世界资源研究所
WORLD RESOURCES INSTITUTE

Towards a Better Hong Kong

PATHWAYS TO NET ZERO CARBON EMISSIONS BY 2050

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FOREWORD

The central goal of the Paris Agreement is to limit global temperature rise to “well below 2°C above pre-industrial levels and to pursue efforts to limit temperature increase to 1.5°C.” The latest science shows that to achieve this goal, global greenhouse gas emissions need to be cut in half by 2030 and reach net-zero by around 2050. This transformation requires ambitious action across all levels of government and sectors of society—countries, states and provinces, cities, companies, investors and the public.

Cities will play a particularly crucial role in achieving national goals and achieving net-zero emissions because they make and implement many emission-reduction policies. Around the world, urban centers such as Copenhagen, London, and New York are at the forefront of ambition climate action by committing to achieving carbon neutrality.

World Resources Institute is working with a number of Chinese cities to rapidly decarbonise by mid-century while achieving higher levels of economic growth and sustainable development. Hong Kong has the opportunity to be an inspiring example for the region by adopting and implementing a strategy to reach net-zero emissions like its counterparts in Europe and the Americas.

New research by World Resources Institute and Civic Exchange proves that achieving net-zero emissions in Hong Kong is within reach. It is not only technically feasible but would offer "multiple wins" including significant economic and environmental benefits. This study shows that by setting a net-zero emissions target and taking action now, Hong Kong will yield HK$460 billion in new wealth. These actions will also reduce local air pollution and its associated detrimental health effects, increase residents’ life expectancy and save about 26,000 lives by 2050.

But to achieve these benefits and reach net-zero emissions at a reasonable cost, action must be taken as soon as possible. This urgency is why our project is named "Hong Kong 2050 Is Now.”

Our report focuses on the solutions that offer Hong Kong the greatest potential for emissions reductions: decarbonising electricity and piped gas, building energy conservation and transportation. In addition, the analysis considers waste management, international travel and lifestyles as further opportunities for significant emissions cuts.

This research provides Hong Kong with a roadmap to a brighter future. Now is the time to translate this research into objectives and further translate the objectives into policy measures—and then ensure these policies are fully implemented. This is a major undertaking that requires joint effort from all stakeholders in Hong Kong—the government, private sector and the public. Together we can achieve a better Hong Kong: a city that is prosperous, healthy and fully decarbonised.

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Chief Representative,
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EXECUTIVE SUMMARY

HIGHLIGHTS

- To keep the Earth's average temperature within 1.5°C of warming above pre-industrial levels, the world must be close to carbon neutral by 2050. Hong Kong, like other regions, must develop a concrete plan that can transform the city into a net zero emissions economy and society.

- The analysis presented in this report demonstrates that Hong Kong can reduce its carbon emissions by 90 per cent by 2050 relative to 2005 levels and offset the remaining 10 per cent which comes from hard-to-abate sectors.

- To progress towards a net zero emissions future, Hong Kong must begin planning and taking accelerated action now. It needs to adopt a significantly more aggressive decarbonisation target, with annual reductions of 6.6 per cent beginning immediately and continuing through 2050.

- The greatest potential for reducing emissions comes from improving electricity generation, making buildings more energy efficient and increasing the sustainability of mobility.

- A net zero emissions economy and society would provide Hong Kong with a cleaner, greener and healthier environment and yield substantial economic and social benefits. Projected reductions in air pollutants would increase life expectancy to the equivalent of about 26,000 lives saved by 2050, and cumulative economic benefits could amount to HK$460 billion.

Introduction

In order to achieve the 1.5°C goal set by the Paris Agreement on climate change, human civilisation must achieve net zero emissions by around 2050. The special report by the Intergovernmental Panel on Climate Change (IPCC) on global warming of 1.5°C, released in October 2018, concludes that human activities have caused global temperatures to rise by about 1°C above pre-industrial levels. Even a significant reduction in emissions by 2030 would not be enough to ensure that temperature increases are kept below 1.5°C by the end of this century.

Rapid and large-scale transformation in energy consumption, land use and urban infrastructure, including transportation, construction and industry, is required, leading to a decline in global net anthropogenic carbon dioxide (CO_2) emissions of 45 per cent from 2010 levels by 2030 and net zero emissions around 2050. Achieving this target will mean decarbonising most emissions while offsetting emissions where decarbonisation is especially difficult. The change will require careful planning, new technology and buy-in with respect to the costs and behavioural change that will need to be embraced. Adjustment time for business and people will also be necessary.

Hong Kong is developing its own long-term decarbonisation strategy. The government kicked off a public engagement program in June 2019 to collect public views; it is expected to announce the results later this year. It will subsequently formulate a long-term decarbonisation strategy. This report analyses the feasibility of Hong Kong's reaching a net zero emission target in 2050 and provide inputs for the formulation of Hong Kong's long-term decarbonisation strategy.

About This Report

This study highlights where action is needed through 2050 and provides context for landmark decisions that must be made under current policy plans until 2030. This project involved a detailed modelling exercise that incorporated scientific, technical and economic perspectives. The model evaluated the medium- and long-term impacts on CO_2e emissions in Hong Kong of key policies for the power, building and mobility sectors and devised additional policy recommendations to strengthen the pathway towards net zero emissions.

The study was conducted in 2019, before the outbreak of COVID-19. The pandemic will not significantly affect the

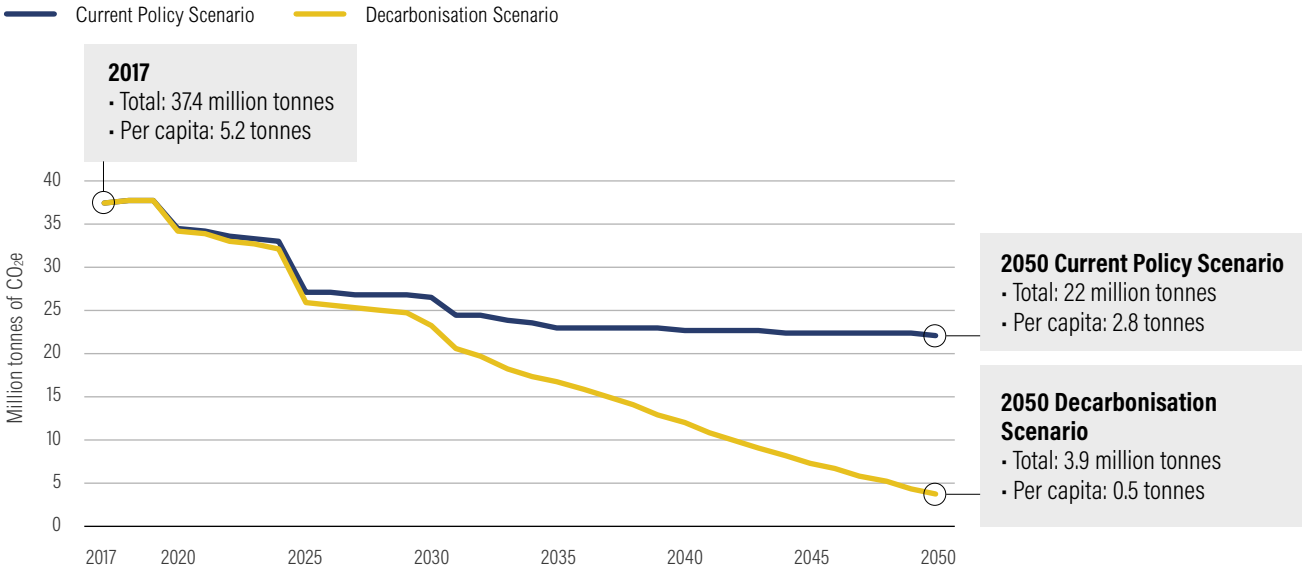
overall trends, especially mid- and long-term decarbonisation, or the study's recommendations. The impacts of the pandemic on the projections in this study will likely be greatest for gross domestic product (GDP) growth. This study takes 2017 as the base year and uses a GDP growth of 3.5 per cent for 2018–21, based on projections from the Financial Services and the Treasury Bureau. Annual GDP growth was 2.9 per cent in 2018, –1.2 per cent in 2019 and –8.9 per cent in the first quarter of 2020. The forecast for 2020 as a whole has been revised downwards to between –4 per cent and –7 per cent, as announced by the Financial Secretary on April 29. The model may have overestimated energy consumption and emissions for 2018–20. The changes in fossil fuel prices associated with the COVID-19 outbreak may also alter cost-benefit estimations. Investment plans may be delayed because of the increased strain on the city's budget, for example; conversely, a green stimulus, if it were provided, could spur investment. However, most of the impact would be in 2020 and 2021; overall trends are unlikely to be significantly affected. Follow-up studies and an update of the model will address the effects of COVID-19.

This report focuses on Hong Kong's direct emissions (Scope 1) that are emitted from Hong Kong Special Administration Region territory. In the last section of the report we also consider 'Scope 2' emissions relating to imports of energy into Hong Kong and 'Scope 3' emissions relating to the embodied carbon in goods traded with other territories.

Conclusions

Hong Kong has high potential to achieve net zero emissions by 2050. In 2017, its greenhouse gas (GHG) emissions amounted to 37.9 million tonnes of carbon dioxide equivalent ($MtCO_2e$), excluding waste, agriculture and forestry, corresponding to per capita emissions of 5.2 tonnes (t). Under the Current Policy Scenario, emissions will be reduced to 22 $MtCO_2e$ by 2050, or 2.8 tCO_2e per capita. Under the proposed Decarbonisation Scenario—which includes additional electricity from renewable energies, energy-efficiency improvements, a shift to lower-emission vehicles and other supportive policies—Hong Kong's emissions can be reduced to 3.9 $MtCO_2e$ in 2050, or 0.5 tCO_2e per capita (Figure ES-1).

Figure ES-1 | **Projected greenhouse gas emissions in Hong Kong under the Current Policy Scenario and the Decarbonisation Scenario, 2017–50**



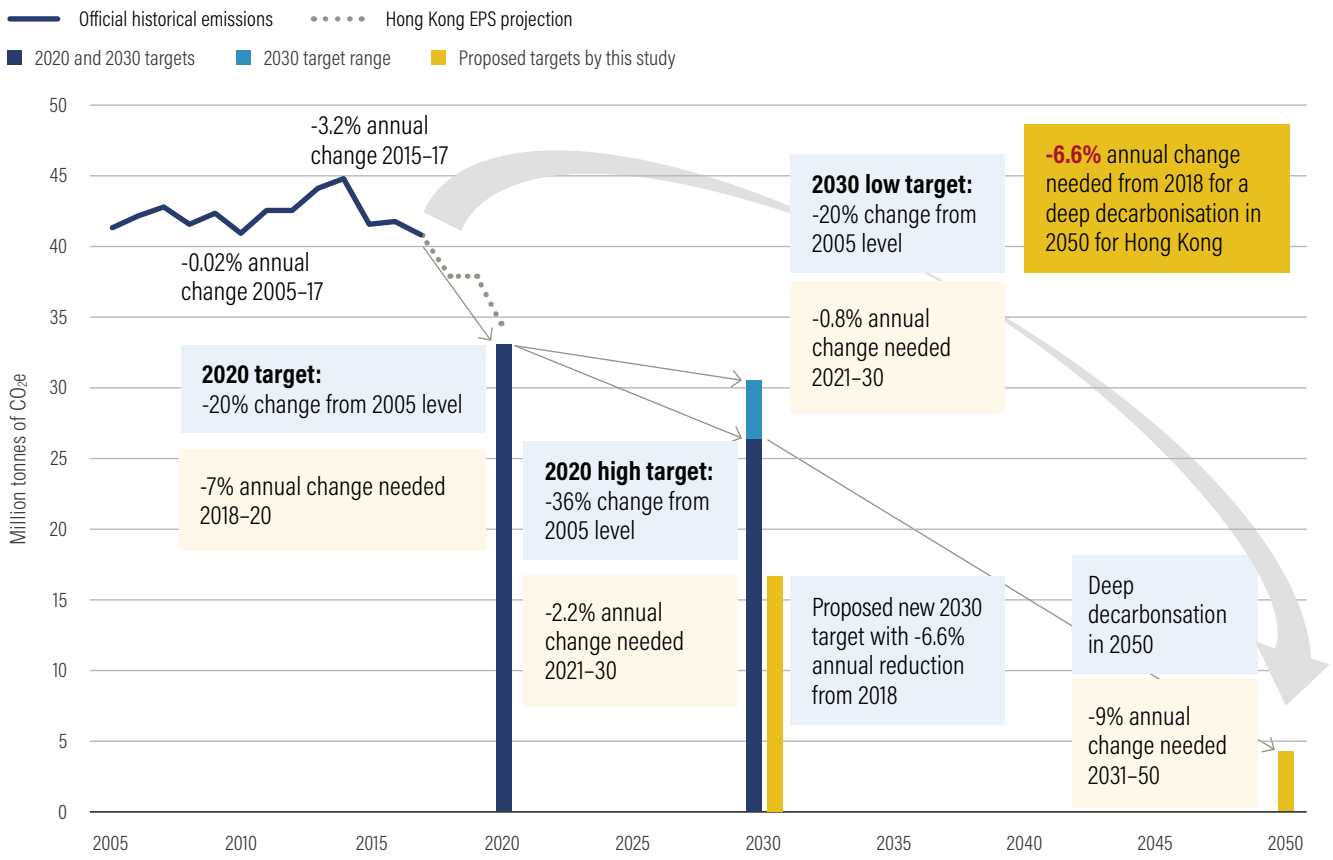
Note: Significant drops in 2024–25 and 2030–31 reflect the retirement of coal-fired power plants. Emissions include energy and industrial processes; waste and land use change and forestry are excluded.
Source: Hong Kong Energy Policy Simulator (EPS) (https://hongkong.energypolicy.solutions/).

Hard-to-decarbonise sectors—mainly remaining gas-fired electricity generation after the introduction of carbon capture and storage (CCS) and industry—account for a very small share of Hong Kong's economy. Therefore, it is appropriate for Hong Kong to target net zero carbon emissions by 2050 as its contribution to the Paris Agreement, which China signed. Hong Kong has a role to play under China's commitments. It needs to develop a clear and concise strategy, with a roadmap for achieving net zero carbon emissions by 2050.

Every day of delay makes the necessary cuts steeper and more difficult. Ambitious emissions-reduction trajectories will be necessary to make net zero emissions a reality. Hong Kong targets GHG emissions reductions of 20 per cent by 2020 and 26–36 per cent by 2030 relative to the 2005 baseline year. The model results indicate that the 2020 goal is reachable under the current commitments of switching from coal- to gas-fired electricity generation, but with a delay of at least two years. The 2030 target could be achieved by continuing to switch from coal to gas. However, little progress is visible in the planned management of energy consumption in buildings or in emissions reductions from transport and waste.

Hong Kong's 2030 target corresponds to an annual emissions reduction of 0.8–2.2 per cent between 2020 and 2030. Meeting the net zero emissions goal in 2050 will require Hong Kong to achieve the more ambitious of its 2030 targets (a 70 per cent reduction in carbon intensity and a 36 per cent reduction in total emissions) and to maintain a 9 per cent a year emissions reduction rate between 2030 and 2050. But if Hong Kong takes more ambitious actions now, a 6.6 per cent annual reduction rate from now to 2050 would be needed (Figure ES-2).

Figure ES-2 | **Emissions gap from now to Deep Decarbonisation in 2050**

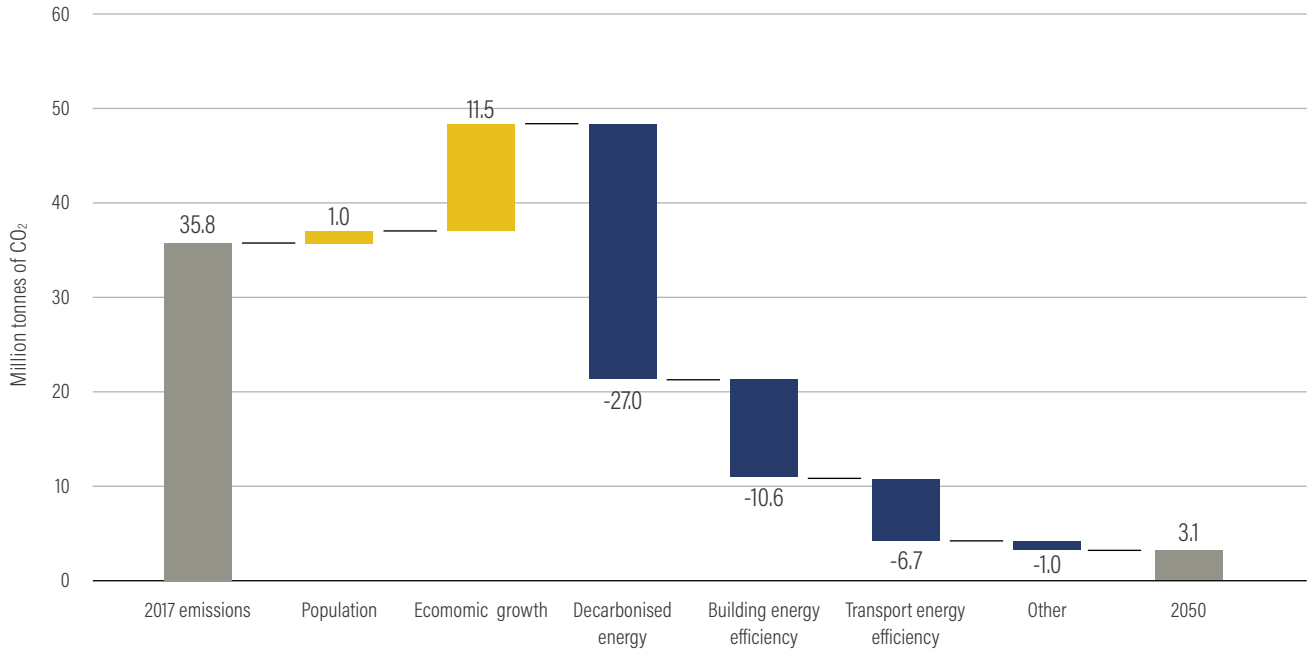


Source: 2005–17 emissions data are from EPD (2019); 2017 emission data are the most updated official information; 2018–19 emissions are from the Hong Kong Energy Policy Simulator (EPS); 2020 and 2030 emissions are calculated using Hong Kong's carbon-intensity targets; 2050 emission data are from the Hong Kong EPS.

Where is the emissions-reduction potential, and what is this study proposing? The total emissions-reduction potential from now to 2050 amounts to 32 $MtCO_2$. Population and economic growth are the key drivers of increasing emissions; power decarbonisation, energy-efficiency improvements in buildings and improvements in mobility are the main contributors to emissions reductions (Figure ES-3).

- **Decarbonising power:** "Power" is the energy distributed in the form of electricity or piped gas. Any future electricity generating capacity installed will have an economic life that extends past 2050. This capacity, which will be needed to replace coal-fired generation, must be capable of achieving net zero emissions by 2050. Vent-to-atmosphere gas that cannot economically be stored via CCS is not good enough. Using lower-carbon fuels for power generation provides the greatest emission-reduction potential (27 $MtCO_2$) by 2050. The proposed measures include developing local renewable energy sources and sourcing more nuclear and renewable energy from neighbouring regions, replacing coal with gas and coupled CCS, and replacing distributed gas with a net zero emission energy.
- **Making buildings more energy efficient:** Hong Kong could abate 10.6 $MtCO_2$ through a range of energy-efficiency enhancements to building. Buildings and infrastructure constructed between 2020 and 2030 are likely to still be in use in 2050. They must therefore comply with the much stricter energy-efficiency standards that will be needed then. Measures include implementing new energy-efficiency standards, retrofitting buildings and improving operational management.
- **Improving mobility:** Hong Kong could abate 6.7 $MtCO_2$ by avoiding journeys—by engaging in better town planning that allows children to walk to school and people to live closer to their workplace; shifting frequent journeys from inefficient transport modes, such as private cars and taxis, to energy-efficient transport modes; and improving transport management. Shifts from diesel- and petrol-powered vehicles to zero-emission

Figure ES-3 | **Changes in and contributors to energy-related CO_2 emissions, 2017–50**

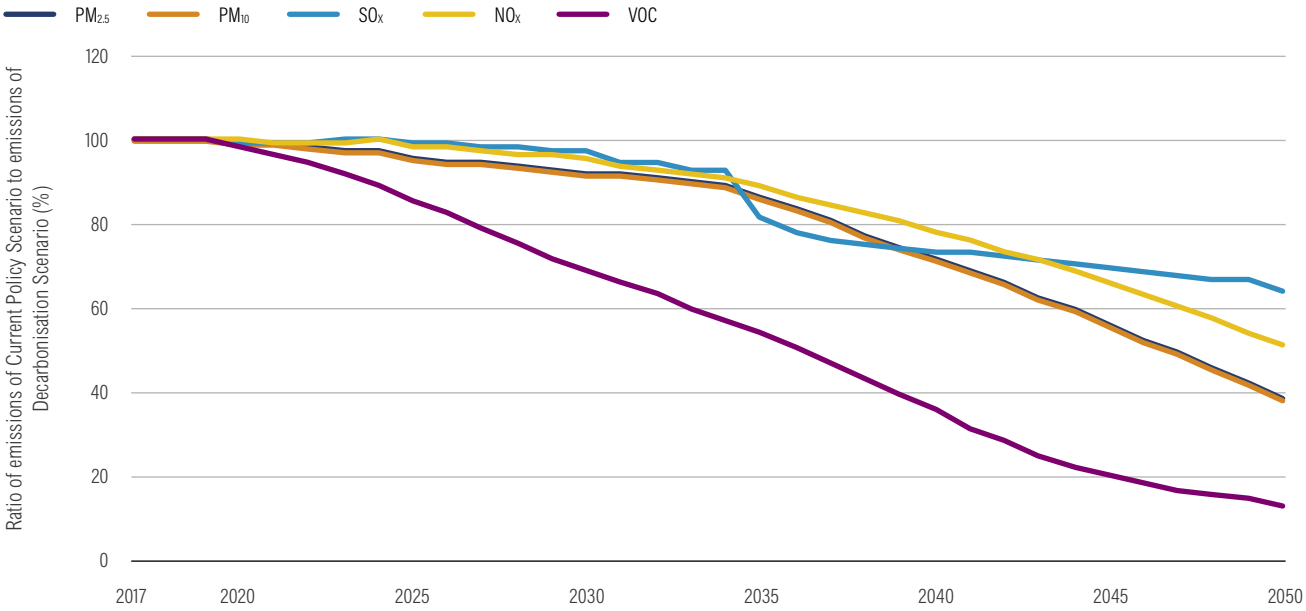


Note: "Other" includes reductions in emissions by industry (including from energy efficiency and fuel switch), increased energy efficiency in gas-fired electricity generation, transport demand control, increased use of public transport and worker training, among other factors.
Source: Data from the Hong Kong Energy Policy Simulator (EPS) (https://hongkong.energypolicy.solutions/).

alternatives should also be pursued. Battery electric vehicles are considered the optimal solution for low-power vehicles; hydrogen fuel cell electric vehicles could replace combustion engines in heavy-duty road vehicles and ships.

Achieving the reduction targets will increase life expectancy, saving about 26,000 lives between 2018 and 2050. A crucial co-benefit of lowering GHG emissions is the simultaneous reduction in local air pollution and its associated detrimental health effects. For example, abatement of 1 tonne of CO_2 leads to a corresponding reduction of 1.69 kilograms (kg) of particulate matter ($PM_{2.5}$) in Hong Kong. Emissions of $PM_{2.5}$ are projected to be 59 per cent lower in 2050 under the Decarbonisation Scenario than under the Current Policy Scenario (Figure ES-4).

Figure ES-4 | **Reduction in air pollutants in Hong Kong under the Decarbonisation Scenario compared with the Current Policy Scenario, 2017–50**

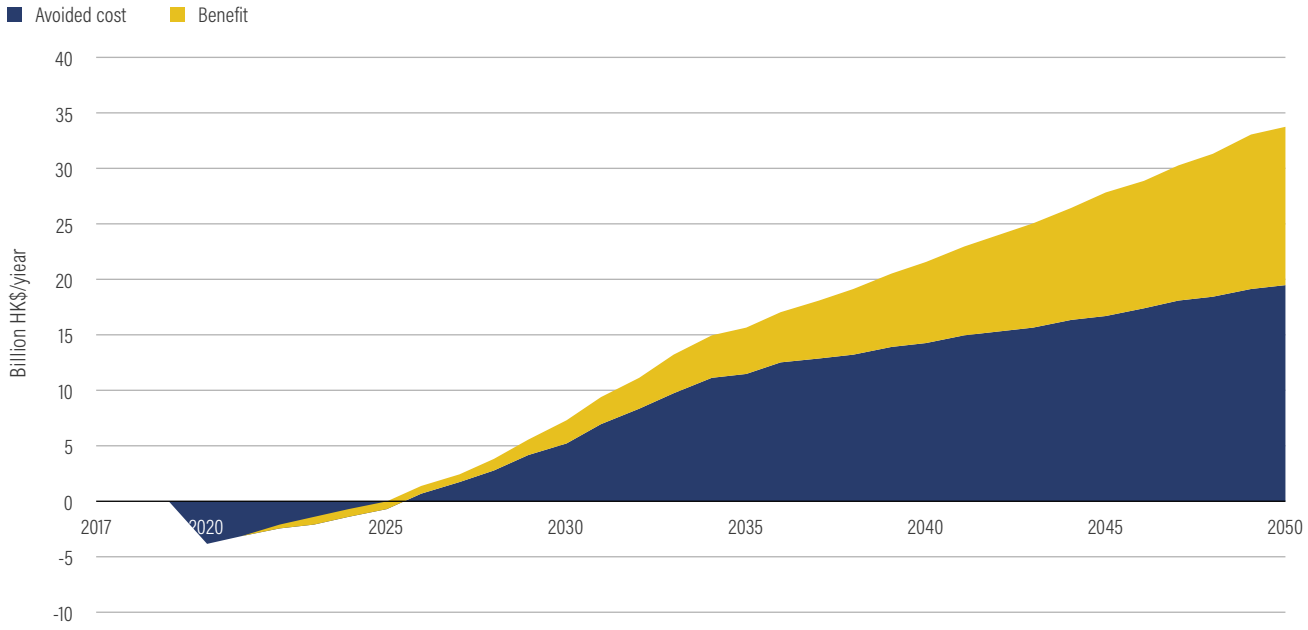


Note: The declines in $PM_{2.5}$ and PM_{10} in 2035 occur because the model assumes more imported nuclear and renewable energy from mainland China. $PM_{2.5}$ represents particulate matter with diameter of less than 2.5 micrometres; PM_{10} represents particulate matter with diameter of less than 10 micrometres; SO_x represents sulphur oxides; NO_x represents nitrogen oxides; and VOC represents volatile organic compounds.

Source: Hong Kong Energy Policy Simulator (EPS) (https://hongkong.energypolicy.solutions/).

Acting now would yield HK$460 billion of new wealth, equivalent to 0.3 per cent of GDP (Figure ES-5). These benefits comprise HK$290 billion in saved capital and operation and maintenance costs and HK$170 billion from avoided deaths and other climate benefits, including averted sea-level rise and water shortages. (The climate benefits are conditional on the rest of the world taking action.)

Figure ES-5 | **Benefits and avoided costs of implementing decarbonisation policies in Hong Kong, 2018–50**



Note: Estimates of the reduction in health damage include only the monetary benefits of reducing mortality. Other benefits, such as avoided hospitalization and health care costs and reduced sick leave, are not included.
Source: Hong Kong Energy Policy Simulator (EPS) (https://hongkong.energypolicy.solutions/).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THE NEED FOR A LONG-TERM DEEP DECARBONISATION STRATEGY

The Intergovernmental Panel on Climate Change (IPCC) sounded the alarm in its 2018 *Special Report on Global Warming of 1.5°C* (IPCC 2018) when it confirmed that to stay within 1.5°C of warming above pre-industrial levels, human civilization as a whole must achieve close to carbon neutrality by 2050. Countries need to achieve a balance between greenhouse gas (GHG) sources (anthropogenic emissions) and sinks (removal) in the second half of this century.

Hong Kong must play its part by developing a concrete plan to transform the city into a net zero emissions economy and society. Doing so means decarbonising most emissions and offsetting emissions that are too difficult or costly to eliminate. The transition will need careful planning, technological change and widespread acceptance of the costs and behavioural change that will be required. It will also require adjustment time for business and people.

Global Climate Goals and the Role of Cities

The Paris Agreement was adopted in December 2015 and came into force in November 2016. Its central goal is to strengthen the global response to the threat of climate change by keeping the global temperature rise this century well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C.

The IPCC concludes that human activities have caused global temperatures to rise by about 1°C above pre-industrial levels. Given past accumulated emissions, even a significant reduction in emissions by 2030 would not be sufficient to ensure that temperature increases are kept below 1.5°C by the end of this century. By 2030, global net anthropogenic carbon dioxide (CO_2) emissions need to decline by 45 per cent from 2010 levels, and global emissions must reach net zero by around 2050 (IPCC 2018).

The Paris Agreement requires countries to communicate their mid-century (2050) climate change strategies to the United Nations Framework Convention on Climate Change (UNFCCC) by 2020. At the UN Climate Action Summit in September 2019, 75 countries committed to deliver 2050 net zero emissions strategies by 2020 (Climate Summit 2019); 17 countries/regions had already done so by May 2020. Among them, France, Germany, the United Kingdom and the European Union have all pledged to achieve carbon neutrality by 2050 (UNFCCC n.d.).

Cities contribute 70 per cent of total global energy-related CO_2 gas emissions and therefore play a central role in addressing climate change. A United Nations Environment Programme (UNEP) report highlights that subnational actors, including states and cities, have the opportunity to implement the commitments made at the national level and to go beyond current pledges and raise ambition (UNEP 2018). Many cities have committed to carbon neutrality or deep decarbonisation by 2050 or earlier. Copenhagen, for example, committed to being carbon neutral by 2025, and London and New York committed to being carbon neutral by 2050 (Table 1-1).

Table 1-1 | **Cities with net zero or deep decarbonisation targets**

CITY	YEAR ACHIEVING DECARBONISATION TARGET	LEVEL OF DECARBONISATION (PER CENT)	BASELINE YEAR
Melbourne	2020	100	
Adelaide	2025	100	
Copenhagen	2025	100	
Oslo	2030	95	1990
Helsinki	2035	80	1990
Stockholm	2040	100	
London	2050	100	
New York	2050	100	
San Francisco	2050	100	
Seattle	2050	100	
Sydney	2050	100	
Washington, DC	2050	100	
Amsterdam	2050	95	1990
Boulder	2050	80	
Hamburg	2050	80	1990
Minneapolis	2050	80	2006
Portland	2050	80	1990
Rio de Janeiro	2050	80	2005
Toronto	2050	80	1990
Vancouver	2050	80	2007
Yokohama	2050	80	2005

Source: Carbon Neutral Cities Alliance website (https://carbonneutralcities.org/); Greater London Authority (2018); City of New York (2019).

Hong Kong's Climate Policies

In 2010, Hong Kong announced its first ever climate target: to reduce carbon intensity (carbon emissions per unit of gross domestic product [GDP]) by 50–60 per cent from 2005 levels by 2020 (Environment Bureau in collaboration with Development Bureau, Transport and Housing Bureau, Commerce and Economic Development Bureau, Food and Health Bureau, Security Bureau 2015), following China's target of reducing carbon intensity by around 45 per cent by 2020. In 2017, in response to the Paris Agreement, the government of Hong Kong published Hong Kong's Climate Action Plan 2030+ report (Environment Bureau in collaboration with members of the Steering Committee on Climate Change 2017), setting a carbon emission-reduction target for 2030 and outlining the city's action plans. Hong Kong pledged to reduce its carbon intensity by 65–70 per cent by 2030 relative to 2005. This target is slightly more ambitious than the intensity reduction goal in China's National Determined Contribution (60–65 per cent). The Hong Kong intensity target is equivalent to a 26–36 per cent reduction in total emissions and an expected reduction to 3.3–3.8 tonnes of carbon dioxide equivalent (tCO_2e) per capita, down from 2005 per capita emissions of 6 tCO_2e.

The Hong Kong government has set relevant climate goals in the areas of energy conservation and efficiency, electricity generation, construction, transportation, and waste management (Table 1-2).

For example, electricity generation accounts for the largest share of GHG emissions in Hong Kong, contributing 65 per cent of emissions in 2017. In response, government proposed switching from coal to gas as one of its key climate change mitigation actions. The Scheme of Control Agreement was set up as a regulatory framework for the government to monitor the operating and financial performance of Hong Kong's power companies. From 2019 onwards, the agreement requires CLP Power Hong Kong Limited (CLP) and Hong Kong Electric Investments Limited (HKE), the two power companies in Hong Kong, to actively address climate change and reach carbon emissions–reduction targets. In the latest approved development plans of the two companies (2018–23 for CLP and 2019–23 for HKE) (GovHK 2018), both companies agreed to commission additional new gas-fired power generation units and to gradually phase out coal-fired units. Natural gas is expected to generate 50 per cent of Hong Kong's electricity, and the proportion generated from coal is expected to drop to 25 per cent by the mid-2020s.

As Asia's world city, Hong Kong should take the initiative to devise its own strategy for achieving net zero carbon by 2050 and to reach beyond its required contribution to fulfil China's obligations under the Paris Agreement.

The government kicked off a public engagement program in mid-June 2019 to collect public views. It is expected to announce results later this year and to subsequently formulate a long-term decarbonisation strategy. This report analyses the feasibility of Hong Kong reaching net zero emissions in 2050 and provides inputs for the formulation of Hong Kong's long-term decarbonisation strategy.

Table 1-2 | **Hong Kong's climate change—related targets**

AREA	POLICY/ INITIATIVE	YEAR ANNOUNCED	TARGET	ESTIMATED PROGRESS
Climate change	Policy address	2010	Reduce carbon intensity by 50–60 per cent by 2020 using 2005 as base	Reduced by 33.3 per cent in 2017 (EPD 2019)
	Hong Kong's Climate Action Plan 2030+	2017	Reduce carbon intensity by 65–70 per cent by 2030 using 2005 as base	
			Reduce absolute carbon emissions by 20 per cent by 2020 and 26–36 per cent by 2030 using 2005 as base	Reduced by 1.2 per cent in 2017 (EPD 2019)
			Reduce per capita emissions to 3.3–3.8 tonnes per capita in 2030	Reduced to 5.5 tonnes in 2017 (EPD 2019)
			Peak emissions in 2020, by which time more electricity generation should come from natural gas	Reduced since 2014 (EPD 2019)

Table 1-2 | **Hong Kong's climate change—related targets (cont.)**

AREA	POLICY/ INITIATIVE	YEAR ANNOUNCED	TARGET	ESTIMATED PROGRESS
Energy conservation and efficiency	Energy Saving Plan for Hong Kong's Built Environment 2015–2025+	2015	Reduce energy intensity by 40 per cent by 2025 using 2005 as base	Reduced by 31.4 per cent in 2017 (EMSD 2019)
Electricity generation	Hong Kong's Climate Action Plan 2030+	2017	Reduce share of coal to 25 per cent and increase share of natural gas to 50 per cent by 2020	CLP: Gas produced 44 per cent of electricity in 2019 (CLP 2019); HKE: Gas produced more than 30 per cent of electricity in 2018 (HKE 2018)
			Continue to phase out coal and increase natural gas and non-fossil fuels by 2030	
Buildings	Policy address	2003, 2009, 2015	Reduce electricity consumption by government buildings by 5 per cent every five years beginning in 2003	Reduced by 7 per cent between 2003 and 2008 and 9 per cent between 2009 and 2014; no data for 2015–2020 (Environment Bureau 2017)
	Energy Saving Plan for Hong Kong's Built Environment 2015~2025+	2015	Ensure that new government buildings with construction floor areas of more than 5,000 m^2 with central air conditioning or more than 10,000 m^2 achieve at least BEAM Plus Gold standards [a]	No data
	Hong Kong Green Building Council Initiative	2014	Reduce total electricity consumption by 30 per cent in 2030 based on 2005 levels	Increased 12 per cent in 2019 (Census and Statistics Department 2011, 2020d)
Mobility	Railway Development Strategy 2014	2014	Complete construction of six railway lines by 2031; increase length of railways in Hong Kong to 270 kilometres in 2021 and 300 kilometres in 2031	262.2 kilometres built in 2019 (Transport Department 2020a)
			Increase share of public transport passengers using rail to 45–50 per cent in 2031	Rose to 42 per cent in 2019 (Transport Department 2019)
	Hong Kong's Climate Action Plan 2030+	2017	Discourage private car growth and usage by introducing electronic road pricing and rationalising bus routes	43,642 private cars registered in 2017, 42,287 in 2018, 38,309 in 2019 (Transport Department 2020a)
Waste	A Food Waste & Yard Waste Plan for Hong Kong 2014–2022	2014	Reduce amount of food waste that goes into landfills by at least 40 per cent by 2022, from around 3,600 tonnes a day to around 2,160 tonnes a day by volume	31 per cent of municipal solid waste (3,565 tonnes) was food waste in 2018 (EPD 2018)
	Hong Kong Blueprint for Sustainable Use of Resources 2013–2022	2013	Reduce per capita municipal solid waste disposal rate to landfills by 40 per cent by 2022 based on 2011 levels (1.27 kg per day to 0.8 kg per day)	Rose to 1.53 kg per day in 2018 (EPD 2018)
			Transform waste-management structure by 2022 so that 55 per cent of waste is recycled, 23 per cent is incinerated and 22 per cent is put in landfills	30 per cent of waste was recycled and 70 per cent put in landfills in 2018 (EPD 2018)

Note: Green shows progress that is on track; red indicates challenges.

[a] HKGBC issues BEAM Plus Certification Plaques for four ratings of BEAM Plus: platinum, gold, silver and bronze. Upon completion of the final assessment, owners can display the plaque, which is designed to reflect the unique identity of the BEAM Plus assessed project. For specifications and order information for the plaque, see https://www.hkgbc.org.hk/eng/BEAMPlusPlaque.aspx.

Source: Government of Hong Kong 2003, 2009, 2010, 2015; Environment Bureau in collaboration with members of the Steering Committee on Climate Change 2017; Environment Bureau in collaboration with Development Bureau, Transport and Housing Bureau 2015; HKGBC 2014; Transport and Housing Bureau 2014; Environment Bureau 2014; EPD 2013.

PATHWAYS TO DEEP DECARBONISATION IN HONG KONG

This study seeks to show how Hong Kong can achieve net zero emissions. It examines the necessary trajectory from scientific, technical and economic perspectives. The scenario analyses demonstrate that Hong Kong has high potential to achieve net zero emissions by 2050. By 2050, Hong Kong can reduce carbon emissions by 90 per cent compared with 2005 levels and offset the remaining 10 per cent of emissions from hard-to-abate sectors.

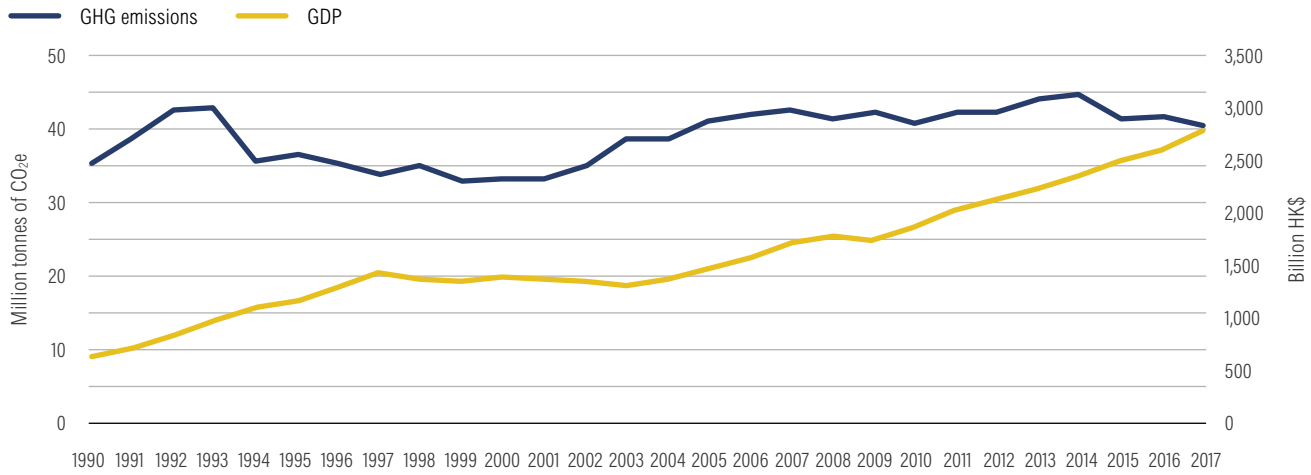
Emissions Profile

Hong Kong has experienced rapid socioeconomic development and urbanisation since the 1950s. In 2017, its GDP was HK$2,659 billion (HK$359,780 per capita) (Census and Statistics Department 2020a), higher than that of developed countries such as Germany and Japan and much higher than that of developing countries. Hong Kong's urbanisation rate reached 100 per cent in 1993 (World Bank 2018).

Hong Kong's direct GHG emissions reached 40.7 $MtCO_2e$ in 2017 (not including international aviation and shipping), according to the latest GHG emissions inventory. Its emissions have fluctuated since 2007, falling after reaching a peak in 2014 (Figure 2-1). Electricity generation contributes 65 per cent of Hong Kong's GHG emissions, with other sectors contributing smaller shares (Figure 2-2). In terms of consumption, buildings are the largest consumers of electricity, accounting for 67 per cent of Hong Kong's GHG emissions (Environment Bureau in collaboration with members of the Steering Committee on Climate Change 2017).

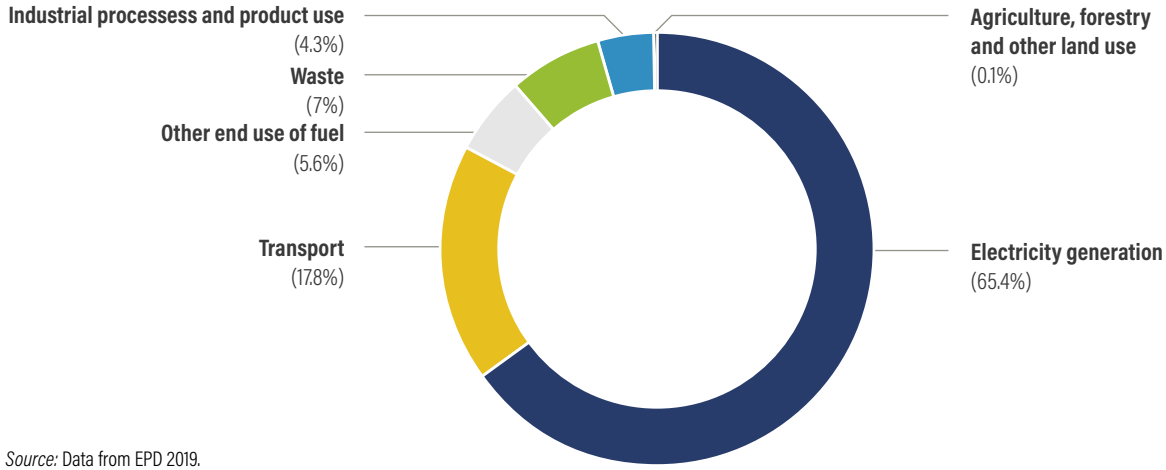
Population, economic growth, energy efficiency, and the energy mix affect GHG emissions (Figure

Figure 2-1 | **Hong Kong's greenhouse gas emissions and GDP, 1990–17**



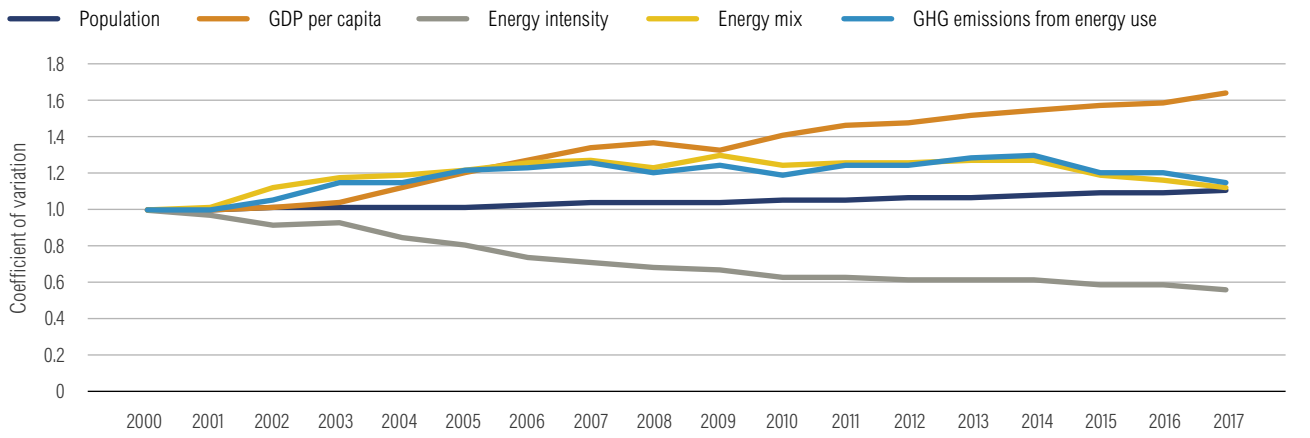
Source: EPD 2019; Census and Statistics Department 2020a.

Figure 2-2 | **Sources of Hong Kong's greenhouse gas emissions, 2017**



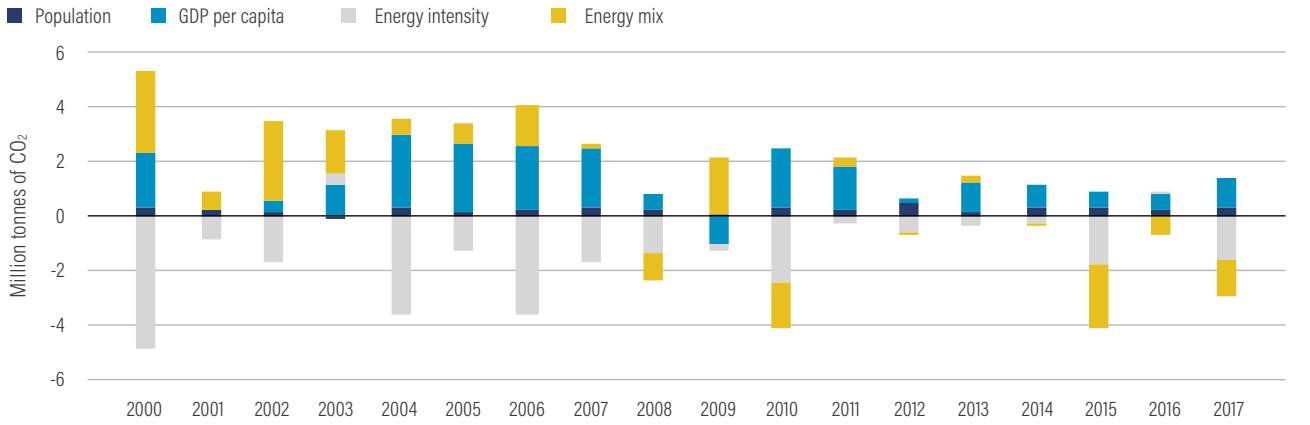
Source: Data from EPD 2019.

Figure 2-3 | **Forces driving Hong Kong's greenhouse gas emissions from energy use, 2000–17**



Note: Energy intensity is energy consumption per unit of GDP. The energy mix represents GHG emissions per unit of energy consumption. The KAYA Decomposition Model was used for the analysis. It was developed in 1990, by Japanese researcher Kaya Yoichi. The basic principle is that four factors determine a region's carbon emissions: population, economic development, energy utilization and energy sources. They can be represented by four parameters: population, GDP per capita, energy consumption per unit of GDP and carbon emission per unit of energy consumption.
Source: Data from Census and Statistics Department 2002, 2008, 2011,2012, 2013, 2014a,2014b, 2015, 2016b, 2017a, 2018, 2020a, 2020c; EPD 2019.

Figure 2-4 | **Contributions of population, GDP, energy intensity and energy mix to fluctuations in greenhouse gas emissions in Hong Kong, 2000–17**



Note: Energy intensity is energy consumption per unit of GDP. The energy mix represents greenhouse emissions per unit of energy consumption. The Logarithmic Mean Divisia Index (LMDI) method was used for the analysis. Together with KAYA decomposition analysis, it can be used to calculate the contribution of each parameter to the change in emissions.
Source: Data from Census and Statistics Department 2002, 2008, 2011, 2012, 2013, 2014a, 2014b, 2015, 2016b, 2017a, 2018, 2020a, 2020c; EPD 2109g.

2-3). Economic growth (GDP per capita) is the major driving force behind rising GHG emissions in Hong Kong, but its contribution has declined in recent years. Hong Kong's urban expansion faces geographic constraints, as the level of urbanisation reached 100 per cent in 1994; annual population growth has remained below 1 per cent over the past 20 years. The increase in emissions from population growth is therefore minor. Hong Kong's energy intensity (energy consumption per unit of GDP) has dropped continuously since 2000; it is the major driving force in emissions reductions. This contribution has decreased, however, as low-hanging-fruit opportunities for energy-efficiency improvements have decreased. Carbon intensity is reflected in the energy mix. Carbon intensity (shown as energy mix) increased between 2000 and 2009, as the share of coal rose. After 2010, it started to slowly decline. It continued to fluctuate for several years, contributing to emissions decreases in some years and increases in others (Figure 2-4).

A Roadmap for Deep Decarbonisation

This study considers two scenarios, a Current Policy Scenario and a Decarbonisation Scenario. Both use 2017 as the base year and are based on identical assumptions about GDP and population growth. They differ substantially in their choice of actions.

The Current Policy Scenario assumes that existing policies continue through 2050 without major policy changes. Under this scenario:

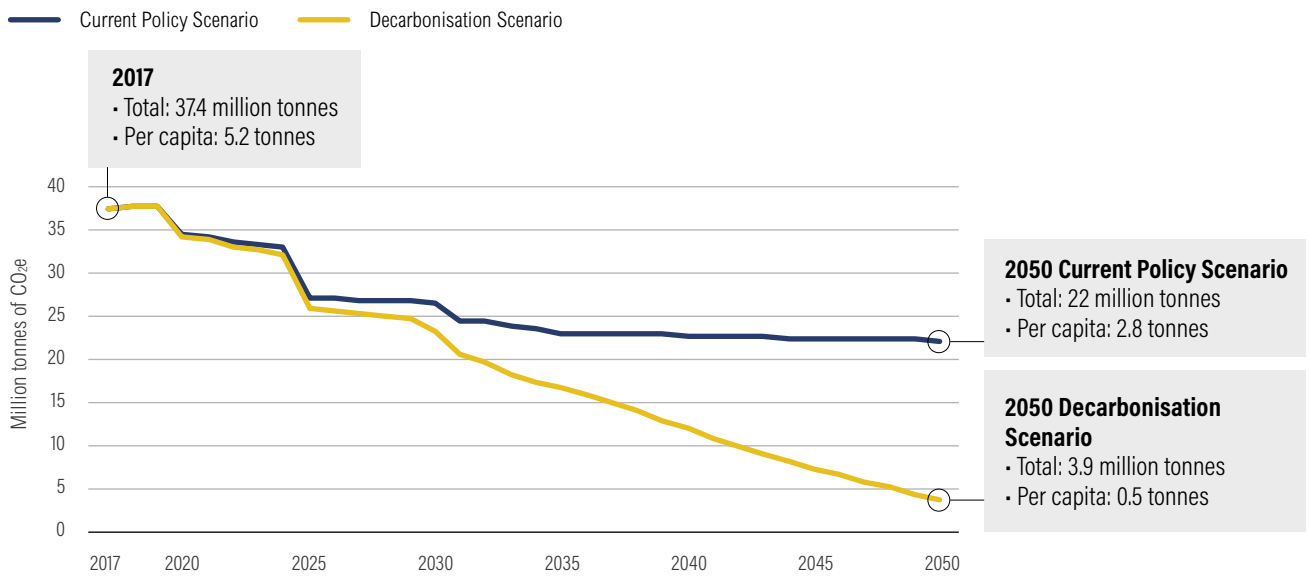
- By 2050, imported electricity will continue to meet around 25 per cent of total electricity demand, gas will be used for the majority of local electricity generation and renewable energy including waste-to-energy will make very limited contributions to the energy mix.
- The energy efficiency of buildings will be continuously improved but by less than the rate of growth in floor area. Consequently, electricity consumption by the building sector will rise.
- Measures to decarbonise mobility, such as improving fuel efficiency or encouraging electric vehicle sales, will be limited.

Under these circumstances, Hong Kong's GHG emissions are expected to drop until 2035, thanks mostly to the 100 per cent switch from coal to gas in power generation. However, CO_2e emissions will fall only to 22 million tonnes in 2050, because reductions will be largely offset by the increase in energy demand from the building sector.

Under the Decarbonisation Scenario, Hong Kong has high potential to achieve net zero emissions by 2050 at reasonable cost if more ambitious action is taken now. This scenario reflects optimal pathways towards the goal. The principal recommendations comprise the following:

- For electricity generation, the two extremes are entirely local electricity supply or entirely outside-sourced electricity supply from neighbouring areas. A solution with a split supply is the most likely. In this scenario, 60 per cent of supply in 2050 is sourced from imported renewable energy and nuclear energy, 35 per cent comes from local gas-powered plants with carbon capture and storage (CCS), and the re-

Figure 2-5 | **Projected greenhouse gas emissions in Hong Kong under the Current Policy Scenario and the Decarbonisation Scenario, 2017–50**



Note: Significant drops in 2024–25 and 2030–31 reflect the retirement of coal-fired power plants. Emissions include energy and industrial processes; waste and land use change and forestry are excluded.
Source: Hong Kong Energy Policy Simulator (EPS) (https://hongkong.energypolicy.solutions/).

maining 5 per cent comes from local renewable energy and waste-to-energy.

- The energy efficiency of building increases by 11–40 per cent, depending on the energy-use purpose.
- Emissions from mobility are reduced by mandating electric vehicle sales, discouraging car sales and other policies.

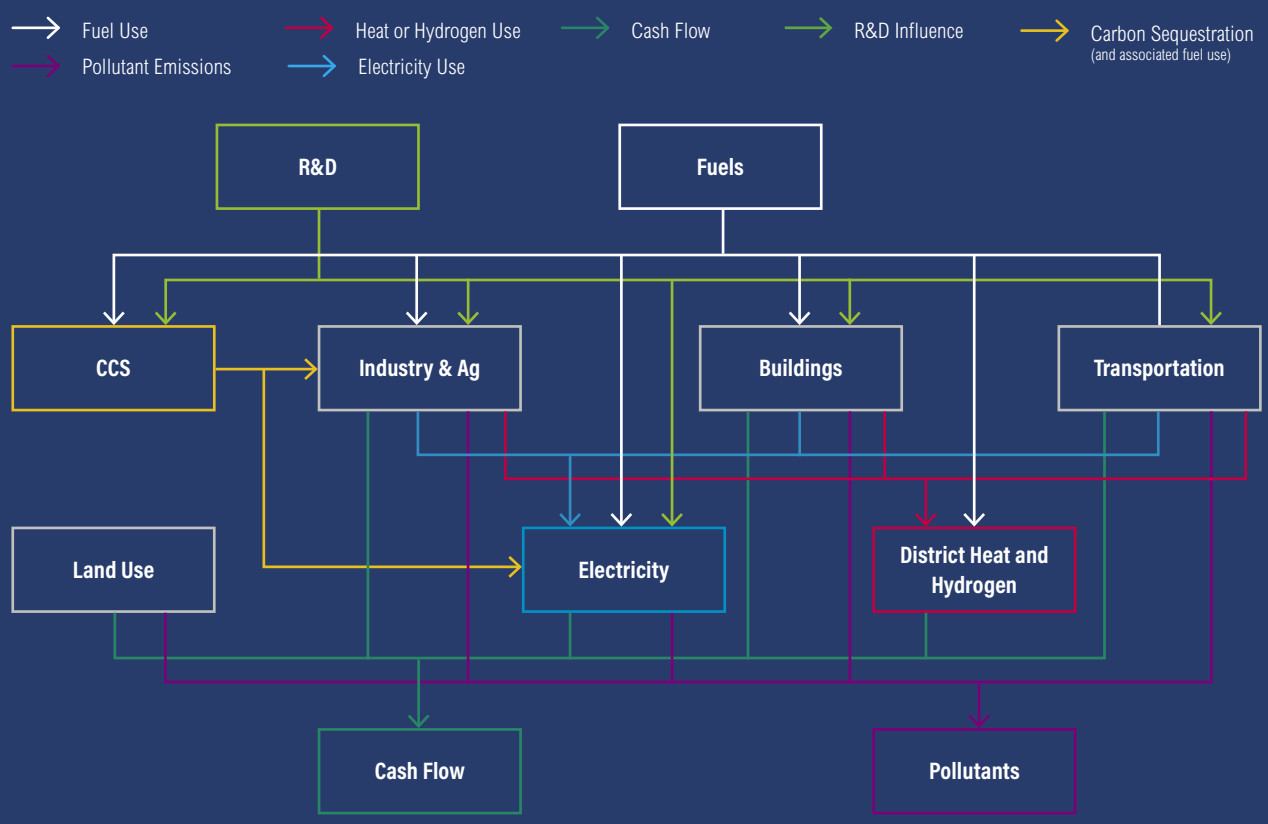
By taking these measures, Hong Kong can reduce its emissions to 3.9 $MtCO_2e$ in 2050—a 90 per cent reduction from 2005 levels (Figure 2-5). The 3.9 million tonnes of residual emissions could be offset by carbon sinks in Hong Kong and purchased offsets in international carbon markets. Under these conditions, Hong Kong would achieve net zero carbon emissions by 2050.

Box 2-1 | The Hong Kong Energy Policy Simulator

This study examines Hong Kong's emissions trajectory from 2017 to 2050 through scenario analysis, in order to evaluate the feasibility of achieving net zero emissions by 2050 and to devise a roadmap for doing so. The Hong Kong Energy Policy Simulator (EPS) was developed to conduct this scenario analysis.

The EPS estimates the effects of various policies on specific indicators, such as emissions, financial metrics, the electricity system structure, the deployment of different vehicle type, and related data. The model comprises six main sectors: industry (including manufacturing and related industries, construction, agriculture and waste management); buildings; mobility; electricity generation; land use, land-use change and forestry; and district heating and hydrogen.

Figure B2-1 | Structure of the Hong Kong Energy Policy Simulator



Source: Energy Innovation Policy and Technology LLC.

Box 2-1 | The Hong Kong Energy Policy Simulator (Cont.)

The Hong Kong EPS produces environmental, economic and social output indicators, including the following:

- emissions of 12 pollutants
- 8 cashflow streams (first-order costs and savings to government, consumers or labour; non-energy industries; and each of the energy industries)
- 9 capacity and generation values related to electricity by type of power plants, market shares of different vehicle technologies and premature deaths avoided by reductions in particulate matter emissions.

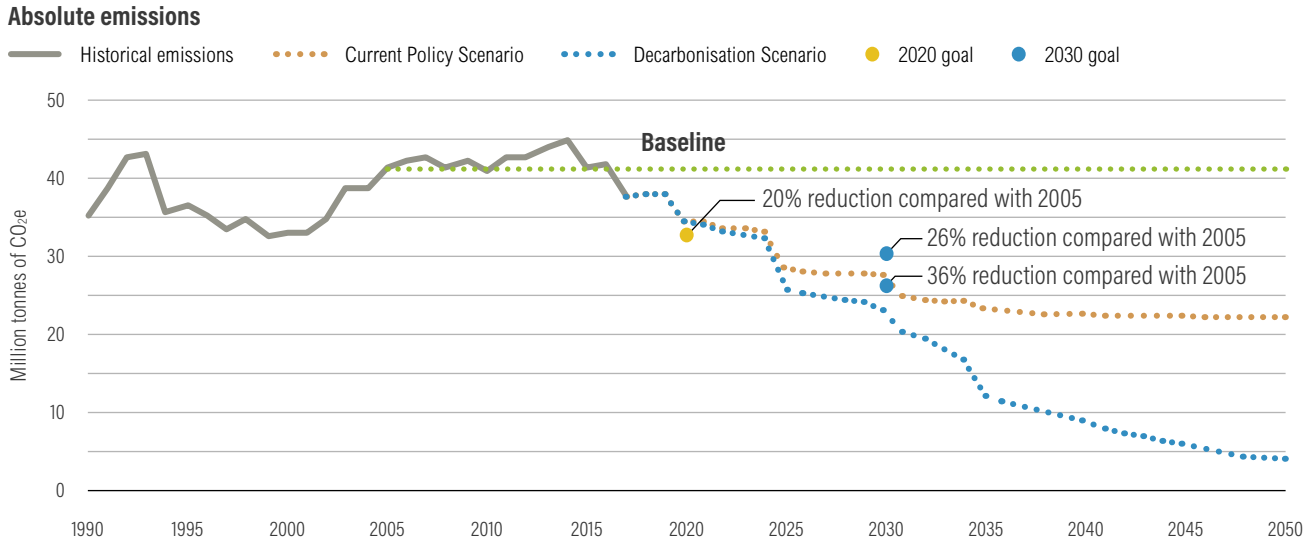
These output metrics can help policymakers anticipate the long-term economic impacts and costs of implementing new policies.
The model is free and open source. It can be accessed via an interactive web interface at https://hongkong.energypolicy.solutions/ or downloaded from the same site.

A technical note, "Hong Kong Energy Policy Simulator: Methods, Data and Scenario Results for 2050", describes the structure, input data sources, outputs and limitations of the EPS-Hong Kong, as well as detailed assumption used in the two scenarios. It is available at http://www.wri.org.cn/en/HONG_KONG_ENERGY_POLICY_SIMULATOR_METHODS_DATA_AND_SCENARIO_RESULTS_FOR_2050_EN.

The Hong Kong EPS model was developed before the COVID-19 pandemic; the GDP projection for 2019–20 does not therefore reflect the pandemic's impact. Annual real GDP growth used in the model is 3.5 per cent between 2018 and 2021, decreasing to 3 per cent between 2022 and 2025 and to 2.5 per cent between 2026 and 2050. Actual annual growth in Hong Kong was 2.9 per cent in 2018 and –1.2 per cent in 2019 (Census and Statistics Department 2020b). GDP contracted by 8.9 per cent in the first quarter in 2020 from a year earlier (GovHK 2020). Average annual population growth is assumed to be 0.4 in 2018 –43 and 0.4 per cent in 2043–50 (Census and Statistics Department 2017b). The model is being updated to reflect the impact of COVID-19, which is expected to be limited to 2020 and 2021. The pandemic is not expected to affect this report's major conclusions or recommendations, especially in the mid- and long term.

Source: Hong Kong Energy Policy Simulator (EPS) (https://hongkong.energypolicy.solutions/).

Figure 2-6 | **Progress toward meeting Hong Kong's 2020 and 2030 goals under the Current Policy Scenario and the Decarbonisation Scenario**



Source: EPD 2019; Hong Kong Energy Policy Simulator (EPS) (https://hongkong.energypolicy.solutions/).

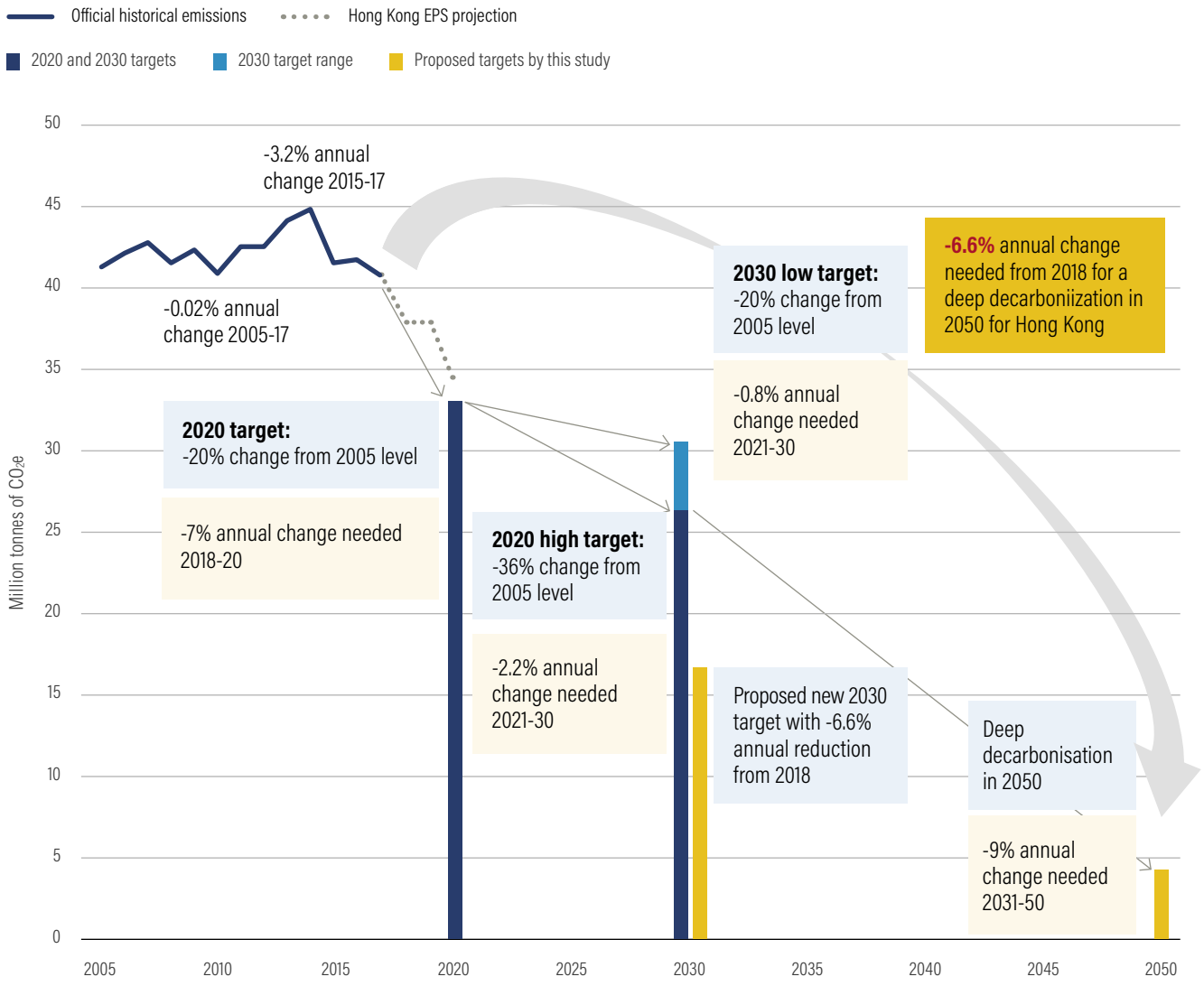
Emission-Reduction Gaps

Hong Kong has set emission-reduction goals for 2020 and 2030. Are they achievable? How would they affect the prospects for deep decarbonisation by 2050?

The 2030 targets currently seem attainable. All lower-level targets for 2030—including the 65 per cent carbon-intensity reduction, the 26 per cent absolute emissions reduction and the 3.8 tonnes CO_2e per capita emissions—are achieved under the Current Policy Scenario. The higher-level targets require additional actions under the Decarbonisation Scenario. In contrast, achieving the 2020 targets on time appears challenging: The Current Policy Scenario projects shortcomings for all targets set for 2020. A delay of at least two years is expected (Figure 2-6).

More ambitious action is needed now, as current policies are insufficiently ambitious to achieve deep decarbonisation by 2050. Achieving this goal requires an average annual decline in absolute emissions of 9 per cent between 2030 and 2050

Figure 2-7 | **Emissions gap from now to Deep Decarbonisation in 2050**



Source: 2005–17 emissions data are from EPD (2019); 2017 emission data are the most up-to-date official information; 2018–19 emissions are from the Hong Kong Energy Policy Simulator (EPS); 2020 and 2030 emissions are calculated using Hong Kong's carbon-intensity targets; 2050 emissions data are from the Hong Kong EPS.

or 6.6 per cent starting now (Figure 2-7). In either case, ambitious action is imperative and must be taken swiftly.

Annual declines in emissions of 6.6 per cent or 9 per cent are averages. Some actions, like retrofitting buildings for greater efficiency, will have gradual effects; actions like gasification of power plants will lead to significant reductions more quickly. However, the average annual reduction in Hong Kong in 2005–17 was a mere 0.02 per cent. A more significant 3.2 per cent average drop was evident from 2015 to 2017, but it is still well below the 6.6 per cent or 9 per cent required to achieve the 2050 goal. To achieve these kinds of reductions, Hong Kong needs to accelerate its actions beginning now.

Potential for Emissions Reduction

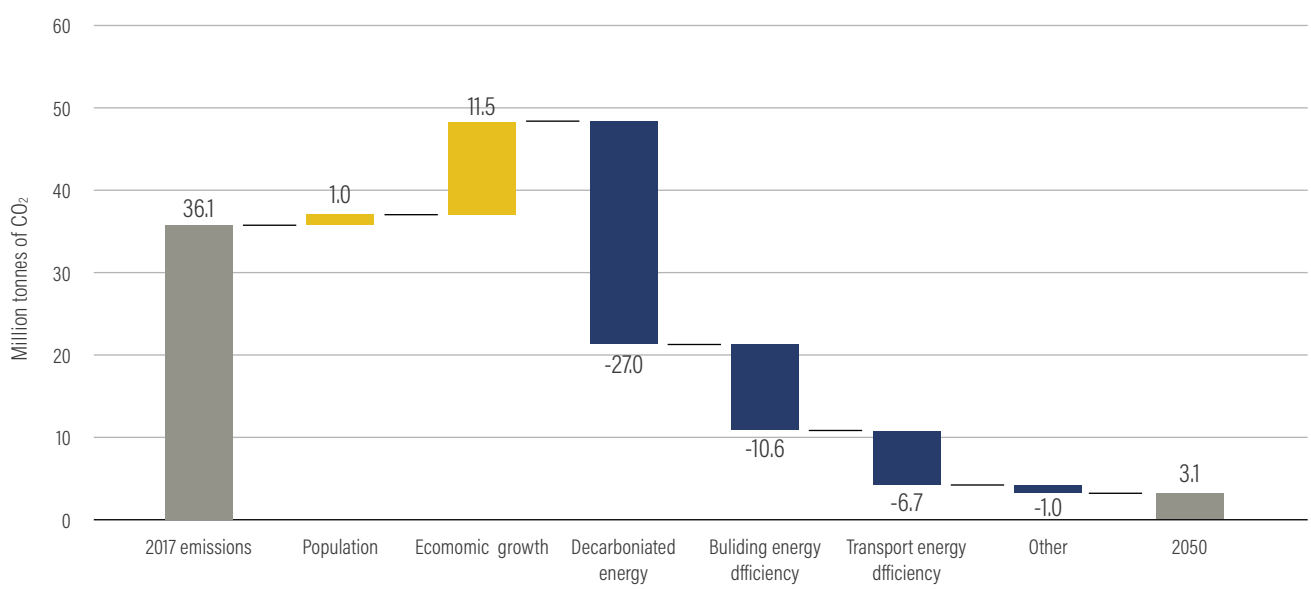
The study team analysed the sources of Hong Kong's emission-reduction potential. It found that the greatest potential for reducing emissions comes from improving electricity generation, making buildings more energy efficient and increasing the sustainability of mobility (Figure 2-8).

Hong Kong's energy-related carbon emissions were 36.1 $MtCO_2$ in 2017; they are forecast to fall to 3.1 $MtCO_2$ in 2050 under the Decarbonisation Scenario. This decline represents a 90 per cent reduction from 2005 levels and an 80 per cent reduction compared with the Current Policy Scenario. Hong Kong's population was 7.1 million in 2017 and is projected to grow to 7.9 million in 2050. The corresponding emissions increase is limited to 1 $MtCO_2$. Hong Kong's GDP in 2017 was HK$2,577 trillion. Assuming a sustained annual growth rate of 2.5–3.5 per cent, it is expected to reach HK$6,233 trillion by 2050, increasing emissions by 11.5 $MtCO_2$.

Decarbonisation in power, buildings and mobility are the three areas with the largest emission-reduction potentials in Hong Kong:

- **Decarbonising power:** "Power" is the energy distributed in the form of electricity or piped gas. Any future electricity generating capacity installed will have an economic life that extends past 2050. This capacity, which will be needed to replace coal-fired generation, must be capable of achieving net zero emissions by 2050. Vent-to-atmosphere gas that cannot economically be stored via carbon capture and storage (CCS) is not good enough. Using lower-carbon fuels for power generation provides the greatest emission-reduction potential (27 $MtCO_2$) by 2050. The proposed measures include developing local renewable energy sources and sourcing more nuclear and renewable energy from neighbouring regions, replacing coal with gas and coupled CCS, and replacing distributed gas with a net zero emission energy.
- **Making buildings more energy efficient:** Hong Kong could abate 10.6 $MtCO_2$ through a range of energy-efficiency enhancements to buildings. Buildings and infrastructure constructed between 2020 and 2030 are likely to still be in use in 2050. They must therefore comply with the much stricter energy-efficiency standards that will be needed then. Measures

Figure 2-8 | **Changes in and contributors to energy-related CO_2 emissions, 2017–50**



Note: "Other" includes reductions in emission by industry (including from energy efficiency and fuel switch), increased energy efficiency in gas-fired electricity generation, transport demand control, increased use of public transport and worker training, among other factors.
Source: Data from the Hong Kong Energy Policy Simulator (EPS) (https://hongkong.energypolicy.solutions/).

include implementing new energy-efficiency standards, retrofitting buildings and improving operational management.

- **Improving mobility:** Hong Kong could abate 6.7 $MtCO_2$ by avoiding journeys—by engaging in better town planning that allows children to walk to school and people to live closer to their workplace; shifting frequent journeys from inefficient transport modes, such as private cars and taxis, to energy-efficient transport modes; and improving transport management. Shifts from diesel- and petrol-powered vehicles to zero-emission alternatives should also be pursued. Battery electric vehicles are considered the optimal solution for low-power vehicles; hydrogen fuel cell electric vehicles could replace combustion engines in heavy-duty road vehicles and ships.

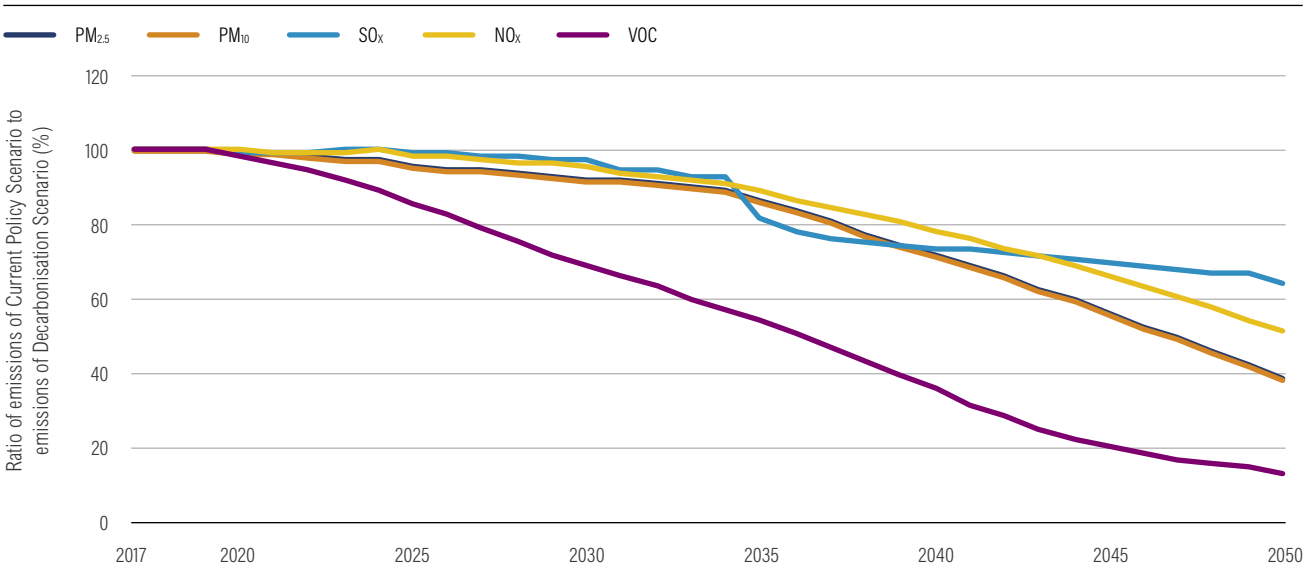
Sections 3–6 provide detailed policy recommendations for each area.

Environmental Benefits of Deep Decarbonisation

Air quality is a major concern in Hong Kong, and the government is implementing a number of initiatives to improve it. The main sources of Hong Kong's air pollution are motor vehicles, marine vessels and power plants. The two greatest challenges are local street-level pollution and regional smog. Diesel vehicles, particularly trucks, buses and light buses, are the main source of street-level pollution. Smog is caused by a combination of pollutants, mainly from motor vehicles, industry and power plants in Hong Kong and the Pearl River Delta (GovHK 2019a). A crucial co-benefit of lowering GHG emissions is the simultaneous reduction in local air pollution and its associated detrimental health effects. Mitigating air pollution is expected to increase life expectancy in Hong Kong, leading to an estimated accumulated avoided mortality of about 26,000 lives by 2050.

According to the Hong Kong EPS, abatement of 1 tCO_2 will lead to a reduction of air pollutants of 1.69 kg for $PM_{2.5}$, 1.66 kg for PM_{10}, 1.93 kg for nitrogen oxides (NO_X) and 1.74 kg for sulphur oxides (SO_X).[1] Figure 2-9 illustrates the reductions in these pollutants under the Decarbonisation Scenario compared with the Current Policy Scenario.

Figure 2-9 | **Reduction in air pollutants in Hong Kong under the Decarbonisation Scenario compared with the Current Policy Scenario, 2017–50**



Note: The declines in $PM_{2.5}$ and PM_{10} in 2035 occur because the model assumes more imported nuclear and renewable energy from mainland China. $PM_{2.5}$ represents particulate matter with diameter of less than 2.5 micrometres, PM_{10} represents particulate matter with diameter of less than 10 micrometres, SO_x represents sulphur oxides, NO_x represents nitrogen oxides and VOC represents volatile organic compounds.

Source: Hong Kong Energy Policy Simulator (EPS) (https://hongkong.energypolicy.solutions/).

Economic Benefits of Deep Decarbonisation

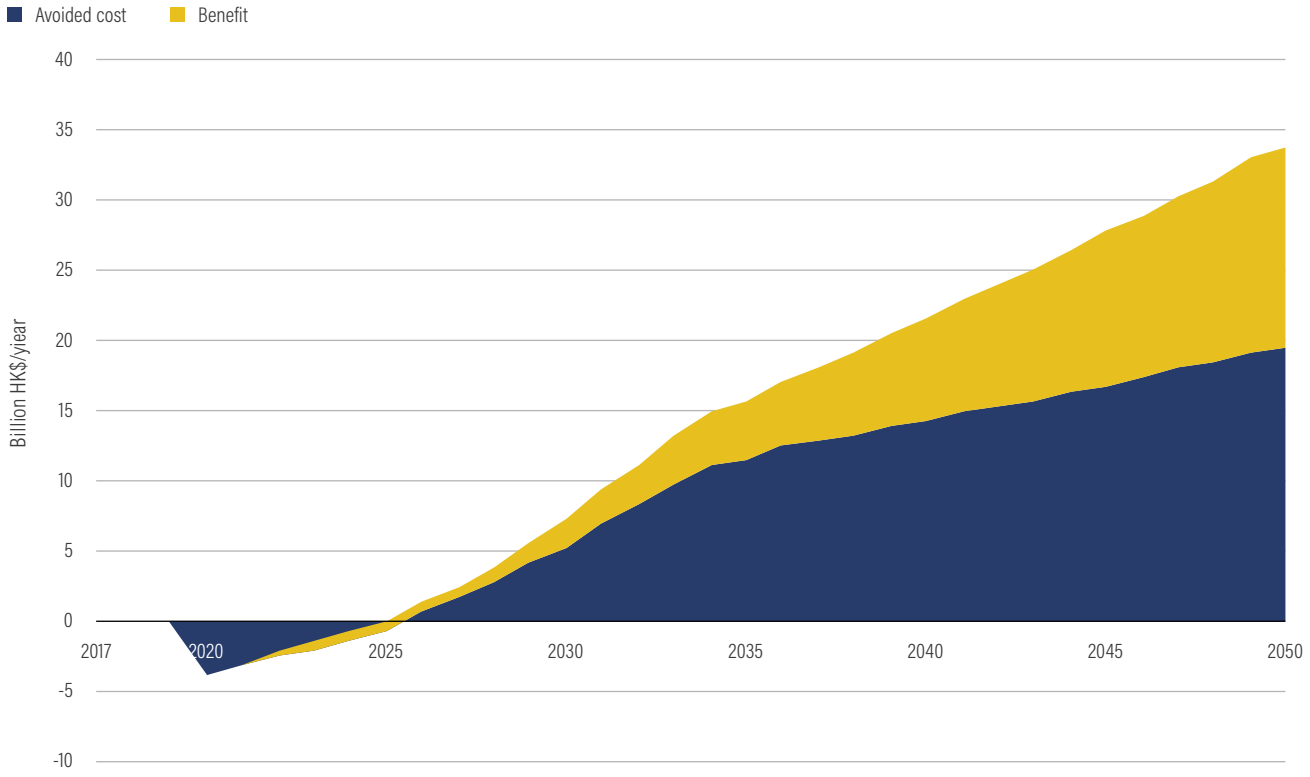
Acting now would create an estimate HK$460 billion of new wealth between 2018 and 2050. The accumulated net benefits include HK$290 billion of saved capital and operations and maintenance (O&M) costs and HK$170 billion in avoided deaths and climate impacts (Figure 2-10). [2]

These benefits do not represent the actual cost of policies; they refer to the difference between implementation of policies under the Decarbonisation Scenario and the Current Policy Scenario. A negative cost indicates that policies under the Decarbonisation Scenario can save money compared with the Current Policy Scenario.

Implementation of the proposed policies incurs capital costs as well as O&M costs for new infrastructure, buildings and vehicles. Capital costs are typically higher than operating costs for buildings and vehicles. However, improvements in the energy efficiency of buildings can lead to significant job creation in the new green economy, particularly in building retrofitting. The Decarbonisation Scenario requires additional investment of HK$170 billion in capital costs between now and 2050 compared with the Current Policy Scenario, but the magnitude of corresponding savings is much larger, with O&M costs reduced by HK$460 billion. The Decarbonisation Scenario thus yields cumulative savings of HK$290 billion.

Avoided damages from climate change impacts, including averted sea level rise and water shortages, among other impacts, would yield another HK$144 billion in benefits, and the accumulated monetized benefits from avoided premature deaths are estimated at HK$26 billion

Figure 2-10 | **Benefits and avoided costs of implementing decarbonisation policies in Hong Kong, 2018–50**



Note: Estimates of the reduction in health damage include only the monetary benefits of reducing mortality. Other benefits, such as avoided hospitalization and health care costs and reduced sick leave, are not included.
Source: Hong Kong Energy Policy Simulator (EPS) (https://hongkong.energypolicy.solutions/).

Table 2-1 | **Cumulative benefits of decarbonisation in Hong Kong, 2018–50**

BENEFIT	AMOUNT (BILLION HK$)	PER CENT OF GDP
Saved capital and maintenance cost	290	0.2
Avoided deaths	26	0.02
Other climate benefits	144	0.1
Total net benefits	460	0.3

Source: Hong Kong Energy Policy Simulator (EPS) (https://hongkong.energypolicy.solutions/).

(Table 2-1). The climate benefits are conditional on the rest of the world taking effective climate actions; the benefits from improved life expectancy and capital and operation cost savings would be realized even if the rest of the world failed to act.

Ensuring a Just Transition

Shifting towards a climate-resilient and low-carbon economy will effect profound changes in how people live and work. Cities need to plan a low-carbon economy for all people, including people whose livelihoods currently depend on high-carbon aspects of the economy and people who are most vulnerable to climate change policies.

Policies aimed at reducing energy consumption and carbon emissions may cause job losses and adverse economic impacts for some people, including lower-income households. The richest 25 per cent of households in Hong Kong reportedly spend only 2 per cent of their income on electricity, gas and water; the second-richest quartile spends 3 per cent; the second-lowest quartile spends 4 per cent; and the poorest quartile spends 5 per cent (Census and Statistics Department 2016a). Low-income groups are thus more vulnerable than other groups to increases in energy bills.

Table 2-2 provides examples of the social impact of climate policy and describes actions that can help ensure a just transition.

The government could consider three options to ensure equity among people adversely affected by the low-carbon transition:

- Identify significant job losses caused by the transition, identify suiTable new jobs and arrange training to reskill workers for new jobs created by the transition.
- Ensure public understanding of and participation in climate decision making.
- Provide financial support for retraining or early retirement.

Table 2-2 | **Examples of social impact of climate policy and actions to help ensure a just transition**

AREA	CLIMATE POLICY	SOCIAL IMPACT	ACTION TO HELP ENSURE A JUST TRANSITION
Power	Discontinue use of coal and town gas. Increase local renewable energy generation.	Very few people affected, as workers for power utilities will have opportunities to redeploy to local renewable energy and demand-management work.	Train people in renewable energy, smart grids and energy storage
Buildings	Adopt and implement energy-efficiency standard. Retrofit buildings.	Costs will increase, but investment will be rewarded by energy saving. Jobs will be created in construction, retrofitting and energy auditing.	Train people who have lost employment to take on these jobs.
Transport	Adopt and implement electric vehicle sales mandate.	Costs will increase. Jobs will move from internal combustion to electric vehicles in regions producing vehicles.	Increase jobs in infrastructure (charging station) construction.
	Shift to public transport, especially mass transit system.	Number of jobs for drivers and car mechanics will decline.	Increase jobs in infrastructure construction.
Waste	Reduce waste, recycle, turn waste into energy.	Jobs will change. Costs will rise.	Create jobs in collecting, sorting and recycling waste and construction of new waste-to-energy plants.

Source: Hong Kong Energy Policy Simulator (EPS) (https://hongkong.energypolicy.solutions/).

IMPROVING THE GENERATION OF ELECTRICITY

Historically, coal dominated Hong Kong's electricity mix. The mix has shifted towards natural gas, but replacing coal with gas reduces emissions by only about 50 per cent. In 2017, Hong Kong's electricity generation sector accounted for 65 per cent of the city's total carbon emissions at 27 $MtCO_2e$ (EPD 2019).

Summary of Policy Recommendations

Seven options could increase the share of zero-carbon emission sources in Hong Kong's electricity sector:

- **Develop local renewable energy.** According to the government, Hong Kong has the potential to increase its use of renewable energy by only 3–4 per cent by 2030. The World Wildlife Fund suggests that the potential could be 10 per cent (WWF 2019). The larger share would require reinforcing local renewable energy incentives and making additional efforts to develop domestic renewable energy potential.
- **Invest in regional renewable energy projects.** Increasing renewable energy significantly beyond local capacity will involve sourcing from Mainland China. It would be helpful if the government could establish an enabling agreement under which Hong Kong companies could invest in renewable energy projects in Mainland China, with power wheeled to Hong Kong at fairly determined cost-plus rates. Public consultation and transparent governance will be important to ensure public confidence in this arrangement.
- **Source more nuclear energy from the region.** The Daya Bay nuclear power plant has supplied Hong Kong with around one-quarter of its electricity, with high reliability, good environmental performance during operation, affordable cost and safe operation for over 25 years. Hong Kong should explore the possibility of investing in a new plant and increasing nuclear energy imports.
- **Generate power from zero- or near-zero-carbon hydrogen** (See Glossary for sources of near zero carbon electricity). The government should consider the feasibility of gas-fired electricity generation running on either natural gas or hydrogen or a blend once generation units that can switch between the two fuels become available.
- **Fit natural gas–fired plants with carbon capture and storage (CCS).** Natural gas plants emit far less carbon than coal-fired plants. However, without the use of CCS, Hong Kong cannot keep natural gas plants and achieve net zero emissions by mid-century. We therefore recommend that Hong Kong position itself so it can be a 'fast follower' implementing CCS after it has been proved commercially elsewhere. Our model-ling assumes this will be in the mid-2030s.
- **Improve electricity storage.** Hong Kong could commission research on storage options and their applicability to Hong Kong. It should consider hybrid systems of renewable energy with storage as part of a broader energy strategy.
- **Improve the demand response.** Options include introducing a premium tariff for guaranteed power at all times and a discount tariff for accounts where the electricity supply can be restricted. Peak-load pricing for electricity could be higher than at times of low load.

Hong Kong's electricity consumption was 157,977 terajoules (Tj) in 2017 and accounted for just over half of total energy consumption. With growing numbers of new buildings, electrification of appliances in buildings and more use of electric vehicles in the future, total electricity consumption and its share of total energy consumption will continue to increase. Decarbonisation of electricity should be the highest priority policy area for Hong Kong.

Other than the 27 per cent of nuclear electricity imported from Mainland China, Hong Kong's electricity supply depends mainly on coal and natural gas. Natural gas has assumed more importance in recent years; it accounted for 28 per cent of Hong Kong's total electricity generation in 2017 (CLP 2019; HKE 2018).

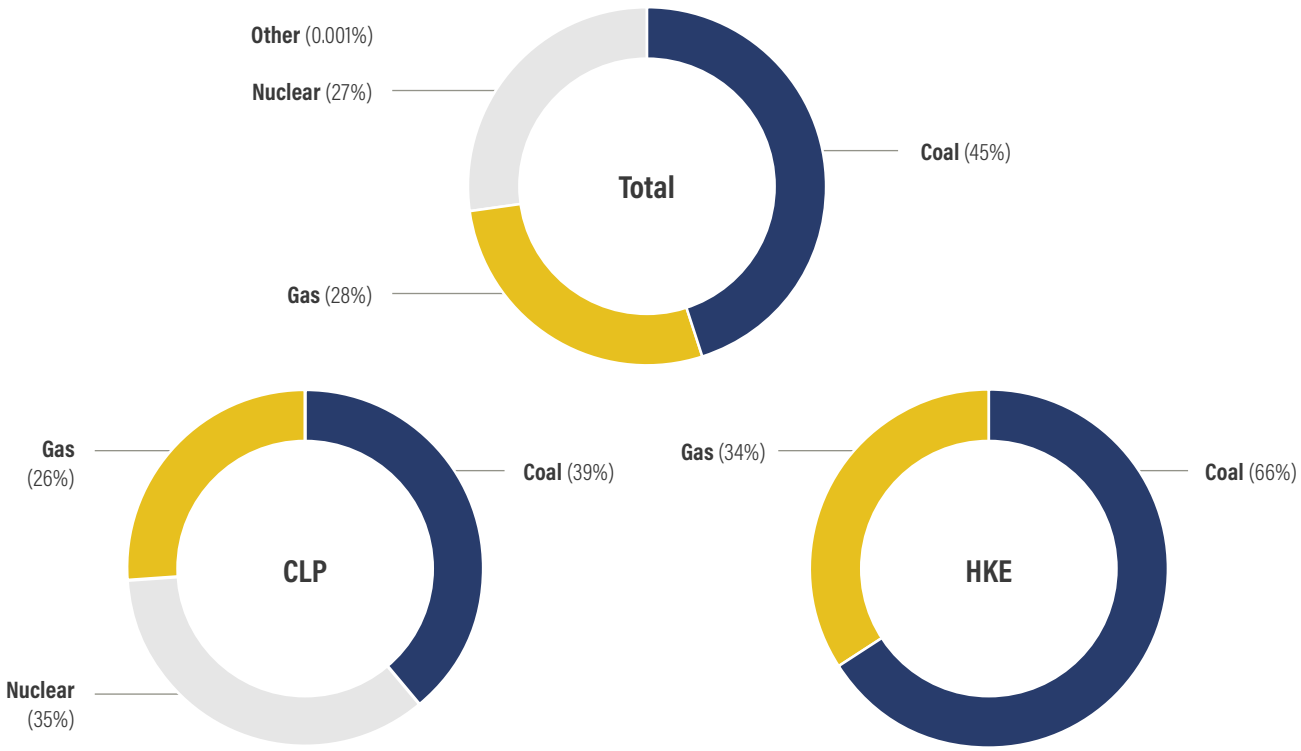
Figure 3-1 shows the sources of electricity generation for Hong Kong and the shares supplied by its two power companies. According to Hong Kong's Climate Action Plan 2030+, the trend towards gas will continue, with natural gas expected to fuel 50 per cent of electricity generation by the end of 2020. Hong Kong's two major power companies—China Light & Power (CLP) and Hong Kong Electric (HKE)—report that Hong Kong is on track to meet this target. However, replacing coal with gas will reduce emissions by only about 50 per cent (US EPA 2018).

There will be significant costs to decarbonising electricity generation. In February 2020, CLP's fuel generation costs per unit of electricity were around HK$0.70 per kilowatt hour (kWh) for gas, compared with around HK$0.25 for coal.

Any proposed policy affecting Hong Kong's electricity supply must balance the following four objectives:

- **Environmental performance:** Hong Kong should reduce the impacts of its power sector on both climate change and local air quality.

Figure 3-1 | **Electricity generation in Hong Kong, by fuel type, 2017**



Source: CLP 2019; HKE 2018.

- **Reliability:** Currently, Hong Kong experiences only about 5 minutes of power outage per year (99.999 per cent reliability) (CLP n.d.). It is most important that reliability remains high given Hong Kong is a high-rise city with finance and logistics services which run continuously. There are concerns that maintaining this reliability will be difficult if a high per centage of Hong Kong's electricity is imported.
- **Affordability:** Hong Kong currently has one of the cheapest electricity tariffs in the world.[3] Prices could be raised on affluent consumers, although CLP's residential tariff is already more than twice as high for large power users than for users with lower consumption levels. Any measure should take into account equity effects and how to avoid burdening less affluent customers.
- **Security and availability:** Hong Kong should avoid dependence on a single fuel type and/or source, in order to ensure energy security and maintain bargaining power over purchase price and terms. However, based on current technology, local renewable energy potential is relatively limited. It is important to have a flexible plan to cope with uncertainty.

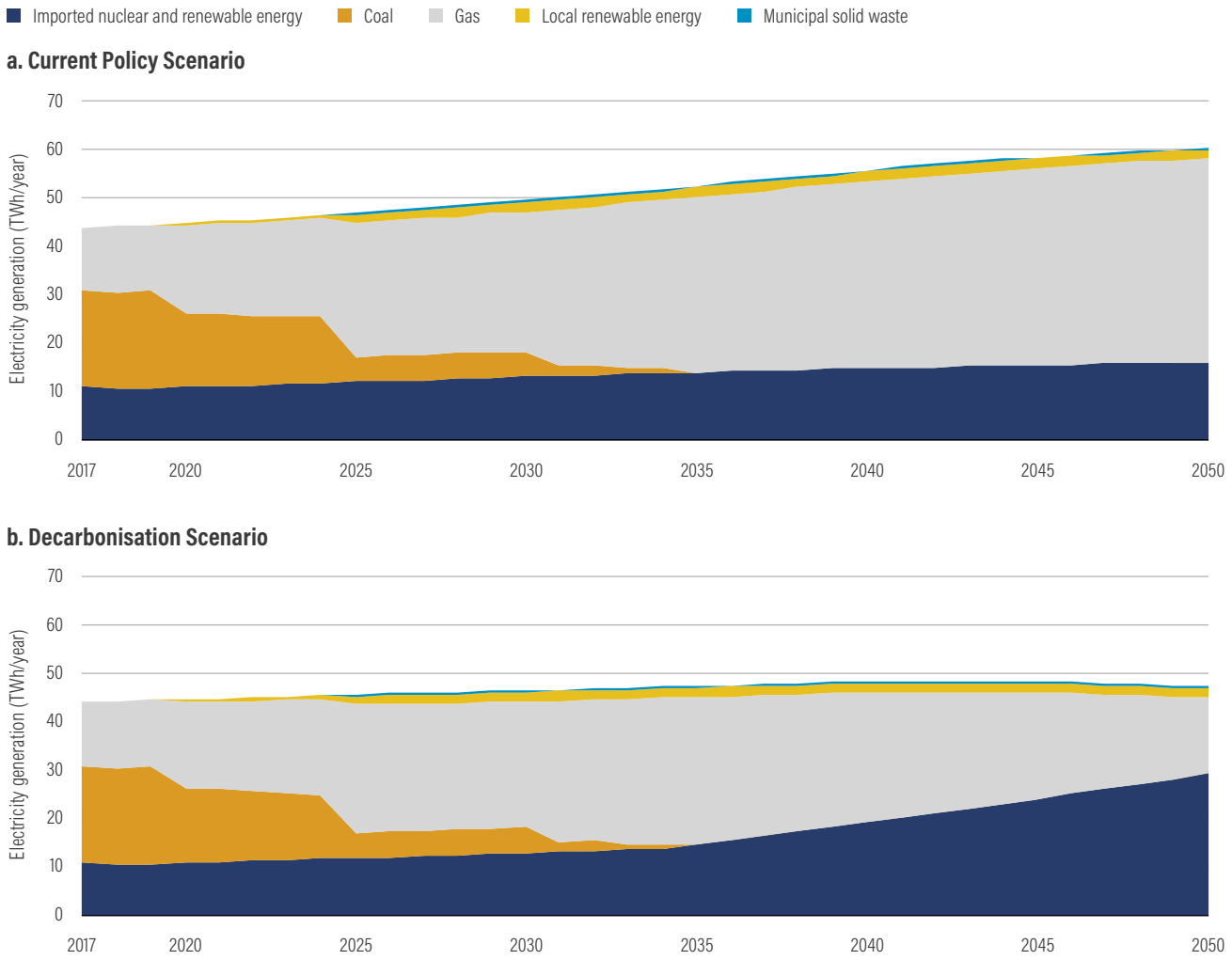
Each objective must be considered and potential trade-offs taken into account.

Average annual growth in electricity consumption under the Current Policy Scenario is projected to be 1 per cent, leading to electricity demand in 2050 of 60.5 TWh, equivalent to per capita electricity demand of 7,419 KWh. This increase is driven by population and GDP growth, a switch from gas, petrol and diesel and limited energy efficiency improvement. Without policy interventions, Hong Kong will continue to import around 25 per cent of its electricity from nuclear plants in Mainland China (provided the Daya Bay station's life can be extended), coal power will be gradually phased out by 2038, and natural gas generation will become by far the biggest source of emissions. Only 3.7 per cent of electricity will come from renewable energy including municipal solid waste (Figure 3-2, panel a).

Under the Decarbonisation Scenario, average annual growth in electricity consumption is projected to reduce to 0.3 per cent, total electricity demand in 2050 reduces to 48 TWh, and per capita electricity demand to 5,918 kWh. The reductions will be driven by energy-efficiency improvements in buildings, mobility and industry but partly offset by more fossil fuel vehicles switching to electric vehicles, increasing demand for electricity. Imported electricity will increase from 25 per cent of total supply in 2017 to 60 per cent in 2050, including 25 per cent nuclear and 35 per cent renewable energy. Only 35 per cent of electricity demand will be satisfied by domestic natural gas with CCS. The remaining demand will be supplied by 4 per cent local renewable energy and 0.7 per cent municipal solid waste (Figure 3-2, panel b).

Replacing coal with gas in the power sector is the most important measure Hong Kong can take immediately to deal with climate change. CLP and HKE expect to meet the target of generating 50 per cent of electricity from natural gas in 2020. However, if Hong Kong is to achieve net zero emissions from its power sector, it will need to increase its use of renewable energy, nuclear

Figure 3-2 | **Projected electricity generation in Hong Kong under the Current Policy Scenario and the Decarbonisation Scenario, 2017–50**



Source: Hong Kong Energy Policy Simulator (EPS) (https://hongkong.energypolicy.solutions/).

power and natural gas with CCS and/or hydrogen. Further decarbonisation of Hong Kong's electricity supply can be achieved by choosing one or more of the following strategies.

Expand Renewable Energy on a Large Scale

Renewable energy in the form of wind and solar has the great benefit of generating no local air pollution or greenhouse gas emissions. For supply from Mainland China where land supply and wind/solar resources are better than Hong Kong the levelised cost of electricity (LCOE)[4] costs are project to fall below the fuel cost of HK$0.70/kWh of gas-fired generation and may compete with the HK$0.29 to 0.37/kWh LCOE estimated for nuclear plants built in China between 2015 and 2002 (World Nuclear Association 2020). The intermittency of supply from wind and solar energy will, however, need to by catered for by storage or demand management and this may raise their costs. However, the technological costs for renewable energy sources and storage are falling quickly. Renewable energy sources with storage can become price-competitive with certain combinations of natural gas and storage prices.

Engage in Holistic Planning and Provide Incentives to Develop Local Renewable Energy

Electricity generated from local renewable energy sources accounted for less than 0.01 per cent of Hong Kong's local generation in 2017 (HKE 2018). According to the government's Climate Action 2030+ plan, the potential for renewable energy within Hong Kong territory is limited to about 3–4 per cent of total energy demand. Some studies estimate that the potential could be as high as 10 per cent (WWF 2019). The government should publish detailed assessments on local renewable energy including notes of potential, which is currently ruled out but might become available given technological advances or regulatory changes. It should also produce an annual progress report giving generation in the last year and planned investments.

Incentivising local renewable energy could help establish a local renewables industry that creates and spurs economic development. Hong Kong has already implemented some supportive measures, such as feed-in-tariffs, renewable energy certificates, appropriate adjustments to building-related regulations, tax incentives on the procurement of renewable energy power systems and enhancement of public awareness of renewable energy technologies. It has also introduced Solar Harvest to support schools and welfare nongovernmental organisations (NGOs).[5]

Hong Kong could consider other incentives, including the following:

- encouraging solar development, including by promoting rooftop solar PV; providing low-cost financing for solar projects; eliminating regulations that make it harder for businesses to adopt solar PV (e.g., counting solar PV as extra building floor space); and providing solar maps to provide information to potential customers.
- building wind farms on outlying islands and offshore wind farms.
- adding waste-to-energy facilities.
- promoting local capacity-building that will

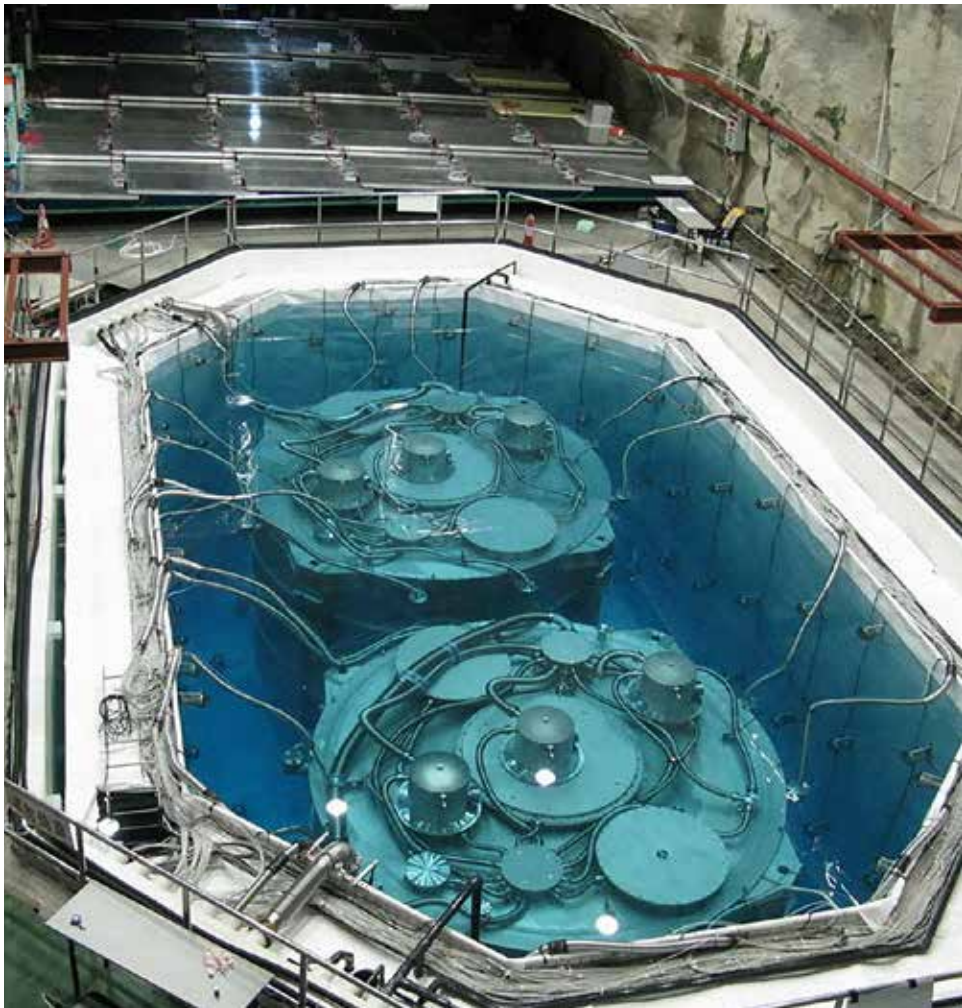
lead to jobs at energy service companies (ESCOs).

Invest in Regional Renewable Energy Projects

Introducing renewable energy projects in Mainland China appears to be an achievable solution. Although direct purchasing of renewable energy may be difficult, because of competition from demand from Mainland China, consumers, the government and local electricity companies should explore opportunities for energy collaboration with Mainland China. Particularly in southern China, Hong Kong could play the role of an investor in utility projects. Joint venture investment in renewable energy generation projects could allow Hong Kong to access low-carbon electricity from renewable sources in Mainland China. Local electricity companies could participate in designing, building, operating and managing the facilities with other investors, ensuring reliability and quality of supply. They should start small to build relationships, public trust and collective governance and then ramp up aggressively. In addition, the Hong Kong government should (a) play a more active rôle to facilitate discussions between local electricity companies and city governments in Southern China and (b) ensure that the discussion process is transparent, offers public consultation and balances the interests of various parties.

Explore Sourcing More Nuclear Energy Regionally

The Daya Bay nuclear power plant has supplied Hong Kong with roughly 25 per cent of its electricity in a safe, clean, low-cost, reliable manner for over 25 years. Hong Kong should explore the possibility of increasing nuclear energy imports from Mainland China while maintaining current cooperation (CLP owns a 25 per cent share of the Daya Bay nuclear power station and has an agreement to purchase 70 per cent of the electricity it generates up till 2034. After that continue power from Daya



Bay will depend on a technical and commercial negotiation).

The government's 2010 public consultation proposed doubling the share of electricity sourced from nuclear power, from 25 per cent to 50 per cent. Discussion of this proposal understandably stopped after the Fukushima accident. However, after carrying out a detailed nuclear safety assessment, Mainland China is building a substantial number of nuclear power stations. Some are being built in Guangdong Province; CLP has a minority share in one of them. Such ownership provides additional transparency and some confidence in the governance of these power stations.

There is no firm, publicly announced nuclear power development plan in Guangdong for supplying Hong Kong in the next decade. Hong Kong should immediately commission a study to assess the case for increasing the share of nuclear energy imported from Mainland China into its energy mix.

Generate Power from Zero- or Near-Zero Carbon Hydrogen

Interest in hydrogen increased in 2019, with China, Japan, Australia, the United Kingdom and other countries looking at it more closely. Whether hydrogen might be part of Hong Kong's future electricity generation mix depends on three things: the availability of near-zero carbon hydrogen; the extent to which hydrogen might be generated when there is surplus electricity from nuclear plus renewable energy and stored for firing gas peaking-plants when there is a shortage; the availability of combined cycle gas turbines which can burn either natural gas or a mix of natural gas and hydrogen.

Use Natural Gas with Carbon Capture and Storage

Keeping gas-fired generation in Hong Kong has the following advantages: (a) The amount of electricity generated by gas-fired plants can be rapidly adjusted to balance supply and demand for electricity. (b) Keeping some generation capacity in Hong Kong helps meet reliability and the security/availability of supply objectives. (c) Security of supply is further enhanced by keeping gas-fired generation in addition to nuclear and renewable energy.

Natural-Gas-fired plants venting to atmosphere, however, produce about 0.4 kgCO_2/KWh which is incompatible with reaching net-zero emissions by 2050. These, therefore, need to be fitted with CCS to reach near-zero emissions.

Issues which must be resolved before Hong Kong commits to gas with CCS include: (a) Availability of geological storage: Guangdong Province has identified substantial saline aquifers about 100km offshore from Hong Kong but there would need to be an agreement with Mainland China for Hong Kong to use this storage; and, (b) Confirmation from large-scale pilots that CCS has a sufficiently high CO_2 capture rate at a reliability and acceptable total cost. This total cost includes the cost of capturing the CO_2, transporting it to long-term geological storage and monitoring that storage.

Given both these issues and the long-term value of having gas-fired generation with CCS, we recommend the Government position Hong Kong to be a "fast follower" in implementing CCS once the technology has been developed elsewhere. This requires four actions: (a) Requiring CLP and HKE to ensure any future gas-fired units are 'CCS ready'. That is, that they can have CCS added to them at a later date. (b) Seeking to join Guangdong Province's studies of offshore storage of CO_2. (c) Maintaining an active watching brief on the development of CCS technology and (d) Developing a policy to fund the cost of CCS.

Store Electricity

In order to realize the full potential of zero-carbon emission sources, including renewable energy and nuclear power, where supply cannot be adjusted, Hong Kong should develop electricity storage capacity. Storage helps bridge the periods when electricity from wind or solar is not available; it acts as a security buffer during short-term interruptions in supply from the Mainland.

Two options are available. The first is lithium-ion batteries, which are becoming more cost-competitive with other energy sources (GTM 2019). Some experts suggest that widespread use of electric vehicles, together with their relatively

low utilisation in Hong Kong, make them an economical source of storage. Other experts express concern that the extra charge/discharge cycles needed for grid balancing will shorten the life of these batteries and raise overall cost.

The second option is new technologies that may provide large-scale, cost-competitive storage in the future. They include vanadium flow redox batteries, which are already cost-competitive with lithium-ion batteries; compressed air; and generation of hydrogen by electrolysis when there is surplus electricity, as a long-term solution in the future.[6]

The government should commission research on storage options and their applicability for Hong Kong and adopt a holistic planning approach to hybrid systems of renewable energy with storage. CLP already runs a pumped storage facility in Shenzhen; more such facilities will presumably be needed. Hong Kong should also monitor technology for improving storage.

Optimize the Demand Response

Energy system emissions can be reduced by optimizing consumer behaviour through demand response. Doing so is particularly helpful in attenuating the fluctuations of renewable energy supply. It represents a clear win on all four of the objectives listed at the beginning of this section.

Demand response provides an opportunity for consumers to play a significant rôle in the operation of the electric grid by reducing or shifting their electricity usage during peak periods in response to time-based rates or other forms of financial incentives. [7] CLP has started a pilot project on demand response (CLP 2017; *South China Morning Post* 2017). The utilities should be required to follow up on such pilot projects and study (a) the best way to combine demand response with variable renewable energy and grid storage for the grid of the future and (b) the cost of implementing such systems.

Options include the following:

- Introducing a premium tariff for guaranteed power at all times and a discount tariff for accounts where the electricity utility can restrict consumer use (by, for example, turning off air conditioners when supply cannot meet total demand). These kinds of programs tend to turn off the cooling function of the air conditioning but leave the fan running; they commit to consumers that restrictions will last for no more than a certain time (e.g., 15 minutes). Consumers do not even notice the service restriction, but that it provides enough demand response to even out the loads for the electricity providers.
- Applying peak-load pricing for electricity.
- Allowing consumers to opt in to programs that shift loads to lower-demand times of day. Such a program could be centrally managed by the electricity provider.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A FIRE RISK

REDUCING THE USE OF PIPED GAS AND NON-TRANSPORT-RELATED LIQUIFIED PETROLEUM GAS

In 2017, Hong Kong's distributed gas and non-transport liquified petroleum gas (LPG) sector accounted for 12 per cent of Hong Kong's total end-use energy and 6 per cent of the city's total carbon emissions (2.2 $MtCO_2e$). Emissions from end-use energy supplied by town gas can be avoided by electrification or the use of hydrogen.[8] The only replacement option for LPG is likely to be electrification.

Summary of Policy Recommendations

This study recommends two options:

- Replacing town gas with zero-carbon electricity: As hydrogen may not be a near-term solution, the Decarbonisation Scenario in this report assumes that town gas is replaced by electrification. The model shows that Hong Kong's town gas and LPG consumption could be reduced by 82 per cent compared with 2017 levels if the government sourced sufficient zero-carbon electricity, industries converted industrial applications of town gas to electricity, and residents changed their cooking appliances and habits to use electricity instead of town gas.
- Replacing town gas with zero- or near-zero-carbon hydrogen: To keep the hydrogen option open, Hong Kong should develop a centre of expertise on the production, transport, storage and use of hydrogen. The main purpose of this centre would be to liaise with Mainland China and monitor other countries that lead research, development and deployment of hydrogen technology—in particular, Japan, South Korea and the United Kingdom—as well as carry out modest research activity.

Use of zero-carbon electricity or hydrogen would reduce Hong Kong's total carbon emissions by 6 per cent (Table 4-1). Further study is required to determine which of the following two options is better.

Replace Town Gas and Non-Transport Liquified Petroleum Gas with Zero-Carbon Electricity

The Taipo plant of the Hong Kong & China Gas Company Ltd. (HKCG) uses steam reforming of natural gas and naphtha to produce town gas. [9] HKCG has a target to reduce carbon intensity by 30 per cent from 2005 levels by 2020, mainly by shifting from a 100 per cent naphtha fuel supply to mainly natural gas plus 5 per cent from landfill gas. An important advantage of naphtha is that a 30-day supply can be stored in Taipo tanks, reducing the risk of supply being interrupted if natural gas from Shenzhen is unavailable.

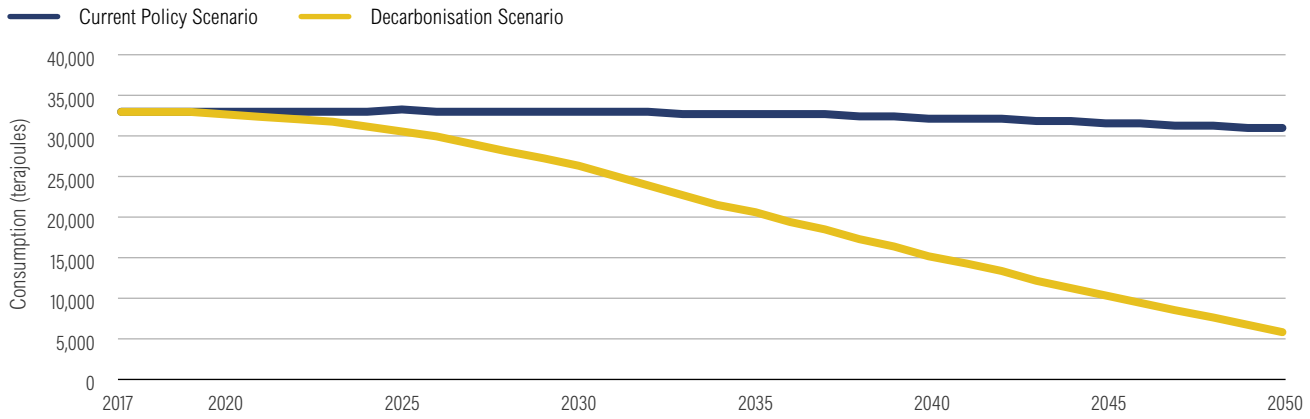
Based on 2017 data, electricity output would need to increase by 22 per cent to replace all town gas and non-transport LPG. This increase is substantial but could be achieved well before 2050 if the switch occurs soon. The model shows that town gas and LPG consumption could be reduced by 82 per cent compared with 2017 levels

Table 4-1 | **Use of piped gas and liquified petroleum gas in Hong Kong and associated emissions, 2017**

ITEM	END-USE ENERGY USED (TERAJOULES)					EMISSIONS ($ktCO_2e$)	
	TOTAL	RESIDENTIAL	COMMERCIAL	INDUSTRIAL	TRANSPORT	TOTAL	EXCLUDING TRANSPORT
Usage							
Town gas	29,049	15,598	12,433	1,017	0	1,901	1,901
LPG	18,858	2,127	2,897	420	13,414	1,207	349
Town gas and LPG	47,907	17,726	15,330	1,437	13,414	3,108	2,249
Total end-use energy	286,270	59,992	125,158	12,705	88,414	40,700	33470
Share of emissions (percentage)							
Town gas	10	26	10	8	0	5	5
LPG	7	4	2	3	15	3	1
Town gas and LPG	17	30	12	11	15	8	6

Source: EMSD 2019; HKCG 2018.

Figure 4-1 | **Projected consumption of liquified petroleum gas and town gas in Hong Kong under the Current Policy Scenario and the Decarbonisation Scenario, 2017–50**



Source: Hong Kong Energy Policy Simulator (EPS) (https://hongkong.energypolicy.solutions/).

(Figure 4-1) if the following issues are overcome:

- Sufficient near-zero carbon electricity sources are used (see section 3 for a discussion of how this might be achieved).
- Chinese cooking preferences adapt. Many Chinese cooks consider gas to be superior to electricity, especially in residential kitchens. This preference persists despite the availability of electric induction woks that can meet cooking requirements and are more efficient than gas. Induction also produces less heat in kitchens, improving working conditions and reducing the energy required for air conditioning. Electricity currently accounts for 27 per cent of energy consumption for cooking in residential buildings and 59 per cent in commercial buildings (EMSD 2019).
- Further research is needed on the difficulties of converting industrial applications of town gas to electricity. Any such applications would, however, be small and can probably be switched to near-zero carbon hydrogen.

Replace Town Gas with Zero- or Near-Zero Carbon Hydrogen

Both blue hydrogen and green hydrogen can be considered zero-carbon hydrogen (van Hulst 2019). However hydrogen is produced, it can be (a) manufactured in Hong Kong; (b) imported by ship in liquefied form, imported as ammonia (which is easier to ship) and then converted to hydrogen; or (c) piped in from a production facility in Mainland China.

There are strong reasons for Hong Kong to use zero-carbon or near-zero-carbon hydrogen to replace town gas:

- Use of hydrogen helps balance electricity supply and demand.
- Hong Kong is likely to suffer the loss of port and other economic activity if shipping switches to hydrogen or ammonia but it is unable to provide these fuels.
- Hydrogen is a better option than electricity for decarbonising heavy-duty vehicles.
- Using hydrogen for road transport would reduce air pollution.

Opportunities for Hong Kong to use hydrogen include the following:

- Town gas could be replaced by a mixture of hydrogen and an inert gas. When HKCG moved from burning coal to steam-reforming naphtha and natural gas to produce town gas, it chose to keep a 50 per cent hydrogen and 30 per cent methane mix. This mix makes the existing distribution system suiTable for using a higher per centage of hydrogen and an inert gas or pure hydrogen to produce near-zero-carbon end-use emissions. The United Kingdom and other countries are exploring both blended and pure hydrogen options (IEA 2019).

- Road transport, especially heavy-duty vehicles, can be powered by hydrogen fuel cells that produce electricity to power electric motors. The June 2019 report by the International Energy Agency (IEA) *The Future of Hydrogen* notes that about 11,000 cars, 25,000 forklifts and 1,000 heavy-duty vehicles in China are using this technology and that several thousand more heavy-duty hydrogen-powered vehicles are expected by the end of 2020.
- The IEA notes that international shipping may be fuelled by hydrogen or ammonia (which can be manufactured from hydrogen), which is in line with projections by the International Maritime Organization (IMO).[10] If Hong Kong is to continue to provide fuel for shipping, it will need to switch from fuel oil to hydrogen or ammonia. The amounts involved are substantial. In 2016, Hong Kong used 6,656 megalitres (Ml) of fuel oil (Census and Statistics Department 2017a) and 3,053 Ml of diesel, for a total energy value of 392,500 Tj to fuel international shipping. These Figures are not included in Hong Kong's report on its territorial carbon emissions, but the energy consumed as shipping fuel is six times that of town gas and LPG use combined.
- As Hong Kong moves towards net zero emissions, it is likely to include a high proportion of nuclear and variable renewable energy (VRE) in its electricity generation mix. Surpluses of electricity from nuclear and VRE can be used to manufacture hydrogen by electrolysis.

Hydrogen does not occur naturally in large quantities; it should be viewed as an energy carrier, like electricity, rather than an energy source. It is more difficult to handle than electricity, but it can be stored. The challenge is to produce hydrogen in a near-zero-carbon manner and to store it. The two main options for producing near-zero-carbon hydrogen are steam reforming natural gas (blue hydrogen) and electrolysis (green hydrogen).

A number of factors affect the cost of hydrogen:

- **Capacity of electricity production:** One scenario is to build sufficient nuclear and VRE

capacity to meet demand most of the time. This combination of nuclear and renewable energy would, at times, create periods when supply exceeds demand, providing "free" electricity for use in electrolysis.

- **Modification of existing gas production facilities in Hong Kong:** Modifications to enable steam reforming to manufacture hydrogen must consider technical feasibility and safety, as well as the cost of CCS. A unit for steam-reforming methane could be added to Hong Kong's floating liquified natural gas (LNG) terminal (currently under construction), with CCS and geological storage in Mainland waters under the South China Sea.
- **Development of coastal industrial clusters:** Coastal industrial clusters, including areas in southeast China near Hong Kong, offer a major opportunity for ramping up the deployment of low-carbon hydrogen (IEA 2019).
- **Importing of liquid hydrogen:** Japan, Korea and China are all evaluating options for importing liquid hydrogen from countries such as Australia, which manufactures the product using VRE electrolysis powered by abundant solar energy (IEA 2019).

A key question is whether Hong Kong has access to suiTable geological areas for large-scale hydrogen storage, such as salt caverns, depleted oil fields or aquifers. Academics based in Guangzhou have confirmed that storage exists in Mainland waters, about 100 kilometres off Hong Kong's shore. Accessing this storage will require agreement with Mainland authorities. For long-distance transport and longer-term storage, it might be more cost-effective to convert hydrogen to ammonia or combine it with liquid organic hydrogen carriers (IEA 2019).

As part of keeping the hydrogen option open, Hong Kong should develop a centre of expertise on the production, transport, storage and use of hydrogen. The main purpose of this centre would be to liaise with Mainland China and monitor other countries that lead research, development and deployment of hydrogen technology—in particular, Japan, South Korea and the United Kingdom—as well as to carry out modest research activity.

MAKING BUILDINGS MORE ENERGY EFFICIENT

The high-rise, high-density built environment of Hong Kong is unique. Activities in buildings account for more than 90 per cent of electricity consumption and 60 per cent of GHG emissions in Hong Kong, equivalent to 27 $MtCO_2e$ in 2017 (not including embedded emissions from the production of iron, steel and other materials used to construct them), according to the Hong Kong Energy Policy Simulator. Reducing energy consumption in buildings is therefore crucial, especially in the short and medium term, before the electricity supply is fully decarbonised.

Summary of policy recommendation

Four policies could help make buildings more energy efficient:

- **Set targets, track performance/benchmark and improve transparency.** The scenario analysis suggests that energy consumption from buildings could be reduced by 20 per cent in 2050 compared with 2017 levels. In addition to overall energy targets, the government could:
  - Expand its current energy-saving target coverage to include other public buildings, such as schools and hospitals.
  - Establish a performance-tracking/benchmarking mechanism that enables annual evaluation and disclosure of performance. Any new tracking and disclosure initiative could benefit from experience gained with the existing Benchmarking and Energy Saving Tool (HK BEST),[11] the Electrical and Mechanical Services Department (EMSD)'s online benchmarking tool[12] and other global best practices. Adoption of tracking and disclosure systems could be made a prerequisite for obtaining gross floor area (GFA) concessions for new buildings[13].
- **Tighten regulations.** The government could progressively tighten requirements and standards in the building energy code, the mandatory energy-efficiency labelling scheme, the Overall Thermal Transfer Value (OTTV) and the Residential Thermal Transfer Value (RTTV). It could promote the Hong Kong Green Building Council (HKGBC) Energy Saving Scheme (BESTOO)[14] and gradually tighten its requirements. It could reform the process for granting GFA concessions to ensure actions that improve buildings' energy efficiency.
- **Improve energy auditing and increase retrofitting.** The current requirement for energy audits every 10 years should be tightened to every 5 years, and building owners should be required to implement energy-efficiency audit recommendations that are justified on cost-benefit grounds. The government could provide training to enable the industry to be better prepared for energy audits. The government could require more retrofitting of inefficient buildings by gradually expanding coverage of building types through mandates or target setting and including public buildings, commercial buildings and energy systems. The government and industry should provide more training to facilitate this work.
- **Improve demand management and user behaviour.** Hong Kong's Energy Charter should be expanded to influence more target business groups, require more precise energy accounting and information disclosure from

the power companies, and promote the use of smart technology in households.[15]

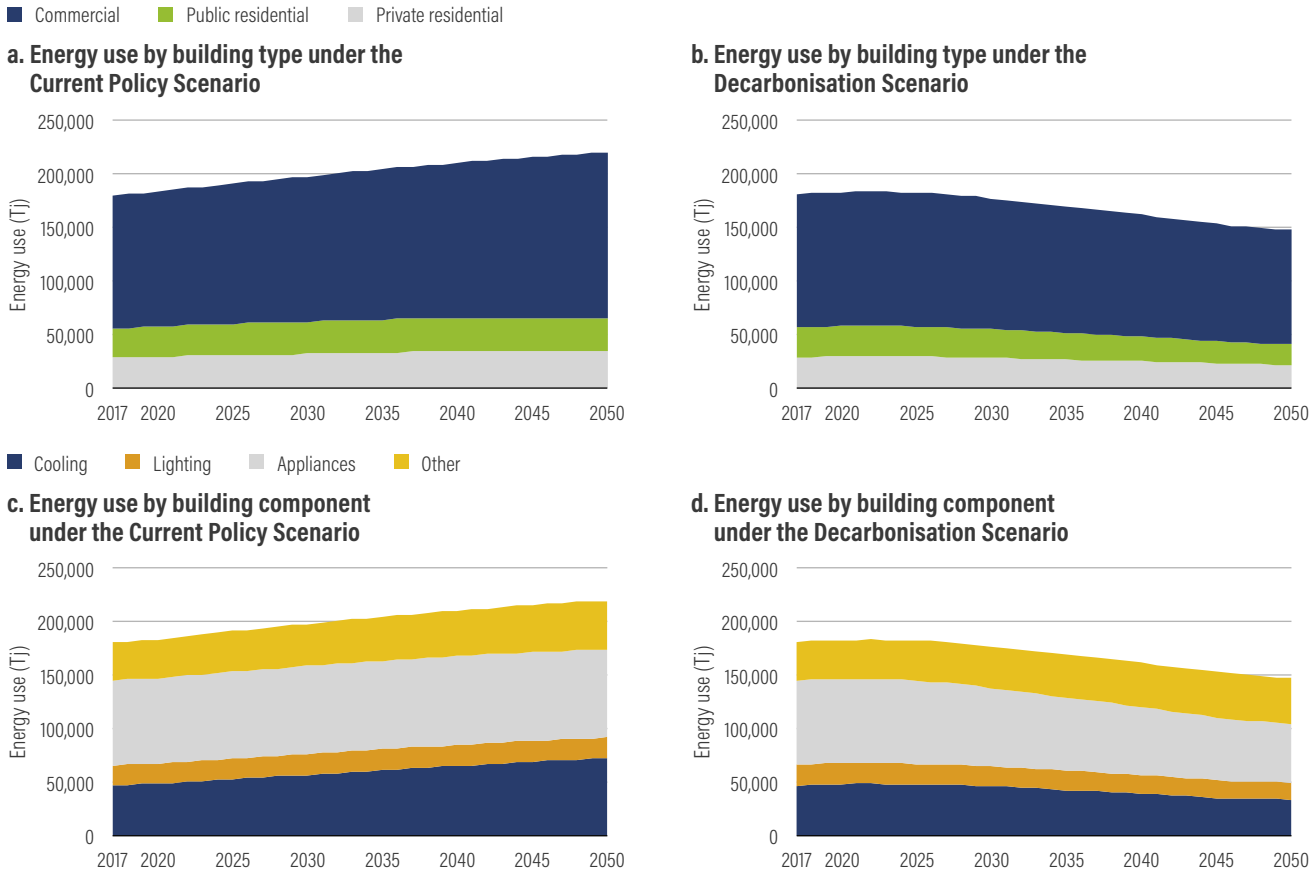
Reducing carbon emissions from energy use in buildings is achieved by improving energy efficiency and decarbonising the energy used. Section 3 covers decarbonisation of electricity generation; section 4 covers piped gas. As noted in section 4, one option is to replace piped gas with low-carbon electricity. This section focuses on improving the energy efficiency of building energy systems and equipment.

Total energy consumption in Hong Kong's building sector was 179,350 Tj in 2017. Under the Current Policy Scenario, total energy consumption will increase by 21 per cent by 2050, driven by a 13 per cent increase in per capita energy consumption and an 8 per cent increase in population. Commercial buildings contribute 80 per cent of this increase.

Under the Decarbonisation Scenario, total building energy consumption will be reduced by around 20 per cent in 2050 relative to 2017 levels, enabled by a 25 per cent decrease in per capita energy consumption, which will be partially offset by the 8 per cent increase in population. Among building types, commercial buildings contribute 52 per cent of this reduction. Among building components, cooling contributes 39 per cent of the reduction (Figure 5-1).

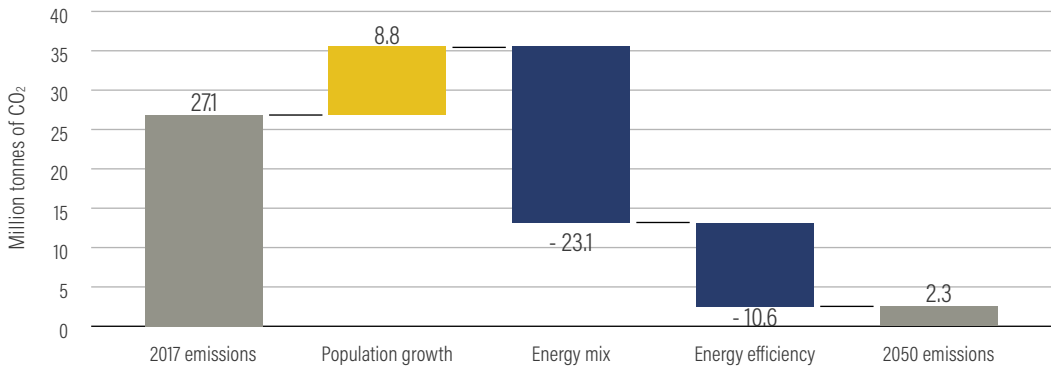
The model also suggests that CO_2 emissions from buildings can fall from 27 Mt in 2017 to 2.3 Mt in 2050, a reduction of 90 per cent (Figure 5-2). Energy efficiency in buildings will account for 10.6 Mt of emissions reduction; replacing town gas with electricity and decarbonising electricity will reduce emissions by 23.1 Mt. This section focuses on how to realise the emissions reduction potential of energy efficiency.

Figure 5-1 | **Use of energy under the Current Policy Scenario and the Decarbonisation Scenario, by building type and component, 2017–50**



Source: Hong Kong Energy Policy Simulator (EPS) (https://hongkong.energypolicy.solutions/).

Figure 5-2 | **Factors contributing to the decline in building-related CO_2 emissions, 2017–50**



Source: Hong Kong Energy Policy Simulator (EPS) (https://hongkong.energypolicy.solutions/).

Set Targets, Track Performance/ Benchmark and Improve Transparency

The government announced the first energy-saving target for government buildings in 2003. It regularly publishes improvements in energy efficiency in the Environmental Affairs Panel of the Legislative Council. In Hong Kong's 2019 policy address, the Chief Executive announced a 6 per cent green energy target for improving energy efficiency in government buildings. Hong Kong has no mandatory energy-saving target for the building sector as a whole or for privately owned buildings, however. The HKGBC proposed a voluntary reduction target, called 3030+, for all buildings, which aims to reduce electricity consumption by 30 per cent by 2030, relative to the 2005 level. The scenario analysis suggests that energy consumption in buildings can be reduced by 20 per cent in 2050, relative 2017 levels.

In addition to the overall targets, the government could expand the existing energy-saving target to more public buildings, including schools and hospitals. It could, for example, consider enhancing the Green Schools 2.0 initiatives by incorporating a green energy target.[16] It could also establish a performance-tracking and benchmarking mechanism that requires annual evaluation and disclosure of performance, which could be built on the existing Benchmarking and Energy Saving Tool (HK BEST), the Electrical and Mechanical Services Department's online benchmarking tool and global best practice.

Owners of commercial buildings have been encouraged to join voluntary schemes to set targets. The Science-Based Targets (SBT) initiative is an example.[17] A few organizations, such as the Swire Group (a diversified conglomerate based in Hong Kong and London), have set their own energy-saving and emission-reduction targets. Energy performance targets through programs like Better Buildings in the United States can encourage building owners to reduce energy consumption in their buildings by 20 per cent in 10 years.[18]

These voluntary schemes have not delivered the required overall result in Hong Kong. This report therefore recommends the phased introduction of compulsory, annual post-certification energy-efficiency reporting to improve disclosure and increase transparency. Initially, developers can be incentivised to adopt the scheme by making it a prerequisite for obtaining GFA concessions for new buildings. Once established, the scheme can be made compulsory in stages, starting with the largest buildings and the central business district.

Tighten Policies and Regulations

Progressively tighten building energy codes

The building energy code can have substantial impacts on energy consumption. Hong Kong's Building Energy Code (BEC) is reviewed every three years, and its Mandatory Energy Efficiency Labelling Scheme (MEELS) is reviewed every five years. The Overall Thermal Transfer Value (OTTV) and the Residential Thermal Transfer Value (RTTV) elements are reviewed every five years for commercial buildings and hotels, and residential buildings and residential recreational facilities will be reviewed in

2020 and 2030 (Environment Bureau 2017).

This report recommends a progressive tightening of requirements of these standards, based on cost-benefit analysis. The scenario analysis suggests that energy efficiency in buildings can be improved by 40 per cent for cooling, 30 per cent for the building envelope, 35 per cent for lighting, 25 per cent for appliances and 11 per cent for other components by 2050.

Promote a scheme that provides transparent annual reporting of energy-efficiency performance in large commercial buildings

Commercial buildings account for 70 per cent of electricity use in Hong Kong's buildings (EMSD 2019). Increasing their efficiency is therefore crucial. Based on studies and experience elsewhere in the world, the most effective way is to introduce and incentivise a measure that makes building energy efficiency public (WBCSD n.d.; HKGBC 2014)

When deciding which system to use in Hong Kong, decision-makers should consider Hong Kong's Benchmarking and Energy Saving Tool–Office Occupants (HK BESTOO), the Electrical and Mechanical Services Department's online benchmarking tool and global best practice. BESTOO promotes energy efficiency in multi-tenant office buildings by providing independent and professional recognition to office premises that achieve an outstanding level of energy efficiency relative to their counterparts. Qualifying buildings receive an Energy Performance Certificate and Label, which is categorised into five ratings based on the level of energy efficiency achieved.[19] This program could be improved in the following ways:

- Each certificate should be valid for one year, after which it must be renewed.
- After a phase-in period, the ratings for large buildings should be published on a public website. Doing so should help building owners rent to increasingly climate-conscious tenants, who might be willing to pay a premium to work in such buildings.
- The certificates should be progressively expanded to cover all large commercial buildings. An initial step would be to require participation in BESTOO as a prerequisite for new buildings being granted a GFA concession. Legislation would probably be needed to expand coverage.
- Strong governance needs to be demonstrated to counter lobbying by vested interests.
- Tax incentives could be offered for building owners/managers who achieve certain certification levels. Incentives could be introduced once there is sufficient coverage and public trust in the scheme's ratings.
- Performance evaluations should be conducted to check whether the tax incentives are effective and offer value for the money.

Reform the gross floor area concession for green features

Certification by BEAM Plus has been one of the prerequisites for granting GFA concessions for certain green and amenity features in new building projects since 2011. The results are published on the Government Buildings Department website. There is, however, no requirement that a building meet even the lowest (bronze) level of certification, and a significant number of the buildings gaining GFA concession are rated as "unclassified".

This report recommends tightening GFA concession requirements by setting a minimum BEAM Plus rating and adding two pre-requisites: (a) Providing a Life Cycle Analysis for the building before its occupation permit is issued; and, (b) Committing to join an annual energy efficiency reporting programme if one is established in Hong Kong. This would be an extension of Buildings Department's existing web publication of GFA concession compliance information. Further, the government should introduce sanctions for not meeting commitments given in return for GRA concessions.

Improve Energy Audits and Increase Retrofitting

Improve energy audits

Hong Kong conducts energy audits of commercial buildings every 10 years, and there is no mandatory requirement for building owners to take the actions suggested by the audit results. These audits should be conducted every five years, and building owners should be required to disclose the reasons if they do not implement the audit recommendations.

Building owners should also be required to prepare better for energy audits, by ensuring that their staff understand the information required and how to collect and record data.

Implement retro-commissioning and retrofitting

Retro-commissioning is defined as overhauling and adjusting existing machinery. Retrofitting is defined as replacing existing machinery where appropriate.

Retro-commissioning provides limited energy saving, but involves little capital investment. The government's retro-commissioning plan covers only its own buildings. This report recommends introducing policy measures to gradually expand retro-commissioning to other types of building, including existing public and commercial buildings and energy systems, in order to reduce operational energy consumption and improve energy efficiency. It also recommends evaluations with cost-benefit analysis of previous actions to guide further action.

Retrofitting can have a much more significant impact on energy saving. The adoption of energy-efficient equipment and building management systems can substantially reduce energy consumption. Retrofitting has a much higher cost than retro-commissioning. An evaluation of whether retrofitting may be cost-benefit justified should be built into decision-making procedures. Expensive retrofits may not be worthwhile for buildings that are nearing the end of their economic life. If near-zero-carbon electricity becomes abundant, it will weaken the economic case for retrofitting. There is a trade-off in such cases. Analysis will be needed to evaluate whether it is worth investing more in decarbonising the energy supply or reducing emissions by improving energy efficiency in buildings, especially over the long term.

Improve Demand Management and User Behaviour

Improve the Energy Charter and take more actions to influence more business groups

User behaviour strongly affects energy consumption in buildings and their carbon footprint. For example, air conditioning is the largest consumer of electricity in buildings. Demand for cooling energy could be moderated by asking more developers and building management companies to maintain an average indoor temperature of 24°C–26°C in summer and shutting down systems when not in use. Office workers should be encouraged to switch off lights and electrical appliances when they leave the building. Requiring buildings to implement the provisions of the Energy Charter would significantly reduce energy consumption in buildings.

Buildings in Hong Kong often use air conditioning systems even in cooler seasons. Malls, offices, restaurants and other buildings pump out very cool air when cooling systems could be switched off or used to bring in cool air from outside the building. With appropriate changes in dress code, higher temperatures can be comforTable.

Behaviour change requires public education, capacity building, incentives, regulations and cultural influences. Large Hong Kong retail tenants are undertaking major energy-efficiency renovations of their premises. The government and industry associations need to do more to educate and encourage more retailers to follow suit.

Accelerate precise energy accounting and information disclosure from power companies

In 2015, the government announced an "energy-aware" and "energy-wise" culture as the highest priority in its Energy Saving Plan (Environment Bureau in collaboration with Development Bureau, Transport and Housing Bureau 2015). Hong Kong's power companies provide data about energy use in the monthly energy bills sent to households. However, summary Figures do not allow consumers to easily make the link between energy use and lifestyle habits. A similar programme in the United States offers detailed energy accounting and information disclosure. It suggests that the average household can save 1,004–1,487 kWh electricity a year (Allcott and Rogers 2014).

CLP has launched benchmark programmes to help both residential and non-residential customers compare their usage with that of their peers. CLP also launched a mass rollout of smart meters to support Hong Kong's transformation into a smart city. The project will install smart meters for all CLP customers over seven years (2018–25) and provide customers with a range of digitised services and solutions to encourage energy saving and improve

supply reliability (CLP 2018). However, public awareness of the project is low; CLP and government must do more to champion the programme.

Set up a "Greening Residential Buildings Fund"

The government should set up a "Greening Residential Buildings Fund" for all energy-efficiency improvements, including smart devices that improve residential energy efficiency. Box 5-1 highlights examples of actions that could be eligible for funding. A similar grant scheme operating from 2009 to 2012—the Buildings Energy Efficiency Funding Scheme—targeted commercial buildings. More than 6,400 buildings applied for the grant, achieving CO_2 emission reductions of 126,000 tonnes (GovHK 2013).

Box 5-1 | Using Smart Technology to Reduce Household Energy Use

Smart home and household upgrades

Technology makes it possible for households to control appliances through their smartphones. It has enabled the proliferation of the "Internet of Things", a way for different devices in a household to be connected to the Internet or to each other (Morgan 2014). "Networks of things" contribute to the creation of smart homes that engage in energy accounting and encourage more energy-efficient behaviour. Aside from monitoring energy use for more precise energy accounting, smart technology can directly and independently control appliances to reduce energy consumption. The government should broadly promote the use of such technology by subsidizing purchases and launching awareness campaigns.

Air conditioning

The largest share of residential energy use in Hong Kong comes from air conditioning, which accounts for up to 34 per cent of electricity use in the residential sector (EMSD 2019). Smart thermostats are energy efficient, enable optimal thermal comfort and are less costly than traditional thermostats in the long run. They are easy to install, requiring no modification of existing air conditioning systems. Simply replacing existing thermostats with smart ones can reduce energy consumption of the fan coil by 20–40 per cent and overall energy consumption by more than 10 per cent for the entire air conditioning system (City University of Hong Kong 2018).

Smart thermostats represent an easy and effective lifestyle change for households. The government should devote more resources to promoting such technology, especially amongst its target audience of higher-end consumers. At the same time, in cooperation with thermostat, air conditioning and power companies, it should devise a rating system for consumers to compare the energy savings potential of different thermostats. When buying new air conditioners, consumers should choose models that are compatible with smart thermostat technology, in order to maximise energy savings.

Another consideration is the cooling capacity (often expressed in British Thermal Units/hour) of the air conditioner. Buying models that are too small or too large leads to unnecessarily high energy consumption. The government should require that importers provide information that helps consumers determine the appropriate-size model for their residence. In addition, the government should create a "top-runner approach" mechanism to eliminate inefficient model options in the market, banning the 10 per cent worst-performing models every year, for example.

Smart lighting

A smart lighting system involves many components; saving the most energy requires the best combination of technology (Constellation Energy Resources 2018).

An LED lightbulb is the perfect bulb for dimming; these bulbs are ubiquitous in Hong Kong Market. Although LED bulbs are more expensive than incandescent bulbs, they last 95–99 per cent longer and are far more energy efficient (Stouch Lighting n.d.). However, to save energy, an LED bulb needs to be paired with an LED-compatible dimmer switch. The government should produce guidelines suggesting the best ways to use smart lighting systems, and businesses should more actively promote packages for the creation of the most energy-saving lighting system.

Smart plugs

Smart plugs are an easy solution that can turn any electrical product into a "smart device". They allow users to monitor energy use and remotely shut down appliances that consume large amounts of energy when not in active use, such as fans and water heaters. Users simply install the associated phone app and plug in the electronic device.

Smart plugs cost around HK$200. A household may need 10 smart plugs, at a cost of HK$2,000 for retrofitting. Users can connect devices into a more integrated smart home system. Smart plugs can reduce energy consumption by 1–4.58 per cent (Constellation Energy Resources 2018). The government should survey the technology available and investigate whether retrofitting sockets to become smart plugs is a feasible option for Hong Kong.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REDUCING EMISSIONS FROM MOBILITY

Fossil fuel–powered transport poses a significant threat to Hong Kong's environment. It creates air pollution, which has a detrimental impact on public health, the economy and quality of life, reducing visibility across the city. In 2017, Hong Kong's transport sector produced at 7.2 $MtCO_2e$, 19 per cent of the city's total carbon emissions (EPD 2019).

Summary of Policy Recommendations

Hong Kong policy makers should consider the actions identified here to reduce emissions across the transport sector. The recommendations are grouped into three categories: avoid, shift and improve.

- Actions to avoid journeys include good city planning and measures that facilitate people living near their place of work or working from home.
- Actions to shift journeys from high-carbon to low-carbon transport modes focus on (a) enhancing public transport and infrastructure and (b) introducing software that enables more convenient use of public transportation. Other actions focus on improving the city's walkability and bikeability. Although Hong Kong has one of the best public transport systems in the world, there is still considerable scope for improvement. Shifting journeys to public transport requires a balance of incentives that (a) make public transport more attractive, by improving its comfort and reducing journey times while keeping it affordable and (b) make the use of private vehicles less attractive, through measures such as higher first registration taxes, higher fuel taxes and electronic road pricing.
- Actions to improve each transport mode include improving fuel efficiency and switching from internal combustion engines to battery electric and hydrogen fuel cell electric vehicles.

Under the Current Policy Scenario, there will be a shift from car and taxi to public transport, the share of electric vehicles will gradually increase to 60–70 per cent of Hong Kong's vehicle fleet by 2050. Combustion engine efficiency will also increase. As a result, emissions from road transport will decline by about half. Under the Decarbonisation Scenario, legislation hastens these changes by facilitating the shift to public transport, mandating higher efficiency requirements for engines, encouraging car sharing, and promoting electric vehicles and changes in urban morphology to improve access for pedestrians and cyclists.

Figure 6-1 shows the reduction potentials for different types of vehicles in both scenarios. The largest contributions will come as private cars and heavy-duty vehicles switch from fossil fuel to electricity and hydrogen.

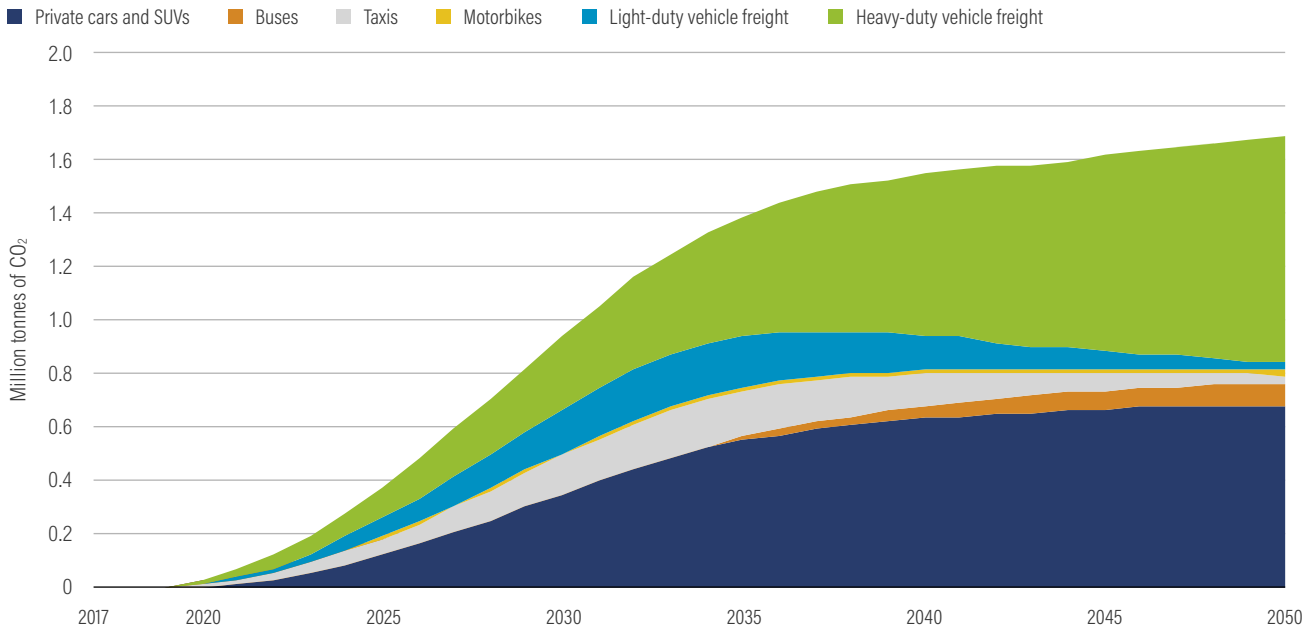
Avoid Journeys

The number and length of journeys can best be controlled by town planning that maintains a compact city design and is friendly towards public transit.

Maintain transit-oriented development as the blueprint for new development areas and redevelopment areas

Hong Kong's transit-oriented development (TOD) model entails building new residential

Figure 6-1 | **Potential emissions reductions in Hong Kong under the Decarbonisation Scenario compared with the Current Policy Scenario, by type of vehicle, 2017–50**



Source: Hong Kong Energy Policy Simulator (EPS) (https://hongkong.energypolicy.solutions/).

and commercial buildings on top of or near public transport hubs so that residents can connect directly with the mass transit system or major bus routes and not have to walk far outdoors to reach a station. This report recommends that the government continue with the TOD model in new developments as well as in redevelopment areas to further encourage the use of public transport.

Improve pedestrian linkages in order to optimise transit-oriented development

The Olympic Mass Transit Railway (MTR) station could serve as a model for TOD planning around the world. The station not only attracted more people to use the railway, it also increased green areas by establishing rooftop parks. Its design shows how a traditional residential area can be improved and made more sustainable by integration into TOD. A residential survey conducted in Hong Kong (Bukowski 2013) shows that the station scored 8 per cent higher than average in the category of "favourable for a healthy lifestyle". Wan Chai, a non-TOD station, scored 16 per cent below the average.

Putting more emphasis on visual attractiveness and public open space could increase walkability and make public space more people-friendly. Conventional footbridges could be replaced by pedestrian landscaped decks or "urban plazas" below or above buildings, so that people can relax and enjoy green space while crossing bridges. The High Line in New York City—an elevated linear park built on an old viaduct—might be a model worth considering. Pedestrian linkages can take on a social function rather than just providing connectivity. Exhibitions, small stalls, suiTable vegetation and performances can be stationed on bridges without affecting the flow of people. Pedestrian linkages represent an opportunity to create more public open space without reducing connectivity between residential buildings and transportation stations. Quantitative analyses of pilot bridges could provide evidence to encourage the authorities to scale up such initiatives.

Facilitate home and workplace mobility

The government should collect and analyse data and explore measures to reduce the need for

citizens to travel for work or education. Useful statistics could include the distances people travel to get to work or school and the transport mode used, the number of people who work from home and the frequency of travel.

Policies to encourage people to work at or closer to home could include the following:

- enhancing broadband connections to facilitate working from home
- facilitating the provision of remote working spaces close to people's homes (appropriate for people living in small flats where it is difficult to work undisturbed from home)
- providing cost reduction for owner-occupiers selling a flat in one part of Hong Kong and buying in another part
- allowing public housing tenants to move to units that are closer to their work.

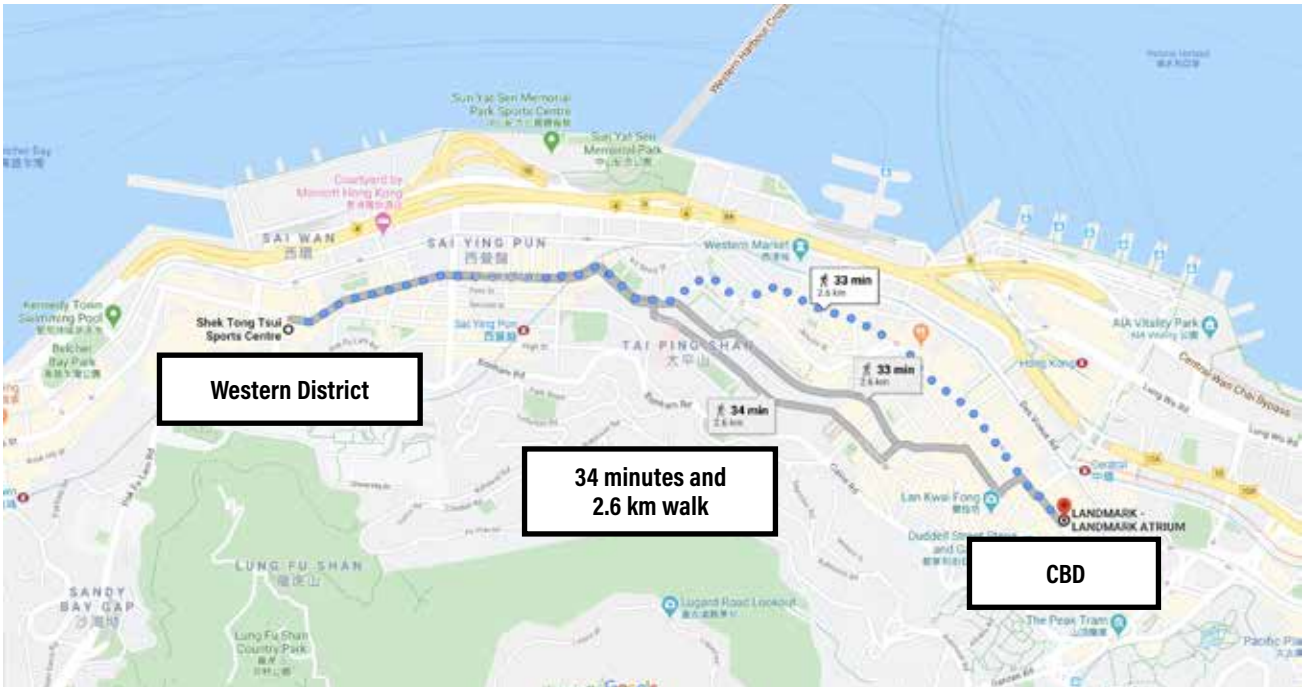
Enhance walkability and bikeability

The government should review the importance accorded to walking and cycling in its mobility strategy. In its upcoming Travel Characteristics Survey, it should consider reclassifying walking and cycling as "trips". It should also investigate the per centage of trips that could reasonably be replaced by walking and cycling and consider how to promote these mobility options.

Walking and cycling should not be thought of merely as first-mile and last-mile options from public transport stations to residential areas, workplaces, schools and open spaces. Rather, the government should encourage citizens to walk to their workplaces, schools and open spaces, especially on the northern Hong Kong island and in new development areas, where journey distances are short. For example, the government could encourage Western and Wan Chai District residents to walk to their office (Figure 6-2).

Many cities have taken advantage of their waterfronts and similar landscape features to promote healthier lifestyles. The government should extend "Walk in HK"—an initiative to create a pedestrian-friendly and walkable Hong Kong—to other districts if the pilot schemes in Central and Sham Shui Po prove successful.

Figure 6-2 | **Illustration of walking from the Western District to the Central Business District**



Source: Google Maps.

Redesign urban morphology

Hong Kong's urban morphology is predominantly car-friendly and discourages citizens from walking or cycling. The government should examine the possibility of redesigning roads and roadside infrastructure to make the streets more walkable and people-friendly. For example, the vibrancy of the roadside environment and comfort could be improved by enhancing the number of amenities along roads, widening sidewalks and creating more attractive scenery.

The government could also explore the feasibility of adding bike lanes in developed areas, especially along Victoria Harbour. The compactness of the city will limit bike-friendly facilities downtown, but it is possible to build them along the harbourfront.

This report strongly suggests that the government follow the recommendations made by the Planning Department and various stakeholders, including district councillors, cyclist groups and local communities, to study the feasibility of building cycling tracks and develop an implementation schedule to connect the core parts of Hong Kong Island. It should also consider investing in basic infrastructure, such as bike rental systems, office bike parking and shower facilities, without which cycling will be relegated to a leisure activity.

Shift to Lower-Carbon Modes of Transport

Use Big Data to upgrade Hong Kong's already excellent public transport

Hong Kong has one of the best public transport systems in the world. The system could be made even better, however, allowing more people to shift from private cars and taxis to public transit. Key to this improvement is accelerating the use of Big Data and improved governance, in the following ways:

- A government-mandated database with real-time GPS-enabled data on all public transport vehicles can be implemented via franchise agreements for all public transport operators to provide these data.
- The database should be used to analyse public transport provision and use, in an effort to optimise the whole system. In particular, the following changes should be made:
  - Transport Department oversight of the system should shift from decisions on matters such as specific bus routes to regulating at the whole-service level.
  - The key service measure should be how long it takes to get from a public transport pick-up point to a destination.
  - District councils should be provided with comparisons of actual and target service levels for their district and focus on the quality of the service level provided rather changes to individual bus routes.
- Facilitating an improved public transport system requires the following steps:
  - Expansion of the MTR and the capacity of its existing lines.
  - Electronic road pricing and other measures to reduce congestion and give buses priority road use.
  - Different modes of public transport working together to provide more of a hub-and-spoke system where people can take fast, non-stop buses for longer-distance travel, with feeder services covering trips from hubs to final destinations.

- Hopper fares providing cost-competitive charges for multi-sector, multi-mode journeys.[20]
- Improved smart phone travel apps that allow free access to the government data base and provide travellers with options for getting where they want to go. This technology is particularly important for informing people of their best option when changes are made to bus routes, hopper fares and making appropriate provisions for disadvantaged groups, such as seniors and people with disabilities.

Extend and enhance the mass transit railway

The government's current policy is to promote the mass transit system as the backbone of public transport development. The Public Transport Strategy Study forecasts that demand for public transport services such as heavy rail will keep increasing in the medium to long term and continue expanding to meet passenger demand in new development areas (Transport and Housing Bureau 2017). In recent years, railway construction projects in Hong Kong have experienced delays of three to six years, mainly because of unrealistically tight completion schedules and a tender bidding mechanism that focuses primarily on project costs (Independent Expert Panel 2014; GovHK 2019c).

Upgrade and enhance signalling systems

Extending the railway network can divert passengers to new lines. However, in some cases, increased passenger loads exacerbate overcrowding during peak hours. For example, the addition of the Hung Shui Kiu Station is expected to increase the load on the West Rail line, which is already running close to capacity.

The signalling replacement project will be implemented in phases between 2018 and 2026, according to the MTR Corporation. However, the plan does not include the West Rail Line or the Ma On Shan Line, even though their loading during peak hour is at 99 per cent and 81 per cent of capacity, respectively. Extra coaches could be added to these two lines to increase capacity, but the MTR Corporation should plan for the long term and take both efficiency and sustainability into consideration by initiating signalling system replacement projects for both lines, which would reduce waiting times and increase carrying capacity by 10 per cent.

Regularly review and update mobility needs, and engage the public

Several factors need to be considered when extending the railway network, including current and anticipated mobility needs; the scope of existing public transport services; project considerations such as technical feasibility, economic and financial benefits, and environmental impact; land use planning; and others. As these factors are highly variable, the government and the MTR Corporation should update their data and review the mobility needs of the city regularly. Public engagement is a good approach to understanding how the current service level can be improved for a more satisfactory user experience.

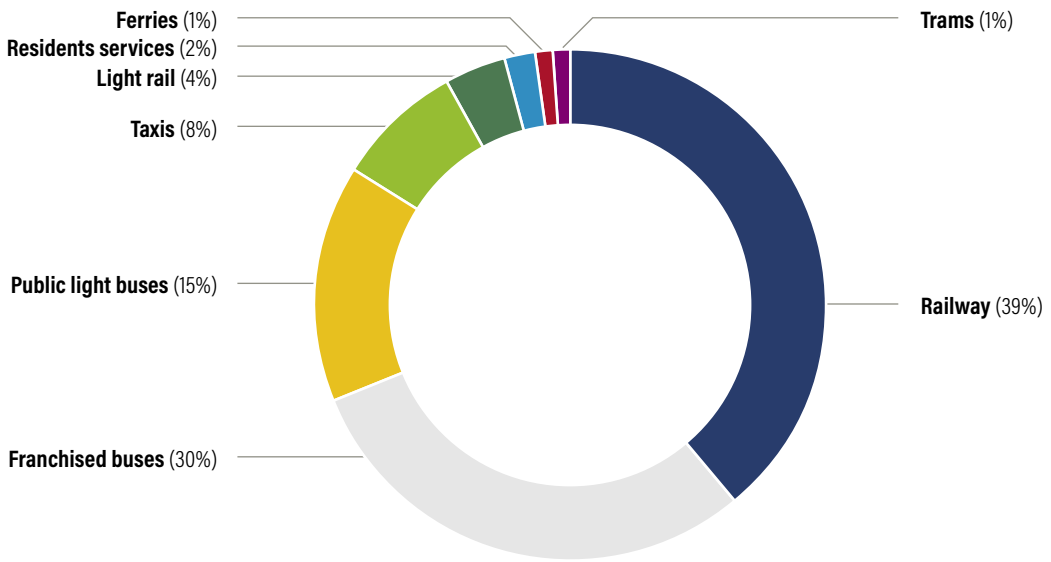
In the long term, Hong Kong's railway system should be extended to areas not covered by the existing network and to new development areas. The latest MTR planning framework covers the period 2014–31. When revising and updating its railway development plan, the government should align extension projects with its long-term mobility strategy. At the same time, it should take an active role in transitioning to lower-carbon forms of mobility. The overall strategy and implementation progress should be reviewed every five years to adapt to social needs.

Daily demand for public transport is expected to increase from 12.6 million passengers in 2016 to 13.8 million in 2031 (Transport and Housing Bureau 2017). Railway ridership will make up around 40 per cent of local public transport patronage. The Railway Development Strategy 2014 detailed plans for seven railway development projects. If these projects are completed on schedule, the share of trips undertaken on heavy railway is expected to rise from 37 per cent in 2016 to 40 per cent in 2031 (Figure 6-3).

Provide competitive and reliable bus services

Bus services are as important as the mass transit system, as they provide wider coverage and more options for direct trips. The government should

Figure 6-3 | **Projected distribution of average daily public transport patronage in 2031**



Note: Resident services serve passengers of specific housing developments, with the aim of relieving heavy demand for regular public transport services, primarily during peak hours, and filling service gaps that cannot be met by regular public transport services. Operators must operate in accordance with the details specified in the Schedule of Service approved by the Transport Department, including routing, service periods, timeTable, stops for boarding and alighting, number of buses and carrying capacity.
Source: Transport and Housing Bureau 2017.

enhance bus service quality by optimising bus routes, developing a more competitive pricing structure and recognising bus services as a cornerstone of the public transport system.

Extend bus route rationalisation and strengthen bottom-up engagement

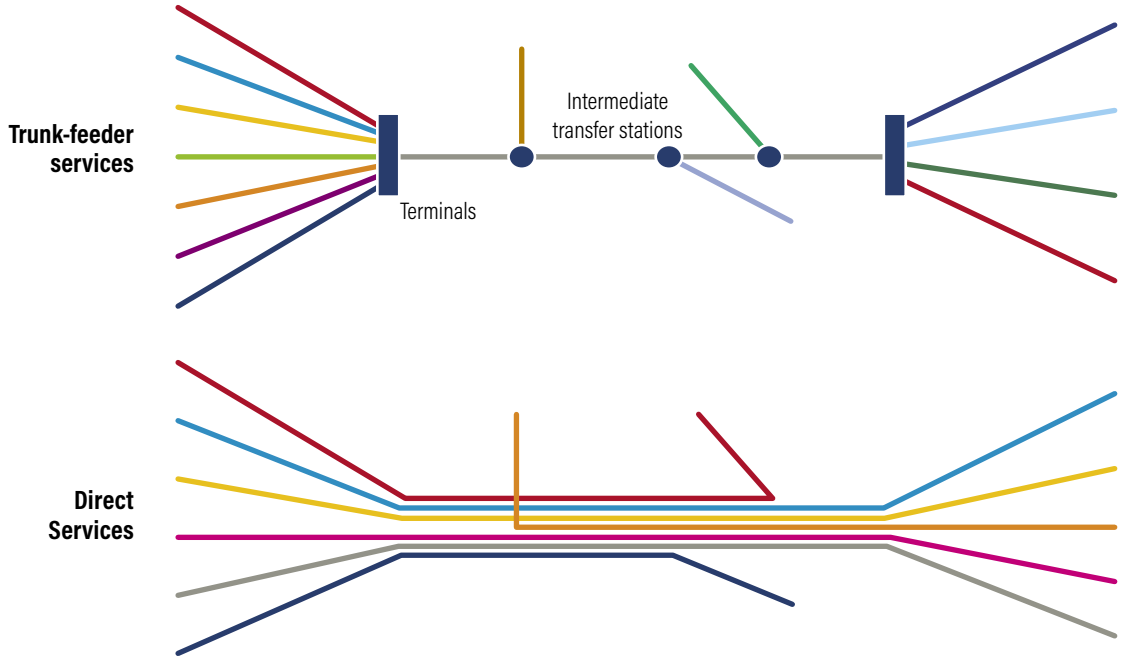
The government has endeavoured to reduce the number of bus routes, enhance efficiency, improve service quality, and reduce roadside emissions and congestion levels. The Transport Department and franchised bus companies are using the "area approach" to holistically review bus systems in seven local areas. An area approach involves optimising the network by considering all bus routes as an interconnected system. Six districts have completed the area approach rationalisation: the North District, Tuen Mun, Yuen Long, Sha Tin, Tsing Yi and Tai Po. Ridership on bus routes in these areas increased by 3–9 per cent between 2013 and 2015, even though the number of deployed buses remained roughly the same (GovHK 2016). There are no comparative data on how patronage increased in areas without rationalisation. The follow-up agenda should cover this question, so that policy makers can weigh the costs and benefits of such actions.

The area approach should be extended to the rest of Hong Kong. In addition, the government needs to balance the rationalisation of bus routes with the expansion of other kinds of public transport. For example, once the Sha Tin–Central Line is completed, passenger volume on bus routes to destinations near the new line is expected to decrease. The government should consider starting public engagement activities in affected communities immediately to discuss the possibility of reducing or merging relevant routes while emphasising the benefits of the new system. Such an effort should help reduce resistance from the District Council.

Establish comprehensive feeder-trunk bus routes

To enhance service efficiency, the government should study the feasibility of changing from direct services to a Hong Kong—wide trunk-feeder bus route system, designed to pick up

Figure 6-4 | **Illustration of feeder-trunk-distributor and direct services**



Source: ITDP 2017.

passengers in one locality and take them to a transfer point where they make an onward journey on a trunk service (Figure 6-4).[21] If pilot trial runs are beneficial, the system could be applied to all long-haul routes between Kowloon or Hong Kong Island and the New Territories.

Establish a hopper fare system

To encourage the use of public transport, the fare concession system in Hong Kong needs to improve significantly. The government should consider allowing passengers to change buses an unlimited number of times within a specified period of time or distance for a fixed price (a hopper system).

The hopper fare system in London is a success story that indicates the potential for increased public transport usage following the introduction of a financial incentive. The hopper created about 350,000 additional journeys every weekday. The system allows passengers to change buses as many times as necessary within an hour for £1.50. As the number of transfers is not linked to price, the negative effects of bus route rationalisation on passengers' transport budgets can be minimized.

Hong Kong could expand the hopper fare policy by allowing transfers between all modes of transport, including subways, public light buses, ferries and trams. The government should help transport companies coordinate, so that this policy can be implemented smoothly and promoted.

Implement a mandatory fleet-wide average carbon dioxide standard

The government should incorporate a mandatory fleet-wide average CO_2 standard for vehicle importers into the Air Pollution Control (Vehicle Design Standards) (Emission) (Amendment) or other relevant legislation. CO_2 emissions are not currently included in such regulations. Because CO_2 is a major contributor to global warming, it is imperative that the government incorporate CO_2 emissions from new vehicles into current regulations as soon as possible. The government should follow the standards set by the European Commission, set a clear target every five years and progressively reduce average CO_2 emissions to zero. To achieve the final goal, the government should adopt the EU fleet-wide average emissions target and require that a per centage of every importer's vehicle fleet meet the 95g CO_2/

kilometre threshold. The policy should retain a certain level of flexibility and be modified based on results from annual reviews.

Review and restructure private car annual licence fees

The polluter pays principle should be introduced into the vehicle licence fee system and should target vehicular CO_2 emissions. The licence fee structure should include a base tax and a CO_2 tax. In Germany, the base tax is €2 per 100 cubic centimetres (cc) of engine displacement for petrol vehicles and €9.50 per 100 cc of engine displacement for diesel vehicles. The CO_2 tax increases linearly at a rate of €2 per gram per kilometre of CO_2 (gCO_2/kilometre) starting from a base emission level of 95 gCO_2/kilometre. Vehicles with CO_2 emissions below 95 gCO_2/kilometre are exempted. As a result of the tax, and complementary regulations, the average CO_2 emissions from new passenger cars sold in Germany declined from 172 gCO_2/kilometre in 2000 to 120 gCO_2/kilometre in 2018 (European Environment Agency 2019).

Hong Kong could maintain the current licence fee as a base tax and establish a CO_2 tax on top. The CO_2 tax could be waived for vehicles emitting less than 95 gCO_2/kilometre. The CO_2 waiver standard should be reviewed every three years. The standard should respect market forces and use competition to drive improved sustainability performance. For instance, vehicles failing to fall within the top 20 per cent performance band in the review year could be required to pay the CO_2 tax.

Discourage dependence on private vehicles

Mobility can be enhanced and pollution reduced by congestion pricing to discourage vehicle use in busy areas. An electronic road pricing (ERP) system with charges which vary by transport type and time of day can be used to reduced congestion by, for example: incentivising delivery vehicles to deliver outside the time periods when there is heavy congestion; penalising cars which circulate in congested areas waiting to pick up someone. Resistance to congestion pricing often comes from drivers who pass through the area daily, shopkeepers (who fear loss of business) and the District Council. Opponents of congestion pricing point out that current transport facilities are insufficient to allow drivers to park private cars outside the toll area and then enter the congestion charging area in other ways.

The government should publicise the merits of ERP and pledge that the fees collected from congestion pricing will be used exclusively to enhance the transport system in Hong Kong and to develop a holistic vision for a public transport–first city. This approach could help increase support from the public. Examples of public engagement, fee setting and practical implementation of congestion pricing can be found in other countries, including Sweden, the United Kingdom and Singapore (Pickford et al. 2017). The government should immediately initiate consultations with stakeholders and subsequently formulate policy proposals for congestion zone boundaries, optimal pricing to ensure deterrence and technology choices.

Improve the Efficiency and Lower the Carbon Intensity of Mobility

Hong Kong had about 600,000 registered private cars in 2017 (Transport Department 2020b), collectively emitting an estimated 1.8 $MtCO_2e$. Without restriction, this fleet is projected to increase to about 840,000 in 2050 (Figure 6-5, panel a). If relevant measures are taken, the size of the private car fleet could be limited to 660,000 in 2050 (Figure 6-5, panel b), a modest increase of about 10 per cent. Corresponding emissions would be 0.7 Mt, a 60 per cent reduction from current levels.

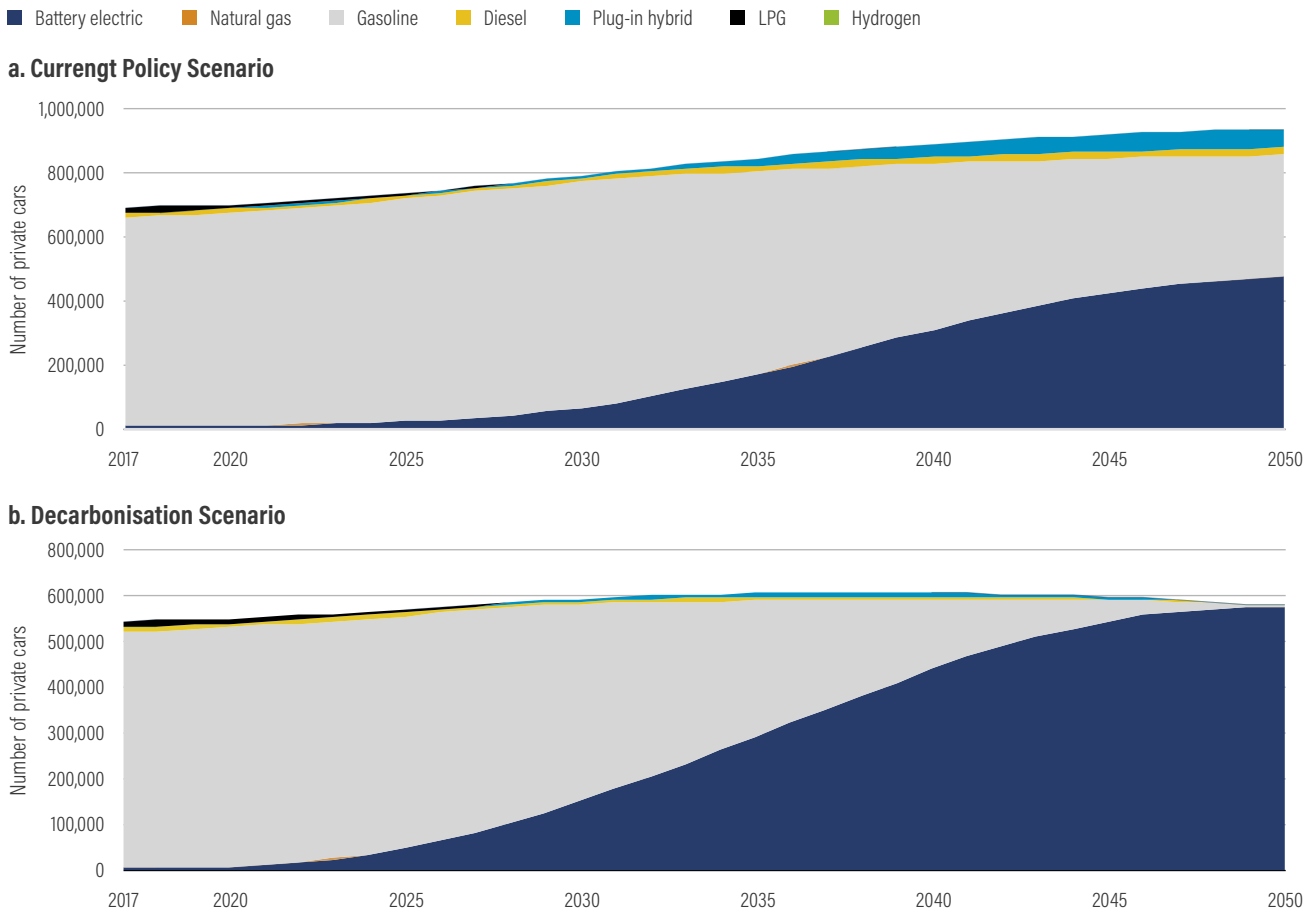
Discourage the use of private vehicles in general and non-electric private vehicles in particular

Action to improve the environmental performance of private vehicles should start from the premise that car use is a less preferred option than public transport or, failing that, taxis. Before 2050, self-driving taxis may change thinking on how best to organise non-public transport.

Improve charging facilities and establish a coverage target

In addition to the tax concession, the government should allocate more resources to enhancing the performance of electric vehicle chargers. A HK$200 million fund exists to support research and development (R&D) on decarbonisation and green technologies, but it is not specific to electric vehicles. The government should encourage technological innovation and cooperate with electric vehicle technology companies globally to increase charging speeds.

Figure 6-5 | **Composition of private car fleet in Hong Kong under the Current Policy Scenario and the Decarbonisation Scenario, by type of fuel, 2017–50**



Source: Hong Kong Energy Policy Simulator (EPS) (https://hongkong.energypolicy.solutions/).

Subsidies for R&D could spur innovation and business engagement.

The UK government's investment in electric taxis has increased the popularity of these vehicles. It will spend £40 million to fund the development of electric vehicle charging technologies (UK Department of Transport 2019). Such financial assistance could lead to a rapid expansion of the charge-point network for people without off-street parking.

In order to develop a more user-friendly charging network, the Hong Kong government should establish a channel to let the public propose charger locations. A demand-driven approach could help the government develop a pragmatic approach to enhancing the coverage of the charging network. The government should establish a charging facility coverage target, such as chargers on all public parking meters and government car park berths by 2025.

As well as increasing the number of public chargers, the government should require developers to build chargers in new private housing estates by amending the Buildings (Planning) Regulation. In existing buildings, the government could subsidize real estate developers to add chargers in car parks. These improvements in charging facilities would increase the convenience of charging and make electric vehicles a substantially more attractive option.

Establish robust targets and pathways to adopt electric vehicles, and ban internal combustion engine vehicles

More than nine countries and a dozen cities or states have announced roadmaps for phasing out internal combustion engine vehicles. [22] The United Kingdom and France will phase out fossil fuel–powered cars by 2040. India will ban the registration of new gasoline or diesel vehicles by 2030. These policies send a strong signal to manufacturers and the market to prepare for a transition away from internal combustion engine vehicles. The transition leads to new regulations and regulatory costs, such as regulations in the United Kingdom that require electric vehicle charging infrastructure in new buildings and buildings undergoing material change of use and major renovation. The additional cost will be approximately £976 per parking space for an average home. The transition will require investment of £1.5 billion (Autovista Group 2019).

The Hong Kong government should set a robust target for the sale of electric vehicles, so that the public can assess progress and make timely adjustments. Electric vehicles should account for 50 per cent of new vehicle sales in Hong Kong by 2030. The government should progressively ban vehicles with internal combustion engines once there is sufficient technology and enough support for electric vehicles.

The government can look to cities in Europe, such as London and Copenhagen, for examples of restrictions on fossil fuel–powered personal vehicles. The United Kingdom will end the sale of new conventional petrol and diesel cars and vans by 2040, by which time it expects the majority of new cars and vans sold to be 100 per cent zero emission and all new cars and vans to have significant zero-emission capability. By 2050, the UK government wants almost every car and van to be zero emission. Towards this end, it has committed to work in partnership with industry, businesses, academia, environmental groups, devolved administrations, local government, consumers and international partners (UK Department of Transport 2020).

Introduce zero-emission taxis

The government has the mandate to regulate taxi fuel. It should actively search for new technology, engage in pilot testing and set a roadmap for converting Hong Kong's 18,163 taxis from internal combustion engine to zero-emission technology.

Hong Kong is transitioning from LPG to hybrid vehicles. However, the government has no policy stipulating when taxi owners should replace their vehicles, and it does not incentivise them to do so. The government should be more ambitious and consider promoting electric taxis or hydrogen taxis rather than hybrid vehicles to avoid a lock-in effect, given that many taxis in Hong Kong are used for more than 20 years. It could target taxis over 13 years old and due for replacement (about 10,000 LPG taxis). It could consider subsidising the industry to deploy zero-emission vehicles. To facilitate this change, it should initiate dialogue with taxi associations and related firms.

Introduce zero-emission bus and freight vehicles

Hong Kong had about 21,000 buses in 2017 (Transport Department 2020b), collectively emitting 0.8 $MtCO_2e$. The "shift" strategy that encourages more use of public transport instead of private cars is projected to increase the bus fleet to about 42,000 by 2050. The associated emissions will be reduced to 47,000 tonnes, however, a 94 per cent reduction from current levels, mainly from the use of zero-emission technologies, including electric vehicle and hydrogen fuel cell electric vehicles.

Enforce the use of biodiesel blend

Hong Kong currently has no legislation to enforce the use of biodiesel. Bus companies and truck drivers are not willing to use biodiesel voluntarily, because biodiesel is more expensive than conventional diesel and hard to obtain in Hong Kong. The Czech Republic, France and Germany require that diesel be mixed with a minimum of 6 per cent biodiesel. The government should follow these countries and enact legislation compelling all diesel vehicles to be fuelled by a biodiesel blend.

Hong Kong has only three biodiesel blend filling stations. The government should retrofit and require all filling stations to provide biodiesel. It should ban conventional diesel immediately and provide subsidies to reduce the cost impact. This report estimates that a 5 per cent biodiesel blend would cost end-users HK$0.065 per litre, a 0.5 per cent premium at the pump. Implementing these policies would avoid 3.6 per cent of annual GHG emissions by Hong Kong's transport sector.

Check the source of biodiesel, and maintain a "local biodiesel first" policy

Biodiesel can be produced from crops (first-generation biodiesel) or waste materials (second-generation biodiesel). First-generation biodiesel is not the preferred option. Apart from the limited scope for agriculture in Hong Kong and the impact of large-scale cash crop production on global commodity market stability, first-generation biodiesel does not minimize GHG emissions. It can exacerbate climate change, because planting large quantities of crops to produce biodiesel feedstocks can lead to deforestation, adverse effects on biodiversity and competition with food production for land and water resources.

Second-generation biodiesel is a better option. Hong Kong should limit its supply to second-generation biodiesel produced locally from waste cooking oil, waste plastic or food, or other waste to ensure high environmental benefits, and it should evaluate the private costs and benefits of requiring it. Local industries in Hong Kong could supply more than 270 tonnes of second-generation biodiesel a day (GovHK 2019b). The government needs to provide financial incentives and back an industry support programme for investors to exploit these opportunities.

Search for emerging technology, and design a long-term technology roadmap

The government should actively study and pilot emerging transportation technologies, in order

to contribute to research and joint-venture development. Hong Kong can learn from the experience of other countries, such as hydrogen fuel use in Japan, and understand how advanced technologies have been introduced into public transport. Priority needs are technologies that shorten charging times and enhance the durability of electric vehicles. In addition, supportive high-level policies, such as the streamlining of road-testing permit procedures and applications for device installation permits, will be necessary to help Hong Kong deploy emerging technology.

The government should establish a long-term roadmap and governance framework for such deployment. It should set a clear target for industries, suppliers and operators to guide their innovation and implementation work. Setting such a target would allow for a more concerted and focused effort towards the large-scale emergence of zero-emission vehicles in the city. To avoid the risk of "picking winners", the roadmap should be conditional, so that new performance information can influence the level of support provided.

Raise the ambition of government vehicle procurement

The government should act as a pioneer by aggressively moving its own fleet from conventional to electric vehicles. Between 2011 and 2014, the Logistics Department spent US$52.8 million to purchase electric vehicles, replacing 131 general-purpose vehicles in the police force with 69 electric-propelled vehicles and 62 electric motorcycles.

Other government departments also use electric vehicles, but the proportion is small. As of January 2018, the government had licenced only 253 electric vehicles out of a total of 6,374 (4 per cent), leaving much room for improvement.

The government should increase the number of electric vehicles in its fleet while immediately stopping the purchase of conventional internal combustion cars. The target for fully adopting zero-emission cars needs to be set up by 2023 and a target for the whole government fleet to fully adopt zero-emission vehicles by 2030. If the government takes the lead, other enterprises and citizens are more likely to follow in purchasing and using electric vehicles.

Accelerate the phase-out of diesel-powered commercial vehicles and buses

Current government policy states that Pre-Euro IV diesel commercial vehicles (DCVs) (pre-Euro, Euro I, Euro II and Euro III vehicles) are phased out at different retirement deadlines, based on their registration dates. As of the end of December 2019, about 78,000 pre–Euro 4 DCVs had been phased out under the ex gratia payment scheme. [23] All pre-Euro, Euro 1 and Euro 2 DCVs have been phased out; and the remaining 1,500 Euro 3 DCVs will be phased out by June 2020 (EPD 2020). In 2017, Euro 4 vehicles accounted for about 23 per cent of respirable suspended particulate and 19 per cent of nitrogen oxide emissions from all vehicles. The government has launched a new incentive-cum-regulatory programme to address emissions from these sources. In addition, it has set a 15-year retirement period for DCVs registered on or after February 1, 2014.This policy is welcome, but more is needed.

The franchised public bus transport sector presents an opportunity for government action. When placing bus franchises out to tender, one study suggests that the government should consider including environmental performance and the per centage of electric vehicles in the bus fleet among the selection criteria, rather than awarding franchises to the most economical bidder (Civic Exchange 2009). Doing so would force bus operators to improve their environmental performance.

The government should closely monitor technology developments in electric and hydrogen vehicles, as well as in software and hardware infrastructure. With the emergence of new technologies, it should consider extending restrictions, by, for example, phasing out Euro 4 and 5 DCVs. The government should set a progressive target for zero-emission vehicle sales and ramp up regulatory standards to promote the replacement of diesel vehicles with electric or zero-emission vehicles. It should phase out all internal combustion engine vehicles by 2050.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OPPORTUNITIES FOR MORE AMBITIOUS CLIMATE ACTION

Hong Kong can reduce emissions in areas other than electricity generation, piped gas, buildings and mobility. Areas include improving the reporting and management of carbon emissions, imposing a carbon price, reducing emissions from the waste sector, international travel, and through lifestyle changes.

Increasing the Reporting and Management of Carbon Emissions

The government currently reports only on the city's Scope 1 emissions—that is, emissions from activities within Hong Kong's administrative boundary.[24] It should also report Scope 2 emissions, which include imports and exports of electricity and hydrogen, for the following reasons:

- By reporting on and targeting Scope 1 and 2 emissions, Hong Kong will avoid any tendency to reduce reported emissions by having electricity generated in Mainland China rather than Hong Kong.
- An increasing number of provinces and cities in Mainland China have begun reporting Scope 1 and 2 emissions. If Hong Kong reports in the same way, it will facilitate China's UNFCCC reporting of emission data for Hong Kong, Macau and Mainland China.
- Reporting on Scope 2 emissions would enable analysis of consumption-related emissions and contribute to decision-making regarding demand-side management policies.

The government should also plan to estimate the main Scope 3 emissions of Hong Kong residents, which include carbon emissions generated in the production of food and manufactured goods imported into Hong Kong. Scope 3 emissions also include transport-related emissions generated by the movement of people and freight outside Hong Kong, including international aviation and shipping. In 2017, 28 per cent of global carbon emissions were caused by building operations and 11 per cent by building construction (UNEP and IEA 2017). Emissions from building construction are referred to as "embodied carbon in buildings". Given the relatively rapid turnover of buildings in Hong Kong, the city's embodied carbon is probably higher than the global average (data are not available).

All these carbon footprints will need to be reduced as the world moves towards global decarbonisation. Expanding the scope of measuring and reporting emissions will help the government plan for the impacts of this reduction.

Imposing a Carbon Price

A carbon price can be applied via a carbon tax or a cap-and-trade emissions-trading scheme (ETS). It can be applied to selected economic sectors. The European Union's ETS covers power stations and industrial plants. California's carbon pollution tax and climate credit scheme (Box 7-1) targets residential buildings. Its Low-Carbon Fuel Standard (Box 7-2) targets transport.

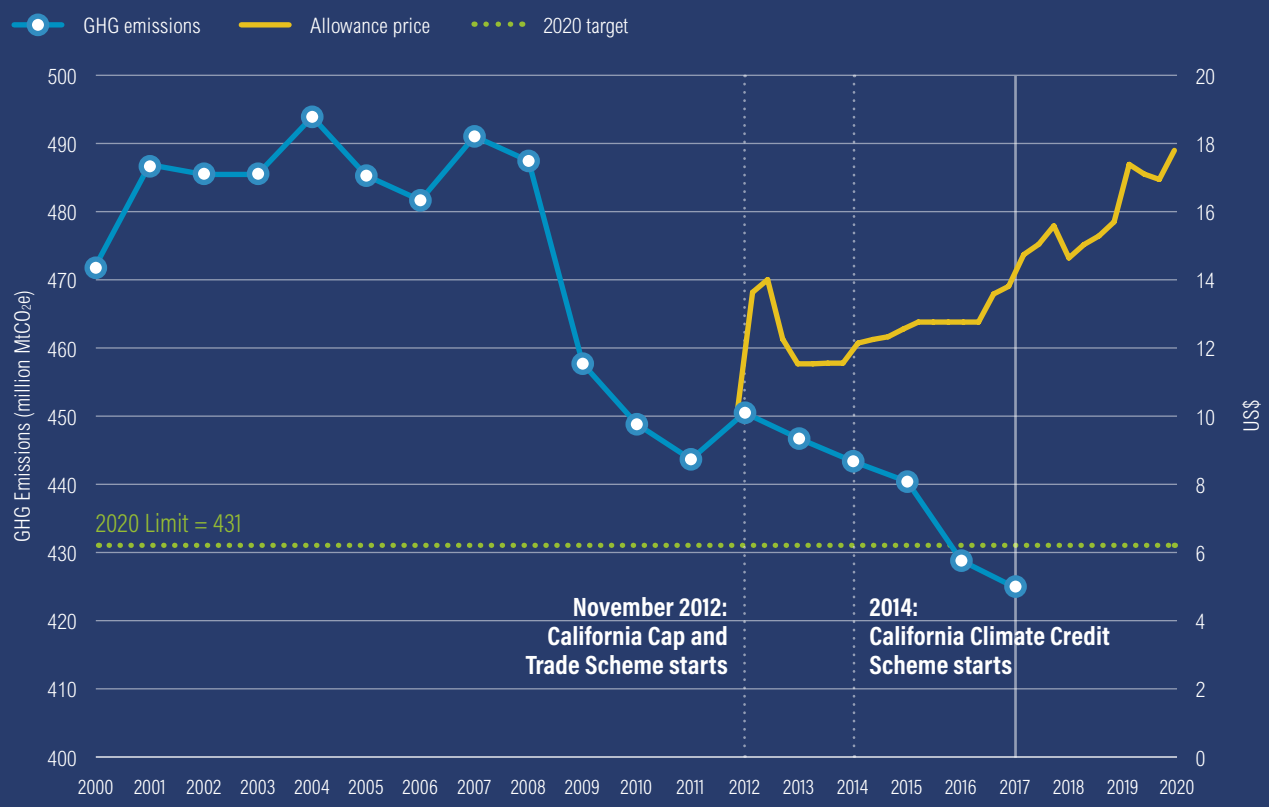
Box 7-1 | California's Carbon Pollution Tax and Climate Credit Scheme

California puts a carbon price on residential electricity and gas consumption. Homeowners pay a "carbon pollution tax" on each unit of electricity and gas they use. The tax drives up the marginal cost of energy and encourages more energy-efficient behaviour in the home. The funds collected, without any deduction for administrative costs or other purposes, are divided by the number of households and the resulting average amount paid back to each homeowner as a lump-sum carbon credit twice a year. Homeowners with below-average energy consumption end up with a lower energy bills as a result of the scheme. Homeowners with above-average energy consumption pay more.

California initially kept the carbon price low, increasing it gradually each year. The auction settlement price in the February 2020 auction was US$17.87 per tonne CO_2e. Since implementation in 2012, emissions in California gradually decreased. In 2016, they reached 429.4 $MtCO_2e$ (excluding land use, land-use change and forestry)—a level just below the 2020 target of 431 $MtCO_2e$ (Figure B7-1). (Emissions were plunging well before the introduction of carbon pricing, but mainly because of the impact of the 2008 financial crisis.)

With their biannual carbon credit report, homeowners receive information on the impacts of climate change (see www.energyupgradeca.org/climate-change/ www.energyupgradeca.org/climate-change/).

Figure B7-1 | Greenhouse Emissions Trends and Cap and Trade Allowance Price in California, 2000–20



Source: Data from the California Air Resources Board 2019, 2020b.

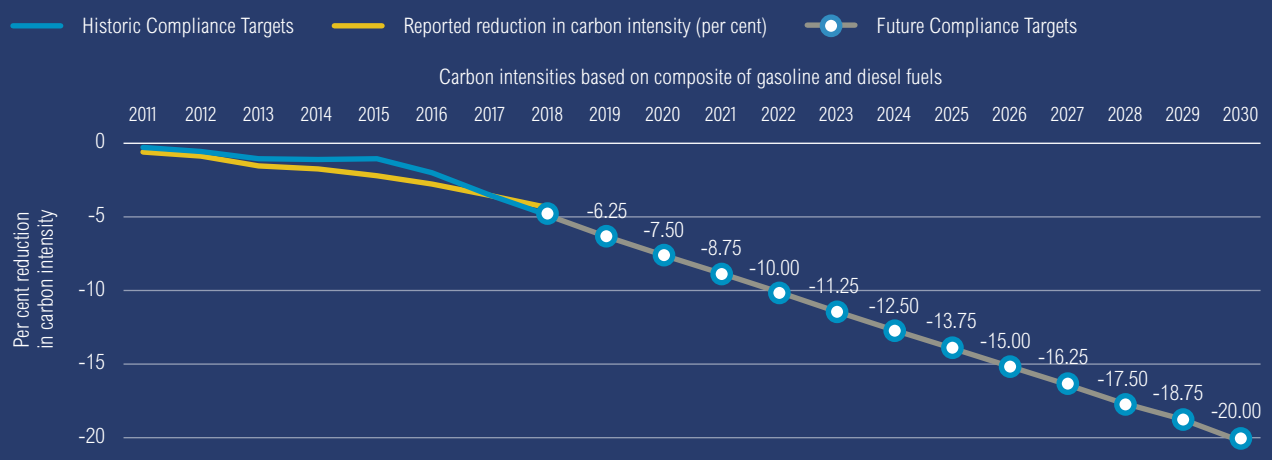
Box 7-2 | California's Low-Carbon Fuel Standard

The Low Carbon Fuel Standard (LCFS)[a] is designed to decrease the carbon intensity of California's transportation fuel pool and provide an increasing range of low-carbon and renewable alternatives that reduce petroleum dependency and achieve air quality benefits. It sets annual carbon-intensity standards, or benchmarks, which decline over time, for gasoline, diesel, and the fuels that replace them. Carbon intensity is expressed in grams of CO_2e per megajoule of energy provided by that fuel. Carbon intensity takes into account the GHG emissions associated with all the steps of producing, transporting and consuming a fuel (known as the complete life cycle of a fuel). The LCFS lets the market determine which mix of fuels will be used to reach the program targets.

Fuels and fuel-blend stocks introduced into the California fuel system that have a carbon intensity higher than the benchmark generate deficits; fuels and fuel-blend stocks with carbon intensities below the benchmark generate credits. Annual compliance is achieved when a regulated party uses credits to match its deficits.

Since the regulation went into effect, the use of low-carbon fuel has increased. Fuel producers are also taking action to decrease the carbon intensity of their fuels.

Figure B7-2 | Performance of California's Low-Carbon Fuel Standard, 2011–30



Note: [a] For information on the LCFS, see https://ww2.arb.ca.gov/our-work/programs/low-carbon-fuel-standard.

Source: California Air Resources Board 2020a.

Arguments can be made both for and against a carbon price. Arguments for a carbon price include the following:

- A carbon price influences decisions throughout the economy, steering choices towards lower-carbon options but leaving individuals, companies and organizations free to make the decisions most appropriate for them.
- Factoring in future carbon prices when investing in long-lived assets makes it more likely that these decisions will be optimized to meet carbon-reduction requirements.
- If Hong Kong does not achieve net zero carbon emissions until after 2050, it could face additional major costs. Introducing a carbon price sooner rather than later could avoid the need to pay such a cost.

Arguments against a carbon price include the following:

- The carbon price will target the electricity sector, but electricity costs represent only a small

fraction (perhaps 0.3–1.0 per cent) of turnover for most service sector businesses. It is therefore unlikely to have much impact on business decisions. (A counter argument is that well-run businesses look to reduce all costs: The fact that rent costs much more than electricity does not prevent businesses from changing to energy-saving light-bulbs.) As the decarbonisation of electricity continues, the effect of a carbon price on the price per kWh will fall.

- Scheme of Control agreements give the government the power to impose decisions on electricity generation to drive decarbonisation of the electricity supply, so carbon pricing is not necessary.

How the money raised by carbon pricing is used is a key question for political bodies considering whether to adopt carbon pricing. Carbon pricing is generally perceived as more attractive if revenues are directed towards social goods. The Hong Kong government ran a fiscal surplus for 15 years (2004–19) and does not need additional revenue. Carbon pricing revenues might be used in various beneficial ways:

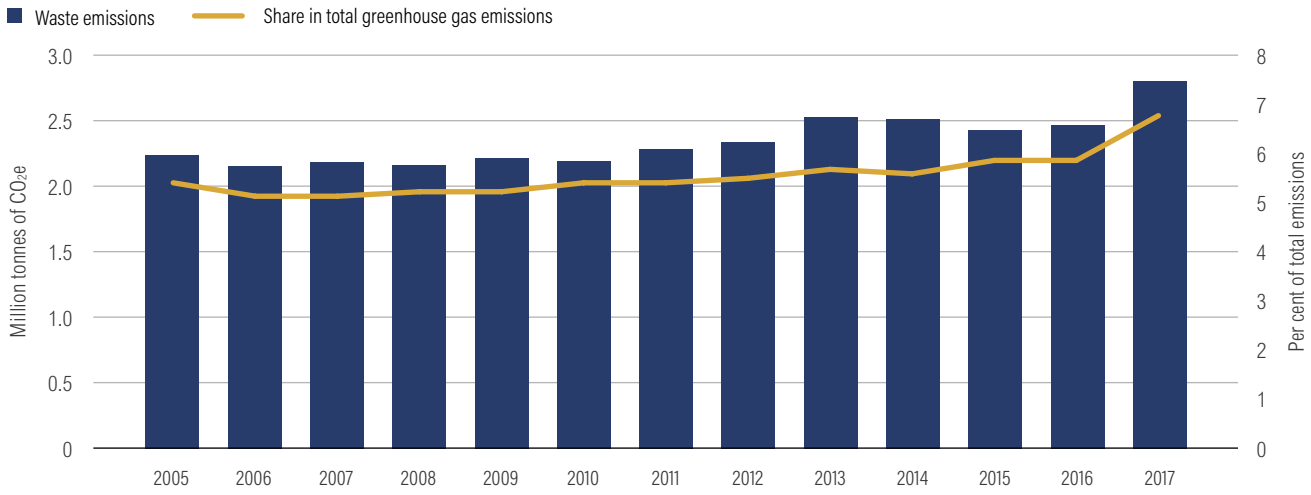
- Reduce property taxes (rates) on commercial buildings. Owners of energy-efficient buildings would save more on rates than they pay as a carbon price; owners of inefficient buildings would pay more. This mechanism would provide an incentive to improve building energy efficiency.
- Redistribute money raised to homeowners, as California has successfully done (see Box 7-1).
- Invest in building upgrades and other programmes to reduce carbon emissions, specifically programmes that increase energy efficiency.

The team preparing this report believes that introducing a carbon price would contribute significantly to decarbonising Hong Kong's economy. Because it did not find consensus on this measure among stakeholders, however, it did not incorporate carbon pricing in the Decarbonisation Scenario. The report team recommends that the government have experts review carbon pricing practises and results around the world and recommend carbon pricing options for Hong Kong. Factors to consider include the impact on reducing carbon emissions, the need to gain public support before introducing changes and the desire to keep Hong Kong's economy efficient and preserve the government's light administrative touch.

Reducing Emissions from the Waste Sector

Hong Kong's waste sector accounted for 7 per cent of the city's total GHG emissions in 2017, amounting to 2.8 $MtCO_2e$ (EPD 2019). This performance is unsatisfactory. Both absolute emissions and the share in total GHG emissions have increased since 2005 (Figure 7-1). The

Figure 7-1 | **Hong Kong's CO_2e emissions from waste management, 2005–17**



Source: EPD 2019.

waste sector has failed to meet the targets in the government's Blueprint for Sustainable Use of Resources 2013–2022. The waste recovery rate, for example, dropped by almost 10 per cent between 2014 and 2018.

Hong Kong should consider the actions listed below to reduce emissions across the waste-management sector.

This study also suggests that Hong Kong pursue opportunities with Mainland China to make Hong Kong more a part of a circular economy. For example, arranging for glass from bottles used in Hong Kong to be processed so they can be used by the factories which make new bottles in China.

Set long-term waste-reduction targets

The latest government waste-reduction target is set out in the Blueprint for Sustainable Use of Resources 2013–2022 (EPD 2013). No replacement is planned for this policy, leaving Hong Kong without mid- to long-term waste-management targets. Enforcement of the 2022 targets has been unsatisfactory. Delays in policy implementation have been a major problem. Some of the progress that was made has since been reversed. For example, daily per capita municipal solid waste disposal to landfills rose from 1.27 kg in 2011 to 1.53 kg in 2018 (EPD 2018).

Establish waste-reduction targets in stages

Based on its current performance, Hong Kong will fail to meet the waste-reduction target it set for 2022. The government should therefore carry out an in-depth study, identify options for increasing recycling and reducing waste and hold a public engagement on these options. It should then adopt new targets and a proactive plan for achieving them. Relevant government agencies should be required to publish regular progress reports.

When preparing for this public engagement, the government might consider the Public Opinion Survey on Bottled Water Consumption conducted by Civic Exchange in 2014, which showed that the public widely acknowledged the plastic waste problem, although the issue did not arouse a strong sense of personal concern or urgency. People generally support government action to address the problem. To reduce plastic waste at source, the government must drive personal behaviour changes by formulating new policies and legislation.

In addition to setting waste-reduction targets, the government should set targets for reducing GHG emissions, in order to align waste-management strategies with the net zero-carbon target.

Develop sector-specific waste-reduction plans and voluntary agreements with industry

As part of setting an overall waste-reduction target, the government must specify targets at a sectoral level and create arrangements for performance benchmarking. Sectoral targets would clarify roles and responsibilities within the overall waste-reduction campaign. The ultimate aim of sector-specific plans is to meet an overall waste-reduction target coordinated by the government.

Prevent and avoid waste generation

Per capita disposal of municipal solid waste reached 1.53 kg a day in 2018 (EPD 2018). This level is higher than other major cities and puts a heavy burden on local landfills. Government regulation on waste generation needs to be ramped up significantly.

The government is considering implementing a municipal solid waste charging scheme, starting in late 2020. It would apply the dedicated-fund-for-dedicated-use principle in spending the revenues generated by the scheme. Revenues could be used to fund waste-reduction and recycling initiatives, offering on-site assistance to communities, providing free territory-wide collection service for waste plastics and implementing a pilot scheme to assess the effectiveness of applying reverse vending machines (devices that accept used beverage containers and return money to the user).

Under the proposed regulations, residents would have to place their garbage into designated, pre-paid bags, with a proposed charge of HK$0.11 per litre. The government must ensure that garbage bag prices are up to date before it rolls out the policy in 2020. It should also conduct periodic reviews and adjust the price regularly, based on factors such as inflation and progress towards waste-reduction targets.

Increase recovery rates and the use of secondary products and materials

In 2013, the government set an ambitious target to recycle 55 per cent of all waste by 2022. In 2017, only 32 per cent of all waste was recycled—a much lower Figure than in 2011, when 48 per cent of all waste was recycled (EPD 2018). On paper, the government seems to have implemented many recycling-related policies, but to increase recovery rates and reduce waste, it needs to evaluate the effectiveness of current measures and fundamentally rethink how recycling is carried out in Hong Kong.

Pass legislation and regulation

The government has to be more proactive in mandating the recovery of products for secondary use. Local legislation has focused mainly on reducing the amount of waste entering landfills; policies on recycling focus on building infrastructure and networks to encourage a higher rate of recovery. These efforts are necessary, but in order to create a low-waste society, the government needs to complement current infrastructure with legislation to maximise its effectiveness.

Hong Kong should look to European Union (EU) regulations, which set stringent guidelines on product design and retail to create an economy based on more circular principles. Early in 2000, the EU submitted a directive that requires automobile manufacturers to ensure a collection rate for reuse and recovery of 85 per cent by 2006 and 95 per cent by 2015. In 2005, the EU mandates that vehicles can be put on the market only if they are 85 per cent or 95 per cent re-usable and/or recyclable by mass, depending on the type of vehicle (Municipal Waste Europe 2019). In 2017, almost 5.3 million passenger cars and light goods vehicles in the EU, with a total weight of 5.7 million tonnes, were scrapped; 94 per cent of parts and materials were reused and recovered, and 88 per cent were reused and recycled (Eurostat 2020). These ambitious policies have been effective at pushing producers to change their mode of thinking towards circularity and led to massive reductions in waste production.

Hong Kong is well placed to motivate shifts in the design and production stages, because of its position as a consumption-based economy that can use demand to compel change. The government should be attentive to international trends in waste-recovery legislation, as most of Hong Kong's goods are imported. Hong Kong already has in place import guidelines that subject cars to inspection. It should align with and actively cooperate with other countries to ensure that goods throughout the supply chain are designed and sold with recovery in mind and that stricter regulations are put in place to tighten waste-recovery standards.

With legislation and regulation in place, the government must simultaneously boost local recycling to encourage higher rates of product recovery at home. Although exporting used products for recovery elsewhere may be an attractive solution, it creates external reliance and a weak local industry. The best way to increase recovery is through a combination of infrastructure (such as waste electrical and electronic equipment [WEEE] treatment and recycling in EcoPark) and policy (legislation, regulation and financial incentives).

Implement a food waste–recycling administrative registration scheme

In 2019, the O.PARK1 and the Tai Po food waste/sewage sludge co-digestion pilot plant handled about 100 tonnes/day of waste on average, about 3 per cent of Hong Kong's total daily waste of 3,600 tonnes.[25] The government must introduce further measures to reduce the quantity of food waste landfilled and increase the recycling rate of food waste. It should ramp up the handling capacity and recovery rate of food waste from 900 tonnes (after the commissioning of organic resources recovery centres to full recovery of all commercial food waste generated in Hong Kong.[26] The government should implement a food waste recycling administrative registration scheme. The Food and Environmental Hygiene Department could add the scheme as an additional licencing condition for restaurants, factory canteens, food factories, bakeries and fixed-pitch hawkers, all of which would be required to hand over their food waste to eligible collectors registered with the Environmental Protection Department for proper collection and disposal.[27] This administrative approach could ensure proper on-source

management and disposal of food waste produced by locally licenced food providers and boost the recovery rate.

Increase individual efforts to use secondary products by coordinating recovery initiatives

Efforts to increase individual use of secondary products are fragmented, with charity shops and second-hand stores dotted across the city. To increase the rate of recovery of products such as clothing, WEEE and furniture, the government needs to be more proactive in uniting these efforts into a concerted campaign. Initiatives to increase the use of secondary products could include repair services, product collection schemes for redistribution and end-of-life recovery. Initial progress has been made in this area through the Producer Responsibility Scheme on Waste Electrical and Electronic Equipment (WPRS) programme, which has made product collection and end-of-life recovery much easier.[28]

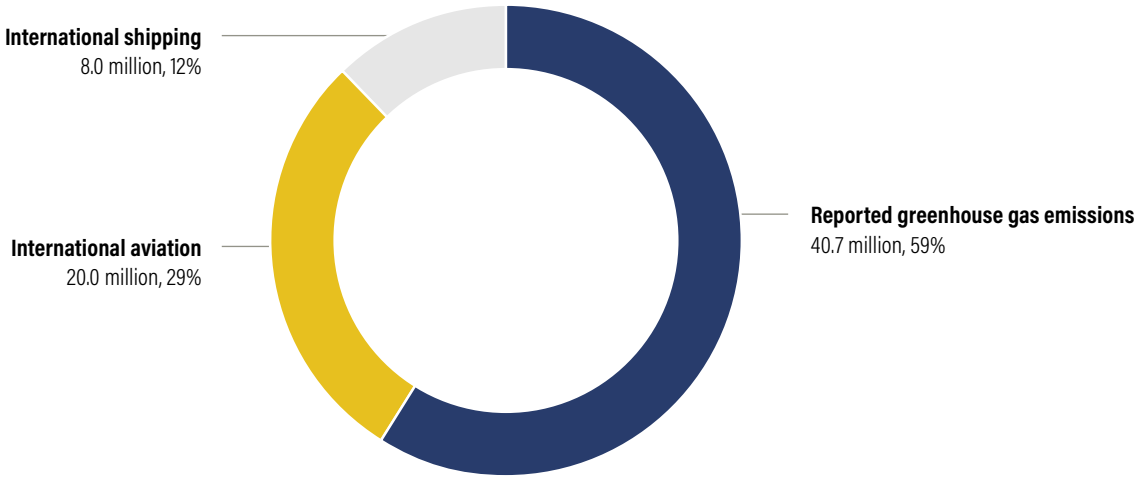
To further encourage repairs of secondary products, the government could offer financial incentives to consumers. Sweden implemented such a policy in 2017, offering value added tax (VAT) breaks on repair services (Margolis 2017). Although Hong Kong does not have a VAT, it could learn from Sweden's experience how the government could incentivise the repair of products. The government could support these efforts by requiring/mandating that materials in consumer products be designed to be repairable, thereby improving the rate of recovery.

Reducing Emissions from International Travel

Globally, aviation is responsible for 2 per cent of anthropogenic CO_2 emissions, and approximately 65 per cent of this amount is from international aviation (ICAO 2016). International shipping accounts for about 2.2 per cent of total global anthropogenic CO_2 emissions.

Hong Kong's current GHG emissions inventory does not include international aviation or shipping. Because of Hong Kong's rôle as an international transport hub, emissions from these sectors are significant and should not be neglected. Some cities, such as London, include international aviation and shipping emissions in their decarbonisation strategy (Greater London Authority 2018).

Figure 7-1 | **Reported greenhouse gas emissions and (unreported) greenhouse gas emissions from international aviation and shipping in Hong Kong, 2017 (tonnes CO_2e)**



Source: Data from EPD 2019 and Census and Statistics Department 2018.

Sales of petrol and kerosene for aircraft in Hong Kong totalled 8.2 billion litres in 2017 (Census and Statistics Department 2018) and caused emissions of 20 $MtCO_2$.[29] Hong Kong's port cargo throughput in 2017 was 282 Mt, and CO_2 emissions from its international shipping were estimated at about 8 $MtCO_2$. Including international aviation and shipping in Hong Kong's total emissions, international aviation accounts for 29 per cent of total emissions and international shipping for 12 per cent (Figure 7-2).

Emissions from international civil aviation and shipping are very high in Hong Kong. It needs to consider the economic impact of action to reduce them.

Comply with the recommendations of the International Civil Aviation Organization and the International Marine Organization

Monitoring, reporting and verification (MRV) is essential to all CO_2 emission–reduction activities, including understanding current and historical trends, forecasting future emissions, setting emission-reduction targets, formulating action plans and tracking performance. The European Union and the International Marine Organization (IMO) launched mandatory MRV schemes for international shipping in January 2018 and January 2019, respectively.

The International Civil Aviation Organization (ICAO) has set targets for international aviation to improve fuel efficiency by 2 per cent per year through 2050 and to achieve carbon-neutral aviation growth from 2020 onwards. The International Air Transport Association (IATA) has set an additional target of reducing net CO_2 emissions from aviation by 50 per cent by 2050 relative to 2005 levels.

The IMO has set targets for global international shipping, which must peak CO_2 emissions as soon as possible; reduce carbon intensity (CO_2 per tonne-mile) by 40 per cent by 2030 and 70 per cent by 2050, compared with 2008 levels; reduce total emissions by at least 50 per cent in 2050 compared with 2008; and achieve zero emissions as soon as possible this century.

Determine the impact on Hong Kong's economy of possible actions to decarbonise international aviation and shipping

Hong Kong should immediately launch its own studies on international aviation and shipping to determine the impact of actions to decarbonise emissions from international aviation and shipping. Boxes 7-3 and 7-4 show examples of the initial findings from our analysis.

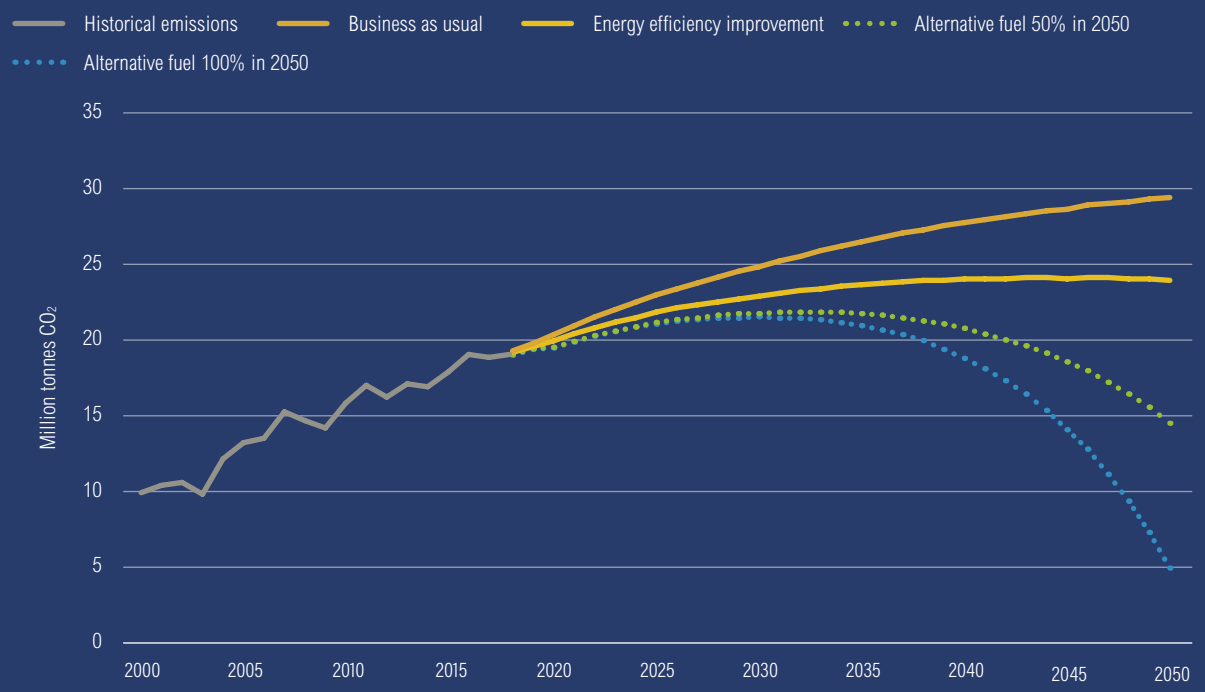
Box 7-3 | Reducing CO_2 Emissions from International Aviation in Hong Kong

Hong Kong International Airport (HKIA) is one of the busiest airports in the world, with over 120 airlines connecting to 220 destinations worldwide. In 2019, HKIA handled 71.5 million passengers and 4.8 million tonnes of cargo and mail.

Figure B7-3 shows Hong Kong's projected emissions from international civil aviation under four scenarios. With completion of the third runway, HKIA's passenger and cargo traffic are projected to reach 100 million passenger trips and 6 million tonnes in 2025, and CO_2 emissions are projected to reach 22 million tonnes. In 2050, CO_2 emissions will reach 30 million tonnes if no additional measures are taken, making the deep decarbonisation of Hong Kong's economy impossible. Even with greater improvement in energy efficiency (2 per cent annually in the Energy Efficiency Improvement Scenario instead of 1.39 in the Business as Usual [BAU] Scenario), emissions in 2050 still reach 24 million tonnes in 2050.

Alternative fuel offers another possible solution. According to the ICAO, it could dramatically reduce CO_2 emissions if used on a large scale. Alternative fuel production costs vary substantially, ranging from around €0.88 per litre for hydro-processed fuels made from waste fats and oils to €3.44 per litre for the direct conversion of sugar to jet fuel. These prices are two to eight times the price of petroleum jet fuel (ICCT 2019).

Figure B7-3 | Hong Kong's CO_2 Emissions from International Civil Aviation, 2000–50



Note: All scenarios use the same assumptions for passenger and cargo traffic. Annual improvement of energy efficiency is 1.39 per cent in the Business as Usual Scenario and 2.0 per cent in the other scenarios. In the two Alternative Fuel scenarios, the share of alternative fuel starts at 2 per cent in 2020 and rises to 50 per cent or 100 per cent in 2050, increasing exponentially during 2020–50.

Source: Emissions data for 2000–17 are from Census and Statistics Department (2011, 2012, 2013, 2014b, 2015, 2016b, 2017a, 2018); projections of emissions were made by the project team based on assumptions identified in the Figure note.

Box 7-4 | Encouraging Passengers to Take High-Speed Rail

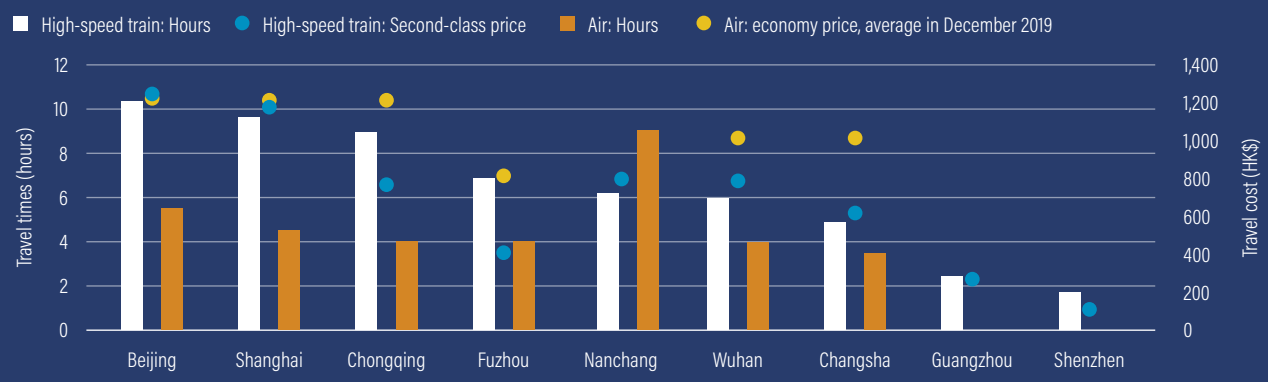
Freight air traffic is closely tied to economic development. Its ability to deliver product quickly means that it is difficult to replace with other modes of transport. The growth of passenger traffic is also tied to economic growth, but it is sometimes a lifestyle choice. People can opt to use other transport modes, such as high-speed rail, on some routes.

Hong Kong was connected to the Mainland's high-speed rail system through the Guangzhou-Shenzhen-Hong Kong Express Rail Link in October 2018. The high-speed rail now connects Hong Kong with 58 mainland stations with no transfers.

Figures B7-4-1 and B7-4-2 compare high-speed rail and air travel in terms of price, travel hours and CO_2 emissions. High-speed rail has an absolute advantage on price for most cities and emits fewer GHG emissions. In the nine cities shown, CO_2 emissions from high-speed rail per person journey are 16–38 per cent those of air travel. When travel time to and from the airport and possible delays are taken into account, high-speed rail may be competitive in terms of time for journeys of less than five hours.

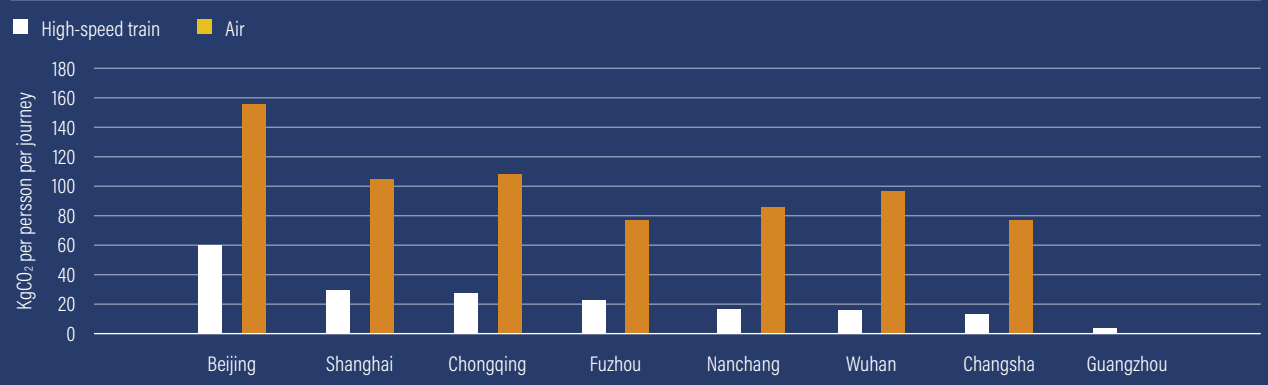
Hong Kong could encourage more people in both Hong Kong and Mainland China to take high-speed rail though public education. If carbon pricing is applied, the price differential could be reduced as well.

Figure B7-4-1 | Travel Time and Cost from Hong Kong to Select Mainland Cities by Air and High-Speed Rail



Note: Price and travel hours by air are averages from Skyscanner, accessed in 2019. All travel hours include approximate time commuting to and from the airport and train station.
Source: https://www.highspeed.mtr.com.hk/en/main/index.html, https://www.highspeed.mtr.com.hk/en/main/index.html.

Figure B7-4-2 | CO_2 Emissions Associated with Air and High-Speed Rail Travel from Hong Kong to Select Cities in Mainland China



Source: Emissions from high-speed rail are calculated by travel distance, assuming 3.8 kWh per 100 passenger-kilometres and emission factors of grids from the National Development and Reform Commission. Emissions from air travel are from the ICAO calculator (https://www.icao.int/environmental-protection/CarbonOffset/Pages/default.aspx).

Reducing Emissions through Lifestyle Changes

Lifestyle drives consumption and hence carbon emissions. If everyone on the planet led the lifestyle of people in Hong Kong, 4.2 Earths would be required to meet the world's resource needs (WWF 2019).

Although lifestyle is partly the result of individual choices, it is to a greater degree influenced by societal norms. Creating low-carbon lifestyles therefore requires a society-wide transformation, based on policies aimed at creating a positive, empowering environment that fosters a circular restorative economy while remaining sensitive to socioeconomic and equity concerns. Policies should motivate businesses to create products and services conducive to lifestyle change and guide individuals to adopt low-carbon lifestyles.

Government actions to promote low-carbon lifestyles

The role of the government is crucial in the transition to low-carbon lifestyles, as it is the only stakeholder capable of coordinating and overseeing a society-wide response. The government must set more specific emission-reduction targets to guide progress and inform decision-making. Government strategies can be divided into three strands:

- **Cultural preferences:** By understanding the motivations of individuals, policies can be implemented to guide consumers into making more sustainable choices. Actions include changing default choices and utilising social norms to guide behaviour.
- **Information:** Low-carbon choices can be promoted though a multi-pronged strategy covering information provision, in particular more precise energy accounting; labelling; feedback and action plans.
- **Regulation:** Government can eliminate or restrict choices in the market through standards, bans, other regulations and market-based financial disincentives.

Business actions to promote low-carbon lifestyles

Businesses can influence lifestyle patterns by modifying the composition and range of products they sell. As part of emission-reduction targets, businesses should be encouraged to adopt green procurement strategies—reducing food miles (the distance between the production site and the end-user), for example, and adjusting their business models to help create a more circular economy.

Businesses also need to consider how they can shift consumer habits through their marketing practises, based on the principles of minimising disruption, creating a compelling benefit, maximising awareness and helping social norms evolve. For a concerted, society-wide effort, industry collaboration on sustainable development is also necessary.

Individual actions to promote low-carbon lifestyles

Individual lifestyle changes can reduce carbon emissions. Changes include dressing appropriately for the ambient temperature so that less energy is needed for heating and air conditioning; using public transport rather than taxis and private cars; changing and washing clothes less often; and eating less red meat (Table 7-1). [30]

ENDNOTES

1. Health impacts depend on the type of abated emission source. Particulate matter emitted from power stations, for example, appears to have a less deleterious impact on health than particulate matter emitted from vehicles at street level and within street canyons.
2. Prices in this section are 2018 constant HK$. Cost-benefit calculations do not include all policies recommended in this study. For example, neither waste reduction nor policies that avoid journeys in transport sector are included. Cost-benefit analysis should be conducted for all policies.
3. The comparison is based on monthly residential constumer consumption of 275 units (see HKE 2019).
4. The levelised cost of electricity (LCOE) is the total cost to build and operate a power plant over its lifetime divided by the total electricity output dispatched from the plant over that period. It takes into account the financing costs of the capital component. The LCOE is used to compare the cost of alternative power generation systems.
5. For more information, see the GovHK website (https://www.gov.hk/en/residents/environment/renewable/index.htm).
6. For more information, see the Energy Storage Association website (http://energystorage.org/energy-storage/energy-storage-technologies).
7. For more information, see the US Department of Energy website (https://www.energy.gov/oe/activities/technology-development/grid-modernization-and-smart-grid/demand-response).
8. Town gas is produced from naphtha and natural gas. With about half the density of air, it rises, dissipating in the air if leakages occur. A special odour is added to town gas so that it can be easily detected. In Hong Kong, town gas is produced at two production plants. Over 98 per cent is supplied from the Tai Po Plant, with the Ma Tau Kok Plant making up the rest. The maximum supply capacity of the two production plants is around 12.6 million standard cubic metres of gas a day.
9. For more information on this, see https://www.towngas.com/en/home.
10. For more information on this, see the IMO home page (http://www.imo.org/EN/Pages/Default.aspx).
11. For more information on this, see http://hkbest.hkgbc.org.hk/com/index.html.
12. For more information on this, see https://www.emsd.gov.hk/en/home/index.html.
13. For more information on this, see https://www.bd.gov.hk/en/resources/codes-and-references/notices-and-reports/GFA.html.
14. For more information on this, see http://hkbest.hkgbc.org.hk/oo/introduction.php.
15. The Energy Saving Charter promotes energy efficiency and energy saving. It is one of the most critical means for Hong Kong to continuously reduce carbon emissions. The government launched it in 2012, to encourage business and community organizations to save energy. By 2018, more than 3,600 premises had signed it.
16. For more information on this, see https://www.hkgbc.org.hk/eng/engagement/guidebooks/green-school-guide/index.jsp.

17. For more information on this, see https://sciencebasedtargets.org/.

18. For more information on this, see https://betterbuildingssolutioncenter.energy.gov/.

19. For more information, see http://hkbest.hkgbc.org.hk/oo/introduction.php.

20. A hopper system allows passengers to change buses an unlimited number of times within a specified period of time or distance for a fixed price.

21. Direct services are a service pattern in which multiple bus routes run in mixed traffic on local streets and then continue onto a bus rapid transit (BRT) corridor. Trunk-and-feeder services are a service pattern in which multiple bus routes run in mixed traffic on local streets and terminate at a single terminal. Another bus route with higher frequency operates up and down the BRT corridor; customers using both must transfer. See https://brtguide.itdp.org/branch/master/guide/service-planning/direct-services-trunk-and-feeder-services-or-hybrids#:~:text=Direct%20Services%3A%20A%20service%20pattern,terminate%20at%20a%20single%20terminal.

22. For more information on this, see https://qz.com/1341155/nine-countries-say-they-will-ban-internal-combustion-engines-none-have-a-law-to-do-so/.

23. For more information on this, see https://www.td.gov.hk/en/public_services/ex_gratia_payment_scheme_for_phasing_out_pre_euro/index.html.

24. The Global Protocol on Community-Scale Greenhouse Gas Emission Inventories classifies emissions as scope 1, scope 2 and scope 3. Scope 1 emissions are GHG emissions from sources located within the city boundary. Scope 2 emissions are GHG emissions occurring as a consequence of the use of grid-supplied electricity, heat, steam and/or cooling within the city boundary. Scope 3 emissions are all other GHG emissions that occur outside the city boundary as a result of activities taking place within the city boundary.

25. For more information, see https://www.opark.gov.hk/en/index.php.

26. Organic resources recovery centres aim to recycle source-separated organic waste generated from the Commercial and Industry (C&I) sectors (mostly food waste) to useful products, thereby reducing the requirement for landfill disposal. For more information, see https://www.epd.gov.hk/epd/english/environmentinhk/waste/prob_solutions/WFdev_OWTF.html.

27. A fixed pitch means any pitch delineated on the ground in any place or street for the use of fixed-pitch hawker licensees. For more information, see https://www.fehd.gov.hk/english/pleasant_environment/hawker/fixedpitch.html.

28. For more information on this, see https://www.info.gov.hk/gia/general/201910/23/P2019102300460.htm.

29. These Figures were calculated using data from the Hong Kong Energy Statistics 2017 Annual Report, and an intensity of kerosene of 0.775 kg/L and an emission factor for kerosene of 3.15 tonnes CO_2/tonne.

30. Fee more information, see https://www.susdev.org.hk/en/public-engagement.php.

ABBREVIATIONS

BAU	Business as usual
BEST00	Benchmarking and Energy Saving Tool–Office Occupants
cc	Cubic centimetre
CCS	Carbon capture and storage
CLP	CLP Power Hong Kong Limited
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
DCV	Diesel commercial vehicle
EPS	Energy Policy Simulator
ETS	Emissions-trading scheme
gCO_2/k	Gram per kilometre of CO_2
GDP	Gross domestic product
GFA	Gross floor area
GHG	Greenhouse gas
HKCG	Hong Kong & China Gas Company
HKE	Hong Kong Electric Investments Limited
ICAO	International Civil Aviation Organization
IEA	International Energy Agency
IMO	International Marine Organization
IPCC	Intergovernmental Panel on Climate Change
kg	Kilogram
kWh	Kilowatt hour
LCOE	Levelised cost of electricity
LNG	Liquified natural gas
LPG	Liquified petroleum gas
Ml	Megalitre
MRV	Monitoring, reporting and verification
$MtCO_2e$	Million tonnes of carbon dioxide equivalent
MTR	Mass transit system
O&M	Operations and maintenance
PM_{10}	Particulate matter with diameter of less than 10 micrometres
$PM_{2.5}$	Particulate matter with diameter of less than 2.5 micrometres
PV	Photovoltaic
tCO_2e	Tonnes of carbon dioxide equivalent
Tj	Terajoule
TOD	Transit-oriented development
TWh	Terawatt hours
UNFCCC	United Nations Framework Convention on Climate Change
VRE	Variable renewable energy
WEEE	Waste electrical and electronic equipment

GLOSSARY

CO_2 and CO_2e

CO_2e (carbon dioxide equivalent) includes seven types of greenhouse gases: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorinated compounds (PFCs), sulfur hexafluoride (SF_6) and nitrogen trifluoride (NF_3). The officially reported historical emissions from Hong Kong's Environmental Protection Department (EPD) include all greenhouse gases; CO_2e is therefore used when presenting these data. The Hong Kong Energy Policy Simulator—the model used in the scenario analysis—also covers all greenhouse gas emissions. Some analysis in this report examines only CO_2 emissions from the energy sector, it uses CO_2 when presenting these data.

Current Policy Scenario

One of two scenarios developed for this study. Illustrates effects of existing policies to 2030 and projected effects to 2050, based on trends from current policies.

Decarbonisation Scenario

One of two scenarios developed for this study. Presents principal recommendations for achieving deep decarbonisation by 2050.

Net zero emissions

Net zero emissions are achieved when anthropogenic emissions of greenhouse gases to the atmosphere are balanced by anthropogenic removals, when accounting for regional or local bio-geophysical effects of human activities that, for example, affect surface albedo or local climate.

Town gas

Town gas is produced from naphtha and natural gas. With about half the density of air, it rises, dissipating in the air if leakages occur. A harmless chemical is added to town gas so that it has an odour, making it easy to detect. Two production plants in Hong Kong produce town gas.

Zero- or near-zero-carbon hydrogen

Hydrogen is similar to electricity. Both occur naturally in only small quantities. Both can be made from zero-carbon sources and used to conveniently distribute energy. Hydrogen (H_2) burns to produce water (H_2O); it is a zero-carbon fuel if made without producing CO_2 emissions. Hydrogen accounts for about half of the piped gas used in Hong Kong, but it is currently made from sources that emit carbon. Zero-carbon hydrogen can be produced in two ways. "Blue hydrogen" is made from natural gas through the process of steam methane reforming. "Green hydrogen"' is produced from water using electricity from zero-carbon sources, including renewables and nuclear.

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ABOUT WRI

World Resources Institute is a global research organization that turns big ideas into action at the nexus of environment, economic opportunity and human well-being.

Our Challenge
Natural resources are at the foundation of economic opportunity and human well-being. But today, we are depleting Earth's resources at rates that are not sustainable, endangering economies and people's lives. People depend on clean water, fertile land, healthy forests, and a stable climate. Livable cities and clean energy are essential for a sustainable planet. We must address these urgent, global challenges this decade.

Our Vision
We envision an equitable and prosperous planet driven by the wise management of natural resources. We aspire to create a world where the actions of government, business, and communities combine to eliminate poverty and sustain the natural environment for all people.

Our Approach
COUNT IT
We start with data. We conduct independent research and draw on the latest technology to develop new insights and recommendations. Our rigorous analysis identifies risks, unveils opportunities, and informs smart strategies. We focus our efforts on influential and emerging economies where the future of sustainability will be determined.

CHANGE IT
We use our research to influence government policies, business strategies, and civil society action. We test projects with communities, companies, and government agencies to build a strong evidence base. Then, we work with partners to deliver change on the ground that alleviates poverty and strengthens society. We hold ourselves accountable to ensure that our outcomes will be bold and enduring.

SCALE IT
We don't think small. Once tested, we work with partners to adopt and expand our efforts regionally and globally. We engage with decision-makers to carry out our ideas and elevate our impact. We measure success through government and busi¬ness actions that improve people's lives and sustain a healthy environment.

ABOUT CIVIC EXCHANGE

Civic Exchange is an independent Hong Kong public-policy think tank established in 2000 with a vision to shape a liveable and sustainable Hong Kong. Its mission is to engage society and influence public policy through in-depth research, dialogue, and the development of practical solutions. With research covering four areas—environmental, economic, social, and governance—Civic Exchange has been ranked among the top 50 environmental think tanks in the world by the Lauder Institute at the University of Pennsylvania since 2011.

ABOUT HONG KONG 2050 IS NOW

"Hong Kong 2050 Is Now" galvanises collective action in science, media, business and policy towards a carbon-neutral Hong Kong by 2050. This initiative of Civic Exchange, World Resources Institute , and the ADM Capital Foundation aims to build a broad-based collective platform for driving action in Hong Kong in response to the 2018 Intergovernmental Panel on Climate Change (IPCC) report on Global Warming of 1.5°C. According to that report, without urgent, large-scale action, global warming is likely to reach 1.5°C above pre-industrial levels, with potentially significant and dangerous consequences for the world. We believe that a decarbonised city is people-centric, more liveable, healthier and successful. That's what we want for Hong Kong.

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