Type Designs for Energy Efficient Residential Buildings

2nd Webinar for Stakeholder Consultation

13th July 2020

german cooperation
DEUTSCHE ZUSAMMENARBEIT

Implemented by
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Introduction

- The **Catalogue of Type designs for energy efficient Residential Buildings** and all related data will be made available to the users through a web-based tool.
- This **web-based platform** is a learning tool that will help **designers, builders and promoters** of residential buildings to understand the ways of designing **energy efficient buildings**.
- The tool covers various aspects of energy efficient design for residential buildings, bringing to the user **sample designs with detailed simulations** and identified **criteria for measuring the performance** of the building.
- The focus of the project is to **enable the user/ builder/ designer** to easily **adopt energy efficiency** measures into construction **with immediate impact**.
- With the help of this tool the user will be able to select the most suitable **Energy Efficiency Measures** (EEMs) applicable to their building to reach a desired performance bench mark.

Objectives

- The objective of the proposed assignment is **Developing a Catalogue of Replicable Design options for Energy Efficient Residential Buildings**.
- The building designs will set an example of energy and environmental performance that goes **beyond existing standards**.
- The project aims to develop a **design template** for building energy efficient homes, catering to:
  - Various **residential types**
  - Across different **house sizes**
  - In **different climatic zones** across India
- It shall implement energy efficiency through:
  - **Energy efficient design** implementing **passive measures**
  - Selection of **Low energy structure and materials**
  - Selection of **efficient mechanical systems** for thermal comfort
- The stakeholders who can benefit from this project include **builders, designers, home owners, Govt. agencies : Municipalities as well as policy makers**.

Sessions covered in 1st webinar

The team is conducting stakeholder consultation through webinar sessions.

The 1st webinar took you through the range of residential building typologies and sizes of dwelling units for which the designs have been developed for all five climatic zones of India, the logic & methods of planning and construction of the proposed design options, the passive design strategies that were adopted during the design phase.

Session 1	'Replicable' Type Designs for energy Efficient Houses
	Residential typologies
Session 2	Principles of planning Energy Efficient buildings
	Construction Methodology & materials
Session 3	Energy Performance
Session 4	The Web-tool Package

Sessions for this webinar

Session 1	Typical Dwelling Unit Design
Session 2	Energy Performance Simulation
Session 3	Energy Performance Results
Session 4	Exemplary Performance Results
Session 5	Web-tool download-able package

Typical Dwelling Unit Design

Session 1

Type Designs

- A **catalogue** will be developed to visualize and compare **building design options** based on **energy performance** and other selection criteria **to enable informed choices** from the proposed design templates.
- **Standard plot proportions** prevalent in various regions are adopted for plotted development type designs.
- The Type Designs being prepared for the **different sizes of apartments may be adopted or adapted for different site conditions**.
- All detailed energy analysis will be at **unit level** with **potential and general guidelines for master planning** with examples of site plans and building plans.
- The Replicable Designs will essentially be layout plans of residences. They will also show the **materials and construction** of **the elements of the external envelope**. Internal finishes and details are left for the designer/ builder to decide, as these have no bearing on the energy performance of the designs.

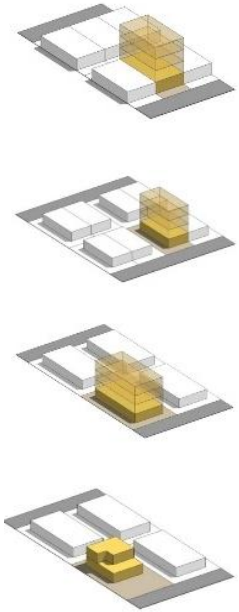
Design Catalogue

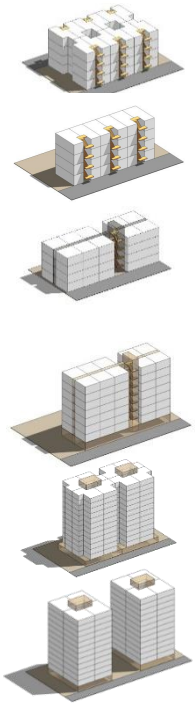
The Design Catalogue will offer a typology & size matrix

Housing Typologies

Single family - Plotted

Multi family – Group Development

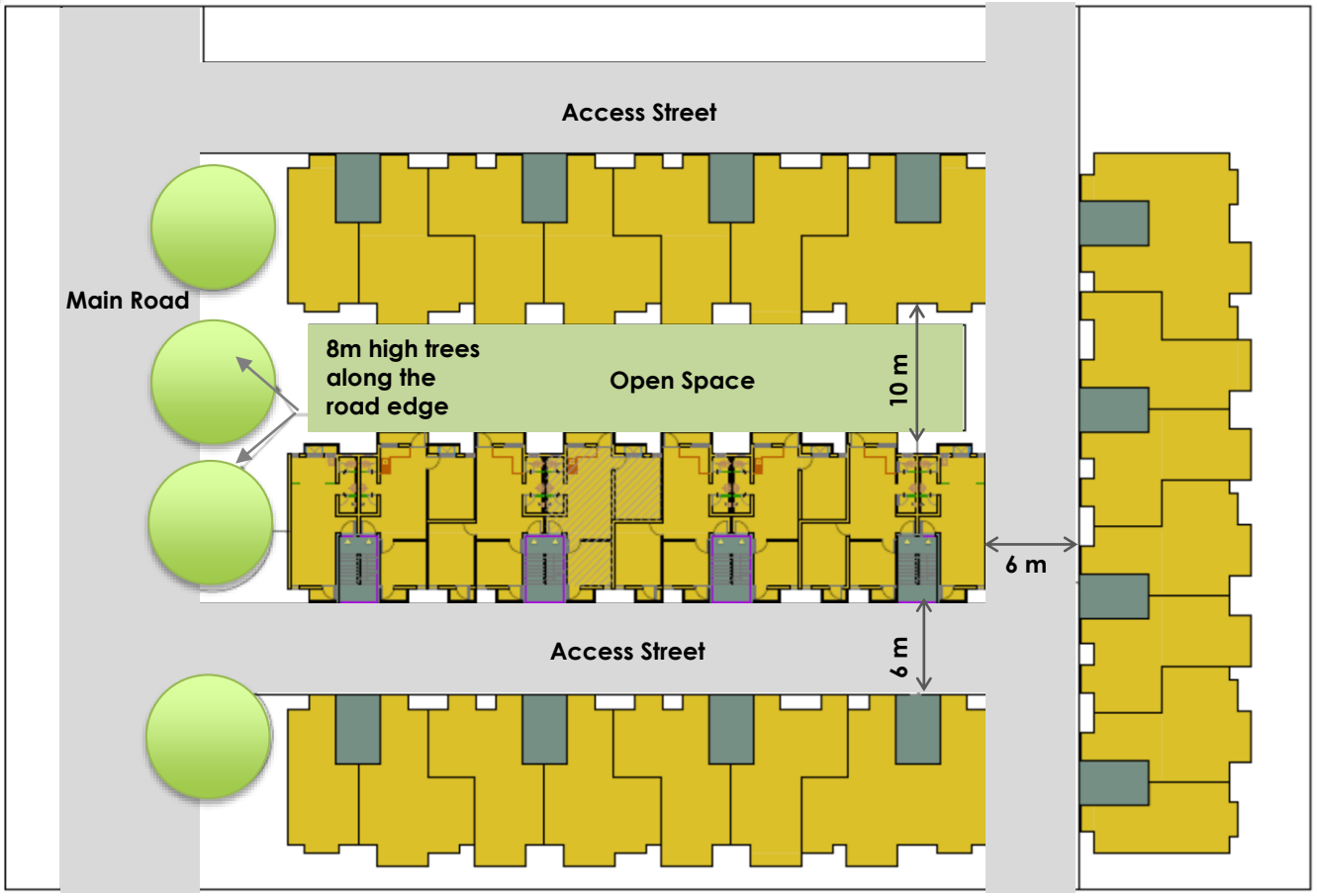




Low Rise (Building Height <=15m)						
Back to back row house	1BHK (30sqm)	2BHK (41sqm)	3BHK (55sqm)			
2 side open row house	1BHK (32sqm)	2BHK (48sqm)	3BHK (62/68 sqm)			
Doubly loaded corridor	1BHK (30sqm)					
Mid/ High Rise (Building Height>15m)						
Doubly loaded corridor		1BHK (44sqm)	2BHK (65sqm)	3BHK (85sqm)		
Connected Towers			3BHK (105sqm)	3BHK (125sqm)		
Stand-alone Towers			3BHK (105sqm)	3BHK (125sqm)	3.5 BHK (156sqm)	4.5 BHK (225sqm)

A typical 2 side open row house 2 BHK unit has been selected as a case example for this webinar

Site Plan



SITE PLANNING

The building configuration is such that the staircases/ cores are aligned to one side of the block. Thus two parallel blocks can be aligned on either side of a street with open spaces behind them. This pattern leads to most blocks in a layout forming streets and linear open spaces.

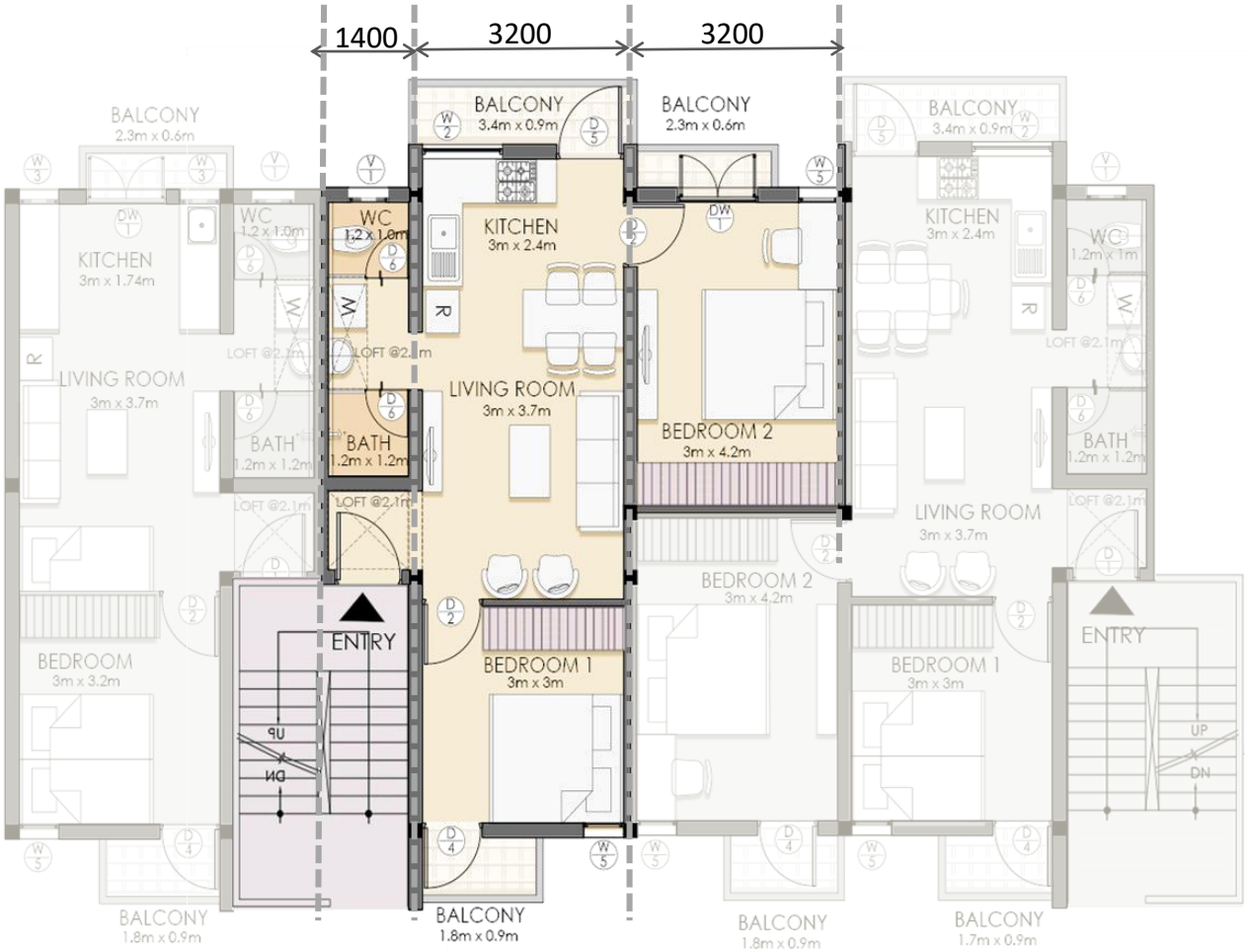
2 side open Row-house : Block

- This typology has units stacked side by side to form a linear block
- These are walkup apartments which can be built upto Ground +3 storeys
- 1,2 & 3 BHK configurations are designed for this typology. Some units are designed as center units while some are designed as end units with additional openings.

Block Plan with mixed unit types

2 side open Row-house : Unit

- This typology has units with longer sides as shared walls and shorter sides open to external façade for light and ventilation.



ROW HOUSE 2 SIDE OPEN
2BHK
Carpet Area – 48sq.m

End of session 1 – Typical Dwelling Unit Design

Session summary:

- **Type Designs** – underlying principles
- **Design Catalogue & Matrix**
- **Typical Design**
  - Site layout
  - Block layout
  - Unit layout

Questions & Feedback

Energy Performance Simulation

Session 2

Simulation Methodology

- The building designs ensure compliance with ENS requirements for a given climatic zone. Energy simulation is conducted upon the ground floor, middle floor and top floor dwelling. Each layout is assessed for 4 different orientations (0 deg, 90 deg, 180 deg and 270 deg). The modelling methodology is adopted based on Residential building Energy labelling program. In the 2BHK dwelling unit, one-bedroom is considered conditioned with a setpoint temperature of 24 deg C for cooling and 21 degC for heating. The living room and the other bedroom is run on mixed-mode use where the cooling and heating setpoint temperature is considered from IMAC.

- Detailed inputs in terms of number floors, building geometry, Envelope details, internal loads and active systems are provided in the simulation software. Detailed natural ventilation modeling is carried out in Energy plus. The schedule for window operation based on temperature.

- Daylight simulations are carried out on Radiance based Lighting Simulation software for detailed analysis and optimization.

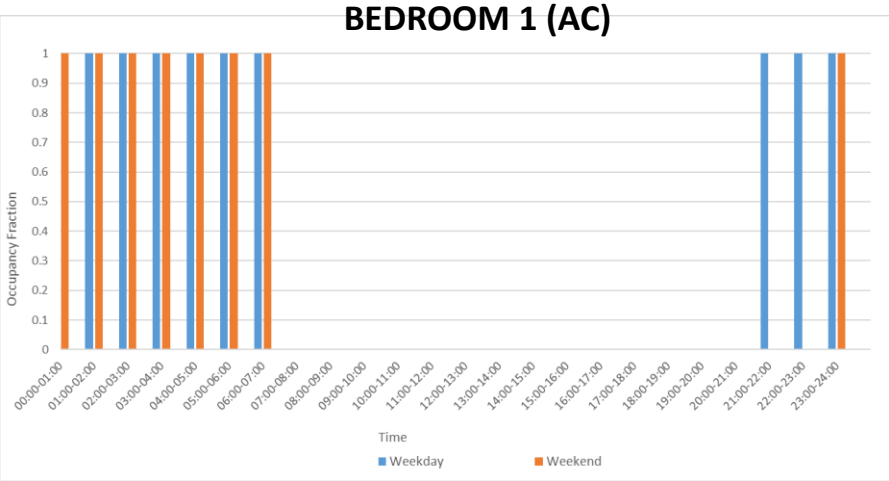
Months	Acceptibility Range	Naturally ventilated
January	90%	23.76
		19.00
February	90%	24.50
		19.74
March	90%	27.06
		22.30
April	90%	30.24
		25.48
May	90%	32.41
		27.65
June	90%	33.07
		28.31
July	90%	32.15
		27.39
August	90%	31.17
		26.41
September	90%	30.70
		25.94
October	90%	29.75
		24.99
November	90%	27.86
		23.10
December	90%	25.58
		20.82

IMAC, NV Set point temperatures for Lucknow (Composite Climate)

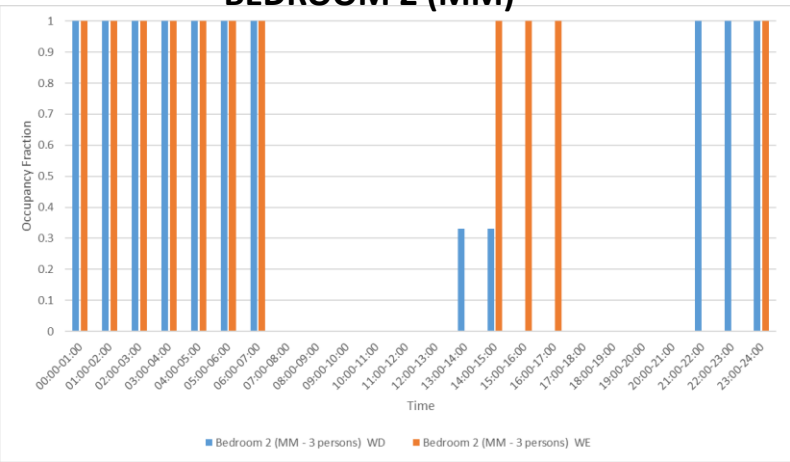
Input Parameter : Occupancy schedule

- Hourly occupancy numbers and schedules are developed based on NBC norms and observed trends in residential buildings.

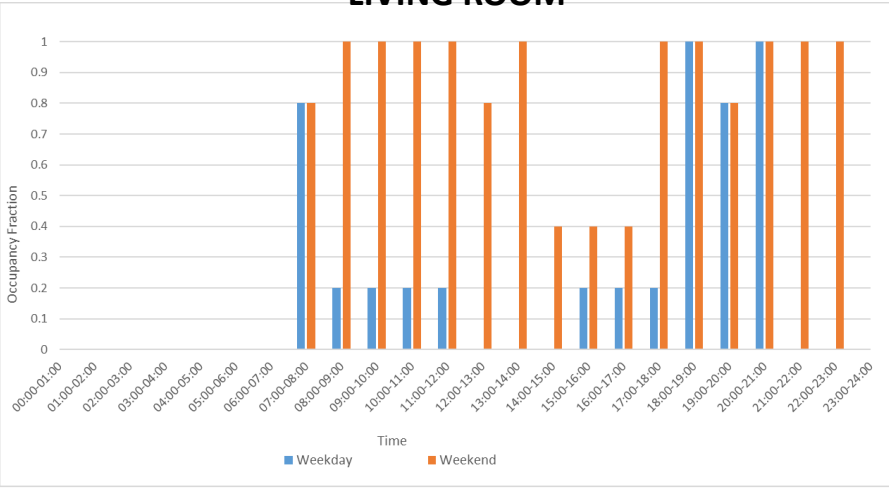
BEDROOM 1 (AC)



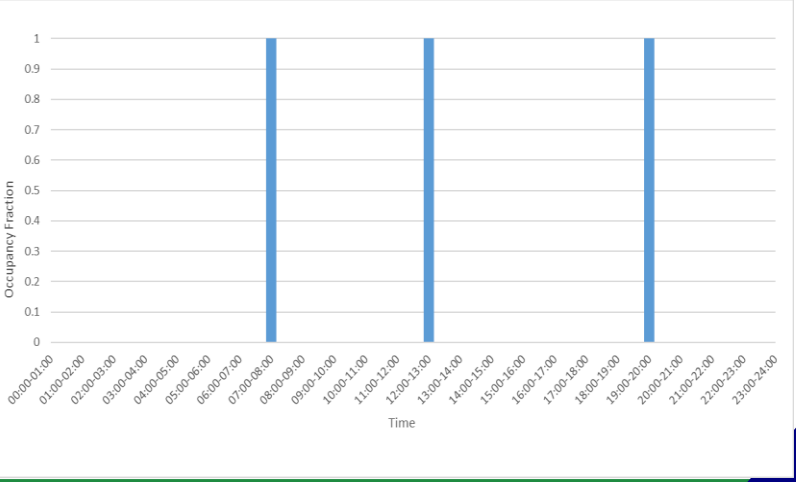
BEDROOM 2 (MM)



LIVING ROOM

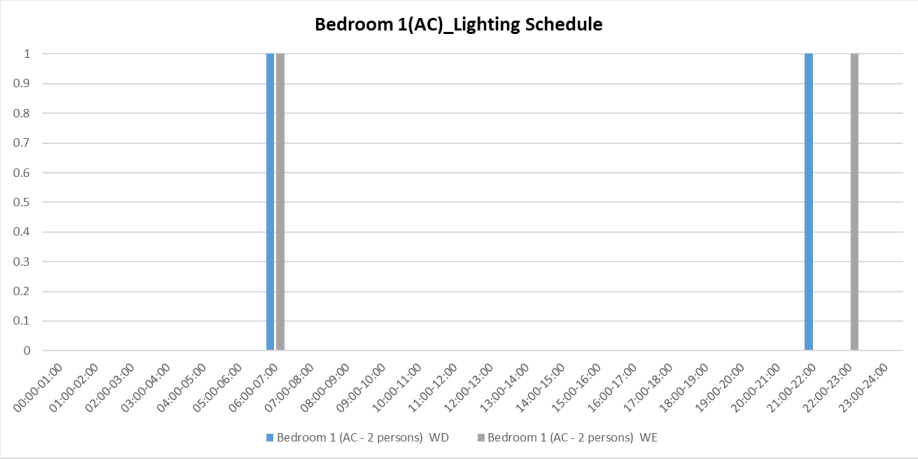


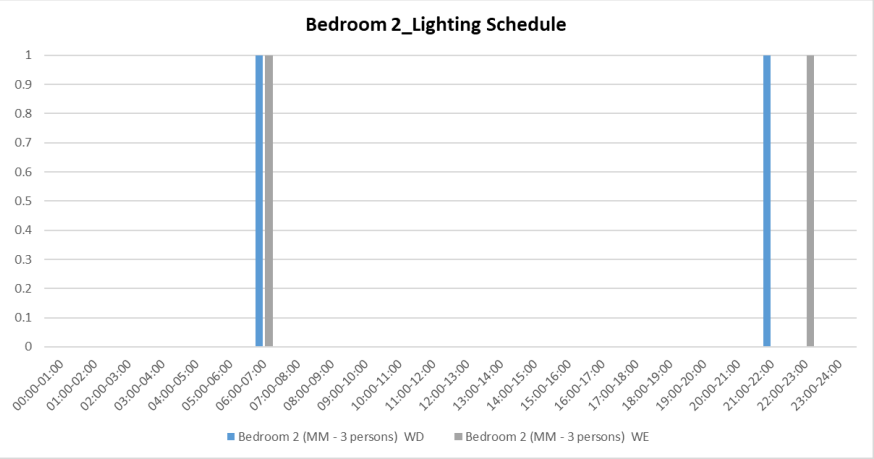
KITCHEN

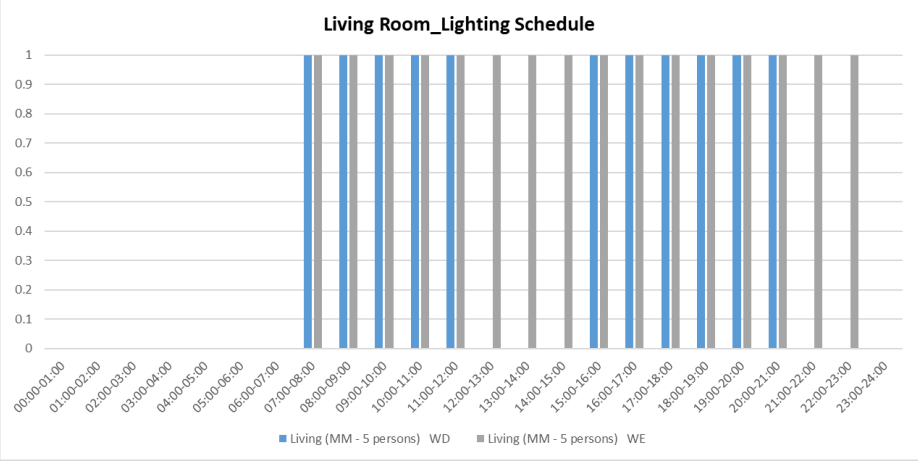


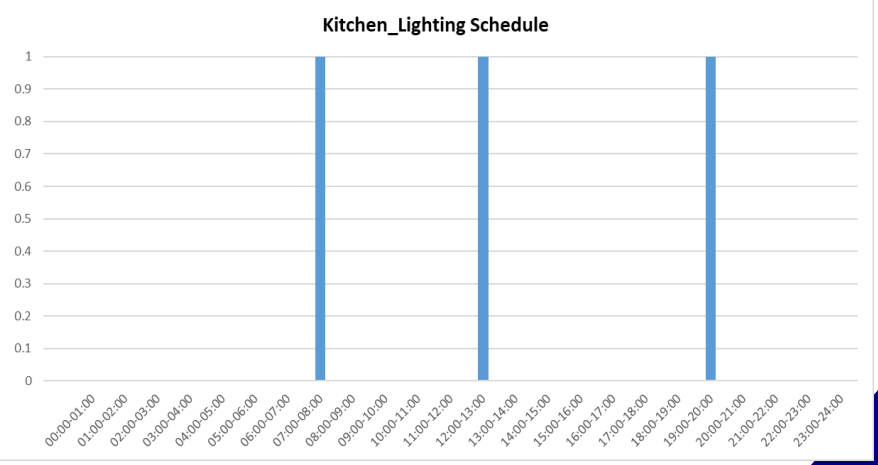
Input Parameter : Lighting schedule

The internally generated loads for equipment and lighting will be assumed based on observed cultural trends.





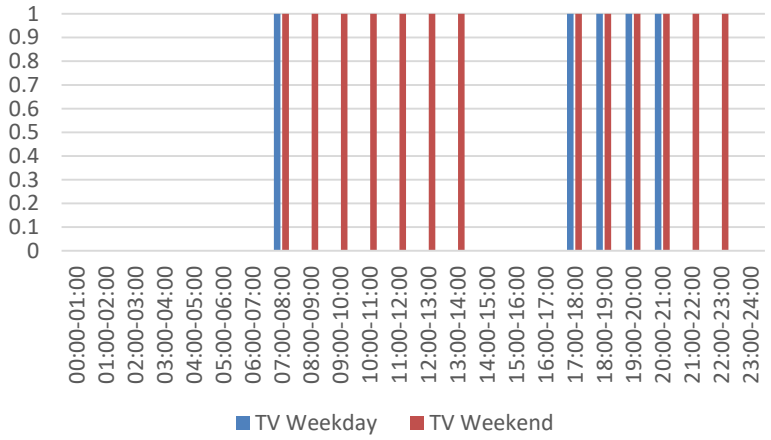




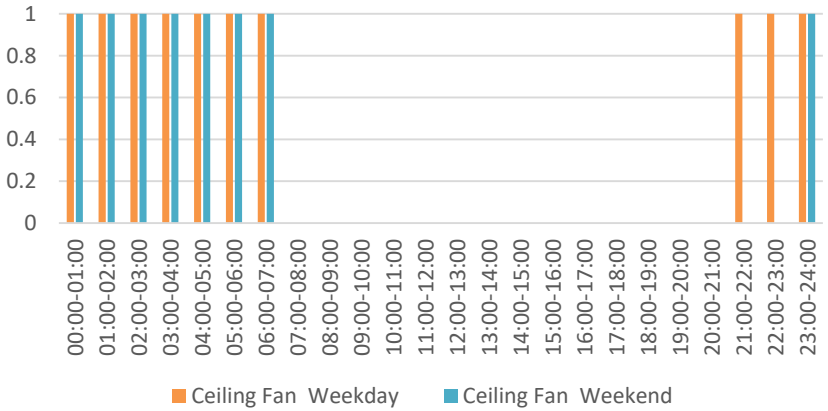
Input Parameter : Equipment schedule

The internally generated loads for equipment and lighting will be assumed based on observed cultural trends.

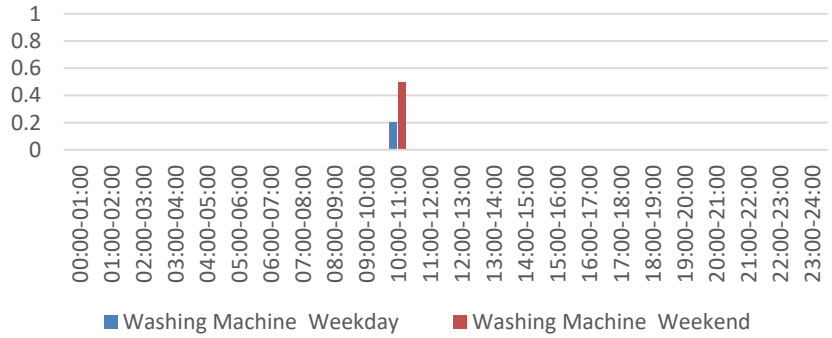
Living Room_TV (On/Off)



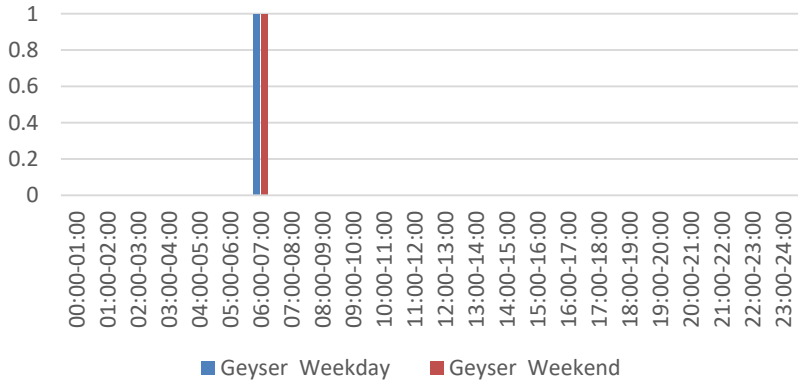
Master Bedroom_Ceiling Fan (On/Off)



Bathroom_Washing Machine (On/Off)

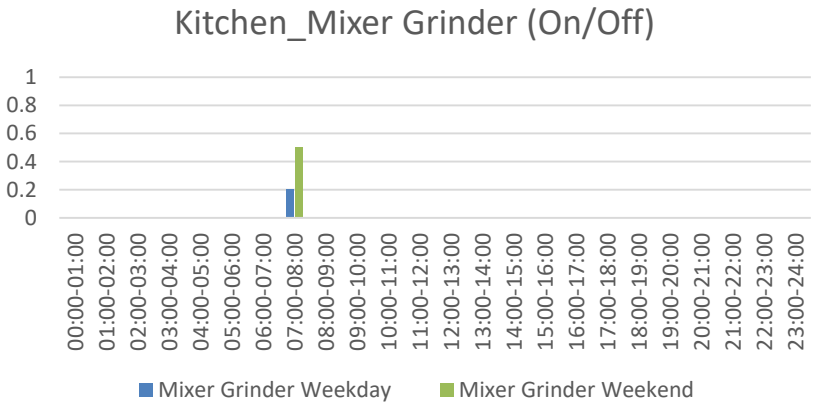


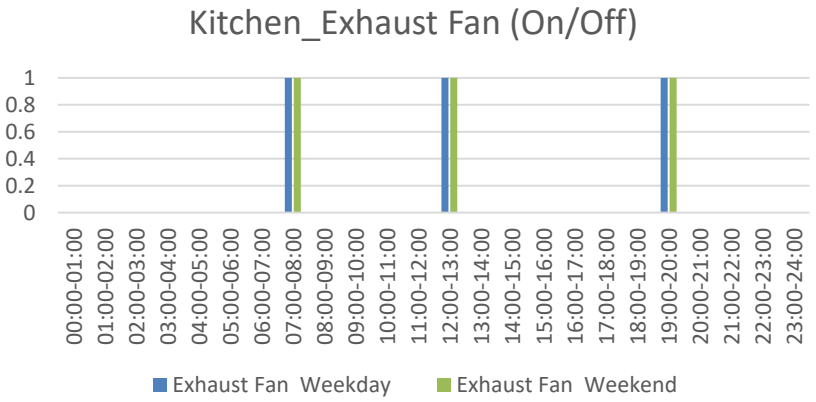
Bathroom_Geyser (On/Off)

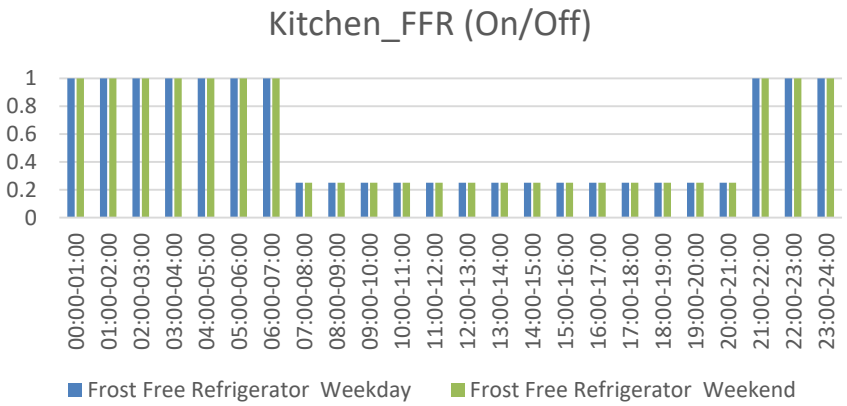


Input Parameter : Equipment schedule

The internally generated loads for equipment and lighting will be assumed based on observed cultural trends.







Ceiling fan ; two ceiling fans are operated once the indoor temperature exceeds the mid point of the IMAC temperature.

Input Parameter : Envelope, Lighting, Ventilation Parameters

An example of input parameters for simulation for the base case is represented below

Composite_Lucknow_Row House Back to Back_2bhk (5 Persons)					
S.No	**Description**	**Level 1**			
		0 Deg	**90 Deg**	**180 Deg**	**270 Deg**
Building Envelope					
1	**Exterior Wall**	230mm thick Solid Burnt Clay Brick			
2	**Roof construction**	50mm thick EPS+Light coloured glazed tile			
3	**Floor slab**	100 mm thick RCC slab			
4	**Glazing**	50 mm Steel Frame; Single glazed Unit (ST 150) - U Value = 5.7 W/m2k, SHGC = 0.56, VLT=0.51			
5	**Door**	Timber frame and Timber Door - Conductivity = 0.144 W/m K			
6	**Shading devices**	**Kitchen** - Overhang (D5,W2); **Bedroom 1** - Overhang (DW1), **Bedroom 2** - Overhang (D4); As per architect's drawing	**Kitchen -** Overhang +Fin (D5,W2); **Bedroom 1** - Overhang +Fin (DW1), Overhang + Fin (W5), **Bedroom 2** - Overhang +Fin (D4), Overhang + Fin (W5); As per architect's drawing	**Kitchen** - Overhang (D5,W2); **Bedroom 1** - Overhang (DW1), **Bedroom 2** - Overhang (D4); As per architect's drawing	**Kitchen -** Overhang +Fin (D5,W2); **Bedroom 1** - Overhang +Fin (DW1), Overhang + Fin (W5), **Bedroom 2** - Overhang +Fin (D4), Overhang + Fin (W5); As per architect's drawing
7	**Roll Down Shading Screen**	None			
8	**Window to wall Ratio**	22.00%			

Input Parameter : Envelope, Lighting, Ventilation Parameters

S.No	Description	Level 1			
		0 Deg	90 Deg	180 Deg	270 Deg
Electrical loads					
10	**Interior Lighting power Density (W/m2)**	4.842			
11	**Equipment loads**	**Living room** - Ceiling Fan = 0.06 kW, TV = 0.0564 kW; **AC Bedroom** - Ceiling Fan = 0.06 kW; **MM Bedroom** - Ceiling Fan = 0.06 kW; **Kitchen** - FFR = 0.185 kW, Exhaust Fan = 0.24 kW, Mixer Grinder = 0.75kW, **Bathroom** - Geyser = 2.0 kW, Washing Machine = 0.50 kW **(3 star rated equipment)**			
HVAC System					
12	**HVAC System type**	**Inverter based split unit with cooling heating provided in the Bedroom next to kitchen**			
13	**Efficiency (COP)**	3.7, 3 star			
14	**Cooling capacity (Tr)**	1.0			
15	**Heating capacity (Tr)**	1.0			
16	**Supply air flow for both Heating and Cooling (m3/min)**	9.6			
17	**Fresh air requirement (m3/min)**	Minimum = 2.5 l/s/person + 0.3 l/s/m2 Actual fresh air provided with 200mm 200mm louver to achieve 3 ACPH - 0.0305 m3/s			
18	**Setpoint temperature**	24 °C cooling and 21°C for heating for conditioned bedroom, unconditioned spaces setpoint based on IMAC temperatures for Natural ventilation			

Input Parameter : Envelope, Lighting, Ventilation Parameters

S.No	Description	Level 1			
		0 Deg	90 Deg	180 Deg	270 Deg
Ventilation					
20	**ACH (Window ventilation during the day)**	As per NBC 2016, Bedroom: 2-4 ACPH Living Room: 3-6 ACPH ACPH designed ; Bedroom = 3 Natural ventilation: As per detailed natural ventilation modeled in the software			
21	**Infiltration**	0.0002m3/s/m2(0.04cfm/ft2) as per section 5.4.3.1.3 b of ASHRAE 90.1.2010			
22	**Kitchen exhaust fan**	2 burner stove: Width: 60cm, Suction: 600 m3/hr around 350CFM; Wattage: 150 Heat gain: 5000 Btu/hr from each burner - 1465 Watts			
Window and Shading Device Schedule					
23	**Window**	50 % operable for Sliding windows and 90% operable for Casement Windows			

Key Performance Indicators

Indicators on energy performance and cost help compare the results across performance levels for the user to judge what they can achieve today & how they can progress in the future.

Performance Indicator		
1	**Building Envelop Efficiency**	Residential Envelope Transmittance Value (RETV)
2	**Natural Ventilation Potential**	Window to floor area ratio (WFR)
3	**Energy Efficiency**	Energy Performance Index (EPI)
4	**Visual comfort**	Day light potential (Useful Daylight Illuminance –UDI)
5	**Thermal Comfort**	Naturally ventilated hours
6	**Cost effectiveness**	Cost of construction & electro-mechanical equipment

Envelope performance

RETV (Residential Envelope Transmittance Value)

Standard: ENS

Performance Indicator		Standard	Units	Simulation required
Building Envelop Efficiency	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.	• All levels to meet an RETV < 15 • 4 levels of energy efficiency leading to decreasing values of RETV as the envelop performance increases	W/sq m	Calculation based on formula (wall area, window area, material properties)

Building Envelop Efficiency

Composite climate | 0 degree orientation | Base performance | Top Floor

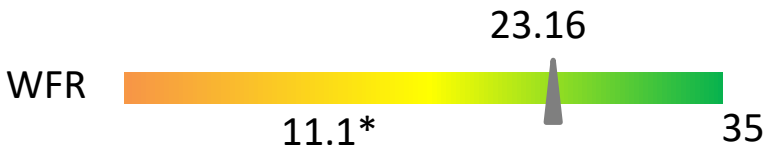
Envelope performance

WFR (Window to Floor area Ratio)

Standard: ENS

Performance Indicator		Remarks	Units	Simulation required
Natural Ventilation Potential	WFR -Is the ratio of openable area to the carpet area of dwelling units.	• Meet min. standards of ventilation (WFR) as per ENS requirements		Calculation based on formula (floor area, window area)

Natural Ventilation Potential



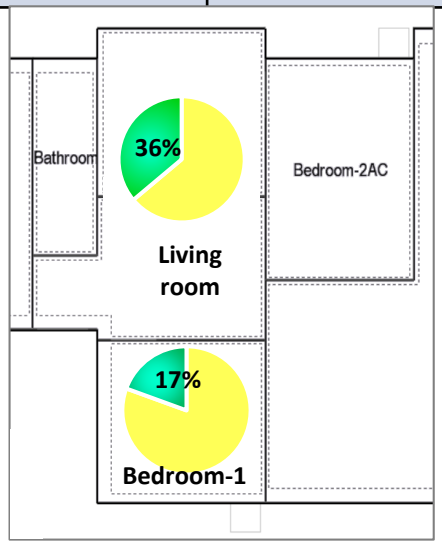
Composite climate | 0 degree orientation | Base performance | Top Floor

Envelope performance

Naturally ventilated hours:

Standard: IMAC (Thermal Comfort)

Performance Indicator		Remarks	Units	Simulation required
Thermal Comfort	IMAC refers to India model for adaptive thermal comfort tool, has defined temperature set points for naturally ventilated spaces are considered for heating and cooling, for all the selected cities.	•% of comfortable hours without AC •Energy performance performed to arrive at naturally ventilated hours for each space	%	Design Builder/ Energy Plus



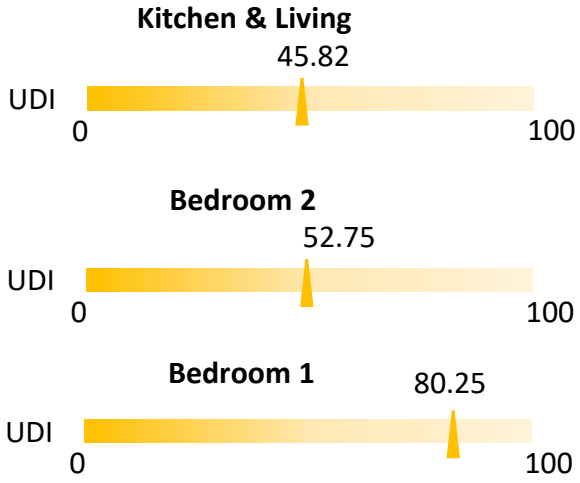
% of comfortable hours without AC

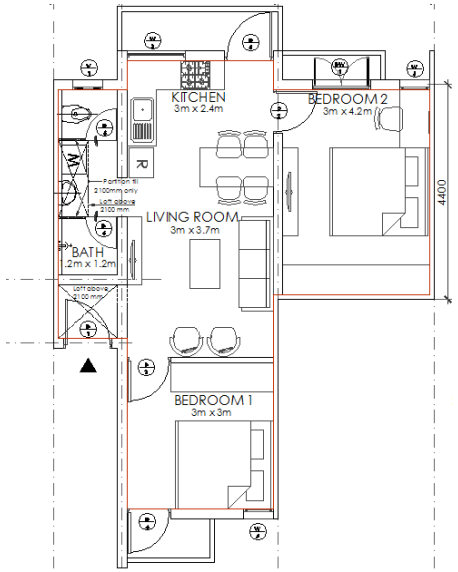
Composite climate | 0 degree orientation | Base performance | Top Floor

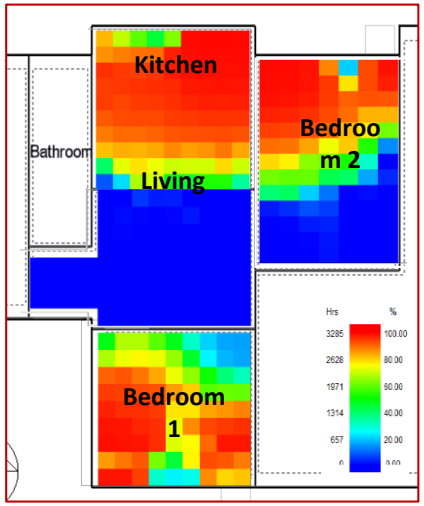
Visual Comfort

Useful Daylight Illuminance (UDI)

Performance Indicator		Remarks	Units	Simulation required
Visual comfort	Daylight simulation is performed to calculate interior daylight levels in a space for a specific location.	• Daylight performance of a typical dwelling unit is assessed by the Percentage of hours receiving UDI (between Level - 100 Lux to 3000 Lux) in a year for 50% potential daylit time (8 am – 5 pm)		Daylight (UDI) Software: Design Builder/Energy Plus







Composite climate | 0 degree orientation | Base performance | Top Floor

Energy Efficiency

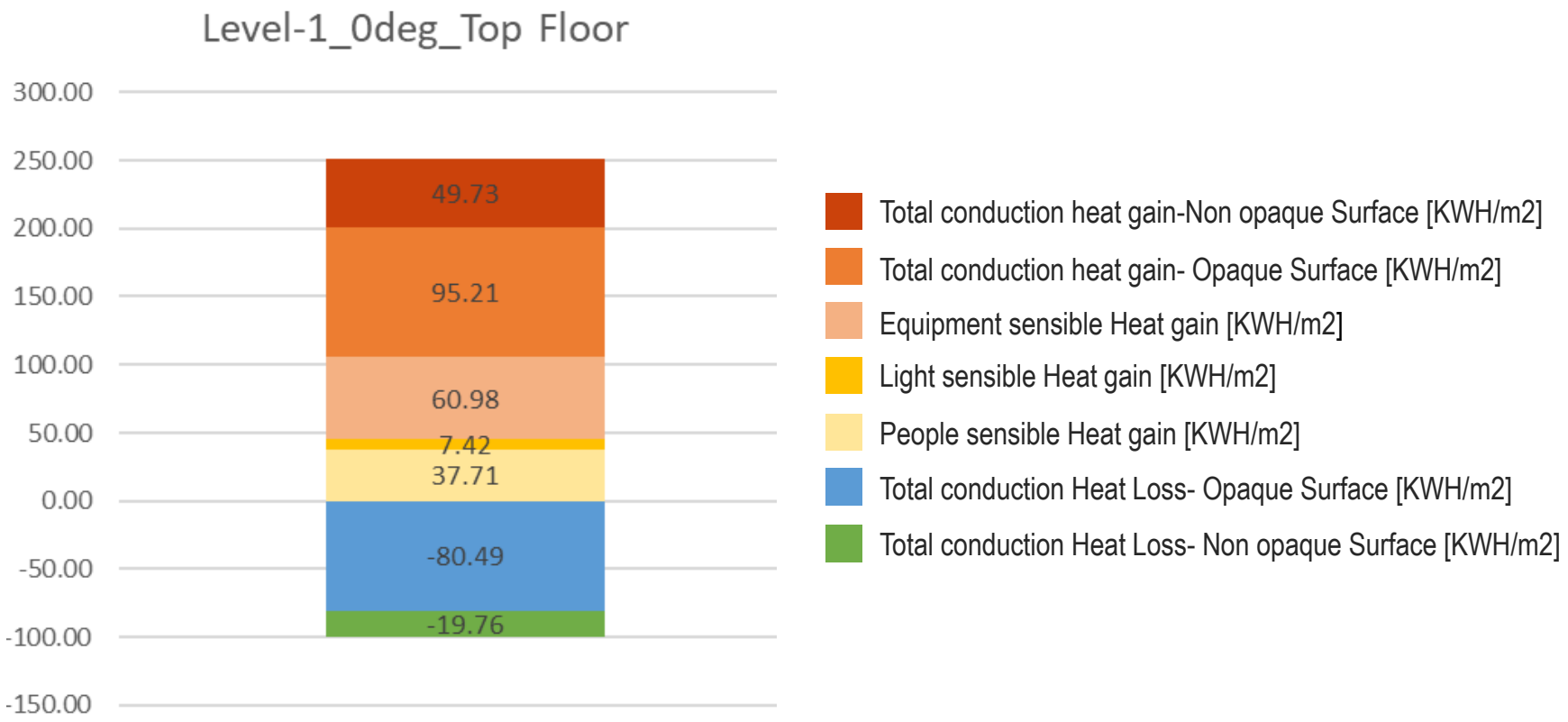
Energy Performance Index (EPI)

Standard: BEE Star Labelling for Residential Buildings

Performance Indicator		Remarks	Units	Simulation required
Energy Efficiency	Bureau of Energy Efficiency (BEE) provides a Residential building Star Rating Plan based on the EPI values calculated for each climatic zone.	• EPI Calculation for Composite, Hot & Dry and Warm & Humid = EPI for air conditioned spaces (25% area) with 24 deg C as set point (E1) + EPI for other spaces (75% area) with natural ventilation (E2) set points defined by IMAC with Air conditioner switched ON* • For Temperate: 100% area operated at IMAC-NV set-point temperature • Energy saved, cost of energy saved and reduction in co2 emission	kWh/sq m/year	Energy simulation through Design Builder/ Energy Plus

Composite climate | 0 degree orientation | Base performance | Top Floor

Heat balance/ histogram



End of session 2 – Energy Performance Simulation

Session summary:

- **Simulation Methodology**
- **Input parameters**
  - Schedules: Occupancy, Lighting, Equipment
  - Envelope
  - Lighting
  - Ventilation
- **Key Performance Indicators**
  - Residential Envelope Transmittance Value (RETV)
  - Window to floor area ratio (WFR)
  - Energy Performance Index (EPI)
  - Day light potential (Useful Daylight Illuminance –UDI)
  - Naturally ventilated hours

Questions & Feedback

Please follow the link in the chat box to fill the feedback survey:

https://www.surveymonkey.com/r/NJZHDTT

Energy Performance Results

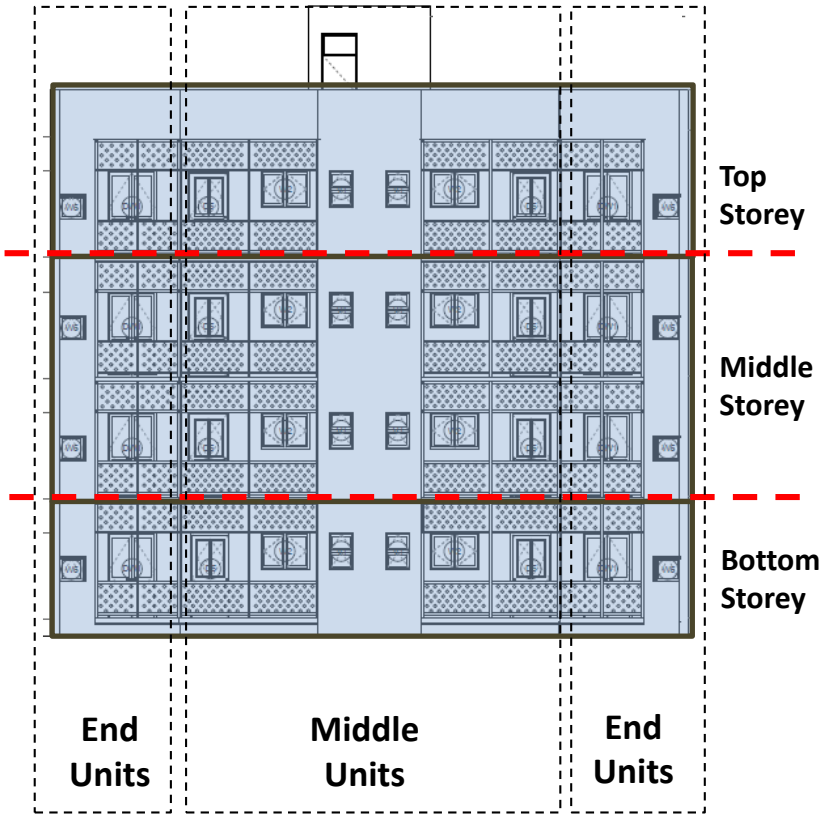
Session 3

Dwelling Unit Placement Variations

Performance varies based on location of a Dwelling unit within a building in Multi-family homes

DWELLING UNIT PLACEMENT

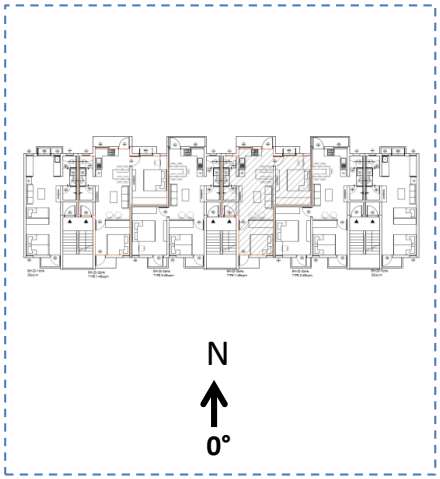
- Top Floor
- Middle Floor
- Bottom Floor
- Center Unit
- End Unit



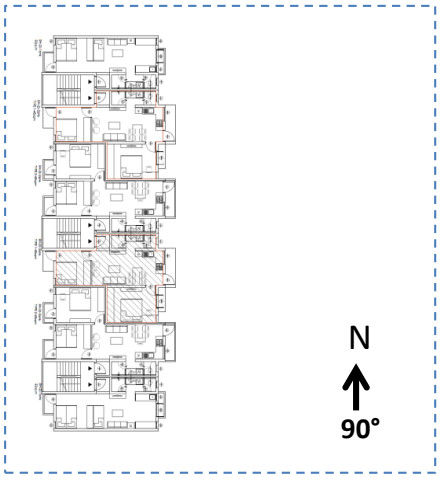
Orientation Variation

ORIENTATION

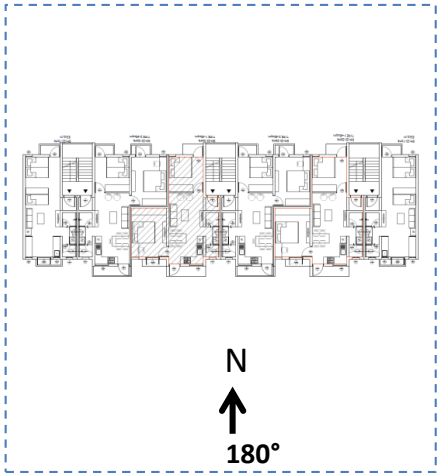
- North
- East
- South
- West



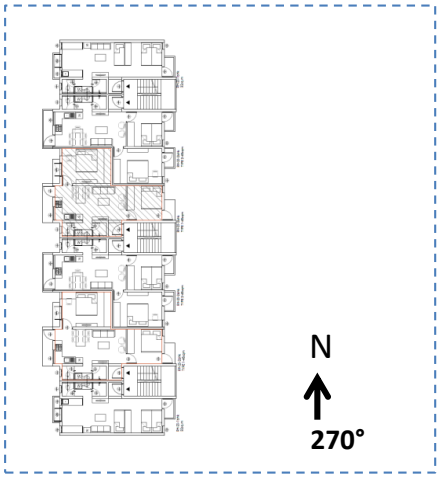
North



East



South



West

Energy performance status Variation

For each given design of a dwelling unit, 3 steps of incremental improvements in building envelop & equipment are proposed and their energy performance is reported.

1. Base

- This is the minimum performance to meet the ENS code.

2. Moderate

- This step achieves a better performance from the basic with better construction material.

3. Good

- This is the ideal step of good performance with improved windows, shading & energy efficient electro-mechanical equipment.

4. High

- This step improves the building envelop and mechanical equipment to the best of latest available technologies.

For some designs we propose the most advanced improvements and report the high performance achieved.

5. Exemplary Passive House

- This is the ultimate step to get close to drastically reduced energy demand, which can then be easily covered by renewable energy while meeting global standards of comfort and air quality.

Energy Performance Results

Composite climate | **Base performance**

	North	East	South	West
Top Floor	48.87	50.50	51.73	52.64
Middle Floor	44.40	43.31	45.99	44.86
Bottom Floor	41.60	40.12	42.09	38.56

Warm & Humid Climate | **Base performance**

	North	East	South	West
Top Floor	48.03	48.67	50.58	51.23
Middle Floor	42.94	41.68	45.19	43.17
Bottom Floor	39.98	38.53	40.53	39.86

DESIGN MEASURES:

- **The door- window opening sizes and shading devices are varied for each specific case to get to these performance results.**

EPI for different performance status

Composite climate | **Middle Floor** | **North Orientation**

Base	Moderate	Good	High
44.40	40.42	35.52	32.66
COMPONENTS & SPECS • **Wall** – 230mm Brick • **Roof** – 50mm EPS insulation + Light colored glazed tile • **Window** – Single glazed unit with rolled steel frame • **Shading** – No shading • **Electro-mechanical systems** – 3 star rated appliances	**COMPONENTS & SPECS** • **Wall** – 200mm AAC Block • **Roof** – 50mm EPS insulation + Light colored glazed tile • **Window** – Single glazed unit with rolled steel frame **Shading** – Additional top and side shading fins & roll down bamboo screens for balcony • **Electro-mechanical systems** – 3 star rated appliances	**COMPONENTS & SPECS** • **Wall** – 200mm AAC Block • **Roof** – 50mm EPS insulation + Light colored glazed tile • **Window** – Double glazed unit with UPVC frame • **Shading** - Additional top and side shading fins & roll down bamboo screens for balcony • **Electro-mechanical systems** – 4 star rated appliances	**COMPONENTS & SPECS** • **Wall** – 200mm AAC Block with 50mm thick EPS insulation • **Roof** – 50mm EPS insulation + Light colored glazed tile • **Window** – Double glazed unit with UPVC frame • **Shading** - Additional top and side shading fins & roll down bamboo screens for balcony • **Electro-mechanical systems** – 5 star rated appliances
ANNUAL ENERGY SAVINGS OVER BASE CASE:	**3.98 KWH/sq.m**	**8.9 KWH/sq.m**	**11.74 KWH/sq.m**
ANNUAL CO2 EMISSION REDUCTION OVER BASE CASE:	**0.16 t Co2 / 1KwH**	**0.53 t Co2 / 1KwH**	**0.93 t Co2 / 1KwH**
PAYBACK PERIOD OVER BASE CASE:	**16.4 Yrs**	**22.4 Yrs**	**22.5 Yrs**

Cost Efficiency

Composite climate | **Middle Floor** | **North Orientation**

Base	Moderate	Good	High
Rs 5,15,576	Rs 5,29,579	Rs 5,92,771	Rs 6,58,544
COMPONENTS & SPECS • **Wall** – 230mm Brick • **Roof** – 50mm EPS insulation + Light colored glazed tile • **Window** – Single glazed unit with rolled steel frame • **Shading** – No shading • **Electro-mechanical systems** – 3 star rated appliances	**COMPONENTS & SPECS** • **Wall** – 200mm AAC Block • **Roof** – 50mm EPS insulation + Light colored glazed tile • **Window** – Single glazed unit with rolled steel frame **Shading** – Additional top and side shading fins & roll down bamboo screens for balcony • **Electro-mechanical systems** – 3 star rated appliances	**COMPONENTS & SPECS** • **Wall** – 200mm AAC Block • **Roof** – 50mm EPS insulation + Light colored glazed tile • **Window** – Double glazed unit with UPVC frame • **Shading** - Additional top and side shading fins & roll down bamboo screens for balcony • **Electro-mechanical systems** – 4 star rated appliances	**COMPONENTS & SPECS** • **Wall** – 200mm AAC Block with 50mm thick EPS insulation • **Roof** – 50mm EPS insulation + Light colored glazed tile • **Window** – Double glazed unit with UPVC frame • **Shading** - Additional top and side shading fins & roll down bamboo screens for balcony • **Electro-mechanical systems** – 5 star rated appliances
COST INCREASE OVER BASE CASE:	**Rs. 14,000**	**Rs. 77,200**	**Rs. 1,43,000**
ANNUAL ELECTRICITY COST DECREASE OVER BASE CASE:	**Rs. 853**	**Rs. 3,451**	**Rs. 6,355**

End of session 3 – Energy Performance Results

Session summary:

- **Impact on results:**
  - Dwelling unit placement
  - Orientation
  - Climate zone

- **Result comparisons across different performance status**
  - EPI, Energy Savings & Payback
  - Cost & LCC

Questions & Feedback

Please follow the link in the chat box to fill the feedback survey:

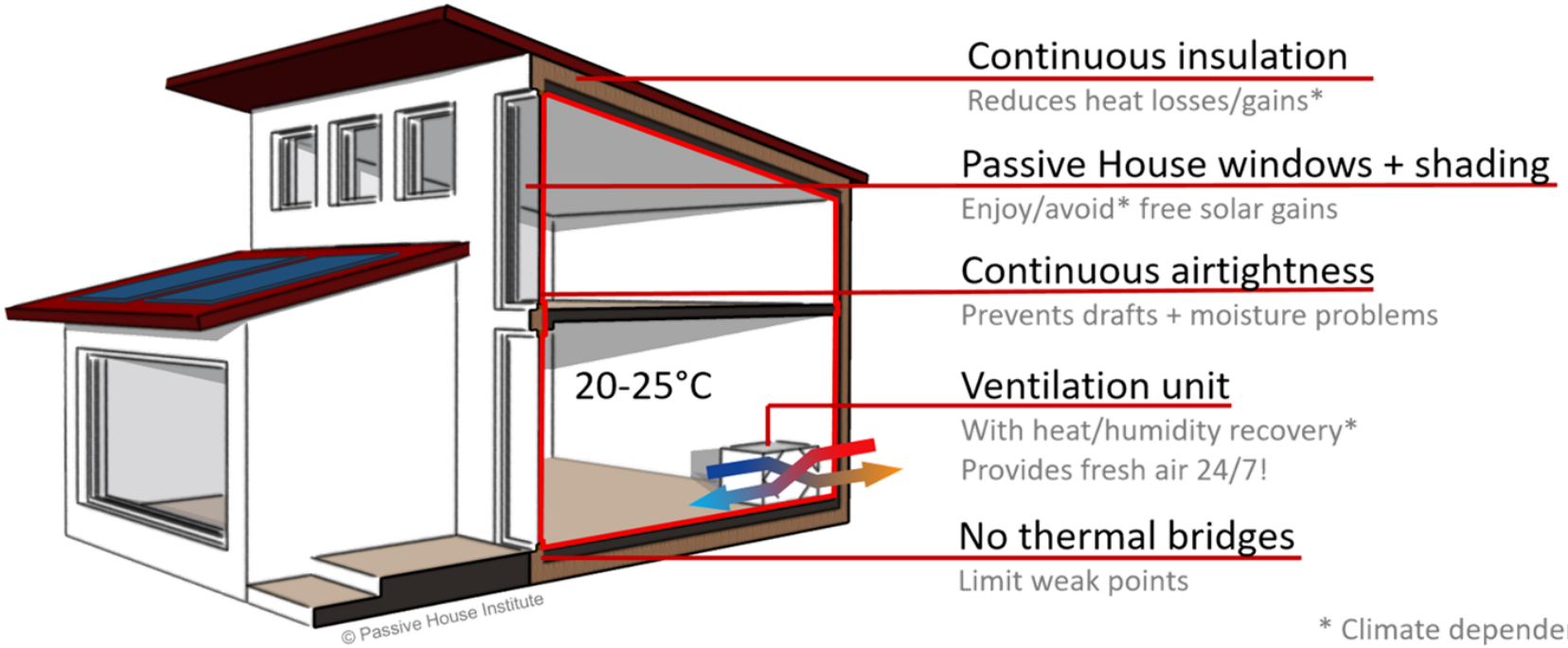
https://www.surveymonkey.com/r/NQ7Y226

Exemplary Passive House Performance Results

Session 4

Exemplary Passive House - Principles

- High comfort according to ISO 7730,
  20-25°C, max. 60% relative humidity
- Small energy consumption
- Improved air quality



Exemplary Passive House - Principles

Composite climate | **Full Building** | **North Orientation**

Energy modelling with standard boundary conditions

(Passive House certification)

RESULTS, ENERGY		CRITERIA	BASE CASE	EXEMPLARY PASSIVE HOUSE	DIFFERENCE
Heating demand (useful energy)	kWh/(m²a)	15	**31**	**0**	99%
Heating load	W/m²	10	**68**	**7**	90%
Cooling & dehum. Demand (useful energy)	kWh/(m²a)	62	**439**	**62**	86%
Cooling demand (useful energy)	kWh/(m²a)	18	204	41	80%
Dehumidification demand (useful energy)	kWh/(m²a)	44	235	22	91%
Cooling load	W/m²	11	**93**	**14**	85%
Frequency of overheating (> 25 or 27.5 °C)	%	-	**-**	**-**	-
Frequency of excessively high humidity (> 12 g/kg)	%	10	**0**	**0**	-
PE demand	kWh/(m²a)	178	**911**	**140**	85%
PER demand	kWh/(m²a)	97	**541**	**75**	86%

Exemplary Passive House - Principles

Composite climate | **Full Building** | **North Orientation**

Energy modelling with projects specific boundary conditions

(local context, India)

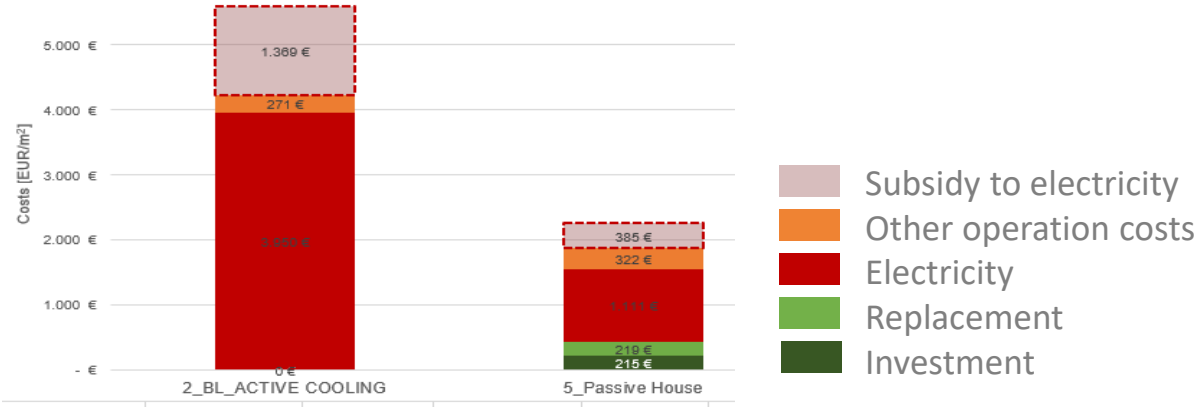
RESULTS, ENERGY			BASE CASE	EXEMPLARY PASSIVE HOUSE	DIFFERENCE
Heating demand (useful energy)	kWh/(m²a)		24	0	100%
Heating load	W/m²		66	-	-
Cooling & dehum. Demand (useful energy)	kWh/(m²a)		536	144	73%
Cooling demand (useful energy)	kWh/(m²a)		249	86	66%
Dehumidification demand (useful energy)	kWh/(m²a)		287	58	80%
Cooling load	W/m²		104	22	79%
Frequency of overheating (> 25 or 27.5 °C)	%		-	-	-
Frequency of excessively high humidity (> 12 g/kg)	%		0	0	-
PE demand	kWh/(m²a)		1160	350	70%
PER demand	kWh/(m²a)		711	212	70%

Exemplary Passive House - Principles

Composite climate | **Full Building** | **North Orientation**

Life cycle costs

(EN 15459 -1: 2017)



		BASE CASE		EXEMPLARY PASSIVE HOUSE		
RESULTS, COSTS (PRELIMINAR		**EUR**	**EUR/sqm**	**EUR**	**EUR/sqm**	
nvestment costs	EUR (VPN)	- €	- €	221.008,94 €	162,44 €	
Replacement costs	EUR (VPN)	- €	- €	298.436,61 €	219,35 €	
Residual value	EUR (VPN)	- €	- €	- 72.033,09 €	- 52,94 €	
Electricity costs	EUR (VPN)	5.374.716,76 €	3.950,46 €	1.511.795,28 €	1.111,18 €	
Other operation costs (gas + maintenance)	EUR (VPN)	368.476,87 €	270,83 €	438.627,91 €	322,39 €	
Total costs	EUR (VPN)	5.743.193,63 €	**4.221,29 €**	2.397.835,64 €	**1.762,43 €**	
Cost-effectiveness (savings)	EUR/sqm				**2.458,86 €**	58%
Subsidy on electricity	EUR (VPN)	1.861.955,45 €	1.368,55 €	523.729,08 €	384,94 €	
Total costs w. subsidy	EUR (VPN)	7.605.149,08 €	**5.589,84 €**	2.921.564,72 €	**2.147,37 €**	
Cost-effectiveness (savings)	EUR/sqm				**3.442,47 €**	62%

13.773 INR

149.405 INR

208.510 INR

Exemplary Passive House - Principles

Composite climate | **Full Building** | **North Orientation**

Life cycle costs

(EN 15459 -1: 2017)

Depends on climate
Depends on building type (e.g compactness, user density)

		BASE CASE		EXEMPLARY PASSIVE HOUSE		
RESULTS, COSTS (PRELIMINAR		**EUR**	**EUR/sqm**	**EUR**	**EUR/sqm**	
nvestment costs	EUR (VPN)	- €	- €	221.008,94 €	162,44 €	
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Cost-effectiveness (savings)	EUR/sqm				**3.442,47 €**	62%

Comparison Bengaluru

EUR/sqm	
36,70 €	
77,23 €	
- 13,36 €	
1.221,06 €	
270,83 €	
1.592,46 €	
748,53 €	32%
423,01 €	
2.015,47 €	
1.042,13 €	34%

Exemplary Passive House - Energy performance

Composite climate | **Full Building** | **North Orientation**

PARAMETERS for building 1.2 in Lucknow	BASE CASE		EXEMPLARY PASSIVE HOUSE	
	VALUE	SOURCE	VALUE	SOURCE
THERMAL ENVELOPE				
Absorptivity of surfaces	White walls and ceiling		Cool colours in roofs, white walls	
Exterior walls	230mm wall, 0mm insulation, U-value [W/(m2K)]: 1.91		200mm wall, 200mm insulation, U-value [W/(m2K)]: 0.18	
Roof	100mm RCC slab, 0 mm foam concrete, concrete laid to slope, 50mm insulation, U-value [W/(m2K)]: 0.63		100mm RCC slab, 0 mm foam concrete, concrete laid to slope, 225mm insulation, U-value [W/(m2K)]: 0.17	
Floor	100mm RCC slab above crawl space, 0mm insulation, U-value [W/(m2K)]: 6.12		100mm RCC slab above crawl space, 150mm insulation, U-value [W/(m2K)]: 0.26	
Thermal bridges	No thermal breaks		Separate balconies, stairs, etc.	
WINDOWS (ALL), DOORS TO BALCONIES - WITH GLAZING (D4, D5, DW1)	Single glazing, solar control, steel frame		Triple glazing, low-e, uPVC frame	
OPAQUE PANELS (BOTTOM OF DW1 AND D4, D5 IN HOT&DRY AND COMPOSITE)	Wooden shutter 35mm, steel frame		PH door board and uPVC frame	
ENTRANCE DOORS (D1)	Wooden shutter 35mm, wooden frame		PH door board and uPVC frame	

Comparison building: 3BHK tower unit in Lucknow

- **Wall** – 150mm insulation
- **Roof** – 50mm insulation + Reflective surface
- **Window** – Double glazing solar control and PH frame

Exemplary Passive House - Energy performance

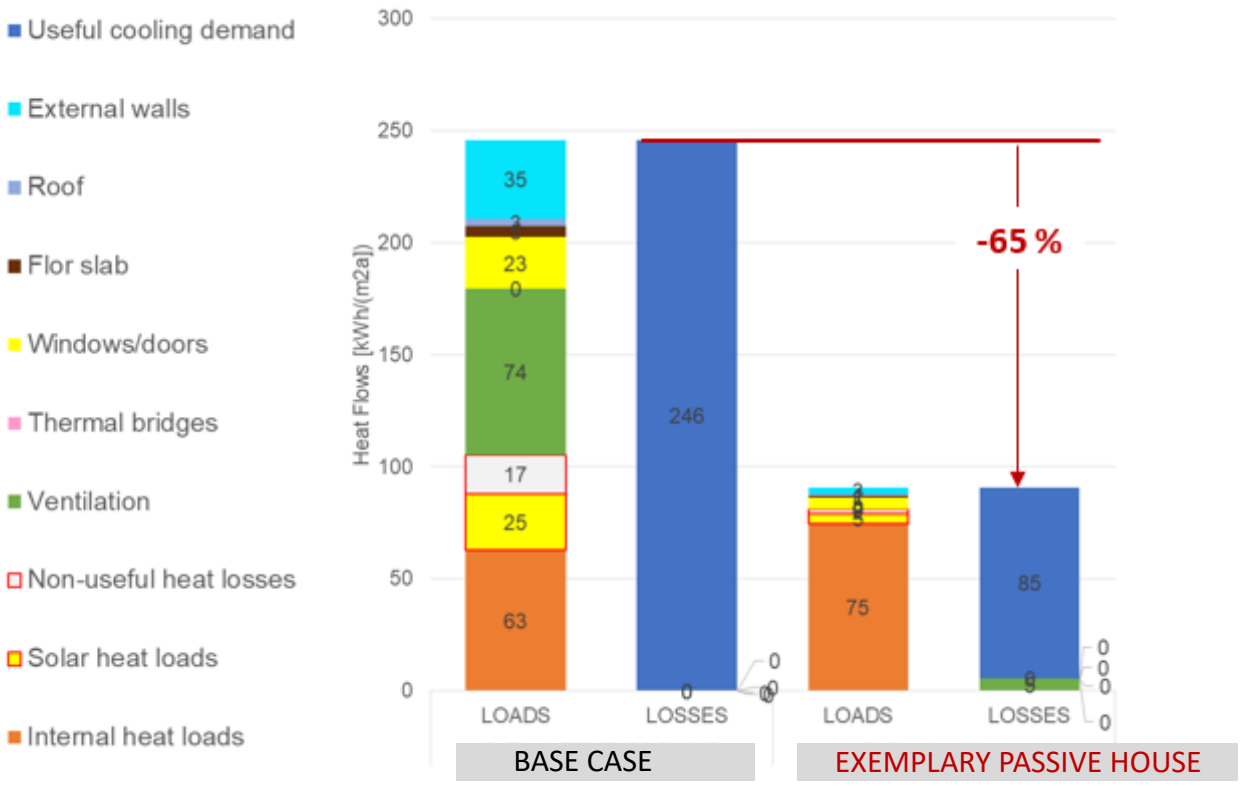
Composite climate | **Full Building** | **North Orientation**

		BASE CASE		EXEMPLARY PASSIVE HOUSE	
Shading from horizon		Neighbouring buildings, similar height		Nieghbouring buildings, similar height	
Lateral reveals		Per design, with window on the interior side		Window on the inside of masonry layer, frame covered with insulation	
Fins		no fins		fins	
Overhangs		Per design, with window on the interior side, no overhangs		Window on the inside of masonry layer, frame covered with insulation, in W5 and W3 (corners) 0.6m	
Temporary shading in summer		None	ABLA	Roll-down shading	ABLA
AIRTIGHTNESS	1/H	5.00	Estimation PHI	0.60	Estimation PHI
VENTILATION		In winter: 1.03/h, Only through windows; in summer: Windows 1.03/h	ABLA	In winter: 1.03/h, MVHR; in summer: MVHR 1.03/h	PHI
Additional night ventilation for cooling (summer)		0.25/h through windows	ABLA	0.25/h through windows	PHI
Kitchen extract system		Extract fan, 5h/day	ABLA	Recirculation hood	PHI
SUMMER STRATEGY COOLING		2split units 1.5 Tr, and dehumidifier		1split units 1 Tr, and dehumidifier	
DHW installation		20mm pipes, to kitchen sink, bathroom sink and shower, 10m per unit			Estimation PHI
ELECTRICITY		3 star appliances		5 Star appliances	

Exemplary Passive House - Energy performance

Composite climate | **Full Building** | **North Orientation**

Sensible cooling demand reduction



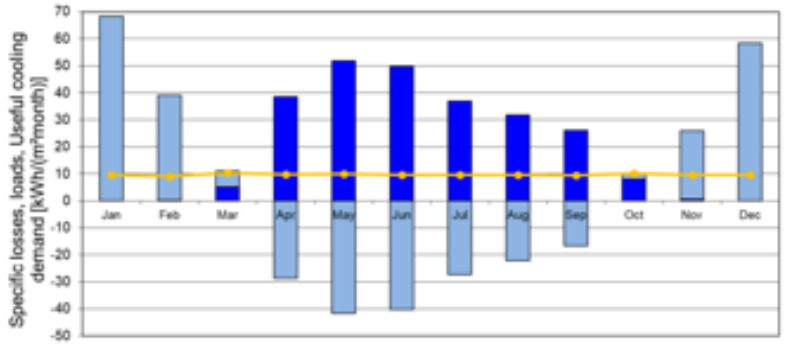
Exemplary Passive House - Energy performance

Composite climate | **Full Building** | **North Orientation**

Sensible cooling demand reduction

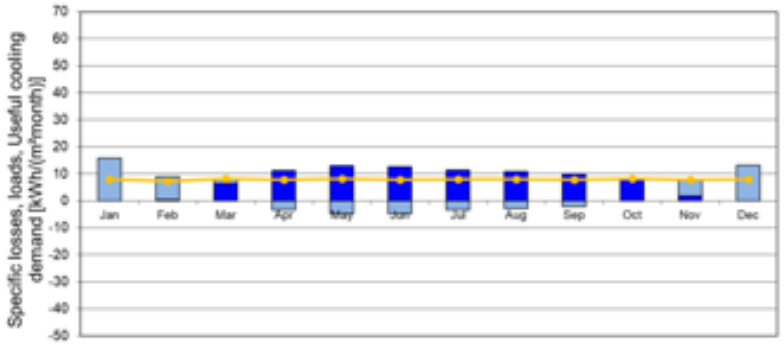
Specific cooling demand
Sum specific heat losses
Sum specific loads (solar + internal)

BASE CASE



Without active cooling (using ceiling fans):
→ 50% of the year >27.5°C
→ 62% of the year >25°C

EXEMPLARY PASSIVE HOUSE



Exemplary Passive House - Energy performance

Composite climate | Full Building | North Orientation

Latent cooling demand reduction (dehumidification)

- Improved airtightness
- Ventilation unit with humidity recovery
- Recirculation hood in the kitchen

BASE CASE	EXEMPLARY PASSIVE HOUSE
Dehumidification demand: 286,9 kWh/(m²a)	Dehumidification demand: 58,2 kWh/(m²a)

Exemplary Passive House - Energy performance

Other orientations

S.No	Description	Level 5 (PASSIVE HOUSE)			
		0 Deg	90 Deg	180 Deg	270 Deg
Building Envelope					
1	Exterior Wall	200 mm thick AAC Block wall with 200mm EPS insulation (color white)			
2	Roof construction	RCC slab + 225mm insulation + Reflective surface (High SRI paint)			
3	Floor slab	RCC slab + 150mm insulation			
4	Glazing	125mm uPVC frame, U-value 1.60 W/m2K; triple glazing, low-E, U-value 0.59W/m2K, g-value/SHGC: 0.39	125mm uPVC frame, U-value 1.60 W/m2K; triple glazing, low-E, U-value 0.59W/m2K, g-value/SHGC: 0.39 Without top glazed panels in D5, D4		
5	Door	125mm uPVC frame, U-value 1.60 W/m2K; opaque panel: U-value 0.64W/m2K			
6	Shading devices	**Kitchen** - Overhang (D5,W2); **Bedroom 1** - Overhang (DW1), Overhang + Fin (W5), **Bedroom 2** - Overhang (D4), Overhang + Fin (W5); As per architect's drawing	**Kitchen** - Overhang +Fin (D5,W2); **Bedroom 1** - Overhang +Fin (DW1), Overhang + Fin (W5), **Bedroom 2** - Overhang +Fin (D4), Overhang + Fin (W5); As per architect's drawing	**Kitchen** - Overhang (D5,W2); **Bedroom 1** - Overhang (DW1), Overhang + Fin (W5), **Bedroom 2** - Overhang (D4), Overhang + Fin (W5); As per architect's drawing	**Kitchen** - Overhang +Fin (D5,W2); **Bedroom 1** - Overhang +Fin (DW1), Overhang + Fin (W5), **Bedroom 2** - Overhang +Fin (D4), Overhang + Fin (W5); As per architect's drawing

End of session 4 : Exemplary Passive House Performance Results

Session summary:

- **Simulation principles**
  - Energy modelling
  - Life cycle costs
- **Required components**
- **Cooling demand reduction**
  - Sensible demand
  - Latent demand (dehumidification)
- **Other orientations**

Questions & Feedback

The Web-Tool package

Session 5

The Web Tool

All the work from this study set will be made available to the user through the web tool for all design typologies to understand the performance through the tool and then to be able to input their own specific details and get results.

This tool will be available at the Eco-niwas Website.

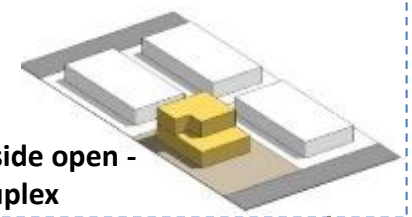
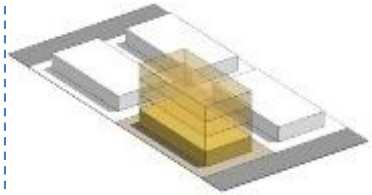
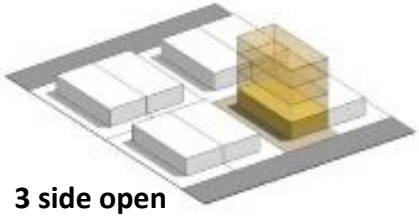
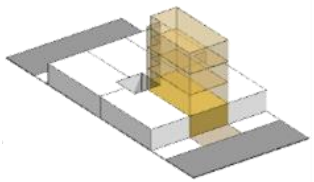
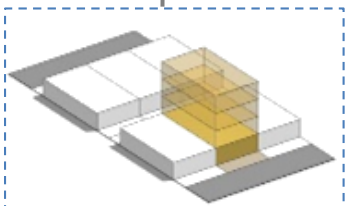
Project Background

Design typologies — **Descriptions of each design typology**

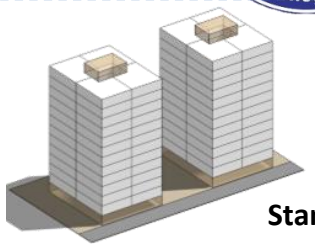
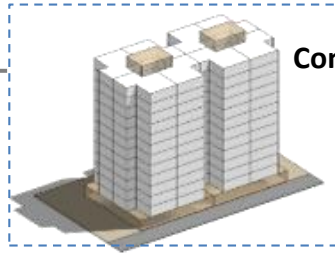
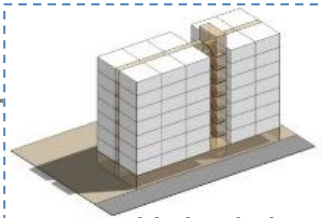
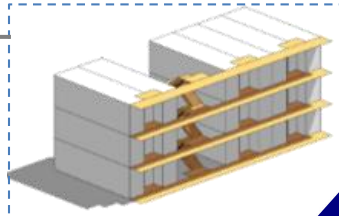
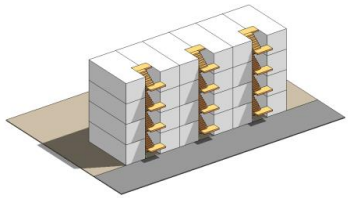
Design Typologies

Housing Typologies

Single family - Plotted

- **Detached**
  - 
    4 side open - Duplex
  - 
    4 side open - Single floor
- **Semi-Detached**
  - 
    3 side open
- **Row House**
  - 
    Back to back
  - 
    2 side open

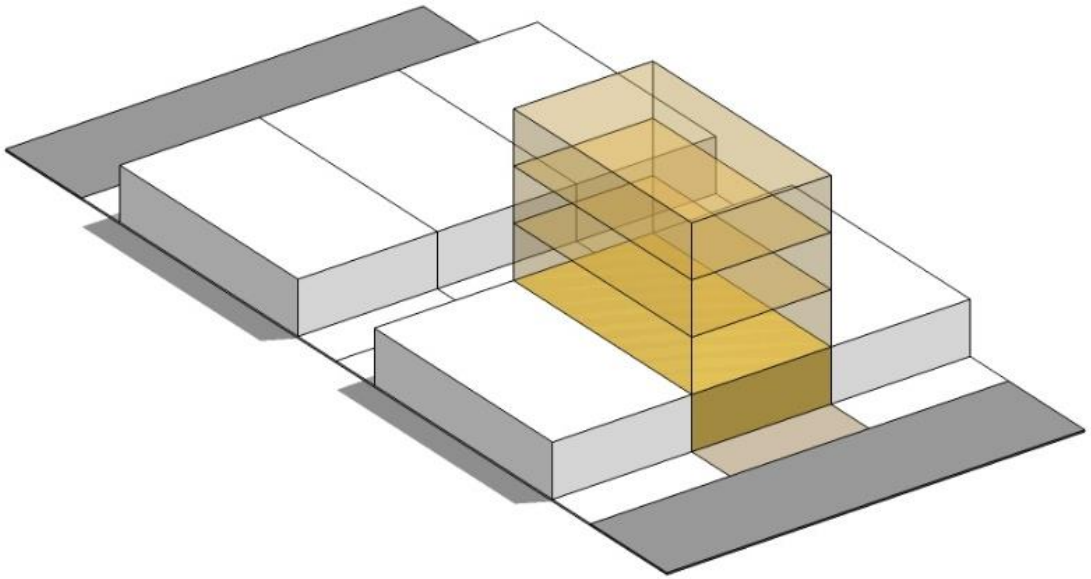
Multi family – Group Development

- **Tower**
  - 
    Stand alone
  - 
    Connected
- **Linear Corridor**
  - 
    Doubly loaded
  - 
    Singly loaded
- **Row House**
  - 
    Back to back
  - 
    2 side open

Single Family–Plotted housing

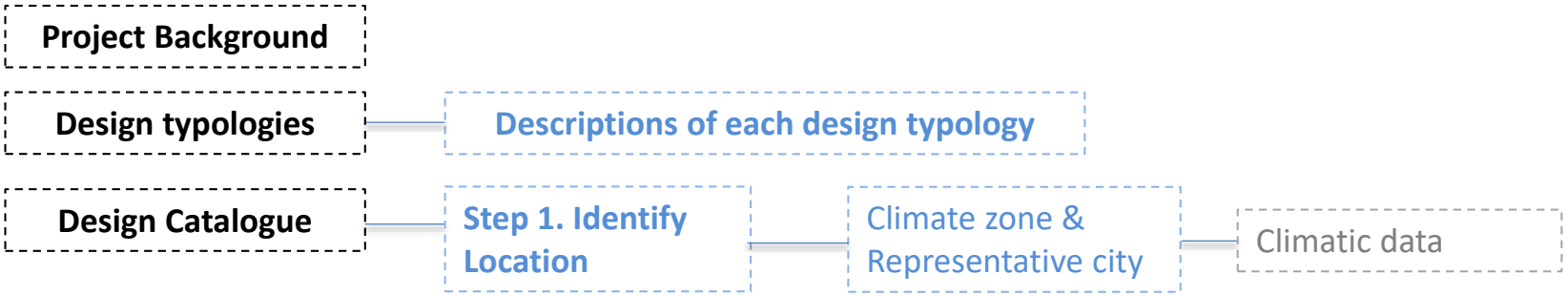
2 Side open Row House

For larger plots or plots situated in warm & humid or temperate climate zones the ventilation requirements may not be met by a single side open plot. Therefore, the two side open row house typology is adopted in such cases. This opens to the front street as well as a back street or a back set-back while the side walls remain shared with the neighbours.



Design Catalogue

The project will provide design layout options in the catalogue in the form of 2D design drawings that are most usable and convenient to implement for a large user base.



Design Catalogue- Identify Location

Project Background

Design typologies

Design Catalogue

Site Map

Please select your State and closest City

State

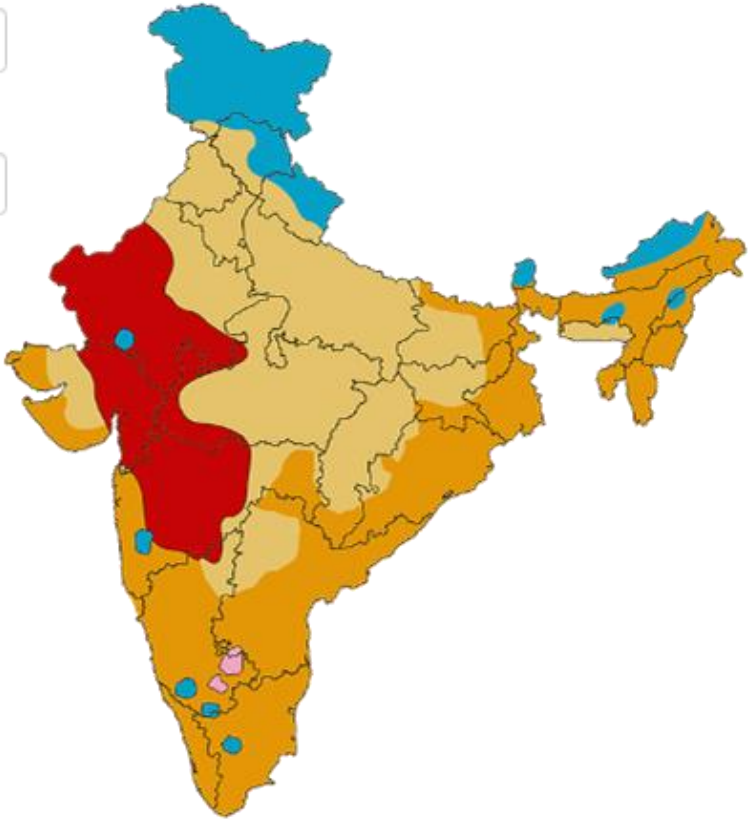
Select State

City

Select City

Climate Zone

- Hot and Dry
- Warm and Humid
- Composite
- Temperate
- Cold



Continue Back

Maharashtra - Mumbai - Warm & Humid

Representative City- Bhubhaneshwar

This study shows results for representative cities in each climate zone. These are not absolute solutions for all locations falling in a particular climate zone as conditions vary geographically. The methodology and rationale of improving energy performance step by step is to be understood from this example and applied for other locations.

Project Background

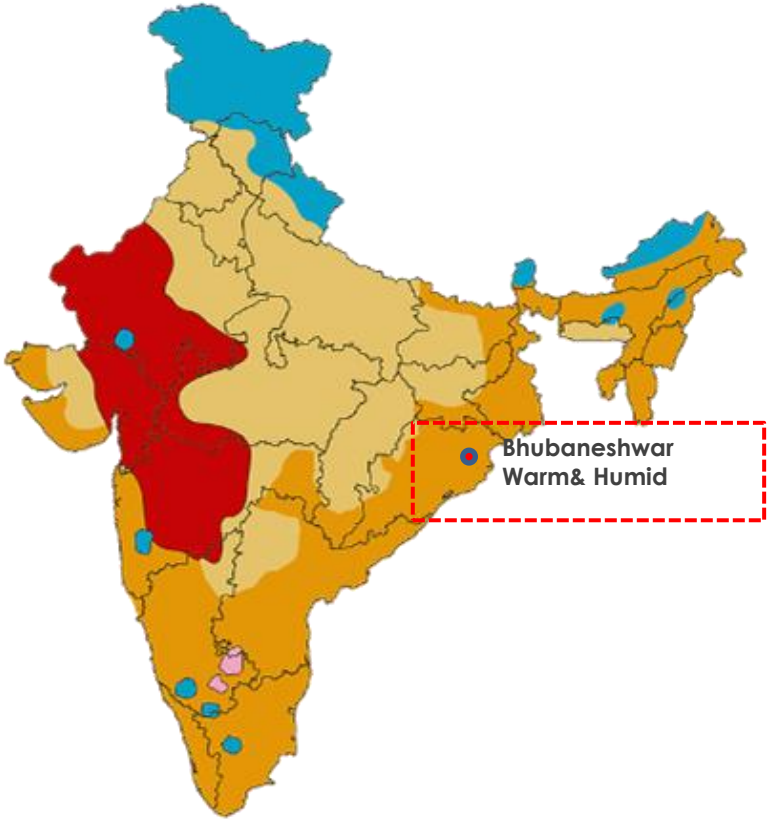
Design typologies

Design Catalogue

Selection criteria for representative cities:
As per ECBC 2017 and ECBC_R (Envelope), India is divided based on 5 climatic zones being, Hot & Dry, Warm & Humid, Composite, Temperate, and Cold. In order to select one city per climate zone the parameters considered are as follows:

i.Cities classified based on Climatic zone in ECBC 2017.
ii.Climate file available for simulation
iv.City classification – Tier 1/2/3
v. Projected development under Smart City Mission, Government of India, Houses sanctioned under PMAY – Pradhan Mantri Awas Yojana (Urban) Scheme – State wise, Housing shortage State wise

The selection is further justified based on the results of the paper, "Development of a method for selection of Representative City in a Climate Zone" , which uses the method of calculating the minimum Euclidean distance with respect to remaining cities of the same climatic zone to be taken as a representative city.



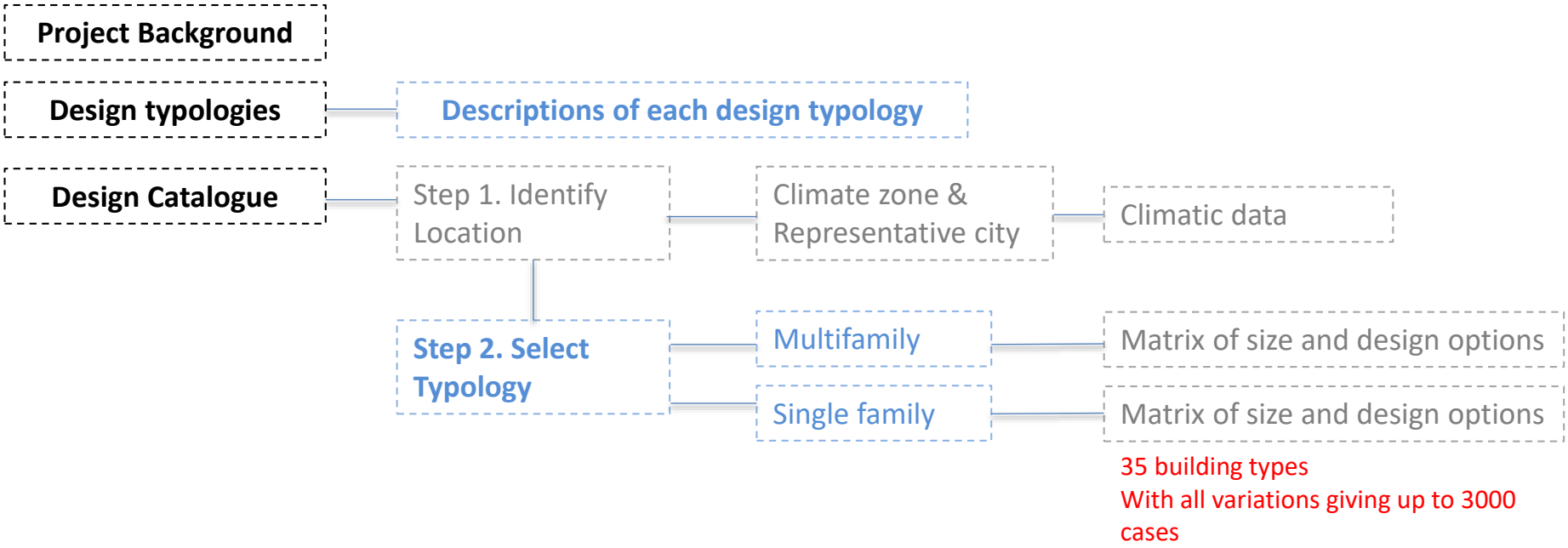
Site Map

Download Climatic Data

Continue Back

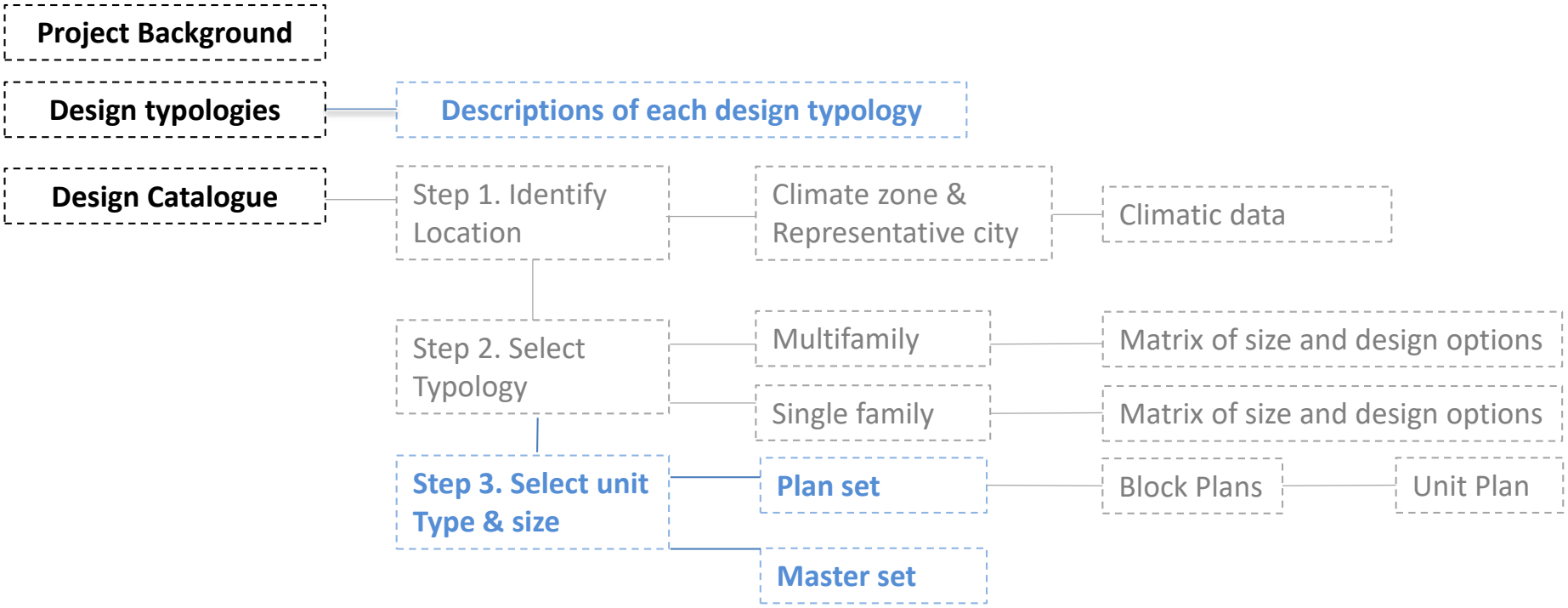
Select Building Typology

The web-tool is designed to go into greater technical depth. It is designed to make information available to a large user base.



Select Unit type and size

The data from this study set will be made available to the user through the web tool for all design typologies to understand the performance through the tool and then to be able to input their own specific details and get results.



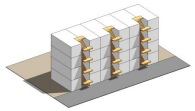
Select Unit type and size

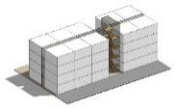
Project Background

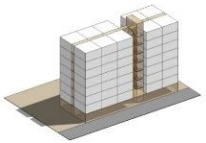
Design typologies

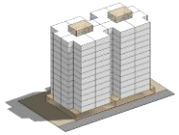
Design Catalogue

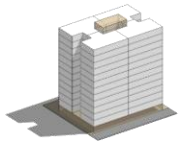
Site Map











Low Rise (Building Height <=15m)							
Back to back row house	1BHK (30sqm) **(1.1A)**	2BHK (41sqm) **(1.2A)**	3BHK (55sqm) **(1.2D)**				
2 side open row house	1BHK (32sqm) **(1.1B)**	2BHK (48sqm) **(1.2B)**	3BHK (62sqm) **(1.3A)**	3BHK (62sqm) **(1.3C)**			
Doubly loaded corridor	1BHK (30sqm) **(1.1C)**						
Mid/ High Rise (Building Height>15m)							
Doubly loaded corridor		1BHK (44sqm) **(1.2C)**	2BHK (65sqm) **(1.3B)**	3BHK (85sqm **(1.4A)**			
Connected Towers				3BHK (105sqm) **(1.4B)**	3BHK (125sqm **(1.5A)**		
Stand-alone Towers				3BHK (105qm) **(1.4C)**	3BHK (105qm) **(1.5B)**	3.5 BHK (156sqm) **(1.6A)**	4.5 BHK (225sqm) **(1.7A)**

MASTER SETS

Continue Back

Master Set

1. Design and Construction data

1.1 Revit Model

1.2 Construction drawings

1.2.1 Marking Plan

1.2.2 Block Layout

1.2.3 Site Layout

1.2.4 Elevations

1.2.4 Sections

1.2.5 Design variants detail

1.2.6 Detail Drawings

1.3 Bill of quantities and Estimate

1.3.1 Civil

1.3.2 MEP

Master Set

2. Simulation and Performance data

2.1 IDF File

2.2 RAD File

2.3 Master sheet

2.3.1 Climate analysis

2.3.2 Schedule of operation

- 2.3.2.1 Occupancy
- 2.3.2.2 Lighting
- 2.3.2.3 Equipment
- 2.3.2.4 HVAC

2.3.3 Input Parameter sheet

- 2.3.3.1 Building Envelope
- 2.3.3.2 Electrical Loads
- 2.3.3.3 HVAC system
- 2.3.3 4Ventilation

2.3.4 ENS Code compliance

- 2.3.4.1 WFR, WWR, VLT, URoof & RETV

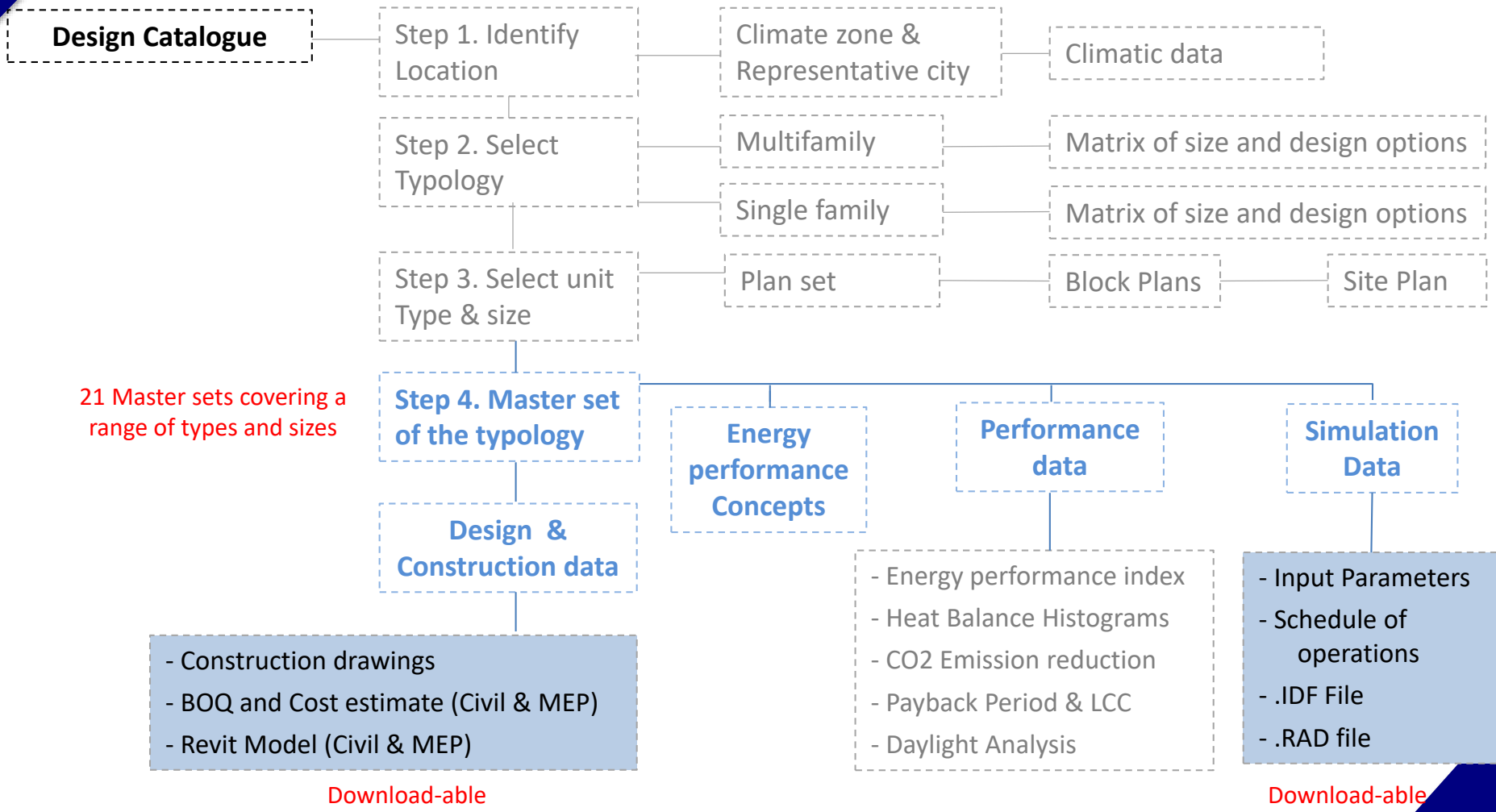
2.3.5 Performance Indicators

- 2.3.5.1 Energy performance index
- 2.3.5.2 Heat Balance Histograms
- 2.3.5.3 CO2 Emission reduction
- 2.3.5.4 Payback Period & LCC
- 2.3.5.5 Daylight Analysis & False UDI renders
- 2.3.5.6 % of comfortable hours without AC

Additional information provided for PH cases

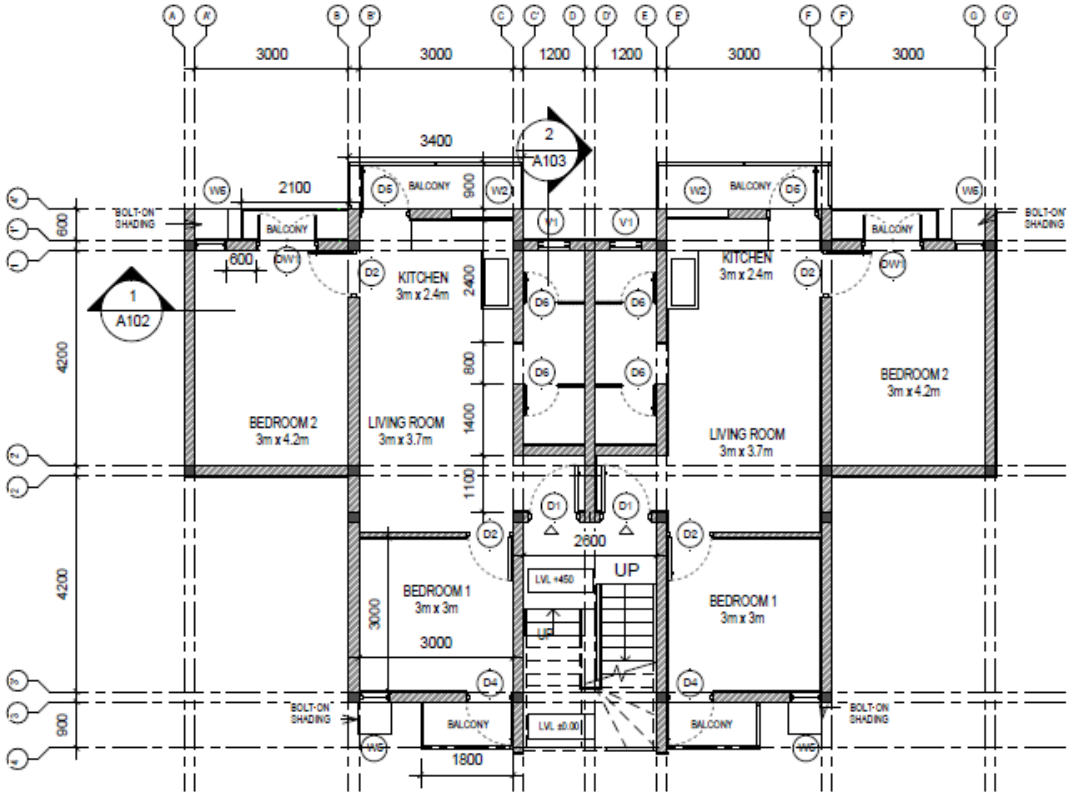
- .ppp file for PHPP energy modelling
- Examples for typical Passive House details
- Qualitative ventilation recommendations

Design Catalogue



Working drawing set

UNIT PLAN

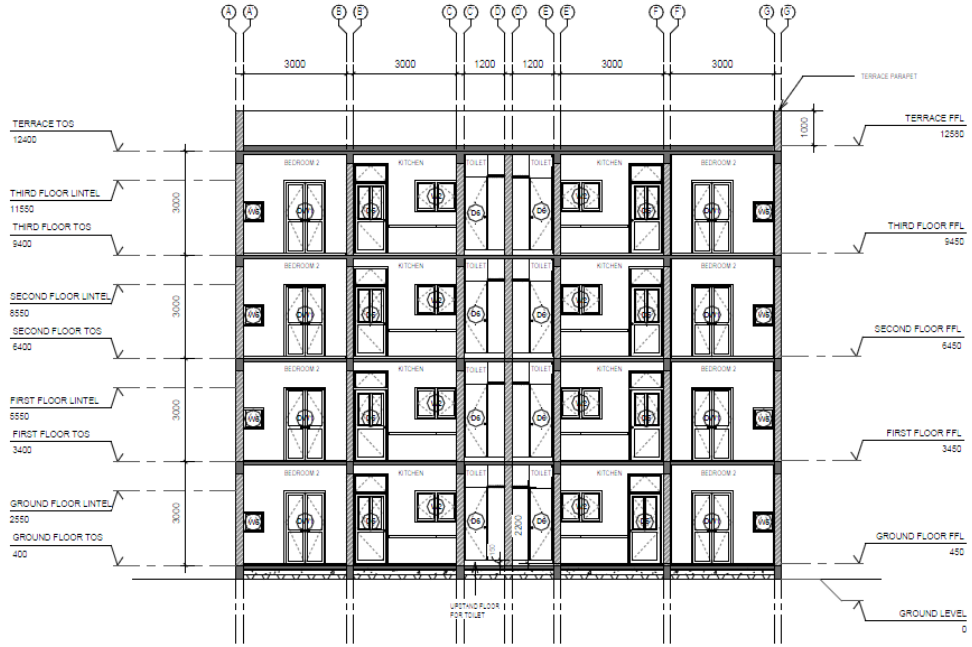


1 GROUND FLOOR FFL

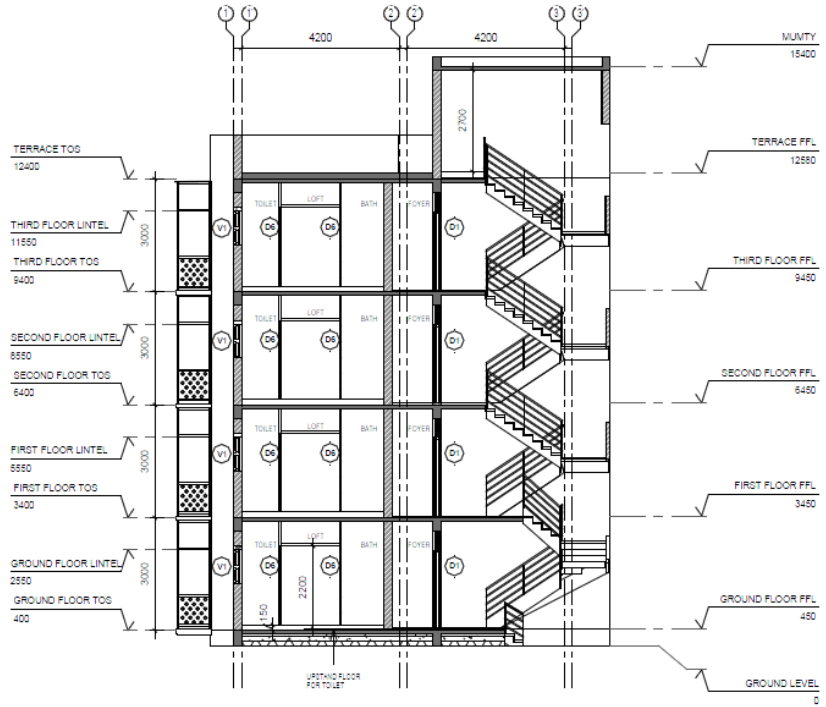
1 : 100

Working drawing set

SECTIONS



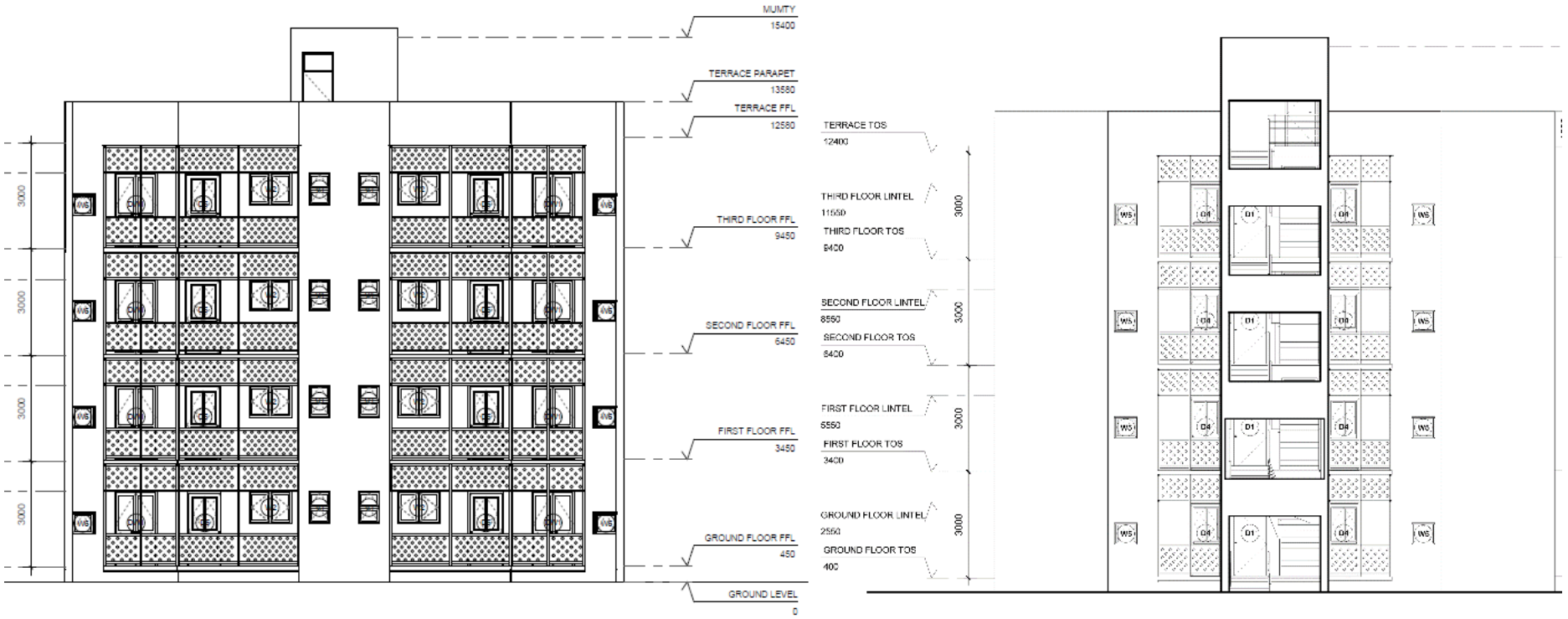
1 SECTION A
1 : 100



2 SECTION B
1 : 100

Working drawing set

ELEVATIONS

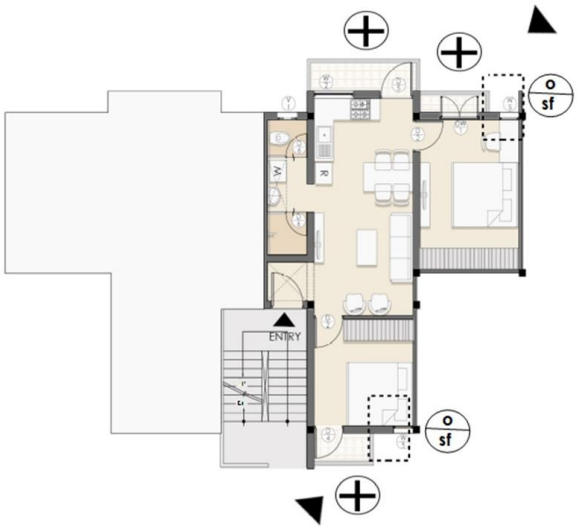


1 NORTH
1 : 100

Shading system information

ROW HOUSE-2 SIDE OPEN -2 BHK (1.2B)

FACADE 1



FACADE 2

Added Fixed Shading Screen side fins

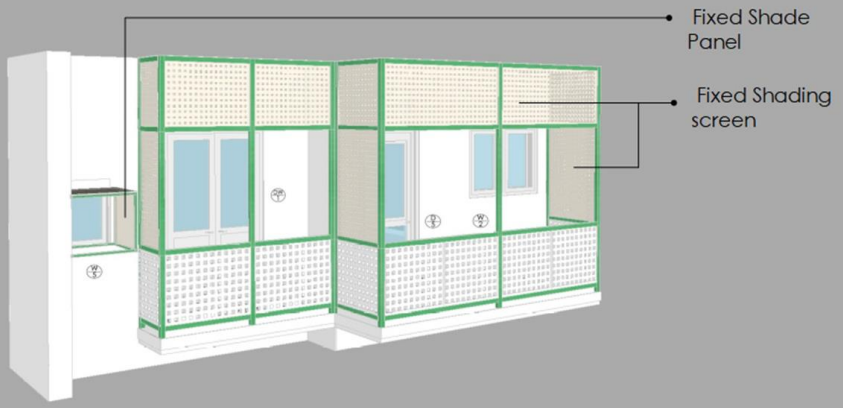
600mm wide window shading overhang with side fins

*Variation from Hot &Dry Base case

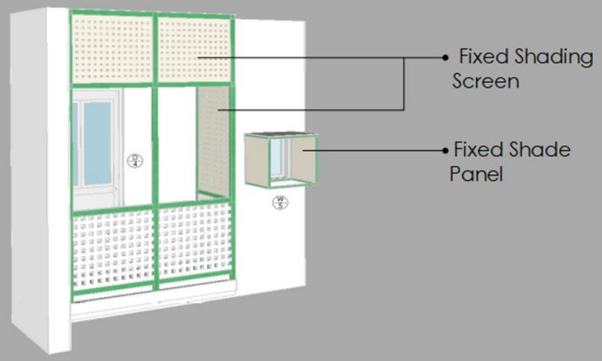
HOT & DRY,COMPOSITE | **BASE CASE** – ALL FLOORS | **East – West Orientation**

WINDOWS AND SHADING DESIGN

FACADE 1



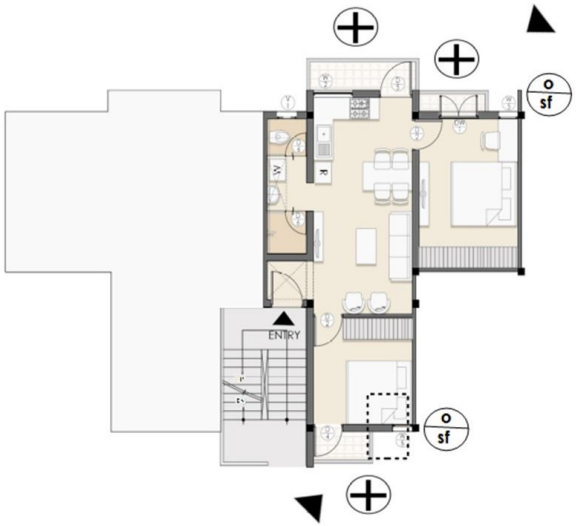
FACADE 2



Shading system information

ROW HOUSE-2 SIDE OPEN -2 BHK (1.2B)

FACADE 1



FACADE 2

Added Roll down adjustable shading screen

600mm wide window shading overhang with side fins

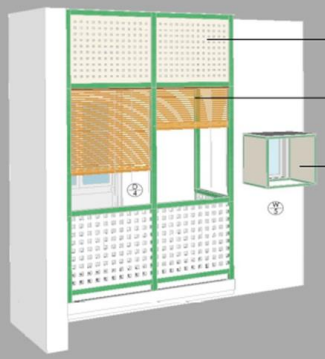
*Variation from Hot &Dry Base case

HOT & DRY,COMPOSITE | **MEDIUM,GOOD AND HIGH** – ALL FLOORS | **North - South Orientation**

WINDOWS AND SHADING DESIGN

FACADE 1

FACADE 2



End of session 5 – Web-Tool Package

Session summary:

- **Web Tool**
  - Tool structure
- **Design Catalogue Provisions**
- **Master sets**
  - Contents
  - Download-able information
- **Information Samples**

Questions & Feedback

Thank you

german cooperation
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giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

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Passive House Institute

KPMG