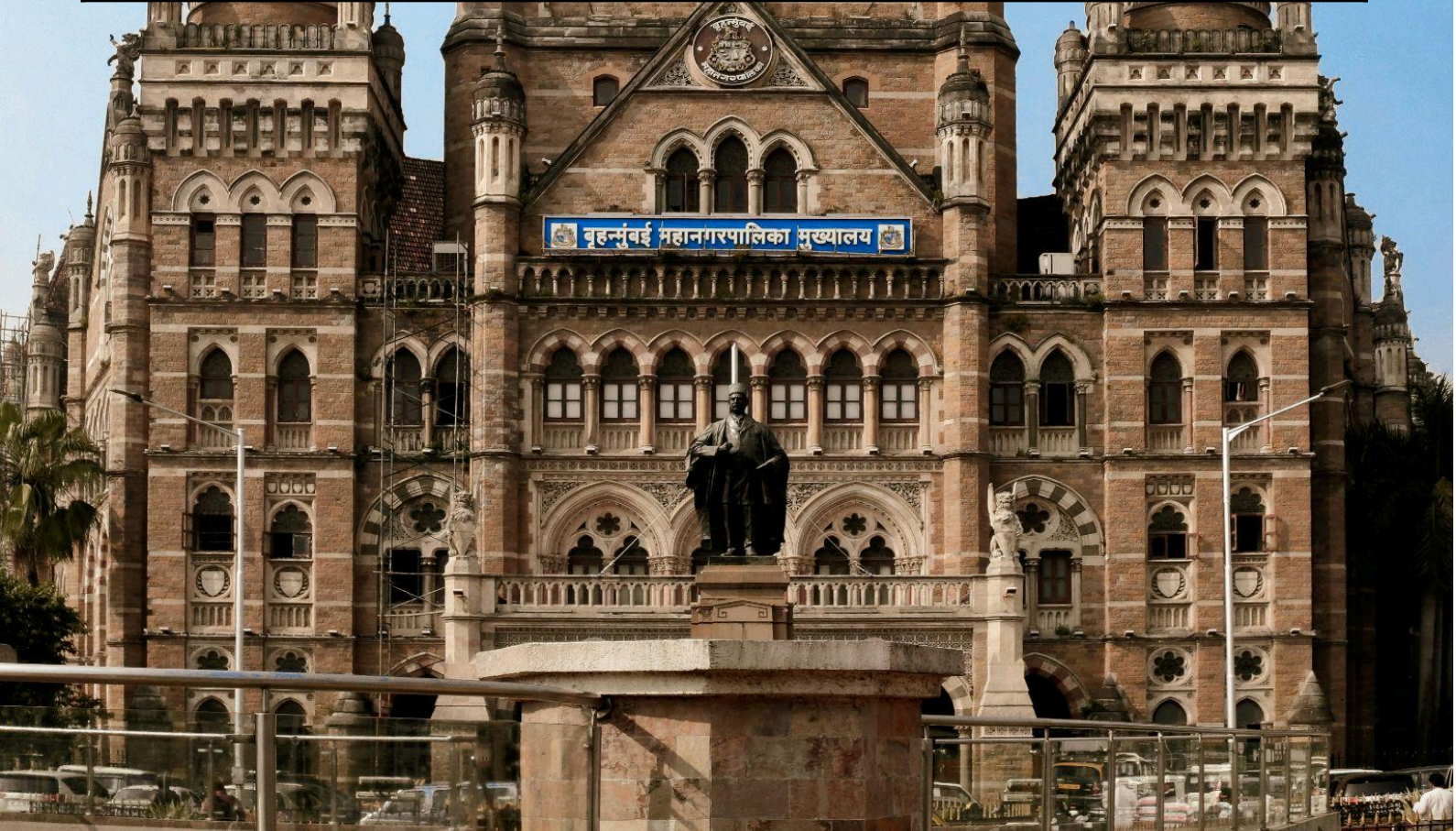




Net Zero Action Plan for Municipal Buildings of Mumbai (BMC)



Technical Partner:



This report has been prepared through a collaborative effort between C40 Cities, the Brihanmumbai Municipal Corporation (BMC), and the Alliance for an Energy Efficient Economy (AEEE). It lays the foundation for a Net Zero Municipal Buildings Action Plan by assessing energy consumption and emissions profile of municipal buildings and identifying priority areas for improvements.

Project Team:

C40 Cities

Ms. Shruti Narayan, Managing Director, Regions and Mayoral Engagement

Mr. Naim Keruwal, Regional Director, South and West Asia

Ms. Irene Skoula, Director, Energy and Buildings

Ms. Frankie Downy, Head of Building Strategy and Implementation

Mr. Nikhil Kulkarni, Head of City Engagements and Implementation

Mr. Bandish Patel, Technical Adviser, Energy & Buildings

Mr. Dante Zayas, Network Manager, Municipal Buildings Decarbonization

Ms. Devashree Ragde, Manager, Climate Governance and Finance

Ms. Shilpa Shashidharan, Manager of Climate Implementation

Alliance for an Energy Efficient Economy (AEEE)

Dr. Satish Kumar, President and Executive Director

Mr. Pramod Kumar Singh, Senior Program Director

Dr. Brijesh Pandey, Principal Research Associate

Dr. Rahul Ukey, Senior Research Associate

Mr. Himanshu Saini, Research Associate

Mr. Pavan R. Sharma, Technical Consultant

Ms. Pooja Gangwar, Senior Research Associate

Report design by:

Tanuj Joshi, Senior Executive (Graphics and Video)

Himanshu Sharma, Senior Executive in Graphics and DTP Design

Disclaimer

The views and analyses are based on a detailed review of the information publicly available or provided to the project team. Every attempt has been made to ensure the correctness of data. Any errors in interpretation are solely of the authors. Readers are encouraged to verify and authors will not accept any responsibility for the consequences of using this data.

All Rights Reserved

© 2026 C40 Cities and Alliance for an Energy Efficient Economy (AEEE).

Message

Smt. Pankaja Gopinath Munde

Honourable Minister for Environment and Climate Change,
Animal Husbandry, Government of Maharashtra



Maharashtra has set a clear and ambitious vision for its future—one that balances economic growth, social equity, and environmental sustainability. Under the state’s long-term development agenda, including Vikasit Maharashtra 2047 and the State Action Plan on Climate Change, the Government of Maharashtra is committed to building climate-resilient cities, strengthening energy security, improving quality of life for citizens, and positioning the state as a national and global leader in low-carbon development.

Cities lie at the heart of this vision. As engines of growth and innovation, Maharashtra’s urban centres also account for a significant share of energy demand and greenhouse gas emissions, particularly from the buildings and energy sectors. Addressing these challenges is not only essential for meeting climate goals, but also for reducing energy costs, improving thermal comfort, enhancing public health, and ensuring inclusive urban development—especially for communities vulnerable to heat.

The report presented here represents a meaningful step in translating the state’s climate and development vision into city-level action. Developed through close collaboration between the Environment and Climate Change Department, the State Climate Action Cell, urban local bodies, and C40 Cities, this work focuses on moving decisively from planning to implementation. By advancing High Impact Actions on decarbonisation through net-zero municipal buildings, rooftop solar deployment, cool and green roofs, behavioural energy efficiency and green municipal procurement, the programme supports Maharashtra’s priorities on clean energy transition, climate adaptation, and sustainable urban infrastructure.

The successful notification and implementation of Cool Roof Bye-laws in Amravati stands as a strong example of how evidence-based planning, sustained technical support, and effective state–city coordination can translate climate priorities into enforceable urban policy aligned with Maharashtra’s goals on heat resilience and low-carbon growth. This leadership is further reinforced by parallel successes in other cities, including the development of Net Zero Municipal Buildings Action Plans in Mumbai and Panvel, behavioural energy efficiency and rooftop solar programmes in Navi Mumbai and Thane, and household-level cooling pilots in Chandrapur demonstrating measurable reductions in indoor temperatures and energy demand. Together, these implementation-ready roadmaps highlight Maharashtra’s ability to move from pilots to policy, and position the state as a national leader in delivering scalable, replicable urban climate solutions for cities across India and the Global South.

I commend the Environment and Climate Change Department, the State Climate Action Cell, the Urban Development Department, the Energy Department participating municipal corporations, and our technical partners for their commitment and collaborative spirit. These reports are not an end in themselves, but practical tools to support cities as they deliver on Maharashtra’s broader vision of resilient, energy-efficient, and people-centred urban development. I am confident that the learnings from this initiative will inform future policies and inspire cities across India and the Global South.

Message



Smt. Jayashree Bhoj

Secretary, Department of Environment and Climate Change
Government of Maharashtra

The Government of Maharashtra's climate and development agenda recognises that effective implementation of climate actions at the city level is critical to achieving the state's long-term goals on sustainability, resilience, and economic competitiveness. As articulated through *Viksit Maharashtra 2047*, the State Action Plan on Climate Change, and sectoral policies on energy and urban development, the state is committed to enabling cities to adopt low-carbon pathways while strengthening institutions, improving service delivery, and safeguarding vulnerable communities.

This set of project reports reflects a deliberate effort to operationalise that vision. Built upon the Maharashtra City Decarbonisation Roadmap, in partnership with C40 Cities, the work moves beyond aspirational targets to provide cities with implementable High Impact Actions, institutional arrangements, and monitoring frameworks in the energy and buildings sector. The emphasis throughout has been on alignment—between city priorities and state policy levers, between climate objectives and development outcomes, and between technical ambition and administrative feasibility.

Four cities—Mumbai, Panvel, Nashik, and Amravati—now have implementation-ready roadmaps of selected high impact actions that support state priorities such as scaling renewable energy, improving energy efficiency in public assets, enhancing thermal comfort, and strengthening procurement systems. Three additional cities—Thane, Navi Mumbai, and Chandrapur—have been supported on immediate actions that build readiness while drawing on the tools and learnings from the deep-dive cities. This tiered model reflects a scalable pathway for extending climate action across Maharashtra's diverse urban landscape.

Equally significant is the strengthening of institutional capacity at both city and state levels. Through sustained consultations, knowledge-sharing sessions, and thematic discussions, officials have been better equipped to integrate climate considerations into budgeting, planning, procurement, and regulatory processes. The development of state-level knowledge products on rooftop solar and green municipal procurement, as well as formal policy inputs to the Urban Development Department, further embeds these learnings within government systems.

Anchored by the State Climate Action Cell, this initiative has also fostered a collaborative ecosystem—bringing together cities, state agencies, utilities, financial institutions, and knowledge partners—to support coordinated action and continuous learning. This foundation will be critical as Maharashtra advances its clean energy transition, explores innovative financing mechanisms, and engages with national and international climate initiatives, including Just Energy Transition frameworks.

These reports are intended as living documents that support ongoing implementation and policy refinement. They reflect Maharashtra's commitment to evidence-based decision-making and climate action that delivers tangible benefits for citizens while advancing the state's long-term development vision.

Message

Shri Abhijit Ghorpade

Director, State Climate Action Cell (SCAC)
Department of Environment and Climate Change
Government of Maharashtra



Maharashtra, India's one of the most industrialised and urbanised states, has drafted its Viksit Maharashtra 2047 vision to achieve a USD 5-trillion economy through a sustainable and inclusive approach, while managing rapid infrastructure and construction expansion. Reflecting its leadership and commitment, Maharashtra has mobilised climate action across cities, with 43 AMRUT cities formally committing to the global Race to Zero initiative. The buildings sector accounts for nearly 37 percent of India's annual primary energy consumption, a share that is projected to increase substantially in the absence of timely and effective interventions.

Cities assume a critical role in shaping the trajectory of climate action, particularly as building stock is expected to grow significantly by 2030. In response, the Department of Environment and Climate Change, in collaboration with C40 Cities and with technical support from Environmental Design Solutions (EDS), developed the Maharashtra City Decarbonization Roadmap for the Energy and Building Sector in 2023, covering 43 AMRUT cities across the State, supporting cities in achieving net-zero emissions by 2050. As part of the roadmap's implementation, seven cities were supported on high-impact actions aligned with local priorities, while remaining consistent with state and national objectives.

This resulted in the development of: 'Net-zero energy action plans for public buildings in Mumbai and Panvel cities', 'Roadmap for accelerating rooftop solar deployment in Nashik city', 'Cool / Green roof policy roadmap for Amravati city', 'Identification of cooling pathways for low-income settlements in Chandrapur city', 'Development of behavioural energy efficiency and renewable energy adoption programmes for municipal buildings in Navi Mumbai and Thane cities.'

In addition, policy notes and guidance documents addressing cross-cutting challenges were also developed. This included 'Road to Renewable Cities', a knowledge product supporting cities in their clean energy transition and 'Greening Municipal Procurement', a step-by-step guide for urban local bodies, that centres "procurement" in the climate action dialogue.

This body of work has been undertaken through close coordination with urban local bodies, relevant state departments and agencies, technical experts, and partner organisations. It reflects an evolving approach towards action-oriented and implementation-focused climate planning, grounded in local realities, informed by analytical evidence, and designed to support scalability and replication across the State.

The Maharashtra State Climate Action Cell remains committed to supporting cities in mainstreaming climate considerations within the urban built environment and strengthening institutional capacities for sustained climate action. The roadmaps, action plans, policy recommendations and knowledge products presented herein are expected to facilitate accelerated implementation, promote innovation, and contribute meaningfully to Maharashtra's transition towards a low-carbon and climate-resilient future.

Message

Mr. Avinash Kate,

Deputy Municipal Commissioner,
Environment and Climate Change,
Brihanmumbai Municipal Corporation (BMC)



Mumbai, as one of India's largest and most vibrant metropolitan cities, stands at the forefront of the global battle against climate change. Following our commitment to the Paris Agreement, the Brihanmumbai Municipal Corporation prepared the Mumbai Climate Action Plan (MCAP), which identified the buildings sector as a critical area for intervention, accounting for 20% of the city's greenhouse gas (GHG) emissions. Within this sector, public buildings alone represented a substantial (7%) electricity consumption. Recognizing this challenge, the Brihanmumbai Municipal Corporation (BMC) acknowledged that to drive city-wide change, we must first lead by example.

It gives me great pleasure to present the Net Zero Action Plan for Municipal Buildings, a comprehensive assessment and strategic action plan prepared through a collaborative effort between the BMC, C40 Cities, and the Alliance for an Energy Efficient Economy (AEEE). This work lays the foundation for decarbonizing our municipal portfolio, focusing on four priority categories: schools, offices, hospitals, and auditoriums.

Our vision for this transition is ambitious. The plan delineates clear pathways for our diverse infrastructure: achieving Net Zero Energy status for existing buildings by targeting operational energy efficiency and renewable energy integration, and Net Zero Carbon status for all new buildings by further incorporating low-carbon materials and passive design strategies. By operationalizing this action plan, BMC aims to reduce its carbon footprint and also set a precedent for other municipal corporations across Maharashtra and India. This document serves as a blueprint for a sustainable, low-carbon urban future, demonstrating that embedding sustainability in municipal buildings is a responsibility. Let's continue the efforts on moving from ambition to action for a cleaner and greener built environment.

Foreword

Naim Keruwala

Regional Director, South and West Asia
C40 Cities



Maharashtra's cities are at the forefront of India's urban climate transition. Through the Maharashtra City Decarbonisation Roadmap for the Energy and Buildings Sector, 43 cities across the state have committed to ambitious, city-led pathways that align with India's long-term climate goals and demonstrate how subnational leadership can drive climate action at scale. This collective approach positions Maharashtra as a model for other states accelerating India's clean energy transition.

Rapid urbanisation, rising energy demand, and increasing exposure to extreme heat and climate risks underscore the urgency of accelerating urban climate action that delivers tangible benefits for residents while supporting long-term economic growth. C40's support to seven cities (Mumbai, Panvel, Nashik, Amravati, Thane, Navi Mumbai and Chandrapur) through development of high impact action roadmaps and critical actions on energy transition and knowledge products are aimed at advancing implementation, and providing cities with the necessary tools and frameworks. .

This suite of reports marks an important milestone in Maharashtra's urban decarbonisation journey. Developed in collaboration with the Government of Maharashtra, seven municipal corporations, and technical experts; these roadmaps demonstrate how cities can use their regulatory, operational, and purchasing power to drive systemic change at scale. Together, they outline practical and implementable pathways to reduce emissions, improve energy efficiency, and strengthen resilience across the energy and buildings sector; one of the most critical and cost-effective areas for urban climate action. The reports focus on key levers available to cities today, including cool and green roofs, rooftop solar, net-zero municipal buildings, behavioral change, and sustainable procurement, translating ambition into clear, actionable steps.

I commend the Environment and Climate Change Department of Government of Maharashtra, Climate Action Cell on its efforts in achieving this significant milestone and collaboration. C40 also acknowledges the engagements and support extended by the Departments of Urban Development, Energy Department along with the Maharashtra Institution for Transformation (MITRA) and seven cities in developing these roadmaps.

C40 looks forward to further supporting Maharashtra's cities to implement and mainstream climate actions supporting objectives of Vikasit Maharashtra 2047 and State Action Plan on Climate Change.

Foreword

Dr. Satish Kumar,

President and Executive Director,
Alliance for an Energy Efficient Economy



Buildings sector is a major contributor to the energy consumption and emissions in the built environment. While immediate attention is often drawn to visible and significant polluters like transport and industry, buildings remain energy guzzlers consuming huge amounts of power which has grown significantly in the past decade due to rising cooling demand. Mumbai Climate Action Plan had highlighted that the buildings sector accounts for 20% of the city's greenhouse gas (GHG) emissions. Equally concerning was the share of municipal buildings' in these emissions.

At the Alliance for an Energy Efficient Economy (AEEE), we view energy efficiency not just as a conservation measure, but as a critical resource that contributes toward meeting India's goals on energy security and climate action. It is in this spirit that we collaborated with C40 Cities and the Brihanmumbai Municipal Corporation (BMC) to develop the Net Zero Action Plan for Municipal Buildings.

Our assessment of the BMC buildings revealed that hospitals, offices, schools, and auditoriums account for 14.7% of total municipal electricity consumption, therefore we propose to prioritize these. For our existing building stock- we must aggressively pursue Net Zero Energy status. This involves retrofitting inefficient appliances, such as replacing conventional fans with BLDC units and upgrading HVAC systems, which our audits have identified as high-impact Energy Conservation Measures (ECMs). For new construction, we must raise the bar further to Net Zero Carbon status. This requires looking beyond operational energy reduction and also address embodied emissions the emissions locked into materials like cement, steel, brick and glass before a building becomes operational. By integrating passive design strategies, low-carbon materials, and planning rooftop solar from the design stage, we can prevent locking in emissions for the decades to come.

This Action Plan is our attempt at achieving decarbonization by leveraging instruments like Energy Service Companies (ESCOs), Cooling-as-a-Service and other innovative strategies. We hope this work serves as a scalable blueprint, proving that sustainable public infrastructure is possible and practical for cities across India.

Acknowledgments

The development of the municipal building “Net Zero Action Plan” was done under the leadership and co-ordination of BMC.

We’d like to sincerely thank the individuals listed below for their support and contributions to the municipal building Net Zero Action Plan:

Brihanmumbai Municipal Corporation

Name of BMC officials:

Shri. Bhushan Gagrani, IAS, Municipal Commissioner, BMC.

Dr. Ashwini Joshi, IAS, Add. Municipal Commissioner (City)

Shri. Avinash Kate, Deputy Municipal commissioner (Environment & Climate Change) (in-charge)

Smt. Varsha Athalye, Ex. Engg- II (Environment & Climate Change)

Smt. Revati Shidhaye, AE (Environment & Climate Change)

Shri. Rohan Kalme, AE (Environment & Climate Change)

Shri. Nikhil Mene, AE (Environment & Climate Change)

Shri. Manish Chaware, SE (Environment & Climate Change)

Shri. Madhur Manve, MCAP Consultant

The project team would like to thank all the advisor and reviewers from C40 Cities, all Joint Municipal commissioners, Deputy Municipal commissioners, Chief Engineers, Assistant Commissioners, department heads at the ward level, stakeholders and external agencies who participated in the stakeholder consultations of the municipal building Net Zero Action Plan.

This report should be referred to as the ‘Brihanmumbai Municipal Corporation (BMC) Municipal Building Net Zero Action Plan, November 2026’

Preface

Mumbai is one of India's largest metropolitan cities. C40's prior engagement on structuring the Paris Agreement aligned Mumbai's Climate Action Plan (MCAP) recognized the buildings sector as a key contributor accounting for 20% of the city's GHG emissions. Public buildings alone represent 7% of electricity consumption, projected to triple by 2050 under a business-as-usual scenario.

Taking cues from MCAP and building up on the commitment by 43 cities in Maharashtra to prepare and implement city-level decarbonization roadmap; C40 supported development of a roadmap for transition of the energy and buildings sector. Launched by the Environment and Climate Change Department of Maharashtra in December 2023; this roadmap was a city-level template that outlined a pathway for supporting energy transition, upscaling energy efficiency, reducing GHG emissions and reliance on fossil fuels, and lowering energy operation costs.

Building on the Maharashtra City Decarbonisation Roadmap, C40 is currently supporting seven (Mumbai, Amravati, Panvel, Nashik, Chandrapur, Navi Mumbai, Thane) out of the 43 cities included in first phase of this work, to develop implementation frameworks and action plans for clean energy and low-carbon buildings. An important initiative in this phase is developing a Net-Zero Municipal Buildings Action Plan. C40, Brihanmumbai Municipal Corporation (BMC), and Alliance for an Energy Efficient Economy (AEEE) have collaborated to assess the current energy and emissions profile of municipal buildings to identify key areas for improvement in this report to further develop the Net Zero Municipal Building Action Plan.

Executive Summary

The **Net Zero Action Plan for Municipal Buildings** presents a comprehensive framework for the **Brihanmumbai Municipal Corporation (BMC)** to transition its municipal building portfolio toward **net-zero energy and carbon** targets by 2050. The plan addresses both **existing** and **new municipal buildings**, focusing on strategies that combine technical, financial, and governance interventions to achieve measurable emission reductions in alignment with the **Mumbai Climate Action Plan** and **Maharashtra's Net Zero Roadmap by 2050** objectives.

Scope and Objectives

The action plan covers four major municipal building categories **schools, offices, hospitals, and auditoriums** which together account for approximately **14.7% of BMC's total electricity consumption**. For **existing buildings**, the goal is to achieve **net-zero energy**, emphasizing operational energy efficiency and renewable energy integration. For **new buildings**, the target is **net-zero carbon**, incorporating both operational and embodied carbon reductions through the use of low-carbon materials, efficient building design practices, energy efficient appliances, rooftop solar PV and clean energy procurement.

Net Zero Strategies for Existing Building

Walkthrough energy audits were conducted for representative buildings within each identified typology to identify **Energy Conservation Measures (ECMs)**. The results were extrapolated to estimate stock-level impacts across BMC's building portfolio. Walkthrough audit of the sampled buildings shows that the most effective ECMs include **rooftop solar PV installation, replacement of conventional fans with BLDC fans, and upgrading inefficient air-conditioning systems** to high-efficiency models.

The impact analysis of the identified ECMs across building typologies indicates that, if implemented effectively, these measures can substantially reduce current energy consumption. In some cases such as **schools** and **auditoriums** they could enable a **net zero energy** status, while **office buildings** could achieve **near-net zero performance** (as shown in Figure E.1).

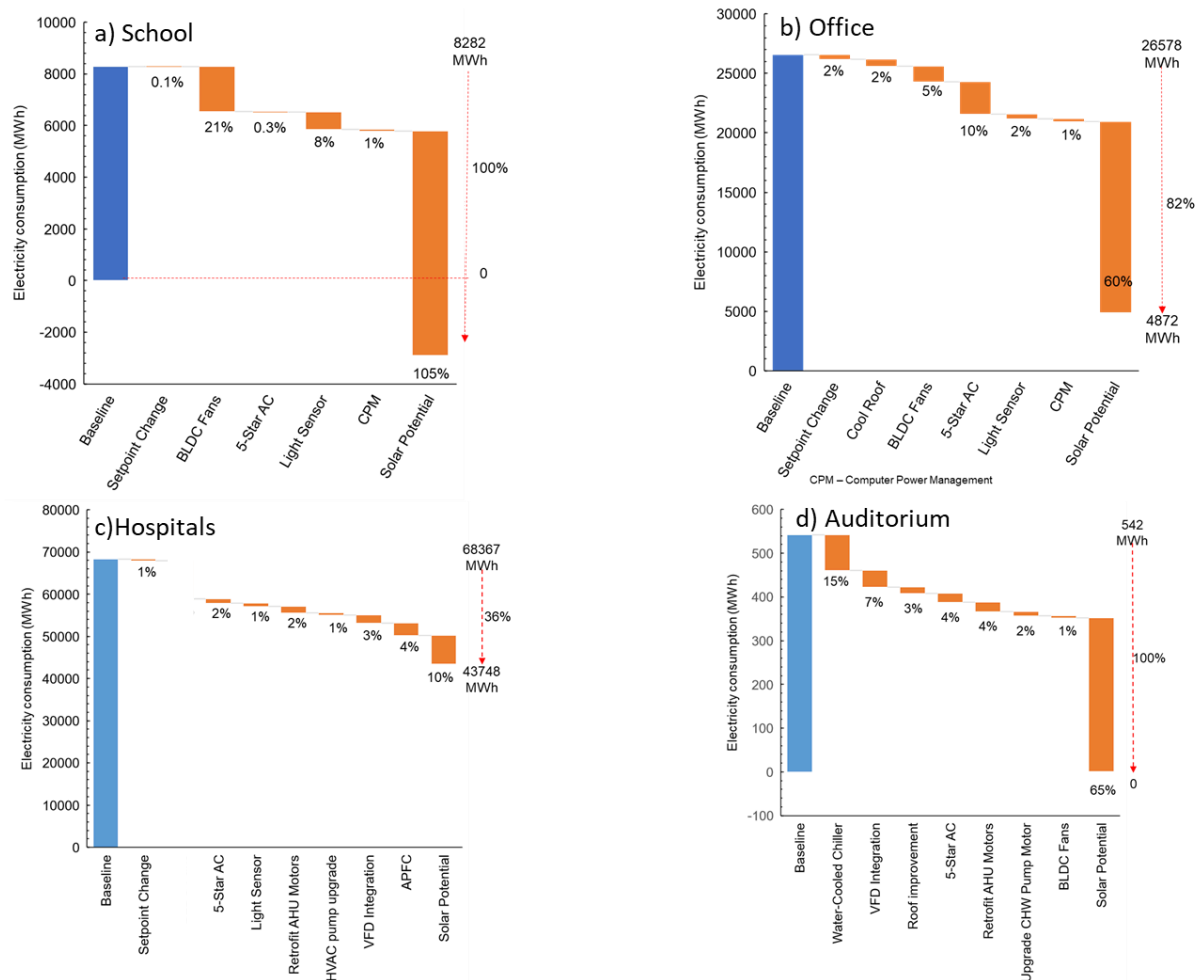


Figure E1: Stock-level impact of energy conservation measures (ECM's) across building typologies

The analysis indicates that **retrofitting existing inefficient appliances** with energy-efficient alternatives and **installing rooftop solar systems** are key strategies to reduce energy consumption in existing buildings and, in some cases, achieve **net zero energy status**.

For certain building typologies, such as **offices** and **hospitals**, where net zero energy cannot be achieved solely through efficiency upgrades and rooftop solar, **procuring green power from the open market under the Green Tariff Policy** can help bridge the gap and enable them to reach **net zero energy status**.

Net-Zero Strategies for New Buildings

Net zero strategies for new municipal buildings is structured around five key pillars:

Passive Design Strategies – Optimized building orientation, high-performance envelopes, shading devices, and cool roofs to reduce cooling loads.

Active Design Strategies – Integration of efficient lighting, BLDC fans, 5-star or VRF HVAC systems, and advanced controls for load management.

Low-Carbon Materials – Use of low-emission cements (PPC, PSC, LC3), high-recycled-content steel, and alternative walling materials such as fly ash or Agrocrete blocks.

Rooftop Solar Integration – Early-stage planning to ensure adequate roof strength, orientation, and capacity for on-site renewable generation.

Clean Energy Procurement – Adoption of the **MERC Green Tariff Policy** and open-access renewable energy to offset residual grid emissions.

Recognizing fiscal constraints at the municipal level, the action plan outlines diverse **financing mechanisms** tailored to different investment scales such as **self-financing** for low-cost measures (LED retrofits, BLDC fans, cool roofs) through the municipal climate budget, revolving funds, or on-bill recovery, **ESCO-based performance contracting** for medium-cost interventions such as air conditioning units and centralized cooling system upgrades, **RESCO and Cooling-as-a-Service (CaaS) models** for capital-intensive measures like rooftop solar and centralized HVAC retrofits and **innovative financing instruments**, including municipal and green bonds, concessional loans, and public-private partnerships (PPPs), for large-scale deployment (Shown in Figure E.2). The report suggests that implementation be overseen by a **Climate Budget Steering Cell**, housed within the Environment Department in coordination with the M&E and Finance Departments through a robust **Measurement, Reporting, and Verification (MRV) Framework**.

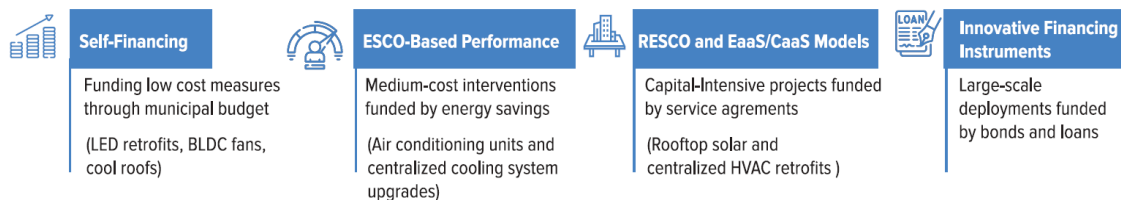


Figure E2: Financing mechanism for implementing ECMs

Finally, for implementation the roadmap outlines **phased implementation targets, by 2030 it proposes to** complete baseline audits and implement all no-cost and low-cost ECMs across priority building categories, **by 2040, achieve 50% portfolio coverage** under net-zero energy through rooftop solar and efficiency measures and by 2050 achieve full transition to **net-zero energy for existing buildings** and **net-zero carbon for all new municipal buildings** (Shown in Figure E.3). Pilot action plans for the **RC Ward Municipal Office** and **Nair Hospital** illustrate the integration of identified ECMs, financial models, and institutional roles to serve as scalable prototypes for all municipal building typologies.

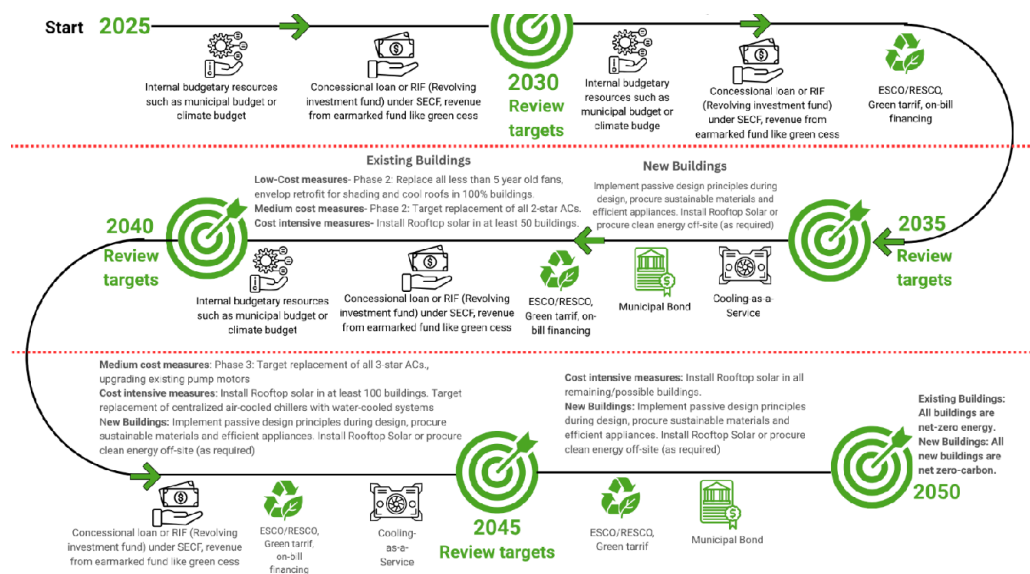


Figure E3: Illustration of Net Zero Road Map and action plan

List of Abbreviations

Abbreviation	Full Form / Description
AAC	Autoclaved Aerated Concrete
AC	Air Conditioner
AEEE	Alliance for an Energy Efficient Economy
AHU	Air Handling Unit
APFC	Automatic Power Factor Correction
BEE	Bureau of Energy Efficiency
BEST	Brihanmumbai Electric Supply & Transport Undertaking
BF-BOF	Blast Furnace–Basic Oxygen Furnace
BLDC	Brushless Direct Current (Fan)
BMC	Brihanmumbai Municipal Corporation
BMTPC	Building Materials and Technology Promotion Council
CaaS	Cooling as a Service
CAC	Climate Action Cell
C&D	Construction and Demolition
CHW	Chilled Water
CO ₂ e	Carbon Dioxide Equivalent
CSR	Corporate Social Responsibility
DISCOM	Distribution Company
DSM	Demand Side Management
ECBC	Energy Conservation Building Code
ECM	Energy Conservation Measure
ECSBC	Energy Conservation and Sustainable Building Code
EE	Energy Efficiency
EESL	Energy Efficiency Services Limited
EMF	Electric Arc Furnace
EPC	Energy Performance Contract
ESCO	Energy Service Company
FY	Financial Year
GFRP	Glass Fibre Reinforced Polymer
GGBS	Ground Granulated Blast Furnace Slag
GHG	Greenhouse Gas
HVAC	Heating, Ventilation, and Air Conditioning

IFC	International Finance Corporation
ISO	International Organization for Standardization
kWh	Kilowatt-hour
LC3	Limestone Calcined Clay Cement
LED	Light Emitting Diode
LT	Low Tension (Electrical Supply)
MahaECBC	Maharashtra Energy Conservation Building Code
MAHAPREIT	Mahatma Phule Renewable Energy and Infrastructure Technology
MERC	Maharashtra Electricity Regulatory Commission
MEDA	Maharashtra Energy Development Agency
MSEDCL	Maharashtra State Electricity Distribution Co. Ltd.
M&V	Measurement and Verification
MWh	Megawatt-hour
MRV	Measurement, Reporting, and Verification
O&M	Operations and Maintenance
OPC	Ordinary Portland Cement
PCC	Portland Composite Cement
PPC	Portland Pozzolana Cement
PSC	Portland Slag Cement
PPP	Public–Private Partnership
PV	Photovoltaic
RE	Renewable Energy
REC	Renewable Energy Certificate
RESCO	Renewable Energy Service Company
RIF	Revolving Investment Fund
SRI	Solar Reflective Index
TR	Ton of Refrigeration
ULB	Urban Local Body
UDCPR	Unified Development Control and Promotion Regulations
VFD	Variable Frequency Drive
VRF	Variable Refrigerant Flow
WWR	Window-to-Wall Ratio

Content

Preface	12
Executive Summary	13
List of Abbreviations	16
List of Tables	19
List of Figures	19
01 Scope of Net Zero Municipal Buildings	1
Understanding of Emissions Across Building Life Cycle	1
Approaches to Achieve Net Zero Energy/Carbon Buildings	2
02 Prioritization of Strategies	5
Energy Conservation Measures in Municipal School Building Category	5
Energy Conservation Measures in Municipal Office Building Category	8
Energy Conservation Measures in Hospital Building Category	10
Energy Conservation Measures in Auditorium Building Category	13
ECM Categorization by Cost-Effectiveness and Impact across Building Typologies	15
Top 3 Measures Based on Energy Savings	17
Strategies for Achieving Net-Zero Carbon Status for New Municipal Buildings	17
03 Implementation Mechanism	31
Finance mechanisms	32
Governance and Roles	39
Standardization of the Procurement Process	42
Measurement Reporting and Verification (MRV) Framework	42
04 From Roadmap to Action Plan	48
Roadmap: Targets, timeline and strategy	48
Action Plan: Pilots	50
Decision Matrix	51
05 Conclusion	54
APPENDIX	56

List of Tables

Table 1: Approaches for net zero energy/carbon buildings	2
Table 2: Impact of ECMs in municipal schools	6
Table 3: Impact of ECMs in municipal offices	8
Table 4: Impact of ECMs in municipal hospitals	10
Table 5: Impact of ECM in municipal auditoriums	13
Table 6: Passive design measures with strategy-wise cooling load and operational carbon	19
Table 7: Active design measures with strategy-wise operational carbon reduction	22
Table 8: Emission factors and reduction potential of cements	23
Table 9: Emission factors and reduction potential of steel	24
Table 10: Emission factors and reduction potential of brick technology and alternative walling materials	24
Table 11: Rooftop solar PV measures	26
Table 12: Approaches for self-financing	32
Table 13: ECM examples with possible financing mechanisms: summary	36
Table 14: Roles & Responsibilities for government departments	39
Table 15: Responsibility and performance matrix	44
Table 16: Decisions matrix for financing strategies	50

List of Figures

Figure 1: Emissions across building lifecycle	2
Figure 2: Distribution of electricity consumption for different municipal building typologies	3
Figure 3: Impact of ECMs at stock level for municipal school buildings	7
Figure 4: Impact of ECMs at stock level for municipal office buildings	9
Figure 5: Impact of ECMs at stock level for municipal hospitals	12
Figure 6: Impact of ECMs at stock level for municipal auditoriums	14
Figure 7: Payback periods and energy savings for different municipal buildings	15
Figure 8: Strategic pillars of the decarbonisation roadmap for new municipal buildings	17
Figure 9: Passive design strategies to optimize orientation, envelope, and shading for reduced cooling demand	18
Figure 10: Active design strategies to enhance energy efficiency through lighting, HVAC, and controls	20
Figure 11: Low-carbon material strategies to reduce embodied emissions in construction	23
Figure 12: Rooftop solar PV integration to maximize onsite renewable energy generation	25

Figure 13: Steps for BMC to procure renewable energy through open market through green tariff	27
Figure 14: Decrease in unit cost during bulk procurement	32
Figure 15: Existing institutional structure of departments relevant for Energy and Buildings in BMC	38
Figure 16: Proposed Buildings and Mobility cell under MCAP	39
Figure 17: Measurement reporting and verification (MRV) framework	42
Figure 18: Near term year-wise resource planning	43
Figure 19: Roadmap outlining strategies and timeline	48
Figure 20: Action plan for RC ward municipal office building	49
Figure 21: Action Plan for Nair hospital	50

01 Scope of Net Zero Municipal Buildings



Over its lifecycle, a building generates substantial greenhouse gas (GHG) emissions, which can be categorized into **embodied emissions, operational emissions, and end-of-life emissions**. The stages of buildings' lifecycle emissions, as defined by ISO 14040/14044, are illustrated in **Figure 1**.

Understanding of Emissions Across Building Life Cycle

Embodied Carbon: Comprises of upfront embodied carbon emissions (from the extraction of the constituent raw materials, transportation to the manufacturing plant, manufacturing process, transportation of materials to the construction site and emissions during the construction stage of the buildings), use phase embodied carbon (from materials used during repair, replacement and refurbishment of the buildings) and end of life cycle emissions resulting from building demolition activities and its recycling and disposal.

Operational Carbon: Results from building operations, once the building is occupied and is associated with building day-to-day energy needs such as lighting, ventilation, cooling/heating, operating electrical appliances and equipment.

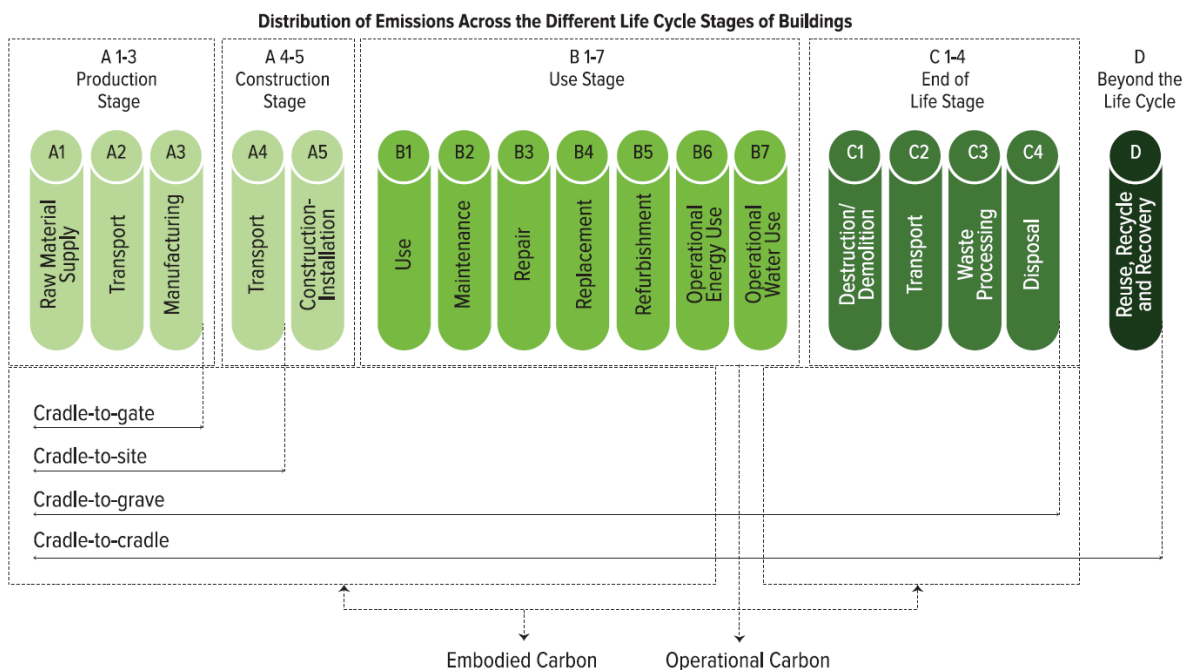


Figure 1: Emissions across building lifecycle¹

Approaches to Achieve Net Zero Energy/Carbon Buildings

The following table captures the approaches through which net zero energy/carbon building status can be met.

Table 1: Approaches for net zero energy/carbon buildings²

Net Zero Status	High level 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 low embodied carbon materials and efficient building envelope design; life-cycle emissions mitigated by on-site and off-site renewable energy interventions
Near Net Zero Energy Building	✓		
Net Zero Energy Building		✓	

¹ B. Pandey and S. Jayram, Life Cycle Assessment of Carbon Emissions: Progress and Barriers in Indian Building Sector (SGRI & AEEE, 2024)

² ICLEI – Local Governments for Sustainability South Asia, Zero Carbon Buildings Action Plan – Nagpur (New Delhi: ICLEI South Asia, 2024)

Net Zero Carbon Building			✓
---------------------------------	--	--	---

This report focuses on developing a Net Zero Action Plan for both existing municipal buildings and new upcoming municipal building stock. For **existing buildings**, the scope is limited to achieving **net zero energy**, as their embodied carbon is already locked in through materials used over the building lifecycle. In contrast, for **new municipal buildings**, the target is **net zero carbon**. This is because upcoming projects have the opportunity to incorporate low-carbon materials, reduce embodied emissions across the lifecycle, and achieve net zero operational energy together resulting in net zero carbon buildings.

The baseline assessment of municipal buildings under the Brihanmumbai Municipal Corporation (BMC) jurisdiction indicates that these buildings account for **19% of total municipal electricity consumption**. Within this, municipal offices, hospitals, schools, and auditoriums contribute **3.8%, 9.8%, 1.2%, and 1%** respectively (Figure 2). Based on these findings, this report prioritizes these key building categories for developing a **Net Zero Energy/Carbon Building Action Plan**. The plan is informed by energy conservation measures identified during walkthrough energy audits of representative buildings within each category and is designed to be scaled up across other municipal building types in subsequent phases.

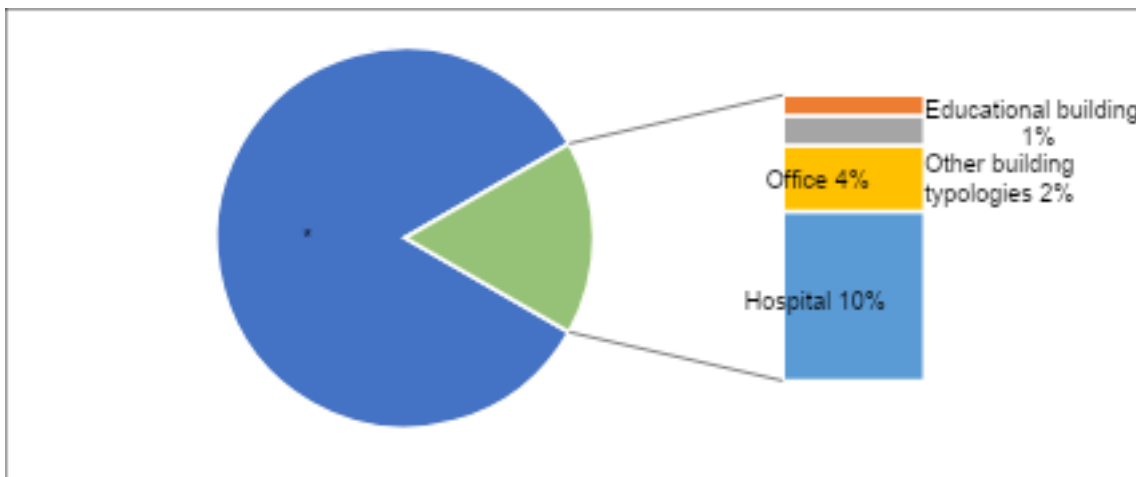


Figure 2: Distribution of electricity consumption for different municipal building typologies
Source: authors



02 Prioritization of Strategies



To identify energy conservation measures (ECMs) across municipal building stock, municipal building categories were first classified based on their share of total electricity consumption. Through this analysis, **hospitals, municipal offices, schools, and auditoriums emerged as priority categories.** Walkthrough energy audits were then conducted for sample buildings within each identified municipal building category to identify the ECMs. The electricity-saving potential from ECMs identified at the individual building level was subsequently scaled up to estimate the total energy saving potential across the entire municipal building stock for identified municipal building category. The detailed results, including category-wise ECMs and their aggregated impacts at the stock level, are presented in the following sections.

Energy Conservation Measures in Municipal School Building Category

The walkthrough energy audit of the three municipal school buildings namely “LK Waghji Mumbai Public School,” “Chhatrapati Shivaji Maharaj Nag. School No1” and “Sodawala Municipal School” have been conducted and the list of identified ECMs and its impact on energy savings, investment required to implement the ECMs and payback

period estimated through energy saving potential has been presented in the following table.

Table 2: Impact of Energy Conservation Measures in municipal schools

(Source: authors own analysis)

S. No.	Energy Conservation Measure (ECM)	Annual energy saving (kWh/year)	Annual saving on electricity bill (INR lakh/annum)	Investment (INR lakh)	Simple payback period (years)
LK Waghji Mumbai Public School					
1	Replacement of old conventional fans with new BLDC fans	9,240	1.03	4.00	4
2	Integration of daylighting / occupancy automatic light sensors	2,445	0.27	1.00	3
3	Effect of switching off computers (vs leaving in standby)	440	0.05	0	0
4	Rooftop solar potential (20 kWp)	-5,715	4.00	9.00	3
Chhatrapati Shivaji Maharaj Nagar School No. 1					
1	Change in set-point temperature	48	0.01	0	0
2	Replacement of old conventional fans with new BLDC fans	14,309	1.60	6.23	4
3	Replacement of old split ACs with new 5-star split AC (1.5 TR)	240	0.03	0.35	13
4	Integration of daylighting / occupancy automatic light sensors	3,055	0.34	1.36	4
5	Effect of switching off computers (vs leaving in standby)	220	0.02	0	0
6	Rooftop solar potential	-9,805	5.05	14.00	3
Sodawala Municipal School					
1	Replacement of old conventional fans with new BLDC fans	3,115	0.35	1.36	4

2	Integration of daylighting / occupancy automatic light sensors	3,168	0.35	2.38	7
3	Effect of switching off computers (vs leaving in standby)	110	0.01	0	0
4	Rooftop solar potential (55 kWp)	86,328	9.67	24.75	3

The impact of the above ECMs have been averaged out and scaled up for the whole municipal school building stock to analyse the impact of the ECMs. Figure 3 shows the impact of each ECMs at the stock level in terms of electricity reduction from the baseline electricity consumption.

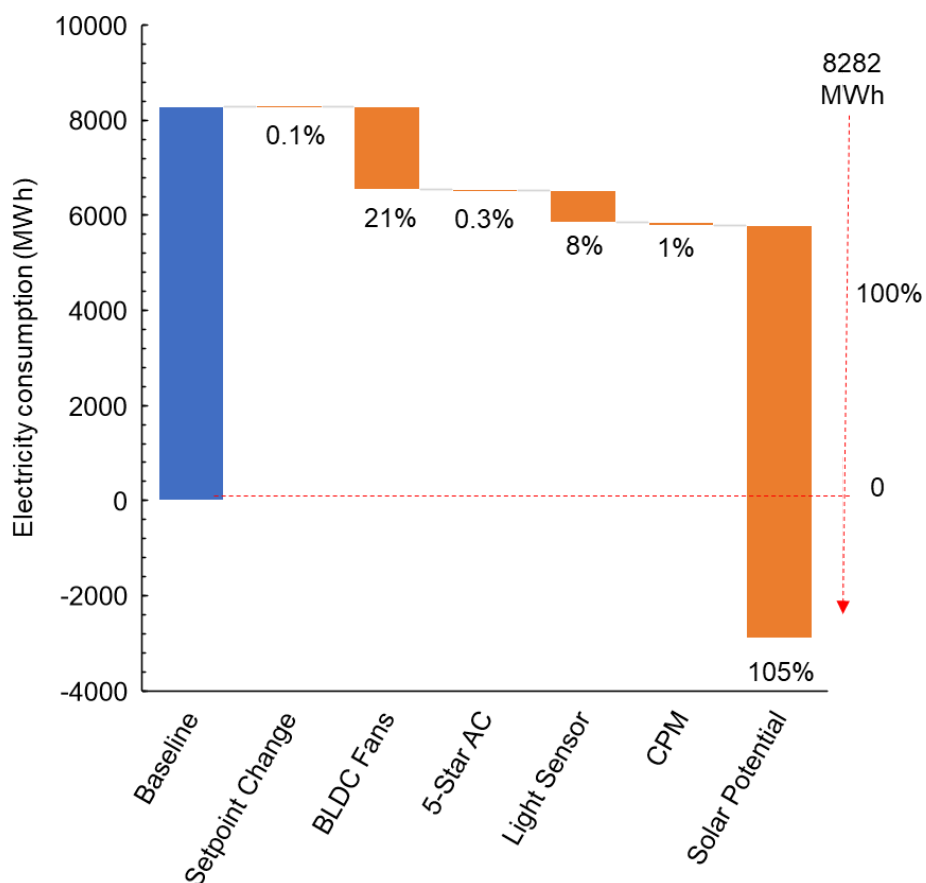


Figure 3: Impact of ECMs at stock level for municipal school buildings

Source: authors

The analysis of ECMs for individual school buildings and their stock-level impact indicates that behavioural measures, such as adjusting the air-conditioning setpoint, can reduce electricity consumption by approximately **5 MWh** from the baseline. Replacing conventional ceiling fans with **5-star rated BLDC fans** shows a substantial reduction potential of **1,733 MWh**. Additional ECMs, including the installation of occupancy sensors and improved plug load management for computers in offices and laboratories, contribute to savings of **665 MWh** and **63 MWh**, respectively. Furthermore, installing rooftop solar PV systems utilizing

50% of the available roof area could enable the municipal school building stock to achieve net-zero energy status.

Energy Conservation Measures in Municipal Office Building Category

To identify the ECMs in the municipal office category buildings, the walkthrough energy audit of the RC ward municipal office and H-West ward municipal office buildings have been conducted. The impact of the ECMs in terms of energy saving potential and annual monetary savings, investment required for the identified ECMs and payback period for that investment has been presented in the table below. Further the impact of the identified ECMs have been scaled up for 245 municipal office building categories to identify the impact at the stock level.

Table 3: Impact of Energy Conservation Measures in municipal offices

(Source: authors own analysis)

S. No.	Energy Conservation Measure (ECM)	Annual energy saving (kWh/year)	Annual monetary saving (INR lakh/annum)	Investment (INR lakh)	Simple payback period (years)
RC Ward Municipal Office					
1	Change in set-point temperature	5,547	0.60	0.00	0
2	Cool roof	5,547	0.60	0.60	1
3	Replacement of old conventional fans with BLDC fans	10,400	1.20	6.00	5
4	Replacement of old split ACs with new 5-star split AC (1.5 TR)	9,328	1.00	4.50	4
5	Replacement of split ACs with new 5-star split AC (2 TR)	8,960	1.00	3.90	4
6	Replacement of old window ACs with new 5-star split AC (1 TR)	1,413	0.20	1.80	9
7	Replacement of split ACs with new 5-star split AC (1 TR)	4,480	0.50	2.50	5
8	Integration of daylighting / occupancy automatic light sensors	2,236	0.30	1.20	5

9	Effect of switching off computers (vs leaving in standby)	3,872	0.40	0.00	0
10	Rooftop solar potential	31,394	3.50	9.00	3
H-West Ward Municipal Office					
1	Change in set-point temperature	4,224	0.47	0.00	0
2	Cool roof	8,448	1.00	2.00	2
3	Replacement of old conventional fans with BLDC fans	22,568	3.00	9.00	4
4	Replacement of split ACs with new 5-star split AC (2 TR)	42,240	5.00	4.00	1
5	Integration of daylighting / occupancy automatic light sensors	7,846	1.00	2.00	2
6	Effect of switching off computers (vs leaving in standby)	2,090	0.00	0.00	0
7	Rooftop solar potential	376,677	42.00	108.00	3

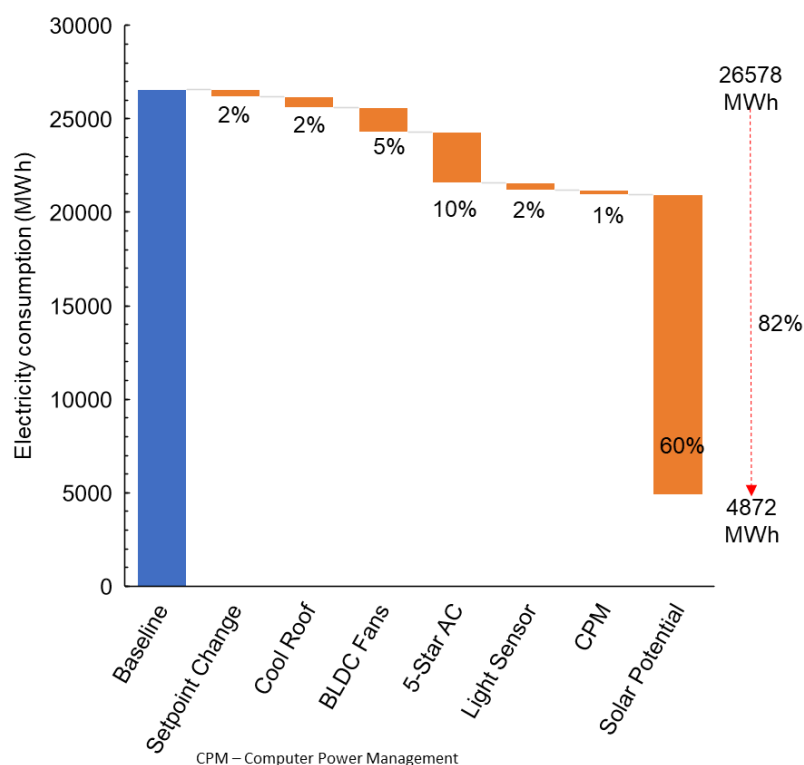


Figure 4: Impact of ECMs at stock level for municipal office buildings
Source: authors

The analysis at both individual building and stock levels indicates that simple measures such as adjusting temperature setpoints, installing lighting and occupancy sensors, and implementing cool roofs can yield electricity savings of approximately **402 MWh** and **567 MWh**, respectively, from the baseline stock-level consumption. Medium-cost measures, including the replacement of conventional ceiling fans with **BLDC fans** and the substitution of old air-conditioning units with energy-efficient models, offer additional savings of **1,327 MWh** and **2,684 MWh**. Installing rooftop solar PV systems utilizing **50% of the available roof area** can further offset around **16,077 MWh** of annual electricity demand. Achieving net-zero energy status for the municipal office building category, however, would require procuring additional renewable electricity through **green tariff mechanisms** offered by DISCOMs.

Energy Conservation Measures in Hospital Building Category

To identify the ECMs in the hospital category buildings, the walkthrough energy audit has been conducted in the Nair hospital and Kem hospital premises. The ECMs have been identified for main hospital buildings as well as the other typologies of buildings in the premises, e.g., staff quarters, hostels, etc. The impact of the identified ECMs in terms of energy savings, investment required for the identified ECMs and payback period of the investment have been presented in table below. The impact of the ECMs have been averaged out for the two hospital buildings and scaled up for the entire hospital building stock to analyse the impact of ECMs at stock level.

Table 4: Impact of Energy Conservation Measures in municipal hospitals

(Source: authors own analysis)

S. No	Energy Conservation Measure (ECM)	Annual energy saving (kWh/year)	Annual monetary saving (INR lakh/annum)	Investment (INR lakh)	Simple payback period (years)
Nair Hospital					
1	Change in set-point temperature (hospital facility, quarters, hostel)	80,676	8.40	0.00	0
2	Replacement of old split ACs with new 5-star split AC (2 TR)	176,904	18.50	43.20	2
3	Integration of daylighting / occupancy automatic light sensors	136,200	14.20	10.00	1
4	Retrofit IE2 AHU motors with EC-fan blowers	244,914	25.50	39.20	2
5	Replacement of IE2 HVAC pump motors with IE5 motors	78,609	8.20	19.00	2
6	HVAC optimization software with VFD-based control (chillers, pumps, AHU, cooling tower fans)	323,476	33.70	46.50	1
7	Installation of Automatic Power Factor Correction (APFC) device	477,962	49.85	15.00	0.3
8	Rooftop solar potential	1,135,742	118.46	579.00	4.9
King Edward Memorial (KEM) Hospital					
1	Change in set-point temperature	116,890	12.20	0.00	0
2	Replacement of old split ACs with new 5-star split AC (1-2 TR)	130,000	13.60	110.00	8
3	Integration of daylighting / occupancy automatic light sensors	154,499	16.10	10.50	1
4	Retrofit IE2 AHU motors with EC-fan blowers	306,634	32.00	62.40	2

5	Replacement of IE2 HVAC pump motors with IE5 motors	193,328	20.20	30.40	2
6	HVAC optimization software with VFD-based control (chillers, pumps, AHU, cooling tower fans)	467,559	48.80	70.00	1.5
7	Installation of APFC device at LT feeder side	448,838	46.81	9.00	0.2
8	Rooftop solar potential	2,096,744	218.69	1,068.70	4.9

The stock-level impact analysis of ECMs for hospital buildings indicates that small behavioural changes, such as adjusting air-conditioning setpoint temperatures, can result in approximately **486 MWh** of energy savings. Medium-cost measures including the substitution of old air-conditioning units with **5-star energy-efficient models**, installation of **lighting occupancy sensors**, retrofitting of inefficient **AHU motors with IE5 motors**, upgrading of **HVAC pumps**, integration of **variable frequency drives (VFDs)**, and installation of **automatic power factor correction (APFC) devices** collectively yield up to **17,599 MWh** of additional savings.

Utilizing **50% of the available roof area** for rooftop solar PV installation can further offset approximately **6,839 MWh** of annual electricity demand. The remaining grid dependence of around **43,433 MWh** can be addressed through **open-market procurement of renewable electricity via DISCOMs' green tariff mechanisms**, enabling large hospital buildings to achieve near **net-zero energy** status. Smaller hospital facilities can fully attain **net-zero energy status** by implementing the identified ECMs in combination with rooftop solar integration.

Energy Conservation Measures in Auditorium Building Category

To identify the ECMs for auditorium category buildings, the walkthrough audit of the two auditorium buildings namely "Kalidas Natyagriha" and "Prabodhankar Natyagriha" have been conducted. The impact of the identified ECMs have been presented for both the auditorium buildings in the following table. Further, the impact of identified ECMs has been scaled up to all auditorium category buildings to analyse the impact of identified ECMs at the stock level.

Table 5: Impact of Energy Conservation Measures in municipal auditoriums

(Source: authors own analysis)

S. No	Energy Conservation Measure (ECM)	Annual energy saving (kWh/year)	Annual monetary saving (INR lakh/annum)	Investment (INR lakh)	Simple payback period (years)
Kalidas Natyagriha					

1	Replacement of water-cooled chiller (0.92 kW/TR) with VFD-operated high-efficiency water-cooled chiller (0.5 kW/TR)	239,171	26.3	90.0	3.4
2	HVAC optimization software with VFD-based control for chillers, pumps, AHU and cooling tower fans	60,710	13.4	21.0	1.6
3	Additional PU foam / high-R false ceiling and reflective coating on GI sheet; edge sealing to reduce air loss	22,766	5.0	13.0	2.6
4	Replacement of old split ACs with new 5-star split AC (1.5 TR)	23,917	5.3	17.6	3.0
5	Retrofit IE2 AHU motors with EC-fan blowers	26,355	4.0	4.0	1.0
6	Replacement of IE2 CHW pump motor with IE5 motor	10,572	2.0	6.0	2.6
7	Rooftop solar potential	775,307	171.0	395.0	2.3
Prabodhankar Natyagriha					
1	HVAC optimization software with VFD-based control for chillers, pumps, AHU and cooling tower fans	37,724	5.3	18.0	3.4
2	Additional PU foam / high-R false ceiling and reflective coating on GI sheet; edge sealing to reduce air loss	15,464	2.2	7.0	3.3
3	Replacement of old split ACs with new 5-star split AC	24,624	3.5	7.5	2.2
4	Retrofit IE2 AHU motors with EC-fan blowers	28,156	4.0	4.0	1.0

5	Replacement of IE2 CHW pump motor with IE5 motor	12,290	1.7	10.0	5.6
6	Replacement of old ceiling fans with BLDC fans	9,979	1.4	2.0	1.3
7	Rooftop solar potential	186,583	26.0	95.0	3.4

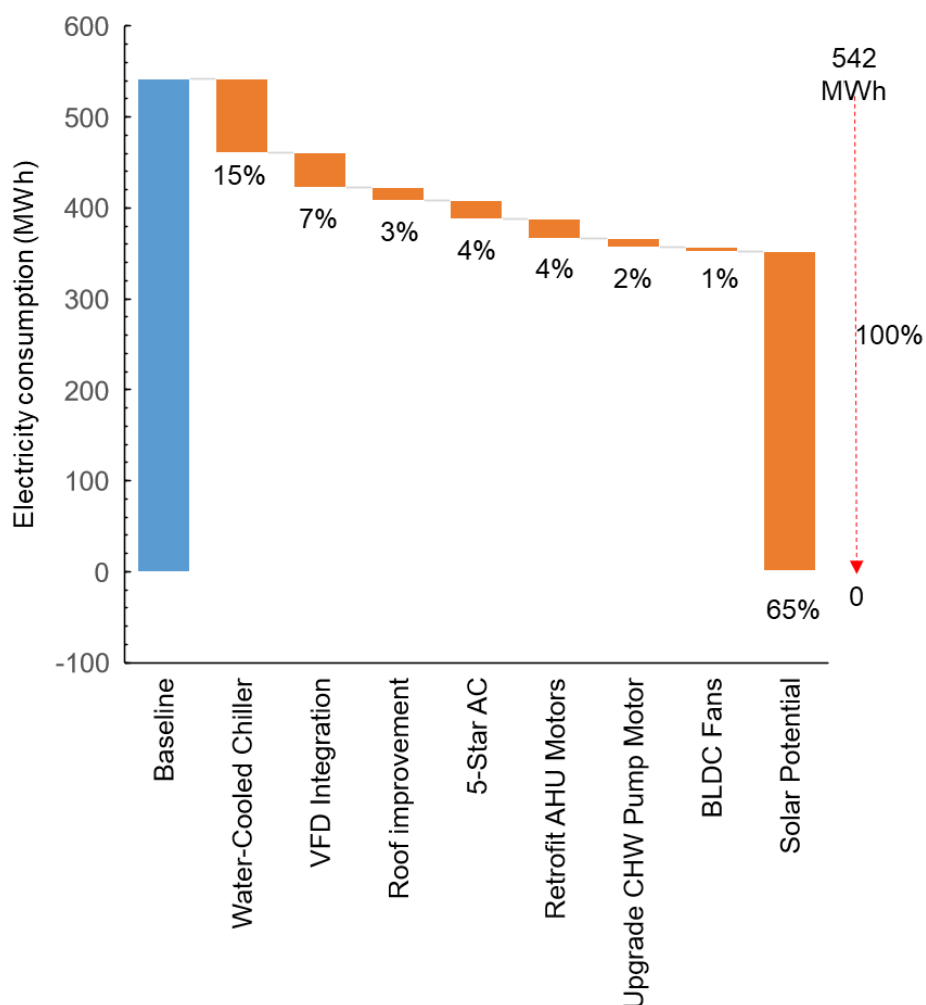


Figure 6: Impact of ECMs at stock level for municipal auditoriums
Source: authors

The impact analysis of the identified ECMs for the auditorium building stock indicates that **passive measures**, such as installing roof insulation, can yield approximately **15 MWh** of energy savings. **Low-cost measures**, including the replacement of conventional ceiling fans with **energy-efficient BLDC fans**, contribute an additional **5 MWh** of savings. **Medium-cost interventions** such as replacing old inefficient air-conditioning units with **high-efficiency models**, retrofitting **AHU motors with IE5- rated motors**, and upgrading existing **pump motors** can collectively achieve savings of about **55 MWh**.

More **capital-intensive measures**, including the replacement of centralized **air-cooled chillers** with **water-cooled systems** and the **integration of variable frequency drives (VFDs)**, offer an additional reduction of approximately **120 MWh** from the baseline

consumption at the stock level. Furthermore, utilizing **50% of the available roof area** for **rooftop solar PV installation** can offset around **351 MWh** of annual electricity consumption across the auditorium building stock.

ECM Categorization by Cost-Effectiveness and Impact across Building Typologies

Based on the analysis of ECMs and their energy reduction potential across different categories of municipal buildings, this section summarizes the measures by grouping them into no-cost, low-cost, medium-cost, and cost-intensive categories along with their respective impacts.

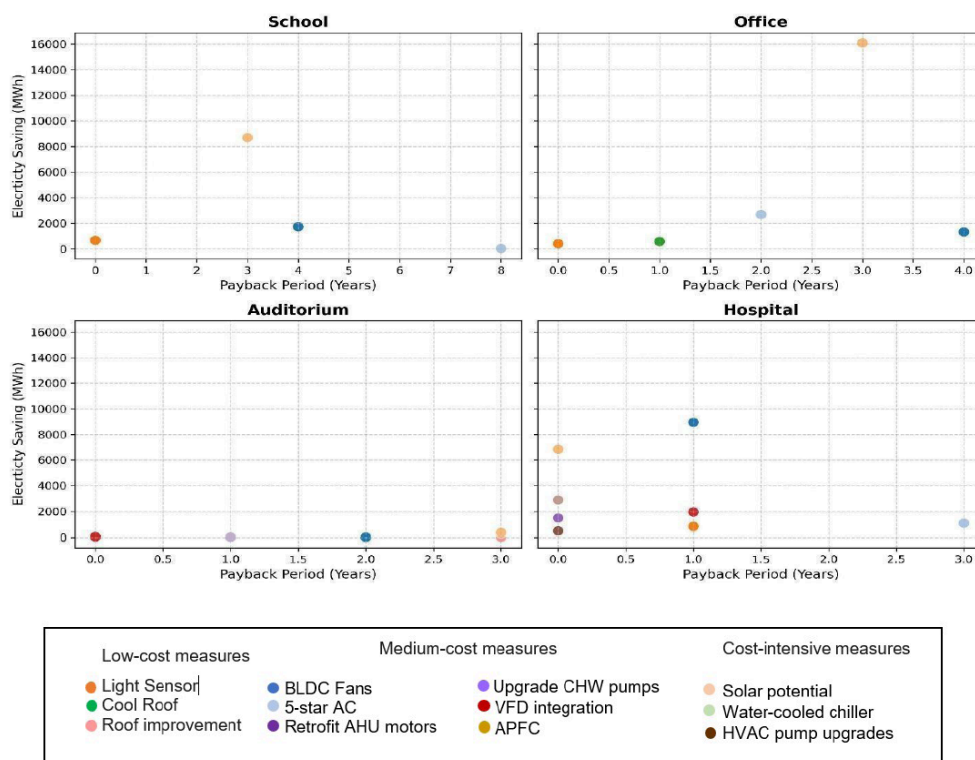


Figure 7: Payback periods and energy savings for different municipal buildings
Source: authors

Figure 7 shows the scatter plots showing the relationship between Simple Payback Period (Years) and Energy Saving (MWh) for various Energy Conservation Measures (ECMs) across different building types, here are the key insights:



Solar Potential is a High-Impact, Quick-Return Measure: Across all four building types (School, Office, Auditorium, and Hospital), «Solar Potential» consistently appears as a measure with significantly high energy savings (MWh) and a relatively low payback period (generally between ≤ 1 and 3 years). This indicates that investing in solar energy systems is a highly effective strategy for achieving net zero energy status and provides a quick return on investment regardless of the building type.



Variability in Performance for Common Measures: Measures like «BLDC Fans» and «5-Star AC» are common across multiple building types, but their performance (both MWh savings and payback period) varies. This suggests that the effectiveness of these measures can be influenced by the specific characteristics and energy usage patterns of each building type. For example, “BLDC Fans” show very high savings in Hospitals with a short payback, but lower savings in Auditoriums with a slightly longer payback.



Quick Payback for Certain Measures: Several measures consistently show a payback period of ≤ 1 year. These include “Light Sensor”, “Cool Roof”, “Water-Cooled Chiller”, “VFD Integration”, “Retrofit AHU Motors”, “Upgrade CHW Pump Motor”, “HVAC Pump upgrade”, and “APFC”. While the MWh savings for these measures might not always be the highest, their rapid payback makes them attractive options for quick wins in energy efficiency.

In summary, the analysis provides an overview of ECMs impact and cost effectiveness, enabling stakeholders to quickly identify high-potential measures and tailor energy efficiency strategies to the specific requirements of different building types.

Top 3 Measures Based on Energy Savings

Energy Conservation Measure (ECM)	Electricity Saving (MWh)
Solar Potential	31,956
BLDC Fans	12,005
5-star Air Conditioners	3,794

Strategies for Achieving Net-Zero Carbon Status for New Municipal Buildings

New municipal buildings offer the opportunity to minimize embodied carbon by adopting **low-carbon construction materials**. When combined with **energy-efficient design, passive architectural strategies, procurement and installation of high-efficiency systems**, and **on-site renewable energy generation** (such as rooftop solar PV), these measures can collectively enable the attainment of **net zero carbon** status.

The following section outlines the **proposed strategy** for achieving net zero carbon status for new municipal buildings.

The action plan for achieving net zero carbon status for new municipal buildings is based on **five key strategies - passive design measures, active design interventions, low-carbon material selection, integration of renewable energy, and clean energy procurement**.

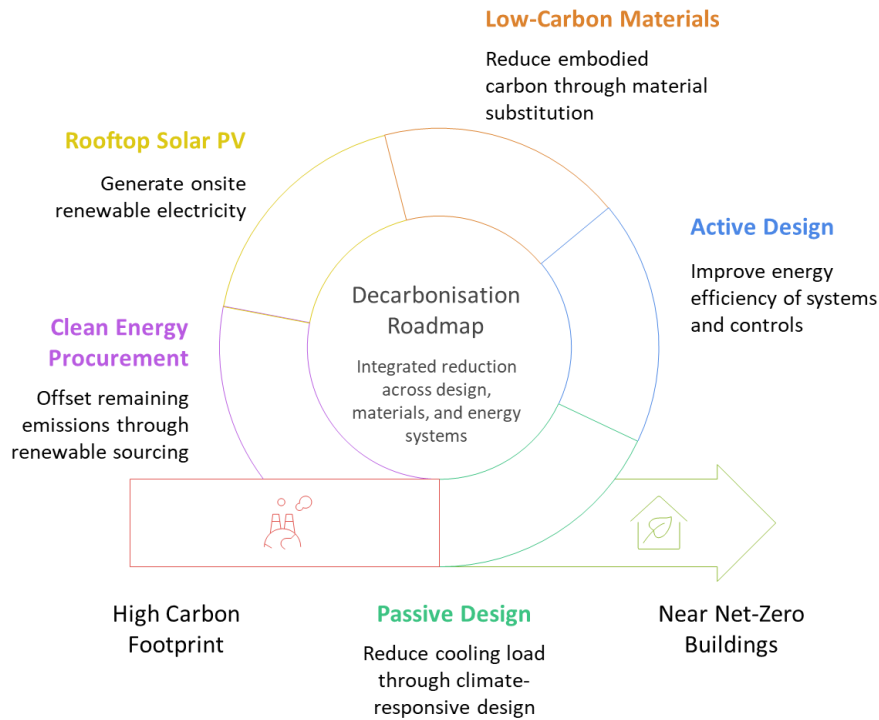


Figure 8: Strategic pillars of the decarbonisation roadmap for new municipal buildings
Source: authors

Passive Design Strategies

Passive design strategies are the foundation of a low-energy and low-carbon building, as they reduce the inherent demand for heating, cooling, and lighting by making use of natural climatic conditions. For new municipal buildings, incorporating passive measures from the earliest design stage ensures long-term energy savings, improves indoor comfort, and minimizes the scale of active systems required. The following key interventions have been identified for implementation to achieve net zero carbon status.

1. Building orientation and WWR optimization
2. Envelope design: The envelope design improvements are based on the MahaECBC³ rules. For the basic improvement, Mahaurja 1-star envelope parameters are considered and subsequently 2-star and 3-star for further improvement.
 - a) External walls
 - b) Roof
 - c) Windows
3. Window shadings
 - a) Horizontal shading devices
 - b) Vertical shading devices

³Industries, Energy, Labour and Mining Department (IELMD), Government of Maharashtra, Notification No. 155 (Mumbai, 2025).

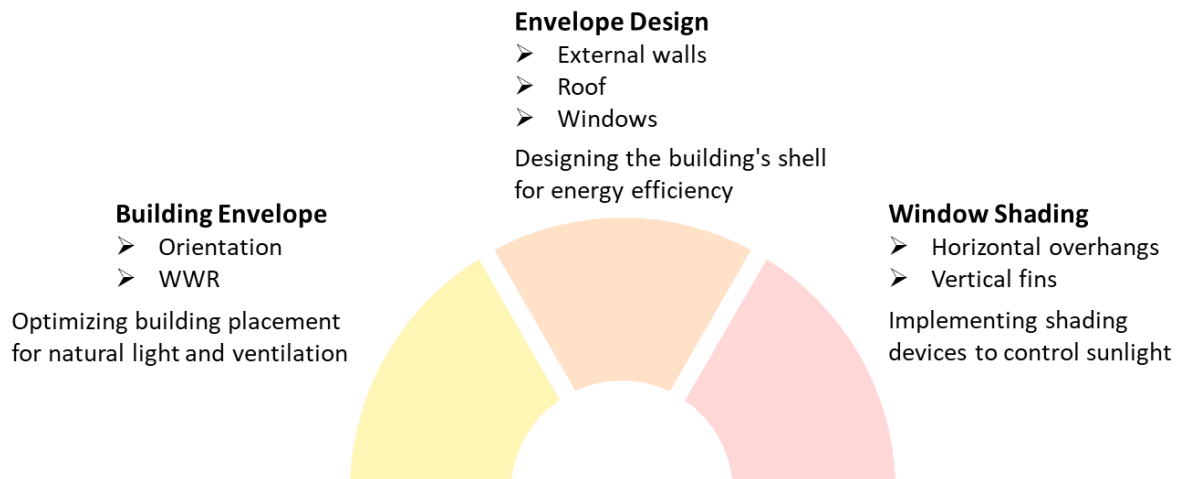


Figure 9: Passive design strategies to optimize orientation, envelope, and shading for reduced cooling demand
Source: authors

Building orientation

Optimizing the building orientation with respect to solar exposure and prevailing winds reduces cooling demand, enhances natural ventilation, and improves daylight utilization. Proper orientation is a **no-cost, high-impact passive strategy** that should be addressed early in the design stage.

Strategies

- Place longer façades along the north–south axis.
- Use shading from nearby trees, structures, or landscape features.
- Align orientation with prevailing wind direction to aid ventilation.
- Consider site-specific constraints in the early design stage.
- Conduct site-specific solar and wind analysis for optimal ventilation and daylighting.

Window-to-Wall ratio (WWR) optimization

Limiting the window-to-wall ratio balances daylight access with thermal gain, reducing artificial lighting demand while minimizing heat ingress. Proper WWR optimization complements shading and envelope strategies to achieve energy efficiency.

Strategies

- Limit WWR on east and west façades.
- Optimize north/south window sizes for daylight and ventilation.
- Balance WWR to meet daylight without increasing cooling loads.
- Follow ECBC/MahaECBC benchmarks for optimal ratios.
- Coordinate WWR adjustments with shading devices for maximum energy efficiency.

Envelope design improvements

The building envelope governs heat transfer between interior and exterior spaces. Enhancing envelope performance reduces heating and cooling loads, improves thermal comfort, and aligns with ECBC/MahaECBC incremental star-rated standards. Envelope measures can be applied to walls, roofs, and windows.

Strategies for walls

- Adopt low-conductivity materials like AAC or fly ash bricks.
- Use insulated or cavity wall assemblies.

- Upgrade to ECBC+ or Super ECBC compliant wall systems.
- Minimize thermal bridges at wall junctions.

Strategies for roof

- Add thermal insulation layers under the roof slab.
- Apply reflective or cool roof coatings.
- Use ventilated or double-skin roof systems.
- Explore green roofs for insulation and heat island reduction.
- Apply higher-performance insulation and reflective surfaces for 2-star and 3-star upgrades.

Strategies for windows

- Use double or low-E glazing.
- Adopt thermally broken window frames.
- Ensure optimized U-value and SHGC as per ECBC levels.
- Limit window size on heat-exposed façades.
- Combine glazing with external shading for maximum effect.

Window shading

Shading devices control solar heat gain while allowing natural daylight, reducing cooling loads and improving occupant comfort. Shading design should be coordinated with window placement, WWR, and building orientation.

Strategies for shading

- Use vertical fins on east and west façades; operable fins for flexible control.
- Provide horizontal overhangs on south façades.
- Install operable louvers for flexible control.
- Combine shading with daylight redirection elements (light shelves).
- Integrate shading design with façade aesthetics and ventilation.

Table 6 shows the indicative cooling load reductions and associated operational carbon reduction potential with different passive design strategies compared to respective base case building design.

Table 6: Passive design measures with strategy-wise cooling load and operational carbon

(Source: authors own analysis)

Passive design measure	Strategy	Indicative reduction potential – Cooling load (%)	Indicative reduction potential – Operational carbon (%)
Building orientation	Longer façade aligned East–West vs North–South	3–5	2–3
Window-to-wall ratio (WWR) optimization	Reduce WWR from 60% to 40%	18–20	9–12
	Reduce WWR from 60% to 30%	25–30	15–20
Envelope design – walls	1-star MahaECBC upgrade	3–5	2–4
	2-star MahaECBC upgrade	4–6	3–5

	3-star MahaECBC upgrade	6–8	4–6
Envelope design – roof	1-star MahaECBC upgrade	7–9	4–6
	2-star upgrade (reflective / ventilated roof)	11–14	9–12
	3-star upgrade (high-performance insulation + green/reflective roof)	14–17	11–14
Envelope design – windows	ECBC compliance	20–25	15–20
	ECBC+ compliance	22–27	15–20
	Super ECBC compliance	25–30	18–22
East–West window vertical shading devices	Shallow depth (0.5 m)	<1	<1
	Medium depth (0.75 m)	<1	<1
	Deep depth (1.0 m)	<1	<1
North–South window vertical shading devices	Shallow depth (0.5 m)	6–8	3–5
	Medium depth (0.75 m)	7–10	4–6
	Deep depth (1.0 m)	9–12	5–8

Note: The indicative percentage reduction in operational carbon is associated with the reduction in cooling energy consumption.

Active energy reduction strategies

Active energy reduction strategies are critical for new municipal buildings, complementing passive measures by improving the efficiency of municipal buildings and reducing operational energy demand. These interventions ensure that the building meets functional requirements while minimizing operational carbon emissions. By integrating energy-efficient lighting, fans, and HVAC systems from the design stage, new buildings can achieve significant energy savings and long-term decarbonisation targets. The following key interventions have been identified for inclusion in the decarbonisation roadmap.

1. Lighting and controls
2. BLDC fans
3. HVAC and controls
 - Split AC upgrade pathway (2-star → 5-star → VRF (centralized system))
 - Chiller upgrade pathway (air-cooled → water-cooled with 1-star, 2-star, 3-star efficiency levels + AHU fans and pumps upgrade)

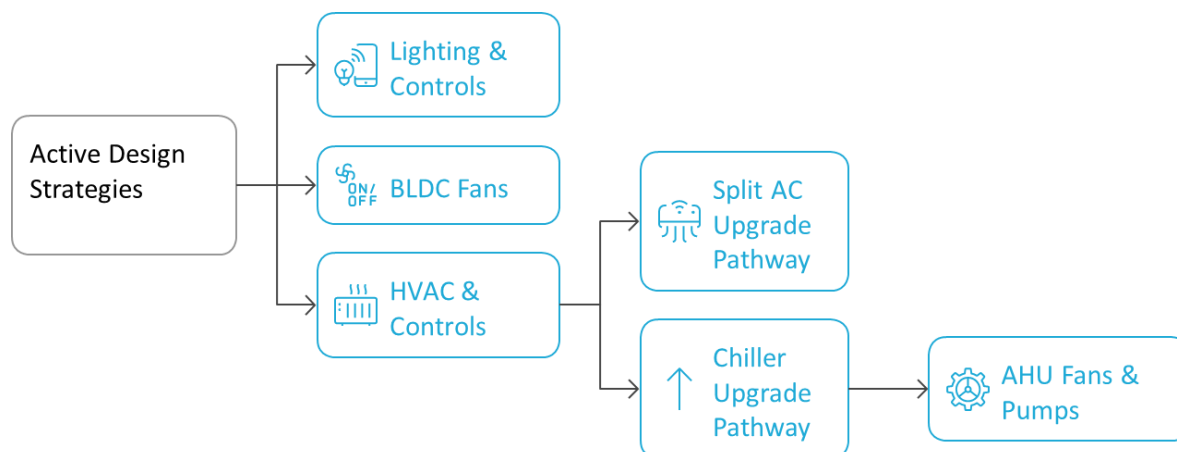


Figure 10: Active design strategies to enhance energy efficiency through lighting, HVAC, and controls

Lighting and controls

For new municipal buildings, designing lighting systems with energy-efficient fixtures and smart control strategies reduces electricity demand, improves visual comfort, and contributes to lower operational carbon. Early integration allows optimal layout, zoning, and coordination with daylighting strategies.

Implementation strategies

- Install high-efficacy LED luminaires throughout the building.
- Integrate daylight sensors in areas with sufficient natural light to minimize artificial lighting use.
- Use occupancy sensors in intermittently used spaces such as meeting rooms, corridors, and washrooms.
- Implement dimming controls for adaptable illumination levels.

BLDC fans

In new municipal buildings, replacing conventional fans with brushless DC (BLDC) fans reduces energy consumption and lowers internal heat gain, indirectly reducing cooling loads. Integration with controls allows flexible operation and part-load savings.

Implementation strategies

- Install BLDC ceiling fans in all occupied spaces.
- Integrate fan operation with smart controllers for speed and occupancy-based control.
- Ensure interoperability with building energy management systems.
- Standardize procurement for consistent efficiency across the building.

HVAC and controls

Split AC upgrade pathway

For new municipal buildings with split AC systems, adopting higher-efficiency units from the design stage reduces energy demand and operational carbon. Installing 5-star AC units or VRF systems allow alignment with ECBC star ratings and long-term energy targets.

Implementation strategies

- Specify 5-star BEE-rated split AC units instead of lower-efficiency units.
- Adopt VRF systems with COP improvements corresponding to BEE 2-star, and 3-star levels.
- Implement zoning and demand-based controls for part-load efficiency.
- Optimize system sizing through detailed load calculations.
- Include regular commissioning and maintenance protocols to maintain efficiency.

Chiller upgrade pathway

For new municipal buildings with centralised cooling, water-cooled chillers with high efficiency should be integrated from the outset. Alongside chiller selection, upgrading **AHU fans and chilled water pumps** ensures overall system efficiency and contributes to operational energy savings.

Implementation strategies

- Specify water-cooled chillers in place of air-cooled systems for new construction.
- Adopt 2-star, and 3-star ECBC-compliant chiller levels for energy efficiency.
- Use energy-efficient AHU fans with variable frequency drives (VFDs).

- Install high-efficiency chilled water and condenser water pumps with VFDs.
- Optimize condenser water temperature and flow rates.
- Integrate advanced building management systems for monitoring and control.

Table 7 presents the potential reduction in operational carbon emissions achieved through the use of energy-efficient active systems compared to conventional inefficient systems.

Table 7: Active design measures with strategy-wise operational carbon reduction

(Source: authors own analysis)

Active design measure	Strategy	Indicative operational carbon reduction (%)
Lighting and controls	LED upgrade with sensors	6–8
BLDC fans	Upgrade from conventional fans	60
HVAC – Split AC pathway (Baseline: 2-star split AC)	Upgrade from 2-star to 5-star	38–42
	Transition to VRF (ECSBC compliant)	42–47
	Transition to VRF (ECSBC+ compliant)	53–57
	Transition to VRF (Super ECSBC compliant)	58–62
HVAC – Centralised chiller pathway (Baseline: air-cooled chiller)	1-star air-cooled chiller	5–10
	2-star air-cooled chiller	10–15
	3-star air-cooled chiller	18–22
	4-star air-cooled chiller	23–28
	5-star air-cooled chiller	28–32
	1-star water-cooled chiller	43–45
	2-star water-cooled chiller	48–52
	3-star water-cooled chiller	54–58
	4-star water-cooled chiller	57–61
	5-star water-cooled chiller	60–65

Note: The indicative percentage reduction in operational carbon is associated with the reduction in cooling energy consumption.

Embodied carbon reduction through low-carbon materials

Embodied carbon emissions from material extraction, manufacturing, transport, and construction forms a major, front-loaded part of a building’s total carbon footprint. For municipal projects, where material choices are shaped by scale and procurement norms, addressing embodied carbon is vital to align upfront emissions with long-term net-zero goals. While active energy reduction strategies reduce energy use and subsequently operational carbon over building lifecycle, early cuts in embodied carbon prevent irreversible “locked-in” emissions. Key strategies include adopting low-carbon and recycled materials, optimizing material efficiency, and integrating procurement policies that prioritize verified low-carbon products. The following subsections outline material-specific pathways and quantified reduction potentials for municipal buildings.

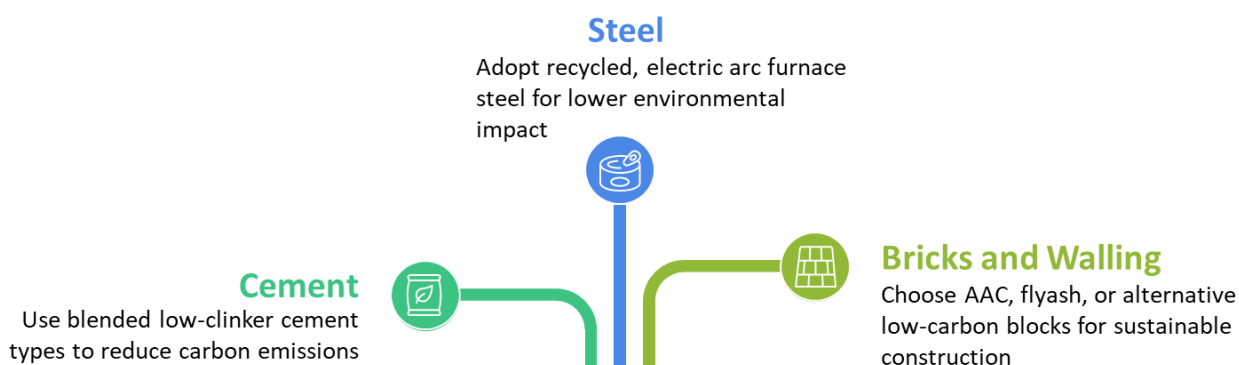


Figure 11: Low-carbon material strategies to reduce embodied emissions in construction
Source: authors

Cement

Concrete, primarily composed of cement, is a major contributor to embodied carbon in the building sector. Structural elements such as foundations, frames, and slabs account for significant cement consumption, making low-carbon alternatives a key lever for decarbonization.

Strategies

- **Prioritize lower-carbon cements:** Portland Slag Cement (PSC) and Portland Pozzolana Cement (PPC) for general construction; GGBS-rich mixes for structural concrete; pilot Limestone Calcined Clay Cement (LC3) in suitable applications.
- **Increase supplementary cementitious material (SCM) content:** Replace OPC clinker with GGBS, fly ash, or pozzolans.
- **Optimize mix design and detailing:** Reduce cement content through performance-based design, high-strength mixes, and durable detailing.
- **Ensure local sourcing and logistics:** Short transport distances and verified low-carbon production minimize embodied carbon.
- **Explore innovative binders:** Alkali-activated and low-clinker cements can provide additional reductions where standards and durability allow.

Table 8: Emission factors and reduction potential of cements

(Source: IFC, authors own analysis)

Cement type	Emission factor ⁴ (kgCO ₂ e/kg)	% reduction vs OPC
Ordinary Portland Cement (OPC)	0.996	Baseline (0%)
Portland Pozzolana Cement (PPC)	0.710	~29%
Portland Slag Cement (PSC)	0.487	~51%
Portland Composite Cement (PCC)	0.541	~46%
GGBS-based cement	0.490	~51%
Limestone Calcined Clay Cement (LC3)	Varies by mix	Up to ~40%

Steel

Steel is extensively used in reinforcement, structural frames, roofing, façades, and building services. Its production is highly energy-intensive, making it a major embodied carbon hotspot in municipal buildings.

⁴ International Finance Corporation (IFC). IFC India Construction Materials Database: Methodology Report. Washington, DC: International Finance Corporation, 2022.

Strategies

- **Maximize recycled content:** Maximize use of high-recycled-content steel (e.g., Electric Arc Furnace steel) wherever structurally feasible.
- **Procure green-rated steel:** Adopt the Ministry of Steel's green steel classifications (three- to five-star ratings).
- **Material efficiency:** Optimize structural design, use high-strength sections, and reduce waste through prefabrication.
- **Use GFRP rebar for non-critical components:** Replace conventional steel reinforcement with Glass Fiber Reinforced Polymer (GFRP) bars where structural demands permit.

The above measures can lower embodied carbon from steel by **40–80%**, depending on sourcing strategy and rating compliance.

Table 9: Emission factors and reduction potential of steel

(Source: IFC, Lodha, Ministry of Steel, authors own analysis)

Steel type	Emission factor (tCO ₂ e/t)	% reduction vs conventional steel	Reference
Conventional (Virgin) steel – BF–BOF route	2.6	Baseline (0%)	IFC ⁵
Recycled steel – EAF route	0.52	~80%	Lodha study ⁶
Green steel (3-star)	2.0 – 2.2	~15–23%	Ministry of Steel ⁷
Green steel (4-star)	~1.6 – 1.8	~30–38%	
Green steel (5-star)	≤1.2	≥50%	

Bricks

Bricks are a predominant walling material in buildings and contribute significantly to embodied carbon, particularly conventional fired clay bricks.

Strategies

- **Replace conventional fired clay bricks with low-carbon alternatives:** Fly ash bricks, Autoclaved Aerated Concrete (AAC) blocks and Agrocrete⁸.
- **Improve fired brick production efficiency:** Encourage procurement of bricks manufactured using the zig-zag kiln process to reduce emissions.
- **Explore emerging materials:** Agrocrete and hempcrete blocks for infill walls.

Table 10: Emission factors and reduction potential of brick technology and alternative walling materials

(Source: IFC, BMTPC, GKSPL, Lodha, authors own analysis)

Walling / brick type	Indicative emission factor (kgCO ₂ e/kg)	% reduction vs conventional burnt clay bricks	Reference
Conventional fired clay bricks	0.57		IFC
Improved kiln-fired bricks (Hoffmann / Bull's Trench)	0.31	~45	IFC

⁵ International Finance Corporation (IFC). IFC India Construction Materials Database: Methodology Report. Washington, DC: International Finance Corporation, 2022.

⁶ Lodha Group. "Building India's Future with Lower Carbon Emissions: The Untapped Potential of Recycled Steel." Lodha Group Blog, n.d. Accessed January 27, 2026.

⁷ Ministry of Steel, Government of India. Taxonomy Brochure. New Delhi: Ministry of Steel, 2025.

⁸ Global Housing Technology Challenge–India (GHTC-India). Agrocrete, Solid & Hollow Concrete Blocks and Binder. Ministry of Housing and Urban Affairs, Government of India.

Fly ash bricks	0.24	~58	BMTPC ⁹
CSEB (Compressed Stabilised Earth Blocks)	0.075-0.084	~85	GKSPL report ¹⁰
AAC blocks	0.5	~12	IFC/LODHA study
Agrocrete block (solid)	-0.15	~126 (carbon negative)	BMTPC

Rooftop solar integration

Rooftop solar photovoltaic (PV) systems are most essential to achieve net zero carbon status for upcoming municipal buildings. By generating clean, renewable electricity onsite, PV integration offsets grid-based fossil fuel consumption, lowers operational carbon emissions, and enhances energy resilience. In new buildings, PV integration should be considered from the early design stage to ensure adequate structural provisions, optimal orientation, and seamless integration with electrical systems.

Figure 12 illustrates the strategies for integrating rooftop solar systems with municipal buildings, mapped in terms of **implementation complexity** and **energy generation potential**. Strategies positioned in the **lower-left quadrant** represent options that are easier to implement but yield relatively low energy generation. Those in the **lower-right quadrant** involve higher installation complexity yet offer limited generation potential. The **upper-left quadrant** includes strategies that are more complex to install but deliver higher energy generation, while the **upper-right quadrant** represents the most complex strategies, offering the **highest potential for energy generation**.

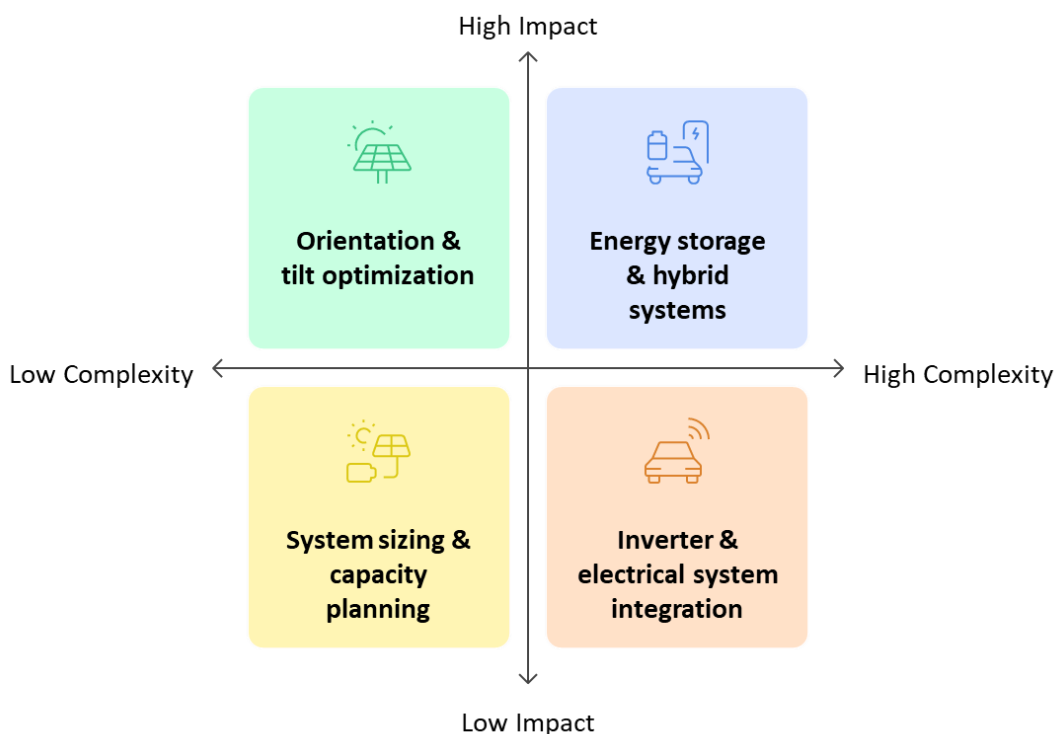


Figure 12: Rooftop solar PV integration to maximize onsite renewable energy generation

Source: authors

⁹ BUILDING MATERIALS AND TECHNOLOGY PROMOTION COUNCIL:

https://www.bmtpc.org/datafiles/cms/file/01_flyash_brick1.pdf

¹⁰ Greentech Knowledge Solutions Pvt. Ltd. (GKSPL):

https://www.gkspl.in/wp-content/uploads/2024/08/Summary_Whole-life-carbon_GKSPL.pdf

System sizing and capacity planning

Proper system sizing ensures that rooftop PV installations meet building energy demand efficiently without overloading the roof structure. Accurate capacity planning balances available roof area, projected energy consumption, and long-term expansion potential, ensuring alignment with state level renewable targets.

Implementation strategies

- Include structural provisions for rooftop load and maintenance access.
- Integrate PV sizing with energy efficiency measures to minimize oversizing.
- Conduct detailed building energy demand assessment.
- Size PV system according to available roof area and ECBC compliance level.
- Plan for modular capacity addition for future expansion.

Orientation and tilt optimization

Optimizing the orientation and tilt of PV panels maximizes annual energy generation and system efficiency. Careful design minimizes shading losses, enhances yield, and allows seamless integration with the building form, including the use of building-integrated PV where roof area is limited.

Implementation strategies

- Orient PV panels south-facing in the Indian context for maximum yield.
- Optimized tilt angle is typically 15°, balances performance across different seasons for Mumbai and Panvel.

Inverter and electrical system integration

Efficient inverters and smart electrical integration ensure reliable power conversion, maximize PV utilization, and enable grid connectivity. Integration with building energy management systems allows real-time monitoring, fault detection, and performance optimization.

Implementation strategies

- Select high-efficiency string or central inverters with MPPT (Maximum Power Point Tracking).
- Connect PV output to the building energy management system (BEMS).
- Incorporate smart inverter features for grid support and reactive power control.
- Enable real-time monitoring of generation and consumption for performance optimization.

Energy storage and hybrid systems

Pairing PV with energy storage enhances renewable energy utilization and ensures continuous power supply during grid interruptions. Storage solutions support peak load management, improve energy resilience, and help municipal buildings achieve higher levels of operational carbon reduction.

Implementation strategies

- Integrate battery systems for partial storage, smooth intermittent solar supply.
- Enable peak shaving and demand response integration.

Table 11: Rooftop solar PV measures

(Source: authors own analysis)

MahaECBC level	Roof area utilized for PV (%)	Orientation & tilt	Typical solar yield (kWh/m ² ·year)
1-star MahaECBC compliant	50	True South, fixed tilt ~15°	250–300
2-star MahaECBC compliant	60	True South, tilt 15–20° (seasonal adjustment optional)	350–400
3-star MahaECBC compliant	70	True South, adjustable tilt 10–25° for seasonal optimization	450–500
Net-zero	>70	True South, adjustable tilt 10–30°, optimized shading	450–500

2.7.5 Clean energy procurement / open-source renewable energy

After implementing passive and active efficiency measures and integrating onsite renewable generation through rooftop PV, the remaining grid dependency can be further offset through clean power procurement. This includes participation in open-access renewable energy programs, purchase of Renewable Energy Certificates (RECs), or entering Power Purchase Agreements (PPAs) with renewable energy producers. BMC can leverage the *Green Tariff Policy* introduced by the Maharashtra Electricity Regulatory Commission (MERC), which enables institutional and bulk consumers to procure renewable energy from distribution licensees (DISCOMs) at a regulated “green tariff.” The process allows municipal consumers to source their electricity entirely or partially from renewable energy without developing captive systems or entering into direct Power Purchase Agreements (PPAs) with generators.

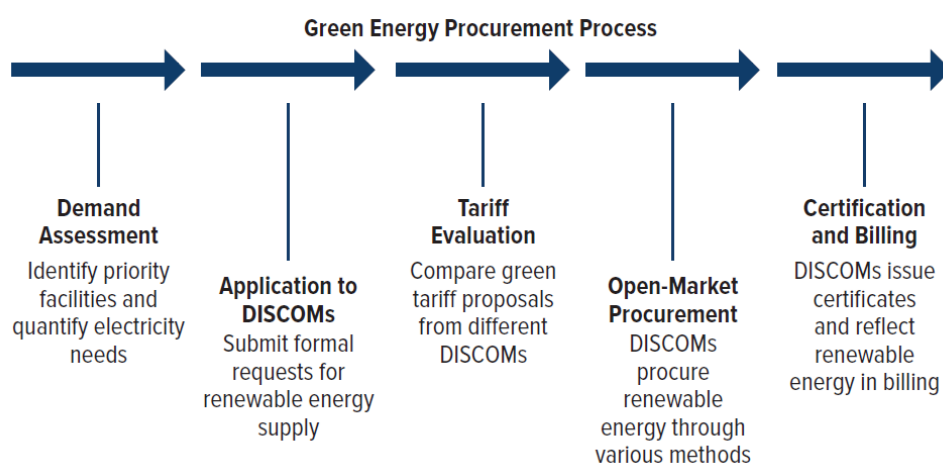


Figure 13: Steps for BMC to procure renewable energy through open market through green tariff

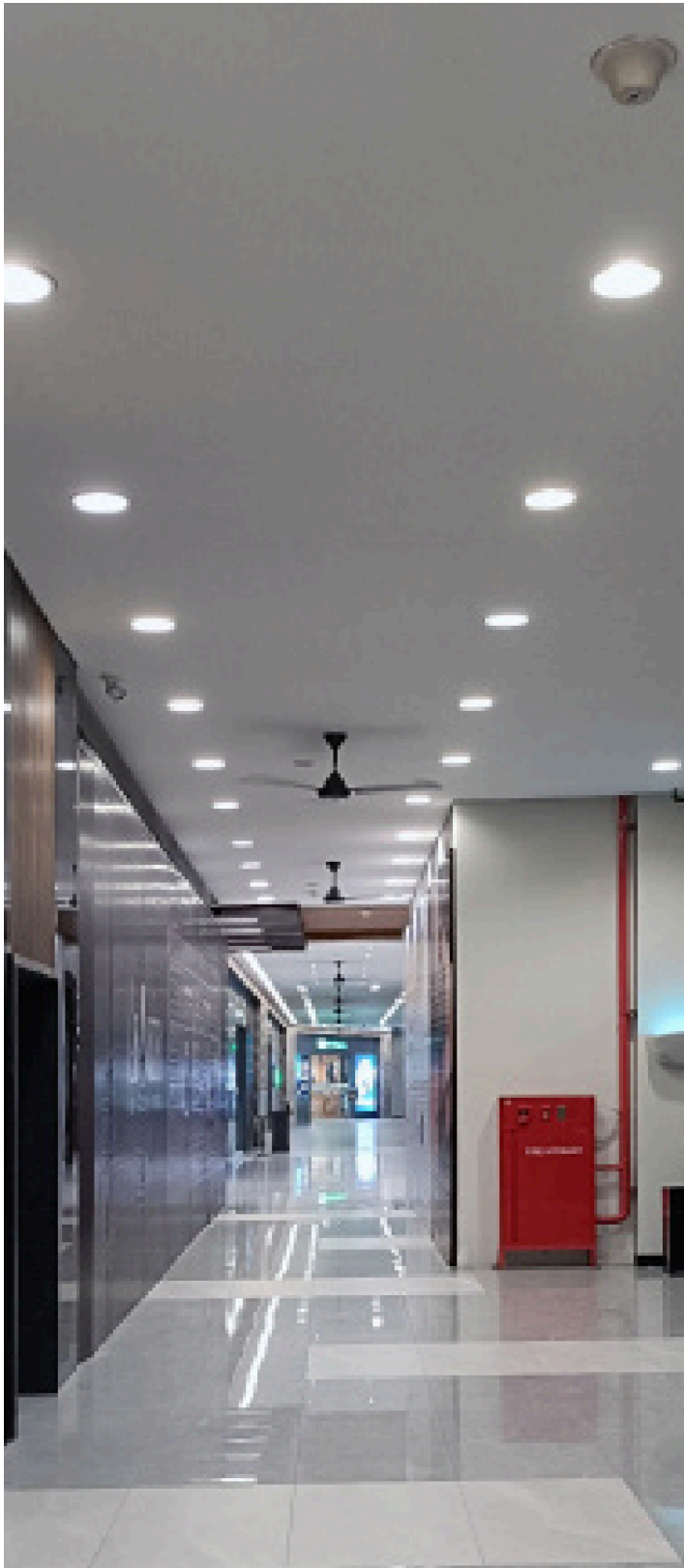
Source: authors

To minimize the cost of renewable energy procurement, BMC can adopt a strategic approach that combines long-term contracting with optimized demand management. By entering into 10–25-year Power Purchase Agreements (PPAs) with DISCOMs through open-market competitive bidding, BMC can secure lower tariffs by leveraging economies of scale and benefiting from the continued decline in renewable energy costs. Further, by aggregating electricity demand across its municipal facilities into a single procurement block, BMC can achieve larger contract volumes, leading to improved price discovery and more favourable terms. After implementing energy efficiency measures across its buildings,

the corporation should align the contracted renewable energy capacity with the reduced post-efficiency base load to avoid over-procurement and ensure optimal utilization of renewable supply. Through this integrated approach combining demand-side efficiency with long-term renewable energy procurement BMC can achieve cost-effective decarbonization, lower its dependence on conventional grid power, and make significant progress toward its municipal Net Zero targets.



03 Implementation Mechanism



Municipal corporations face major financial barriers to scaling energy-efficiency measures due to:

- **Tight budgets:** Most funds are tied to essential operations, leaving little for capital-intensive upgrades.

- **High upfront costs:** Projects like solar or retrofits need large initial investment with long payback periods and uncertain savings.

- **Limited financing options:** Weak credit profiles and lack of tailored instruments (e.g., performance contracts, shared-savings models) restrict access to loans or private capital.

- **Regulatory bottlenecks:** Ambiguous policies and absence of guaranteed savings deter financiers.

- **Low prioritization:** Energy efficiency often takes a backseat to immediate service needs like water, sanitation, and roads.

Many city and state climate plans recognise both the opportunity and the financing barrier: Mumbai's Climate Action Plan¹¹ highlights energy and buildings as priority sectors but flags implementation and financing challenges for large-scale retrofits; Ahmedabad's Climate Resilient City Action Plan¹² and Pune's district Climate Action Plan¹³ similarly call for greener, energy-efficient buildings while stressing the need for innovative financing and capacity building at the municipal level. State Energy Efficiency Action Plans (for example Karnataka¹⁴ and Maharashtra¹⁵) set out programmes and demonstration projects for public buildings and recommend financial mechanisms and performance-based models (such as ESCOs, revolving funds, and state-supported incentives) to bridge the upfront funding gap yet they also note that limited municipal creditworthiness and weak baseline data reduce bankability and slow uptake. Strengthening municipal balance sheets, de-risking projects through state or national credit enhancements, and scaling performance contracting with robust measurement & verification are recurring policy recommendations across these plans to unlock municipal investments in energy efficiency.

Finance mechanisms

Self-implementation through internal/public budgetary resources

In FY 2024–25, the **Brihanmumbai Municipal Corporation (BMC)** allocated **32.18% of its total capital budget** to climate-relevant activities. Of this, **0.1% (~`32.5 crore)** was earmarked specifically for the **energy and buildings** sector supporting measures such as **LED retrofits** and **rooftop solar installations**.

Several low-cost **Energy Conservation Measures (ECMs)** with strong returns on investment can be implemented directly through BMC's **municipal or climate budget**. These include:

- Replacing inefficient lighting systems with LEDs
- Upgrading conventional ceiling fans to BLDC fans
- Replacing outdated air-conditioning units with energy-efficient models
- Utilizing green cess revenues to fund small-scale interventions

Implementation Strategy of Low Cost ECMs – Example of Fan Replacement

Walkthrough energy audits of BMC buildings indicate heavy reliance on **conventional ceiling fans**, which consume significantly more electricity than newer models.

- **BLDC fans** consume **30–40% less electricity**, resulting in **5–10% overall energy savings** at the building level.
- Large-scale replacements are needed across **municipal offices, hospitals, schools, and auditoriums**.

3.1.1 Phased replacement approach

- Target fans **6–10 years old** in the first phase.
- Replace fans **under 5 years old** in subsequent phases.

Procurement strategy:

¹¹ Brihanmumbai Municipal Corporation (BMC). Mumbai Climate Action Plan (MCAP). Mumbai: Brihanmumbai Municipal Corporation, 2022.

¹² Ahmedabad Municipal Corporation (AMC). Ahmedabad Climate Resilient City Action Plan (CRCAP). Ahmedabad: Ahmedabad Municipal Corporation, 2021.

¹³ Pune Municipal Corporation (PMC). Pune Climate Action Plan / Climate Change and Environment Action Plan (CCEAP). Pune: Pune Municipal Corporation, 2022.

¹⁴ Government of Karnataka. State Energy Efficiency Action Plan (SEEAP) and Karnataka State Action Plan on Climate Change. Bengaluru: Government of Karnataka.

¹⁵ Government of Maharashtra. State Energy Efficiency Action Plan and Maharashtra State Adaptation Action Plan on Climate Change. Mumbai: Government of Maharashtra.

- Implement **bulk procurement** to leverage economies of scale and reduce per-unit costs.
- The unit cost of BLDC fans declines significantly with higher procurement volumes.
- The following figure illustrates how the **unit cost decreases** as the procurement volume increases.

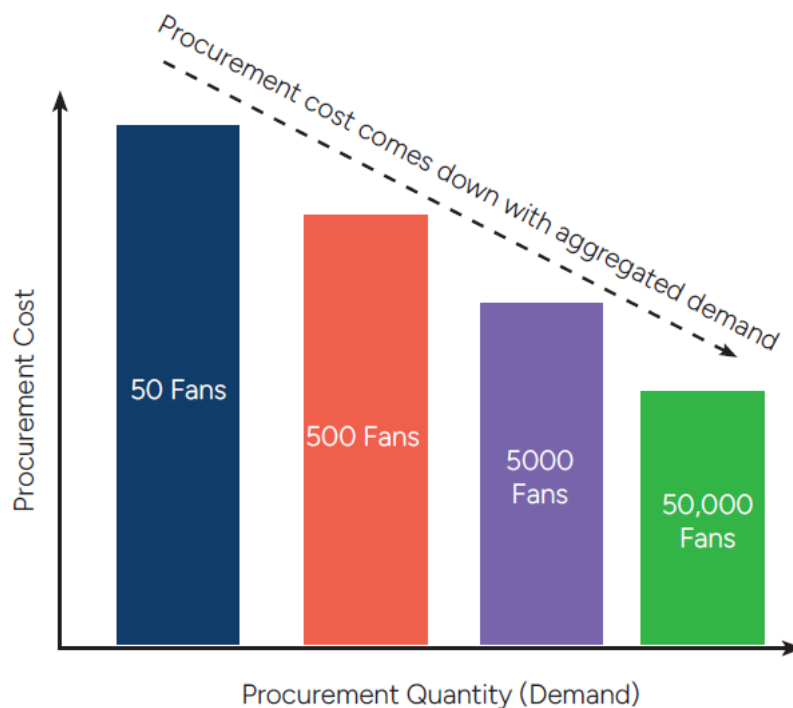


Figure 14: Decrease in unit cost during bulk procurement

**Numbers used are for creative visualisation purposes only*

In addition, other low-cost measures such as applying cool roof strategies and high-SRI (Solar Reflective Index) paints to selected municipal building typologies offer short payback periods and can also be implemented through BMC’s dedicated climate budget resources.

The table below presents various financing mechanisms that BMC can use to implement low-cost energy efficiency measures through a self-financing approach.

Table 12: Approaches for self-financing

Mechanism	How it works	Municipal examples
Energy savings reinvestment (Revolving Fund)	Use the municipal climate or energy budget to implement initial low-cost ECMs (such as LEDs, BLDC fans, and occupancy sensors). Verified electricity bill savings are then reinvested into a revolving fund to finance subsequent energy efficiency upgrades.	Ahmedabad Municipal Corporation (AMC) established an Energy Efficiency Cell to monitor and reinvest savings; Nagpur Municipal Corporation (NMC) expanded LED streetlighting using internally generated savings.
Dedicated climate / energy budget earmarking	Allocate a fixed share of the municipal budget exclusively for energy efficiency measures (e.g., LED lighting, replacement of ceiling fans). Reduced	Brihanmumbai Municipal Corporation (BMC) earmarked 0.10% of its FY 2024–25 capital budget for energy and buildings; Pimpri-Chinchwad Municipal

	operational energy costs generate savings that self-finance further interventions.	Corporation (PCMC) under its Green City Action Plan and Delhi MCD implemented LED and solar projects using municipal budget allocations.
On-bill financing via utility partnership	The electricity utility finances energy efficiency upgrades upfront. The investment is recovered through a share of reduced electricity bills over an agreed period, while the municipality still benefits from net savings.	Odisha municipal corporations implemented LED streetlighting projects financed through on-bill savings recovery mechanisms.

Another approach to finance low-cost ECMs involves **demand aggregation** and **targeted low-interest loans**:

- BMC could **aggregate demand** for high-efficiency equipment (e.g., BLDC fans, efficient ACs) across all municipal facilities.
- This consolidated demand can be used to obtain a **concessional loan** from the **Maharashtra Energy Development Agency (MEDA)**, potentially supported by the **state’s climate action budget**.
- **Loan repayments** (principal and interest) can be serviced through **energy cost savings**, creating a **self-sustaining financing model**.

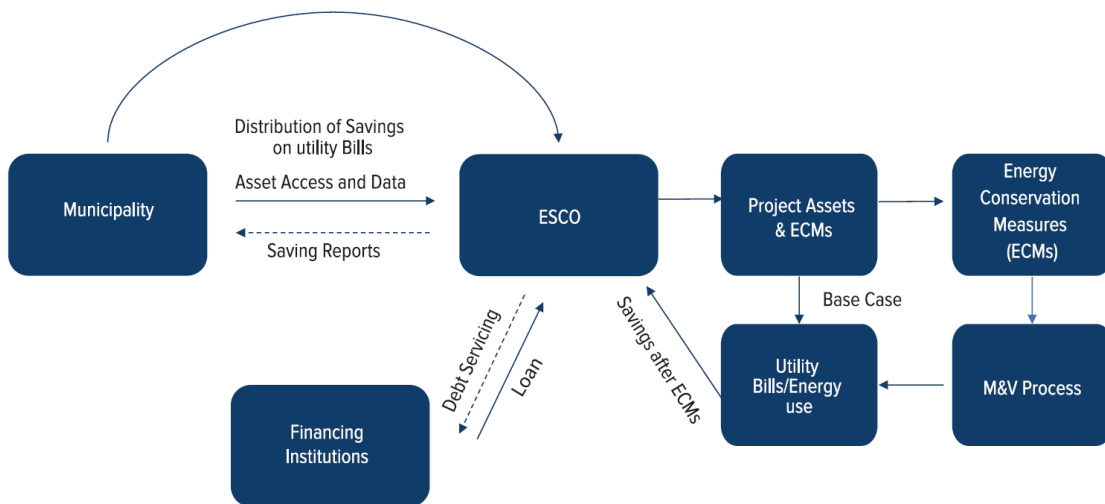
3.1.2 Third-Party and Performance Based Financing

ESCO-based implementation

Energy conservation measures of the nature of medium to high cost with near to long term payback period can be implemented through ESCO based financing mechanism. In this financing mechanism, BMC can establish a performance contract for energy savings with an ESCO which could be a company with technical expertise that enters into a **performance contract** with the municipality to implement energy efficiency measures that optimize energy usage and reduce expenditure in a technically or commercially viable manner. The EPC can be established for commercially feasible energy efficiency measures that offer attractive returns in the form of reduced operating costs due to optimized energy usage and reduced energy expenditure and improved delivery of services. BMC can establish multiple types of performance-based contracts with ESCOs depending on the nature of the energy efficiency project and investment required. These EPCs are described below:

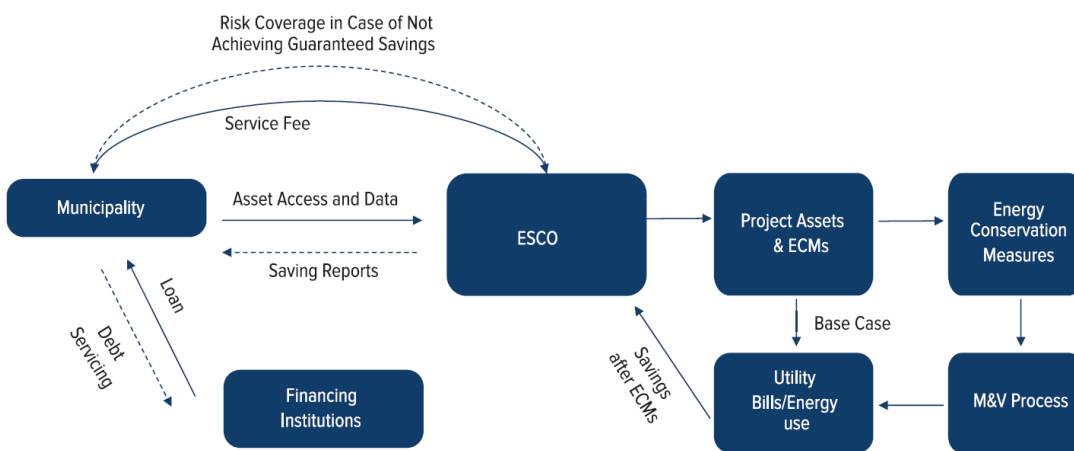
Shared Savings

Under this model, the ESCO finances the project either through its own funds or by borrowing from a third party. The ESCO takes on the performance risk of the project. The cost savings are divided between the ESCO and customer at a prearranged percentage for an agreed length of time. Under this mechanism, BMC can do the demand aggregation at the municipal building portfolio level for ECMs such as replacement of inefficient ceiling fans with energy efficient BLDC fans in all municipal buildings and appoint ESCOs (e.g., MahaPreit or private players) based on the pre-agreed EPCs terms. ESCO would bring the investment to deploy the energy efficient ceiling fan in all municipal buildings and savings from the electricity bill can be aggregated into an ESCROW account and shared between BMC and ESCOs.



Guaranteed Savings

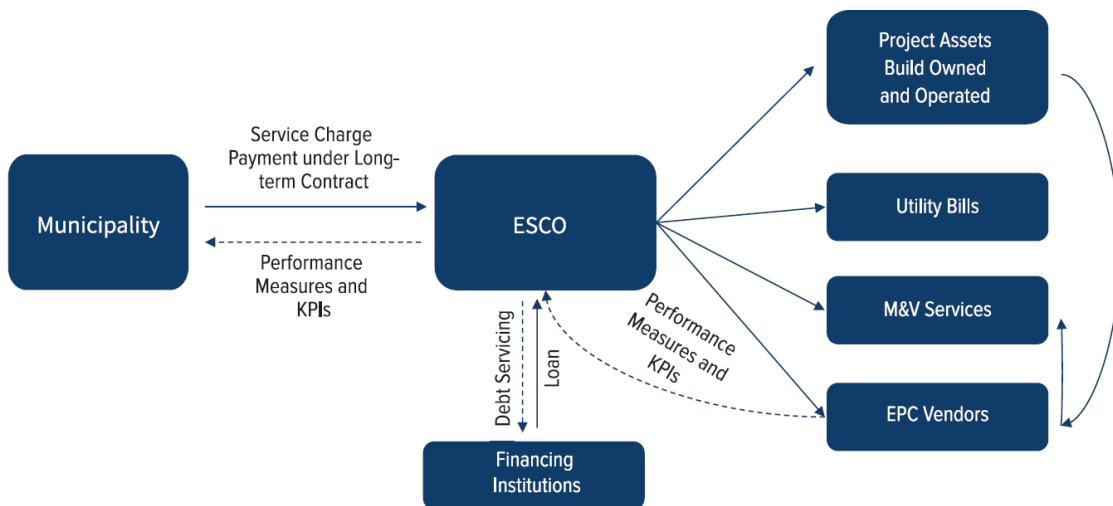
In this case, the customer finances the design and installation of the project by borrowing funds from a third party such as a bank or through leasing the equipment. The ESCO has no contractual arrangement with the bank but does assume the project risk and guarantees the energy savings made. If the savings do not reach agreed minimums the ESCO covers the difference; if they are exceeded then the customer agrees to share the savings with the ESCO.



Build Operate and Own (BOO) Model

In this model, a private organization builds, owns, and operates the energy-efficient facility. The government does not provide direct funding but may offer financial incentives, such as tax exemptions.

This financing mechanism is particularly suitable for **Cooling-as-a-Service (CaaS)**. For example, a private entity can upgrade existing cooling systems in selected municipal buildings and provide cooling services under pre-agreed terms, with municipalities paying based on actual usage.



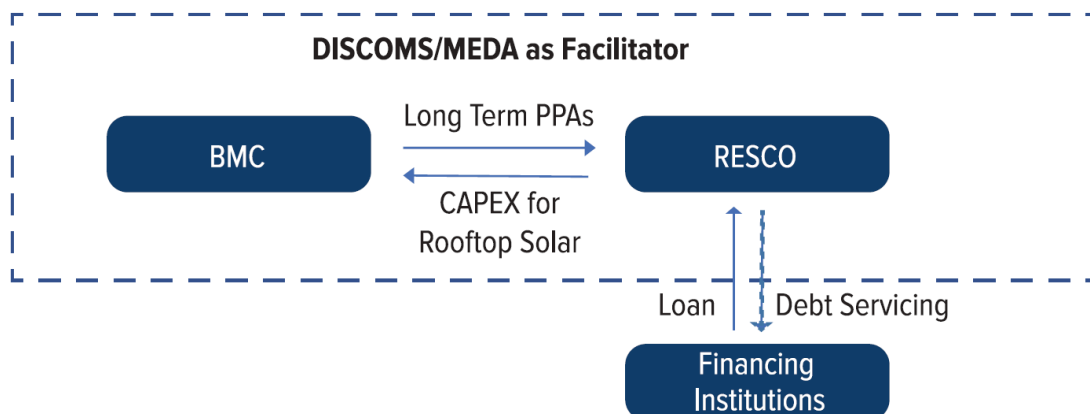
**A draft tender document for energy efficiency related project implementation under ESCO route has been provided in the appendix A which can be used by BMC to implement the identified ECMS in one of the identified municipal building categories on pilot basis.*

Renewable Energy Service Company (RESCO) Models for Renewable Energy

Under this model, a third party installs, owns, and operates renewable systems (e.g., rooftop solar) and sells electricity to municipalities under a long-term Power Purchase Agreement (PPA). Municipalities pay only for energy consumed at an agreed tariff often below grid rates avoiding RESCO would convert capital cost into operating expenditure, enabling large-scale deployment without straining municipal budgets. The RESCO entity would raise equity and debt against PPA-backed cash flows, while municipalities would benefit from immediate tariff savings and faster decarbonization of public assets.

Financing Route under RESCO Model

For the rooftop solar potential identified through the baseline assessment of municipal offices, hospitals, schools, and auditoriums, financing can be enabled through the RESCO model. Under this arrangement, BMC enters into a long-term PPA with a RESCO developer, facilitated by the DISCOM or MEDA. BMC pays for the electricity generated as per the agreed PPA tariff, ensuring timely and secure payments to the RESCO.



3.1.3 Financing through Specialized Institutional Debt

BMC can also attempt alternate sources of financing to provide funding for initiatives with a range of risks, rewards, and investment tenures. These consist of, among other things CSR funds (through partnership), municipal bonds, green bonds, carbon credits, and public-private partnerships. For example, PCMC successfully issues a 200 crore green municipal bond to fund sustainable urban mobility projects with 5.13 times subscription which is the first in Maharashtra¹⁶.

Municipal bonds are now becoming an alluring source of funding. An estimate by ICRA shows that municipal bond issuances to raise over `1500 crore in FY 2025-26 primarily driven by the Government's push¹⁷. Reporting and compliance obligations for municipal bond issues are similar to those for corporate bond issues. These bonds provide investors with a fixed or variable rate of interest and have a minimum term of three years. India has so far issued medium-term, fixed-interest municipal bonds with maturities of five or ten years.

To raise a municipal bond, the corporation should have an operating surplus in the last three fiscal years and should not have a history of defaulting at repayment of loans or debt instruments acquired from financial institutions in the last one year. Municipal corporation can achieve a lower coupon rate if the municipal bonds that raise funds are used for green initiatives. Additionally, it is preferred that the issuing body has a minimum investment grade credit rating AA or more from one of the top credit rating agencies.

Table 13 classifies the ECMs by investment level low, medium, and high and identifies corresponding financing options for their implementation.

Table 13: Energy Conservation Measures examples with possible financing mechanisms: summary

<p>Low-cost (Near term- by 2030)</p>	<p>Measures: LED lights and occupancy sensors, Conventional fan replacement with BLDC fans, External window shading, Cool roofs/ceiling innovations</p> <p>Priority:</p> <p>Immediately (1-year timeline) replace all inefficient lighting system with efficient LED lighting fixtures.</p> <p>Fan replacement can be done in phases. e.g.</p> <p>Phase 1: Replace the most inefficient stock first, i.e. 6-10+ years old,</p> <p>Phase 2: Less than 5 years old.</p> <p>Possible Financing Mechanism: Aggregate demand and use bulk procurement through Internal/Public Budgetary Resources such as Municipal Budgets, Revolving Investment Funds (RIFs) such as from State Energy Conservation Fund, Revenue from earmarked Funds (Green Cess), ESCROW account through O & M budget and refinancing through savings.</p> <p>Implementation through DISCOM-led on-bill financing mechanism.</p>
<p>Medium cost (Mid-term – by 2040)</p>	<p>Measures: Replacement of inefficient old split AC with efficient one</p> <p>Priority: Replacement can be done in phases based on star-ratings, e.g.</p> <p>Phase 1- Replace all 1-star (most inefficient stock) ACs with 5-star</p> <p>Phase 2- Replace 2-star ACs with 5-star</p>

¹⁶ ET Government. "Pimpri-Chinchwad Makes History with India's First Green Municipal Bond." ET Government, June 13, 2024.

¹⁷ Business World. "Municipal Bond Issuances to Raise over Rs 1,500 Cr in FY25-26: Report." Business World, n.d. Accessed January 27, 2026.

	<p>Phase 3- Replace 3-star ACs with 5-star</p> <p>Possible Financing Mechanism: Demand Side Management activities by DISCOMs (BEST- Brihanmumbai Electricity Supply and Support replaced old air conditioners with energy efficient air conditioners¹⁸) through on-bill financing</p> <p>Implementation through ESCOs under EPC models (shared-savings/ guaranteed-savings)</p>
<p>Cost-intensive (Long term – by 2050)</p>	<p>Measures: Rooftop Solar, replacement of centralized air-cooled chillers with water cooled systems and integration of variable frequency drives (VFDs), Replacement of old centralized HVAC system with efficient one.</p> <p>Priority:</p> <p>Phase-wise Implementation of Rooftop Solar:</p> <p>Phase 1: Prioritize installation in municipal schools and auditoriums with large, structurally suitable roof areas offering high solar potential.</p> <p>Phase 2: Extend implementation to hospitals and municipal offices.</p> <p>Phased Replacement of Inefficient HVAC Systems:</p> <p>Phase 1: Replace old, inefficient centralized HVAC systems in buildings with high EPI values corresponding to BEE’s 1-star ratings.</p> <p>Phase 2: Upgrade HVAC systems in buildings with BEE’s 2-star and 3-star EPI ratings to further enhance overall portfolio efficiency.</p> <p>Possible Financing Mechanism:</p> <p>Rooftop Solar Installation: Implement through Renewable Energy Service Company (RESCO) or Energy-as-a-Service (EaaS) models, supplemented by municipal bond financing to enable capital-free deployment and long-term energy cost savings.</p> <p>Replacement of Inefficient HVAC Systems: Adopt a Cooling-as-a-Service (CaaS) model implemented via qualified Energy Service Companies (ESCOs) under performance-based contracting frameworks to ensure efficiency gains and measurable energy savings.</p> <p>Measures: Offsite RE procurement</p> <p>Financing Mechanism: Open market procurement through DISCOMs under MH’s green tariff policy</p>

Achieving the proposed energy efficiency targets for the municipal building stock necessitates coordinated commitments across multiple departments of the BMC, including Engineering, Mechanical and Electrical (M&E), Environmental, and Procurement divisions. These departments must collaborate to establish baselines, assess potential energy efficiency measures and their impacts, and develop key performance indicators (KPIs) to monitor progress. Furthermore, comprehensive financial planning is required to explore self-financing, co-financing, and external financing mechanisms for energy efficiency projects. For medium-depth retrofits, ESCOs with EPC models is essential, particularly where payback periods align with contractual terms. At a portfolio level, BMC should prepare aggregated tenders to reduce transaction costs and enhance scalability. For deep retrofitting initiatives, innovative financing approaches such as the issuance of green or municipal bonds, or the mobilization of external capital through public-private partnerships (PPPs), will be critical to ensuring long-term financial viability and sustained impact.

¹⁸ Bureau of Energy Efficiency. “Sustainable and Accelerated Adoption of Energy Government of India”, Ministry of Power.

Governance and Roles

BMC has several departments like- Engineering Services Department (M&E, School infrastructure Cell), Education and Health department, Disaster Management Cell, and general administration (e.g. IT, Accounts) etc. Mechanical & Electrical(M&E) Department currently oversee some functions and activities that fall under the proposed Energy Conservation Measures for Municipal buildings. For instance, the department has installed solar panel installations at a number of hospitals, and is taking actions to replace inefficient AC stock in municipal office and hospital buildings with efficient ones. Additionally, it has installed an IoT-enabled automated distribution system at the BMC Head Office with the goal of improving electrical safety and energy efficiency¹⁹. This department can continue as earlier and take up additional measures like replacement of old conventional fans with new BLDC fans in municipal buildings, retrofitting AHU motors and HVAC optimization. The Education department and Health department look after all programs within municipal schools and hospitals, which related to purchase of equipment like CCTV cameras, machines, or awareness regarding judicious use of resources. These departments can coordinate with M&E department for installation of energy-efficient appliances.

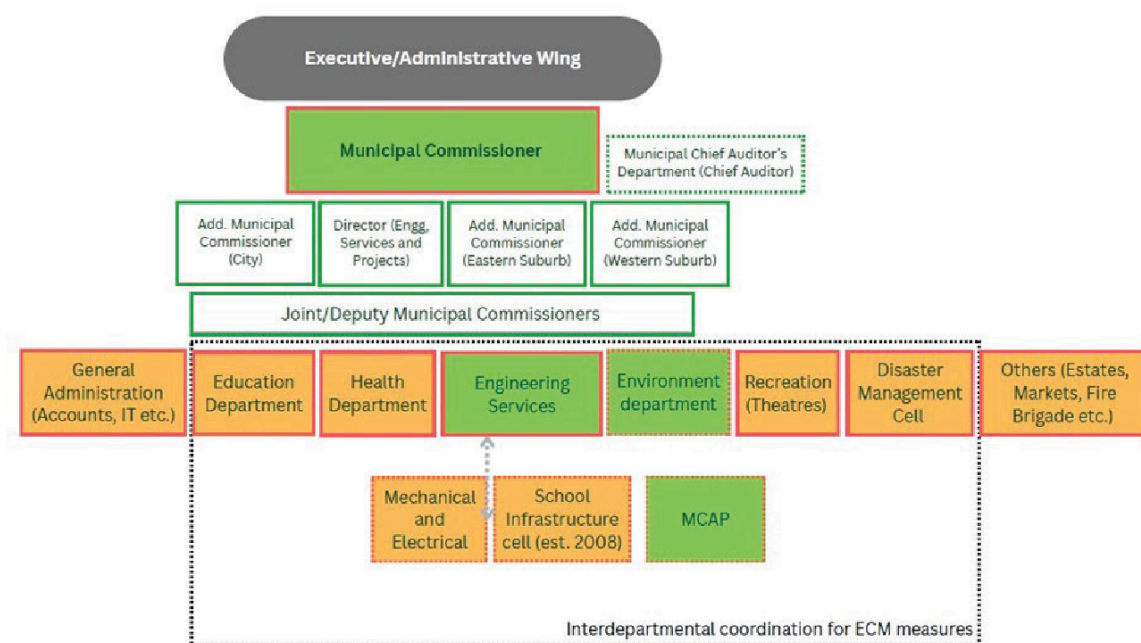


Figure 15: Existing institutional structure of departments relevant for Energy and Buildings in BMC²⁰

A 'School Infrastructure Cell' was established here in the year 2008 within Engineering Services department to oversee- repair, upgradation, reconstruction and new Construction of BM. school buildings²¹. This department can continue with all coordination for municipal schools like envelope retrofitting and installation of rooftop solar in municipal schools. The Recreation Department looks at auditoriums and therefore could coordinate with other departments to implement energy-conservation measures in those buildings. The Disaster Management Cell also exists within the corporation which could dedicatedly take up heat-resilience measures like application of SRI paints on roofs of municipal buildings.

¹⁹ Brihanmumbai Municipal Corporation (BMC). Climate Budget Report 2024–25. Mumbai: Brihanmumbai Municipal Corporation, 2024.

²⁰ Brihanmumbai Municipal Corporation (BMC). Document Repository. Mumbai: Brihanmumbai Municipal Corporation.

²¹ Brihanmumbai Municipal Corporation (BMC). Year Book 2025. Mumbai: Brihanmumbai Municipal Corporation, 2025.

As per MCAP, the Environment Department is expected to take all necessary steps towards driving transition to net-zero. Therefore, this department could be appointed as the key nodal agency to monitor targets and activities taken up by others. Since no energy cell currently exists, MCAP proposed a department 'Buildings and Mobility' within the Environment Cell which co-ordinates with state level agencies like MEDA, MSEDCL, others (refer figure 16 taken from MCAP).

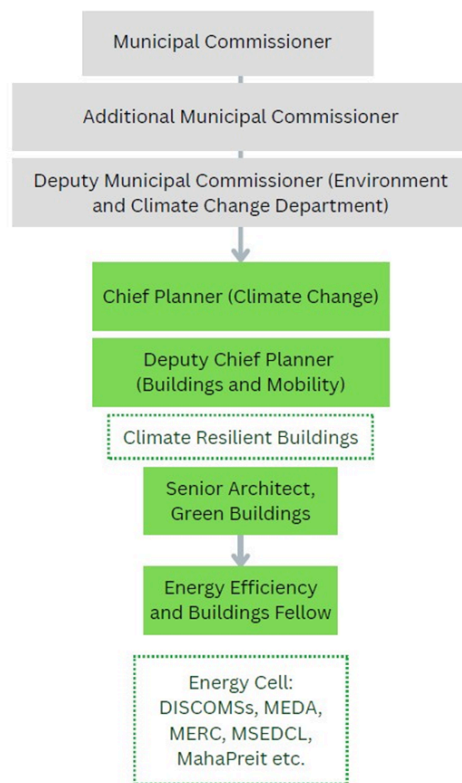


Figure 16: Proposed Buildings and Mobility cell under MCAP²²

Roles and Responsibilities

Table 14: Roles & Responsibilities for government departments

Roles	Municipal Departments	MEDA/ DISCOMS	ESCOs (Government/ Private)	Financial Institutions
Baselining of Municipal Buildings Energy Consumption and Benchmarking				
Enact energy performance standards for existing municipal buildings	Environment Department M&E Department			
Baseline assessment and energy benchmarking	Environment Department M&E Department			

²² Brihanmumbai Municipal Corporation (BMC). Mumbai Climate Action Plan (MCAP) Portal. Mumbai: Brihanmumbai Municipal Corporation.

Energy audit of municipal buildings	Environment Department M&E Department			
Identification of ECMs for municipal building categories	Environment Department M&E Department			
Aggregation of ECMs for different municipal building typologies	Environment Department M&E Department			
Financial Planning under Climate Budget for Self-Financing and Concessional Loans				
Allocating budget for energy efficiency projects under climate budget	Environment Department M&E Department Finance Department	MEDA		
Application of concessional loan for EE projects to MEDA	Environment Department M&E Department	MEDA		
of repayment mechanisms	Environment Department M&E Department Finance Department			
Financial planning under ESCO mode for EE projects				
Preparing the tendering and procurement process	Environment Department M&E Department	MEDA/ DISCOMs	MahaPreit/ EESL/ Public & Private Sector	Public & Private Sector
Developing the M&V protocols	Environment Department M&E Department	MEDA/ DISCOMs	MahaPreit/ EESL/ Public & Private Sector	Public & Private Sector
Verification of M&V reporting	Environment Department M&E Department	MEDA/ DISCOMs	MahaPreit/ EESL/ Public & Private Sector	Public & Private Sector
Structuring the repayment mechanism to ESCOs	Environment Department M&E Department	MEDA/ DISCOMs	MahaPreit/ EESL/ Public & Private Sector	Public & Private Sector

	Finance Department			
Prepare tripartite agreement for large scale and cost intensive EE upgrades	Environment Department M&E Department	MEDA/ DISCOMs	MahaPreit/ EESL/ Public & Private Sector	Public & Private Sector
Ensuring regulatory and code compliances	Environment Department M&E Department			

Standardization of the Procurement Process

Standardized procurement processes would help in the repeatable process of bringing energy efficiency projects to market. By using standardized requests for proposals with common scope of work, defined baselines, clear measurement & verification requirements and evaluation criteria – BMC can ensure that every bid they receive is evaluated consistently. This reduces ambiguity for vendors, speeds up the approval process (rapid awards), and makes it easier to compare results across projects. Importantly, aligning these criteria with *climate budget methods* ensures that project outcomes can be reliably quantified for Monitoring, Evaluation, and Reporting (MER) against climate and energy targets. Instead of taking up energy efficiency related projects in individual municipal buildings, portfolio aggregation bundles project together by municipal building typologies (e.g., schools, hospitals, offices). This has several advantages:

- **Reduced transaction costs:** Fewer procurement cycles, shared administrative costs, and standardized contracts.
- **Risk diversification:** Performance risks are spread across multiple buildings rather than concentrated in one.
- **Comparability of outcomes:** Since similar building types are grouped, results are easier to benchmark and integrate into climate budget reporting tables and sectoral action tracks. This allows municipalities to track not only project-level savings but also sector-wide progress in a structured way.

Measurement Reporting and Verification (MRV) Framework

The effective implementation of energy efficiency measures, whether through a self-financing mechanism or the ESCO route, requires a robust MRV framework. Figure illustrates the suggested MRV steps that the BMC can adopt for implementing energy efficiency related projects. As a first step, BMC should compile 12–24 months of historical electricity consumption data for the identified municipal building categories to establish a reliable baseline, followed by post-implementation data collection after the execution of ECMs. To enhance accuracy, BMC should also aim to capture data at the appliance or system level through sub-metering. Based on this measured data, suitable performance indicators such as energy use intensity (kWh/m²) or energy consumption per appliance unit should be developed to compare pre and post ECM implementation performance. Once the performance results are analysed, BMC should engage an accredited third-party verifier to validate and certify the actual energy savings achieved. The verification process should adhere to standardized protocols such as those outlined in the International Performance Measurement and Verification Protocol (IPMVP) to ensure consistency and accuracy. Finally, if the ECMs are implemented under the ESCO route, BMC can link verified savings

to payment terms, thereby ensuring performance-based accountability and transparency in project delivery.

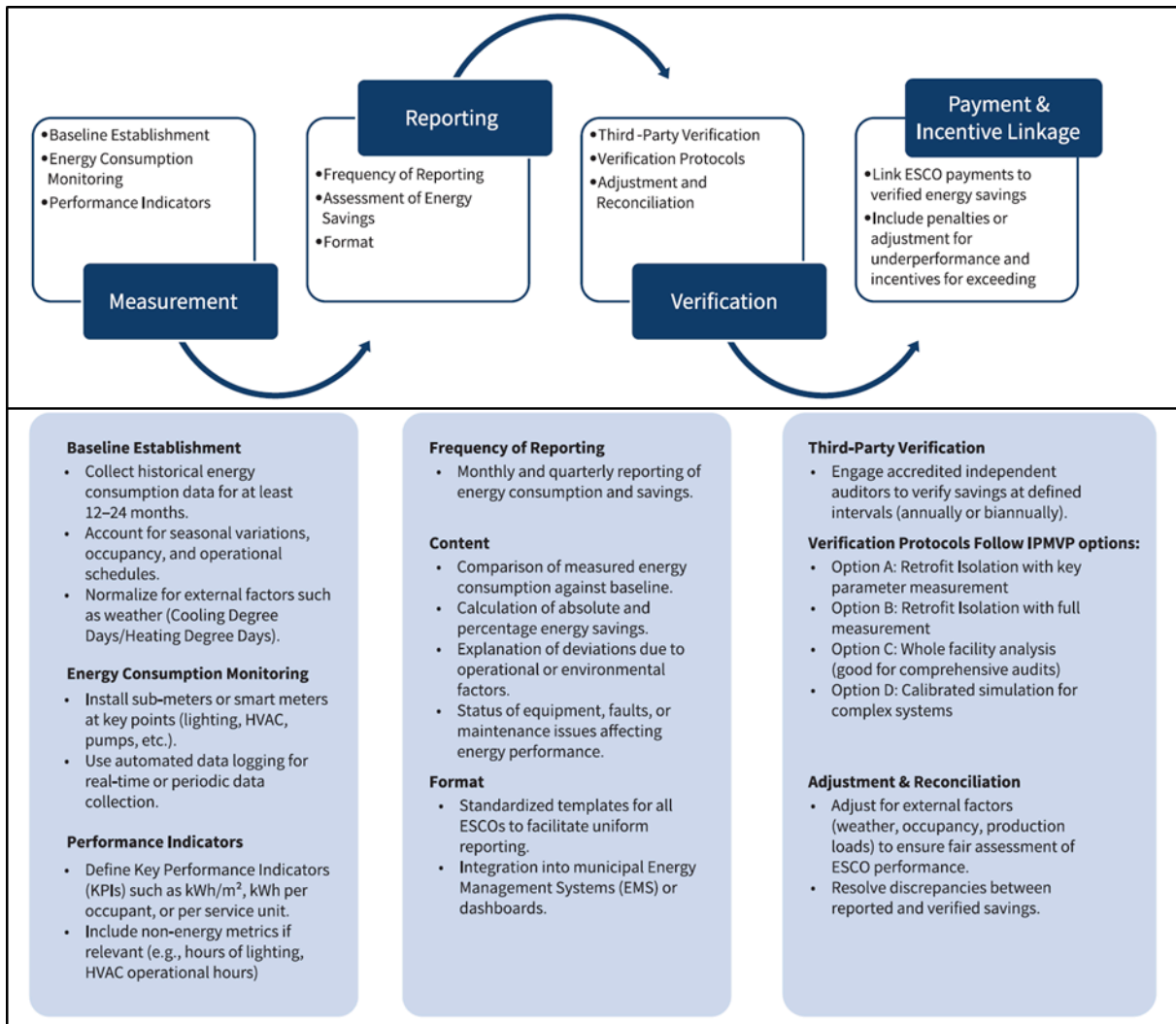


Figure 17: Measurement reporting and verification (MRV) framework

Figure below shows the near-term strategy for resource planning for taking up the energy efficiency projects in municipal buildings.



Figure 18: Near term year-wise resource planning
Source: authors

Risk Assessment and Resilience

Risk assessment is a fundamental component of performance-based contracts involving ESCOs, such as Energy Savings Performance Contracts (ESPCs) and Utility Energy Service Contracts (UESCs). In these agreements, a third-party contractor (the ESCO or utility provider) implements ECMs and guarantees a specified level of facility performance and cost savings.

The goal of risk assessment and management in this context is twofold: **to allocate project risks and responsibilities between the ESCO and the municipal corporation, and to use Measurement and Verification (M&V) to reduce the risk of non-performance to an acceptable level**

Key Tool for Risk Assessment: The RRP Matrix

The primary tool used for structured risk assessment and allocation is the **Risk, Responsibility, and Performance Matrix (RRP Matrix)**.

- **Purpose:** The RRP Matrix summarizes risks, responsibilities, and verification requirements that must be considered when developing performance contracts. It helps identify critical project risks, assess their potential implications, and clarify which party is responsible for managing them.
- **Process:** Early in project development, the ESCO (contractor) and the municipal corporation review the RRP Matrix to evaluate how key responsibilities will be allocated. This allocation drives the M&V strategy. The final agreed-upon RRP Matrix significantly influences the M&V approaches chosen for the project.

Categories of Project Risk: The RRP Matrix typically addresses three main categories of risk that influence performance contracts:

Table 15: Responsibility and performance matrix

Risk Category	Description and Scope	ESCO/Contractor Responsibility
Financial Risk	Risks related to savings shortfalls, unforeseen changes during implementation of ECMs, future facility changes, and energy prices (including annual escalation rates).	The ESCO is responsible for determining implementation costs and generally assumes responsibility for cost overruns in a fixed-price contract (unless the customer causes delays). Falling energy prices place the ESCO at risk of failing to meet guaranteed cost savings.
Operational Risk (Usage Risk)	Risks resulting from factors generally outside the ESCO's control that affect energy use and savings, such as facility operating hours, equipment loads, and weather.	Because ESCOs often cannot control usage factors, the customer generally assumes usage risk. This risk transfer is often achieved through stipulations (agreed-upon fixed values for parameters, regardless of actual behaviour).
Performance Risk	Uncertainty associated with an ECM's ability to achieve savings and meet contractual conditions (e.g., temperature setpoints or lighting levels). Performance risks are directly related to equipment efficiency and availability.	The ESCO assumes responsibility for the selection, application, design, installation, commissioning, and long-term performance of the equipment. The ESCO also bears the ultimate risk for guaranteed savings tied to operations, preventive maintenance, repair, and replacement, regardless of which party performs the physical activity.

M&V and Risk Management

M&V is integral to managing risk by balancing the cost of M&V activities with the value of increased certainty in the cost savings.

- **Risk of Achieving Savings:** The perceived risk associated with achieving the expected energy or cost savings determines the necessary **rigor** of the M&V

approach. ECMs with high estimated savings uncertainty may warrant greater attention.

- **M&V Option Selection:** The selection of an M&V option depends partly on the **risk of achieving savings** and the **complexity of the ECM**. For example, simple ECMs with low risk may use “Retrofit Isolation with Key Parameter(s) Measurement”, while complex, interrelated ECMs with higher risks may require “Whole Facility Measurement” or “Calibrated Simulation”.
- **Using Stipulations:** Stipulating certain fixed parameters in the M&V plan is a practical, cost-effective way to reduce M&V costs and allocate risks, particularly operational risks that neither party can fully control (e.g., equipment operating hours). Stipulation, however, is acceptable only for individual parameters and is prohibited for the total savings associated with an entire ECM.
- **Cost vs. Rigor:** The M&V effort must be scaled appropriately to the value of the project to ensure M&V costs are reasonable. Historically, overall annual M&V costs are often estimated at **1.5% to 3% of typical annual guaranteed cost savings**. Increasing M&V rigor increases cost but decreases the uncertainty in savings calculations, following a “law of diminishing returns.”



04 From Roadmap to Action Plan



This section gives an overview of targets, finance strategy and timeline (discussed in previous chapters) in the form of a comprehensive roadmap followed by action plan for two identified buildings for pilots. It also provides a decision matrix for choosing financial strategy for interventions and finally a figure showcasing roles and responsibilities of various departments for seamless coordination.

Roadmap: Targets, timeline and strategy

The provided figure illustrates a comprehensive **Roadmap** detailing targets and finance strategies for municipal buildings across various timeframes, from 2025 to the year 2050 with the aim of reviewing actions at every 5-year interval. The plan addresses both **Existing Buildings**, prioritizing actions like energy audits, behavioural changes (e.g., AC temperature settings), and phased equipment replacement (fans and air conditioners) based on inefficiency, alongside **New Buildings**, where the focus is on developing sustainable procurement guidelines, utilizing low-carbon materials, and implementing passive design principles. A significant recurring goal throughout the decades is the installation of **Rooftop Solar** on municipal buildings, culminating in a target of all existing buildings becoming net-zero energy and all new buildings being net-zero carbon by 2050. To fund these transitions, a variety of **Finance**

Mechanisms are proposed, including internal budgets, concessional loans, revolving funds, and innovative models such as On-bill.

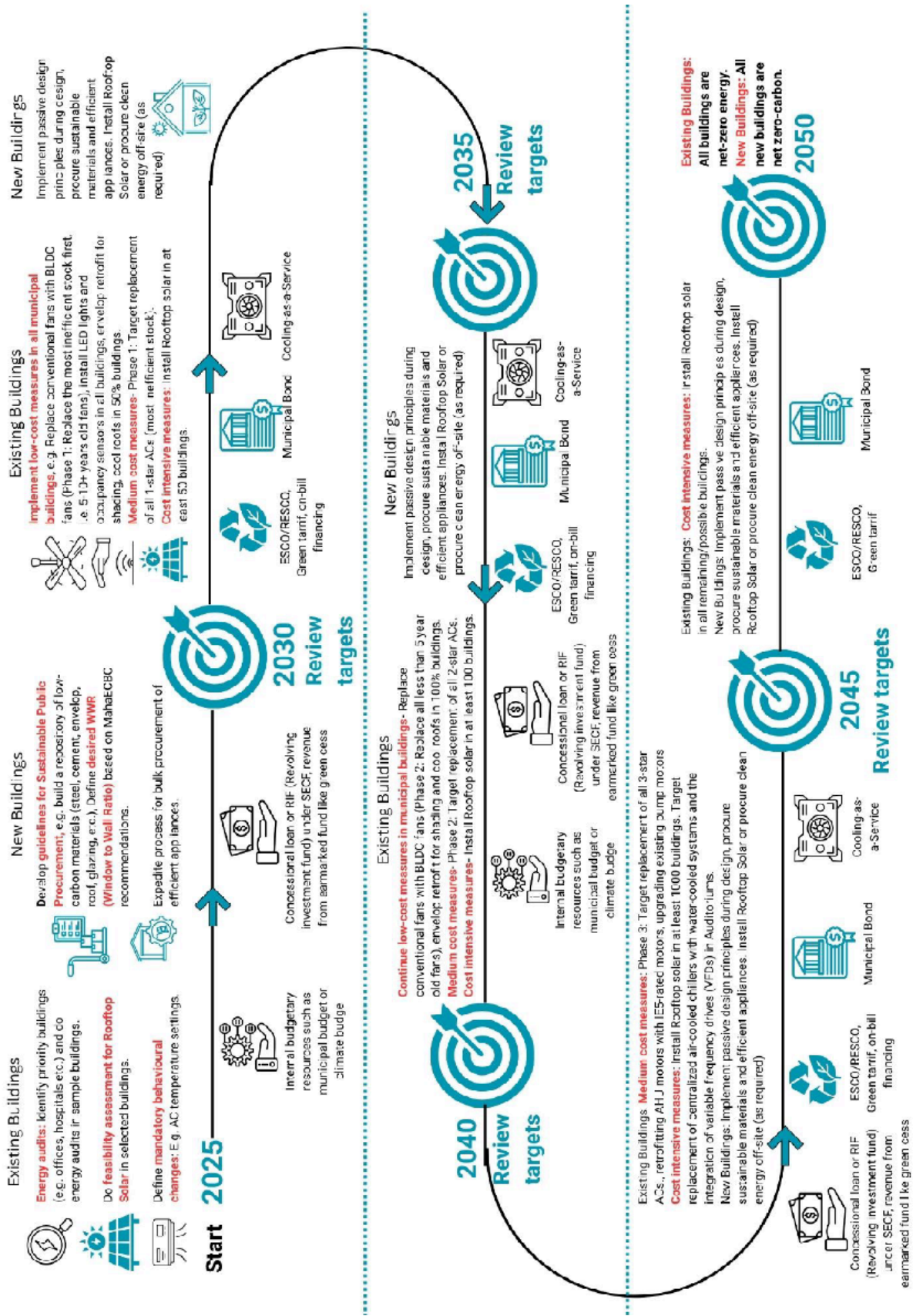


Figure 19: Roadmap outlining strategies and timeline

Action Plan: Pilots

The baseline assessment of municipal buildings under BMC's jurisdiction (refer Chapter 1) showed that hospitals, municipal offices, school buildings and auditoriums are the largest energy consumers and therefore should be prioritized for action. Further, the walkthrough energy audit of the sample buildings under the identified municipal building categories helped to identify the ECMs and their impact on energy consumption reduction potential. The analysis showed that the scale of **impact of the identified ECMs is larger for the municipal offices and hospital category buildings compared to schools and auditoriums**. Therefore, two buildings- one from municipal offices and one from the hospital category buildings have been selected and action plans are illustrated. The RC Ward municipal office building has been selected under office category buildings and Nair Hospital premises has been selected under hospital category. The identified ECMs for both categories of municipal buildings has been categorized into five major strategies which are envelope and roof retrofitting, behavioural changes, appliances retrofitting, rooftop solar installation and offsetting the remaining grid dependency through open market procurement of RE through green tariff policy.

Draft templates for ESCO-based contracting for implementing the identified ECMs and for Measurement & Verification (M&V) have been provided in **Appendices A and B**, respectively. These templates can be utilized by the Municipal Corporation while issuing tenders.

The impact of the ECMs in terms of energy saving potential and annual monetary savings, investment required for the identified ECMs, payback period for that investment and financing mechanism for implementation is presented in figure 21 and 22 for RC ward municipal office and Nair hospital building respectively.

RC Ward Municipal Office Building

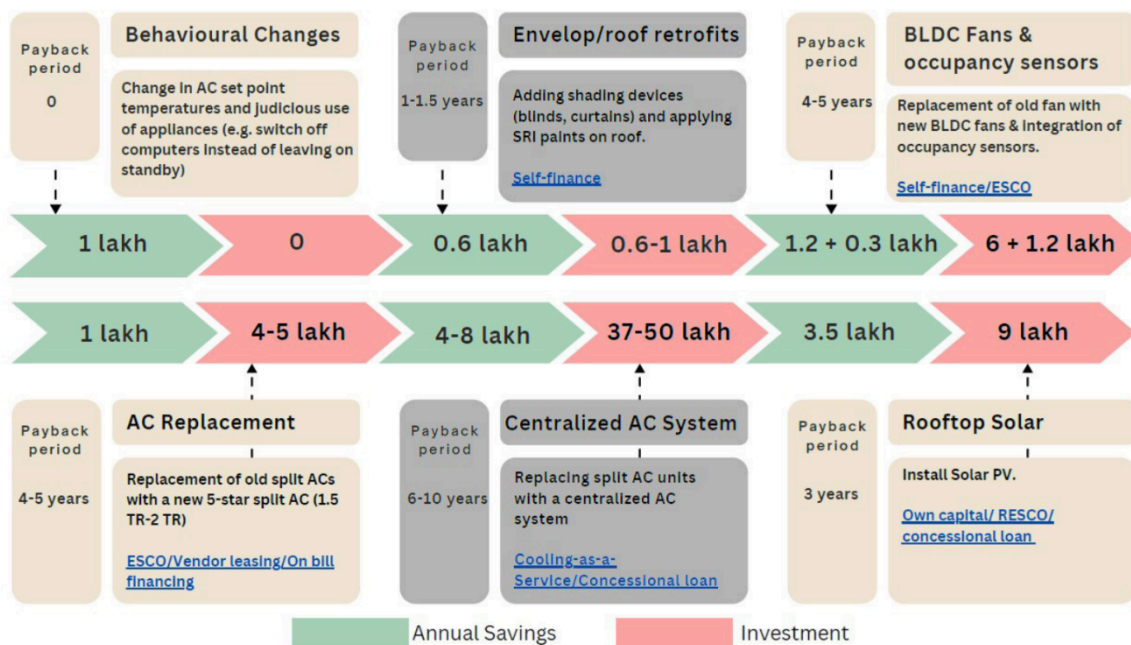


Figure 20: Action plan for RC ward municipal office building

Source: authors

Nair Hospital Building

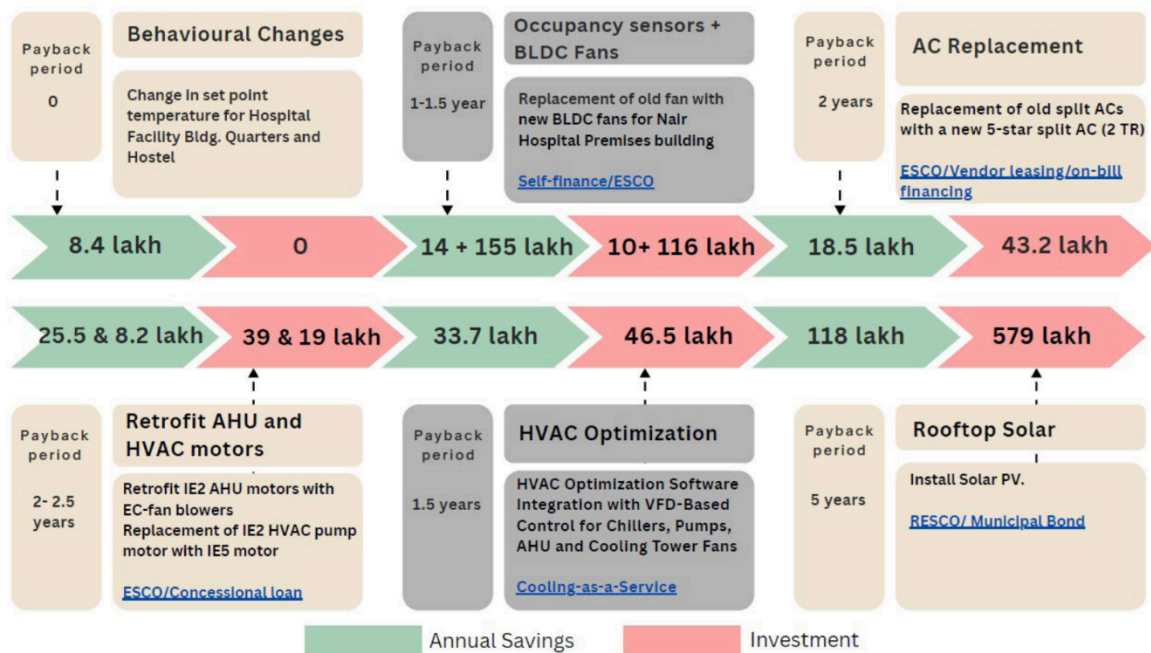


Figure 21: Action Plan for Nair hospital
Source: authors

Decision Matrix

The decision matrix provided can assist municipal corporations in picking suitable financing mechanisms for various interventions through a sequence of questions about funding sources starting with internal budgets and progressing through state government funds, ESCOs, utility-based financing, CSR grants, leasing/vendor financing, and municipal bonds. Finally, to achieve seamless coordination a chart illustrating roles and responsibilities is provided.

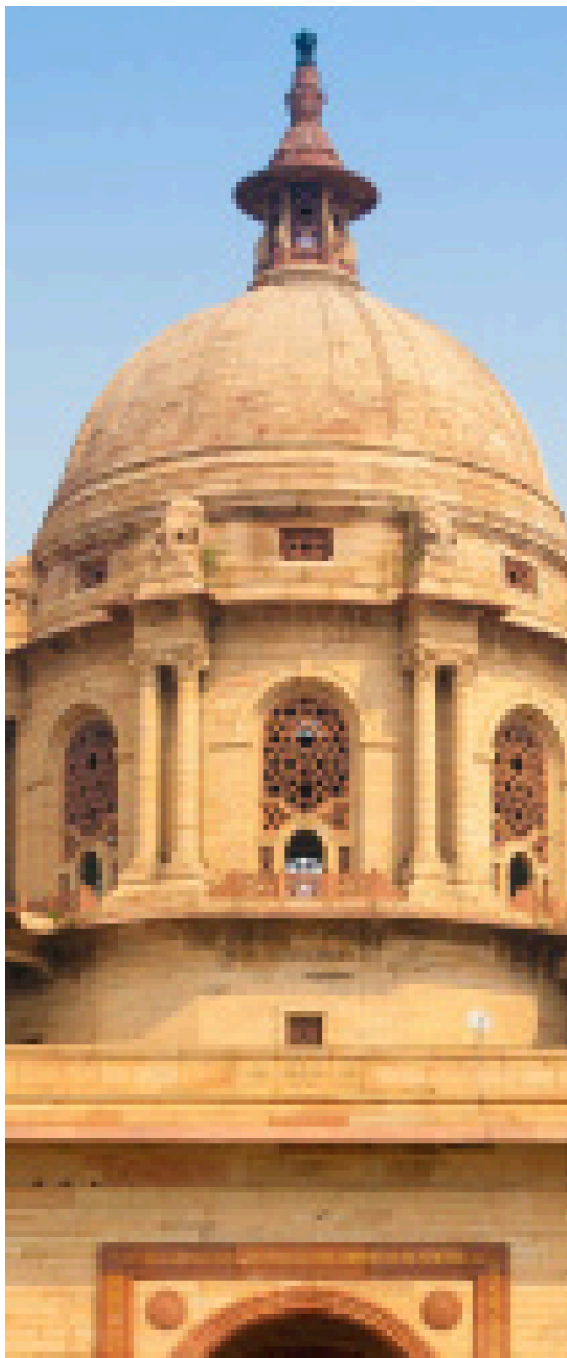
Table 16: Decisions matrix for financing strategies

Building Identification and ECM Selection			
Target buildings based on baseline assessment and benchmarking	Categorise buildings based on BEE's star level benchmarking and target efficiency measures implementation in phased manner Phase 1 – Target buildings under 1-star category Phase 2 – Target buildings under 2-star category Phase 3 – Target building under 3-star category		
Identification of ECMs	Conduct ASHRAE investment grade Energy Audit to identify ECMs		
Categorization of ECMs	Low cost	Medium cost	Cost intensive
Decision questions to implement the identified ECMs	Decision	Action	Financing Mechanism

Does the municipal corporation have sufficient sources to fund the project itself?	If Yes → If No ↓	Prepare application	Internal Budget/ Sources
Are funds available from state government bodies (e.g. State Energy Conservation Fund – SECF)?	If Yes → If No ↓	Prepare application for the state-government	State public budgetary resources
Is utility on-bill financing possible?	If Yes → If No ↓	Form partnership with a utility provider to fund and administer	Investment by utilities and repayment through bill
Are leasing or vendor financing programs available?	If Yes → If No ↓	Check terms of leasing or vendor financing agreement	Specialized Institutional Debt and Leasing
Are grants or CSR funding available?	If Yes → If No ↓	Partner with a CSR-registered implementing agency	External funding mechanisms
Is financing through public or super ESCO possible?	If Yes → If No ↓	Develop EPC (Energy Performance Contract)	Investment by ESCOs, repayment based on EPC
Is the municipal corporation eligible to raise a municipal bond?	If Yes → If No ↓	Check eligibility and prepare application	Specialized Institutional Debt and Leasing



05 Conclusion



The Net Zero Municipal Buildings Action Plan marks a pivotal step in BMC's transition toward a climate-resilient and energy-efficient future. It sets a clear and actionable pathway for the BMC to decarbonize its building portfolio by 2050 anchored in evidence-based strategies, governance structure, scalable pilot projects, and innovative financing mechanisms. By addressing both existing and new buildings, the plan emphasizes the dual priorities of improving operational efficiency and reducing embodied emissions through low-carbon materials, passive design, and renewable energy integration.

The roadmap outlines a phased transition implementing all no-cost and low-cost measures by 2030, achieving 50% portfolio coverage under net-zero energy by 2040, and realizing full net-zero energy and carbon goals by 2050. Through institutional reforms such as establishing a Climate Budget Steering Cell, strengthening measurement, reporting, and verification (MRV) systems, and promoting cross-departmental coordination, BMC can embed sustainability within its core governance framework. Realizing this vision will require sustained commitment, capacity building, and partnerships across government, private sector, and civil society. By leveraging models like ESCO, RESCO, Energy-as-a-Service and Cooling-as-a-Service, along with municipal climate budgets and concessional financing, Mumbai can overcome fiscal barriers and

unlock long-term energy and cost savings. As one of India's largest and most influential urban local bodies, BMC's leadership in implementing this Municipal Building Net Zero Action Plan will set a precedent for other municipal corporations across Maharashtra and the country. By demonstrating that municipal buildings can lead the way to net-zero, BMC not only advances Mumbai Climate Action Plan and Maharashtra Decarbonization Roadmap commitments but also inspires a broader shift toward sustainable, low-carbon urban development.

APPENDIX

Measurement and Verification Template

Part of Model ESCO Performance Contract

INTRODUCTION- PLANNING	
This M&V planning tool has been developed to assist M&V planners capture and incorporate the various M&V design elements for a particular project. The template is presented in a spreadsheet for ease of calculations, with the following contents:	
Worksheet	Purpose
Project	A summary of the overall
EMC Project	To capture details for the site and ECM, including the estimated project benefits, implementation plan and key
M&V	To capture the essential elements of the M&V Plan. This includes preferred M&V Option, measurement boundary definition, details of key parameters, and process information relating to conducting measurements, calculating saving and uncertainty.
M&V	Schedule and time of
M&V	To capture the step-by-step list of tasks, and allocation of

SCHEDULING AND REPORTING of M&V				
Project Information				
Project Name		Project#		
Project Manager		Last updated on Date		
Measured period				
	Start date	End date	Duration (in months)	Comments
Baseline period				
Performance period				
Item	Description	Time of submission	Owner review and acceptance	Frequency
M&V monthly report				
M&V quarterly report				
Final M&V report				

Project information					
M&V Approach					
Project	M&V option selected		Overall approach	Baseline period	Post retrofit period
		(%)			
Tariff related measures					
Measurement boundaries					
Project	Description of measurement boundary			Linked document or drawing	
Key parameters and variables					
Key parameters to be measured	ECM's	Parameter	Measurement period and duration	Method for collecting data	
Other parameters to consider			Reason for consideration	Method for considering or estimating data	

MEASUREMENT AND VERIFICATION - REPORTED OUTCOMES							
PROJECT INFORMATION							
Project Name	0		Project #	0			
Project manager	0		Last Updated Date				
PROJECT BENEFITS - SUMMARY							
Component	Unit of Measure	Adjusted Baseline	Post-Retrofit	Savings (This Period)	Total Savings (Till Date)	Precision %	Confidence %
Total							
Demand	kW						
Energy and Demand Cost (Rs)	Rs						
PROJECT BENEFITS - DETAILS							
Component	Unit of Measure	Adjusted Baseline	Post-Retrofit	Savings (This Period)	Total Savings (Till Date)	Precision %	Confidence %
Total							
Project 1 - Tarrif Related Measures							
Electricity	kWh						
other	tbc						
Project 2							
Electricity							
other							
Demand							
Demand (kW)	kW						
Demand (kVA)	kVA						
Energy and Demand Cost (Rs)							
Electricity	Rs						
Demand (kW)							
Demand (kVA)							

