Building Efficiency Accelerator

# Factsheets on Nagpur's Technical Guidelines for Energy Efficient and Climate Responsive Homes

**SEPTEMBER 2020**


Sustainable Energy for All Accelerator
World Resources Institute
ICLEI Local Governments for Sustainability
UN environment United Nations Environment Programme
gef

Nagpur city has prepared city-specific **"Guidelines for Energy Efficient and Climate Responsive Homes"** to help build efficient housing with reduced environmental and climate impacts and without compromising comfort levels. This publication includes five factsheets prepared to capture and communicate key information and recommendations from Nagpur's Technical Guidelines.


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### Acknowledgement:

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## Background

The central Indian city of Nagpur, also known as the "Orange City", is a fast-growing city spanning an area of 227 square kilometres and housing 2.4 million residents[1]. Nagpur is a part of a select group of 100 Smart Cities in India, supported by the Smart City Mission of the Government of India, and envisions transforming into a liveable, eco-friendly and educational city that electronically connects people with the government to co-create an inclusive ecosystem.

The city's local government - the Nagpur Municipal Corporation (NMC) and its Smart City Special Purpose Vehicle (SPV) - the Nagpur Smart and Sustainable City Development Corporation Limited (NSSCDCL), have led planning and implementation of various progressive sustainability initiatives in the city.

Keen to adopt large scale energy efficiency measures in its buildings, Nagpur city joined the Building Efficiency Accelerator (BEA) Initiative in 2018. The city was interested in integrating green building principles into new housing and in improving energy efficiency of its existing stock of buildings. Nagpur was selected by the Global BEA Partnership as a deep dive city partner for deeper engagement and technical support.

## Building Efficiency Accelerator (BEA) Program

The Building Efficiency Accelerator (BEA), one of the six accelerators of energy efficiency under the Sustainable Energy for All (SE4ALL) initiative of the UN, assists sub-national governments in improving the energy efficiency of buildings within their jurisdictions to reduce energy costs, create new market opportunities and reduce the GHG emission associated with them. This multi-sectoral public-private collaboration aims to accelerate the process of adoption of best-practice policies and implementation of building efficiency projects in cities across the world, with the goal of doubling the rate of energy efficiency improvement in the building sector by 2030. Further information on the BEA is available at www.buildingefficiencyaccelerator.org.

## Nagpur's Building Efficiency Actions under the BEA Deep-Dive Engagement

Nagpur city joined the BEA Initiative in April 2018 to become one of 52+ partner cities from 25 countries. Given the city's past and on-going initiatives on renewable energy and energy efficiency, Nagpur was selected as a deep-dive city and received assistance through the BEA on identifying building energy efficiency actions, developing work plans and implementing policies, projects and tracking methods to fulfil its BEA commitments.

The NMC and NSSCDCL, are both partners to the BEA engagement in the city, with NSSCDCL coordinating project implementation from the city's side. This BEA deep-dive technical assistance was implemented by ICLEI-Local Governments for Sustainability, South Asia (ICLEI South Asia) with the support of World Resources Institute (WRI), an organization that leads global coordination of the BEA.

Key activities undertaken to address energy efficiency in Nagpur's housing under the BEA deep-dive engagement include:

- **Design Review of Nagpur Smart City's 'Home Sweet Home' affordable housing scheme** of about 900 dwelling units. The design review identified suitable design measures that can be adopted to enhance building energy performance as well as thermal comfort levels of inhabitants.

- **Preparation of a technical guideline to support development of energy efficient housing** in the city. This guideline provides energy efficient measures which can be adopted by various stakeholders in Nagpur across the stages of design and construction of future homes.

Through close collaboration of NMC, NSSCDCL and BEA project partners, the **"Guidelines for Energy Efficient and Climate Responsive Homes in Nagpur"** have been formulated and are customized for Nagpur city, taking inputs from existing national building efficiency policies and standards. The Guideline presents locally adoptable principles and energy efficient measures that cover aspects from the building design stage to materials, energy efficient appliances and renewable energy generation at site.

The Guideline document has been prepared so that it can be easily used by all stakeholders such as individuals, city officials, architects, builders & developers to create comfortable homes that have low climate impact and are healthier spaces to live in.

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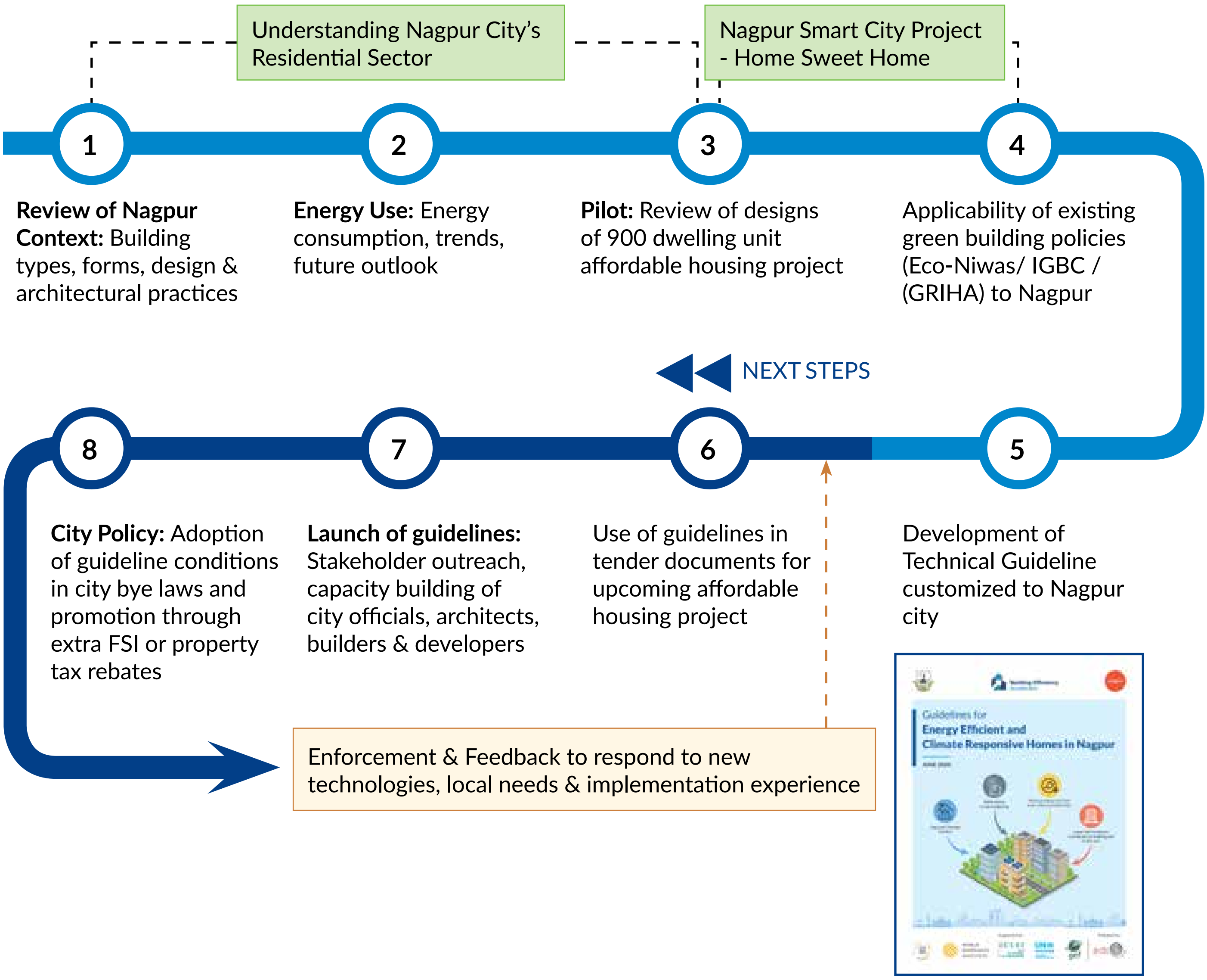
Population based on Census of India, 2011

**To capture and communicate key information and recommendations** from Nagpur's Guidelines for Energy Efficient and Climate Responsive Homes to government officials and local stakeholders, **five factsheets have been prepared.** These five factsheets presented in this document are:

1. Introducing the Guidelines
2. Form & Orientation, Building Envelope & Materials
3. Day Lighting
4. Thermal Comfort
5. Towards Net Zero Energy Buildings

## Nagpur's Energy Efficient Housing Roadmap – Where the city stands and Way Forward:



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# Building Energy Efficient and Climate Responsive Homes in Nagpur:
# Introducing the Guidelines

**Factsheet - 1**

Nagpur falls under
**“Composite”** climate Zone

**Summer**
Hot & Dry
(27 to 45°C)

**Monsoon**
Warm & Humid
(18 to 35°C)

**Winter**
Cold & Dry
(4 to 25°C)

Nagpur has about
**0.55 million**
residential properties that*

Consume
**1.09 billion kWh**
of electricity per year

Contribute around
**0.90 million** tons
of $CO_2e$

Consume electricity
contributing to
**33% of** Nagpur’s
GHG emissions

**Energy efficient homes** have significant economic benefits over their life cycle along with lower **GHG emissions.**

**Nagpur** faces harsh summers with heat waves prevalent. In comparison, the temperature drops significantly during its winters. With Nagpur’s local climate and resulting high electricity use in residences, safer and comfortable homes are needed for people from all walks of life.

Homes in Nagpur need to be designed and built as passive habitats that are responsive to micro climatic conditions, environmentally sustainable as well as cost effective.

**“Climate Responsive Design’** is based on local climatic conditions and takes advantage of natural elements like Sun and Wind to create livable and comfortable homes by effectively ‘locking in’ thermal and visual comfort”

**Benefits of Climate Responsive Design of Buildings**

- Improved Thermal Comfort
- Better access to natural lighting
- Reduced energy cost from lower reliance on electricity
- Lower GHG emissions contribution by building over its life span

*all figures are from 2017-18

*September 2020*

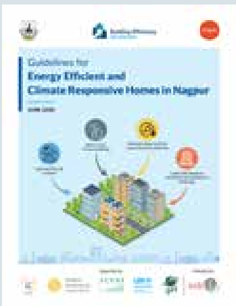
## How to BUILD in response to LOCAL CLIMATE?

Modern building methods depend on **artificial materials, advanced technologies, and fossil fuels** to keep **residents comfortable and safe** but can often have negative environmental impacts

Over long periods of time, by trial and error, vernacular building solutions have evolved based on **local climatic conditions.** Integrating vernacular features helps to improve the **comfort and energy performance** of the homes we create.

**Climatic responsiveness** is achieved by appropriately orienting and siting the **buildings, carefully designing the building envelope (roof, walls, windows, floors),** and selecting the right material for construction, keeping in mind the local climate.

The most economical way to **achieve good climate responsive homes** is by making improvements in how they are **designed and constructed.**



The **"Guidelines for Energy Efficient and Climate Responsive Homes in Nagpur"** is a technical guiding document containing specific design principles and recommendations.

The Guidelines are prepared under Nagpur city's work as part of the Building Efficiency Accelerator initiative of the UN and aim at supporting creation of comfortable homes that are healthier spaces to live in with low impact on the environment.

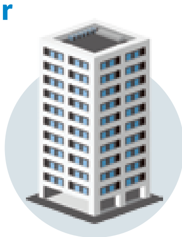
The Guidelines can be applied at various stages while building homes and will help the users in:

- **Siting and orientation of buildings**
- **Design of building envelope**
- **Selecting the right building materials**
- **Choosing suitable renewable energy technologies**

The Guideline is applicable for
**Independent Houses, Bungalows and Apartments in Nagpur**


Independent Houses


Bungalows


Apartments

## Who can use this GUIDELINE DOCUMENT?


**Architects**


**City Government Engineers & Officials**


**Real Estate Developers & Builders**


**Homeowners**

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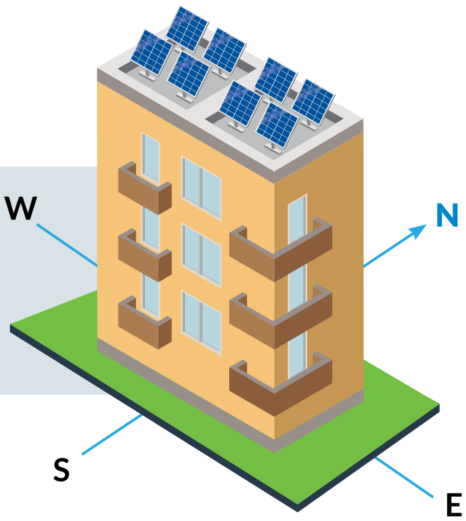
For more information on the Guidelines and specific topics, please see the four other factsheets in this series on **Building Envelope & Materials, Day Lighting, Thermal Comfort, and Transitioning to Net Zero Energy Buildings.**

# Building Energy Efficient and Climate Responsive Homes in Nagpur:

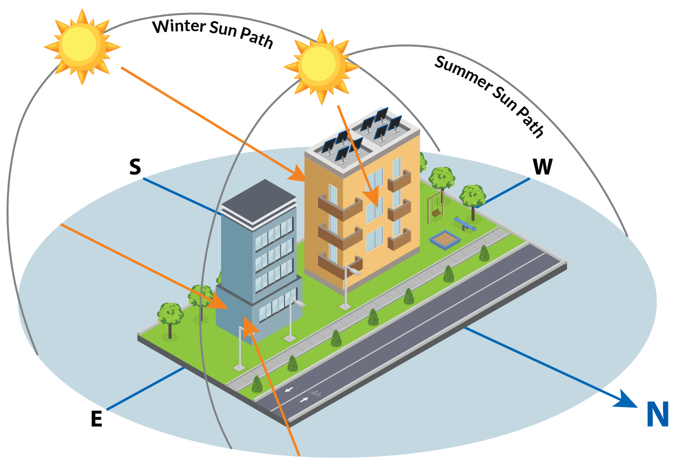
## Form & Orientation, Building Envelope & Materials

Factsheet - 2




### Building Orientation

- Longer Facade (exterior wall) should face towards North.
- Facades facing East/West directions should avoid openings or keep these minimal.




#### Summer

Sun is at a higher angle, and providing openings on the North facade enables glare free day light and lower solar heat gain even without any additional shading.

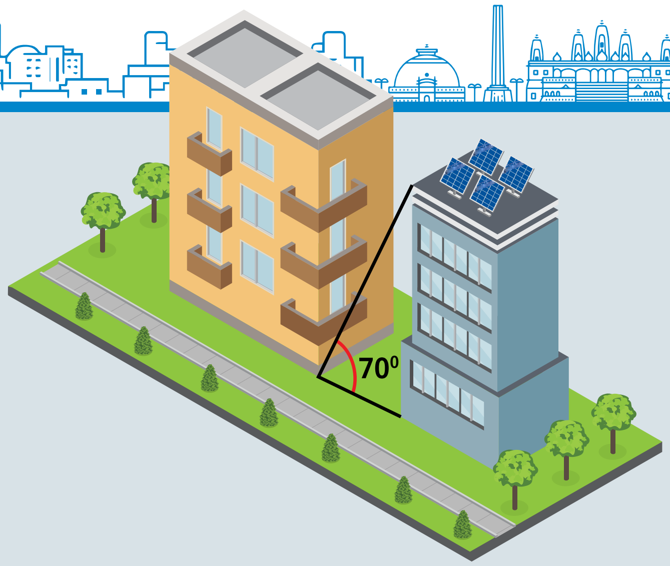
#### Winter

Sun is at a lower angle, and sun light penetrates deeper through openings in the south facade providing adequate day light and warmth during the colder months of the year.

### Building Spacing

In case of clusters of buildings, keeping the right distance between adjacent buildings ensures adequate natural light to all floors of a building.

For optimum access to natural light, angle of obstruction between two adjacent buildings shall be <70°, which can be achieved by increasing spacing between buildings.

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## Window sizing for optimal daylight

- Keep the Window-to-Wall Ratio to a maximum of 0.3
- Minimize window area on the east and west facades; especially in the west direction.
- For adequate illumination, keep the breadth of indoor spaces with exterior walls at 1.5 to 2 times the window height.
- Increase surface area of window opening. Tall and narrow windows are preferable for Nagpur's climate.


## Form and Surface to Volume Ratio (S/V)

- Compact forms such as a square form (low S/V ratio) will have lower heat gain as compared to a long and narrow form (high S/V ratio) but will have less surface area available for day lighting.
- Architectural decisions on form and S/V ratio should carefully consider the potential for day lighting and associated solar heat gain.

### Form of buildings with similar built-up area

- Built-up area **1200m²**
- Floors **3**
- Floorplate **28.6m X 14m**
- Form **Rectangular**

**Better For Day Lighting**

- Built-up area **1200m²**
- Floors **3**
- Floorplate **20m X 20m**
- Form **Square**

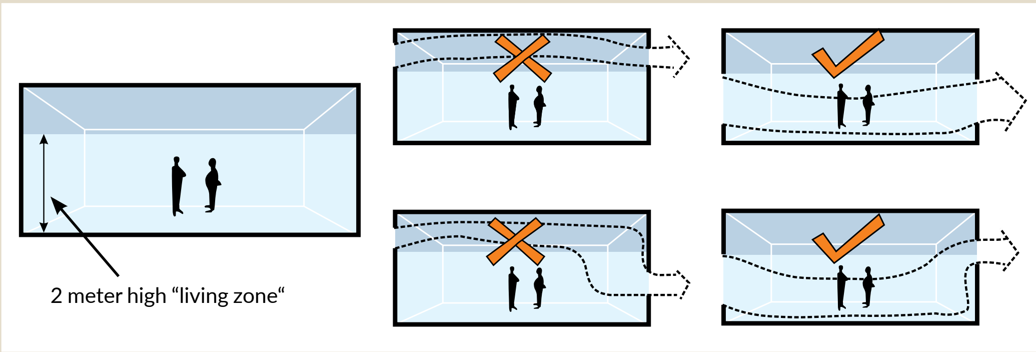
**Better For Thermal Comfort**

## Ventilation at Site

Arrange buildings in ascending order of their heights and in staggered manner to allow for air flow throughout the site and better natural ventilation

## Natural Ventilation

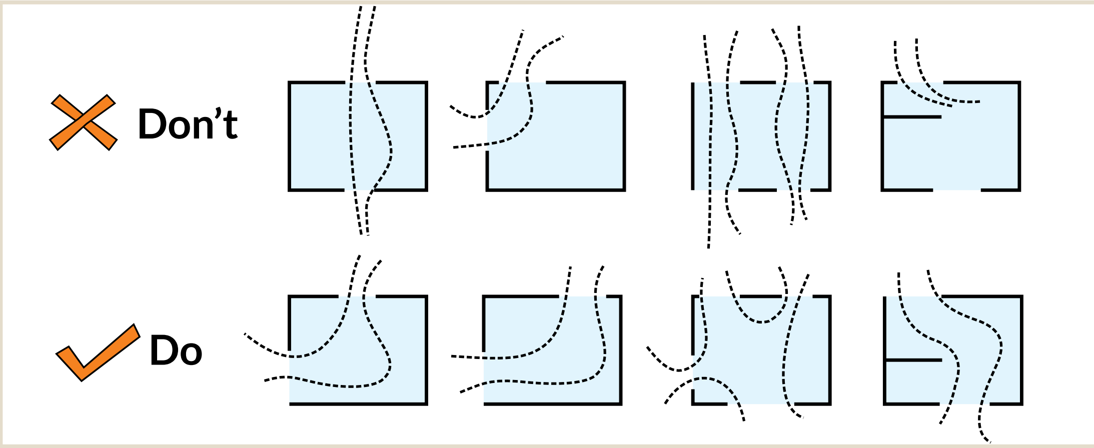
Good natural ventilation brings in fresh air and improves thermal comfort of homes. Designing a building envelope that allows for cross ventilation is the most basic and cost effective technique for achieving better natural ventilation in homes.




Optimal design and location of openings by carefully considering the carpet area & prevailing wind is important to achieve desired cross ventilation.

*Source: https://nzeb.in/knowledge-centre/passive-design/natural-ventilation/*

Location of façade openings and interior partitions influence the route of air flow through a space

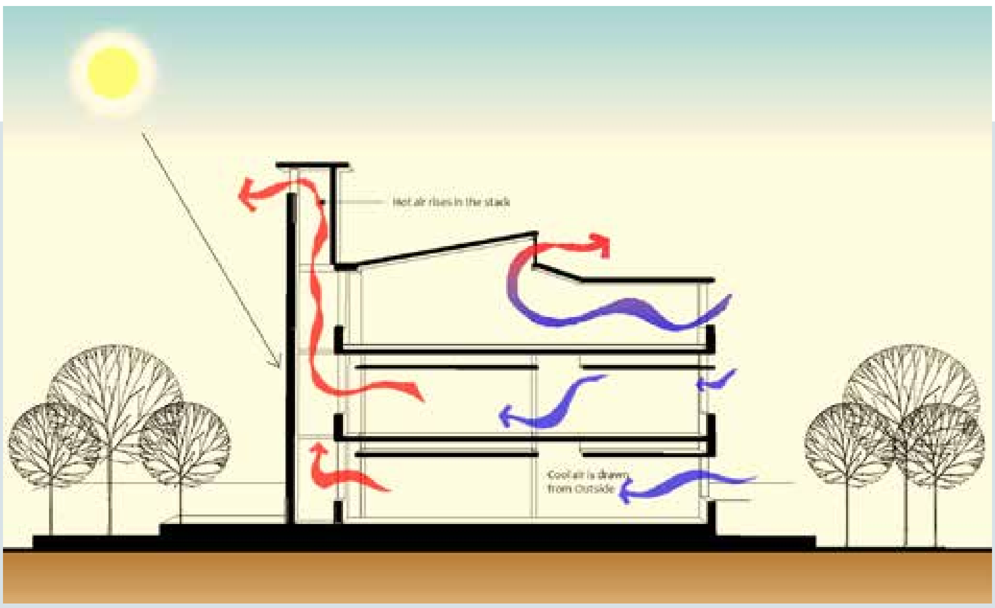



**Advanced ventilation techniques** such as stack effect, courtyard effect, earth air tunnels and evaporative cooling can work effectively for Nagpur's climate. Stack effect is a viable and commonly used ventilation technique.

## Stack effect

Stack effect in buildings occurs at vertical passages such as stairwells, elevators, or shafts when air inside the building becomes warmer than the air outside.

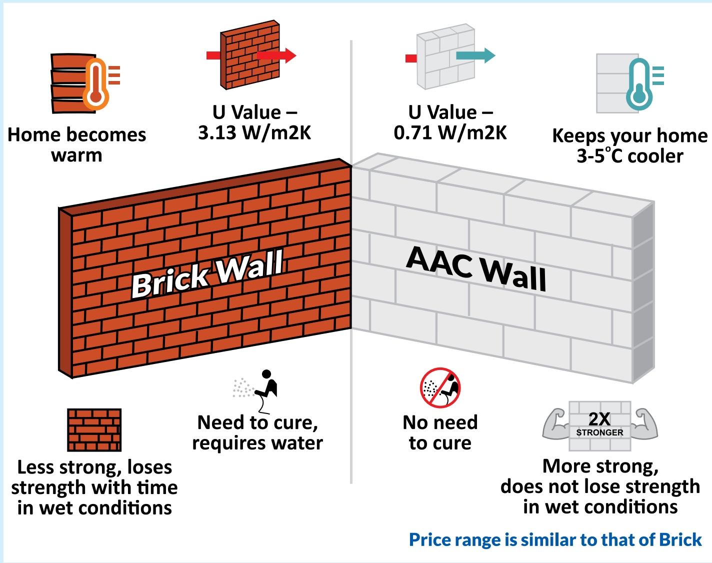
Ventilation cum utility shafts in high rise buildings are a good example of application of stack effect for natural ventilation.




*Source: https://nzeb.in/knowledge-centre/passive-design/natural-ventilation/*

## Building Materials

Choosing the right building material with suitable heat transfer coefficient (U-Value) for envelope components such as wall, windows and roofs, gives better thermal performance and keeps the indoor temperatures comfortable.




## Walls

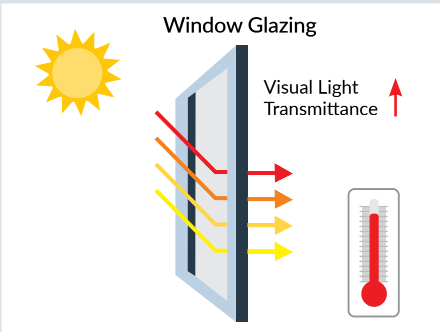
Replace regular bricks with sustainable materials such as Autoclaved Aerated Concrete (AAC) blocks for walls.

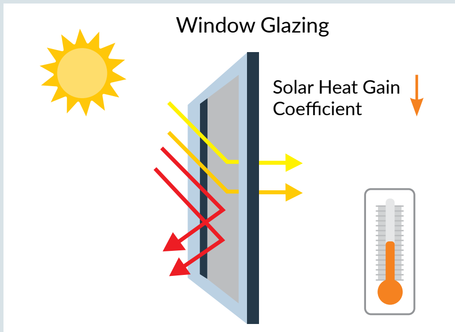
Walls can also be built with insulation materials such as EPS/XPS insulation panels, rockwool, and providing air gaps within the walls to significantly reduce the heat transfer from the building exterior.

## Glazing for building openings

Based on the location and orientation of the opening, glass materials with the right combination of Solar Heat Gain Coefficient (SHGC) and Visual Light Transmittance (VLT) parameters should be chosen.

Lower SHGC (more tinted) glass reduces heat ingress but prevents light to pass through, thereby, affecting the daylighting in the space. On the other hand, high VLT glass (less tinted/clear) transmits adequate light but can significantly increase the indoor temperatures.




## Cool Roofs

Roofs receive direct sun light and have high heat gain. Nagpur, with predominantly independent houses, can reduce daytime heating of buildings and heat island effect by using insulation material/ adhesives with high solar reflectance index such as china mosaic tiles and white coating for roofs. Roofs can also be covered with vegetation (Green Roofs).

White coating on the roofs

China Mosaic Tiles

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For more information on the Guidelines and specific topics, please see the four other factsheets in this series on **Introducing the Guidelines, Day Lighting, Thermal Comfort, and Transitioning to Net Zero Energy Buildings.**

# Building Energy Efficient and Climate Responsive Homes in Nagpur:

# Day Lighting

Factsheet - 3

## Passive Day lighting Strategies for visual comfort at homes

### Building Orientation

Buildings with longer façade (external walls) and window openings oriented towards the North direction can get more indirect sun light with minimum heat gain.

*(Refer Factsheet 2 for more info)*

### Window Sizing

Increase window surface area within Window-to-Wall Ratio (WWR) limits on North & South facades, and minimize window area on East and West facades.

### Skylights

Traditional Indian 'Jaali' is an excellent example for passive design of buildings to achieve optimal day lighting.

Solar tubes can be used to illuminate poorly lit indoor spaces especially ones that receive little day lighting from sun.

### Shading Devices

Design shading devices based on the type of window and its orientation to maximize day lighting and minimize glare from direct sun light.

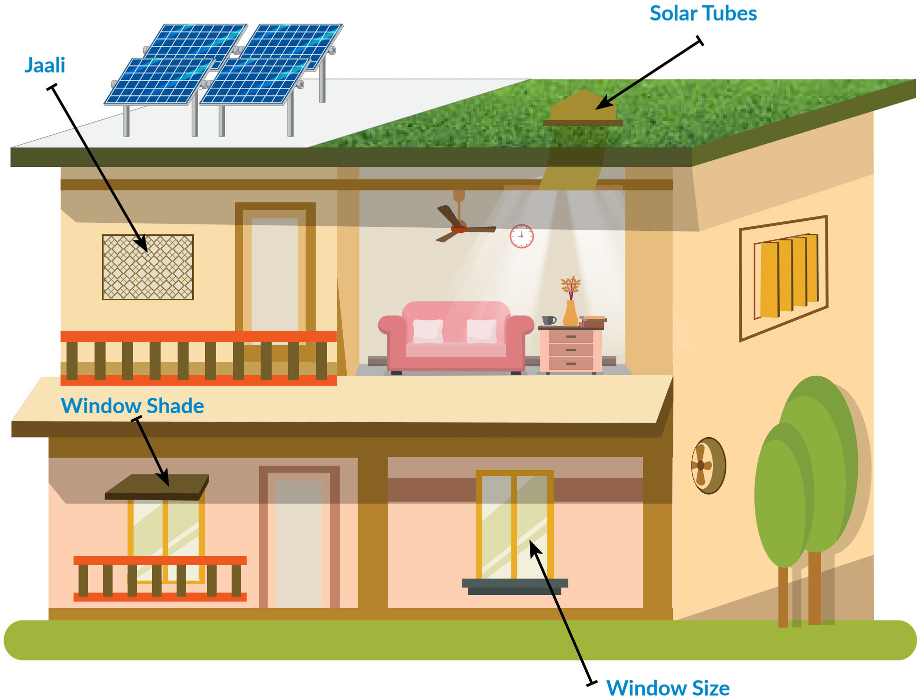
**North** – Minimal Horizontal shading or No shading is required

**South** – Horizontal shading like overhangs and external louvers would work

**East & West** – Both Vertical & Horizontal shading is necessary

### Indoor Aesthetics

Lighter color paint should be preferred for the indoor space to enable reflection and better day lighting

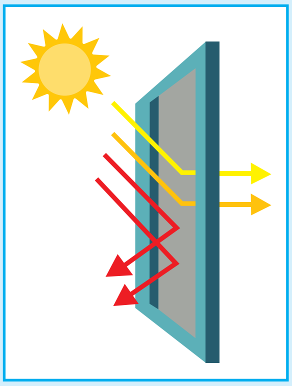



### Window Glazing

Select window glazing that has a good balance between allowing day light to pass through (higher VLT) and restricting heat gain (lower SHGC). The VLT of glazing should be at least 27% for Window-to-Wall Ratios (WWR) between 0 to 0.3.

**Visual Light Transmittance (VLT)** is the amount of light that passes through glazed material. Higher the VLT, higher is the day light received inside the building through the glass.

**Solar Heat Gain Coefficient (SHGC)** impacts the amount of solar radiation (heat) that is transmitted by the glass. Lower SHGC value allows less heat gain and can keep the building cooler.



Please refer to Eco-Niwas Samhita to discover more techniques and methods to make your home green. Link: http://www.econiwas.com. It's an initiative of Bureau of Energy Efficiency, Government of India.

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# Good Practices for optimal and efficient day lighting

## Window Design:

1. Tall and narrow windows increase depth of day lighting
2. Splay the windows for reduced glare from direct sun light
3. Recess widows to reduce heat gain and glare, especially in the East/West facades
4. Select window glazing and sizing at the same time to achieve the right combination

**Splayed Window**

### Lighting Control

Manually controlled window louvers, interior shades etc. and sensor based switching and brightness control devices where appropriate would enable optimal day lighting and lower energy costs.

### Integration with Mechanical System Design

Mechanical energy calculations during glazing selection, window sizing, shading design can help in reducing cooling loads with optimal day lighting.

### Glazing Factor Approach

Glazing Factor (GF)* calculated from area of window, floor area and VLT of glass can be used to check adequacy of day lighting in a specific type of space.

*Glazing Factor (GF) = [Window Area (sq. m.)/ Floor Area (sq. m.)] X Actual VLT of Glazing X Constant X100

Indian Green Building Council (IGBC) recommendations for GF : Living Room – 1 | Bedroom/study room – 1 | Kitchen - 2

# Good Daylighting Conditions

**Before**

**After**

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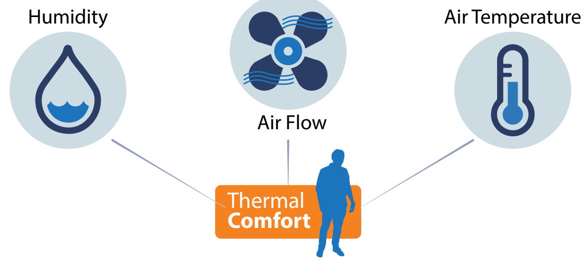
# Building Energy Efficient and Climate Responsive Homes in Nagpur: Thermal Comfort

Factsheet - 4

## What is Thermal Comfort?

Human beings are more comfortable with temperatures from 24 °C to 27°C and relative humidity in the range of 30% to 60%. Designing your homes to passively achieve these comforts levels will also enable significant cost and energy savings




## Cooling Strategies for Thermal Comfort at Homes

### Self-Shading design features for building envelope

Self-shading envelope design that includes balconies, inclined walls or other architectural projections can shade building openings as well as wall & roof surfaces, thereby, significantly reducing solar heat gain.

Window placement and design should allow for natural ventilation while shading direct sunlight to minimize solar heat gain and visual glare

### Cool or Green Roof

Cool roofs are designed to reflect more sunlight and absorb less heat than standard roofs, through the use of highly reflective materials.

Green roofs reduce heat ingress and heat island effects while providing an opportunity for urban farming, rainwater management and can also be used as recreational spaces.

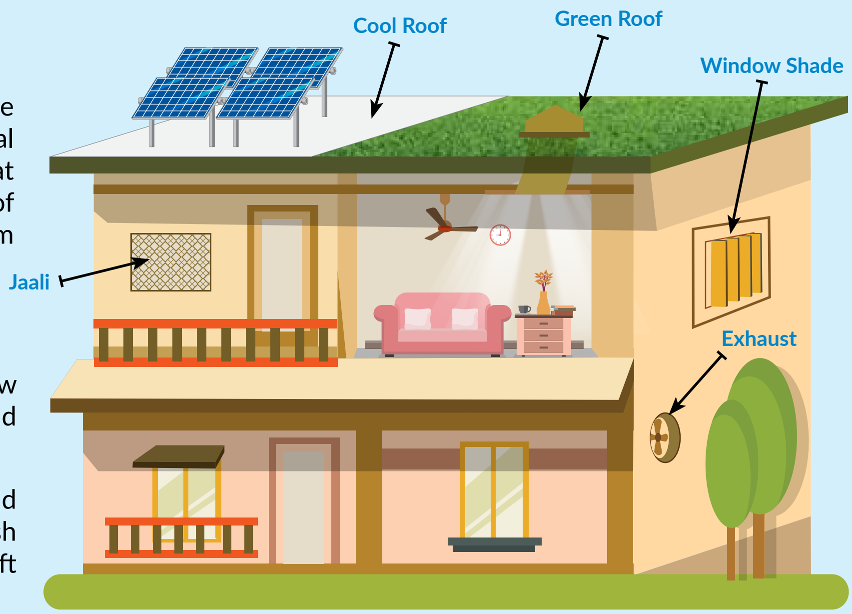
### Natural Cooling of Buildings

Strategies like radiant cooling, evaporative cooling, earth coupling and natural ventilation avoid or reduce a building's heat gain by combining architectural features of the building with the energy available from the natural environment.

### Forced Ventilation

Ceiling and exhaust fans support air flow through spaces, enabling optimal natural and cross ventilation at homes

Ventilation shafts fitted with propeller and centrifugal fans at the exhaust side force fresh air into the building by inducing negative draft and enable optimal cooling




During the design and construction stage, **well-informed architectural decisions** with respect to **a building's form & orientation, envelope and the choice of buildings material** can significantly improve its thermal comfort levels.
*(Refer to Factsheet 2 for more info)*

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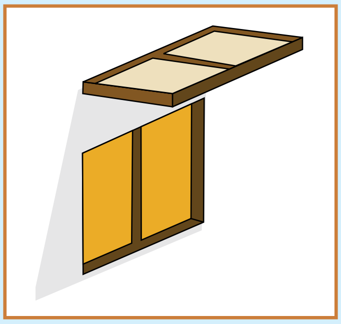
# Designing of window shading devices

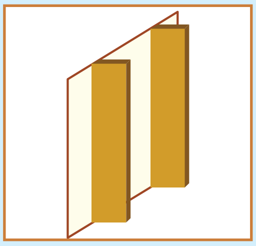
Due to Sun's angle of incidence with any building in Nagpur, North facing windows hardly receive direct irradiation, contributing to minimal heat gain. However, windows facing other directions need to be adequately shaded for better thermal performance.

**North:**
Horizontal overhang = ¼ th of the window height, is adequate to shade North facing windows completely.

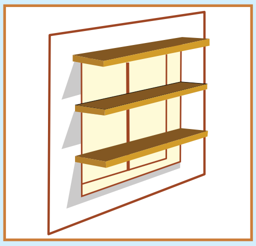


**South:**
Horizontal overhang = ½ of window height, is required to shade the direct radiation from penetrating south facing windows.

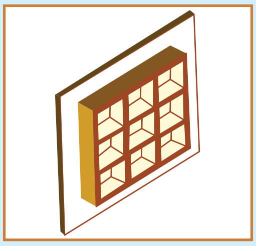
**East/West:**
Combination of horizontal & vertical shading devices is necessary to minimize solar heat gain by effectively shading the low angle solar radiation during morning and evening hours of a day.



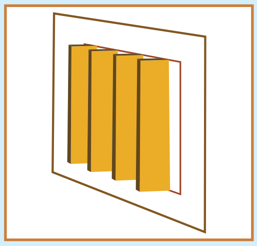
Vertical Side fins



Multiple Horizontal Overhangs



Egg Crate



Vertical fins/louvers

**Shading control:**
Provide adjustable external shading devices when necessary to control solar heat gain and internal blinds to adjust for glare from sunlight in South/West/East facing windows.

# Good Practices for improving thermal comfort and energy efficiency at homes

**LANDSCAPING:** In individual homes & bungalows, planting deciduous trees on the East, South & West side of the house keeps heat away in the summer season and adds warmth during the winter season.

**AIR CONDITIONER OPERATION:** Positioning ACs at a height of 7-8 feet from the floor, and operating ACs at high setpoint temperatures (>23°C) along with ceiling fans provides better human thermal comfort and reduces energy consumption due to uniform & faster cooling of space.

**INTERNAL HEAT GAIN:** Internal heat gain and cooling loads can be reduced by aggressively minimizing plug load heat gains inside a space.

**ADEQUACY OF NATURAL VENTILATION:** Window-to-floor (WFR op)* ratio is a commonly used approach to check adequacy of natural ventilation in a dwelling unit. For composite climate of Nagpur, **minimum of 12.5% $WFR_{op}$ is recommended** by India's Energy Conservation Building Code for residential buildings.

$*WFR_{op} = Area_{openable} / Area_{carpet}$

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# Building Energy Efficient and Climate Responsive Homes in Nagpur:
# Towards Net Zero Energy Buildings

Factsheet - 5

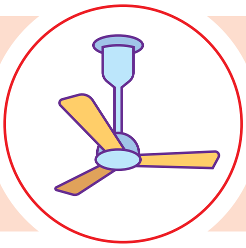
## Energy Efficient Technologies for Home Appliances

Technological advancements and energy efficiency policies of India have significantly improved the energy performance of typical household appliances; helping to reduce the energy consumption in our homes potentially by 30 – 50%.

### Ceiling Fans

Brush Less Direct Current (BLDC) motor based fans

BLDC fans consume only 25 to 35 Watts of electricity, which is about half of what a conventional ceiling fan would consume.

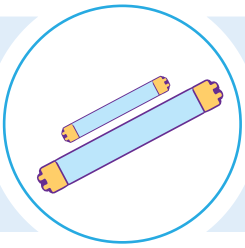


With ceiling fans used in most homes for cooling, using energy efficient BLDC fans will realize considerable cost and energy savings.

### Tube Lights

Light Emitting Diode (LED) filament lamps

LED lamps consume about 18 Watts for the same lighting levels as conventional tube lights, which typically consumes 40 Watts.

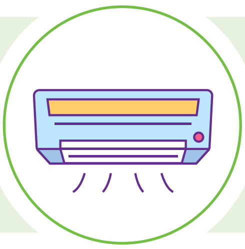


Use of energy efficient lighting devices like LED lamps ensures 20-30% energy savings and significant cost savings.

### Air-Conditioners

Invertor Compressor based / heat pump

40% of energy consumption in typical Indian homes is for air conditioning. Investing in efficient ACs significantly reduces associated operational costs.



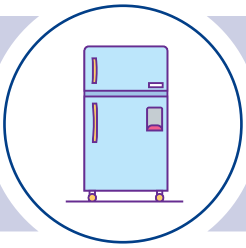
Heat pumps can operate in heating and cooling mode, thus can replace air conditioners and room heaters.

*September 2020*

## Refrigerators/Freezers

Invertor Compressor based refrigerators

Invertor compressor based refrigerators consume about 20-40% less electricity than conventional refrigerators.

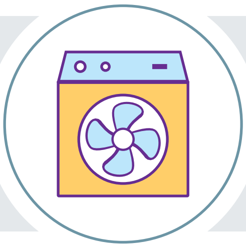


Inverter compressors have longer life span due to low wear and tear and produce less noise, making them ideal for home use.

## Air Coolers

Multi Stage Evaporative Coolers

Multi stage evaporative coolers have better energy performance due to their higher cooling efficiency (90%) compared to conventional pad based coolers (65%). This is significant for Nagpur, where citizens have to use air coolers during summers.



Water consumption of multi stage coolers is very low due to their efficient water evaporation mechanism, thus energy required for pumping the water through the coolers is also lower.

## Washing Machine

Digital inverter and /or Direct Drive based

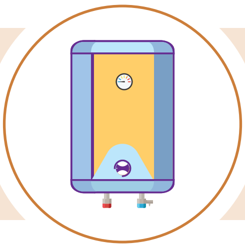
Direct Drive motors are highly efficient for use in washing machines due to reduction in moving parts and associated friction, noise and vibrations.

Opt for washing machines using Direct Drive motors, in combination with digital inverter technology, that operate optimally based on washing load and also improve the energy and washing efficiency of the machines.

## Water Heater

Low Standing Losses / Heat Pump

Among conventional water heaters, models with low standing losses, and advanced energy saving features based on timers and sensors consume significantly less energy.

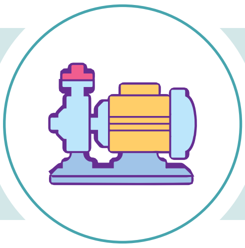


Heat pump water heaters consume only 20% of energy compared to conventional electric heaters to heat the same quantity of water and can also provide cooling simultaneously.

## Water Pump

Variable Frequency Drive (VFD) based/BLDC motor based

BLDC motor based pumps consume less energy, have low wear and tear and are less noisy.



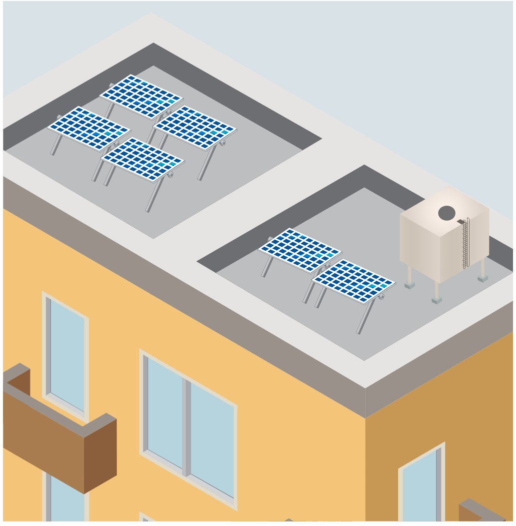
Energy consumption of VFD equipped AC motor pumps is lower than conventional motors, especially when continuously or frequently operated in residential apartments.

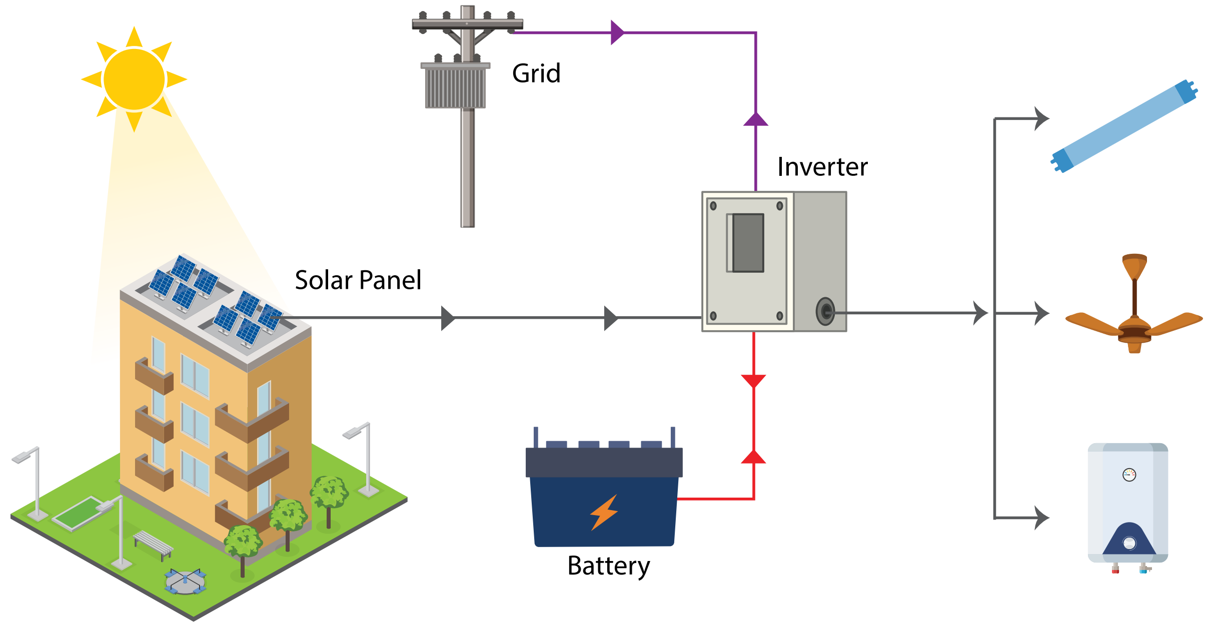
## Renewable energy for residential applications

A Solar Photovoltaic (PV) system installed on the rooftop of an individual house or an apartment will generate clean energy to meet its energy demand.

### Strategies to enable Solar PV installation on rooftops:

- Place Over head water tanks (OHT) towards the Northern part of the roof to reduce the chances of such tanks casting a shadow and impacting energy generation of Solar PV panels.
- Ensure adequate space on the roof for installing PV panels (1 kW of solar PV installation requires 7 to 10 sq. m of area)
- Accommodate an additional dead load of 30-40 kg/sq. m on the building roof while designing the building structure.
- Take future expansion of nearby buildings and growth of trees into consideration and plan for panel mounting accordingly. Elevated mounting should be considered if shading is an issue.
- Allocate a utility space on the roof to house system components such as inverters, and in case of off-grid systems a dedicated utility room (with adequate ventilation) is required to house the batteries.






### Two types of roof-top solar PV system

**1 Battery based off-grid system**

**2 Net-metering based grid connected system**

Off grid solar PV systems with battery backup can function as a supplementary source of power but batteries significantly add to the capital and operation and maintenance (O&M) cost. Batteries are more suited for small scale systems connecting to only essential loads in a building.

In cases where the power generation of roof-top solar PV system exceeds the power requirements of the house, especially during summers, net-metered grid connection allows residents to export and sell excess solar power generated to the grid.

Nagpur's residents looking to connect their roof-top solar PV systems with MSEDCL's network can find more information in Maharashtra Electricity Regulatory Commission's 2015 Net-Metering Guidelines at this link:

*https://www.mahadiscom.in/consumer/solar-rooftop-net-metering/*

## Solar Water Heater system

Solar Water Heaters consist of roof-mounted solar collectors that absorb solar radiation and use it to heat water, which can be stored in a tank to supply for home use.

**Two commonly used Solar Hot Water Systems for homes:**

1. Flat Plate Collectors
2. Evacuated Tube collectors

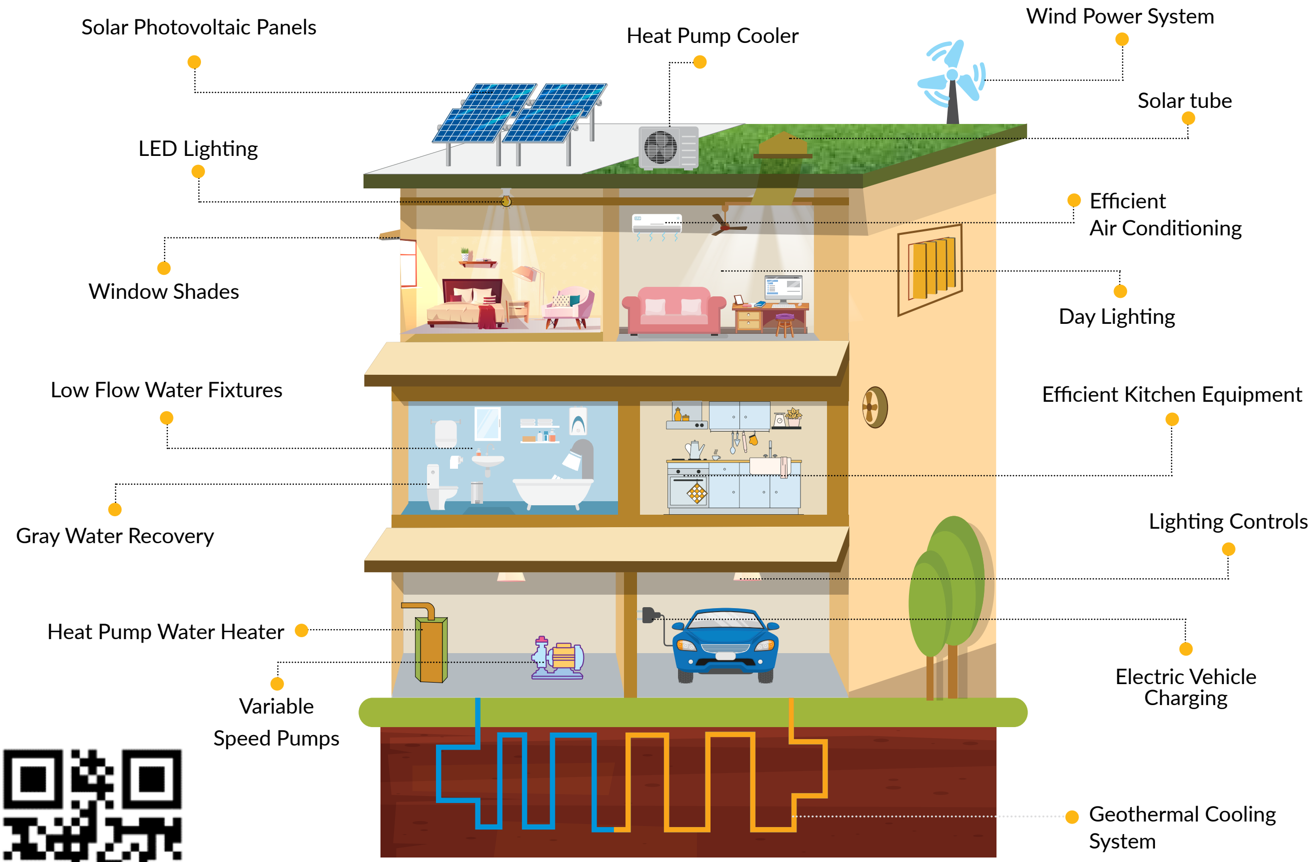
The average hot water demand in Indian homes, for a family of 4 members, is about 100 litres per day (LPD). This requires a solar collector area of approximately 2 sq. m and a tank of 100-150 litres size to account for the heat losses during storage.

Flat Plate Collectors

Evacuated Tube collectors

## Towards NZEB

Net or nearly zero energy buildings (NZEB) are highly efficient buildings with extremely low energy demand, which is met by using renewable energy sources (RES), when accounted for annually. For a building to move towards being net zero energy, the logical approach is to reduce energy demand using energy efficient solutions, and to meet the residual demand with RES. The Indian Green Building Council (IGBC) has developed the 'Net-Zero Energy Rating', which provides a structured guideline to achieve Net Zero Energy buildings in India, including for residential sector.




*For more information on NZEB, please refer to https://nzeb.in/*

*Nagpur is a Building Efficiency Accelerator (BEA) partner city. The Technical Guidelines for Energy Efficient and Climate Responsive Homes in Nagpur were prepared through the collaboration of Nagpur Municipal Corporation, Nagpur Smart and Sustainable City Development Corporation Ltd., ICLEI South Asia, World Resources Institute and technical experts from Environment Design Solutions Pvt. Ltd., with the BEA initiative's support.*

For more information on the Guidelines and specific topics, please see the four other factsheets in this series on **Introducing the Guidelines, Building Envelope & Materials, Day Lighting, and Thermal Comfort.**

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