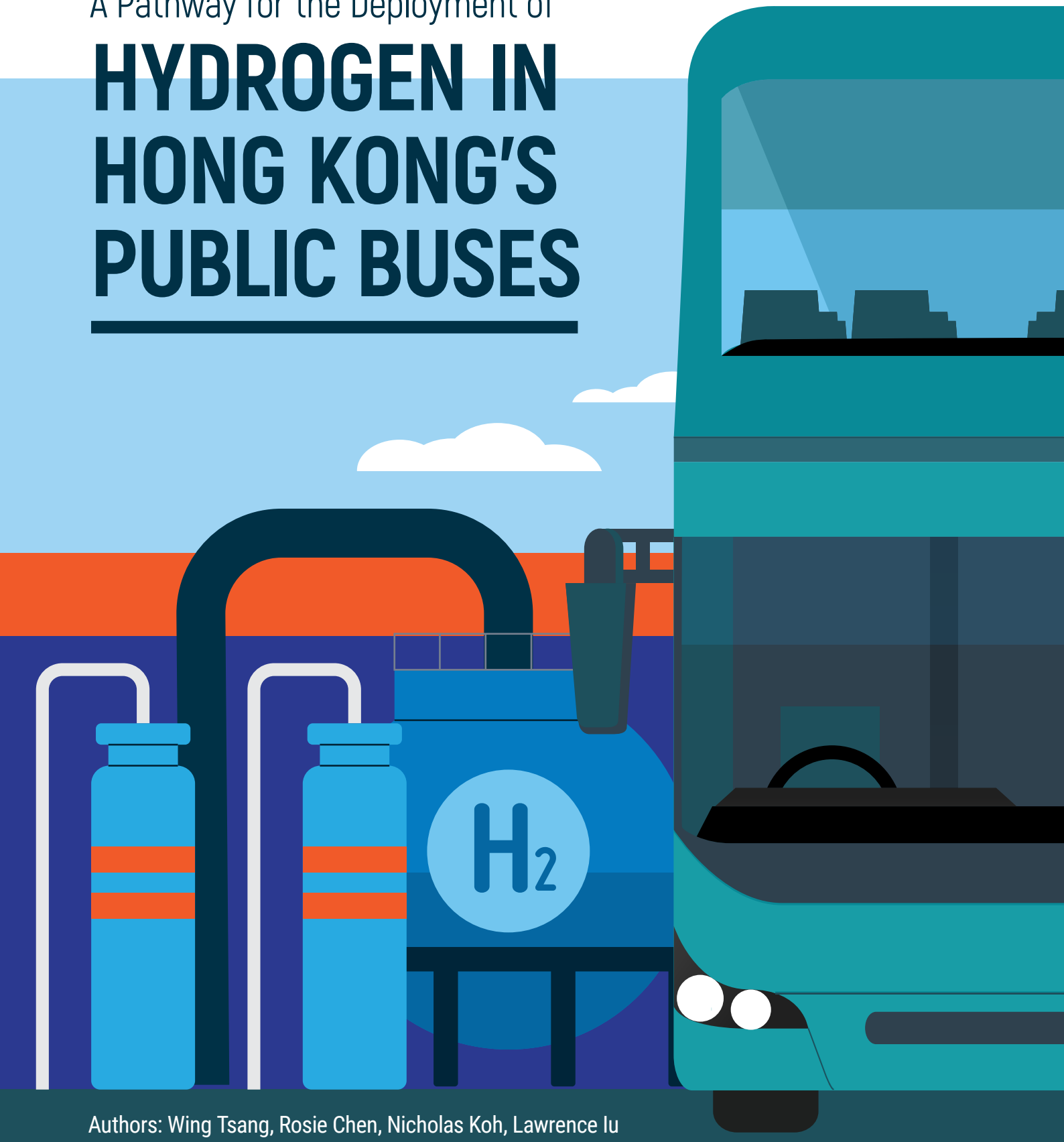
A Pathway for the Deployment of

HYDROGEN IN HONG KONG'S PUBLIC BUSES



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EXECUTIVE SUMMARY

Background: Paving the way for carbon-neutral bus operations

Growing concerns about climate change has prompted a shift towards using hydrogen as a solution for reducing greenhouse gas emissions. In the transport sector, bus operations account for 2% of Hong Kong's total greenhouse gas emissions. To achieve the city's 2050 carbon neutrality goal, bus franchises established their own zero-emissions target in 2022, identifying hydrogen fuel cell and battery-electric buses as versatile replacements for fossil-fuel used today.

Hong Kong's Bus Operations: A Global Model

Hong Kong's franchised bus operations serves as a world-class model for livability and sustainability. The franchise terms enable operators to retain all passenger revenue, manage route adjustments, and benefit from their efforts in improving productivity.

Challenges in Transitioning to Zero-Emission Buses

To meet the 2050 carbon neutrality commitment, bus franchises must navigate challenges such as the mandatory retirement of buses after 18 years of service and the financial impacts of declining patronage during the pandemic. These factors have necessitated the development of a transition plan, encouraging companies to phase out conventional fuel buses by 2032 to align with the long-term goal of carbon neutrality.

Policy Support for New Energy Adoption

The Hong Kong Government has introduced key policies, including the Climate Action Plan, the Roadmap on Popularisation of Electric Vehicles, and the Strategy of Hydrogen development in Hong Kong, to support the adoption of both hydrogen fuel cell and battery-electric solutions, tailored to the city's unique topography and climate conditions. Hydrogen fuel cell double-decker buses offer a compelling value proposition, with advantages such as long range, fast refuelling, heavy payload capacity, and zero tailpipe emissions compared to other fuel types.

To foster innovation in low carbon technologies, the Government has launched the New Energy Transport (NET) Fund and the Green Tech Fund (GTF) . Additionally, the issuance and amendment of technical guidelines and ordinances respectively have laid a solid foundation for the safe adoption of hydrogen as a fuel.

A Viable Green Transition Business Model

Understanding the business models of leading cities in decarbonising bus operations is crucial for Hong Kong as it seeks to reform its bus franchise model for a complete fleet transition. While London and Singapore operate right-hand drive double-decker buses similar to Hong Kong, their models diverge significantly. Singapore's collaborative approach and London's focus on innovation offer greater flexibility for technological advancements and quality improvements—areas which Hong Kong's model leaves limited room for enhancement.

Notably, Hong Kong's bus companies underwent a major transition in the 1980s by introducing air-conditioned buses as a premium service, ultimately justifying higher fares with improved service quality. However, new energy buses may not immediately resonate with passengers or present a clear value-added experience. Therefore, a re-evaluation of the business model is essential to ensure alignment with market expectations to foster acceptance when introducing new energy buses to the fleet.

Financial Implications of Transitioning to New Energy Buses

This white paper conducts a financial analysis of the total cost of ownership (TCO) for franchised bus operators in Hong Kong. Key findings indicate that the TCO for hydrogen fuel cell buses in Hong Kong is 53% higher than in Mainland China, primarily due to differences in hydrogen pricing. The white paper also presents three bus procurement conditions and a bus retirement schedule identifying the annual number of buses reaching the end of their useful life.

The analysis reveals a significant financial gap of significant financial gaps of $5.7 billion needed to transition all buses to new energy alternatives. To bridge this gap, this white paper explores seven bus business models used in other cities, identifying best practices, challenges and solutions to inform Hong Kong's approach to decarbonising its bus operation system.

TABLE 1
Scenario Comparison

Scenario	Ownership	Operation	Revenue Stream	Government Role	Examples
BAU	Private	Private	Farebox income, advertisements	Franchise agreements	Franchised bus in Hong Kong
Carbon Offset Reliance	Private	Private	Farebox income, advertisements	Franchise agreements	n/a
B+P	Private	Private	Farebox income, property development	Property development rights	Rail-plus-property model
PPP	Government	Private	Farebox income	Owns assets, contracts operation	Land Transport Authority in Singapore
Government with asset ownership and operation	Government	Government	Government funding	Owns and operates	Guangzhou Public Transportation Group
Government subsidising franchised companies	Private	Private	Farebox income, advertisements	Subsidies for assets and operations	n/a
Leasing Contracts	Service Provider	Private	Per mile payment	Owns assets	Enel X in Santiago

TABLE 2
Cost Structure comparison of different scenarios to bus franchises

Scenario	Initial investment	Operational Costs	Maintenance Costs	Revenue Potential	Government Subsidy Required
BAU	Moderate	High	High	Moderate	None
Carbon Offset Reliance	Moderate	High	High	Moderate	None
B+P	High	Moderate	Moderate	High	Low
PPP	High	Low	Low	Moderate	Moderate
Government with asset ownership and operation	Very High	Low	Low	Low	High
Government subsidising franchised companies	Moderate	Moderate	Moderate	Moderate	High
Leasing Contracts	Low	Moderate	Low	Moderate	Moderate

Stakeholder Insights on Achieving a Zero-Emission Bus Fleet

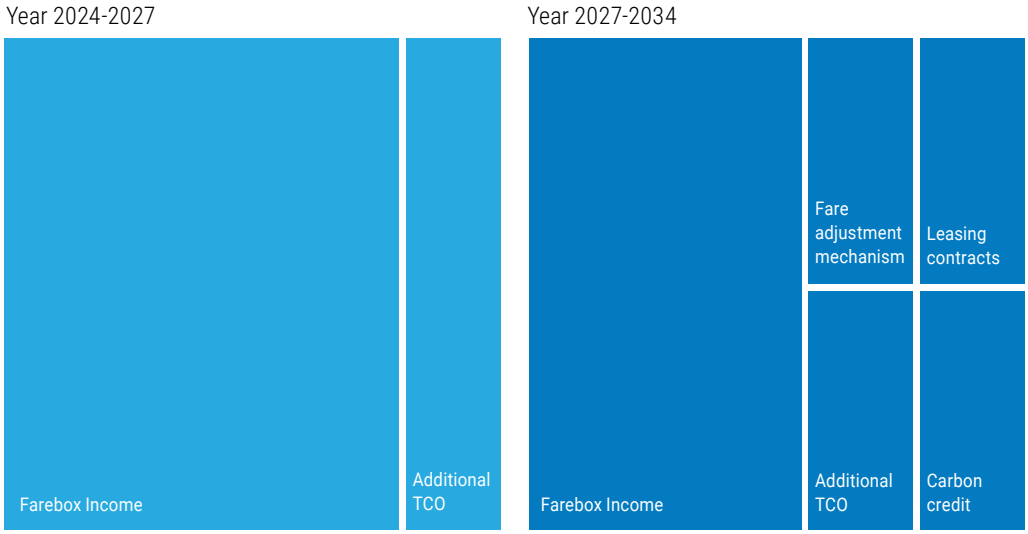
Three rounds of strategic stakeholder interviews were conducted with industry experts in the franchised bus sector. The insights gathered highlight critical aspects of the zero-emission goal, scalability, fare predictability, service differentiation, and non-franchise revenue earnings that goes beyond a financial way.

- The Zero-Emission Goal: Bus franchises are less likely to replace diesel buses on a one-to-one basis; the replacement ratio is estimated at 0.8 to 0.9, signifying the need for careful fleet management planning.
- Scalability: Fleet-level trials should be conducted to deliver an optimised zero-emissions bus fleet and develop enhanced infrastructure, in a way to reflect the true cost of new energy applications from a whole-life cycle perspective.
- Fare Predictability: In a new energy transition, bus operators must adopt rule-based approach to adjust fare increments or deductions at a rational level, all while fostering high levels of bus service quality.
- Service Differentiation: Bus franchises should enhance services in terms of efficiency, affordability and competitiveness throughout the new energy transition processes.
- Beyond Financial Support: Relying only on Government subsidies is not a sustainable approach for transitioning to new energy solutions. Instead, a comprehensive plan is needed for charging and hydrogen refueling stations, as well as related infrastructure.

Recommendations for a Sustainable Fleet Transition Hub

The white paper proposes an innovation-supportive business model to transition Hong Kong's bus fleet from diesel to new energy vehicles. It addresses the current model's reliance on farebox revenue as insufficient for funding upfront investments for fleet transition. The model will position Hong Kong as the hub to showcase the Mainland's hydrogen fuel cell and battery electric buses proof-of-concepts.

Income and Expenditure Account under innovation-supportive business model



Short-Term (2024–2027)

Subsidies: Provide subsidies to cover the additional TCO incurred by bus operators, including capital and fuel cost differences, to meet the Government's short-term target of introducing 700 electric buses by 2027.

Medium- to Long-Term (2027–2034)

1. Fare Adjustment Mechanism: Introduce a fare adjustment mechanism to ensure fare increments or reduction certainty and transparency during the transition while supporting long-term decarbonisation investments and public affordability.
2. Leasing Contracts: Implement a bus leasing system to reduce capital expenditure and improve cash flow by transferring asset ownership. Leasing contracts could also include rental buses with extended lifecycles to offset costs of new energy buses.
3. Non-Franchised Revenue: Facilitate a bus-plus-property model by providing property development opportunities, allowing bus franchises to generate non-farebox income.
4. Carbon Credits: Enable bus companies to actively participate in the carbon trading market as suppliers, trading their carbon offsets to create a sustainable long-term financing mechanism.

CHAPTER 1

POLICY TARGETS AND REGULATORY OBJECTIVES

Introduction to bus franchises in Hong Kong

Franchised bus operators in Hong Kong are characterised by complete commercial operations with neither financial support nor subsidies from the Government.

This granting of bus franchises allows operators to gain the non-exclusive right to certain routes and retain all the passenger revenue from its operations. In contrast to most of the road public transport regimes worldwide, Hong Kong's regulatory system for bus is notably entrepreneurial, with operators bearing the full risk of revenue fluctuations and cost changes. The quid quo pro places the onus on the operators to initiate route changes, frequency adjustments and fare modifications, with the final approval for these initiatives lying with the Government. This bus franchise system is effective due to the high level of trust between the operators and the Government.

The bus operators are acutely aware of the Government's target to achieve zero emissions before 2050 in the transport sector. The bus franchises in Hong Kong also established their own zero emissions targets back in 2022, despite facing challenging headwind that will be discussed later.

Pressing need on preparing transition plans

All franchised bus companies expressed their ambition to foster a coexistence of both battery-electric and hydrogen solutions for achieving the zero emissions targets (Civic Exchange 2022). In the meantime, there is a critical need for building up a greater supply chain resiliency for zero emission technologies and increased adaptation efforts to meet the diverse needs of Hong Kong's urban environment.

As part of this initiative and to avoid any early retirement of assets, these companies are encouraged to cease purchasing conventional fuel buses by 2032 at the latest, considering the legal lifespan of a bus in Hong Kong is just short of eighteen years from the date of first registration (Hong Kong Legislative Council 2021).

Hong Kong needs to proactively expedite and enlarge scale of implementation for both battery electric buses ("BEBs") and hydrogen fuel cell buses with the franchised bus operators. In particular, accommodating specific route requirements in Hong Kong is challenging, including high air-conditioning requirements, frequent door cycles, difficult topography and bus operating cycles of 300-450km per day, being performed by heavy-loaded three-axle double-deckers. There are also limited termini and depot spaces (Civic Exchange 2022). These factors may make BEB solution unfeasible for 30% to 40% of the total bus fleets in Hong Kong. An estimated one-third of bus routes are required to identify alternative technologies beyond battery electric for their transition plans[1].

Major road transport competitor and an overall ridership decline from COVID

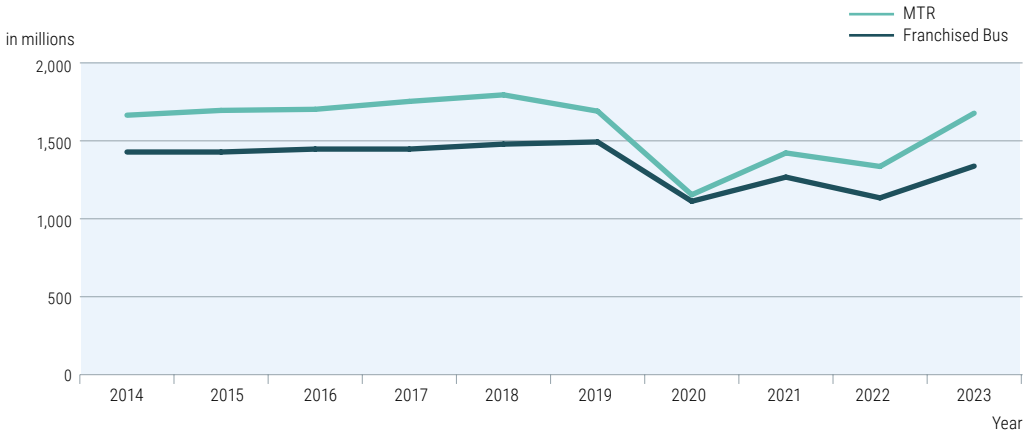
In the past two decades, the successful rationalisation of the bus network has allowed the bus system to remain financially viable, despite the increasing rail's mode share. The overall bus fleet size has not been changed much, in part due to the lengthening journey times arising from slower traffic speeds and the introduction of new long-distance routes operating on new expressways.

The Government has identified the railway network to serve as the backbone of Hong Kong's public transport system (Transport and Logistics Bureau, 2023). As such, the extensive and efficient railway network has made it a preferred mode of transport for many commuters, leading to fewer people riding buses. Notwithstanding this strategy, the Government's policy of allowing ''healthy competition between modes'' has resulted in some of the most profitable and busy bus routes in Hong Kong operating in parallel with the new railways (Transport and Logistics Bureau, 1999).

In fact, between 2014 and 2019, franchised bus operators contributed to benefit from a transient increase in ridership and market share due to extensive route reorganisation and route introduction running in duplication to railway lines that attracted a significant number of riders away from railways (Figure 1). On these routes, there are many passengers who choose the bus as the mode of first choice, for example, to enjoy a seat over a long distance and to enjoy more individual space.

Moreover, between 2012 and 2015, there was a circa 10% increase in passengers per kilometres at one of the bus franchises. This is a testament to the success of bus network rationalisation schemes. Indeed, in this period, passenger numbers were maintained, despite the large reduction in bus kilometres due to rationalisation, resulting the market responding to a higher quality of service, albeit with a reduced quantum of service.

FIGURE 1
Ridership on franchised buses and MTR from 2014 to 2023



However, the COVID-19 pandemic led to a low-risk appetite and an overall ridership decline to bus operators, making them less willing to pursue growth opportunities and increase major capital expenditures, that is, transitioning into new energy bus fleets.

Bus companies in Hong Kong have been keeping up with the recent new normal and the consequential shift in the local consumption patterns. A growing indication of work-from-home routine and surged number of locals travelling to Mainland during weekends, have weakened the demand for bus services in Hong Kong.

Under this new normal, bus operators are still struggling to rally back to a full pre-covid patronage. Faced with the changing public transport sentiment in Hong Kong, companies have focused on maintaining their balance sheets, prioritising survival and stability over expansion.

Policy overview in planning ahead the upcoming roadmap for public buses

In alignment with international developments, the Hong Kong Government has published the Hong Kong's Climate Action Plan ("CAP2050"), Hong Kong Roadmap on Popularisation of Electric Vehicles ("EV Roadmap"), and the Strategy of Hydrogen development in Hong Kong to outline the zero-emission transition directive by using both battery electric and hydrogen solutions. These policies are poised to play an important role to facilitate the coexistence of the both technologies, that is, to consider them as complementary technologies and create a well-designed policy framework that does not prioritise or lock-in one specific technology over the other.

As the Government has targeted to review the CAP2050 and EV Roadmap by 2025, it is crucial to detail the status quo reflecting the present policy landscape and leverage favourable policies to zero emissions solutions when the Government strategises fleet transition towards the 2050 target.

Additionally, the Government has been investigating the feasibility to repurpose existing petrol stations into refuelling stations. This approach could mitigate some challenges related to choosing new locations, as the public is already familiar with the risks of petrol stations. One of the objectives is to assess the impact of repurposing on the existing petrol and diesel vehicle fleet to ensure a smooth transition that aligns with Hong Kong's future demand.

New Energy Transport Fund

The New Energy Transport (NET) Fund in Hong Kong is a government initiative designed to support the adoption of new energy vehicles among commercial transport operators. Enhanced in April 2024, the fund aims to reduce emissions and promote sustainable transport solutions.

Eligibility criteria requires applicants to be existing transport operators who manage commercial transport and have not received other government or public funding for the same purpose, except for tax incentives related to electric and environmentally friendly commercial vehicles. The fund primarily subsidises the capital cost of new energy vehicle hardware, excluding recurrent expenses. Subsidies are capped at $12 million per application and are distributed with 75% provided upfront and the remaining 25% after the trial period.

The NET Fund has specific quotas for different types of vehicles: 90 single-deck electric buses, 90 electric taxis, and 15 units for each new model of non-van-type electric light goods vehicles. However, the quotas for electric medium goods vehicles have been exhausted, and applications for van-type electric light goods vehicles and electric taxis have been suspended. Hydrogen fuel cell vehicles are yet to be subsidised. (Environment and Ecology Bureau, 2024)

The fund also covers retrofitting costs for conventional vehicles to new energy vehicles and supports fuel-saving devices, with specific financial caps on various components and conversion processes.

Green Tech Fund

The Green Tech Fund (GTF) in Hong Kong was established in 2020 to support research and development projects aimed at decarbonisation and environmental protection. With a total allocation of HK$400 million, the fund provides financial support ranging from HK$2.5 million to HK$30 million per project under the condition that applicants contribute at least one-third of the total cost. The fund does not support double subsidies. The GTF prioritises projects such as net-zero electricity generation, energy-saving and green buildings, green transport, and waste reduction.

The fund is open to applications from local public research institutions, Research and Development (R&D) centres, and private companies. It emphasises the practical application of technologies that cater to Hong Kong's specific environmental needs and

challenges. The GTF approved five projects on hydrogen, including those focused on hydrogen energy production, as well as few other projects relating to intelligent energy storage systems using retired electric vehicle batteries, and the development of low-carbon materials from recycled waste.

Particularly for hydrogen technology, the table below outlines the Government's efforts to provide a regulatory framework in adopting hydrogen use through these transition plans on regulatory and policy grounds.

TABLE 3
Hong Kong's development on hydrogen vehicles – a regulatory and policy overview

Policies	Status	Specifics	Impact on Hydrogen	Opportunities for bus franchises
Gas Safety Ordinance (Cap. 51)	Pending amendment in 2025	Regulates safe use of hydrogen as fuel	Provides a legal binding effect for safe hydrogen use as a fuel	Shift from projects being government-led to commercially led
Technical Guidelines on Hydrogen Fuel Application	Published in January and February 2024	Issues Codes of Practice (CoP) for vehicles, workshops, and filling stations[2]	Provides technical specification for the upcoming Gas Safety Ordinance (Cap. 51) legislation	Groundwork for training programs, lowered insurance costs, reduced liability risks
Hong Kong Roadmap on Popularisation of Electric Vehicles	Published in March 2021	Promotes hydrogen fuel cell electric vehicles for heavy commercial vehicles	Encourages shift from internal combustion engine vehicles that are ready to phase out	Market expansion opportunities
Climate Action Plan 2050	Published in October 2021	Establishes inter-departmental Working Group to test out hydrogen fuel cell electric buses and heavy vehicles	Raises public awareness on hydrogen use	Potential long-term cost savings
The Strategy of Hydrogen Development in Hong Kong	Published in June 2024	Outlines core strategies to hydrogen development and develop infrastructure for hydrogen applications, including cross-boundary hydrogen transportation and supply facilities.	Provides lofty commitment to a legal framework and hydrogen infrastructure	Groundwork for training programs, reduced operational costs over time through shared innovations and economies of scale

Private Sector Initiative

The policy environment surrounding battery electric and hydrogen fuel cell buses in Hong Kong has seen a marked improvement in recent years, with an established part of it being driven by the private sector. The Kowloon Motor Bus Company (1933) Limited (KMB) and Citybus Limited (Citybus), Hong Kong's two leading bus franchises, have set ambitious decarbonisation targets in alignment with the Government's carbon neutrality goals. KMB aims to achieve zero emissions by 2040, while Citybus is targeting zero emissions by 2045.

In 2024, one of the operators in Hong Kong has commenced servicing the world's first hydrogen tri-axle double decker in the Kowloon district late February. Meanwhile, the bus had its inaugural run traversing the Hong Kong island and New Territories in July, marked as a cornerstone as it passes through toll tunnels.

CHAPTER 2

ANALYSIS ON CURRENT BUSINESS MODEL

Business model case comparison: Hong Kong, London and Singapore

Understanding existing business models among leading cities reveals innovative practices that can inform operational adjustments at a local level. As cities worldwide intensify their decarbonisation efforts in the transport sector, elements from London and Singapore can inspire adaptations to Hong Kong's unique bus business model. Notably, these cities share similar climate conditions and operate double-decker buses within a right-hand drive system, making their experiences particularly relevant for Hong Kong's transition to sustainable bus solutions.

In cities where operators are responsible for asset ownership, like Hong Kong, the high costs of transition can deter adoption. Conversely, in places like Singapore, where assets are state-owned, financial and operational risks are more evenly distributed. This creates a stable foundation for electrification efforts, facilitating a smoother transition to sustainable transportation solutions.

TABLE 4

Bus business model comparison – an overview

Area	London	Singapore	Hong Kong
Fleet	Operator-owned	Government-owned	Operator-owned
Depots	Mostly operator-owned	Government-owned	Operator-owned
Bus Stops	Government-owned	Government-owned	Operator-owned
Contract Structure	Route-based, 5+2 years	Gross cost franchise, 5 years, bundled routes	Long-term license, fewer tenders
Bus Management Systems	Government oversight	Centralised system with performance monitoring	Minimal centralised oversight
Penalties & Incentives	Strong penalties and incentives	Balanced penalties and incentives	No penalties or incentives
Tender Evaluation	Primarily cost-focused	50% price, 50% quality	Financial viability
Marketing	Government-led marketing	Government-controlled marketing	Operator-managed marketing

Key insights on each city's model

- **London** follows a cost-efficiency model with operators owning the assets, leading to high entry barriers. Incentive schemes have boosted performance, though profitability remains a challenge.

- **Singapore** leverages a government-owned asset model, fostering competition and reliability through a balanced evaluation of cost and quality. This collaborative approach promotes moderate profitability and innovation.

- **Hong Kong** emphasises financial independence, placing full commercial responsibility on operators. This focus on self-sufficiency creates high entry barriers and may limit service improvements.

TABLE 5
Synthesising bus franchise models in London, Singapore, and Hong Kong

Characteristics	London	Singapore	Hong Kong
Operational Structure			
Entry Barriers	High, due to asset ownership requirements and certain operators dominate specific areas	Low, due to the contracting out of bus services through competitive tendering	High, due to lack of subsidies and commercial risk, making entry difficult
Operational Approach	Emphasis on headway (frequency) and cost management, reflecting an efficiency-driven approach	Balances quality and cost management, aiming for high service standards at reasonable prices	Focus on fare management and ridership growth to maintain financial stability
Financial Viability			
Profitability	Most operators face financial losses due to high operational costs	Moderate profitability, enabled by a balanced focus on quality and competitive pricing	Focus on financial viability, requiring operators to be self-sustaining without subsidies
Value for Money	Primarily cost-based, sometimes compromising long-term sustainability	Well-priced and competitive, encouraging bids that balance quality and cost-efficiency	Profit-driven approach may limit service improvements
Market Dynamics			
Competition	Limited due to high entry barriers and operator dominance	Highly competitive environment, fostered by government ownership of assets	Limited competition due to high financial and operational demands
Competitive Bids	Primarily price-driven evaluation on individual routes	Competitive bidding for bundled routes, promoting innovation and service reliability	Long-term licenses with minimal tendering
Innovation & Performance			
Innovation	Some innovation driven by incentives, though constrained by cost focus	Partnership model actively encourages innovation and creative solutions	Limited due to profitability focus restricting service enhancement investments
Performance Analysis	Managed through the iBUS system with standardised performance metrics	Centralised system with structured performance monitoring	Subjective performance evaluation, lacking standardised metrics
Public-Private Relations			
Operator-Government Relations	Limited collaboration, with operators handling responsibilities under contractual terms	Close cooperation fosters a collaborative environment with aligned interests	Minimal government intervention, with operators handling most responsibilities independently

Despite similar climate conditions and the iconic double-decker buses in a right-hand drive system, Hong Kong's franchise bus industry exerts high operational dominance and limited room for transformation. However, these factors from other cities cannot be directly replicated in Hong Kong. The city's unique urban layout and specific challenges require tailored solutions to sustainable transport.

Evolution of farebox revenue amidst service transitions

In the 1980s, bus companies underwent a radical transition by introducing air-conditioned buses as a premium service to enhance passenger experience. And despite some initial resistance, by 1998, the public fully accepted the differentiated fare system. As time went by, passengers became accustomed to this value-added service, seeing air-conditioning necessary as a way to improve living standards.

This evolution in service offerings highlights a broader trend in the public transport sector where enhancements in passenger comfort and convenience are increasingly linked to fare structures. While the introduction of air-conditioned buses was met with initial skepticism, it ultimately led to an acceptance of higher fares justified by improved service quality.

In contrast, the current transition towards new energy buses poses unique challenges, as these vehicles may not resonate with passengers in the same way, and it does not provide obvious value-added experience to passengers. This shift necessitates a business model reevaluation to ensure that the implications align with passenger expectations and market demands.

Financial analysis on the current model

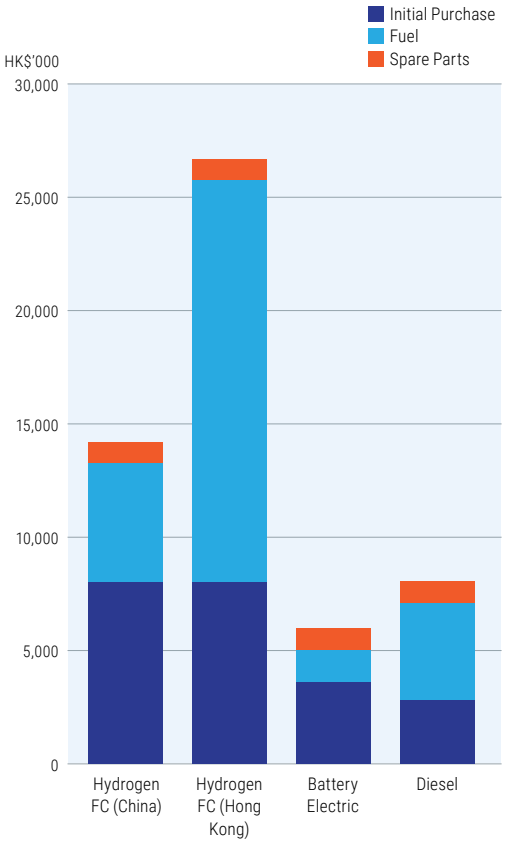
To assess the real financial impact to a franchised bus operator, the total cost of ownership ("TCO") reflects both operational and maintenance expenses. The price of new energy vehicle is generally higher than conventional fuel vehicles (IDTechEx 2023; Nascimento & Silva 2023). Lifecycles cost savings, however, can be realised through reduced operating costs.

Figure 2 presents a cost comparison of three different fuel types for buses, acknowledging that it is not possible to accurately predict future price reductions for hydrogen fuel cell and battery electric vehicles. Figure 2 follows a similar methodology of calculating the TCO to compare cost of buses reaching the end of their useful life and being retired from the company's fleet. The calculation excluded financing costs and fuel station costs due to data invisibility, as well as to better reflect the impact of expenditures in capital price and fuel.

A notable distinction from the TCO of Mainland China's bus shows a TCO for a hydrogen fuel cell bus 53% lower than that of Hong Kong, which is primarily due to the difference in the cost of hydrogen.

FIGURE 2

Cost comparison of the three fuel types for buses over 18 years[3]



Source: Residual value, daily average driving range and average fuel cost for battery electric buses from Transport Department, Legislative Council and Environment and Ecology Bureau. Fuel cell buses average fuel cost and driving range from SCMP and Ballard.

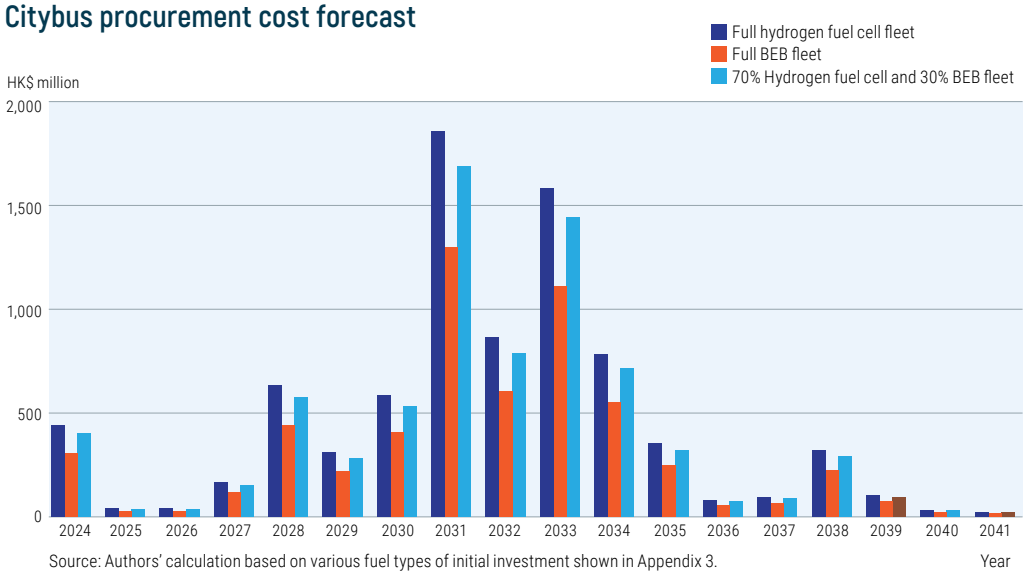
As shown, the companies would face significant financial challenges when adopting battery or hydrogen technologies amidst transitioning towards greener public transportation. Government subsidies are crucial to balance off these additional costs and ensure a smooth transition to sustainable energy solutions.

Factoring-in the assumption that the two leading bus franchises in Hong Kong would replace each retired bus into a new energy vehicle, Figure 3 and Figure 4 are generated to present the yearly procurement cost for Citybus and KMB respectively under three possible procurement plans:

1) replace all conventional buses into hydrogen fuel cell buses;
2) replace all conventional buses into battery electric buses;
3) replace 70% of conventional buses into hydrogen fuel cell buses and 30% into battery electric buses.

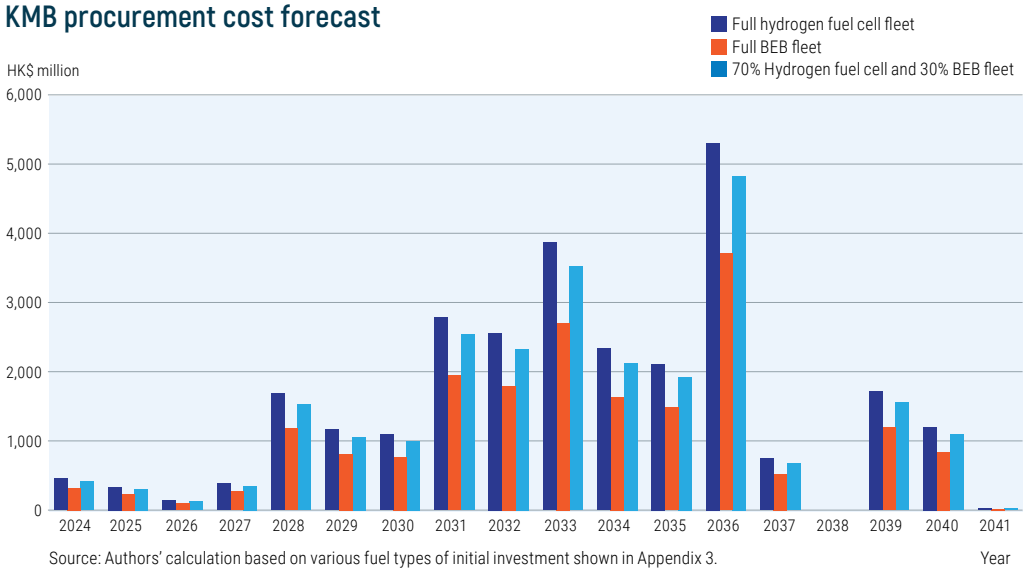
To understand the number of buses retiring every year, the bus retirement schedule for CityBus and KMB in Appendix 1 highlights the annual number of buses required to be phased-out with new ones as they reach eighteen years of services.

FIGURE 3
Citybus procurement cost forecast



Source: Authors' calculation based on various fuel types of initial investment shown in Appendix 3.

FIGURE 4
KMB procurement cost forecast

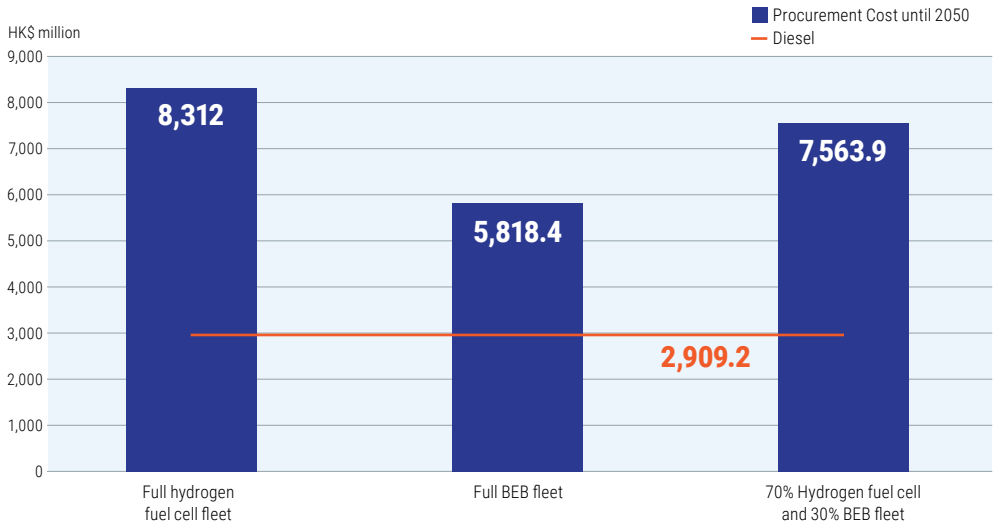


Source: Authors' calculation based on various fuel types of initial investment shown in Appendix 3.

Both leading bus franchises will need to buy time to strategically plan for these retirements, ensuring a smooth transition to new energy buses. It indicates a critical need for funding and infrastructure development, particularly in the peak years, to maintain service levels and meet decarbonisation targets.

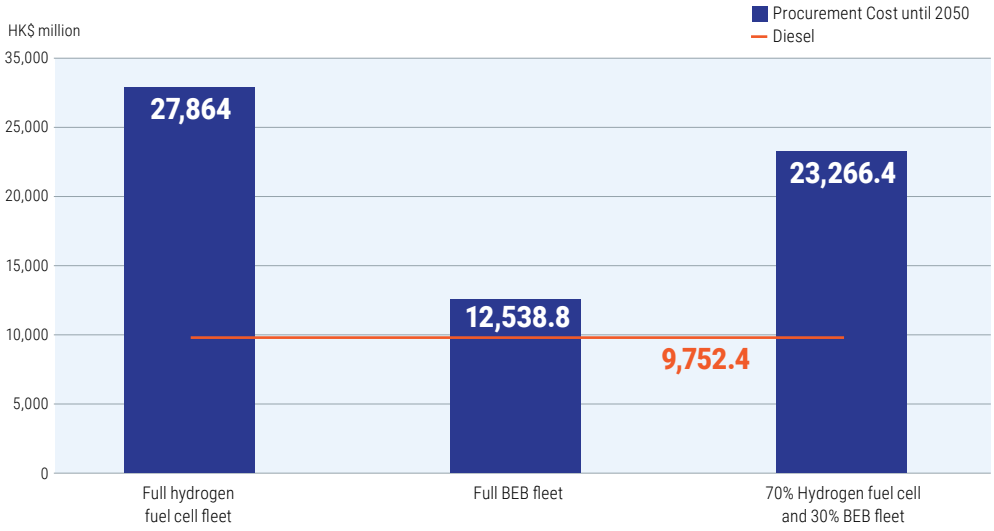
Figures 5 and 6 illustrate substantial financial implication for Citybus and KMB as they transition their conventional bus fleets cumulatively to 2050 from now on. For Citybus, the minimum financial gap required to facilitate the transition based only on the difference between new energy and diesel capital expenditure is projected to be an additional HK$2.9 billion for converting conventional buses into battery electric buses. In contrast, KMB faces a smaller financial gap, incurring a minimum financial gap of HK$2.8 billion as company replaces its current fleet into battery electric buses.

FIGURE 5
Cumulative procurement cost on bus fleet procurement until 2050 for Citybus



Source: Authors' calculation based on various fuel types of initial investment shown in Appendix 3.

FIGURE 6
Cumulative procurement cost on bus fleet procurement until 2050 for KMB

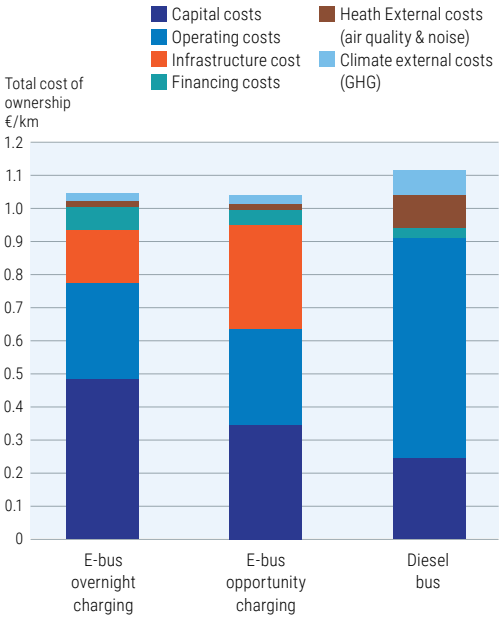


Source: Authors' calculation based on various fuel types of initial investment shown in Appendix 3.

Total cost of ownership in the European market

Numerous international studies indicated that the TCO for battery electric buses has already reached parity with that of diesel buses (Figure 7), albeit this conclusion is not by any means proven in the Hong Kong context. In contrast, hydrogen technology is still in its developmental stages; however, if it follows a trajectory similar to that of battery electric vehicles, it is anticipated that hydrogen will become significantly more cost-effective than currently projected.

FIGURE 7
Eight Year TCO calculation for daily distance travelled bus of 250km in Europe



Source: Adopted from The European Federation for Transport and Environment, 2018

Potentiality extending lifespan of bus and its implications

Furthermore, the advancement in the durability of new energy vehicles would mitigate bus companies' operating expenses. The current legal lifespan of eighteen years for buses was stipulated at a time when the buses were highly polluting under Euro 1 standards and predominantly constructed from steel, rendering them susceptible to rust. In contrast, new energy vehicles are made of aluminum and are less vulnerable to vibrations. While battery or fuel cell replacements will still be necessary for both battery electric and hydrogen buses, these buses have the potential for significantly extended lifespans.

Currently, the actual lifecycle of bus is eighteen years, with an estimated useful life of fourteen years. This estimate is reviewed annually, considering factors such as deployment plans, scrapping schedules, and technological changes that may impact their lifespan (Transport International Holdings, 2020).

An increase in buses' life expectancy beyond eighteen years as a result of transitioning to a new energy fleet would affirm a new, longer estimated useful life for each of the newly procured buses. Under a new depreciation schedule with an extended accounting period, bus companies can write off less of their operating expense over their annual financial statements.

Reducing annual depreciation costs could better reflect the actual usage experience and compensate for capital expenses attributable to the purchase of new energy buses.

Seven scenarios outlining transition pathways on decarbonising public buses

Hong Kong will need to identify a financial mechanism that fills the approximate financial gap of HK$5.7 billion to ensure public buses can reach net-zero emissions before 2050. However, upgrading existing public transportation assets, such as buses or infrastructure, does not help bus operators gain additional fare box income nor significantly reduce the operation cost.

Another characteristic that underscores a comprehensive transition is the requirement for key safety measures and proper training for the bus operators, as well as the regular inspection and maintenance for the safe usage of relevant infrastructure. Successful demonstrations of safety measures and training are essential to garner public support and prevent exaggerated safety hazard concerns. This was similarly done to alleviate public worries during the introduction of liquefied petroleum gas taxis in 2000.

Therefore, the following section will explore seven distinct scenarios which illuminate the various pathways and their implications for stakeholders. This analysis will not only highlight the current situation but will also identify potential challenges and opportunities, paving the way to enable the strategic decision-making in the zero-emission transition for public transportation.

Scenario 1: Business-as-usual (BAU)

In the Business-as-usual (BAU) model, a private franchised company owns all of its assets and manages all the operations of bus services. The Government grants franchise agreements which specify exclusive routes, regulated fare structures, and strict service standards. This model ensures that the bus services are operated efficiently and met with the required standards set by the Government.

In Hong Kong, the bus services are managed by private franchised companies under the Franchise Term model. These companies are granted franchise agreements by the Government. The main revenue stream for these companies is generated from passenger fares, with a limited proportion of the additional income being generated from non-fare box sources like advertising.

Advantages:

- Guarantees a proven and established system that has maintained effective and reliable public transportation services in Hong Kong.
- Promotes efficiency and innovation.

Disadvantages:

- Dependence on passenger fares might restrict the capacity to invest in costlier, sustainable bus technologies, like hydrogen fuel cell electric vehicles.
- The revenue stream only covers the traditional bus replacement and neglects the transition needs of the bus company.
- Given the franchised agreement renews every ten years, there is a mismatch between the eighteen years of the buses' legal lifespan, which exposes operators to recontracting risk.

Scenario 2: Carbon Offset Reliance

On top of the BAU model, the Carbon Offset Reliance model solely relies on purchasing carbon offsets to achieve carbon neutrality, even beyond 2050. The responsibility for funding these offsets falls on various stakeholders such as the Government, bus franchises, and passengers. Distributing the financial responsibility amongst these stakeholders provides flexibility in reaching carbon neutrality whilst keeping the existing diesel fleet operational. If the Government

establishes a carbon trading market in Hong Kong, the carbon offset quotas owned by the bus companies that are made from forfeiting the expansion of diesel buses can be sold to polluting sectors like property development. This will obviate the impact of fares for the citizens and create a sustainable financing mechanism for buses.

Advantages:

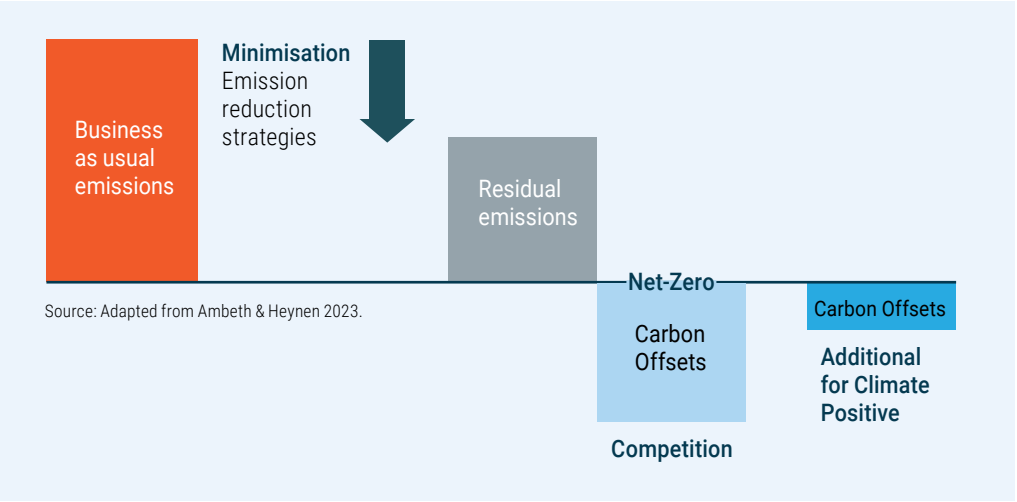
- Allows the current model to transition towards carbon neutrality without drastically changing the operating structure.

Disadvantages:

- Without a carbon trading market, increased costs from carbon offsets may be passed on to passengers, making public transportation less affordable in the long term.

FIGURE 8

Decarbonisation pathway for achieving net-zero emissions using carbon offsets



Source: Adapted from Ambeth & Heynen 2023.

Scenario 3: Bus-plus-Property (B+P)

The Bus-plus-Property (B+P) model involves the Government granting bus companies property development rights. This concept is taken from the "rail-plus-property" model, which allows public transport companies to generate income from both rail operations and property developments above ground. By integrating property development with bus operations, companies can create a diversified revenue stream, reducing their reliance on passenger fares alone.

Moreover, the model will help bus companies resolve parking space and charging issues, as the B+P development model can create additional depots for bus operators.

The "rail-plus-property" model is currently adopted by Hong Kong's rail services company, MTRC, which has successfully leveraged property development alongside its transport services to enhance its financial stability with a diversified revenue stream beyond passenger fares.

Advantages:

- Allows bus operators to generate additional revenue streams beyond just fare collection.

Disadvantages:

- Distracts from the core operation of providing efficient and quality bus services.
- The required upfront investment for property and the current weak market has left several MTRC developments unsold.

Scenario 4: Public Private Partnership (PPP)

In this model, bus services are provided through the collaboration between the Government and the private sector. The Government owns all of the assets, while the day-to-day operations, maintenance, and service delivery is managed by an independent operator. Public and private partners share the risks and rewards, utilising the strength of both sectors. The model shift would depart from the longstanding policy in Hong Kong of operating public transport according to prudent commercial principles.

This model is illustrated by the Land Transport Authority (LTA), a statutory board under the Ministry of Transport that owns Singapore's buses and other fixed assets, including the railway system and road infrastructures. The operation of buses is franchised to private operators through competitive contracts to run services, including hiring staff and leasing vehicles.

Advantages:

- Allows the Government to maintain control over public transportation assets whilst leveraging private sector expertise and efficiency in operations.
- Ensures that public transportation services can continue to be delivered at a high standard whilst maintaining public ownership of critical infrastructure.
- Financial and operational risk can be shared between the public and private sectors, potentially leading to better risk management.

Disadvantages:

- The Government may face difficulty in aligning incentives with private operators, and struggle to manage the procurement and leasing of vehicles.
- Higher propensity of politicisation of fares as bus operations are taken in by the Government and the principle of "user-pays" is lost.
- Aligning the private sector's profit objectives with public interest goals can be difficult.
- Could potentially initiate direct subsidy streams to operators that may grow larger each year. The absence of healthy competition between modes and the current practice of "self-reliance" by operators will likely result in reduced levels of innovation and efficiency.

Scenario 5: Government with asset ownership and operation

In this model, the Government owns all assets and manages the operation of bus services. An example of this model is the Guangzhou Public Transportation Group. In Guangzhou, China, the Guangzhou Municipal Government owns and operates bus services through a state-owned enterprise. The Government fully subsidises the company, taking responsibility for owning all bus assets and managing service operations.

Advantages:

- Guarantees that public transportation services are fully controlled and funded by the Government, allowing for comprehensive planning and integration with other public services.
- Ensures that public transportation remains affordable and accessible to all citizens, as the Government can directly influence fare structures and service standards.

Disadvantages:

- This structure may suffer from bureaucratic inefficiencies and would be less flexible than private sectors in adopting market changes.
- Increases government financial burden and can potentially lead to financial instability if subsidies are reduced or withdrawn.
- Higher propensity of politicisation of fares as bus operations are taken in by the government and the principle of "user-pays" is lost.
- Could potentially initiate direct subsidy streams to operators that may grow larger each year. The absence of healthy competition between modes and the current practice of "self-reliance" by operators will likely result in reduced levels of innovation and efficiency.

Scenario 6: Government subsidising franchised companies

In this model, Hong Kong's bus sector adopts Franchise Term model, where a private franchised company owns all of the assets and manages the operation of bus services. However, the Government provides subsidies to cover the asset and operational differences.[4] This could be done in two approaches, where any subsidies granted are predicated upon a thorough total cost of ownership analysis:

1. Capital Offset: Reducing asset costs for new energy bus procurement and phasing out conventional engine buses.
2. Operational Offset: The Government subsidises maintenance expenses and clean energy fuel refilling per kg/kWh.

An example of this model is the Zero Emission Bus Regional Areas (ZEBRA) Scheme in the United Kingdom. In the UK, local transportation authorities are funded by the ZEBRA Government initiative to purchase zero-emission buses, such as hydrogen and electric buses. Additional costs associated with adopting new energy buses are also covered by the scheme. In addition, necessary infrastructure like charging or refuelling stations are also funded, while operational costs such as energy refilling and maintenance are sometimes covered too.

Advantages:

- Ensures that the bus companies can gradually transition their fleets to meet environmental standards while keeping operational costs manageable.
- Supports the steady transition to more sustainable public transportation options, aligning with broader environmental goals.
- Maintains the broad commercial principles of the current economic regulation system in the industry, preserving benefits such as innovation and efficiency.

Disadvantages:

- Due to political and fiscal complications, it may be hard to ensure the longevity of continuous government subsidies.

Scenario 7: Leasing contracts

In this model, bus operators and fleet providers collaborate with the Government to provide buses as a service. Fleet providers centrally plan and allocate the service to bus operators through a leasing contract, whilst the Government procures new energy buses to facilitate the leasing. This model is designed where the Government is a counterparty as both operator and asset owner. The Government uses several competing asset owners to minimise the risk of high lease payments and issues tenders to asset owners for a fixed payment in return for asset availability. Alternatively, the Government may use several competing operators to achieve competitive fares to the public. Compensated through fare revenue, the operators' only incentive is to provide good service and expand ridership without the need to recover the cost of assets, which are covered by the Government.

This model is deployed in Santiago, Chile, to attract new energy fleet renewal and to lower funding costs for bus operators by settling payment based on mileage.

Advantages:

- The role of the counterparty ensures fleet providers are offered availability at the most competitive rates by the Government.
- Reduces upfront capital expenditure and payment risks for bus operators.

Disadvantages:

- Locking into a potentially higher long-term costs due to ongoing lease payments.

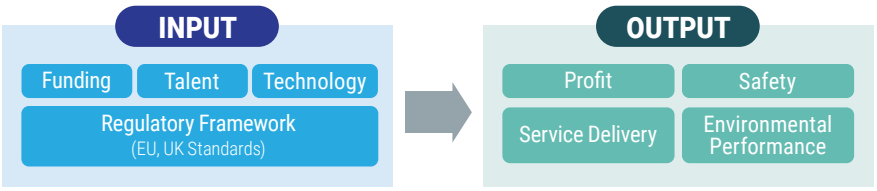
CHAPTER 3

EXPERTS REVIEW ON STATUS QUO

Input-output analysis for bus franchise businesses

Currently, Hong Kong bus franchise businesses can be summarised within an input-output model that reflects the operational dynamics of the franchised bus network. The interplay between these input domains is aimed to deliver reliable and efficient public transportation whilst adapting to changing economic and environmental landscapes.

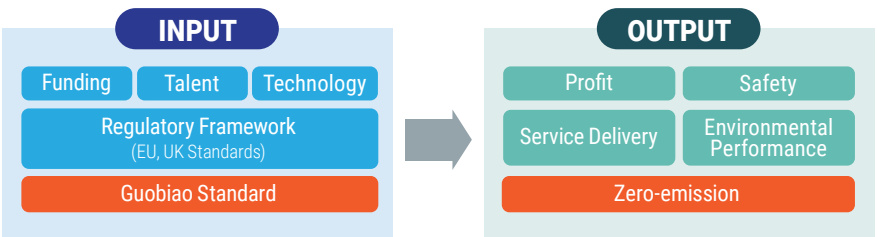
FIGURE 9
An Input-Output Diagram for a traditional bus franchise



Stakeholder consultation

To gain a view of the realities impacting bus companies, several expert interviews were conducted with professionals who could provide an insider perspective from within the bus franchise industry. Interviewees possessed extensive industrial expertise and financial insights within the field of franchised bus operations. Based on the interviewer's analysis, it can be concluded that the transition necessitates the inclusion of two additional elements within the input-output diagram, as illustrated in Figure 10.

FIGURE 10
An Input-Output Diagram for a revised bus franchise model for transition



Furthermore, experts accentuated five key business model components to advance the franchised bus industry transition to new energy solutions:

The zero-emission goal

With mounting pressure on the public transportation industry to contribute its fair share to the new energy transition, adopting new energy vehicles has become a key business strategy for companies.

As the lifecycle of diesel buses reaches eighteen years, it is highly probable that bus franchises will not replace diesel buses with a new energy bus on a one-to-one basis, with the fleet replacement ratio estimated to be 1:0.8-0.9.

Scalability

Expanding the scale of new energy vehicle trials is crucial for decarbonising the commercial fleet. Currently, the testing of new energy vehicles is a public-private initiative, yet it lacks a time-sensitive roadmap for large-scale implementation to bring economic and environmental impact. The true cost of new energy applications in the bus sector from a whole-life cycle perspective cannot be fully understood until the technology evolves from its pilot phase.

Moving forward, if the circumstances allow financial institutes to provide loans to bus companies to purchase new energy buses, the Government would not only capture external zero-emission benefits from this investment, but also position Hong Kong as a clean energy hub, demonstrating the commercial applications of regionally recognised low-carbon technology to the world.

Fare Predictability

In a new energy transition, predictability is crucial for bus companies to anticipate future business outcomes. A fare adjustment mechanism could ensure revenue certainty throughout the transition process. By using a rule-based approach to adjust fare increments or deductions at a rational level, companies can identify the breakeven point and guide their strategic decisions accordingly. However, if not justified, it could undermine price sensitivity and significantly impact passenger numbers.

Service Differentiation

Bus franchises need to enhance service offerings during organic growth to bolster competitiveness and preserve local stewardship and ownership of technology. By focusing on constantly improving the provision of efficient services, the flexibility allows bus companies to thrive on what they are good at, such as improving service efficiency, conducting asset upgrades, and creating alternative revenue streams through premium services.

Beyond a Financial Way

To increase revenue during the business transition, bus franchises are seeking alternative sources of revenue over the long term, such as property development or other non-franchise revenue opportunities. Experts have expressed that relying on financial solutions as a short-term remedy to address public transport energy transition problems is not strategic. Measures such as purchasing carbon offsets and subsidies would yield no additional benefits for either the business or the local economy, while also forgoing the opportunity to cultivate a new green industry.

Creating a comprehensive plan for charging and hydrogen infrastructure, including refuelling stations and storage facilities, is crucial for the broad adoption of the both clean energy. Strategic infrastructure development is essential to pave the way for a better electric-powered and hydrogen-powered future.

CHAPTER 4

RECOMMENDATIONS

2032 would be a critical year to commence an implementation plan that replaces diesel buses for new energy buses to meet the Government's 2050 carbon neutrality target. Bus companies would only have eight years to formulate a plan that comprehensively entails a fleet transition pathway, detailing the infrastructure required and the relevant costs necessitated each year to achieve the transition. Given each bus franchise's individual zero-emission fleet targets (i.e. 2040 and 2045), they would be given less than eight years to execute.

Policy recommendations

Responding to new challenges

There is an urgency to devise a new business model that can support the transition to both battery electric and hydrogen fuel cell buses. The traditional model relies on farebox income and may not be sufficient to address the financial, operational, and regulatory demands of hydrogen and battery electric technology in a Franchise Term model. Moreover, the current business model and Government policies provide no extra investments amidst transitioning to zero emissions that attract new customers and generate additional farebox income.

A ten-year innovation-supportive business model

By establishing a self-sustainable business model that takes reference from the listed scenarios, bus franchises can enable technological development and create a predictable plan for the business sector to introduce and develop technological solutions for Hong Kong. Given that all technologies require significant initial investment before achieving sustainability, the Government should consider a mixed approach that utilises various scenarios to support this transition and negotiate the extent of each mechanism as the optimal proportional response.

FIGURE 11

Income and Expenditure Account under innovation-supportive business model

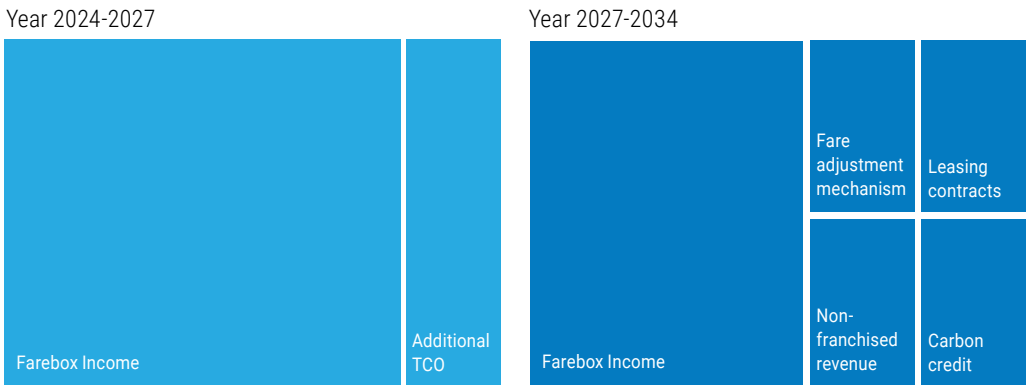
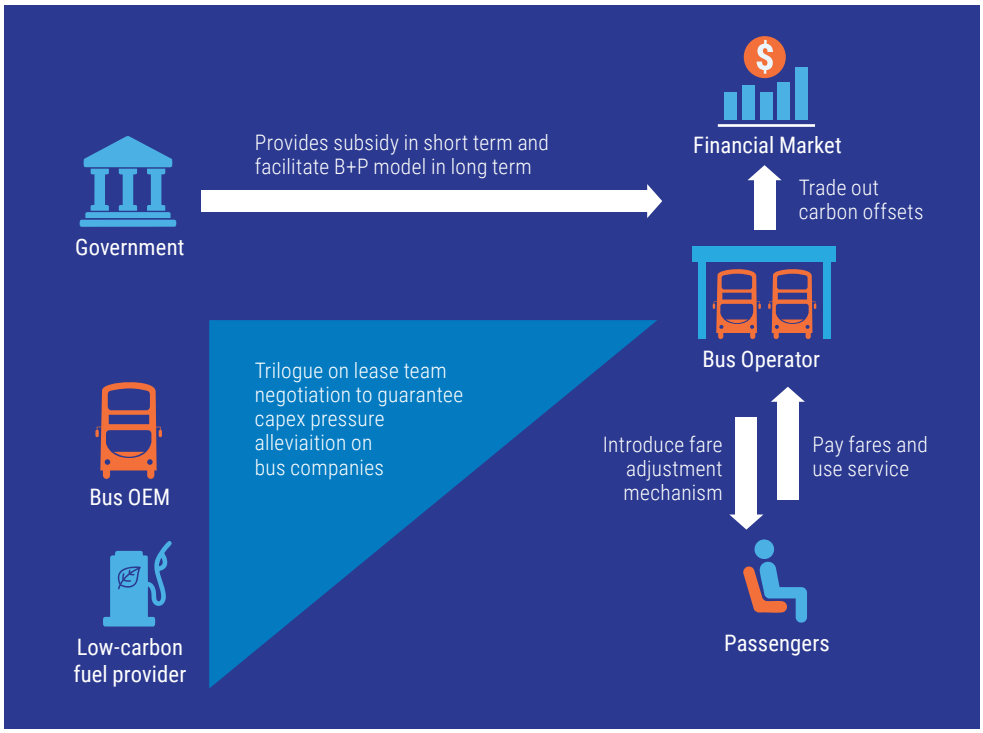


FIGURE 12
Illustrative innovation-supportive business model



Innovation-supportive business model: from 2024 to 2027

As the Government has set the target of introducing about 700 electric buses by the end of 2027, it is inevitable that the Government will need to commit financial assistance to bus operators for a timely facilitation of the transition. This business model involves providing short-term subsidies that cover the differences in capital expenditure and fuel costs.

Government subsidies for additional total cost of ownership

If the Government collaborates with the bus franchises to formulate a comprehensive new energy bus transition roadmap, experts have welcomed the Government subsidising bus franchises in the short term as its most preferred financial mechanism to conduct a full fleet transition.

In addition to the Government forecasting subsidy amounts in collaboration with bus franchises, a dedicated research centre conducting comprehensive studies on the hydrogen supply chain and battery electric technology developments can also take the lead in validating subsidy levels.

With a well-planned transition pathway, the Government subsidising cost difference would not only prevent a surge from the company's operational expenses, but would also create added benefits by reducing the volatility on the globally fluctuating oil prices. The bus franchise does not have to face the risks of procuring new energy buses and committing to an unjustified amount of procurement costs that exploits capital expenditure and harms the overall financial performance of the company.

Innovation-supportive business model: from 2027 to 2034

This business model would transition into a medium-to-long-term strategy, requiring the Government to negotiate with bus companies on several key initiatives. The Government should guarantee bus companies the development of a whole bus life-cycle lease term to alleviate capital expenditure pressure. Secondly, significant investment in infrastructure is necessary to ensure adequate space requirements.

Fare adjustment mechanism

To sustain long-term decarbonisation investments and balance public affordability, the bus franchises could introduce a fare adjustment mechanism that provides certainty to the fare price during the transition process.

Leasing contracts

This model could apply a bus leasing system to alleviate capital expenditure and prevent constraints to the cash flow by switching asset ownership to other entities. Additionally, rental buses that have an increased life-cycle would be allowed under the leasing contracts to compensate for a considerable amount of capital expenditure of the new energy buses.

Non-franchised revenue

The Government could facilitate a bus-plus-property model by offering property development opportunities that enable bus franchises to generate non-farebox income.

Carbon credits

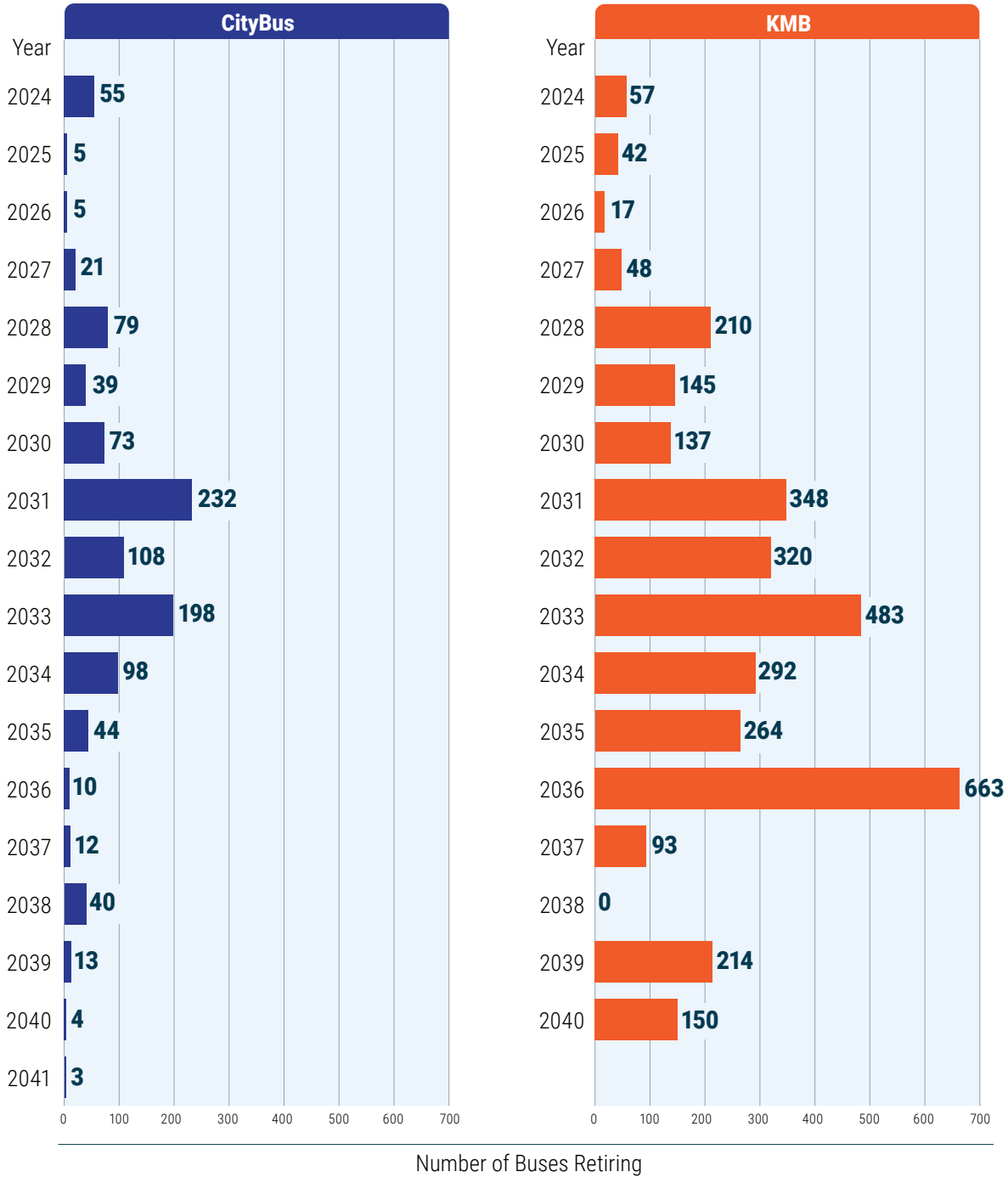
Rather than establishing a practice of buying carbon credits, bus companies could play an active role as a supplier in the carbon trading market that trades out its carbon offset generated to polluting sectors. This could create a sustainable financing mechanism for buses in the long term.

The ten-year innovation-supportive business model would not only provide subsidies to bus companies, but would also attract global innovators, establish new energy suppliers, invite international partners, and demonstrate economically feasible technologies for operation and export. This would position Hong Kong as a transition technology proof-of-concept site, attracting talent and capital back to the region while exporting technology and expertise to the world.

APPENDICES

APPENDIX 1

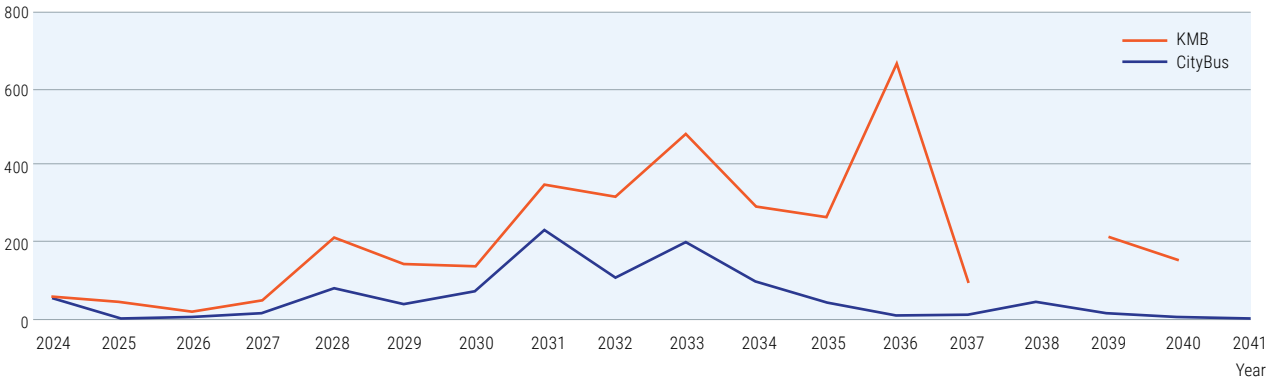
Bus retirement schedule for CityBus and KMB[5]



The bus retirement schedule for CityBus and KMB highlights a significant transition period. For CityBus, with a fleet of 1,273 buses, will see a peak retirement year in 2031 with 232 buses retiring, followed by 198 in 2033. KMB, operating 4,029 buses, faces its highest retirement rate in 2036 with 663 buses, and another substantial wave in 2033 with 483 buses.

APPENDIX 2

Number of buses retiring annually corresponding to lifespan[6]



APPENDIX 3

Cost Comparison breakdown in the European market context corresponding to Figure 7

	Initial investment		Operating Cost[7]	Maintenance Cost
Diesel	HK$ 2,800,000[8]		HK$ 1,303,900	HK$ 220,000
Hydrogen fuel cell	HK$ 8,000,000		HK$ 1,595,600	HK$ 200,000
Battery electric	Citybus' Wisdom Motor DD12	KMB's BYD B12D	HK$ 1,175,400	HK$ 180,000
	HK$ 5,600,000	HK$ 3,600,000		

Sources: Initial investment from the Customs and Excise Department, operational and maintenance costs from Kolodziejski, Matuszak & Zabinska 2022.

APPENDIX 4

Cost Comparison breakdown in a Hong Kong market context

	Initial Purchase	Fuel	Spare Parts	Residual Value
Hydrogen Fuel Cell	HK$8,000,000	HK$17,739,000	HK$959,526	-HK$10,000
Battery Electric	HK$3,600,000	HK$1,419,120	HK$959,526	-HK$10,000
Diesel	HK$2,800,000	HK$4,284,936	HK$959,526	-HK$10,000

REFERENCES

Vanaraja Ambeth, P & Heynen, A.P. 2023. Sustainable Legacies of a Climate Positive Olympic Games: An Assessment of Carbon Offsets and Renewable Energy for Brisbane 2032. Sustainability, 15, 1207. https://doi.org/10.3390/su15021207

Ballard. 2019. Hydrogen Fueling for Fuel Cell Bus Fleets. https://info.ballard.com/hubfs/Premium%20Content/Hydrogen%20Fueling%20for%20Fuel%20Cell%20Bus%20Fleets/WP-Ballard-Hydrogen-Refueling-for-Fuel-Cell-Bus-Fleets.pdf

Customs and Excise Department. 2024. "Motor Vehicles First Registration Tax System". https://eservices.customs.gov.hk/FRT/pbs/searchPrp

Civic Exchange. 2022. "Recommendations of the Zero Emissions Mobility Consortium". https://civic-exchange.org/report/recommendations-of-the-zero-emissions-mobility-consortium/

Environment and Ecology Bureau. 2024. New Energy Transport Fund. https://www.eeb.gov.hk/en/new-energy-transport-fund.html#Eligibility_for_Application

Environment and Ecology Bureau. 2020. Pilot Green Transport Fund: Trial of Electric Single-deck Bus for Shuttle Service (Sun Bus Limited). https://www.eeb.gov.hk/sites/default/files/en/node5762/Executive%20summary%2024-month%20Final%20Report_Sun%20Bus_Eng_20200720.pdf

IDTechEx. 2023. Electric and fuel cell buses 2025-2045: Markets, players, technologies and forecasts. IDTechEx. https://www.idtechex.com/en/research-report/electric-and-fuel-cell-buses-2025-2045-markets-players-technologies-and-forecasts/1012

Kolodziejski, M., Matuszak, Z., & Zabinska, I. 2022. Possibilities of using hydrogen buses in urban transport. Scientific Papers of Silesian University of Technology Organization and Management Series 2022(161):53-64. http://dx.doi.org/10.29119/1641-3466.2022.161.4

Nascimento, D. C., & Silva, F. J. G. 2023. Sustainability assessment of electric and fuel cell buses: A case study in public transportation. Sustainability, 16(1), 259. https://doi.org/10.3390/su160100259

MTR, 2023. "The Year in Review." Annual report 2023. https://www.mtr.com.hk/archive/corporate/en/investor/annual2023/E12.pdf

South China Morning Post. 2023. https://www.scmp.com/news/hong-kong/health-environment/article/3242212/calls-law-amendments-first-hong-kong-hydrogen-fuelling-station-set-be-completed-2024

South China Morning Post. 2023. https://www.scmp.com/news/hong-kong/transport/article/3239957/hong-kong-bus-firms-could-get-government-subsidies-go-electric-without-high-fare-rises-minister-says

The European Federation for Transport and Environment. 2018. "Electric Buses Arrive On Time". https://te-cdn.ams3.cdn.digitaloceanspaces.com/files/Electric-buses-arrive-on-time-1.pdf

Transport and Logistics Bureau. 1999. Hong Kong Moving Ahead: A transport strategy for the future. https://www.tlb.gov.hk/eng/publications/transport/publications/hk_move_ahead_txt.html

Transport and Logistics Bureau. 2023. "Hong Kong: The Facts Railway Network." https://www.tlb.gov.hk/eng/publications/transport/publications/railwaynetworkMay2024.html

Transport Department. 2014-2023. "Monthly Traffic and Transport Digest," Table 2.1. https://www.td.gov.hk/en/transport_in_hong_kong/transport_figures/monthly_traffic_and_transport_digest/index.html

Transport Department. 2023. "Franchise". https://www.td.gov.hk/filemanager/en/content_387/ctbf2%20franchise%202023-2033.pdf

Hong Kong Legislative Council. 2019. "Promoting the Use of Electric Vehicles". https://www.legco.gov.hk/yr18-19/english/panels/ea/papers/ea20190128cb1-487-3-e.pdf

Hong Kong Legislative Council. 2021. "Legislative Council Brief on New Bus Franchises". https://www.tlb.gov.hk/eng/legislative/transport/panels_subcommittees/2022/LegCo%20Brief%20on%20New%20Bus%20Franchises%20(E).pdf

ENDNOTES

1. Close-door roundtable meetings between Civic Exchange and transport stakeholders
2. Formulated CoP for Hydrogen Fuelled Vehicles and Maintenance Workshops. It covers the design, installation, testing, commissioning, operation and maintenance of hydrogen fuel systems; CoP for Hydrogen Filling Stations; as well as the Guidance Note for Quantitative Risk Assessment Study for Hydrogen Installations in Hong Kong
3. The calculation excludes financing costs and labour costs due to data invisibility and unpredictability respectively. The formula for TCO is Initial Purchase Price + (Total Annual Cost × Useful Life) − Residual Value
4. The provision of capital offsets should be sufficient, as there is ample statistical evidence demonstrating the lower operational and maintenance costs associated with battery electric buses (BEBs).
5. Number of Citybus and KMB buses omitted from calculation is 234 and 546 respectively.
6. Additionally, there are missing data points for both companies, with Citybus lacking information for 234 buses and KMB for 546 buses, which will need to be addressed to complete the transition plan effectively.
7. Operating Costs are the aggregated amount of fuel cost, labour cost, parts replacement, insurance cost, and fuel station cost. In particular, battery is a part of an electric vehicles' capital cost, therefore parts replacement cost is excluded in calculating the operating cost for battery electric buses.
8. The average price of a common diesel bus model Air-conditioned Trident Enviro500 New generation Euro V (Enviro500 MMC), adopted by the leading bus operators in Hong Kong and manufactured by Alexandar Dennis in 2012.

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