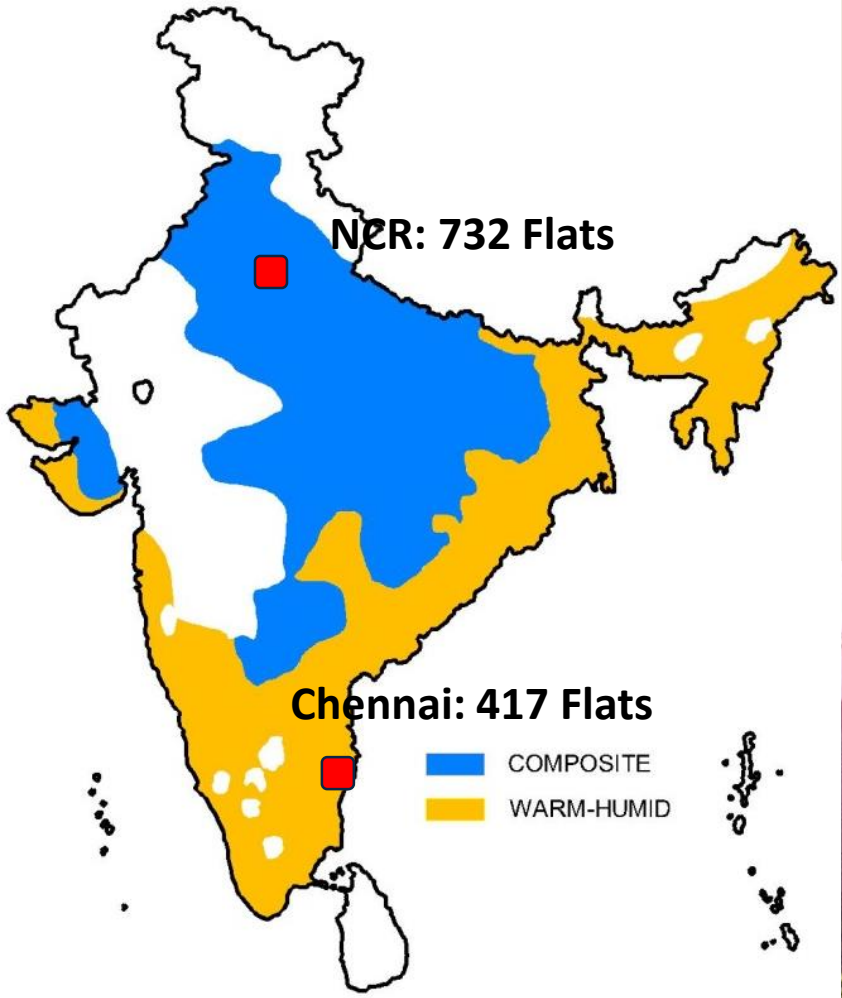
BEEP
BUILDING ENERGY
EFFICIENCY PROJECT

Energy-Efficient Housing

Outline

- Introduction to Energy Efficient Housing
- Climate analysis of Rajkot & its impact on design of buildings
- Key Design Strategies for Energy Efficient Housing
- Conclusions

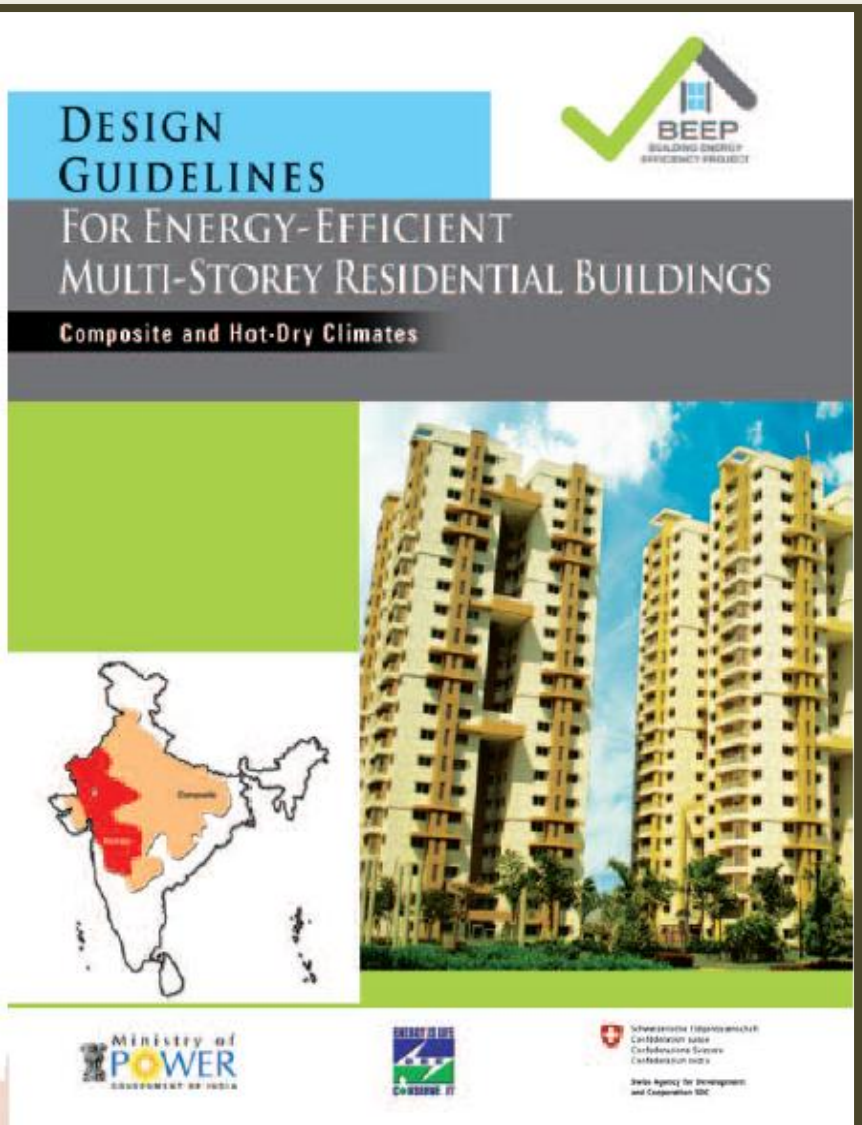
Survey of electricity use and designs of flats – NCR & Chennai



- Flat Area ~ 800-1300 sq. ft
- Year 2009/2010

Conclusions - Survey

Design Guidelines for Energy-Efficient Residential Buildings – 15 key Recommendations



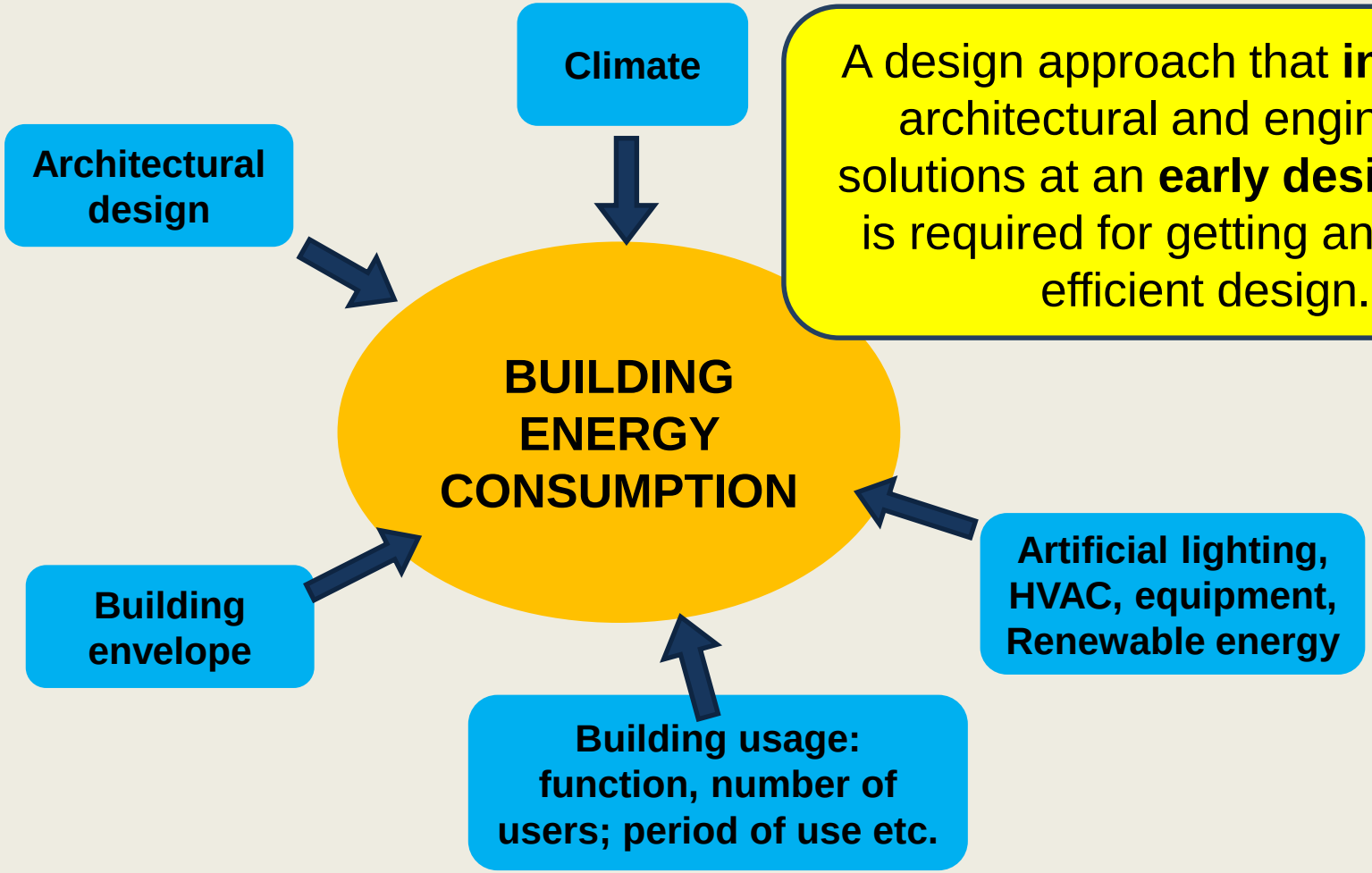
Building Massing → Building Envelope → Space Cooling Systems

Energy Efficient Appliances → Common Services → Renewable Energy

Energy-Efficient Housing ?

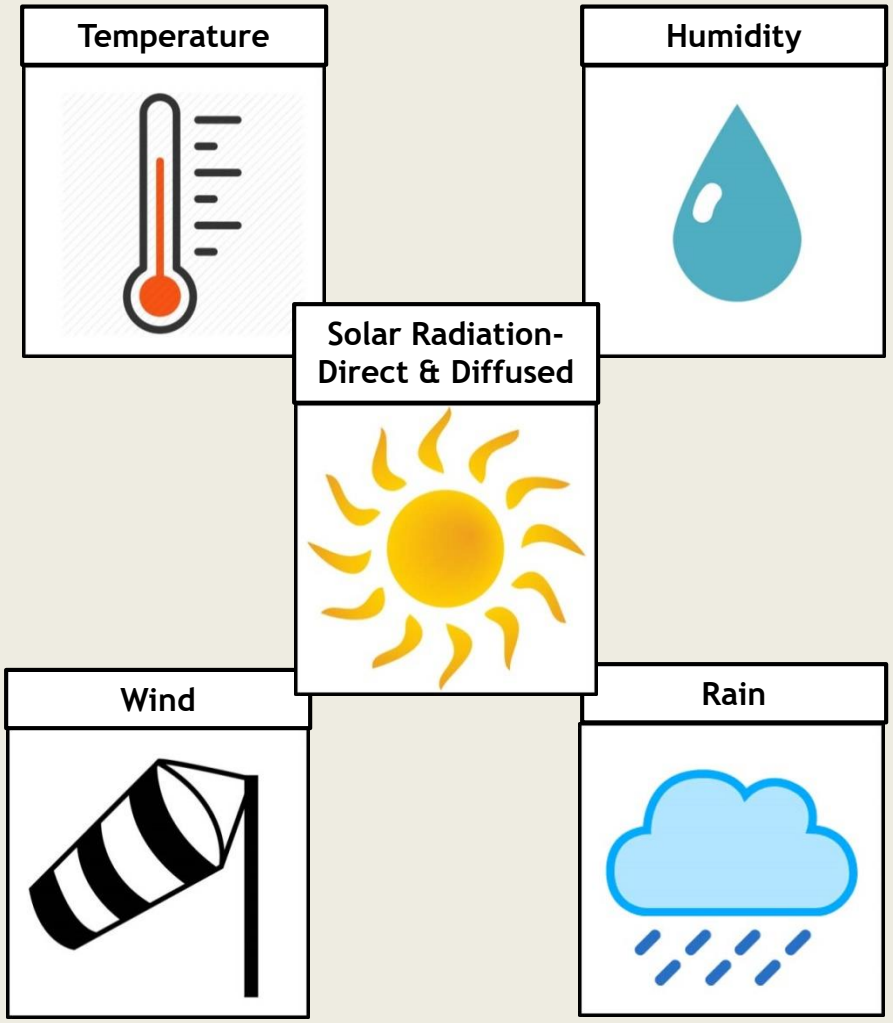
- Does not heat up abnormally during long summer season.
  - The requirement for use of coolers and ACs is minimized.
- Good ventilation to utilize cool breeze during evening, night and mornings.
- Adequate day lighting (kitchen, corridors, rooms,..); minimizes the need to switch-on artificial light during day.
- The use of electricity/fuel for heating water is minimized. Utilizes solar energy for meeting part of electricity/ water heating requirements.
- Energy-efficient lighting, equipments, appliances,…
- Low embodied energy in construction – minimizing the use of energy intensive materials – steel, cement, glass,….
- Affordable
  - No/low additional construction cost.
  - Low electricity bill for occupants.
  - Easy and low-cost maintenance.

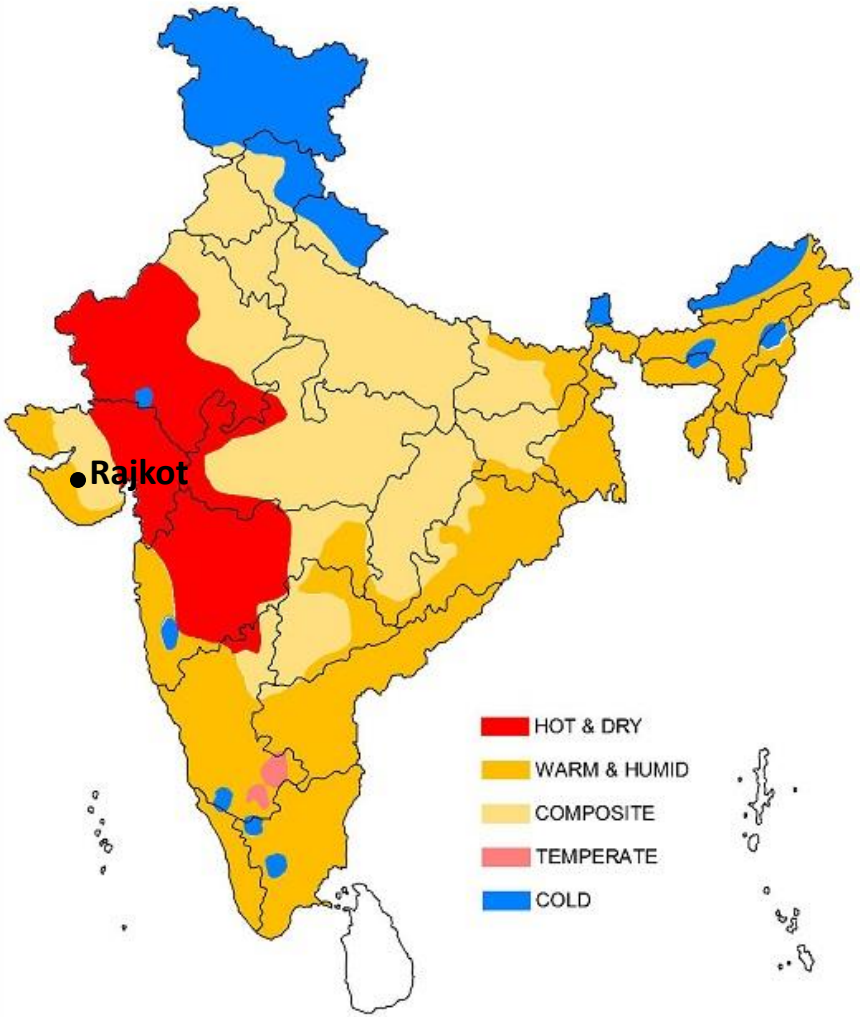
Approach to Energy Efficient Building Design



A design approach that **integrates** architectural and engineering solutions at an **early design stage** is required for getting an energy-efficient design.

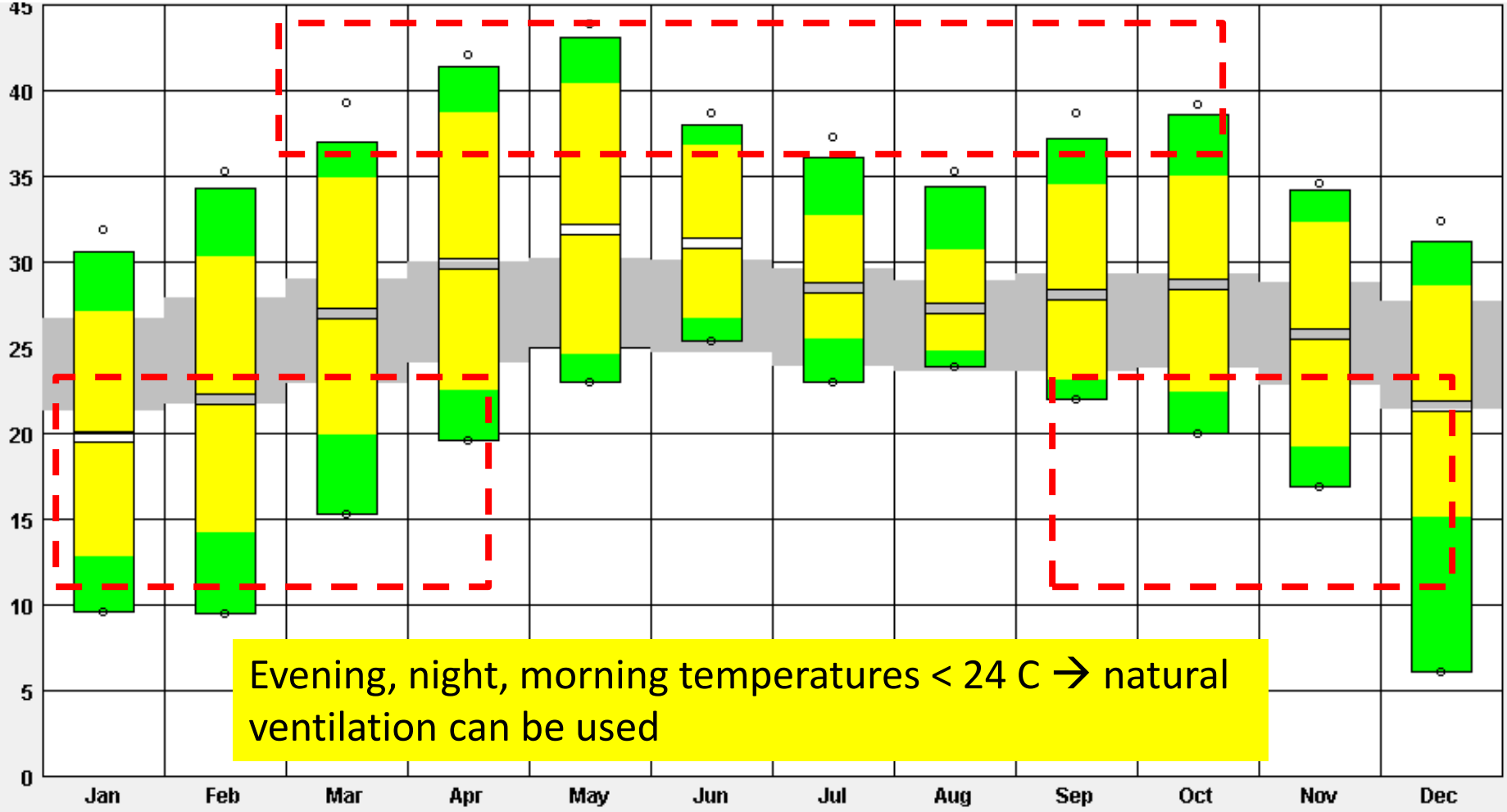
Climate


Temperature
Humidity
Solar Radiation-
Direct & Diffused
Wind
Rain


Rajkot
HOT & DRY
WARM & HUMID
COMPOSITE
TEMPERATE
COLD

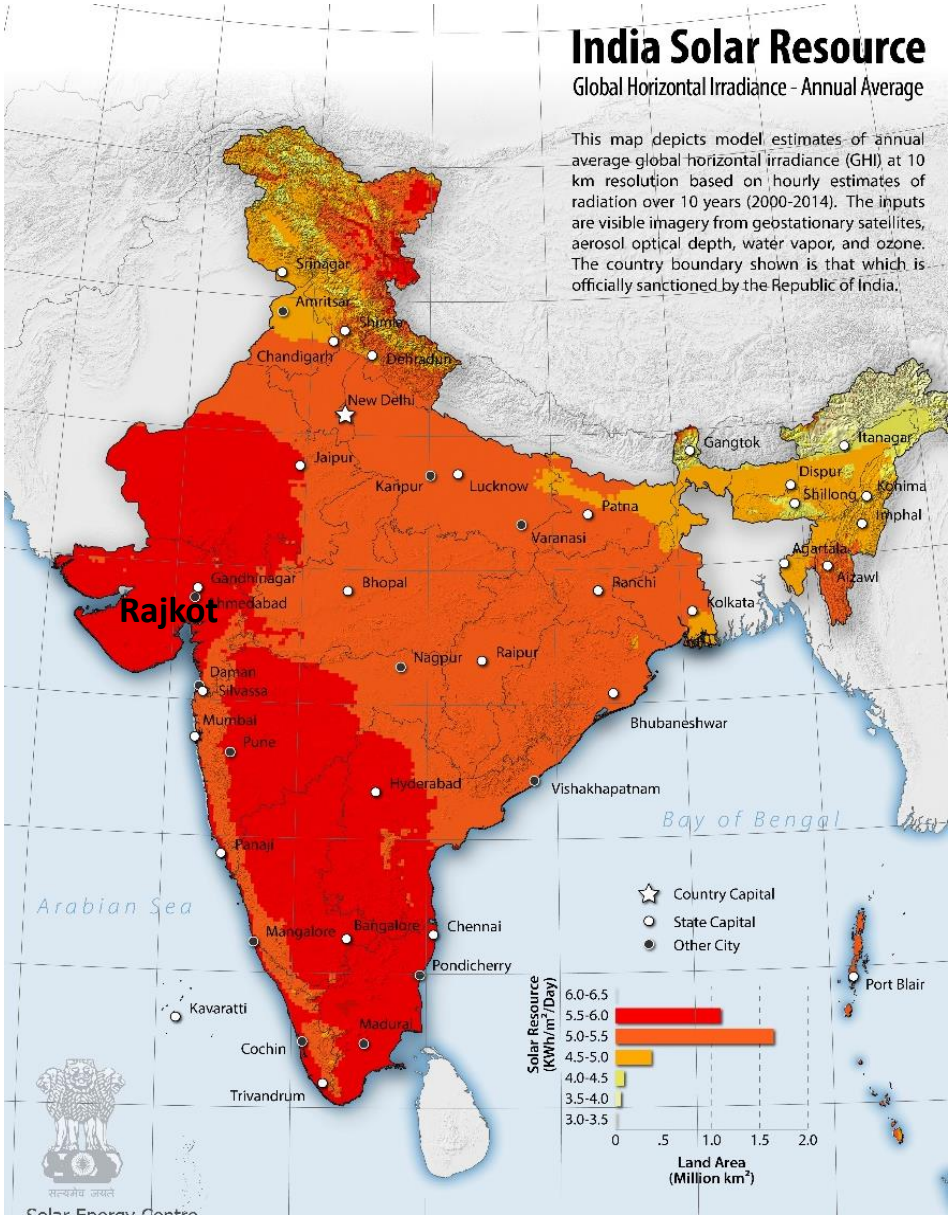
Rajkot - Ambient Temperatures

Avg. Max. Temperature > 35 C → reducing heat gains from building envelope



Evening, night, morning temperatures < 24 C → natural ventilation can be used

Rajkot- Solar Radiation



Very high solar radiation

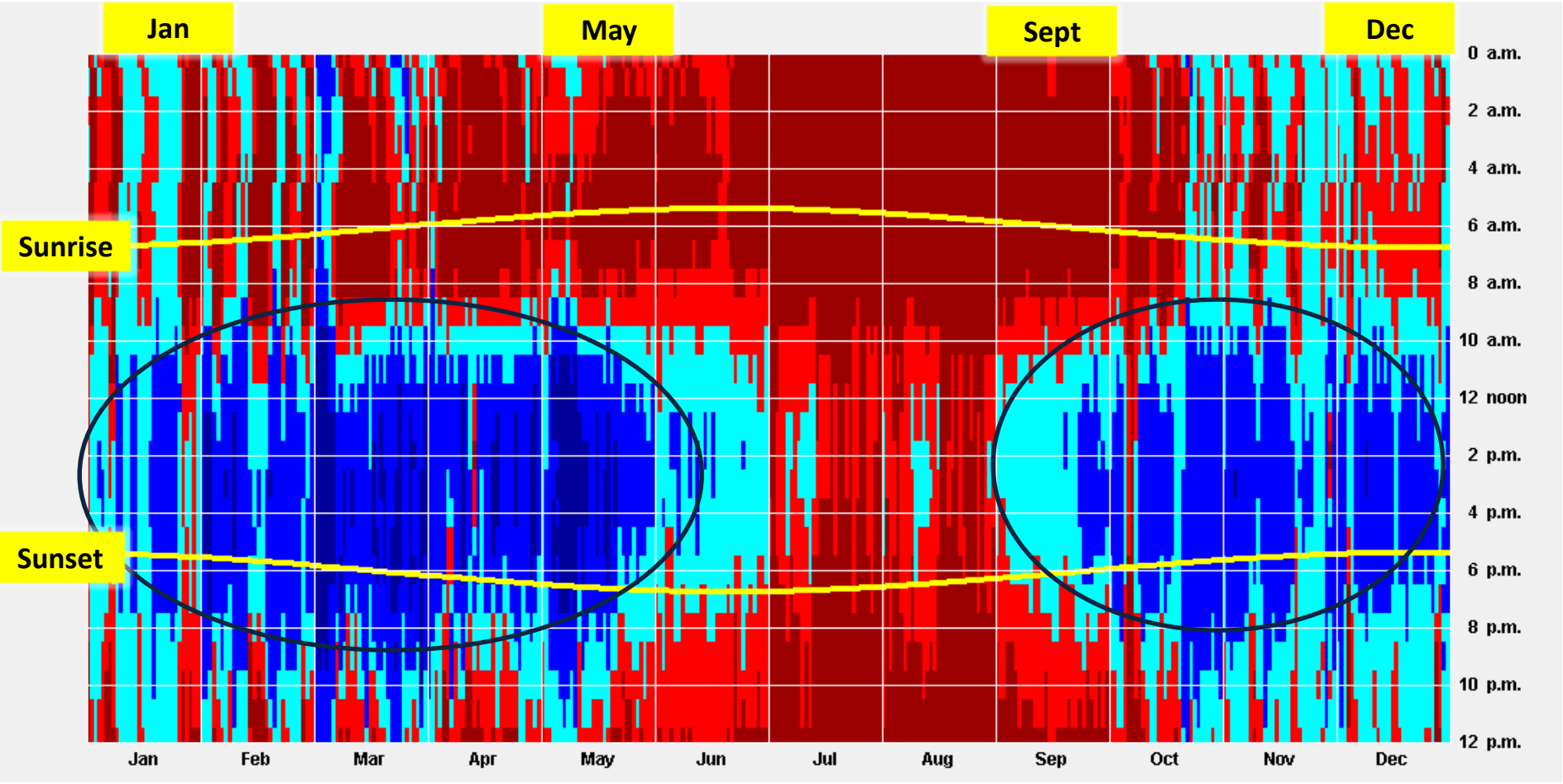
Insulation of roof/cool roof a must

Reasonable window to wall ratio (< 30 %). High glazing area to be avoided

Windows shading a must – static and shutters

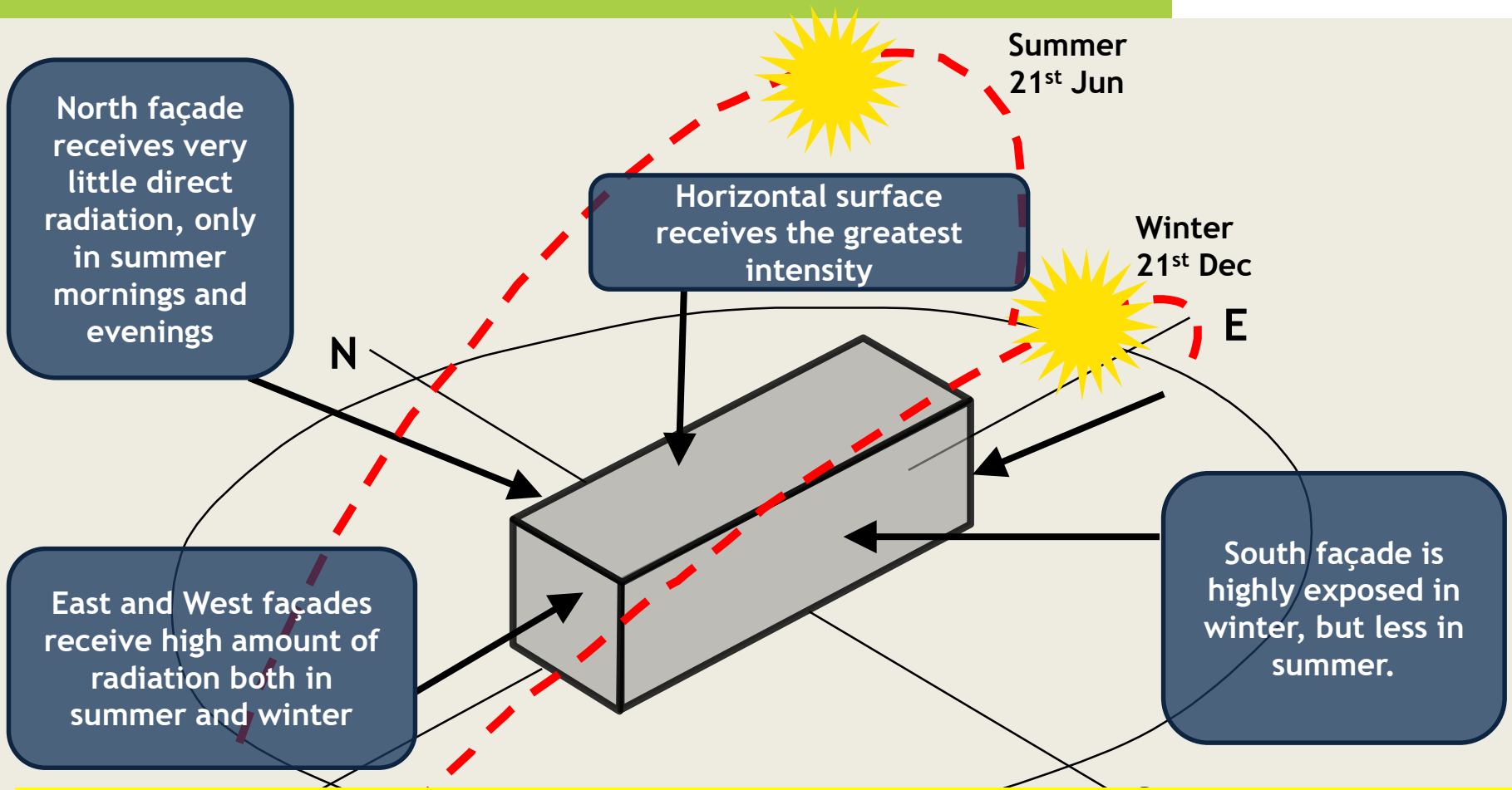
Good outputs from solar PV or hot water systems

Rajkot - Relative Humidity



Oct to May → Dry Climate →Evaporative cooling possible
June to August →Warm & Humid →Air Conditioning

Rajkot - Sun Exposure In Different Directions



- Reducing heat gains from roof – insulation, shading, reflection,..
- Minimizing exposed surfaces on east & west; fixed shades not effective
- Windows on north & south can be protected to some extent by fixed shades

1. Reducing Solar Heat Gains Through Proper Orientation & Massing

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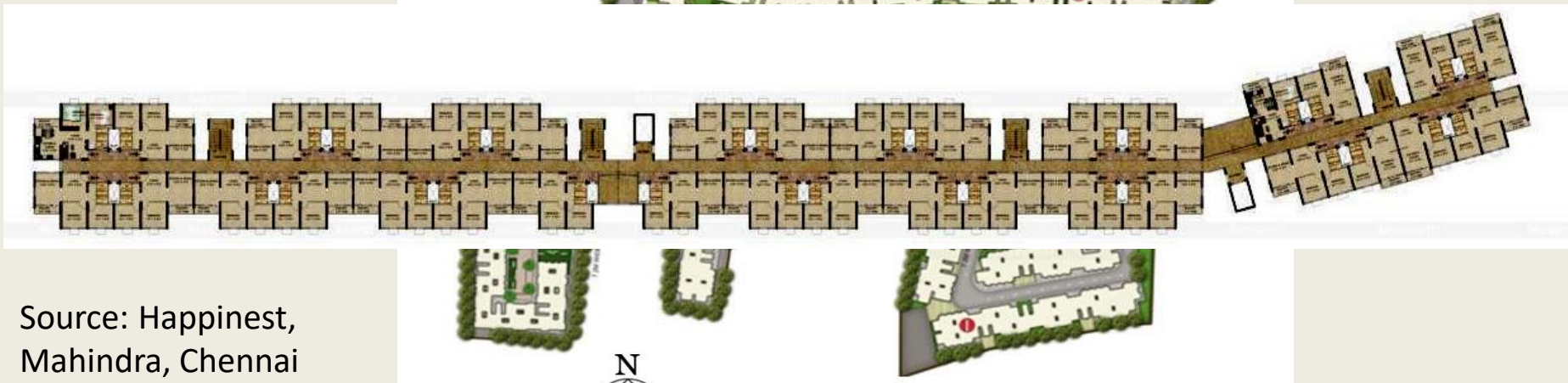
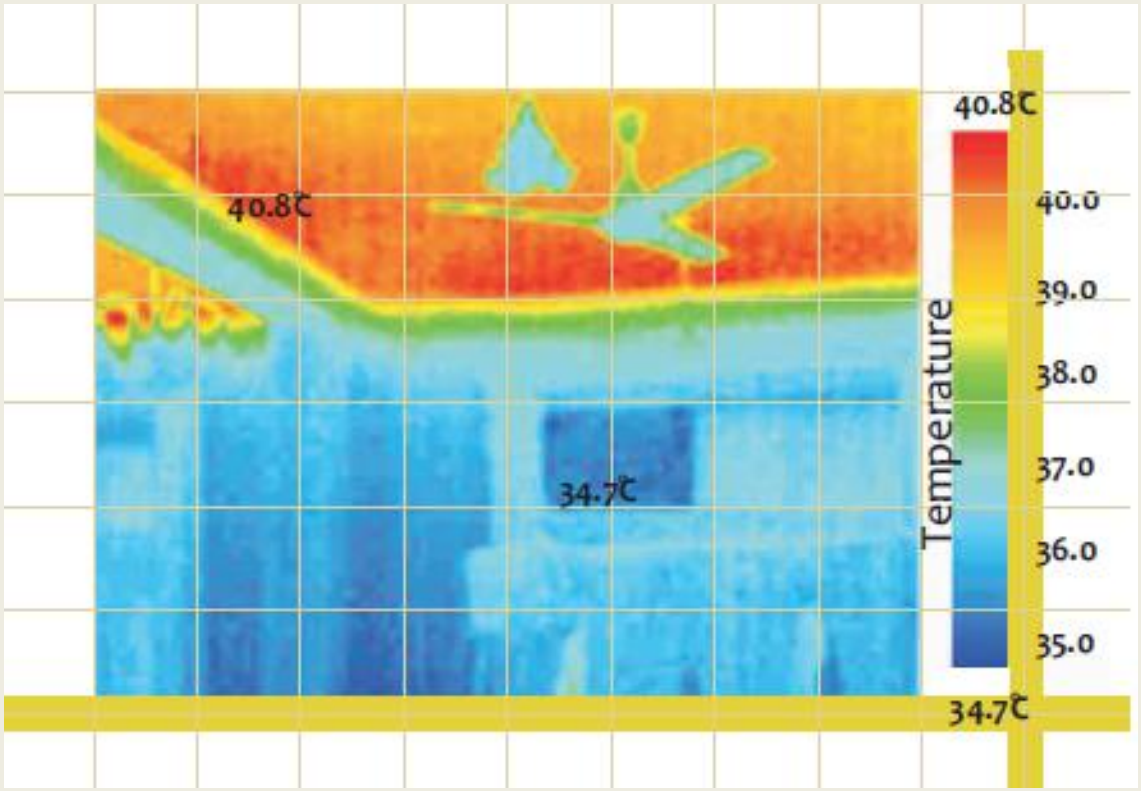
Reduction in solar exposure:

1. By orienting the buildings i.e. larger façade on North and South direction.
2. Double Loaded Corridors, to reduce exposed wall area.



Source: Happinest, Mahindra, Chennai

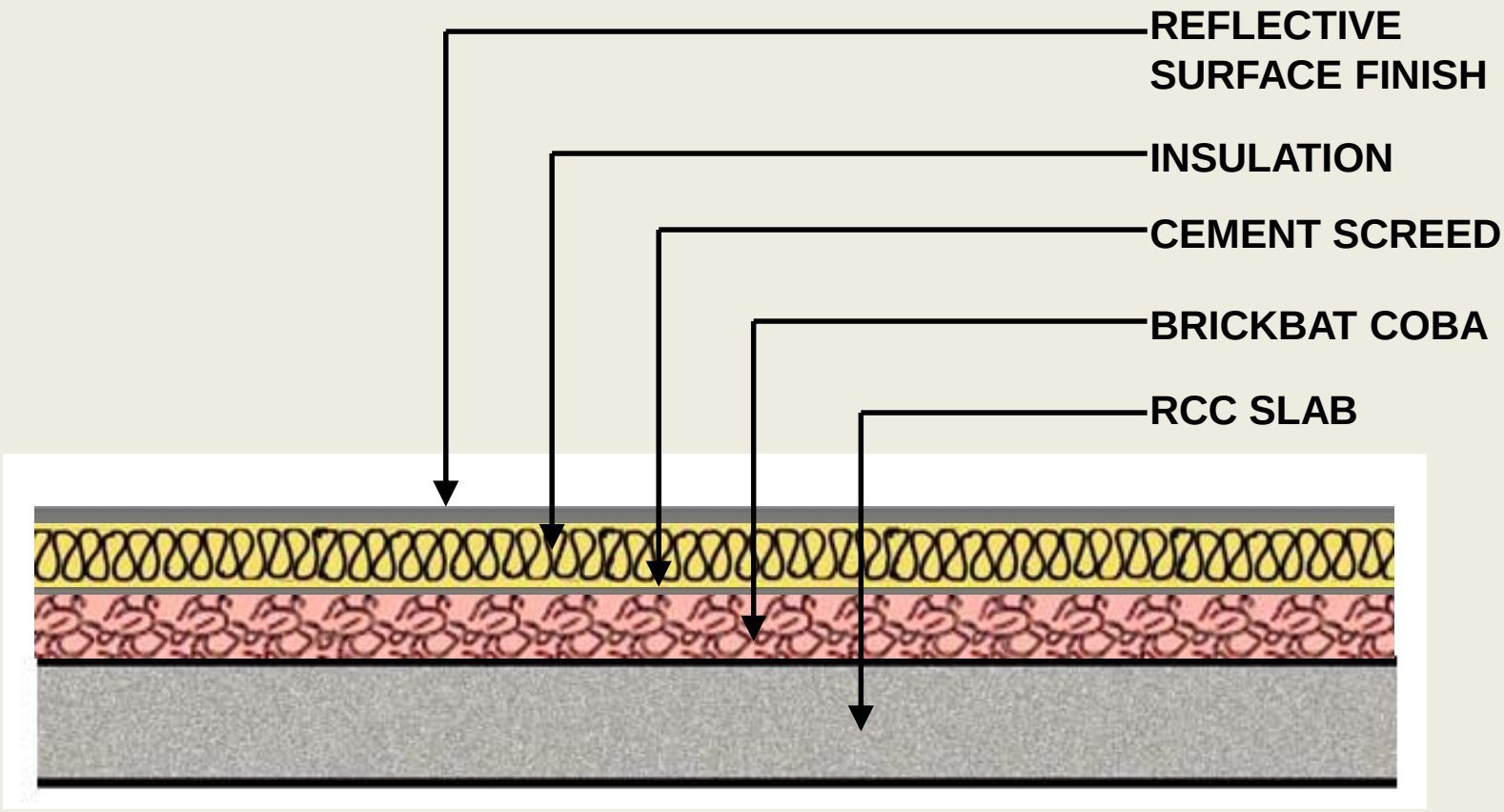
2. Reducing Heat Flow Through Roof



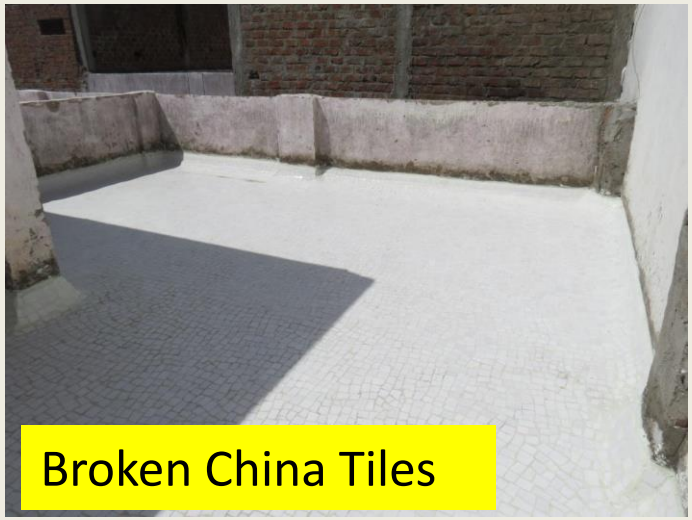
Source: Coolroofs for cool Delhi, EDS

- In case of uninsulated concrete roof slab, the inside roof surface temperature in summer > 40 ^{o}C.
- Proper treatment of roof can help in reducing room temperatures by 4-5 ^{o}C.

Reducing Heat Flow Through Roof



Reducing Heat Flow Through Roof


Broken China Tiles

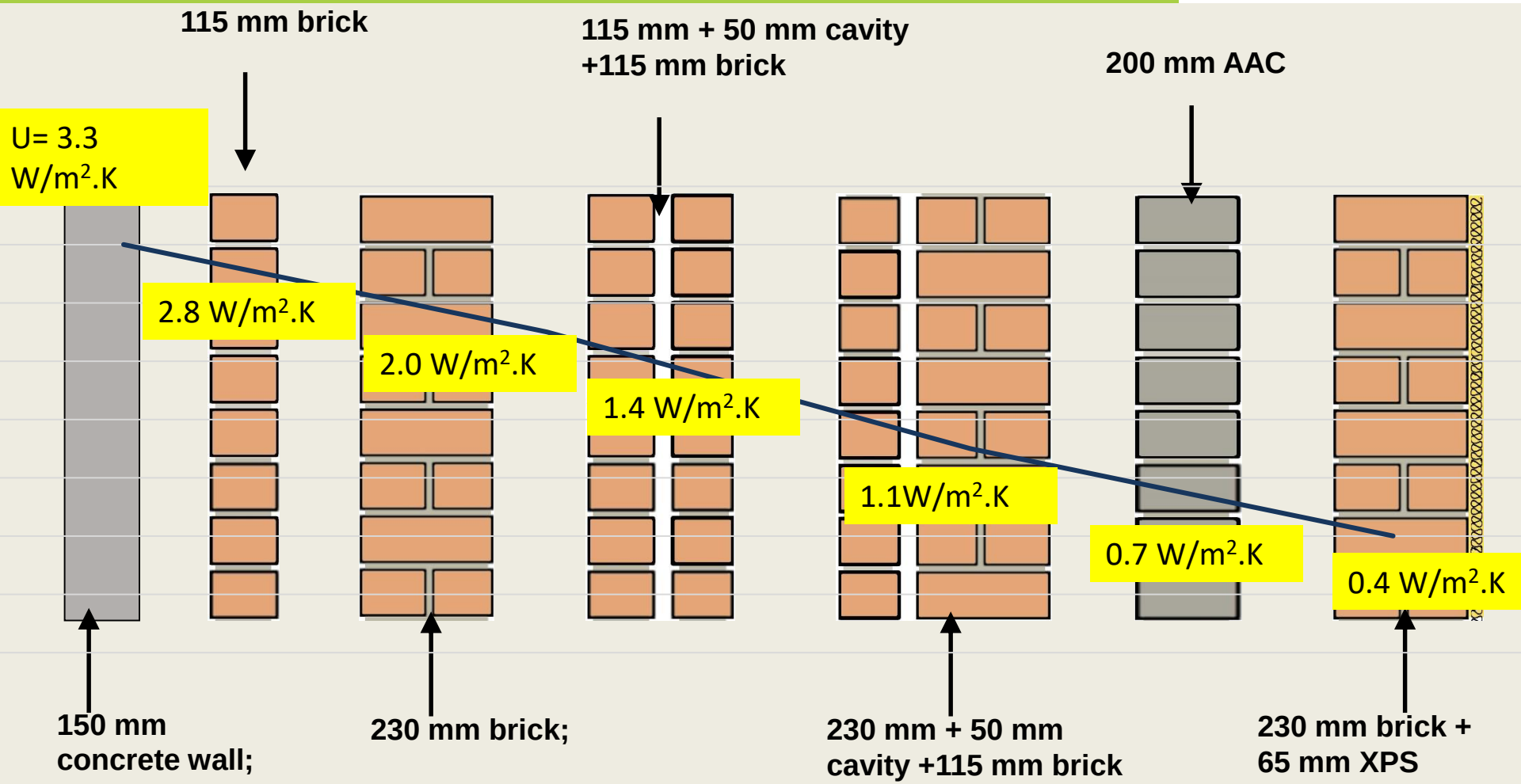

Fresh Reflective Paint


Shading of roof


Hollow Clay Tiles

Source: TARU & BEEP

3. Reducing Heat Flow Through Walls



Reducing Heat Flow Through Walls

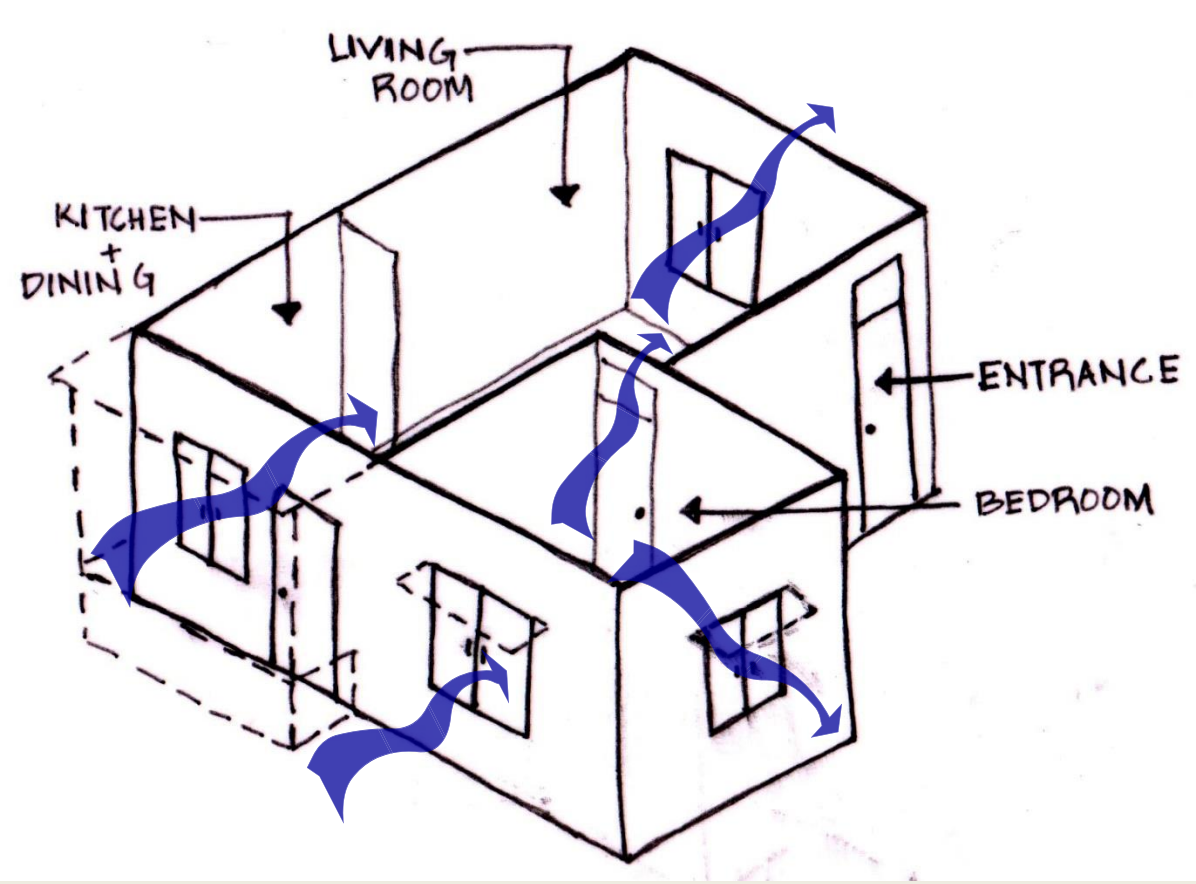
Shear walls

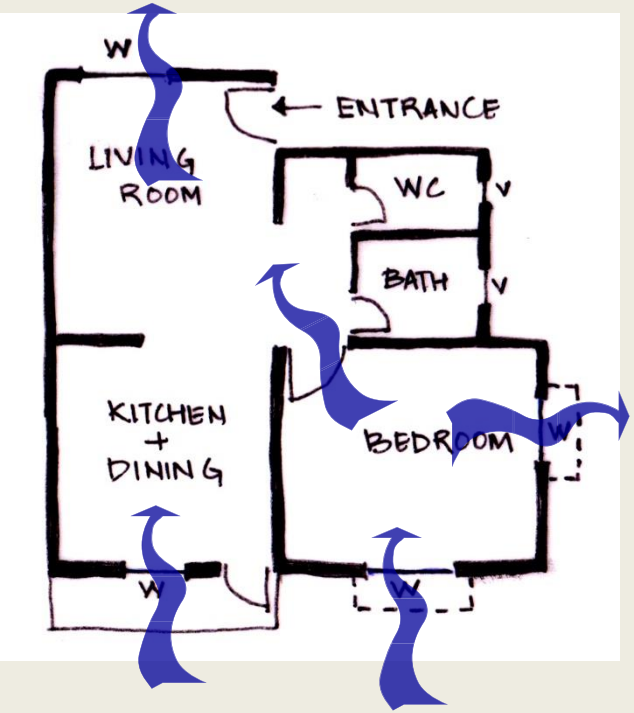
CLC / AAC walls

Source: Happinest, Mahindra, Chennai

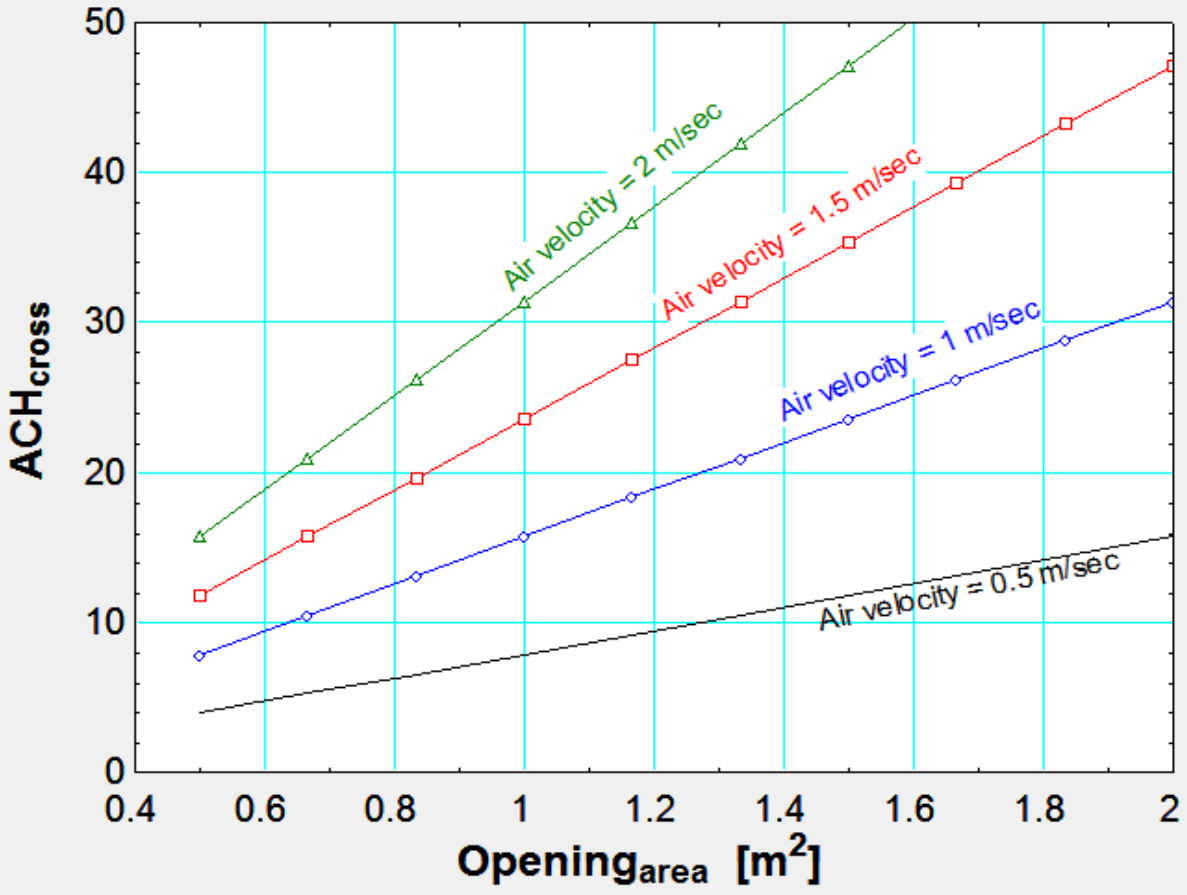
Use Light Colours/ Lime White Wash on External Walls

4. Cross Ventilation at Flat & Room Level





Cross Ventilation



In a room of 120 sq ft, having two openings of 4x3 ft (fully openable)

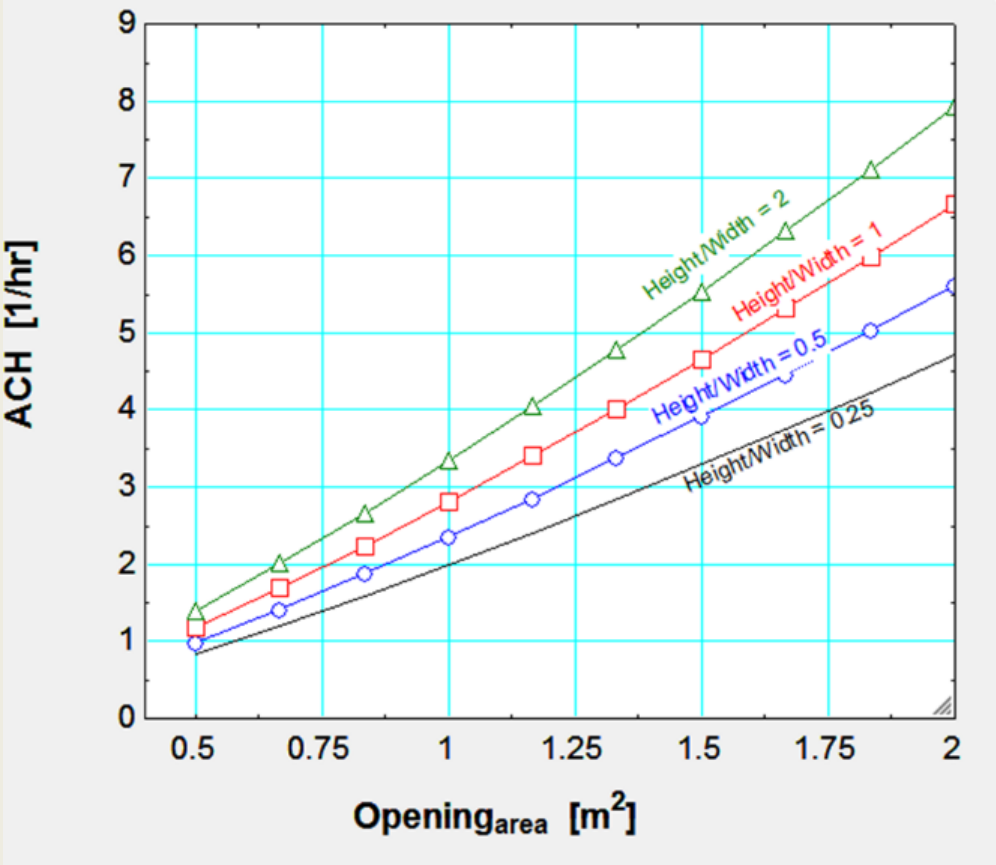
- 10 ACH at very low velocities
- 20-30 ACH at higher velocity.

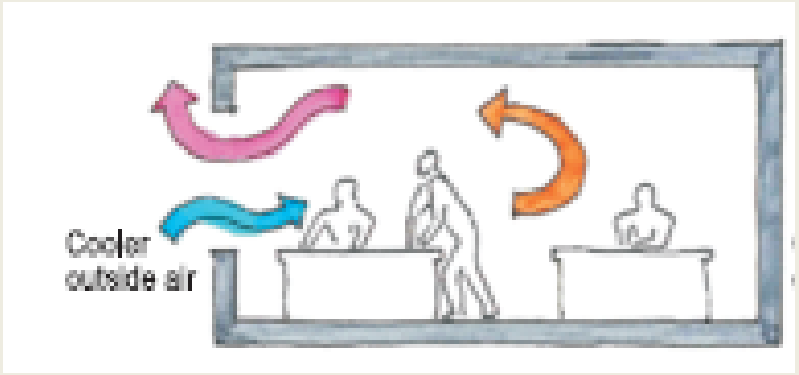
Openable area of openings on external walls of a flat ~ 20-25% of the flat area.

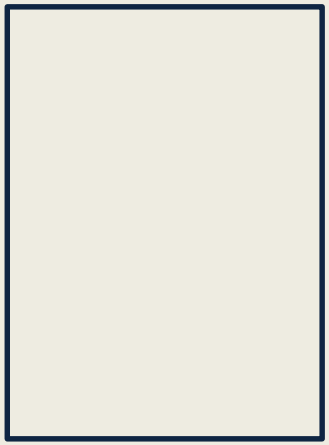
Provision of ventilators above doors.

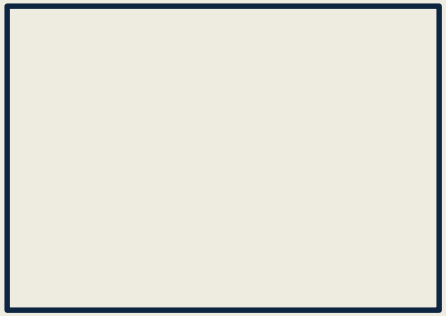
Single-Sided Ventilation

Single sided ventilation 3°C
Temperature difference inside-outside









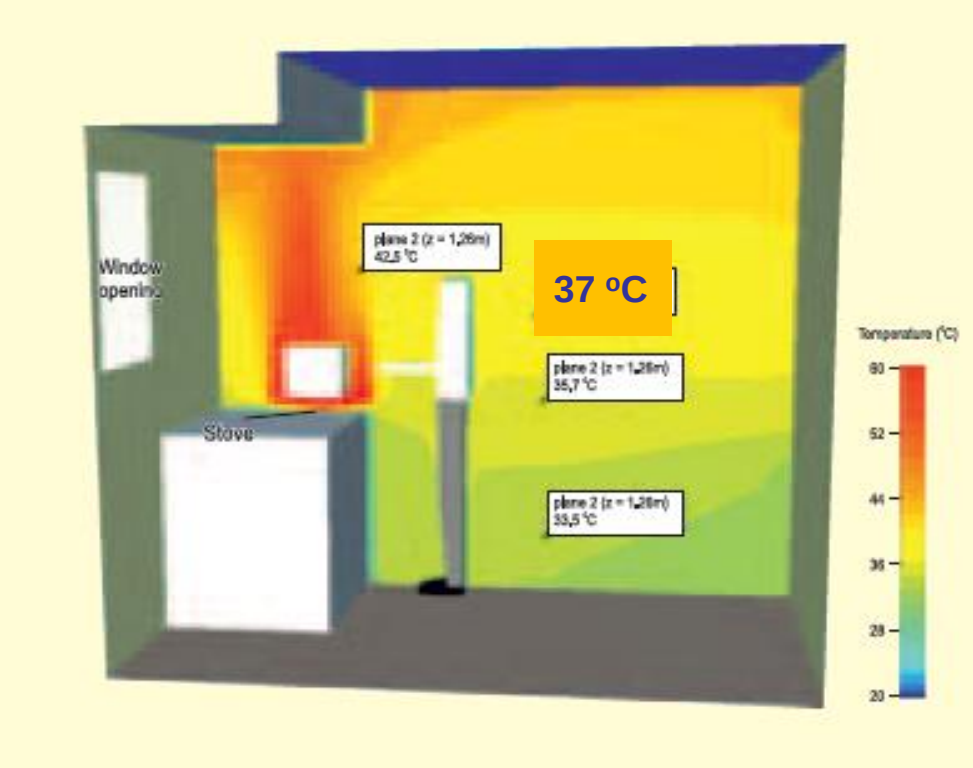
Taller windows provide better ventilation.

Natural Ventilation

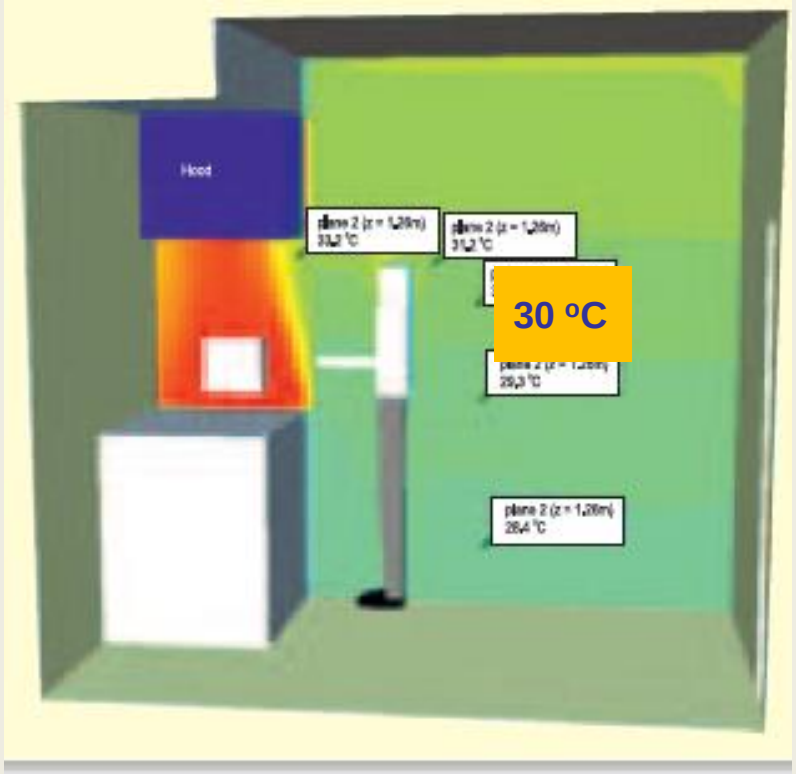
The window is designed as a system- one that brings in daylight, has a shading fixture, can be opened to bring in cool air and can also accommodate an AC if required.

Source: Happinest, Mahindra, Chennai

Design kitchen for good ventilation

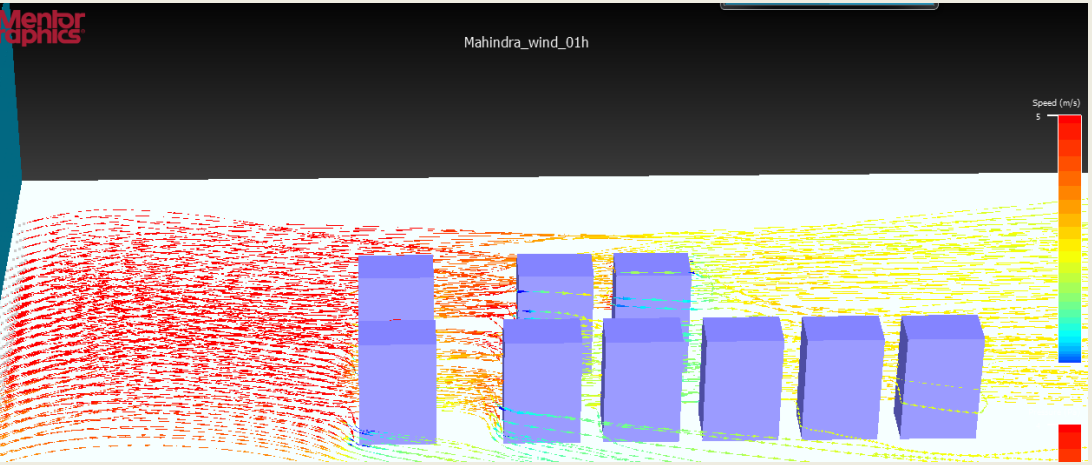


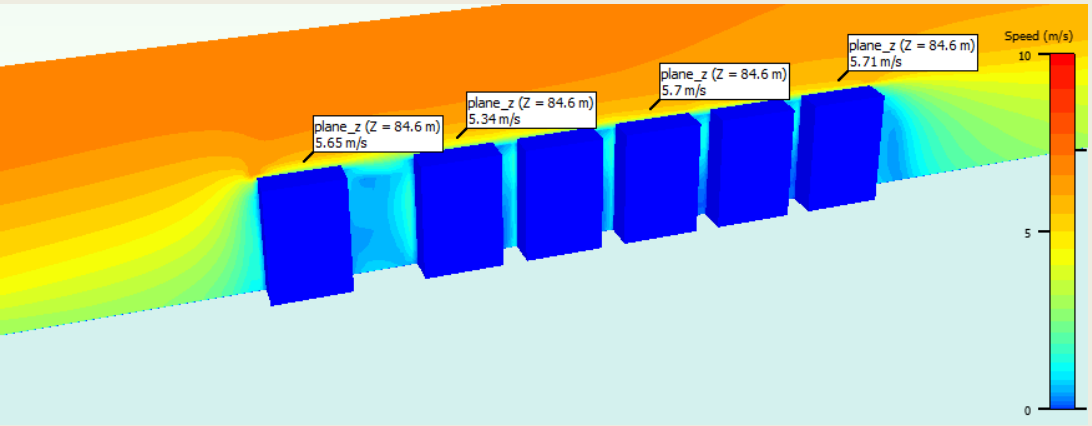
Poor ventilation

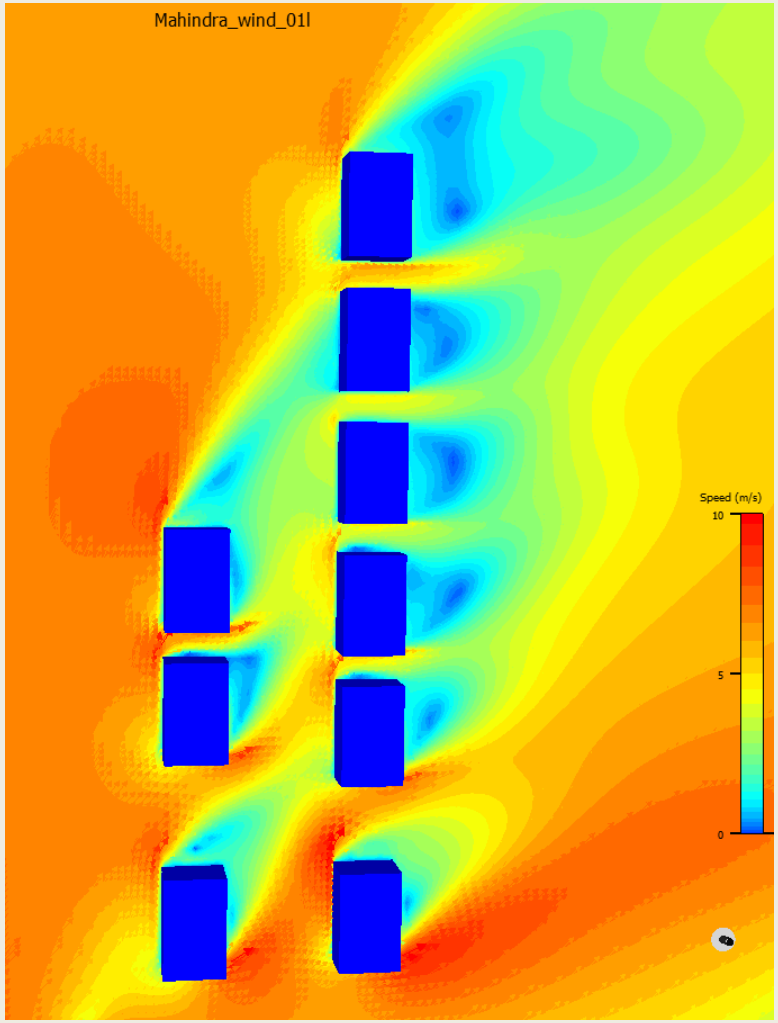


Good ventilation

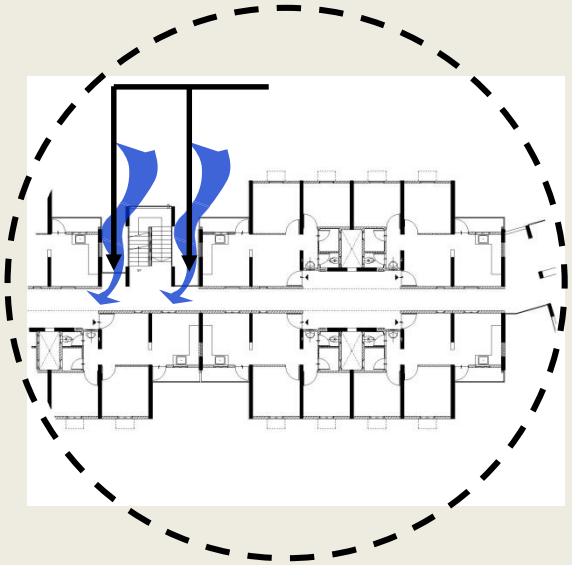
Analysis of wind flow for large projects



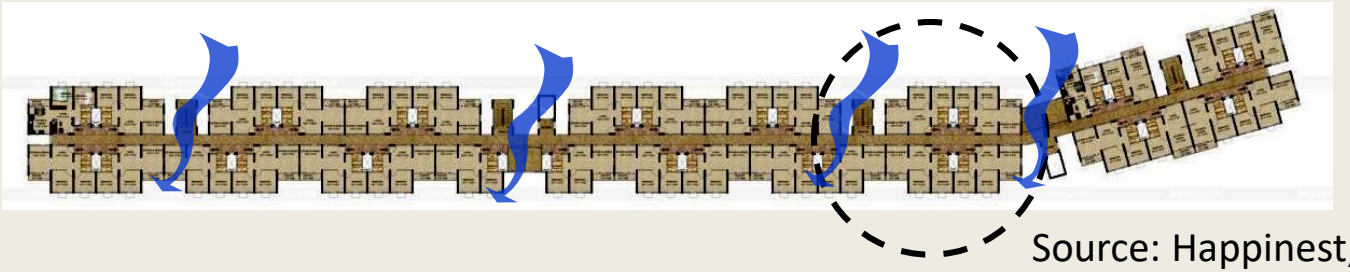




5. Daylighting & Ventilation of Corridors

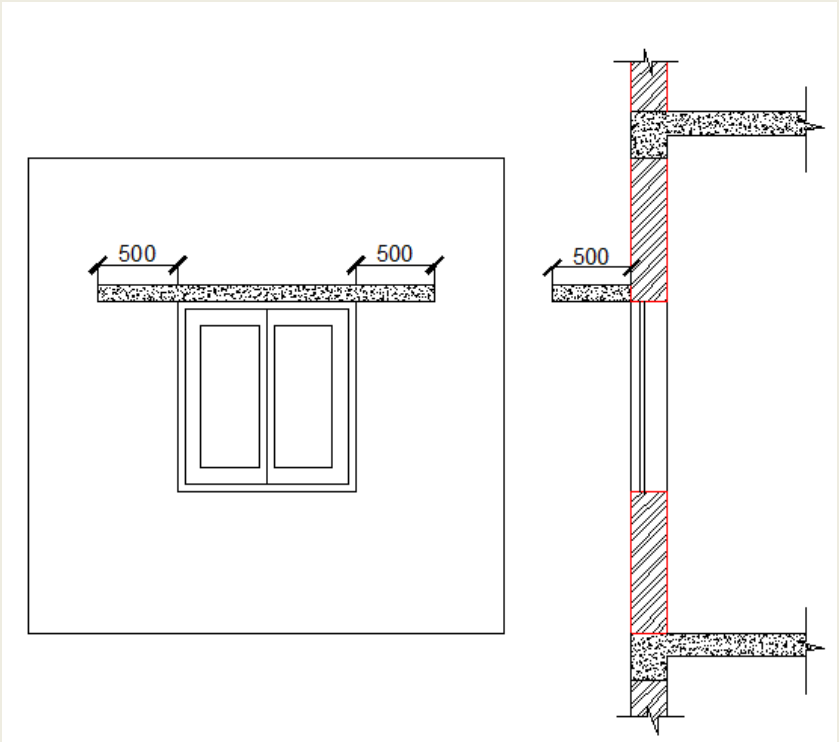


Break in the corridor which allows air movement



Source: Happinest, Mahindra, Chennai; Kesar City, Ahmedabad

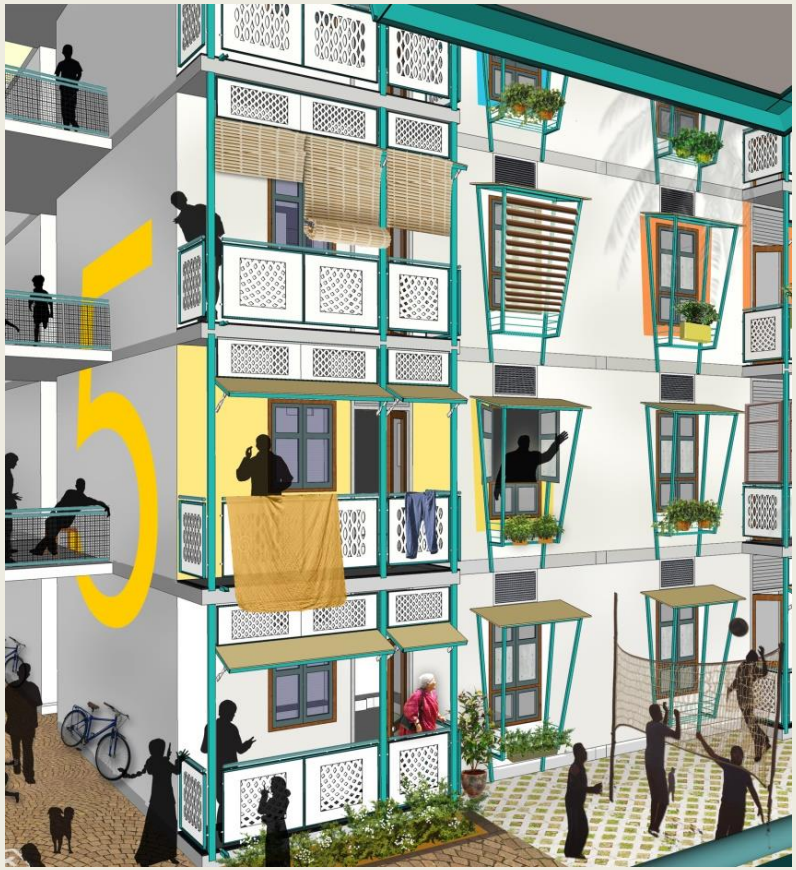
6. Shading of Windows



Source: Adlakha Associates; Kesar City, Ahmedabad

Shading of windows

MS frames in balcony for possible installation of chiks and blinds.



Source: Happinest, Mahindra, Chennai

External Movable Shading of Balcony

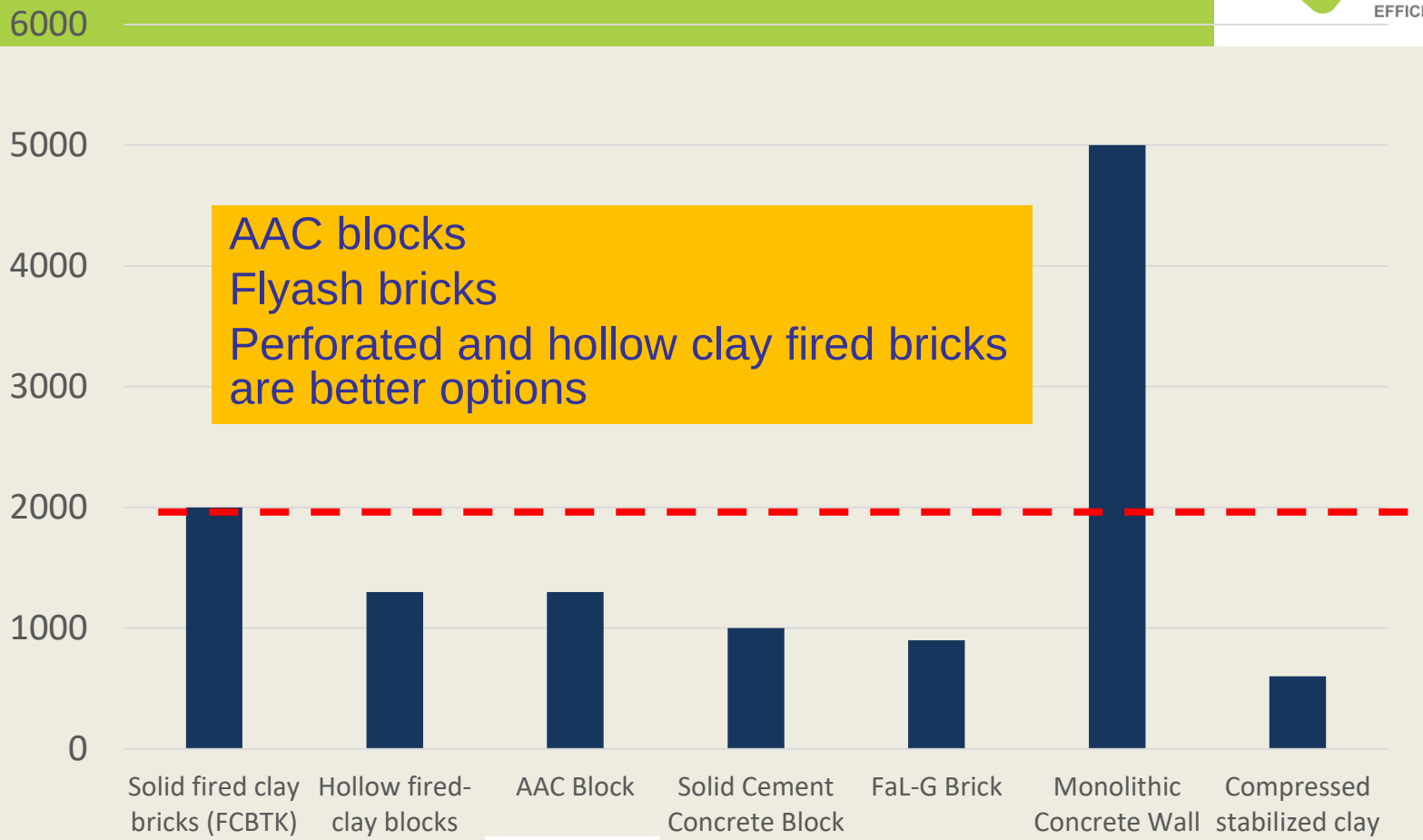
Source: M A Architects, Jaipur

7. Renewable Energy Integration – Low Rise Residential Buildings can be Net Zero Energy Buildings

- Utilise rooftops for the generation of hot water and/or electricity using solar energy
- **For energy-efficient residential buildings (overall EPI < 30 kWh/ m^2/year) of up to 4 storey, it is possible to generate enough electricity over a year through rooftop solar PV to meet all electricity requirements.**

Project: Topland Residency, Rajkot

8. Embodied Energy (MJ/m³) – Walling Materials



Embodied Energy – Complete House

Load bearing construction	Load bearing structure of up to 4 storey using perforated clay bricks/ flyash bricks
Savings in plaster	plaster, further savings in cost.
Savings in material consumption	Roof slab of precast RC planks and joist system
No shuttering	Steel consumption <1 kg/ ft^2 (conventional 3-4 kg/ ft^2)
Minimum transportation and fuel cost	cost of transportation.
Low maintenance and high life cycle	Cement consumption <0.25 bags/ ft^2 (conventional 0.45 kg/ ft^2)

Source: Adlakha Associates

Not a good example

- Monolithic Concrete Construction: Large heat gains through walls; High consumption of steel and cement high embodied energy.
- Windows not shaded and hence high heat gains

Conclusion: Appropriate design interventions can lead to energy efficient housing

- Houses that are thermally comfortable and use small amount of energy for operation.
- A significant part of this energy is produced by renewable energy systems and it might be possible to approach net-zero energy housing.
- The embodied energy of the houses can be reduced by upto 50% and the use of highly energy intensive materials like cement, steel, glass reduced.

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THANK YOU !

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