

Bangkok City

Climate Investment Opportunities Diagnostic



DEVELOPED USING



This activity was funded by the City Climate Finance Gap Fund, a Multi-Donor Trust Fund with support from the Governments of Germany and Luxembourg



About this Report

This report presents a summary of the Bangkok City Climate Investment Opportunities Diagnostic (CIOD), focusing on prioritized climate investments and potential financing mechanisms. The CIOD 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 was funded by the City Climate Finance Gap Fund, a Multi-Donor Trust Fund.

Disclaimer Notice

IFC does not guarantee the accuracy, reliability, or completeness of the content included in this work, or the conclusions or judgments described herein, and accepts no responsibility or liability for any omissions or errors (including, without limitation, typographical errors and technical errors) in the content whatsoever or for reliance thereon. The boundaries, colors, denominations, and other information shown on any map in this work do not imply any judgment on the part of the World Bank Group concerning the legal status of any territory or the endorsement or acceptance of such boundaries. The findings, interpretations, and conclusions expressed in this volume do not necessarily reflect the views of the executive directors of the World Bank Group or the governments they represent.

The contents of this work are intended for general informational purposes only and are not intended to constitute legal, securities, or investment advice, an opinion regarding the appropriateness of any investment, or a solicitation of any type. IFC, or its affiliates, may have an investment in, provide other advice or services to, or otherwise have a financial interest in, certain companies and parties named herein.

All other queries on rights and licenses, including subsidiary rights, should be addressed to IFC's Corporate Relations Department, 2121 Pennsylvania Avenue, N.W., Washington, D.C. 20433.

International Finance Corporation is an international organization established by articles of agreement among its member countries, and a member of the World Bank Group. All names, logos and trademarks of IFC are the property of IFC and you may not use any of such materials for any purpose without the express written consent of IFC. Additionally, "International Finance Corporation" and "IFC" are registered trademarks of IFC and are protected under international law. All other product names, trademarks and registered trademarks are property of their respective owners.

Table of Contents

Message from Governor of Bangkok	04
Message from the World Bank Group	05
Acknowledgments	06
Acronyms and Abbreviations	07
Executive Summary	09
Introduction	14
City Context	15
Bangkok Master Plan on Climate Change	19
City Financial Overview and Enabling Conditions	22
Climate Investment Opportunities Diagnostic	25
Green and Upgrade Municipal Buildings	29
Green Infrastructure	33
Investing in Climate-Smart Infrastructure and Public Services	34
Mobilizing Green Financing Towards Low-Carbon Investments	38
Summary and Conclusion	47
Appendix: APEX City Data	49
General City Information	49
Built Environment & Energy	50
Transportation	52
Waste	54
Water	55
References	56

Message from Governor of Bangkok

Bangkok, the capital city of Thailand, is a mega city that continues to grow rapidly. The expansion of economic activities in the city releases a large amount of greenhouse gas (GHG) emissions into the atmosphere contributing to climate change. In addition, recent PM2.5 air pollution phenomena, which seem to relate to the GHG emissions, has become the new challenge for Bangkok to maintain the citizens' well-being, along with sustainable growth and prosperity of the city.

Recognizing the significance of the climate change problem, the Bangkok Metropolitan Administration (BMA) has formulated the Bangkok Master Plan on Climate Change 2021-2030 by setting a target for GHG emission mitigation to no less than 19% compared to a business as usual (BAU) by 2030. Furthermore, a vision to achieve "a net-zero GHG emissions city" by 2050 has also been established.

The Master Plan covers 5 sectors, including sustainable and environmentally friendly transport, efficient energy use and alternative energy use, efficient waste management and wastewater treatment, green urban planning and adaptation to climate change. Launching Climate Change Master Plan was only the first step in our journey towards net-zero emissions by 2050. It is clear that we will need innovative delivery models and participation with the private sector to achieve our goals, and we are exploring approaches and partnerships to get us there. Our collaboration with International Finance Corporation (IFC) and the World Bank has been vital in helping us take our plans closer towards implementation. This assessment is the result of a collaborative effort that will help us identify opportunities and define BMA's role can play in engaging stakeholders towards a shared vision of a green Bangkok City.



On behalf of the BMA, I would like to take this opportunity to express my sincere gratitude to International Finance Corporation (IFC) and the World Bank as a development partner as well as Japan International Corporation Agency (JICA), and all stakeholders for their participation and support in preparing the Climate Investment Opportunities Diagnostic report. The BMA sincerely hopes to gain further collaboration from the private sectors in developing Bangkok to become a livable and resilient metropolis, capable of withstanding climate-related disasters, while ensuring sustainability in every dimension in the future.

Chadchart Sittipunt
Governor of Bangkok

Message from the World Bank Group

Cities play a crucial role in the global climate agenda, facing unique challenges and opportunities.

Bangkok, with over 10 million inhabitants, has the potential to transform itself into a truly climate-smart city by making the right investments that facilitate the climate transition.

The Climate Investment Opportunities Diagnostic (CIOD) serves as an outline for Bangkok to achieve its climate targets and net-zero vision. By identifying and prioritizing a green investment pipeline, the CIOD provides a blueprint for comprehensive city-level planning, policies, and investments. This roadmap is based on factors such as greenhouse gas (GHG) savings, co-benefits, indicative costs, and potential financing options.

Building upon the JICA-supported Bangkok Climate Change Master Plan, the CIOD leverages IFC's APEX Green Cities tool which brings the World Bank Group's investment expertise to transform proposed climate actions to viable solutions based on global practices that are aligned with local context. APEX empowers cities like Bangkok to accelerate the implementation of ambitious and transformative climate policies and investments.

The World Bank Group is committed to supporting cities in their efforts to decarbonize, build resilience, and pursue sustainable urban development. By providing technical assistance and financing, we aim to help cities mitigate climate change impacts while achieving broader development goals.

We commend the Bangkok Metropolitan Administration (BMA) for their unwavering commitment to a Green Bangkok. The completion of the CIOD marks a pivotal milestone in the city's sustainability journey and we look forward to working on more joint initiatives to make Bangkok a truly green city.

Melinda Good, Country Director, World Bank



Jane Yuan Xu, Country Manager, International Finance Corporation



Acknowledgments

This Climate Investment Opportunities Diagnostic is the result of a strong collaboration between Bangkok City officials, IFC, and the World Bank. The diagnostic leverages a new IFC initiative, APEX, which is supported by the APEX Online App, a tool that helps quantify and prioritize policy and investment solutions across four key sectors: energy, transportation, waste, and water.

IFC's team was led by Prashant Kapoor, working closely with Rachanee Chanawatr, Lorraine Sugar, Kelvin Tagnipez, Pichaya Moeller, Risa Komatsuzaki, and Nancy Moreno Mora. The diagnostic was part of a broader World Bank Group engagement on climate-smart city investments for Bangkok Metropolitan Administration, with additional components undertaken by World Bank teams led by Steven Rubinyi.

The diagnostic was coordinated by Bangkok Metropolitan Administration's Department of Environment. It benefitted from the strong support of the Governor of Bangkok, Mr. Chadchart Sittipunt, as well as important input from the BMA Advisor to the Governor and Chief Sustainability Officer, Mr. Pornphrom N.S. Vikitsreth, Department of Environment, Department of Drainage and Sewerage, Department of Public works, and Department of Finance.

The teams wish to thank all workshop participants and reviewers for their valuable feedback.

The diagnostic was supported by the City Climate Finance Gap Fund, a Multi-Donor Trust Fund with support from the government of Germany and Luxembourg.

BMA and its partners come together for workshops to develop the Bangkok climate investment plan.



Image: BMA

Acronyms and Abbreviations

APEX	Advanced Practices for Environmental Excellence in Cities	KT	Krungthep Thanakom Co., Ltd.
ARL	Airport Rail Link	LFI	Local Financial Institution
BAU	Business-as-usual	LVC	Land Value Capture
BMA	Bangkok Metropolitan Administration	m²	Square meters
BMTA	Bangkok Mass Transit Authority	m³	Cubic meters
Bn	Billion	MEA	Metropolitan Electricity Authority
BOO	Build-Own-Operate	MLD	Million Liters per Day
BOOT	Build-Own-Operate-Transfer	MRF	Material Recovery Facility
BOT	Build-Operate-Transfer	MRT	Metropolitan Rapid Transit
BTO	Build-Transfer-Operate	MtCO_{2e}	Million tonnes of carbon dioxide equivalent
BTS	Bangkok Mass Transit System (Bangkok Sky Train)	MWA	Metropolitan Waterworks Authority
BTSC	Bangkok Transit System Corporation	MWp	Megawatt peak
CAMACOL	Colombian Chamber of Commerce	NDC	National Decentralization Committee
CIOD	Climate Investment Opportunities Diagnostic	OECD	Organisation for Economic Co-operation and Development
DDS	Department of Drainage and Sewerage	PISU	Private Investments in State Undertakings
DFI	Development Financial Institution	PPP	Public-Private Partnerships
EaaS	Energy-as-a-Service	PPSU	Private Participation in State Undertakings
EE	Energy Efficiency	PV	Photovoltaics
EIU	Economist Intelligence Unit	RCF	Revolving Credit Facility
E-Motorcycle	Electric Motorcycle	SEK	Swedish Krona
ESPC	Energy Service Performance Contract	SLB	Sustainability-linked Bond
ESCO	Energy Service Company	SLL	Sustainability-linked Loan
EUR	Euro	STEG	Tunisian Company of Electricity and Gas [<i>Société Tunisienne de l'électricité et du gaz</i>]
EV	Electric Vehicles	THB	Thai Baht
GHG	Greenhouse Gas	TRIS	Thai Rating and Information Services Co., Ltd.
HKD	Hong Kong Dollar	UCLG	United Cities and Local Governments
HVAC	Heating, Ventilation, and Air Conditioning	USD	United States Dollar
IFC	International Finance Corporation	WTE	Waste-to-Energy
JICA	Japan International Cooperation Agency		
KPI	Key Performance Indicator		



Executive Summary

The Bangkok City Climate Investment Opportunities Diagnostic (CIOD) aims to support the implementation of Bangkok Metropolitan Administration's (BMA) Master Plan on Climate Change 2021-2030 by evaluating several of its actions in terms of potential investments, indicative costing, and potential funding sources. It leverages a new platform developed by the International Finance Corporation (IFC) called APEX (Advanced Practices for Environmental Excellence in Cities), an online software tool that helps quantify and prioritize city-based policy and investment solutions in the energy, transport, water, and waste sectors.

The priority actions in the Master Plan, as well as others identified by city stakeholders, were aligned with sectors and measures in the APEX tool to identify green investments that could contribute towards BMA's greenhouse gas (GHG) reduction targets. In total, 23 measures were prioritized, which APEX classifies as either direct cost measures where the cost is the responsibility of the municipality and other public agencies, or indirect cost measures where the cost is mobilized by municipal policies, regulation, and outreach programs. Potential financing options were then identified and analyzed within Bangkok City's specific regulatory and financial context. Details of investments, scopes, and suggested financing delivery models are detailed in this report.

The CIOD identifies and outlines investment opportunities totaling THB 887,184 million (USD 24,200 million)¹ that would be required to implement the measures across the four key sectors of built environment and energy, transport, solid waste, and water and wastewater. Around 77 percent (THB 679,536 million) of these total investments would be indirect cost measures, and 23 percent (THB 207,648 million) direct cost measures. If all these investment opportunities are carried to fruition, they are expected to deliver a 21 percent GHG reduction to Bangkok City across all four sectors under analysis.

The CIOD presents financing options for these 23 measures within four groups, categorized based on shared characteristics and financing opportunities, as follows:

- 1. Investing in Green Municipal Facilities** – Reduce energy consumption in both new and existing public buildings through energy efficiency upgrades and renewable energy (*Table 1*).
- 2. Investing in Green Infrastructure** – Expand urban parks, green corridors, and rainwater collection systems (*Table 2*).
- 3. Investing in Climate-Smart Infrastructure and Public Services** – Enhance transport options, improve waste management, and increase water security (*Table 3*).
- 4. Mobilizing Green Financing Toward Low-Carbon Investments** – Mobilize climate-smart building policies, facilitate private financing for alternative energy, climate-smart upgrades and greening of both existing and new private buildings, and incentivize the e-vehicle transition (*Table 4*).

¹ Final investment volumes have been presented excluding the large rail projects led by other agencies, which represent an additional THB 1,690,560 million (USD 46,020 million).

Executive Summary

Table 1: Investing in Green Municipal Facilities.

MEASURES	Direct Cost (THB Million)	GHG Savings (%)	Financing Options	
			1 st	2 nd
EE Refurbishment of Municipal Buildings	116,460	0.9	Energy Service Performance Contracts and Guarantee Fund	Municipal Loan
Solar PV on Municipal Buildings	9,180	0.7		
Energy Efficient Street, Traffic Lights	1,800	<0.1		
Total	127,440	1.7%		

Note: EE = energy efficiency; PV = photovoltaics.

Table 2: Investing in Green Infrastructure.

MEASURES	Direct Cost (THB Million)	GHG Savings (%)	Financing Options	
			1 st	2 nd
Urban Green Corridors and Parks	288	<0.1	Own Revenue Sources	Municipal Loan
Rainwater Storage (Ponds, Lakes, Reservoirs)	14,796	<0.1		
Total	15,084	<0.1%		

Table 3: Investing in Climate-Smart Infrastructure and Public Services.

MEASURES	Direct (BMA) Cost (THB Million)	Direct (Other) Cost (THB Million)	GHG Savings (%)	Financing Options		
				1 st	2 nd	
Bicycle Lanes	72		<0.1	Municipal Loan	Public-Private Partnerships (Traditional Contracts)	
Bus Lanes	216		<0.1			
Electric Buses (BMTA)		13,392	0.2			
Anaerobic Digestion Facilities	324		0.7			
Extend BTS and MRT		1,467,000	3.5	Public-Private Partnerships (Traditional Contracts)	Private Financing through Local Intermediaries	
Extend Monorail and Airport Rail		223,560	0.4			
Park-and-ride in Transit Stations	864		<0.1			
Improve Waste Collection	1,368		-			
New Materials Recovery Facilities	2,808		2.1			
Waste-to-Energy Facilities	8,604		1.4			
Composting Facilities	14,724		1.5			
Wastewater Reuse at Municipal Scale	5,220		<0.1			
New Wastewater Treatment Facilities	17,532		0.3			
Total	51,732	1,703,952	10.1%			Municipal Loan

Note: BMTA = Bangkok Mass Transit Authority; BTS = Bangkok Mass Transit System; MRT = Metropolitan Rapid Transit.

Table 4: Mobilizing Green Financing Toward Low-Carbon Investments.

MEASURES	Indirect Cost (THB Million)	GHG Savings (%)	Financing Options	
			1 st	2 nd
EE Refurbishment of Private Buildings	190,260	1.3	On-Bill Financing	Private Financing through Local Intermediaries
Private Solar PV	91,800	6.8		
Wastewater Reuse for Flushing & Outdoor Uses	1,476	<0.1		
E-Motorcycles for Private Consumers	36,000	0.2	Private Financing through Local Intermediaries	Leasing
EVs for Private Consumers	360,000	1.0		
Total	679,536	9.3%		

Note: EE = energy efficiency; PV = photovoltaics; E-Motorcycle = electric motorcycle; EV = electric vehicle.



Image: timelockz on Pexels

Developing green infrastructure, such as Lumpini Park, is a priority of the Bangkok climate master plan.

There are a few measures that stand out with the highest contributions towards the GHG targets. Taken together, these measures will contribute to nearly 90 percent of the emissions reduction potential and can be considered priorities for future implementation:

- A city-wide solar PV program and greening of private buildings with energy efficiency upgrades. Mechanisms such as on-bill financing and mobilizing financing through green city charter commitments can help spur these investments.
- The extension of the BTS and MRT will help expand public transportation offerings, while financing and incentives for EVs can encourage the transition towards electric mobility.
- New waste management technologies, including composting and anaerobic digestion for organic waste, waste-to-energy, and recycling, will help avoid the GHG emissions associated with landfills.

It is clear from the CIOD assessment that the private sector will need to play a large role in ensuring Bangkok City reaches its GHG reduction targets. As shown in *Figure 1a*, indirect cost measures make up nearly two-thirds of the green investment opportunity in Bangkok, primarily in energy and water efficiency upgrades in private buildings and solar panels (together 33%), as well as private electric mobility (46%). Even for direct cost measures, such as greening municipal buildings and waste management, BMA can engage the private sector through innovative delivery models (*Figure 1b*). For some types of direct investments, working with the private sector can help reduce financial risk and free up BMA's own-source revenue to deliver other essential services. Given the importance of mobilizing private investment towards green city actions, BMA will also play an important role in convening stakeholders, providing incentives, and educating residents and businesses about green city financing opportunities.

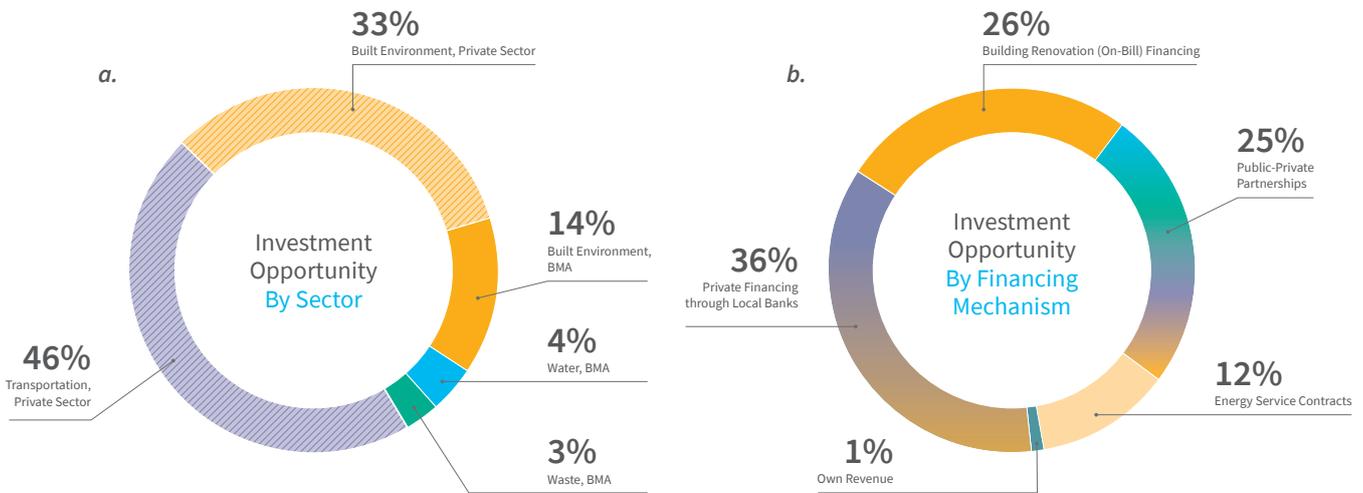
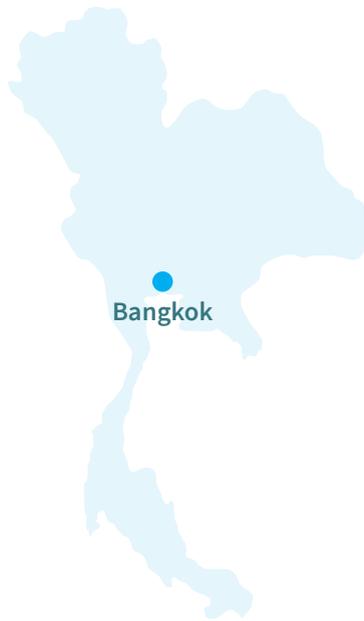


Figure 1: The distribution of Bangkok's green investment opportunity (approximately THB 890 billion) presented two ways: a) by sector, and b) by potential financing mechanism.

Introduction



City Context



Bangkok stands as the most populous urban area in the country and one of the most visited cities the world. With the rapid expansion, the city is home to over 10 million residents, commuters, and visitors. Bangkok serves as the central hub for Thailand's economic, political, and cultural activities.

The city is characterized by a tropical monsoon climate, with three distinct seasons: the dry-hot season from March to June, where the temperatures could be above 35 degrees Celsius; the rainy season from July to October; and the cool-dry season from November to February, which offers a range of temperatures lower than 30 degrees Celsius. The Chao Phraya River, one of the country's most significant waterways, cuts across the city, playing an important factor in its climate dynamics. Politically, Bangkok City is divided into fifty districts, each represented by an elected councilor.

Bangkok aims to be the "Capital of Asia" and a net-zero emission city.



Image: Mikhail Nilov on Pexels

Built Environment & Energy

Bangkok’s built environment has undergone significant changes in land use over the past few decades. The urbanization of the city has been characterized by both extension and densification to accommodate the influx of population as well as visitors. The built-up area has expanded in all direction from the existing city core structure. The majority of Bangkok’s land area, accounting for 78 percent, is dedicated to residential use, which includes homes and apartments (Figure 2). Another 16 percent comprises non-residential buildings, such as offices, hotels, hospitals, schools, universities, warehouses, convention centers, and others. The remaining 6 percent is allocated for mixed-use properties.

Bangkok and the surrounding provinces rely exclusively on the Metropolitan Electricity Authority (MEA) for their electricity distribution. With the region’s high population density and rapid urbanization, the electricity consumption in Bangkok and its adjacent provinces—Nonthaburi and Samutprakarn—constitutes a significant 27 percent of the total electricity generated in the country.

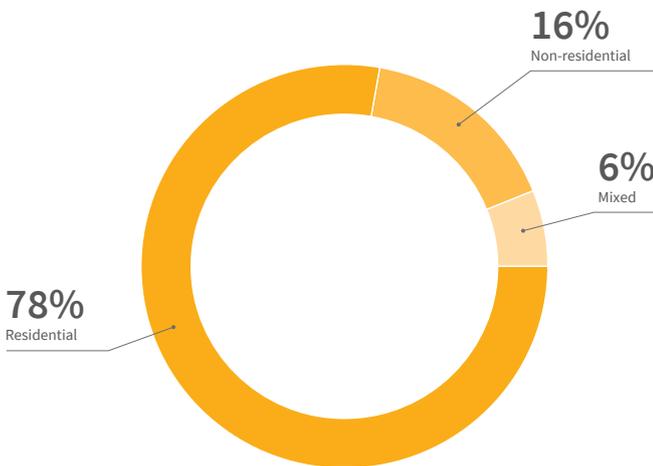


Figure 2: Building area percentage by type.

Transportation

Despite Bangkok’s extensive public transportation system, rail transit accounts for only 6 percent of total travel based on kilometers traveled. Residents of Bangkok predominantly rely on four-wheeler vehicles (38 percent) and motorcycles (19 percent) for their daily commuting needs. Remarkably, as shown in Figure 3, over 90 percent of the distance traveled in the city continues to heavily depend on combustion engine vehicles.

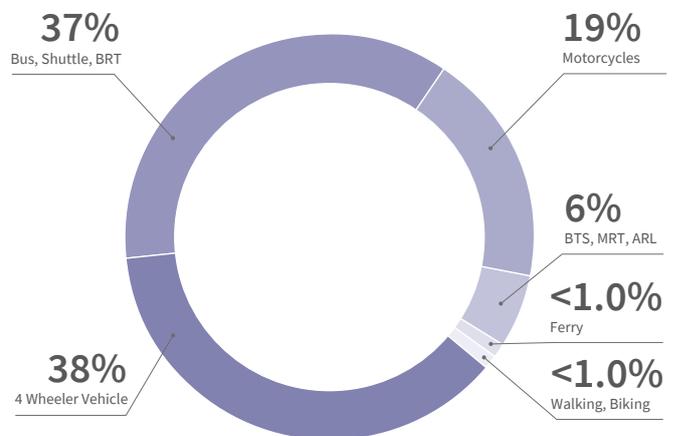


Figure 3: Modal split by passenger kilometers travelled.

Note: BRT = bus rapid transit; BTS = Bangkok Mass Transit System; MRT = Metropolitan Rapid Transit; ARL = Airport Rail Link.

Waste

On average, each resident of Bangkok produces approximately 0.41 tonnes of waste per year, resulting in a staggering total of 3.2 million tonnes annually. Nearly half of this waste consists of organic waste generated from food scraps. Unfortunately, over half of the total waste ends up in landfills, while only 22 percent is sorted for recycling, and a mere 16 percent is composted (Figure 4). Several challenges in waste management persist in Bangkok. These include a lack of general public awareness and knowledge about recycling, leading to limited practices in waste separation. Additionally, the city faces an inadequate official waste collection network, prompting residents to rely on informal recycling methods.

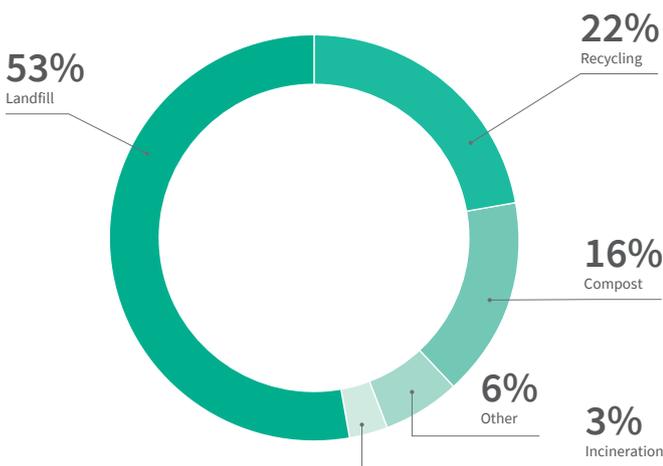


Figure 4: Waste composition by type.

Water

Residents of Bangkok have access to safe, potable water. The Metropolitan Waterworks Authority (MWA) plays a crucial role in filtering, treating, and distributing potable water across Bangkok and adjacent cities, including Samutprakarn, Nonthaburi, Pathum Thani, and Nakhon Pathom.

In terms of wastewater management and sewerage systems in Bangkok, the Department of Drainage and Sewerage (DDS), a department under the BMA, plays a crucial role. DDS oversees the infrastructure of drainage systems, including rainwater management, flood prevention, and waterways within the city. Additionally, DDS is responsible for overseeing the sewer network, ensuring proper wastewater collection, and managing wastewater effectively.

On average, Bangkok residents utilize 470 liters of water per person per day, which accumulates to 2.6 billion liters per day throughout the city consumed by residents and commuters/visitors serviced by the MWA. All this water goes through the treatment system in Bangkok. Forty-four percent flows through the city’s sewerage system, while the remaining 56 percent is treated in septic tank systems as shown in Figure 5.

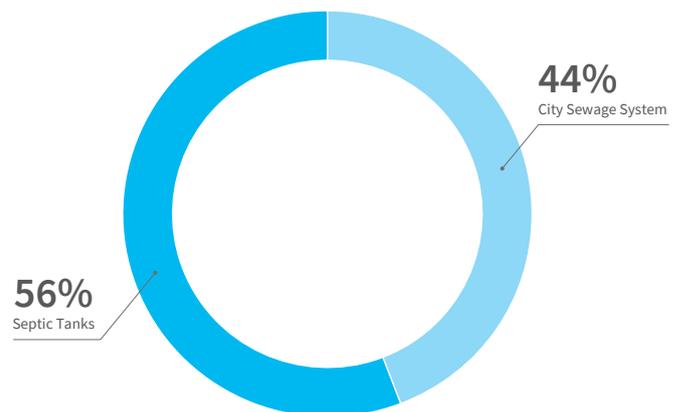


Figure 5: Wastewater treatment methods.

Greenhouse Gas Emissions

Using the APEX Online App to develop a GHG baseline for 2023 and building on the BMA’s Master Plan on Climate Change 2021-2030², the GHG inventory revealed that Bangkok produces over 27 million tonnes of carbon emissions across the energy, transportation, waste, and water sectors. As shown in *Figure 6*, the majority of which (67 percent) from the built environment and energy; the remaining third from transportation

(23 percent), solid waste (9 percent), and water and wastewater (<1 percent). The GHG baseline does not include emissions from industry or freight, as these sectors have not yet been included in APEX because they can be difficult to influence with city-level policies and investment.

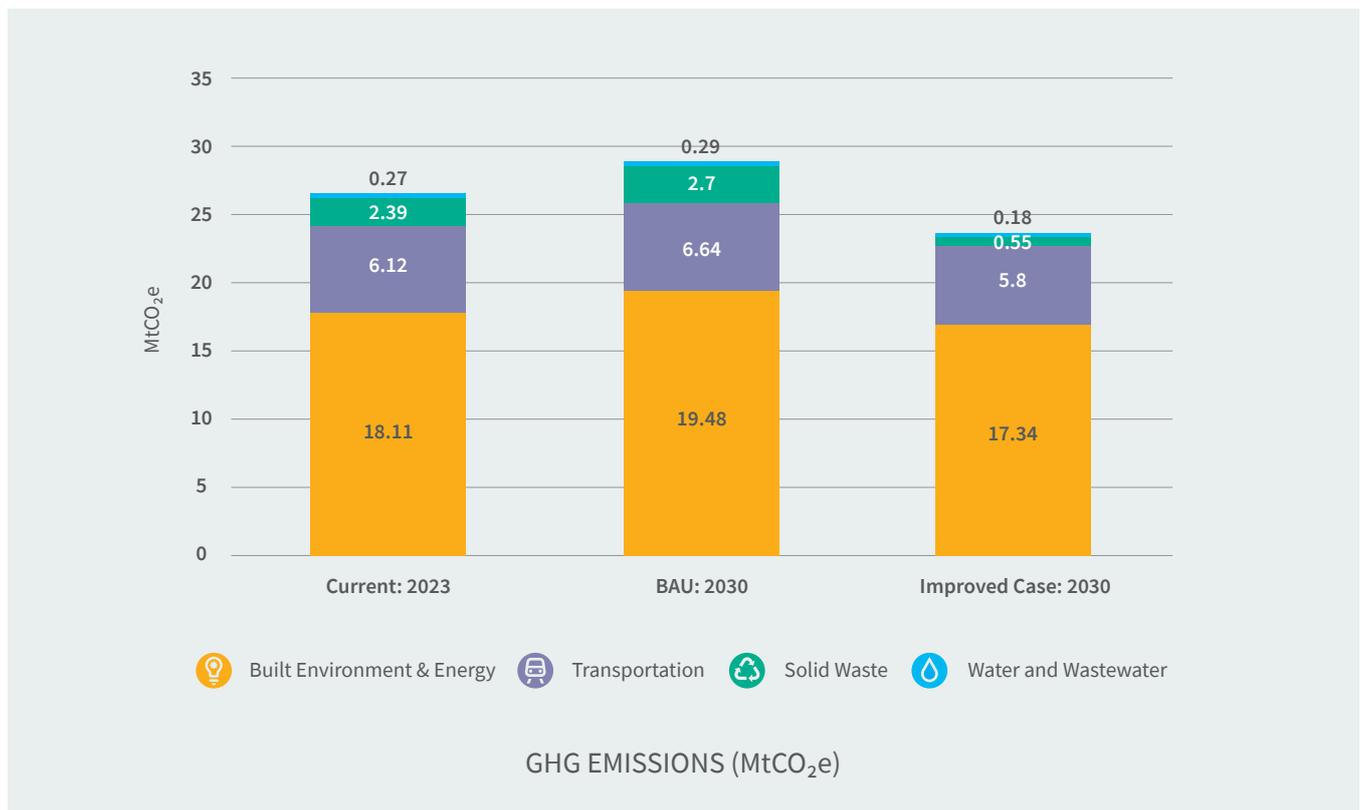


Figure 6: GHG baseline, as well as the improved case emissions, for Bangkok for the four APEX sectors: built environment, transportation, solid waste, and waste and wastewater.

Note: MtCO₂e = million tonnes of carbon dioxide equivalent; BAU = business-as-usual; GHG = greenhouse gas.

² The APEX GHG baseline for 2023 follows a methodology consistent with the BMA’s most recent GHG inventory from 2020, developed in partnership with Japan International Cooperation Agency (JICA), i.e., the GHG Protocol for Cities, available: <https://ghgprotocol.org/ghg-protocol-cities>.

Bangkok Master Plan on Climate Change



BMA, IFC, and the World Bank hosted the Bangkok Green City Solutions forum to present the CIOD to the private sector, and to gain insights on climate strategies from leading corporations.

The series of masterplans aimed at addressing climate change in Bangkok not only underscores the city's unwavering commitment to tackling environmental challenges but also signifies an effort to foster sustainable urban development. These strategic blueprints serve as vital roadmaps, guiding the city toward a greener, more resilient future for its residents and the generations to come.

In 2007, BMA embarked on a journey to address climate change. This endeavor began with the implementation of the Global Warming Mitigation Action Plan (2007-2012). During this period, BMA formulated its inaugural action plan to mitigate greenhouse gas (GHG) emissions. The primary objective was twofold: to reduce Bangkok's carbon footprint and enhance environmental resilience.

This first masterplan had led to the formulation of the Bangkok Master Plan on Climate Change (2013 -2023), which BMA had developed in collaboration with the Japan International Cooperation Agency (JICA). This masterplan established the foundation for climate action in Bangkok, aiming for a 13.6 percent reduction in GHG emissions relative to the business-as-usual (BAU) scenario by 2020. The plan prioritized four main

sources of GHG emissions: transportation, energy, waste, and wastewater. Additionally, it emphasized mitigation strategies centered on green urban planning to foster a more sustainable city environment.

In 2021, BMA and JICA carried out the second comprehensive assessment of the Bangkok Master Plan on Climate Change 2013-2023. The review revealed that the GHG emissions for 2020 amounted to approximately 40.75 million tonnes of carbon dioxide equivalent (MtCO₂e), which was below the 2020 target of 46.4 MtCO₂e. This indicates that BMA achieved the GHG reduction target as provide in the Master Plan, demonstrating effective the implementation in the city's climate action efforts.

Subsequently, the Bangkok Masterplan on Climate Change (2021-2030) was developed by BMA and JICA. The plan emphasizes five key aspects, including environmentally sustainable transport, energy efficiency and alternative energy, efficient solid waste management and wastewater treatment, green urban planning, and adaptation planning (Figure 7). The masterplan sets a GHG emissions reduction target of 19 percent from BAU by 2030 and includes a vision to achieve net-zero greenhouse gas emissions by 2050 (Figure 8).

As a local government entity, BMA has a pivotal role in spearheading climate action and guiding Bangkok’s transition toward emission reduction and climate resilience. The core duty of local government lies in safeguarding the well-being and assets of residents. Beyond GHG emissions, mitigation efforts also encompass fostering and advancing environmental industries within the city. Simultaneously, disaster prevention, an integral facet of adaptation, seeks to shield both lives and the city’s economic stability. Consequently, local government policies should consistently integrate adaptive measures, including robust disaster prevention strategies.



Figure 7: Scope of Bangkok Masterplan on Climate Change (2021-2030). Source: Climate Change Department, BMA.

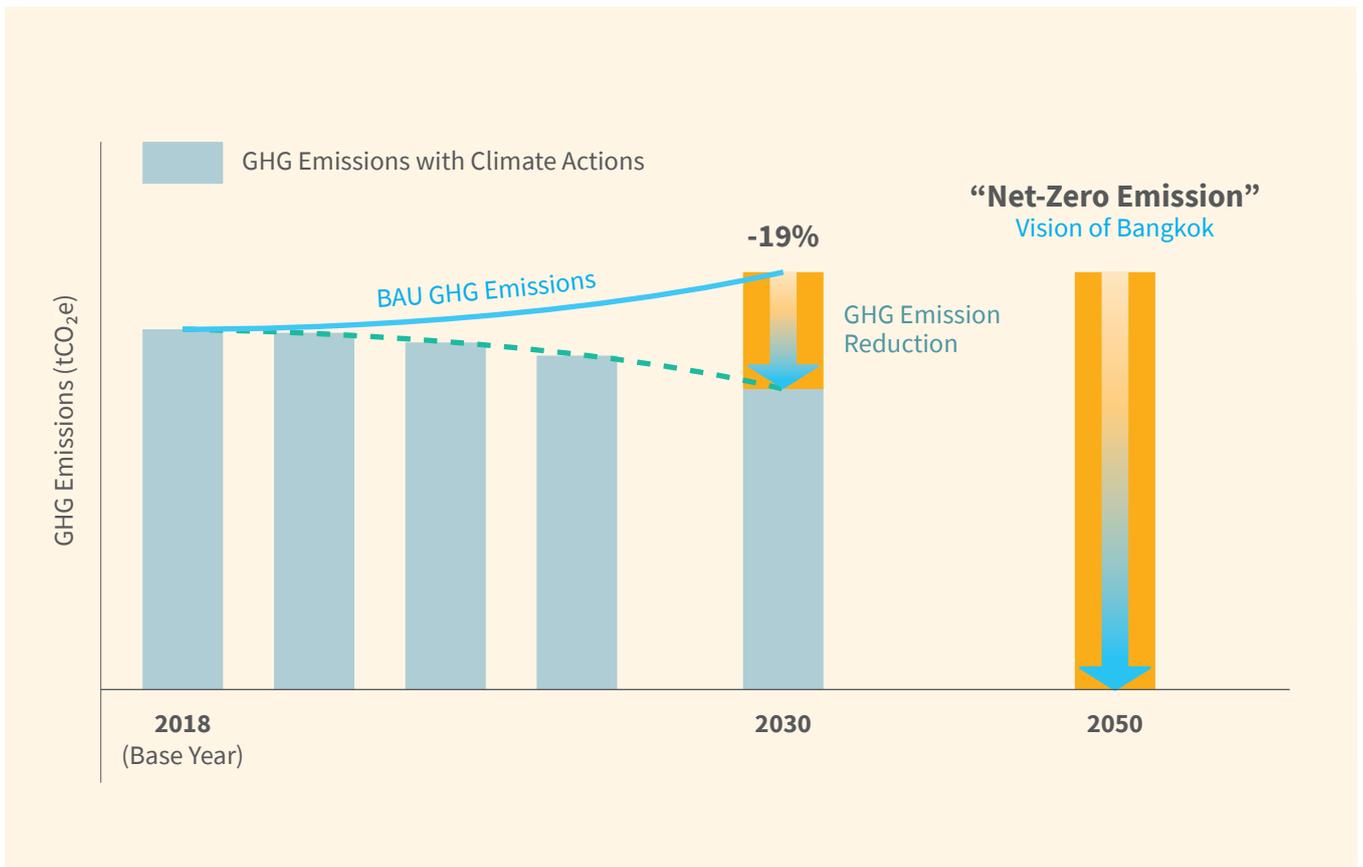


Figure 8: Bangkok's interim target by 2030 and long-term vision towards net-zero emission by 2050.



Image: Markus Winkler on Pixels

Increasing share of travel on public transport and electric vehicles is key to achieving Bangkok's climate targets.

City Financial Overview and Enabling Conditions

The CIOD identifies potential financing options for prioritized measures, which takes into consideration BMA's budget and financial context. The analysis of BMA's financial overview and enabling conditions includes six dimensions: fiscal autonomy and net taxes, subnational debt capacity, creditworthiness and prior debt experience, status of land value capture (LVC) legislation, and the legal framework for public-private partnerships (PPP). The six dimensions are described in further detail below and summarized using a traffic-light approach in *Figure 9*.

Fiscal Autonomy and New Taxes

The 1991 State Administration Act in Thailand establishes two levels of subnational government: provincial and local. Thailand is divided into 77 provinces and the Metropolitan City of Bangkok, where the national government is represented at the regional level through deconcentrated entities. Bangkok is governed by a special body, BMA, which has the same status as a province (OECD/UCLG, 2022).

The 1999 Decentralization Act regulates the financial aspects of subnational government in Thailand. According to this act, subnational governments receive transfers from the central government and have the ability to generate local revenue from various sources. However, Thailand's subnational governments face two significant challenges in terms of finance. On the expenditure side, their decision-making power is limited as the central government controls budget allocation through the National Decentralization Committee (NDC). On the revenue side, subnational governments lack fiscal autonomy and self-sufficiency, relying heavily on grants and subsidies from the central level, which are often insufficient to cover public services.

In fiscal year 2020, subnational government expenditure in Thailand accounted for 4 percent of the country's GDP and 16 percent of total public expenditure. In the same year, subnational governments directly invested 32 percent of their total spending, which also represented a significant portion (31 percent) of public investment at the national level. These ratios have remained stable since 2016. Subnational governments in Thailand are responsible for carrying out public infrastructure projects, which can be funded through their own revenue or through specific transfers from the national government. However, they have limited autonomy in carrying out these investments as they are closely supervised by the national government and must adhere strictly to the guidelines and strategies set by the central level ministries.

The main sources of revenue for subnational governments are grants (general purpose and conditional grants) and subsidies from the central government, income from shared and local taxes, tariffs and fees, and income from assets. Subnational government own-source (or locally levied) taxes include mostly the land and building tax (property tax), accounting for 3 percent of subnational government tax revenue in 2020, and a tax on property transfer (15 percent of subnational government revenue). There are also minor local taxes such as signboard taxes, animal slaughter taxes, bird nest collection taxes, and hotel rental taxes. Provincial governments only levy taxes from the sale of cigarettes, tobacco, and gasoline.

BMA relies heavily on tax revenue, which accounts for over 90 percent of its total revenue (TRIS Rating, 2021). There are two types of taxes: local taxes collected directly by BMA and allocated taxes collected by other government agencies and distributed to BMA. Local taxes, primarily property tax, contribute around 18 percent of BMA's total revenue, while allocated taxes make up the majority (77 percent).

During the past five years, four key taxes have been the primary sources of revenue for BMA, comprising over 80 percent of the total. These taxes include property tax, value-added tax, land transfer fees, and automobile tax. The amounts collected from these taxes are influenced by the country's economic conditions, and the government may occasionally reduce one or more of these taxes to stimulate economic growth.

BMA's expenditures can be classified into two categories: operating expenditures and capital expenditures. Operating expenditures have accounted for around 75 percent of total expenditures annually for the past five years. BMA reduced and postponed some of its capital expenditures due to the drop in revenue. Subsidies from the central government provide an alternative source of funds. However, government subsidies usually involve a lengthy approval process that may not meet the timely execution requirements in some instances. BMA has, in many instances, operated through Krungthep Thanakom Co., Ltd. (KT), its subsidiary, as a conduit in contracting and obtaining financing for some key infrastructure undertakings in Bangkok.

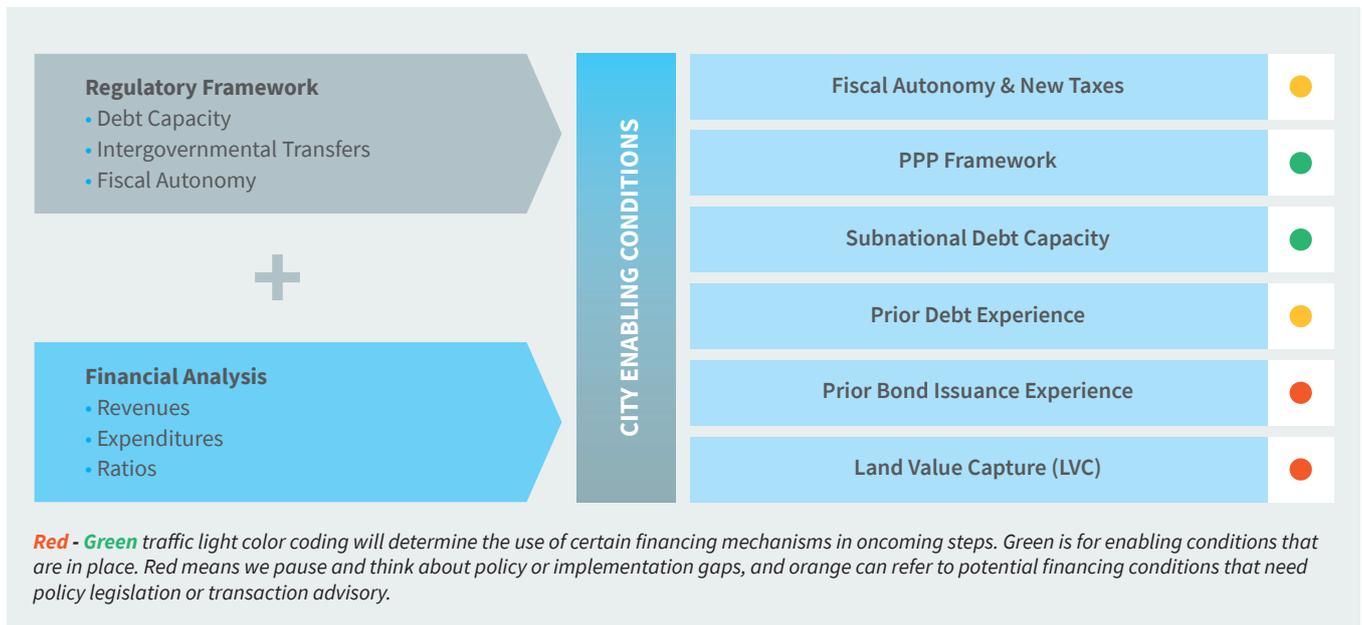


Figure 9: BMA's Financial Overview and Enabling Conditions.

Subnational Debt Capacity

The 1999 Decentralization Act established that municipalities may borrow from ministries or other legal persons, and that they can contract loans with foreign organizations and issue bonds with the approval of the Council of Ministers (OECD/UCLG, 2022).

The subnational debt ratio must not exceed 10 percent of subnational revenues, calculated using a three-year moving average of revenue data. Since April 2018, a new rule for local government borrowing from financial institutions has been in force in Thailand. Local governments can borrow from financial institutions exclusively to spend and invest in three specific objectives: investment projects, debt restructuring, and to manage local government pawnshops with the approval of the central government.

In addition, subnational governments that wish to use debt as a financial instrument must have financial plans, a standard accounting system, an internal monitoring system, and a financial management and repayment system. The central government does not guarantee debt contracted by subnational governments. While fiscal rules for subnational governments are described in the various guidelines provided by the Ministry

of Interior and fall under the scrutiny of the Office of the Auditor General, this often results in the Ministry overriding local governments' budget decisions in order to align them with national priorities.

Unlike other local governments, BMA is authorized by law to issue municipal bonds, subject to clearance from the Ministry of Interior. Despite positive ratings, the lack of tax revenue has been one of the major hindrances for bond issuance.

Thai Rating and Information Services Co., Ltd. (TRIS) Rating has affirmed the issuer rating of the BMA at AA+ with a stable outlook. The rating is based on the significance of Bangkok as the capital city and economic hub of Thailand. It also considers BMA's dependable tax revenue, its balanced budget approach, and its substantial cash reserves. TRIS Rating anticipates continued support for BMA from the central government. The rating acknowledges the budgetary challenges faced by BMA due to the substantial capital investments required for public transportation and infrastructure projects.

Creditworthiness and Prior Debt Experience

At the end of September 2020, BMA's total debt was THB 51 billion (TRIS Rating, 2021). Most of BMA's debt consists of loans, agreements, and contracts (plus KT's obligations). The total debt was expected to increase substantially due to the acquisition of the two Green Line Skytrain extension (loans from the Ministry of Finance).

LVC Legislation in Place

Implementing LVC instruments may face challenges due to the outdated land and property tax systems in place (ADB, 2019). The tax system is highly centralized, which adds to the complexity. There is a Draft Property Windfall Tax that aims to introduce LVC by imposing a tax on property owners near infrastructure projects. However, the current status of its approval is unclear. There is also a potential demand risk based on past experiences with auction-based development for metro projects in Bangkok.

PPP Legal Framework in Place

In 2019, Thailand introduced the Public Private Partnership Act, which aims to promote private sector involvement in infrastructure projects, facilitate knowledge transfer, and enhance support measures for PPPs (OECD/UCLG, 2022). According to World Bank data, Thailand has approved 185 PPP projects with a total investment of USD 44 billion since 1990. However, subnational governments have limited involvement in the implementation of PPP projects, with the exception of BMA, which has more flexibility in adopting such contracts. A notable example of successful PPPs in Bangkok is the Metropolitan Waterworks Authority, which implemented a project in 2000 to reduce non-revenue water through a performance-based contract. This initiative helped the city save 165 million liters of water per day and resolve a crisis that had previously caused a 40 percent loss in water production.

The Thai government has widely used PPP procurement since 1992, when the Private Participation in State Undertakings (PPSU) Act was first introduced to support infrastructure development (EIU, 2018). In 2013, the original Private Investments in State Undertakings (PISU) Act was revised to streamline the government's PPP approval process, and additional resources were allocated to the PPP central unit, the State Enterprise Policy Office. The 2013 PISU Act and its ancillary laws allow government projects to be funded and/or operated through partnerships with private entities using different forms of concessions, including Build-Own-Operate (BOO), Build-Transfer-Operate (BTO) and Build-Operate-Transfer (BOT).

The Bangkok Mass Transit System (BTS), also known as Bangkok Skytrain, is one of the most well-known PPP projects in Bangkok Metropolitan Region. The BTS PPP project was developed in 1992, with service beginning in 1999. BMA was the public partner, and the Bangkok Transit System Corporation (BTSC) was the private partner (BTSC was formed especially for this project). Financing had to come from both equity and debt. The BTS project faced huge initial losses because of overestimated ridership forecasts, missing integration with other transportation modes, a low level of accessibility, limited network, and high fare rate. However, after connecting the transportation modes, installing direct ramps into important buildings and escalators between floors, and extending the BTS line, the project became profitable in 2008.

Climate Investment Opportunities Diagnostic





Image: Bobby Brown on Pixels

A significant share of GHG emissions in Bangkok is from energy use of buildings.

The CIOD identifies 23 investment opportunities that can be converted into a green investment pipeline for Bangkok City (Table 5). The green investment pipeline includes a mix of both direct-cost (i.e., public sector) and indirect-cost (i.e., private sector) actions, for which potential financing options are provided. The project pipeline is anticipated to reduce 21 percent of the city's GHG emissions across all sectors under analysis.

The financing options for these 23 measures are divided into four groups, categorized based on shared characteristics and financing opportunities, as follows:

- 1. Investing in Green Municipal Facilities** will help reduce energy consumption in both new and existing public buildings through energy efficiency upgrades and renewable energy.
- 2. Investing in Green Infrastructure** includes expansion of urban parks, green corridors, and rainwater collection systems.
- 3. Investing in Climate-Smart Infrastructure and Public Services** includes measures that enhance transport options, improve waste management, and increase water security.

4. Mobilizing Green Financing Toward Low-Carbon

Investments through implementing climate-smart building policies, facilitating private financing for alternative energy, climate-smart upgrades and greening of both existing and new private buildings, and incentivizing the e-vehicle transition.

The total investment cost for all measures totals approximately THB 887,184 million (USD 24,200 million), not including the large rail projects led by other agencies, which are an additional THB 1,690,560 million (USD 46,020 million). Direct cost measures (not including the rail projects) add up to THB 207,648 million (USD 5,650 million). The list of investments includes actions where the city can nudge behaviors through policy implementation such as green building codes, through pilot projects such as EV charging stations, or through leveraging the private sector to invest in green measures through mechanisms such as loans, PPPs, etc. The potential for alternative sources of financing is visualized in the investment flow diagram shown in Figure 10.

Climate Investment Opportunities Diagnostic

Table 5: Summary of the 23 investments in the green investment pipeline. Total cost includes direct and indirect investments to be made by the public and the private sector, respectively. The 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.

Measures	Direct (BMA Cost) (THB Million)	Direct (Other) Cost (THB Million)	Indirect Cost (THB Million)	GHG Savings (%)	Potential Financing Options						
					Own Revenues	Municipal Loans / Bonds	PPPs (Multiple Contract Modalities)	Energy Service Performance Contracts & Guarantee Fund	Leasing	On-Bill Financing	Private Financing Through Local Intermediaries
Built Environment	Private Solar PV		91,800	6.8%						✓	✓
	EE Refurbishment of Private Buildings		190,260	1.3%						✓	✓
	EE Refurbishment of Municipal Buildings	116,460		0.9%		✓		✓			
	Municipal Solar PV		9,180	0.7%		✓		✓			
	Energy Efficient Streetlights	1,404		<0.1%		✓		✓			
	Energy Efficient Traffic Lights	396		<0.1%		✓		✓			
	Urban Green Corridors & Parks	288		<0.1%	✓	✓					
Transportation	Extend BTS and MRT		1,467,000	3.5%			✓				✓
	EVs for Private Consumers		360,000	1.0%					✓		✓
	Extend Monorail and ARL		223,560	0.4%			✓				✓
	Electric Buses		13,392	0.2%		✓	✓		✓		
	Electric Motorbikes for Private Consumers		36,000	0.2%					✓		✓
	Park-and-ride in Transit Stations	864		<0.1%		✓	✓				
	Bus Lanes	216		<0.1%		✓	✓				
	Bicycle Lanes	72		<0.1%	✓		✓				
Waste	New Materials Recovery Facilities	2,808		2.1%		✓	✓				
	Waste to Energy	8,604		1.4%		✓	✓				
	Centralized Composting Facilities	14,724		1.5%		✓	✓				
	Centralized Anaerobic Digestion Facilities	324		0.7%		✓	✓				
	Improve Waste Collection	1,368		-		✓	✓				
Water	New Wastewater Treatment Facilities	17,532		0.3%		✓	✓				
	Rainwater Storage	14,796		<0.1%	✓	✓					
	Wastewater Reuse at Municipal Scale	5,220		<0.1%		✓	✓				
	Wastewater Reuse for Flushing/Outdoor			1,476	<0.1%					✓	✓
	185,076	1,713,132	679,536	21.0%	15,151	13,928	1,741,680	127,461	-	283,530	396,000

INITIAL COSTS BASED ON LOCAL & APEX CITIES DATA; SUBJECT TO FURTHER STUDY

✓ 1st Option; ✓ 2nd Option

Climate Investment Opportunities Diagnostic

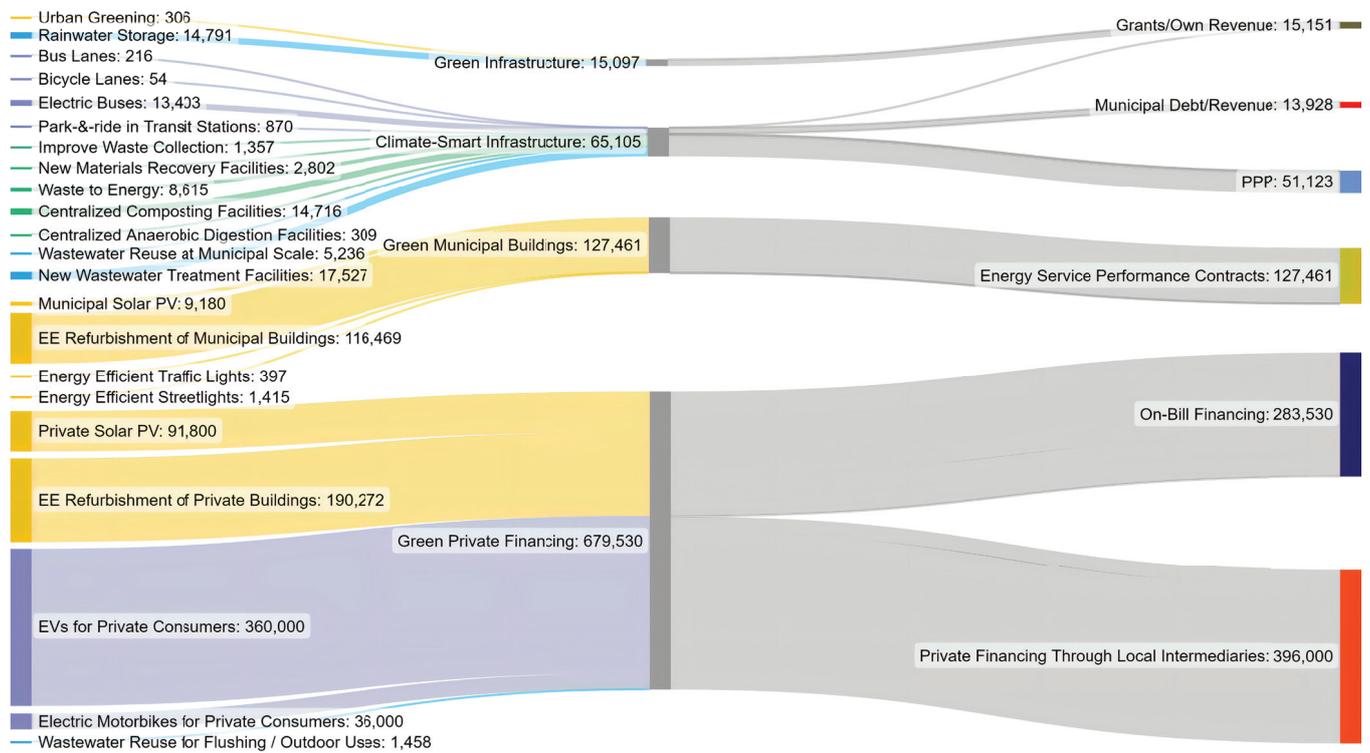


Figure 10: Investment flow diagram showing the potential financing volumes aligned to measures in the green investment pipeline (shown in THB million).

Green and Upgrade Municipal Buildings

To reach its emissions targets stated in the Master Plan on Climate Change, BMA aims to prioritize more energy efficient, more resilient, green buildings, as well as the solarizing of public buildings to secure clean and affordable energy.

This group includes 3 measures for greening and upgrading municipal buildings, as follows:

1. Energy Efficiency (EE) Refurbishment of Municipal Buildings

– Implement an energy efficiency refurbishment program for all municipal buildings. Existing municipal buildings are upgraded to reduce their energy consumption by 20 percent. Upgrades may include efficient technologies, improved windows and building envelopes, upgraded ventilation and cooling systems, and others.

2. Rooftop Solar Photovoltaics (PV) on Municipal Buildings

– Install solar PV systems on municipal buildings equivalent to 300 megawatt peak (MWp) of additional renewable electricity generation. While this measure is displayed in terms of rooftop area, PV panels could also be ground-mounted or floating on water bodies where feasible.

3. Energy Efficient Streetlights and Traffic lights

– Upgrade all streetlights (17,710 bulbs) and traffic lights (886 traffic light sets) with energy efficient bulbs, which use approximately 80 percent less energy than existing bulbs.

In total, these measures will cost THB 127,440 million.

Investments in green municipal buildings could be financed with municipal debt, grants, or own-source revenue sources, as well as implemented through a PPP structure. One such structure is described in further detail below: **Energy Service Performance Contracts (ESPC) and Guarantee Fund.**

MEASURES	Direct Cost (THB Million)	GHG Savings (%)	Financing Options	
			1 st	2 nd
EE Refurbishment of Municipal Buildings	116,460	0.9	Energy Service Performance Contracts and Guarantee Fund	Municipal Loan
Solar PV on Municipal Buildings	9,180	0.7		
Energy Efficient Street, Traffic Lights	1,800	<0.1		
Total	127,440	1.7%		

Note: EE = energy efficiency; PV = photovoltaics.

ESPC and Guarantee Fund

ESPCs are financial mechanisms used to pay for today's facility upgrades with tomorrow's energy savings – without tapping the organization's capital budget. Potential areas of application for ESPCs include technology upgrades for energy and water efficiency, low carbon heating and cooling systems, and renewable energy supply, such as rooftop solar. ESPCs involve a risk of financial obligations not being met due to financial shortfalls or technological underperformance. To address this, a guarantee fund can act as an insurance facility, offering different types of guarantees to cover several types of risks and stakeholders involved in the model.

The model's operation combines two instruments: ESPCs and Guarantee Fund (*Figure 11*). The ESPC is a partnership between the facility owner and the energy service company (ESCO). Once the project is operational, periodic energy savings are measured and verified. Users make fixed payments based on the baseline energy bill. The public utility contracts services providers to implement projects using performance-based contracts, and then it keeps the energy cost savings from the reduced energy bill to recover its costs. The project cost, energy and financial savings, and equipment performance are guaranteed.

The public utility can procure the services of private-sector ESCOs through ESPCs to deliver energy efficiency equipment and solutions in public buildings. The public utility also might help with building the capacity of local private-sector ESCOs and developing guidance for monitoring and verification of energy savings to strengthen the market. In certain cases, the implementation of ESPCs can be seen as a long-term contractual obligation, comparable to utility payments. As a result, this can be an off-balance solution.

The Guarantee Fund has the potential to provide financial protection for any financial shortfalls or technological underperformance that may occur among participants in this model, such as ESCOs, end users, equipment lessors, or third-party investors. The energy performance guarantee and reduced credit risks mean that the public utility may undertake projects with less creditworthy customers or those belonging to more financially volatile industries. The public utility company could work in partnership with the Thai ESCO Association to scale up the model.

Box 1 shows case study examples for two cities, Houston and Paris, that used energy performance contracts to upgrade public buildings.

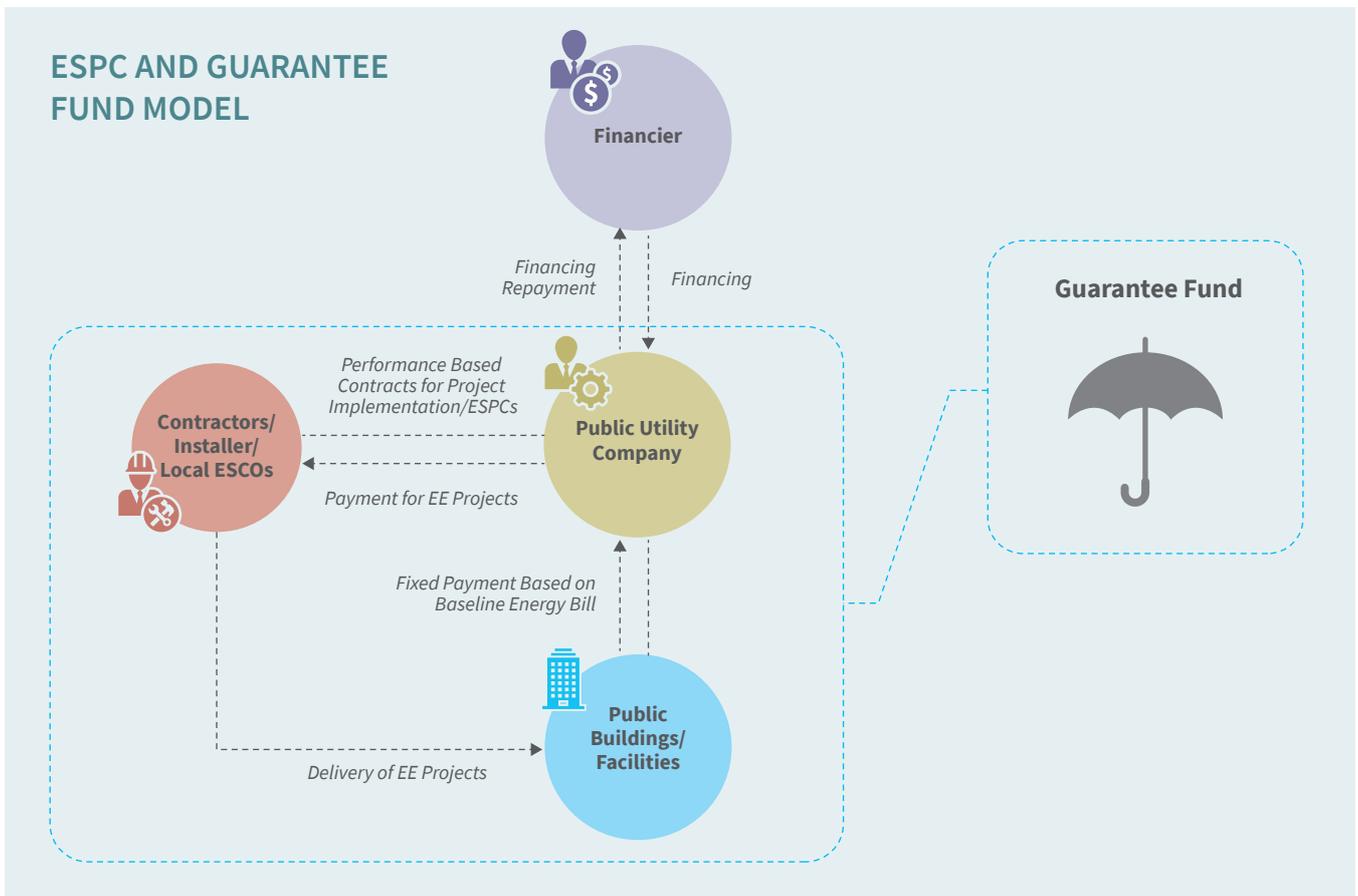


Figure 11: ESPC and Guarantee Fund Model.

Note: EE = energy efficiency; ESPC = energy service performance contract.

Box 1: City case studies showing applications of the ESPC model in Houston, USA, and Paris, France.

CASE STUDY:

Municipal Building: Houston, USA

- In 2007, Houston committed 271 buildings with a total area of around 1,000,000 square meters (m²) and target to reduce energy consumption by 25 percent.
- The city issued an open tender energy performance contract split into different tranches according to building typologies.
- Data from the first 87 buildings resulted in savings of USD 5.2 million (THB 187 million) a year and a payback period of 10 years.
- Energy conservation measures included heating, ventilation, and air conditioning (HVAC) and lighting improvements, energy management systems, solar heating, among others.

Public Schools: Paris, France

- In 2012, Paris used energy performance contracts to refurbish 240 schools with a target to reduce energy consumption by 30 percent.
- Data from the first 100 schools shows energy savings reaching 38 percent.
- The first phase of project was financed through lenders, such as the European Investment Bank, with the following phases implemented through the city's own savings and revenues.
- Building energy efficiency investments are not the only way to reduce building energy consumption. The City of Paris also published guidelines early in 2020 to standardize and regulate the internal temperature of municipal buildings.

Sources: Clinton Climate Initiative, n.d.; C40 Cities, 2020.

Climate Investment Opportunities Diagnostic

Green Infrastructure

The backbone of Bangkok’s climate change adaptation vision revolves around strategies to prioritize nature-based solutions to, for example, increase water security and mitigate flood risk.

The green infrastructure group includes 2 measures, as follows:

1. Increase Urban Green Corridors and Parks – Increase urban forest canopy by 5 percent, approximately 310,000 m², to reduce the urban heat island and save energy.

2. Development of Ponds, Lakes, Reservoirs for Rainwater Storage – Create nature-based rainwater storage with a capacity of 1,494,000 cubic meters (m³).

In total, these measures will cost THB 15,084 million.

Investments in green infrastructure could be financed with grants, existing revenue sources, or as a component of a municipal loan.

MEASURES	Direct Cost (THB Million)	GHG Savings (%)	Financing Options	
			1 st	2 nd
Urban Green Corridors and Parks	288	<0.1	Own Revenue Sources	Municipal Loan
Rainwater Storage (Ponds, Lakes, Reservoirs)	14,796	<0.1		
Total	15,084	<0.1%		

Note: EE = energy efficiency; PV = photovoltaics.



Benchakitti Park.

Image: Ruripratheep Nilpech on Unsplash

Investing in Climate-Smart Infrastructure and Public Services

Investing in climate-smart infrastructure is critical for Bangkok City to reach its emissions goals of reducing city-wide GHG emissions by 19 percent by 2030 and achieving carbon neutrality by 2050.

The climate-smart infrastructure and public services group includes 12 measures, as follows:

- 1. Bicycle Lanes** – Build an additional 50 kilometers (km) of bicycle lanes and other bicycle infrastructure (i.e., bicycle parking) to promote the shift to active transportation by improving conditions for cyclists, including improved safety while riding, property security when the bicycle is not in use, and ease of routing.
- 2. Bus Lanes** – Designate street lanes as bus lanes over ten corridors with an approximate distance of 60 km identified by BMA to improve travel times and increase ridership.
- 3. Electric Buses** – Through the Bangkok Mass Transit Authority (BMTA), purchase electric buses to replace conventional buses for a target of 40 percent electric vehicles (EVs) in the bus fleet or approximately 1,240 electric buses. Electrification of the bus fleet will also require bus depots and service stations to be upgrade with charging infrastructure.
- 4. Extend BTS and Metropolitan Rapid Transit (MRT) system** – Led by other agencies, support the 163 km system expansion
- 5. Extend the Monorail and Airport Rail Line (ARL) system** – Led by other agencies, support the 54 km system expansion
- 6. Park-and-Ride Lots in Transit Stations** – Construct park-and-ride lots equivalent to 6,000 car and motorbike spaces next to transit stations across Bangkok to help increase public transport ridership in areas without adequate feeder buses, such as suburban and peri-urban areas.
- 7. Expand Centralized Anaerobic Digestion Facilities** – Expand existing and/or add new anaerobic digestion facilities to process an additional 700 tonnes of food waste per day (covering 20 percent of existing organic waste); produced biogas to be captured and used to generate and sell electricity.
- 8. Improve Waste Collection** – Procure new equipment, fleet, and facilities to bring waste collection to 100 percent coverage.
- 9. Expand Materials Recovery Facilities** – Add new Material Recovery Facilities (MRF) or expand existing MRFs to process an additional 2,891 tonnes per day with a target of 85 percent of recyclables processed for recycling.
- 10. New Waste-to-Energy (WTE) Facilities** – Add new WTE facilities to process 1,000 tonnes per day. WTE is primarily a waste management solution that can also deliver base load electricity to the grid. It typically relies on a combination of tipping or gate fees and electricity tariffs for financial viability.
- 11. Expand Composting Facilities** – Construct new centralized composting facilities to process an additional 700 tonnes per day with target of 20 percent of organic waste treated. Centralized composting can help divert organic waste from landfill to produce soil-enriching compost material.
- 12. Wastewater Reuse at Municipal Scale** – Reuse 196 million liters per day (MLD) of treated effluent from the centralized wastewater treatment plants for various standards. Non-potable water is suitable for irrigation or industrial purposes while more extensive treatment standards deliver potable water that is suitable for domestic consumption.
- 13. New Wastewater Treatment Facilities** – Develop several wastewater treatment plants to provide 1,500 MLD additional capacity to the wastewater treatment system.

In total, these measures will cost THB 51,732 million directly to BMA and another THB 1,700,953 million to other BMA-adjacent agencies such as BMTA, BTS, and MRT.

Investments in climate-smart infrastructure could be financed with municipal debt, grants, or own-source revenue sources, implemented through traditional PPP contracts, or financed through performance-based financing. Two financing mechanisms are described in further detail below: **Traditional PPP Contracts and Climate Performance-based Loans or Bonds.**

MEASURES	Direct (BMA) Cost (THB Million)	Direct (Other) Cost (THB Million)	GHG Savings (%)	Financing Options			
				1 st	2 nd		
Bicycle Lanes	72		<0.1	Municipal Loan	Public-Private Partnerships (Traditional Contracts)		
Bus Lanes	216		<0.1				
Electric Buses (BMTA)		13,392	0.2				
Anaerobic Digestion Facilities	324		0.7				
Extend BTS and MRT		1,467,000	3.5	Public-Private Partnerships (Traditional Contracts)	Private Financing through Local Intermediaries		
Extend Monorail and Airport Rail		223,560	0.4				
Park-and-ride in Transit Stations	864		<0.1				
Improve Waste Collection	1,368		--		Municipal Loan		
New Materials Recovery Facilities	2,808		2.1				
Waste-to-Energy Facilities	8,604		1.4				
Composting Facilities	14,724		1.5				
Wastewater Reuse at Municipal Scale	5,220		<0.1				
New Wastewater Treatment Facilities	17,532		0.3				
Total	51,732	1,703,952	10.1%				

Note: BMTA = Bangkok Mass Transit Authority; BTS = Bangkok Mass Transit System; MRT = Metropolitan Rapid Transit.

Bangkok aims to replace 40% of its current fleet with electric buses.



Image: Thairnag Ops on Unsplash

Traditional PPP Contracts

Traditional PPP contracts would apply to the greening of new municipal buildings wherein the management of new infrastructure projects falls under one of three models: Build-Transfer-Operate (BTO), Build-Operate-Transfer (BOT), or Build-Own-Operate-Transfer (BOOT). PPP contracts can either implement user or government payments. Transfer of the new build asset would be subject to the type of contract (e.g., after construction for BTO, or after an agreed period of operation for BOT).

The traditional PPP contract model is shown in *Figure 12*. Considerations for the private entity in entering a traditional PPP contract for the greening of new municipal infrastructure follows:

- Service providers or operators may require financial resources to deliver services, which would require a financier to make financing available in multiple forms, such as debt and equity.
- Specificities of the PPP contract agreed upon with the city will determine the way in which the private entity delivers outputs and manages risks.

- To recover investments, the private entity must collect fees and charges, and/or receive full-or-partial government payments.
- In the case of an Availability Payments arrangement, payments are contingent upon the measurement and verification of outputs or results delivered.

From the city government’s perspective, engagement in a traditional PPP contract for the greening of new municipal buildings may entail the following considerations:

- The need to identify the most competitive partner, and to manage the PPP contract effectively.
- If required, provide either franchise or grant concessions to operate the facilities, including usufruct rights so that the occupant can legally use the building.
- If a “User Pays” arrangement is stipulated in the PPP contract, the city government may be required to guarantee minimum fee levels that the user could be charged.
- The need to regulate activities of the PPP contract, making consistent payments against the achievement of results.

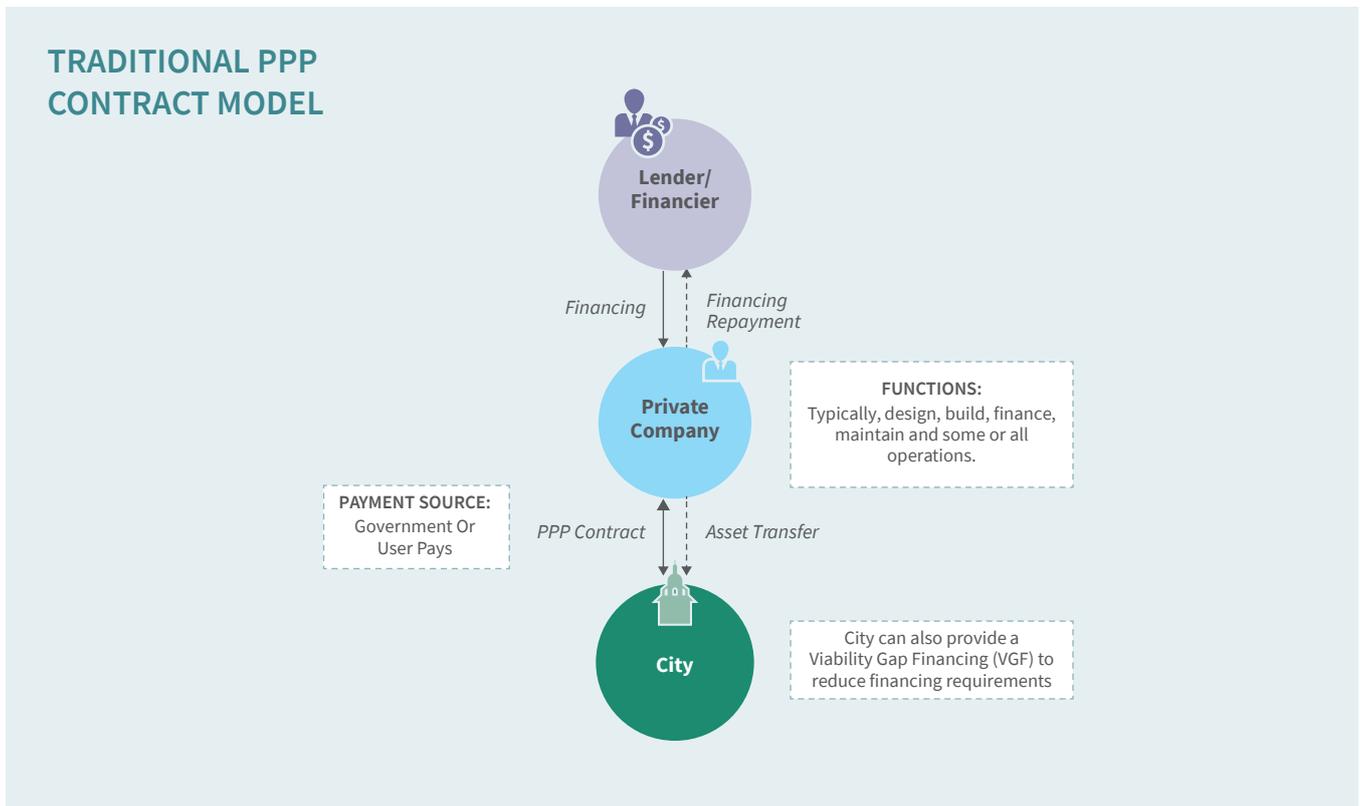


Figure 12: Traditional Contracts Through PPP.

Climate Performance-based Loans or Bonds

Performance-based financing can help Bangkok City access lower-cost debt to finance municipal investment projects and receive financial benefits from meeting targets. These instruments focus on key performance indicators (KPIs) and targets, and they do not necessarily establish the use of proceeds in detail.

Climate performance-based loans or bonds may help Bangkok City achieve its sustainability targets by tying interest rates to the delivery of sustainability results. These instruments focus on impact indicators, such as reductions in GHG emissions, and rely on robust datasets that APEX can provide to measure progress. Unlike other types of sustainable finance instruments, these

performance-based instruments do not impose restrictions on how the funds are to be used. Blended finance may also be used to support the development of performance-based financing in emerging markets.

To successfully implement these instruments, a sustainability coordinator with expertise in performance metrics, reporting, and incentives can be appointed by the city, with the support of development finance institutions (DFIs) to ensure the technical viability of new decarbonization technologies. Box 2 shows a few city-based sustainable-linked financing examples from around the world.

Box 2: City case studies for climate performance-based financing.

Issuer	City of Helsingborg	West Kowloon Cultural District Authority	Zagreb Holding	City of Gothenburg
				
Size	SEK 500 million	HKD 4.0 billion	EUR 305 million	SEK 8 billion
Maturity	4 years	3 years	5 year	3- and 5-years tranches
Product	Sustainable-linked Bond	Sustainable-linked Loan	Sustainable-linked Bond	Sustainable-linked Loan (RCF)
Country	Sweden	Hong Kong SAR	Croatia	Sweden
Date	January 2022	April 2022	July 2023	April 2022
KPIs	<ul style="list-style-type: none"> Trajectory consistent with reducing emissions by 80% by 2030 and by 85% by 2035 in the geographic area of Helsingborg as compared to 1990 baseline year 	<ul style="list-style-type: none"> Achieving green building certification Offering accessibility services to persons with disability or underprivileged groups Providing arts and cultural learning programs to youth 	<ul style="list-style-type: none"> Increase the share of municipal waste separate collected to 58% by December 2027 Increase the share of renewable electric energy in total electric energy consumption to 70% by March 2028 	<ul style="list-style-type: none"> Reduce energy use in buildings Own production of district heating to be fossil-free by 2025 Fossil-free vehicle fleet by 2023 Do not have any “particularly vulnerable” areas by 2025
Boundary	Whole city (public + private)	District	Municipal services	Whole city (public + private)

Note: SEK = Swedish Krona; SLB = sustainability-linked bond; HKD = Hong Kong Dollar; Bn = billion; SLL = sustainability-linked loan; EUR = Euro; RCF = revolving credit facility.

Mobilizing Green Financing Towards Low-Carbon Investments

When added together, indirect measures equate to almost 40 percent of the total GHG savings in Bangkok's green investment pipeline. A critical pathway to achieving this is through the mobilization of green financing towards carbon-smart policies and other low-carbon investments in the private sector.

Local financial institutions (LFIs) are crucial to low-carbon city development. They serve as a link between private investors and green projects, optimizing the use of private financing to support sustainable development, while promoting the involvement of local communities and businesses in the process. Mobilizing private funding to support climate-smart investments through local intermediaries, such as banks, microcredit entities, cooperatives, leasing operators, or other financial institutions, can finance sustainability initiatives across sectors and in areas such as renewable energy, energy efficiency, electric mobility, and others.

We consider 4 measures in this group where Bangkok City can encourage private participation in the city's sustainable development via the mobilization of local, private financial resources, as follows:

- 1. EE Refurbishment of Private Buildings** – Develop a financing program for energy efficiency refurbishment of 10 percent existing private buildings to achieve 20 percent energy savings. This is equivalent to approximately 35,364,000 m² of area refurbished. The program can be developed by the city, or through a financial institution partnered with the city. For example, a Green City Charter can be used to gain commitment of property developers to reduce emissions by 30 percent in 2030.

A city-wide solar PV program is one of the most effective ways to reduce GHG emissions.



Image: Trinh Tran on Pexels

- 2. Solar PV on Private Buildings** – Implement a rooftop solar PV program with a target of 3,000 MWp capacity installed on private buildings through fiscal incentives and non-fiscal incentives, such as priority lanes for building permits.
- 3. Wastewater Reuse for Flushing & Outdoor Uses** – Encourage on-site wastewater treatment to make effluent suitable for reuse in non-potable applications, equivalent to 7.5 MLD of water reused.
- 4. Electric Vehicles and E-Motorcycles for Private Consumers** – Work with banks to offer buyers financing to purchase EVs in support of a 30 percent EV penetration target in 2030, equivalent to approximately 1,000,000 EVs. Financing can be paired with other incentives offered by the city and partners, such as access to public charge points, expedited or discounted vehicle registration, discounts on electricity at private charge points, and others.

In total, these measures will cost THB 679,536 million.

The aforementioned low-carbon investments would be paid through green financing by developers, industries, local businesses, and private consumers. Some interesting models that could be employed include **On-Bill Financing** and **Leasing and Incentives for EVs**. Measures can also be enabled through **Lending through Local Financial Intermediaries**. A **Green City Charter** initiative can help spur the private sector to act and mobilize financing.

MEASURES	Indirect Cost (THB Million)	GHG Savings (%)	Financing Options	
			1 st	2 nd
EE Refurbishment of Private Buildings	190,260	1.3	On-Bill Financing	Private Financing through Local Intermediaries
Private Solar PV	91,800	6.8		
Wastewater Reuse for Flushing & Outdoor Uses	1,476	<0.1		
E-Motorcycles for Private Consumers	36,000	0.2	Private Financing through Local Intermediaries	Leasing
EVs for Private Consumers	360,000	1.0		
Total	679,536	9.3%		

Note: EE = energy efficiency; PV = photovoltaics; E-Motorcycle = electric motorcycle; EV = electric vehicle.

On-Bill Financing

On-bill financing is a mechanism where financing repayments are made monthly through an existing utility bill. On-bill financing allows a loan for energy efficiency measures to be repaid over a more extended period via an additional line item on the recipient’s utility bill, which decreases repayment risk for the lender. Loans can be provided by the utility or by a third party, such as an LFI. Potential areas of application for on-bill financing include technologies for building energy and water efficiency upgrades, rooftop solar, and electric vehicles, such as e-motorcycles. The on-bill financing model is shown in *Figure 13*.

There are several advantages to the on-bill financing model. Customers can achieve efficiency upgrades cost-free as their monthly payment is equal to or lower than energy payments before the project due to cost savings from energy efficiency

retrofits. The model allows for longer-term loans and links the loan to the energy meter rather than the customer; therefore, when the customer moves, the loan continues to be repaid by the new customer. The instrument reduces the financing risks due to the relationship between the utility company and its customers. Lenders can use a customer’s bill payment history to underwrite upgrades, and the default rates are usually very low. On-bill financing also brings tax benefits because loan payments are regarded as operating expenses that can offset taxable income. The financing is structured as utility payments rather than direct debt, which reduces customer debt on the balance sheet.

Box 3 shows case study examples for on-bill financing in California, Colombia, and Tunisia.

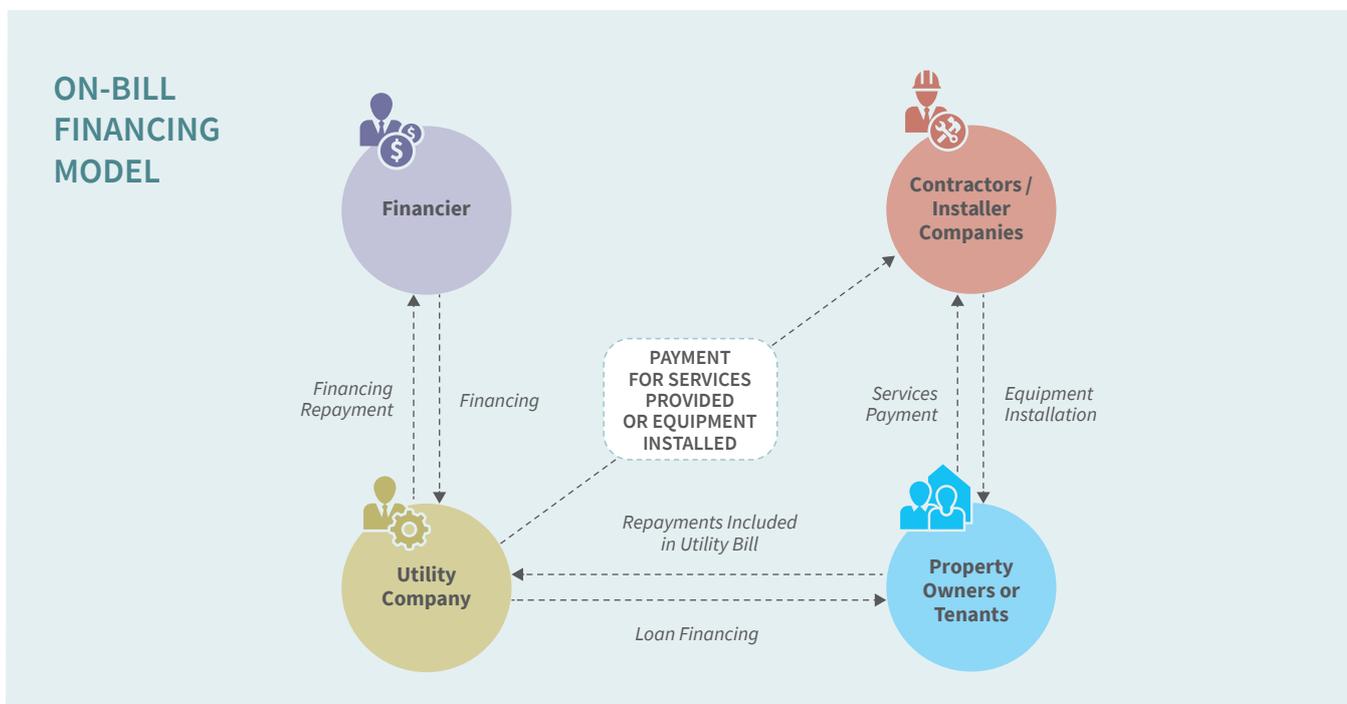


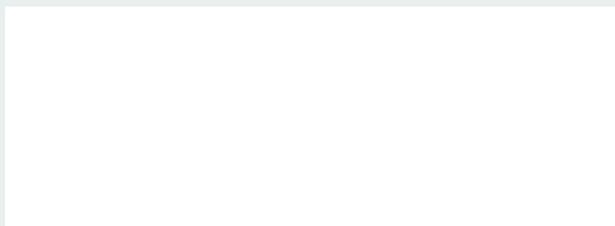
Figure 13: On-Bill Financing Model.

Box 3: Case studies showing on-bill financing in Southern California, Mexico, and Tunisia.

CASE STUDY:

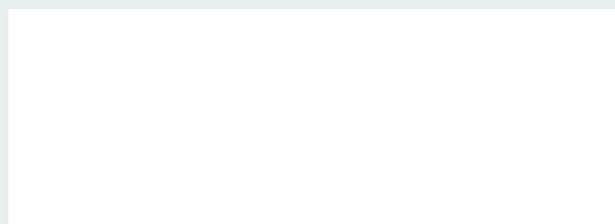
Southern California

- Southern California Edison’s on-bill financing program for energy efficiency improvements.
- Non-residential customers (businesses) can fund qualified energy efficiency projects for zero interest, 5-year loans and no fees, reduce their monthly electricity usage, and receive financial incentives for installing qualifying energy-efficient equipment.
- Highly successful, with over 2,400 loans issued, for USD 99 million, and a 99.3 percent collection rate since 2008.



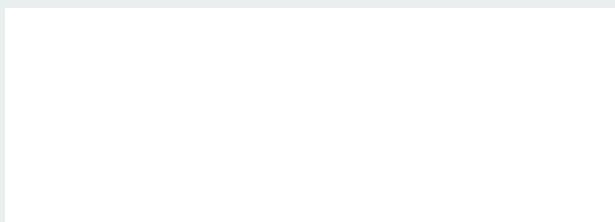
Mexico

- Partnership between Mexican utility, Secretariat of Energy and Mexican development bank supported by USD 250 million World Bank loan.
- The financing support consists of a loan (up to 4 years term at 12 percent interest rate) that will be charged through the electricity bill on a bimonthly basis.
- Led to replacement of 1,682,802 refrigerators and 201,327 air conditioners 10 years old or older.
- It contributed to energy savings of 9,242 gigawatt-hours and 5 MtCO₂e.



Tunisia

- Tunisian commercial bank, Attijari, partnered with local electricity utility company, Tunisian Company of Electricity and Gas (STEG), to create a USD 73 million On-Bill Finance platform.
- Attijari provides the loan to the consumer through a line of credit over a 5 years period.
- STEG provides credit recovery on electricity bills and provides the security for the loan repayment.
- National Agency for Energy Conservation manages the program and ensure its promotion.
- Target to deploy 500,000 homes with solar hot water and 85 MWp of solar photovoltaics.



Sources: Southern California Edison, n.d.; World Bank, 2017; Bellini, 2017.

Leasing and Incentives for EVs

A leasing and incentives financing scheme for private EVs may include the following key aspects: (a) a leasing model that manages the vehicle and battery separately to reduce the upfront cost barrier; (b) coordination with the charging infrastructure operators to facilitate energy provision and maintenance; and (c) existence of public incentives.

The roles and operation of the model is shown in *Figure 14*. Lease service providers may be local financial intermediaries, microcredit institutions, and/or EV manufacturers, which is central to the leasing model of the vehicles. EV drivers and/or companies will take the vehicles and batteries under lease agreements and pay fees in exchange. Operating leases are one of the most common methods of off-balance-sheet financing, allowing drivers/companies to record only the rental cost as an operating expense, which lowers liabilities on balance sheet. By de-coupling the battery from the vehicle, financiers have an opportunity to factor risks for battery and vehicle separately. This can help transfer the risk of maintenance of the battery from the owner to the lessor. Leasing payments can be set up in a way that includes an option to buy the vehicle, so drivers can become owners after a certain period.

For the EV charging infrastructure and battery ownership, third-party entities can be part of the model by supplying the necessary infrastructure and acquiring and leasing the EV batteries to the leasing service providers. The third-party entities may also need financing for charging infrastructure and batteries, which local financing institutions can provide.

The city can play an important role by adopting a variety of incentives to stimulate private EV uptake, such as tax benefits, registration incentives, reducing toll and parking charges, preferred charging schemes, and allowing the use of dedicated lanes for EVs.

Access to low-cost capital can be facilitated through the creation of a risk-sharing facility, such as a loan loss reserve that can cover general default or loss due to specific risks (e.g., product failure). This reserve can be created at the behest of the government and structured to include multiple stakeholders across the EV ecosystem through funding mechanisms like grants, risk underwriting, debt, equity, debt and equity with first loss guarantee, and others.



Image: Kindel Media on Pexels

Charging infrastructure will be necessary to support the ambitious EV transition of Bangkok.

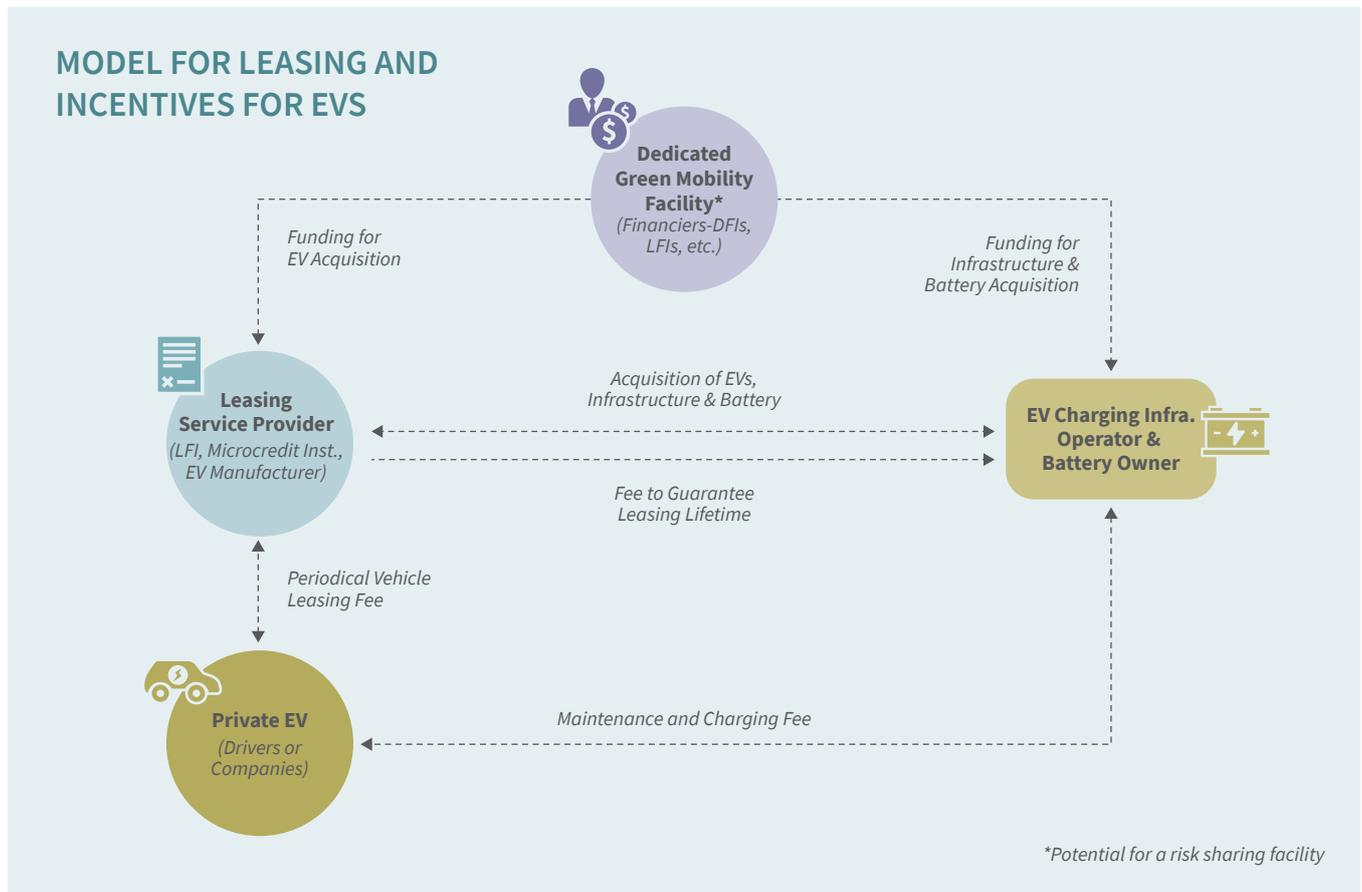


Figure 14: Model for Leasing and Incentives for EVs.

Note: EV = electric vehicle; DFI = development financial institution; LFI = local financial institution.

Lending Through Local Financial Intermediaries

Banks can offer financing options to private buyers looking to make low-carbon purchases, such as EVs, rooftop solar panels, and green homes (mortgages), as well as green building construction finance for developers. These financing options can be paired with other incentives offered by the city.

Box 4 shows the case of rapid scaling of green buildings in Colombia, in which IFC worked with the Colombian Chamber of Construction (CAMACOL) and Bancolombia to support green building construction and mortgage finance. Lessons from this case inform initial recommendations for how the public sector could work with local financial intermediaries to scale up green actions:

- The city can offer green building incentives to encourage voluntary certification that the banks can use to offer green financing.

- The city can endorse a green building certification with third-party verification, such as EDGE, and embed it in the building permitting process as an alternative compliance method to meet and exceed energy and water efficiency codes.
- The city can adopt a variety of incentives to stimulate green building growth in local communities such as regulatory flexibility or benefits for green buildings (i.e., extra floor allowance), expedited or reduced permits, net metering, and lowering parking costs for EVs.
- The city can partner with local banks to help them launch green buildings and EV financing investment programs via public advocacy campaigns, technical assistance for developers, and capability-building programs.

DFIs could offer financing for banks, along with risk sharing facilities with potential blended finance, to scaling up low-carbon public and private investments.

Box 4: Case study showing how local financial intermediaries enabled the rapid scaling of green buildings in Colombia.

CASE STUDY:

Rapid scaling of green buildings in Colombia



In Colombia, IFC worked with **policymakers and the leading industry association**, CAMACOL, to create the right context for IFC client Bancolombia to launch green finance in 2017. Bancolombia held 17 events with 500 developers, supported by a major marketing push and training for loan officers. IFC invested USD 115 million in the first green bond in Colombia. Proceeds supported green building construction and mortgage finance. Within four years, certified green buildings reached 20% of annual new building construction.

As of June 2022, 5 local banks were offering green building nance products. Approximately USD 9 billion worth of floor space has been green certified. Of the 114,000 homes certified, 60% is affordable housing. Homeowners save up to USD 20 per month in utility bills. In August 2022, IFC provided a USD 200 million loan to one of the largest banks in the country, BBVA Colombia, to support net zero carbon ready homes.



Sources: Andrade, 2021; IFC's EDGE data.

Green City Charter

A Green City Charter can bring together key ingredients to accelerate climate action in the private sector. The Charter aims to build a broad network of climate-smart businesses and organizations, of all sizes and from all sectors, that are committed to achieving the city’s GHG reduction targets.

A Green City Charter is a three-way partnership between the city, private companies, and financial institutions (Figure 15). It can be collaborative framework for decarbonizing buildings and businesses and scale up finance for green city climate action. The city acts as convenor to bring together private sector actors, create incentives, and set reduction targets. The city and development partners can offer support and guidance to committed parties in sectors such as energy, transportation, water, and waste, in collaboration with banks and industry.

The private sector participants commit to reduction targets, identify efficiency improvements, and benefit from savings. Financial institutions can then finance the identified energy improvements through products such as green mortgages and green construction finance.

Box 5 shows an example Green City Charter from London.

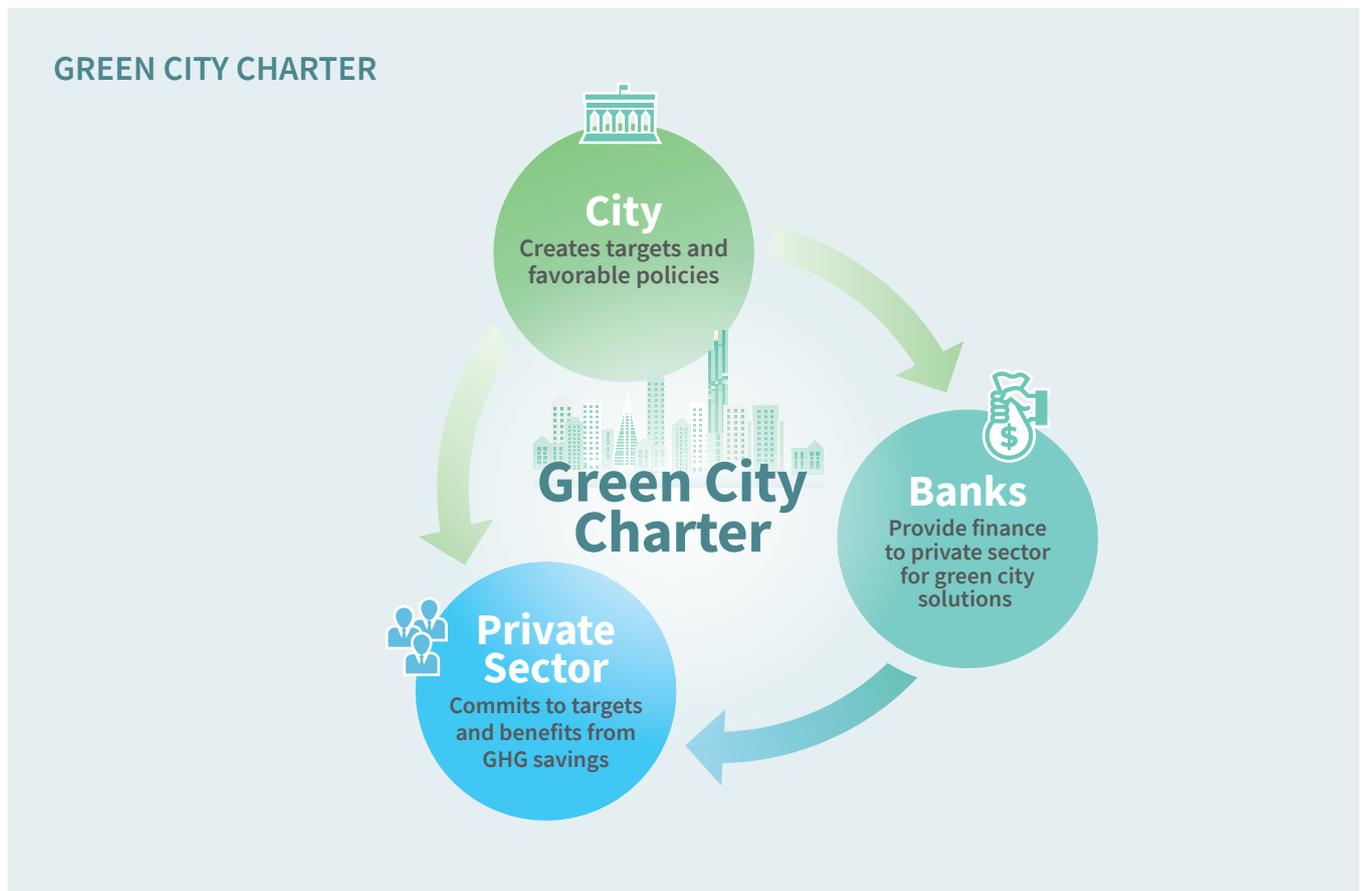


Figure 15: Model for a Green City Charter.

Note: GHG = greenhouse gas.

Box 5: Westminster (London) Sustainable City Charter.

CASE STUDY:

Westminster, United Kingdom

- In February 2023, the City of Westminster in Greater London, United Kingdom, launched the Sustainable City Charter.
- The Charter aims to build a network of local businesses and organizations that are committed to working collectively to achieve the goal of carbon neutral city by 2040.
- When they join the Charter, participants make a public commitment to delivering improvements to their buildings, including reducing energy consumption, green procurement, transport and fleet, and waste management, among other aspects.
- The partnership will help coordinate local action, as well as enable shared knowledge and expertise through a toolkit with consolidated advice.



Source: City of Westminster, 2023.



Wat Arun Ratchawararam Ratchawaramahawihan.

Image: Anantachai Saohong on Unsplash

Summary and Conclusion



Summary and Conclusion

The Bangkok CIOD identifies 23 investment opportunities spanning four sectors of analysis: built environment and energy, transport, solid waste, and water and wastewater. The investment volume totals THB 887,184 million (USD 24,200 million), plus large rail projects led by other agencies, which are an additional THB 1,690,560 million (USD 46,020 million). If fully implemented, these investments could collectively contribute 21% GHG reduction towards Bangkok City’s climate change mitigation targets.

A summary of the investment opportunity by sector is shown in *Figure 16a*. About 23 percent (THB 207,648 million) of the total investments are considered direct cost measures; that is, fall to the responsibility of BMA and its agencies. These include greening and solarizing public buildings, technologies to extract value from waste, and water and wastewater upgrades. The remaining majority of the investments, 77 percent (THB 679,536 million), depend on individual residents, businesses, and others in the city making decisions about incorporating low carbon technologies into their homes, buildings, and transportation choices.

In terms of GHG impact, there are about 7 measures that stand out with the highest contributions. High impact items on the built environment and energy side include a city-wide solar PV program and greening of private buildings with energy efficiency upgrades. Mechanisms such as on-bill financing and mobilizing financing through green city charter commitments can help

spur these investments. The extension of the BTS and MRT will help expand public transportation offerings, while financing and incentives for EVs can encourage the transition towards electric mobility. Finally, new waste management technologies, including composting and anaerobic digestion for organic waste, waste-to-energy, and recycling, will help avoid the GHG emissions associated with landfills. Taken together, these measures will contribute to nearly 90 percent of the emissions reduction potential and can be considered priorities for future implementation.

The private sector will play an essential role in ensuring Bangkok City reaches its climate targets. A summary of the investment opportunity associated with different potential financing mechanisms is shown in *Figure 16b*. Even for some direct cost measures, such energy efficiency in municipal buildings, solar energy, and waste management, BMA can engage the private sector through innovative delivery models. For some types of direct investments, working with the private sector through mechanisms such as PPPs and energy performance contracts can help reduce financial risk and free up BMA’s other resources. Given the importance of mobilizing private investment towards green city actions, BMA will also play an important role in convening stakeholders, providing incentives, and educating residents and businesses about green city financing opportunities.

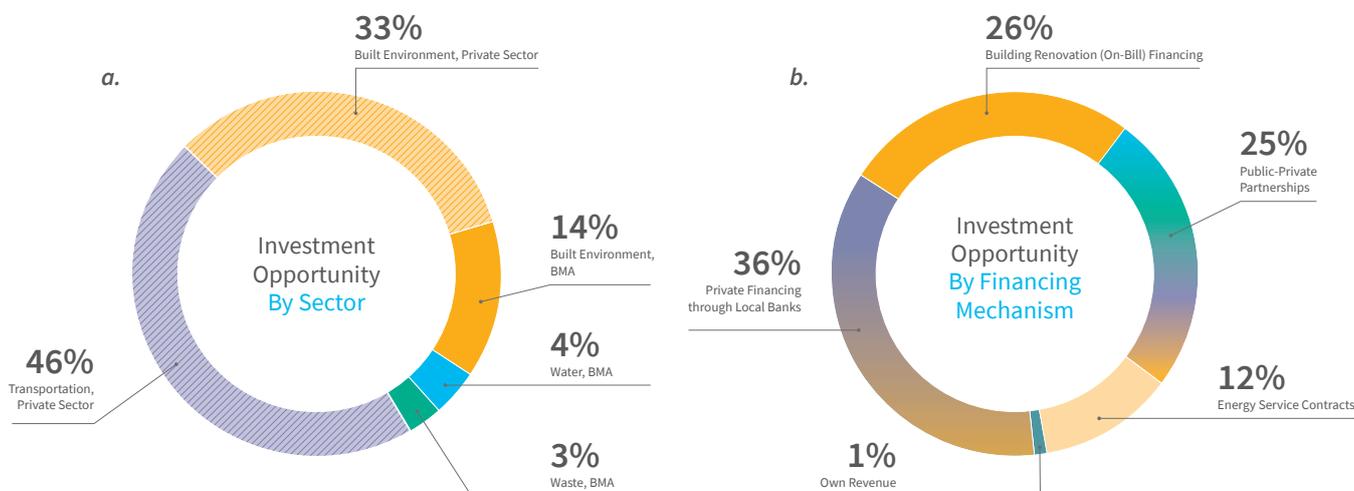


Figure 16: The distribution of Bangkok’s green investment opportunity (approximately THB 890 billion) presented two ways: a) by sector, and b) by potential financing mechanism.

Appendix: APEX City Data

This Appendix shows the city data and assumptions underlying the CIOD analysis. Most data were provided to IFC by BMA, as specified.

General City Information

Data	Value	Notes and Reference
Resident population	5,494,932	National Statistics Office 2022
Annual growth rate (%)	1.43%	
Commuter population (non-resident)	2,753,400	
Population at working age, 15-74 years old (%)	80.2%	
Persons per household in urban areas	3.68	Estimated with data provided by BMA

Built Environment & Energy

Data	Value	Notes and Reference
City area (km ²)	1,563.99	National Statistics Office 2022
Length of streets (km)	1,771	Department of City Planning and Urban Development, BMA
Number of streetlights	17,710	Estimated based on global average of lights per km of street length
Number of traffic light sets	886	
Area of parks and green spaces (km ²)	4.9	Green Parks Report, BMA
Area of forest canopy (km ²)	333	National Statistics Office 2022
Total building area (million m ²)		
Retail	16.50	Estimated using Google Environmental Insights Explorer, Bangkok Land Use and Zoning Maps
Office	26.42	
Hotel	9.85	
Health	3.99	
Education	14.17	
Institutional/Assembly	7.25	
Warehouse	0.80	
Transport	0.40	
Residential		
Apartments	144.87	
Homes	139.30	
Average building area per person (m ²)	66.16	
Area of municipal buildings (m ²)	21,633,500	Estimated using Google Environmental Insights Explorer, Bangkok Land Use and Zoning Maps

Data	Value	Notes and Reference
Building energy consumption (kWh/m ² /year)		
Retail	150	Adapted from IFC's EDGE tool
Office	105	
Hotel	260	
Health	250	
Education	110	
Institutional/Assembly	105	
Warehouse	100	
Transport	100	
Residential		
Apartments	50	
Homes	55	
Energy Source (%)		
Grid Electricity	95.5%	Calculated with data provided by MEA, BMA, CIRIS GHG Inventory 2020
Local heat sources	4.5%	
Energy emissions factors (kgCO ₂ e/kWh)		
Grid electricity	0.597	Calculated with data provided by MEA, BMA, CIRIS GHG Inventory 2020
Local heat sources	0.22	

Transportation

Data	Value	Notes and Reference
Average trips per day per resident	2.52	Estimated with data provided by BMA
Average trip distance (km)	22	
Working days per year	303	
Modal split by passenger-kilometers (%)		Calculated with data provided by BMA, Metropolitan Bangkok transport studies from JICA
Automobile	38%	
Motorcycle	19%	
Bus, BRT	37%	
Metro system	6%	
Ferryboat	<1%	
Bicycle	<1%	
Walk	<1%	
Transit ridership (passengers/day)		Traffic and Transportation Department, Bangkok Metropolitan Administration 2023
Bus, BRT	556,375	
Metro system	1,396,643	
Ferryboat	122,385	
Transit infrastructure		Traffic and Transportation Department, Bangkok Metropolitan Administration 2023
Number of buses in fleet	6,308	
Length of metro system (km)	276	
Average occupancy rate (passengers)		Estimated based on national/regional averages
Automobile	1.8	
Motorcycle	1.4	
Bus	47.5	
Metro system	123.6	

Data	Value	Notes and Reference
Number of vehicles in fleet		
Automobile	6,947,904	Department of Land Transport, Thailand 2022
Taxi	83,262	
Motorcycle	4,197,486	
Moto-taxi	79,582	
Microbus / Shuttles	232,000	
Annual growth in private vehicle ownership (%)		
Automobiles	6.84%	Estimated based on national/regional averages
Motorcycles	1.3%	
Annual rate of vehicle retirement/obsolescence (%)		
Automobiles	5.0%	Estimated based on the global average
Motorcycles	5.0%	
Average vehicle efficiency (km/L)		
Automobiles	9.09	Estimated based on national/regional averages
Motorcycles	56.11	
Bus	5.27	

Waste

Data	Value	Notes and Reference
Municipal solid waste generation (t/person/year)	0.41	Carbon Disclosure Project Report 2022, BMA
MSW composition (%)		
Organic waste	49.9%	Solid Waste and Sewage Management Office, Department of Environment, BMA
Paper and cardboard	11.3%	
Wood	4.8%	
Textiles	5.5%	
Rubber and leather	1.4%	
Plastics	19.8%	
Metal	1.3%	
Glass	1.5%	
Other	4.5%	
Organic waste composition (%)		
Food waste	91.2%	Solid Waste and Sewage Management Office, Department of Environment, BMA
Organic waste	8.8%	
Waste treatment (%)		
Compost	15.8%	Policy and Planning Division, Department of Environment, BMA
Landfill	52.9%	
Incineration	3.3%	
Recycling	22.2%	
Other	5.8%	
Recycling composition (%)		Estimated based on country/regional data
Paper and cardboard	24.8%	
Wood	10.5%	
Textiles	12.1%	
Rubber and leather	43.3%	
Plastics	3.1%	
Metal	3.3%	
Glass	2.9%	

Water

Data	Value	Notes and Reference
Municipal water consumption (MLD) - system input/bulk	2,582	Sustainability Report, MWA 2021
Potable water (%)	100%	
Average consumption per person (L/day) - bulk/population	470	
Industrial water consumption (MLD)	166	
Unaccounted-for water losses (%)	33.1%	
Water source (%)		Sustainability Report, MWA 2021
Groundwater	0%	
Surface water	100%	
Desalination	0%	
Recycled wastewater	0%	
Rainwater capture	0%	
Wastewater treatment		
Wastewater flow (MLD)	3,455	Adapted from Sustainability Report, MWA 2021
Treatment type (%)		Environment Department, BMA
Septic tank	56%	
Activated sludge process (ASP) without AD	44%	
Untreated sewer (discharge into water)	10%	

References

Andrade, Cecilia Lozada. 2021. "Colombia: Green Buildings Accelerate from Zero to 20 percent of the Market in Four Years." *IFC EDGE Stories*. October 29, 2021. Available: <https://edgebuildings.com/the-transformation-of-colombias-green-building-market-from-zero-to-20-percent/>.

Asian Development Bank (ADB). 2019. "Sustaining Transit Investment in Asia's Cities: A Beneficiary-Funding and Land Value Capture Perspective." Manila, Philippines.

Bellini, Emiliano. 2017. "Attijari bank finances Tunisia's solar rebate program with \$73 million." *PV Magazine*. Available: <https://www.pv-magazine.com/2017/11/13/attijari-bank-finances-tunias-solar-rebate-program-with-73-million>.

C40 Cities. 2020. "How Paris used energy performance contracts to retrofit schools." Available: https://www.c40knowledgehub.org/s/article/How-Paris-used-energy-performance-contracts-to-retrofit-schools?language=en_US.

City of Westminster. 2023. "Sustainable City Charter." Available: <https://www.westminster.gov.uk/tackling-climate-change-westminster/business-climate-action/sustainable-city-charter>.

Clinton Climate Initiative. N.d. "Building Retrofit Case Study: City of Houston." Available: http://www.greenhoustontx.gov/reports/Energy_Efficiency_Building_Retrofit_Case_Study-Tranche1.pdf.

Organisation for Economic Co-operation and Development (OECD/UCLG). 2022. "Country Profiles of the World Observatory on Subnational Government Finance and Investment." Available: <https://www.sng-wofi.org/country-profiles/> [accessed 2023-09-14].

Southern California Edison. N.d. "Energy Efficiency Financing." Available: <https://www.sce.com/business/Energy-Efficiency-Financing#:~:text=SCE's%20OBF%20program%20has%20been,99.3%25%20collection%20rate%20since%202008>.

Thai Rating and Information Services Co., Ltd. (TRIS Rating). 2021. "TRIS Rating Affirms Issuer Rating on "BMA" at "AA+" with "Stable" Outlook." Available: <https://www.ryt9.com/en/trsn/253930> [accessed 2023-09-15].

The Economist Intelligence Unit (EIU). 2018. "Evaluating the environment for public-private partnerships in Asia." Available: <https://infrascope.eiu.com/> [accessed 2023-09-15].

World Bank. 2017. "Transforming a Market Toward Low-Carbon Growth in Mexico." Available: <https://www.worldbank.org/en/results/2017/04/04/transforming-a-market-toward-low-carbon-growth-in-mexico>.

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.

www.apexcities.com

IFC

IFC is a member of the World Bank that focuses on private sector development. Working with partners in more than 100 emerging markets, IFC invests, advises, and mobilizes resources from others, creating opportunity for clients in a broad range of industries. Standing between the public and private sectors, IFC brings market-based solutions to respond to the challenge of creating low-carbon economic growth.

www.ifc.org

