Building Efficiency Accelerator

.nagpur

ZERO CARBON BUILDINGS ACTION PLAN – NAGPUR

Supported by

WORLD RESOURCES INSTITUTE

gef

UN environment
United Nations Environment Programme

Prepared by

ICLEI
Local Governments for Sustainability
SOUTH ASIA

Title: Zero Carbon Buildings Action Plan – Nagpur

April 2023

The Zero Carbon Building Action Plan for Nagpur was led by the Nagpur Municipal Corporation and Nagpur Smart and Sustainable City Development Corporation Ltd. and developed jointly with the implementing partners of the "Zero Carbon Building Accelerator (ZCBA)" project. The ZCBA project was launched by the World Resources Institute (WRI) in 2021, and supported by the **Global Environment Facility (GEF), UN Environment Programme (UNEP), World Green Building Council (WGBC) and other global partners**. Nagpur is one of the six global cities, along with Turkey and Colombia in which the ZCBA project is being implemented. ICLEI South Asia is the implementing partner for the ZCBA project in Nagpur.

The Nagpur Municipal Corporation and Nagpur Smart and Sustainable City Development Corporation Ltd. acknowledge the support provided by the project partners to advance the development of zero-carbon buildings and low-carbon development strategies in Nagpur and for the development of this action plan. The Nagpur Municipal Corporation and Nagpur Smart and Sustainable City Development Corporation Ltd. would like to thank all the government agencies, departments, institutions, private entities and stakeholders from the city for their support. The inputs from the WRI team are appreciated.

Authors from ICLEI South Asia: Akshay Kashikar, Shardul Venegurkar, Nikhil Kolsepatil

Contact
ICLEI South Asia
C-3, Lower Ground Floor, Green Park Extension, New Delhi - 110016, India
Email: iclei-southasia@iclei.org | Web: http://southasia.iclei.org

Contents

List of Tables

List of Figures

1. Background and Context

India has set a target to reduce the greenhouse gas (GHG) emissions intensity of its GDP by 45% by 2030 from 2005 levels, in its updated Nationally Determined Contribution (NDC) submitted in mid-2022. The country's urban areas contribute to 60% of its Gross Domestic Product (GDP) and are responsible for 70% of GHG emissions. With an expected addition of 416 million people by 2050, it is estimated that 50% of India's total population would reside in urban areas (Chen et al., 2022) which would further add to the embodied and operational emissions of the construction sector. Thus, it is crucial to ensure that urban development plans and buildings sector are aligned with the new urban agenda and are ready to deliver within the 'Decade of Action' by 2030 to attain the common goal of maintaining the global temperature rise well below 2 degrees.

India's Long-Term Low Carbon Development Strategy (LT-LEDS) highlights climate responsive urban planning and design, and energy and material efficient buildings as key elements of its low-carbon development transition. LT-LEDS has emphasized promoting climate-responsive and resilient building design, construction, and operation in existing and future buildings as a key strategy.

India's Building Sector Energy and Emissions Trends

India's residential building stock is expected to grow from 15.3 million sq. m. in 2017-18 to 21.9 million sq. m. in 2027-28 (Kachhawa et al., n.d.). The country's building-related GHG emissions have more than doubled from 2000 to 2017 while the indirect emissions, i.e., the embodied emissions associated with procurement, manufacturing, construction use, and disposal of building materials over the lifecycle of a building have tripled (Pallerlamudi, 2021). Over the course of the next 20-30 years, GHG emissions from India's steel and cement industry are estimated to increase by nearly three and six times, respectively. The cement industry does, however, intend to reduce its GHG emission intensity by 45% by 2050 from its 2010 levels. Brick kilns are another major source of carbon monoxide, sulphur dioxide, NOx, and other particulate emissions across the country (Pallerlamudi, 2021). India could easily experience an increase of seven times in its building energy consumption and CO_2 emissions by 2050, compared to 2005 levels (Garg et al., 2017). End-uses such as cooling are expected to drive such growth, with cooling demand in the building sector projected to increase 11 times by 2037-38 as compared to the 2017-18 baseline as per India's Cooling Action Plan (Government of India, 2019). Presently, only 4% of Indian households own RACs due to low income levels, which is likely to increase as more households get access to electricity and higher incomes, in addition to climatic conditions (International Energy Agency, 2018).

From an urban governance standpoint, this 'Decade of Action' is highly dependent on how the local governments in India revamp regulations and policies and remodel their budgets to fast-track low carbon development. To meet the housing demands of the growing urban population, IEA estimates that, India will add twice its building space in the upcoming decades with 70% of new construction coming in urban areas wherein 97% of new urban houses are being built using modern materials (International Energy Agency, 2021).

Material and energy efficiency, and uptake of low carbon materials would play major role to meet this growing urban infrastructure demand and in reducing the GHG emissions over the building lifecycle, with opportunities identified for potential emission reductions of over 50% in for the country's residential buildings (Hertwich et al., 2020).

Advancing from Energy Efficient Buildings to Zero Carbon Buildings in Nagpur

Maharashtra state is one of India's highly urbanized states and contributes about 14% to the country's economy. Nagpur, being the second capital and third largest city of Maharashtra, is experiencing rapid transformation owing to strong industrial area in the district, and growing service industry within the city along with major infra push by government such as city-wide metro rail network, and logistics hub due to its geographical position, which is near the centre of India.

With this background and with the interest shown by Nagpur city administration to further the work in the building efficiency sector, the 'Zero Carbon Building Accelerator (ZCBA), project is implemented in the city as an extension of the previously implemented Building Efficiency Accelerator project. The ZCBA program is launched by World Resources Institute (WRI) and supported by the Global Environment Facility (GEF) and United Nations Environment Programme (UNEP) in 2021. ICLEI South Asia is a regional partner of the ZCBA and is supporting Nagpur Smart & Sustainable City Development Corporation Limited (NSSCDCL) and Nagpur Municipal Corporation (NMC) for implementing the ZCBA project in Nagpur.

The Zero Carbon Buildings Action Plan for building decarbonization comprises transformative actions and strategies developed through stakeholder consultations, considering its suitability to the local context, aligned with the existing national and state policies and frameworks pertaining to building codes and bye laws.

Nagpur is in the process of preparing its new development plan with the vision of making the city more resource efficient, liveable, and sustainable. Nagpur's 'Zero Carbon Building Action Plan' is prepared at the right time and will pave the way towards decarbonising city's rapidly growing building and construction sector. This Action Plan will contribute to India's pledge to become Carbon Neutral by 2070. The plan has been prepared with the intended goal of making all upcoming new buildings to be net zero carbon by 2030 and all buildings to operate at net zero carbon by 2050.

2. About Nagpur City

Nagpur is located in central India and is an important administrative centre in the state of Maharashtra. It is one of the greenest cities in India and is also known as Orange City, being a prominent centre for the cultivation of orange fruit. Nagpur spans an area of 227.29 sq. km and houses a population of about 2.9 million as of 2020.

Being a city with tropical wet and dry climatic conditions, Nagpur experiences seasonal weather patterns with an annual average rainfall of about 1,100 mm, and is known for its hot and dry summers where temperatures can go up to 48°C in May.

Nagpur is emerging as a major medical, logistics and education hub. The peripheral areas of the city host various industries such as chemicals, cement, electrical, electronics, textile, ceramics, pharmaceuticals, food processing, wood, and paper-based industries. The city is witnessing a rise in real estate investments, especially in its larger metropolitan region due to the metro rail project and improved road connectivity.

The Nagpur Municipal Corporation is the primary agency responsible for the city's urban governance. The Nagpur Smart and Sustainable City Development Corporation Limited (NSSCDCL) is a Special Purpose Vehicle (SPV) established to implement the Government of India's Smart Cities Mission in Nagpur and supports the NMC in urban planning and infrastructure development.

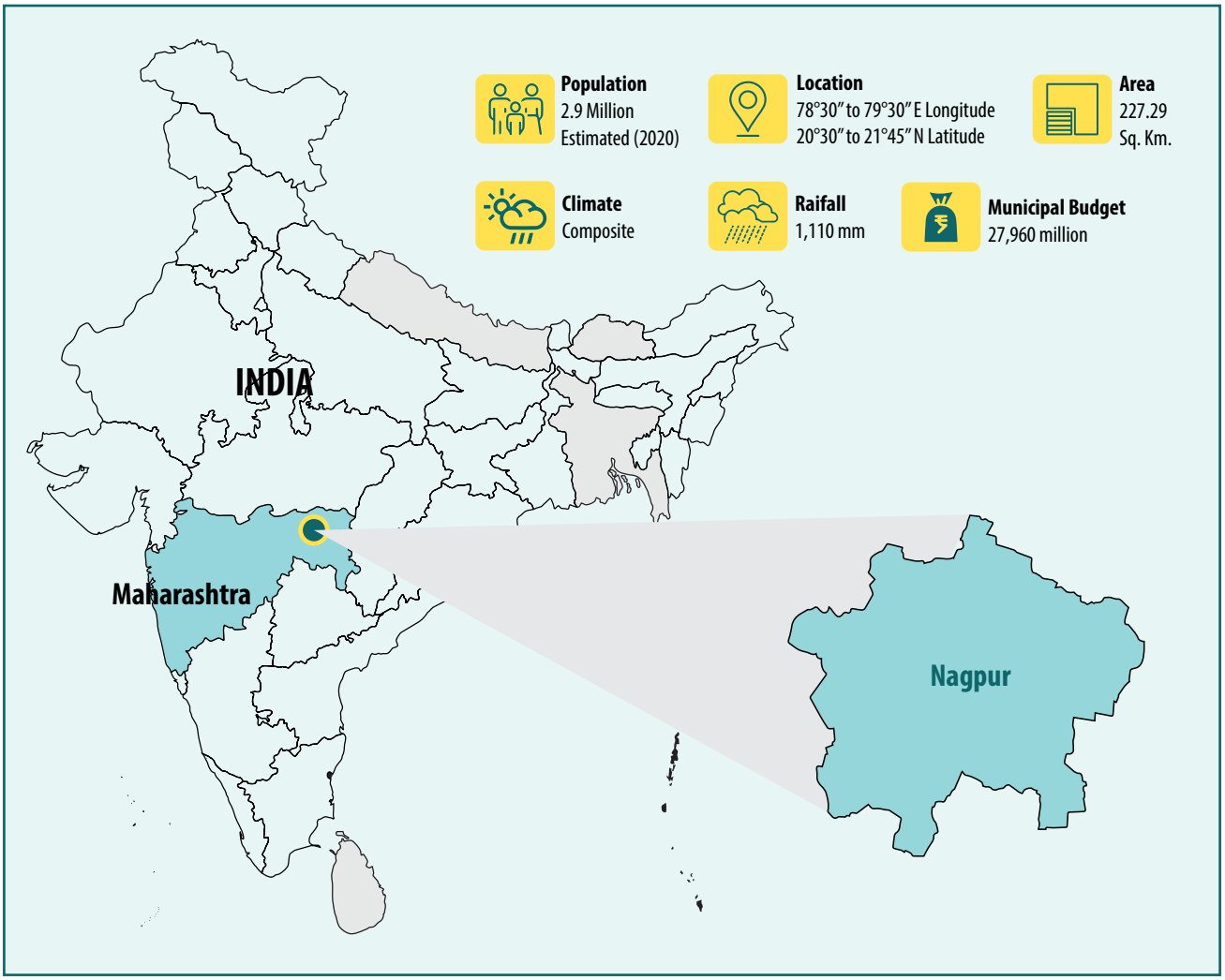


Figure 1: Nagpur city profile

3. Defining Zero Carbon Buildings for Nagpur

Over the course of its lifecycle, a building emits significant quantities of GHG emissions in the form of embodied, operational and end-of-life emissions respectively (see Figure 2). In this section, these lifecycle emissions have been elaborated along with the stages where mitigation potential is higher and ZCBs for Nagpur have been defined.

3.1. Understanding Building Lifecycle Emissions

- **Embodied emissions:** These GHG emissions result right from the extraction of the constituent raw materials to the completion of the building's construction. Embodied emissions need to be addressed from the early planning and design stage, since the potential to reduce these emissions decreases significantly as a building project advances (see Figure 2).
- **Operational emissions:** Pertains to emissions resulting from building operations, once the building is occupied and contributes to a majority of GHG emissions during the building lifecycle. This also includes any changes, additions, and alterations to the building and its machinery.
- **End-of-life emissions:** End-of-life or demolition emissions result from processing from building demolition activities and processing of the construction and demolition (C&D) waste. While end-of-life emissions are generally comparatively lower than embodied and operational emissions from buildings, management and processing of C&D waste is becoming a critical in cities.

Better information and measurement of energy and resource consumption, GHG emissions and environmental impacts across stages of the building lifecycle can help policymakers and authorities to design and implement suitable low carbon and n measures across the value chain, without restraining the development and economic benefits of the building and construction industry.

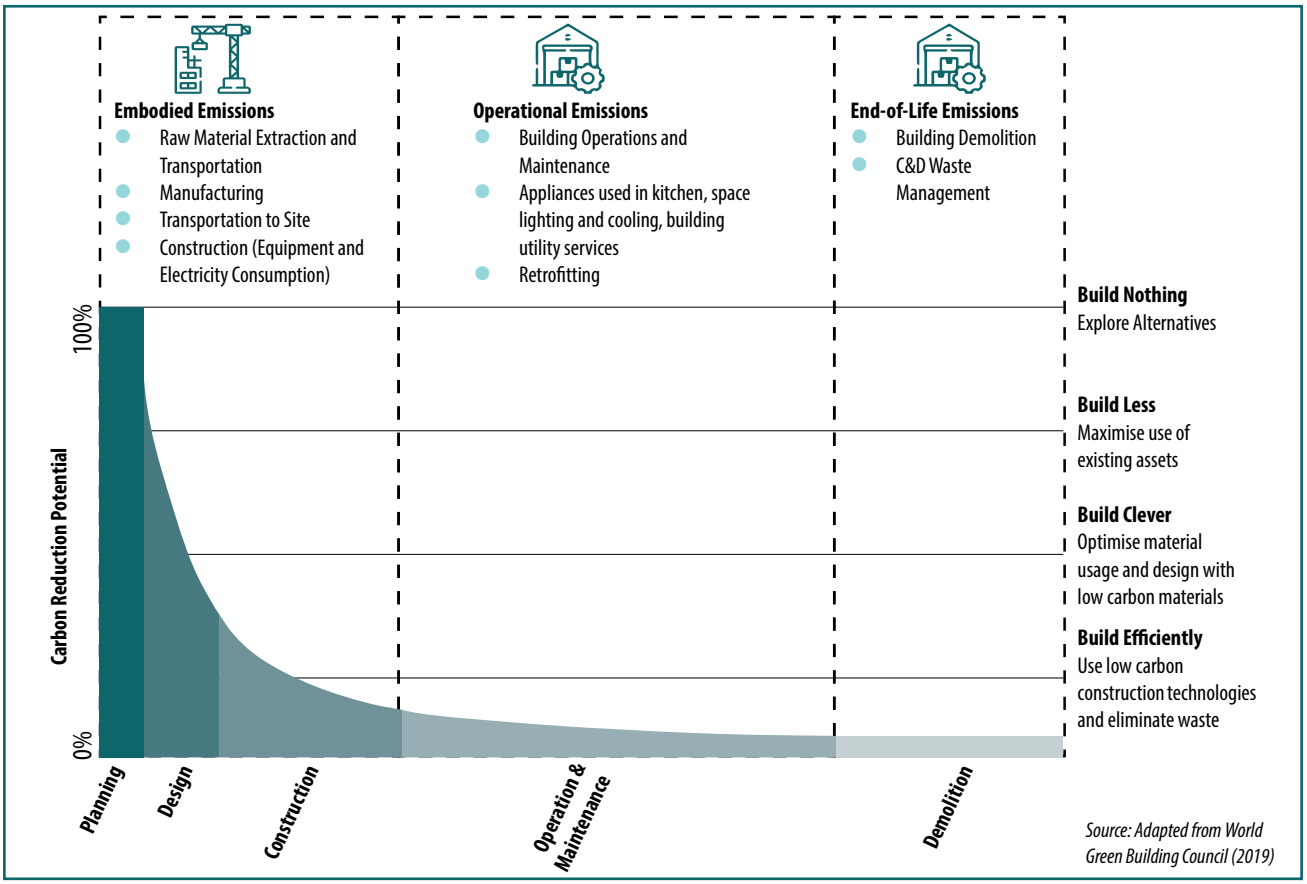


Figure 2: Sources of Energy Use and GHG Emissions in the Building Lifecycle and Carbon reduction potential in different building phases over time

Thus, there is a need and opportunities to reduce GHG emissions from the choice building materials, and how buildings are designed, built, operated and deconstructed. As shown in Figure 2, the highest potential to influence embodied and operational carbon reduction exists during the planning and design stage. This is also the stage when authorities and the industry have opportunities to explore how the existing building asset serviceability can be optimized for a longer period of time. In the subsequent stages of building, climate responsive design and opting for low carbon materials with efficient construction techniques and technologies can help to further reduce GHG emissions.

One approach is moving towards a 9R framework (Figure 3) circular economy to reduce the need to use virgin materials and optimizing the material supply chain such that the building materials are repaired and reused till they reach their redundancy. Improvements in the manufacturing process can be implemented by reducing the GHG emission due to extraction of raw materials and repurposing the existing building materials so that they can have a similar or alternative function to their original. Above all, any solution, whether to reuse the materials or to dispose-off the materials or to repurpose the materials, would need to consider the overall direct and indirect GHG emissions associated with them.

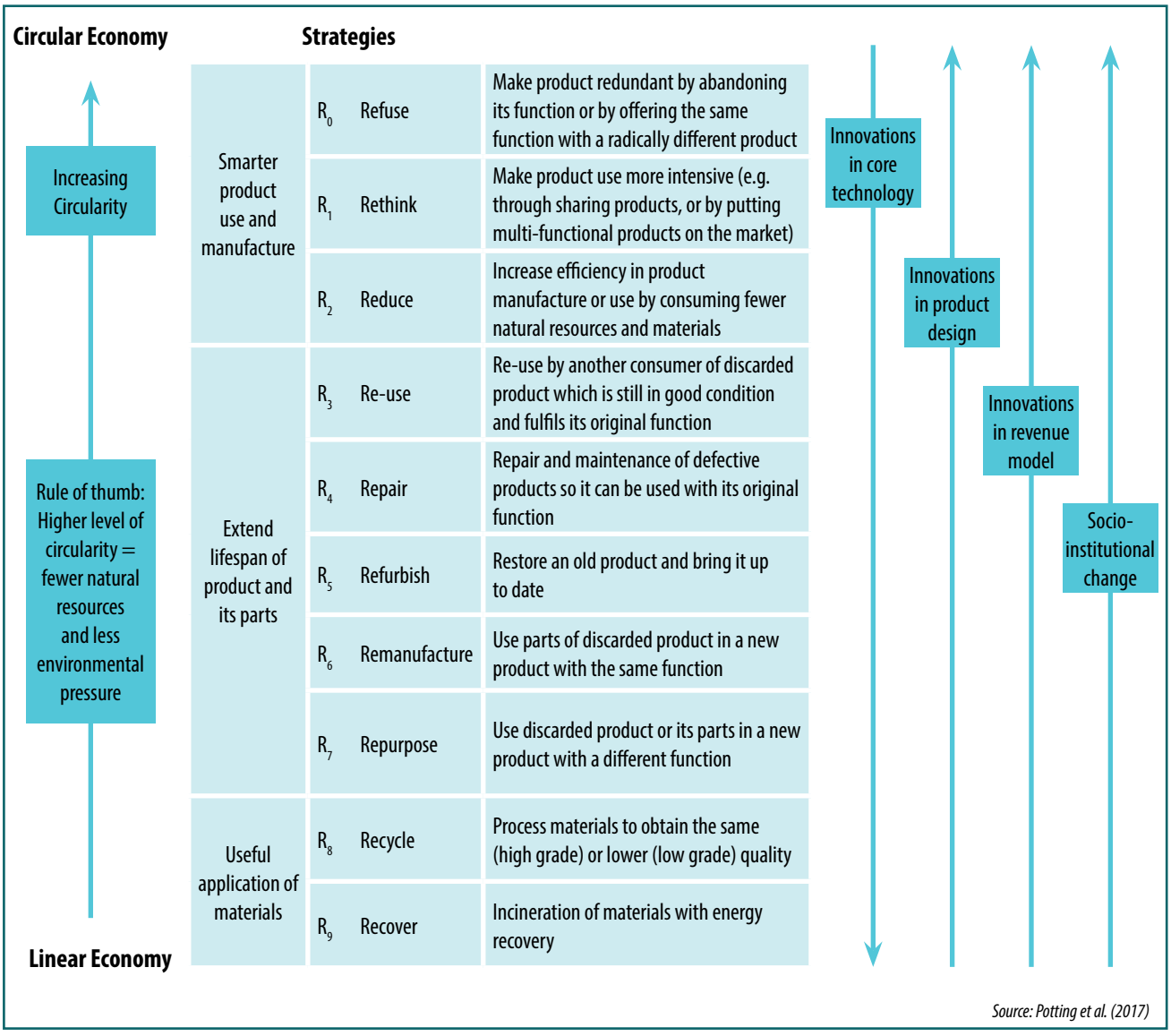


Figure 3: Circularity strategies within the production chain

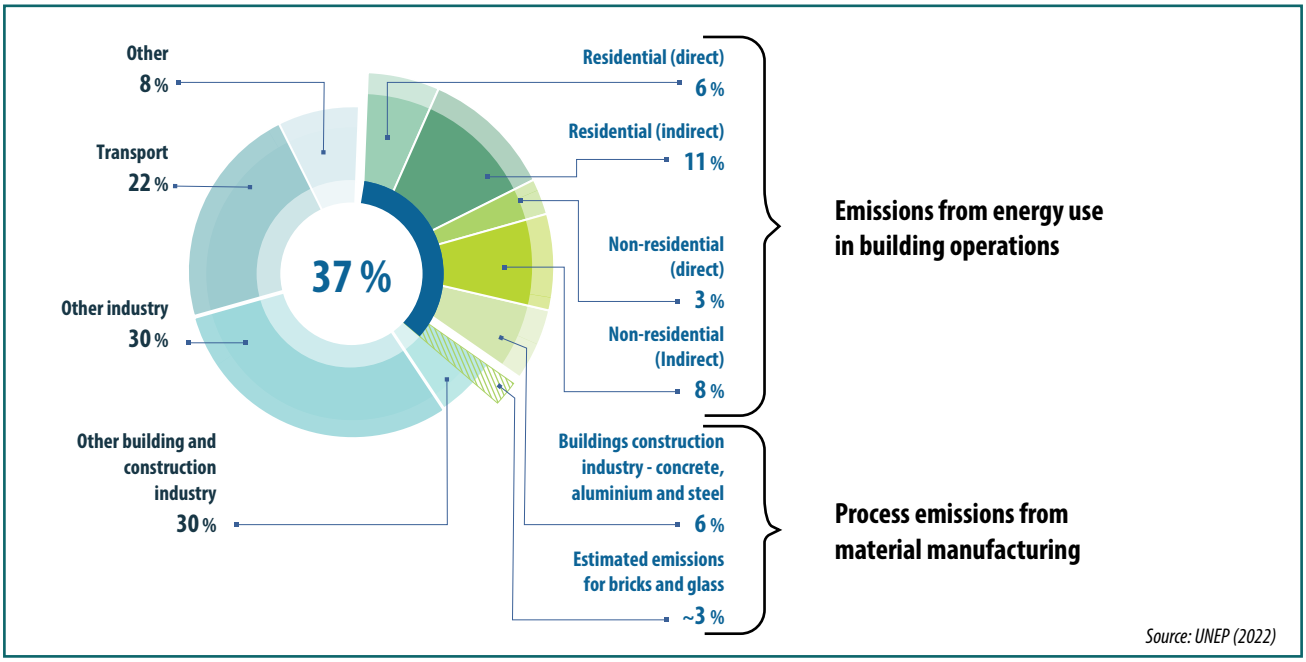


Figure 4: GHG Emissions from Building and Construction sector in 2021

As shown in Figure 4, the building construction industry accounts for 37% of global CO_2 emissions. Of this share, 28% of emissions are from energy use in building operations, with direct emissions from fossil fuel use in buildings contributing to 9% and electricity consumption leading to 19% of operational emissions. Process related emissions from manufacturing of building construction materials such as concrete, steel, aluminium, glass and bricks account for about 9% of global CO_2 emissions.

3.2. Understanding Net-Zero Carbon Buildings

The United Nations defines Net-zero emissions as cutting GHG emissions as close to zero as possible, with any remaining emissions re-absorbed from the atmosphere by sinks such as oceans and forests (United Nations, 2022). India's Ministry of Environment, Forests and Climate Change (MoEFCC) defines Net-zero emissions as removing as many emissions of carbon dioxide (CO_2) from the atmosphere as those produced (Press Information Bureau, 2022).

The building sector is responsible for significant GHG emissions, which are generated at different stages of a building's life – right from the production and sourcing of construction materials that go into a building to its end-of-life processing. Therefore, from the perspective of buildings, net-zero carbon emissions would mean cutting down or reducing GHG emissions over its lifecycle, i.e., embodied emissions from building materials' production and construction activities, emissions from energy use and building operations, and emissions from its demolition, through appropriate measures.

The adoption of zero carbon buildings has grown globally based on the advancements in technology, regulatory and policy landscape. The following Table captures the different levels of building performance and associated definitions of zero carbon buildings.

Basis/Definition	High levels of energy efficiency with limited adoption of renewable energy due to feasibility constraints	High levels of energy efficiency with operational energy demand met through renewable energy on site	Highest levels of energy efficiency supplemented with uptake of low embodied carbon materials and efficient building envelope design. Life cycle emissions to be mitigated by on-site and off-site renewable energy interventions
Near Net Zero Building	✓		
Net Zero Energy Building	✓	✓	
Net Zero Carbon Building	✓	✓	✓

Transition of buildings from energy efficient to Zero Carbon Buildings

Zero Carbon Buildings status can be achieved in progressive manner as shown in figure 4, going anticlockwise:

- Energy Efficient buildings involve adoption of active and passive efficiency improvement measures such as LED lighting, natural ventilation, wall and roof insulation, heat pumps, among others.
- Nearly Zero Carbon buildings are energy efficient and additionally utilize renewable energy generation (on-site or off-site) to meet a portion of their energy demand while also serving their cooling demands through more efficient technologies such as district cooling.
- Net Zero Carbon buildings can then be understood as the buildings that additionally meet all of their energy demand through zero-emission energy sources (grid or on-site) while Whole Life Zero Carbon buildings go a step further ahead and utilise building materials that are produced with minimum or zero environmental footprint.

For achieving the status of energy efficient buildings, the progress can be initiated by adopting building energy efficiency improvement active and passive measures such as LED lighting, natural ventilation, wall and roof insulation, heat pumps, among others. Nearly Zero Carbon Buildings are the ones that are equipped with on-site renewable energy generation and meet cooling demands through more efficient technologies such as district cooling. Net Zero Carbon and whole life zero carbon buildings can then be understood as the buildings that procure energy through decarbonised grid and utilise building materials that are produced with minimum or zero environmental footprint.

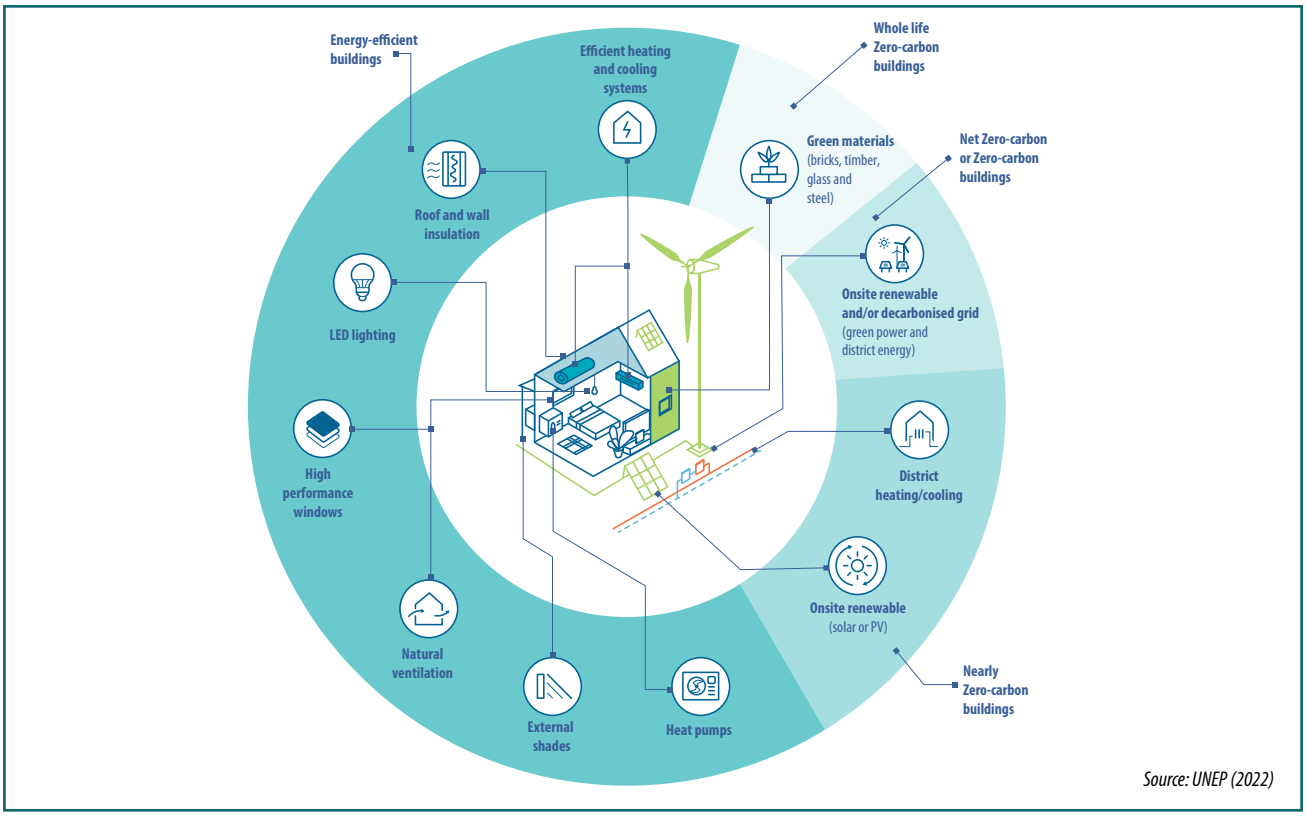


Figure 5: Illustration of defining Net Zero and Zero Carbon Buildings

3.3. Defining Zero Carbon Buildings for Nagpur

The following figure provides the approach followed to arrive at the definition of Net-zero carbon buildings and to guide Nagpur's roadmap and actions. Advancing towards and achieving net-zero carbon buildings at scale in Nagpur will be driven by local sector trends, technology uptake, policy and regulatory actions, costs and financing, and coordinated action by all stakeholders involved in the value chain.

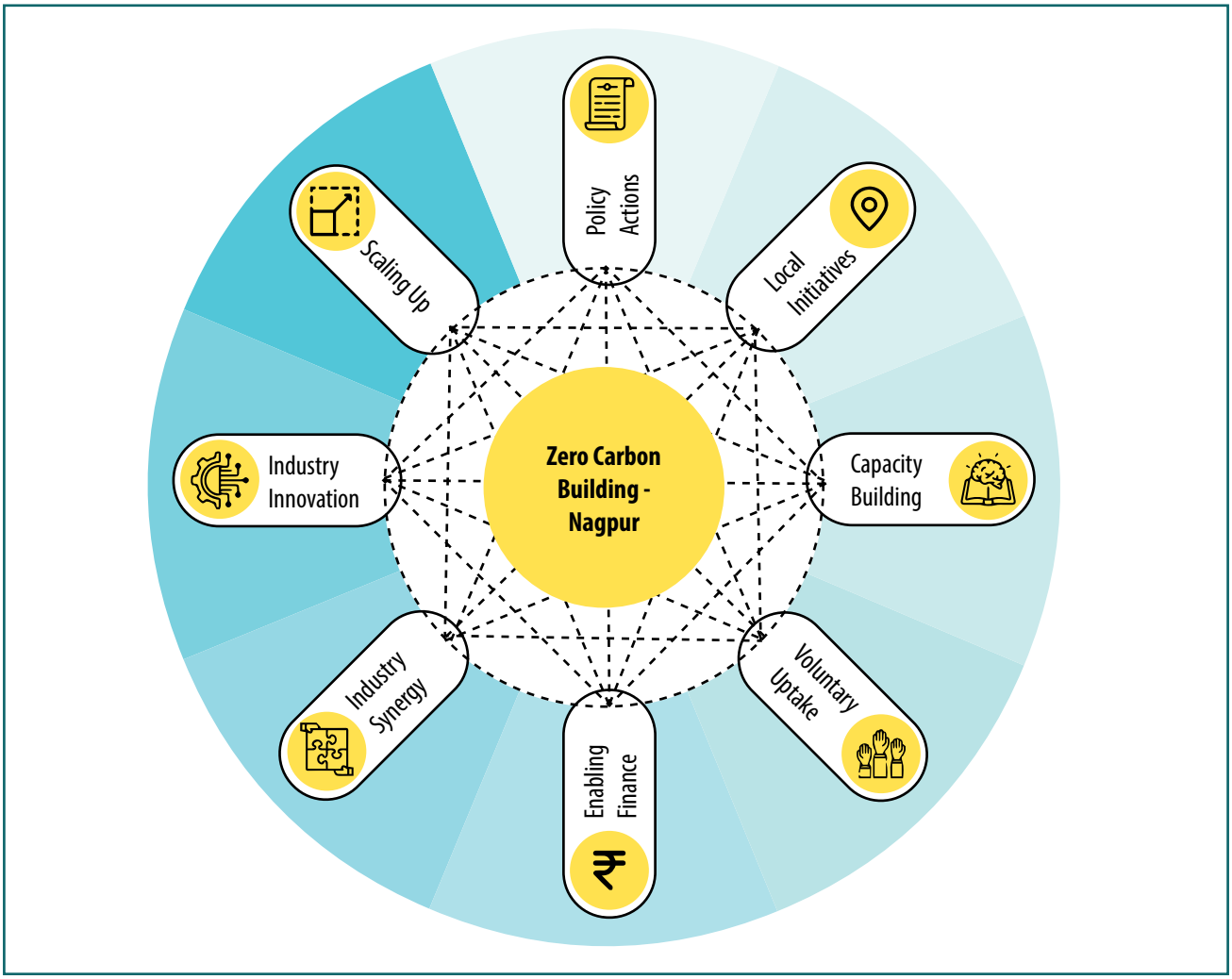


Figure 6: Approach to Nagpur's Zero Carbon Buildings Definition

Definition of Zero Carbon Buildings for Nagpur

Buildings that improve their lifecycle environmental performance through measures that reduce embodied, operational and end-of-life GHG emissions without compromising visual and thermal comforts

4. Enabling National and Sub-national Policies and Strategies for Building Decarbonization

As already established, the building and construction sector is one of the most energy and GHG emission intensive sectors. Conventional buildings have significant lifecycle emissions and energy requirements related to constituent building material, construction activity, energy consumption for building operations, building retrofit or renovation activities, and from building demolition and waste management. It is therefore necessary to have frameworks in place to keep the energy consumption and GHG emissions in check, in both existing and new buildings.

In this regard, roadmaps and policy frameworks exist at the national, state and city level that support reduction of GHG emissions and non-renewable energy consumption and promote sustainability in the buildings sector (see Table 1). These frameworks are a part of India's strategy to contribute to global climate change action and sustainability development goals (SDGs).

Nagpur's Zero Carbon Building Action Plan builds upon these frameworks and initiatives to formulate building sector decarbonization strategies at the local-level. In the long term, these strategies would require to be progressively scaled up with forward-looking actions to enhance the overall sectoral impact at the city-scale. The following table attempts to capture the gist of enabling national, sub-national, and local initiatives, policies, and mechanisms to reduce emissions in the buildings sector.

Table 1: Policy Frameworks and Initiatives supporting Building Decarbonization

Enabling Framework	Key goals and elements
National Linkages	
India's Nationally Determined Contributions (NDCs) (updated) and climate commitments, 2022	• Reduce GHG emissions intensity of its GDP by 45% by 2030 • Achieve 50% cumulative electric power installed capacity from non-fossil fuel-based resources by 2030 • Develop frameworks for cutting-edge climate technology • Promote a healthy and sustainable way of living following principles of LIFE[1] • Enhance climate resilience • Net-zero emissions goal by 2070

India's Long-Term Low-Carbon Development Strategy	• In 2022, MoEF&CC submitted a Framework Document on India's "Long-term low greenhouse gas emission development strategies", taking into account national circumstances and priorities for sustainable development.
	• For the building and construction sector, the strategies to achieve low carbon development include
	  ○ Mainstreaming adaptation measures in urban planning and measures for enhancing energy and resource efficiency within urban planning guidelines, policies and bylaws
	  ○ Promoting climate-responsive and resilient building design, construction, and operation in existing and future buildings

Energy Conservation Building Code, 2017	• ECBC is mandatory for new commercial buildings having a connected load of 100 kW or contract demand of 120 kVA or more. ECBC recommends energy related standards and criteria on building envelope, HVAC, lighting, electric power and distribution among others. • Energy saving requirement of 25% at minimum for ECBC compliant buildings. Buildings with 50% energy saving are rated as Super ECBC buildings.

1. LIFE - Lifestyle for Environment

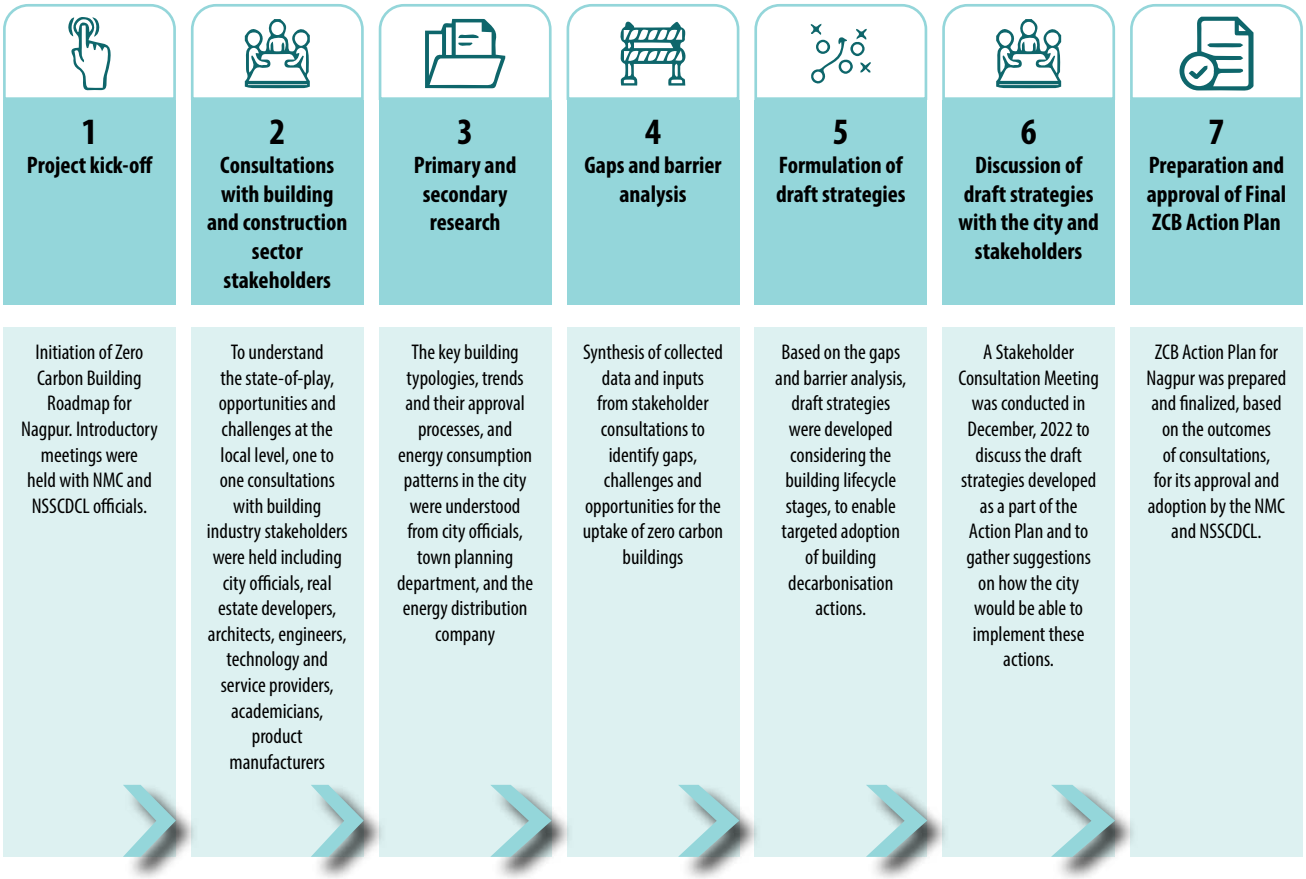
Enabling Framework	Key goals and elements
Eco-Niwas Samhita, 2018	• Eco-Niwas Samhita is applicable for all residential buildings built on plot area greater than or equal to 500 sq. m. • Part-I of Eco-Niwas Samhita provides minimum building envelope performance standards to limit heat gains (for cooling dominated climates) and to limit heat loss (for heating dominated climates), as well as for ensuring adequate natural ventilation and daylighting potential. • Part-II is focused on electro-mechanical and renewable energy in addition to the envelope parameters.
Energy Conservation (Amendment) Bill, 2022	• Seeks to give powers to the Central Government to mandate ECBC compliance for **commercial and residential buildings with a connected load of 100 kilowatt or above**. • Aims to introduce a carbon credit trading scheme to reduce carbon emissions, and an obligation to meet a certain percentage of energy demands through non-fossilized sources for designated (large) consumers
Renewable energy Open Access amendments, 2022	• Open access limit has been reduced from 1 MW to 100 kW for any open access consumer to increase renewable energy mix in the grid. Helps to promote renewable energy adoption in buildings.
Smart Cities Mission, 2015	• Aims to integrate smart technologies in different sectors to achieve sustainable urban development in an energy-efficient and cost-effective manner in identified Smart Cities, including Nagpur • Promotes creation of urban spaces that are energy and resource efficient. Guidelines outline that 80% of the buildings in the smart city areas need to be energy-efficient with adoption of green building design and 10% of the smart city area's energy requirement should be met by solar energy.
India Cooling Action Plan, 2019	• The National Cooling Action Plan maps India's cooling growth scenarios for a 20-year period and provides potential pathways and cross-cutting recommendations to achieve sustainable cooling. • Action areas include space cooling (or comfort cooling) in buildings, air conditioning and refrigeration technologies, and alternative refrigerants.
Ministry of Housing and Urban Affairs - Climate Smart Cities Assessment Framework (CSCAF), 2019-21	• Climate responsive urban planning assessment framework to guide climate action across sectors in Indian cities • Provides a framework for cities to undertake climate action and improve performance in five focus areas i.e. (i) Urban Planning, Green Cover and Biodiversity (ii) Energy and Green Buildings; (iii) Mobility and Air Quality (vi) Water Management and (v) Waste Management.
Standards and Labelling Programme, 2006	• The Standards & Labelling Program sets energy performance standards for refrigerators, air conditioners, ceiling fans, LED lamps, motors, and other appliances. The electrical appliances need to adhere to minimum energy performance standards (MEPS) and display energy consumption labels. Currently, the scheme covers 30 types of equipment/appliances. The implementation of this mandate has resulted in increased adoption of energy efficiency amongst consumers and the manufacturers.
BEE Building Materials Directory	• A low carbon material directory is being developed by the BEE for building sector stakeholders across the country to promote and facilitate adoption of sustainable building materials
Pradhan Mantri Awas Yojana – Urban	• PMAY-U is a flagship mission of the Central Government to provide more than 12 million low-cost affordable houses by year 2024. • The Global Housing Technology Challenge (GHTC), initiated under the PMAY-U, aims to showcase innovative and alternative construction technologies to transition to sustainable and eco-friendly housing.

Enabling Framework	Key goals and elements
Green Building Rating Systems and Energy Efficiency Star Rating for Buildings	• Various green and energy efficient building certification systems developed by Bureau of Energy Efficiency (BEE), Leadership in Energy & Environmental Design (LEED), Excellence in Design for Greater Efficiencies (EDGE), Green Rating for Integrated Habitat Assessment (GRIHA), Indian Green Building Council (IGBC), Green and Eco-friendly Movement (GEM) have been adopted across the country. • Systems such as IGBC, GRIHA and GEM have been developed for various building typologies of varying scales including institutional, commercial, residential, existing building and large developments. • The BEE's Building Star Rating, rolled out for various building typologies, is a voluntary building rating scheme to reflect the level of energy efficiency achieved, based on the building's energy performance index (EPI) score.
Material Certifications and Declarations Initiatives	• Recognizes materials that adhere to low emissions and environment friendly manufacturing criteria established by relevant green certifying agencies. • Ensures that declarations such as environmental product declarations (EPD) are in place for various building materials to increase transparency and help buyers make a conscious choice.
State-level Linkages	
Green Building Incentives and Mandates in Maharashtra State's Unified Development Control Regulations, 2020	• Maharashtra state's Unified Development Control and Promotion Regulations (UDCPR), 2020 incentivises compliance with green building concepts and strategies for various building typologies. To promote adoption of green buildings, it offers an FSI incentive of 3% to 7% based on the level of green building compliance. • For plot size above 4000 sq.m., all buildings shall incorporate solar water heater/solar PV and plot sizes above 500 sq.m. buildings are mandated to have rain water harvesting systems.
Local Linkages	
Climate Resilient City Action Plan for Nagpur	• The Climate Resilient City Action Plan (CRCAP) for Nagpur, ratified and adopted by the city government, provides a comprehensive assessment of energy use and GHG emissions from urban activities and services, and the impact of climate change on urban infrastructure. It suggests potential strategies and actions to increase urban climate resilience. • Adopting the multi-sectoral mitigation strategies has the potential to reduce Nagpur's GHG emissions by 20% i.e., 614,376 tCO_2e by 2025-26 considering the 2017-18 emissions baseline. • Includes building sector strategies such as implementation of green building measures, adoption of ECBC and climate responsive guidelines in the building byelaws, scaling up use of RE systems like rooftop solar PV and solar water heater, use of energy efficient equipment and appliances, among others.
Building Efficiency Accelerator (BEA)	• Under the BEA project, a technical guideline specific to Nagpur has been prepared for energy efficient and climate responsive housing. The document aims to guide the building industry and end users to adopt energy efficiency measures at various stages of design and construction and for municipal authorities to include appropriate measures in tender documents and local building bye-laws. • Pilot energy benchmarking and energy audits were conducted for select public and private buildings in the city. The aim was to help the ULB to promote building energy efficiency by scaling up the exercise in both public and private buildings.
Property Tax Incentives for sustainable actions in buildings	• The ULB provides property tax incentives of up to 10% for houses incorporating at least two out of four eco-friendly practices, which include, producing compost through waste segregation, rainwater harvesting, wastewater treatment and reuse, and adoption of solar or any type of renewable energy.

5. Approach for Action Plan Development

Nagpur has developed this roadmap to support its ambition for at-scale decarbonization of its buildings sector. NMC and NSSCDCL initiated the process for development of Nagpur's ZCB Action Plan in June 2022, with technical support from ICLEI South Asia provided through the Zero Carbon Buildings Accelerator (ZCBA), enabled by funding assistance from the World Resources Institute through the Global Environment Facility (GEF). The Action Plan has been developed through on-ground information gathering, stakeholder consultations, review of literature, and technical analyses to outline actions and steps necessary for the city to advance on its building decarbonization goals.

The key steps undertaken to develop this Action Plan include:

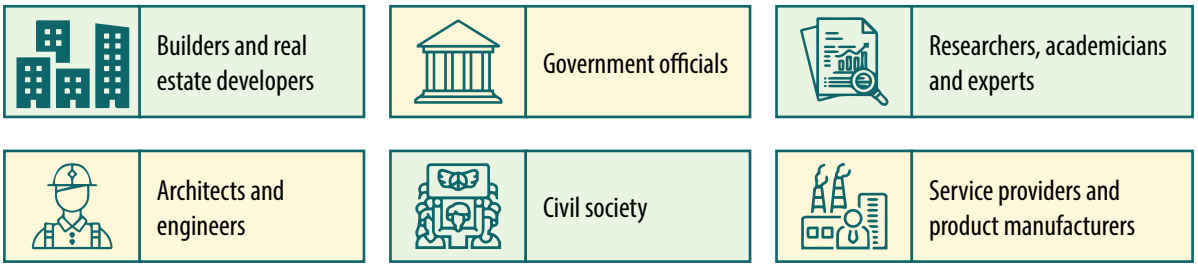


6. Baseline Assessment and Gap Analysis

A baseline assessment was undertaken, using primary and secondary research, considering elements such as the city's climate and built environment characteristics, land use pattern, building stock, and its electricity consumption and GHG emissions. Information was collected from relevant municipal and utility companies, to understand the existing status, trends, gaps, and key enablers for Nagpur's buildings and construction sector to transition to zero carbon buildings.

Simultaneously, stakeholder mapping was carried out to identify key stakeholders to support the Zero Carbon Buildings transformation locally. Extensive consultations were undertaken with the identified building industry stakeholders, spanning public sector departments to private building developers and product manufacturers to understand the status, gaps and barriers related to adoption of low carbon materials and practices. Further information on the stakeholders consulted is available in Annexure 1. This section provides an overview of Nagpur city's building sector baseline and profile followed by a gap analysis.

Stakeholder mapped and consulted



6.1. Climate Characteristics Relevant to Built-Environment

Nagpur falls under the composite climate zone as identified by the National Building Code. The city experiences both wet and dry climate conditions with pronounced dry conditions prevailing for most of the year. 90% of the city's annual average rainfall of 1,110 mm is received between June and September. Summers are extremely hot in Nagpur, lasting from March to June, when temperature can go up to 48°C in May, the hottest month. The summer season is the driest part of the year when the relative humidity goes down to 20% or less particularly in the afternoons. Winter lasts from November to January, during which temperatures drop below 10°C.

In terms of seasonal wind-flow patterns for Nagpur, during the summer season it is observed that hot winds flow between the North and West direction. With high speed hot winds flowing from the Northwest direction, it is important to block these hot winds to ensure indoor thermal comfort. In the winter season, cold winds are predominantly seen to flow between the Northwest and Northeast direction. High speed cold winds blow from the North and blocking these winds is important. During the monsoon season, the wind direction is observed to predominantly between Northwest and West directions and thereby windows should be oriented strategically so as to maximize cross-ventilation during this season.

Based on climate projections, both at the regional and city-level (Masalvad & Vasudeo, 2015), it is anticipated that Nagpur will witness increased temperatures in the future. Regional assessments indicate that the annual mean temperature will increase by around 1.95 - 2.2°C in the Nagpur region by 2050s (TERI, 2014). Based on the heat index (which combines relative humidity and air temperature) estimations, Nagpur division is expected to witness increased heat stress in the form of an increase in the number of dry days (5 to 6 days) in 2030s. These projections imply an increased need for indoor thermal comfort in the built environment, potentially leading to higher energy demand in the current scenario.

6.2. Land Use

Nagpur's land area is primarily used for residential purposes/spaces (45%), followed by the land under public use (41%), as of 2011. Commercial and industrial developments occupy 6% of the city's land while 8% of the land use is towards parks and gardens.

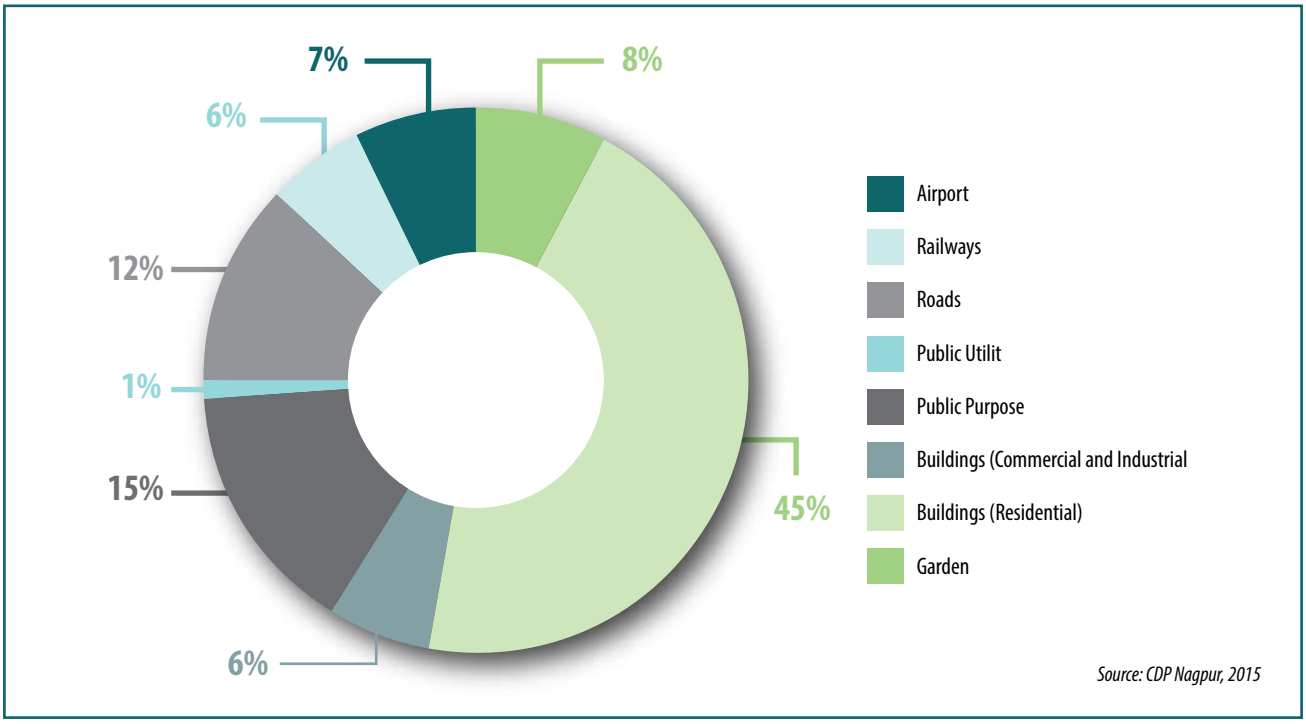


Figure 7: Existing land use breakup of Nagpur - 2011

Nagpur is currently updating its City Development Plan to outline its future development and to plan for urban infrastructure and services until year 2031. The total area being considered under this revised Development Plan is 235 sq. km. Land use has been proposed for 2031 to conform to the required norms as per Urban and Regional Development Plans Formulation and Implementation (URDPFI) guidelines.

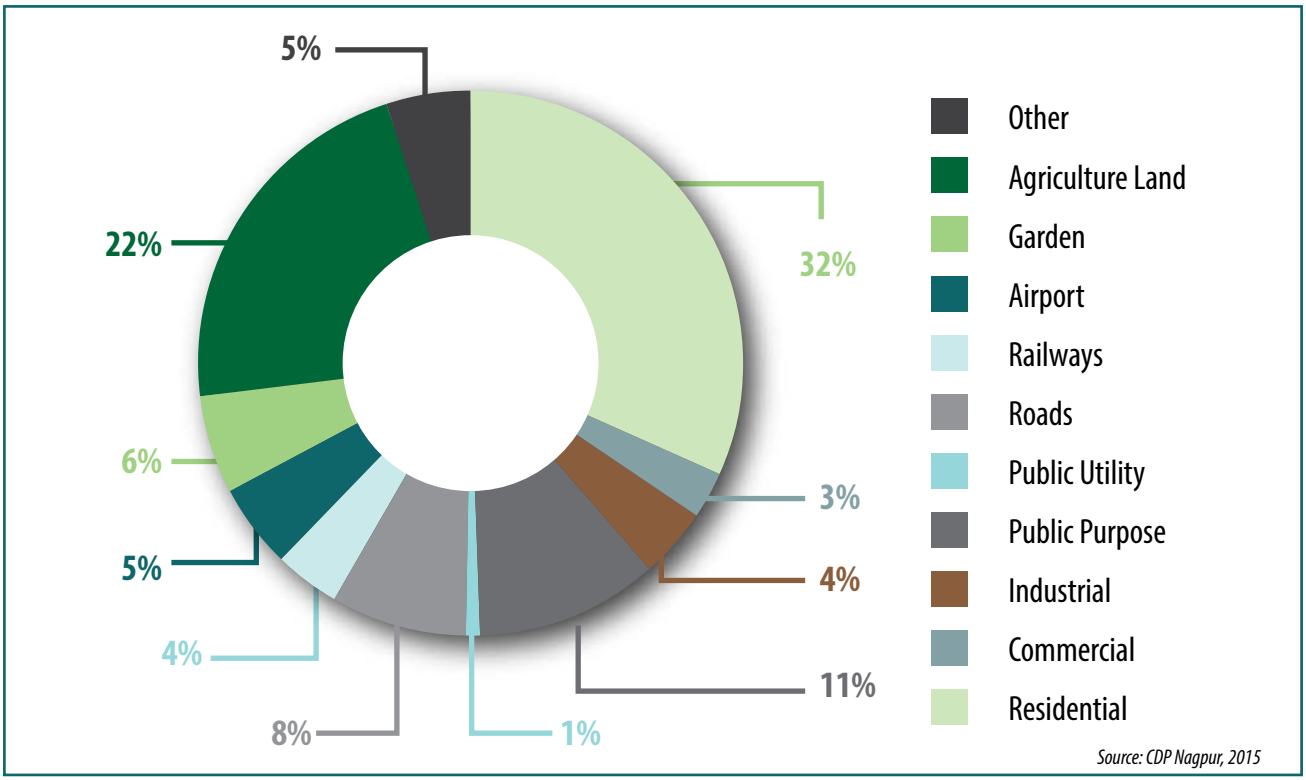


Figure 8: Proposed Landuse for Nagpur City - 2031

6.3. Building Sector Profile

Nagpur city's building stock mainly comprises of residential buildings, characterized mainly by independent houses or bungalows, and low to mid-rise buildings. High-rise buildings have begun to emerge in the vicinity of the mass-rapid transit network of the Nagpur metro, that began operating in 2019, due to the development of the high-density Transit Oriented Development (TOD) Zone.

The western part of Nagpur has a predominance of independent or detached and semi-detached (i.e. having common walls) bungalows/houses, and residential apartments, whereas the central and eastern part is more populated with a higher density of residential buildings having common walls on at least one face. The Southern part of Nagpur has developed of late, with a trend of construction of new high-rise structures being witnessed. The Eastern peripheral regions such as Pardi, Punapur and Bharatwada primarily feature low-rise independent semi-pucca and kuchha houses/bungalows.

With Nagpur being an important administrative centre, it houses numerous public and institutional buildings, located mostly in its central Civil Lines area. These public and institutional buildings are typically observed to be a mix of mid and high-rise buildings. Social housing is being built by NMC and NSSCDCL in the Area Based Development area of Nagpur's Smart City Project, with green building principles being incorporated in such housing.

Commercial establishments such as shops, offices and retail establishments are concentrated in the city's established central business districts including Sitabardi, Itwari, Sadar, Mahal, and CA Road. Small, medium and large-scale commercial buildings and establishments (such as malls, hotels and high-end commercial outlets) are generally located along the major arterial and sub-arterial roads in these areas. Small establishments are observed to generally have a compact building footprint with a single storeyed to three storeyed structures. Medium and large commercial establishments have large footprints and are generally high rise structures (G+4 or 15m and above), often with considerable open areas and plot setbacks. Large high-rise commercial buildings such as IT buildings, which are few in number, are concentrated in the Gayatri Nagar IT Park and MIHAN (outside the city limits).

6.4. Building Stock Assessment

To understand the growth and trends in Nagpur's building stock, data and insights on existing buildings and on new building approvals were gathered from the Property Tax and Town Planning departments of NMC.

The Property Tax department is responsible for levying taxes for different types of building developments, segregated primarily into residential and non-residential categories. As shown in the figure below, residential buildings dominate the city's building stock with average annual growth rate of 7% observed from 2012-13 to 2018-19.

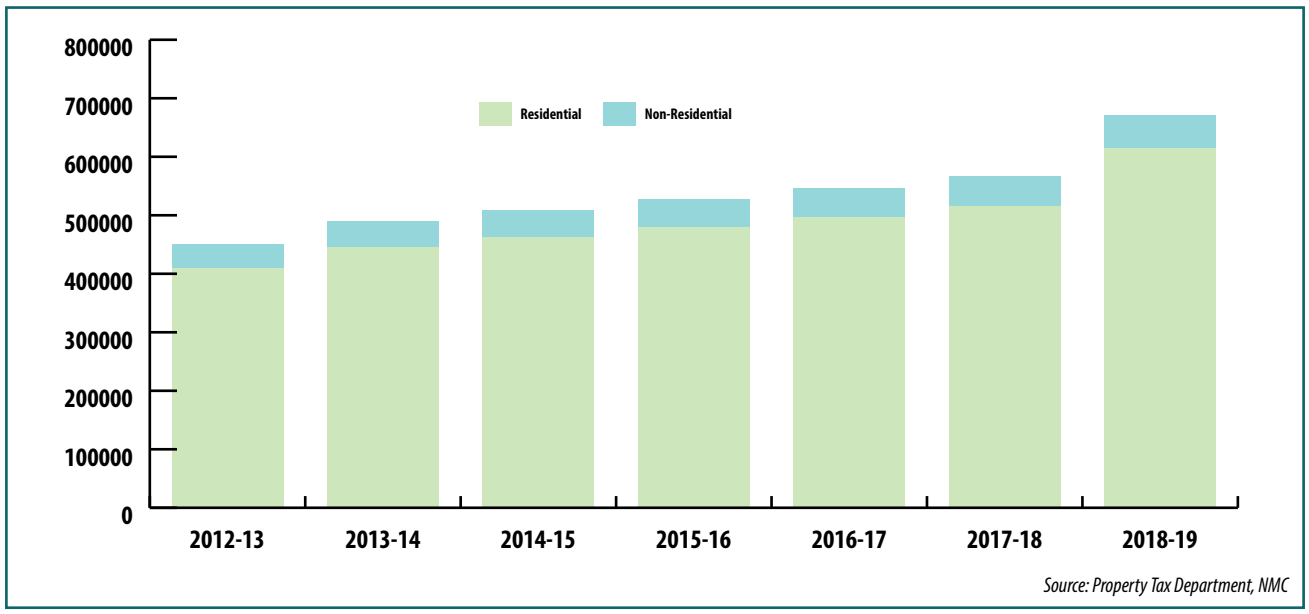
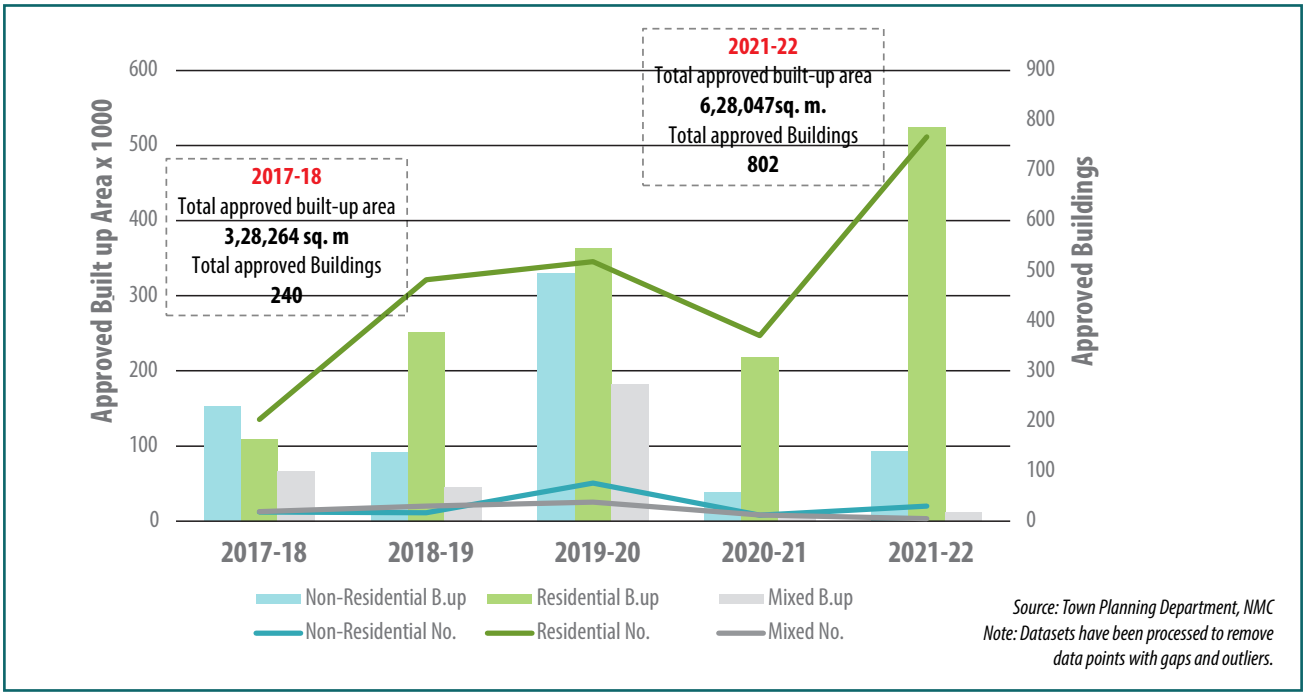


Figure 9: Nagpur Building Stock 2012-2018

The Town Planning Department of NMC maintains data on building approvals/permits. This building approval dataset from the department categorizes new buildings receiving approvals by their plot area, height, number of stories, and building typology. Based on the data available from 2017-18 to 2021-22, analysis of the building approval dataset presented in this section is divided into three major categories[2]: residential, non-residential, and mixed-use.

- **Residential:** Consisting of purely residential building use.
- **Non- residential:** Consisting of purely non-residential building use.
- **Mixed-use:** Consisting of a combination of residential and non-residential building use.



Source: Town Planning Department, NMC
Note: Datasets have been processed to remove data points with gaps and outliers.

Figure 10: Building typology-wise approved built-up area vs number of buildings approved annually

Key Observations and inferences

- Predominance of new residential buildings being constructed annually
- Gradual growth in trend towards high-rise buildings (four storeyed structures and above)
- Decline in building approvals in FY 2020-21 due to CoVID related lockdowns/restrictions
- Future building sector growth will probably continue to be driven by the residential sector.

	Purely Residential	Purely non Residential	Mixed Use
Average Building Footprint	672 Sqm	4,603 Sqm	2,998 Sqm
Average Buildings Approved Annually	468	31	21

6.5. Energy Consumption Assessment

The residential sector, primarily through residential buildings, is a key driver of energy consumption and thereby GHG emissions in Nagpur. Based on Nagpur's Climate Resilient City Action Plan (CRCAP), it is seen that the residential sector accounted for 43% of the city-wide energy consumption and 38% of GHG emissions in 2017-18.

2. The Town Planning department categorises the building approval dataset into two typologies: Residential and Non-Residential. However, based on the data obtained, buildings have been divided into three categories.

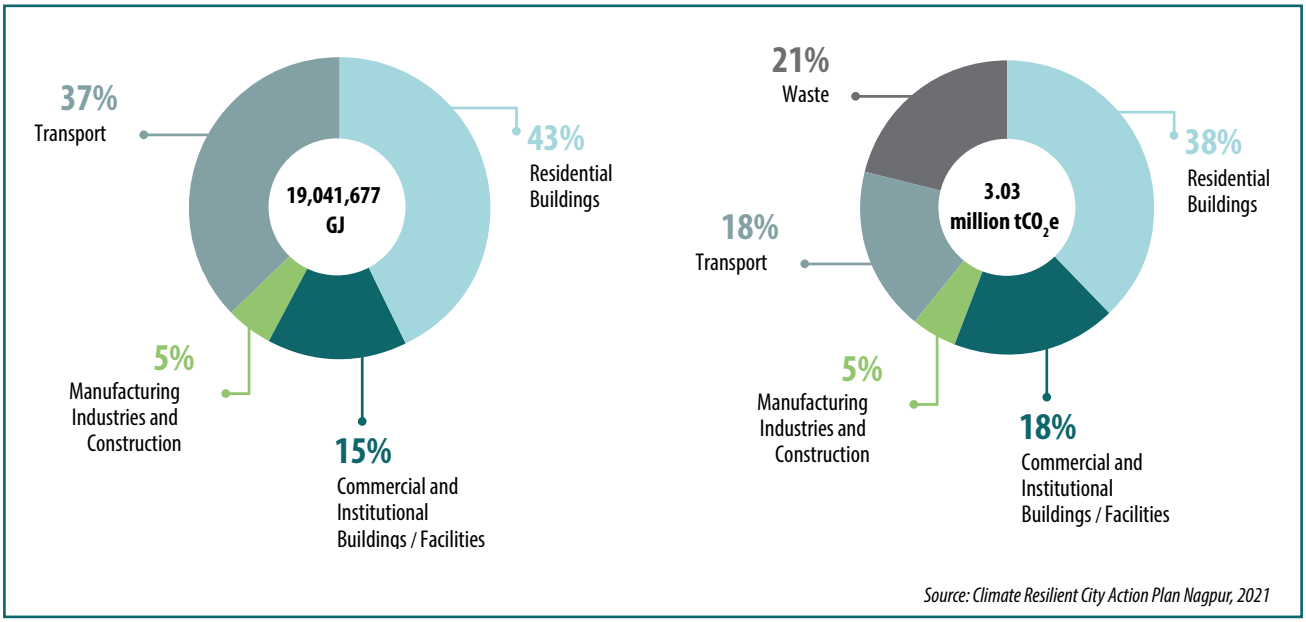


Figure 11: Left: Share of Sectoral Energy Consumption in Nagpur (2017-18). Right: Share of Sectoral GHG in Emissions in Nagpur (2017-18)

With electricity being the prominent energy source used in buildings, it is observed that residential buildings accounted for 75% of electricity consumption and related GHG emissions at the city-scale in 2021-22.

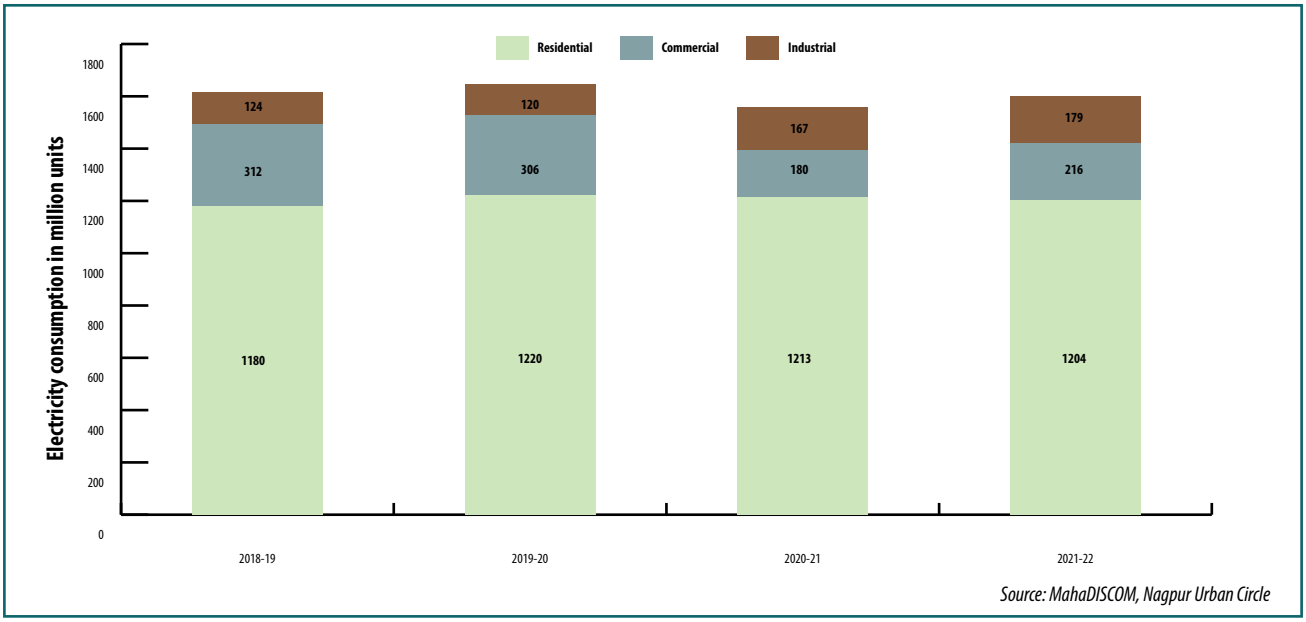
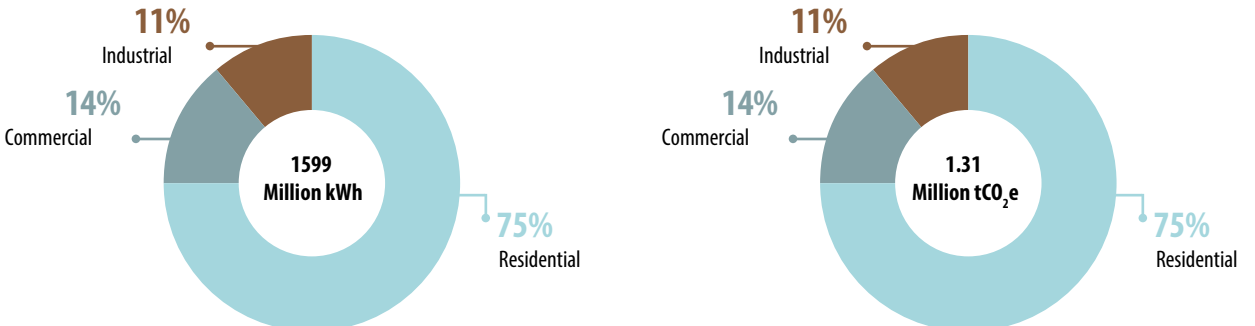
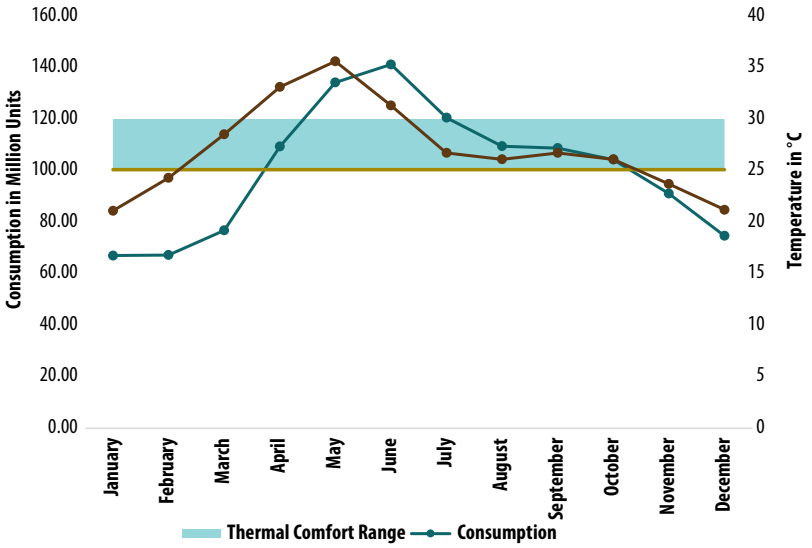


Figure 12: Sector-wise Electricity Consumption in Nagpur



Source: MahaDISCOM, Nagpur Urban Circle and internal analysis

Figure 13: Left: Share of electricity consumption by building type (2021-22). Right: Share of electricity related GHG emissions by building type (2021-22)



Source: MahaDISCOM, Nagpur Urban Circle and climate-data.org

Figure 14: Monthly electricity consumption pattern vs average monthly temperature, 2021-22[3]

Key Observations and Inferences

- Residential sector is the largest consumer of energy, including both electricity and fuel-based consumptions, and the highest contributor to GHG emissions in Nagpur. The commercial and industrial sector also have significant contributions.
- For year 2021-22, residential buildings had the highest electricity consumption and associated GHG emissions.
- Electricity consumption across the months has a correlation with thermal comfort in terms of average temperature and humidity levels. It is seen that electricity consumption for residential sector increases during the summer and monsoon months. In the monsoon months, humidity exceeds 50%, thereby contributing to an increase in electricity demand. The monthly consumption during the months of April and May is 34 and 41%[4] higher than the average monthly consumption.

3. National Building Code 2016 defines thermal comfort between TSI values of 25°C and 30°C with optimum condition at 27.5°C. Tropical Solar Index (TSI) is defined as the temperature of calm air, at 50 percent relative humidity which imparts the same thermal sensation as the given environment.
4. Utility companies record and issue the energy consumption bill of previous month in the current month hence figure 14 shows peak consumption in June month.

6.6. Key Gaps and Barriers Identified

The uptake of ZCBs and particularly the uptake of low carbon materials depends on the readiness of the stakeholders involved in the value chain. It is important to understand and address the gaps and barriers which prevent wider uptake of ZCB interventions and actions. To best capture stakeholder insights and experiences, a questionnaire was formulated for consultations with relevant stakeholders. About 30 stakeholders from Nagpur's building industry, such as, city officials and planners, real estate developers, material suppliers and manufacturers, architects, civil engineers, academicians, and civil society representatives were identified and approached to understand the existing trends in the buildings and construction sector, and to identify various gaps and barriers in the uptake of low carbon materials and techniques. Stakeholder insights on gaps and barriers have been captured below.

1 Building Regulations and Policies

Regulations at sub-national level deterring the uptake of ZCBs

- ULBs need to adhere to multiple statutory guidelines such as National Building Codes, UDCPR and CPWD norms and to check various compliances, making the process tedious. Moreover, ULBs have to approach the State Government to modify or make any changes in the building bye-laws and UDCPR. In general, more clarity is required in various regulations in terms of detailed cohesive guidelines for key stakeholders to follow.
- ECBC is limited to large commercial buildings and is voluntary in nature for residential buildings (Eco-Niwas Samhita). Green building compliances in UDCPR are mandatory for projects of certain size and scale[5] and are voluntary in nature for remaining building developments.
- State government of Mahrashtra has initiated retrofitting of public buildings based on Green Building principles. However, uptake is slow and there is a gap to promote and implement interventions to transition to net-zero buildings.

Low-carbon building related regulations at local level are voluntary

- NMC provides tax incentives for specific measures such as rainwater harvesting and solar water heaters through the local building regulations. However, it lacks provisions and incentives for promoting other low-carbon interventions and for ZCBs in general are lacking.
- The mechanism for the ULB to record and check implementation of green building interventions needs to be strengthened and expanded to address ZCB measures. The ULB relies on the green building certifying agencies to track compliance at present.
- Promition of ZCBs and related strategies is not considered in overall urban and land use planning processes and practices. There is a need to include ZCB enabling guidelines/regulations into the building permit process and criteria as administered by the city's Town planning department.

Lack of institutional capacity to promote ZCBs

- Lack of coordination, particularly between builders and developers and green building certification agencies, with very limited understanding of ZCBs across building and construction sector stakeholders is resulting in ZCB adoption being absent.
- ULB needs to setup formal institutional structures and stakeholder committees/groups comprising of building industry stakeholders to take informed decisions and closely monitor and regulate the developments with a focus on uptake of ZCBs

Operations and End of Life regulations

- Retrofitting initiatives for improving building energy performance are not prevalent. BEMS systems are not integrated with residential and small/mid commercial buildings which hinders building energy performance monitoring.
- Regarding construction and demolition waste, it is being directed towards Bhandewadi landfill site or outside the city and there is no decentralised/centralised C&D waste collection/segregation and transport mechanism. However, recently ULB has awarded work to a private agency to manage the C&D waste.

5. It is mandatory that the buildings in an Integrated Township Project have at least 3 star ratings from GRIHA / Silver from IGBC / Silver from LEED / equivalent rating from The ASSOCHAM GEM.

2 Building Materials and Construction

Preference to certain materials and techniques considering safety, economic and durability aspects

- Use of Reinforced Cement Concrete (RCC) is a prevalent construction technique as it is fast, affordable, durable and has an established ecosystem. Whereas alternative low carbon materials are yet to be established or mainstreamed, considering their safety, lifespan, limited availability, being perceived as expensive, and need for additional skills to use them.

Limited availability of major building materials locally

- Primary building materials such as cement and steel are sourced from well-established supply chains that usually involve transboundary procurement, adding to embodied energy and overall emissions.
- Finishing materials such as stones and floor tiles are sourced from other states as they are cheaper than their local counterparts.

Low carbon building materials have low acceptance

- Low carbon materials have low acceptance due to apprehensions surrounding their structural performance, thermal performance, resistance to weather, among others. There is a perceived lack of demonstrated suitability of low-carbon materials over the long term.
- Certified green rated building materials are costlier than their conventional counterparts. Hence, their uptake is low.
- Few established brand manufacturers have started providing voluntary Environmental Product Declarations (EPDs) for their materials. However, use of materials with EPDs and green certification is not mandatory in the Indian context.
- Various start-ups manufacture or are exploring supply of low-carbon building materials but face stiff market competition due to their limited market reach and established supply chains of large private sector players.

Low carbon building materials and techniques have technical limitations

- Various mud or earth based construction techniques have practical limitations with regard to achievable height and span of structures, need for regular maintenance, and susceptibility to weather conditions, among others.
- For building types such as IT offices, hospitals, malls, research facilities, and other large non-residential buildings, mechanical cooling systems may be unavoidable even if materials with low thermal transmittance and passive design strategies are used.
- During summers when temperatures go beyond 40°C, artificial cooling may be unavoidable to achieve indoor human thermal comfort levels, even if the thermal transmittance of the envelope materials is low. Moreover, with summer temperatures going beyond 40°C in Nagpur, mechanical cooling may be required to achieve indoor thermal comfort levels.
- Masonary structures using envelope materials such as Fly-Ash bricks and AAC bricks can develop cracks if such materials are not deployed as per their requisite specifications and guidelines.
- A mechanism monitor and reduce emissions generated from construction equipment and machinery is lacking.

Limited use of renewable energy and E-mobility in construction activity

- The use of Electric Vehicles (EVs) for transporting building materials is negligible.
- Financial support and incentives such as the assistance for grid-connected solar rooftop programme is not available to commercial and industrial consumers during the construction stage. Guidelines promoting the use of grid-tied solar PV systems during construction are lacking.

Lack of skilled workforce

- Certain low carbon construction techniques such as filler slab, rat trap bond and guna tile based roofing require skilled workforce which is not easily available

3 Financing Zero Carbon Buildings

Slower growth of Zero Carbon Buildings footprint, especially residential and commercial spaces hindering investments

- Limited market demand exists for green and zero carbon buildings from the consumer side, given that buyers generally consider initial costs in purchasing decisions. Given limited information and awareness on resulting benefits and savings, ZCB projects are perceived to be more expensive by building developers throughout the project lifecycle, i.e., from designing of green buildings till their operation phase. Moreover, benefits and cost savings from adoption of ZCB measures are realized at a later stage over the building's operational lifetime and not considered by buyers/occupiers, who are not willing to pay additional upfront costs for such benefits.
- FSI incentives of up to 7% additional FSI are offered to green buildings under the Maharashtra UDCPR, 2020. However, the existing level of incentives are insufficient to cover the additional capital expenditures incurred by developers to adopt ZCB strategies holistically. Moreover, in the case of Nagpur, developers are not always able to fully utilize and monetize the additional floorspace offered through such FSI incentives, due to relatively low market demand for real estate in the city. There is a need to identify the right type of fiscal/monetary benefits that sufficiently incentivize developers and adequately reflect additional costs incurred at market rates.

Unavailability of concessionary financing mechanisms that can offset Zero Carbon Building premiums at project initiation phase

- Financing for real estate projects differs as per the project size and on case to case basis. Dedicated financing mechanisms offered by banks for green buildings are very limited and completely absent for ZCBs.
- Few banks have the facility of providing additional loans for specific low-carbon interventions such as installation of rooftop solar PV systems. These financial offerings however do not provide concession in interest rates.

Lack of knowledge dissemination through success stories.

- State and local government environment departments need to expand their coordination with industries/stakeholders that have successfully implemented ZCB and green building projects and understand operational and financial needs
- Limited evidential information exists in the local context on ZCB related strategies and solutions and associated benefits. This poses challenges in monetizing the benefits possible from adoption of ZCB strategies, thereby making it difficult to attract private capital and external financing for implementation of ZCB projects at-scale.

4 Capacity Building

Limited capacity at local level across building sector stakeholders

- There is a significant gap in knowledge and capacity with regard to ZCBs across stakeholders. Capacity building exercises led by public sector, builder/developer associations and certifying agencies need to be strengthened further to promote adoption of ZCB strategies and materials.
- Government led construction sector training courses focus more on conventional RCC and brickwork-based construction techniques
- Building occupants (especially residential occupants) have limited knowledge on improving energy efficiency and managing building emissions during the occupancy stage.
- There is a need for ULB led pilot interventions to generate awareness and increase the uptake of ZCB strategies

Lack of product transparency and knowledge database

- There is a lack of an exhaustive single source database of low carbon building materials for Nagpur.
- Information related to building material LCA, benefits, GHG emission, is not easily accessible or not published on public forums. Efforts and exercises to generate such holistic information on building material sustainability and inform decision-making are currently largely absent at the local and regional level.

7. Vision Statement for Nagpur's Zero Carbon Buildings

Nagpur has set its vision to outline its ambition to transform its buildings to net-zero carbon buildings and to steer the roadmap and action plan to realize this ambition.

> *To initiate the decarbonization of Nagpur city's building and construction sector by encouraging key stakeholders to adopt strategies that reduce embodied, operational and end of life energy and emissions of buildings.*
>
> *The Zero Carbon Buildings Action Plan has the goal of developing new buildings as Net Zero by 2030 and all buildings to be Net Zero by 2050.*

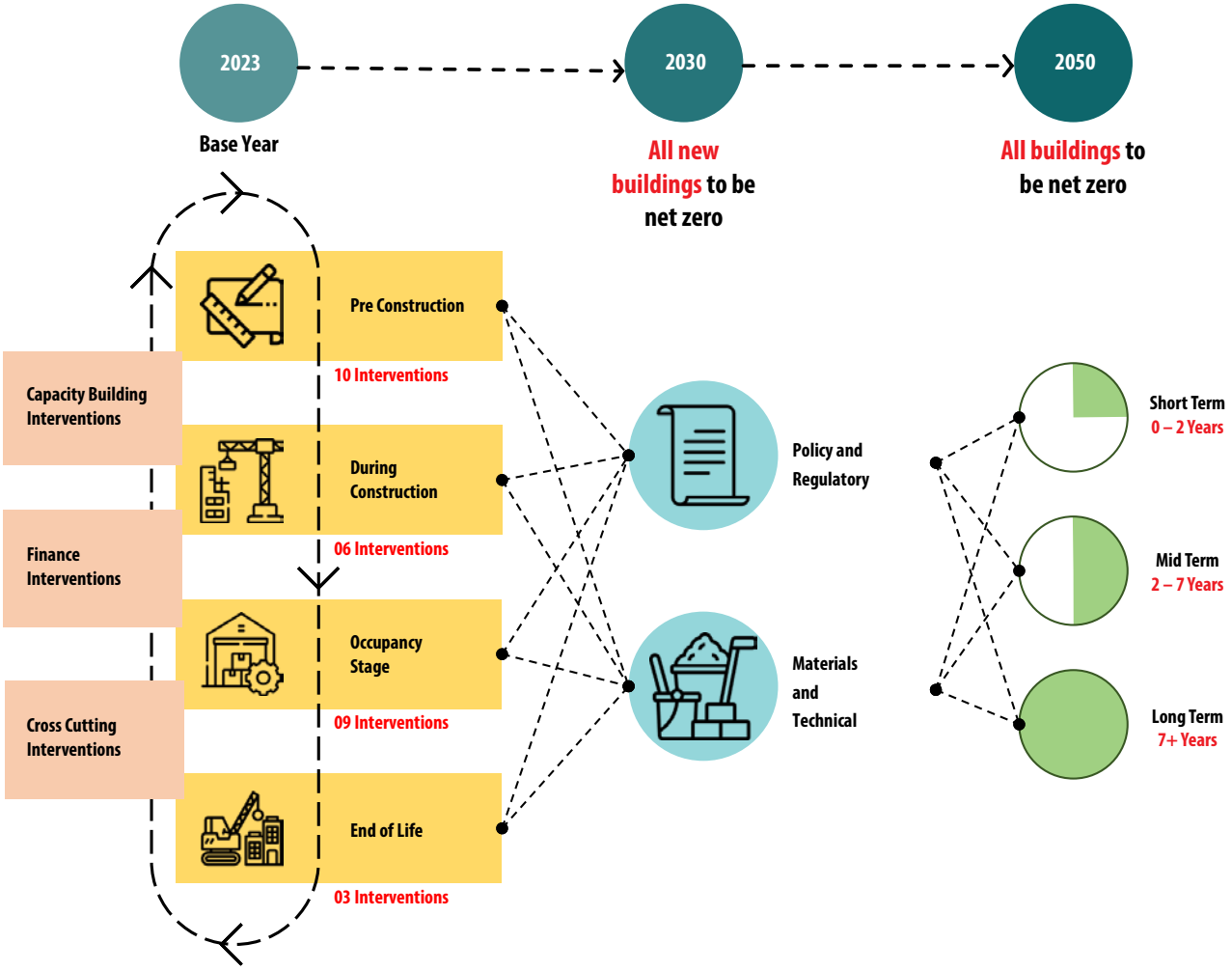
In the construction sector, the urban local governments play a vital role to regulate and guide the development activities in the city as a part of their statutory powers. For Nagpur, the NMC and NSSCDCL will lead, coordinate, and facilitate actions to help achieve this vision, through their planning and regulatory authority. These two city agencies will aim to promote and implement certain city specific initiatives, with the support of the State Government and other nodal bodies, that can have wider impacts and benefit all its citizens.

Building industry stakeholders, including builders and real estate developers, architects, civil engineers, material suppliers and manufacturers, service and utility providers, technical institutes and research organizations, NGOs and associations, as well as occupants and end-users of buildings, will be key players to drive the sectoral transformation in Nagpur. The industry is currently reliant on energy and emission intensive techniques because of sluggish pace of uptake of low carbon strategies. While Nagpur's ZCB Action Plan does not aim to disrupt the existing supply chain and its dependents, it does strive to gradually transform the existing ecosystem to include low carbon strategies in various phases of the building and material lifecycle and increase the city's capacity to support the entailing actions.

8. Approach to Formulating the Transformative Interventions

Transformative actions have been identified in this section in line with Nagpur's vision of developing all buildings to be net-zero carbon by 2050. Interventions have been identified addressing the building lifecycle, across four phases including pre-construction, during construction, occupancy and end-of-life. It should be noted that building decarbonisation opportunities with higher potential exist at pre-construction stage or planning stage. 28 interventions have been recommended across the four building lifecycle phases, including policy and regulatory measures as well as actions addressing building materials and technical measures.

For the interventions, short (0-2 years), mid (2-7 years) and long-term (>7 years) goals have been outlined for effective policy planning, to identify forward looking demonstration projects and support implementation at scale as depicted in the Figure below. The implementation strategy for the proposed interventions extends across these timeframes and broadly targets building sub-types in a phased manner, starting with implementation in government owned public buildings as proof of concept in the short term, transitioning into decarbonising the large commercial and residential complexes by mid-term, and eventually extending actions to cover the city's entire building stock to achieve net-zero buildings starting from 2050. A list of cross-cutting interventions have also been identified, encompassing aspects such as integrated urban planning, whole building lifecycle with promotion of conscious public procurement and circularity. To enable the net zero buildings transition, key enabling actions on finance and capacity building are also included.



The Figure above captures all the core interventions identified across four major building lifecycle phases, covering ambitious yet attainable actions based on policy and regulatory recommendations, low carbon materials, building operations' and energy use, and end-of-life of buildings. Recommended interventions focus more on activities that contribute to direct energy and resource consumption and GHG emissions. The identified measures address activities that are largely controlled and managed by key stakeholders such as local authorities, builders and developers and building material manufacturers, considering the current byelaws, enabling state and national level policies and targets, capacity of local builders and developers, and materials and technology providers, and overall trends in the construction industry.

Stakeholders to lead and support implementation of the recommended interventions have been identified. Lead stakeholders would have the primary responsibility to issue and implement the relevant policy and guidelines to support the intervention, as is the case with ULB, State and Central Government, and nodal agencies. Various technical experts and actors such as architects, civil engineers, service and utility providers, and material manufacturers will lend vital support by providing necessary push for voluntary initiatives and ensure implementation and technical compliance of the suggested interventions. In addition, these technical experts would also play an important role to advise the ULB to frame enabling policy measures. Real estate developers, building owners, managers and occupants shall ensure that the interventions are implemented as per the issued guidelines and norms and as per the advice of the technical experts to integrate net zero strategies and maximize building efficiency throughout its lifecycle.

8.1. Interventions Overview

An overview of the 28 ZCB interventions identified for Nagpur, capturing policy and regulatory measures and materials and technical measures, are listed below.

1 Pre-Construction

- Guidelines & codes on low-emission buildings included in DCR locally
- Adopt climate responsive building envelope design
- Faster approvals & financial benefits for green buildings
- Consider building lifecycle & include conditions in building approval
- Adopt certified low-carbon materials, technologies & techniques in new construction
- Incorporate passive cooling solutions & strategies into building design
- Building approval requirements to use high energy-efficiency utilities & appliances
- Design buildings to support rooftop solar PV uptake
- Promote RE open access facility for net-zero buildings
- Plan building project sites to maximise & conserve green cover

2 During Construction

- ULB to enforce the implementation of dust mitigation measures at construction sites as per CPCB guidelines
- Promote construction workers' well-being & inclusion
- Create an ecosystem to promote reuse of industrial & agricultural by-products
- Encourage local procurement & manufacturing of construction materials
- Use of renewable energy & energy efficient equipment for building construction sites
- Use electric vehicles for transportation of building materials and personnel

3 Occupancy Stage

- Enact energy performance standards for existing buildings
- Promote green rating & performance labelling of existing buildings
- Guidelines for retrofit measures to improve energy performance
- Promote high energy efficiency in common utilities
- Energy benchmarking program for reporting of energy use & performance
- Building renovation program to conduct energy audits & implement energy improvement measures
- Adopt building energy management systems in large public & private buildings
- Scale up uptake of rooftop solar PV – potential study for existing rooftops & to enable large-scale adoption

4 End of Life

- Promote deconstruction of old buildings instead of demolition. Mandate adoption of deconstruction strategies to obtain approvals for new buildings & redevelopments
- Implement appropriate C&D waste management guideline and policy
- Procurement & use of recycled C&D waste and its products

The interventions for this roadmap have been identified through stakeholder consultations, which helped understand the existing gaps and barriers and determine the enablers required to make the building decarbonisation transition easier. NMC and NSSCDCL are expected to lead this transition by formulating robust and ambitious policy actions, showcasing implementation of ZCB actions through demonstrative projects in public buildings and affordable housing, promoting replication and scale-up in commercial and residential building segments, and establishing effective monitoring mechanisms. The ULB shall closely work with the identified stakeholders while designing the polices and key enablers such as financial models to fast-track the adoption of ZCBs in Nagpur. The following section outlines the list of interventions and their details across the four targeted building lifecycle phases.

9. Interventions

9.1. Pre-Construction

The interventions have been formulated with the aim to include ZCB guidelines, recommendations and statutory provisions in the UDCPR to drive low/no carbon building designs. Pre-construction or design stage for any project has maximum potential to reduce embodied carbon and the strategies have been formulated to realise this potential.

Interventions

Intervention 1
Include relevant guidelines, codes and regulations on efficient and low emission buildings into the Development Regulations at local level


Short Term

ULB to coordinate with the State Government to update & modify relevant sections in the UDCPR pertaining to building sustainability & energy performance, in accordance with codes & guidelines such as ECBC, Eco-Niwas Samhita, National Building Code (Part 11), Nagpur's Guidelines for Energy Efficient & Climate Responsive Homes.


Mid to Long Term

Updated provisions & measures from codes & guidelines to achieve net-zero buildings to be incorporated into the UDCPR locally, considering Nagpur's context.

Intervention 2
Adopt climate responsive building envelope design with building typology-wise minimum criteria for building energy performance


Short Term

Implement pilots in new public & affordable housing buildings. Incorporate climate responsive design guidelines in UDCPR.


Mid Term

Increased adoption in new residential, commercial & public buildings due to inclusion in UDCPR & improved awareness


Long Term

All new residential, commercial, & public buildings shall adopt climate responsive designs due to requirements in UDCPR.

Intervention 3
Provide building approval related and financial benefits for green building pre-certification


Short to Mid Term

ULB to provide faster approvals, precertification assistance and FSI monetization options for pre-certified green buildings, targeting small and mid-size commercial, residential and institutional buildings.


Long Term

ULB to provide faster approvals, precertification assistance and FSI monetization options targeting all buildings.

Policy and Regulation Materials and Technical

Anticipated Benefits for Proposed Interventions

Benefits →	Climate Resilience	Energy Savings	Health and Well Being	Emissions Reduction	Resource Efficiency	UHIE Reduction
Intervention 1	●	●	●	●	◉	●
Intervention 2	●	●	◉	◉	◉	◉
Intervention 3	●	●	●	●	◉	◉

Highest Impact ●◉○○ **Lowest Impact**

Intervention 4
Include consideration of lifecycle impact of buildings & requirements for the same in building approval

Short Term — Carry out LCA & identify benchmarks for all new public buildings & affordable housing. Issue guidelines for simplified LCA & establish initial performance criteria for building types. Inclusion of LCA in green building certification.

Mid Term — Establish LCA benchmarks for different building categories. All new large commercial, residential & public buildings to perform LCA & meet benchmarks for building approval. Promote LCA during major renovations.

Long Term — All buildings shall perform whole-building LCA & meet minimum benchmarks for embodied carbon for building approval, during new construction & for major renovations.

Intervention 5
Adopt certified low-carbon materials, technologies & techniques in the construction of new buildings

Short Term — Use of low carbon materials & certified green products (alternative cements, recycled envelope materials) & construction techniques in new public buildings & affordable housing by including requirements in tenders. Implementation of pilots.

Mid Term — All new large commercial, residential & public buildings shall use low carbon techniques & materials for their major components. Use of alternative eco-friendly cements for all structural & non-structural components of buildings.

Long Term — All commercial, public & residential buildings shall adopt low-carbon techniques & materials for nearly all building components, during new construction & major renovations.

Intervention 6
Incorporate passive & energy efficient cooling solutions & strategies into the building & microclimate design

Short Term — Adopt & integrate solutions in new public buildings & affordable housing. Promote initial uptake in new large commercial & residential buildings along with district cooling potential study in building clusters.

Mid Term — Expand uptake in new commercial & public building construction & in all new mid to large-size residential buildings & homes. Integrate district cooling infrastructure for new developments with high potential.

Long Term — City-wide uptake in all new non-residential construction & residential buildings. Passive & energy efficient cooling solutions shall be included in large renovations. Implement district cooling systems in high cooling demand zones.

Policy and Regulation

Materials and Technical

Anticipated Benefits for Proposed Interventions

Benefits →	Climate Resilience	Energy Savings	Health and Well Being	Emissions Reduction	Resource Efficiency	UHIE Reduction
Intervention 4	●	●	○	●	●	○
Intervention 5	◉	◉	◉	◉	◉	○
Intervention 6	◉	●	●	◉	○	●

Highest Impact ●◉◉○ **Lowest Impact**

Intervention 7
ULB to include requirements in building approval to use high energy-efficiency utility & indoor appliances


Short Term

Mandate use of high energy efficiency appliances in new large-scale commercial & public buildings, residential apartments & large independent houses through UDCPR.


Mid Term

Mandates extended to new mid- sized commercial buildings, residential apartments & independent houses. ULB to facilitate & incentivize uptake in low-income households.


Long Term

All building types shall use super-efficient appliances & equipment.

Intervention 8
Establish mandates & design buildings to help tap into rooftop solar PV potential


Short Term

Mandates set for minimum share of total electricity demand to be met by rooftop solar PV in large-scale commercial, public, affordable housing & residential buildings through UDCPR.


Mid Term

Mandates extended to mid-sized commercial, public & residential buildings. Renewable energy (RE) programme & financial incentives for small scale commercial & low-income residential buildings.


Long Term

All buildings with accessible rooftops use on-site solar PV & it shall cater to most of their energy demand. DISCOMs shall offer additional RE power supply through open access to consumers for near net-zero building operations.

Intervention 9
Promote open access facility for renewable energy purchase to support net-zero buildings


Short Term

ULB in consultation with DISCOM to issue guideline to support & integrate RE open access for upcoming large public, residential & commercial buildings.


Mid Term

Majority of public & private buildings opt for open access RE purchase.


Long Term

All the eligible public & private buildings opt for open access RE purchase.

Policy and Regulation

Materials and Technical

Anticipated Benefits for Proposed Interventions

Benefits →	Climate Resilience	Energy Savings	Health and Well Being	Emissions Reduction	Resource Efficiency	UHIE Reduction
Intervention 7	●	●	●	●	●	○
Intervention 8	●	●	○	●	●	○
Intervention 9	●	●	○	●	●	○

Highest Impact ●●○○ **Lowest Impact**

Intervention 10
Plan building project sites to maximise and conserve permeable surfaces and green cover

Short Term — ULB to plan & maximise green cover and site permeability in public buildings & affordable housing projects. Issue guidelines for maximizing green cover for buildings and site permeability.

Mid Term — Large commercial & residential projects plan & design buildings ground level open spaces, facades, balconies, common areas & terraces to maximise green cover and site permeability.

Long Term — All building typologies shall maximise green cover and site permeability as per guidelines issued by the ULB.

Policy and Regulation

Materials and Technical

Anticipated Benefits for Proposed Interventions

Benefits →	Climate Resilience	Energy Savings	Health and Well Being	Emissions Reduction	Resource Efficiency	UHIE Reduction
Intervention 10	●	○	●	○	○	●

Highest Impact ●●○○ **Lowest Impact**

Stakeholder Responsibility Matrix for Pre-Construction Stage

Highest Role
Major Role
Minor Role
Minimal Role

	Urban Local Body (ULB)	Architect/Civil Engineer	Real Estate Developer	Occupants/ Owners	Service & Utility Providers/ Installers	Building Material Manufacturers	Associations, Institutes, Academia, NGOs	State/ Central Government Agencies	MEDA & DISCOM	Financial Institutions
Intervention 1: Include relevant guidelines, codes and regulations on efficient and low emission buildings into the Development Regulations at local level	■	▒	▒		▒	▒	▒	■	▒	▒
Intervention 2: Adopt climate responsive building envelope design with building typology-wise minimum criteria for building energy performance	■	▒	▒		▒	▒	▒	■	▒	▒
Intervention 3: Provide building approval related and financial benefits for green building pre-certification	■							■		
Intervention 4: Include consideration of lifecycle impact of buildings & requirements for the same in building approval	■	▒	▒		▒	▒	▒	■		
Intervention 5: Adopt certified low-carbon materials, technologies & techniques in the construction of new buildings	▒	■	▒		▒	■		▒		
Intervention 6: Incorporate passive & energy efficient cooling solutions & strategies into the building & microclimate design	▒	■	▒		▒	■		▒		

	Urban Local Body (ULB)	Architect/Civil Engineer	Real Estate Developer	Occupants/ Owners	Service & Utility Providers/ Installers	Building Material Manufacturers	Associations, Institutes, Academia, NGOs	State/ Central Government Agencies	MEDA & DISCOM	Financial Institutions
Intervention 7: ULB to include requirements in building approval to use high energy-efficiency utility & indoor appliances										
Intervention 8: Establish mandates & design buildings to help tap into rooftop solar PV potential										
Intervention 9: Promote open access facility for renewable energy purchase to support net-zero buildings										
Intervention 10: Plan building project sites to maximise and conserve permeable surfaces and green cover										

Highest Role
Major Role
Minor Role
Minimal Role

9.1.1. Detailed Interventions for Pre-Construction Stage

Policy and Regulation

Intervention 1: Include relevant guidelines, codes and regulations on efficient and low emission buildings into the Development Regulations at local level

	Stakeholder	Role
Lead Stakeholder	ULB and State Government	Policy implementation and local enforcement
Supporting Stakeholder	Architects/ Civil Engineer, Real Estate Developers	Policy advisory, compliance, voluntary initiatives

- ULB to coordinate with the State Urban Development Department to include building energy related guidelines, codes and regulations into the UDCPR at the local level. Relevant guidelines and codes to be incorporated include Nagpur's Guidelines for Energy Efficient and Climate Responsive Homes, National Building Code (Part 11 Approach to Sustainability), and ECBC for commercial and residential buildings (Eco-Niwas Samhita, 2018). Inclusion of ECBC and Eco-Niwas Samhita shall be as per the Energy Conservation (Amendment) Bill, 2022.

Intervention 2: Adopt climate responsive building envelope design with building typology-wise minimum criteria for building energy performance

	Stakeholder	Role
Lead Stakeholder	ULB and State Government	Policy implementation and local enforcement
Supporting Stakeholder	Architects/ Civil Engineer, Real Estate Developers	Policy advisory, compliance, voluntary initiatives

- Improving energy and thermal performance of buildings by following the design strategies in applicable guidelines and standards such as
  - "Nagpur's Guidelines for Energy Efficient and Climate Responsive Homes" to be included as a notified supplementary guideline in building bye-laws for building envelop design along with ECBC and Eco-Niwas Samhita as statutory mandates (as applicable)
  - Part – 11: Approach to Sustainability, NBC 2016
  - Mandating Green Building certification for buildings that are not under the purview of ECBC or Eco-Niwas Samhita
- ULB to promote and include requirements for building designs that:
  - incorporate optimised form and orientation with suitable windows sizing
  - wall and roof insulation techniques
  - shading devices
  - appropriate cross ventilation to lower heat gains and improve thermal comfort in the buildings
  - maximising daylighting

Intervention 3: Provide building approval related and financial benefits for green building pre-certification

	Stakeholder	Role
Lead Stakeholder	ULB and State Government	Policy implementation and local enforcement
Supporting Stakeholder	Architects/ Civil Engineer, Real Estate Developers	Policy advisory

- Setup single window/faster approval process for pre-certified green buildings
- ULB to provide incentives such as financial assistance on pre-certification fees, reduced approval fees
- ULB to provide an option to sell additional built-up obtained as incentive, in the form of TDR

Intervention 4: Include consideration of lifecycle impact of buildings & requirements for the same in building approval

	Stakeholder	Role
Lead Stakeholder	ULB and State Government	Policy implementation and local enforcement
Supporting Stakeholder	Architects/ Civil Engineer, Real Estate Developers, Service & Utility Providers/ Installers, Material Manufacturers	Policy and technical advisory, compliance, technology and building material disclosures

- Promote building use, design and choice of materials based on the lifecycle impact of the buildings and its components, through awareness and capacity building.
- Plans and designs for new buildings and for renovations to focus on reducing impact over the entire lifecycle (from construction to demolition)
- ULB to issue guidelines to apply simplified LCA exercises
- ULB to establish minimum energy and environmental performance criteria based on LCA approach for different building types, linked with building approval mechanism

Materials and Technical

Low Carbon Construction

Intervention 5: Adopt certified low-carbon materials, technologies & techniques in the construction of new buildings

	Stakeholder	Role
Lead Stakeholder	Architect/ Civil Engineer, Material Manufacturers	Push for voluntary uptake and create a strong market for low carbon materials, technologies and techniques
Supporting Stakeholder	Real Estate Developer	Maximise voluntary uptake

- Encourage the use of concrete reducing techniques such as Filler Slabs, Mangalore Tile Roofs, Guna Tile Roof, among others
- Encourage construction of certain parts of buildings using earth-based construction techniques such as Wattle and Daub construction, Adobe Brick walls, among others
- Implement pilot interventions to demonstrate the use of alternative cements like Limestone Calcined Clay Cement (LC3) and green cement
- Encourage the use of construction techniques such as Rat Trap Bond and Cavity Walls that reduce heat ingress
- Promote the use of insulation materials made from recycled materials for the building envelope
- Encourage use of timber or bamboo as a replacement material for steel and concrete structures, where possible
- Encourage procurement of materials that have been certified green by Greenpro, GRIHA, and similar certifying agencies
- Encourage use of pre-cast/pre-fabricated components, such as dense concrete hollow core columns, pre-cast beams, lintels, staircases, wall panels, among others during building design

Renewable Energy and Energy Efficiency

Intervention 6: Incorporate passive & energy efficient cooling solutions & strategies into the building & microclimate design

	Stakeholder	Role
Lead Stakeholder	Architect/ Civil Engineer, Material Manufacturers	Push for voluntary uptake
Supporting Stakeholder	Real Estate Developer	Maximise voluntary uptake

- Promote vertical gardening for vegetative cooling on facades and window openings
- Install evaporative cooling ponds or water screens on the windward side of buildings to cool the hot air entering them

- Position windows for improved cross-ventilation, incorporating techniques such as stack effect and venturi effect
- Use elongated chajjas and shading devices for protection from solar radiation
- Encourage the use of glass with low thermal ingress and high light transmittance in building facades and common areas
- Use of cool roofs and reflective surfaces for walls and pavements
- Evaluate and incorporate low-carbon district cooling systems at an early planning stage, particularly for dense commercial and institutional clusters with high cooling demand

Intervention 7: ULB to include requirements in building approval to use high energy-efficiency utility & indoor appliances

	Stakeholder	Role
Lead Stakeholder	ULB, MEDA and DISCOM	Policy implementation and enforcement
Supporting Stakeholder	Architects/ Civil Engineer, Service & Utility Providers/ Installers	Policy and technical advisory, ensure maximum compliance

- ULB to promote BEE star labelled energy efficient equipment including water pumps, lifts, and indoor appliances such as lighting, cooling, and electronic items
- Include conditions and enforcement measures in the building approval process on the use of energy efficient equipment and appliances.

Intervention 8: Establish mandates & design buildings to help tap into rooftop solar PV potential

	Stakeholder	Role
Lead Stakeholder	ULB, MEDA and DISCOM	Policy implementation and enforcement
Supporting Stakeholder	Architects/ Civil Engineer, Service & Utility Providers/ Installers	Policy and technical advisory, ensure maximum compliance

- ULB to mandate use of rooftop solar PV systems in UDCPR to meet building energy demand in new buildings and link it to building approval and occupancy certification. ULB to establish appropriate enforcement and monitoring mechanism to ensure compliance.
- Building plans and designs to include solar PV systems. Design of rooftops and structures to be done so as to optimize solar PV potential.

Intervention 9: Promote open access facility for renewable energy purchase to support net-zero buildings

	Stakeholder	Role
Lead Stakeholder	ULB, MEDA and DISCOM	Policy implementation and enforcement
Supporting Stakeholder	Architects/ Civil Engineer, Service & Utility Providers/ Installers	Policy and technical advisory, ensure maximum compliance

- ULB and DISCOM to promote and facilitate renewable energy open access to consumers having load above 100 kW in line with latest operational norms provided by the Ministry of Power.

Permeable Surfaces and Green Cover

Intervention 10: Plan building project sites to maximise and conserve permeable surfaces and green cover

	Stakeholder	Role
Lead Stakeholder	Architect/ Civil Engineer	Push voluntary uptake
Supporting Stakeholder	Real Estate Developer	Ensure maximum uptake

- ULB to promote enhanced permeability of hard surfaces at the site level to improve water percolation (through use of open grid grass pavement, adoption of grid of pavers and void space filled with sand) and prepare guidelines for the same.
- Encourage water efficient landscaping and plantation offering sufficient shade for buildings and site
- Promote plantation of native tree species to enhance local biodiversity and allied ecosystems services
- Encourage greening and landscaping on the terraces and rooftops, especially for plots with limited open space available
- Encourage planning of built-up areas around existing tree cover on-site and green spaces to ensure minimal need for tree-felling, harm, and disruption

9.1.2. Case studies for Pre-Construction Stage

Box 1: Sustainability and Climate Resilience focused Urban Design Guidelines, Ranchi

As part of its Smart City proposal, Ranchi has proposed greenfield development spanning 656 acres. To enhance the quality of the built area and open spaces in this new area, it is proposed that due focus will be given to sustainable urban design through guidelines focusing on:

- Creating a vibrant, safe, inclusive and sustainable city to live and work in for citizens
- Integrating city's ecological assets with the built environment thus ensuring sustainability
- Incorporating sustainable technologies and materials in building designs while leveraging natural elements
- Developing suitable strategies for climate resilience and incentivizing the same

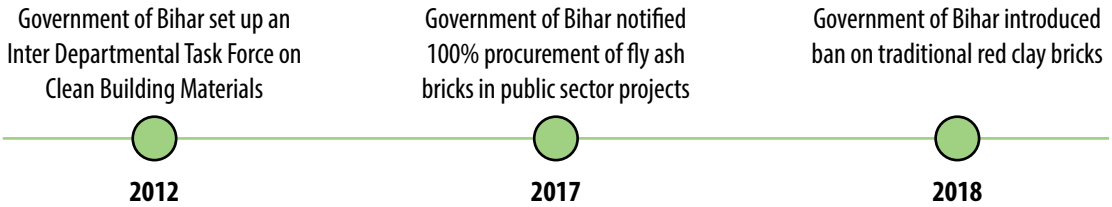
Co-benefits: Active involvement of local Sohrai, Dhokhra, bamboo and wood, and other indigenous art form's artisans within Ranchi

Source: : Ministry of Housing and Urban Affairs, 2019

Box 2: Fly Ash Brick Procurement Policy Mandates, Bihar

In Bihar, the brick sector is the third highest emitter of CO_2 after agriculture and energy. This high rate of GHG emissions is due to the present technology of manufacturing clay brick by using coal as a fuel for brick firing. Agricultural soil is required in the manufacturing of such clay bricks, leading to an impact on agricultural activity. To address the issue, the Government of Bihar implemented project to promote fly ash bricks. During the project period from 2012-2018, the market share of fly ash brick industry has improved from 0% to 17% at present.

Timeline:



Source: Ministry of Housing and Urban Affairs, 2019

Box 3: TZED homes in Bangalore by BCIL

TZED (ZED stands for Zero Energy Development) is located at airport Whitefield Road, Bangalore. This five-acre site comprises of 95 homes built on sustainability principles. The project demonstrates that modern comfort standards can still be met while adopting sustainable built environment practices. The sustainable strategies used are:

Energy

- Centralised district refrigeration system and air conditioning system using an ammonia-based chilling unit
- Intelligent lighting systems using motion sensors, ambient light sensors and timers
- LED lights in common areas
- Energy and water use monitoring systems

Construction Materials and Techniques

- Filler slabs, incorporating fly ash blocks
- External walls are built using soil-stabilised blocks (around 500,000 blocks have been used), laterite blocks and finishing treated with fine waterproof coating.
- Incorporated green roofs
- Rubberwood, a non-forest timber, is used for door shutters and as flooring
- Palm wood has been used for external walkway decking
- Compressed coir door panels for the door shutters
- Bamboo composites provide roofing for part of the club and the interior woodwork in places

Water Efficiency

- Self-sufficient and secure water supply system provided, using the rainwater collected from the roofs
- All wastewater (grey water) is treated, through a process of filtration, aeration and ozonization to be reused for gardens

Source: Architecture & Developpement, 2023

Box 4: Use of Renewable Energy technologies in social housing, Rajkot

Rajkot Municipal Corporation (RMC) deployed rooftop solar PV systems in SMART GHAR scheme (social housing) to offset the energy demand of common utilities such as water pumps, elevators, common lighting.

Project is aimed at creating model project of introducing EE and RE measures reducing conventional electricity from residential sector. After this successful pilot, RMC decided to implement similar projects in all upcoming social housing projects. Project provided economic benefits in-terms of reduced building maintenance charges. Residential Welfare Association members were trained to keep the solar system performance consistent.

Source: Best Practices Compendium: ClimateSmart CITIES, 2019

Box 5: Statutory adoption of ECBC codes in Telangana state

Telangana state established web-based Development Permission Management System (DPMS), integrated with ECBC compliance into the building approval application system. System is being governed by a steering committee for effective implementation.

Key Features:

- Applies to any commercial building with plot area of 1,000 square meters or more or a built-up area of 2,000 square meters or more
- Buildings such as multiplexes, hospitals, hotels, and convention centers, must comply with the ECBC, irrespective of their built-up area.
- Code compliance is verified through third-party assessors during the building design approval stage and after construction.

Source: Natural Resources Defense Council, 2018

Box 6: Vikas Community Apartments, Auroville

This project was the first development in Auroville, which used stabilized earth right from foundations to roof.

Building Materials and Construction Techniques:

- Stabilised rammed earth foundations with 5 % cement
- Plinths and walls in compressed stabilised earth blocks
- Stabilised rammed earth walls with 5% cement
- Composite beams and lintels and composite columns
- Vaults and domes for floors and roof, made of CSEB
- Paints and plasters with stabilised earth Floorings with CSEB tiles, 2.5cm thick with 5 % cement
- Ferrocement channels of 25mm thickness Various ferrocement items for different uses
- Ferrocement doors, shelves, etc. of 12mm thickness
- Ferrocement plasters for water tanks and ponds

Source: Auroville Earth Institute, n.d.

Box 7: Design with material circularity in mind: Circl, Amsterdam

The new 'Circl' pavilion in Amsterdam Netherlands is the first constructed practical example of sustainable and circular designs. The reuse of the applied materials was factored into the process right from the start. As far as possible, parts of the structure have been put together in such a way that in the event of a replacement or demolition, they can be reused.

Examples of material used with circularity:

- Rejected wooden window frames have been cut into wooden floors and tiled floors were made from reused concrete with added PCM[6] (phase changing materials) that controls the indoor climate.
- The timber support structure is made from fully dismountable locally sourced Larch wood.
- Old jeans of employees and bank staff have been included in the ceiling as insulating material.
- The lifts in Circl have not been purchased but have been leased and will return to the manufacturer after ten years.
- All the materials, parts and components used to create the building have been recorded in the form of a "digital twin", the building's passport[7], referred to as LLMNT

Source: Architizer, 2019

6. PCM is a material that changes phase at a certain temperature (liquid or solid). During this phase change the material can release warmth or cold to the surroundings to reduce temperature variations
7. 'A material passport describes all materials, components and elements used in a building. It is a digital model, a dataset, with valuable information on different building levels. This information gives value for present use, recovery and reuse' (Mulhall, et al., 2017; Circle Economy, van Odijk, van Bovene, 2014)

Illustrative Examples for Pre-construction Stage Interventions

Egg Crate Shading Device (Source: 2030 palette, n.d.)

Permeable paving (Source: Indiamart, n.d.)

Filler slab construction (Source: Blurring Boundaries, n.d.)

XPS roof insulation installation (Source: SPL Insuboard, 2021)

9.2. During Construction Stage

During In this stage, interventions are formulated to reduce emissions that occur during on-site construction activities. Strategies would be applicable for new buildings, to ensure emissions compliance, use of renewable energy and energy efficient systems for construction, and material reuse.

Interventions

Intervention 1
ULB to enforce the implementation of dust mitigation measures at construction sites as per CPCB guidelines

- Short Term: ULB to implement pollution control measures and monitor dust mitigation at construction sites for new public building projects as per CPCB guidelines.
- Mid Term: Initiate & expand dust mitigation monitoring & reporting for new large commercial & residential buildings to meet norms.
- Long Term: All new constructions to undertake dust mitigation as per the prescribed norms.

Intervention 2
Promote construction workers' well-being & inclusion

- Short to Mid Term: ULB to update/ modify SOPs to ensure employment of women in ULB led construction activities in line with prevailing regulations (Building & Other Construction Workers Act, 1996). Provide training facilities for skill development of women.
- Long Term: ULB to ensure compliance & enforcement of regulations. Increased employment for women in private construction.

Intervention 3
Create an ecosystem promoting the reuse of industrial & agricultural by-products

- Short Term: ULB to construct **non-structural parts** of new public buildings & affordable housing projects with concrete mixes using agricultural by-products & natural resins
- Mid Term: Large commercial & residential buildings to incorporate concrete mixes with agricultural by-products & natural resins for non-structural members. ULB to **reuse industrial & agricultural by-products for structural members of public & affordable housing buildings** as a proof of concept.
- Long Term: All commercial, residential & institutional buildings incorporate **concrete mixes with agricultural by-products & natural resins for structural & non-structural members.**

Policy and Regulation Materials and Technical

Anticipated Benefits for Proposed Interventions

Benefits →	Climate Resilience	Energy Savings	Health and Well Being	Emissions Reduction	Resource Efficiency	UHIE Reduction
Intervention 1	●	○	●	●	○	●
Intervention 2	○	○	●	○	○	○
Intervention 3	●	●	●	●	●	●

Highest Impact ●●●○ **Lowest Impact**

Intervention 4
Encourage local procurement & manufacturing of construction materials


Short Term

ULB to develop, maintain & annually update a repository of local materials. ULB to procure local materials for public buildings & notify guidelines to source raw materials for in-situ production of materials such as non-fired bricks.


Mid Term

Uptake of local materials in large commercial & residential projects, manufactured within 400 km from the project site- as per the ULB norms or the relevant green rating agency, whichever is applicable.


Long Term

Increased uptake of in-situ production & local building materials in all types of public & private building projects.

Intervention 5
Use of renewable energy & energy efficient (EE) equipment for building construction sites


Short Term

ULB to promote use of RE & EE equipment in the construction of public buildings by including conditions in tender documents. Uptake of on-site solar PV system initiated at construction sites of commercial & residential buildings, where sufficient open space is available.


Mid to Long Term

Expand the uptake of RE systems & efficient equipment at construction sites of all building typologies.

Intervention 6
Use electric vehicles for transportation of construction materials & personnel


Short Term

Initiate the switch to electric vehicles using available EVs like E-Rickshaws. ULB to strengthen EV infrastructure such as fast charging stations & EV parking lots to support EV adoption in construction activity.


Mid Term

Vendors & suppliers to begin use of light commercial EVs to locally move lightweight construction materials to site.


Long Term

Based on the advancement in EV technology, vendors & suppliers to use heavy commercial EVs to supply heavy loads & materials to construction site.

Policy and Regulation Materials and Technical

Anticipated Benefits for Proposed Interventions

Benefits →	Climate Resilience	Energy Savings	Health and Well Being	Emissions Reduction	Resource Efficiency	UHIE Reduction
Intervention 4	●	●	○	●	●	○
Intervention 5	●	●	○	●	●	○
Intervention 6	●	●	○	●	●	○

Highest Impact ●●●○ **Lowest Impact**

Stakeholder Responsibility Matrix for During Construction stage

Highest Role
Major Role
Minor Role
Minimal Role

	Urban Local Body (ULB)	Architect/Civil Engineer	Real Estate Developer	Occupants/ Owners	Service & Utility Providers/ Installers	Building Material Manufacturers	Associations, Institutes, Academia, NGOs	State/ Central Government Agencies	MEDA & DISCOM	Financial Institutions
Intervention 1: ULB to enforce dust mitigation measures at construction sites as per CPCB guidelines	Highest	Major	Highest		Minor		Major	Highest		
Intervention 2: Promote construction workers' well-being & inclusion	Highest		Highest					Highest		
Intervention 3: Create an ecosystem promoting the reuse of industrial & agricultural by-products	Minor	Highest	Highest			Major	Minor	Minor		
Intervention 4: Encourage local procurement & manufacturing of construction materials	Highest	Major	Major			Highest		Highest		
Intervention 5: Use of renewable energy & energy efficient (EE) equipment for building construction sites	Major		Highest		Highest			Minor	Highest	Major
Intervention 6: Use electric vehicles for transportation of construction materials & personnel	Major		Highest			Highest		Major		Minor

Photo by Anjali Lokhande on Unsplash

9.2.1. Detailed Interventions for During Construction Stage

Planning and Regulation

Intervention 1: ULB to enforce dust mitigation measures at construction sites as per CPCB guidelines

	Stakeholder	Role
Lead Stakeholder	ULB and State Government	Policy implementation and en-forcement
Supporting Stakeholder	Real Estate Developer	Ensure compliance

- ULB shall develop construction emission norms and monitoring protocols based on CPCB Guidelines and actions stated in Nagpur City Air Pollution Control Action Plan.
- ULB shall conduct training for builders, architects, and civil engineers towards on-site emission monitoring and reduction measures.
- ULB to undertake regular inspections at site to monitor construction emissions

Intervention 2: Promote construction workers' well-being & inclusion

	Stakeholder	Role
Lead Stakeholder	ULB and State Government	Policy implementation and en-forcement
Supporting Stakeholder	Real Estate Developer	Ensure compliance

- Ensure provision of basic amenities to construction workers as per "The Building and Other Construction Workers Act, 1996" especially women and children-specific interventions considering their health and safety
- Identify and assign skilled and unskilled roles to women in the building construction industry

Materials and Technology

Intervention 3: Create an ecosystem promoting the reuse of industrial & agricultural by-products

	Stakeholder	Role
Lead Stakeholder	Architect/ Civil Engineer	Push for voluntary uptake
Supporting Stakeholder	Real Estate Developer	Ensure maximum uptake

- Identify and encourage the use of agricultural and industrial by-products like fly ash, natural resins, bagasse, hemp, and pozzolans, to be used as binders and additives in the preparation of concrete and making non-structural parts of the building. The composition of the concrete mix shall be as per the structural design specifications.

Intervention 4: Encourage local procurement & manufacturing of construction materials

	Stakeholder	Role
Lead Stakeholder	ULB and State Government	Policy Implementation
Supporting Stakeholder	Material Manufacturers	Develop a strong local supply chain

- Project proponents to procure majority of the building materials (excluding major building materials such as steel and cement) that are manufactured within 400 km from the project site, or as specified by the relevant green rating agency, whichever is applicable
- Encourage in-situ production of non-fired bricks like sun-dried bricks and Compressed Stabilized Earth Blocks (CSEB) wherever possible

Intervention 5: Use of renewable energy & energy efficient (EE) equipment for building construction sites

	Stakeholder	Role
Lead Stakeholder	MEDA & DISCOM	Policy implementation and issue of permits
Supporting Stakeholder	Real Estate Developer	Ensure maximum uptake

- Use on-site solar PV systems and off-site RE options (such as virtual net metering) to meet electrical energy demand during construction
- Use of energy efficient lighting fixtures, water pumps, star rated diesel generators and other relevant equipment for improving on-site energy efficiency

Intervention 6: Use electric vehicles for transportation of construction materials & personnel

	Stakeholder	Role
Lead Stakeholder	Building Material Manufac-turer & Real Estate Developer	Initiate and maximise transition to EVs
Supporting Stakeholder	ULB and State Government	Implement EV centric policies and increase essential EV infrastruc-ture

- Encourage transition to EVs for transportation of materials to the building construction sites as well as for other activities during construction

Case Studies for During-Construction Stage

Box 1: In-situ Production of CSEB Blocks at Institute of Rural Research And Development, Gurgaon

The Institute of Rural Research and Development at Gurgaon uses soil excavated from its basement to produce CSEB Blocks for its masonry and for its landscape garden slopes.

In addition, the entrance lobby, boardroom and the central atrium use waste plywood wooden crating planks, broken tiles and glass to demonstrate reuse of waste.

Source: Lall, 2018

Illustrative Examples for During Construction Stage Interventions

Agro-waste Gypsum Hollow Blocks construction (Source: Singh et al., 2022)

CSEB Block Production (Source: Auroville Earth Institute, n.d.)

Local Stone Paving (Source: ExportersIndia, n.d.)

EV based goods transport solutions (Source: Lidhoo, 2022)

9.3. Occupancy Stage

The strategies for this stage are aimed towards improving the energy performance of existing buildings by notifying guidelines for energy benchmarking and auditing practices for buildings and by launching retrofit programmes and strengthening of compliances through energy monitoring and management systems.

Interventions

Intervention 1
ULB to enact energy performance standards for existing buildings


Short Term — Introduce minimum EPI requirements for existing public & mid to large size commercial buildings (such as hotels, retail, IT offices).


Mid Term — Update & expand minimum EPI requirements to apply to all existing public & commercial buildings. Also, frame the minimum EPI requirements for large residential buildings.


Long Term — Set mandatory minimum EPI requirements for near net-zero energy use applicable for all existing commercial, public & residential buildings.

Intervention 2
Promote green-rating & performance certification/ labelling of existing buildings


Short Term — Promote green rating certification/labelling for existing public & large commercial buildings (such as hotels, retail, IT offices).


Mid Term — Establish green rating certification/labelling requirements for all existing public & commercial buildings. Also, promote green certification/labelling of existing mid to large-size residential buildings.


Long Term — Mandate green rating certification/labelling for near-net zero performance required for all existing commercial, public & residential buildings.

Intervention 3
ULB to issue guidelines for retrofitting measures to improve building energy performance


Short Term — Promote conformance to guidelines for renovations of existing public & large commercial buildings. Establish policy for government offices to periodically replace old low-efficiency equipment, supplemented by an E-waste management strategy.


Mid Term — Establish conditions for renovations of all existing public & commercial buildings to adhere to guidelines & update guidelines to include advancements in measures & solutions for near net-zero performance.


Long Term — Establish conditions for renovations of all existing commercial, public & residential buildings to adhere to guidelines.

Policy and Regulation Materials and Technical

Anticipated Benefits for Proposed Interventions

Benefits →	Climate Resilience	Energy Savings	Health and Well Being	Emissions Reduction	Resource Efficiency	UHIE Reduction
Intervention 1	●	●	●	●	●	●
Intervention 2	●	●	●	●	●	●
Intervention 3	●	●	○	●	●	●

Highest Impact ●●●○ **Lowest Impact**

Intervention 4
Promote highly energy efficient common utilities by establishing energy performance requirements & conditions to obtain building permissions


Short Term

All new & existing public buildings achieve the minimum performance criteria for utilities as per UDCPR guidelines. Promote adoption in large-size commercial & residential buildings.


Mid Term

All new & existing mid to large size public, commercial & residential buildings meet the minimum energy performance criteria for common utilities. ULB to revise the benchmark requirements for future constructions.


Long Term

All new & existing buildings of all types meet the minimum energy performance requirements for common utilities.

Intervention 5
Expand energy benchmarking program to promote reporting of energy use & performance in buildings


Short Term

Promote energy performance reporting & minimum energy use/EPI benchmarks initiated for existing public buildings & mid to large-size commercial buildings (such as hotels, retail, IT offices).


Mid Term

Establish mandatory requirements for public & commercial buildings to meet minimum EPI benchmarks. Promote reporting & benchmarking in large residential apartments & independent houses.


Long Term

Entire building stock (non-residential & residential buildings) to report on energy performance & to adhere to minimum EPI benchmarks for near net-zero operations.

Intervention 6
Establish a building renovation/retrofit program to conduct energy audits & implement deep retrofit measures for energy performance improvement & decarbonization


Short Term

Carry out audits & implement deep energy retrofit measures in prioritized public & commercial buildings with high energy consumption. Pilot projects in public buildings & affordable housing to demonstrate potential benefits of renovations.


Mid Term

Expand program to cover all existing public & commercial buildings as well as large residential apartments & houses.


Long Term

All existing buildings implement periodic energy audits & energy improvement measures for near net-zero operations.

Policy and Regulation

Materials and Technical

Anticipated Benefits for Proposed Interventions

Benefits →	Climate Resilience	Energy Savings	Health and Well Being	Emissions Reduction	Resource Efficiency	UHIE Reduction
Intervention 4	●	●	○	●	●	●
Intervention 5	●	●	○	●	●	●
Intervention 6	●	●	○	●	●	●

Highest Impact ●●●○ **Lowest Impact**

Intervention 7
Promote use of cool and reflective surfaces at building roofs, walls, and pavements to reduce urban heat

Short Term — ULB to undertake renovation of external walls and roofs in public, institutional and affordable housing buildings, and prepare and notify guidelines for adoption of cool and surfaces for various building types including initial uptake in large commercial and residential buildings.

Mid Term — Expand the implementation to cover all existing public buildings and commercial buildings and promote for mid-large size residential apartments and houses.

Long Term — All existing buildings undertake renovations to deploy cool roofs and surfaces.

Intervention 8
Adopt Building Energy Management Systems (BEMS) in large public & private buildings

Short Term — Implement IoT tools/BEMS in all large public buildings. Promote use of BEMS in large commercial/non-residential buildings.

Mid to Long Term — Mandate use of IoT tools/BEMS in existing large commercial buildings & in all mid to large size public buildings.
Introduce IoT/BEMS in common utility meters of mid to large size residential apartments.

Intervention 9
Scale up uptake of rooftop solar PV – potential study for existing rooftops & to enable large-scale adoption

Short Term — ULB to take up implementation of rooftop solar PV in public & affordable housing buildings. Initiate feasibility assessment to maximise rooftop solar PV uptake in commercial & residential buildings.

Mid Term — Increase rooftop solar PV uptake in large commercial & institutional buildings & high consuming residential townships through demand aggregation & mechanisms such as RESCO.

Long Term — All commercial, institutional & residential buildings implement rooftop solar PV.

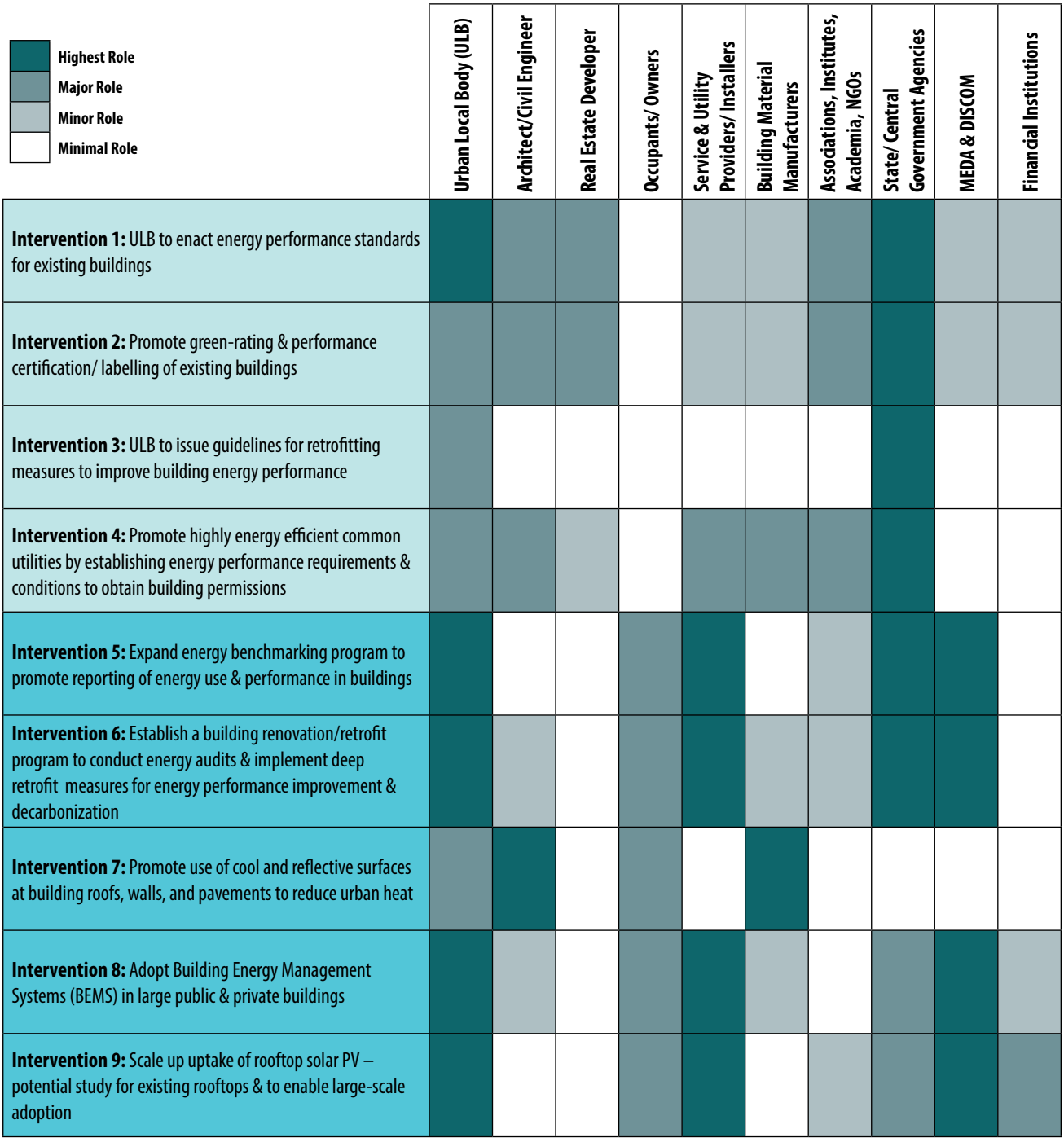
Policy and Regulation Materials and Technical

Anticipated Benefits for Proposed Interventions

Benefits →	Climate Resilience	Energy Savings	Health and Well Being	Emissions Reduction	Resource Efficiency	UHIE Reduction
Intervention 7	●	●	●	○	●	●
Intervention 8	○	●	○	○	○	○
Intervention 9	●	●	○	●	○	○

Highest Impact ●●○○ **Lowest Impact**

Stakeholder Responsibility Matrix for Occupancy Stage



9.3.1. Detailed Interventions for Occupancy Stage

Policy and Regulations

Intervention 1: ULB to enact energy performance standards for existing buildings

	Stakeholder	Role
Lead Stakeholder	ULB and State Govern-ment, MEDA and DISCOM	Policy implementation and en-forcement
Supporting Stakeholder	Service & Utility Providers/ Installers	Ensure maximum compliance

- Introduce minimum energy performance index (EPI) requirements for commercial, institutional, and residential buildings in phased manner. EPI requirements can be based on BEE benchmarks or relevant green building rating systems (as applicable to Nagpur's climatic zone) and built using local energy performance data for different building typologies and building sizes.
- Update the EPI progressively for different building types to help them achieve nearly net-zero operations.
- Include conditions for buildings to undertake energy performance improvement and decarbonization measures to meet minimum EPI requirements

Intervention 2: Promote green rating & performance certification/ labelling of existing buildings

	Stakeholder	Role
Lead Stakeholder	Architect/Civil Engineers, Service & Utility Providers/ Installers	Plan retrofits for maximum com-pliance
Supporting Stakeholder	Building Material Manufac-turers	Develop a strong local supply chain

- Encourage existing residential and non-residential buildings to secure green rating certification (such as GRIHA, IGBC for existing buildings) and energy star labels (BEE labels for Hotels, Commercial Office Buildings, Residential buildings) in line with ECBC regulations for commercial and residential buildings.
- Establish incentive mechanisms such as tax rebates, concessions, and financial assistance for buildings obtaining certification/labels on implementation of deep energy renovations

Intervention 3: ULB to issue guidelines for retrofitting measures to improve building energy performance

	Stakeholder	Role
Lead Stakeholder	Architect/ Civil Engineer, Service & Utility Providers/ Installers	Plan retrofits for maximum energy efficiency performance
Supporting Stakeholder	Occupants/ Owners	Ensure maximum compliance

- Incorporate guidelines in the UDCPR for specific building elements such as shading devices/chajjas and overhangs, glazing materials and installation of UV films, 2-stage evaporative cooling techniques, external and internal paints, and cool/green roof techniques for existing buildings based on BEA project outcomes
- Establish a policy for Government offices to periodically replace old low efficiency equipment and appliances with high-efficiency models.

Intervention 4: Promote highly energy efficient common utilities by establishing energy performance requirements & conditions to obtain building permissions

	Stakeholder	Role
Lead Stakeholder	Service & Utility Providers/ Installers	Plan retrofits for maximum energy efficiency performance
Supporting Stakeholder	Occupants/ Owners	Ensure maximum compliance

- ULB to prepare and notify an exhaustive list of energy efficient common utility equipment and appliances (water pumps, common area lighting, lifts, on-site sewage treatment plants) based on building typologies in the UDCPR and as per the guidelines provided by BEE and linked with occupancy certificate
- ULB to provide occupancy/part occupancy certificates based on the fulfilment of minimum energy performance criteria for common utilities

Materials and Technical

Intervention 5: Expand energy benchmarking program to promote reporting of energy use & performance in buildings

	Stakeholder	Role
Lead Stakeholder	ULB and State Govern-ment, MEDA & DISCOM	Policy implementation, enforce-ment and monitoring
Supporting Stakeholder	Service & Utility Providers/ Installers	Implement compliance measures

- Based on BEA project outcomes, ULB to expand energy use benchmarking program to a larger stock of commercial and non-residential buildings. Promote annual reporting of energy use and performance by buildings.
- ULB to introduce a centralised energy benchmarking monitoring and reporting tool in consultation with the local DISCOM and state and national agencies such as MEDA and BEE.
- ULB to develop the tool and conduct training and dissemination amongst occupiers/owners of energy intensive buildings.

Intervention 6: Establish a building renovation/retrofit program to conduct energy audits & implement deep retrofit measures for energy performance improvement & decarbonization

	Stakeholder	Role
Lead Stakeholder	ULB and State Govern-ment, MEDA & DISCOM	Policy implementation, enforce-ment and monitoring
Supporting Stakeholder	Service & Utility Providers/ Installers	Implement compliance measures

- Based on reported building energy use data and benchmarking process, identify and prioritize buildings with high energy use
- Conduct energy audits and identify energy improvement measures for the portfolio of prioritized buildings
- Implement deep energy retrofit measures in the target buildings to improve energy performance and meet minimum energy use benchmarks

Intervention 7: Promote use of cool and reflective surfaces at building roofs, walls, and pavements to reduce urban heat

	Stakeholder	Role
Lead Stakeholder	Architects/ Civil Engineers, Building Material Ma	Push for maximum uptake and strengthen local supply chain
Supporting Stakeholder	Occupants/ Owners	Implement compliance measures

- Install cool roofs and reflective surfaces in buildings through a Cool Roof and Surfaces programme. Solutions such as china mosaic, green roofs, earthen pots on roofs, reflective paints, insulation membrane cladding to be deployed and promoted in target buildings.
- ULB to prepare and notify guidelines for reflective roofs and walls, including list of suitable plaster materials and roof surfaces, adhesives, high reflective and low VOC paints, insulation to increase reflectivity from these surfaces and reduce heat absorption. Materials for permeable pavements and soft scape shall also be included.

Intervention 8: Adopt Building Energy Management Systems (BEMS) and technology driven components in large public & private buildings

	Stakeholder	Role
Lead Stakeholder	ULB, MEDA & DISCOM	Policy implementation, enforce-ment and monitoring
Supporting Stakeholder	Service & Utility Providers/ Installers	Implement compliance measures

- ULB to build a centralized infrastructure to collect and monitor building performance data for large public buildings, and encourage developers to incorporate BEMS to provide data and high-level analysis based on energy usage
- BEMS to include minimum level of automation in the system such as lighting and temperature control
- Buildings to use automation and sensor-based tools to regulate building energy consumption based on occupancy, equipment and appliance use, time of day, microclimate variation, among others

Intervention 9: Scale up uptake of rooftop solar PV – potential study for existing rooftops & to enable large-scale adoption

	Stakeholder	Role
Lead Stakeholder	ULB, MEDA & DISCOM	Policy implementation and issue of permits
Supporting Stakeholder	Service & Utility Providers/ Installers	Implement uptake

- ULB to undertake the technical assessment of mapping rooftop solar PV potential of Nagpur city and explore options of maximising uptake of solar PV and its supply, through business models and mechanisms such as demand aggregation and RESCO models.

9.3.2. Case Studies for Occupancy Stage

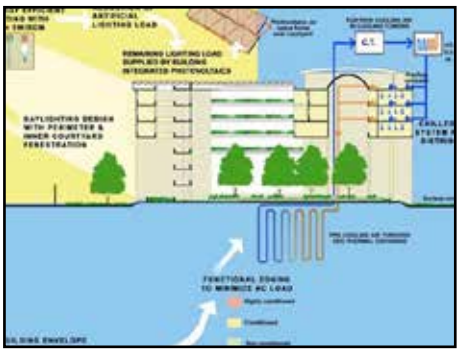
Box 1: Indira Paryavaran Bhawan, New Delhi

RE Measures: 930kW capacity solar PV system generating 14.3 units of electricity annually making it India's 1st Government building to achieve net zero electricity consumption

Appliances and Technologies:

- Use of efficient lighting system that uses a lux level sensor to optimize the operation of artificial lighting
- Use of a chilled beam system to meet 160 TR air conditioning load, thereby lessening energy use by 50 % in comparison to a conventional system
- All HVAC equipment controlled & monitored through an integrated building management system.
- Using functional zoning to reduce air conditioning loads

Source: : NZEB, n.d. and Khandelwal et al., 2020



Box 2: Apollo Hospitals and Smart Joules

- Apollo Hospitals has entered into a 10-year pay-as-you-save agreement (JoulePAYS) with an energy efficiency company, Smart Joules, that guarantees 20% reduction in overall energy consumption through for their 17 largest hospital buildings in India.
- Energy management measures addressing heating, cooling, ventilation and automation are being implemented to achieve the energy reduction.
- In FY 2021-22 Apollo Hospitals has reported monthly energy savings ranging from 12.9% to 27.6% as compared to 2019 baseline

Source: Apollo Hospitals, 2022

Box 3: Energy Efficiency Retrofit: Godrej Bhavan, Mumbai

Year of retrofit completion: 2010

Cost of retrofits: 53.84 Lakhs

Energy efficient measures and audit:

- HVAC-system replacement
- Water-flow meters
- Energy-metering system
- Auto blow down controller at the cooling tower
- High-reflectance paint for the terrace surface
- Energy audit
- Lights with energy-efficient tube lights

Estimated payback period: 9.6 years (Escalating Tariff Scenario)

Estimated cumulative electricity cost saving: 30.34 lakhs (Escalating Tariff Scenario)

Source: Natural Resources Defense Council, 2013

Box 4: Shifting Household Energy Use in Bangalore, India: Using Behaviourally Informed Energy Reports

- The citizen-focused behavior change program called VidyutRakshaka (VR), a joint initiative of Technology Informatics and Design Endeavor (TIDE) and World Resources Institute (WRI) India, aims to drive long-term change in energy-use behavior of residential consumers in Bangalore and Chennai through behaviorally designed household energy reports that create more sustainable energy use by tapping into the principles of behavioral science.
- VR reports provide customers with personalized feedback as well as social comparisons and energy-conservation recommendations that includes basic information on current consumption, historical consumption, comparison to neighbors, actionable tips, and energy-savings goals.
- Quantitative survey of over 2,000 households in Bangalore, India, who received Household Energy Reports in 2018 was undertaken.
- It was observed that there was a 7 percent decrease in average monthly energy consumption per household over the course of 12 months, compared to the monthly average consumption of the same households before receiving the reports.
- There is a city wide potential to save almost US$60 million per year and help avoid emissions from the generation of 604 million kilowatts of electricity, compared to the case of normal billing.

Source: Hernandez et al., 2022

Box 5: Cool roof programme in low-income households of Ahmedabad

Four intervention type roofs: (clockwise) (a) Thermocol ceiling, (b) Modroof, (c) Solar reflective white paint, (d) Airlite ventilation.

Under the Cool Roof Programme, roofs of low-income households deployed cool roof solutions such as thermocol insulation, solar reflective white paint on the outer surface of the roof, and ModRoof. These solutions were effective in reducing the heat ingress and indoor temperatures.

Source: Vellingiri et al., 2020

Illustrative Examples for Occupancy Stage Interventions

Applying high SRI paints on roof surface (Source: Shield Waterproofing Solutions, 2023)

Green Roofs (Source: Architonic, n.d.)

Vertical Gardening (Source: Organic Fertiliser, 2022)

Maximizing Rooftop Solar PV (Source: Gupta, 2021)

9.4. End of Life

For this building stage, strategies for scientific management of the construction and demolition waste are provided along with promoting the aspects of circularity and reuse of waste materials, and safeguarding the immediate surroundings and environment.

Interventions

Intervention 1
Promote deconstruction of old buildings instead of demolition.
Mandate adoption of deconstruction strategies to obtain approvals for new buildings & redevelopments

- Short Term: Implement building deconstruction guidelines & techniques with procedural mandates for deconstruction, disassembly & new building approval.
  Develop a formal register of building demolition contractors & local guidelines and improve awareness.
- Mid to Long Term: Update local guidelines & mandates for building deconstruction.
  Large redevelopment projects to increase & maximize salvaging & reusing of building materials for structural & non-structural components.

Intervention 2
Implement appropriate C&D waste management guideline and policy

- Short to Mid Term: ULB to issue & enforce C&D waste management mandates for mass generators based on type & quantity of C&D waste generated.
  ULB to issues guidelines for reuse of C&D waste generated on-site.
- Mid to Long Term: Promote C&D waste management amongst small generators.
  Scale up C&D waste management across the city based on future growth & technological advancements.

Intervention 3
Procurement & use of recycled C&D waste

- Short Term: ULB to implement pilot projects with reuse of C&D waste materials in upcoming public buildings .
  ULB to coordinate with PWD to include building materials made from C&D waste into the ASR & promote their uptake.
- Mid Term: Increased uptake of building materials made from C&D waste in large commercial & residential projects.
- Long Term: All buildings to use high share of building materials made from C&D waste & to utilize C&D waste generated on-site.

Policy and Regulation Materials and Technical

Anticipated Benefits for Proposed Interventions

Benefits →	Climate Resilience	Energy Savings	Health and Well Being	Emissions Reduction	Resource Efficiency	UHIE Reduction
Intervention 1	●	●	○	●	●	○
Intervention 2	●	●	●	●	●	○
Intervention 3	○	●	○	●	●	○

Highest Impact ●●●○ Lowest Impact

Stakeholder Responsibility Matrix for End-of-Life Stage

Highest Role
Major Role
Minor Role
Minimal Role

	Urban Local Body (ULB)	Architect/Civil Engineer	Real Estate Developer	Occupants/ Owners	Service & Utility Providers/ Installers	Building Material Manufacturers	Associations, Institutes, Academia, NGOs	State/ Central Government Agencies	MEDA & DISCOM	Financial Institutions
Intervention 1: Promote deconstruction of old buildings instead of demolition. Mandate adoption of deconstruction strategies to obtain approvals for new buildings & redevelopments	Highest	Minor	Highest	Minimal	Minimal	Major	Minimal	Major	Minimal	Minimal
Intervention 2: Mandate appropriate C&D waste management & encourage its reuse in building construction	Highest	Minimal	Highest	Minimal	Minimal	Major	Minimal	Major	Minimal	Minimal
Intervention 3: Procurement & use of recycled C&D waste	Major	Highest	Highest	Minimal	Minimal	Major	Minimal	Minor	Minimal	Minimal

9.4.1. Detailed Interventions for End of Life / Demolition Stage

Policy and Regulation

Intervention 1: Promote deconstruction of old buildings instead of demolition. Mandate adoption of deconstruction strategies to obtain approvals for new buildings & redevelopments.

	Stakeholder	Role
Lead Stakeholder	ULB	Policy implementation and en-forcement
Supporting Stakeholder	Real Estate Developers	Implement uptake

- ULB to promote building repurposing and deconstruction instead of demolition to help salvage and re-use building materials and reduce C&D waste generated from old/dilapidated buildings and redevelopment projects.
- Develop a formal register of building demolition contractors and conduct training on building deconstruction and C&D resource recovery and management.
- Develop local guidelines and protocols for building deconstruction and disassembly to improve material reuse and recovery. Recommendations from BMTPC Guidelines for Utilization of C&D Waste in Construction, 2017 can be incorporated.
- ULB to mandate submission of a building Deconstruction Plan along with structural design in order to obtain approvals/permits for new building structures and redevelopment projects. The Deconstruction Plan should incorporate strategies for engineered disassembly, recycling and reuse of materials as possible, appropriate disposal of non-salvageable items and protection of immediate surroundings.

Intervention 2: Mandate appropriate C&D waste management & encourage its reuse in building construction

	Stakeholder	Role
Lead Stakeholder	ULB	Policy implementation and en-forcement
Supporting Stakeholder	Real Estate Developers	Implement uptake

- Appoint an agency for the collection and management of C&D waste
- Incorporate C&D waste utilization recommendations from BMTPC C&D Waste Management Ready Reckoner for construction and demolition waste, which supplements the MoEFCC Notification for management of C&D waste, 2016 into local guidelines and regulations
- Establish and enforce mandates for procurement of materials made from C&D waste in new and redeveloped public, commercial, residential and institutional buildings, subject to strict quality control

Materials and Technologies

Intervention 3: Procurement & use of recycled C&D waste

	Stakeholder	Role
Lead Stakeholder	Architect/ Civil Engineer, Real Estate Developer	Maximise uptake of recycled C&D waste and materials
Supporting Stakeholder	Building Material Manufacturers	Establish supply chain using recycled C&D waste materials

- ULB to encourage the use of building materials made from recycled C&D waste as per the building and site suitability and requirement.
- ULB to promote the use of recycled aggregates in concrete mixes as per IS 383:2016 and as filler materials during construction.

9.4.2. Case Studies for End of Life / Demolition Stage

Box 1: Reuse of Construction Debris and Industrial Waste at Galaxy School, Rajkot

The Galay School in Rajkot designed by Ar. Surya Kakani follows a principle of minimum carbon footprint through recycling, reuse and use of renewable material.

- Debris from 2008 Bhuj earthquake, industrial wastes like fly ash from a Gujarat Electricity Board thermal plant, gypsum-waste from the sanitary ware industry at Thangadh and lime-waste from Tata Chemicals Ltd, Mithapur, have been used as the primary building blocks.
- The trusses for the roof are made from steel pipes brought from the ship-breaking works at Alang.
- The roofing incorporates renewable matting of date palm leaves on a bamboo framework over which a final layer of thatch has been laid.

Source: DownToEarth, 2016

Box 2: Adaptive reuse of steel in L.A.

Hudson Pacific Properties in their One Westside project in Los Angeles were able to achieve 33% reduction in embodied energy when compared to a ground-up construction approach. Majority of the savings came from adaptive reuse of structural steel that was repurposed from the mall that was in its place.

Source: Hudson Pacific Properties, 2021

Illustrative Examples for End of Life

Crushing Unit at C&D waste Recycling Plant, Burari (Source: IL&FS Pvt. Ltd., n.d.)

Salvaging of building components (Source: BMTPC, 2018)

Pavers made from recycled C&D waste (Source: Bansal & Singh, 2013)

Products manufactured from recycled C&D waste (Source: BMTPC, 2018)

9.5. Cross Cutting

Strategies suggested take multi-pronged approach of integrated urban planning and improved procurement policies including circularity to maximise the uptake zero carbon buildings in the city.

A Interventions

Intervention 1
Incorporate Green Public Procurement Policy (GPP) and SOPs.

Intervention 2
Constituting a Working Group/ Committee for facilitating the implementation of Zero Carbon Buildings

Intervention 3
Disincentivizing non-compliance with net-zero norms

Intervention 4
Use land development mechanisms to create urban-level amenities

Intervention 5
Promote urban design and development to promote wind-induced air flow and address urban heat island effect at the neighbourhood-scale

Intervention 6
Undertake integrated city development planning approach

Intervention 7
Promote circularity and reuse in materials and resources

Intervention 8
Encourage procurement of building materials from manufacturers that undertake (Life Cycle Analysis) LCA and publish (Environmental Product Declarations) EPD

Policy and Regulation Urban Planning Materials and Technical

Anticipated Benefits for Proposed Interventions

Benefits →	Climate Resilience	Energy Savings	Health and Well Being	Emissions Reduction	Resource Efficiency	UHIE Reduction
Intervention 1	●	●	○	●	●	◔
Intervention 2	●	●	●	●	●	●
Intervention 3	◕	●	◕	●	◕	◕
Intervention 4	●	○	●	○	○	●
Intervention 5	◔	◕	◕	○	○	●
Intervention 6	●	●	●	●	●	●
Intervention 7	◔	○	○	◕	●	○
Intervention 8	◔	◔	○	●	●	○

Highest Impact ●◕◔○ **Lowest Impact**

Stakeholder Responsibility Matrix for Cross Cutting Strategies

Highest Role
Major Role
Minor Role
Minimal Role

	Urban Local Body (ULB)	Architect/Civil Engineer	Real Estate Developer	Occupants/ Owners	Service & Utility Providers/ Installers	Building Material Manufacturers	Associations, Institutes, Academia, NGOs	State/ Central Government Agencies	MEDA & DISCOM	Financial Institutions
Intervention 1: Incorporate Green Public Procurement Policy (GPP) and SOPs	■				▒	▒		■		
Intervention 2: Constituting a Working Group/ Committee for facilitating the implementation of Zero Carbon Buildings	■	■	■		■	■	■	■	■	▒
Intervention 3: Disincentivizing non-compliance with net-zero norms	■	▒	▒	▒	▒	▒	▒	■	■	
Intervention 4: Use land development mechanisms to create urban-level amenities	■	▒	▒				▒	■		▒
Intervention 5: Promote urban design and development to promote wind-induced air flow and address urban heat island effect at the neighbourhood-scale	▒	■	■	▒						
Intervention 6: Undertake integrated city development planning approach	■	▒	▒				▒	■	▒	▒
Intervention 7: Promote circularity and reuse in materials and resources	▒					■	■			
Intervention 8: Encourage procurement of building materials from manufacturers that undertake (Life Cycle Analysis) LCA and publish (Environmental Product Declarations) EPD	▒	▒	▒		▒	■				

9.5.1. Detailed Interventions for Cross Cutting Strategies

Policy and Institutional

Intervention 1: Incorporate Green Public Procurement Policy (GPP) and SOPs

	Stakeholder	Role
Lead Stakeholder	ULB & State Government	Policy implementation and enforcement
Supporting Stakeholder	Service & Utility Providers/ Installers, Building Material Manufacturers	Establish a local supply chain and ensure compliance

- ULB to set up GPP policy that aligns with national targets pertaining to renewable energy, energy efficiency, sustainable low-carbon building materials and technologies
- ULB shall update the standard operating procedures (SOPs) to incorporate RFP criteria maximising building level performance in terms of energy and material resource efficiency

Intervention 2: Constituting a Working Group/Committee for Zero Carbon Buildings

	Stakeholder	Role
Lead Stakeholder	ULB & State Government, MEDA and DISCOM	Discretionary Role
Supporting Stakeholder	Service & Utility Providers/ Installers, Building Material Manufacturers, Architects/ Civil Engineers, Real Estate Developers, Associations, Institutes, Academia, NGOs	Advisory Role

- The State Government shall constitute a Working Group/ Committee comprising of building industry experts like builders and developers, academicians, researchers, architects and civil engineers, representatives from civil societies and organizations and city officials, among others, to monitor, review and assess the progress of the ZCB Action Plan, and propose and make periodic updates

Intervention 3: Disincentivizing non-compliance with net-zero norms

	Stakeholder	Role
Lead Stakeholder	ULB & State Government	Framing norms and enforcement
Supporting Stakeholder	Real Estate Developer, Occupant/ Owner	Ensure net-zero compliances

- ULB and DISCOM may disincentivize non-compliance with net-zero norms for new and existing buildings through higher utility and civic service provision charges, disincentivized property tax structure and higher land and property transaction charges among others.

Urban Planning

Intervention 4: Use land development mechanisms to create urban-level amenities

	Stakeholder	Role
Lead Stakeholder	ULB & State Government	Implementation agency
Supporting Stakeholder	Associations, Institutes, Academia, NGOs	Advisory Role

- ULB shall use land development mechanisms listed in the MRTP Act 1966 to provide and develop public amenities like parks and playgrounds, district cooling infrastructure, community Solar PV, EWS housing, and other infrastructure

Intervention 5: Promote urban design and development to encourage wind-induced air flow and address urban heat island effect at the neighbourhood-scale

	Stakeholder	Role
Lead Stakeholder	Architect/ Civil Engineers	Push for uptake
Supporting Stakeholder	Real Estate Developer	Maximise uptake

- Design orientation, shape, size, openings of new buildings and regulate building density and heights based on natural wind flow patterns for quicker heat removal at the neighbourhood scale, wherever possible
- Adopt nature-based solutions in new developments at the neighbourhood scale including blue spaces such as water bodies along with green spaces such as tree plantation and vegetation for cooling. Plan for tree plantation and vertical gardens at major roads and junctions.

Intervention 6: Integrated city development planning approach

	Stakeholder	Role
Lead Stakeholder	ULB & State Government	Implementation agency
Supporting Stakeholder	Associations, Institutes, Academia, NGOs	Advisory Role

- Integrate climate resilience-based multi-sectoral planning solutions (like Comprehensive Mobility Plan, Environmental Status Report, Climate Resilient City Action Plan, and Guidelines for Energy Efficient and Climate Responsive Homes in Nagpur, among others) into city development and master planning process to incorporate necessary strategies and recommendations into the Land-Use Plans

Intervention 7: Promote circularity and reuse in materials and resources

	Stakeholder	Role
Lead Stakeholder	Associations, Institutes, Academia, NGOs	Promote inter-industry co-operation and resource sharing arrangements
Supporting Stakeholder	Building Material Manufacturers	Establish an inter-industry supply chain

- Traders and manufacturers associations to extend their inter-industry co-operation to establish a supply chain for use of various industrial by-products for building industry
- Incorporating water swapping mechanisms to reuse treated wastewater from households and commercial buildings for industrial uses

Intervention 8: Encourage procurement of building materials from manufacturers that undertake (Life Cycle Analysis) LCA and publish (Environmental Product Declarations) EPD

	Stakeholder	Role
Lead Stakeholder	Building Material Manufacturers	Increase voluntary disclosures
Supporting Stakeholder	ULB, Architect/ Civil Engineer, Real Estate Developer	Promote procurement from compliant manufacturers

- Building material manufacturers to undertake LCA and provide EPDs for their portfolio of products and publish the results on their website and/or printed literature
- Project proponents including ULB to provide first preference to manufacturers that undertake LCA and publish EPD for their building material portfolio

9.5.2. Case Studies for Cross-cutting strategies

Box 1: Environmental Product Declarations: Tata Steel

Tata Steel Limited has taken a step towards responsible manufacturing by declaring its first Environmental Product Declaration (EPD) for Steel Reinforcing bar (Rebar) used in Reinforced Cement Concrete (RCC) construction.

- EPD is a requirement in the green building projects for scoring the required credit points
- EPD is seen as a verified document in communicating a product's life cycle environmental impact for disclosure purposes
- The Life Cycle Assessment (LCA) study carried out for developing the EPD for steel products is done as per ISO 14040 and ISO 14044 standards

Source: TATA Steel, 2022

Box 2: Energy Efficiency Cell, Surat Municipal Corporation

Surat Municipal Corporation has established an institutional unit in the form of an Energy Efficiency Cell which conducts energy audits, promotes energy conservation and renewable energy projects, and monitors electricity consumption of the city government's buildings and facilities.

Functions

- To conduct in-house energy audits for Surat Municipal Corporation's buildings
- To conduct energy audits for other public and private buildings
- To identify energy conservation projects and their feasibility
- To identify sources for procuring clean power at affordable costs
- Feasibility studies for own power generation from renewable energy sources
- To examine new buildings with connected load of more than 30 kW for integration of energy efficiency measures

Through implementation of various initiatives and the support of the Energy Efficiency Cell, Surat Municipal Corporation is able to meet 34% of its energy demand through renewable energy sources (as of 2019).

Source: Rajasekar et al., 2021, Surat Municipal Corporation, n.d.

Box 3: Procurement Framework for Public Building Retrofit in Spain

This was the first of 330 public building renovations in Spain that aimed at reducing the energy consumption and CO_2 emissions. The work carried out included the upgrade of the building envelope, substitution of most of the building services, and the implementation of a new energy management strategy.

Procurement Framework

The project delivery system included design (considering existing constraints) – construction (renovation works) – energy management, in which the best value-for-money tender wins the contract. The consortium combined four partners with high expertise in renovation works, energy management and energy supply. The project was awarded to the consortium with the best price and best technical proposal.

Source: United Nations Environment Programme, 2018

9.6. Capacity Building and Finance

Interventions in the section aim to bring city administration and external experts together towards generating awareness around ZCBs and knowledge dissemination of best practices and improve the city's workforce to implement ZCB strategies. The interventions also aim to financially enable various stakeholders particularly developers and occupants develop ZCB projects.

Interventions

Intervention 1
Undertake training and awareness generation campaigns to promote ZCBs.

Intervention 2
ULB to work with associations, certifying agencies and experts to create a knowledge base of low carbon building materials and technologies.

Intervention 3
Create a pool of skilled workforce trained in Zero Carbon Building construction and provide platform for networking amongst the relevant stakeholders to further the ZCB efforts.

Intervention 4
ULB to explore and develop RE financing arrangements, models and mechanisms developed by other ULBs, authorities and private lenders.

Intervention 5
Provide financial incentives and support for Renewable Energy (RE) and Energy Efficiency (EE) for net-zero buildings.

Intervention 6
Provide dedicated financial assistance to project proponents, home buyers and green building material manufacturers.

Capacity Building Financial

9.6.1. Detailed Interventions for Capacity Building and Finance Strategies

Capacity Building

Intervention 1: Undertake training and awareness generation campaigns

- Various government and non-government organizations and institutes shall partner for awareness generation and outreach to the community and building developers
- Experts, NGOs and technical institutes shall undertake training of building sector practitioners and city officials
- Experts, NGOs and technical institutes shall undertake training of large building managers & owners for ECBC compliance, energy use reporting, net-zero building technologies & operations during building occupancy
- ULB shall use social media for outreach and knowledge dissemination

Intervention 2: ULB to work with technical associations, certifying agencies and experts to create a knowledge base of low carbon building materials and technologies

- ULB shall create a database of local, regional, national case studies and best practices on ZCB projects and solutions for dissemination
- ULB shall launch and publicize a digital repository of low carbon materials, their manufacturers, and their suppliers in Nagpur on the ULB website for easy reference

Intervention 3: Create a pool of skilled workforce trained in Zero Carbon Building construction

- ULB, experts, NGOs and technical institutes shall conduct training courses and skill development on low carbon/alternative construction techniques, non-RCC construction materials
- ULB shall include and continuously update ZCB strategies and materials in the curriculum for fields like Architecture, Engineering and Planning
- Technical courses such as architecture and civil engineering shall have adequate focus on practical training and hands-on learning for low carbon materials, techniques and technologies

Finance

Intervention 4: Provide financial incentives and support for Renewable Energy (RE) and Energy Efficiency (EE) for net-zero buildings

- ULB, DISCOM and financial institutions shall provide financial assistance and tax benefits for deployment and use of solar PV
- DISCOM shall facilitate access for households to Central Finance Assistance for the Grid-connected Rooftop Solar Scheme Phase-II
- DISCOM shall explore option wherein it shall pay upfront cost of RE equipment and the consumer shall repay the amount through the electricity bills (On-Bill Financing)
- Equipment vendors shall explore arrangements for long-term leasing for RE equipment

Intervention 5: Explore RE financing arrangements and mechanisms

- Building owners/developers may incorporate cost sharing clauses in lease/rent agreements to offset their upfront cost for incorporating RE and EE measures in the building
- ULB to leverage assets and land-pooling mechanisms to finance city and neighbourhood level zero carbon building and renewable energy infrastructure
- ULB and State Government shall work with banking and financing institutions to formulate green loans and preferential lending
- Building owners and managers can approach and engage ESCOs to support upfront costs and guarantee for pooled large commercial and residential buildings

Intervention 6: Provide financial assistance to project proponents, home buyers and green building material manufacturers

- Financial institutions shall provide loans at reduced interest rates to home buyers and self-owned developments for green certified residential units or their retrofits
- ULB to provide tax incentives, stamp duty rebates for certified green buildings, and projects that are low-carbon/net-zero carbon generators.
- ULB to work with the State Government to provide tax benefits and concessions for certified green product manufacturers and developers of building projects using such products
- ULB, financial institutes, building industry associations, NGOs and technical institutes to provide technical and financial assistance to small scale green material manufacturers to have their products green certified

9.6.2. Case Studies for Capacity and Finance

Box 1: Green Building Incentives

National and various State and Local Governments provide non-built-up area based financial incentives to promote green building certification. Some of these are:

Rajasthan

- MSME sector Enterprises can get a subsidy in the form of reimbursement of 50% of amount paid to the suppliers for process or technology adopted to obtain green rating under Indian Green Building Council

Punjab

- Apart from FAR incentives, Department of Housing and Urban Development, Government of Punjab offers 100% exemption on building scrutiny fee for green certified buildings

Gujarat

- Gujarat Tourism Policy 2021-25 offers reimbursement of 50% of Certification fee, with a maximum limit of INR 10.0 lakh, to hotel / wellness resorts obtaining green rating
- Industries Commissionerate, Industries and Mines Department provides incentive up to 50% of consulting charges, with a maximum limit of INR 2.50 lakh, for Industrial Buildings with green rating

Source: Indian Green Building Council, n.d.

Box 2: Green Building Incentives

Tamil Nadu

- TN Industrial Policy 2021, offers a 25% subsidy on the cost of setting up environmental protection infrastructure, subject to a limit of Rs. 1 cr., for industrial projects that obtain green certification.
- TN Data Centre Policy 2021, offers Data Centre Units undertaking green and sustainable initiatives as per IGBC rating shall be eligible for a 25% subsidy on cost of undertaking such initiatives, subject to an upper limit of Rs. 5 Crore

Kerela

- Local Self Government Department has approved up to 50% reduction in One time building tax, up to 1% reduction in Stamp duty and up to 20% reduction in Property tax for projects obtaining green building certification

Andhra Pradesh

- The Industries & Commerce Department offers 25% subsidy on total fixed capital investment of the project (excluding cost of land, land development, preliminary and preoperative expenses and consultancy fees) for green certified buildings
- Municipal Administration and Urban Development Department offers 20% Reduction on Permit Fees and one-time reduction of 20% on Duty on Transfer of Property (Surcharge on Stamp Duty) on the submission of Occupancy Certificate issued by the Local Authority, if the property is sold within three years.

Source: Indian Green Building Council, n.d.

Box 3: SUNREF Affordable Green Housing India

Agence Française de Développement (AFD) launched the SUNREF Affordable Green Housing India programme in partnership with the National Housing Bank (NHB), with support from the European Union (EU) in 2017, with a goal to finance green and affordable housing projects through banks and financing institutions.

Housing projects for EWS, LIG and MIG groups and certified/pre-certified as gold/platinum or 4/5 star under are eligible under IGBC or GRIHA rating system, respectively are eligible for the benefits under the programme.

As of 15th September 2021, NHB has disbursed 501 Cr under the SUNREF Programme of which 53% of the amount has been provided for EWS and LIG units.

By 2025, more than 4000 households are estimated to benefit from the SUNREF Housing Programme in terms of improved housing conditions, through the construction of an estimated 329,000 square meters of new habitable floor

Source: National Housing Bank, n.d.

Box 4: Awareness Dashboard Uttar Pradesh SDA

The project for energy saving was conceived and launched in December 2015 by UPNEDA, An Organization designated by the Govt. of Uttar Pradesh for promoting energy conservation and energy efficiency

The website www.upsavesenergy.com focuses on educating masses and inculcating behavioral changes in them, to have a long-term impact on sustainable energy conservation and reduced energy consumption through various activities, equipment, practices and motivate them through certificate. The dashboard also includes an energy calculator for direct assessment of energy consumption.

Source: SAATHEE, 2019

Box 5: Karmika School of Construction Workers

The Karmika School of Construction Workers in Ahmedabad, established by Mahila Housing Trust (MHT) provides training in the following trades: masonry, painting, plastering, tiling plumbing, electrical wiring, carpentry, welding, roller operation, excavation, rubble masonry, bar bending, and training for lab technicians. It has also started to offer specialized courses in toilet construction, disaster resistant houses, climate-adaptive housing. Initiated following a training program to train men and women in masonry after the Bhuj earthquake in 2002, the school has now expanded and tied up with private and certification agencies and has provided training to over 22,045 women construction workers from Gujarat, Delhi, Rajasthan, Bihar and Madhya Pradesh.

Source: Shah et al., 2022

10. Priority Interventions

The transformative interventions encompassing various building stages have been envisioned keeping in mind a long-term goal to decarbonize the building sector by 2050. While it is understood that implementation and city-wide adoption of interventions would depend on diverse factors, especially for different economic strata and across building typologies, scaling up actions and achieving long term benefits would take time. It is imperative for the city and the building industry stakeholders to take up certain interventions that can have immediate benefits in the short-term to kick start the decarbonization process.

To identify such crucial interventions, a prioritization matrix has been prepared based on the benefits offered by interventions. Factors such as political willingness, economic feasibility, ease of implementation, speed of results, scale of impact, and the mandatory or voluntary nature of the interventions have been considered for prioritizing the interventions.

The results of the prioritization are reflected in this section below, with high priority interventions denoted in green colour. Annexure 2 provides more details on the prioritization matrix and method adopted. Figure 15 represents how each intervention for the four building stages fares on their anticipated benefits vs. the ease of implementing these interventions. The factors that determined the benefits and ease of implementation are:

Bene fits:

- Climate Resilience
- Energy Savings
- Emissions Reduction
- Resource Efficiency
- Health and Well Being
- UHIE Reduction

Implementation factors:

- Mandatory and Voluntary nature of interventions
- Administrative and Political Willingness
- Economic Feasibility
- Ease of Implementation
- Speed of Results
- Scale of Impact

The size of the bubble is the cost component of the intervention that will be borne by the primary implementing person(s) or entity. The larger the bubble the more is the estimated cost for implementing the intervention. Certain high ranking interventions that are both easy to implement and have high benefits have significant cost component associated with them. However, implementing them can significantly benefit the city in achieving its building sector decarbonization goal.

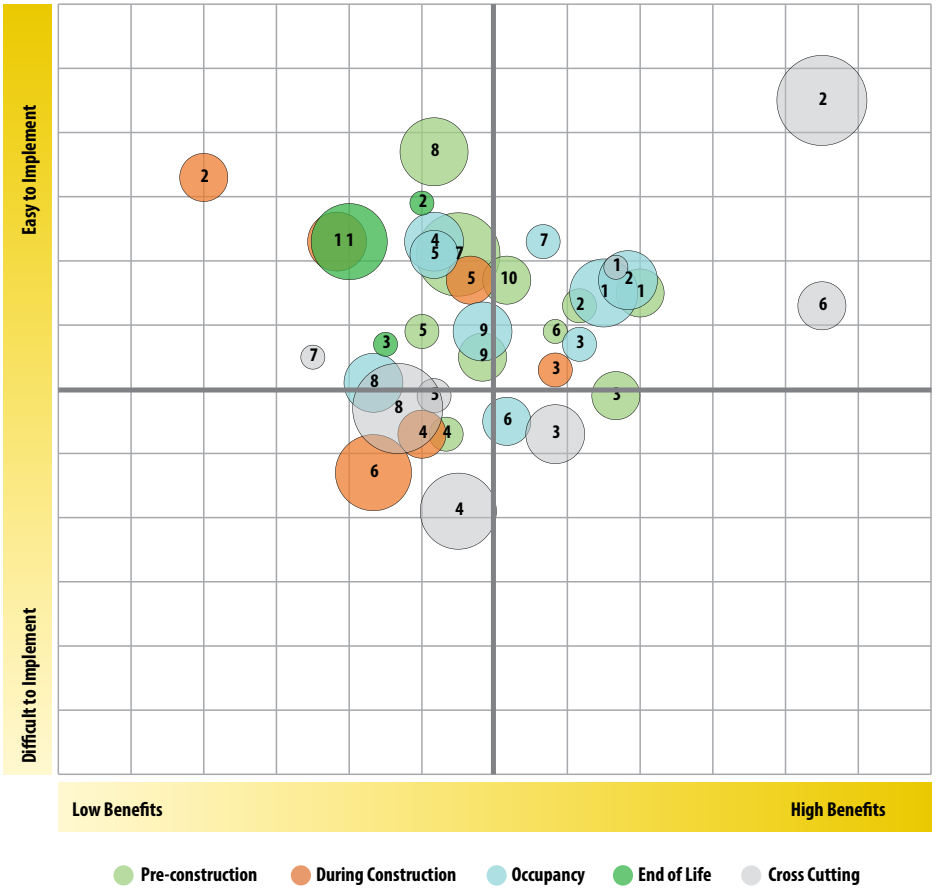


Figure 15: Graph for interventions depicting their Benefits vs Ease of Implementation

1	Pre-Construction	
●	**Intervention 1:** Include relevant guidelines, codes and regulations on efficient and low emission buildings into the Development Regulations at local level	
●	**Intervention 8:** Establish mandates & design buildings to help tap into rooftop solar PV potential	
●	**Intervention 2:** Adopt climate responsive building envelope design with building typology-wise minimum criteria for building energy performance	
●	**Intervention 10:** Plan building project sites to maximise and conserve permeable surfaces and green cover	
●	**Intervention 6:** Incorporate passive & energy efficient cooling solutions & strategies into the building & microclimate design	
●	**Intervention 7:** ULB to include requirements in building approval to use high energy-efficiency utility & indoor appliances	
●	**Intervention 3:** Provide building approval related and financial benefits for green building pre-certification	
●	**Intervention 9:** Promote open access facility for renewable energy purchase to support net-zero buildings	
●	**Intervention 5:** Adopt certified low-carbon materials, technologies & techniques in the construction of new buildings	
●	**Intervention 4:** Include consideration of lifecycle impact of buildings & requirements for the same in building approval	

Low Priority | Medium Priority | High Priority | Highest Priority

2	During Construction	
●	Intervention 5: Use of renewable energy & energy efficient (EE) equipment for building construction sites	
●	Intervention 3: Create an ecosystem promoting the reuse of industrial & agricultural by-products	
●	Intervention 1: ULB to enforce the implementation of dust mitigation measures at construction sites as per CPCB guidelines	
●	Intervention 2: Promote construction workers' well-being & inclusion	
●	Intervention 4: Encourage local procurement & manufacturing of construction materials	
●	Intervention 6: Use electric vehicles for transportation of construction materials & personnel	

Low Priority | Medium Priority | High Priority | Highest Priority

3	Occupancy Stage	
●	**Intervention 2:** Promote green-rating & performance certification/ labelling of existing buildings	
●	**Intervention 1:** ULB to enact energy performance standards for existing buildings	
●	**Intervention 7:** Promote use of cool and reflective surfaces at building roofs, walls, and pavements to reduce urban heat	
●	**Intervention 3:** ULB to issue guidelines for retrofitting measures to improve building energy performance	
●	**Intervention 4:** Promote highly energy efficient common utilities by establishing energy performance requirements & conditions to obtain building permissions	
●	**Intervention 5:** Expand energy benchmarking program to promote reporting of energy use & performance in buildings	
●	**Intervention 9:** Scale up uptake of rooftop solar PV – potential study for existing rooftops & to enable large-scale adoption	
●	**Intervention 6:** Establish a building renovation/retrofit program to conduct energy audits & implement deep retrofit measures for energy performance improvement & decarbonization	
●	**Intervention 8:** Adopt Building Energy Management Systems (BEMS) in large public & private buildings	

Low Priority | Medium Priority | High Priority | Highest Priority

4	End of Life	
●	**Intervention 2:** Mandate appropriate C&D waste management & encourage its reuse in building construction	
●	**Intervention 1:** Promote deconstruction of old buildings instead of demolition. Mandate adoption of deconstruction strategies to obtain approvals for new buildings & redevelopments.	
●	**Intervention 3:** Procurement & use of recycled C&D waste	

Low Priority | Medium Priority | High Priority | Highest Priority

5	Cross Cutting	
●	Intervention 2: Constituting a Working Group/Committee for Zero Carbon Buildings	
●	Intervention 6: Integrated city development planning approach	
●	Intervention 1: Incorporate Green Public Procurement Policy (GPP) and SOPs	
●	Intervention 3: Disincentivizing non-compliance with net-zero norms	
●	Intervention 5: Promote urban design and development to promote wind-induced air flow and address urban heat island effect at the neighbourhood-scale	
●	Intervention 8: Encourage procurement of building materials from manufacturers that undertake (Life Cycle Analysis) LCA and publish (Environmental Product Declarations) EPD	
●	Intervention 7: Promote circularity and reuse in materials and resources	
●	Intervention 4: Use land development mechanisms to create urban-level amenities	

Low Priority | Medium Priority | High Priority | Highest Priority

11. Monitoring and Evaluation Process

To successfully implement the recommended strategies, and to ensure their sustenance and adequate outcomes, it would be important to monitor their implementation, identify opportunities to improve the strategies, align them with updated national and sub-national goals, and to ensure that there are measurable impacts in reducing GHG emissions of Nagpur's construction industry.

To support and monitor implementation of the Climate Resilient City Action Plan for Nagpur and climate actions therein, institutional structures have been established locally in the form of Climate Core Team and Stakeholder Committee. It is recommended that a Sub-committee or Working Group for Zero Carbon Buildings be formed under the existing Climate Core Team to steer, monitor and evaluate the progress of the Zero Carbon Buildings Action Plan for Nagpur.

NMC and its departments, NSSCDCL, and various nodal agencies such as MahaDISCOM, MEDA and MPCB can be included as the decision-making wing of such a Sub-committee/Working Group. In addition, the Sub-committee can also comprise of various building industry representatives such as builders, architects, civil engineers, vendors, manufacturers, academicians, researchers, builders, manufacturers associations and relevant technical institutes, that would form part of the advisory wing.

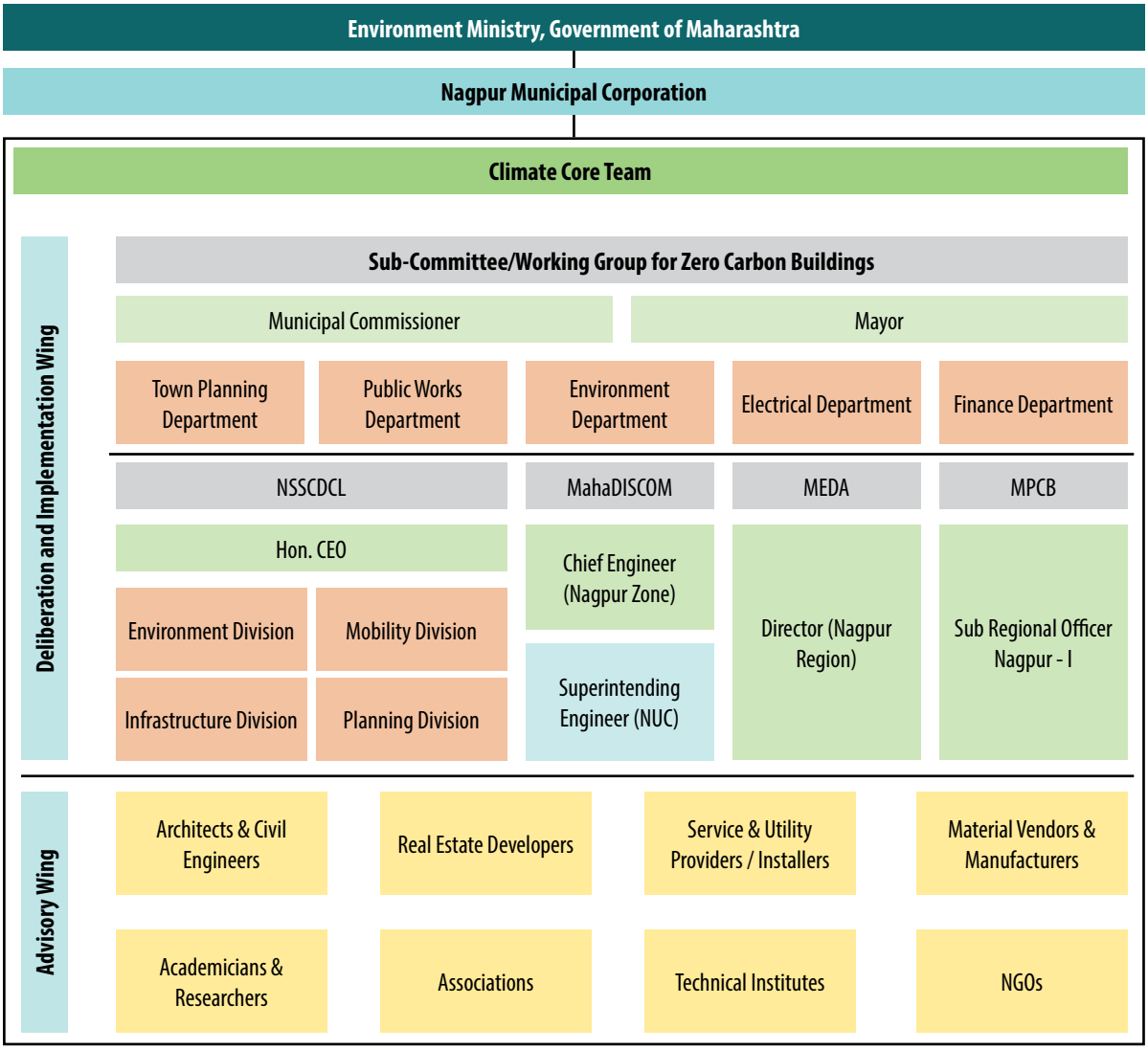


Figure 16: Sub-Committee/Working Group for Steering and Monitoring ZCB Action Plan

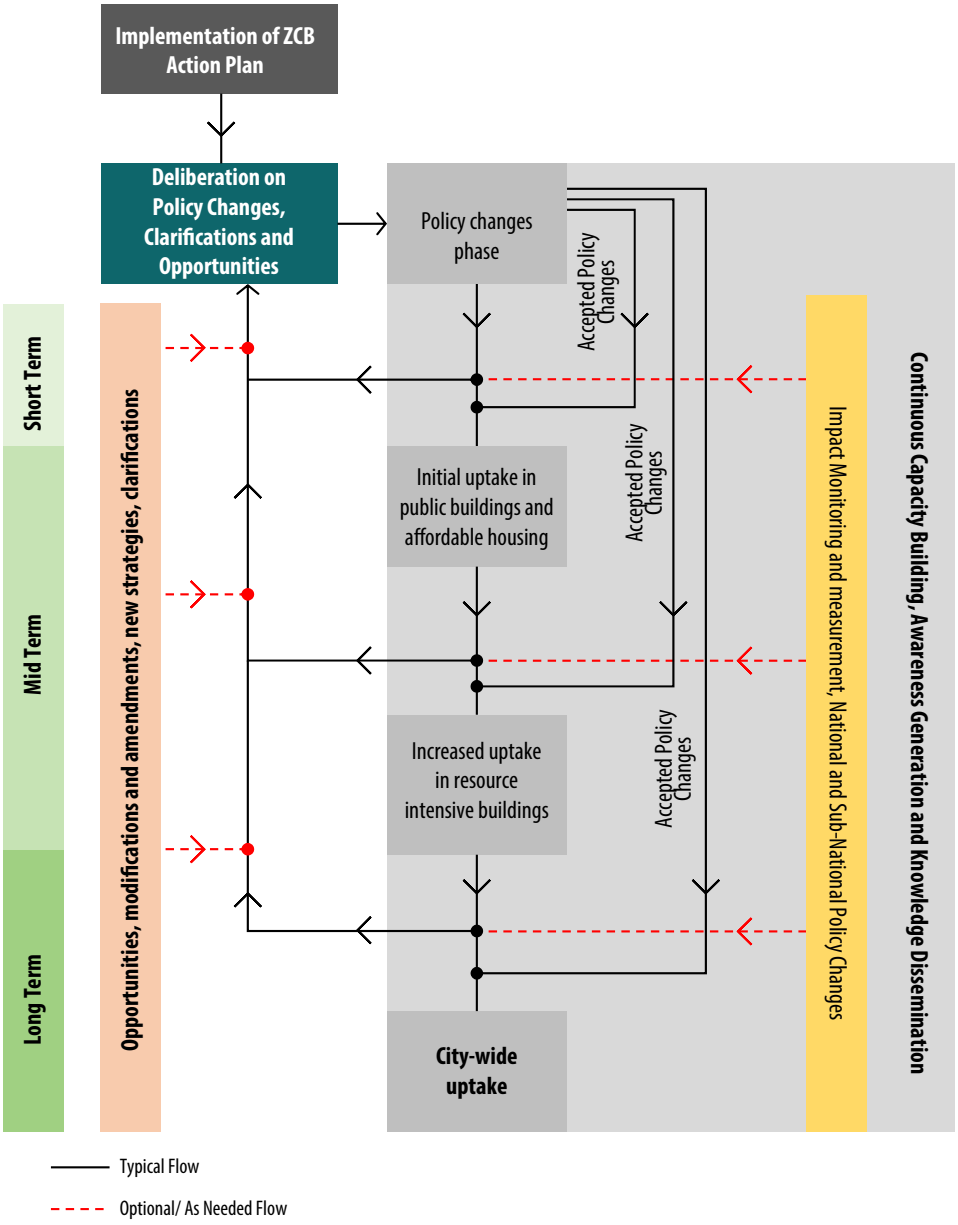


Figure 17: Implementation Plan for the ZCB Action Plan

The responsibilities of the ZCB Sub-committee would include:

- Implement the ZCB Action Plan efficiently at the city-scale
- Ensure inter-departmental and inter-governmental co-operation for implementation of recommended interventions
- Take stock of national and sub-national goals, policies and targets pertaining to decarbonizing the building sector, and updating the ZCB Action Plan accordingly
- Staying apprised of the latest net-zero, climate resilient development trends, nationally and sub-nationally.
- Identify and partner with relevant internal and external experts and organizations to periodically undertake capacity building and knowledge dissemination activities
- Identify upcoming and existing public and private sector projects to implement ZCB initiatives and pilot projects
- Identify building sector decarbonization actions not included in the ZCB Action Plan that are relevant for Nagpur and strategize their implementation over time
- Issuing clarifications, explanations and fast grievance redressal for any actions and policies
- Meet periodically (at least biannually) to discuss the progress of the ZCB actions in the city, deliberate on the next steps, incorporate changes or modifications to the Action Plan, and maintain official minutes of the meeting.

12. Monitoring and Tracking Progress

The successful implementation of the ZCB Action Plan would entail monitoring and tracking progress through relevant indicators. To help understand the progress of the city towards net-zero carbon building goals and targets and to identify areas which need additional interventions and strategies as well as policy updates, key indicators have been outlined in the following Table.

Action Area	Key Performance Indicators (KPIs)	Monitoring and Evaluating Agency
Preconstruction / Design Stage		
Policy and Regulation		
Include relevant guidelines, codes, and regulations on efficient and low emission buildings into the Development Regulations at local level	• Progressively updating guidelines, codes and regulations on efficient and low emission buildings aligned with national & state policies and goals.	Town Planning Department, state urban development department, MahaDISCOM, MEDA.
Adopt climate responsive building envelope design with building typology-wise minimum criteria for building energy performance	• Number of upcoming public and private buildings implementing ZCB notifications • Verification of level of compliance, including the criteria in the existing building approval process	Town Planning Department, PWD, MahaDISCOM, MEDA, BEE
Provide building approval related and financial benefits for green building pre-certification	• Number of buildings opting for green building precertification and plan for revising the benefits as per the response	Town Planning Department, accounts department, PWD, MahaDISCOM, MEDA, BEE
Include consideration of lifecycle impact of buildings and requirements for the same in building approval	• Supply of building low carbon materials and skilled workforce	Town Planning Department, PWD, Material Certifying Agencies
Materials and Technical		
Adopt certified low-carbon materials, technologies and techniques in the construction of new buildings	• Availability of building low carbon materials and skilled workforce	Town Planning Department, PWD, Material Certifying Agencies, industrial associations as technical supporting group
Incorporate passive and energy efficient cooling solutions and strategies into the building and microclimate design	• Number of upcoming buildings implementing passive and energy efficient cooling strategies • Verification of level of compliance during building scrutiny	Town Planning Department, PWD, Green Rating Agencies
ULB to include requirements in building approval to use high energy-efficiency utility and indoor appliances	• Availability of energy efficient equipment • Availability of energy efficient products directory for awareness • Verification of level of compliance during building scrutiny	Town Planning Department, PWD, Electrical Department Green Rating Agencies
Establish mandates and design buildings to help tap into rooftop solar PV potential	• Number of permissions and approvals for incorporating rooftop solar PV • Verification of level of compliance during building scrutiny	Town Planning Department, PWD, Electrical Department, MahaDISCOM, MEDA, BEE

Action Area	Key Performance Indicators (KPIs)	Monitoring and Evaluating Agency
Promote open access facility for renewable energy purchase to support net-zero buildings	• Increase in the number of consumers opting for RE open access • Tracking intra and interstate RE consumption	Town Planning Department, PWD, Electrical Department, MahaDISCOM, MEDA,
Plan building project sites to maximise and conserve permeable surfaces and green cover	• Verification of level of compliance during building scrutiny	Town Planning Department, PWD
During Construction		
Policy and Regulation		
ULB to enforce the implementation of dust mitigation measures at construction sites as per CPCB guidelines	• Dust mitigation monitoring during various stages of building construction	Town Planning Department, PWD, MPCB, Environment Department
Promote construction workers' well-being and inclusion	• Number and assessments standards of site visits to check compliance	Town Planning Department, PWD
Create an ecosystem promoting the reuse of industrial and agricultural by-products	• Voluntary reporting of industrial and agricultural by-products usage by type, quantity and location in the building	Town Planning Department, PWD
Encourage local procurement and manufacturing of construction materials	• Increase in the number of registered manufacturing units within the city • Voluntary reporting on the supply and use of locally manufactured building materials	Town Planning Department, PWD, Builders, Manufacturers, Vendors, Traders Associations
Use of renewable energy and energy efficient equipment for building construction sites	• Number of permissions and approvals for using RE systems during construction • Regularity of site visits to check compliance • Resolution of bottlenecks for uptake of RE systems at sites	Town Planning Department, PWD, Electrical Department, MahaDISCOM, MEDA, BEE
Use electric vehicles for transportation of building construction materials and personnel	• Number of registered medium and heavy goods transportation EVs as an indicator • Successful pilot uptakes at public building projects	Nagpur RTO, Town Planning department
Occupancy Stage		
Policy and Regulation		
ULB to enact energy performance standards for existing buildings	• Verification of compliance through central monitoring and smart metering	Electrical Department, MahaDISCOM, MEDA, BEE
Promote green-rating and performance certification/labelling of existing buildings	• Number of buildings opting for green building certification • Progressively updating green building certification requirement and compliance criteria	Town Planning Department, PWD, Green Rating Agencies
ULB to issue guidelines for retrofitting measures to improve building energy performance	• Verification of compliance through central monitoring and smart metering • Reframing the guidelines as per the response for faster uptake	Town Planning Department, PWD, Electrical Department, MahaDISCOM, MEDA, BEE
Promote adoption of highly energy efficient common utilities by establishing energy performance requirements and conditions to obtain building and occupancy permissions	• Verification of compliance during building occupancy/ part occupancy permission • Verification of compliance through central monitoring and smart metering	Town Planning Department, PWD, Electrical and E-governance department

Action Area	Key Performance Indicators (KPIs)	Monitoring and Evaluating Agency
Materials and Technical		
Expand energy benchmarking program to promote reporting of energy use and performance in buildings	• Verification of compliance through central monitoring and smart metering	Town Planning Department, PWD, Electrical Department, MahaDISCOM, MEDA, BEE
Establish a building renovation/retrofit program to conduct energy audits and implement deep measures for energy performance improvement and decarbonization	• Verification of compliance through central monitoring and smart metering	Electrical Department, MahaDISCOM, MEDA, BEE
Promote use of cool and reflective surfaces at building roofs, walls, and pavements to reduce urban heat	• Tracking voluntary uptake • Assessing the performance through external experts and expanding program for city wide uptake	Town Planning Department, PWD
Adopt Building Energy Management Systems (BEMS) in large public and private buildings	• Verification of compliance through central monitoring and smart metering	Electrical Department, MahaDISCOM, MEDA, BEE
Scale up uptake of rooftop solar PV – potential study for existing rooftops and to enable large-scale adoption	• Number of permissions and approvals for incorporating rooftop solar PV • Ensure scientific mapping of solar rooftop potential considering factors that reduce/ increase the system yield	Electrical Department, MahaDISCOM, MEDA
End of Life		
Policy and Regulation		
Promote deconstruction of old buildings instead of demolition. Mandate adoption of deconstruction strategies to obtain approvals/ permits for new buildings and redevelopment projects.	• Number of applications for building deconstruction based on structural audits	Town Planning Department, PWD Environment Department
Mandate appropriate C&D waste management and encourage its reuse in building construction	• Increase in the quantity of C&D waste at designated areas • Increase demand for recycled C&D waste building materials	Town Planning Department, PWD, Environment Department
Materials and Technical		
Procurement and use of recycled C&D waste	• Increased demand for recycled C&D waste building materials	Town Planning Department, PWD, Environment Department
Cross-Cutting Strategies		
Policy and Institutional		
Incorporate Green Public Procurement Policy (GPP) and SOPs	• Continuously updating SOPs as per low carbon development trends and aligning with national and sub-national goals	Town Planning Department, PWD, Electrical Department
Constituting a Working Group/Committee for Zero Carbon Buildings	• City performance based on Action Plan and national and sub-national goals, and make necessary modifications • Ensuring multidisciplinary and gender equal composition of the committee	Sub-Committee headed by NMC

Action Area	Key Performance Indicators (KPIs)	Monitoring and Evaluating Agency
Urban Planning		
Use land development mechanisms to create urban-level amenities	• Tracking city's blue and green cover • Tracking implementation and performance of city and neighbourhood level RE infrastructure	Town Planning Department, PWD, Electrical Department, MahaDISCOM
Integrated city development planning approach	• Tracking multi-sectoral planning solutions and policies w.r.t Action Plan goals	Town Planning Department, PWD, Environment Department
Materials		
Promote circularity and reuse in materials and resources	• Increased reporting of supply and reuse of resources and industrial by-products by various industries to NMC	Manufacturers, Associations
Encourage procurement of building materials from manufacturers that undertake (Life Cycle Analysis) LCA and publish (Environmental Product Declarations) EPD	• Identify and promote the number of material manufacturers identified that are undertaking LCA and providing EPDs • Verification of LCA reports and EPDs	Environment Department
Capacity Building		
Undertake training and awareness generation campaigns	• Number of workshops/ training sessions conducted annually. • Number of attendees and their diversity • Assessing readiness of stakeholders, especially real estate developers through focussed group discussions for undertaking LCA approach	Associations, Academicians, Institutions, NGOs
ULB to work with technical associations, certifying agencies and experts to create a knowledge base of low carbon building materials and technologies	• Robustness of database website, including engagement analytics such as number of visitors, time spent, data searched, among others • Online surveys and polls to gather local insights and practices	ULB E-Governance Department
Create a pool of skilled workforce trained in Zero Carbon Building construction	• Number of persons enrolled and completing opted courses • Direct engagement/ recruitment of trained workforce • Assessment of readiness and capacity for building deconstruction amongst stakeholders	Associations, Academicians, Institutions, NGOs

13. Risk Mitigation

The proposed interventions could face challenges and risks that hinder their implementation. The possible roadblocks could be a combination of financial feasibility, public acceptability and social barriers, administrative provisions, among others. It is therefore necessary to understand these risks and identify suitable mitigating solutions. The possibility of encountering the identified roadblocks in relation to the proposed interventions has been qualitatively assessed and ranked as low, moderate, and high.

Table 2: Identified risks and recommended solutions

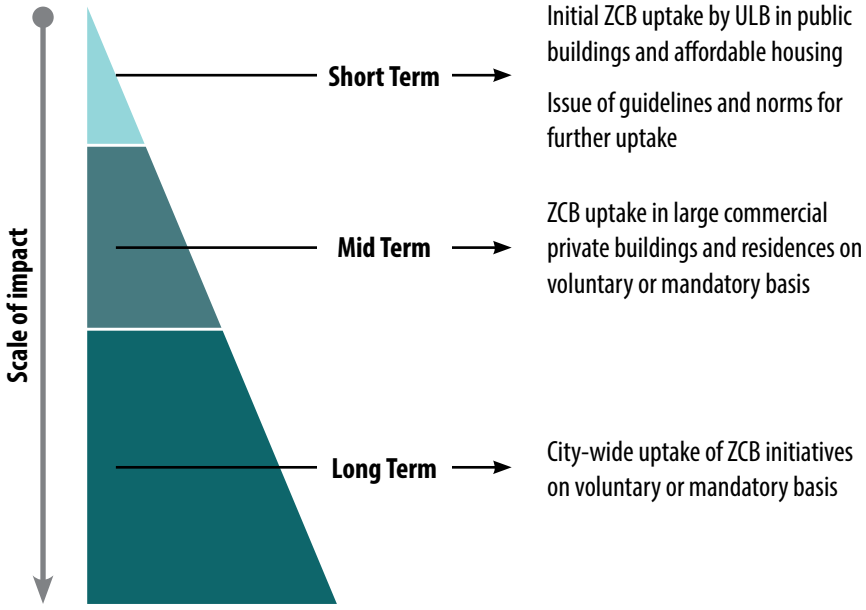
Sl. No.	Risk Identified	Probability	Potential Solution
1	Mandating green rating systems and compliances would be financially unviable for certain project proponents, especially those belonging to lower income groups	High	Proposed interventions on financial incentives and benefits would help reduce the cost component for meeting compliances/ requirements. ULB may consider providing more benefits to low income groups.
2	Issuance of financial incentives may affect the resource allocation and revenues of the concerned departments	High	Financial incentives/benefits could be issued one time to promote adoption and not necessarily be recurrent. Benefits such as property tax incentives could be for a limited duration and for targeted groups
3	Incorporating amendments in policy or making guidelines statutory/mandatory will be time consuming.	Moderate	Institutional structures such as the Sub-Committee for ZCB can review the proposed policy and regulatory changes/ interventions and fast-track their implementation. Consultations with other cities and state governments that have already incorporated such policy amendments.
4	Adoption of low-cost alternative construction techniques may have negative implications on structural integrity and building lifespans	Low	Design, feasibility, and applicability decisions should be taken in consultation with appropriate experts including structural engineers, technology experts, architects, among others. Regional/local experiences and suitable best practices should be considered to streamline the effort.
5	Unavailability of local skilled workforce to incorporate low carbon construction techniques	Moderate	Proposed intervention for rolling out vocational courses for low carbon construction would help bridge the gap for skilled workforce demand.
6	Required low carbon/alternate building materials may not be available locally	High	Materials unavailable locally may be substituted with green certified materials. Policy decisions at the regional/state-level are oriented to promote establishment of such industries locally.
7	Safety and performance of materials manufactured using natural substitutes and C&D waste and uncertified green materials	Moderate	Promote certification of green building materials through nationally accredited labs as per BIS standards. ULB to implement pilot projects using such products. Such substitutes to be used in conformity with relevant IS Codes
8	Viability for manufacturers to undertake LCA and provide EPD for their products	Low	MSME and green manufacturing linked incentives can be used to offset the cost of such compliances. NGOs, technical institutes, building industry associations and banking/financing institutions can lend support to small manufacturers to ensure compliance.
9	It may not be possible for building developers to undertake LCA exercises at the design stage	Low	ULB along with technical institutes, ISO certified experts, and green building professionals shall provide support to developers to undertake necessary LCA exercises at the design stage.

Sl. No.	Risk Identified	Probability	Potential Solution
10	ULB may need additional funds to implement pilot interventions and skill development initiatives	Moderate	ULB may implement pilot interventions in convergence with ongoing Central and State Government programs and schemes. Funds can be tapped from municipal budget, MP/MLA funds, CSR. Alternatively, the ULB may explore PPP models like DBOO and DBOOT.
11	Present EV infrastructure is under-developed and expensive to sustain commercial operations for supporting E-mobility for construction sector	Moderate	The ULB is expected to focus on improving EV infrastructure and leveraging policy and financial incentives to meet E-mobility targets. DISCOM may initially deploy EV charging stations at strategic locations, including at its own facilities, to reduce infrastructure costs.
12	Disincentivizing non-compliance with net zero building norms/conditions would attract resistance from building occupants and developers	High	ULB can undertake awareness and sensitization programs on the need to adopt net-zero buildings and continuously promote and support on the same. Compliance may be targeted in priority building types to begin with, starting with high income commercial/residential buildings, and gradually expanded. Timelines/deadline for compliance can be set with sufficient time to build readiness. Charges/penalties can be determined based on the level of non-compliance through stakeholder engagement.
13	Developers are not always able to fully utilize and monetize the additional floorspace offered through Green Building based FSI incentives, due to relatively low market demand for real estate in the city.	Low	ULB to update the current FSI/TDR policy and identify the right type of fiscal/monetary benefits that sufficiently incentivize developers and adequately reflect additional costs incurred at market rates.

14. Way Forward

Nagpur has shown its commitment towards climate resilience and sustainable development through various projects implemented in the city earlier. With the announcement of India's Net Zero Targets, this is the right time to deep dive into the construction sector to make it net-zero. The Zero Carbon Buildings Action Plan is first of its kind roadmap prepared for an Indian city taking the whole building lifecycle into the consideration, with the aim of reducing embodied and operations emissions produced in different building phases. The strategies developed for this action plan are a result of elaborate stakeholder consultations backed by secondary research which includes recommendations on building phases, from designing to end of life, covering both policy and technology aspects with indicative short, medium and long-term targets that are aligned with national emissions reduction targets.

To increase the uptake of zero carbon building strategies, there is a need of continuous dialogue between the building sector stakeholders and authorities, to develop the technical capacity and appropriate tools, mechanisms and business models including suitable financial incentives thereby bringing systemic change that can drive Nagpur's building sector decarbonization. Case studies along with enabling policies have been linked to the action plan to showcase their effectiveness and impact and for implementing these ambitious yet attainable strategies. This action plan has the potential to provide the necessary push for a bottom-up approach to reduce the sector's environmental impact in the long term.



The action plan's success requires collaborative approach amongst authorities, builders, academia, NGOs, CSOs as well as the citizens of Nagpur, as this systemic change is required at all levels from making raw material procurement sustainable to making behavioural changes for negating operational energy emissions to zero, and ensuring the health and well-being of construction workforce and finally to optimize the use of resources in building's operational and end of life phase. To initiate the process for Nagpur's building sector decarbonization, the ULB shall be the flagbearer of change, initiating various interventions as pilots and proof of concept to demonstrate their effectiveness along with undertaking IEC and awareness generation activities. The priority actions identified in the earlier chapter will be important for the short term as these are high impact-easy to implement interventions. As the benefits of these interventions comes forth and due to parallel capacity building and ZCB awareness campaigns, private stakeholders will have to take up these interventions incrementally to have a city-wide impact in the long term for Nagpur to achieve the status of all buildings to become net-zero by 2050.

Bibliography

Apollo Hospitals. (2022). *Business Responsibility and Sustainability Report - FY 2021-22*. Apollo Hospitals. https://www.apollohospitals.com/apollo_pdf/AHEL-ESG2022-Final-(20220802)-1.pdf

Architecture & Developpement. (2023, April 10). *Case Study III: TZED homes in Bangalore by BCIL*. Architecture & Developpement. https://www.archidev.org/spip.php?article1151

Architizer. (2019, January 9). *Circl by de Architekten Cie*. Architizer. https://architizer.com/projects/circl/

Auroville Earth Institute. (n.d.). *Vikas Community*. Auroville Earth Institute UNESCO Chair Earthen Architecture. Retrieved 10 April 2023, from https://www.earth-auroville.com/vikas_community_en.php

Chen, L., Hasan, R., & Jiang, Y. (2022). Urban Agglomeration and Firm Innovation: Evidence from Asia. *The World Bank Economic Review*, 36(2), Article 2. https://doi.org/10.1093/wber/lhab022

DownToEarth. (2016, October 1). *Galaxy School*. Pressreader. https://www.pressreader.com/

Garg, A., Dhar, S., Kankal, B., & Mohan, P. (2017). Good Practice and Success Stories on Energy Efficiency in India. *Copenhagen Centre on Energy Efficiency*, 77.

Government of India. (2019). *India Cooling Action Plan* (p. 126). Ozone Cell, Ministry of Environment, Forest & Climate Change. http://ozonecell.nic.in/wp-content/uploads/2021/09/India-Cooling-Action-Plan-Actionable-Points.pdf

Hernandez, M., Bhagavatula, K., Cibi, S., K, R., Krishnan, S., Malaviya, S., & Jairaj, B. (2022). Shifting Household Energy Use in Bangalore, India: Using Behaviorally Informed Energy Reports. *World Resources Institute*. https://doi.org/10.46830/wriwp.20.00046

Hertwich, E., Lifset, R., Pauliuk, S., & Heeren, N. (2020). *Resource Efficiency and Climate Change: Material Efficiency Strategies for a Low-Carbon Future* (p. 179). United Nations Environment Programme. https://doi.org/10.5281/ZENODO.3542680

Hudson Pacific Properties. (2021). HPP's *Approach to Embodied Carbon.* Hudson Pacific Properties. https://app.box.com/s/ii8jyq20xt5rabi06rg6wvzbr7ah8dw3

IBEF. (2021, May). *Maharashtra*. https://www.ibef.org/download/1654507774_Maharashtra-May-2022.pdf

Indian Green Building Council. (n.d.). *Government Incentives to IGBC-rated Green Building Projects*. Indian Graa. Retrieved 11 April 2023, from https://igbc.in/igbc/redirectHtml.htm?redVal=showGovtIncentivesnosign

International Energy Agency. (2018). *The Future of Cooling—Opportunities for energy efficient air conditioning*. https://iea.blob.core.windows.net/assets/0bb45525-277f-4c9c-8d0c-9c0cb5e7d525/The_Future_of_Cooling.pdf

International Energy Agency. (2021). *India Energy Outlook 2021*. OECD. https://doi.org/10.1787/ec2fd78d-en

Kachhawa, S., Singh, M., & Kumar, S. (n.d.). *Decoding India's residential building stock characteristics to enable effective energy efficiency policies and programs*. 6.

Khandelwal, R., Jain, R. K., & Gupta, M. K. (2020). *Case Study: India's First Net-Zero Energy Building- Indira Paryavaran Bhavan* (No. 11). 9(11), Article 11.

Lall, A. B. (2018, April 26). *Institute of Rural Research and Development at Gurgaon*, by Ashok B Lall. Institute of Rural Research And Development at Gurgaon. https://architecture.live/institute-of-rural-research-and-development-at-gurgaon-by-ashok-b-lall/

Masalvad, S. S., & Vasudeo, A. D. (2015). Climate Change and its Impact on Nagpur's Water Supply. *International Journal of Engineering Research And*, V4(10), Article 10. https://doi.org/10.17577/IJERTV4IS100152

Ministry of Housing and Urban Affairs. (2019). *Best Practices Compendium: ClimateSmart CITIES*. https://niua.in/csc/assets/pdf/key-documents/Best-Practices-Compendium-full-version.pdf

National Housing Bank. (n.d.). *Go Green Initiative*. National Housing Bank. https://nhb.org.in/wp-content/uploads/2021/11/Go-Green-initiative-of-NHB.pdf

Natural Resources Defense Council. (2013). *Saving Money and Energy: Case Study of the Energy-Efficiency Retrofit of the Godrej Bhavan Building in Mumbai*. Natural Resources Defense Council. https://www.nrdc.org/sites/default/files/energy-retrofit-godrej-bhavan-CS.pdf

Natural Resources Defense Council. (2018). *Getting Cities Climate-Ready: The Story of India's First Mandatory Energy Efficient Building Compliance System & How to Guide in Five Steps.* https://seors.unfccc.int/applications/seors/attachments/get_attachment?code=0JIFFVI450AB87T1FU0DZ2RYT160JMLE

NZEB. (n.d.). Indira Paryavaran Bhawan Case Study. *NZEB*. Retrieved 10 April 2023, from https://nzeb.in/case-studies/nzebs-in-india/nzebs-in-india-case-studies-list/ipb-case-study/

Pallerlamudi, S. S. H. (2021, November 12). *Reducing Embodied Carbon Is Key to Meeting India's Climate Targets*. RMI India. https://rmi-india.org/reducing-embodied-carbon-is-key-to-meeting-indias-climate-targets/

Potting, J., Hekkert, M., Worrell, E., & Hanemaaijer, A. (2017). Circular Economy: Measuring Innovation in the Product Chain. *PBL Publishers*. https://www.pbl.nl/sites/default/files/downloads/pbl-2016-circular-economy-measuring-innovation-in-product-chains-2544.pdf

Press Information Bureau. (2022). *India geared for Energy Transition and Climate Action*. Ministry of Information and Broadcasting, Government of India. https://static.pib.gov.in/WriteReadData/specificdocs/documents/2022/feb/doc202222519401.pdf

Rajasekar, U., Shankar, V., Singh, R., Gupta, A. D., Mandal, A., Dutta, M., Gandhi, P., Bhaisare, M., Kumar, E. U., Shravani T, Thool, P., Abbasi, A., Kaur, A., & Atreja, A. (2021). *Climate Smart Cities Assessment Framework 2.0: Cities Readiness Report 2021*. Ministry of Housing and Urban Affairs, Government of India. https://heyzine.com/flip-book/31ddf6adfe.html

SAATHEE. (2019). *Website Initiative by Uttar Pradesh SDA*. Bureau of Energy Efficiency. https://www.saathee.beeindia.gov.in/Content/SdaStateBriefFiles/Website%20Initiative%20by%20Uttar%20Pradesh%20SDA.pdf

Shah, K., Batra, N., Varghese, S., & Krishna, U. (2022). *Jobs and Skilling Landscape for Women Construction Workers in India: Learning from Case Studies*. Habitat Forum INHAF. https://drive.google.com/file/d/1jDWsWpj1d7bnBsMZ-8V7_6xyyySTOxSE/view?usp=embed_facebook

Surat Municipal Corporation. (n.d.). *Home*. Energy Efficiency Cell. Retrieved 11 April 2023, from https://www.suratmunicipal.gov.in/Departments/EnergyEfficiencyCellHome

TATA Steel. (2022, August 30). *Tata Steel Limited publishes Environmental Product Declaration (EPD) for Steel Rebar.* Press Releases. http://www.tatasteel.com/media/newsroom/press-releases/india/2022/tata-steel-limited-publishes-environmental-product-declaration-epd-for-steel-rebar/

TERI. (2014). *Assessing Climate Change Vulnerability and Adaptation Strategies for Maharashtra: Maharashtra State Adaptation Action Plan on Climate Change (MSAAPC)* (No. 2010GW01; Issue 2010GW01, p. 306). The Energy and Resources Institute. https://www.teriin.org/projects/nutrition-security/files/Maharashtra-CC-Report.pdf

United Nations. (2022, September 7). *Net Zero Coalition*. United Nations; United Nations. https://www.un.org/en/climatechange/net-zero-coalition

United Nations Environment Programme. (2018). *Guidance Document on Procuring Sustainable Buildings and Construction*. United Nations Environment Programme. https://www.efcanet.org/sites/default/files/2019-06/Guidance%20Document%20on%20Procuring%20Sustainable%20Buildings%20and%20Construction_Final.pdf

Vellingiri, S., Dutta, P., Singh, S., Sathish, L. M., Pingle, S., & Brahmbhatt, B. (2020). Combating climate change-induced heat stress: Assessing cool roofs and its impact on the indoor ambient temperature of the households in the Urban slums of Ahmedabad. Indian Journal of Occupational and Environmental Medicine, 24(1), Article 1. https://doi.org/10.4103/ijoem.IJOEM_120_19

Annexure 1

Sl. No.	Type	Name	Organization/Department/Office
1	ULB- Town Planning Department	Mr. Pramod Gawande	Nagpur Municipal Corporation
2	Builders & Developers	Mr. Mahesh Dande	JD Buildcon
3		Mr. Raunak Diote	Rachna Constructions
4		Mr. Shriniwas Warnekar	Integrity Constructions Pvt. Ltd.
5			Mahindra Bloomdale
6		Building Manager	TATA Capitol Heights
7		Mr. Patankar	Ensara Metropark
8		Mr. Mahesh Sadhwani	Nanik Group
9		Mr. Sunil Duddalwar	Himalaya Infra/IGBC Co-Chair
10		Mr. Dilip Bharade	Raghukul Developers
11	Building Material Manufacturers	Mr. Bindesh Paul	Paul Bricks
12		Mr. Nitin Sudame	Spacewood Furnitures
13		Mr. Prakash Jaiswal	Apna Ghar Pvt. Ltd
14	Architect	Ar. Habeeb Khan	Smita and Habeeb Khan Architects
15		Ar. Rajendra Dongre	AB Dongre and Associates
16		Ar. Sneha Mokha	Ashok Mokha Architects
17		Ar. Pratham Pincha	CRIUPA, Nagpur
18		Ar. Parikshit Mudholkar and Ar. Sameer Kachore	Bold Design Studio
19	Structural Engineer	Er. Satish Raipure	Satish Raipure and Associates
20		Er. Dilip Mase	P.T. Mase and Associates
21	Academician/Researcher	Dr. Rahul V Ralegaonkar	Dept. of Civil Engineering, VNIT Nagpur
22		Dr. Sameer Deshkar	Dept. of Architecture and Planning, VNIT Nagpur
23		Mr. Amol Shingarey	Geotech Services Pvt. Ltd.
24	CREDAI	Mr. Sandeep Agarwal	Sandeep Dwellers
25	Research Organization/NGO	Dr. Rajesh Biniwale	NEERI, Nagpur
26		Mr. Shivkumar Rao	Vidarbha Economic Development (VED)
27		Ar. Nitin Kurvey	Indian Institute of Architects
28		Mrs. Anusaya Kale	Swachh Association
29	Technology/Service Providers	Mr. Hitesh Harkare	Technodeal Enpower
30		Mr. Naik	Apple Chemie
31	Banking Institutions	Mr. Prakash Kajrekar	State Bank of India

Annexure 2

The tables below provide the total scoring based on which interventions have been prioritized. Scoring for each intervention has been given considering several benefits and implementation factors listed below.

Benefits:

- Climate Resilience
- Energy Savings
- Emissions Reduction
- Resource Efficiency
- Health and Well Being
- UHIE Reduction

Implementation factors:

- Mandatory and Voluntary nature of interventions
- Administrative and Political Willingness
- Economic Feasibility
- Ease of Implementation
- Speed of Results
- Scale of Impact

1	Pre-construction Phase	
Intervention 1: Include relevant guidelines, codes and regulations on efficient and low emission buildings into the Development Regulations at local level		145
Intervention 2: Adopt climate responsive building envelope design with building typology-wise minimum criteria for building energy performance		135
Intervention 3: Provide building approval related and financial benefits for green building pre-certification		126
Intervention 4: Include consideration of lifecycle impact of buildings & requirements for the same in building approval		96
Intervention 5: Adopt certified low-carbon materials, technologies & techniques in the construction of new buildings		109
Intervention 6: Incorporate passive & energy efficient cooling solutions & strategies into the building & microclimate design		127
Intervention 7: ULB to include requirements in building approval to use high energy-efficiency utility & indoor appliances		126
Intervention 8: Establish mandates & design buildings to help tap into rooftop solar PV potential		139
Intervention 9: Promote open access facility for renewable energy purchase to support net-zero buildings		113
Intervention 10: Plan building project sites to maximise and conserve permeable surfaces and green cover		129

<100 = Low Priority 100-115 = Medium Priority 115-130 = High Priority >130 Highest Priority

2	During Construction Phase	
Intervention 1: ULB to enforce the implementation of dust mitigation measures at construction sites as per CPCB guidelines		111
Intervention 2: Promote construction workers' well-being & inclusion		103
Intervention 3: Create an ecosystem promoting the reuse of industrial & agricultural by-products		121
Intervention 4: Encourage local procurement & manufacturing of construction materials		93
Intervention 5: Use of renewable energy & energy efficient (EE) equipment for building construction sites		124
Intervention 6: Use electric vehicles for transportation of construction materials & personnel		80

<100 = Low Priority 100-115 = Medium Priority 115-130 = High Priority >130 Highest Priority

3	Occupancy Phase	
Intervention 1: ULB to enact energy performance standards for existing buildings		140
Intervention 2: Promote green rating & performance certification/ labelling of existing buildings		145
Intervention 3: ULB to issue guidelines for retrofitting measures to improve building energy performance		129
Intervention 4: Promote highly energy efficient common utilities by establishing energy performance requirements & conditions to obtain building permissions		125
Intervention 5: Expand energy benchmarking program to promote reporting of energy use & performance in buildings		123
Intervention 6: Establish a building renovation/retrofit program to conduct energy audits & implement deep retrofit measures for energy performance improvement & decarbonization		107
Intervention 7: Promote use of cool and reflective surfaces at building roofs, walls, and pavements to reduce urban heat		140
Intervention 8: Adopt Building Energy Management Systems (BEMS) in large public & private buildings		94
Intervention 9: Scale up uptake of rooftop solar PV – potential study for existing rooftops & to enable large-scale adoption		117

<100 = Low Priority 100-115 = Medium Priority 115-130 = High Priority >130 Highest Priority

4	End of Life Phase	
Intervention 1: Promote deconstruction of old buildings instead of demolition. Mandate adoption of deconstruction strategies to obtain approvals for new buildings & redevelopments.		113
Intervention 2: Mandate appropriate C&D waste management & encourage its reuse in building construction		129
Intervention 3: Procurement & use of recycled C&D waste		102

<100 = Low Priority 100-115 = Medium Priority 115-130 = High Priority >130 Highest Priority

5	Cross Cutting Interventions Across Building Phases	
Intervention 1: Incorporate Green Public Procurement Policy (GPP) and SOPs		146
Intervention 2: Constituting a Working Group/Committee for Zero Carbon Buildings		200
Intervention 3: Disincentivizing non-compliance with net-zero norms		111
Intervention 4: Use land development mechanisms to create urban-level amenities		86
Intervention 5: Promote urban design and development to promote wind-induced air flow and address urban heat island effect at the neighbourhood-scale		101
Intervention 6: Integrated city development planning approach		168
Intervention 7: Promote circularity and reuse in materials and resources		90
Intervention 8: Encourage procurement of building materials from manufacturers that undertake (Life Cycle Analysis) LCA and publish (Environmental Product Declarations) EPD		94

<100 = Low Priority 100-115 = Medium Priority 115-130 = High Priority >130 Highest Priority


Sun Path Lab
CENTURYPLY
Raho Befikar
JAWAHARLAL DAR
ART GALLER

ICLEI - Local Governments for Sustainability, South Asia
C-3, Lower Ground Floor, Green Park Extension, New Delhi - 110016, India
Tel: +91 – 11 – 4974 7200; Fax: +91 - 11 - 4974 7201