Building Envelope Design *for* Energy Efficient & Thermally Comfortable Group Housing

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GRIHA Summit 2017, Delhi

Ministry of POWER GOVERNMENT OF INDIA

ENERGY IS LIFE BEE CONSERVE IT

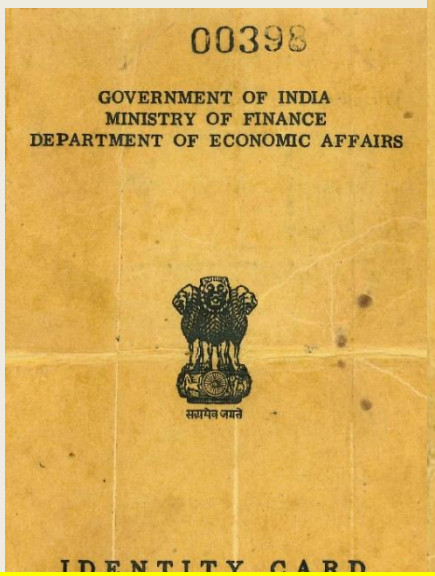
Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Agency for Development and Cooperation SDC

- Short introduction
- Why focusing on Residential Buildings is Essential
- Baseline study on AC buildings
  - Importance of cooling in the electricity bill
- Importance of Good Thermal Quality of Building Envelope in Group Housing
  - Key features of Building Envelope for Group Housing
  - Development of a simple formula based envelope thermal heat gains
  - Natural/assisted ventilation in the case of high density projects

India an old story

- Not exactly new to India
- First exposure to India 1981-1983 in Bhavnagar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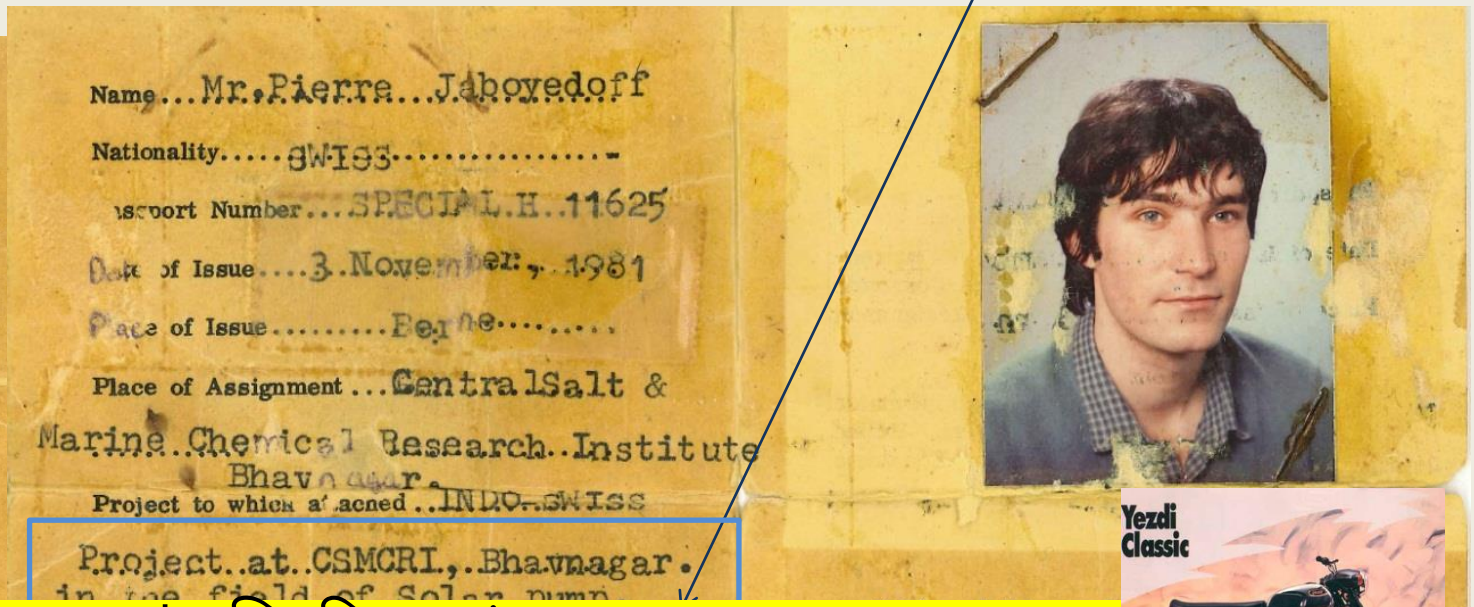
GOVERNMENT OF INDIA
MINISTRY OF FINANCE
DEPARTMENT OF ECONOMIC AFFAIRS

सत्यमेव जयते

IDENTITY CARD


Name...Mr.Pierre...Jahovedoff

Nationality.....SWISS.....

Passport Number...SPECIAL H..11625

Date of Issue....3.November..1981

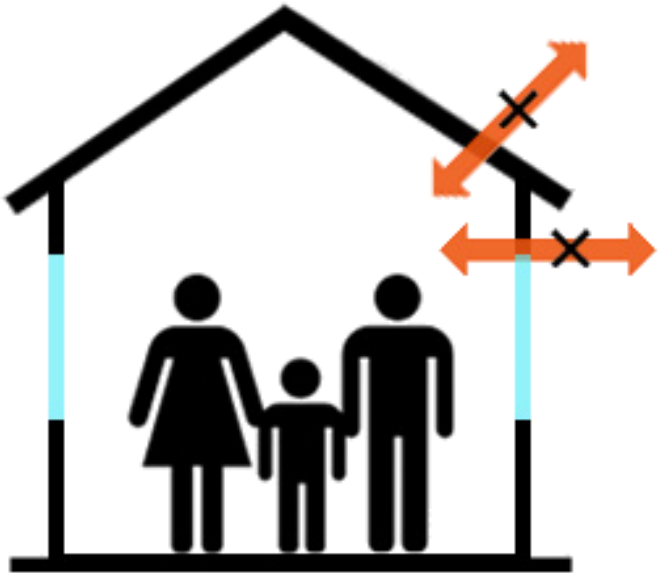
Place of Issue.....Berne.....

Place of Assignment ...Central Salt &
Marine Chemical Research Institute
Bhavnagar.

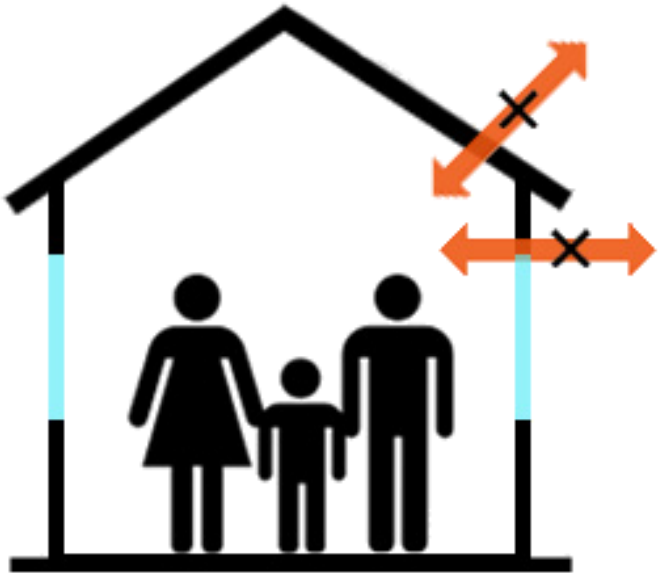
Project to which attached..INDO-SWISS

Project..at..CSMCRI,..Bhavnagar.
in the field of Solar Pump

- In 1981-83 Known as the यिजडि वाल in ભાવનગર
- Driving from Bhavnagar and return to Ahmedabad in May-June (temperature reaching 47°C some days (seems like driving (without helmet) against a hair dryer))
- Some real experience of «hot weather», no AC at home, only ceiling fan and a જુલા outside, sleeping on the roof



FOCUSING ON RESIDENTIAL BUILDINGS



BASIC RESEARCH ON BASELINE OF MIG AC DWELLINGS

Baseline study

- Study conducted by BEEP (about 1200 dwellings) in 2011-13 shows that for MIG HIG dwellings, Air Conditioning represents 33-65% of the electricity bill for both composite/hot and dry climates as well as Warm and humid

Composite (NCR)

Warm and humid (Chennai)

Baseline Scenario of Energy Consumption of Urban Multi- Storey Residential Buildings in India, BEEP, 2014 PLEA Conference

Importance of efficient passive design

- Allows reducing capacity of AC (1.5-2 tons → 0.5-0.75 tons)
- Allows reduce AC energy consumption for AC dwellings

Exhibit 1: India remains under penetrated vis-à-vis other countries

Country	Penetration (%)
Taiwan	90%
US	87%
Korea	70%
China	53%
Thailand	30%
Indonesia	8%
India	4-5%

Source: Industry, Blue Star, MOSL

- Improve thermal comfort for non AC dwellings
  - All over India, AC penetration now about 5%[1]

1. Room air conditioners: Focus shifts to inverters, Motilal Oswal research, April 2017

Importance of Good Thermal Quality of Building Envelope in Group Housing

a) Exposed façade area to Built-up area ratio 2 -3 times more in residential buildings as compared to office buildings.
b) Cooling loads in commercial buildings usually dominated by internal loads; while in residential buildings *dominated by heat gains through the envelope*.
c) Peak occupancy of residential buildings during the night, and hence greater role of natural ventilation
d) Greater relevance of adaptive thermal comfort
e) Most of the houses are not air-conditioned

Wide Variations in Building Envelope Thermal Quality

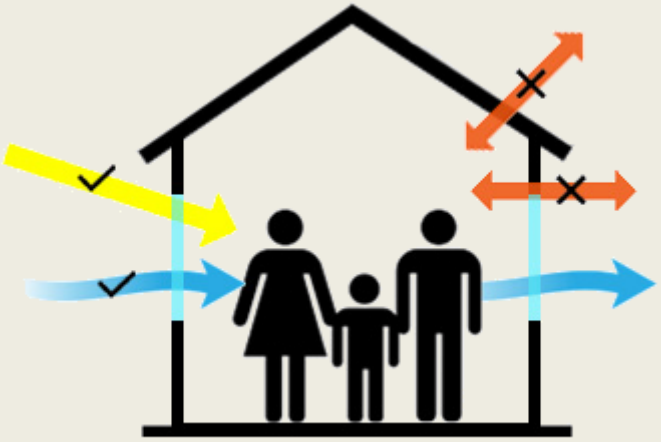
U (wall) ~ 0.5 W/m^2.K

WWR ~ 10%
Shaded Windows

U (wall) ~ 3.5 W/m^2.K
Monolithic concrete wall

WWR ~ 35%
Inadequate Shading of Windows

Key features of a good performing Building Envelope for Group Housing (principles)



- Reducing Heat Gains/Loss
- Ensuring Natural Ventilation

Improved Thermal comfort (reduction of discomfort duration)
Reduced energy consumption for cooling or heating

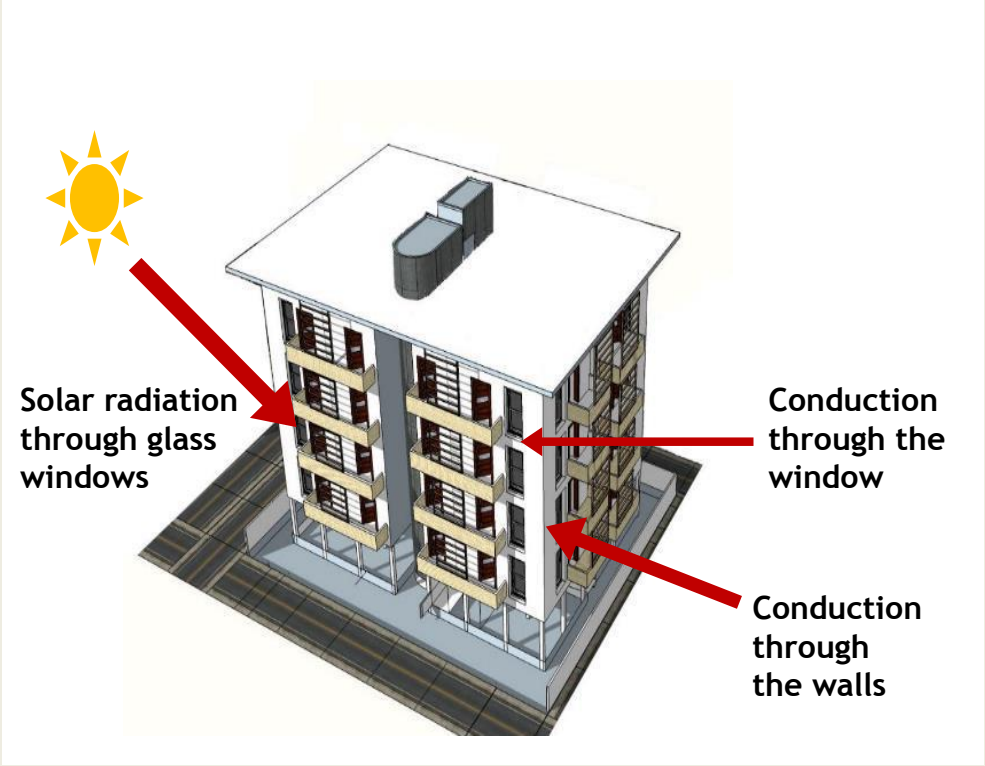
A formula based calculation called RETV has been developed and can be used to define the thermal quality of the Building Envelope

Residential Envelope Heat Transmittance (RETV) is the net heat gain rate through all the building envelope components (excluding roof) divided by the total envelope area; calculated for the cooling period.

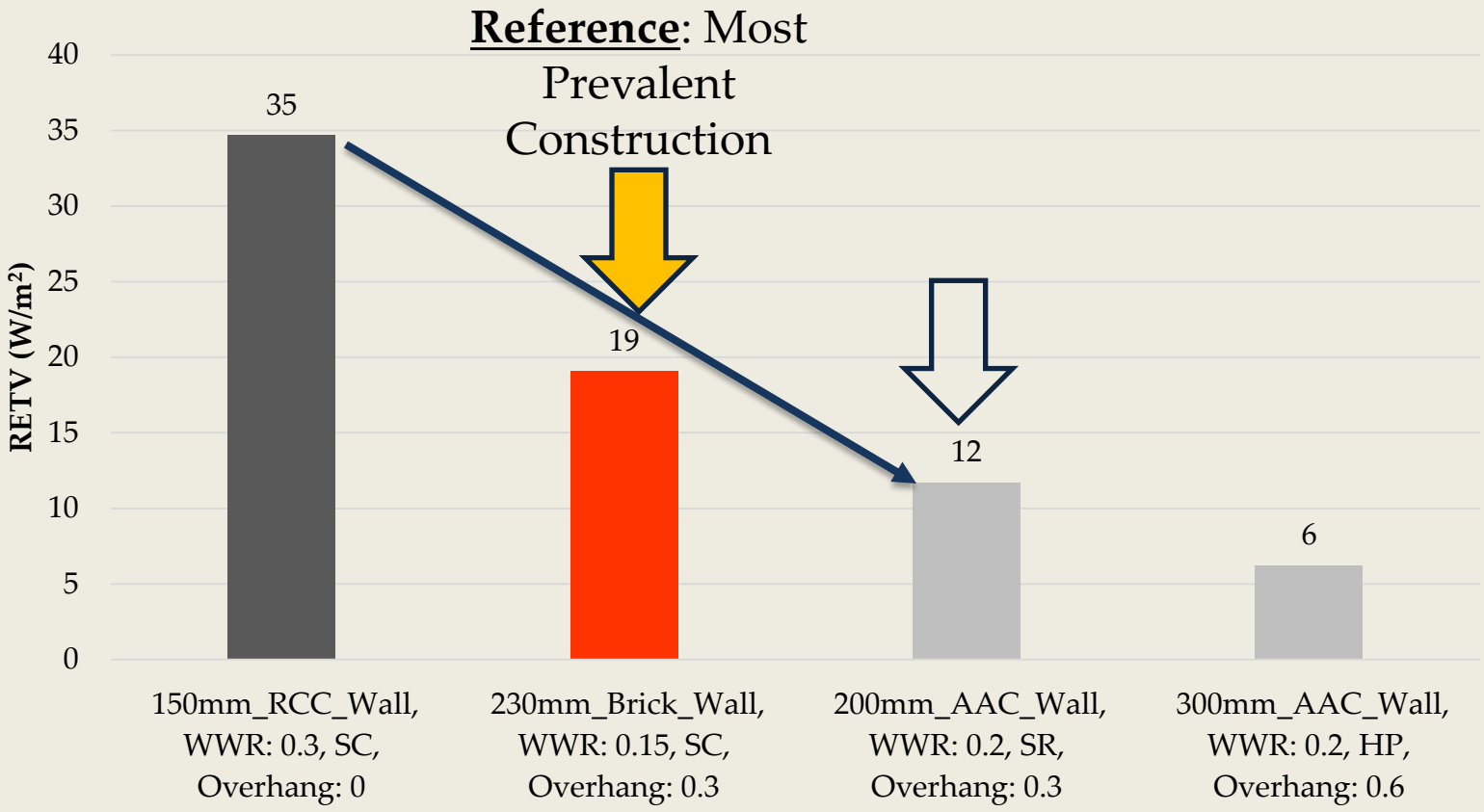
Developed for BEE with over 40'000 dynamic thermal simulations (EnergyPlus 8.5, U.S. Department of Energy , BEEP Indian and Swiss team)

RETV is calculated based on

- Window wall ratio
- Thermal insulating property of wall (U_{wall})
- Thermal insulating property of glazings (U_{win})
- Solar heat gain coefficient of the glazings



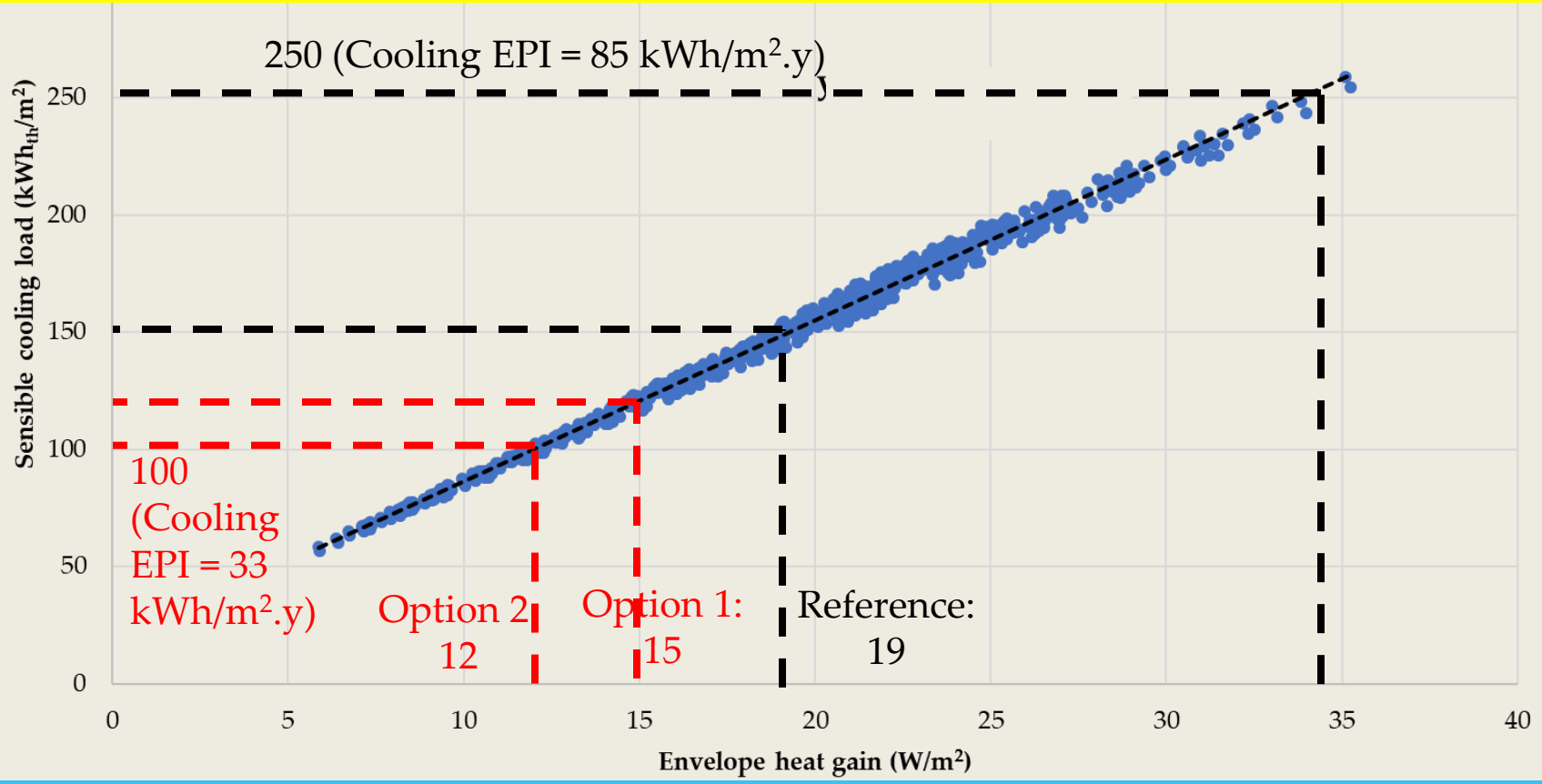
Typical RETV for different construction types

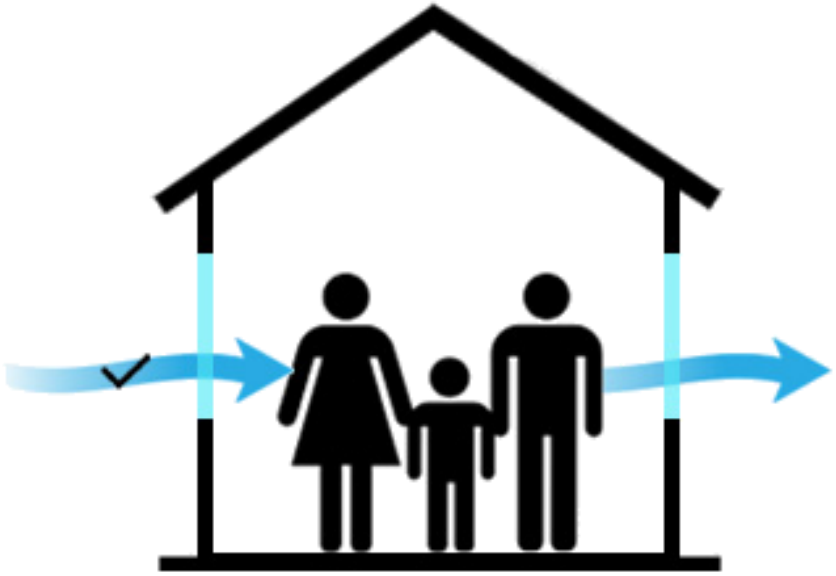


The heat gains from a building envelope having poor thermal quality can be ~3 times that having good thermal quality

Composite/Hot-Dry Climate (Air Conditioned): Envelope Heat Gains v/s Sensible Cooling Load

The electricty consumption for airconditioning from a building envelope having poor thermal quality can be ~3 times that having good thermal quality



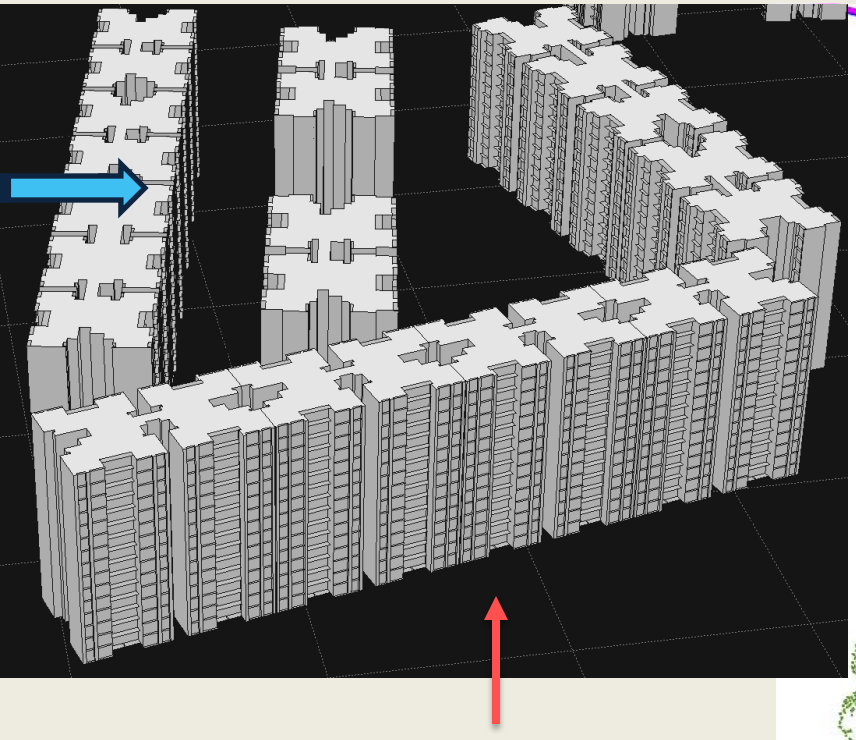


ENSURING ADEQUATE NATURAL/ASSISTED VENTILATION

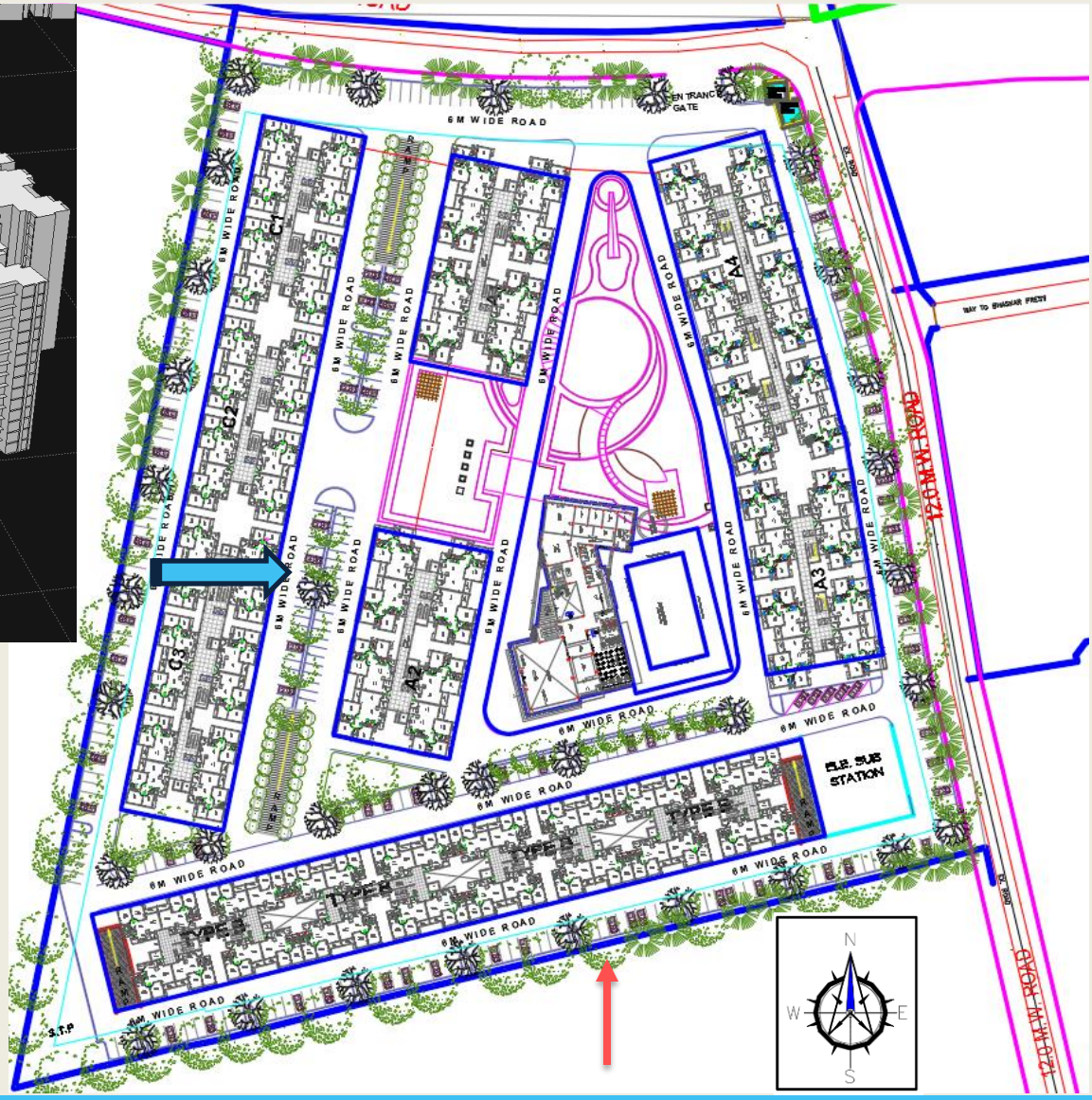
Example of wind distribution for the DB Pride Project at Indore

- View from North
- Main wind direction from the west

Example of wind distribution for the DB Pride Project at Indore

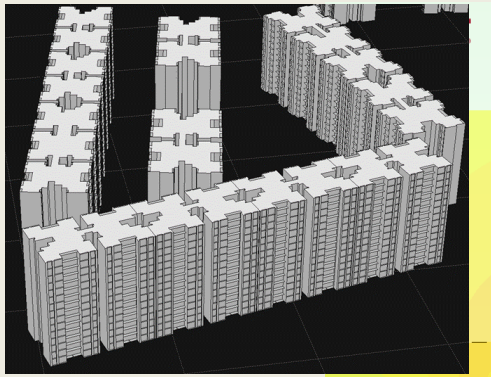


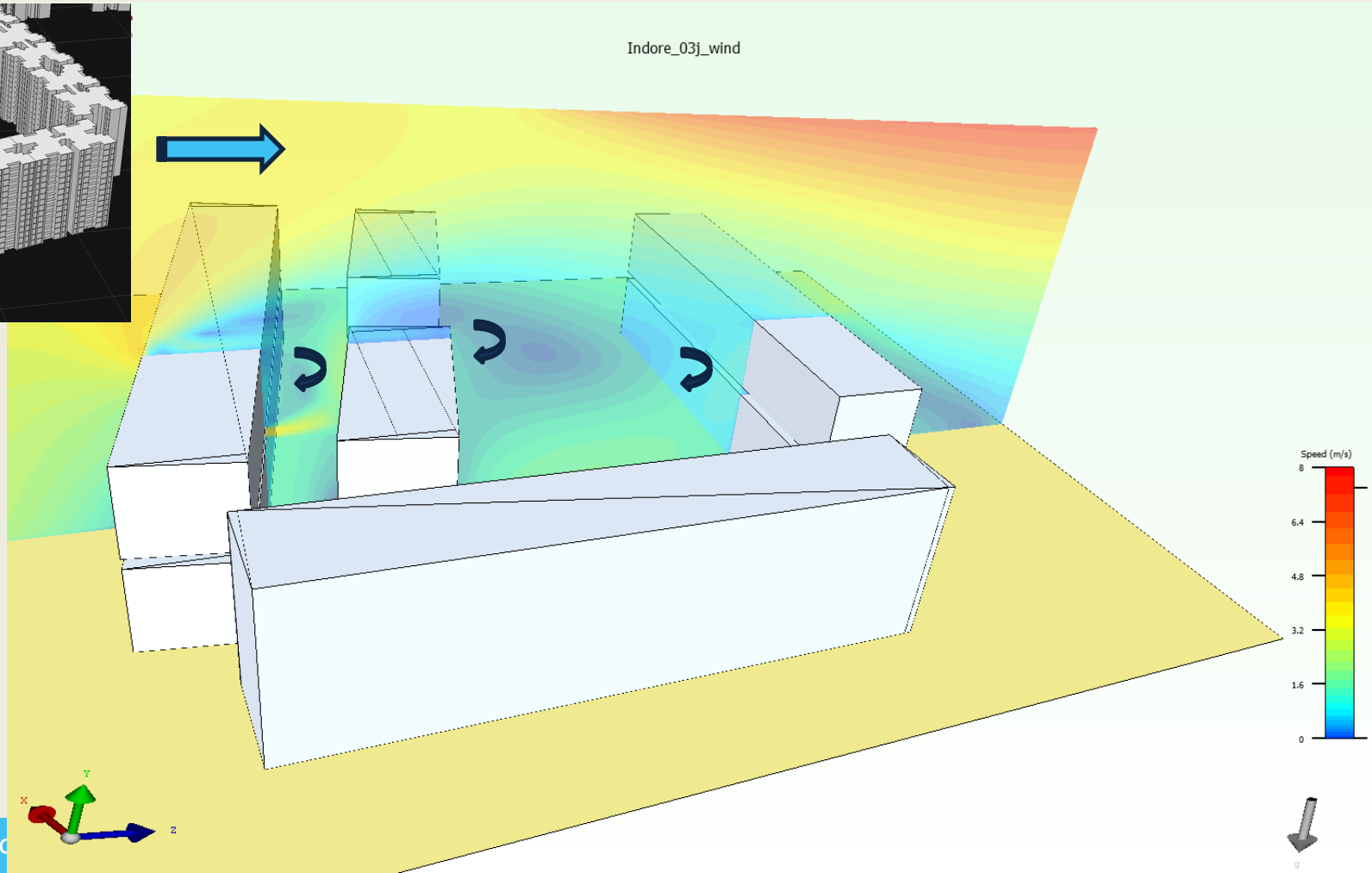
- View from south
- Main wind direction from the west



Example of wind distribution for the DB Pride Project at Indore

- Computational Fluid Mechanics (CFD) Simulation with a west wind

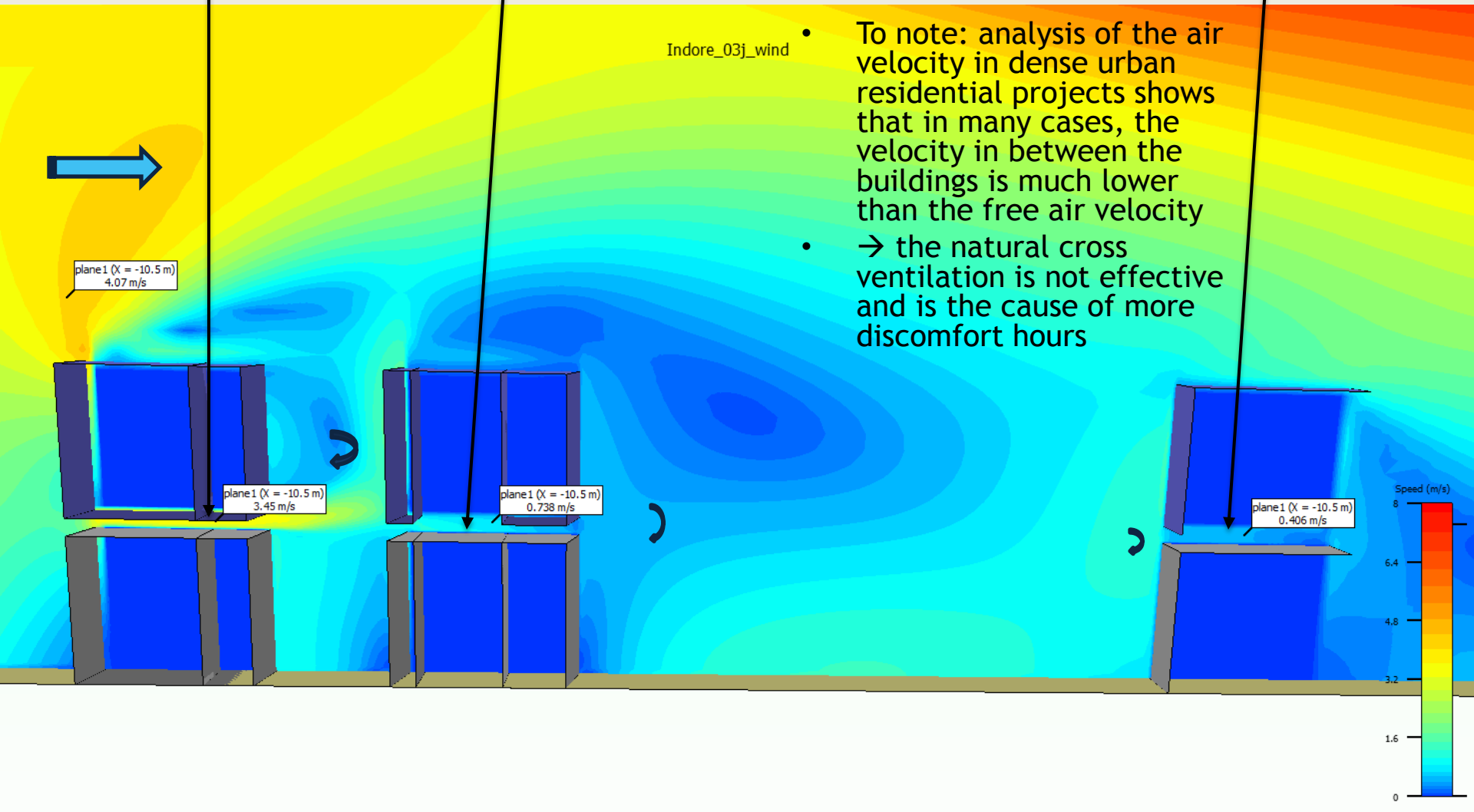




Observations on wind velocity in dense urban residential project (DB Pride Indore)

- Velocity through the buildings (in between floor 3 meters height free)

3.4, 0.75, 0.4 m/sec

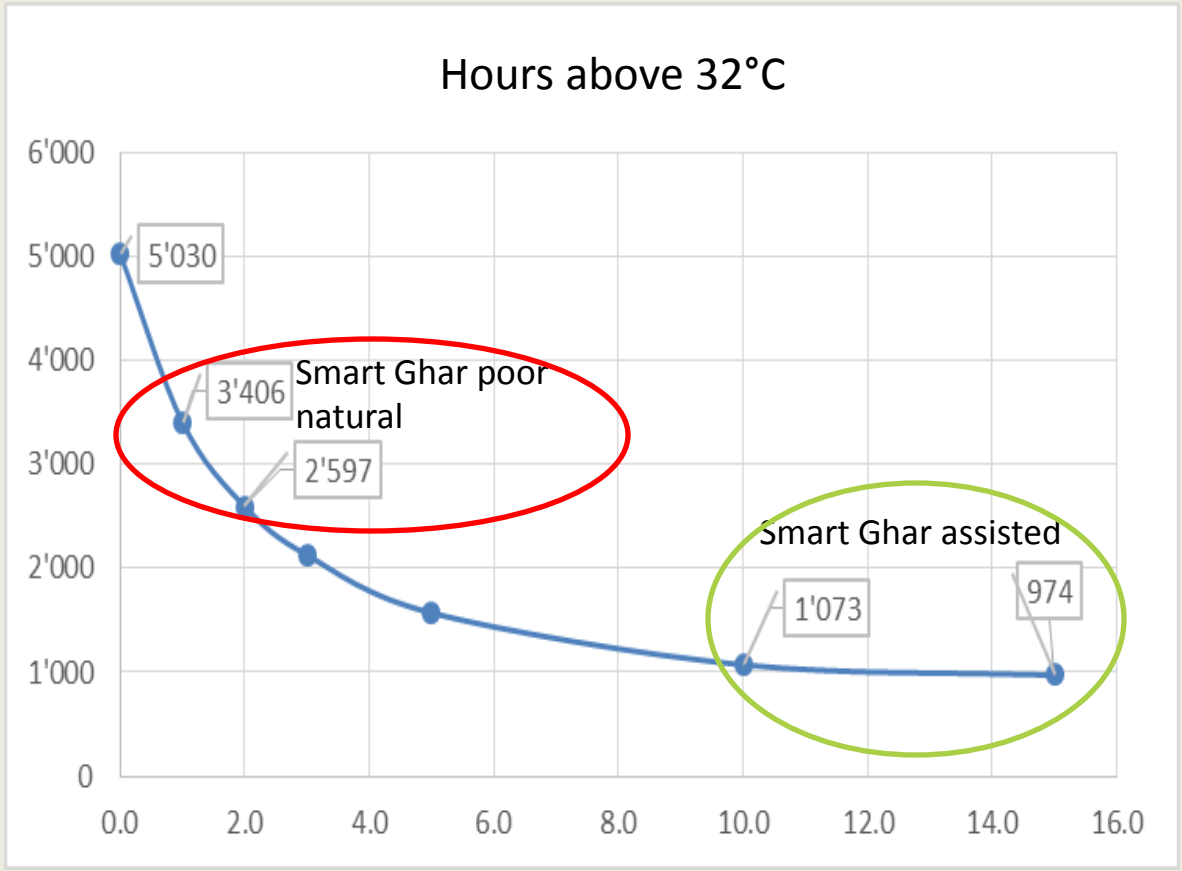


- To note: analysis of the air velocity in dense urban residential projects shows that in many cases, the velocity in between the buildings is much lower than the free air velocity
- → the natural cross ventilation is not effective and is the cause of more discomfort hours

EXAMPLE : SMART GHAR III RAJKOT MUNICIPAL CORPORATION LOW COST HOUSING SCHEME

Natural ventilation issues, climate of Rajkot impact of fresh air change on the comfort in non AC dwellings

- Shading with partly opaque windows (2/3) shutters
- Natural ventilation in unfavourable locations
  - ~2000 hours/yr more discomfort hours
- Assisted cross ventilation (centralised or decentralised ~1W/m² of floor area)



Air change per hour (1/h)

Smart Ghar 3, Rajkot, Gujarat

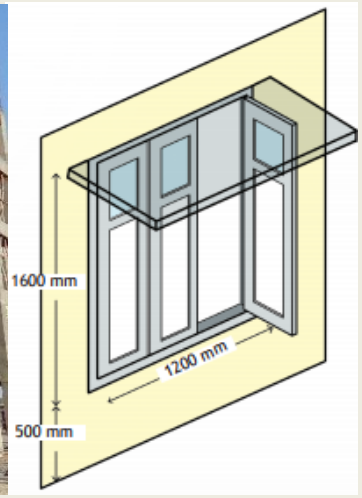
1176 Housing Units

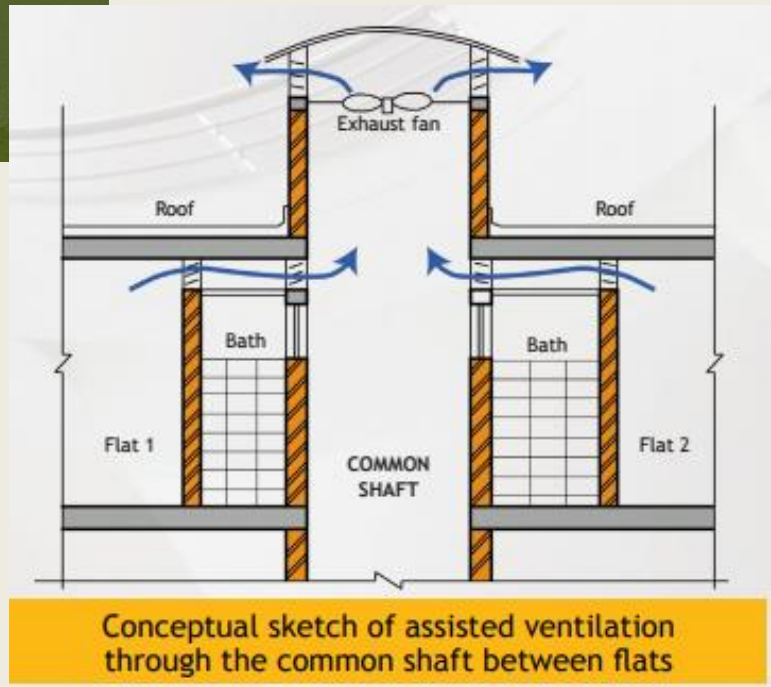
Impact :

a) Reduce peak summer room temperature by >5˚C

b) Increase the number of comfortable hours (room temp. below 30˚C) from ~2600 hours to ~6300 hours

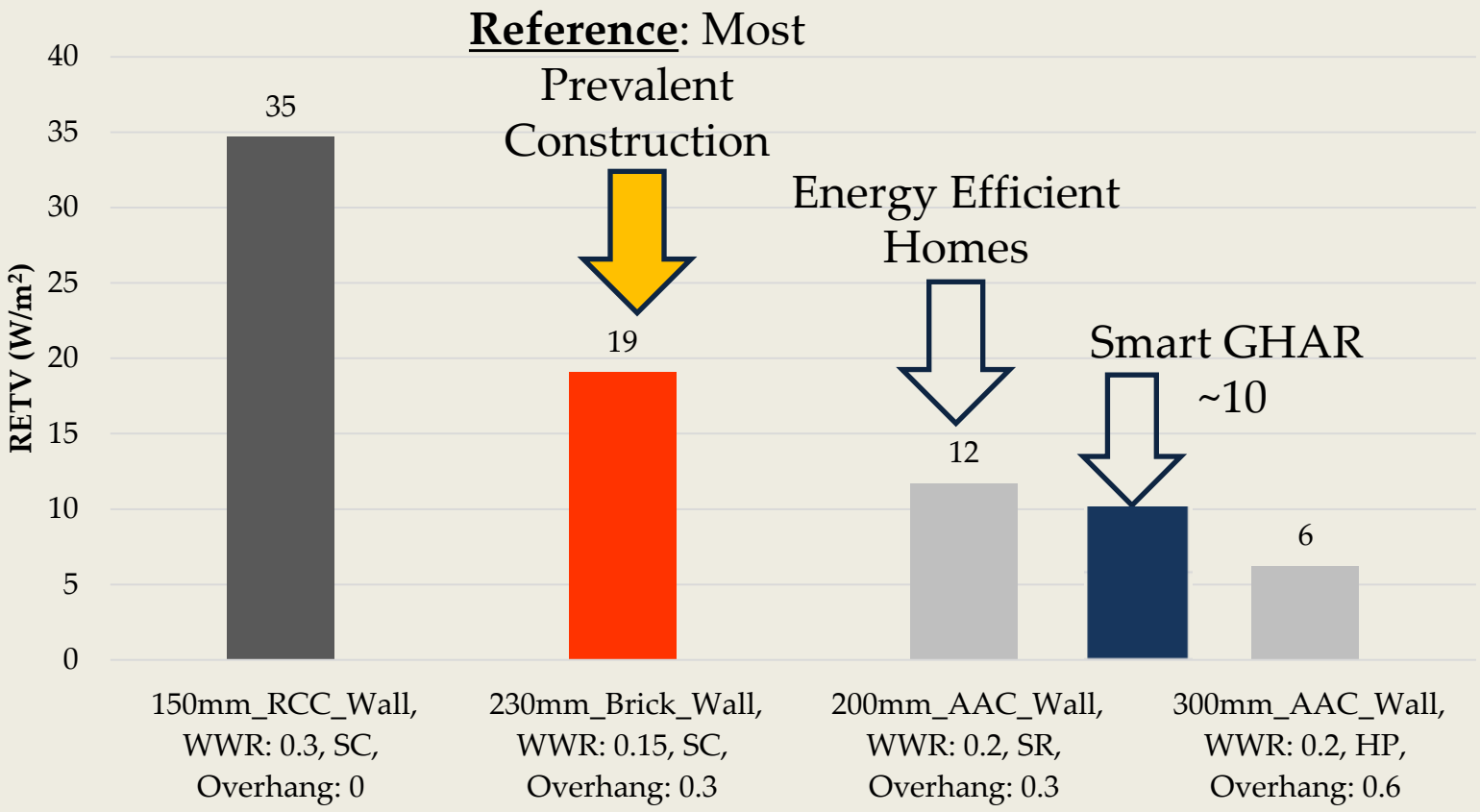
c) Assisted cross ventilation shaft (~1W/m²)





Conceptual sketch of assisted ventilation through the common shaft between flats

Conclusions: Typical RETV for different construction types



Various combinations with marginal difference in the construction cost

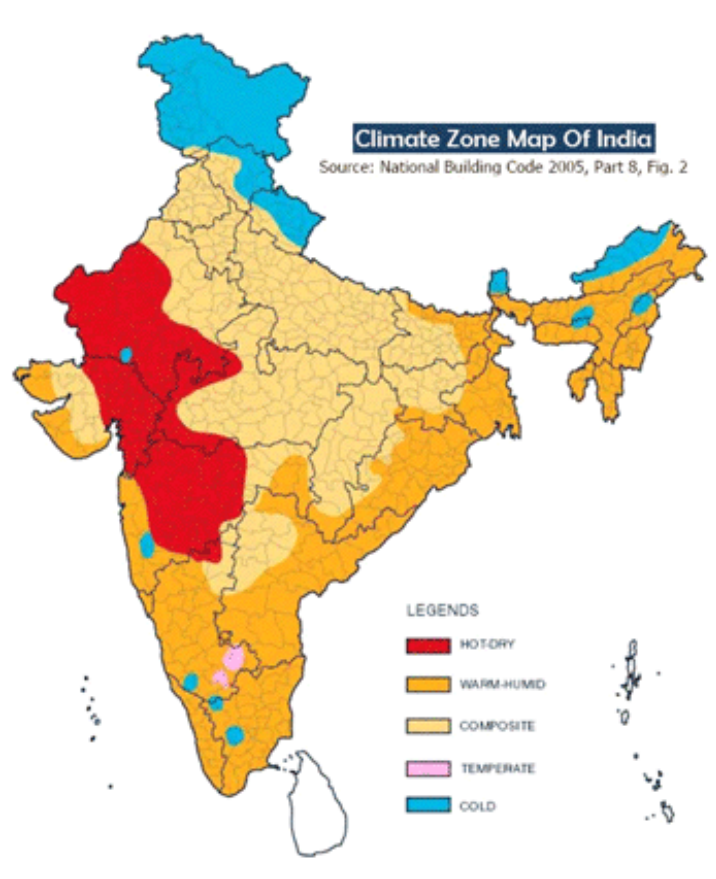
Conclusion

- Key elements
  - Walling with a U_{value} <1 W/m^2 → no uninsulated concrete
  - Glazing heat transmission by conduction not so important in the Indian climates, but shading is most important
    - Heat losses at night increased by low sky temperature
  - Natural/assisted ventilation designed to allow cross ventilation at night > 10 ACH
  - The formula (RETV) developed for 5 climates in India can be used easily also at sketch design stage
  - It is possible practically without additional investment costs to reduce the heat gain by 30-50% as compared to the business as usual practice
  - Better designs will allow reducing the Air Conditioning penetration rate and also with lower capacity (e.g. 1.5 Ton → to 0.75 Ton)

THANKS!

Climate Zones

- Climatic zones
  - **Composite & Hot-dry, Warm-humid, Temperate**: Cooling dominated climates, responsible for fast growth in air-conditioning electricity requirement; accounts for >96% of the population and new construction
  - **Cold**: Heating dominated climate



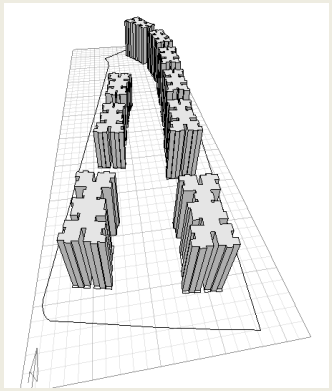
Output 1.5: Online tool for natural ventilation design

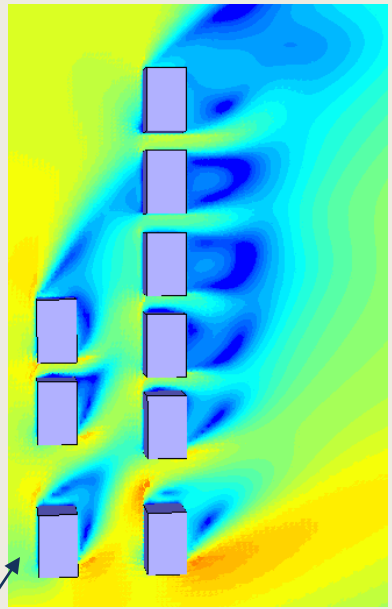
Activity 1.5.1 Development of methodology/tool based on publicly available CFD software

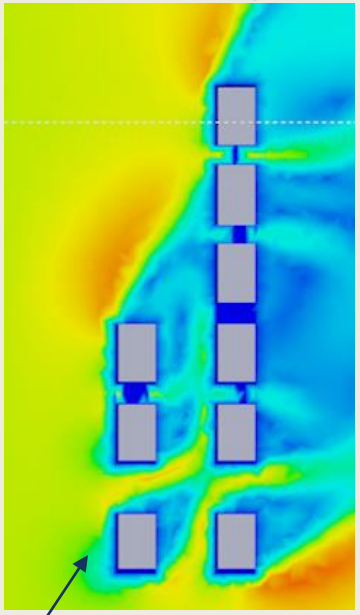
- Wind patterns: Preliminary qualitative comparisons (Mahindra Live Space Chennai Charrette)
- Charrette mass plan

Mahindra WORLD CITY

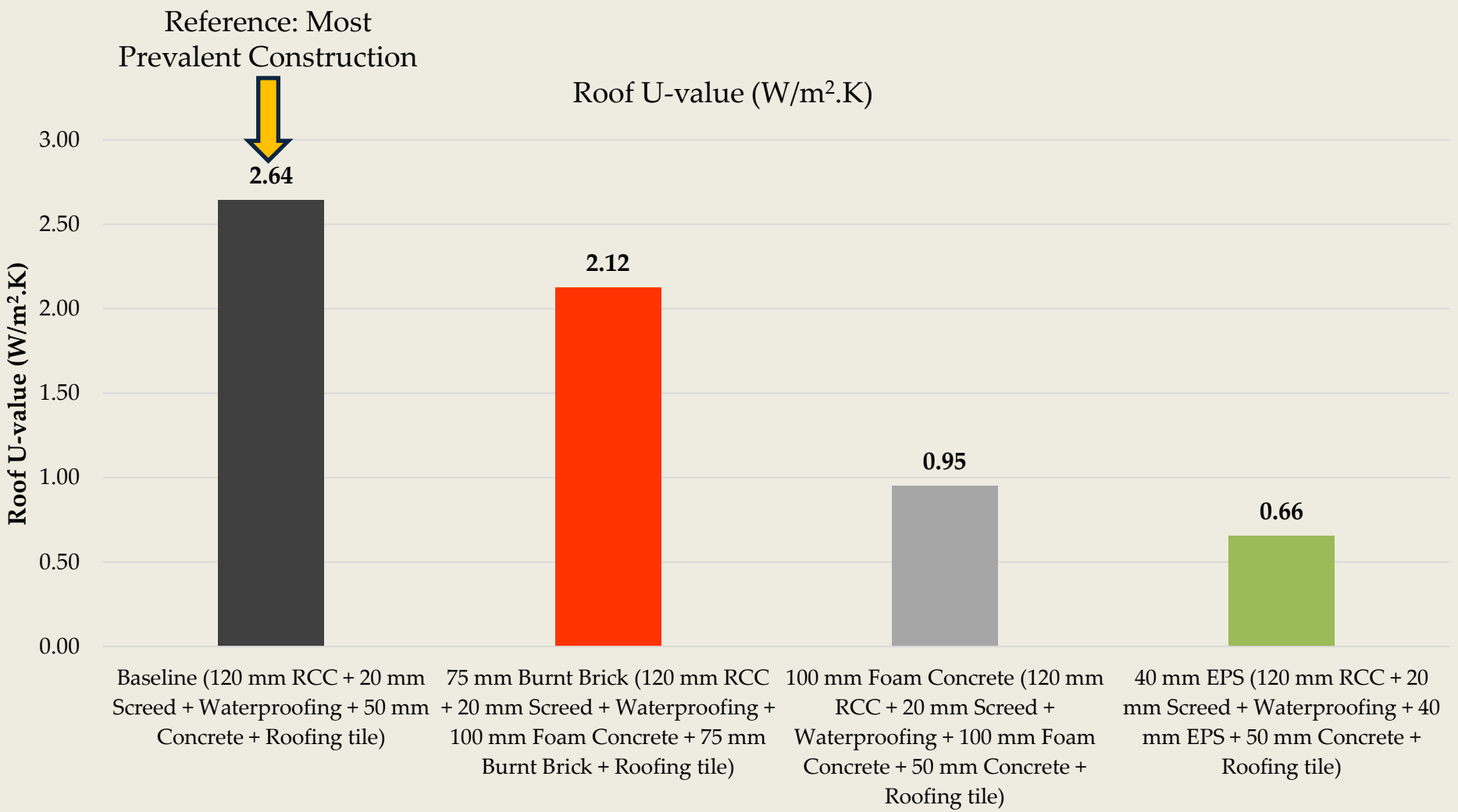
Commercial CFD Open Source CFD



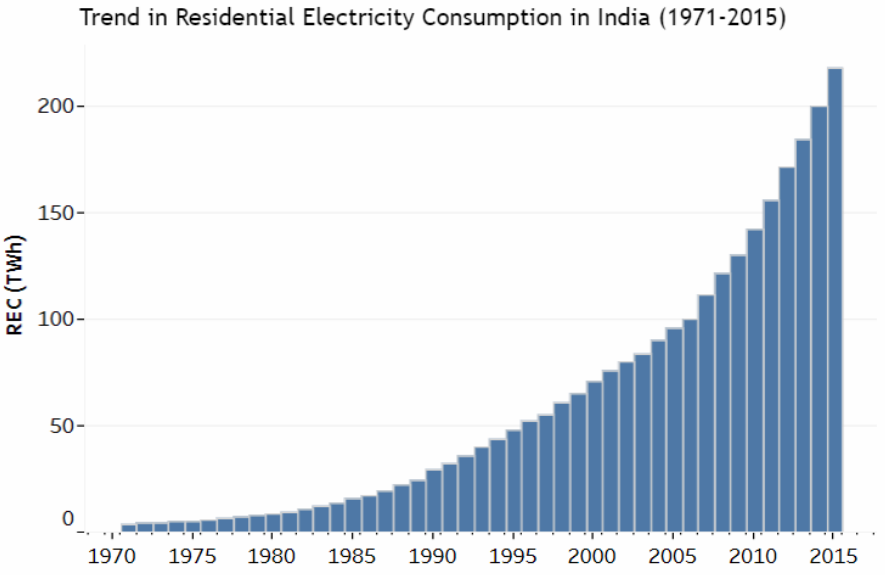


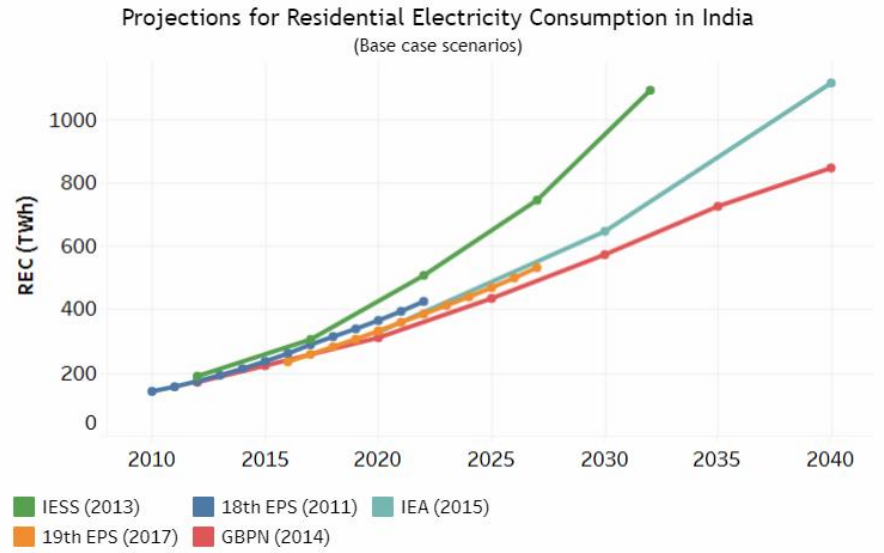


Roof U-value


Reference: Most Prevalent Construction
Roof U-value (W/m².K)
Roof U-value (W/m².K)
3.00
2.50
2.00
1.50
1.00
0.50
0.00
2.64
2.12
0.95
0.66
Baseline (120 mm RCC + 20 mm Screed + Waterproofing + 50 mm Concrete + Roofing tile)
75 mm Burnt Brick (120 mm RCC + 20 mm Screed + Waterproofing + 100 mm Foam Concrete + 75 mm Burnt Brick + Roofing tile)
100 mm Foam Concrete (120 mm RCC + 20 mm Screed + Waterproofing + 100 mm Foam Concrete + 50 mm Concrete + Roofing tile)
40 mm EPS (120 mm RCC + 20 mm Screed + Waterproofing + 40 mm EPS + 50 mm Concrete + Roofing tile)

Why focusing on Residential Buildings is Essential ?





- Buildings consumes over 30% of the electricity, out of which around **75%** is consumed by **residential buildings. Highest growth registered in electricity consumption.**
- The residential building stock to double from **13 billion m^2 (2012) to 26 billion m^2 (2030).**
- The electricity use in residential buildings is projected to grow sharply **by 4-5 times between 2012 and 2030.**
- Managing GHG emissions from energy use in residential buildings operation and construction would be key in meeting country's commitments under the Paris agreement
- 12 million new affordable houses in urban areas to be constructed by 2022.Thermal comfort key to well-being and health of occupants.

National Building Code (NBC)

BIS

SP 41:1987
(Handbook on functional requirements of buildings- other than industrial buildings)

*"**national instrument providing guidelines** for regulating building construction activities across India; guiding code for municipalities and development authorities to follow in formulating and adopting building bye-laws; existing PWD codes, municipal bye laws and other regulatory media could either be replaced by NBC or suitably modified to cater to local requirements"*

*"**explanatory handbook** based on IS codes. Its purpose is to provide guidance to architects, engineers, agencies dealing with lighting, ventilation, air-conditioning and illuminating engineering aspects"*

Model building bye-laws

TCPO

*"**legal tools** used to regulate coverage, height, building bulk, architectural design and construction aspects of buildings, so as to achieve orderly development of an area. They are **mandatory in nature** and serve to protect buildings against fire, earthquake, noise structural failures and other hazards."*

The importance of good thermal performance of building envelope has been established (NBC, SP 41, Model Building Bye-Laws); but often they are not put in practice. New methods to quantify more precisely have been developed

RETV