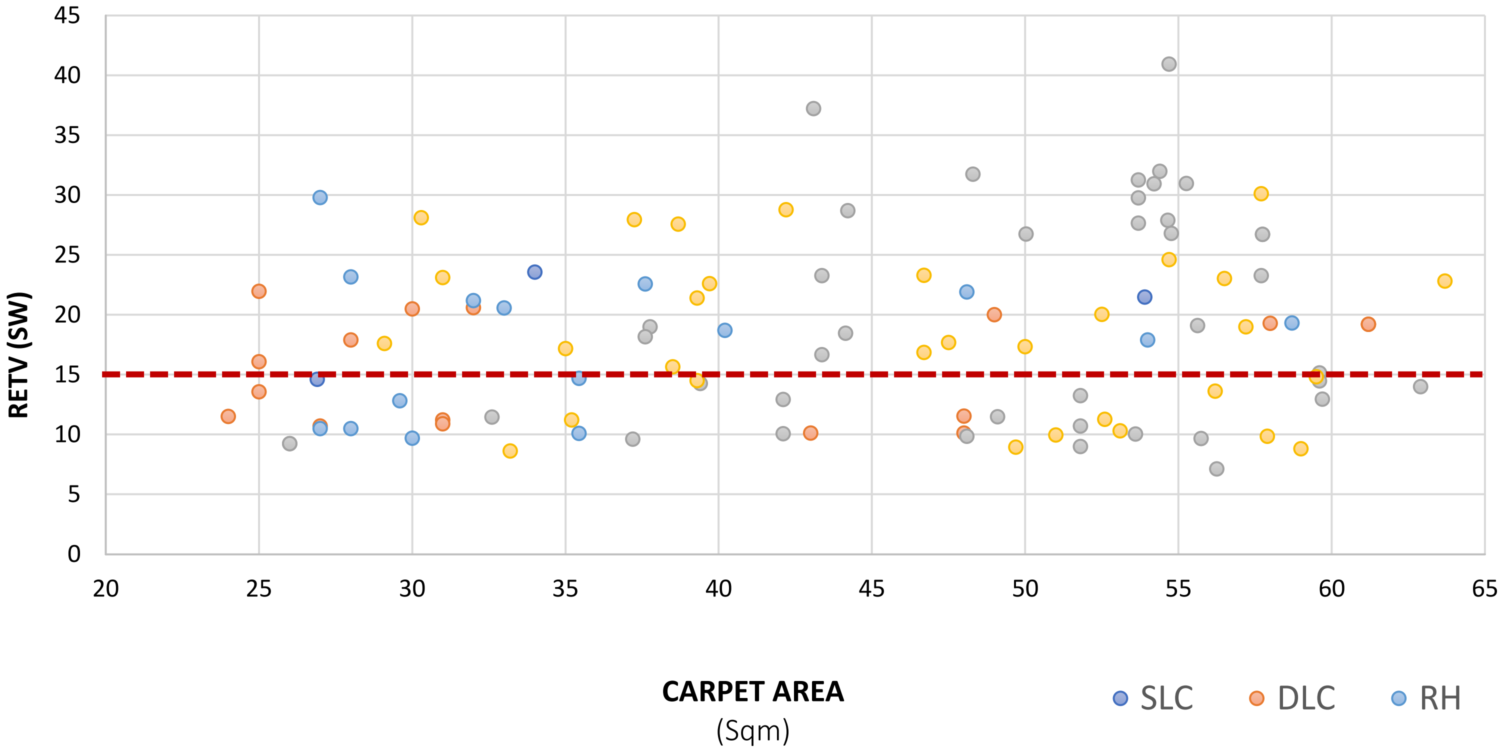


- When considering the worst case **SW orientation** for the main facade, the **RETV performance declines significantly.**

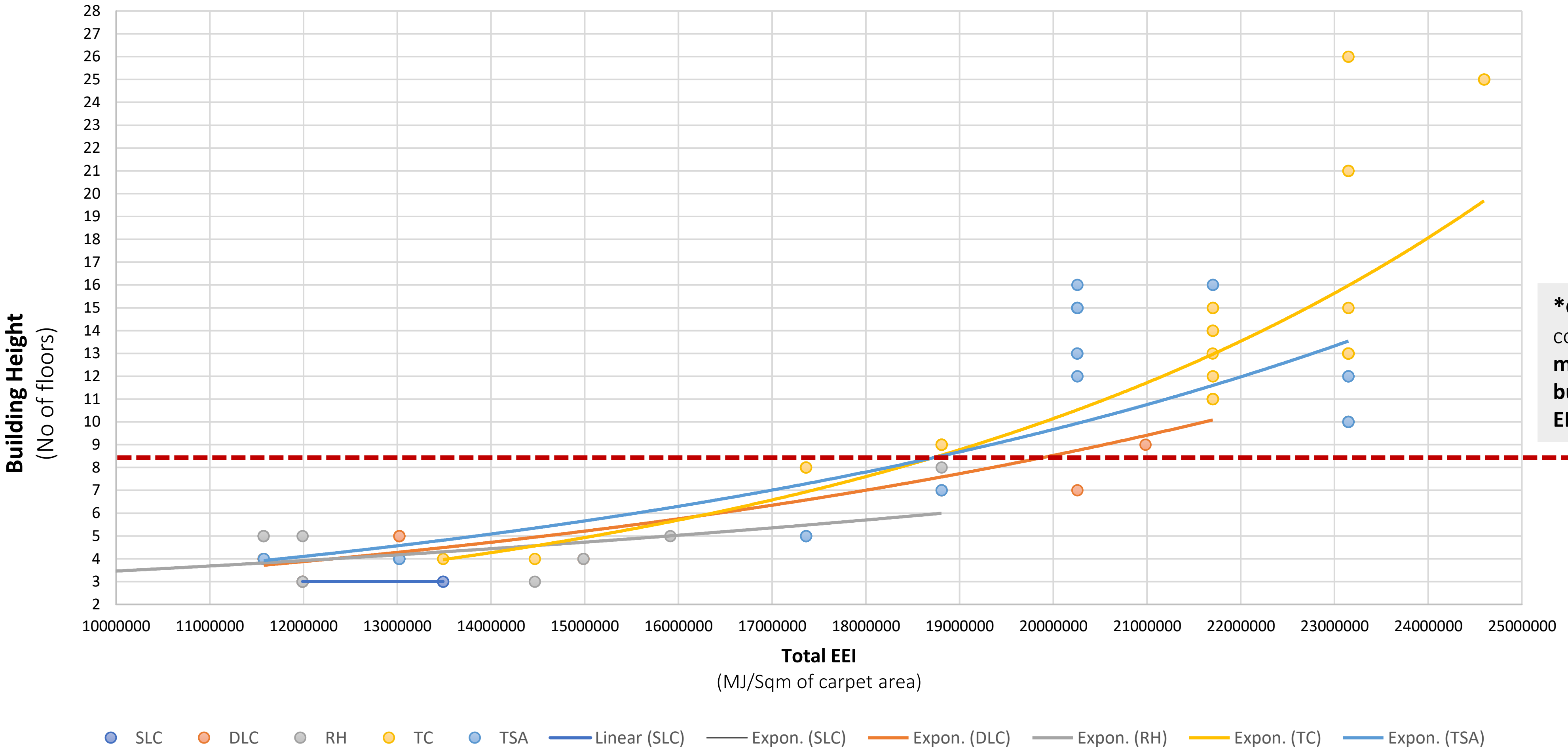
- The **TC and TSA** projects have the **worst RETV performance** between **a range of 20 and 32.**

Embodied Energy Intensity

•Embodied energy intensity (EEI) is measured as embodied energy of structural system and external walling per sqm of DU Carpet area.

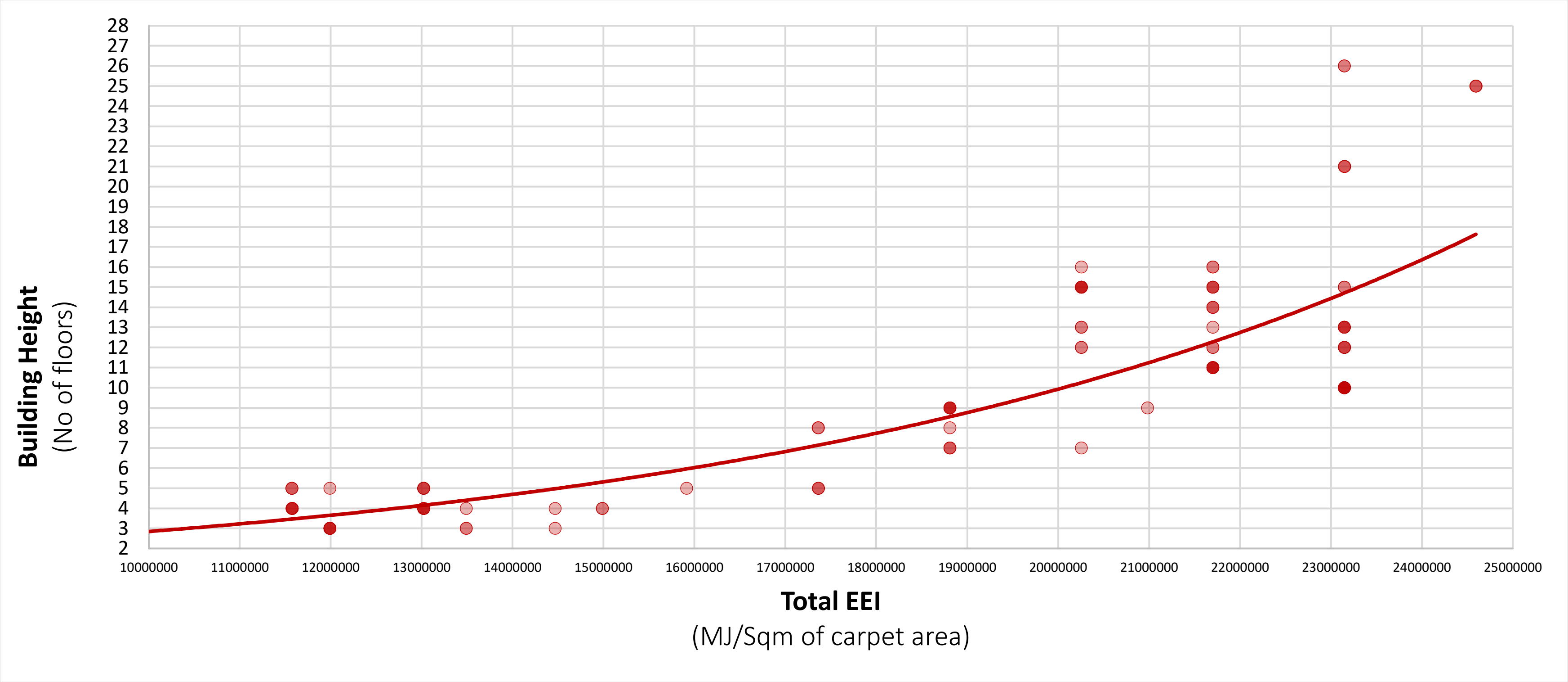
•EEI will be the dominant source of CO2 emissions in affordable housing. This becomes very important given the large scale of housing anticipated in

• EEI is analyzed in relation to building height. Low EEI will be preferred.



***G+7** may be considered as the **maximum building height for EEI control**.

Embodied Energy Intensity - Inferences



- It can be seen clearly that embodied energy intensity **(EEI) rises significantly** with **increase in building height.**

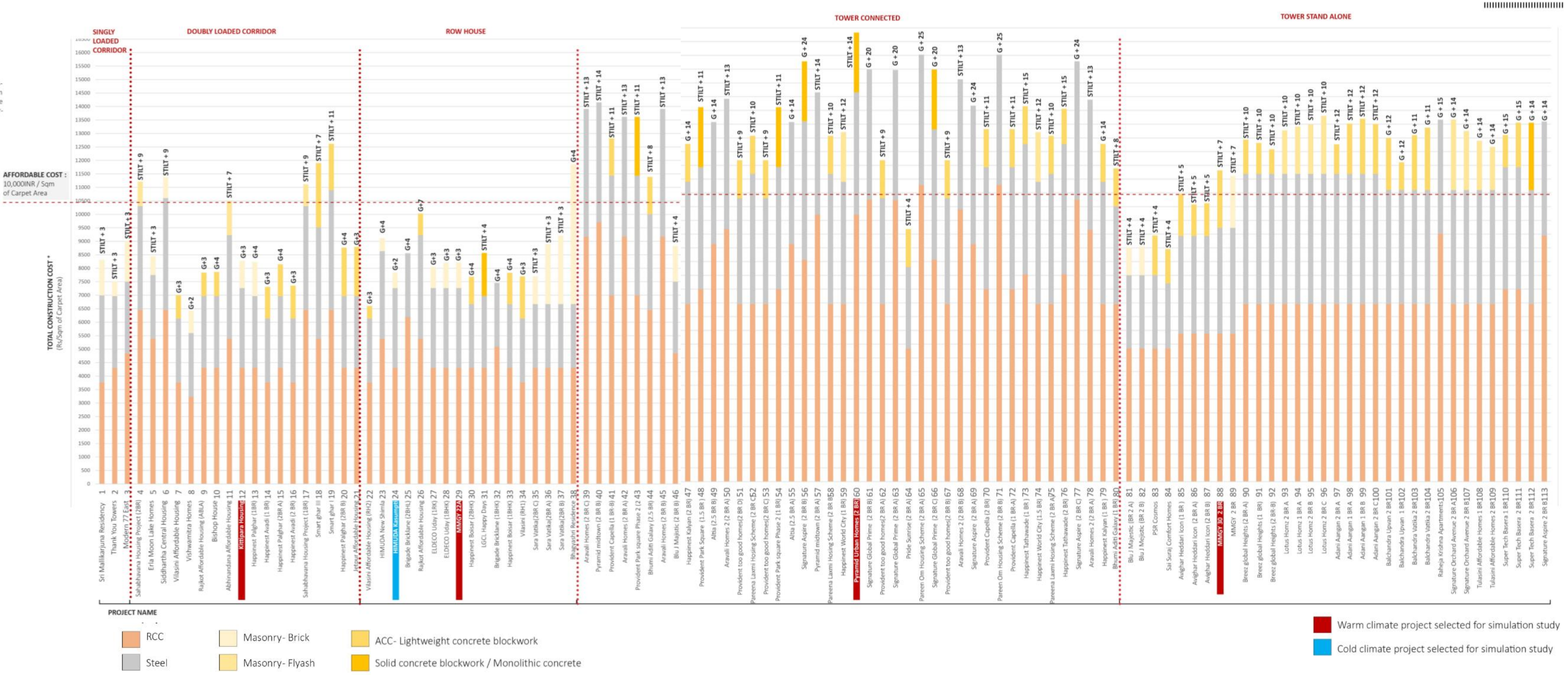
- It is seen that **EEI rises steeply** as we **move towards taller buildings**. It can be seen that the building height may be limited to **G+7 for EEI control .**

- Affordability of construction system is an important concern for affordable housing.

- Cost of construction systems is primarily determined by the structural system (RCC & Steel) employed and the external walling material.

- Construction cost of these two components per sqm of carpet area is proposed as a comparative measure to understand cost trends in relation to building height and building plan type.

TOTAL COST OF CONSTRUCTION = COST/Sqm carpet area RCC + COST/Sqm carpet area Steel + COST/Sqm carpet area Walling ONLY



*Does not include cost of finishes and secondary building components (doors ,windows and cabinets)

Cost Trends - Inferences

- **Affordability** of building construction is **directly proportional to building height** and the **construction technology** adopted.
- It is observed that **monolithic concrete** technology is **the most expensive cost/Sqm carpet area.**
- **Low to mid-rise buildings** remain **reasonably affordable** at a price of approximately **10,000 INR /Sqm of carpet area.**
- It is seen that **steel** contributes approximately **45-55% of the total building cost** and **concrete** about **35-40% remaining cost.**

Summary - *Gap analysis*

COMPACTNESS

For smaller homes (25-45Sqm) it would be **advisable to adopt SLC, DLC and RH** since it is easier to design them compactly.

RETV

Approximately **60% projects do not meet RETV** requirements.

This clearly indicates that **buildings are not being designed with respect to orientation** which indicates the **need for external shading system and window sizing** with response to orientation.

EMBODIED ENERGY

For building heights **beyond G+7**, the **EEI value rises sharply**. This is **most evident in the high-rise tower typologies**

COST OF CONSTRUCTION

The **cost of taller buildings rises with height**. This may be **correlated with the increase in the quantity of steel** consumed in the structural system of taller buildings.

Building **height of up to G+7** which curtail the intensity of steel **would be a positive and productive strategy** to maintain construction **affordability.**

End of Session 1

Points discussed

1. WP1 Documentation divided into two parts:

- General trends of affordable housing construction
- Prevalent gaps in design / construction practices in adopting strategies for thermal comfort

2. Survey dataset

1. Climatic range 2.Building height range 3.Building plan type range 4.Construction technology range

3. General trends of affordable housing construction

- Building plan types are **not climate specific**
- **From the dataset** : Most prevalent building plan type is **tower connected**, most prevalent construction technology is **RCC with AAC** and most prevalent building height range is **high-rise**

4. Criteria for gap analysis

1.Passive strategies 2.Thermal comfort simulation 3.Embodied energy Intensity 4.Construction cost trends

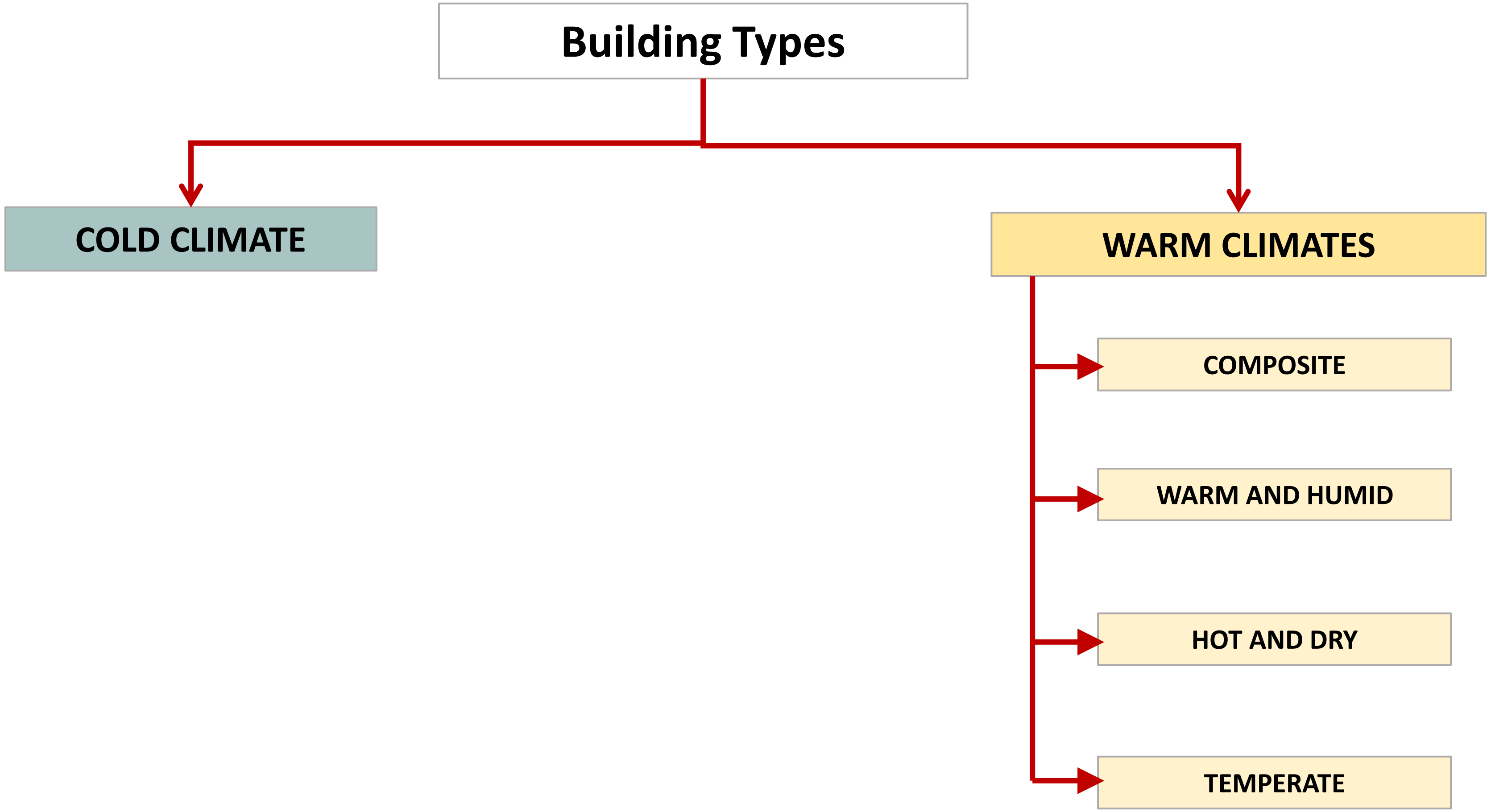
5. Gap analysis inferences

1. Compactness ratio of 0.8
2. Orientation and shading to improve RETV performance
3. Building up to G+7 for better EEI control
4. Reducing quantity of steel and building up to G+7 as positive strategies for affordability

SESSION II

Framework for development of type designs

SESSION II : Categorization of residential buildings for Type designs



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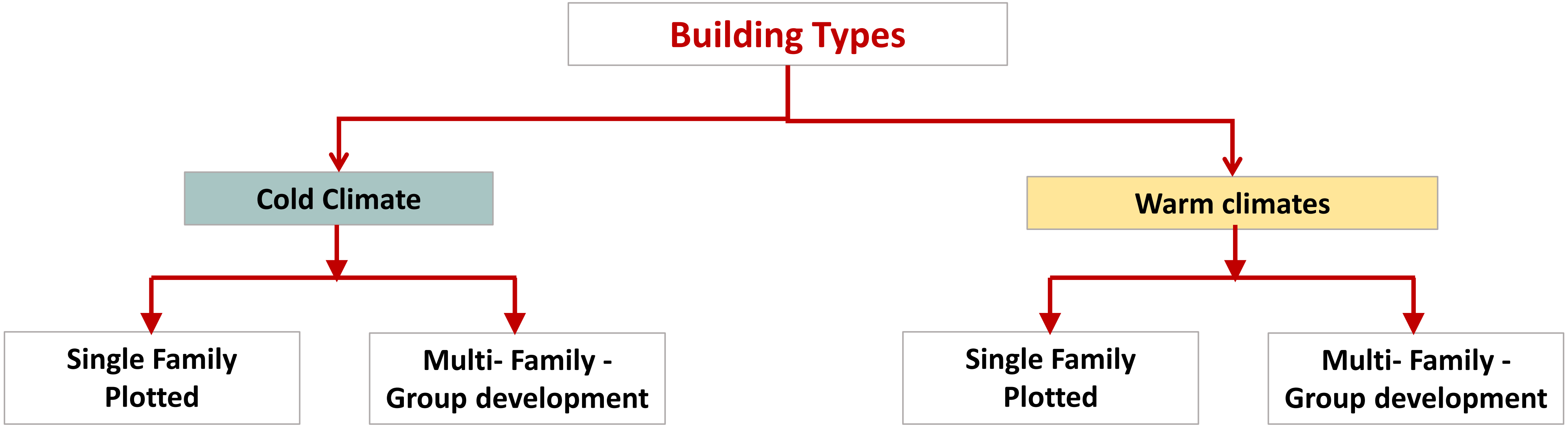
Building Types
Cold Climate
Warm climates
Single Family Plotted
Multi- Family - Group development
Single Family Plotted
Multi- Family - Group development

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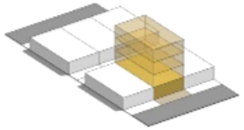
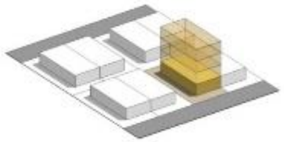
Building Types

Single Family Plotted

Multi- Family group development



ROW HOUSE 2 SIDE OPEN
(PMAY(U) BLC)

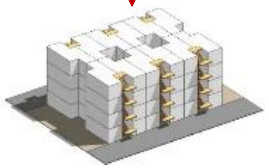


ROW HOUSE SEMI-DETCHED
(PMAY(U) BLC)

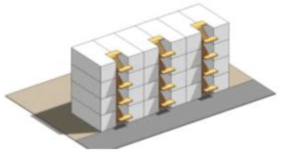
Building Types

Single Family Plotted

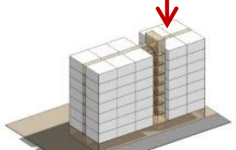
Multi- Family group development



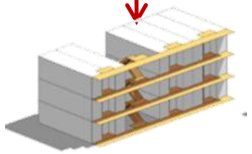
ROW HOUSE BACK TO BACK
1 BHK



ROW HOUSE 2 SIDE OPEN
1 BHK
2 BHK

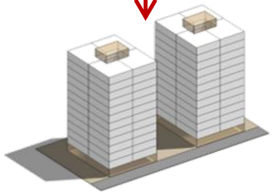


DOUBLY LOADED CORRIDOR
1 BHK
2 BHK
DORM (PMAY(U) Rental)
HOSTEL (PMAY(U) Rental)



SINGLY LOADED CORRIDOR
1 BHK
2 BHK
DORM (PMAY(U) Rental)

TOWER CONNECTED
2 BHK
2.5 BHK



TOWER STAND ALONE
2 BHK
2.5 BHK

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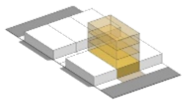
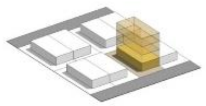
Replicable Type Design Matrix

Single Family Plotted

Multi- Family group development





LOW RISE (BUILDING HEIGHT <=12M (G+3))				
ROW HOUSE – 2 SIDE OPEN	**1BHK**	1BHK	**2BHK**	**2BHK**
ROW HOUSE SEMI-DETACHED			**2BHK**	2BHK

Selected type designs will –

- **Consider 2 construction technologies**
- **2 orientations** (best and worst)

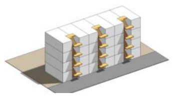
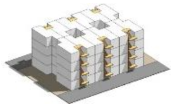
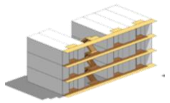
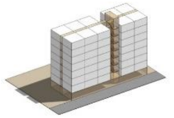
Replicable Type Design Matrix

Single Family Plotted

Multi- Family group development

Selected multi-family type designs will –

- **Consider 3 construction technologies**
- **2 orientations** (best and worst)
- **2 Vertical locations** (Middle and Bottom)
- **2 Horizontal locations** (Edge and Middle)

LOW RISE (BUILDING HEIGHT <=12M(G+3))					
ROW HOUSE – 2 SIDE OPEN	**1BHK** (<= 30SQM)	1BHK (30-45SQM)	1BHK (30-45SQM)	**2BHK** (30-45SQM)	**2BHK** (45-60SQM)
ROW HOUSE BACK TO BACK	**1BHK** (<= 30SQM)				
SINGLY LOADED CORRIDOR	**1BHK** (<= 30SQM)	**DORM 1** (<= 30SQM)	1BHK (30-45SQM)		
DOUBLY LOADED CORRIDOR	1BHK (<= 30SQM)	**DORM 2** (<= 30SQM)	**HOSTEL** (<= 30SQM)		

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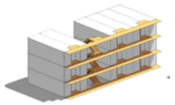
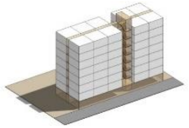
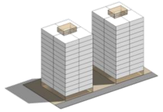
Replicable Type Design Matrix

Single Family Plotted

Multi- Family group development

Selected multi-family type designs will –

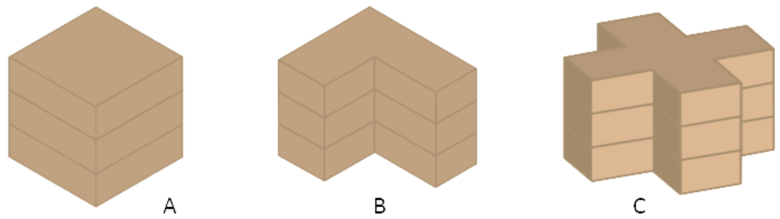
- **Consider 3 construction technologies**
- **2 orientations** (best and worst)
- **2 Vertical locations** (Middle and Bottom)
- **2 Horizontal locations** (Edge and Middle)


MID RISE (BUILDING HEIGHT <=15-24M(G+4 – G+7))				
SINGLY LOADED CORRIDOR	**2BHK** (45-60SQM)			
DOUBLY LOADED CORRIDOR	**1BHK** (<= 30-45SQM)	**2BHK** (30-45SQM)		
TOWER STAND ALONE	**1BHK** (45-60SQM)	**2BHK** (45-60SQM)	**2BHK** (45-60SQM)	**2.5BHK** (45-60SQM)
TOWER CONNECTED	**2BHK** (45-60SQM)	**2.5BHK** (45-60SQM)		

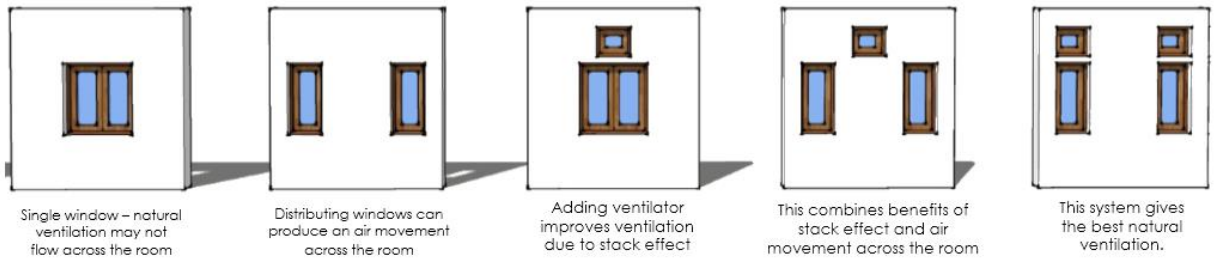
1. COMPACTNESS

Surface to Volume ratio increase from A to C as the built form gets more complicated



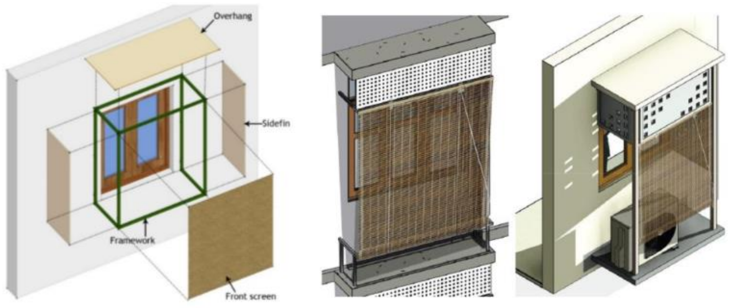
2. PROTECTION FROM HEAT

- Controlling Window to Wall area Ratio (WWR)
- Selecting external wall/roof materials for insulation value



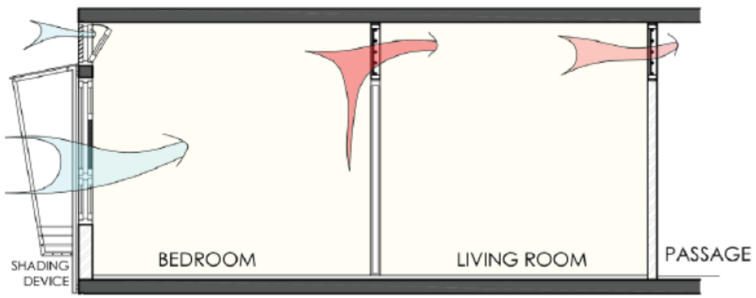
3. PROTECTION THROUGH SHADING

Use of shading devices to cut Solar gains

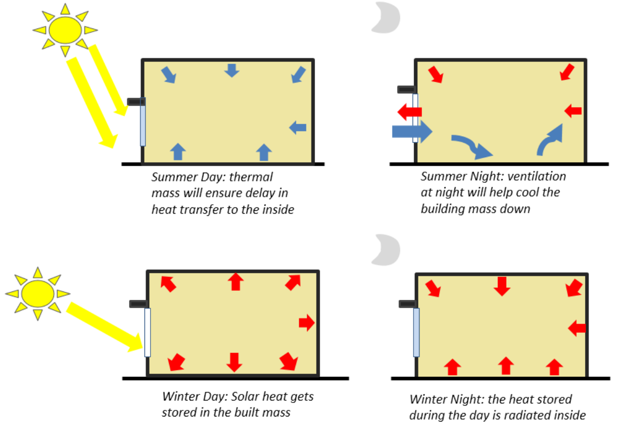


4. 0PTIMIZING OPENINGS FOR VENTILATION

Ensuring cross ventilation through all living spaces of the house



5. USE OF THERMAL MASS & SOLAR GAINS TO ENSURE INDOOR COMFORT



End of Session 2

Points discussed

1. Climate classification

1. Warm climates
2. Cold climate

2. Building Plan types

1. Single family plotted
2. Multi family group development

3. Principles for planning and passive design for thermally comfortable affordable housing

1. Compactness
2. Protection from heat
3. Protection through shading
4. Optimizing openings for ventilation
5. Use of thermal mass and solar gains to ensure indoor comfort

SESSION III

Type design overview of Thermal Performance and Carbon Footprint of Construction

Type design performance

Thermal performance

1. ENS compliance for Envelope

- Check for compliance for WFR, WWR, U value (Walls, Roof), RETV for Composite, Warm & Humid, Hot & Dry and Temperate climates
- Check for compliance for WFR, WWR, U value (Roof), for Cold climates

Software used : N.A.

Outputs :

1. ENS Value for each type design

2. Energy Simulation

The building design - architectural, mechanical and electrical systems will be replicated in the energy simulation software to analyze the energy data, design effectiveness, performance of different systems, energy demand, energy consumption etc.

Software used: Design builder and Energy plus engine

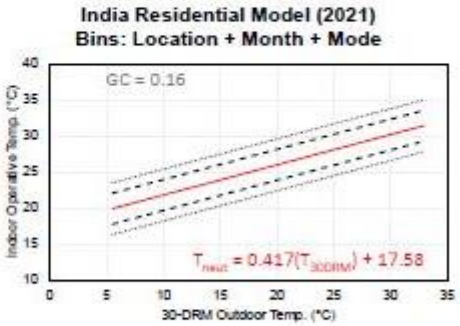
Outputs:

1. **Degree-discomfort hours**
2. **Daylight performance**

Embodied Energy Intensity

SESSION III: A) Thermal performance : Methodology for simulation

- Energy simulation is carried out in **Design Builder software** and detailed modelling is carried out in the **Energy plus engine**.



80% Acceptability at ± 3.60 °C
90% Acceptability at ± 2.15 °C

Source: CARBSE, CEPT, 2022 (unpublished)

- **IMAC-R will be used as the setpoint temperature.** For window operating schedules NV is considered as the upper and lower limit.

- Detailed inputs in terms of **number floors, building geometry, Envelope details, and internal loads are provided in the simulation software.** Detailed **natural ventilation modelling** is carried out in Energy plus.

- The **schedule of occupancy is considered based on general practice in Indian household**. **No. of occupants are taken from NBC standards** varies based on 1BHK/2BHK/3BHK.

- **Lighting assumption** for Baseline case study models is **4 W/m2 LPD.**

- Equipment is considered as **BEE 3-star equipment,** default from BEE Star Labelling for Residential buildings).

SESSION III

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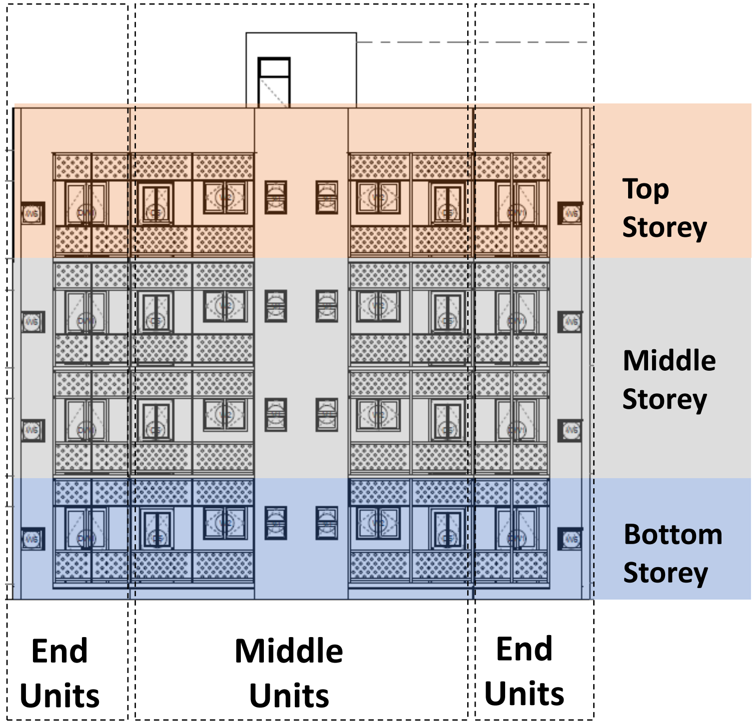
SESSION III: A) Thermal Performance variants –DU location, orientation and walling/roofing material

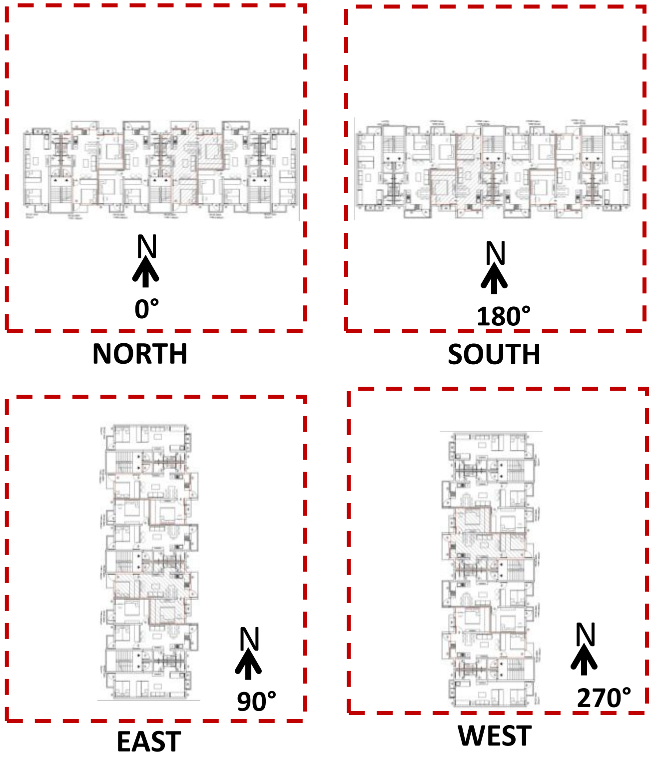
LOCATION

- **VERTICAL**
  Ground, Middle and Top floor
- **HORIZONTAL**
  Edge and middle units



ORIENTATION

- The variants are in turn tested for **different orientations** with respect to true North.
- The proposed type designs will be such that all unit variants meet the minimum standards of thermal performance.



WALLING / ROOFING MATERIAL

- The variants are in turn tested for **different orientations** with respect to true North.

Simulation results will be given for 1000 cases.

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Type design performance

Thermal performance

Embodied Energy Intensity

EEI will help understand the correlation between the building types and construction systems. It is measured as Kg of CO_2 emitted per sqm of carpet area of dwelling unit). Total EEI for each type design will be a sum of three quantities :

1. Steel EEI
2. Concrete EEI
3. Walling EEI

Software used: NA

Outputs:

1. **Embodied energy intensity (EEI) / Sqm of carpet area for all typed designs.**

- The EEI is measured as **Kg of CO2 emitted per sqm of carpet area** of dwelling unit

- Depends on type of structural system, building height and earthquake zone location

- Calculating the EEI will **allow comparative observations of the type designs**, construction technologies and building height

TOTAL EEI BUILDING

30% Finishes and sub-components

70% Structural support and walling system

Total Embodied Energy Intensity (EEI)

EEI Steel
- Highest contributor to EEI
- EE of total volume of structural steel / Sqm of carpet area

+

EEI concrete
- Second significant component of building EEI
- EE of total volume of concrete / Sqm of carpet area

+

EEI Walling
- Significant contributor of building EEI
- EE of total walling area / Sqm of Carpet area

End of Session 3

Points discussed

1. Key parameters for analyzing type design performance

- **Thermal performance** - ENS Compliance for envelope, Energy simulation
- **Embodied energy intensity –** Total EEI = Steel EEI + Concrete EEI + Walling / Infill material EEI

2. Methodology for simulation

3. Thermal Performance variants

- Location
- Orientation
- Walling / Roofing material

4. Embodied Energy Intensity and carbon footprint of construction

Way Forward

WEBINAR 1

- Overview of existing design and construction practices to identify gaps in achieving optimal thermal comfort
- Framework for development of type designs
- Overview of thermal performance and carbon footprint of construction

WEBINAR 2

- Range and size of type designs
- Logic and methods of planning and construction of the type designs
- Passive design strategies that have been adopted
- Methodology and input parameters for the simulation models and results obtained

WEBINAR 3

- Discussing the simulation results of different building plan typologies to understand their thermal performance.
- Thermal performance results across different climate zones and trends observed in different orientations
- General observations and learnings from the project with examples and comparisons across different typologies.

WEBINAR 4

- Webtool structure and layout
- Navigating the web-tool

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THANK YOU

Knowledge Partners:

Ashok B Lall Architects

LEAD Consultancy

Greentech Knowledge Solutions