Pimpri Chinchwad

Green City Action Plan

DEVELOPED USING

Apex Advanced Practices for Environmental Excellence in Cities

AN INNOVATION OF IFC International Finance Corporation WORLD BANK GROUP

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Ministry of Foreign Affairs of the Netherlands

पिंपरी चिंचवड महानगरपालिका पिंपरी २१ ०१ २०

कटिबध्दा जनहिताय

About this Report

This report presents the Pimpri Chinchwad Green City Action Plan, which an overview of the city's green ambitions and prioritized actions. The Plan was developed using Advanced Practices for Environmental Excellence in Cities (APEX), an innovation of the International Finance Corporation (IFC), a member of the World Bank Group. The work is implemented in partnership with the Government of the Netherlands.

Disclaimer notice

July 2024

Cover Image: IFC

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Foreword

Image: PCMC

In the face of rapid urbanization and industrial growth, the need for sustainable development has never been more pressing. The Green City Action Plan for Pimpri Chinchwad is not just a document; it is a blueprint for the future—a future where economic growth and environmental stewardship go hand in hand.

Cities play a role in contributing to climate change through greenhouse gas emissions from sectors like energy, transportation, and waste management. However, by adopting better urban planning strategies, implementing effective policies, and making informed choices regarding infrastructure development, we have the power to reduce energy consumption and greenhouse gas emissions. A proactive approach not only strengthens the resilience of our urban infrastructure in the face of climate change but also minimizes its impact on marginalized communities.

Our collaboration with the IFC has enabled us to envision and embark on transformative projects that prioritize energy efficiency, sustainable mobility, waste management, water conservation, and the harnessing of private sector innovation and investment. This plan underscores our dedication to creating a city that is not only industrially prosperous but also ecologically resilient.

As we implement this action plan, we are guided by the principle that a green city is a safe city—a haven for its citizens and a beacon of climate action. We are determined to balance the scales of industrial advancement with the weight of environmental protection, ensuring that the legacy we leave for future generations is one of harmony between humanity and nature.

The journey towards a greener Pimpri Chinchwad has begun, and through this action plan, we invite all stakeholders to join us in forging a path to sustainability that is as innovative as it is imperative.

Mr. Shekhar Singh (I.A.S.)
Commissioner, Pimpri Chinchwad Municipal Corporation

Acknowledgments

The Pimpri Chinchwad Green City Action Plan is the result of a robust collaboration between Pimpri Chinchwad Municipal Corporation (PCMC) officials and the International Finance Corporation (IFC). The Green City Action Plan leverages a new platform developed by IFC called Advanced Practices for Environmental Excellence in Cities (APEX), which is supported by an online software tool that helps quantify and prioritize policy and investment solutions across four key sectors: built environment and energy, transport, waste, and water and wastewater.

The IFC team was led by Prashant Kapoor, working closely with Kanishk Bhatt, Kelvin Vergara Tagnipez, Lorraine Sugar, Mohit Ganeriwala, and Chavi Walia.

The Plan was coordinated by the City Transformation Office (CTO, PCMC), while the following officials at Pimpri Chinchwad Municipal Corporation (PCMC) led the development of the plan across the key sectors as Sector Leads: Makarand Nikam (Building Permission Department), Bapu Gaikwad (Traffic and Transport Department), Sanjay Kulkarni and Harvinder Singh Bansal (Environment Department), Shrikant Shrinivas Savne (Water Department), and Nilesh Deshmukh (Property Tax Department).

The teams also acknowledge the contributions of various organizations and entities that have played a pivotal role in the Plan's development. These include: Rocky Mountain Institute (RMI), for their expertise in making Pimpri Chinchwad electric vehicle (EV) ready; Institute for Transportation and Development Policy (ITDP), for their insights into effective urban transport systems for the city; Maharashtra Metro Rail Corporation (Maha Metro), for their plans on enhancing the Pune Metro infrastructure; and Pune Mahanagar Parivahan Mahamandal Ltd (PMPML), for their insights and plans on public bus transport and commitment to improving mobility in the city. Several case studies in the report were produced for the APEX program by Sustainia. The teams would also like to thank reviewers for their valuable input. The Action Plan will be further enhanced through the insights and feedback provided by the active participation of the city's residents during the public comment period.

The Green City Action Plan of Pimpri Chinchwad is part of the broader strategic collaboration between the Government of Maharashtra and IFC to support urban infrastructure projects that promote sustainable and low-carbon growth in the state. It is a component of the advisory support provided by IFC to PCMC to develop a comprehensive approach for reducing greenhouse gas emissions and implementing environmentally sustainable solutions in Pimpri Chinchwad.

Objective of this Report

This report presents the Pimpri Chinchwad Green City Action Plan. It provides an overview of the city's green ambitions along with the results of the green city assessment conducted using IFC's APEX online software tool. The purpose of the assessment was to identify, analyze, and prioritize key climate actions based on future savings in greenhouse gas emissions, energy, private vehicle travel, waste, and water, as well as capital costs. The report is intended to support PCMC as it proceeds with implementing environmentally sustainable solutions related to its strategic plans, including the City Strategy Plan for 2030.

The APEX assessment covers 4 key sectors: built environment and energy, including residential, commercial, and municipal buildings; transportation, including resident travel and municipal fleet; waste, including municipal solid waste management; and water and wastewater. The APEX tool focuses primarily on quantifying opportunities related to climate change mitigation, while there are certainly resilience co-benefits for certain measures in the form of water security, energy security, and urban heat island mitigation. The APEX tool does not currently include industry, agriculture, or freight transportation sectors. Industry is a particularly important sector for Pimpri Chinchwad, and it will be the subject of future standalone reports.

It is important to note that the results presented herein are indicative only. They are intended to help inform future action, but ultimately represent just one of the many factors influencing PCMC's decisions on if/how to proceed with implementation. The baseline was developed using a variety of sources, including data provided by city officials, data found in public-facing reports, and when otherwise not available, values estimated using proxies from country data and regional data within the APEX database. The prioritized actions will all require further feasibility work prior to implementation.

Methodology and Approach

The Green City Action Plan development process followed three main steps: **1) data collection and baseline setting; 2) selection and prioritization of measures; and 3) final analysis.**

IFC collaborated with PCMC officials to compile data, review current plans, and identify and prioritize solutions. The APEX software uses information for the baseline year and projects forward to the target year using anticipated population growth rates. It evaluates actions relative to the business-as-usual (BAU) case—that is, the scenario where the city government does not take any specific actions, and municipal operations and resident behaviors are the same as in the baseline year. The key assumptions for the BAU case can be adjusted in accordance with anticipated economic growth and initiatives of other spheres of government.

APEX then helps quantify the impact of investment, planning, and policy solutions—referred to as measures—in the target year. There are over 100 measures preloaded into APEX, as well as the option to create custom measures. Each measure has an engine that quantifies its impacts and costs based on the specific situation in the city. The methodology behind each measure is based on prevailing engineering calculations, existing studies in literature, and/or case studies from other cities. The APEX online software was designed to help cities to quickly assess the most cost-effective way to incorporate measures into their investment and policy pipelines, to achieve targets related to energy, transportation, waste, water, and GHG emissions.

Caption for this illustration.

Acronyms & Abbreviations

APEX	Advanced Practices for Environmental Excellence in Cities
ASP	Activated Sludge Process
ATS	Automated Test Stations
BAU	Business-as-usual
BEE	Bureau of Energy Efficiency
BIS	Bureau of Indian Standards
BRT	Bus Rapid Transit
C&D	Construction and Demolition
CAFC	Corporate Average Fuel Consumption
CNG	Compressed Natural Gas
CO_2	Carbon Dioxide
CTO	City Transformation Office
DBOT	Design, Build, Operate and Transfer
DMA	District Metered Area
EaaS	Energy-as-a-Service
e-auto	Electric Auto-Rickshaw
EC	Environmental Clearance
ECBC	Energy Conservation Building Code
EDGE	Excellence in Design for Greater Efficiencies
EE	Energy Efficiency
ENS	Eco-Niwas Samhita
EPR	Extended Producer Responsibility
ESCO	Energy Service Company
EV	Electric Vehicle
FAME	Faster Adoption and Manufacturing of Electric Vehicles
FAR	Floor-area ratio
GHG	Greenhouse gas
GIS	Geographic information system
GPS	Global Positioning System
GRIHA	Green Rating for Integrated Habitat Assessment
GWh	Gigawatt-hours
HDFC	Housing Development Finance Corporation
HVAC	Heating, ventilation, and air conditioning
ICCT	International Council on Clean Transportation
ICE	Internal combustion engine
ICT	Information and Communication Technology
IFC	International Finance Corporation
IGBC	Indian Green Building Council
INR	Indian Rupee
IPP	Independent power producer
IS	Indian Standard
ITDP	Institute for Transportation & Development Policy
ITMS	Intelligent Traffic Management System
km	Kilometer
km^2	Square Kilometers
$ktCO_2e$	Kilotonnes of Carbon Dioxide Equivalent
kW	Kilowatt
kWh	Kilowatt-hours
L	Liters
m	Meters
m^2	Square Meters
m^3	Cubic Meters
Mt	Million Tonnes
$MtCO_2e$	Million Tonnes of Carbon Dioxide Equivalent
MBR	Membrane bioreactor
MEDA	Maharashtra Energy Development Agency
MLD	Million Liters per Day
MNRE	Ministry of New and Renewable Energy
MSEDCL	Maharashtra State Electricity Distribution Company Limited
MSW	Municipal Solid Waste
MW	Megawatt

Maha Metro	Maharashtra Metro Rail Corporation Limited
MoHUA	Ministry of Housing and Urban Affairs, India
MoRTH	Ministry of Road Transport and Highways
MuDSM	Municipal Demand Side Management
NCAP	The National Clean Air Program
NGO	Non-Governmental Organization
NIUA	National Institute of Urban Affairs
NMT	Non-Motorized Transport
PACE	Property Assessed Clean Energy
PCMC	Pimpri Chinchwad Municipal Corporation
PKT	Passenger-Kilometers Travelled
PMPML	Pune Mahanagar Parivahan Mahamandal Ltd
PMRDA	Pune Metropolitan Region Development Authority
PPP	Public-Private Partnerships
PRGFEE	Partial Risk Guarantee Fund for Energy Efficiency
PSU	Public Sector Unit
PUB	Public Utilities Board, Singapore
PV	Photovoltaic
PWD	Public Works Department
QR	Quick Response code
RESCO	Renewable Energy Service Company
RMI	Rocky Mountain Institute
ROI	Rate of Interest
RTO	Regional Transport Office
RTPV	Roof-top photovoltaic
RVSF	Registered Vehicle Scrapping Facilities
SBI	State Bank of India
SBR	Sequencing Batch Reactor
SCADA	Supervisory Control and Data Acquisition
SEIAA	State Environment Impact Assessment Authority
STP	Sewage Treatment Plant
SVAGRIHA	Simple Versatile Affordable GRIHA
SWH	Solar-assisted Water Heating
t	Metric Tonnes
tCO_2e	Tonnes of Carbon Dioxide Equivalent
TERI	The Energy and Resources Institute
TPD	Tonnes per day
UDCPR	Unified Development Control and Promotion Regulations for Maharashtra State
UFMP	Urban Forestry Management Plan
ULB	Urban Local Bodies
UPI	Unified Payments Interface
USD	United States dollar
VKT	Vehicle Kilometers Travelled
WEP-I	Water Efficient Products-India
WRI	World Resources Institute

Executive Summary

Pimpri Chinchwad is part of the Pune Metropolitan Region. The city has a population of about 2.8 million and is known for its industrial and automotive sectors. The Pimpri Chinchwad Municipal Corporation (PCMC) is committed to becoming a green and sustainable city, with various initiatives and plans to achieve this goal. Through implementation of the City Strategy Plan for 2030 (PCMC, 2018), the city aims to become the "most inclusive economic powerhouse and livable city of India" by 2030 (p2, PCMC, 2018).

As part of its strategy, the city has prioritized responding to climate change through various initiatives, including the development of a Green City Action Plan, which was coordinated by PCMC and developed in collaboration with the International Finance Corporation (IFC). The actions identified in the Green City Action Plan will contribute to the various strategic areas of the City Strategy Plan for 2030, in particular: *Sustainable Mobility: Promotion of public transport, non-motorized modes of transport, road safety and Environment and Living: Zero waste Pimpri Chinchwad, Pollution free city, Waste management, and Energy efficiency.*

The Green City Action Plan identifies actions—including city-level policies, investments, and planning strategies—that can help the city meet its climate mitigation and sustainability targets. As such, it aims to increase the pipeline of public and private climate-related investments, which can be influenced by city-level policies and plans. The Green City Action Plan leverages a new platform developed by IFC called Advanced Practices for Environmental Excellence in Cities (APEX), supported by an online software tool that helps quantify and prioritize policy and investment solutions across four key sectors: built environment and energy; transportation; water; and waste sectors.

Using the year 2023 as its baseline, and projecting to the year 2030, the Green City Action Plan prioritizes and quantifies the impacts of 32 selected solutions, called measures, across the four sectors. Implementing these measures is expected to support a 27 percent reduction, 1.6 million tonnes of carbon dioxide equivalent ($MtCO_2e$) in greenhouse gas (GHG) emissions, as shown:

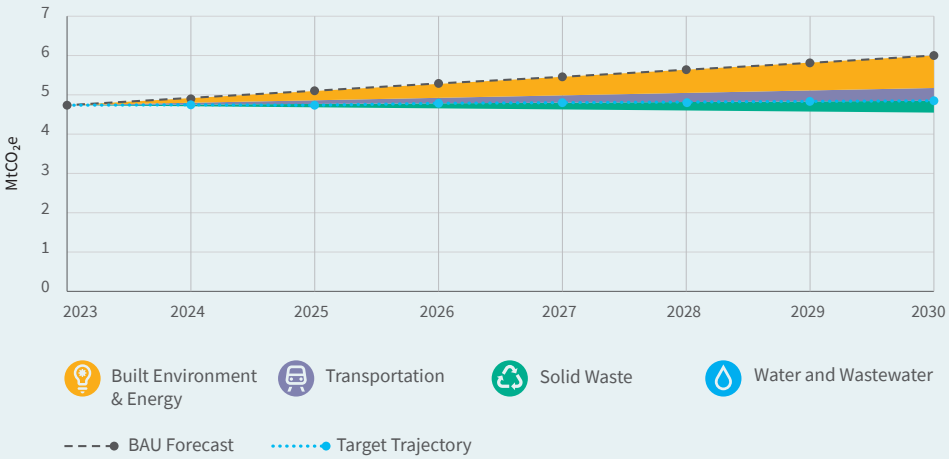
Image: IFC

APEX Sectors	Measures	Sector Indicator	GHG Savings from City-wide BAU (%)	GHG Savings from City-wide BAU ($KtCO_2e$)
Built Environment & Energy	Rooftop Solar Hot Water	21% Fossil Fuel Energy Savings	17%	1,023
	Urban Forestry			
	Green Building Certification			
	EE Refurbishment for Private Buildings			
	Rooftop Solar PV Program for Private Buildings			
	Green Municipal Buildings			
	Rooftop Solar PV on Municipal Buildings			
Transportation	Retire Inefficient Vehicles	28% Less Private Fossil Fuel Vehicle Travel	6%	346
	Minimum Efficiency for New Vehicles			
	EV Charging Infrastructure			
	Promote Private Electric Vehicles			
	Bicycle Lanes			
	Extend BRT System			
	Expand & Electrify BRT Bus fleet			
	Extend Metro System			
	Add Park-and-ride Lot to Transit Stations			
	Smart Fare Integration Across Transit System			
	Electrification of Municipal Fleet			
	Electrification of Auto-Rickshaws			
Solid Waste	Decentralised Composting	94% Waste Diverted from Landfill	4%	244
	Ban Single Use Plastics			
	Improve Waste Collection			
	Waste-to-Energy Facility			
	Centralised Anaerobic Digestion			
Water & Wastewater	Rooftop Rainwater Harvesting	43% Water Security Improvement	0.2%	6
	Reuse Wastewater at Municipal Scale			
	Reuse of Wastewater from New & Existing Buildings			
	Reduce Unaccounted-for Water Losses			
	Improve Efficiency For Water Conveyance Pumps			
	Efficient Fittings in New & Existing Buildings			
	Smart Water Meters			
	New Centralized Wastewater Treatment Facilities			
Total GHG Reduction			**27%**	**1,620 $KtCO_2e$**

The target trajectory of GHG emissions reduction to 2030 is shown relative to the business-as-usual (BAU) scenario below:

Image: IFC

27%
GHG Emissions Savings

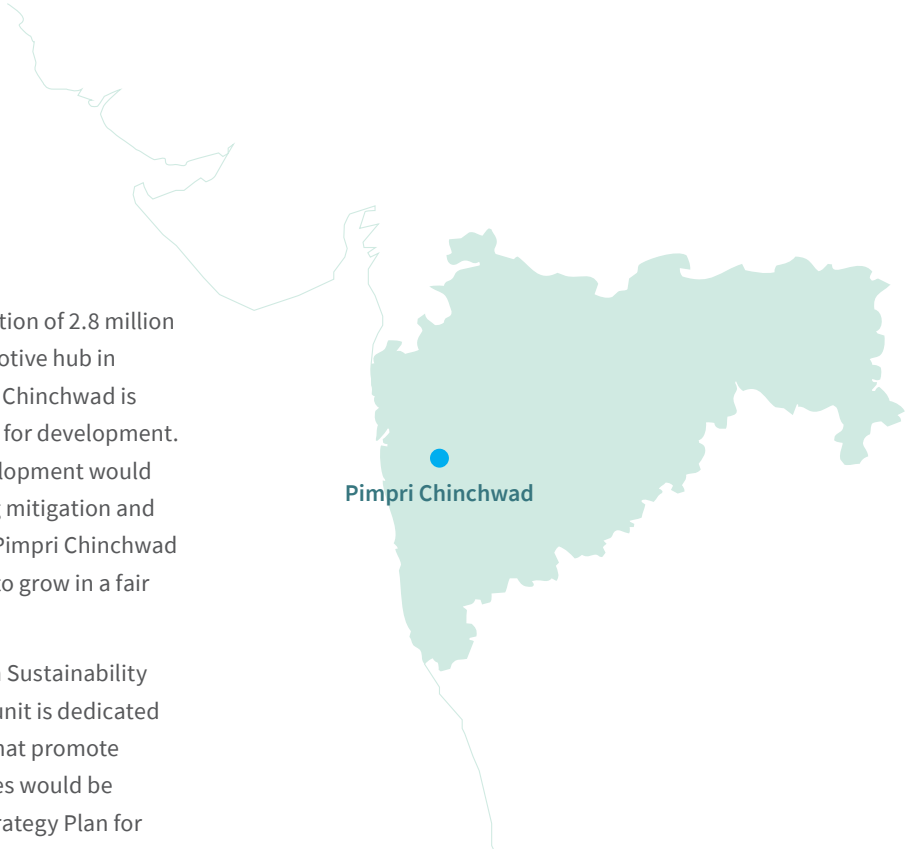


Solutions in the Green City Action Plan can be converted into a pipeline for green investment in Pimpri Chinchwad, supported by both public and private sector funding. All 32 measures with their associated costs are listed in the Green Investment Pipeline section of this report. It includes estimated indirect capital cost to the private sector, as well as the direct cost to the city and its agencies. Where the cost is for investment that falls within the city's mandate, the full cost is reflected as a direct cost. Direct costs total approximately INR 11,997 crore (equivalent to about USD 1,441 million) over 7 years and include actions where the city can enable or incentivize (i.e., through implementing policy) the private sector to invest in green measures. In addition, the city can leverage sources of finance, e.g., through municipal finance or public-private partnerships (PPPs), for capital investments.

The Green City Action Plan is one piece of the city's comprehensive approach to addressing climate change and promoting sustainable development. The Green City Action Plan focuses specifically on climate change mitigation, as well as resource efficiency in terms of energy consumption, private vehicle travel, waste reduction, and water security.

Introduction

Background & Purpose



Pimpri Chinchwad, with an estimated population of 2.8 million people, is an important industrial and automotive hub in Maharashtra, India. The population of Pimpri Chinchwad is steadily growing, which is driving up demand for development. Without regulation and planning, urban development would result in an unorganized future, necessitating mitigation and adaptation measures on the part of the city. Pimpri Chinchwad plans to implement these measures in order to grow in a fair and sustainable way.

To facilitate this strategy, PCMC established a Sustainability Cell as part of its governance structure. This unit is dedicated to implementing unconventional initiatives that promote sustainable development. The cell's objectives would be aligned with the strategic goals of the City Strategy Plan for 2030 (PCMC, 2018). For a comprehensive result, it would also aim to meet the objectives established by numerous national and international frameworks.

The City Strategy Plan targets the city becoming “The Most Inclusive Economic Powerhouse & Livable City of India” by 2030 (p2, PCMC, 2018). Among the six pillars of the plan are sustainable mobility and clean, green and environment-friendly city. To support these objectives, the city has started initiatives like Navi Disha, a community led toilet model by engaging women; the Harit Setu Master Plan; EV initiatives; incentives for auto drivers to purchase e-autos; 14 MW waste to energy plant; construction and demolition (C&D) waste plant; and hotel waste to biogas plant. As part of the Smart City Mission initiated by the Government of India, the city has developed a smart city program that focuses on integrating and centrally managing data and services through smart technologies to enhance service delivery and improve the quality of life for its citizens.

The Green City Action Plan complements these efforts and aims to identify actions—including city-level policies, investments, and planning strategies—that can help the city meet its climate mitigation and sustainability targets. As such, it aims to increase the pipeline of public and private climate-related investments, influenced by city-level policies and plans.
The Green City Action Plan, coordinated by PCMC, has been developed in collaboration with IFC. It leverages a new platform developed by IFC called APEX, an online software tool that helps quantify and prioritize policy and investment solutions in the energy, transportation, water, and waste sectors. The key focus areas in the City Strategy Plan for 2030 have been integrated into the Green City Action Plan, by mapping these areas to the APEX sectors.

This work is a collaborative analysis exercise to determine the potential impact of various actions. It is meant to assist with the city’s internal planning processes by providing a framework for prioritization of possible measures and does not necessarily equate to commitment by the city to proceed with the actions. Furthermore, climate is just one aspect to be considered in any investment decision being made by the city, as it will also need to consider a range of other factors. Assumptions used in calculations are specified herein.

The Green City Action Plan Development Process

The Green City Action Plan was developed over a six-month period from July 2023 to December 2023. The draft was then finalized following stakeholder review (by various municipal departments and external partners) and released for public comment in July 2024. *Figure 1* illustrates the Green City Action Plan development process. IFC collaborated with representatives from PCMC, Pune Mahanagar Parivahan Mahamandal Ltd. (PMPML), Maharashtra Metro Rail Corporation Ltd. (Maha Metro), Rocky Mountain Institute (RMI), Institute for Transportation and Development Policy (ITDP) and National Institute of Urban Affairs (NIUA) to compile data and review current plans, identify, and prioritize solutions using the APEX software, and develop a roadmap for green city action.

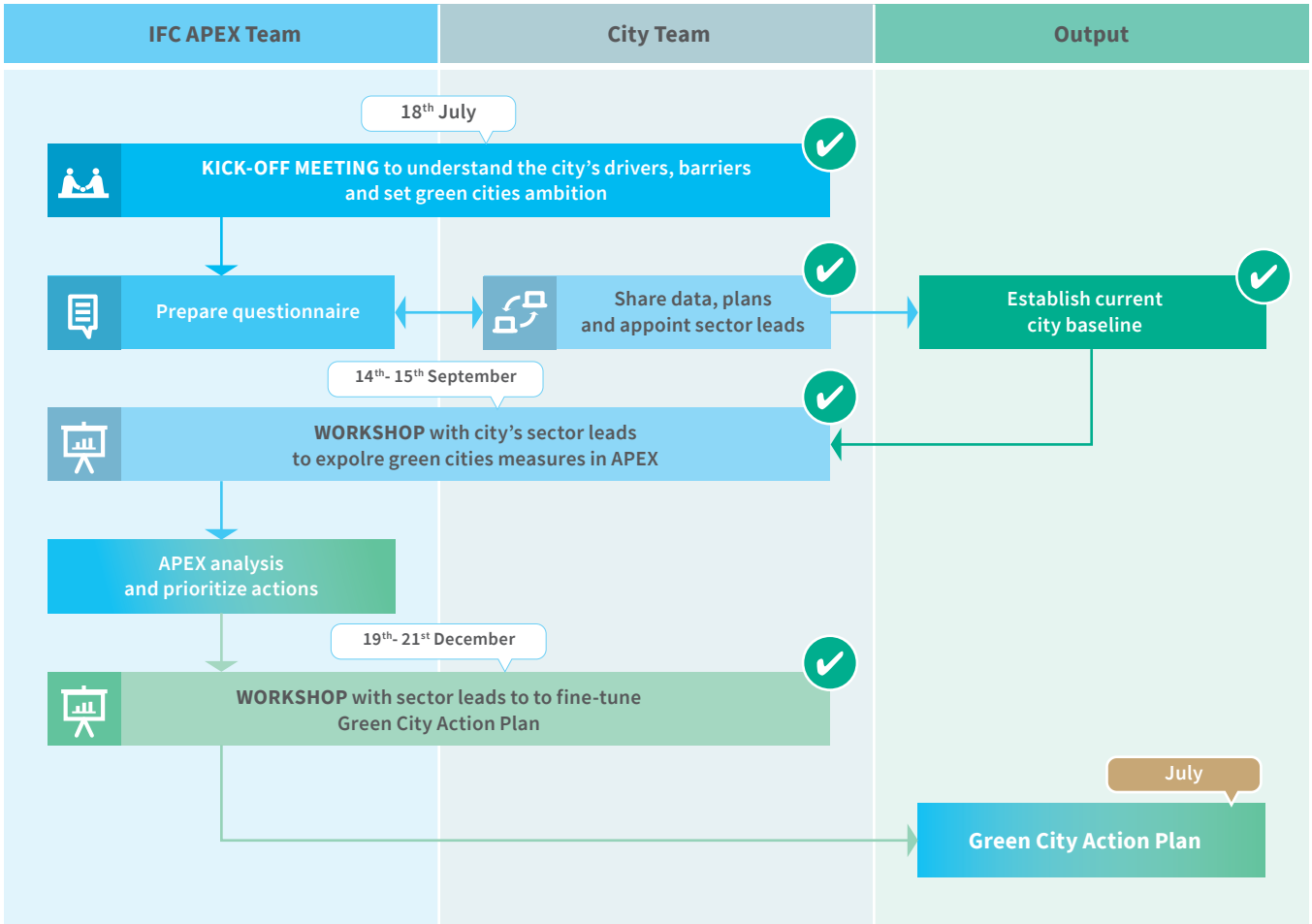


Figure 1: *The Green City Action Plan Development Process.*

Measures were selected and prioritized during successive phases of the development process, as follows:

Initial List of Measures

Following data collection and a review of existing plans and strategies, the IFC team prepared an initial list of measures, which served as a basis for discussion in the Sector Measures Workshops. The initial list of measures was selected by answering questions such as:

- What are the ongoing projects and strategies being implemented by the city?
- Has the action been identified in existing city plans and strategies?
- What is the GHG emission target and what are the priorities of the city?
- Are local stakeholders and partners currently working on implementation?

Final List of Measures

During the Sector Measures Workshops (*Figure 2*), the measures were discussed and explored using the APEX online software together with Sector Leads of the city; officials from PMPML, Maha Metro, and Moshi Waste-to-Energy plant; ITDP; RMI; and NIUA. Measures were finalized by exploring questions such as:

- Is the measure identified applicable to the city's local context?
- Is the action feasible in terms of scope and payback?
- If there are barriers to implementation, are potential solutions available?
- Is there interest and appetite from the city to develop the measure?
- Will the measure support a clear impact in terms of the city's targets?

Measures in the final list were included in the Green City Action Plan analysis and Green Investment Pipeline.

Built Environment & Energy

Build green to address largest emitter

Transportation

Invest in NMT & public transport

Solid Waste

Collect and manage municipal waste

Water & Wastewater

Improve water security and resilience

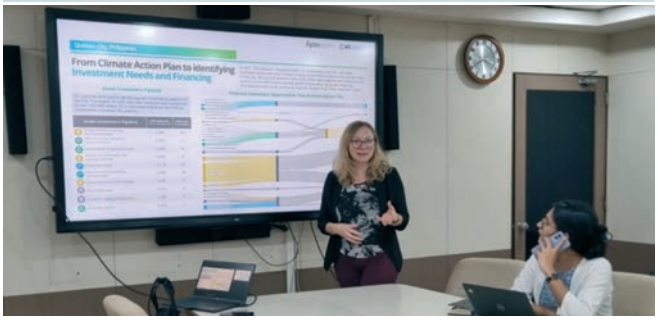


Figure 2: *Key sector priorities identified through consultations, site visits, and workshops.*

Structure of the Document

The Green City Action Plan is structured into the following four sections:

1. City Context

This chapter includes a brief profile of the city of Pimpri Chinchwad, the city-wide baseline performance across the sectors of interest (Built Environment and Energy, Transportation, Waste, and Water), and overview of city-wide GHG emissions.

2. Green City Action Plan Summary

This chapter summarizes the Green City Action Plan, first in terms of overall performance on future GHG emissions, and then sector-by-sector impacts on fossil fuel energy consumption, private fossil fuel vehicle kilometers travelled, waste diverted from landfill, and water security.

3. Priority Measures

This chapter details the specifics of each measure, including a description, the context in the city of Pimpri Chinchwad and India, the scope and assumptions used in calculations, and the next steps for implementation. This chapter also includes some case study examples to help illustrate successful implementation in other cities in India and around the world.

4. Green Investment Pipeline

This chapter presents the measures of the Green City Action Plan as a Green Investment Pipeline, including the total cost of each measure, possible directs costs to the city and its agencies, and potential funding sources.

City Context

Pimpri Chinchwad City Profile

Pimpri Chinchwad is a rapidly growing industrial and residential hub in the Pune Metropolitan Region, Maharashtra, India. The city has a population of about 2.8 million and covers an area of 181 square kilometers (km^2). The city is home to several large and small-scale industries, especially in the automotive, engineering, and electronics sectors. The city's strategic plan aims to make it the most inclusive economic powerhouse and livable city of India by 2030. This vision includes a focus on sustainable mobility, environmental health, economic development, and information and communication technology (ICT)-enabled smart governance to promote ease of doing business and quality of life.

In Pimpri Chinchwad, the following entities are responsible for various aspects of the city's infrastructure and services:

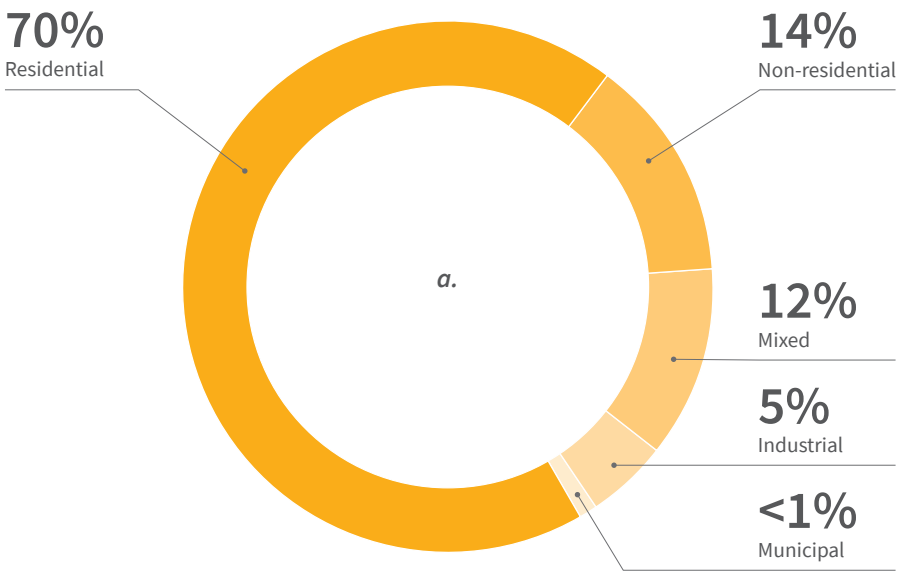
- **PCMC (Pimpri Chinchwad Municipal Corporation):** PCMC is the civic body that governs the Pimpri Chinchwad area. It is responsible for urban planning, development, and maintenance of the city's infrastructure. This includes services like water supply, sewage treatment, and solid waste management. It also handles property tax collection and maintenance of city facilities.
- **PMPML (Pune Mahanagar Parivahan Mahamandal Limited):** PMPML is the public transport service provider in the Pune Metropolitan Region, which includes Pimpri Chinchwad. It operates bus services within the city and its suburbs, providing connectivity and public transportation options to residents.
- **Maha Metro (Maharashtra Metro Rail Corporation Limited):** Maha Metro is responsible for the development and operation of the Pune Metro, an urban Mass Rapid Transit System (MRTS) in Pune and Pimpri Chinchwad. The metro system aims to provide a fast, reliable, and efficient mode of transportation to reduce traffic congestion and improve connectivity.
- **MSEDCL (Maharashtra State Electricity Distribution Company Limited):** MSEDCL is responsible for the distribution of electricity in Pimpri Chinchwad. It manages the power supply, maintenance of the electrical infrastructure, and ensure uninterrupted electricity to homes, businesses, and industries in the area.
- **MIDC (Maharashtra Industrial Development Corporation):** MIDC focuses on the industrial development of the region, providing infrastructure and facilities to promote industries.

Key strategic priorities of the city include: a new administrative building, a new 850-bed multi-specialty hospital in Moshi, a 4.5-kilometer (km) Pune metro extension from PCMC station to Nigdi, 30 percent EV penetration in new vehicle registrations by 2026, 500 public EV charging points by 2025, an increase in non-motorized transport infrastructure like bicycle lanes, phasing-out of diesel buses and 192 additional electric buses.

Image: IFC

Built Environment & Energy

Pimpri Chinchwad covers an area of 181 km², with 1,378 km of roads and 51.6 million square meters (m²) of buildings, 70 percent of which are residential (*Figure 3a*). There are approximately 145 thousand m² of municipal buildings, 37 percent of which are residential and 36 percent of non-residential (*Figure 3b*). The state-owned utility, MSEDCL, supplies electricity to households and businesses. Most of the energy used by buildings is electricity from the grid (83 percent).



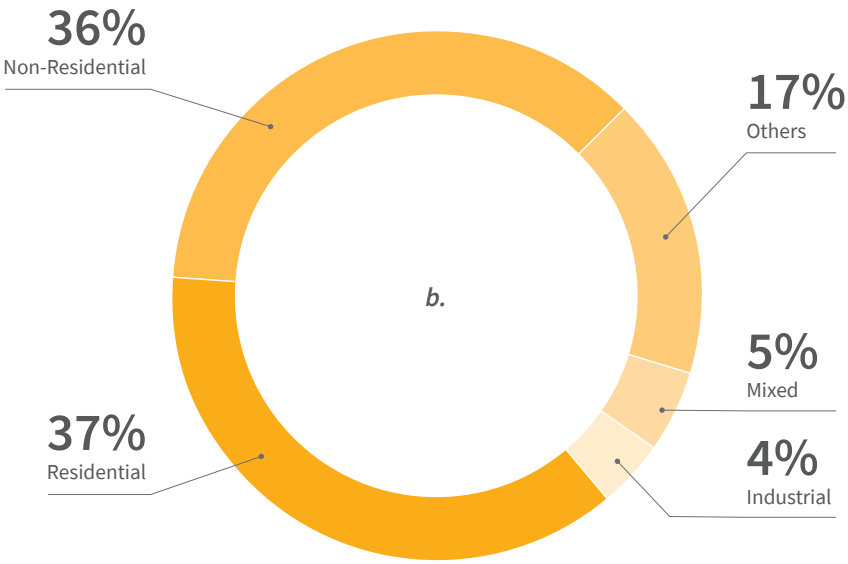


Figure 3: *a) City-wide Building Area; b) Municipal Building Area. Data for 2023, explanation and sources are shown in Appendix A.*

Transportation

Each resident of Pimpri Chinchwad is estimated to take an average of 2 trips per day, and the estimated average distance travelled per trip is 12 km. There are over 1.4 million two-wheelers and 0.4 million private automobiles operating in the city. As shown in *Figure 4*, most passenger-kilometers travelled (PKT) are by two-wheelers (35 percent) and bus rapid transit (BRT) buses (33 percent). Additional public transportation options include auto-rickshaw (10 percent), metro (2 percent PKT) and taxi (2 percent). The Rainbow BRT system is a hybrid bus system with a daily ridership of 520,000 passengers. The system uses 45.5 km of dedicated two-way bus lanes and extends in mixed traffic to outlying areas. Non-motorized transport modes make up a relatively low percentage of the total PKT (walking is 3 percent and bicycling is 2 percent).

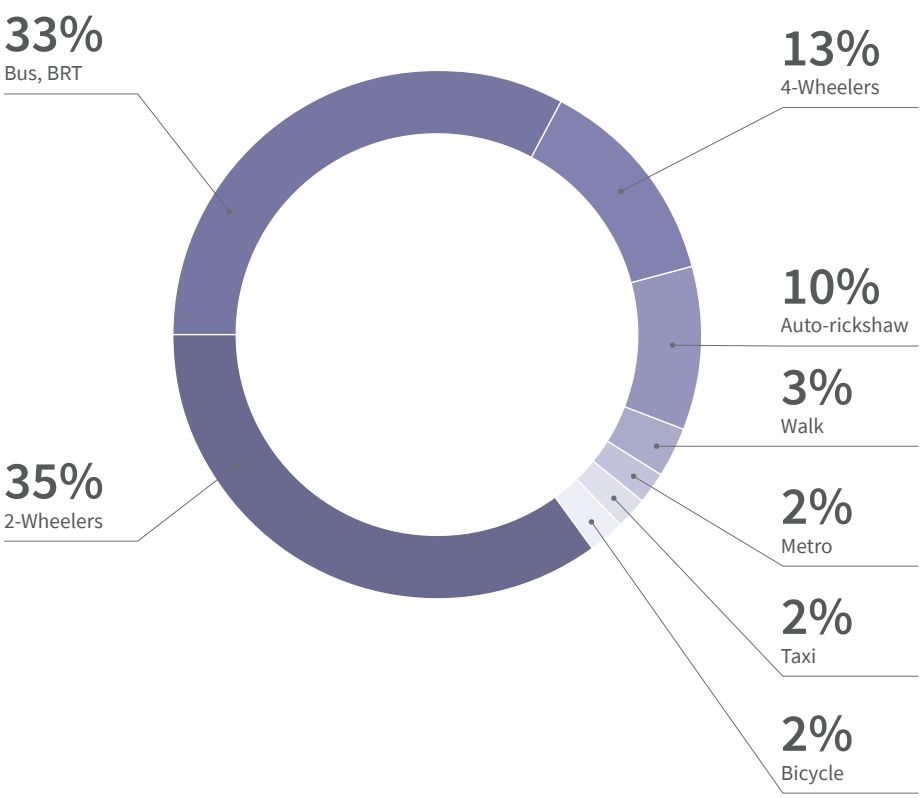


Figure 4: *Modal split by PKT for 2023. Data and sources are shown in Appendix A.*

Solid Waste

The primary landfill site for Pimpri Chinchwad is located at Moshi Village, approximately 15 km from the city center on an area of 33 hectares. Excluding industrial and C&D waste, municipal solid waste (MSW) generation is 0.15 metric tonnes (t) per person per year, as per Environmental Status Report 2021-2022 provided by the city.

As shown in *Figure 5a*, the composition of MSW is predominately organic waste (52.6 percent), followed by wood (10.5 percent), plastics (9.3 percent), textile (9.2 percent), rubber and leather (4.2 percent), glass (3.8 percent), paper and cardboard (2.1 percent), metal (1.2 percent) and other waste (7.1 percent). Waste treatment methods include waste-to-energy (40 percent; *Figure 5b*), landfill (35 percent), anaerobic digestion (8 percent), recycling (8 percent), and composting (7 percent).

Figure 5: *a) MSW composition; b) Waste treatment methods. Data for 2023, explanation and sources are shown in Appendix A.*

Water

Most of the water supply in Pimpri Chinchwad is sourced from surface water (95 percent; *Figure 6a*), with some supply from recycled wastewater (5 percent). The city's water utility supplies an average bulk water consumption of 140 liters (L) per person per day, with unaccounted-for water losses comprising 45 percent of that value. Industrial water consumption is at 30 million L per day (MLD). As shown in *Figure 6b*, the majority of wastewater is treated by the city at wastewater treatment plants using Sequencing Batch Reactor (SBR) systems (50 percent) and Activated Sludge Process (ASP) systems (45 percent). There are also some households that treat wastewater with septic systems (4 percent). The remaining 1 percent of sewage is released into water bodies without undergoing any treatment process.

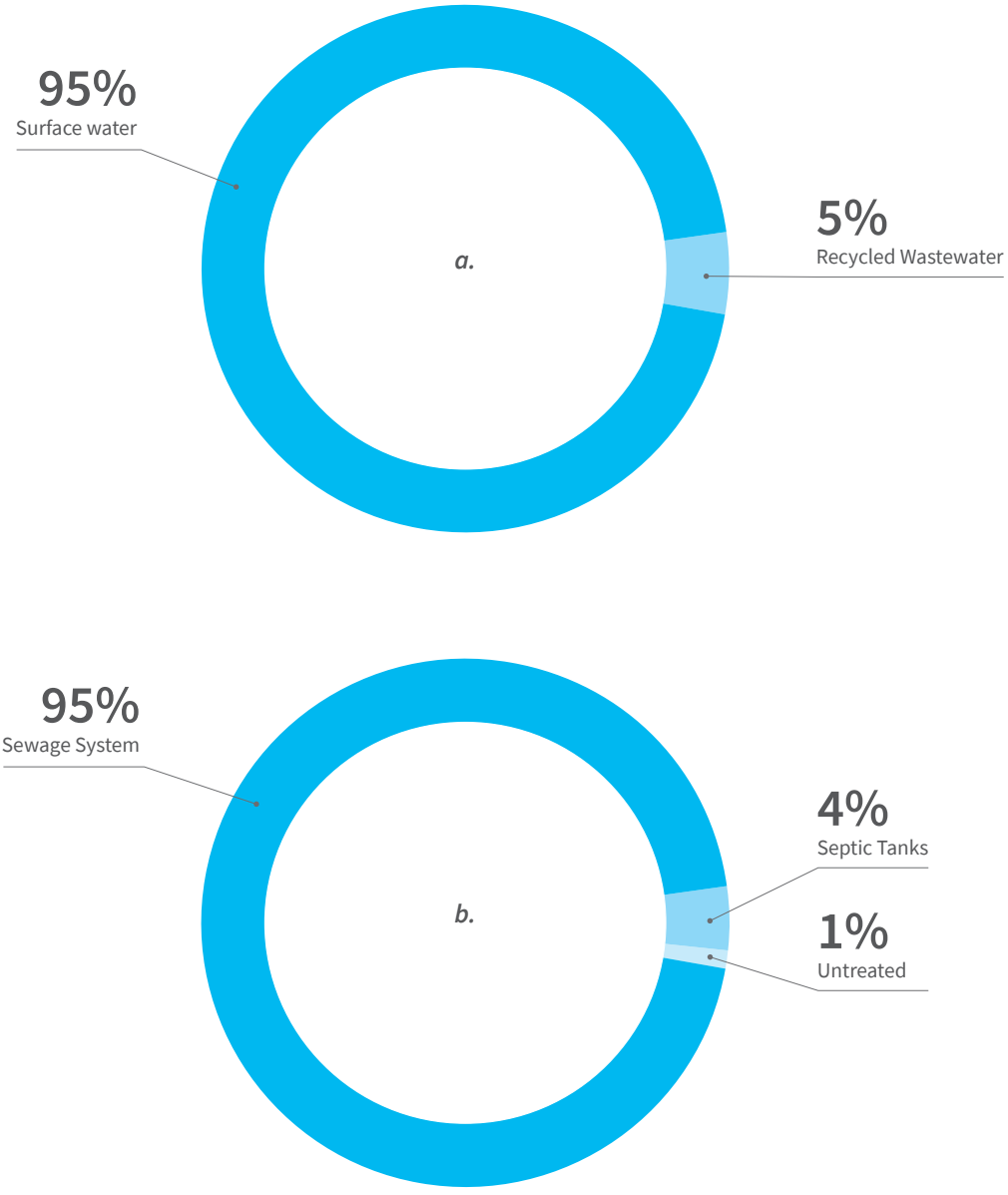


Figure 6: *a) Water supply; b) Wastewater treatment methods. Data for 2023, explanation and sources are shown in Appendix A.*

Greenhouse Gas Emissions

APEX can be used to help build a GHG emissions inventory with the data above[1]. For the baseline year 2023, tonnes of carbon dioxide equivalent missions from all the sectors listed above were 4.7 $MtCO_2e$, or approximately 1.7 tonnes of carbon dioxide equivalent (tCO_2e) per capita. As shown in *Figure 7*, the largest contributor to GHG emissions was the built environment and energy sector (75 percent), followed by transportation (20 percent), solid waste (4 percent), and water and wastewater (1 percent).

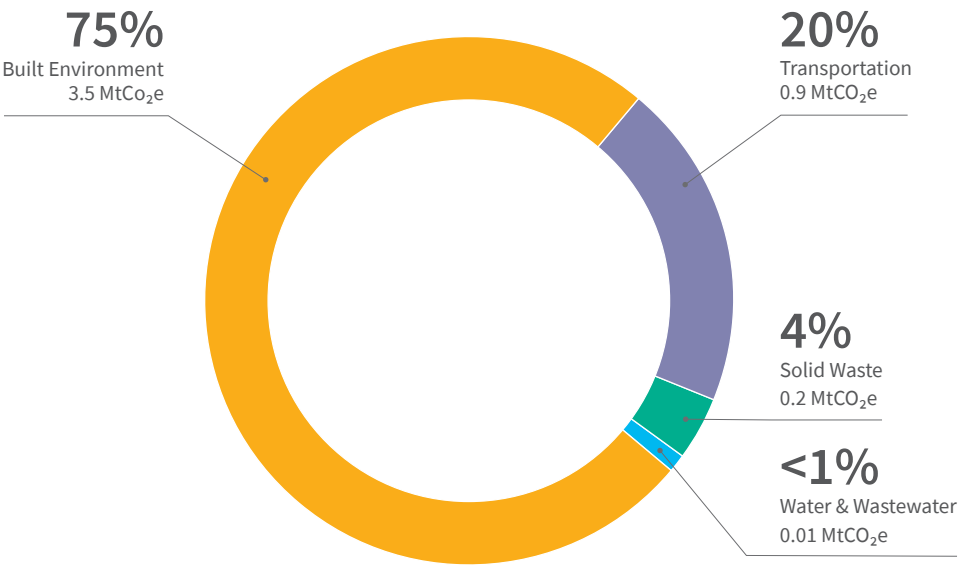


Figure 7: *Sectoral breakdown of Pimpri Chinchwad's GHG emissions in 2023. Calculated using APEX for Built Environment & Energy, Transportation, Waste, and Water sectors.*

[1] The APEX GHG methodology is consistent with the BASIC reporting requirements of the GHG Protocol for Cities, available: https://ghgprotocol.org/ghg-protocol-cities. The APEX GHG methodology does not currently include emissions from industrial or agricultural sectors.

Green City Action Plan Summary

Through the process of developing the Green City Action Plan, the IFC team worked with representatives from several departments within PCMC (including the Building Permission Department, Traffic and Transport Department, Environment Department, Water Department, and Property Tax Department, among others), as well as PMPML and Maha Metro to explore various actions and evaluate them in terms of their costs and benefits.

The Green City Action Plan uses the year 2023 as its baseline, and projects to the year 2030. The APEX online software helped to quantify the impact of investment, planning, and policy solutions—referred to as measures—in the year 2030. The Green City Action Plan includes 32 solutions across the four sectors: built environment and energy, transportation, waste, and water (*Figure 8*).

Figure 8: *The Green City Action Plan includes 32 solutions across built environment and energy, transportation, waste, and water sectors.*

Note: The text is written in the present tense to reflect what has been modelled by the APEX tool today. The scenario that is modelled takes place in the future.

Greenhouse Gas Emissions

With all 32 measures combined, the Green City Action Plan could result in a **27 percent savings in carbon emissions** compared to the business-as-usual (BAU) forecast for 2030. *Figure 9* shows the baseline year emissions for 2023, the future BAU emissions forecast for 2030, as well as the potential savings with all 32 measures implemented, referred to as the Improved Case for 2030.

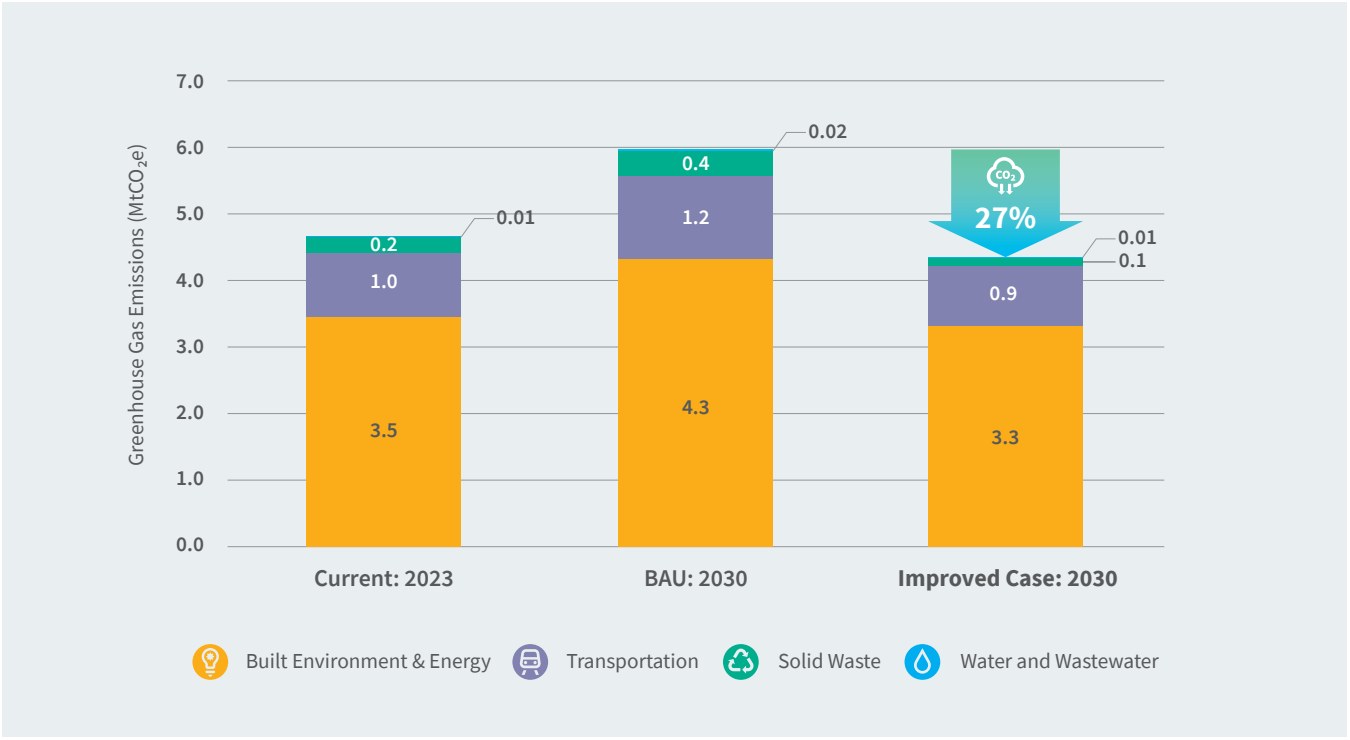


Figure 9: *Current, BAU, and Improved Case for GHG emissions ($MtCO_2e$/year). The 32 measures are expected to reduce the 1.62 $MtCO_2e$, representing a savings of 27 percent compared to the BAU case.*

PCMC generates up to 12 MW energy at its Moshi waste-to-energy plant

Image: IFC

Built Environment & Energy

The actions in the built environment and energy sector include upgrades to both private and municipal buildings, including improving energy efficiency in existing buildings, building new green buildings, and increasing solar electricity generation. Energy savings are defined as reductions in fossil fuel energy consumption, which encompasses reducing demand for fossil fuel-generated electricity, as well as replacing energy sources with renewables.

The 7 prioritized measures and individual impacts are shown in *Table 1*. With all Built Environment & Energy measures combined, the Improved Case scenario represents a **21 percent savings in fossil fuel energy use** compared to BAU (*Figure 10*).

Image: IFC

Table 1: *Built Environment & Energy measures and individual impacts.*

Individual Measure	Fossil Fuel Energy Savings	GHG Savings
1. Rooftop Solar Hot Water	0.7%	0.6%
2. Urban Forestry	<0.1%	0.1%
3. Green Building Certification	5.2%	4.3%
4. EE Refurbishment for Private Buildings	1.8%	1.5%
5. Rooftop Solar PV Program for Private Buildings	10.9%	9.0%
6. Green Municipal Buildings	0.3%	0.3%
7. Rooftop Solar PV on Municipal Buildings	1.6%	1.3%
Total	**21%**	**17%**

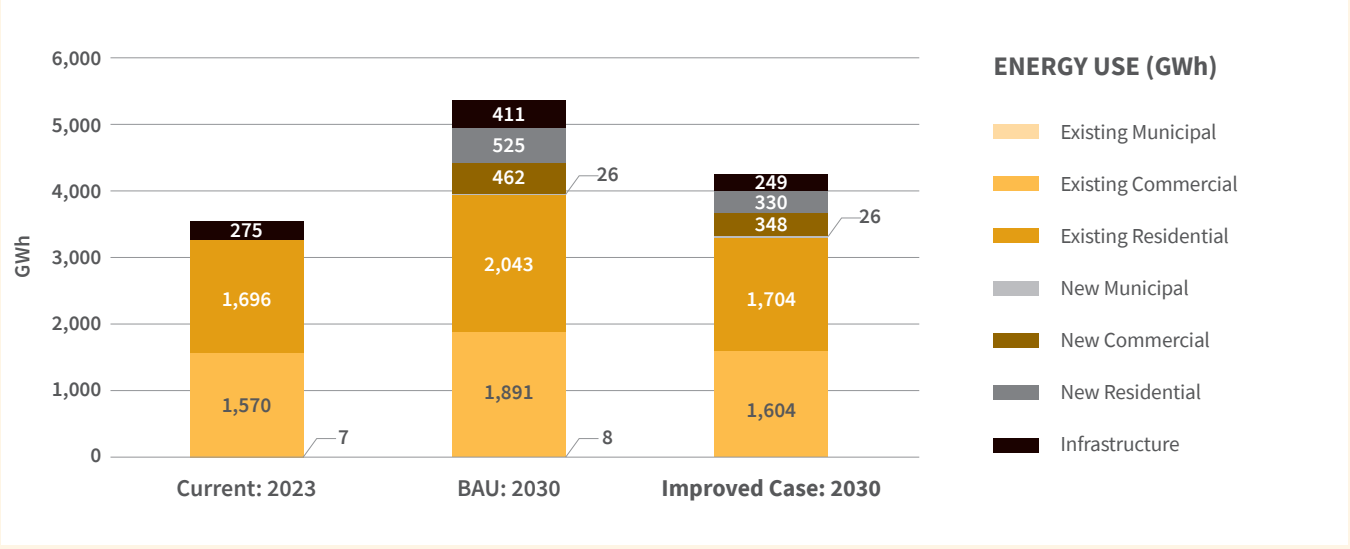


Figure 10: *Current, BAU, and Improved Case for fossil fuel energy use in gigawatt-hours per year (GWh/year).*

Transportation

Actions in the transportation sector focus on shifting travel from private cars to public transport, as well as electrifying public and private vehicles. There are ambitious plans to expand public transportation infrastructure and drive adoption of electric mobility in Pimpri Chinchwad, and these aspirations are reflected in the large number of measures in this sector. It is important that increasing supply of public transportation is accompanied by appropriate policies, initiatives, and spatial planning strategies to ensure successful implementation.

The 12 prioritized measures and individual impacts are shown in *Table 2*. With all measures combined, the Improved Case scenario represents a **28 percent savings in private fossil fuel vehicle-kilometers travelled (VKT)** compared to 2030 BAU (*Figure 11*).

Image: Ernest Ojeh on Unsplash

Table 2: *Transportation measures and individual impacts.*

Individual Measure	Private Fossil Fuel VKT Reduced	GHG Savings (%)
1. Retire Inefficient Vehicles	-	0.2%
2. Min. Efficiency for New Vehicles	-	0.5%
3. EV Charging Infrastructure	0.2%	<0.1%
4. Promote Private Electric Vehicles	5.1%	0.8%
5. Bicycle Lanes	1.0%	0.3%
6. Extend BRT System	0.5%	0.1%
7. Expand & Electrify BRT Bus Fleet	17.1%	3.6%
8. Extend Metro System	0.3%	0.1%
9. Add Park-and-ride Lot to Transit Station	<0.1%	<0.1%
10. Introduce Fare Integration Across Transit System & Smart Transit Fare Cards	0.2%	<0.1%
11. Electrification of Municipal Fleet	<0.1%	<0.1%
12. Electrification of Auto-Rickshaws	3.2%	0.1%
Total	**28%**	**6%**

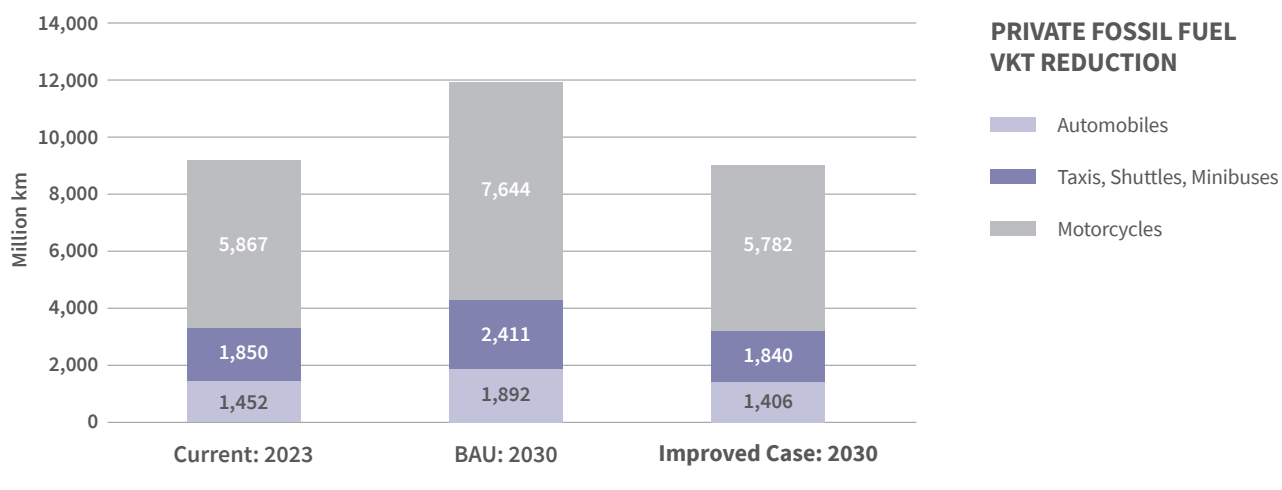


Figure 11: *Current, BAU, and Improved Case for private fossil fuel vehicle travel (Million km/year).*

Waste

Actions in the waste sector support extraction of value from waste that is diverted from landfill, including composting, anaerobic digestion, and waste-to-energy. It also including reducing waste that is generated through a single use plastic ban, as well as expanding waste collection as the city grows. There are ambitions in Pimpri Chinchwad to have nearly zero waste sent to landfill.

The 5 priority measures and individual impacts are shown in *Table 3*. With all measures combined, the Improved Case scenario represents a **94 percent savings in waste sent to landfill** compared to 2030 BAU (*Figure 12*).

Image: IFC

Table 3: *Waste measures and individual impacts.*

Individual Measure	Landfill Waste Reduced	GHG Savings
1. Decentralized Composting	11%	0.5%
2. Ban Single Use Plastic	0.1%	<0.1%
3. Improve Waste Collection	11%	0.4%
4. Waste-to-Energy Facility	51%	2.0%
5. Centralized Anaerobic Digestion	22%	1.1%
Total	**94%**	**4%**

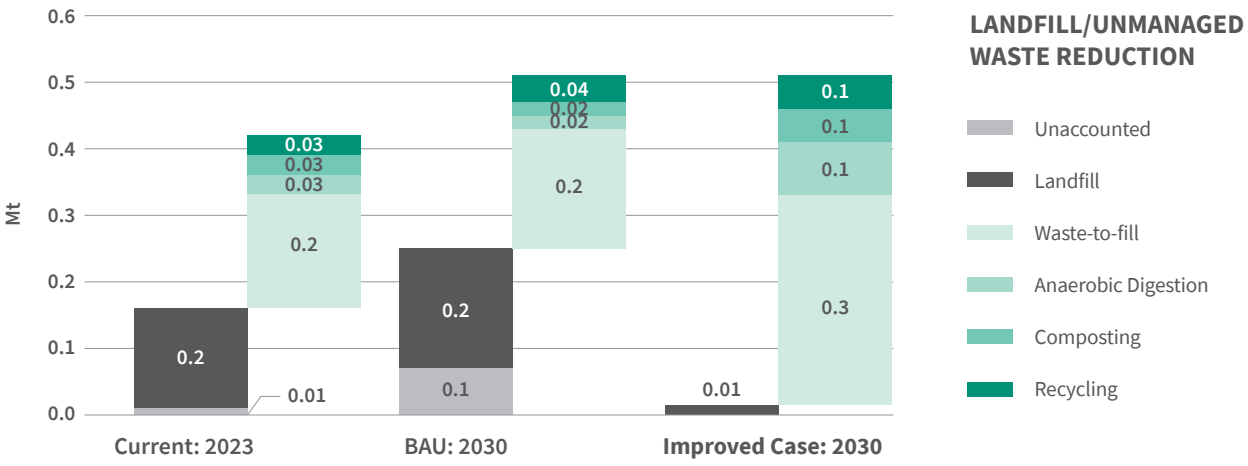


Figure 12: *Current, BAU, and Improved Case for waste disposal in million tonnes per year (Mt/year).*

Water

Actions in the water sector focus on improvements to water security, which includes both reducing the demand for water and diversifying sources for water supply. The measures target water security at the building level with efficient fittings, rainwater harvesting, and building water reuse, as well as system-wide with actions such as reducing water losses, improving efficiency of water pumping, and water reuse at the municipal scale. This sector also includes expansion and improvement of wastewater treatment facilities.

The 8 priority measures and individual impacts are shown in *Table 4*. With all measures combined, the Improved Case scenario represents a **43 percent improvement to water security** compared to 2030 BAU *(Figure 13)*.

Image: IFC

Table 3: Waste measures and individual impacts.

Individual Measure	Water Security Improved	GHG Savings
1. Rooftop Rainwater Harvesting	0.5%	<0.1%
2. Reuse Wastewater at Municipal Scale	10%	<0.1%
3. Reuse of Wastewater From New & Existing Buildings	3%	<0.1%
4. Reduce Unaccounted-for Water Losses	27%	<0.1%
5. Improve Efficiency For Water Conveyance Pumps	-	0.1%
6. Efficient Fittings in New & Existing Buildings	2%	<0.1%
7. Smart Water Meters	0.8%	<0.1%
8. New Centralized Wastewater Treatment Facilities	-	0.1%
Total	**43%**	**0.2%**

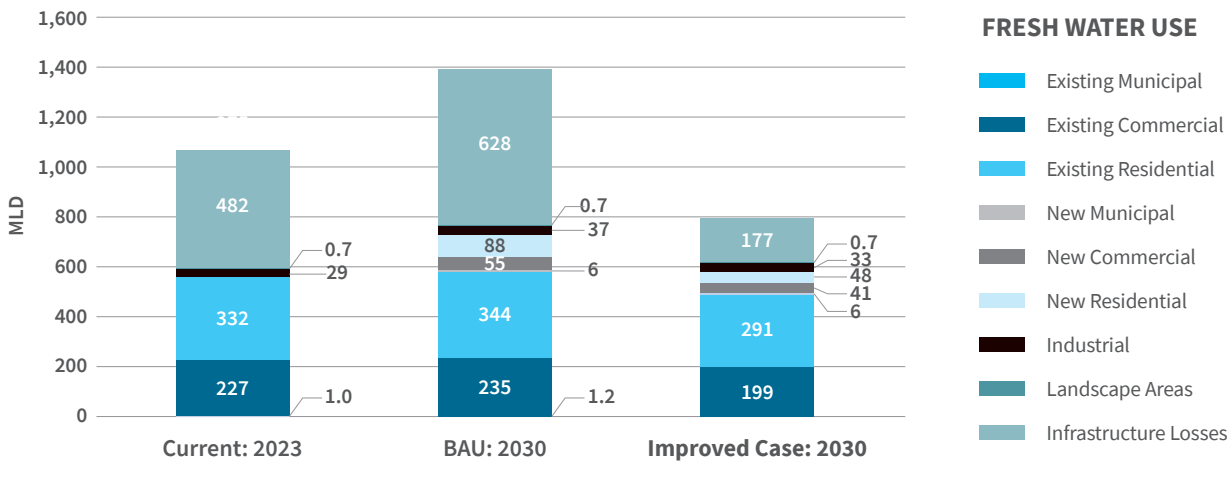


Figure 13: Current, BAU, and Improved Case for freshwater use (MLD).

Priority Measures

Built Environment & Energy

Measures in the built environment and energy sector include reducing energy consumption in public and private buildings, promoting green building certification for new construction, increasing green space, and increasing the share of renewables in the energy mix. Building energy consumption includes electricity and other fuels that power all energy needs, including water heating, space cooling, cooking, lighting, appliances, and other equipment. Measures target reductions to fossil fuel energy use in both commercial and residential buildings.

Table 5: Summary of all Built Environment and Energy measures.

Measure	Fossil Fuel Energy Savings (Gwh/year)	GHG Savings ($ktCO_2e$/year)	Total Cost (INR crore)
1. Rooftop Solar Hot Water	39	36	2,595
2. Urban Forestry	0.4	6	1,094
3. Green Building Certification	281	258	1,000
4. EE Refurbishment for Private Buildings	98	90	1,124
5. Rooftop Solar PV Program for Private Buildings	586	539	3,530
6. Green Municipal Buildings	19	17	82
7. Rooftop Solar PV on Municipal Buildings	83	77	503
Total	**1,106**	**1,023**	**9,927**

Rooftop Solar Hot Water

Description

For this measure, the city requires solar hot water systems on 25 percent rooftops of habitable buildings, including hotels, health, and residential buildings. Solar hot water systems work by using rooftop solar collectors to warm water that then flows through the building's plumbing system. Active solar hot water systems circulate water using pumps, while passive systems rely on gravity to circulate hot water.

Context

The city has adopted Unified Development Control and Promotion Regulations for Maharashtra State (UDCPR) policy to promote the use of renewable energy sources in new buildings (Urban Development Department, Government of Maharashtra; 2020). According to this policy, any new building that has a plot area of more than 4,000 m² must install either a roof top photovoltaic (RTPV) system or a solar assisted water heating (SWH) system on their roofs. At least 25 percent of the roof area shall be utilized for installation of the SWH/RTPV system. These systems can generate electricity or heat water using solar energy, respectively.

Projects with built up area of 20,000 m² and above require prior Environmental Clearance (EC) from the State Environmental Impact Assessment Authority (SEIAA) (Ministry of Environment, Forest and Climate Change; 2022). To get an EC, it is mandatory for commercial and institutional buildings to have a solar water heating system that can provide at least 20 percent of the hot water demand. The code also encourages residential buildings to meet hot water demand from solar water heaters, as far as possible.

Results

39
Fossil Fuel Energy Savings (GWh/year)

36
GHG Savings ($ktCO_2e$/year)

2,595
Total Cost (INR crore)

Implementation Next Steps

Further scoping is required to include small and medium scale projects. The city can establish a dedicated helpdesk to provide technical support to building owners and developers. Detailed guidelines and best practices for the installation and maintenance of solar energy systems may be published to assist with planning.

The city can introduce incentives for early adopters and provide subsidies for solar hot water installation, particularly targeting residential buildings. An awareness campaign can educate the public on the benefits of solar hot water systems, and workshops can be offered to professionals involved in building design and construction. The city can develop partnerships with solar technology providers and educational institutions, as well as collaborate with local utilities to integrate these systems into the energy infrastructure seamlessly.

The following case study illustrates an implementation example from Bengaluru, India.

Case Study: Bengaluru, India

Image: Singh VP on Pixabay

Rooftop solar water heater in Bengaluru.

Problem

In the hopes of addressing its long-standing power shortage issues, the city of Bengaluru aimed to promote the widespread use of solar energy in its residential, public, and industrial buildings.

Solution

In 2007, Bengaluru Electricity Supply Company (BESCOM) mandated the installation of solar water heaters in buildings with a floor area of at least 55 m² and constructed on land parcels of 110 m² or larger. The required solar thermal capacity is proportional to the size of the room.

Results

In a span of ten years, 1,234 million m² of solar water heater collector area had been installed, supplying energy equivalent to approximately 611 million kWh of electricity required for showering per year. Annual installations of solar water heater collector area increased from 12,374 m² in 2007 to 113,684 m² in 2017.

Financing

In 2012–2015, the Ministry of New and Renewable Energy (MNRE) deducted an incentive amount from the electricity bills of households in a multi-family building with several systems, provided that the capacity of the system is 100 liters or more.

Urban Forestry

Description

With this measure, the city aims to increase the extent of urban forestry by planting more trees, creating more green spaces, and creating green belt along the non-motorized transport (NMT) infrastructure. It includes the 14 km long Harit Setu Project that will be executed as Green Corridors at five locations (D.Y. Patel College stretch in Akurdi, D.P. Road in Pimple Nilakh, Nigdi Pradhikaran, Akurdi Station road, and Bhondwe Chowk in Ravet). Through this project, 0.21 km^2 of green cover will be added within the city. The estimate is based on 30 m wide NMT street design, of which 50 percent of the street is covered by trees. The project will enhance the environmental, social, and economic benefits of urban forests, such as carbon sequestration, air quality improvement, biodiversity conservation, recreation, and health.

Context

The green area of the city covers 48.2 percent (85.3 km^2) of the total area of the city (*Figure 14*). This includes areas like gardens, trees, shrubs, herbs, and other dense patches. The city has forested lands within its boundaries. These lands are areas of greenery that are owned and maintained by the Indian Army and are not accessible to the public. However, they still provide some benefits for its residents, such as reducing the urban heat island effect, improving air quality, and enhancing biodiversity.

The city has prepared an urban forestry master plan (Terracon Ecotech Pvt Ltd., 2021). It suggests the native planting materials appropriate for the Pimpri Chinchwad region, along with various landscape guidelines that are applicable to each ward and the city as a whole.

The city has 164 gardens with a total area of 166 hectares (PCMC, 2019). The Garden Department of Pimpri Chinchwad Municipal Corporation works towards maintaining and increasing the open and green spaces of the city. The department has undertaken road beautification and 45 km of roadside plantation projects on various roads. An additional 14 km of roadside tree plantation or median beautification under the Harit Setu project is under construction.

Some specialized and popular gardens are ornamental assets of the city, including: Bahinabai Choudhari Zoo, Bird Valley, Rajershi Shahu Udyan, Bhakti Shakti Udyan, Thergaon Boat Club, Bhosari Tourism Centre, Durgadevi Park, Veer Sawarkar Udyan and Nana Nani Park.

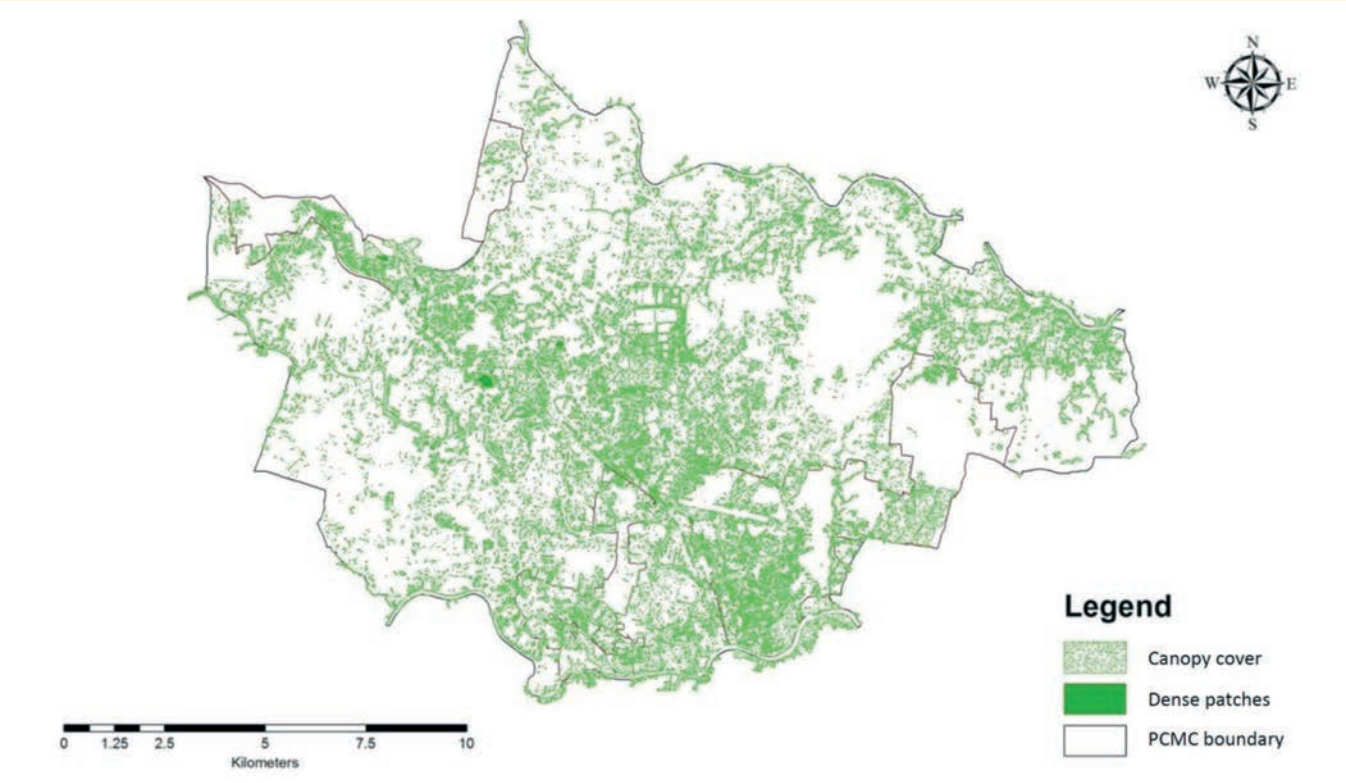


Figure 14: *Green Cover of the city. (Source: Census of Trees and Development of Application for Tree Management using GIS Platform, Terracon Ecotech Pvt. Ltd, 2021)*

Results

0.4
Fossil Fuel Energy Savings (GWh/year)

6
GHG Savings ($ktCO_2e$/year)

1,094
Total Cost (INR crore)

Implementation Next Steps

To foster the growth of urban forestry, a dynamic approach is essential. The city can lead this initiative by revising the urban forestry master plan every five years. This periodic update ensures that the strategy remains relevant and responsive to the evolving needs of the urban ecosystem.

A robust monitoring and evaluation system is crucial to track the progress and health of the urban forest. Such a system would not only monitor growth but also assess the forest's impact on air quality, biodiversity, and its role in carbon sequestration. This data is invaluable for making informed decisions that align with environmental sustainability goals.

By involving local communities in the planning process, the city can cultivate a sense of ownership and stewardship among residents. Organizing tree-planting events and educational workshops empowers citizens to take an active role in enhancing their environment.

The integration of green spaces with NMT infrastructure can significantly improve the quality of life for pedestrians and cyclists. These green corridors serve as a buffer zone, reducing noise pollution and providing a serene environment for commuters and recreational users alike.

Securing funding and establishing partnerships are pivotal for the long-term success of urban forestry projects. The city can explore various avenues, including government grants, private sponsorships, and collaborations with local NGOs, educational institutions, and businesses. These partnerships not only provide financial support but also foster community involvement and innovation.

Finally, the city can develop a long-term Urban Forestry Management Plan (UFMP) for the gradual expansion of green spaces, setting ambitious yet achievable targets to increase the city's green cover percentage over the next decade.

Green Building Certification

Description

For this measure, the city requires new developments to take advantage of green building incentives. The measure targets 50 percent of new buildings receive green building certification, which entails achieving a minimum of 20 percent energy savings beyond Energy Conservation Building Code (ECBC) and Eco Niwas Samhita (ENS) code requirements. Some green building certification programs, such as IFC's EDGE program, including savings in water use and embodied energy in materials in addition to energy savings. IFC's EDGE certification is well-suited to be tied into municipal policy due to its ease of use, low cost, and scalability. The city can pair the regulatory policy with incentives to support developers to pursue green buildings.

Results

281
Fossil Fuel Energy Savings (GWh/year)

258
GHG Savings ($ktCO_2e$/year)

1,000
Total Cost (INR crore)

Context

The city has approximately 51.6 million m^2 of building stock, with 40 million more expected to be constructed in the next 7 years. The city is a major manufacturing hub for several industries, including the automotive and pharmaceutical industries. A few initiatives exist to encourage developers to build green. First, developers qualify for additional floor-area ratios (FAR) for new green buildings rated by India Green Building Council (IGBC) and Green Rating for Integrated Habitat Assessment (GRIHA). The city is working with IFC on including EDGE in the FAR incentive. Second, buildings with a green rating certification qualify for 10-50 percent discounts on premium charges for building permission depending on the GRIHA rating (1-5 stars) of the project. Additionally, the end users of the GRIHA compliant projects also get a discount of 5-10 percent on property tax for 3–5-star GRIHA rated buildings and 5-15 percent for Simple Versatile Affordable GRIHA (SVAGRIHA) rated buildings (PCMC, 2011).

Implementation Next Steps

The next step for the city to progress further is to include low cost, scalable and easy to use green building rating system like EDGE for the incentives. With EDGE infrastructure and networks already in place in India, the next step is to develop the regulatory approach and incentive structure that works for all green building rating systems. An approach for incentives can be based on performance on energy, water, and material savings instead of level of rating.

Along with the financial incentives, to further increase the uptake of green buildings, the city can provide technical assistance and training for developers who want their properties to be green certified. The technical assistance and capacity building can be done in collaboration with NGOs and green building rating facilitators. This support is useful since green building requirements are often new or unfamiliar for private sector initiators.

With EDGE infrastructure and networks already in place in India, the next step is to develop the regulatory approach and incentive structure that works for all green building rating systems.

Image: edgebuildings.com

Energy Efficiency Refurbishment for Private Buildings

Description

This measure targets private residential and commercial buildings for energy efficiency improvements, aiming for upgrades in 10 percent of existing buildings. Upgrades may include efficient lighting/appliances, improved windows and building envelopes, upgraded heating, ventilation and cooling systems, energy efficient ceiling fans, and others.

Context

The city currently lacks a financing program for the energy efficiency refurbishment of private buildings. Energy efficiency refurbishment offers a significant opportunity to reduce energy consumption and GHG emissions in existing residential and non-residential buildings. The city has an existing building footprint of 51.6 million m^2, with 70 percent residential, 18 percent commercial, and the remaining 12 percent comprising various other types of buildings, including institutional and healthcare facilities.

By focusing on energy efficiency improvements in these structures, especially in the residential and commercial sectors, which constitute the majority of the building footprint, the city can achieve substantial reductions in energy use. Measures such as improved insulation, energy efficient windows, and modern air conditioning systems can lead to significant savings.

Results

98
Fossil Fuel Energy Savings (GWh/year)

90
GHG Savings ($ktCO_2e$/year)

1,124
Total Cost (INR crore)

Implementation Next Steps

The city, or a financial institution partnered with the city, can develop a financing program for energy efficiency refurbishment of private buildings. There are several models that have worked well in cities around the world, including property-linked financing, on-bill financing with utilities, and energy service companies (ESCOs) providing equipment for a periodic fee tied to energy savings. One example of such a program is the Property Assessed Clean Energy (PACE) program, which finances energy efficiency improvements and renewable energy in existing buildings. The PACE loan is attached to the property rather than the individual or company that owns the building. Governments or private lenders provide financing to building owners to cover the upfront costs of energy efficiency improvements. Loans are repaid by increasing property taxes at a set rate for an agreed-upon term. Property owners can start saving on energy costs while paying for improvements, often resulting in net gains despite increased property tax.

Rooftop Solar PV Program for Private Buildings

Description

With this measure, the city implements a program to encourage installation of solar photovoltaic (PV) panels on rooftops of buildings, along with existing government rooftop solar subsidy programs. The measure aims for an installed capacity of 400 megawatts (MW), which is equivalent to 30 percent of the roof area of all buildings in the city, though solar panels could also be ground mounted.

Context

The city has adopted the Maharashtra State UDCPR policy that promotes renewable energy sources in new buildings. According to this policy, any new building that has a plot area of more than 4,000 m² must install an RTPV system on its roof. At least 25 percent of the roof area shall be utilized for the system.

Furthermore, it is mandatory for projects with a built-up area between 5,000 and 20,000 m² to install a solar/wind/hybrid renewable system that can meet at least 1 percent of the demand load. This is part of the PCMC Environmental Clearance Self Declaration list, which contains a set of environmental norms and standards that are mandatory for developer compliance.

The city has adopted the solar project subsidy of Maharashtra, managed by the Maharashtra Energy Development Agency (MEDA). The subsidy is available through the central government Rooftop Solar Program Phase II scheme by the Ministry of New and Renewable Energy (MNRE). The program provides INR 30,000 per kilowatt (kW) subsidy for rooftop solar PV systems up to 2 kW capacity, INR 18,000 per kW for additional capacity upto 3 kW, and subsidy for systems larger than 3 kW capped at INR 78,000 for individual households (MSEDCL, 2024).

Results

586
Fossil Fuel Energy Savings (GWh/year)

539
GHG Savings ($ktCO_2e$/year)

3,530
Total Cost (INR crore)

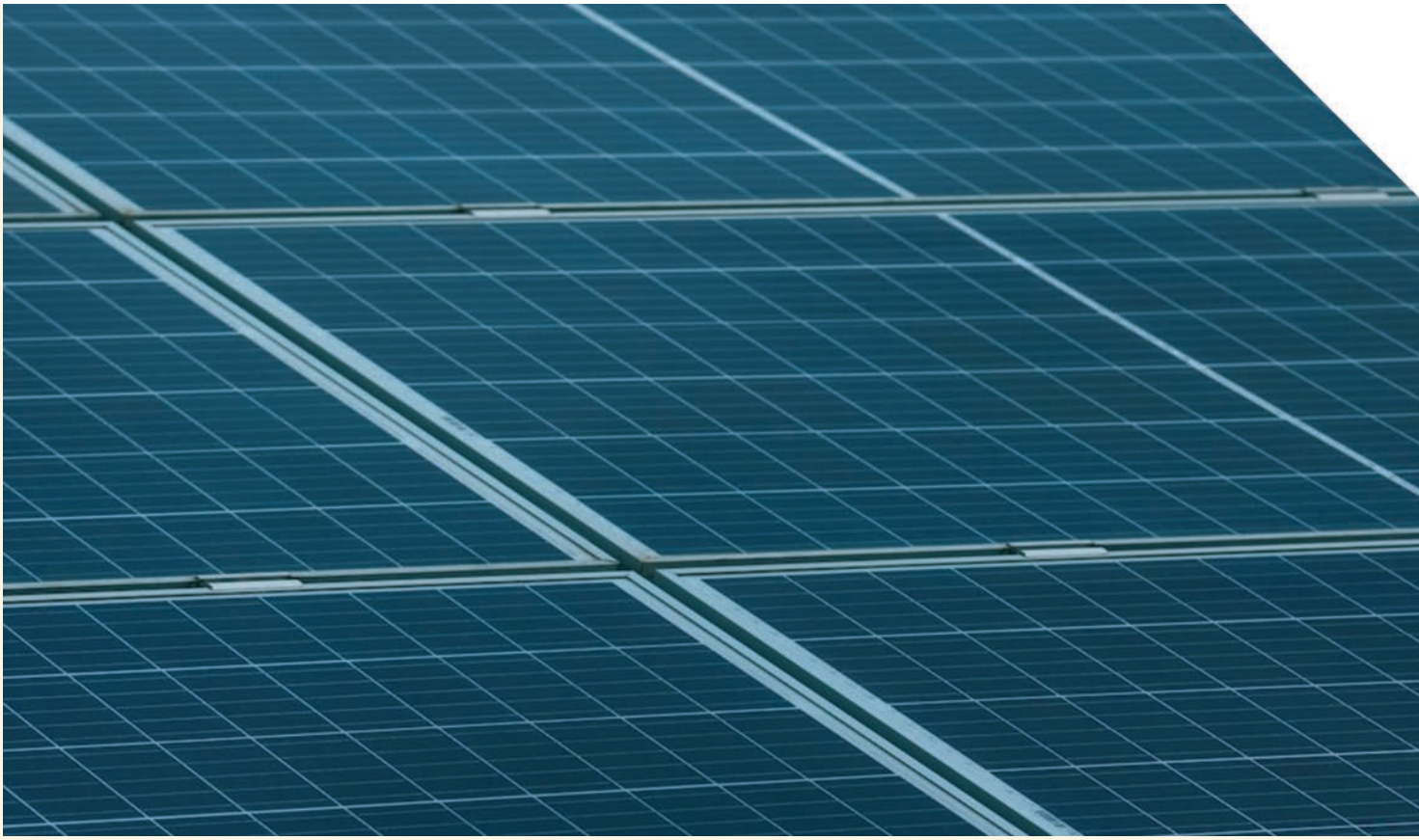
Implementation Next Steps

The city can initiate a dialogue with the local power distribution company, MSEDCL, and MEDA to improve coordination and data sharing to make informed implementation decisions. The city can leverage government schemes and initiatives like the grid connected rooftop solar program (Phase II) and solar net metering. The city can also work with the private sector to implement business models such as Renewable Energy Service Company (RESCO) with a long-term power purchase agreement or roof leasing, which allow consumers to access renewable energy without upfront costs. Further implementation steps involve exploring technical and legal details, as well as engaging stakeholders.

The following case study illustrates an implementation example from Vadodara, India.

Case Study: Vadodara, India

Image: Markus Spiske on Unsplash



Madhav Solar has installed solar PV panels on privately-owned properties under the Vadodara Solar project.

Problem

To improve energy services at affordable prices and support the transition to renewable energy, the government of Gujarat sought to replicate a rooftop solar project from 2010, this time in the city of Vadodara.

Solution

Solar PV panels were installed on the rooftops of primarily privately-owned properties, offering a lease rental to the owners for accessing the roofs. The individual solar systems were connected to the local grid by the developers, who then sold the generated power to the local distribution utility.

Results

The project, which was projected to become operational between 2015–2016, is estimated to provide improved energy services at affordable prices to 9,000 individuals while reducing GHG emissions by 5,443 tonnes per year. Rooftop owners can now access economic benefits from their previously unused spaces, in the form of rent from developers.

Financing

IFC, as the lead advisor, was responsible for bidding out the Vadodara Solar project. The estimated total project cost is $8 million, which would be fully financed by the winning bidder, Madhav Solar, under a 25-year concession.

Green Municipal Buildings

Description

With this measure, the city commits to building green for all new municipal buildings, as well as retrofitting existing buildings to be more energy and water efficient. The results are based on over 300 thousand m² of new municipal buildings to be constructed according to green building principles, resulting in at least 20 percent reduction in their energy and water use. Results also consider energy efficiency refurbishment is conducted in all existing municipal buildings, 145,000 m², reducing energy use in these buildings by at least 20 percent on average.

Context

The city owns and operates over 145,000 m² of buildings, including municipal offices, emergency services, cultural centers, schools, sports facilities, hospitals, among others. The city is growing and there are construction projects under development.

The city has adopted GRIHA, the national rating system for green buildings in India, to reduce the environmental footprint generated by the building industry. At present, IFC is providing advisory services to the city in pursuing EDGE certification for the new 850-bed hospital in Moshi and the new municipal office building.

Results

19
Fossil Fuel Energy Savings (GWh/year)

17
GHG Savings ($ktCO_2e$/year)

82
Total Cost (INR crore)

Implementation Next Steps

By adopting green building rating systems like EDGE, the city aims to reduce the carbon footprint, resource consumption, and GHG emissions of its buildings. The next step for the city is to finalize EDGE certification for Moshi hospital and the new municipal office building, which can serve as pilots for other new municipal buildings.

Energy efficiency refurbishment efforts for existing municipal buildings would be most effectively carried out in a sequence, ranked by total facility energy consumption. Upgrade efforts can be prioritized by annual energy consumption statistics, which should be gathered for all eligible city-owned facilities. Specific energy efficiency upgrades within each facility can be identified with an energy audit. Energy auditors will assess building elements such as lighting equipment, ventilation and cooling equipment, external envelope fabric, hours of use of the facility, general building fabric and building services equipment condition, and age of installations and residual life expectancy of this existing equipment. Upgrade planning and budgeting would be based on these assessments.

The city can utilize central schemes such as Bureau of Energy Efficiency (BEE) facilitated energy audits and situational surveys to identify suitable projects to save electricity under Municipal Demand Side Management (MuDSM). The city can explore financing support through BEE's Partial Risk Guarantee Fund for Energy Efficiency (PRGFEE). After refurbishment is complete, the city can continue to collect annual energy consumption statistics to assess the building's energy performance over time.

The following case study shows an implementation example from San Antonio, USA.

Case Study: San Antonio, USA

Image: Public Domain via goodfreephotos.com

The Energy Efficiency Fund was established in to support San Antonio's endeavor to retrofit buildings for energy efficiency.

Problem

With public buildings significantly contributing to the city's annual $34 million utility budget, San Antonio set out to reduce costs while significantly decreasing energy usage and lowering local emissions.

Solution

The Energy Efficiency Fund (EEF) was established in 2011 to help finance cost-effective retrofits and upgrades across the city's facilities. Moreover, the city is able to manage all retrofits in-house from design to close-out, which reduces management and installation costs while eliminating debt service.

Results

By 2015, the city had implemented 398 energy-efficiency projects across 180 facilities, resulting in annual electricity savings of 58,227,372 kWh and emissions reductions of 22,011 tonnes of CO_2e per year. Between fiscal year 2011 through 2019, San Antonio further achieved a total annual avoided cost savings of $1.6 million.

Financing

The fund was initially established using $4.6 million allocated to the city through the federal American Recovery and Reinvestment Act (ARRA). Since then, it has operated as a revolving loan fund, sustained by revenue generated from energy savings and rebates.

Rooftop Solar PV on Municipal Buildings

Description

With this measure, the city aims to add an additional 57 MW to its installed solar electricity generation capacity. This will include rooftop solar PV integration for new municipal projects, showcasing a forward-looking approach to sustainable energy practices. The city aims to install PV systems on the roofs of all new and existing public buildings, such as schools, hospitals, offices, and community centers. In addition to this, the city is also exploring the feasibility of constructing a solar park, which will help the city to reduce its electricity bills, GHG emissions, and dependence on fossil fuels, while also creating local jobs and promoting renewable energy awareness.

Results

83
Energy Savings (GWh/year)

77
GHG Savings ($ktCO_2e$/year)

503
Total Cost (INR crore)

Context

Pimpri Chinchwad is one of the fastest-growing urban areas in India; as such, it has a high and growing demand for electricity. The city has a high solar potential, with an average annual solar irradiation of 5.5 kilowatt-hours (kWh) per m² per day.
At present, the municipal buildings have an energy contract demand of 75 MW. However, the current share of solar energy in municipal buildings' electricity mix is 7 percent (5 MW). Most of the electricity is supplied by the state grid, which relies heavily on coal-fired power plants. The administration building of the city, Pimpri Chinchwad Mahanagarpalika Bhavan, generates renewable electricity with a 170-kW solar PV system on the rooftop.

The city has set an ambitious target of generating 57 MW of solar power in addition to already existing 5 MW. It has identified municipal buildings as a priority sector for rooftop solar deployment.

Implementation Next Steps

The first step for implementing the rooftop solar PV project on municipal buildings of Pimpri Chinchwad is to conduct a feasibility study. The study will assess the technical, economic, social, and environmental aspects of the project, and identify the optimal locations, sizes, and orientation of the rooftop solar PV systems. The study will also estimate the potential energy generation and savings, as well as the environmental benefits of the project.

The subsequent step is to prepare a detailed project proposal, based on the findings of the feasibility study. The proposal will include the scope, budget, timeline, and expected outcomes and impacts of the project. The proposal will also outline the process of applying for the rooftop solar subsidy scheme from the Ministry of New and Renewable Energy, which provides a financial incentive for installing rooftop solar PV systems in residential, institutional, and social sectors. The proposal will also describe the criteria and procedure of selecting an empaneled vendor from the National Portal for Rooftop Solar, which lists the qualified and registered vendors who can execute the projects through the portal (pmsuryaghar).
The proposal will also specify the contract terms and conditions with the selected vendor, and the necessary approvals and permits from the relevant authorities, such as the municipal corporation, the electricity distribution company (MSEDCL), and the fire department.

In cities around the world, there are several PPP-type arrangements that work well for increasing the share of solar power in municipal operations. The city does not necessarily need to own the solar PV assets to benefit from zero carbon solar electricity. For example, energy-as-a-service (EaaS) is a way to procure solar energy that transfers the operational and maintenance risks associated with rooftop solar PV infrastructure from the city to the private sector. The EaaS company arranges for financing and installation of the solar panels, and then carries out the energy services without the city investing its own capital into the projects. The city pays a recurring fee to the EaaS for delivery of solar electricity based on performance.

The following case study shows an implementation example from Cape Town, South Africa.

Case Study: Cape Town, South Africa

Image: Bill Mead on Unsplash

Cape Town is spearheading renewable energy with solar power initiatives, including solar panels on buildings and large-scale installations on city-owned land.

Problem

As the continent's largest energy consumer and emitter, South Africa is committed to reducing its carbon footprint and promoting the shift to renewable energy through the launch of several solar power initiatives.

Solution

Exploring options such as rooftop, ground-mounted, and floating installations, Cape Town aims to achieve a combined installed capacity of 5 megawatt-peak (MWp) on municipal buildings and roughly 50 MWp on city-owned land by 2030. Initiatives further include training programs for solar PV installers.

Results

As of 2015, Cape Town had installed rooftop solar PV at numerous municipal buildings and facilities, achieving a peak generation capacity of 247 kW. Although installations have been relatively small-scale and mainly offset electricity consumption rather than generate power, they help prepare the municipal staff for new forms of energy provision.

Financing

The city had invested approximately $8.57 million in grant and city funds towards energy efficiency interventions by 2015, which included the installation of rooftop PV panels on municipal buildings.

Sources: C40 Cities/Nordic Sustainability, 2019; City of Cape Town, 2015; International Renewable Energy Agency, 2018; World Energy Cities Partnership, n.d.

Transportation

Transportation measures focus on shifting travel from private cars to public transit, as well as electrifying cars, buses, and autorickshaws. The measures primarily focus on new infrastructure and vehicles, but there is an important balance between supply and demand of public transportation; that is, increasing the supply of public transportation must be balanced with policies that discourage private vehicles and making driving less convenient. It is important that new infrastructure is well-connected, safe, and accessible to make it easy for public transport riders to transition between modes.

Table 6: Summary of all Transportation measures.

Measure	**Fossil Fuel VKT Reduced** (Million Gwh/year)	**GHG Savings** ($ktCO_2e$/year)	**Total Cost** (INR crore)
1. Retire Inefficient Vehicles	-	10	1,553
2. Min. Efficiency for New Vehicles	-	29	2,925
3. EV Charging Infrastructure	23	1.6	67
4. Promote Private Electric Vehicles	612	50	14,985
5. Bicycle Lanes	121	15	10
6. Extend BRT System	54	5	4,582
7. Expand & Electrify BRT Fleet	2,039	218	482
8. Extend Metro System	39	5	583
9. Add Park-and-ride Lot to Transit Station	2	0.3	26
10. Introduce Fare Integration & Smart Transit Fare Cards Across Transit System	27	3	-
11. Electrification of Municipal Fleet	0.7	0.1	17
12. Electrification of Auto-Rickshaws	383	8.7	354
Total	**3,301**	**346**	**25,583**

Retire Inefficient Vehicles

Description

In this measure, the city aims to retire older, inefficient vehicles, including both cars and motorcycles, from city streets. The measure targets 8 percent of the most inefficient cars and 12 percent of the most inefficient two-wheelers to be scrapped or removed from use. This policy can be enforced through several methods, such as requiring vehicles to pass minimum efficiency tests for registration renewal or limiting street access to vehicles below a certain age threshold. The policy should be paired with incentives designed to motivate vehicle owners to transition towards more efficient and sustainable mobility options.

Context

The government of India introduced the Vehicle Scrappage Policy in 2021 (TERI, 2022). This policy targets the retirement of old and inefficient vehicles that no longer meet the required fitness and emission standards. It mandates that vehicles undergo fitness tests after the expiration of their registration period—20 years for passenger vehicles and 15 years for commercial vehicles. To encourage vehicle owners to comply, the policy offers incentives for scrapping old vehicles and purchasing newer, more efficient ones. The incentives include up to 5 percent discount for purchasing a new vehicle; a vehicle registration fee waiver; up to 25 percent and 15 percent refund of road tax for personal and commercial vehicles, respectively; and scrap value equivalent to 4 to 6 percent of the ex-showroom price of the new vehicle.

The Ministry of Road Transport and Highways (MoRTH) launched a Voluntary Vehicle Fleet Modernization Program in 2021 that aims for phased scrapping of government and public sector units (PSU) vehicles older than 15 years.

Results

-
Fossil Fuel VKT Reduced (Million KM/year)

10
GHG Savings ($ktCO_2e$/year)

1,553
Total Cost (INR crore)

Implementation Next Steps

The implementation of the Vehicle Scrappage Policy can begin with the establishment of Automated Test Stations (ATS) through a collaborative effort between the state government and private partners, who will provide the necessary land and machinery. A centralized database can be developed to manage vehicle fitness tests and ensure compliance, with a notification system in place to remind owners of their vehicle's test schedules. Penalties can be imposed for non-compliance. Additionally, the city can enforce age restrictions on vehicle registration to prevent older vehicles from other states from entering the local vehicle pool. Public awareness campaigns will be crucial in educating residents about the policy's benefits, with programs designed specifically for the region. Finally, the state government can assist in land acquisition for Registered Vehicle Scrapping Facilities (RVSFs), recognizing the high resource demands of these centers.

The following case study highlights an implementation example from Bangkok, Thailand.

Case Study: Bangkok, Thailand

Image: Oat Appleseed on Unsplash

The Bangkok Motorcycle Upgrade Project sought to promote better maintenance practices and encourage the retirement of inefficient two-stroke motorcycles.

Problem

Inefficient two-stroke motorcycles constituted 80% of the Bangkok fleet by the turn of the century, leading to adverse effects on air quality, traffic congestion, and public health.

Solution

Launched in 2000, the Bangkok Motorcycle Upgrade Project (MUP) sought to promote better maintenance and encourage the retirement of inefficient two-stroke motorcycles. The project facilitated scrapping and repair, raised awareness, and offered financial incentives such as trade-in coupons.

Results

The project sought to replace 21,000 vehicles with new, less polluting models and decrease the number of motorcycles over five years old from 290,000 (approximately 42% of the fleet) in 2000 to around 180,000 by 2004. In the end, the project yielded a net benefit of of $20.2 million and a benefit-to-cost ratio of 3.1.

Financing

The project was a PPP, with motorcycle manufacturers and dealers financing and executing motorcycle upgrades while providing financial and in-kind incentives to encourage proper maintenance and purchase of newer models.

Sources: World Bank, 2003.

Minimum Efficiency for New Vehicles

Description

With this measure, the city mandates minimum efficiency requirements for all new vehicles, including cars and motorcycles. The results are based on a 15 percent improvement in average car efficiency and 10 percent improvement in two-wheeler efficiency. This policy aims to reduce emissions from internal combustion engines across various modes of transportation, while also encouraging the adoption of electric vehicles and the use of cleaner fuel alternatives to foster a more sustainable urban environment.

Context

The government has established fuel consumption standards for new passenger cars since fiscal year 2017-18, which are enforced by the Ministry of Power (The Gazette of India, 2015). These standards are part of the Corporate Average Fuel Consumption (CAFC) norms, which mandate manufacturers to maintain a certain average fuel efficiency across all the vehicles they sell.

There is no specific fuel consumption standard for the two-wheeler segment, though it represents a significant portion of sales and fuel consumption. In fiscal year 2020-21, two-wheelers accounted for more than 80 percent of total vehicle sales and were responsible for 60 percent of India's petrol consumption (ICCT, 2021).

Results

-
Fossil Fuel VKT Reduced (Million KM/year)

29
GHG Savings ($ktCO_2e$/year)

2,925
Total Cost (INR crore)

Implementation Next Steps

While fuel standards exist for passenger cars, they are still needed for two-wheelers. The city could work with stakeholders to pilot a corporate average fuel consumption standard for the new two-wheelers. This could be an effective way to encourage the adoption of modern technologies and accelerate the electrification of the fleet, which is crucial for reducing GHG emissions in the long term.

Electric Vehicle Charging Infrastructure

Description

This measure encourages residents and businesses to switch from vehicles with internal combustion engines to electric vehicles (EVs) by providing charging infrastructure accessible to the public. The city has a robust, future-ready Charging Infrastructure Plan in place. The measure aims for 500 public chargers installed throughout the city.

Context

Pimpri Chinchwad, a part of the Pune Urban Agglomeration, is one of the six urban areas identified by the Maharashtra State EV Policy to accelerate the adoption of EVs in the state. The city has taken proactive measures to support the EV transition and align with the national and state government EV policies. One of the key initiatives is the establishment of a city EV cell (PCMC, 2023), a dedicated and coordinated governance body to facilitate EV ecosystem-related developments in the city and engage with various stakeholders.

The city has also developed an EV readiness plan, which aims to achieve 30 percent EV penetration in new vehicle registrations by 2026. The plan includes strategies such as installing at least 100 public/semi-public charging points by 2023 and 500 by 2025, as well as establishing at least 100 public/semi-public battery swapping points by 2025. The city's efforts have shown positive results, as the total share of EVs in new vehicle registrations between June 2022 and April 2023 was approximately 11 percent, according to the Regional Transport Office (RTO) Pimpri Chinchwad.

Currently, the city incentivizes the installation of EV charging stations by granting a 2 percent property tax rebate to individual owners and a 5 percent rebate to housing societies.

Results

23
Fossil Fuel VKT Reduced (Million km/year)

1.6
GHG Savings ($ktCO_2e$/year)

67
Total Cost (INR crore)

Implementation Next Steps

With the city's EV Readiness Plan in place, the adoption of electric vehicles will likely surge, fostering a cleaner and more sustainable urban environment while reducing carbon emissions and dependency on traditional fossil fuels.

However, the city needs to create a detailed plan for the charging infrastructure that identifies local barrier and sets design guidelines and standards, digital payment options, and vendor selection guidelines.

The city can start by conducting a demand assessment and gap analysis to identify the optimal locations and types of charging stations and battery swapping facilities required in the city. This will help develop detailed design specifications for the charging and battery swapping infrastructure, including the technical, operational, and safety standards, as well as the user interface and payment options. The city can look into opportunities for private sector investment and space rental to build charging points. Implementation of charging infrastructure could be undertaken by PSUs on their premises, such as fuel companies.

It is important to consider the carbon intensity of the electricity used to power new electric vehicles. If the carbon intensity of electricity is high, as is the case with the national grid in India, the carbon savings resulting from a switch to electric vehicles will be minimal. Therefore, it is recommended to pair vehicle charging stations with renewable electricity generation to maximize the carbon impact.

The following case study illustrates an implementation example from Thane, India.

Case Study: Thane, India

Image: Fer Troulik on Unsplash

Thane Municipal Corporation partnered with Mahindra & Mahindra Limited and Kinetic Green to set up 100 e-charging stations in Thane.

Problem

Thane has set out to foster an electric vehicle ecosystem that addresses key mobility challenges faced by the city's residents, such as last-mile connectivity, traffic congestion, and air pollution.

Solution

In 2019, the city teamed up with two local partners to establish 100 e-charging stations in Thane, with additional support from the IFC. Public spaces near malls, theaters and other areas are targeted, and owners can enjoy subsidized charging rates for the first three years.

Results

The deployment of 100 e-charging stations was expected to reduce CO_2 emissions by 43% in 2021 compared to a business-as-usual scenario, translating to a reduction of 3,981 tonnes of CO2 emissions daily. Notably, the stations will feature battery swapping technologies, and the city will also aid in procuring electric vehicles and facilitating loans.

Financing

The partners will cover the setup cost of these stations, while Thane Municipal Corporation will provide the land and be responsible for covering the maintenance costs of the stations for the next 15 years.

Sources: DNA India, 2018; Ghangurde, 2018.

Promote Private Electric Vehicles

Description

This measure aims to increase privately-owned EVs in the city, with the results based on 180,000 new EVs added to the city-wide fleet. The city has been proactive in promoting the adoption of EVs to reduce air pollution and GHG emissions. The city has successfully implemented its EV Readiness Plan, which outlines various strategies and actions to facilitate the transition to EVs. The city regularly revisits its targets and monitors its progress in achieving them. Some of the key initiatives under the EV Readiness Plan include providing preferential parking spaces for EVs, mandating EV-ready parking spaces in existing and upcoming residential and commercial establishments, directing fleet aggregators to switch to EVs in a phased manner, updating building bylaws to be inclusive of EV charging, and so on. The city also benefits from awareness campaigns that educate the public about the environmental and economic benefits of EVs. Moreover, the city is developing a robust network of EV charging stations across the city, which removes the range anxiety of EV users and encourages more people to opt for EVs.

Context

The share of EVs in new vehicle registrations in Pimpri Chinchwad is steadily increasing (*Figure 15*). The city registers approximately 150,000 new vehicles every year. Before 2021, the share of EVs in the new vehicle registrations in Pimpri Chinchwad was 1 percent. After the notification of the Maharashtra State EV Policy in 2021, EV penetration has been more pronounced. Currently, EVs represent over 11 percent of new vehicle registrations in Pimpri Chinchwad (Pimpri Chinchwad Municipal Corporation, 2023).

In partnership with the Electric Vehicle Cell of the city and the Rocky Mountain Institute (RMI), the city has formulated the Pimpri Chinchwad City Electric Vehicle Readiness plan. The plan's objective is to achieve a 30 percent EV penetration rate by 2026. To facilitate this, the city has set a target of electrifying 50 percent of the three-wheeler fleet, 40 percent of the two-wheeler fleet, and 15 percent of car fleet. A 48 percent and 20 percent target has been set for three-wheeler and four-wheeler goods carriers, respectively (PCMC, 2023).

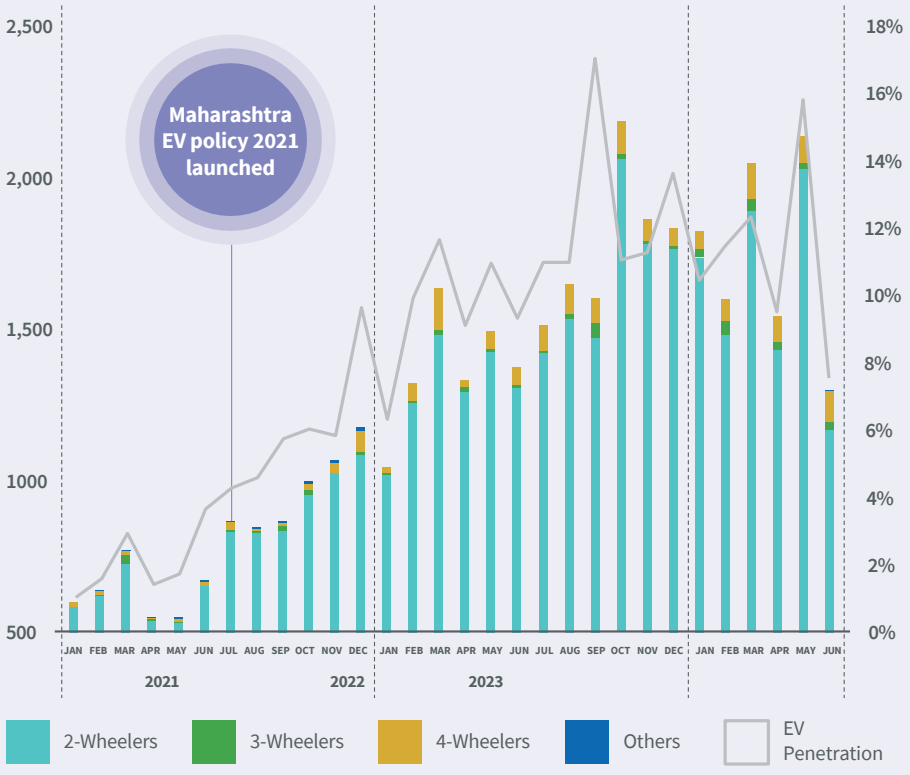


Figure 15: *New EV Registrations in Pimpri Chinchwad. Source: Adopted from Pimpri Chinchwad City EV Readiness Plan (Pimpri Chinchwad Municipal Corporation, 2023).*

Some of the incentives offered for EVs are:

1. **State-level subsidies:** The Maharashtra State EV Policy provides demand incentives for EV buyers, such as exemp tion from road tax and registration fees, and direct subsidies based on battery capacity (Environment and Climate Change Department- Maharashtra, 2021).
2. **Property tax rebate:** The city incentivizes the installation of EV charging stations by granting a 2 percent property tax rebate to individual owners and a 5 percent rebate to housing societies (PCMC, 2023).
3. **Lower rate of interest (ROI) on loans to EV buyers:** Bank of Maharashtra has a Maha Super Green Car Loan Scheme that offers 0.25 percent concession in ROI from its existing car loan scheme (Bank of Maharashtra, 2024). Similarly, Union Bank has a Union Green Miles scheme that offers loans for EVs with flexible repayment options. Other banks like SBI, Axis Bank, and HDFC Bank also have special schemes for EV loans (Kulkarni, 2022).

Results

612
Fossil Fuel VKT Reduced (Million km/year)

50
GHG Savings ($ktCO_2e$/year)

14,985
Total Cost (INR crore)

Implementation Next Steps

Further scoping is needed to increase the adoption of EVs in the city. Successful implementation of policies related to preferential parking and mandating EV-ready parking spaces will help encourage citizens to switch to EVs as it eliminates issues related to adequate parking and the widespread presence of EV-ready infrastructure. In addition, the city administration can guarantee the inclusion of EV charging infrastructure in new residential and commercial buildings by making the required changes to building bylaws.
Also, an EV awareness campaign that targets the consumers and is led by the city administration can help increase the knowledge of EVs among the people.

The city can also seek to enable financing for EV purchasers by working with financial institutions. Financing can be enabled through incentives with banks, urban local bodies (ULBs), and central government vehicle tax relief. Furthermore, the city's EV cell can examine the feasibility of offering financial assistance to private service providers of first- and last-mile connectivity by partnering with Maha Metro and PMPML.

Bicycle Lanes

Description

With this measure, the city aims to increase NMT with the addition of 150 km of dedicated bicycle lanes. The city has embraced a series of initiatives aimed at supporting NMT and making 100 percent of its streets safe for cycling. To solidify these efforts, the city will implement a robust monitoring system to track NMT usage and its effects on travel patterns, safety, and environmental quality. This data-driven approach will guide future infrastructure and policy development.

Context

Thirty-three percent of the city's daily trips in Pimpri Chinchwad, including trips to access jobs, education, and amenities, are made by foot and cycle (Civil-BRTS Department -PCMC, 2022). In the last decade, private motor vehicle ownership in the city has been rising by around one lakh per year. This exponential upsurge has resulted in increased congestion, road accidents, and a sharp decline in air quality.

Initiatives taken by the city include:

1. **NMT Policy:** The city intends to create a statutory frame work to prioritize NMT in the city. The policy strives to ensure proper planning, design, implementation, and management of footpaths and cycleways. One of the 15-years outcome of the policy is to make 100 percent of streets safe for cycling by creating dedicated cycle tracks or by using traffic calming measures to create safe, low-speed space that can be shared by motorized and non-motorized vehicles.
2. **Cycles4Change:** Under the Cycles4Change Initiative of the Government of India Smart Cities Mission, 5 km of pop-up cycle lanes were created on Aundh-Ravet Road and other streets to encourage cycling and provide a safe route for cyclists (ITDP, 2022).
3. **Harit Setu Masterplan:** The city's "Harit Setu" (green connectivity) Master Plan aims to improve links between residential, commercial, and other properties. Cycling lanes will serve as the foundation for a pilot "15-minute city" initiative in which inhabitants may reach the majority of amenities via bicycle. (Bloomberg Cities, 2023).

Results

121
Fossil Fuel VKT Reduced (Million KM/year)

15.1
GHG Savings ($ktCO_2e$/year)

10
Total Cost (INR crore)

Implementation Next Steps

To further the initiatives, the city can set up a monitoring system that can track the usage of NMT infrastructure and its impact on travel behavior, safety, and environment quality. The data collected will inform future decisions on infrastructure expansion and improvements, as well as policy revisions.

The integration of cycling with other public transport modes is another key aspect. Strategies can be developed to provide secure bicycle parking at transit stations and to accommodate bicycles on public transport, making longer, multi-modal journeys more feasible.

The following case study highlights an implementation example from Bogotá, Colombia.

Case Study: Bogotá, Colombia

Image: © Municipality of Bogota

CicloRutas enables 450,000 daily trips, saving the average family $165 per month.

Problem

Once plagued by traffic congestion, air pollution, and overcrowded buses, Bogotá has cemented its commitment to sustainable transportation by expanding the city's extensive bicycle lane network.

Solution

In 2020, officials announced plans to add 280 km of bike lanes to the existing 550 km network over the next four years. To make cycling more accessible, bicycles are available for lease in designated sites throughout the city, and GPS tracking allows cyclists to find routes, parking, and share tips.

Results

CicloRuta enables 450,000 daily trips, saving the average family $165 per month. Increased usage has also reduced bicycle-related deaths and injuries, as well as CO2 emissions by 33,203 tonnes in over 10 years. Bogotá currently leads Latin America with almost 7% of all trips made on bicycles.

Financing

The funding for this initiative is a joint effort between the city government and a grant received from the World Bank in 1996 for the first CicloRuta lanes.

Sources: Colombia Country Brand, n.d.; Development Asia, 2016; Smith, 2010.

Extend BRT System

Description

This measure includes constructing a 40 km extension to the current BRT system. BRT systems are bus networks that operate on purposely constructed, dedicated lanes, similar to rail networks. Extending the BRT system includes building new service corridors, as well as building new stations. The results are based on a daily ridership increase of 700,000 passengers.

Context

PMPML is actively reshaping the city's public transport, emphasizing the strategic expansion of the BRT system. Currently, 449 BRT buses serve Pimpri Chinchwad through three key depots: Bhosari, Pimpri, and Nigdi. The Rainbow BRT system is a hybrid bus rapid transit system with a daily ridership of 520,000 passengers. The system uses 45.5 km of dedicated two-way bus lanes with 92 stations and extends in mixed traffic to outlying areas.

PMPML initiatives include:

1. **Route expansion:** Currently operating on 6 corridors, the plan envisions a 150 km BRT network throughout Pune and Pimpri Chinchwad. The ongoing dialogue with the ministry reflects a keen awareness of the need for optimal routes.
2. **New electric bus depots:** Two new electric depots are planned in Charholi and Nigdi to accommodate 102 and 90 electric buses respectively.
3. **Command Centre and Technological Integration:** PMPML is set to introduce a command center with a mobile application. Collaborating with the Google team, the application will feature GPS tracking, mapping of stops, and real-time information.

Results

54
Fossil Fuel VKT Reduced (Million km/year)

5
GHG Savings ($ktCO_2e$/year)

4,582
Total Cost (INR crore)

Implementation Next Steps

The city's strategic expansion of the BRT system is expected to begin with a series of intentional activities targeted at improving the public transport framework. The rationalization of routes is central to this effort, and it will require a detailed investigation of urban growth trends to identify new high-demand locations. This will allow for route optimization for maximum efficiency, ensuring that the BRT network successfully serves the increasing regions. In addition, the user experience at new BRT stations will be improved by the inclusion of facilities such as real-time information displays, Wi-Fi access, and comfortable waiting areas. A feedback mechanism will also be implemented to continuously improve service quality based on passenger input. The BRT system could be funded through government grants and schemes such as Smart Cities Mission and AMRUT (Atal Mission for Rejuvenation and Urban Transformation), municipal bonds, and loans for urban infrastructure projects from private banks and international financial institutions.

Expand & Electrify BRT Bus Fleet

Description

This measure includes the addition of 192 new electric BRT buses, representing 20 percent of the BRT bus fleet. As part of its efforts through EV Readiness Plan, the city works with PMPML to optimize business models for e-bus procurement and skill development of existing employees. The city has already converted 40 percent of its BRT buses to electric vehicles, which emit zero tailpipe emissions and have lower operating costs. To support the electrification of its bus fleet, the city has a robust network of EV charging stations across its territory, ensuring that the buses can run smoothly and efficiently throughout the day.

Context

PMPML plays a pivotal role in addressing the growing demand for efficient and sustainable transit solutions in the region. With a total fleet of 2,079 buses and a daily ridership of 1.3 million passengers, PMPML serves both Pune and Pimpri Chinchwad, operating 1,750 buses on the road, out of which only 89 are diesel-powered. In Pimpri Chinchwad, PMPML operates 120 electric, 300 compressed natural gas (CNG), and 29 diesel buses (*Figure 16*). Based on a study, PMPML has 26 buses per lakh population, which is half of the MoHUA benchmark of 50 buses per lakh population (ITDP, 2022).

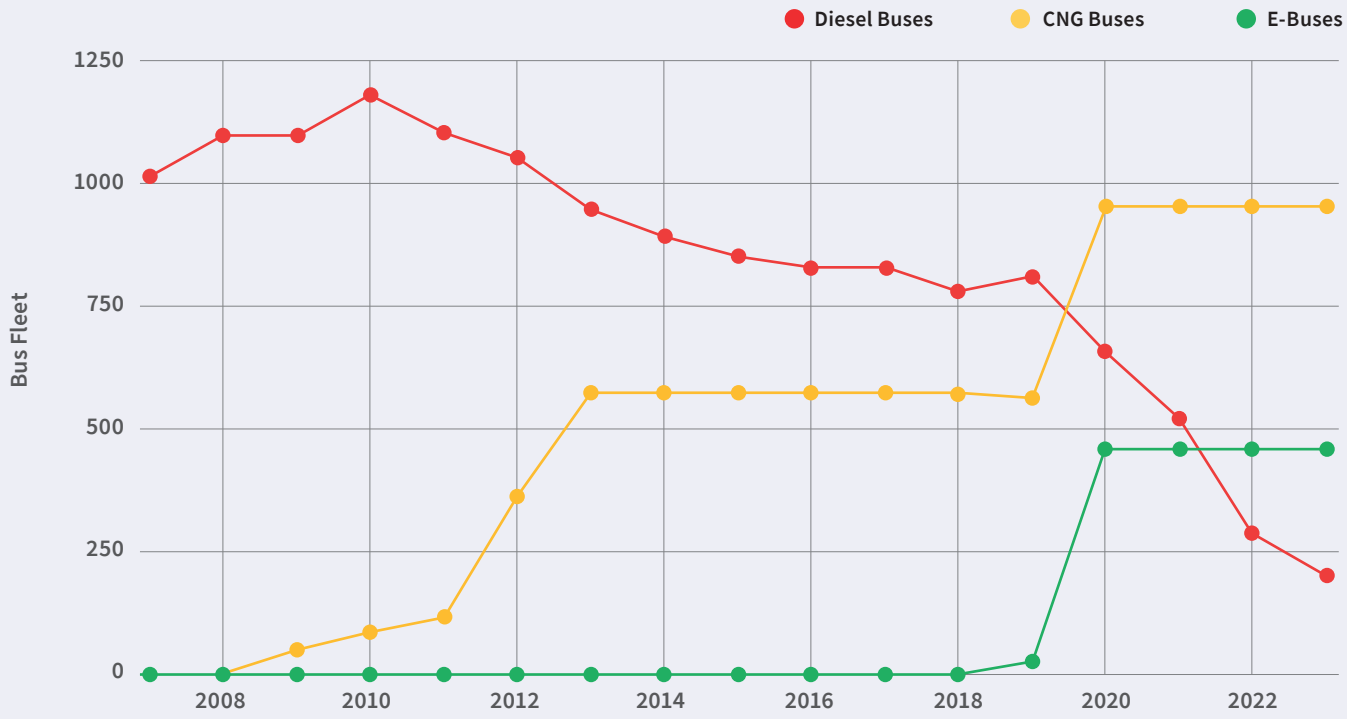


Figure 16: *PMPML's transition to Clean and Modern buses in past decade. Source: PMPML Office.*

Image: IFC

PMPML Electric bus fleet.

PMPML initiatives include:

1. **Phase-out of Diesel Buses:** PMPML aims to completely replace diesel buses with CNG buses by 2028.
2. **Electric Buses:** PMPML's e-bus project features 650 electric midi and standard e-buses, with 458 already in operation. These include 433 12-meter BRT buses and 25 9-meter non-BRT buses. Additionally, plans are underway to establish two more electric depots in Charholi and Nigdi, along with the addition of 192 more electric buses (PMPML, 2023).
3. **Community Engagement:** PMPML actively engages with the community through awareness campaigns, surveys, and collaboration with local NGOs. Special initiatives, such as discounted rates for student passes and working professionals, contribute to their commitment to sustainability.

Results

2,039
Fossil Fuel VKT Reduced (Million km/year)

218
GHG Savings ($ktCO_2e$/year)

482
Total Cost (INR crore)

Implementation Next Steps

A strategic plan is required to electrify and grow PMPML's bus fleet. This roadmap would detail the transition to electric buses, including specific timelines and milestones, as well as key performance indicators to track progress. New buses could be funded through ULB and Smart City budgets, financial institutions, and Central Government Schemes like FAME II (Faster Adoption and Manufacturing of Hybrid and Electric Vehicles) and NCAP (The National Clean Air Program) Fund.

The following case study shows an implementation example from Zhengzhou, China.

Case Study: Zhengzhou, China

Image: Windmemories on Wikimedia Commons

The Zhengzhou BRT project features one of the largest fleets of hybrid and electric buses in the world.

Problem

As with many Chinese cities, Zhengzhou faces challenges from a surge in private vehicles, leading to concerns around traffic congestion and air pollution.

Solution

Zhengzhou's BRT project features over 2,000 hybrid and plug-in hybrid buses, alongside more than 110 fully electric buses. To support the large fleet of battery-electric buses, the city also planned to establish three public battery swapping stations and 143 charging stations by 2020.

Results

Hybrid and electric buses emit 40 to 60% less GHG emissions than conventional buses and operate on zero emissions in the city center. The electric buses in Zhengzhou alone have resulted in emission reductions of around 1,000 tonnes of CO_2. By providing more sustainable options, the project encourages people to make the switch to public transport.

Financing

The project is fully funded by the local government through budgetary allocations. Although the BRT generates some revenue from ticket sales, these only partially cover operational costs and are supplemented with subsidies from the Zhengzhou Development and Reform Commission.

Sources: GIZ, 2020; Grütter, 2014; UNFCCC, 2015; UNFCCC, 2017.

Extend Metro System

Description

This measure includes the 4.5 km Phase 1A extension of the Pune Metro from PCMC station to Nigdi, consisting of 3 stations. The city also engages in a partnership with Maha Metro to promote the usage of public transportation and environmentally sustainable last-mile connectivity. This involves the provision of e-bikes, charging points, and shared electric auto-rickshaws at metro stations, along with the opportunity for commuters to bring bicycles on the trains. To further support ridership, the city can enhance pedestrian-friendly pathways around metro stations, ensure convenient accessibility, and establish parking facilities in proximity to major junctions.

Context

The metro infrastructure in the city is a part of the Pune Metro project (*Figure 17*), which aims to provide a fast, reliable, and eco-friendly mass transit system for the city and its surrounding areas. As of August 2023, the Pune Metro is operating 6 stations along 7 km within Pimpri-Chinchwad, from PCMC station to Dapodi station. Expected ridership is about 20,000 passengers per day. The flow of passengers between Pimpri-Chinchwad and Pune is more or less equal in both directions, with 80 percent of passengers commuting to and from work and 20 percent of passengers joyriding on the new system. The Pune Metro is owned by Maha Metro, a joint venture between the Government of India and Government of Maharashtra. The city has contributed to the system with land as well as 5 percent of the INR 116.2 billion (USD 1.4 billion) cost for Lines 1 and 2.

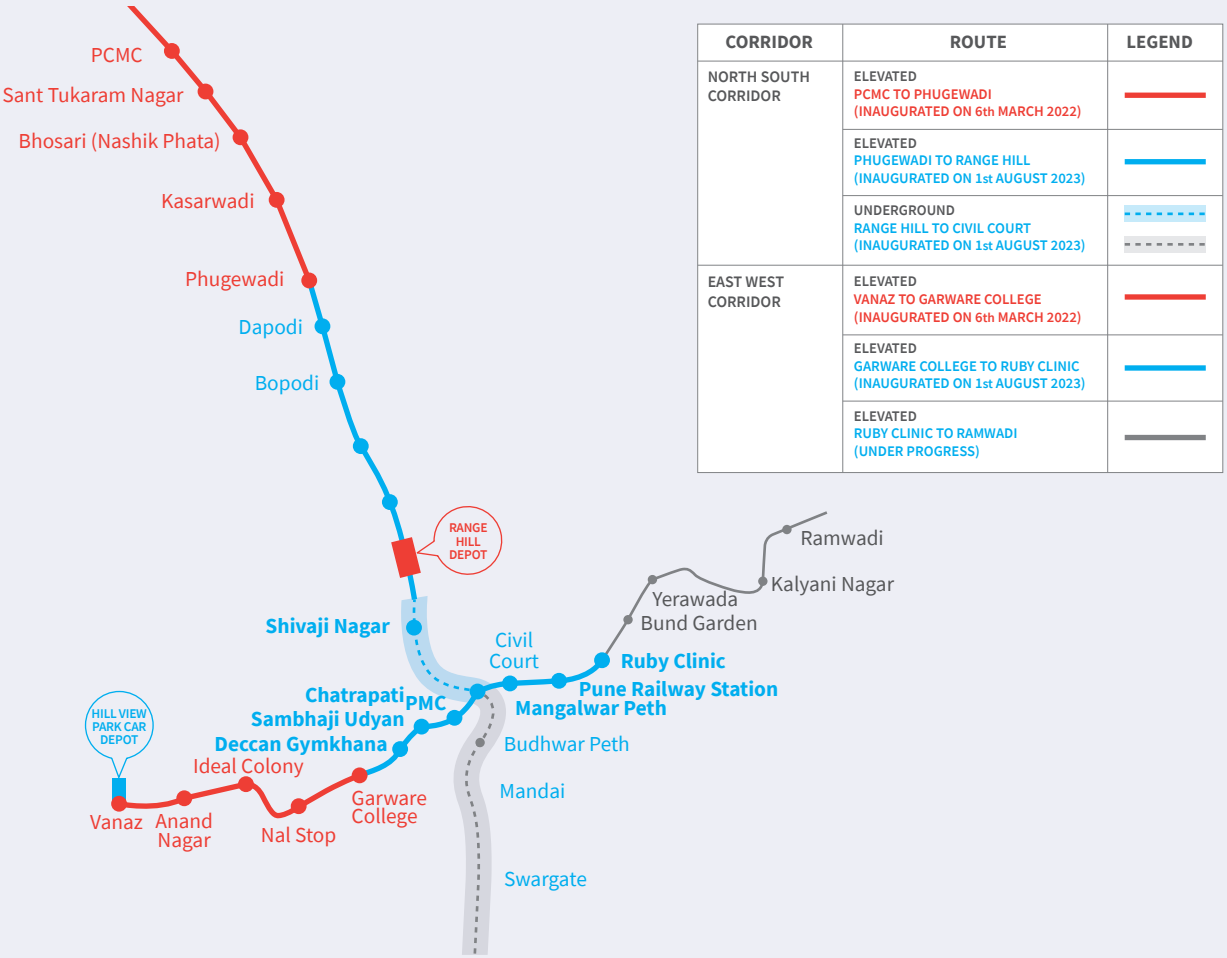


Figure 17: *Route map of Pune Metro Rail Project. Source: https://www.punemetrorail.org/route-map.*

Results

39
Fossil Fuel VKT Reduced
(Million km/year)

5
GHG Savings ($ktCO_2e$/year)

583
Total Cost (INR crore)

Implementation Next Steps

Pune Metro expansion plans for the Pimpri-Chinchwad area include: Phase 1A northwards extension from PCMC station to Nigdi (4.5 km, 3 stations, 43,000/day ridership); and Phase 2 Line 3 from Hinjewadi to Shivajinagar (23 km, 22 stations, 330,000/day ridership). Line 3 will be implemented by Pune Metropolitan Region Development Authority (PMRDA) througha PPP.

Regarding last-mile connectivity and ridership, the city can work with stakeholders and transport-related NGOs to develop strategic plans and demonstration projects for improving accessibility of stations and multi-modal transfer opportunities, particularly related to NMT.

Aerial view of PCMC Metro station.

Image: https://www.punemetrorail.org/station/pcmc/

Add Park-and-ride Lot to Transit Stations

Description

In this measure, the city builds a park-and-ride lot next to a transit station. A park-and-ride lot is a parking facility for public transport riders, where they can leave their private vehicles to avoid driving into the city. Park-and-ride lots can help increase public transport ridership in areas without adequate feeder buses, such as suburban and peri-urban areas. The results consider 780 two-wheeler parking spaces added near metro and BRT bus stations leading to additional 1,170 transit riders daily.

Context

The city has made parking available for BRT users at 6 spots along the Nashik Phata-Wakad corridor. These parking spaces accommodate 57 automobiles, 365 two-wheelers, and 171 bicycles (PCMC, n.d.).

Maha Metro has introduced a pay-and-park service at 8 metro stations of the Pune Metro. Three of these stations are within the Pimpri Chinchwad limits, offering parking capacity for 90 automobiles, 165 two-wheelers, and 42 bicycles (PuneMirror Bureau, 2024).

Results

2
Fossil Fuel VKT Reduced (Million km/year)

0.3
GHG Savings ($ktCO_2e$/year)

26
Total Cost (INR crore)

Implementation Next Steps

To improve the park-and-ride system and encourage public transport use, the city should explore expanding parking services to additional transit stations, particularly those in high-traffic regions. The city can evaluate the potential of multi-level parking structures to maximize space efficiency. PPPs can be formed to fund, construct, and run new parking facilities, with a revenue-sharing framework to encourage private investment while ensuring public accessibility. PMPML and Maha Metro can collaborate with the city to find and acquire suitable land for park-and-ride facilities, and underutilized government land can also be considered.

The following case study highlights an implementation example from Abu Dhabi, United Arab Emirates.

Case Study: Abu Dhabi, UAE

Image: Ruffo Jone Reyes on Unsplash

Since 2021, Abu Dhabi's 'Park & Ride' service has allowed residents and visitors to park their vehicles in designated spots and travel the city for free on public buses

Problem

Abu Dhabi is turning to park-and-ride lots to assist motorists in avoiding toll charges and support the emirate's efforts to alleviate traffic congestion during peak hours.

Solution

Since 2021, the so-called 'Park & Ride' service has allowed residents and visitors to park their vehicles in designated spots and hop aboard a public bus for free. Offering 1,000 parking spaces as a starting point, users can receive a card at no cost for three individuals, with unlimited use for one day.

Results

A total of 58 trips are arranged daily. To ensure that the service meets the needs of the public, the Integrated Transport Centre will continually evaluate its performance. If demand for the service increases, they will explore the possibility of expanding the free bus service by adding more destinations and buses.

Financing

While there are no parking charges or bus fare, those traveling without a Park & Ride service card will be subject to a $55 fine.

Sources: Emirates News Agency, 2020; Gupta, 2021; SJ, n.d.

Introduce Fare Integration & Smart Transit Fare Cards Across Transit System

Description

In this measure, the city implements a robust Integrated Smart Transit System that combines fair integration system and common smart transit fare cards for streamlined, secure, and cashless travel experience. This system allows riders to seamlessly travel across different public transport modes—be it buses or metro—using a single, reloadable smart card. By tapping or swiping their card, passengers can pay for their journey and switch between various transit agencies without the need for multiple tickets. This integration simplifies the payment process, reduces transit time, and encourages the use of public transportation by making it more accessible and user-friendly.

Context

The Rainbow BRT system in Pune and Pimpri Chinchwad initially started with traditional payment methods, primarily cash payments to the bus conductor upon boarding.
The introduction of an Intelligent Traffic Management System (ITMS) in 2015 enhanced the efficiency and quality of the bus service by providing real-time information. At present, PMPML buses have QR-based payment systems in all ticketing machines. Passengers can request a QR code from the conductor to make online payments for their tickets.
The service accepts all types of Unified Payments Interface (UPI) payments.

The payment options for Pune Metro include traditional options like cash, debit and credit cards, as well as UPI mobile wallets. The tickets can be purchased at ticket counters and digital kiosk at metro stations. Additionally, there's the One Pune Card (smart transit card), which can be used for various transactions within the metro system. There has been a proposal to implement a single ticket system that would allow the use of One Pune Card for both Pune Metro and PMPML buses.

Results

27
Fossil Fuel VKT Reduced (Million km/year)

23
GHG Savings ($ktCO_2e$/year)

-
Total Cost (INR crore)

Note: This is considered a policy measure that is not costed in the current version of APEX tool.

Implementation Next Steps

PMPML and Maha Metro can launch a pilot program to test the interoperability of the One Pune Card across a select number of PMPML buses and Pune Metro services. This initial phase is crucial for gathering data on usage patterns and system performance, as well as user feedback. Simultaneously, the existing ITMS will undergo technological upgrades to support the smart card across both public transport modes. The installation of additional card readers and digital kiosks at all metro stations and major bus stops will facilitate easy access and top-up options for the One Pune Card. Additionally, like FASTag, the national electronic toll collection in India, One Pune Card can be linked to passengers' UPI mobile wallets managed by their issuer bank. This can eliminate the hassle of regular top-up of the smart card.

The following case study illustrates an implementation example from Seoul, South Korea.

Case Study: Seoul, South Korea

Image: Allen Yoo on Unsplash

By 2014, T-Money dominated subway and bus transactions in Seoul, with over 14 million card transactions daily.

Problem

As part of the launch of its integrated fare system, the city of Seoul took further measures to enhance the convenience, efficiency and quality of its public transport services.

Solution

Launched in 2004, the T-Money smart card is Seoul's proprietary public payment card which allows commuters to pay for all public transport services. Like the integrated fare system, T-Money charges passengers based on the total distance they have traveled on any mode of public transportation.

Results

By 2014, T-Money had become the preferred payment method for almost all subway and bus transactions in the Seoul metropolitan area, with over 14 million card transactions daily. Besides promoting public transport, T-Money's collected data helps with Seoul's smart transport management and big data analysis, improving public transport services in the city.

Financing

T-Money is the result of a collaboration between the Seoul Metropolitan Government and an IT company as part of a PPP.

Sources: Development Asia, 2019.

Electrification of Municipal Fleet

Description

In this measure, the city transitions its service vehicles, such as garbage trucks, utility vehicles, passenger vehicles and other municipal service vehicles, from conventional internal combustion engines to electric power. This shift aims to reduce GHG emissions, lower operating costs, and decrease dependency on fossil fuels. It involves not only acquiring EVs but also establishing the necessary charging infrastructure at municipal depots, maintenance facilities, and other service areas to support the new fleet. This transition supports environmental sustainability and can contribute to cleaner air and reduced noise pollution in urban areas. The results consider 100 percent of municipal owned automobiles and light duty vehicles are replaced with EVs, approximately 200 vehicles.

Context

The city has historically managed a sizable fleet of petrol and diesel vehicles, incurring substantial monthly costs. Acknowledging the environmental toll and escalating expenses, the city undertook a comprehensive fleet evaluation. Out of 1011 vehicles, 534 were either scrapped or sold through auctions, and 30-40 non-operational vehicles are slated for scrapping. Currently, the city operates 121 automobiles (cars, vans, jeeps), 79 light duty vehicles (small trucks, tractors, and buses); and 18 heavy duty vehicles (big trucks and excavators) leading to INR 3.85 crore (USD 0.46 million) in annual fuel expenses.

The city has leased 79 EVs for five years, in addition to the 22 EVs it already operates, to replace the conventional vehicles used for official and political transportation (Pathare, 2023). The city aims to phase out all petrol and diesel vehicles and adopt a flexible rental model for EVs, which is expected to reduce the monthly expenses by 50 percent in terms of driver salaries, insurance, maintenance, repairs, and fuel.

Results

0.7
Fossil Fuel VKT Reduced (Million km/year)

0.1
GHG Savings ($ktCO_2e$/year)

17
Total Cost (INR crore)

Note: This is considered a policy measure that is not costed in the current version of APEX tool.

Implementation Next Steps

As the city works to electrify its municipal fleet, several key actions can be taken to ensure a smooth transition. The expansion of charging infrastructure is critical, necessitating a rapid installation at municipal facilities and service locations to accommodate both existing and future EVs. A review of the city's EV Policy can be done to ensure that the electrification project's aims are met. Procurement strategies can be put in place to prioritize electric vehicles and related technologies. Financial planning will remain a top priority, with an emphasis on the most cost-effective financial models for leasing versus purchasing EVs, as well as potential subsidies and incentives. Finally, regular evaluations of the fleet composition and consumption trends may be done to optimize efficiency and cost-effectiveness, ensuring the municipal fleet remains sustainable and economic.

Electrification of Auto-Rickshaws

Description

This measure aims to add 17,000 new electric auto-rickshaws (e-autos), based on 50 percent penetration target set by the city. Auto-rickshaws are a vital part of the city's transport system, but they also pose environmental and social challenges. By adopting the e-auto policy and encouraging the transition to electric rickshaws, the city can address these challenges and achieve multiple benefits for its people. E-autos can offer a cleaner, greener, and smarter mobility solution for the city, and make it a model city for EV adoption in India.

Context

Auto-rickshaws are a popular mode of transport for the residents and visitors of the city, as they provide convenient and affordable mobility options. The adoption of CNG auto-rickshaws became mandatory in 2009 with a view to reduce air pollution. Now, there are more than 34,000 existing CNG three-wheelers in the city. Although slightly less than petrol auto-rickshaws, CNG auto-rickshaws still emit harmful gases and contribute GHG emissions.

To address these issues, the city has launched an e-auto policy, which aims to promote the adoption of electric auto-rickshaws in the city (Bhusari, 2023). According to the policy, e-auto owners can avail an incentive of INR 5,000 per kWh or INR 30,000 per e-auto, whichever is lower. The incentive is part of the Pimpri Chinchwad City Electric Vehicle Readiness Plan 2023, which aims to achieve 50 percent EV penetration in three-wheeler auto registrations by 2026.

Furthermore, no permit is required for e-auto-rickshaws, as per the notification issued by MoRTH, Government of India.

Results

382
Fossil Fuel VKT Reduced (Million km/year)

8.7
GHG Savings ($ktCO_2e$/year)

354
Total Cost (INR crore)

Implementation Next Steps

To enhance the penetration of e-auto rickshaws, the city could expand its strategy beyond the current incentive. Developing a robust infrastructure with dedicated charging stations and maintenance facilities is crucial for ensuring convenience and reliability. Additional financial incentives such as low-interest loans, subsidies for battery replacement, and reduced electricity rates for charging could further encourage drivers to make the switch.

Raising public awareness about the benefits of e-autos through targeted campaigns can increase demand and acceptance. Policy support, including priority lanes, parking spaces, and access to high-demand areas, can make e-autos a more attractive option. Furthermore, partnerships with companies that promote the use of EVs, like Uber's introduction of electric auto-rickshaws in Ayodhya, can help boost visibility and usage.

Waste

Measures in the waste sector aim to divert waste from landfill and extract value from waste materials, including through composting, anaerobic digestion, and waste-to-energy. The city has ambitions to have nearly zero waste sent to landfill, as well as extract value from waste currently sitting in landfills. The treatment measures are complimented by actions like reducing waste generation through a single use plastic ban, as well as expanding waste collection services to accommodate a rapidly growing city population.

Table 7: Summary of all Waste measures.

Measure	Landfill Waste Reduced (kt/year)	GHG Savings ($ktCO_2e$/year)	Total Cost (INR crore)
1. Decentralized Composting	27	29	268
2. Ban Single Use Plastics	0.3	1	-
3. Improve Waste Collection	26	26	17
4. Waste-to-Energy (Hydrogen) Plant	128	122	979
5. Centralized Anaerobic Digestion	54	66	14
Total	**236**	**244**	**1,278**

Decentralized Composting

Description

In this measure, the city mandates decentralized composting facilities in housing societies, apartment complexes, and buildings used for commercial purposes. The results consider that 15 percent of domestic and 5 percent of commercial organic waste is converted into compost.

Context

Over half of the total municipal solid waste consists of organic waste. This is equivalent to 594.4 tonnes per day (TPD) of organic waste being sent to the landfill. The city aims to reduce organic garbage collection and encourages citizens to participate in home composting of waste produced in their respective households (Bhusari, 2021).

Residential complexes located within municipal limits are eligible for a tax rebate ranging from 3 percent to 10 percent upon implementation of environmentally friendly projects. Such projects may include the establishment of an on-site composting system, adoption of a zero-waste system, or installation of sewage treatment plants (STPs) (Bhusari, 2023).

Results

27
Landfill Waste Reduced (kt/year)

29
GHG Savings ($ktCO_2e$/year)

268
Total Cost (INR crore)

Implementation Next Steps

While tax rebate incentives exist, there is still a challenge of housing societies not adopting compost systems. The city can take several proactive steps to encourage uptake. First, the city can conduct targeted engagement with key stakeholders within housing societies, such as resident associations and management committees. Misconceptions can be addressed by explaining the benefits of composting and emphasizing financial incentives available. Second, the city can highlight demonstration projects. Selecting pilot housing societies willing to participate and setting up model composting systems allows residents to witness the process firsthand. Success stories from other societies can further inspire adoption. Third, the city can nudge participating using peer influence and recognition. Leveraging successful adopters to share experiences and recognizing early adopters can foster healthy competition. Fourth, the city can assist with regular follow-up and troubleshooting, including by appointing composting champions, checking progress, and addressing barriers with technical support. Finally, the city can ensure continuous communication via newsletters and feedback loops to keep residents informed and engaged.

The following case study highlights an implementation example from Alappuzha, India.

Case Study: Alappuzha, India

Image: https://www.kila.ac.in/wp-content/uploads/2022/04/Report.pdf

To fight environmental pollution caused by an alarming waste crisis in 2012, the city of Alappuzha launched decentralized composting and anaerobic digestion.

Problem

In 2012, Alappuzha was plagued by an alarming waste crisis which brought environmental pollution and the outbreak of diseases, leading nearby residents to protest the municipality's waste management.

Solution

The city launched the Clean Homes Clean City pilot program in 12 urbanized wards, encouraging the segregation of wet waste at the household and neighborhood level. Bio bins and small-scale biogas plants were provided to households, while aerobic bin units were introduced at the community level.

Results

By 2016, 12 wards in Alappuzha had achieved Total Sanitation status, with 80% of households having composting/biogas facilities and good sanitation facilities. As of 2022, only 54% of the aerobic bins in the town were functional at a capacity of 34%, with poor maintenance, lack of acceptance, and poor working conditions limiting long-term effectiveness.

Financing

Suchitwa Mission, the state's nodal agency in charge of the sanitation program, provides a 75% subsidy to biogas plants at a cost of approximately $61 to the user, and a 90% subsidy to the pipe composting system, leaving installation costs at only $1.20.

Sources: Rakendu, 2022; Sambyal, 2016.

Ban Single Use Plastics

Description

This measure includes a ban in single-use plastic waste, which is estimated to account for 2 percent of plastic waste generated in the city. The ban is accompanied by awareness campaigns, imposing fines on violators, promoting alternatives like cloth bags, and collaborating with businesses, industries, and community organizations.

Context

About 10 percent of all solid waste generated in the city is composed of plastic items. While much of the plastic can be recycled, including bottles and other sturdy plastics, many single-use items cannot, such as bags and wrappers. The city has been implementing the single-use plastic ban in its jurisdiction following the state government's notification of the Plastic Waste Management Amendment Rules in 2021.

Other efforts by the city to reduce single use plastic include:

1. **Demonstration project.** The city declared Thergaon Bhaji Mandi as a single-use plastic-free market.
2. **Citywide inspection and awareness campaign** to stop the usage of plastic bags and encourage the use of cloth bags.
3. **Imposing fines** to prevent shopkeepers from selling the banned plastic bags and other single-use plastic items.

Results

0.3
Landfill Waste Reduced (kt/year)

1
GHG Savings ($ktCO_2e$/year)

-
Total Cost (INR crore)

Implementation Next Steps

The city is actively implementing a single-use plastic ban. They are conducting awareness campaigns and encouraging cloth bags, as well as conducting inspections and issuing fines for violators. To further reduce plastic waste, the city can engage industries and implement Extended Producer Responsibility (EPR) programs for producers and brand owners. Community partnerships and clean-up drives can also raise awareness about the downstream effects of plastic pollution, while having a positive impact on the environment.

Improve Waste Collection

Description

This measure targets 100 percent of future generated waste to be collected or treated on site. The city has implemented a highly efficient solid waste management system that collects and processes almost all waste generated by residents. With this measure, the city increases its capacity to maintain a high level of service as the population—and waste generation—grows in the future. Capital costs for this measure include additional bins, additional trucks, and a waste transfer station.

Context

The city has achieved a high level of efficiency in its solid waste management system, reducing unaccounted waste to only 2 percent. This indicates that almost all waste generated by residents is collected and processed. The city employs a house-to-house operation, wherein waste collectors visit each household. Waste collection and transportation services are outsourced to private contractors under a PPP model, with the city paying a fixed amount per tonne of waste collected. To encourage waste diversion from landfills, the city provides incentives to collectors, such as allowing them to sell recyclable materials and paying a tipping fee for collecting additional waste and delivering it to processing plants.

Results

26
Landfill Waste Reduced (kt/year)

26
GHG Savings ($ktCO_2e$/year)

17
Total Cost (INR crore)

Implementation Next Steps

The city can monitor and evaluate the performance of the private contractors and the waste processing plants to ensure quality and efficiency. This can be done by using indicators such as waste collection coverage, waste diversion rate, waste processing capacity, customer satisfaction, and others. The city can also use data management and technology to track the waste collection and transportation vehicles, measure the waste quantity and composition, and identify the sources and destinations of waste. The funding for resources to improve waste collection could be pursued through government grants, such as Swachh Bharat Mission, and/or additional PPP arrangements.

Waste-to-Energy Facility

Description

In this measure, the city works with the private sector to construct a waste-to-hydrogen plant. Waste-to-hydrogen is a process that converts municipal solid waste into hydrogen gas, which can be used as a clean fuel for transportation, power generation, and industrial applications. This measure considers a facility that processes approximately 500 TPD.

Context

The city is planning to install a waste-to-hydrogen plant in the city that will convert 500 TPD of MSW into hydrogen. This project aims to contribute to the city's environmental goals by diverting waste from the Moshi garbage depot, complementing the existing waste-to-energy plant. Key advantages of the waste-to-hydrogen project include reducing landfill and incinerator use, thereby mitigating environmental and health concern; generating green hydrogen that emits no carbon dioxide or pollutants during combustion; and establishing a local, renewable energy source to diminish dependence on fossil fuels and enhance energy security.

Results

128
Landfill Waste Reduced (kt/year)

122
GHG Savings ($ktCO_2e$/year)

979
Total Cost (INR crore)

Implementation Next Steps

The city can learn from the ongoing construction of a waste-to-hydrogen plant in Pune (CNBCTV18, 2023). By studying this nearby facility, the city has the opportunity to thoroughly assess the project's costs, benefits, risks, and opportunities. This evaluation should also consider alignment with local context and needs.

A potential avenue for project implementation is through a PPP, mirroring the model of the Moshi waste-to-energy plant. In this setup, the city provides the necessary land, while a private solution provider designs, builds, and operates the plant for a defined period. The city, in turn, offers a tipping fee per tonne for the treated waste and shares revenue with the private partner on the sale of hydrogen produced.

Centralized Anaerobic Digestion

Description

In this measure, the city collects and processes 30 percent of food waste using anaerobic digestion. In anaerobic digestion facilities, microorganisms break down organic waste in the absence of oxygen and produce a biogas that can be used as fuel. Contamination of food waste, including food packaging and utensils, can interfere with both mechanical and biochemical aspects of the digestion process. Therefore, food and beverage manufacturing and pre-consumer food waste sources are preferred, as they tend to have lower levels of contamination.

Context

The city has several small- and medium-scale food and beverage manufacturing and agro-processing enterprises, as well as large hospitality facilities, fast food and fine dining establishments such as hotels, restaurants, and street food vendors. This suggests that commercial food waste arisings are likely substantial.

The city is on the verge of completing a 50 TPD bio-methanation plant that will process kitchen waste for bulk producers, such as hotels, resorts, industrial canteens, hostels, institutes, and others. The plant will be operated and maintained for 15 years by a private operator on a Design, Build, Operate and Transfer (DBOT) basis for the city at Moshi Landfill site. The plant is expected to produce 5,000 cubic meters of biogas per day (PCMC, 2020).

Results

128
Landfill Waste Reduced (kt/year)

122
GHG Savings ($ktCO_2e$/year)

979
Total Cost (INR crore)

Implementation Next Steps

The next step in implementation is a feasibility study. The study should include a comprehensive assessment of food waste sources, including domestic and commercial arisings, as well as determine the most practical placements, sizes, and types of anaerobic digestion equipment. Commercial food waste could be targeted given its prevalence in the city and typically lower levels of contamination.

The following case study shows an implementation example from Rio de Janeiro, Brazil.

Case Study: Rio De Janeiro, Brazil

Image: Maarten Zeehandelaar on istock

In Rio de Janeiro, a pilot waste-to-energy plant treats organic waste from urban solid waste and produces renewable, inexpensive energy.

Problem

In 2019, Rio de Janeiro took a major step towards sustainable waste management, striving to reduce landfill waste and promote the generation of renewable energy.

Solution

Ecoparque, a pilot waste-to-energy plant, was adapted from units across the globe to treat organic waste from urban solid waste, regardless of whether it has been segregated at the source. Sources primarily include supermarkets and street stalls, however it can also be used to manage household waste.

Results

With a capacity to treat 31.75 tonnes of waste per day, the unit can serve a population of up to 70,000 people daily. The plant can produce between 9 and 18 tonnes of organic compounds and generate 3,150 normal m^3 of biogas daily, translating to an annual production of 2,408 MWh of electricity and avoiding approximately 14 million tonnes of CO_2e annually.

Financing

Funded by the Brazilian Development Bank, the facility now generates sufficient energy to power not only itself but also the larger on-site waste facility and the company's fleet of 19 electric vehicles.

Sources: C40, 2020; Yeung, 2020.

Water & Wastewater

Measures in the water sector focus on improvements to water security, such as reducing water demand in buildings with efficient fittings, reducing water system losses, and exploring alternative sources of water supply, such as rainwater and treated wastewater. This sector also includes improvements to wastewater treatment facilities and energy efficient pumping in the water supply network.

Table 8: Summary of all Water and Wastewater measures.

Measure	Water Security Improved (MLD)	GHG Savings ($ktCO_2e$/year)	Total Cost (INR crore)
1. Rooftop Rainwater Harvesting	7	0.01	316
2. Reuse of Wastewater at Municipal Scale	141	0.3	776
3. Reuse of Wastewater from New & Existing Buildings	42	0.4	1,918
4. Reduce Unaccounted-for Water Losses	370	0.8	1,162
5. Improve Efficiency for Water Conveyance Pumps	-	3.5	19
6. Efficient Fittings in New & Existing Buildings	30	0.3	2,790
7. Smart Water Meters	11	0.02	14
8. New Centralized Wastewater Treatment Facilities	-	0.8	1,316
Total	**600**	**6**	**8,312**

Rooftop Rainwater Harvesting

Description

For this measure, the city requires rooftop rainwater harvesting on habitable buildings, including residentials buildings, hotels, and health care facilities. Rainwater captured on rooftops can be stored in cisterns for later use or filtered through soil as groundwater recharge. Capturing rainwater on rooftops prevents it from entering the stormwater drainage system, which can also help with flood mitigation. The results for the measures are based on capturing rainwater from 70 percent of habitable buildings' rooftop area and storing it for future use.

Context

As part of the PCMC Environmental Clearance Self Declaration list (PCMC, n.d.), it is mandatory for projects with a built-up area between 5,000 and 20,000 m² to have at least 1 rainwater recharge pit per 5,000 m² of net plot area. Furthermore, all new societies over 20,000 m² are required to have rooftop rainwater harvesting, solar water heating or solar PV panels, on-site sewage, and composting to obtain a building permit.

Results

7
Water Security Improved (MLD)

0.01
GHG Savings ($ktCO_2e$/year)

316
Total Cost (INR crore)

Implementation Next Steps

A comprehensive approach is necessary for the city to increase the adoption of rainwater harvesting and groundwater recharge. Engaging communities through awareness campaigns and educational workshops is essential to inform the public about the benefits of rainwater harvesting. The city can also provide technical resources and recommendations for viable technologies and/or installation approaches. The city could complement its mandate by offering financial incentives like tax rebates or subsidies.

Reuse of Wastewater at Municipal Scale

Description

In this measure, the city develops or expands the reuse of treated effluent from its centralized wastewater treatment plants. Wastewater treatment technology is available that can treat effluent to various standards of use. Non-potable water is suitable for irrigation or industrial purposes, and some cities are treating wastewater to potable standards that is suitable for domestic consumption. This measure considers 141 MLD of treated wastewater is made available for non-potable reuse.

Context

Following instructions from the Maharashtra government, the city has created a plan to ensure that society owners, washing centers, commercial and industrial facilities, and large housing societies are able to use treated wastewater for purposes other than drinking. Through a formal agreement, the city will make this water available at a low rate (Kelapure, 2023). At present, the city treats 300 MLD of sewage in various treatment facilities.

Results

141
Water Security Improved (MLD)

0.3
GHG Savings ($ktCO_2e$/year)

776
Total Cost (INR crore)

Implementation Next Steps

To enhance the acceptance of treated wastewater reuse, the city can initiate public awareness campaigns to educate the community on the benefits and address any misconceptions, drawing from successful case studies. Engaging stakeholders, including local businesses, industries, and residential communities, is crucial for participatory planning sessions that discuss expanding treated wastewater use.

The development of infrastructure, such as the expansion of treated water pipe networks, will facilitate the distribution of treated wastewater to new areas. A clear regulatory framework will ensure the safe use of treated wastewater, along with incentive programs to encourage industries and commercial entities to adopt this practice. Wastewater reuse could be implemented with PPP arrangements, and the city utility could generate revenue from the sales.

Lastly, the city can learn from global best practices by partnering with international cities that have successfully implemented wastewater reuse programs. In Singapore, NEWater is part of a comprehensive water resource policy. In general, the reuse of water covers up to 40 percent of the water demand (PUB, 2018).

The following case study illustrates a best practice example from Windhoek, Namibia.

Case Study: Windhoek, Namibia

Image: https://www.wingoc.com.na/our-history

The Goreangab water treatment plant in Namibia uses a process that mimics nature to transform wastewater into drinking water.

Problem

Due to heat and evaporation, only one percent of the yearly 250 mm average rainfall infiltrates into the ground, making Namibia one of the most arid countries in Africa.

Solution

The Goreangab plant recycles municipal wastewater through a 'multi-barrier' technology including ozone treatment, ultra membrane filtration, and residual chlorination. At the city center, Goreangab's pipe meets with another from the Namibia Water Corporation (NamWater) in a one-to-three ratio.

Results

The plant produces a total of 21,000 m^3 of drinking water daily, and has been combined with a public awareness campaign, a water usage control system, and efforts to reduce water consumption and eliminate leaks. Moreover, the plant hosts tours for at least one school group per month, and the students spread their newfound knowledge to adults in the city.

Financing

Since 2001, the Goreangab water treatment plant has been operated by the Windhoek Goreangab Operating Company (WINGOC), which is a consortium made up of Veolia, Berlinwasser International, and WABAG.

Sources: Kings, 2016; Veolia, 2018; Veolia, 2019.

Reuse of Wastewater from New & Existing Buildings

Description

In this measure, the city mandates that habitable buildings, whether newly constructed or existing, implement systems to treat and reuse wastewater generated within the premises. The results are based on 70 percent of new habitable buildings and 30 percent of existing buildings are equipped with on-site treatment systems. These on-site wastewater treatment systems can be designed to process greywater and/or blackwater, converting it into effluent that is suitable for non-potable uses. The treated water is then distributed through a secondary water supply network for non-drinking purposes, including toilet flushing, clothes washing, and irrigation. The adoption of on-site blackwater treatment is especially advantageous in urban areas where local or city-wide wastewater treatment facilities are spatially constrained or heavily burdened.

Context

Currently in Pimpri Chinchwad, all new housing societies exceeding 20,000 m² must install an on-site STP system to be eligible for a building use permit. Societies with operational STPs are entitled to a 3 percent property tax discount. This discount may increase to 10 percent when an on-site composting system and a zero-waste policy are also adopted in conjunction with the STP.

Results

42
Water Security Improved (MLD)

0.4
GHG Savings ($ktCO_2e$/year)

1,918
Total Cost (INR crore)

Implementation Next Steps

The city can consider expanding the current mandate to include a variety of building typologies, such as commercial and educational establishments, and to lower the area threshold to encompass medium-sized developments.

For existing buildings, incentivization through property tax discounts can encourage the adoption of on-site STPs. A recognition program could further motivate adherence to wastewater management practices. Public awareness campaigns and educational workshops are essential to inform and educate stakeholders about the benefits and implementation of STPs. Financial support, such as subsidies and low-interest loans, along with technical assistance, can aid in the installation and maintenance of these systems.

Integrating wastewater reuse policies with other urban development regulations can help ensure a cohesive approach, such as promoting green building certification programs that include water savings as a component. The city can collaborate with NGOs and the private sector to bring in additional expertise and resources. A robust system of inspections and penalties for non-compliance can be established to enforce the mandate.

Reduce Unaccounted-for Water Losses

Description

This measure aims to implement a program to reduce unaccounted-for water losses to 15 percent by 2030. Unaccounted-for water losses are calculated as the bulk system input less the authorized consumption. Unaccounted-for water losses include apparent losses (i.e., unauthorized consumption, metering inaccuracies) and real losses (i.e., leakage on transmission and/or distribution mains, leakage and overflows of utility storage tanks, and leakage on service connections up to the point of customer metering). Strategies to reduce water losses include repairing and replacing leaking water pipes and tanks, improvements to metering systems, and removal of unauthorized connections.

Context

Pimpri Chinchwad experienced about 45 percent unaccounted-for water losses in the baseline year, which included both transit loss and water treatment plant loss. To address this issue, the city has taken several measures, such as conducting surveys to identify illegal water connections (TNN, 2022) and changing 40 percent (950 km) of the old water supply pipelines. The city aims to improve the situation to 15 percent unaccounted water losses by 2030. Key initiatives that have been prioritized are installation of smart water meters, installation of remote sensors that signals any potential leakage of water, proactive leak detection and repairs, and pipeline replacement.

Results

370
Water Security Improved (MLD)

0.8
GHG Savings ($ktCO_2e$/year)

1,162
Total Cost (INR crore)

Implementation Next Steps

Loss reduction could be funded by the city utility and/or through a private sector deployment model. In order to leverage private sector finance to address water losses, the following next steps are proposed:

- Analyze water supply and consumption data, focusing on a selected areas of the city experiencing high water losses, to identify root causes of losses and prioritize interventions, including smart or digital solutions where these enhance viability;
- Develop a non-revenue water action plan, bill of quantities, and financial assessment;
- Determine a deployment model to attract private sector expertise, for example through a performance-based contract; and
- Replicate the approach across the city.

It will be important to gain community support for the efforts to reduce water losses. Awareness campaigns, targeted consultations, and community-tailored solutions can help with the transition.

Improve Efficiency for Water Conveyance Pumps

Description

This measure improves the efficiency of conveyance pumps in the water system. Results for this measure are based on retrofitting of all existing water conveyance pumps across the Pimpri Chinchwad region. It involves identifying pumps that are below current energy efficiency standards and replacing or upgrading them with high-efficiency models. The project covers various pumping stations, including those for water distribution, wastewater management, and irrigation systems. The strategy can also include measures to enhance efficiency, such as optimizing pump size, incorporating advanced control systems, and regular maintenance.

Context

Water conveyance systems are integral to ensuring a reliable supply of water to residential, commercial, and industrial areas. However, these systems often consume a significant amount of energy, primarily due to outdated and inefficient water pumps. Improving the efficiency of these pumps is crucial for reducing operational costs, conserving energy, and contributing to the city's sustainability goals.

Results

-
Water Security Improved (MLD)

3.5
GHG Savings ($ktCO_2e$/year)

19
Total Cost (INR crore)

Implementation Next Steps

The immediate next step for implementation is to conduct an energy audit to assess the performance of current pumps and identify those requiring upgrades. Following the audit, the procurement process for high-efficiency pumps should ensure that the selected models meet the latest standards and are tailored to the region's needs. Proper installation is important for optimal performance. Performance monitoring can help track the energy savings and functionality of the new pumps.

Additionally, efficiency can be further improved by avoiding oversized pumps, trimming the impeller, using variable frequency drives, installing parallel pumping systems, limiting pipeline pressure loss, installing control systems to eliminate unnecessary use, and performing preventive maintenance.

Efficient Fittings in New & Existing Buildings

Description

With this measure, the city mandates the installation of water-efficient fittings in all buildings. Results for this measure are based on 70 percent of new buildings and 30 percent of existing buildings equipped with water-efficient fittings. Efficient fittings consume 25 percent to 35 percent less water than traditional fittings. For new construction, developers are required to equip buildings with water-saving taps, showers, and toilets, bearing the primary cost, while also potentially receiving incentives from the city or national government. For existing structures, a comprehensive program is implemented to retrofit water fittings, encouraging building owners and households to participate in the upgrade. Support for this initiative may include providing water-saving equipment at no cost, offering rebates, or other incentives facilitated by the city to promote water conservation across all properties.

Context

The building bylaws of Maharashtra, Unified Development Control and Promotion Regulations for Maharashtra State (UDCPR), and the National Building Code (NBC) of India currently do not mandate the installation of water-efficient fixtures in new buildings. However, the progress of water efficiency standards in buildings has been gaining momentum in India, with several initiatives and rating systems being developed to promote sustainable water management. Water Efficient Products-India (WEP-I), for example, is a voluntary labelling program for water-efficient plumbing products. Bureau of Indian Standards (BIS) 17650 (Part 1) and 17650 (Part 2) cover additional requirements for assessment and water efficiency rating of sanitary wares and sanitary fittings for their performance. The increasing awareness of water conservation and sustainable practices has led to a rising demand for water-efficient products, prompting manufacturers to produce innovative and durable fixtures that meet regulatory standards and cater to consumer needs.

For existing buildings, there are several water-efficient fittings that are easy to retrofit, including toilet cistern displacement products, low flow tap aerators and showerheads, and water-efficient appliances such as dishwashers and washing machines. Water-saving equipment is widely available in India at reasonable costs. Globally, cities and local utilities have implemented replacement programs that offer efficient plumbing fittings and toilets to homeowners for free or with a rebate, sometimes with free installation as well. Some cities have implemented upgrade requirements linked to a change of building ownership or issuance of building permits for renovations.

Results

30
Water Security Improved (MLD)

0.3
GHG Savings ($ktCO_2e$/year)

2,790
Total Cost (INR crore)

Implementation Next Steps

The next step is to develop the regulatory approach, which could include an ordinance tied to plumbing regulations. At the product level, this could include requiring water-efficient fixtures that comply with a labelling program or meet maximum flow rate thresholds. The city could alternatively explore requirements at the building level, such as mandatory water performance ratings or minimum water performance requirements. An awareness campaign and incentives can help build community support and promote compliance with the regulations. Lastly, the city can work with the state government to include a minimum water efficiency requirement for the fittings for new and existing buildings.

The following case study shows an implementation example from Australia.

Case Study: Australia

Image: Photo by PhotoMIX Company on Pexels

The Australian government promotes water efficiency by mandating labeling on various fixtures and appliances, allowing for informed consumer choices.

Problem

Ever since the Millennium Drought, Australia has made significant strides in curbing water consumption by advocating for the use of more efficient products.

Solution

Launched in 2005, the Water Efficiency Labelling and Standards (WELS) scheme mandates labels on a diverse range of fixtures and appliances such as showers, toilets, and washing machines, thereby enabling consumers to make informed choices when selecting water-efficient products.

Results

Between January and September 2022, householders and businesses had already achieved savings totaling $1 billion in utility bills while conserving a substantial 158 gigaliters of water. Through the reduction of energy usage, the scheme has effectively cut emissions by 21.8 megatonnes of CO_2e since it was first introduced.

Financing

The scheme follows a cost-recovery model, with 80% of the costs borne by the industry, while the remaining 20% is split equally between national and state governments. Each year, the government contributions increase by four percent.

Sources: Australian Government, 2022; DCCEEW, 2022; Institute for Sustainable Futures, 2019.

Smart Water Meters

Description

In this measure, the city implements installation of smart water meters within its limits. Smart water meters give the utility real-time data on water use, send notifications when there is a leak or burst in the distribution network, and can help ensure fair billing with accurate monitoring. Results for this measure consider a program that targets 20 percent of new buildings, including hotels, hospitals, large new residential developments, and some schools. Smart meters can help reduce water use and leakage in these buildings by 10 percent.

Context

Water supply is one of the key sectors that the city has been focusing on improving and expanding, especially in the wake of rapid urbanization and industrialization. One of the major challenges faced by the city is the inefficient and inequitable distribution of water to its consumers. The city relied on a flat-rate billing system that did not reflect the actual water consumption of each household or commercial establishment. This resulted in low revenues, high water losses, frequent disputes, and unauthorized connections.

Traditionally dependent on mechanical water meters, the city has started implementing data and technology in partnership with private sector to improve its water distribution and billing system, as well as reduce water losses. PCMC has implemented several initiatives such as installing water meters, deploying meter inspectors, and developing a water billing and analytics system. Embracing a data-driven and technology-based approach, the city has increased revenues from INR 24 crore per year to INR 45 crore per year and reduced non-metered connections from 28,777 to 2,229 (Pahuja, 2021).

Results

11
Water Security Improved (MLD)

0.02
GHG Savings ($ktCO_2e$/year)

14
Total Cost (INR crore)

Implementation Next Steps

The city has already started implementing smart meters, so the next steps include developing deployment models to expand and build on current efforts. It will also be important to gain community support through awareness campaigns, incentives, and community-tailored solutions. Smart meters benefit consumers by ensuring they are charged for the correct water usage, and they can help avoid billing disputes. Smart meters can also help encourage conservation by providing real-time feedback on consumption, as well as allow the utility to match tariffs to water demand management measures.

The following case study illustrates an implementation example from Johor Bahru, Malaysia.

Case Study: Johor Bahru, Malaysia

Image: Photo by Luis Quintero on Pexels

In late 2018, Johor, a state at the southern tip of the Malay Peninsula, lost almost a quarter of its water through leaks, bursts, and unauthorized connections

Problem

Towards the end of 2018, Johor, a state located on the southern tip of the Malay Peninsula, was losing nearly a quarter of its water due to leaks, bursts, and unauthorized connections.

Solution

Under a technology trial in the capital city of Johor Bahru, 295 so-called Enigma3m remote correlating noise loggers were installed in a smart district metered area with the aim of pinpointing leaks in the water distribution network using an innovative cloud-based platform.

Results

A total of 115 leaks were identified and successfully repaired, including small leaks at hydrant valves and communication pipes. Following the trial, the net night flow dropped from 30.99 liters per second to 20.08 liters per second, amounting to a monthly savings of 705 m3 per day and an estimated cost reduction of around $4,000.

Financing

As the smart DMA concept is expanded throughout the state, water supply company Ranhill SAJ plans to procure a greater quantity of Enigma3m loggers depending on infrastructure age and site conditions.

Sources: WaterWorld, 2019.

New Centralized Wastewater Treatment Facilities

Description

To enhance urban sustainability and environmental health, the city has undertaken a significant initiative to expand its wastewater treatment capabilities. To realize this vision, the city is exploring innovative PPP models, inviting the expertise and investment of the private sector in the construction and operation of these new treatment facilities. This measure includes the construction of 300 MLD of additional centralized wastewater treatment facilities.

Context

In Pimpri Chinchwad, there are 14 sewage treatment facilities at 9 different locations, with a total treatment capacity of 353 MLD. There are supervisory control and data acquisition (SCADA) systems installed at all STPs, and the inlet flows are monitored on daily basis. The combined inflow across all STPs is 300 MLD with 100 percent treatment.

The city aims to add another 300 MLD of wastewater treatment facilities. This will be implemented in three phases of 100 MLD each. Treated wastewater from the first phase will be used for industrial purposes.

Results

-
Water Security Improved (MLD)

0.8
GHG Savings ($ktCO_2e$/year)

325
Total Cost (INR crore)

Implementation Next Steps

The next step for expansion of wastewater treatment facilities is to identify and select a wastewater treatment process based on wastewater characterization and regulatory requirements for discharge from the plant. Engaging with private entities through PPPs can be a strategy where the private sector can participate in the construction and/or operation of the wastewater treatment facilities.

Green Investment Pipeline

Solutions in the Green City Action Plan can be converted into a pipeline for green investment in Pimpri Chinchwad, supported by both public and private sector funding. All 32 measures with their associated costs are listed in *Table 9*, which includes indirect cost as well as the direct cost to the city and its agencies. Where the cost is for investment that falls within the city's mandate, the full cost is reflected as a direct cost. However, the city can leverage other funding sources, including private sources of financing for these investments, including through direct finance (such as bonds and loans) as well as PPPs and other business models. Some indirect-cost actions rely on policies, mandates, and incentives to generate investment from the private sector and individuals, such as building energy retrofits, electric vehicles, water efficient fittings, and others.

The green investment pipeline can be visualized in *Figure 18*. Direct costs total approximately INR 11,997 crore (equivalent to about USD 1,441 million) over 7 years, which includes municipal buildings and public infrastructure. Indirect costs are nearly three times as much at INR 33,104 crore, corresponding to almost two-thirds of the GHG savings. These indirect investments are split between private buildings and private transportation. While indirect costs are borne by private developers, buildings owners, and vehicle owners, they are also influenced by city policies and incentives.

Image: IFC

Table 9: The direct and indirect cost for all 32 measures, as well as possible financing options that may be considered. The green investment pipeline includes actions where the city can nudge (i.e., implement policy) or leverage (i.e., through PPP, etc.) the private sector to invest in green measures. Costs are indicative only; all would need further feasibility work.

APEX Sectors	Measures	Direct Cost (INR crore)	Indirect Cost (INR crore)	GHG Savings (%)	Potential Funding Sources			
					Own Revenue /Internal Grants	Municipal Loan/ Bond	PPP Modalitie	Private Finance
Built Environment & Energy	Rooftop Solar Hot Water		2,595	0.6%			✓	✓
	Urban Forestry	1,094		0.1%	✓	✓		
	Green Building Certification		1,000	4.3%			✓	✓
	EE Refurbishment for Private Buildings		1,124	1.5%			✓	✓
	Rooftop Solar PV Program for Private Buildings		3,530	9.0%			✓	✓
	Green Municipal Buildings	82		0.3%	✓	✓	✓	
	Rooftop Solar PV on Municipal Buildings	503		1.3%		✓	✓	
Transportation	Retire Inefficient Vehicles		1,553	0.2%				✓
	Minimum Efficiency for New Vehicles		2,925	0.5%				✓
	EV Charging Infrastructure	67		<0.1%		✓	✓	✓
	Promote Private Electric Vehicles		14,985	0.8%				✓
	Bicycle Lanes	10		0.3%		✓	✓	
	Extend BRT System	4,582		0.1%		✓		✓
	Expand & Electrify BRT Bus Fleet	482		3.6%		✓	✓	✓
	Extend Metro System	583		0.1%		✓	✓	
	Fare Integration and Smart Transit Fare Card Across Transit System			0%				
	Add Park-and-ride Lot to Transit Stations	26		<0.1%	✓	✓	✓	
	Electrification of Municipal Fleet	17		<0.1%	✓		✓	
	Electrification of Auto-Rickshaws		354	0.1%	✓			✓
Solid Waste	Decentralized Composting	268		0.5%		✓	✓	
	Ban Single Use Plastics			<0.1%				
	Improve Waste Collection	17		0.4%	✓		✓	
	Waste-to-Energy/Incineration Facility	979		2.0%			✓	✓
	Centralized Anaerobic Digestion	14		1.1%			✓	✓
Water & Wastewater	Rooftop Rainwater Harvesting		316	<0.1%				✓
	Reuse Wastewater at Municipal Scale	776		<0.1%			✓	
	Reuse of Wastewater From New & Existing Buildings		1,918	<0.1%				✓
	Reduce Unaccounted-for Water Losses	1,162		<0.1%		✓	✓	
	Improve Efficiency for Water Conveyance Pumps	19		0.1%		✓	✓	
	Efficient Fittings in New & Existing Buildings		2,790	<0.1%			✓	✓
	Smart Water Meters		14	<0.1%			✓	✓
	New Centralized Wastewater Treatment Facilities	1,316		0.1%		✓	✓	
	Total	**11,997**	**33,104**	**27%**				

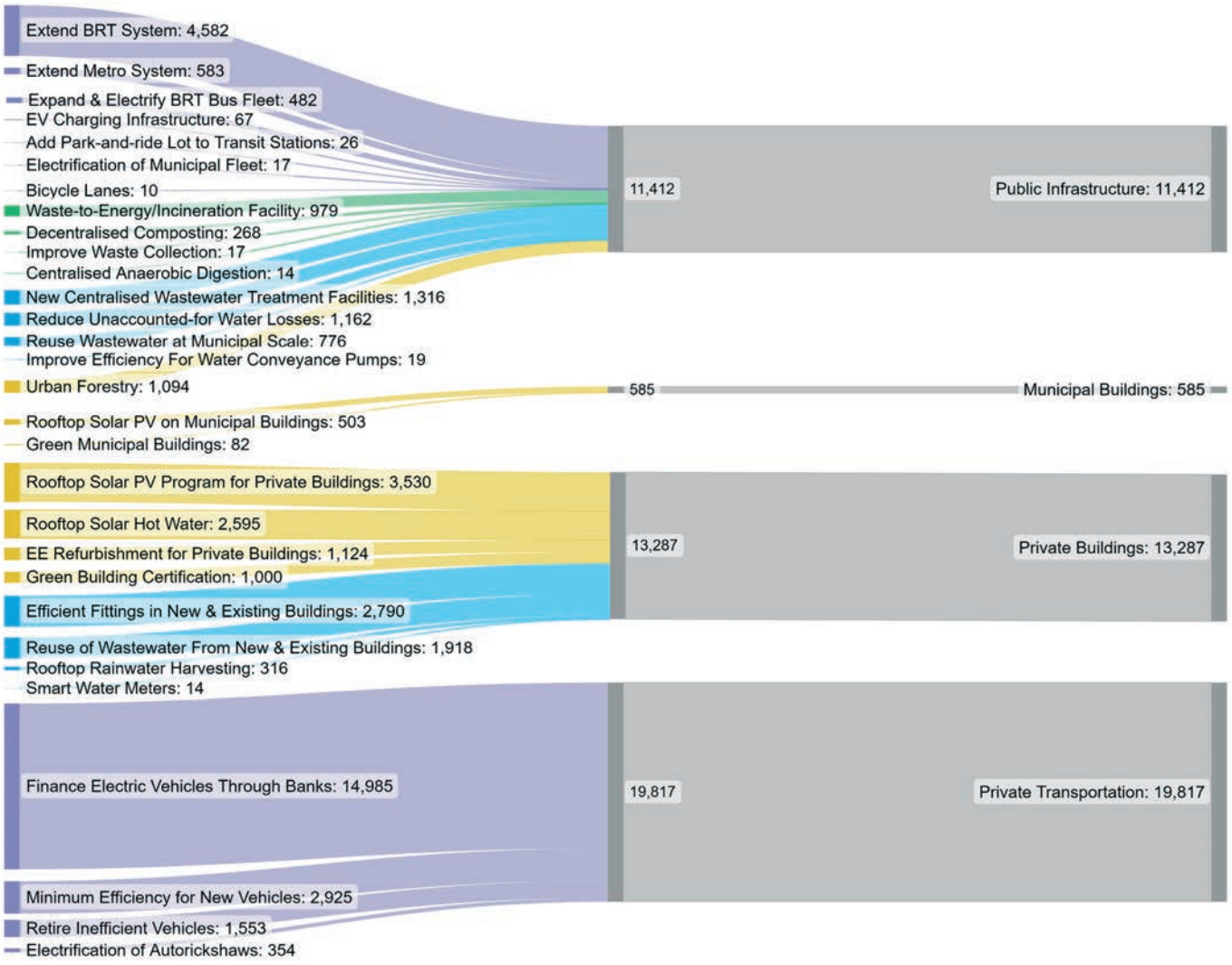


Figure 18: Investment flow diagram showing the potential financing volumes aligned to measures in the green investment pipeline (shown in INR crore).

Appendix A: Baseline Data

Baseline date is for year 2023.

Population

Item	Value	Source / Notes
Resident population	2,766,090	Calculated based on India Census 2011; 1.7M Census (2011) and 2.1M PCMC estimate (2017)
Annual growth rate (%)	4%	PCMC estimated
Employment rate (% of 15–74-year-olds)	56.7%	India Census 2011
Population at working age, 15-74 years old (%)	69%	India Census 2011
Persons per household in urban areas	4.	India Census 2011
Population distribution by income (%)		
Low	36.2%	Estimated from NSSO (National Sample Survey Office) 68th Round Consumer Expenditure Survey
Lower-middle	42.2%	
Upper-middle	11.1%	
High	10.5%	

Built Environment & Energy

Item	Value	Source / Notes
City area (km²)	181	PCMC Environmental Status Report 2022
Length of streets (km)	1,378	Smart City Data Portal, MoHUA (2022) / PCMC Urban Outcome Framework 2022
Number of streetlights	89,852	Smart City Data Portal, MoHUA (2022)
Number of traffic light sets	1,561	Smart City Data Portal, MoHUA (2022)
Area of parks and green spaces (km²)	1.66	PCMC City Biodiversity Index (2019)
Area of forest canopy (km²)	59.70	PCMC City Biodiversity Index (2019)
Total building area (million m²)		
Retail	3.6	Estimated from PCMC Property Tax Department (2023)
Office	3.6	
Hotel	2	
Health	0.1	
Education	4	
Institutional/Assembly	1.	
Warehouse	0.5	
Transport	1	
Residential		
Apartments	21.5	
Homes	14.3	
Average building area per person (m²)	18.7	Calculated by APEX
Area of municipal buildings (m²)		
Non-residential	91,050	Property Tax Department, PCMC (2023)
Residential	54,446	
Building energy consumption (kWh/m²/year)		
Retail	165.6	APEX Default
Office	92	
Hotel	260.2	
Health	270.7	
Education	101	
Institutional/Assembly	92	
Warehouse	97	
Transport	97	
Residential		
Apartments	67	
Homes	72	
Energy source (%)		
Grid electricity	83%	Estimated based on Ministry of Statistics and Program Implementation (MoSPI) Report (2020)
Local electricity generation	-	
Local heat sources	17%	
Energy emissions factors ($kgCO_2e/kWh$)		
Grid electricity	0.92	National Grid Study, Central Electricity Authority, Ministry of Power
Local electricity generation	-	
Local heat sources	0.26	

Transportation

Item	Value	Source / Notes
Average trips per day per resident	2	APEX Calculation
Average trip distance (km)	12	
Working days per year	303	APEX global default
Total resident passenger travel (million km)	20,115	Calculated with data above
Modal split by passenger-kilometers (%)		
Automobile	13%	Estimated based on PCMC CMP (2020)
Motorcycle (Two wheeler)	35%	
Taxi	2%	
Moto-taxi (Auto-rickshaw)	10%	
Bus, BRT	33%	
Subway	2%	
Bicycle	2%	
Walk	3%	
Transit infrastructure		
Length of BRT System (km)	45.5	Pune Mahanagar Parivahan Mahamandal Limited (PMPML)
Number of BRT buses in fleet	449	
Length of subway system (km)	16	Maharashtra Metro Rail Corporation Limited (Maha Metro), Pune
Number of subway stations	14	
Number of subway trains	8	
Average occupancy rate (passengers)		
Automobile	1.8	APEX defaults
Motorcycle (Two wheeler)	1.2	
Taxi	2.3	
Moto-taxi (Auto-rickshaw)	1.2	
Bus, BRT	61	Pune Mahanagar Parivahan Mahamandal Limited (PMPML); estimate from PMPML meetings
Subway	124.8	APEX defaults
Number of vehicles in fleet		
Automobile	434,856	Vahaan Parivahan Portal, Ministry of Road Transport and Highways (2023)
Motorcycle (Two wheeler)	1,418,438	
Taxi	26,327	
Moto-taxi (Auto-rickshaw)	34,485	

Transportation

Item	Value	Source / Notes
Annual growth in private vehicle ownership (%)		
Automobiles	9.7%	Parivahan and Maharashtra Transport Department Data (2019)
Motorcycle (Two wheeler)	8.4%	Parivahan and Maharashtra Transport Department Data (2019)
Annual rate of vehicle retirement/obsolescence (%)		
Automobiles	3%	Center for Science & Environment (CSE), 'What to do with old Vehicles', 2020 https://www.cseindia.org/what-to-do-with-old-vehicles--10379
Motorcycle (Two wheeler)	7%	
Average vehicle efficiency (km/L)		
Automobiles	10.6	Country-level estimate, Climate Smart City Assessment, National Institute of Urban Affairs (NIUA)
Motorcycle (Two wheeler)	35.8	
Taxi	10.6	
Moto-taxi (Auto-rickshaw)	35.8	
Bus, BRT	3.5	
Bus, standard	1.7	
Parking		
On-street parking spaces	206,700	Calculated based on APEX Defaults
Off-street parking spaces	756,000	

Solid Waste

Item	Value	Source / Notes
Municipal solid waste (MSW) generation (t/person/year)	0.15	Estimated based on PCMC Environmental Status Report (2022)
MSW composition (%)		
Organic waste	52.6%	PCMC Environmental Status Report (2022)
Paper and cardboard	2.1%	
Wood	10.5%	
Textiles	9.2%	
Rubber and leather	4.2%	
Plastics	9.3%	
Metal	1.2%	
Glass	3.8%	
Other	7.1%	
Organic waste composition (%)		
Food waste	67%	APEX Defaults
Organic waste	33%	
Waste treatment (%)		
Anaerobic digestion (AD)	8%	PCMC Environmental Status Report (2022)
Compost	7%	
Incineration	40%	
Landfill, unspecified	35%	
Recycling	8%	
Unaccounted-for	2%	
Recycling composition (%)		
Paper and cardboard	9.5%	APEX Defaults
Wood	0%	
Textiles	14.3%	
Rubber and leather	2.4%	
Plastics	66.5%	
Metal	2.6%	
Glass	4.8%	

Water & Wastewater

Item	Value	Source / Notes
Municipal water consumption (MLD)	590	PCMC Water Department
Potable water (%)	100%	
Non-potable water (%)	0%	
Average consumption per person (L/day)	140	
Industrial water consumption (MLD)	30	Maharashtra Industrial Development Corporation (MIDC)
Unaccounted-for water losses (%)	45%	PCMC Water Department
Water source (%)		
Surface water	95%	PCMC Water Department
Recycled wastewater	5%	PCMC Water Department
Wastewater treatment		
Wastewater flow (MLD)	300	PCMC Water Department
Treatment type (%)		PCMC Environment Department
Septic tank	4%	
Activated sludge process (ASP) without AD	45%	
Sequencing Batch Reactor (SBR)	50%	
Untreated sewer (discharge into water)	1%	

Greenhouse Gas Emissions

Item	Value	Source / Notes
Built Environment & Energy ($MtCO_2e$/year)	3.5	Residential, Commercial/Institutional buildings
Transportation ($MtCO_2e$/year)	1	On-road transportation, Metro
Solid Waste ($MtCO_2e$/year)	0.2	Solid waste, Biological waste
Water & Wastewater ($MtCO_2e$/year)	0.01	Wastewater

Appendix B: Key Assumption for Measures

Built Environment & Energy

Prioritized Measure	Key Assumptions	APEX Measure Code (Version 2023-05)
1. Roof-top Solar Hot Water	• 25% of habitable buildings to have solar water heaters • Cost is INR 664 / unit	A.3 – Mandate Roof-top Solar Hot Water
2. Urban Forestry	• 10% increase in urban greening project • 6 km² planted • Cost is INR 181.7 crore/km²	A.8 – Increase Extent of Urban Forestry
3. Green Building Certification	• 50% of new private buildings • 6,485,000 m² certified • Cost is INR 1,577/m²	A.9 – Incentivize Green Building Certification (e.g. EDGE)
4. EE Refurbishment for Private Buildings	• 10% of existing buildings refurbished • 4,621,000 m² refurbished • Retrofit cost is INR 2,407/m²	A.10 – Finance for private energy efficiency refurbishment
5. Rooftop Solar PV Program for Private Buildings	• About 30% of the roof tops have solar panels • Additional 400.00 MWp Installed • Cost is INR 87,980/kWp	A.14 – Implement Rooftop Solar PV Program
6. Green Municipal Buildings	• All new municipal buildings are green certified; All existing buildings are retrofitted with energy efficient appliances and systems • 300,000 m² certified; 145,496 m² refurbished • Cost is INR 1,577/m² for new municipal buildings; 2,407/m² for existing municipal buildings	A.16 – Implement Green Certification/labelling For All Municipal Buildings A.17 – Implement EE Refurbishment Program For All Municipal Buildings
7. Rooftop Solar PV on Municipal Buildings	• Additional 57,000 KWp Installed • Cost is INR 87,980/kWp	A.18 – Install Rooftop Solar PV on Municipal Buildings

Transportation

Prioritized Measure	Key Assumptions	APEX Measure Code (Version 2023-05)
1. Retire Inefficient Vehicles	• 5% most inefficient vehicles retired • 32,318 inefficient cars retired • 96,238 inefficient motorcycles retired	B.1 – Mandate Retirement of Inefficient Cars B.2 – Mandate Retirement of Inefficient Motorcycles
2. Min. Efficiency For New Vehicles	• Increased efficiency applies to 8% of new cars • Increased efficiency applies to 11% of new motorcycles • 54,100 efficient cars added • 211,800 efficient motorcycles added • Cost is INR 3,63,540 per new car and INR 44,820 per new motorcycle	B.3 – Mandate Min. Efficiency For New Cars B.4 – Mandate Min. Efficiency For New Motorcycles
3. EV Charging Infrastructure	• 700 new chargers added • Cost is INR 952,840 per charger	B.15 – Provide EV Charging Infrastructure
4. Promote Private Electric Vehicles	• 180,000 EV penetration (Source: PCMC EV Policy) • Cost is INR 830,000 per Electric Vehicle	B.16 – Finance Electric Vehicles Through Banks
5. Bicycle Lanes	• 150 kilometer of bicycle lanes (Source: IFC PCMC Workshop) • Cost is INR 675,039 per kilometer	B.19 – Build Bicycle Lanes
6. Extend BRT System	• Additional 40 kilometer of BRT system • Project cost is approx. INR 114 crore per kilometer	B.23 – Add / Extend BRT System
7. Expand & Electrify BRT Bus Fleet	• Addition of 192 electric buses to the existing fleet (Source: PMPML Workshop) • Cost is INR 2.4 crore per e-bus	B.24 – Expand BRT Bus Fleet B.25 – Electrify BRT Bus Fleet
8. Extend Metro System	• 4.5 km extension of Pune Metro from PCMC metro station to Nigdi metro station (Source: Maha Metro workshop) • Cost is INR 580 crore per project	B.26 – Add / Extend Subway System
9. Add Park-and-ride Lot to Transit Station	• Addition of 780 parking spaces near transit stations • Cost is INR 334,490 per vehicle space	B.31 – Add Park-and-ride Lot to Transit Station
10. Introduce Fare Integration & Smart Transit Fare Cards Across Transit System	•	B.32 – Introduce Fare Integration Across Transit System B.33 – Introduce Smart Transit Fare Cards
11. Electrification of Municipal Fleet	• 200 new EVs added in municipal fleet replacing the old internal combustion engine vehicles • Cost is INR 830,000 per Electric Vehicle	B.35 – User-Defined Measure
12. Electrification of Auto-Rickshaws	• 17,000 new e-auto rickshaws added • Cost is INR 208,000 per vehicle	B.36 – User-Defined Measure

Solid Waste

Prioritized Measure	Key Assumptions	APEX Measure Code (Version 2023-05)
1. Decentralized Composting	• 15% domestic and 5% commercial food/organic waste composted • 74 tonnes of food/organic waste per day	C.1 – Mandate decentralized Composting
2. Ban Single Use Plastics	• 2% of plastic waste reduced	C.5 – Ban Single Use Plastics
3. Improve Waste Collection	• 100% Waste is collected • 189 tonnes per day collection increase • Cost is INR 872,286 per tonne per day, consists of 10,000 additional bins, 5 additional trucks, 189 tonnes per day waste transfer station	C.9 – Improve Waste Collection
4. Waste-to-Energy Facility	• 400 tonnes per day of waste converted to energy • Cost is INR 2.4 crore per tonne per day	C.12 – Add / Expand Incineration Facilities
5. Centralized Anaerobic Digestion	• 148 tonnes of food/organic waste treated per day • Cost is INR 968,318 per tonne per day	C.14 – Add / Expand Centralized Anaerobic Digestion

Water & Wastewater

Prioritized Measure	Key Assumptions	APEX Measure Code (Version 2023-05)
1. Rooftop Rainwater Harvesting	• 70% of habitable building roof area is utilized for rainwater harvesting • 138,000 m^3 per year water storage capacity • Cost is INR 22,832 per m^3 per year	D.1 – Mandate Rooftop Harvesting
2. Reuse Wastewater at Municipal Scale	• Additional 127MLD for alternative purposes • Cost is INR 6.1 crore per MLD	D.7 – Reuse Wastewater at Municipal Scale
3. Reuse of Wastewater	• 70% of new and 30% of existing habitable buildings reuses wastewater • New buildings: 26,700 m^3 of wastewater reuse per day • Existing buildings: 13,300 m^3 of wastewater reuse per day • Cost is INR 493,020 per m^3 per day – reuse	D.9 – Mandate Reuse of Wastewater From New Buildings D.11 – Mandate Reuse of Wastewater From Existing Buildings
4. Reduce Unaccounted-for Water Losses	• Losses down from 45% to 15.8% (65% improvement) • 429,600 m^3 per day savings • Unit cost: INR 26,975 per m^3 per day – loss reduction	D.14 – Reduce Unaccounted-for-Water Losses
5. Improve Efficiency For Water Conveyance Pumps	• Pumped volume: 944,189 m^3 per day • Unit cost: INR 203 per m^3 per day – pumped volume	D.15 – Improve Efficiency for Water Conveyance Pumps
6. Efficient Fittings in New & Existing Buildings	• 70% of new and 30% of existing buildings have efficient fittings • Scope: 4,644,500 m^2 for new buildings and 15,352,351 m^2 for existing buildings • Uplift cost for new buildings: INR 1,746 per m^2 • Uplift cost for existing buildings: INR 1,284 per m^2	D.18 – Mandate Efficient Fittings in New Buildings D.19 – Mandate Efficient Fittings in Existing Buildings
7. Smart Water Meters	• 20% of buildings are outfitted with smart water meters • Unit cost is INR 11 per m^2	D.20 – Install Smart Meters to Reduce Consumption and Leakage
8. New Centralized Wastewater Treatment Facilities	• Additional treatment capacity: 300 MLD • Unit cost is INR 4.3 crore per MLD	D.21 – Add New Centralized Wastewater Treatment Facilities

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APEX

An innovation of IFC, APEX supports cities in emerging economies to accelerate the implementation of ambitious and transformative policy actions and investments that significantly contribute to transitioning to low-carbon and resource-efficient growth pathways. The platform leverages the APEX Online App, which helps cities to quickly assess the most cost-effective ways to incorporate measures into their investment and policy pipelines.

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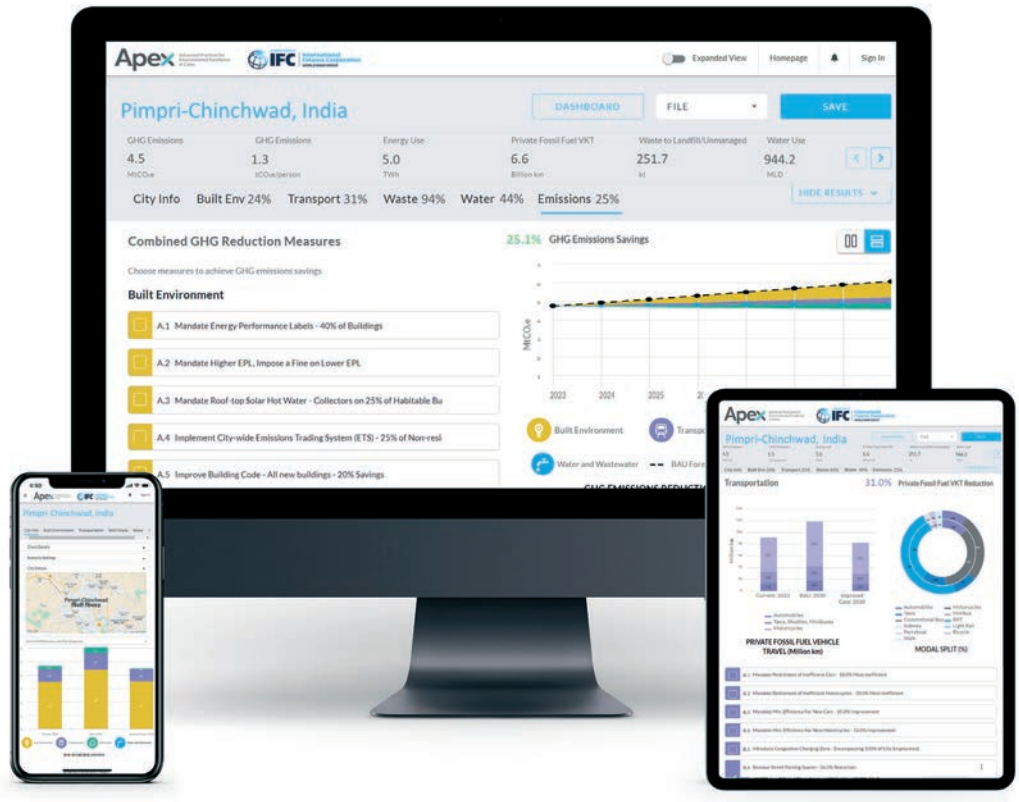

The APEX Online Application (available at www.apexcities.com).