



WRI INDIA  
— ROSS CENTER

Capacity Building for Improving the Implementation of Affordable Housing in Indian Cities

# Thermal Comfort Using Passive Design



FORD  
FOUNDATION

# Introduction

# Module Overview

## Objective

To build a comprehensive understanding to achieve thermal comfort in affordable housing using passive design strategies.

## Outcomes

Learners will get familiarized with basic knowhow of passive design strategies and its importance to achieve thermal comfort through different design principles. They will further be equipped with recommendations toward decision making and implementation through case studies.



*Image Source: Associated Press*

# Significance

## Economy

Lower Operating Costs -25% and 50% in energy saving.

Sustainable buildings achieve higher demand because of lower operating costs, thus average 7% higher property valuations than non-green buildings.

## Environment

Unmaintained ACs consume up to 20% more electricity and emit harmful refrigerants to the environment

Passive Design Strategies reduce the need for air conditioning which contributes to 10% of global GHG gas emissions

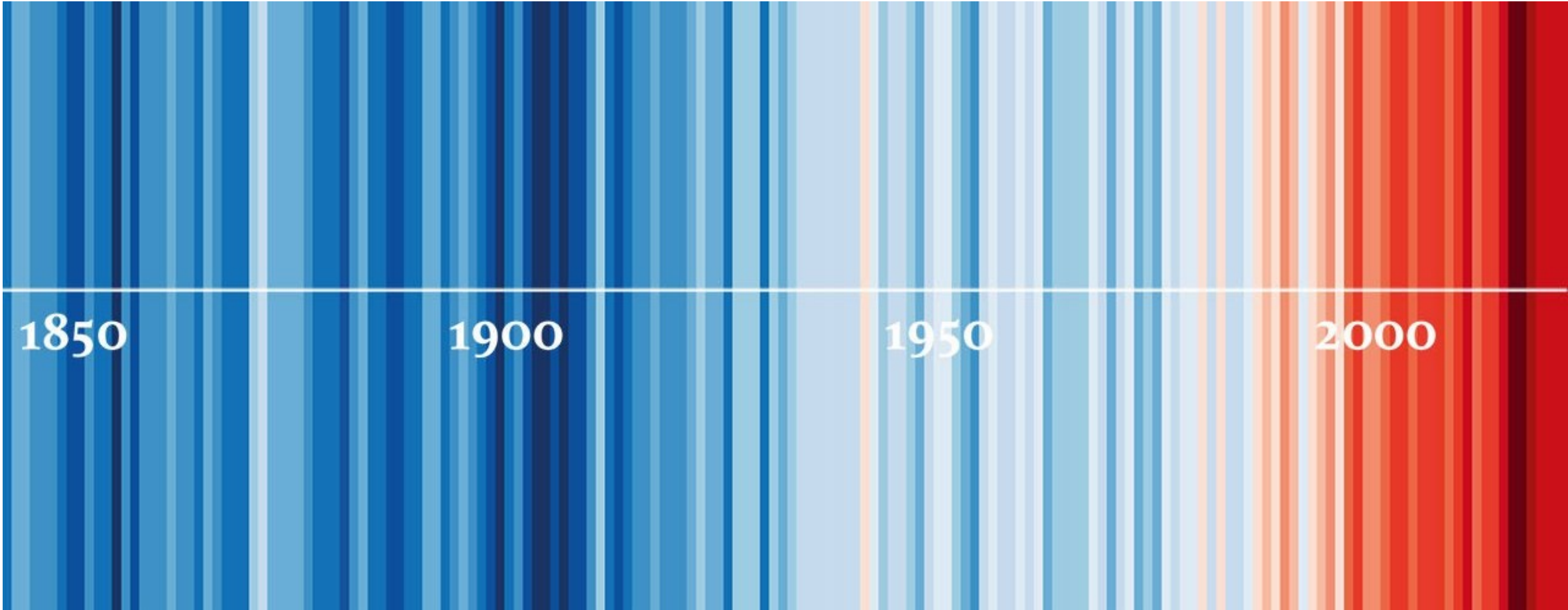
## Equity

Sustainable buildings increase the overall well-being of their occupants and productivity by up to 20%.

For urban poor, income spent on illness and cooling devices can be reduced significantly.

# Global Scenario

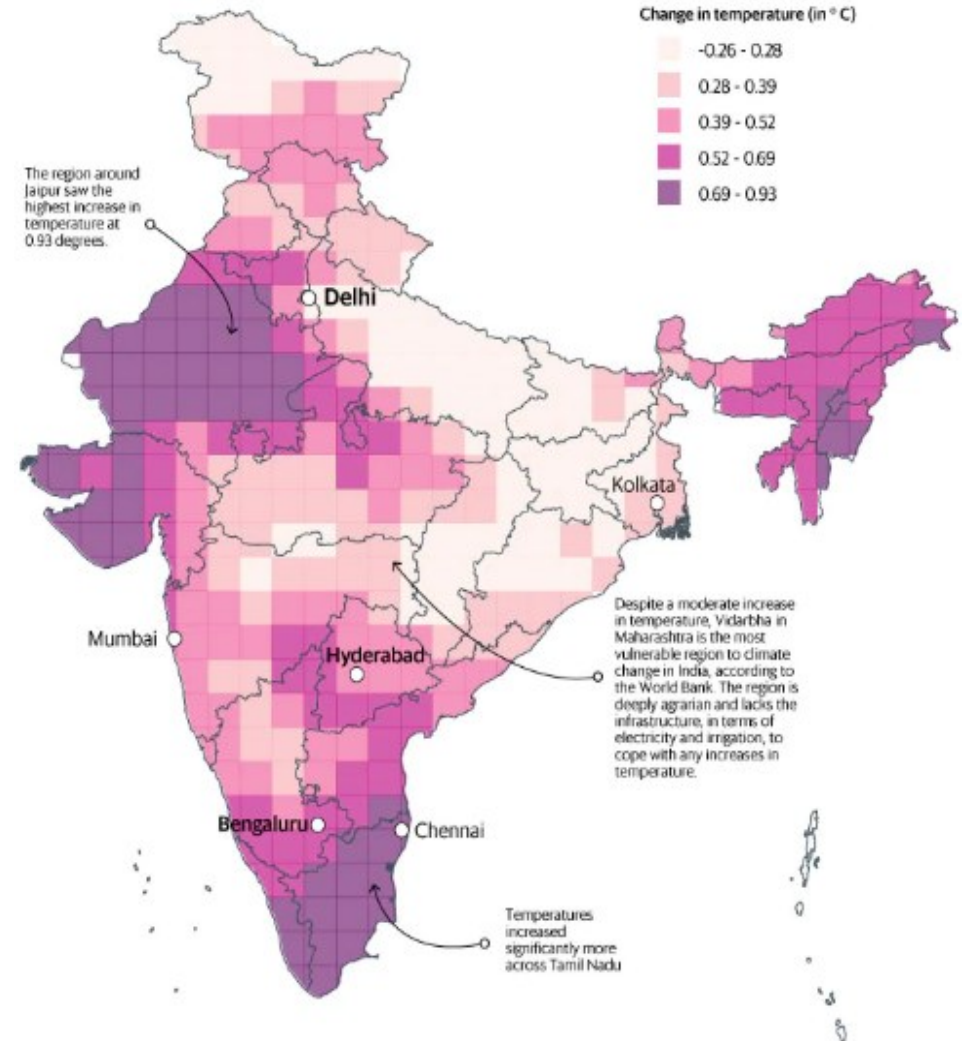
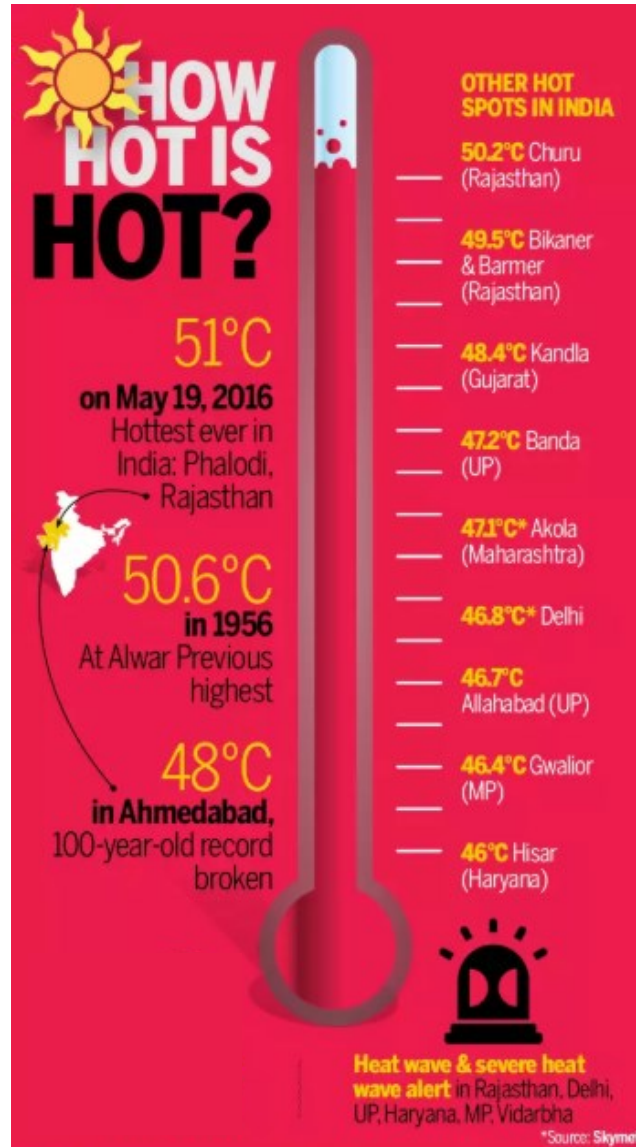
The world is becoming warmer with each passing year.



Source – Ed Hawkins

# Indian Scenario

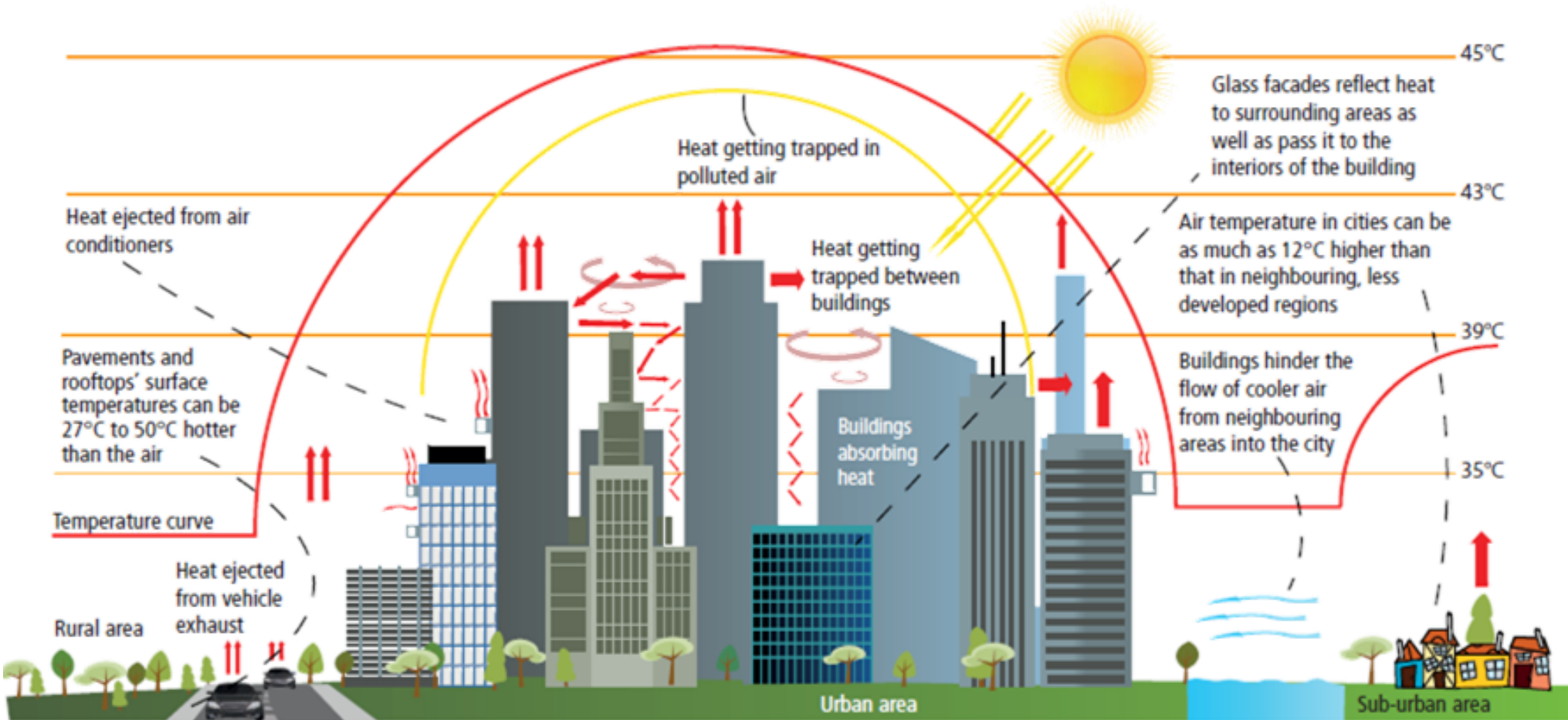
Average temperatures have been rising across most of the country.



Sources – Times of India, Skymet, and IMD

# Impact of Global Warming

Impacts at a localized level.

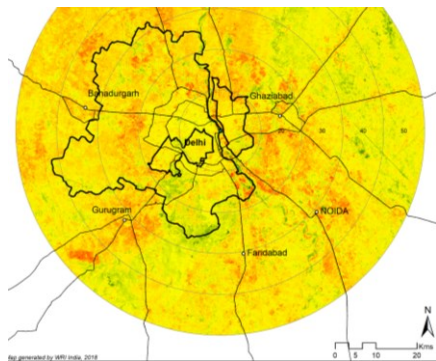


Source – CSE

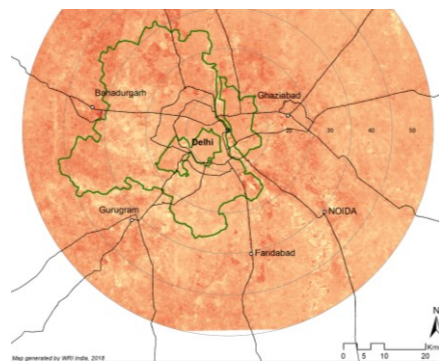
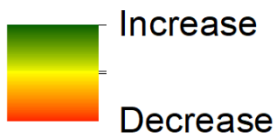
# Urbanization vs. Climate Change

Delhi will become the world's largest city by 2030, and have an estimated population of 2030.

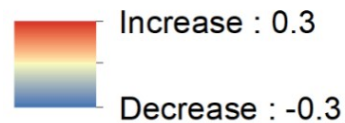
Rapid increase in built-up area to be accompanied with drop in vegetation cover and rise in surface temperatures.



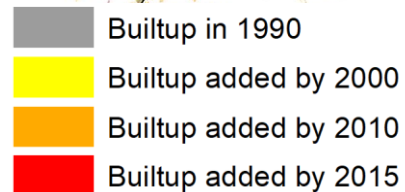
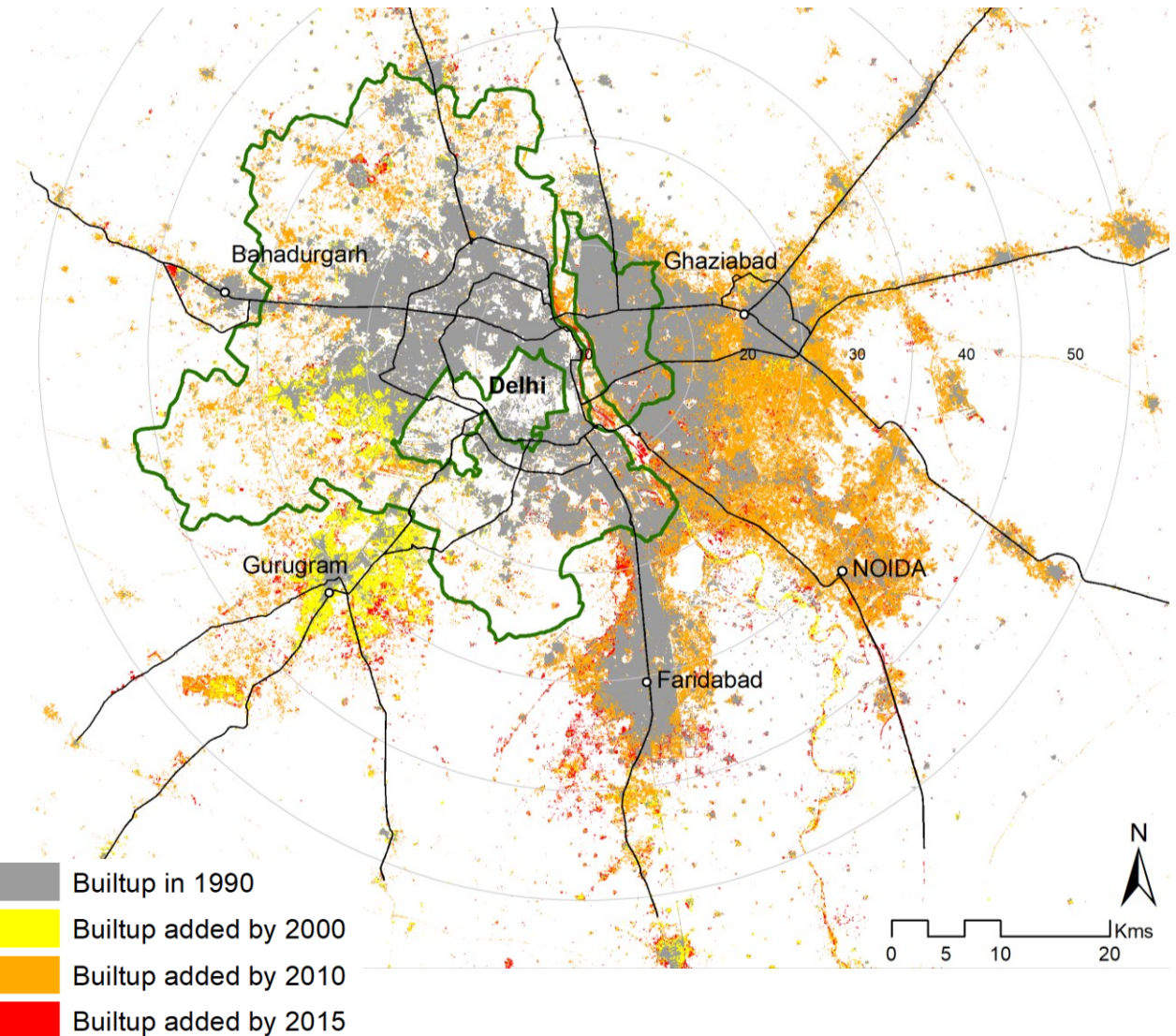
**Vegetation Trend**



**Surface Temperature Trend  
Deg celsius per year**



Sources – USGS/NASA; Maps generated by WRI India





# Understanding Passive Design

# Passive vs. Active Design

## Passive Design

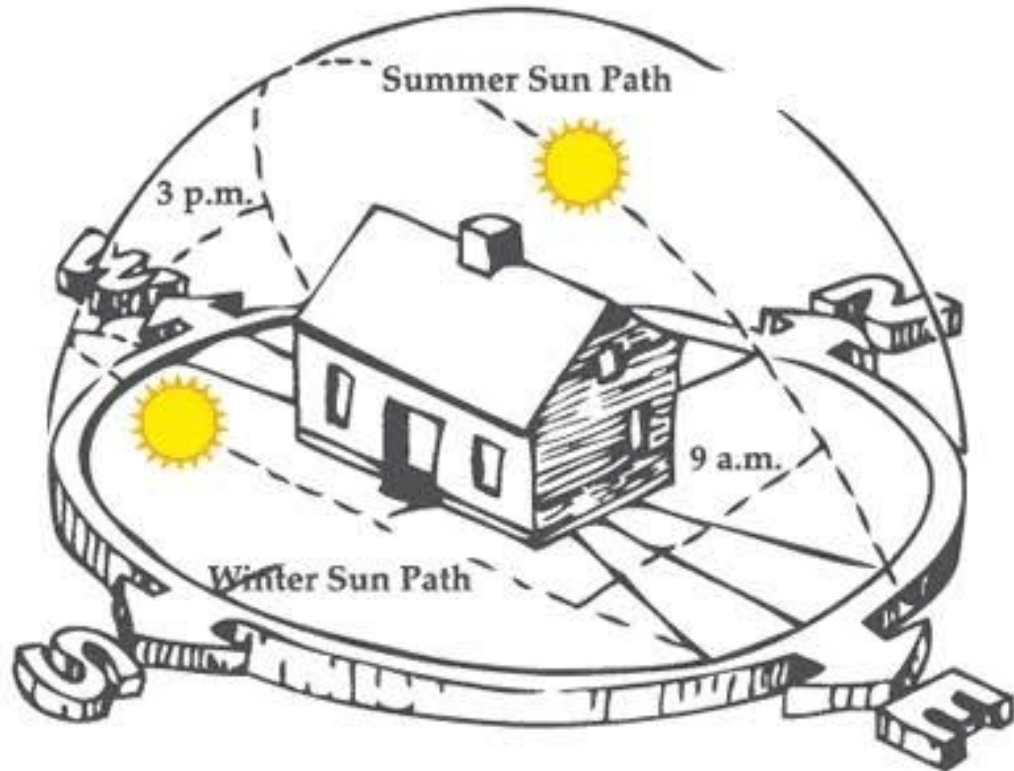
Design that leverages climatologically responsive design to encourage natural heating/cooling, ventilation, and lighting.

## Active Design

Design that relies largely on mechanical / electrical sources of heating / cooling, ventilation, and lighting.

**Passive design** needs **active users**.

**Active design** needs **passive users**.



# Climate Types in India

## Zones

Hot-dry – Much of Rajasthan, parts of Gujarat and Maharashtra

Warm-humid – Much of peninsular India, West Bengal, and Northeast

Composite – Much of the Northern Plains and parts of Central India

Temperate – Hilly tracts in the Northeast and along the Western Ghats

Cold – Himalayan regions

## Key Considerations

Temperature, humidity, pressure, precipitation, sky conditions, solar radiation, and wind speed

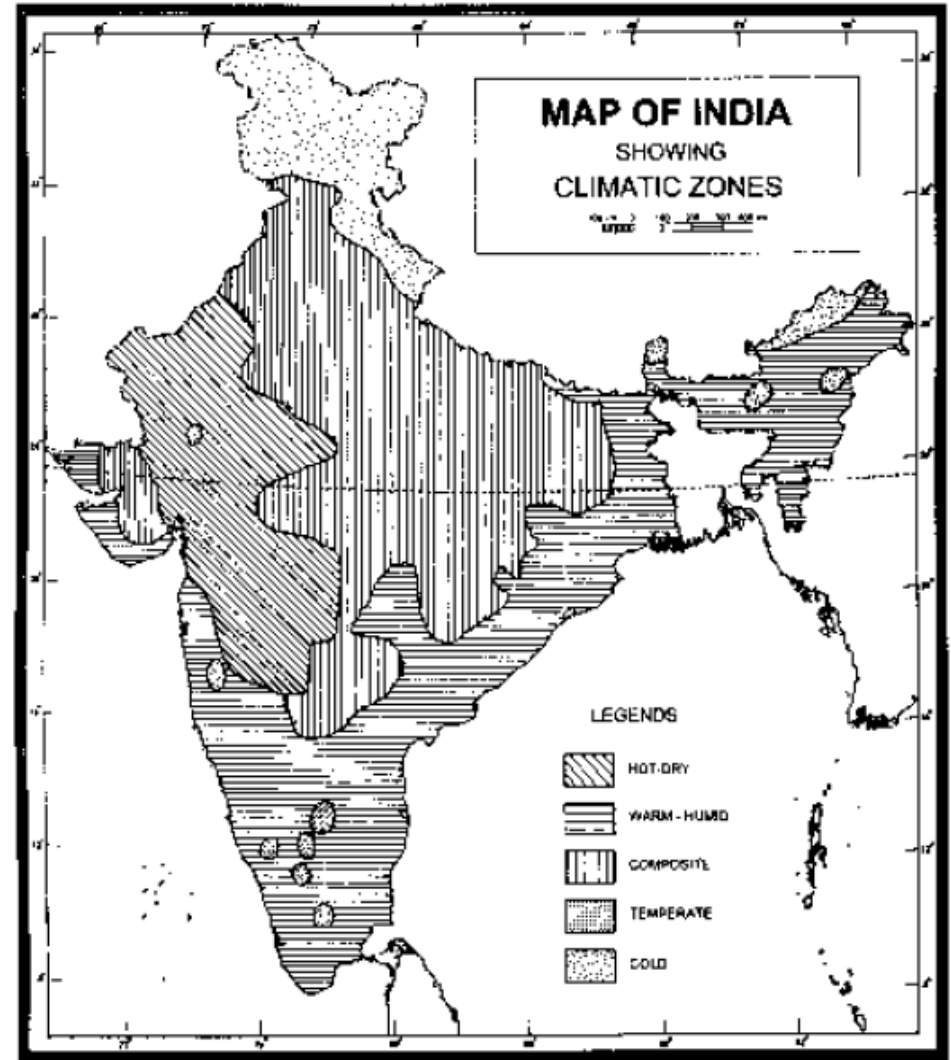


Image Source: National Building Code

# Thermal Comfort

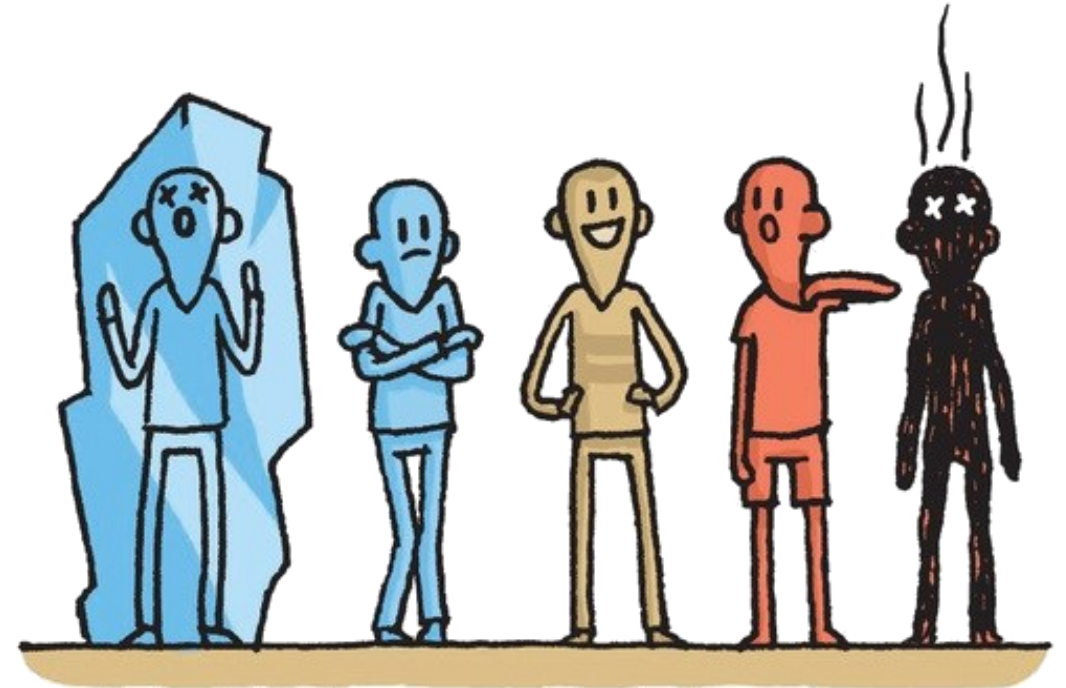
## Conditions

When at least 80% of a space's users feel comfortable for more than 80% of the time spent in the space. Optimum temperature, natural lighting, and fresh air are key components of thermal comfort.

Air temperature, radiant temperature, air velocity, and humidity are the measurement factors considered in calculating thermal comfort.

## Significance

We spend 90% of our time indoors. Thermal comfort not only enhances ease of living, but also reduces dependence on active heating/cooling, ventilation, and lighting.



*Image Source: Archdaily*

# Traditional Solutions

Each region has historically evolved its own building typology that responds prevalent climatological conditions through passive design.

An example of Delhi's havelis is provided here.

**Roof Overhangs**  
Provide shading and protection from rain

**Windows**  
Provide cross-ventilation on humid days

**Recessed Entrance**  
Create a heat buffer

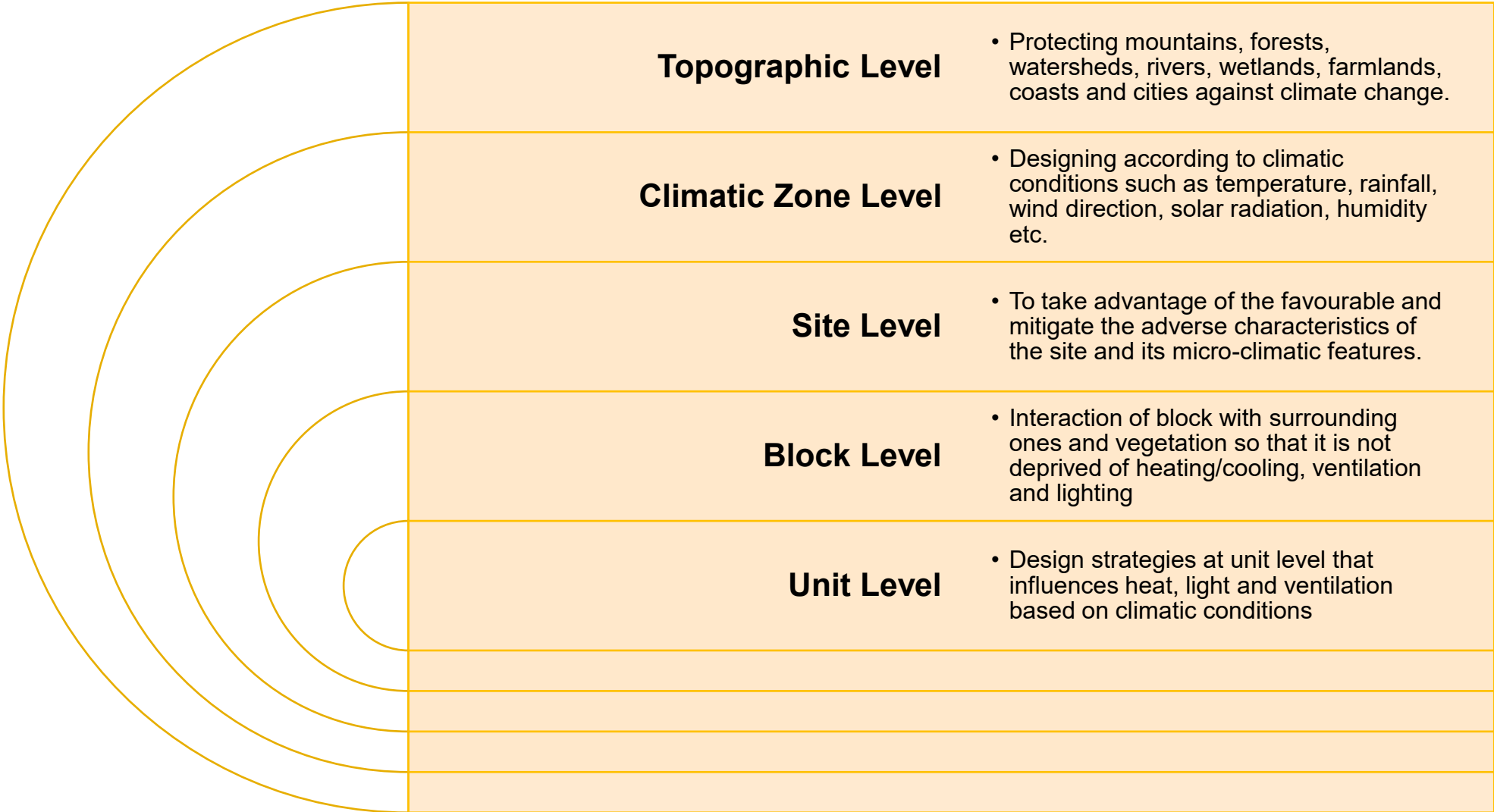
**Raised Plinth**  
Protect from flooding / waterlogging



Image Source: Akanksha Gupta

# Strategies for Passive Design

# Levels of Response



# Topographic Level


**HAZARD: Loss of life & assets due to intense wildfires**  
SOLUTION: Forest management to reduce risk of super-fires

**HAZARD: Asset loss, yield reduction & contamination due to flooding**  
SOLUTION: Restore wetlands to absorb and filter flood waters


**HAZARD: Crop failures and livestock loss due to drought**  
SOLUTION: Agroforestry to make better use of soil moisture and reduce evaporation

**HAZARD: Urban flooding due to intense rainfall**  
SOLUTION: Restore watercourses, expand greenspaces, and introduce porous surfaces to reduce flood risk

**HAZARD: Loss of land, livelihoods, and assets due to rising sea levels and coastal erosion**  
SOLUTION: Restore coastal wetlands, including enhance engineered measures

  
**HAZARD: Landslides, soil loss, and siltation due to intense rainfall**  
SOLUTION: Protect and restore forests to stabilize soils and slow water runoff

  
**HAZARD: Reduced or intermittent river flow due to drought**  
SOLUTION: Protect and restore forests and watersheds to regulate flow

  
**HAZARD: Asset loss, yield reduction & transport disruption due to flooding**  
SOLUTION: Protect and restore forests to slow water runoff

  
**HAZARD: Heat stress due to urban heat islands**  
SOLUTION: Expand green spaces in and around cities

  
**HAZARD: Loss of life and assets due to storm surges and inundation**  
SOLUTION: Protect and restore mangroves, marshes, and reefs to buffer coasts and absorb floodwaters

**MOUNTAINS, FORESTS & WATERSHEDS**

**RIVERS & WETLANDS**

**FARMLAND**

**CITIES**

**COASTS**

Source: WRI



# Climatic Zone Level

Best exemplified by vernacular / traditional architectural typologies that respond to the specific climate of the region.

Examples:

- Earth architecture with thick walls and small windows for maximum insulation in Ladakh
- Courtyard havelis in Rajasthan which leverage pressure differences and mutual shading for natural cooling and ventilation.
- Sloping roofs and to protect from heavy rains in Kerala

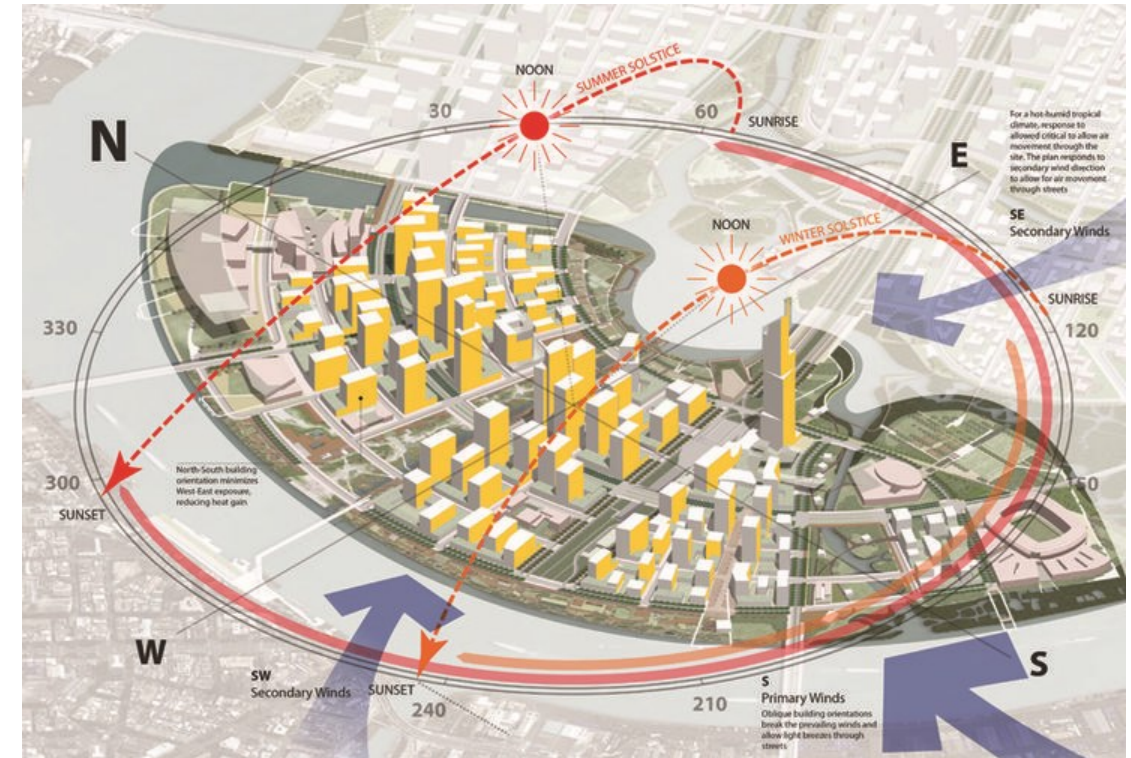


Source: Prayash Giria

# Site Level

Reducing 'heat island' effect by techniques such as:

- Building around courtyards / open courts
- Leveraging mutual shading of blocks
- Creating wind passages through site massing
- Reducing hard paving to allow water absorption
- Using complimentary vegetation that control sunlight penetration through seasonal changes

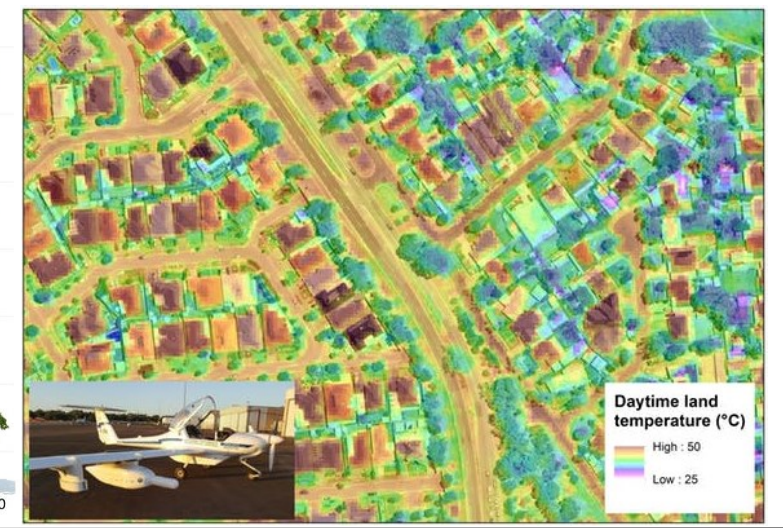
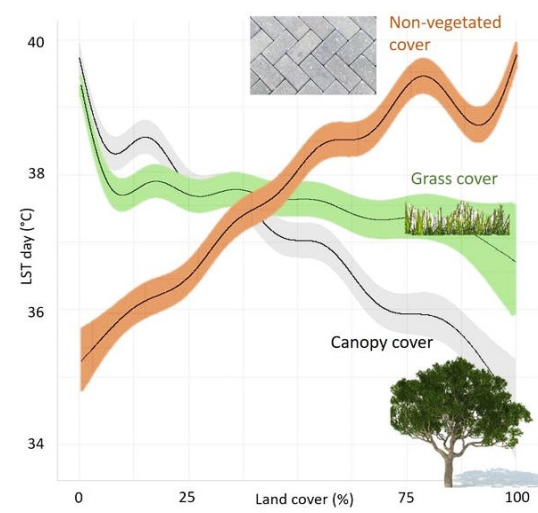
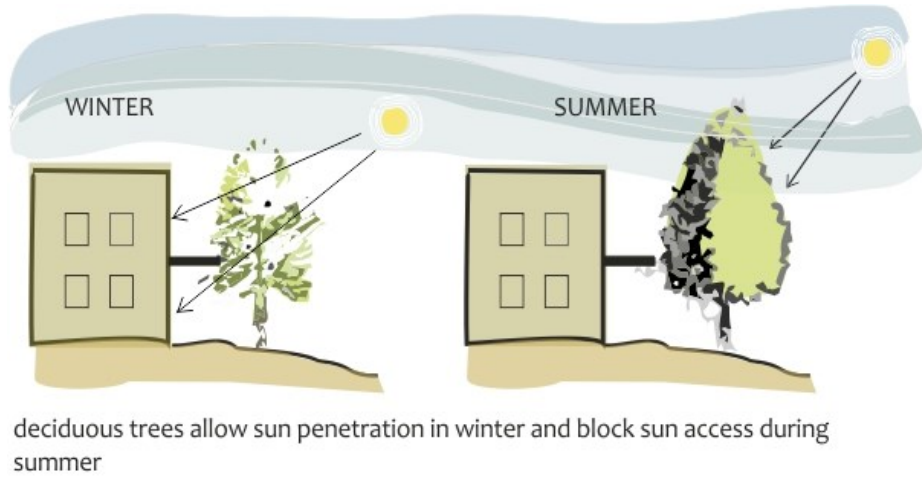
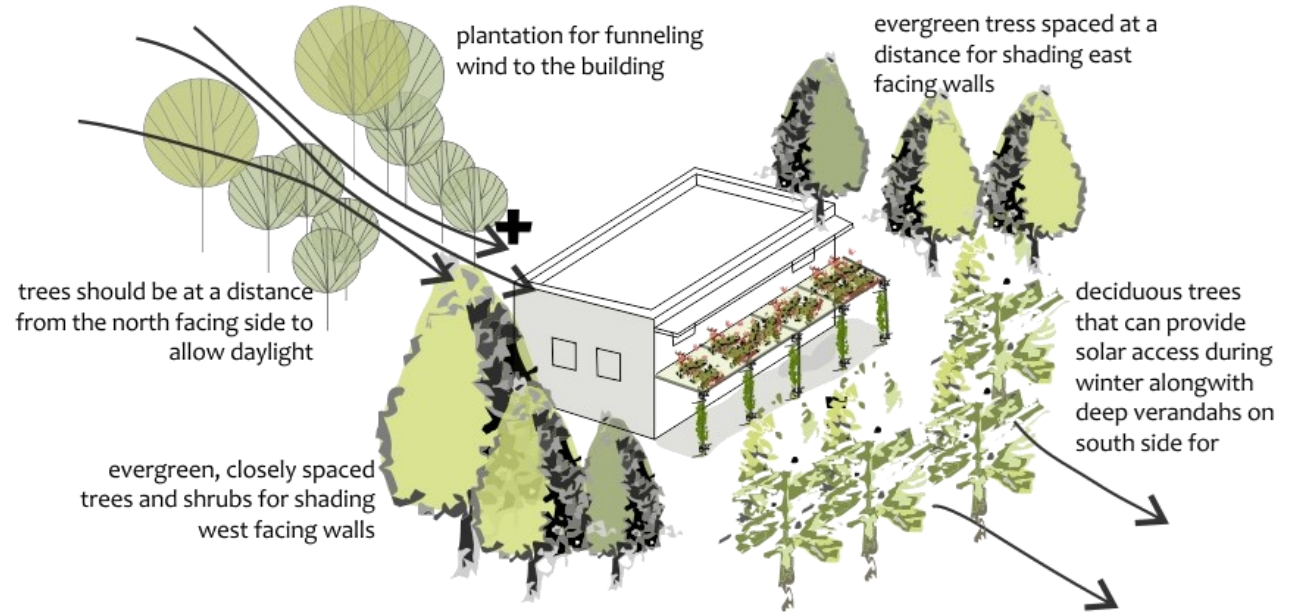


Sources: University of Waterloo; Tropical Climate Analyst

# Site Level: Leveraging Plantations

Appropriate plantation of trees to promote shading and ventilation can temper extreme weather to a significant degree.

In Adelaide, a study estimated that districts with higher vegetation cover remained cooler by up to 6°C during heatwave conditions.

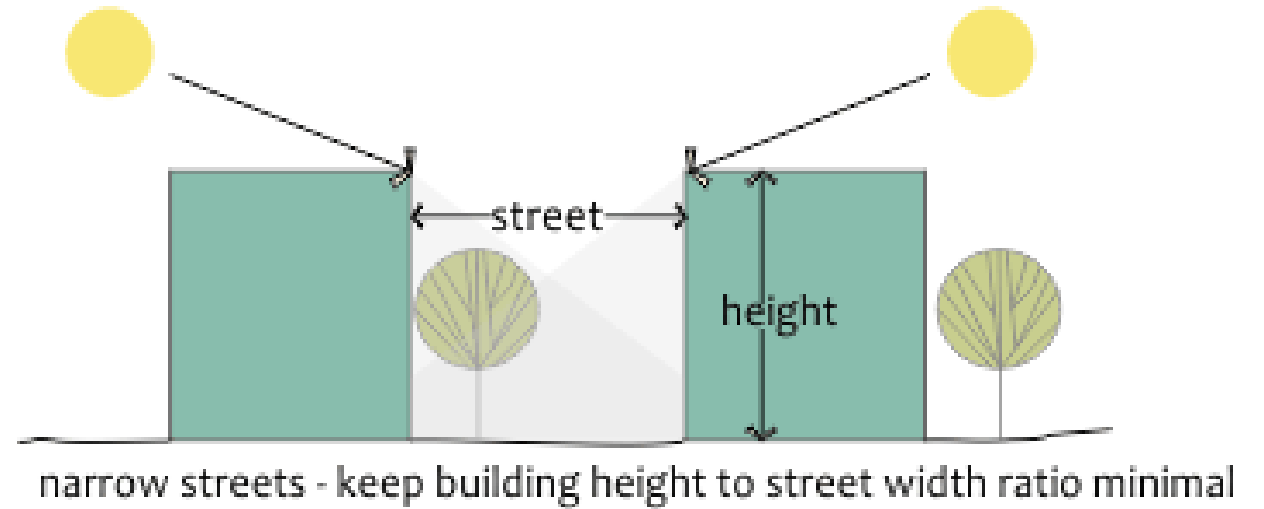
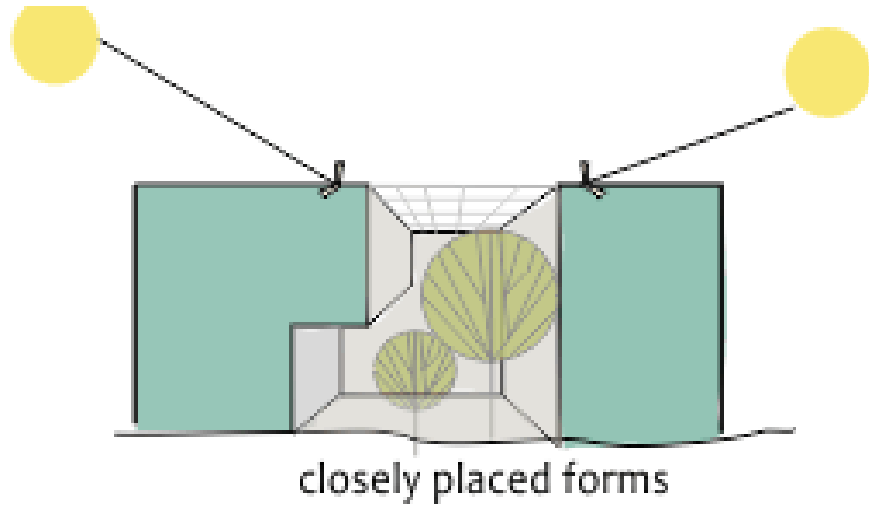


Sources: The Conversation; NZEB

# Block Level

## Heating / Cooling Strategies

Arrange blocks such that mutual shading is achieved, thereby preventing solar heat gains in warm months.



Arrange longer facades along North / South to encourage glare-free lighting in summer, and maximize solar penetration in winter.



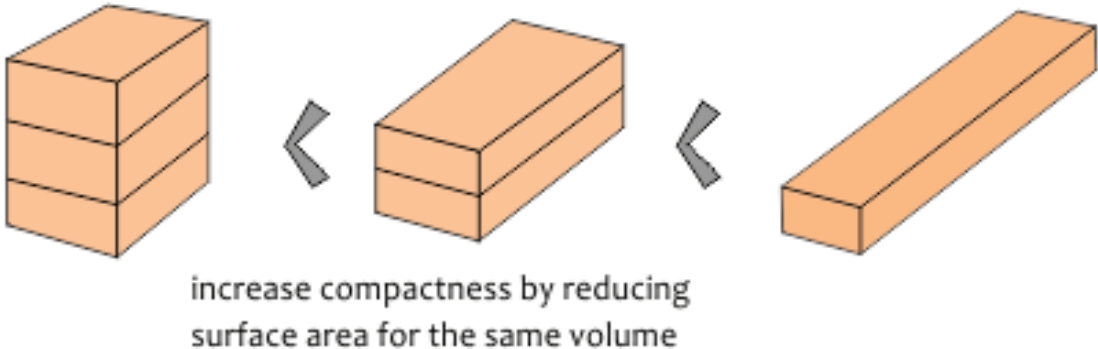
Source: NZEB

# Block Level

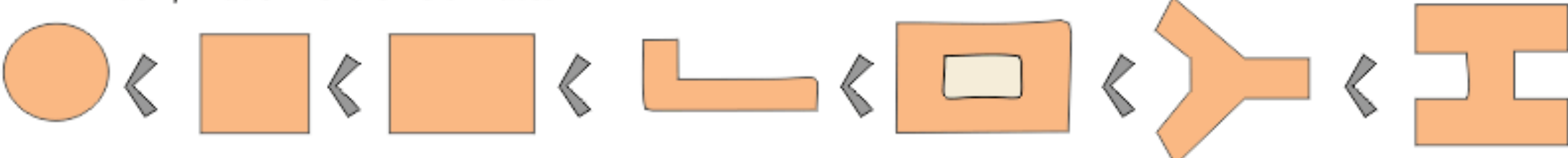
## Heating / Cooling Strategies

Minimize surface area to building volume and perimeter to area ratios in extreme climate zones to minimize exposure to solar radiation.

### Minimise S/V ratio in extreme climates



### Minimise P/A ratio in extreme climates

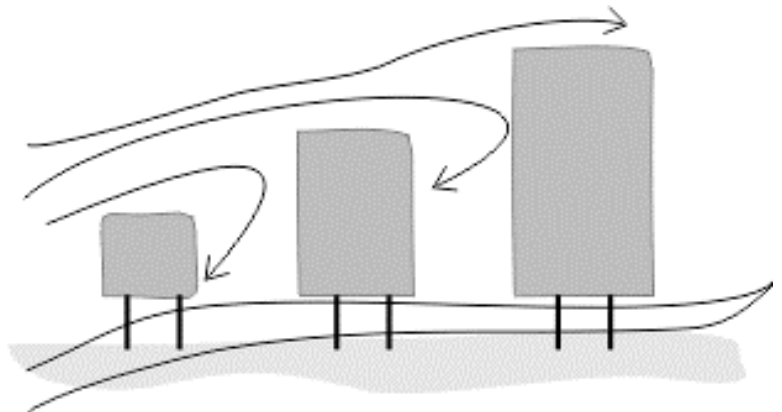


Source: NZEB

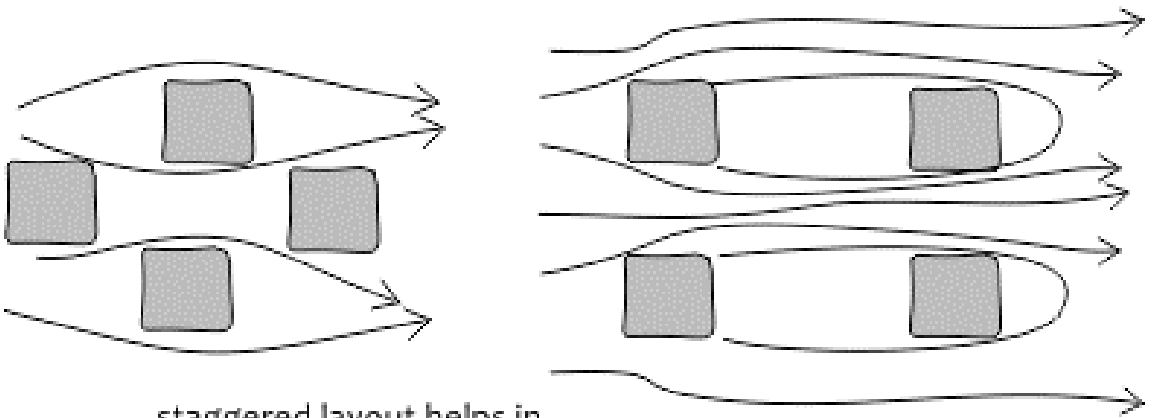
# Block Level

## Ventilation Strategies

Buildings should be oriented to avoid creation of 'wind shadows'



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



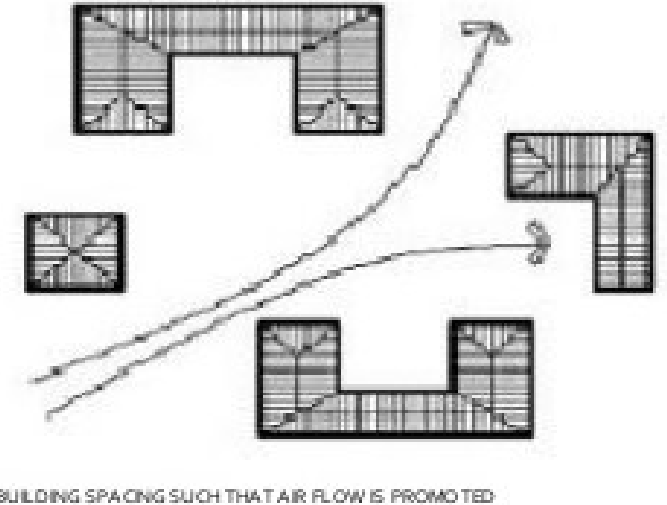
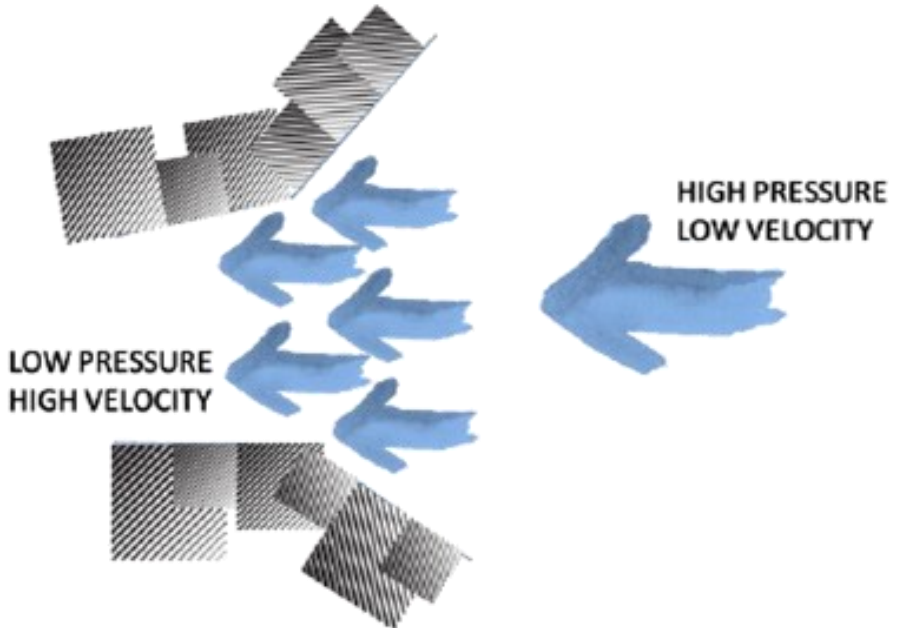
staggered layout helps in accentuating wind movement

Source: NZEB

# Block Level

## Ventilation Strategies

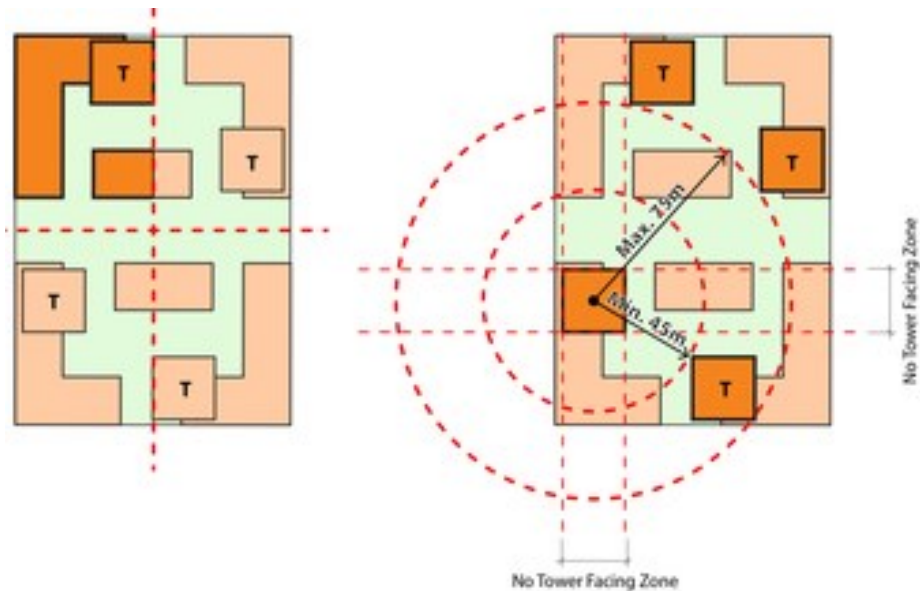
Wind flows can be harvested by creating variably sized courts and catchment areas. This can enhance ventilation and serve an overall cooling effect for the blocks.



Source: MaS-SHIP

# Block Level

## Lighting Strategies



### RULE 1-1

Since full block is optimal, each zone as a potential small block is also optimal.

### RULE 1-2

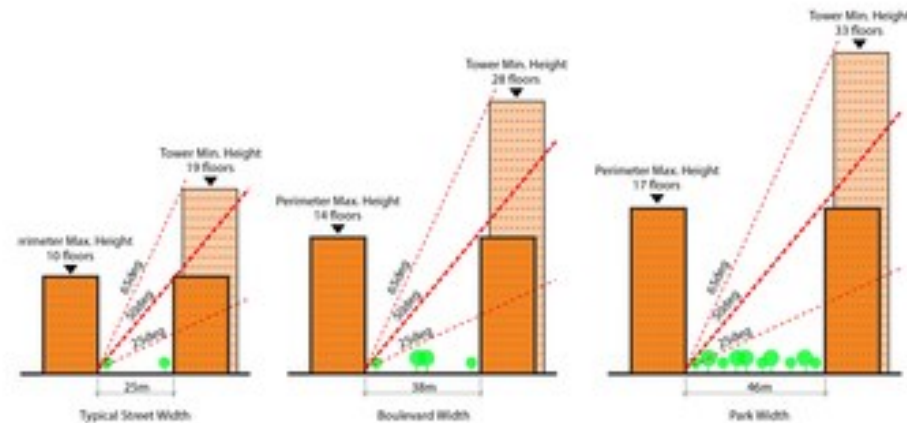
Generally, 1 tower per each zone.

### RULE 2-1

Any tower should be separated a minimum of 45m center to center of a tower to minimize the impact on each other.

### RULE 2-2

Towers should be located at no more than 75m apart to maintain typology efficiency. Additionally, towers should not directly face each other.



### RULE 3-1

The tower and perimeter block height is defined by the street or courtyard width and a range of BRE recommended obstruction angles.

25 deg (BRE recommended) : conventional window design will usually give reasonable result.  
 65 deg (BRE recommended) : it is very difficult to provide adequate daylight, unless very large windows are used.  
 50 deg (KPF recommended) : it provides higher density with reasonable solution to improve daylight condition through designing adequate room layout and enlarged windows

Source: ui.kpf.com

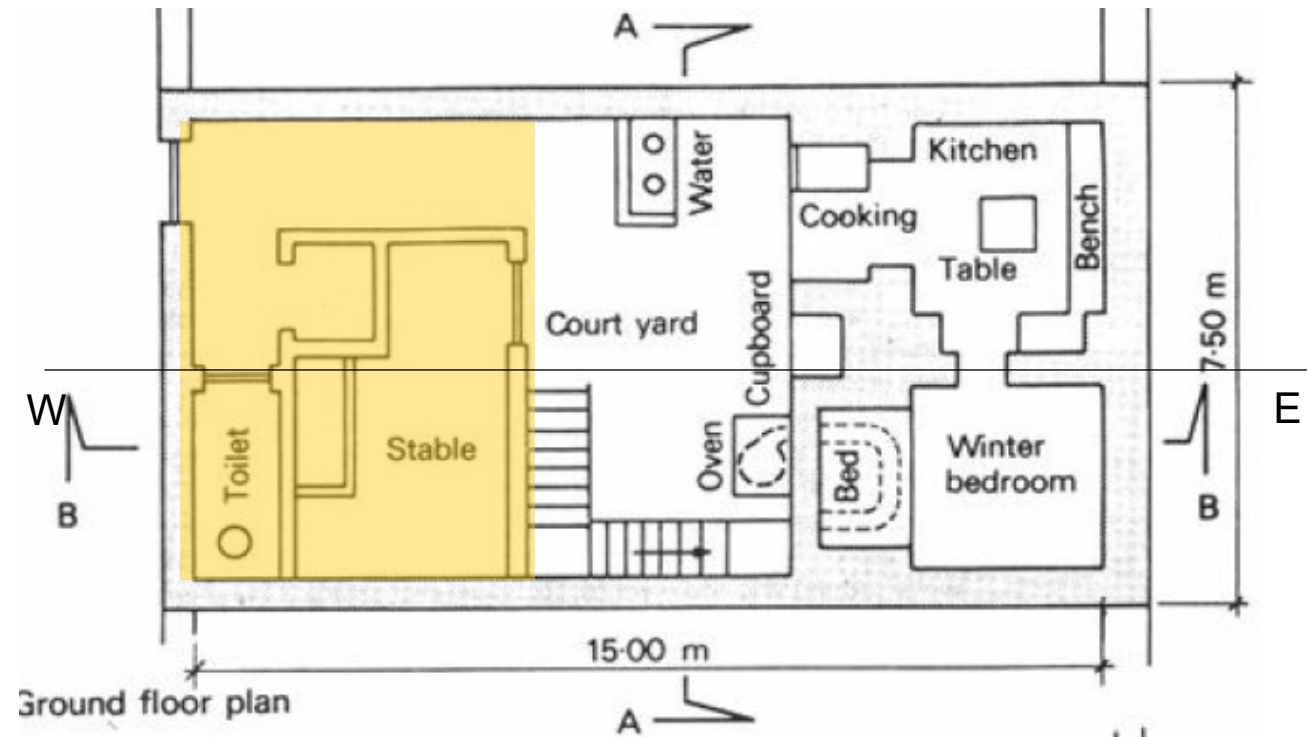


# Unit Level

## Heating / Cooling

### Form & Orientation

- The alteration in solar path affects solar radiation penetration patterns during different seasons and consequently, heat gain and loss in a building.
- Moderately compact courtyard type internal planning. Lesser exposure to sun on East-West external walls to minimize heat gain.
- Non-habitable rooms (stores, toilets, etc.), can be effectively used as thermal barriers if planned and placed on the east and, especially, the west end of the building.



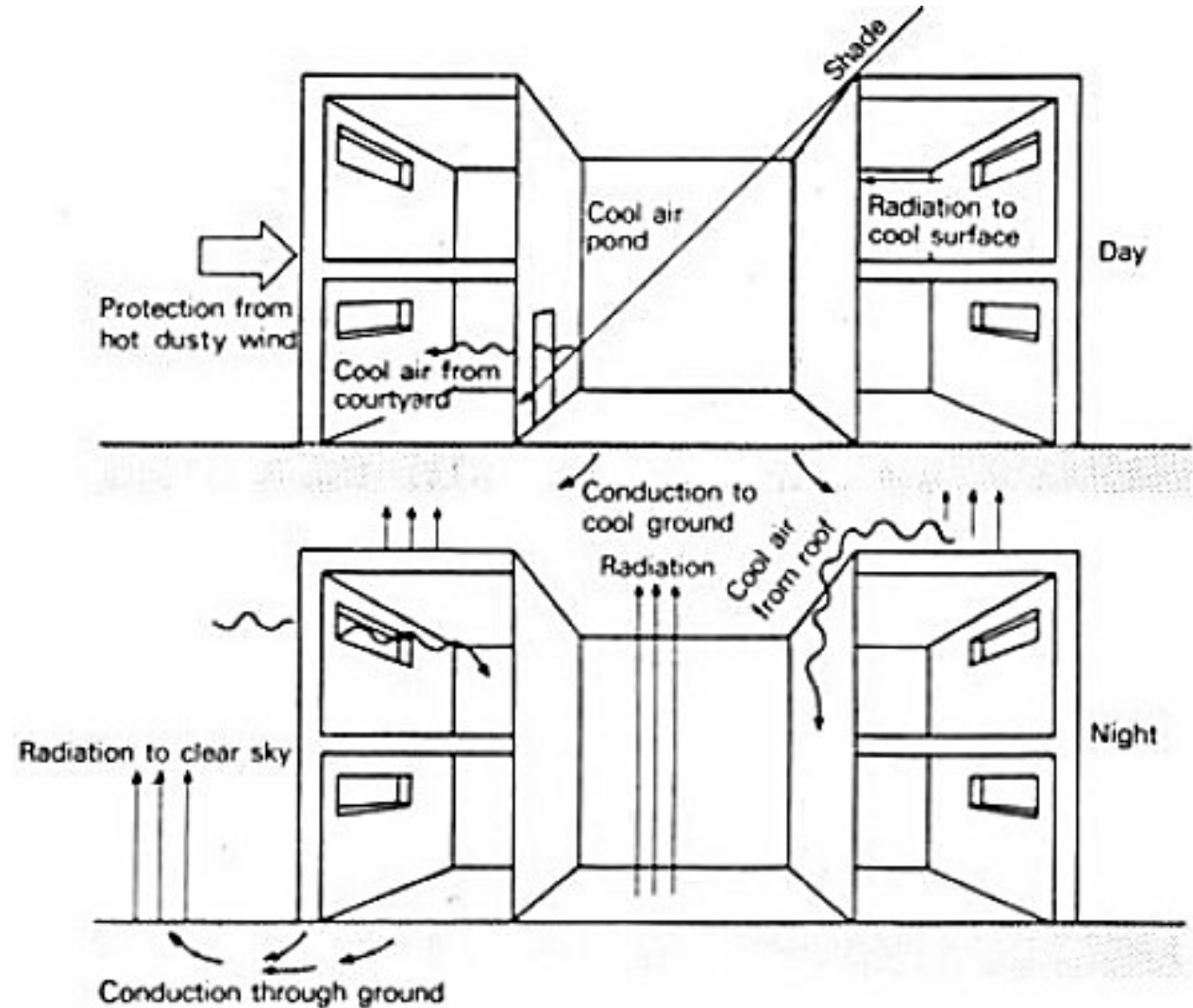
Source: <http://www.nzeb.in>

# Unit Level

## Heating / Cooling

### Form & Orientation

- Courtyard Effect - high walls cut off the sun, and large areas of the inner surfaces and courtyard floor are shaded during the day.
- Cooler air, cooler surfaces, the earth beneath the courtyard will draw heat from the surrounding areas, reemitting it to the open sky during the night.



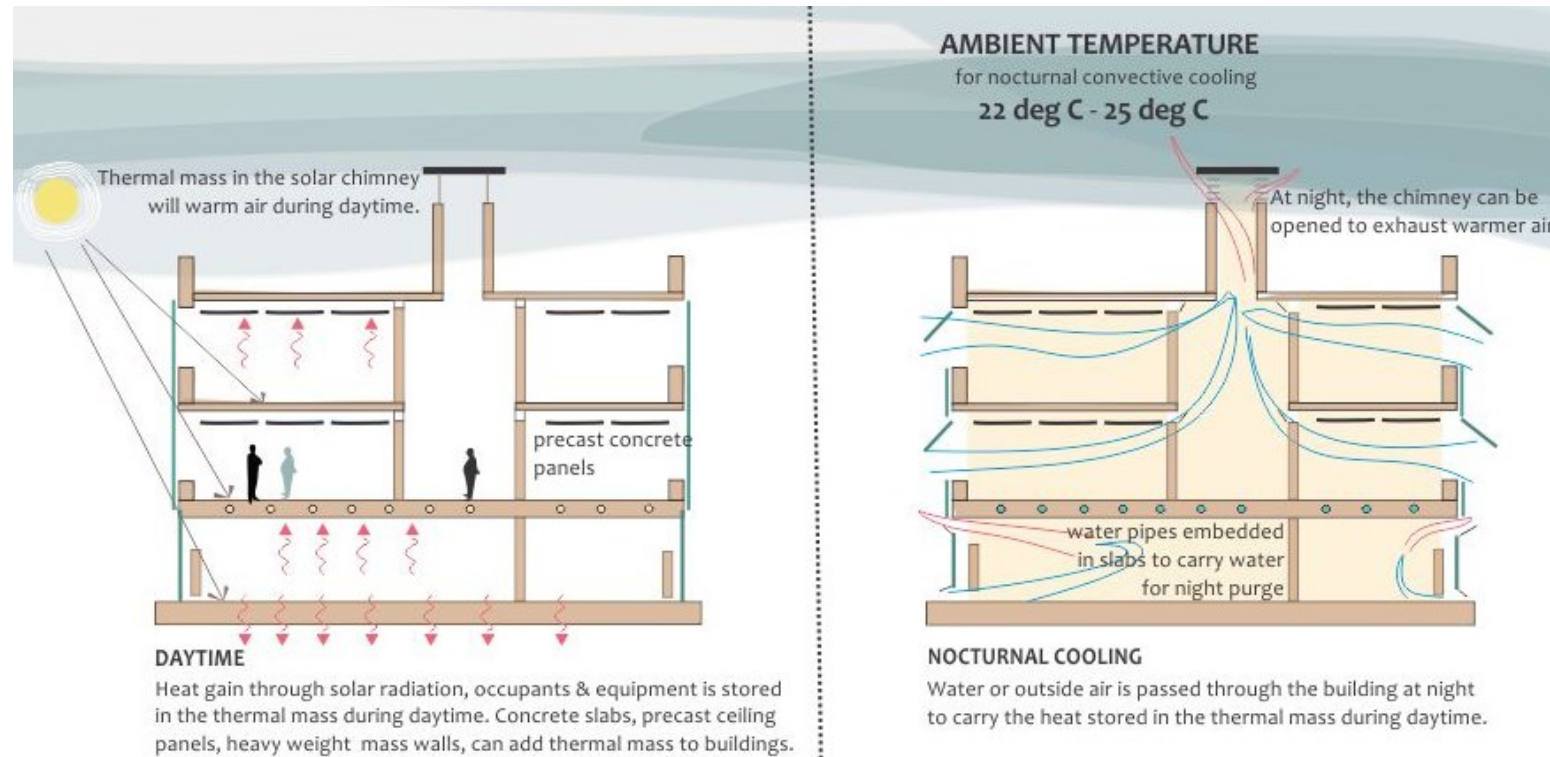
Source: Königsberger

# Unit Level

## Heating / Cooling

### Thermal Mass

- Thermal mass can be used with nocturnal convective cooling or 'night cooling' for cooling buildings passively.
- Diurnal swing must be high for thermal mass to be an effective passive cooling and heating strategy.



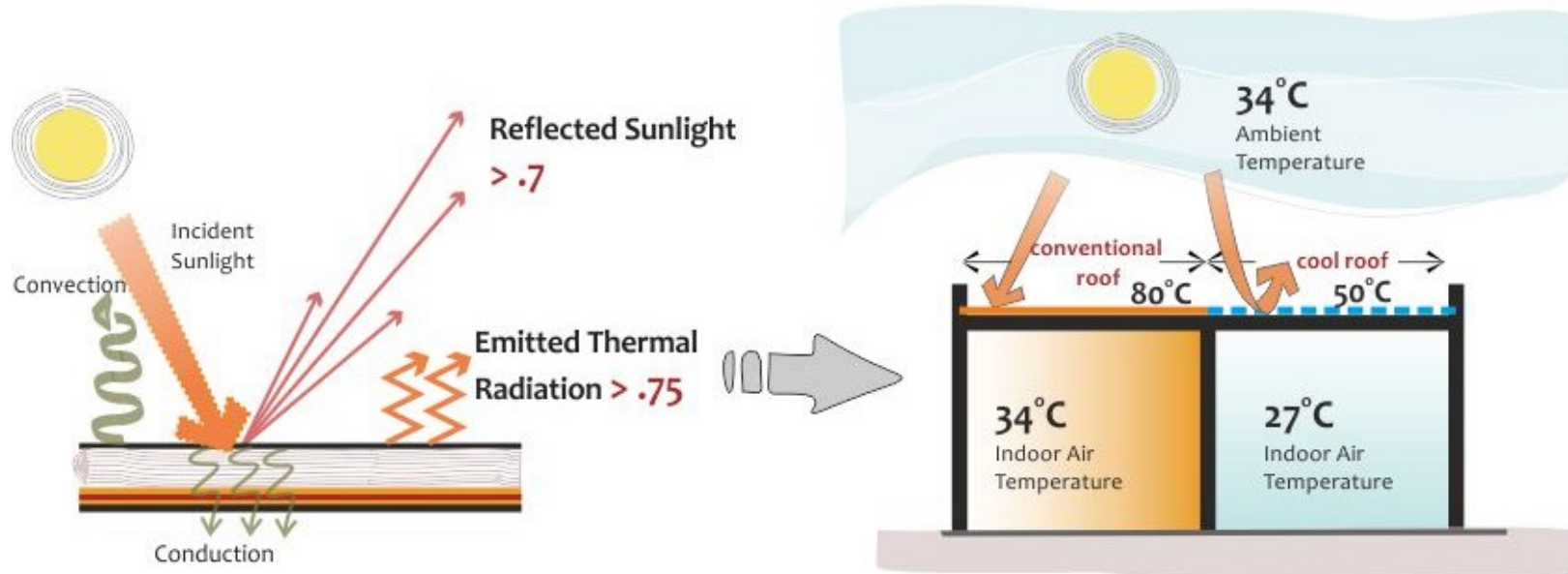
Source: NZEB

# Unit Level

## Heating / Cooling

### Cool Roofs

- Thermal emittance (re-radiation of absorbed heat), and solar reflectance of cool roofs is much higher than conventional roofs, which enables them to prevent solar radiation from being passed on to the interior of a building. Cool Roofs reduce annual air conditioning energy use of a single story building by up to **15%**.



Performance of cool roofs can be assessed in terms of thermal emittance, solar reflectance or Solar Reflectance Index (SRI), which is a measure of both emittance and reflectance.

Cool roofs are able to maintain a temperature differential of 6-8 deg celcius between ambient and indoor air temperature due to high thermal emittance and solar reflectance.

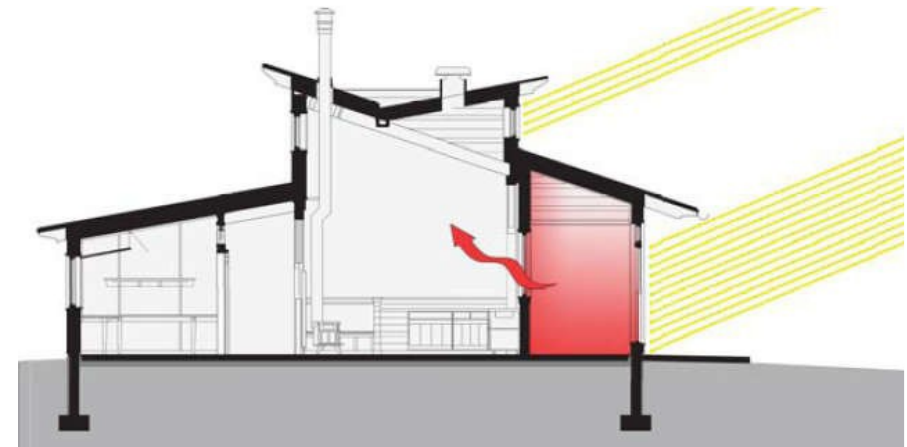
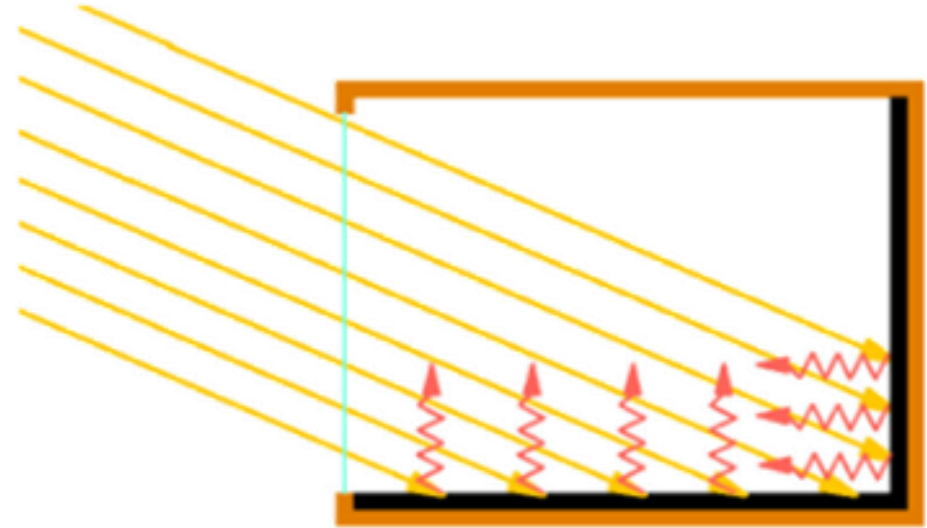
Source: NZEB

# Unit Level

## Heating / Cooling

### Direct Heat Gain

- Sunlight is admitted into the living spaces, directly through openings or glazed windows, to heat the walls and floors and thereby the air inside.
- The glazed windows are generally located facing south to receive maximum sunlight during winter (in northern hemisphere). They are generally double glazed, with insulating curtains, to reduce heat loss during night time.
- Glazed corridors and verandahs can also be used to trap sunlight transfer heat to living / working spaces beyond. At night, these buffers can help retain heat in living areas.



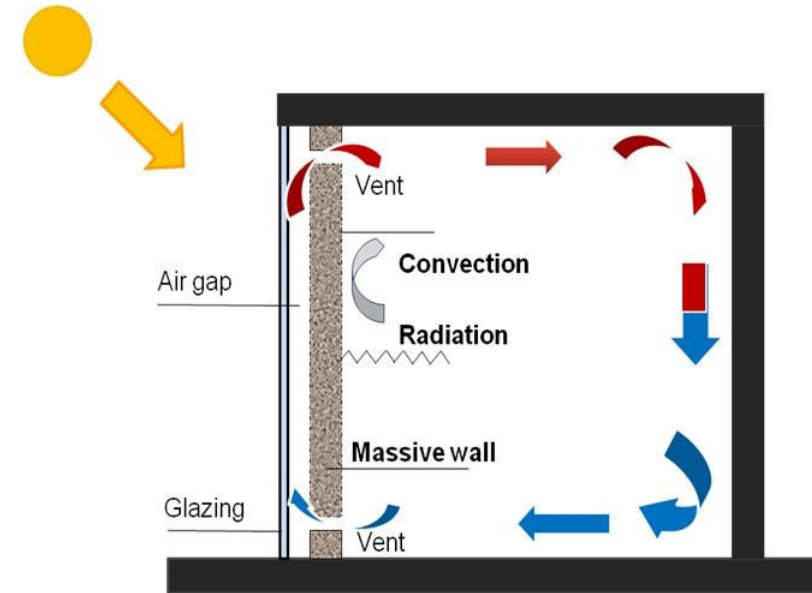
Source: [https://www.new-learn.info/packages/clear/thermal/buildings/passive\\_system/passive\\_heating](https://www.new-learn.info/packages/clear/thermal/buildings/passive_system/passive_heating)

# Unit Level

## Heating / Cooling

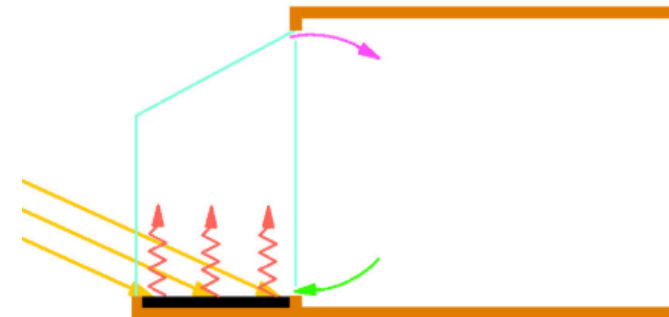
### Indirect Heat Gain

- Trombe walls, thick solid walls with vents along the lower and upper ends, can be used in conjunction with glazing along south facades to have a heating effect on internal air circulation.



### Isolated Heat Gains

- A south-facing sunspace can be created with glazing, wherein sunlight heats trapped air, and convection enables its internal circulation.



Isolated Gain: Sunspace

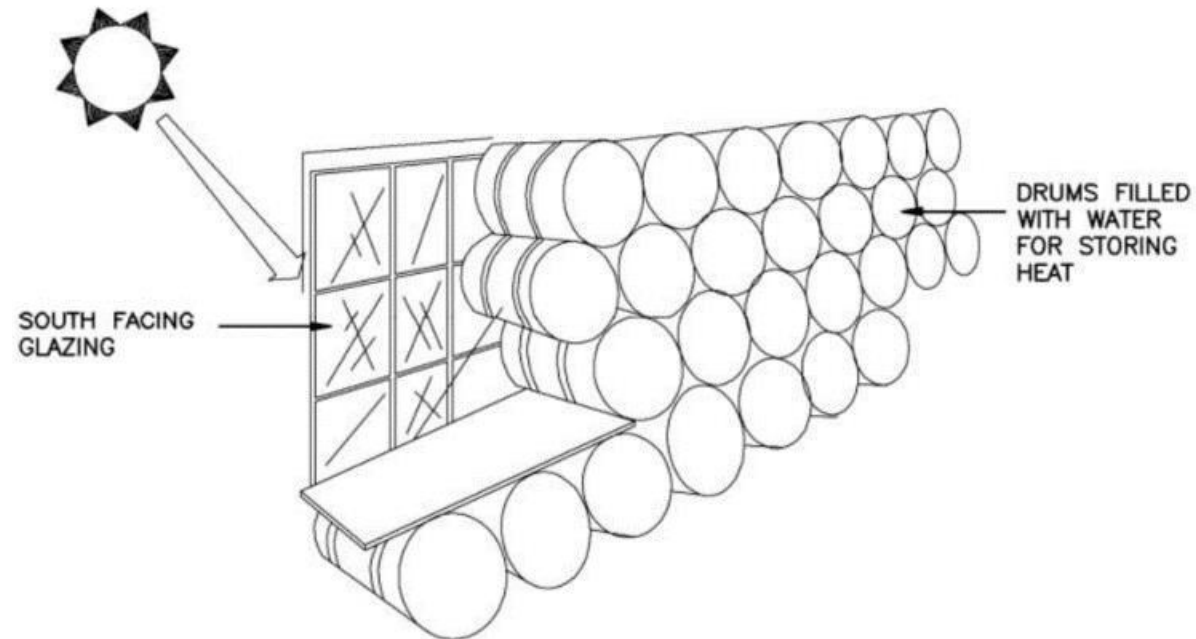
Source: Göksal Özbalta, Türkan & Kartal, Semiha. (2010)

# Unit Level

## Heating / Cooling

### Water Walls

- Water walls are based on the same principle as that of the Trombe wall, except that they employ water as the thermal storage material. Water walls are thermal storage wall made up of drums of water stacked up behind glazing. It is painted black externally to increase the absorption of radiation. This setup can store more heat than concrete walls due to higher specific heat.



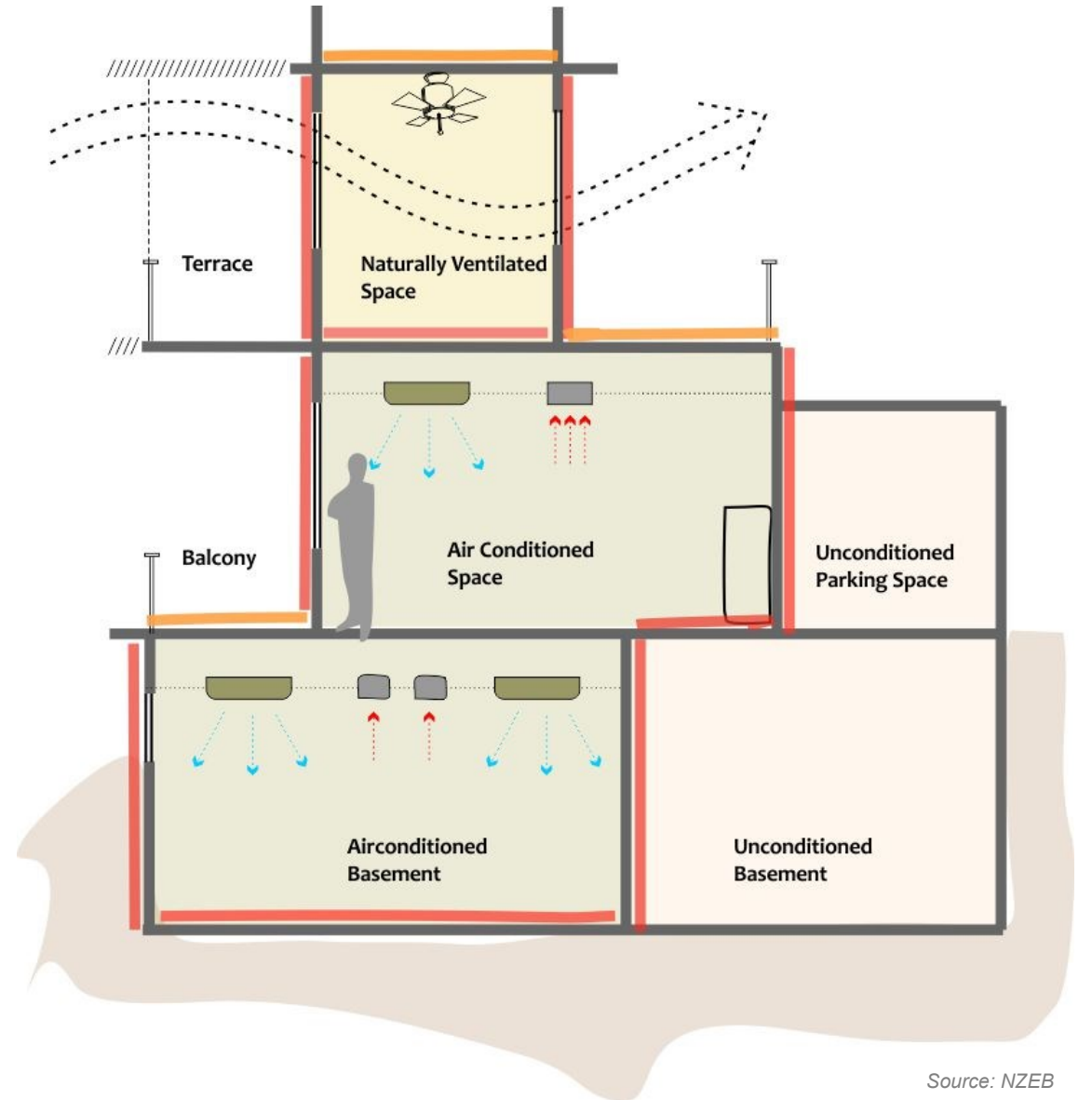
Source: NZEB

# Unit Level

## Heating / Cooling

### Insulation

- Insulation should always be placed on the warmer side of the envelope.
- In warm climates, insulation should be installed on the outside and in cold climates, on the inside.
- Insulation is rated in terms of R-value. Higher R-values denote better insulation and translate into more energy savings.
- Providing insulation beyond 100mm thickness does not provide a much further benefit in terms of energy efficiency. Provision of the initial 25mm of insulation, provides the highest incremental energy saving.
- As the insulation material becomes incrementally thicker, the incremental energy saved becomes smaller and smaller until it is almost insignificant, especially after an insulation thickness of 100mm onwards.



Source: NZEB

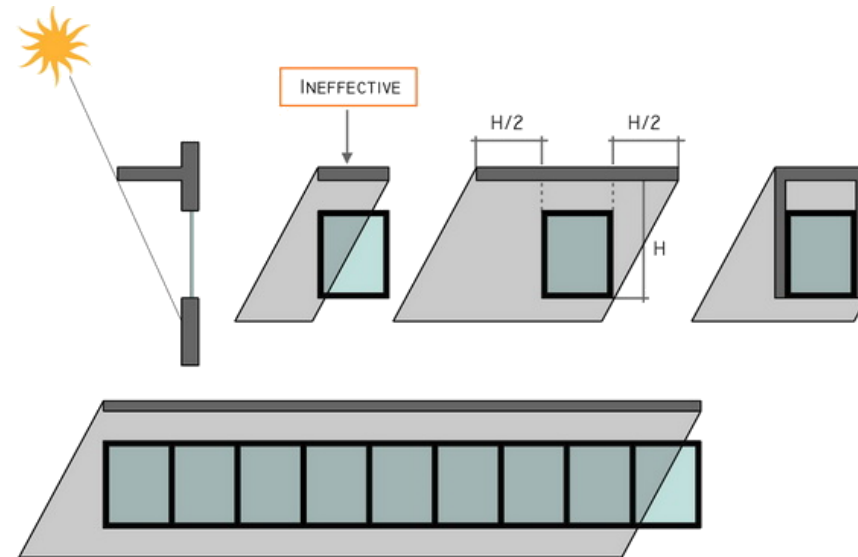
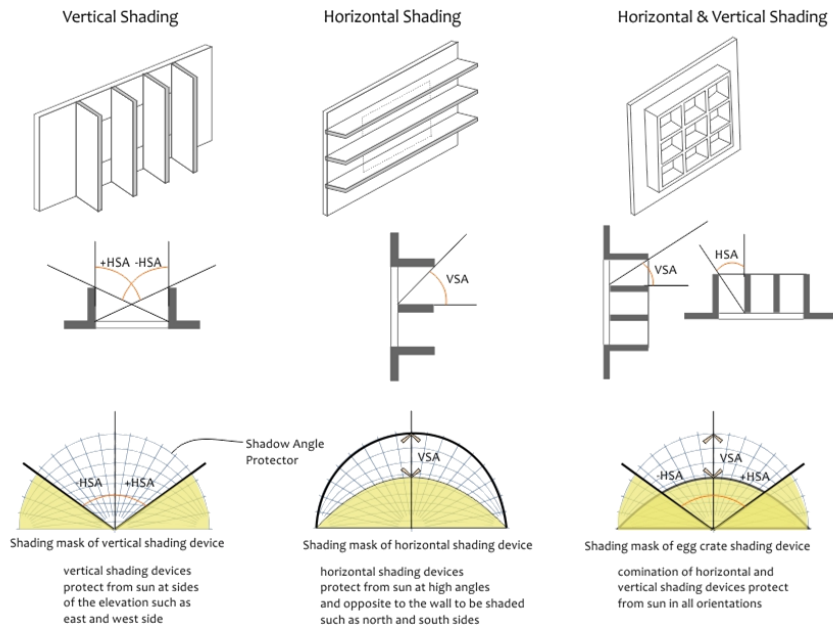
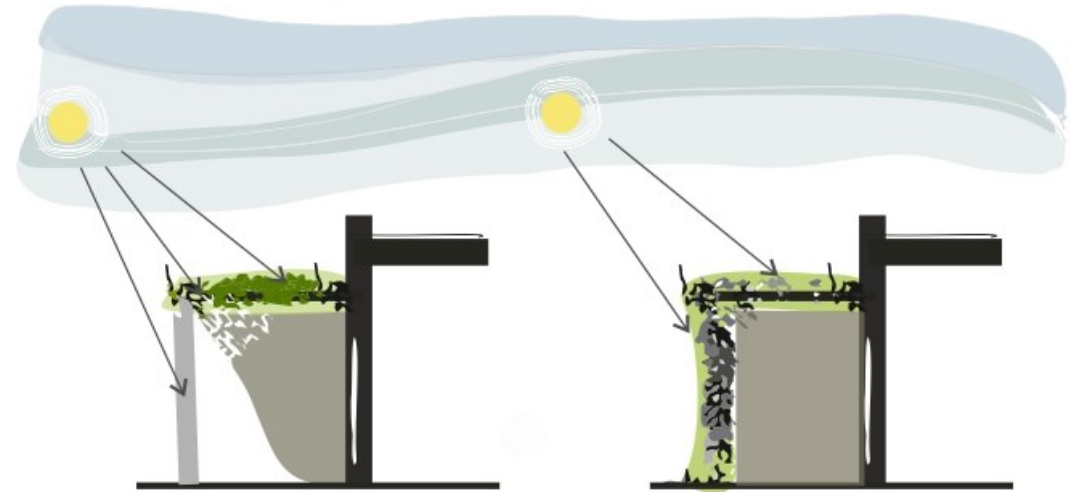


# Unit Level

## Heating / Cooling

### Shading

- Plants like creepers may be used to promote shading.
- Fenestrations and shades / chajjas may be designed to optimize solar radiation as per climate type.



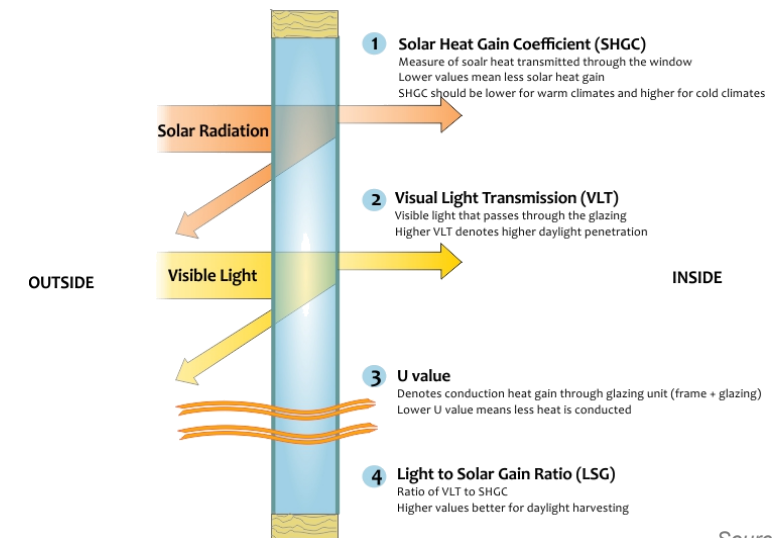
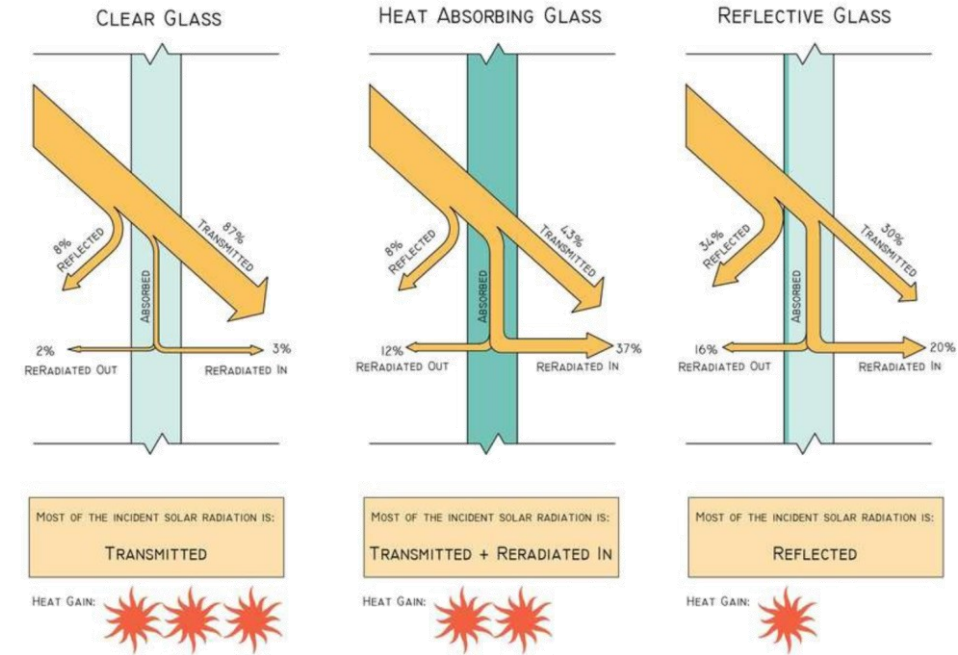
Source: NZEB

# Unit Level

## Heating / Cooling

### Glazing

- Location, sizing and glazing of windows can be used judiciously to reducing cooling load, and resultantly, smaller building cooling systems.
- Achieving a balance between daylight penetration and heat gain requires a careful calibration between visual and heat transmission qualities of glazing, and the orientation and sizing of opening.
- Reduce Solar Heat Gain Coefficient (SHGC) as less heat will be transferred into the building.
- Reduce the U-Value of glazing and also lower the SHGC except for the cold climate where higher SHGC is recommended.



Source: University of Waterloo

# Unit Level

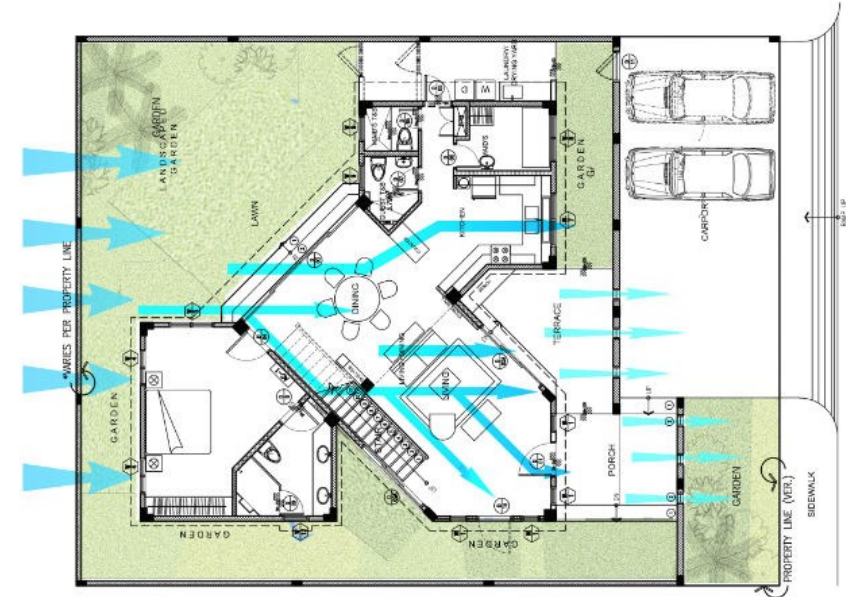
## Ventilation

### Orientation

- Buildings can be oriented at an angle between  $0^\circ$  to  $30^\circ$  with respect to the prevailing wind direction.
- Buildings that feature a courtyard (in climates where cooling is desired), orienting the courtyard  $45^\circ$  from the prevailing wind maximizes wind flow into the courtyard and enhances cross ventilation in the building.

### Creating Pressure Differences

- When wind enters through a smaller opening and exits through a bigger opening, that's a 'squeeze point.' This creates a natural vacuum which increases wind velocity.
- Total area of openings should be a minimum of 30% of floor area.
- Window-Wall-Ratio (WWR) should not be more than 60%.



# Unit Level

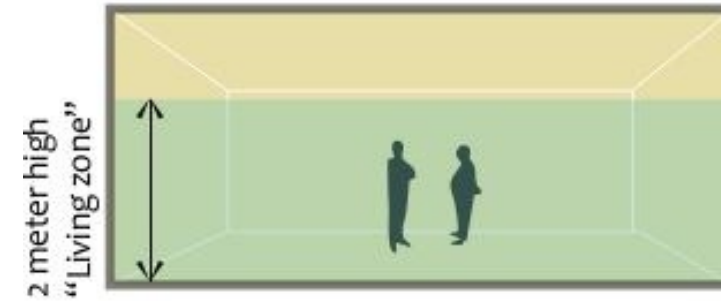
## Ventilation

### Openings

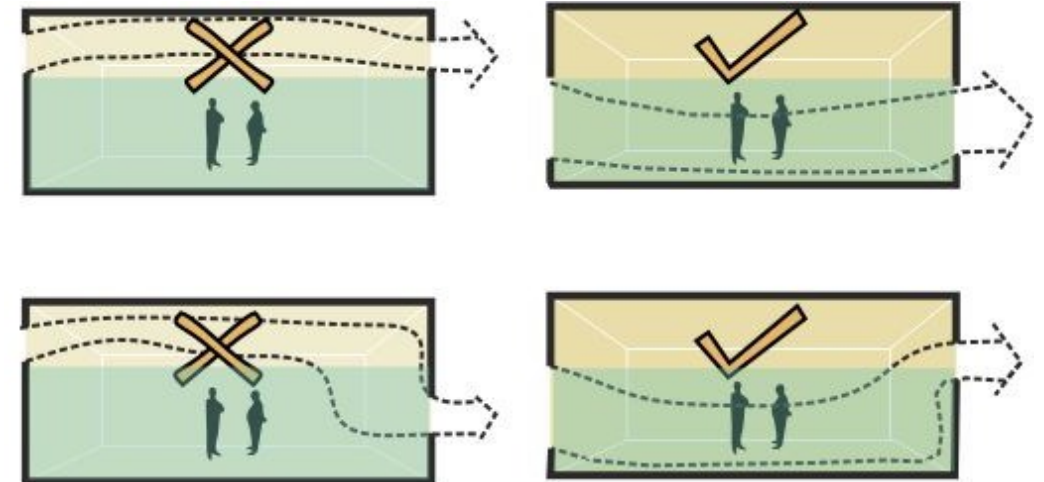
- Maximum air movement is achieved by keeping the sill height at 85% of the critical height.
- Greatest flow per unit area of the opening is achieved by keeping the inlet and the outlet of nearly same sizes at nearly same levels.

### Stack Ventilation

- Stack ventilation is a form of cross ventilation that enhances air circulation inside a space by combination of buoyancy and venturi effect. It is good for cooler temperatures.
- The lighter warm air rises to escape the building through window openings at high level and is replaced by cool night time air or day time air drawn from shaded external areas from inlets at lower level.



Living zone is the space commonly used by occupants. Air movement should be directed through this space.



inlet openings placed at high level deviate air flow away from the living zone irrespective of outlet position

Source: NZEB

# Unit Level

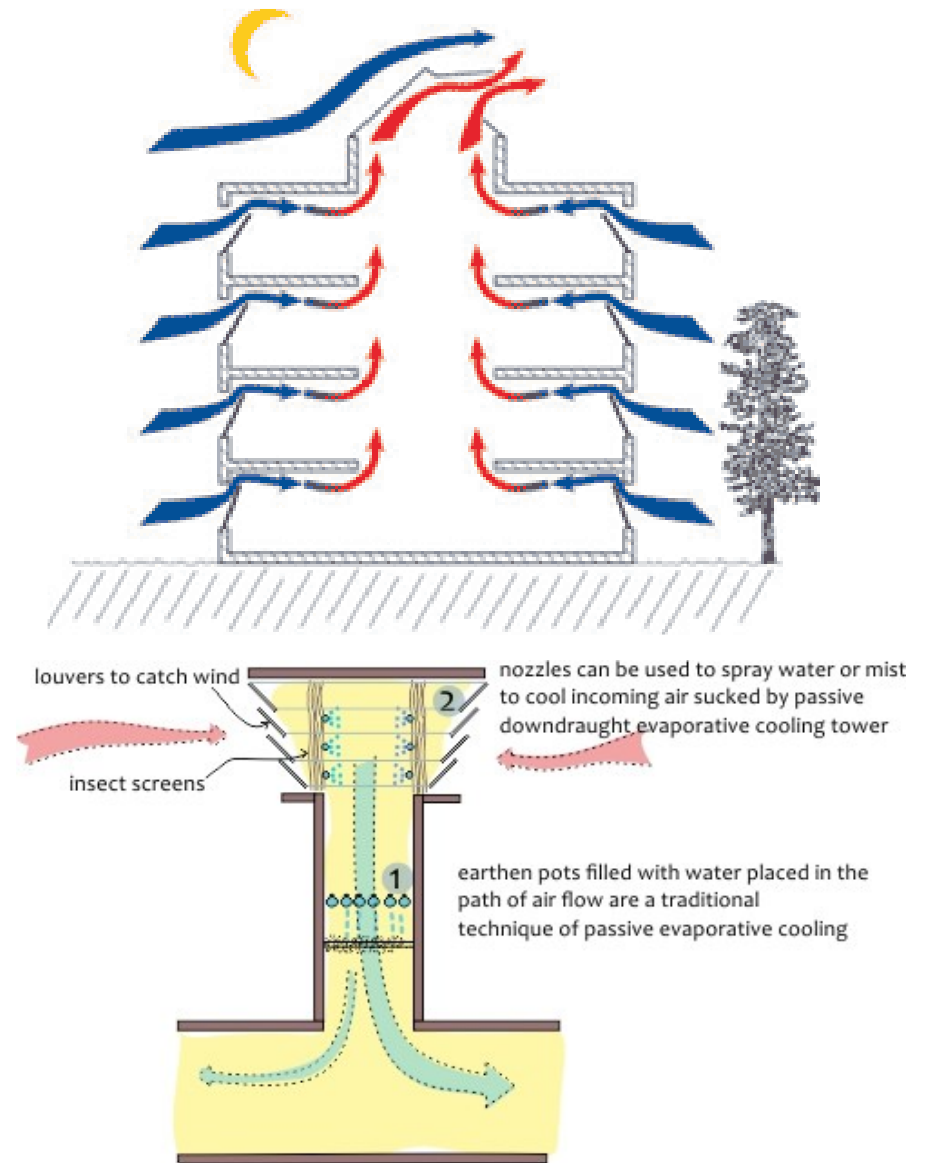
## Ventilation

### Wind Towers

- The cardinal principle behind its operation lies in changing the temperature and thereby density of the air in and around the tower.
- The difference in density creates a draft, pulling air either upwards or downwards, through the tower.

### Downdraught Evaporative Cooling

- Passive downdraught towers catch hot ambient air through wind scoops at the top. This air is cooled either through mechanical systems like nozzle sprays or through passive systems like water filled vessels. The heavy cool air sinks to the bottom zone of habitable spaces. Efficiency depends on the temperature differential between the warm outside air and cool air inside the tower.



Sources: MaS-SHIP; NZEB

# Unit Level

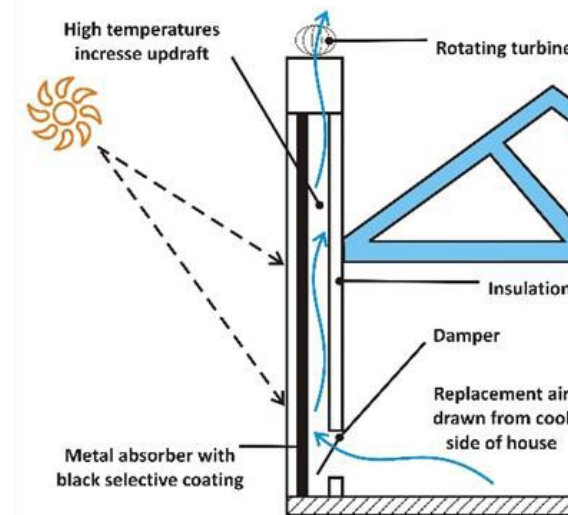
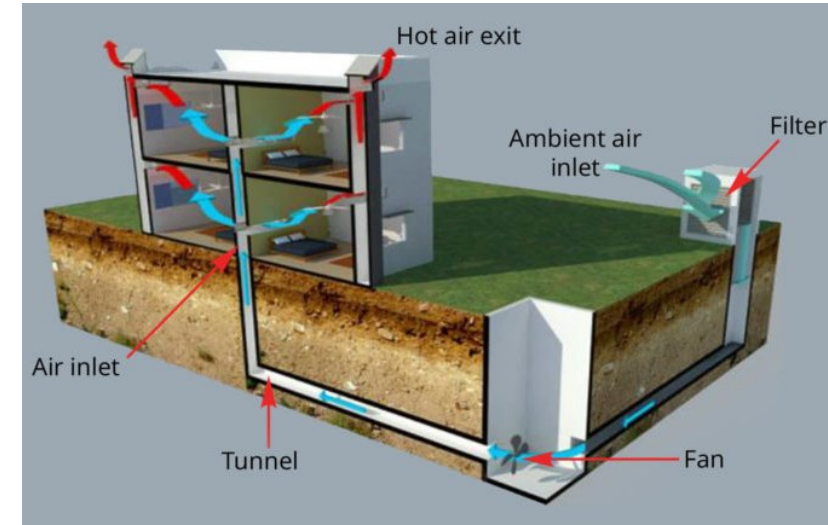
## Ventilation

### Air Earth Heat Exchanger

- A pre-cooling or pre-heating system which consists of a pipe or network of pipes buried at reasonable depth below the ground surface. It either cools the air by rejecting heat to the ground or heats the air absorbing heat from the ground. It utilizes the fact that the deep earth temperature remains almost same as the annual average mean air temperature of the location.

### Solar Chimney Wall

- Solar Chimney, on an external wall, enhances stack ventilation by providing additional height and well-designed air passages thereby increasing the air pressure differential.
- Via solar radiation, the chimneys warm the rising air which increases the difference between the temperatures of incoming and outflowing air. These measures increase the natural convection and enhance the draw of air through the building.



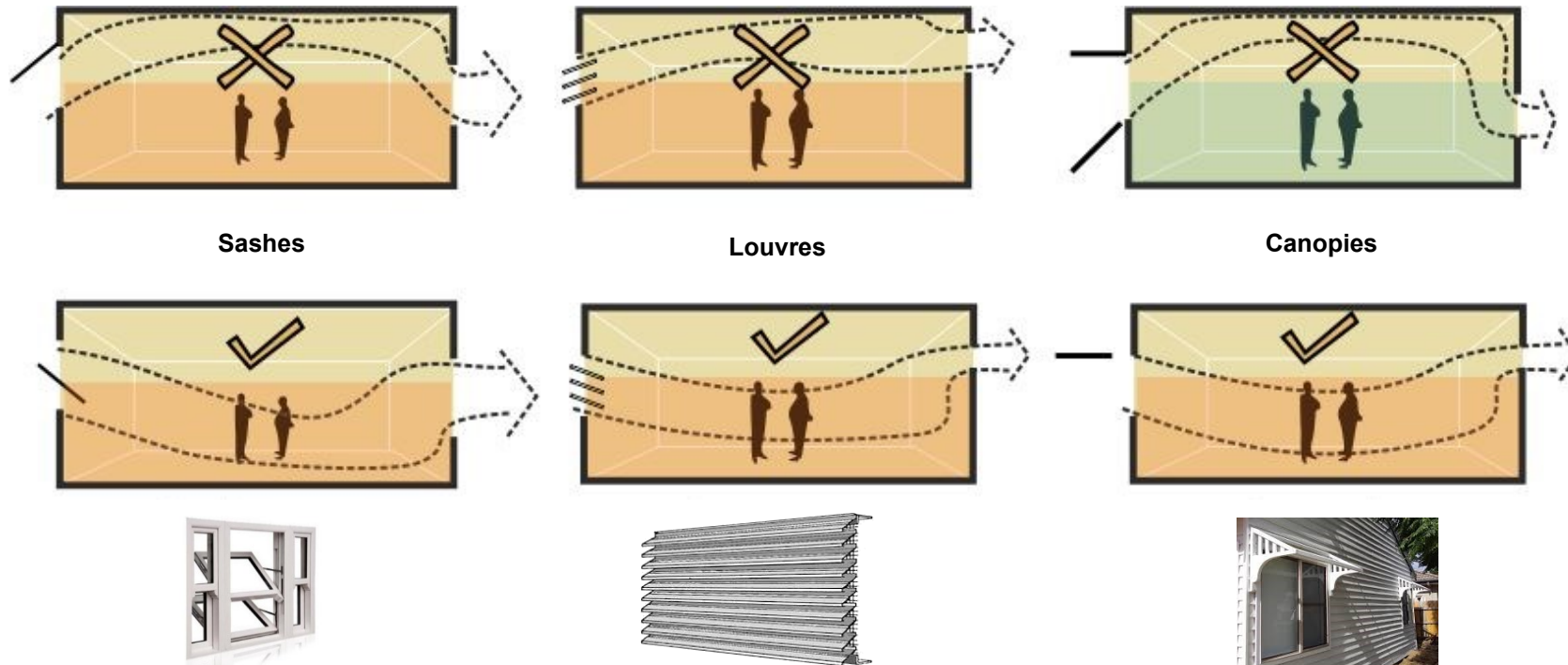
Sources: MaS-SHIP; BEEP

# Unit Level

## Ventilation

### Directing Air Flow through Openings

- Louvres and shades can be so designed as to direct air in specific directions, while protecting from sun and rain.



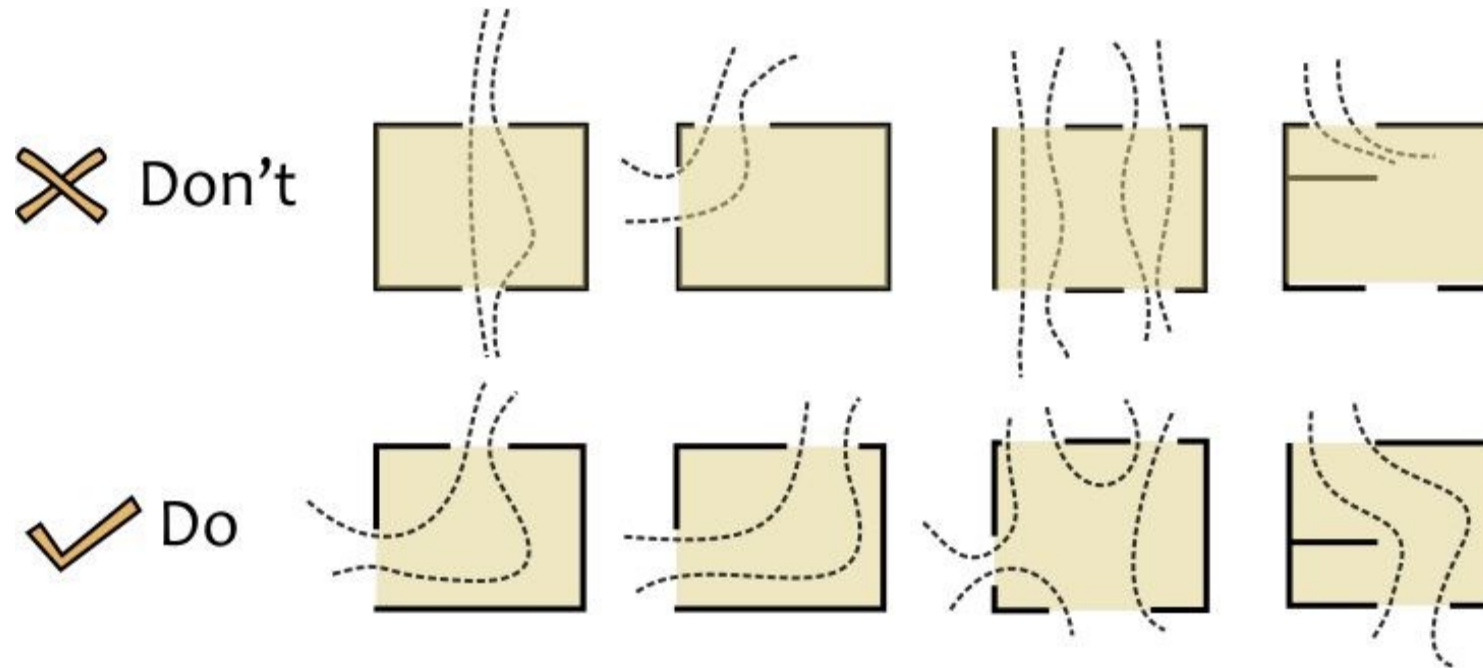
Sources: NZEB

# Unit Level

## Ventilation

### Positioning of Openings

- To encourage ample ventilation, openings should be positioned on opposite walls, diagonally across rooms.



Sources: NZEB



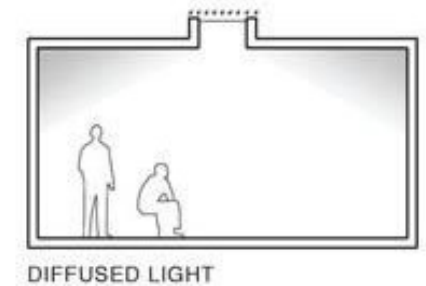
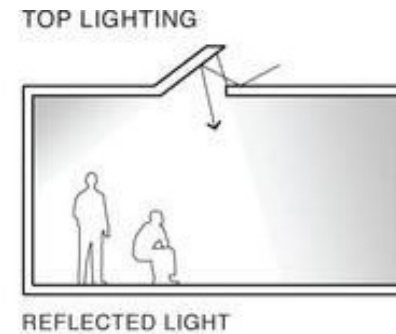
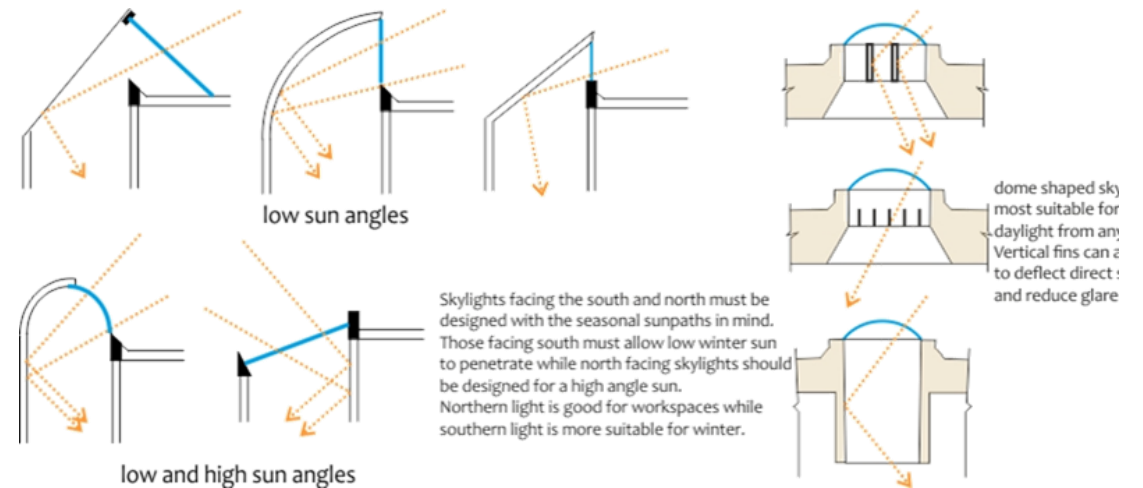
# Unit Level

## Lighting

Good lighting strategies can bring down energy demand by 20-30%. Windows / fenestrations can be designed in unique ways to encourage such savings.

## Skylights

- Top lighting is an effective daylighting solution for wide buildings where side lighting cannot be used for adequate lighting of the deeper areas of the floorplate.
- To reduce glare, skylights must be designed with reflective surfaces that redirects direct sunlight into the space.
- Higher positioning of windows also enables deeper and wider penetration of natural light in the interiors. Combining with lighter coloured interior surfaces further improves internal visibility.



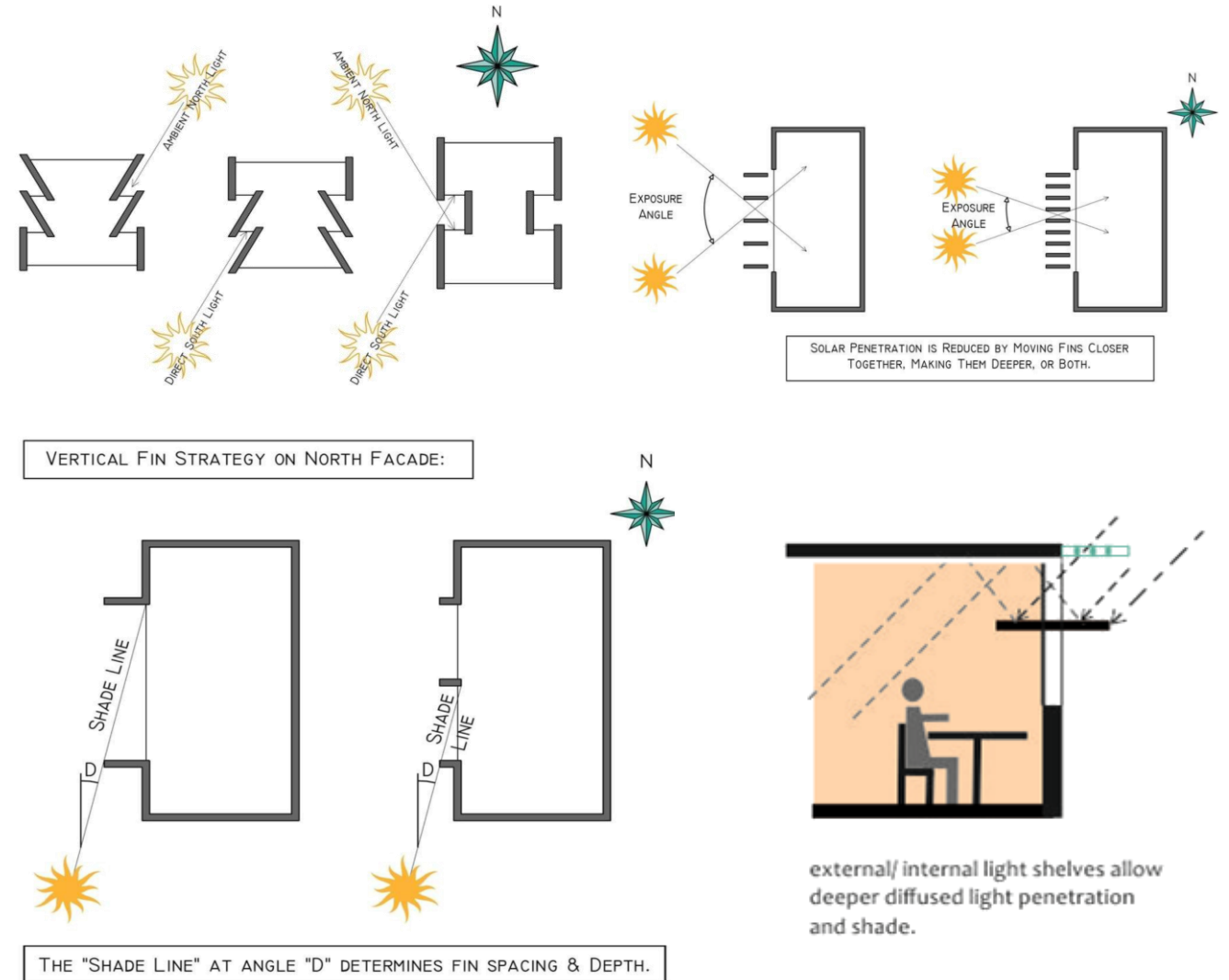
Sources: NZEB

# Unit Level

## Lighting

### Directional Modifications

- Ambient, glare free light comes from the North, while direct light comes from the South.
- East / West light has a lot of glare as it is generally at a lower angle.
- Orient windows along the East and West façade such that they are angled toward North / South.
- Alternatively, incorporate fins along East / West façade windows.
- Shading is generally not required along North facades, or only minimal shading interventions may be necessary.
- Window shades can be used to optimize light coming from the South.



Sources: NZEB

# Exercise

- Divide into groups.
- From the deck of cards draw one and put it under the category mentioned on the sheets provided as under:

Start	Stop	Continue

- The deck of cards contains certain passive/active cooling practices in India or some innovative suggestions or non-recommended solutions in the field of passive design.

Sources: NZEB

# Traditional Solutions

Passive cooling techniques	Results
Indirect gain	Heating load may be reduced by 25 %.
Evaporative cooling	<ul style="list-style-type: none"> <li>• Reduction of about 9.6 °C may be achieved (Amer, 2006).</li> <li>• With use of fountain, indoor temperature was found to fall within the comfortable zone of 20 °C for hot arid regions (Qiu &amp; Riffat, 2006).</li> <li>• 2- 6.2 °C drop in the room temperature may be achieved for hot humid climate (Chungloo &amp; Limmeechokchai, 2007).</li> <li>• Water retaining material (porous roof) laid over roof may reduce surface temperature by 4-6 °C (Chen, et al., 2015).</li> <li>• Indirect evaporative cooling may lead to a reduction of 1 °C in mean daily temperature for regions with daily mean temperature ranging between 26.5 °C- 27.6 °C. Also, it may reduce the thermal discomfort due to heat in about 95- 100 % of the year (Cruz &amp; Krüger, 2015).</li> <li>• Indirect evaporative cooling may reduce the energy demand by the HVAC system by 20% in next 20 years (Zhiyin, et al., 2012).</li> </ul>

Sources: *Journal of Buildings & Sustainability*, 2017

## Natural ventilation

- More than 30 % energy savings may be achieved (Ciampi, et al., 2005).
- Recommended value of air movement is 0.2 m/s for winters and 0.4 m/s for summers (Tiwari, 2012).
- For living rooms, dining areas, mean window to wall ration should be 0.34. The same for bedroom should be 0.27 in high rise buildings (Wan & Yik, 2004).
- Artificial mechanical airflow systems should not disturb the natural ventilation (Pfafferott, et al., 2004).
- Comfortable indoor thermal conditions may be achieved with air movement of 2-3 m/s (Gupta & Tiwari, 2017).

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## Wind tower

- About 12-15 °C decrease in the indoor temperature can be achieved (Hughes, et al., 2012).
- Reduction of up to 17.6 °C in room air temperature may be achieved by using wetted surface design for hot dry regions (Bouchahm, et al., 2011).
- With introduction of evaporative cooling concept in terms of 10 m high wet columns may reduce the inside temperature by 12 °C and a drop in relative humidity by 22% for hot arid areas (Benhammou, et al., 2015).
- For windy areas, new installation of wind towers was introduced which could align itself in the pre dominant wind direction. Also, transparent

Sources: *Journal of Buildings & Sustainability*, 2017

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## Natural Daylight

- Window to wall and window to ground ratios (0.33-0.58) have a huge contribution to the effectiveness of natural ventilation and daylight (Wan & Yik, 2004).
  - 10 % additional energy savings may be achieved by changing the size of the windows (Zain-Ahmed, et al., 2002).
  - Skylights may lead to a reduction in energy savings by 77 % (Treado, et al., 1984).
  - With integration of semi-transparent photovoltaic systems with buildings, about 7150 W daylight savings may be achieved for cold climatic conditions (Gupta & Tiwari, 2017)
  - Annual daylight savings of 11233.79 kWh may be achieved by building integrated semi-transparent photovoltaic systems (Gupta & Tiwari, 2017b)
- 

## Courtyard planning

- Potential to save up to 25% of the power consumption for Tropical climate (Hanif, et al., 2014).
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Sources: *Journal of Buildings & Sustainability*, 2017

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### Solar shading techniques

- Energy demand for south exposing facades may be reduced by about 9 % with proper use of shading techniques (Grynning, et al., 2014).
  - With additional provision of insulation, about 4.4-6.8 °C decrease in the indoor temperature may be achieved (Bansal, et al., 1994) (Kumar, et al., 2003).
  - By providing a roof cover from locally available materials like hay, inverted earthen pots, plants, insulation, terracotta tiles etc., indoor temperature may be reduced since roof has the maximum exposed area for solar gains (Kamal, 2012).
- 

### Radiative cooling

- The cooling power measurements ranges from 20- 80 W/m<sup>2</sup> (Cavelius, et al., 2005).
  - Specific cooling power of 120 W/m<sup>2</sup> may be achieved by open water based system (Beck & Büttner, 2006).
  - Cooling load decreases with increase in the elevation with large radiative cooling potential (Zhang, et al., 2002).
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Sources: *Journal of Buildings & Sustainability*, 2017



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## Landscaping

- Presence of a park can reduce the surrounding temperature by 2 °C (Ca, et al., 1998).
  - Surrounding temperature may be reduce by 2- 5 °C due to the shading effect and evapotranspiration offered by trees (Bansal, et al., 1994) (Kamal, 2012).
  - Deciduous trees should be planted on the south and southwest of the buildings whereas evergreen trees towards the south and west side of the building (Kamal, 2012).
  - Due to the presence of a park, the indoor temperature may be reduced by 2 °C (Ca, et al., 1998).
  - A comparison of shaded (tree buffering) and non-shaded area was conducted and it was observed that the peak solar irradiation at same time was 100 W/m<sup>2</sup> and 600 W/m<sup>2</sup> respectively for a south east oriented building located in Athens (Papadakis, et al., 2001).
- 

Sources: *Journal of Buildings & Sustainability*, 2017

## Earth Shelter

- About 7.0-8.5 °C decrease in the indoor temperature can be achieved (Tiwari, et al., 2014).
- For desert climatic conditions, reduction of 2.8 °C in room temperature was observed during summer months (Al-Ajmi, et al., 2006).

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## Trombe wall

- Trombe walls can be seen in the great pyramid of Gizeh to maintain 23 °C in the king's and the queen's chamber throughout the year (Gupta, 1984).
- Screened Trombe walls have 18 times lower heat gains when compared to the screened Trombe walls for Mediterranean type of climate (Gupta, 1984).
- With introduction of cross ventilation and devices like overhangs, rolling shutters, reduction of 65 % and 72.9 % in cooling energy was observed respectively when compared to unvented Trombe wall (Gupta, 1984).
- Reduction of 1.4 °C in the room temperature was observed with reduction of 0.5 MJ/m<sup>2</sup> in daily heat gains with additional screening (Stazi, et al., 2012).
- 20.7 % reduction in cooling load was observed due to storage capacity of Trombe wall (Soussi, et al., 2013).

Sources: *Journal of Buildings & Sustainability*, 2017

# Case Studies

# Smart Ghar III, Rajkot

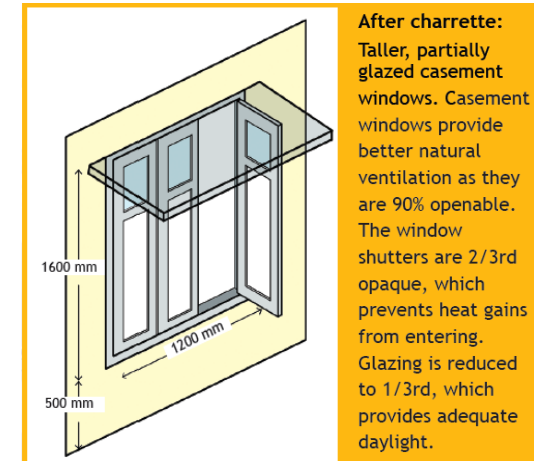
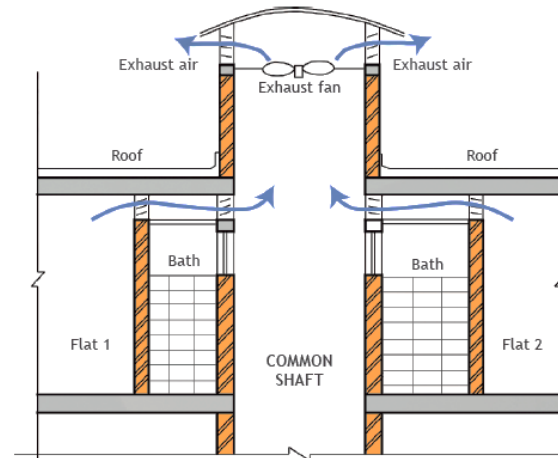
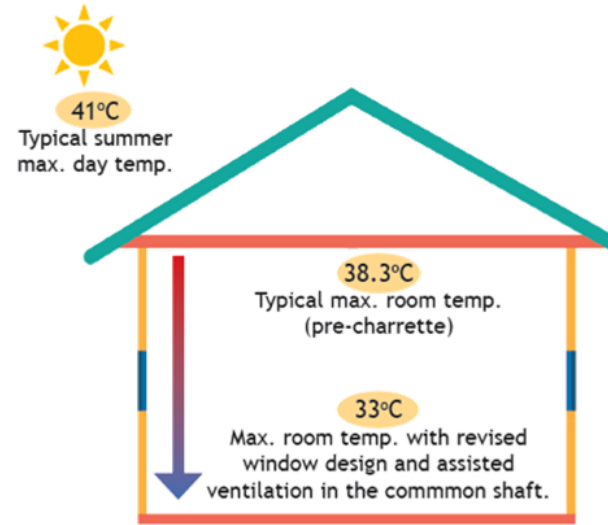
- Project: Affordable housing in Rajkot under PMAY Untenable Slum Redevelopment.
- Site area: 17,593 m<sup>2</sup>
- Built-up area: 57,408 m<sup>2</sup>
- Number of dwelling units (DU): 1176 (All 1 BHK)
- 11 residential towers : Stilt + 7

## Key Features

- Sensitively designed window shades to reduce heat gains while improving day light.
- Use of a fan-serviced ventilation shaft to improve air quality inside.

## Outcomes

- Reduced peak summer room temperature by >5°C
- Increased number of comfortable hours from ~2600 hours to ~6300 hours.



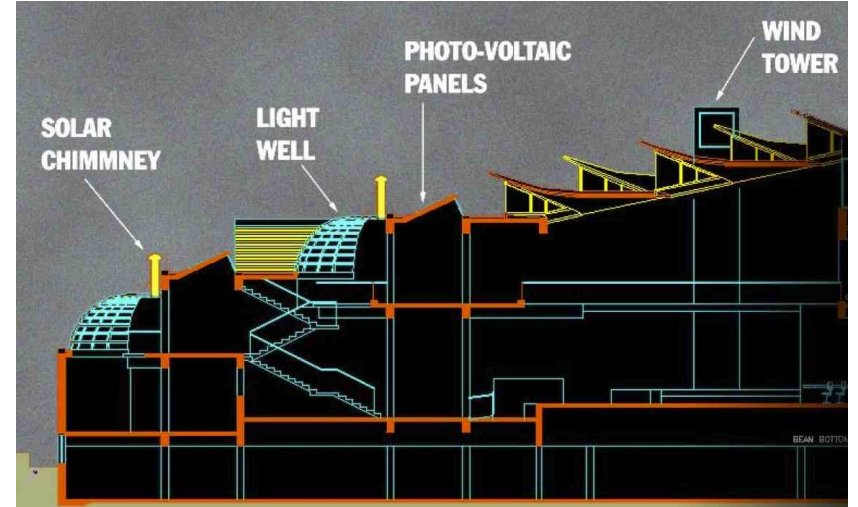
Source: BEEP

# Punjab Energy Development Agency, Chandigarh

- Secretariat complex of Ministry of Environment and Forests (MoEF)

## Key Features

- The building integrates daylight and Natural Ventilation Strategies through Light and ventilation wells with renewal energy systems, i.e. Photovoltaic and Solar Water Heating
- Light Wells: The vertical cut-outs in the floating slabs are integrated with light vaults and solar activated naturally ventilating, domical structures in the south to admit day light without glare and heat.
- The shell roof is angled in such a manner that the opening beneath the shell is shaded from the summer sun but allows the winter sun to penetrate.
- Wind towers used for ventilation
- Internal fountains used to cool inner courts.



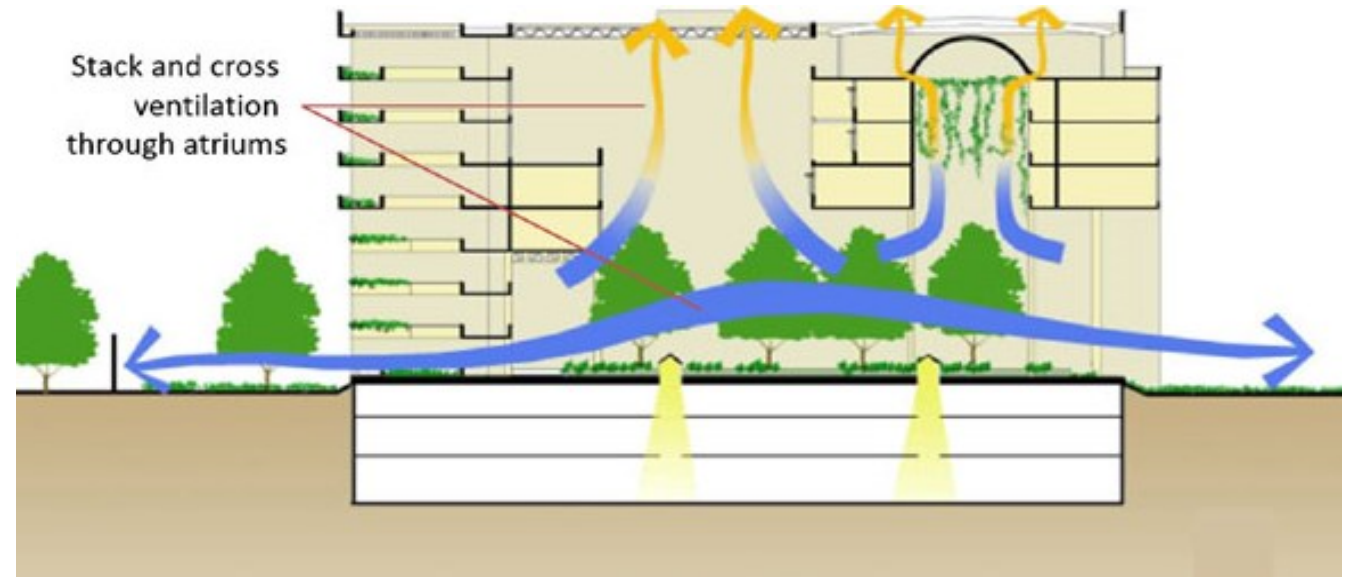
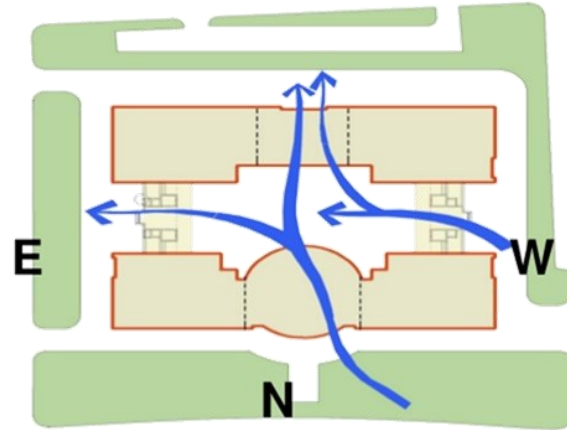
Source: BEEP

# Indira Paryavaran Bhavan, Delhi

- Institutional complex in Chandigarh designed to harness natural light and ventilation

## Key Features

- Building is north south oriented, with separate blocks connected through corridors and a huge central courtyard.
- Stack ventilation used to promote internal air circulation.
- Jaalis and windows used extensively to further boost air flow.
- Soft paving features incorporated to allow groundwater seepage.
- Solar panels placed over the roof to offset need to draw power from grid.



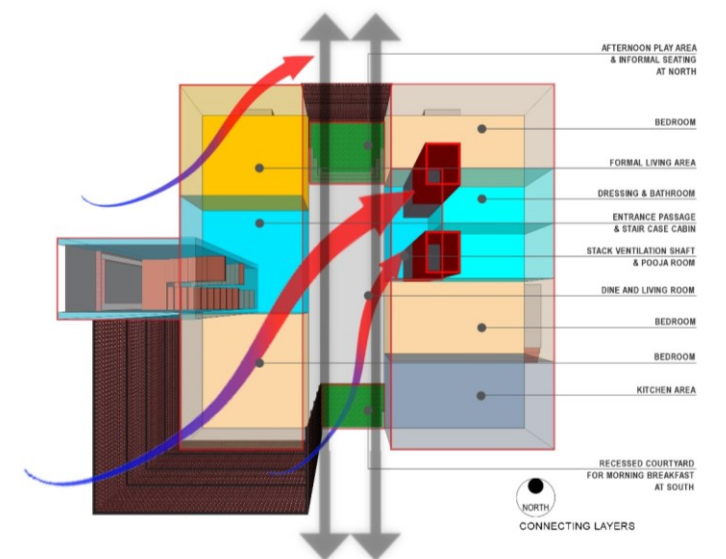
Source: CPWD

# Ram Baugh, Burhanpur

- A residence which has been designed to remain cool without the use of an air conditioner.

## Key Features

- Design relies on mutual shading and optimal building orientation.



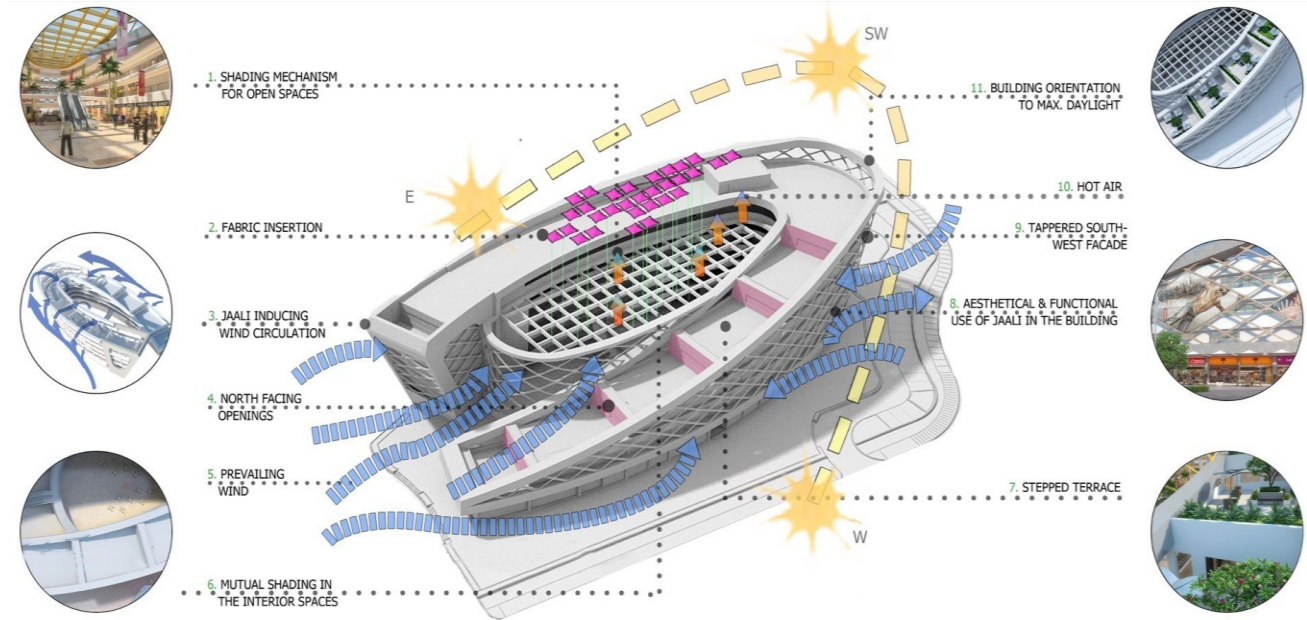
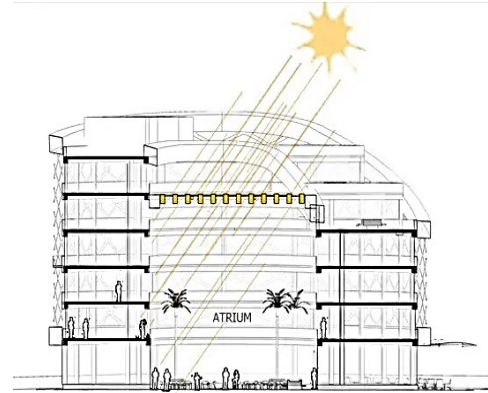
Source: Parekh Collaborative

# Times Square Mall, Naya Raipur

- A shopping mall that does not require air conditioning.

## Key Features

- Building form and direction oriented toward maximal daylight and natural ventilation harnessing.
- Inner court acts as a vertical stack. It is also capped with a pergola that can be covered / uncovered with cloth to control daylighting of interior areas.
- External façade is enveloped in a large screen that aids lighting control, ventilation, and provides heating/cooling advantages.



Source: Architecture Live

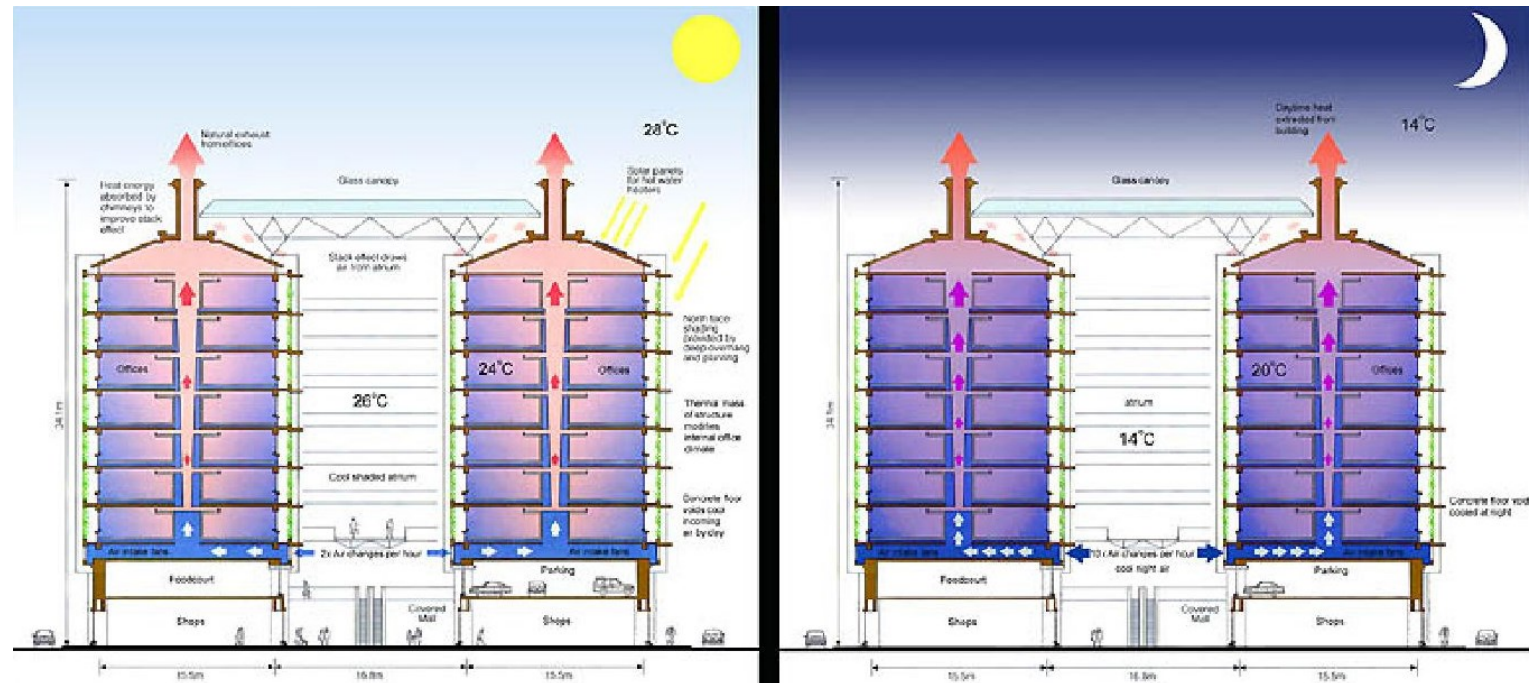


# Eastgate Centre, Zimbabwe, Harare

- Commercial complex that does not need any air conditioning.
- Design draws inspiration from termite mounds and local masonry skills.

## Key Features

- Extensive use of ventilation stacks to promote optimal temperatures in interior spaces.
- Incorporates a series of vents to promote and regulate optimal air flow.
- External façade has a masonry screen that provides optimal shading and has a cooling effect on air flow.



Source: Mick Pearce Architecture

# Key Takeaways

# Learnings

- Mainstreaming passive strategies in buildings for thermal comfort can significantly reduce cooling, ventilation and lighting requirements in buildings;
- Lesser dependency on mechanical cooling/ heating approaches will decrease formation of surface ozone, hence better air quality.
- Greater awareness of the benefits of sustainable building design will spur greater demand from all strata of society
- Sensitivity in building practices will tend to decrease disparity in thermal comfort of different economic classes.
- **Make active strategies passive, and passive strategies active.**
- **70% of the buildings required in India by 2030 are yet to be built. Maintaining status quo is irrelevant, and there is a great opportunity for incorporating passive design strategies successfully across our built environment.**

*Source: McKinsey*

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# Thank you.