A ROADMAP TO ACHIEVE NET-ZERO EMISSIONS FOR TRANSPORTATION SECTOR IN HONG KONG

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HONG KONG 2050 IS NOW

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This publication is initiated by the project *Net-Zero Emissions Roadmap for Transportation in Guangdong and the Greater Bay Area* conducted by the Innovation Centre for Energy and Transportation (iCET), as the project aims to accelerate the electrification and decarbonisation of transportation in the Greater Bay Area. This publication is a collaborative project between Civic Exchange and iCET on a Hong Kong-focussed roadmap for achieving net-zero carbon emissions in transportation. We would like to express our gratitude to those who provided timely and helpful advice, support, and assistance during the preparation of this publication.

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Executive Summary

Highlights

- China is at the forefront of implementing pronounced decarbonisation practices to cut transportation emissions to fulfil its nationally determined contribution. The transport sector, the second largest emitting sector, accounts for 18.7% of the total greenhouse gas emissions in Hong Kong. Without ambitious decarbonisation efforts, transportation emissions and threat of climate change will not reduce significantly.

- Transportation system in Hong Kong differs from China in many facets, such as infrastructure, pollution standard, motor vehicle type and regulation. To reduce transportation emissions in the Guangdong-Hong Kong-Macao Greater Bay Area (GBA) over time, the region must emulate effective coordination and integration of transport policies for transformative changes.

- Each transport mode in Hong Kong presents opportunities for interagency collaborations and case-to-case financial incentives that hone determination within the public sector to adopt new energy vehicles. However, more could be done to enhance the intensity and rate of transport decarbonisation.

- The adoption of battery electric vehicles has widely proliferated as a prominent decarbonisation approach for transportation in Hong Kong. Under the assumption that the government and transport sector implement decarbonisation yearly to achieve said targets, findings reveal that medium goods vehicles would be the second largest roadside emissions source midway from net-zero by 2050.

- All stakeholders must work under one roof to implement ambitious transition pathways to achieve zero carbon transport emissions by 2050. Given the unique challenges in Hong Kong's transportation systems, the successful development of a prototype not only addresses local impediments but also establishes a valuable reference for other nations facing similar issues.

Chapter 1 Background on Decarbonising Transport Needs

1.1 Global Call for Action

The IPCC has urged the world to commit to reaching net-zero carbon emissions by 2050 and limit global temperature rise by 2100 to 1.5°C above pre-industrial levels[i]. With International Energy Agency (IEA) global stocktake on the emissions for transportation, the IEA tracked that between 1990 and 2022, emissions from the transportation sector increased at an annual average rate of 1.7%, outpacing most other end-use sectors except for the industry, which also experienced a similar growth rate. To align with the IPCC target, carbon emissions from transportation ought to decrease by over 3% annually until 2030.

1.2 China's Drive for Transport Decarbonisation

According to Climate Watch, a data platform by World Resources Institute, China accounted for 26% of the world's greenhouse gas emissions in 2020[ii]. To fulfill its role as a leader in climate action, China has set out its 30•60 Goals, striving to peak emissions by 2030 and reach carbon neutrality by 2060.

The transport sector will play a critical role if China is to achieve its 30•60 Goals. In the first quarter of 2023 alone, there was a notable 4% increase in China's transportation-related carbon emissions, marking a record high for the first three months of the year[iii].

The central government has dedicated significant efforts towards planning the region's decarbonisation development, evident from the overarching *14th Five-Year-Plan for Green Transportation Development*[iv], to the technology-specific targets such as *Made in China 2025*[v] and *Guiding Opinions on Further Building a High-Quality Charging Infrastructure System*[vi]. In the past decade, China has continuously introduced regulations and policies aimed at reducing the fuel consumption of newly produced vehicles and vigorously promoting the electrification transformation of vehicles.

In tandem with the policy implementations, the GBA stands as a compelling exemplar of becoming a thriving and sustainable global economic bay area. Guangzhou and Shenzhen excel in the GBA in regard to new energy vehicle development. The latter, in 2017, even became the first city to achieve 100% electrification of its public buses and attained 25% penetration rates in private cars. In 2020, it achieved 100% electrification in vehicles offering ride-hailing services[vii].

The triumphant outcome act as proof to bolster Hong Kong's confidence in achieving carbon neutrality by 2050. It is a prime chance to harness the prerequisites for actualising decarbonisation in Hong Kong's transport sectors, venturing into new collaborative avenues.

Chapter 2 Hong Kong Transport Decarbonisation Initiatives

2.1 Hong Kong Climate Action Plan 2050[viii]

The *Hong Kong Climate Action Plan 2050*, issued in October 2021, inherits what was committed, as stated in the *Hong Kong Roadmap on Popularisation of Electric Vehicles*, with the goal to achieve zero vehicular emissions across all modes of transport by 2050. The *Climate Action Plan 2050* also seeks to electrify vehicles and ferries, develop new energy transport, and implement measures to improve traffic management. It signifies government willingness to collaborate with the franchised bus companies and other stakeholders in the next three years to assess the feasibility of hydrogen fuel cell electric buses and heavy vehicles.

2.2 Hong Kong Roadmap on Popularisation of Electric Vehicles[ix]

The government announced the *Hong Kong Roadmap on Popularisation of Electric Vehicles* in March 2021, outlining the long-term policy objectives and action items needed to promote electric vehicle adoption and the construction of associated supporting infrastructures.

Concurring with the surging global demand for a green and smart city development, the *Hong Kong Roadmap on Popularisation of Electric Vehicles* lays out milestones to mobilise transport stakeholders to act towards carbon neutrality. To reinforce milestone development of technological readiness, vehicle availability and supporting facilities, each milestone will be reviewed in every five years.

One of the key measures under the *Hong Kong Roadmap on Popularisation of Electric Vehicles* is to halt the new registration of fuel-propelled and hybrid private cars (PCs) in 2035 or earlier. The surge in Hong Kong's electric private car adoption is evident, yet the electrification rates for other vehicle categories lags behind. The differences can be further substantiated in the report’s analysis.

The *Hong Kong Roadmap on Popularisation of Electric Vehicles* demonstrates qualities that suffice a sustainable urban transport notion “avoid, shift and improve”[x]. The government established New Energy Transport Fund (previously named Pilot Green Transport Fund) in March 2011 to **improve** the proliferation rates of electric vehicles. In 2018, the One-for-One Replacement Scheme was introduced, **shifting** away from maintaining an environment dominated by internal combustion engine vehicles to a landscape favouring electric vehicles. Subsequently, strategic studies are conducted to gauge railway opportunities and to **avoid** emission-intensive vehicles since the beginning of new town planning.

2.3 Hong Kong 2030+: Towards a Planning Vision and Strategy Transcending 2030[xi]

The *Hong Kong 2030+: Towards a Planning Vision and Strategy Transcending 2030* is a strategic study that offers a comprehensive spatial planning framework for future land and infrastructure development on par with focusing on climate change responsiveness into transport infrastructure development, for instance, the study analyses estimated hectares of land required for transport land use environmental features. Based on the study, the Highways Department has launched a public consultation for the *Strategic Study on Railways beyond 2030* in December 2020 with an aim of producing a comprehensive publication titled *Hong Kong Major Transport Infrastructure Development Blueprint*.

2.4 New Energy Transport Fund (NET Fund)[xii]

Previously known as the Pilot Green Transport Fund, a $300 million fund was in place to subsidise the transport trade and charitable/non-profit making organisations to try out green innovative transport technologies in March 2011. The NET Fund supports the testing and encourages wider adoption of green innovative transport technologies for a variety of commercial transport tools, vehicles or vessels, as well as after-treatment emission reduction devices or fuel saving devices.

Table 1: Hong Kong's transport decarbonisation initiatives summary

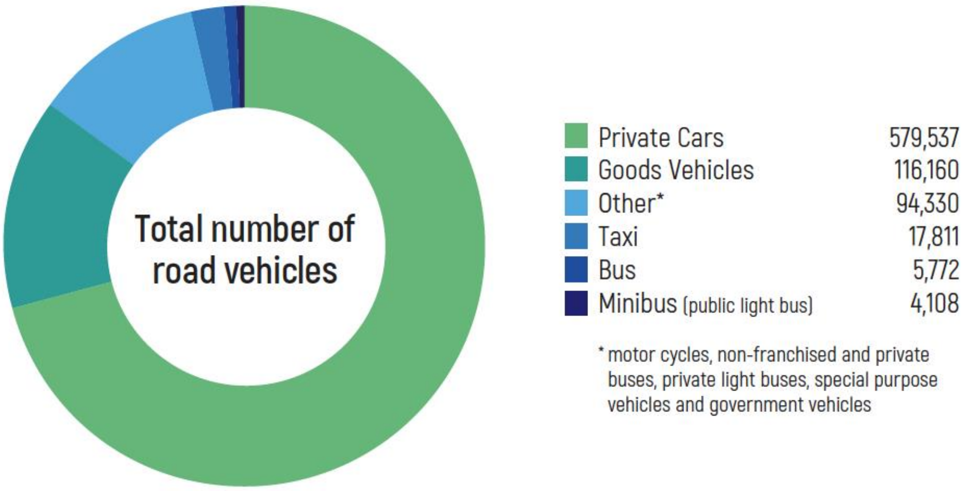
	New Energy Transport Fund	Hong Kong Roadmap on Popularisation of Electric Vehicles	Hong Kong 2030+: Towards a Planning Vision and Strategy Transcending 2030	Hong Kong Climate Action Plan 2050
Release Date	March 2020	March 2021	October 2021	October 2021
Format	Incentive	Policy Targets	Study	Policy Targets
Initiatives Highlights	• As of July 2023, the NET Fund has approved 314 trial projects with a total subsidised amount to about $258 million for green transport and relevant technologies.	• Install more than 150,000 and 5,000 private and public charging infrastructure respectively. • Set electric vehicles as standard for government small and medium private cars to be procured or replaced. • Strive to legislate a Producer Responsibility Scheme for retired electric vehicle batteries in the next few years.	• Render planning support and essential infrastructure that is smart, green and resilient. • Adopt innovative designs to minimise environmental impact.	• Cease the new registration of fuel-propelled and hybrid private cars. • Progressively replace traditional ferries with new energy ferries before 2035 or earlier.

Chapter 3 Status Quo of Hong Kong Transport Sector

The transport sector is the second-largest greenhouse gas emission source in Hong Kong, following the power sector, with road transport being one of the primary contributors. Public transport accounts for nearly 90% of Hong Kong people's daily journeys[xiii].

3.1 Road Vehicles

Figure 1: Total Number of Road Vehicles (Monthly Traffic and Transport Digest July 2023 figures)



3.1.1 Private Cars

The private cars category accounts for the greatest number of licensed motorised vehicles with a total of 580,376 as of June 2023. In terms of fuel type, the percentage of licensed private cars is as follows: petrol with 510,605, electric with 58,798, diesel with 10,906, and turbine engine-propelled/ fuel cell vehicles with 67 cars[xiv]. The plurality of fuel types showcases that Hong Kong's private cars segment is comparatively dynamic compared to other transport modes.

In 2022, the electric private vehicle sales accounted for 52% of total private car sales in Hong Kong, and 62% of that in the first half of 2023. The government estimates an additional 12,000 electric private vehicle sales by year-end. In which for every 10 cars sold, more than 6 of them are electrified. With a target to cease new internal combustion engine vehicle registration in 2035, the government has plans to accomplish the target in 2032, 3 years sooner than the initial target.

Opportunities

First Registration Tax Concessions (FRT)

To promote the wider adoption of electric vehicles (EVs) in Hong Kong, the government has been offering the first registration tax concessions for EVs. For electric private cars, the FRT will be waived up to $97,500. It is stated cars owners can "scrap and de-register their own eligible old cars and first register a new electric private car in a higher FRT concession up to $287,500", under the One-for-One Replacement Scheme[xv].

As the deadline for FRT Concessions has been deferred to 31st March 2024, the general public has been enthusiastic in switching into cars propelled by electricity.

Bottlenecks

Growth in numbers

Transport Digest, a gazette on monthly traffic statistics in Hong Kong, published July 2023 that the segment of private car accounts for 70.9% of total vehicle licensing by class of vehicles[xvi]. Although research showed "private cars growth is expected to further slow down from the current level of about 2.5% per year to about 1% in the longer term"[xvii], traffic gridlock, reasonable parking prices and inadequate charging spaces remain vexatious for the highly dense city.

Charging spaces availability

The Government aims to increase the number of public and private parking spaces with charging infrastructure to 200,000 by mid-2027, as well as 300 quick-charging stations[xviii] by 2025 to extend its charging network. A total of $3.5 billion has been invested in adding EV charging points and constructing its related facilities. Nevertheless, by December 2022, as of 5,434 EV chargers across 18 districts, only around 18% of them are quick chargers, which may not aptly provide sufficient support to the rising number of electric private cars.

3.1.2 Taxi

The franchised taxi service currently has a total of 18,163 registered taxis in Hong Kong, with more than 99% of them propelled by liquefied petroleum gas (LPG) and accounting for 2.6% and 17.1% of the total local nitrogen dioxide and carbon monoxide emissions respectively. There are 70 LPG filling stations across 18 districts in Hong Kong.[xix]

Most taxis are individually owned, but there are also some taxis owned by taxi companies, rented or hired by drivers to operate. In 1994, the government stopped issuing taxi licences to avoid taxi oversaturation, reduce traffic congestion and improve roadside air quality[xx], thereby honed by the fact that registration number has stagnated at 18,163 ever since. The market is witnessing a constant drop in licensed taxis numbers. One contributing factor[xxi] is that insurance premiums for taxis have doubled, which taxi proprietors would rather choose to opt to keep their vehicles idle as they grapple with the challenge of meeting the elevated operating costs.

Opportunities

Previous fleet transition examples

The Chief Executive announced in the 2021 Policy Address that the Government would subsidise electric taxis trials. The government is keeping a close eye on the market development and formulating policies to further promote the adoption of electric taxis.

In 1999, the Chief Executive announced in his Policy Address to require all new taxis to use Liquefied Petroleum Gas (LPG) as their fuel source. It took 3 years to replace the entire diesel and petrol taxi fleet to LPG taxis[xxii].

Bottlenecks

Quick-charging spot availabilities

The government is committed to establishing an electric taxi charging service network and has also appointed contractors to provide quick charging services for electric taxis in Lantau Island and later in Sai Kung District. It is expected that there will be no less than 10 related chargers put into deployment in phases, starting in mid-2023. The amount involved in providing charging services for five years is expected to be approximately $27 million.

In light of the time needed for taxis to take turns from their everyday shifts, taxis in general could only set aside a short period of time each day for charging their e-taxis, practically not more than two hours. The current charging network also indicates the need for electric taxi drivers to compete with electric private car owners on charging spots. Unlike other parts of the Mainland like Shenzhen, taxis in Hong Kong are operating day and night, with a driving range of up to 500 km a day.

3.1.3 Bus

Hong Kong showcases an extensive network of bus services covering almost all areas of Hong Kong Island, Kowloon and the New Territories, as the current landscape plays an essential role in being the second largest carrier of passengers. Franchised bus services face explicit oligopolistic competition. The market is held by private companies and the government presents no ownership. The Hong Kong franchised bus market was previously shared by four bus companies. It was not until New World First Bus completed its acquisition and merger on early July 2023, adding its fleet into Citybus Limited[xxiii].

The following shows the market dominators of Hong Kong franchised bus service market and the number of licensed buses[xxiv]:

Table 2: Market dominators of Hong Kong franchised bus service market and bus fleet structure

		Diesel	*Electric*	*Total*
Kowloon Motor Bus Co. (1933) Ltd.	Single Deck	123	24	147
	Double Deck	3692	2	3694
Citybus Ltd.	Single Deck	17	4	21
	Double Deck	1490	1	1491
New Lantao Bus Co. (1973) Ltd.	Single Deck	77	4	81
	Double Deck	59	0	59
Long Win Bus Co. Ltd.	Single Deck	0	4	4
	Double Deck	275	0	275

Note: The first hydrogen fuel cell double decker owned by Citybus Ltd. will undergo trials in late 2023, it is not a licensed bus.

Opportunities

Ambitious transition determination

The franchised operators have developed their transition plan and set forth an overarching zero emission goal for Hong Kong's bus sector. All bus franchises, energy providers and other transport stakeholders have also formed an alliance to suggest actionable items to the government in actualising their decarbonisation commitments across bus franchises' operational lifecycle[xxv]. Such joint communique is considered unprecedented for road transport sector in Hong Kong.

Extensive network

Part of the service is converted into feeder buses, dedicated to connecting catchment areas without direct railways in accessing into railway networks. Likewise, connecting various

outlying new towns into central districts, franchised bus companies also develop express routes that offer point-to-point services.
Bus services thus synergise with the heavy rail, backbone of Hong Kong's public transport system which stipulates an approximate of 42% of all daily passenger journeys made on public transport[xxvi].
Since 2013, the government has undertaken annual revamp in bus route rationalism and planning programmes in avoiding bus bunching situations and developing hassle-free schedules and frequencies. The forward-looking preparation has endorsed Hong Kong franchised bus market and made itself differentiated from other bus markets, where the issue of two bus plying the same route appears at bus station at the exact same time persists.

Non-farebox Income

In terms of profitability, franchised bus companies have been relying on fare adjustment mechanisms, contributing significantly to their total earnings. Since fares are kept relatively low, bus companies would be better off in seeking alternative income source on any research and development opportunities. The government has granted franchised bus companies on generating non-farebox income, though the percentage of non-fare box revenue was very low when compared to the Star Ferry and tram. Leveraging high patronage rates, bus companies could enhance its operating strategies, for example, by validating the feasibility of setting up convenience stores at bus stops and interchanges[xxvii].

Bottlenecks

Unmatched government funds and infrastructures

In contrast, Hong Kong's private franchise bus companies are required to financially support their electrification from acquisition to maintenance costs on their own. The government earmarked $180 million to purchase 36 single deck electric bus. However, infrastructure and regulations are not adequate to support the whole operating cycle of electric bus[xxviii]. No study has been conducted on the implications regarding electricity, grid load quantity speculation, as well as the demand for a substation to be installed in various locations.

Unique topographical and weather conditions

The introduction of new energy vehicles and their related infrastructures has been further affected by the uncompromising topography, such as hilly terrains and humid weather conditions that Hong Kong presents. The frequent door cycles, rather prolonged actual boarding and alighting times, as well as acceleration and braking rates caused by traffic, are also the contributing factors to the need for a significant cooling load.

Absence of science-based targets

In accordance with the Hong Kong 2050 net-zero objective, individual franchised bus companies have set up their own carbon-neutral objective and corresponding targets specific to reducing greenhouse gas emissions. For instance, KMB and CityBus have pledged to become a carbon neutral bus operator by 2040 and 2045 respectively, through various means, including upgrades to their entire bus fleet to zero-emission buses and install solar photovoltaic panels on current internal combustion engine bus fleets.

Nevertheless, the companies have yet to substantiate net-zero targets to be science-based, thus showcasing the target's compatibility with the company's overall transition strategy. A lack of common metrics also prevents further comparisons among other franchised bus companies in Hong Kong.

3.1.4 Minibus

Public Light Buses (PLBs), also known as minibuses, are small buses built to carry less than 19 seats. One type of PLBs is used for scheduled services (green minibuses) and the other type of PLBs for non-scheduled services (red minibuses). Red minibuses are free to operate anywhere without fixed routes or fares. As of 2022, there are 997 red minibuses. Green minibuses operate on fixed routes and frequencies at set prices. Red minibuses carry approximately 159,500 passengers a day, while green minibuses transport about 1,170,500 passengers daily.

Retrieved from the Transport Department

Opportunities

<u>Pilot Trial Scheme dedicated to PLB electrification</u>

The Government earmarked $80 million in 2020 to launch a 12-month trial that will subsidise about 40 electric PLBs running on various routes to test their operations under the local environment. Currently, statistics show that average electric minibuses can operate a maximum of 350km when fully charged.

Bottlenecks

<u>Trial scheme approval process</u>

Industry experts expressed that "it is unlikely that any minibus operators will consider buying it because the government has no clear timeframe as to when funding will be available. Moreover, the Transport Department attains restrictions on the maximum overall length and the maximum gross vehicle weight of a light bus, resulting new energy minibus inspections being overly strict and lengthy[xxix].

<u>Expensive new energy minibus procurement costs</u>

A latest electric minibus model has been designed and manufactured by Shui Cheong Motors, one of the prequalified suppliers of Electric Public Light Bus Pilot Scheme, with trials in accompanied by Hong Kong Science and Technology Parks (HKSTP) and Hong Kong Productivity Council (HKPC). The trial model costs at least $1.8 million, though a diesel minibus only costs $0.8 million. With the $1 million cost difference as well as inadequate charging infrastructure in place, the community is unsupportive of replacing their current LPG fleets.

As of November 2023, there are currently 6 suppliers participating from the trial scheme.[xxx]

Table 3: Prequalified suppliers trial electric minibus models and respective prices

PREQUALIFIED SUPPLIERS	MODEL	PRICE (HK$)

GREEN MOBILITY INNOVATIONS LIMITED	THOR	1,383,060
JUPITER EV HK LIMITED	WD6757BEVRG01	1,500,000
E. TECH DYNAMIC TECHNOLOGY CO. LIMITED	XML6722JEV	1,680,000
SHUI CHEONG MOTORS LIMITED	SOLUTION	1,800,000
SHUN HING NEW ENERGY CO., LTD.	GTQ6721BEVBT30	2,000,000
CHINA DYNAMICS NEW ENERGY TECHNOLOGY COMPANY LIMITED	YST6700BEVG/ APEX MINI	2,280,000

<u>Electric Minibus charging spots availability</u>

Regarding to the Pilot Scheme for Electric Public Light Buses, the Environmental Protection Department (EPD) plans to provide battery charging services at 2 to 3 public transport interchanges at an estimated cost of $14 million[xxxi]. Each charging station or pantograph include two fast charging bows and two plug-in backup charging guns (as known as double-gun direct current charging pile).

Two public pantographs will soon be in place in Kwun Tong and Kowloon Tong. Yet, no further study has been made in exploring major minibus interchanges like Mong Kok overhead charging installations.

3.1.5 Goods Vehicles

Goods vehicles in Hong Kong contribute significantly to air pollution. Heavy and medium goods vehicles in particular contribute 46% of nitrogen dioxide and 54% of particulate matter emissions in the city, as well as 4.4% of total carbon emissions in 2018[xxxii]. In response, Hong Kong has committed to reducing its greenhouse gas emissions by 26-36% by 2030 compared to 2005 levels. However, progress towards decarbonising heavy and medium goods vehicles are lagging behind other vehicle types, such as passenger cars, which already have a roadmap for transitioning to zero-emission vehicles.

Currently, 99% of freight vehicles in Hong Kong are diesel-powered. A total of 212 electric goods vehicles were approved for trials, including 170 light goods vehicles (LGV) and 5 medium goods vehicles (MGV) as at end December 2021. Some of the trials have not commenced yet. No electric heavy goods vehicles (HGV) are put on trials.

The goods vehicles market has a share of 60% individual vehicle owners and 40% corporate vehicle owners[xxxiii]. The market condition presents high number of market participants in the industry.

Opportunities

<u>Quick wins on electrifying goods vehicles</u>

In actualising decarbonisation in the goods vehicles sector, there are immediate actions on vehicles operating on fixed routes with short distances as a key entry point, such as road-based crossings between Hong Kong and Mainland open for goods vehicles, as well as refuse collection vehicles and tractors within containers ports that allows a tactical small-scale electric truck deployment for measuring impact and foreseeing future obstacles. By targeting these entry points, the progress of full electrification can achieve early wins, build momentum, and lay the foundation for more ambitious long-term goals.

Partnership with bus operators

Given the current allocation of land and approval processes for charging facilities installations, Hong Kong's goods vehicle owners have been proactively discussing possibilities with the bus operators on sharing charging facilities. These stakeholders are seizing the opportunity to leverage a beachhead strategy, as trucks and buses have different downtime features: the former is charged at daytimes and the latter is charged at night times.

Bottlenecks

Unclear market conditions

In light of the dynamic commercial vehicle operation modes, a sophisticated study is needed to enhance transparency regarding a market overview, as well as to understand the operation scenario and duty cycle features among different market players. Such a study could facilitate insights and knowledge exchanges unique to probing various application scenarios complementing zero-emission technologies, against the currently unfavourable market conditions for introducing electric vehicles to their fleets.

Regulatory restrictions

Taking gross vehicle weight and other indicators of trucks into consideration, retail companies in Hong Kong would only be allowed to consider an iota of options due to regulatory restrictions (see Case Study below). Excluding other electric truck competitors, inadequate truck model choices in the market would result in a monopoly market structure that directly effects the procurement costs. Electric truck procuring companies would need to spend more effect in convincing the company shareholders since purchasing electric trucks is necessary.

Case Study

One of the logistics companies encountered a bottleneck regarding payload exemption while piloting an electric medium goods vehicle (under Environmental Production Department's New Energy Transport Fund). **CAP.374A Road Traffic (Construction and Maintenance of Vehicles) Regulations** constrain the gross vehicle weight of 3-axled medium goods vehicles to 24 tonnes.

This requirement hampers the company's efforts to electrify their medium goods vehicle fleet, as the electric vehicles they purchased weigh up to 27 tonnes. This indicates that the Highways Department will need to conduct a territory-wide road structural study before granting exemptions for payload.

3.2 Railway

Rail transport in Hong Kong stands out as an environmentally friendly mode of transportation, with all passenger carriers within the rail system running on electricity. The patronised railway network is operated by MTR Corporation Limited (MTR), offering a high-capacity and extensive public transport system. The railway plays a vital role in meeting Hong Kong's transportation needs and serves as the backbone of the transport system. In line with its commitment to addressing climate change, has set an ambitious goal to achieve net-zero emissions by the year 2050. This formidable objective rests on four key pillars, encompassing carbon emissions reduction, adoption of green energy and energy efficiency, incorporation of green and low carbon design and effective waste management to combat climate change.

MTR also provides feeder buses services for the convenience of passengers using MTR rail networks. To facilitate full electrification, MTR has procured three-axle electric feeder buses capable of carrying up to 130 passengers per trip into rail networks. However, it's worth noting that the electric fleet is not yet fully licensed for operation.

Opportunities

Enhanced connectivity with the GBA cities

The previous Policy Addresses have strongly emphasised expanding MTR development to connect with Hong Kong's new towns and neighbouring GBA cities, including projects like Hong Kong-Shenzhen Western Rail Link, which connect Qianhaiwan and Hung Shui Kiu station, and the Tseung Kwan O Line Southern Extension, which enhances transportation within Tseung Kwan O Area 137 and opportunities to adopt low-carbon innovations into operation.[xxxiv]

Hydrogen Vision

While MTR has outlined its intention to shift its feeder bus fleet from diesel to electric power, it is vital to underscore that feeder bus service does not constitute the core of MTR's operations. Therefore, replacing its feeder bus fleet may not yield a significant reduction in the scope 3 emissions. Reeling substantial reduction in greenhouse gas emission, MTR is exploring alternative clean energy sources for its railway network operation. The government has given agreement-in-principle to test hydrogen-powered light rail in Tuen Mun and has initiated the process of seeking tenders for overhead charging infrastructure and hydrogen storage facilities[xxxv].

Establishment of Science-based Target

The announcement of Science-Based Targets Initiative (SBTi) endorsement on MTR was officially made in June 2023. It is anticipated that the SBTi roadmap will be unveiled in the third or fourth quarter of the same year. MTR contemplates the incorporation of an intensity target as a standalone target for addressing scope 3, taking into consideration its multifaceted business operations, which include property development. MTR's rationale stems from its belief that relying solely on an absolute emissions reduction target might lead to an increase in emissions in the years ahead. As part of this endeavour, the SBTi has granted MTR the flexibility to establish two distinct carbon intensity target by 2030, one for its railway operations and the other for its property division.

Bottlenecks

Vehicle electrification

MTR identifies diesel feeder bus and diesel wagon as the entry point to electrification. Nevertheless, transitioning from diesel to electric bus fleet is accompanied by significant costs, which stand in stark contrast to the more straightforward diesel-to-diesel replacement. Moreover, MTR shoulders the full burden of these additional costs. While MTR has made a commitment to introduce 30 feeder buses in the Northern District by the year 2026, it is important to highlight that only one electric double-decker is currently on a trial run for feeder bus services[xxxvi]. This serves as a clear indicator of the challenges associated with expeditiously electrifying MTR's fleet of feeder buses.

3.3 Aviation

In 2018, it was reported that emissions from civil aviation accounted for an approximate of 8% of the total local emissions of air pollutants in Hong Kong[xxxvii]. The aviation industry in Hong Kong is predominantly led by Cathay Pacific and its affiliated subsidiaries, which include Hong Kong Express and Air Hong Kong. As of 2022, the Cathay Pacific and its affiliated subsidiaries operated a total number of 222 aircrafts, while Hong Kong Airline operated 30 aircrafts, representing 12% of the total aircraft in Hong Kong[xxxviii].

Opportunities

Existing Biofuel plant in Hong Kong

Hong Kong has a waste-based biodiesel plant located at Tseung Kwan O that collects waste cooking oil, acidified grease trap oil and wasted animal fat and recycle into biodiesel. A prominent airline company has engaged in discussions and research collaboration with local biodiesel firms. The aviation industry's stakeholders hold great anticipation for the potential conversion of these facilities to support the production of sustainable aviation fuels (SAF).

Bottlenecks

Biofuel Exploration

Past efforts have been directed towards exploring the application of biofuels, initially in private cars and with the potential for extension to other road transport modes. However, the absence of legislations pertaining to biofuels has been kept in abeyance for its utilisation. Government concerns have revolved around the potential rise in nitrogen oxide emissions associated with biodiesel use, which a study was revealed later that it shows no correlation between these emissions and biodiesel utilisation.

3.4 Maritime Transport

The Government in the *Hong Kong Climate Action Plan 2050* has taken proactive measures by establishing an inter-departmental working group tasked to map out the forthcoming trials involving new energy ferries. The working group will play a crucial role in overseeing the execution of these trials and evaluating the performance of electric and hybrid ferries within the local maritime context.

A consultancy study commissioned by the Environmental Protection Department (EPD) in 2017 underscored the suitability of electric and hybrid ferries for local ferry operations. While electric ferries are characterised by their proficiency in short-distance and lower-speed in-harbour routes, hybrid ferries emerge as a viable choice for outlying island routes, known for their longer sailing distance and higher speeds[xxxix].

An expert panel has been constituted, featuring local naval architects, the academia and members of an inter-departmental working group for a pilot scheme on electric ferries. The panel will assess the design proposals of electric and hybrid ferries. With trials of electric and hybrid ferries are being tentatively scheduled in 2023 and 2024 respectively, the efforts represent a significant step toward enhancing the sustainability and efficiency of Hong Kong's maritime transport.

The present transport decarbonisation policies place substantial focus on inter-river ferries. There is limited articulation on formulating ways to decarbonise ocean-going vessels except "requiring all vessels to use compliant fuel (including fuel with sulphur content not exceeding 0.5% or liquefied natural gas) within Hong Kong waters, irrespective of whether they are sailing or berthing", as stated from the CAP.311AB Air Pollution Control (Fuel for Vessels) Regulation[xl].

Opportunities

Hong Kong's first liquified natural gas (LNG) bunkering

The two utilities companies, CLP Power Hong Kong (CLP) and Hongkong Electric (HKE) in late September 2023 celebrated the commencement of the first-of-its-kind LNG Terminal that supplies low-carbon power generation located in the east waters of the Soko Island, Hong Kong[xli].

The terminal, costing over $8 billion and covering around 8 hectares of sea surface began operations in July and has already received 4 LNG transport ships by end of October, storing a total of 150,000 m^3 of LNG. The subsea pipeline connects the double berth jetty to onshore power plants and the industries. When required to fulfil local gas demand, the LNG is re-gasified into natural gas and sent out to these gas end-users.

Bottlenecks

Industry forging stronger government partnerships for progress

In the context of Hong Kong, LNG offshore operation facilities have emerged as a promising solution to meet the energy demands of incoming ships. These facilities, often operated in cooperation between entities like CLP and HKE, carry the potential to serve as bunker facilities to supply ocean-going vessels. However, maritime industry leaders encountered obstacles in the form of the government's requirement for a comprehensive safety study and reluctance to fund the studies, despite the goal of enhancing Hong Kong's standing as an international maritime hub.

Tightening of sulphur oxides fuel standards

China has enforced a stringent 0.1% sulphur limit in inland water emission control areas to mitigate maritime pollution. Ships at berth in European Union ports, Mediterranean Sea and other parts of the world also require shipping to burn fuel oil not exceeding the said limit. Racing to satisfy bunker fuel sulphur content into 0.1%, maritime industry participants ask for ensuring a level-playing field with international maritime entities and consider LNG's uptake to alleviate some pressure on the demand for bunker fuel with sulphur content less than 0.1%.

Chapter 4 Scenario Building and Methodology

4.1 Research Scope

This research engages in transportation modes that are currently operating in and are the prevalent transportation taken by the general public in Hong Kong. The diverse facets of the transportation sector within the context of this research are presented in the table below.

Table 4: Categorisation of different transport types and the delineation of the research scope

	Transport Types	Interpretation
Road Transport	Private Vehicle	Privately-owned vehicles propelled for individual uses.
	Taxi	Motor vehicle licensed to transport passengers in return for fare payment.
	Bus	Buses serving fare-paying passengers.
	Minibus	Both public and private light buses. Non-franchise private light buses are excluded.
	Goods Vehicle	Light, medium and heavy goods vehicles on road for any purposes.
	Railway and Feeder Bus	Rail transport that carries passengers and bus services feeding passengers to the railway network.
Shipping	Inter-river ferry	Shipping serving inner harbour and outlying islands routes.
Aviation	Flight traveling inbound and outbound of HK	Both freight and passenger flights serving national and international routes.

4.2 Data Retrieval

The existing data that constitutes the critical parameters for calculations, including car ownership, fuel efficiency, and the percentage of various fuel types in road vehicle fleets and inter-river ferries, is based on disclosed publications, such as the Transport Digest and Energy Utilization Index, from relevant government authorities such as the Transport Department, Electrical & Mechanical Services Department, and Environmental Protection Department. In addition to local government sources, data regarding transport turnover, especially in the railway and aviation sectors, is obtained from corporate financial and sustainability reports. All statistics shown are round-up to 2 significant figures.

In regard to database projections, the team seeks references from government issued roadmaps and key measures outlined on the government policies, as well as targets established by corporations and transport operators, such as the major bus franchises, Toyota for taxis, MTR for railway and Cathay Pacific for aviation.

Furthermore, the research team takes inferences from scholarly articles from globally recognised oragnisations (e.g. International Energy Agency, Organization for Economic Co-operation and Development (OECD) environment working papers). Such ensures the infusion of international and updated insights into our analysis and guarantees the technological plausibility of our parameters and outcomes. This also stems from the current lack of an in-depth explanation from the local government regarding how they intend to reach the mentioned goals and comprehensive investigation on technological advancement within the local context.

4.3 Scenario 1: Business-as-usual (BAU) scenario

The BAU scenario aligns with Hong Kong's existing decarbonisation policies, as outlined in the Hong Kong Transport Decarbonisation Policies section, aimed at achieving carbon neutrality by 2050. In this scenario, a backward-forecasting approach is applied and corporate efforts to reduce vehicular emissions are also considered, as many local businesses are adopting 2050 net-zero targets that complement the government's objectives. These targets encompass both short-term and long-term goals and are characterised by their measurability and a higher likelihood of successful implementation. Additionally, the scenario incorporates global assessments and predictions from intergovernmental organisations, considering technological advancements like the enhancement of EV batteries. The BAU scenario employs a predictive modelling approach to comprehensively evaluate the decarbonisation landscape.

4.4 Scenario 2: The 2050 scenario

This scenario builds upon the Business-as-Usual (BAU) scenario while also hypotheses structural and technological transformations necessary to align with a trajectory leading to net-zero emissions by 2050. A notable shift in this scenario is the substantial increase in the adoption of new energy vehicles.

4.5 Methodology

- Emissions

The calculation of carbon emissions involves both the emissions at the tailpipe and those upstream within the research boundaries. This methodology encompasses the full life cycle assessment (LCA) emissions, providing a holistic perspective on the environmental impact associated with the processes in ensuring that all relevant factors are accounted for in the analysis.

Upstream emission factor for electricity must be obtained to calculate LCA emissions for EV road transports and railway services. Data on emission factor of electricity production in Hong Kong were extracted from annual sustainability reports by CLP and HKE. In projecting the emission factor of HKE specifically for the period 2023 – 2035, it is noted HKE pledged to reduce their Scope 1 Emissions by 68.4% by 2035, equivalent to around 0.22436 kg CO_2e of HKE's electricity emission factor against 2020 baseline levels. Meanwhile, CLP targeted to attain 0.3 kg CO_2e by 2030. Thus, it is presumed that there will be a constant decrease in the emission factor throughout the projection period and projection is completed accordingly.

Table 5: Projection of upstream emission factor for electricity

	2020	2030	2040	2050
Emission Factor (CO_2e)	467.36	250.55	86.72	0

- Formula for energy consumption:

$$EC_{road} = VKT \times FE \times \alpha$$

E_{road} is the energy consumption for road transport in standard coal ton, *VKT* denotes vehicular kilometres travelled per year, *FE* denotes fuel efficiency and α (coefficient alpha) is the scale to ensure internal consistency of measures.

$$EC_{non-road} = TT \times FE \times \alpha$$

$E_{non-road}$ is the energy consumption for aviation and maritime transport in standard coal ton, TT denotes transport turnover, FE denotes fuel efficiency and α (coefficient alpha) is the scale to ensure internal consistency of measures.

- Formula for direct CO2 emission:

$$E_k = VKT \times FE_k \times EF_k \times \alpha$$

k represents fuel type, E_k is the direct carbon dioxide emissions in CO_2 (10^4 ton), *VKT* denotes vehicular kilometres travelled per year, FE_k denotes fuel efficiency, EF_k denotes combustion emission factor and α (coefficient alpha) is the scale to ensure internal consistency of measures.

- Vehicular Kilometres Travelled (VKT)

The data pertaining to Vehicle Kilometres Travelled (VKT) was obtained from the Emission Factor (EMFAC) model reports and subsequently converted to an annual basis by multiplying it by 365 days. This annualised data serves as the foundation for statistical analysis. The data is then subjected to projection using the EMFAC model, extending the analysis up to the year 2050.

Table 6[xlii]: Vehicle Classes input selected as input in correspondence to road transport types.

Road Transport Types	**Input Selection**
Private Vehicle	Private Cars (PC)
Taxi	Taxi
Bus	Non-franchised Bus <=6.4t Non-franchised Bus 6.4-15t Non-franchised Bus 15-24t Non-franchised Bus >24t Franchised Bus (Single Deck) Franchised Bus (Double Deck)
Minibus	Public Light Buses Private Light Bus <=3.5t Private Light Bus >3.5t
Goods Vehicle	Light Goods Vehicles <=2.5t Light Goods Vehicles <3.5t Medium Goods Vehicles <=15t Medium Goods Vehicles 15-24t Heavy Goods Vehicles >24t

- Fuel efficiency

A lower figure represents higher fuel efficiency among vehicles. The data on fuel economy for various vehicle types is sourced from Energy Utilisation Index – Transport Sector published by the Electrical & Mechanical Services Department.[xliii] In line with estimates made by Tikoudis et al., which indicated a 2.3% increase in fuel efficiency for **conventional vehicles** by 2050.[xliv]

Fuel efficiency of **electric vehicles** by estimation would undergo an annual reduction of 0.1 kWh per 100 kilometers from 2030 to 2050[xlv], with the presumption that the said general trend of electric battery enhancement applies universally on all types of vehicles. The rationale lies in the similarity of electric batteries that are used in vehicles, with the primary distinction being the battery's volume or capacity, which varies to accommodate vehicles of different weights. Nonetheless, there is no compelling reason to believe that the volume of batteries would impact the energy efficiency. Hence, it could be in-principle presumed that the said general trend of electric battery enhancement applies universally to all types of vehicles.

The fuel efficiency of **hydrogen fuel cell** vehicle[xlvi] for heavy goods vehicles cite 9 kg per 100 kilometers[xlvii]. Hydrogen fuel efficiency for buses is presumed to be on par with that of HGVs. Likewise, the fuel efficiency for LGV is also applicable to minibuses. Meanwhile, MGV are expected to achieve a hydrogen fuel efficiency rate of 6 kg per 100 kilometers.

- Fuel type percentage of fleet

The data for the distribution of fleet fuel types is sourced from Table 4.4 sectioned Registration and Licensing of Vehicles by Fuel Type of the Monthly Traffic Digest. From 2023 onwards, the projected percentages were derived from a variety of government policies and objectives, particularly those outlined in the Climate Action Plan 2050, as well as internal decarbonisation targets formulated by transport operators.

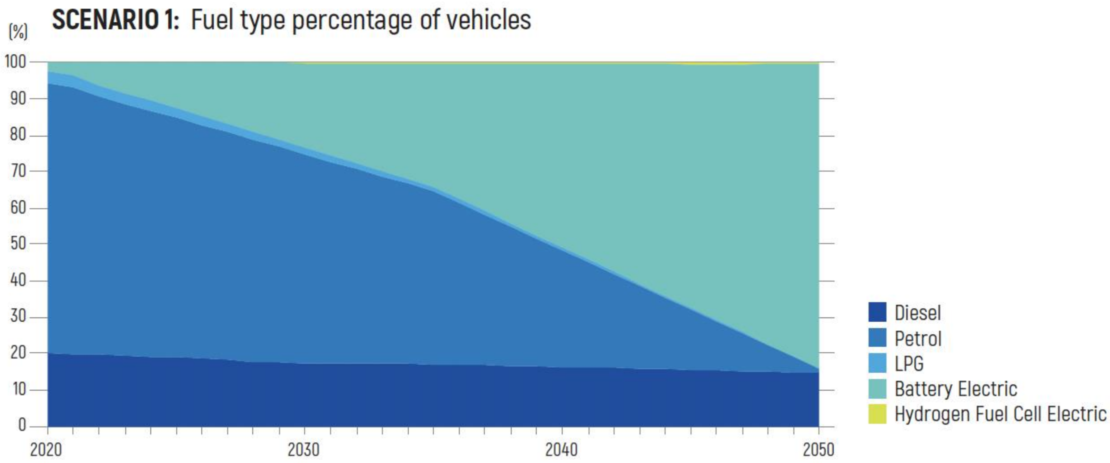
In cases where specific fuel type percentages were not determined by any relevant transport stakeholders in Hong Kong, the research teams devised projections for Scenario 2, as detailed in Table 9. This approach ensures a well-informed assessment of the fuel type distribution within the vehicle fleet.

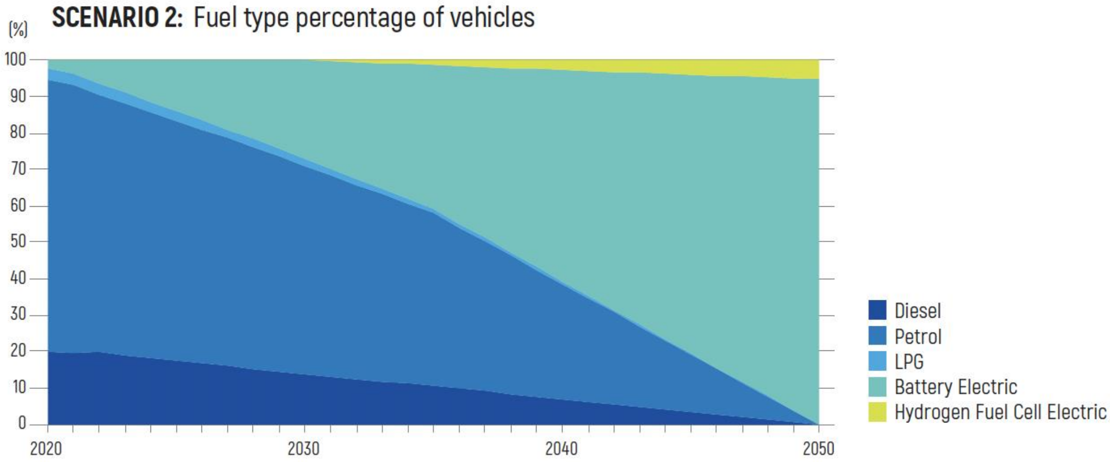
Chapter 5 Research Findings

5.1 Battery electric vehicles lead among new energy vehicles in Hong Kong.

In both scenarios, the adoption of battery electric vehicles after 2035 shows an outsize rise than its previous years. Compared to the BAU Scenario, the 2050 scenario shows a rather salient dwindling in both petrol-licensed and diesel-licensed vehicles, as indicated by a steeper downward trajectory.

Figure 2: Projections on fuel type percentage of each roadside vehicle type under the BAU Scenario and 2050 Scenario



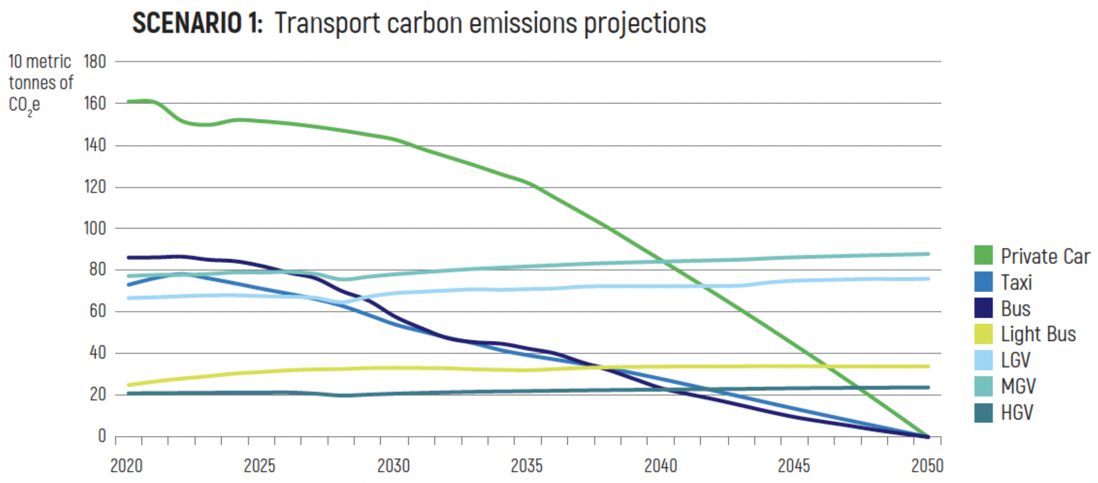


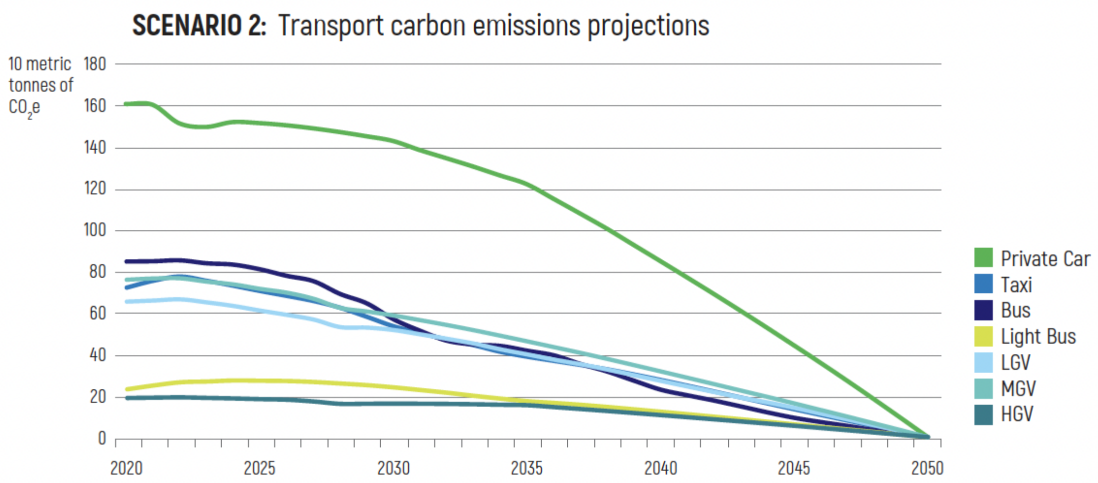
5.2 Medium goods vehicle-specific measures could take precedence in upcoming EV Roadmap to reduce commercial vehicles emissions.

As shown in figure 3, the variation between the BAU and 2050 scenario for roadside emissions is largely attributed to a change in fuel type percentage of fleet. Using 2020 statistics as baseline, light and medium goods vehicles could optimistically halve their emissions in 2038.

Likewise, minibus and heavy goods vehicles in the 2050 scenario could halve their emission by 2040 and 2041 respectively. This underscores the importance of bringing progressive commercial vehicles-targeted initiatives into play so as to lay the groundwork in reaching zero vehicular emissions by 2050.
Midway through the timeframe, medium goods vehicles present the second largest roadside emissions source. Despite light and heavy goods vehicles attain higher statistics for VKT per year, medium goods vehicles contribute to higher vehicular emissions as a result of a proportionately lower fuel efficiency projections. Measure specific to medium goods vehicle could be prioritised in their upcoming EV Roadmap to effectively reduce roadside emissions brought by commercial vehicles.
Regarding passenger transport, as private cars continue to play a pivotal role in achieving carbon neutrality, local government should integrate the promotion of new energy vehicles with measures that encourage mode-shifting to reduce emissions.

Figure 3: Projections on roadmap vehicular emissions under the BAU Scenario and 2050 Scenario, by vehicle types



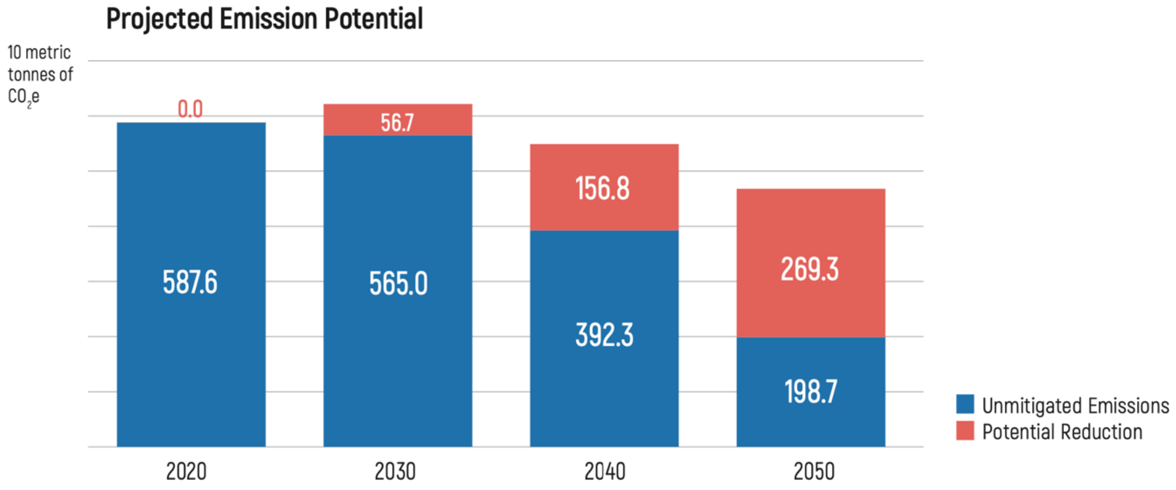


5.3 Taking action to a maximum extent, enhanced efforts could embark upon a 'two-speed' emission reduction path earliest by 2048.

In figure 4, each bar illustrates the anticipated emissions based on decarbonisation and corporate initiatives that are discernible to the general public. The orange-shaded area represents emission potential as key transport stakeholders undertakes on a more assertive adoption of new energy vehicle, mainly by manifesting more new energy vehicles in operation and proactively set up required charging and fuelling infrastructures.

In this side-by-side evaluation of the two scenarios, if the key-themes of roadside decarbonisation policies are established in advance to settle business sentiment, it is evident that the commercial sector's enhanced efforts reaffirmed by visionary regulatory frameworks, could lead to doubling emission reduction potential earliest by 2048 (51.01%).

Figure 4: Potential roadside emissions reduced through the NEV adoption and technological advancements.



Note: Potential emission reduction is obtained by subtracting the more assertive 2050 scenario (Scenario 2) from the Business-as-usual scenario (Scenario 1).

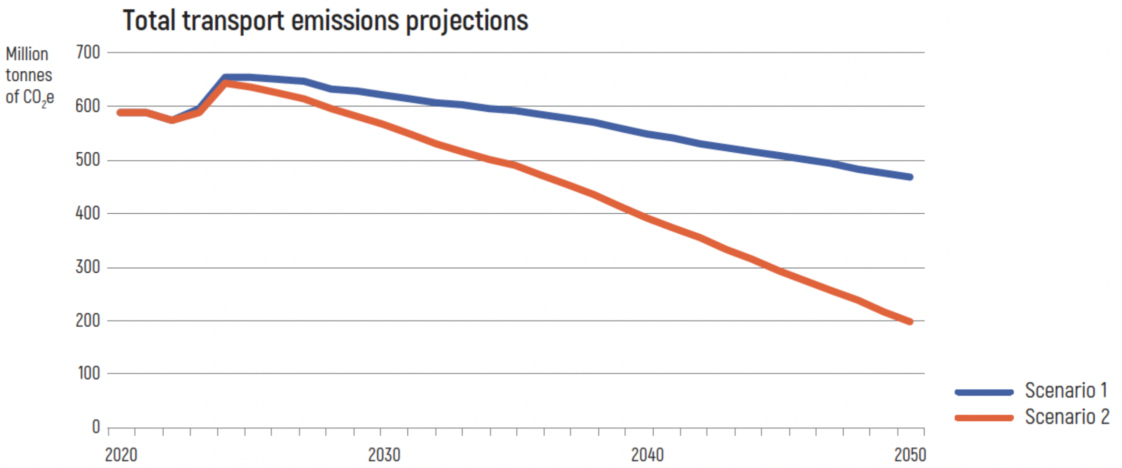
5.4 Carbon neutrality by 2050 for Hong Kong's transportation sector is a challenging goal.

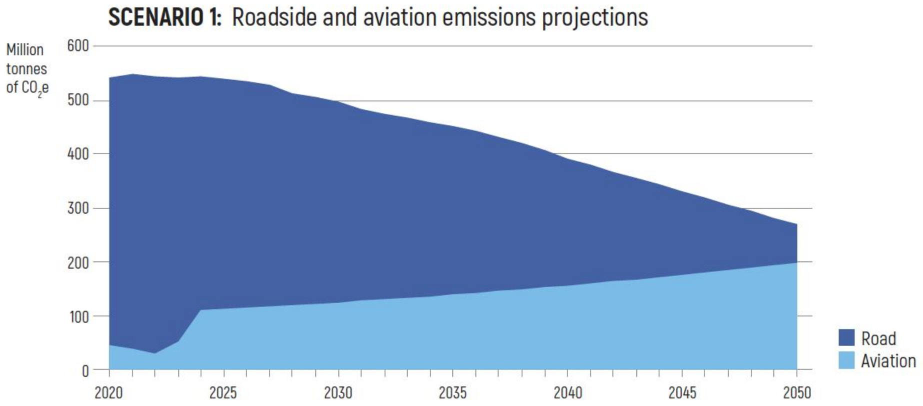
Both scenarios identify the year 2024 as the peak of Hong Kong's carbon emissions in its transportation sector, with that said, the apexes Hong Kong's transportation emissions would be at 0.66 million tonnes and 0.664 million tonnes carbon emissions for BAU Scenario and 2050 Scenario respectively.

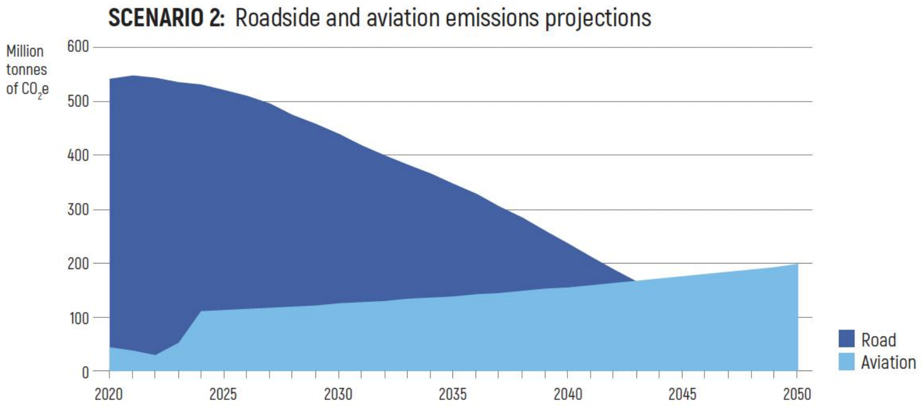
As per the 2050 scenario, emissions generated apart from roadside vehicles demonstrate a different pattern of emission projection throughout the period. Inter-river ferry fleet shows a reduction in emissions in year 2040 onwards. Meanwhile, aviation emissions would experience a more than proportionate surge in both freight and passenger flight emissions on 2024, as a result of heightened air travel during the post-COVID pandemic recovery.

In both scenarios, nonetheless, aviation is expected to be a significant factor that could impede Hong Kong's ability to achieve net-zero in transport sector, resulting in an estimated 0.20 million tonnes carbon emissions in 2050 that is required to be reduced. The aviation industry still faces a multitude of challenges in its journey toward full decarbonisation, including the adoption of sustainable propulsion technologies and modification of existing infrastructure to accommodate them.

Figure 5: Projections on roadside, inter-river ferries and aviation emissions under the BAU Scenario and 2050 Scenario







Chapter 6 Policy Recommendations

For Hong Kong to leap towards a carbon-neutral environment, decarbonising the transport sector is crucial. This research details the landscape of the high emissions transportation sector and analysed scenario-based potentials to reduce vehicular emissions from the various public and private transport modes in Hong Kong. It is vital to bring together the government and like-minded sustainability practitioners under one roof to implement ambitious sectoral transition pathways to accelerate climate action as well as initiate **proactive stakeholder engagement** to better understand the needs and ambitions of the private sector.

6.1 All-embracing policy engagements on transportation

An **overarching transport decarbonisation pathway** must be clearly defined and adopted to achieve net-zero emissions, aligning itself with the Hong Kong government's 2050 target. This necessitates an integrated approach to rethink land use and transportation for future planning. By planning future developments in the vicinity of transport nodes, this can optimise the capacity of public transport and allow the government to put these recommendations into consideration in its upcoming *Hong Kong Roadmap on Popularisation of Electric Vehicles.*

6.1.1 Modulate financial assistance to steer new energy vehicles development in Hong Kong

Since the commencement of the vehicular fleet's decarbonisation efforts, industry players have expressed intentions/tendencies to utilise the current government financial support mechanism. New energy vehicle owners are aware of the disproportionality between the subsidised amount and the actual financing that is needed for the transition. To yield the full potential of the budgets provided, the government can reevaluate its funding model to contain **guarantee coverage funding** and **competitive financing** that supports vehicle electrification. The model should also ensure the purpose of funding consistencies from cradle-to-grave, covering a range of contract lengths. For instance, the funding model should touch upon minimising stakeholders' upfront costs on acquiring new energy vehicles, operating and infrastructure costs, as well as scrappage costs when the new energy vehicle retires.

Additionally, the government can curate a **land transport sandbox** to expedite the market of future innovations in urban transportation. By examining versatile technologies through a controlled environment that is currently not covered under the scope of current standards and regulations, the sandbox can create an enabling environment for rapid trials and large-scale deployment of proven technologies.

6.1.2 Revamp on Hong Kong-wide transportation decarbonisation policies

This section is dedicated to the upcoming 5-year periodic review of the *Roadmap on Popularisation of Electric Vehicles*, which should review its electrification policy concerning all types of vehicles.

The government can reinforce carrot-and-stick actions by ceasing new internal combustion engine vehicle (ICE) registration by 2050, subject to each vehicle type. One of the findings delves into the replacement potential of diesel vehicles with electric or zero-emission vehicles. That is to say, the government could move the registration year of ICE private vehicles forward to **2030**; ICE buses to **2032**; and ICE commercial vehicles to **2035.** For instance, scenario 2 describes that by 2035, diesel fleets will persist at a range of 50-75% amongst each good vehicle type, according to the data model. It takes the government 8 years to phase out Euro-

IV commercial vehicles. Beginning in 2023, it gives an ample 12 years to phase out Euro-V and Euro-VI and a green light to set cessation by 2035.

Other Hong Kong-wide initiatives pertaining to current policy development could be suggested as below:

- Consider heightening restrictions within the **phasing out policy for Euro-IV and Euro-V** commercial vehicles, by virtue of new technologies emergence.
- Devise **targets for a progressive rise** in zero-emission vehicle sales.
- Establish a **toll concession** on ICE-propelled transport modes.
- Reposition current **Low Emission Zones** located in Central, Causeway Bay, Mong Kok, with the compliant vehicle types extended to bus and commercial vehicles.
- Provide **custom clearance incentives** (i.e. toll fee or green channel) to accelerate the cross boundary time.

As cross-boundary activities between Mainland cities and Hong Kong become increasingly prevalent, Hong Kong must equip its bureaucratic fundamentals whilst giving the go-ahead to facilitate coordination with the Mainland cities. The roles and responsibilities for each bureau and its subsequent department, such as the Electrical and Mechanical Services Department and Environmental Protection Department must be clarified to better reinforce the inter-departmental relations and to implement policies accordingly.

6.1.3 Establish a cross-boundary collaboration platform with Mainland China

A regional sustainable future of transport should incorporate a **green transport corridor (GTC) ecosystem**. The concept of GTC uses an array of greener transportations to satisfy the objective to reduce environmental and climate impact while increasing safety and efficiency with the application of sustainable logistics solutions[xlviii]. With policy regulation being the entry point to develop GTC ecosystem, the government can conduct regulatory amendments by removing rigid ordinances that impede the swift deployment of the latest mainland and international technologies from being imported and operated within Hong Kong. Moreover, the government can implement preferential policies to attract and encourage logistic companies to actively participate in the GTC ecosystem.

In particular, the government can make plans to introduce mainland vehicle manufacturers that are necessary to stimulate demand for Mainland NEVs and strengthen transport connectivity. Ways to expand model availability include:

- Incentivise Mainland manufacturers like BYD Company and Great Wall Motors to manufacture right-hand drive vehicles.
- InvestHK to consolidate a catalogue of mainland new energy vehicles, informing the public of recommended vehicles regarding its operational performances and standards.

6.1.4 Develop Green hydrogen supply chains

In tandem with the forthcoming development on the usage of hydrogen energy in road transport, the government could develop a **comprehensive grey-to-green hydrogen roadmap** that outlines a transition timeline to solicit confidence in hydrogen vehicles for vehicle owners, for example, setting a penetration target for hydrogen fuel cell vehicles for 2025 and 2030.

In doing so, a possible entry point could be leveraging the **inter-departmental Working Group** on hydrogen matters. A high level of transparency could be maintained on issues to:

- engage international testing corporations to recommend relevant hydrogen standards applicable to Hong Kong.

- set up a fund to specifically support pilot projects on hydrogen technology.
- absolve hydrogen fuel cell vehicles from regulatory constraints without compromising safety.

Given Hong Kong's position as a robust international finance centre, the government should create a **carbon certification and trading platform** in Hong Kong to attract the development of green hydrogen. Specifically, an intact certification and trading platform could assist f**ranchised bus operators** in conducting hydrogen trials on battery electric buses in parallel with identifying compatible technologies that are suitable under local conditions.

6.1.5 Expedite electric vehicle infrastructures for road transports

The government can carry out a **strategic study** aimed at identifying potential fast-charging locations. This includes the potential installation of EV charging in the 500 taxi stands and 180 gas stations; as well as leveraging hotel chains, cruise terminals and airports possessing extensive locations across all Hong Kong districts, at the same time providing adequate parking spaces to avoid long queues. There is a tendency to enable private chargers (ie. franchised bus depots chargers) into public use. Further engagement with contractors to provide, manage and operate the common charging facilities at public transport interchanges would aid in creating a reliable EV charging infrastructure.

Due to Hong Kong's land constraints, there is a need to **adopt fast chargers** above 100kWh to maximise the efficient use of spaces. The Scheme of Control Agreement (SCA) can contribute to facilitating power companies' future investments over power grid infrastructure, as well as signalling public confidence to procure electric vehicles.

Charging standards for electric buses and commercial vehicles between mainland cities and Hong Kong have not been fully consolidated. There is a need to examine alternative charging technologies (i.e. battery swapping technology) by exploring other Greater Bay Area (GBA) counterparts for the large-scale deployment of EV charging infrastructure in the mid-to long-term. Both newly built and existing charging facilities should pay attention to charging standards alignment. Lastly, a publicly accessible **platform** for charging facility providers displaying charging locations and payment could be invented for a better user experience.

Regarding **battery disposal** issues, a revenue-neutral levy on private EV buyers could be imposed aiding the development of a battery disposal and recycling system in Hong Kong. Enshrining the Principle of Polluter Pays, the authority should keep none of the money collected from the levy and redistribute all of it on the aforementioned system. Stakeholder partnerships including local start-ups and battery recycling industries would ensure cradle-to-cradle cycle of batteries, as well as obliging vehicle manufacturers to arrange vehicle owners a free removal service for disposal of batteries that are no longer to be used.

6.2 Specific Actions actualising decarbonisation pathways

Transportation faces unique transition challenges that can be addressed by using an in-depth investigation of each transport modes' fuel efficiency, technological readiness, turnover etc. Referencing Civic Exchange's previous reports, a 5% modal shift target through incentives mechanisms should be set in place to create a demand shift from private vehicles to public transportation. For Aviation and Shipping, Hong Kong can reposition itself as a Green Fuel hub and regional trading platform for aviation and maritime A clear pathway is needed to signal to the international stakeholders.

6.2.1 Private Vehicles

- Increase **First Registration Tax** and impose vehicle licence quotas for fuel-propelled vehicles.

6.2.2 Taxis

- Implement an **incentive-cum-regulatory** programme with a strict timeline and sufficient incentives, with reference to the experience in promoting electric private cars in Hong Kong.
- Conduct **large-scale trial** on a fleet-level to identify operational issues and cost differences, in the meantime provide sufficient electric taxi models with comprehensive maintenance support.

6.2.3 Bus and Minibus

- Offer bus operators with land **development rights** at public transport interchanges or depots with reference to the rail plus property (R+P) model.
- Contemplate **in-the-pit scenario** to optimise EV chargers sharing and coordination between E-bus and E-minibus users.
- Define an **appropriate funding model** for commercial bus operators, which is to provide innovative solutions to support fleet transition from start to finish through designing a proven system resolving land use issues that is operational cost-saving. A funding model distinguishes itself from subsidies would effectively lessen the burden for private investors to seek long-term finance.
- Refine **intermodal public transport system** to position bus services as the cornerstone for all passenger transport modes. Features include setting up public transport exclusive corridors, direct bus routes at peak hours; and a feasibility and demand responsivity study of a trunk feeder bus route system.

6.2.4 Goods Vehicles

- Invest on new **transportation management system (TMS)** to improve truck efficiency from both software and hardware perspectives.
- **Loosen up the maximum gross vehicle weight** in Hong Kong to compensate the battery weight that is around 1-2 tonnes.
- Identify delivery hotspots and set up **emission-free zones** for loading and unloading activities.

6.2.5 Aviation

- Incorporate **consumer-borne carbon tax** and solicit the adequate amount for SAF development.
- Establish **regional SAF joint-supply storage** and initiate discussions on accommodating China's SAF application standards to the rest of the world as well as leveraging Hong Kong biofuel bunkering operation.
- Impose a **mandate** on airline company's SAF use while ensuring the level-playing field principle, with reference to current SAF usage targets enacted by leading airline companies.
- Inaugurate a **central working group** to assist SME airlines in conducting SAF group purchase dialogues.

6.2.6 Maritime Transport

- Develop green shipping fuel bunkering hub offering pipe-to-port services at berth to keep pace with other Asian seaports.
- Seek partnerships between seaports to accelerate maritime freight decarbonisation through regulatory, green fuel infrastructural and technological changes.
- Utilise developed networks (e.g., Hong Kong Container Terminal Operators Association, Liner Shipping Association) in Hong Kong to expand LNG bunkering capability.
- Consider onshore power supply (OPS) installation to reduce vessel emissions by providing a cleaner power source to support lighting and other onboard activities of berthed ships.
- Conduct evaluative studies (e.g., Quantitative Risk Assessment, Marine Traffic Impact Assessment) that are necessary to put forward marine standards and requirements and ensure safety under Simultaneous Operations (SIMOPS)
- Safeguard **LNG bunkering supply**, measures include but not limited to:
  - Reviewing the safety, reliability and environmental impacts of the liquefied natural gas supply and consider introducing additional supply infrastructure and large-scale reload capability
  - Introducing measures to attract LNG-fuelled vessels calling Hong Kong
  - Utilising the potential of Hong Kong's first LNG floating storage, Hong Kong Offshore Liquefied Natural Gas Terminal (HKOLNGT) and re-gasification unit (FSRU) supplying electricity generation plants for vessel use.
  - Extending the port LNG stations licensing duration to prevent complex procedures needed in order to reinstate the contract.
- Promote **hydrogen** as alternative bunkering fuel
  - Explore the feasibility to build hydrogen production facilities and promote the use of hydrogen as marine fuel

Appendix Supplementary Information for Methodology

- Fuel Efficiency

The Government in the Energy Utilisation Index – Transport Sector has delineated the fuel efficiency for vehicles according to their types and service scopes (e.g. fuel efficiency for Private Vehicles (Diesel) is broken down into fuel efficiency for Private Diesel Vehicles with different engine sizes, taxis serving different regions of Hong Kong also have different fuel efficiency). Therefore, to complete the spreadsheet, we must first calculate the average of fuel efficiency of a particular type of vehicle.

Calculation of fuel efficiency (using Private Vehicles as example):

- Step 1: Number of Registered Vehicles with engine size ≤ 1,000cc [xlix] x $\frac{\text{Total Number of Licensed Vehicles}}{\text{Total Number of Registered Vehicles}^{l}}$ = Number of Licensed Private Vehicles with engine size ≤ 1,000cc
- Step 2: Fuel efficiency of Vehicles with engine size ≤ 1,000cc x $\frac{\text{Number of Licensed Vehicles with engine size} \leq 1{,}000\text{cc}}{\text{Total Number of Licensed Vehicles}}$
- Step 3: Repeated Steps 1 & 2 for Vehicles with other engine sizes.
- Step 4: Sum up the results in Steps 2 & 3 to get the fuel efficiency for Private Vehicles.

Table 7: Projected fuel efficiency of various transport modes for Scenario 1 in standard coal ton.

Transport Mode	2020	2030	2040	2050
Private Car	73.8	70.2	50.1	20.0
Taxi	42	32	18.6	3.9
Bus	41.2	31.5	27.6	19.5
Minibus	13.1	16.7	16.2	16.2
Light goods vehicle	31.9	33.1	34.7	36.8
Medium goods vehicle	9.9	37.4	40.4	42.5
Heavy goods vehicle	15.7	9.8	10.8	11.3

Table 8: Projected fuel efficiency of various transport modes for Scenario 2 in standard coal ton

Transport Mode	2020	2030	2040	2050
Private Car	73.8	70.2	50.1	19.9
Taxi	4	4	4	4
Bus	41.2	30.6	26.6	16.8
Minibus	13.1	15.0	11.3	8.0
Light goods vehicle	31.9	27.7	21.6	14.6
Medium goods vehicle	37.0	32.0	27.7	21.4
Heavy goods vehicle	9.9	9.2	8.8	7.3

Table 9: Suggested new energy fuel type percentage of fleet agreed by project team

Transport Mode	Fuel	2020	2030	2040	2050
Bus	Battery Electric	0	0	30	60

	Hydrogen Fuel Cell	0	0	20	40
Minibus	Battery Electric	0	0	30	60
	Hydrogen Fuel Cell	0	0	20	40
Light goods vehicle	Battery Electric	0	0	40	80
	Hydrogen Fuel Cell	0	0	10	20
Medium goods vehicle	Battery Electric	0	0	30	60
	Hydrogen Fuel Cell	0	0	20	40
Heavy goods vehicle	Battery Electric	0	0	30	60
	Hydrogen Fuel Cell	0	0	20	40
Aviation	Sustainable aviation fuel	0	10	39	65
Ferry	Electric inter-river ferry	0	0	0	100

Endnotes

[i] https://www.ipcc.ch/site/assets/uploads/sites/2/2019/06/SR15_Summary_Volume_Low_Res.pdf
[ii] https://civic-exchange.org/wp-content/uploads/2023/04/GBA_EN.pdf
[iii] https://www.carbonbrief.org/analysis-chinas-co2-emissions-hit-q1-record-high-after-4-rise-in-early-2023/
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[viii] https://www.eeb.gov.hk/sites/default/files/pdf/cap_2050_en.pdf
[ix] https://www.evhomecharging.gov.hk/downloads/ev_booklet_en.pdf
[x] https://ledsgp.org/app/uploads/2016/01/SUTP_GIZ_FS_Avoid-Shift-Improve_EN.pdf
[xi] https://www.pland.gov.hk/pland_en/p_study/comp_s/hk2030plus/TC/document/2030+_booklet.pdf
[xii] https://www.eeb.gov.hk/en/new-energy-transport-fund.html
[xiii] https://www.legco.gov.hk/yr2023/english/panels/tp/papers/tp20230714cb4-680-3-e.pdf
[xiv] https://www.td.gov.hk/filemanager/en/content_5211/2306_e.pdf
[xv]https://www.td.gov.hk/filemanager/en/content_4889/How%20to%20Participate%20in%20the%20OFO%20Scheme_English_rev23Dec2021.pdf
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[xxi] https://www.info.gov.hk/gia/general/202212/14/P2022121400261.htm?fontSize=1
[xxii] https://www.devb.gov.hk/filemanager/tc/content_437/article.pdf
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[xli] http://www.hongkongmaritimehub.com/17324-2/
[xlii] https://www.epd.gov.hk/epd/sites/default/files/epd/Briefing%20on%20EMFAC-HK%20Update%20V4.3.pdf
[xliii] For data in 2020 and 2021, please see https://web.archive.org/web/20210804093635/https://ecib.emsd.gov.hk/index.php/en/energy-utilisation-index-en/transport-sector-en. For data in 2022, please see https://ecib.emsd.gov.hk/index.php/en/energy-utilisation-index-en/transport-sector-en.

[xliv] It is worth noting that the unit of measurement in the paper was km/m3. To align with this, a unit conversion is necessary, resulting in a 2.3% decrease in our specific case. Therefore, an overall reduction of 2.3% is applied when projecting the data until 2060, presuming that the percentage decrease remains unchanged even after 2050 (which is beyond the research scope of the said OECD Paper).

[xlv] https://enveurope.springeropen.com/articles/10.1186/s12302-020-00307-8

[xlvi] https://theicct.org/publication/fuel-cell-tractor-trailer-tech-fuel-jul22/

[xlvii] following a hydrogen unit conversion of 1kg=11.126 m3

[xlviii] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52001DC0370&from=SL

[xlix] The Government has only provided the data on the number of registered private vehicles by their engine size, instead of the number of licensed vehicles.

[l] Tables 4.2 and 4.4 of the reports published for 2022, 2021 and 2020 accessible via https://www.td.gov.hk/en/transport_in_hong_kong/transport_figures/monthly_traffic_and_transport_digest/index.html

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