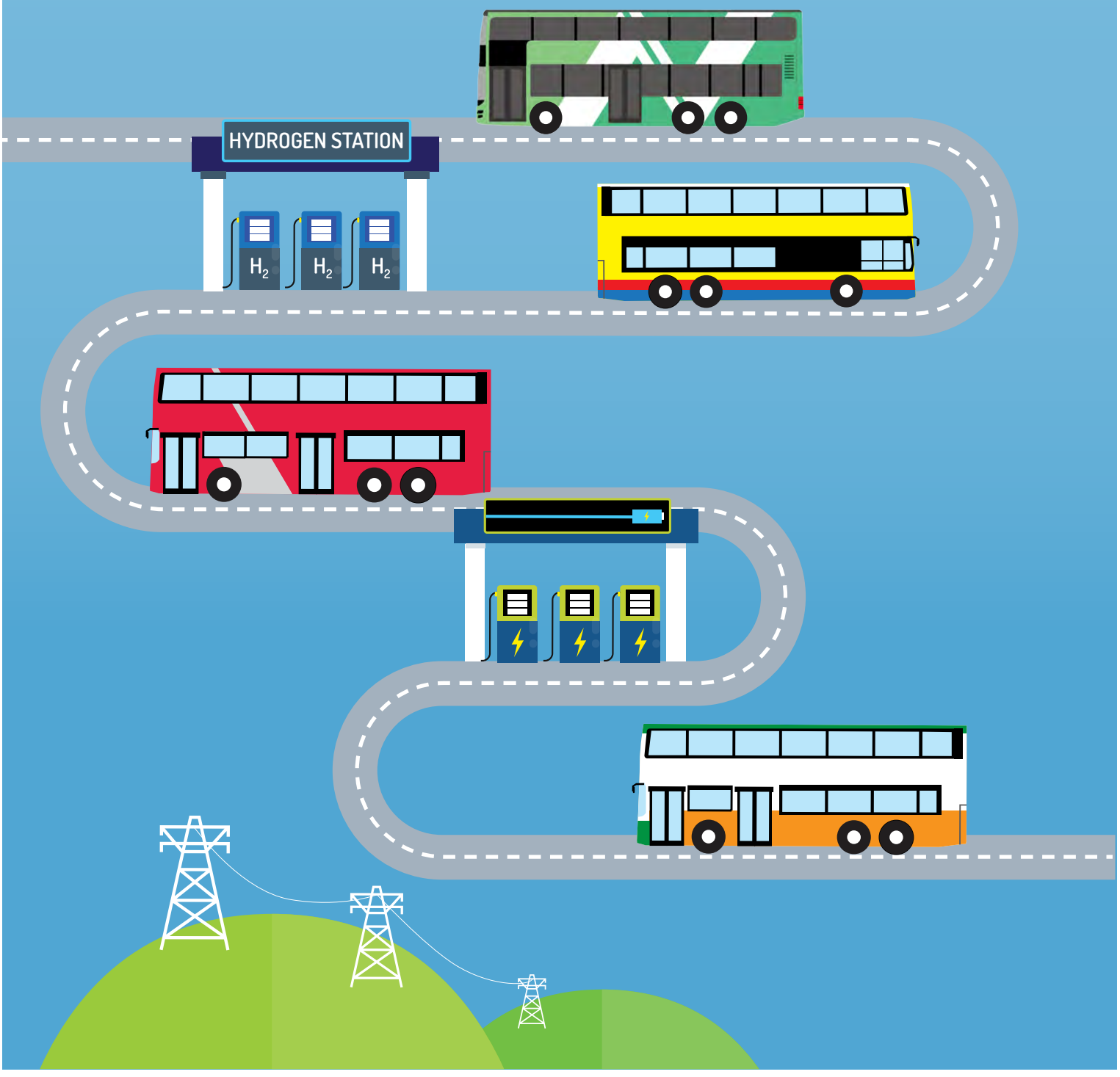
Zero Emissions Mobility Consortium

HONG KONG 2050 IS NOW

RECOMMENDATIONS OF THE ZERO EMISSIONS MOBILITY CONSORTIUM



PURPOSE OF THIS PAPER

This white paper serves as a joint communique issued by the Zero Emissions Mobility Consortium ("the Consortium") for the consideration of the Government. It outlines the results of the discussion among the Consortium Members on pathways towards decarbonising Hong Kong's transportation sector, challenges associated with the transition, and recommendations on actions to be taken by Government.

Zero Emissions Mobility Consortium Members:
listed by category, in alphabetical order

This project is sponsored by WYNG Foundation. The views expressed in this white paper do not necessarily represent those of the sponsor.

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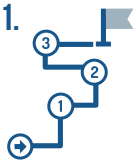
EXECUTIVE SUMMARY

Hong Kong's commitment to achieve carbon neutrality by 2050, as well as banning the new registration of Internal Combustion Engine ("ICE") private cars (including plug-in hybrid vehicles) by 2035, requires a process involving Government, industries, and academia to critically examine the current status, opportunities, barriers, and resources required to strengthen the city's capability in transitioning to zero emission road transport. To supplement this, the Zero Emissions Mobility Consortium was formed in July 2021 and comprises major franchised bus operators, power companies, and a variety of academic, research, and non-profit organisations, hereinafter called "Members". Equipped with wide spectrum of deep knowledge of the subject matter, Members held nine meetings from July 2021 to June 2022 to discuss the way forward to realise the zero emission goal for road transport in Hong Kong.

Members identified that the decarbonisation of 3-axle double decker buses—which compose 95% of the franchised bus fleet—currently face challenges of i) limited zero-emission makes-and-model availability, ii) insufficient vehicle driving range(s) for Hong Kong's intensive bus operation, iii) high capital investment costs for zero emission buses operation including the high prices of buses and infrastructure installation, and iv) passenger capacity losses. To address these challenges, Members propose a full decarbonisation pathway comprising approaches in vehicle technology, refuelling infrastructure, vehicle regulatory framework, and funding model.

To move forward with the full decarbonisation pathway, Members recommend six key action points for Government to engage in:

1. 

Provide clarity on a time-specific zero-emission roadmap for road transport, in which the new registration of ICE vehicles is banned by 2032. Government must take the lead in determining the appropriate Roadmap.

2.

Expedite and enlarge scale of trials for both battery electric buses ("BEBs") and hydrogen fuel cell buses with the franchised bus operators to avoid investing in a technology that may not be feasible in the long term through finding out operating performance under fleet level scale, for example operating entire routes with different operating conditions.

3.
Remove the regulatory barriers for technology development and adoption.

4.
Identify areas requiring cross bureau policy coordination for the relevant transport infrastructure development and plan accordingly with standards.

5.

Define an appropriate funding model for commercial operators to support the implementation of the roadmap, e.g., through providing for capital expenditure ("CAPEX") to retrofit bus depots and build infrastructure or purchasing capital assets and renting them to bus operators, plus supporting any extra operating costs, if applicable.

6.

Make significant investments in achieving a quantified modal shift target to public transport, while making its path towards zero emissions. There are several benefits to this beyond decarbonising the transport sector, including a significant decrease in air pollutants, which would have a positive direct impact to Hong Kong. To achieve this, Government could consider various best-in-class initiatives from other leading international cities, including road congestion charging, bus priority in tunnels and along heavily congested corridors, Bus Rapid Transit systems, etc. For impact to be significant, the modal shift target should be set at 5%.

Failing to take action to achieve the above will mean the only path for Hong Kong to achieve net zero in the transport sector would be through purchasing carbon offsets. This path is considered to be the "no courage to take real actions" way and is not recommended by the Consortium. Of the cities that have aimed for decarbonisation, no city has taken the offset path as its primary solution, as this would essentially be exporting one city's carbon issues into another domicile. For this reason, in the pathway towards net zero, all facets of society will need to internalise the externality costs of carbon emissions, with the operators being incentivised by Government to ensure alignment in achieving the common decarbonisation objectives. With oil prices remaining at elevated levels, the need to decarbonise Hong Kong's public transportation system is further intensifying.

The Zero Emissions Mobility Consortium hopes for Government to take the Members' recommendations into consideration while propelling Hong Kong's decarbonisation strategy for the road transport sector. The Members would be happy to meet collectively with the Government to present and discuss these areas in more detail, as required.

SIGNATORIES TO THE RECOMMENDATIONS OF

THE ZERO EMISSIONS MOBILITY CONSORTIUM

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Bravo Transport Services Limited

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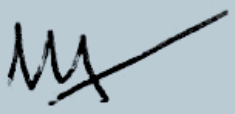

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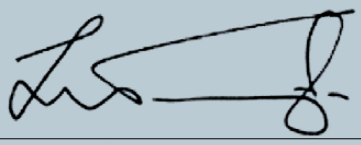

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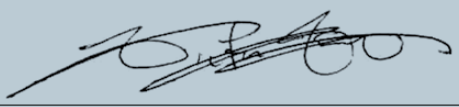

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Civic Exchange

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CEO
Clean Air Network

BACKGROUND

In order to achieve the 2050 carbon neutrality target announced by the Chief Executive of Hong Kong, a process involving Government, industries, and academia is required to critically examine the current status, opportunities, barriers, and resource requirement with the purpose of strengthening the city's capability in transitioning to zero emission road transport.

The Zero Emissions Mobility Consortium was formed in July 2021 with the objective to build knowledge, engage stakeholders, and advise on public policy on decarbonising the transport sector. The Consortium comprises major franchised bus operators, energy companies, and a variety of academic, research, and non-profit organisations, hereinafter called "Members".

Members attended nine meetings which took place from July 2021 to June 2022. All such meetings were hosted in a manner of transparency, proportionality, and non-discrimination, where Members drove discussions and the floor was open to all. As a result, Members reached a consensus on recommendations informed by facts and research, leading to the creation of this paper, which has been vetted and jointly produced by all Members.

During the meetings, Members discussed the ways in which the transportation sector can reach net-zero, in addition to the challenges of meeting this goal, including funding issues, and potential solutions. Members studied the regulations, incentives, and innovative policies enacted by other global benchmark cities, as well as partnered with the World Resources Institute ("WRI") to access more in-depth associated research.

FIGURE 1 **Members of the Consortium**
(listed by category, in alphabetical order)

Franchised bus operators	Energy companies	Academics	Research and non-profit organisations
Citybus Limited	CLP Power Hong Kong Limited	Academic from the Hong Kong Polytechnic University	Civic Exchange
Kowloon Motor Bus Company (1933) Limited	The Hong Kong and China Gas Company Limited (Towngas)	Academic from the Hong Kong University of Science and Technology	Clean Air Network
New Lantao Bus Company (1973) Limited	Power Assets Holdings Limited		

STATUS REVIEW

1 SUMMARY

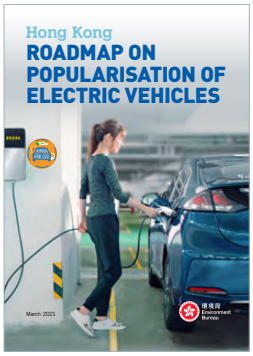
To enhance the Members' understanding and provide a basis for discussions, research was conducted on the status of the transportation sector in Hong Kong. Current trends on regulations and incentives for zero-emission transportation in the global landscape were also studied as examples of policies that may be applicable in Hong Kong.

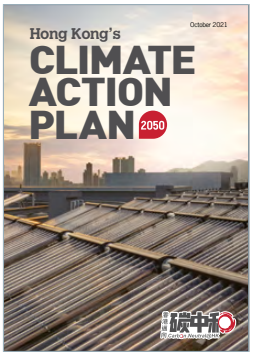
Government policies and gaps to be filled in Hong Kong

In the recently released Hong Kong's Climate Action Plan 2050 ("CAP") and Roadmap on Popularisation of Electric Vehicles in 2021 ("EV Roadmap"), electrification of vehicles (and ferries) is listed as the prioritised action needed to achieve the transport sector's goal of zero carbon emissions before 2050. More concretely, the Hong Kong Government aims to:

1) for private cars, ban the new registration of fuel-propelled private cars (including plug-in hybrid vehicles) by 2035 or earlier; and

2) for commercial vehicles, promote electric vehicles on a large scale and test out battery electric and hydrogen fuel cell electric buses and goods vehicles in the next three years.





The EV Roadmap mapped out the EV transition pathways for different vehicle classes. The roadmap is a living policy, which is to be reviewed every 5 years, with the purpose of adapting targets and policy measures in response to technology advancements and changing momentums.
To aid in the implementation of this roadmap, the Hong Kong government has promulgated a series of policies to promote EVs. These policy instruments vary by vehicle classes.

The $800 million New Energy Transport Fund (previously named Pilot Green Transport Fund) is in place to encourage the trial of low carbon technologies — including battery electric vehicles, hybrid vehicles, and plug-in hybrid vehicles — for commercial vehicles. Numerous commercial vehicles including buses, public light buses, taxis, and trucks, are eligible for funding within this scheme. Moreover, a $180 million subsidy was dedicated for franchised bus companies to procure eight super-capacitator buses and 28 electric single deckers for trials that lasted two years. In addition to subsidies, enterprises are entitled to 100% profits tax deductions for the capital expenditure on EV acquisition in the first year of procurement. Further, the first registration tax (FRT) is fully waived for commercial electric vehicles (including trucks, buses, light buses, taxis, and special purpose vehicles).

As of the end of October 2021, the total number of electric vehicles (EVs) in Hong Kong was 24,540, having been fewer than 100 at the end of 2010. Whilst this increase is significant between 2010 to 2021, it, however, remains insignificant in terms of proportion to the total number of registered vehicles of 813,601 (only 3%). This rests on a few reasons:

- Hong Kong's market share of electric private cars in new sales has jumped from 0.3% in 2017 to 30% in October 2021 (Transport Department 2017 and 2022). The electrification of private cars has shown steady performance due to growing incentives to promote EVs. However, this market share is much lower than global EV frontrunner cities such as Shenzhen and Shanghai.

- Contrary to conventional thinking, buses, and taxis — usually at the forefront of vehicle electrification — are the least electrified types of vehicles in Hong Kong. Only 25 (0.41%) franchised buses were electrified by the end of 2021, while taxis and public light buses entirely lack EVs. Although technological barriers represent one factor for this, the lack of charging infrastructure, huge financial barriers, limited make-and-model availability, operational viability, and low public awareness are also major reasons.

- Hong Kong's current vehicle electrification ambition is not on pace to meet the city's carbon neutrality target. For example, only banning the sales of ICE private cars (26.9% of the road transport emissions) is not sufficient to attain Hong Kong's 2050 carbon neutrality goal without clear roadmaps to decarbonise its large commercial fleet.

Landscape of operation of franchised buses in Hong Kong

Hong Kong's public transport accounts for over 90% of our daily journeys — proportionately more than any other city worldwide — and provides efficient and highly satisfactory services. Franchised buses play an important role in this as the second largest carrier of passengers. Optimisation of the service network has been undertaken annually since 2013 in bus route rationalisation programmes and bus route planning programmes, both of which consider views and recommendations from local level stakeholders.

The combined effect of rail expansion and bus route rationalisation consistently kept the increase in the number of passenger journeys on franchised buses to 1.1% between 2003 and 2019. The number of operated franchised bus vehicle kilometres shrunk considerably by 12.2% during the same timeframe, indicating substantial improvements in operational efficiency. Moreover, the impact of COVID-19 has further reduced transport operations, thus reducing profitability. Additionally, geopolitical tensions have instigated further fuel price volatility in the markets. The combination of COVID-19 and uncertain fuel prices is creating pressures for local bus operators. Hong Kong's long-established practices on efficient operation and competitiveness of bus services through the franchise mechanisms now face challenges in terms of bus decarbonisation:

- 95% of the franchised bus fleet is composed of 3-axle double deckers (gross vehicle weights over 24 tonnes). The decarbonisation of these double deckers currently faces challenges of limited electric makes-and-model availability, insufficient vehicle driving range(s) for Hong Kong's intensive bus operation, at present prohibitive prices, and passenger capacity losses due to Hong Kong's unique operating needs. These needs include, high air-conditioning requirements, three-axle double-deck loadings, operating range of 300-450km per day with more than 90% up time and near full day operations, alongside limited termini and depot space. Transitioning to zero emission vehicles could potentially lead to a massive increase in fleet size to just keep status quo of operations if this is not done in the right way.

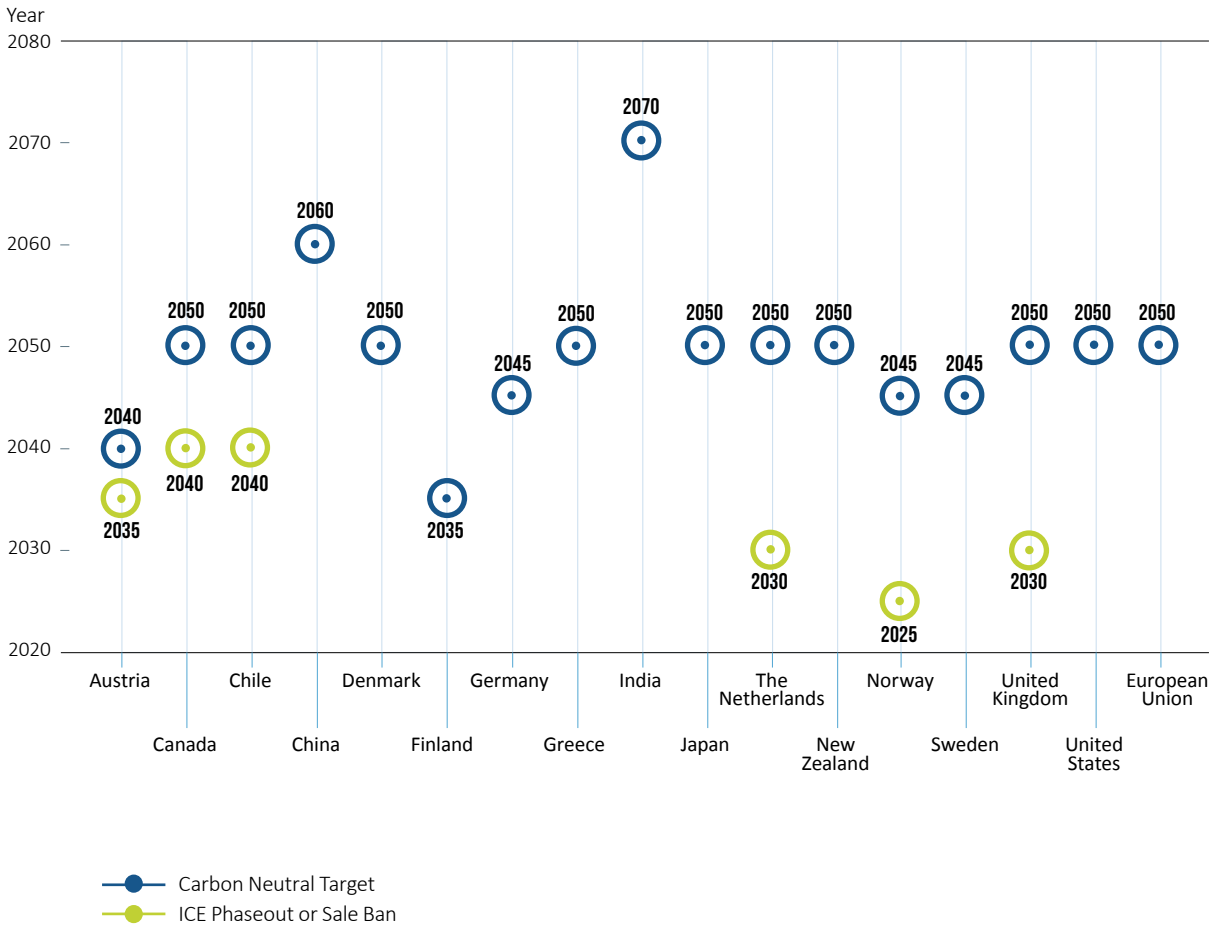
- As with London and Singapore, Hong Kong's buses operate under a franchise scheme. In London, private bus operators are responsible for capital investments in acquiring environmentally friendly buses and operating them for 10 years, while in Singapore, the Bus Contracting Model allows private bus operators to bid on the operation of vehicles owned by the Land Transport Authority.

Global trends and status on zero-emissions transportation

Overview

Globally, countries have enacted carbon neutrality targets—the earliest being 2035 in Finland, the latest being 2070 in India, and the majority being around 2050, as is in Hong Kong. To aid in transitioning their respective mobility sectors, several countries have also enacted ICE phaseout or sale bans—the earliest being 2025 in Norway and the latest being 2040 in Canada, Chile, and the United Kingdom, as shown in Figure 2 below. To better understand the ways Hong Kong can transition its public transport sector, Members reviewed regulations, incentivising policies, infrastructure, and innovative policies around the world. Further details on these can be found in Appendix A.

FIGURE 2 Global Overview of Carbon Neutrality and ICE Vehicle Ban Targets



Regulations

Several countries have enacted emission standards and fuel consumption targets. For instance, China has regulated HDV fuel consumption with set targets for fuel consumption for each weight class, while the EU has enacted emission standards such as Euro V or Euro VI, as well as monitoring and reporting requirements for original equipment manufacturers ("OEMs"), which several EU and non-EU countries follow.

Incentivising policies

Policy incentives around the world aid in pushing global transport systems towards net-zero emissions. Incentives range from subsidies and grants to tax exemptions or reductions. For example, China has a subsidy of up to RMB3000/kWh — approximately RMB1.05 million for a 350kWh electric bus.

Infrastructure

Charging and refuelling infrastructure is a key part in the transition to a net-zero transportation system. Globally, costs are being covered by governments in their own respective countries. Infrastructure funding ranges from government-built chargers, private/commercial charging incentive rebates, and tax depreciation rates. In China, grid operators such as the State Grid Corporation of China and China Southern Power Grid are increasing infrastructure investment to a total of nearly RMB28 billion. The UK is also supporting public charging installations, including their Rapid Charge network along strategic corridors with £500 million in funding until 2025.

Innovative policies

Majority of innovative policies concerned with transforming transportation systems to net-zero emissions involve zoning policies. China has implemented preferential zone/street access for new-energy vehicles in select cities, as has London and Oxfordshire in the UK. In London, vehicles that do not conform to zero-emission vehicle standards are charged a fee.

Implications

Governments around the world are providing sufficient incentives (funding, infrastructure, regulations, etc) to win over the industry's buy-in on the zero-emission transition. With current oil prices soaring, incentives are much needed to decarbonise road transportation around the world.

Hong Kong's Government should take reference from the Mainland and overseas experiences in developing a policy package that includes regulation, incentives, infrastructure, and innovation to create favourable conditions for the zero-emission transition. The Mainland and the UK are successes that Hong Kong should refer to, with both countries having worked closely with operators throughout their decarbonisation journey and enacting policy that decarbonises their respective public transportation systems.

Details of the policies of different countries can be found in Appendix A.

2 KEY CHALLENGES IDENTIFIED BY MEMBERS

Battery-electric technology may be more appropriate in certain instances than hydrogen fuel cell technology, and vice versa. For example, charging BEBs is simpler, while hydrogen vehicles can deliver longer daily ranges and higher passenger capacities, although BEBs can also serve short and medium city service routes. Both BEBs and hydrogen fuel cell vehicles are still undergoing technology improvements. To promote a development pathway for both BEBs and hydrogen fuel cell buses, Members identified and examined both technologies in terms of their i) technological maturity, ii) infrastructure, iii) regulatory framework, and iv) funding model challenges.

Technology

- Current zero-emission technologies may have lower passenger capacity compared to the presently operating diesel buses due to Hong Kong's unique operating needs today. Whereas other cities have selected certain technologies to match their needs, Hong Kong is unique due to its air-conditioning requirements, three-axle double-deck loadings, operating range of 300-450km per day with more than 90% up time and near full day operations, alongside limited termini and depot space. Hong Kong's unique geographical and climate conditions create performance uncertainties for bus companies' plans for deployment of BEBs and hydrogen fuel cell buses. For this reason, maintaining service level and reliability may require bus operators to deploy extra number of vehicles and drivers, which bear significant implications for operations, cost, and land use.

- As the performance of both BEBs and hydrogen fuel cell buses in Hong Kong's geographical and climate conditions are unknown, extensive like-for-like trials, are required to allow continuous improvement and adaptation of the technologies to Hong Kong's specific operating conditions.

Infrastructure

- In terms of infrastructure, BEBs require the installation of charging facilities amidst limited termini and depot spaces. Extensive modifications to the grid load of power companies will also be needed. This will require additional space, charging stations, switch rooms, and transformers. Installing chargers at as many buildings may be needed to help with Hong Kong's land space issue.

- Bus companies and Charge Point Operators (CPOs) find it difficult to navigate various government departments to find sufficient space to install chargers and provide charging services to the commercial sector. Government should identify areas requiring cross-bureau policy coordination for the relevant transport infrastructure development and plan accordingly.

- Currently, Hong Kong does not have the requisite infrastructure to enable trials of hydrogen fuel cell buses. If and when hydrogen fuel cell buses pass through trials safely and successfully, this technology will also face challenges in its supply structure and fuelling system, as the technology is unlike any other conventional technology. Logistics behind hydrogen fuelling stations and storage tanks will need to be understood and worked upon, especially as land in Hong Kong generally or in termini and bus depots is limited for hydrogen storage. A secure supply of hydrogen at large quantity sufficient to power bus fleets and at a reasonable price is also an important challenge to overcome for decarbonisation.

Regulatory framework

- Members have indicated that besides BEBs, hydrogen fuel cells vehicles are an interesting opportunity for Hong Kong. Although the technology has been extensively tested elsewhere in the world, hydrogen vehicles are still new to Hong Kong. Current hydrogen regulations in Hong Kong hinders the testing of hydrogen fuel cell buses.

- Hydrogen technology will also face challenges in its availability from green sources, supply structure, and fuelling system as like other emerging technology; in particular, logistics behind fuelling stations, fuel cell batteries, and storage tanks and public concerns on safety. Members believe the cost and steady supply of green hydrogen in Hong Kong will need to be understood and well planned for.

- Current regulations on bus specifications, such as bus weight and length, limits the adoption of new technologies to Hong Kong, as non-conventional buses do not align with current specification requirements.

Funding model

- Members have indicated that bus operators face a funding gap when operators purchase BEBs and hydrogen fuel cell buses at a large scale. Assuming transport operators continue to operate on a commercial basis, the funding gap must be met by subsidies and incentives, such as government subsidies or operators' revenue increase from fare/non-fare mechanism.

- Fare increases are usually met with public resistance and thus less preferred by Government. Government already has blanket subsidies in place for fares to aid people in need.

- True costs of large-scale implementation will only be understood after conducting operational trials for the unique Hong Kong environment, due to various unknowns and uncertainties, such as whether adapting the new technologies would require an extra number of buses to accommodate limited vehicle driving range(s) when operating the current level of service for customers.

PATHWAY TO DECARBONISATION

Based on the discussions, Members have recommended the way forward for the transition of Hong Kong's transportation system through full decarbonisation. This path involves addressing challenges identified by members in terms of technology, infrastructure, regulatory framework, funding model, as well as stakeholder alignment as described in the previous section.

Full decarbonisation pathway: Shifting to new zero-emission bus technologies

The full decarbonisation pathway requires a gradual transition from the existing diesel buses to new, clean technologies, without compromising the current service level to customers. In overcoming the associated challenges, which have been previously outlined, active collaboration between Government, industry players, academic and research institutions, and other relevant stakeholders, is essential.

The key points for this approach, as agreed upon by the Members, are as follows.

Operational viability

- Members have identified BEBs and hydrogen buses as the two technologies worth exploring in Hong Kong. However, local application of both technologies still needs to be studied in detail, as their performances are uncertain in Hong Kong's operational conditions. Betting on one technology means the supporting infrastructure will be centred around that one technology, which could pose a problem, should it not work out well in the future. As such, full deployment of a technology should not take place until it is robustly tested, similar to the current rigour in rolling out new bus models.

- Going forward, the Government should lead investments in trials of both zero-emission technologies so as to bring scale, coordination, and efficacy towards finding the right path forward. The trials will be a basis for a well-informed decision on which technology to select, and on when and how to simultaneously phase out the existing buses and phase in the new fleets.

- As both technologies call for large infrastructural changes, the trials should also consider the associated obstacles. The charging facilities required to operate BEBs will face issues in terms of land space, which will require extensive cross-bureau and cross-departmental coordination by the Government. Adopting hydrogen buses will need a thorough understanding of the land and logistics behind safe hydrogen fuelling stations and storage tanks in the Hong Kong landscape. Securing a clean, stable and reasonably priced hydrogen supply is also vital in preventing hydrogen shortage.

- For either technology, a unified charging configuration and standard of battery must be decided upon. A clear protocol for handling all batteries at their life-end should be established to minimise their environmental impact.

- Maintaining the current service level to customers is of high importance in the transition. The assessment of the new technologies and related infrastructure should consider their operational capacities, the potential additional vehicles or charging/fuelling facilities needed. In this regard, it would be preferable to have buses go out in the morning and return to the depot at night for charging/fuelling to prevent possible disruptions to the bus operations. Additional relevant factors to consider include the space required for bus parking in termini, and related raise in operational costs.

- To facilitate the trials and the transition in terms of a regulatory framework, amendments should be made to current regulations on bus specifications, such as bus weight and length. Specifically for hydrogen buses, Government is to amend Hong Kong's outdated hydrogen regulations. Government should also lay out a framework for the logistics of supplying green hydrogen to Hong Kong.

Commercial and Economic Viability

- Economic viability is one key pillars of sustainability and is equally as important as environmental and social pillars. In Hong Kong, bus operators have been operating under a commercial model, thus improvements in environmental and social facets should not sacrifice the business model of the bus operators.

- In this regard, although bus operators are supportive of government initiatives to full fleet decarbonisation, it would simply not be possible for bus operators to proceed without a better funding mechanism. There are investment risks and costs to be covered, not only in terms of capital expenditure, but also operational costs and other considerations. This is critical in aligning bus operators to be fully supportive of this effort. Bus operators do not have the financial capital to proceed with full decarbonisation if they were to be responsible financial stewards of their companies. Therefore, the government must first and foremost develop options for feasible funding models to facilitate operators' transition towards net-zero transportation. This may include filling in the funding gap, introducing key incentives, such as government subsidies, or allowing for operators to increase revenue via fare and non-fare mechanisms, or having the government directly purchasing and/or subsidising infrastructure and/or operating assets.

- In the transition, it is imperative to ensure that the commercial operations will generate sufficient returns in the long term in order to maintain the financial sustainability of the bus operators. Government should study the feasibility of all available funding options and provide regulatory incentives in partnership with bus operators to ensure the smooth implementation of this pathway to full decarbonisation via the adoption of new technologies.

"Weak action" Pathway: Using existing technology while setting sector-specific emission limits and carbon pricing

The Consortium has recommended the preferred pathway as per the above but realises that there is significant work and challenges to overcome in achieving the desired outcome. The Consortium further discussed the "what if" scenario, where the Hong Kong Government, alongside transport sector stakeholders, fail to deliver on the above plan – what would be the way forward?

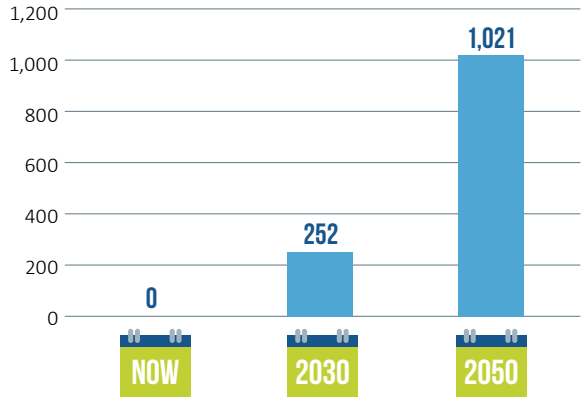
Although this is not preferred and not recommended, the Consortium recognises that Hong Kong could help global decarbonisation with carbon offsets, while continuing to run existing diesel bus fleets. This pathway relies on setting sector-specific emission limits to be met using improvements on the current technology and purchasing emission offsets in the global carbon markets. This means that Hong Kong will still have to bear the cost of offsetting its carbon emissions but will not realise any local benefits such as reduced local carbon emissions and air pollution or improved public health. In addition, as carbon offsetting mechanisms are generally directed to hard-to-abate sectors, no other global jurisdictions have implemented this approach with regards to their transportation sectors.

In the short term, utilising the readily available technologies, such as retrofitting current fleets to comply with Euro VI standards, would be a feasible way to reduce the emissions of public buses. Whereas, in the medium term, as an alternative to local decarbonisation, Government would enact several offsetting and carbon finance mechanisms, such as carbon trading or carbon pricing, as a means to decarbonise without major changes to current business operations in the public transport sector. The transition period should cease by 2050 or earlier where all bus operators should utilise BEB or hydrogen fuel cell buses.

The following calculation adopted the EU Emissions Trading System (EU ETS) price projection to underscore the current, medium term (year 2030), and long-term (year 2050) costs of both the decarbonisation and the "weak action" pathways. Further calculations can be found in Appendix B.

Cost of no action for transport sector

Million HKD (Annual Charges)



In reviewing the profits of each bus operator, the data shows that delaying or denying action on decarbonising the transport sector will result in a grave amount of costs. By 2050 or earlier, the cost of no action may create circumstances in which it will be impossible for bus operators to sustain their business and will not be in the public interest.

RECOMMENDATIONS OF THE ZEMC

As the global trend shifts towards zero emissions transportation, Hong Kong has an environmental and social responsibility to act as a part of the collective climate action in this sector. Members agree that, despite the rigorous changes and major efforts required, the full decarbonisation pathway would be a more action-oriented long-term plan towards decarbonising Hong Kong's transportation sector, commensurate with practices of Mainland China and the rest of the world. To achieve zero emissions, top-down leadership from Government administration is required to create a time-specific roadmap and lead the transition.

Critical roles served by Government and participatory process expected

Hong Kong's franchised bus operators are willing to evolve their operations towards zero-emission technologies, and the power industry is likewise willing to support this transition. However, Members believe it is critical that Government provides clarity on a time-specific zero-emission roadmap for road transport (the "Roadmap"), in which the purchase of new ICE vehicles is banned by 2032, as well as the development pathways for technologies, infrastructure construction, and regulatory framework amendments required so that proper planning and investments could be made. Non-technology solutions, such as providing incentives for a modal shift from private vehicles to buses (or public transport in general), would also play an important role in decarbonising the sector, and thus should be included in the roadmap.

Given the scale of the potential investment and the complex policy execution and coordination requirements, Government — in consultation with industry stakeholders such as the Members — must take the lead in determining the appropriate roadmap. As an example, Members believe that Government must work with Members on an appropriate funding model to help finance the transition. This may be best through a special task force where all industry players—policymakers, bus operators, power companies, academic institutions, vehicle and battery manufacturers, and other stakeholders involved in the transition—can work together to resolve both technical and non-technical issues.

Technologies available for Hong Kong and related infrastructure

- Members agree that, at present, due to a lack of testing taking place, there does not yet exist a universal zero-emission bus technology suitable for all Hong Kong operations at full scale. Nevertheless, Members agree that via investments and operational trials in greater scale, technologies appropriate for Hong Kong could be developed over time.

- In terms of currently available technologies, Members agree that both BEBs and hydrogen fuel cell buses are the technologies most worthwhile to study for investment into Hong Kong's transition path towards net zero mobility. While hydrogen fuel cell bus technology is new to Hong Kong, it has been successfully tested and operated throughout Europe and Asia, and therefore worth trialling in direct comparison with BEBs, where Electric buses are widely used in Shenzhen and other Mainland cities to determine the most suitable propulsion technology for the local operating market. Currently, however, without significant testing and development in Hong Kong operating environment, neither of these technologies provide a Hong Kong-specific total solution to deal with the city's unique terrain, land space, supply chain, infrastructure, as well as the substantial operating costs.

To move forward with the full decarbonisation pathway, the specific areas which need Government's swift actions are:

Technology

- As the applicability of zero-emission technologies in Hong Kong is still uncertain, trials must be undertaken to understand the performance and real cost of their adoption. Trials should be undertaken for both BEBs and hydrogen fuel cell buses to avoid deciding on a technology that may be less feasible in the long term.

- Through public-private partnerships, Government is to lead and fund large-scale trials that lead Hong Kong down this roadmap while coordinating infrastructure development to support the evaluation of two technologies (battery electric buses and hydrogen fuel cell buses).

- The above trials must be put into a timeline where decisions on technology choices must be made in order to achieve full decarbonisation objectives.

Infrastructure

- Building infrastructure for the adoption of zero-emission buses requires land space, which is a scarcity for Hong Kong. Bus termini and depots, as well as parking spaces, may need to be restructured to accommodate the buses' charging requirements or refuelling requirements.

- As these changes involve various government departments and bureaux, Government is to identify areas requiring cross bureau policy coordination and plan accordingly.

Regulatory framework

- Several regulations in Hong Kong are outdated and prevent Hong Kong from moving towards zero-emission vehicles. The specifications, i.e., width, height, and length, of new zero-emission technologies do not align with those of the diesel buses operating at present, regulated by the Transport Department.

- To allow the smooth execution of trials of the new technologies, Government should identify outdated regulations that would potentially become barriers for technology development and adoption.

Funding

- Large-scale operational trials for the adoption of zero-emission technologies in Hong Kong require sufficient funds. While Members, both franchised bus operators and power companies alike, have expressed their intentions to fully cooperate in the transition towards zero-emission mobility in Hong Kong, they would require Government's extensive support throughout.

- Government's focus should be on the making whole of the commercial operators. The right funding model should be defined to support the implementation of the roadmap, e.g., providing subsidies for CAPEX and retrofitting bus depots and building infrastructure, or purchasing capital assets and renting them to bus operators.

Near-term initiatives

Members would also advise the government to implement near-term initiatives to lower the emissions from Hong Kong's transportation sector:

- Government must work together with Consortium Members in seriously considering the abovementioned recommendations.

- Support and incentivise retrofitting, e.g., the installation of catalytic converters, on all ICE vehicles prior to 2032 to accelerate emissions reduction and improve Hong Kong's air quality.

- Encourage modal shift by creating a better travelling experience for passengers.

- Improve road efficiency, e.g., by controlling the growth of private vehicle ownership, implementing congestion charging schemes, and installing bus priority lanes.

APPENDIX

A. GLOBAL TRENDS AND STATUS ON ZERO-EMISSIONS TRANSPORTATION

Regulations

- The European Union (EU) is the world's leading body in emission-limiting regulations. Countries globally follow the EU's emission standards such as Euro V or VI, as well as monitoring and reporting requirements for OEMs. The EU has set targets on reducing GHG emissions from heavy duty vehicles (HDVs) by 15% by 2025 and 30% by 2030 (with 2020 as the baseline).
- Other countries have also followed in the EU's steps to reduce emissions. The United States aims to reduce CO2 emissions by 5-27% in 2027 compared to 2017 levels, while China has regulated HDV fuel consumption with set targets for fuel consumption for each weight class. In New Zealand, the Energy Efficiency (Vehicle Fuel Economy Labelling) Regulation was enacted in 2007.

Incentivising policies

Policy incentives around the world are aiding in pushing global transport systems towards net-zero emissions. Incentives range from subsidies to grants to tax exemptions or reductions.

- Subsidy-based incentives include up to RMB3000/kWh in China (approximately RMB1.05 million for a 350 kWh bus), $1.5 billion investments that cover upfront costs of battery-electric buses (BEBs) for 4000 zero-emission buses in Canada, and a direct subsidy of €2000 for battery electric vehicles (BEVs) under €50,000 in Finland.
- Grant-based incentives for EV buses include €130,000 in Austria, €1.2 billion in Germany, $1.4 billion for 7000 battery-electric buses in India, purchase price incentives for 20-40% of incremental costs between diesel and electric buses in Sweden, and $182 million in the United States.
- Tax incentives exist in Canada, where zero-emission vehicles are given a 100% tax write off; Finland, where there is a 5% tax reduction on BEVs; Norway, where BEVs and FCVs are exempted from number of taxes associated with ICE vehicles including tax and VAT, New Zealand, where HDEVs are exempt from Road User Charge, and the US, where tax credits up to $40,000 are provided for MHD-FCVs.

Infrastructure

Charging and refuelling infrastructure is a key part in the transition to a net-zero transportation system. Globally, costs are being covered by governments in their own respective countries. Infrastructure funding ranges from government-built chargers, private/commercial charging incentive rebates, and tax depreciation rates.

- Governments in several countries are directly funding the building of EV charging equipment.
  - In China, grid operators such as the State Grid Corporation of China and China Southern Power Grid are increasing infrastructure investment to a total of nearly RMB28 billion.
  - Canada has a multiyear initiative to establish networks of DC fast-chargers along national highways by providing funding to public sites and municipalities.
  - Germany is requiring all gas stations to have EV charging points by providing $2.8 billion for charging infrastructure and battery cell production.
  - Norway already has 16,000 charging points, which is 9% of the European total, although its population is less than 1% of Europe's, and has established fast-charging stations every 50km on all main roads. Sweden has devoted €15 million for 2020-22 to complete nationwide fast-charging infrastructure deployment.
  - Finally, the UK supports public charging installations, including their Rapid Charge network along strategic corridors with £500 million in funding until 2025.

- The provision of funding for commercial charging infrastructure is available in Austria up to €20,000, in Finland up to 35% of total purchase and installation costs for chargers, in India up to 100% of project cost funding, in the Netherlands up to 75% of amount invested, in the US through the INFRA Grant Program.

Innovative policies

Majority of innovative policies concerned with the transformation transportation systems to net-zero emissions involve zoning policies.

- China has implemented preferential zone/street access for new-energy vehicles in select cities.

- The Netherlands will implement zero-emission zones in 30-40 of its largest cities by 2025 and has built a pilot fast-charging plaza in Rotterdam. In Oslo, Norway, there is a low-emission zone in the form of three toll rings around the city, in which EVs pay only 50% of the total rate, while zero-emission trucks (weight above 3.5 tonnes) are exempt from paying the toll.

- In the UK, London's low-emission zone encourages the use of zero-emission commercial vehicles through charging a fee to vehicles that do not conform to the standard. Oxfordshire is piloting a similar zero-emission zone throughout the city in 2022.

A systemic view to modernising transport can effectively contribute to avoiding and shifting journeys and integrate measures across the board with common objectives have both been lacking in Hong Kong.

B. ETS CALCULATIONS: EMISSIONS, BUSINESS-AS-USUAL COSTS, AND FULL DECARBONISATION PATHWAY COSTS

Total Hong Kong GHG emission

40.1 million ton

Franchised buses emission

of Hong Kong's total carbon emissions: **2%***

of transport sector carbon emissions: **11%**

BAU transport emissions

7.23 million ton

BAU = Business-as-usual
DEC = Full decarbonisation pathway

* Note that in 2020, emissions from electricity generation fell to ~19,400kt, from 26,300kt in 2019. Unless the transport sector showed a similar level of reduction, the % share from land transport may have risen.

Million tonnes of CO_2e	Now (2019)	2030	2050
BAU transport emissions	7.23	5.41	1.94
DEC transport emissions	7.23	4.67	0.33
BAU Franchised buses emission	0.80	0.80	0.80
DEC Franchised buses emission	0.80	0.52	0.04

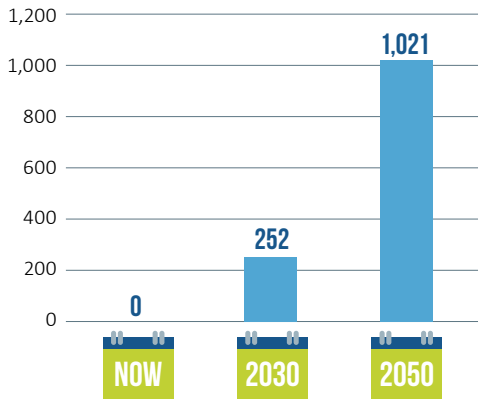
Source: HK GHG inventory and HK EPS

	Now (2021/2022)	2030	2050
EU ETS Carbon price (EURO)#	87	100	150
China ETS Carbon price (RMB)#	48	93	167
EU ETS Carbon price (HKD)#	776	892	1,338
China ETS Carbon price (HKD)#	59	113	204

\# CHN/HKD exchange: 1 RMB = 1.22 HKD
EURO/HKD exchange: 1 EURO = 8.92 HKD

- China ETS price 48, 93, 167 RMB in 2021, 2030, 2050
  http://www.xinhuanet.com/fortune/2021-07/19/c_1127668200.htm;
  https://ecep.ofweek.com/2021-08/ART-93004-8420-30514937.html
- EU ETS price 87
  https://tradingeconomics.com/commodity/carbon
- Benchmark prices in the ETS currently trade around 53 euros a tonne
- Analysts see EU carbon allowance prices under the EU Emissions Trading System rising to a range of Eur56/mt ($67/mt) to Eur89/mt by 2030
- Carbon prices to hit €140 by 2030, analysts forecast in newly-launched EU ETS coverage
- Assume 100 EURO IN 2030 and 150 EURO in 2050

Adopting EU ETS's carbon price
Cost of no action for transport sector
Million HKD (Annual Charges)



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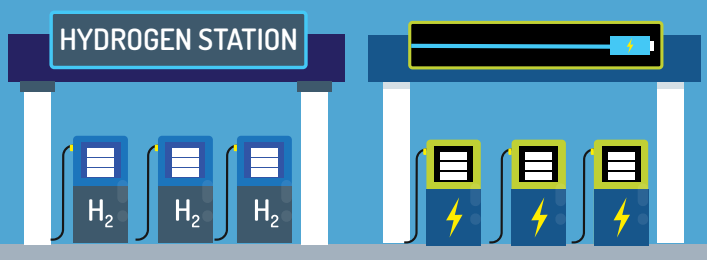
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