In Collaboration with
McKinsey & Company

Unlocking Large-Scale, Long-Term Capital for Sustainable Mobility:
Introducing Key Mobility Investment Archetypes

INSIGHT REPORT

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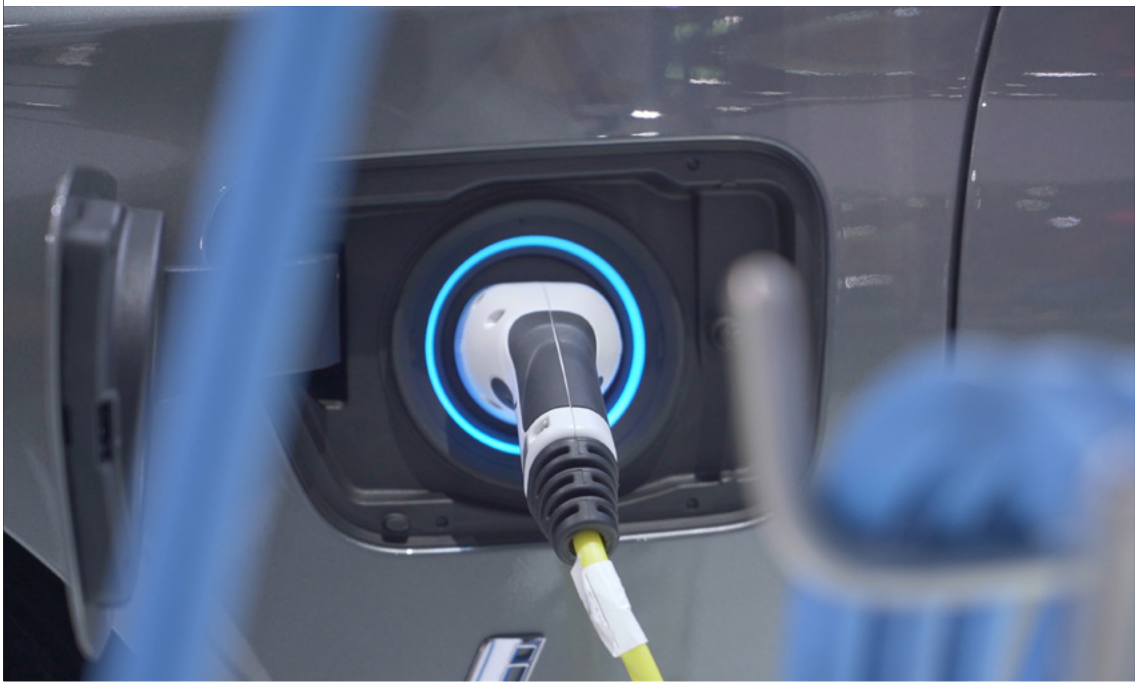
Preface

Unlocking large-scale, long-term capital for sustainable mobility

With the signing of the Paris Climate Accords and extreme weather events in many parts of the world, climate change and decarbonization are at the forefront of many minds in government and industry. Solutions are being widely discussed, but research suggests that net greenhouse gas (GHG) emissions need to be reduced much faster than anticipated to meet the targets set forth by the Paris Agreement in December 2015.[1] Transport[2] contributes roughly 10% of global GHG emissions,[3] and reducing emissions from this sector is vital to meeting these climate targets. While current efforts are ongoing, the pace of transformation is unlikely to be sufficient, and barriers to a quicker transition (at scale) to zero-emission road transport must be addressed.

One of the key barriers facing this transition is the lack of coordinated investment in the shift from internal combustion engine (ICE) to zero-emission vehicles. In particular, fleets – meaning a (larger) number of vehicles managed by a single entity – represent an opportunity to accelerate the zero-emission transition for two reasons. By targeting fleets, particularly of larger operators, multiple vehicles can be transitioned to zero emissions at once. Furthermore, the majority of fleets consist of commercial vehicles,[4] which typically have a higher use rate, hence CO_2 emissions, than their non-commercial counterparts. Concentrating efforts on electrifying fleets rather than privately owned vehicles could accelerate reductions in CO_2 emissions by up to four times in the next 10 years, according to several studies.[5]



Executive summary

Accelerating the zero-emission mobility transition globally through a large-scale collaborative effort

The need for investment into zero-emission greenhouse gas (GHG) technologies is apparent. McKinsey estimates that €28 trillion of investments will be required to reach net-zero by 2050 in the 27 European Union members alone, compared with no climate action. The domestic transportation sector[6] accounts for 21% of European GHG emissions (10% for transport globally[7]) and makes up 40% of the total investment need (€12 trillion), so it is a critical sector for abatement.[8] Current momentum – which is far below what is needed to limit global warming within 1.5 degrees Celsius of pre-industrial levels[9] – does not suffice, and barriers to a faster transition to zero-emission transportation must be overcome quickly. The barriers include long investment horizons to achieve positive business cases, the chicken-and-egg problem of limited charging and refuelling infrastructure in advance demand take-up (at scale) of alternative powertrain vehicles, the need for significant large-scale investment, and non-negligible risk – at least for a single industry player or private investor.

These barriers could potentially be mitigated via a structured, collaborative effort – including relevant industry leaders, federal and local governments, and global investors – that is designed to create large-scale investment opportunities in the global domestic sustainable mobility sector.

The World Economic Forum, in collaboration with McKinsey & Company as a knowledge partner, has developed a process that allows for structured and continuous consultation, with dialogue between all three stakeholder groups. This process has identified sustainable mobility investment cases and relevant stakeholders for each case.

Sustainable mobility investment cases propose collaborative solutions to collective transition barriers along the domestic transport sub-asset classes that make up 95% of emissions in the sector – buses, passenger cars, trucks and last-mile delivery vehicles – plus charging infrastructure, which is a key enabler for all sub-asset classes. Investment cases are designed to unlock large-scale capital flows to sustainable mobility by aggregating and matching demand and supply. They also propose a private-public partnership approach to unleash investment from the private sector. The proposed solutions mitigate the chicken-and-egg problem, thus allowing a scaled solution that moves beyond one-off projects and is quickly scalable beyond pilot locations.

This joint white paper introduces six proposed sustainable mobility investment cases:

1. City buses – Zero-emission buses in major cities via the shift from capital to operating expenditures (capex to opex)

2. School buses – Zero-emission school buses via the change from capex to opex in a specific region

3. Passenger cars – Shared-ride vehicle fleets replaced by electric vehicles (EVs) in a major city

4. Heavy-duty trucks – Joint venture set up to create a zero-emission truck leasing model

5. Last-mile delivery – Joint venture set up to lease short-haul light commercial vehicles to retailers and logistics players in a major urban area

6. Charging infrastructure – Hydrogen refuelling station build-up on highways and city mobility hubs for public use.

These six cases are meant to provide an introduction to the programme; they are, however, not exhaustive. While the investment opportunities presented here largely focus on early-adopter regions in Organisation for Economic Co-operation and Development (OECD) nations, the intent is to also deploy them in developing economies as rapidly as possible.

The World Economic Forum and its partners are committed to facilitating the multistakeholder approach along each of these investment cases to aid the transition to zero-emission and sustainable mobility. They intend to continue its partnership and incubation role in this process.

Introduction

The need for a structured collaborative effort to accelerate the zero-emission mobility transition globally

21%
of EU 27 CO_2 emissions can be attributed to domestic transport

The transport sector is responsible for a significant amount of GHG emissions. For example, in the 27 members of the European Union (EU 27), domestic transport emits 820 million tonnes[10] of carbon dioxide equivalent (CO_2e) per year, accounting for 21% of total EU emissions.[11] Globally, the transport sector emits 8 metric gigatons of GHG, accounting for 10% of total GHG emissions; road transport accounts for 15% of global carbon dioxide emissions. Consequently, the global transition to zero-emission mobility plays a crucial role in achieving the reduction in CO_2 emissions required to limit global warming to within 1.5 degrees Celsius of pre-industrial levels, as targeted at the December 2015 Paris Climate Conference. Although many initiatives are already in place, the current momentum in transportation is moving toward a 2- to 3-degree pathway. Thus, reaching the 1.5-degree target will require the accelerated adoption of zero-emission vehicles (ZEVs).

It is apparent that a faster trajectory is needed, yet key challenges faced by industry stakeholders are blocking an accelerated transition. While in some cases ZEVs can already achieve operational cost benefits today, the upfront capital expenditure (capex) is a significant impediment to the transition, particularly for individual vehicle owners and those of smaller fleets, and requires a paradigm shift in the traditional incremental replacement approach taken by many fleet owners. Furthermore, a chicken-and-egg problem exists: an acceleration in charging and refuelling infrastructure is required to advance ZEV adoption, yet economically viable investments in electric vehicle infrastructure (EVI) are in turn dependent on a demand-side acceleration – that is, ZEV adoption.

While technologies are ready for takeoff and many small-scale initiatives are already in place around the world, the scale-up, moving beyond individual projects to a large-scale roll-out, poses a major challenge. In order to achieve scaled solutions, the mobility sector as a whole requires a large-scale investment, which carries significant non-negligible risks that are prohibitive for a single industry player or private investor.

Individual industry players alone can likely not overcome the challenge alone. It requires a structured collaborative effort by a new large-scale coalition consisting of relevant incumbent and emerging industry leaders, federal and local governments, and global investors, and that is designed to unlock long-term, large-scale capital for sustainable mobility and thus an accelerated zero-emission mobility transition globally. This collaboration also needs to engage local communities, particularly disadvantaged ones, that are directly affected by the implications of climate change and should benefit from opportunities created by the global zero-emission transition.

This paper provides an overview of zero-emission transition challenges faced by the sustainable mobility sector along key sustainable mobility areas and introduces the structured collaborative approach currently pursued by the World Economic Forum and McKinsey & Company as a knowledge partner. It further introduces six concrete investment cases that could serve as blueprints for a global roll-out at scale.

Mobility transition investment opportunities

A joint approach to unlock large-scale, long-term capital in sustainable mobility

Context

Reaching net-zero for the EU domestic transport sector alone will require €180 billion in incremental capex until 2030.

Reaching the climate targets set by governments around the world represents an unprecedented scale-up challenge. For instance, McKinsey & Company estimates that reaching net-zero emissions in Europe by 2050 will require an investment of up to €28 trillion in clean technologies and techniques, with the transportation sector requiring nearly half of the capital. Comparing this with the total annual EU 27 investments, decarbonization would require the redirection of roughly a quarter of all annual investments in addition to increasing the investment pool by 7%, a major challenge for government and financial institutions.[12]

The transportation sector plays a critical role in reaching the net-zero target, as approximately 21% of overall CO_2 emissions in Europe are produced as a result of domestic transportation. While a zero-emission transition of the sector would require a massive incremental capex of approximately €180 billion by 2030,[13] it can generate net capex savings from 2040 onward and almost completely break even by 2050. Consequently, accelerating the zero-emission mobility transition globally seems like a good place to start. Yet, while many initiatives are already in place, the current momentum in transportation is on the path toward 2 to 3 degrees Celsius, instead of the target: within 1.5 degrees Celsius of pre-industrial levels. It is apparent that a faster trajectory is needed, particularly by developed economies to allow for slower adoption by developing countries. The transition, however, has been slowed down by three key challenges.

Mobility players[14] face a "chicken-and-egg" problem of whether to first address the limited availability of charging infrastructure or the ZEV adoption required for a solution at scale. While ZEV uptake requires sufficient charging stations to mitigate operational risk and justify high capex, the reverse also is true. Mobility players therefore face difficulties explaining distinct investment objectives to private investors and they lack the scale to single-handedly structure and finance large, high-impact projects.

Significant large-scale projects often lack funding because financial players face economic barriers to investing in zero-emission mobility. These barriers include uncertain market outcomes and (thus) returns, operational risk based on the need to manage projects of unprecedented scale, and a potential adoption risk due to the industry's rather young age. Furthermore, many business cases require long investment horizons to become positive; and about one-third of the required capital outlays in transportation are missing a positive business case altogether.

The magnitude, complexity and longevity of the required investment rule out most of the more short-term-oriented investors. Long-term-oriented institutional investors seem to be better suited but are often put off by adoption and technology risk if they are not properly mitigated.

Governments do not sufficiently close the funding gap, despite having the lowest cost of capital. The reasons behind this can range from organizational capacity issues to restrictions from public debt limits.

Approach

Overcoming the challenges will be far from easy and will require a large-scale collaborative effort by stakeholders to structure scalable mobility investment cases. These cases should be designed to overcome challenges faced by industry players and at the same time suit the investment characteristics of global investors, representing large-scale investments with sufficient long-term stable returns. The creation of such investable opportunities will require close collaboration between industry leaders, government and regulators, and global investors. This collaboration might take the form of a sustainable mobility investment network, in which each player contributes their unique skills.

Industry leaders comprise incumbent and emerging industry players that are relevant to each mobility investment case and that want to drive change in the respective mobility space. These industry leaders contribute the capabilities to provide and scale up infrastructure and vehicle supply and to implement and operate large-scale zero-emission projects. While global industry could enable fast scaling to further locations (including emerging economies), the approach should include local industry players so local communities can benefit from the opportunities.

Long-term investors could contribute in two ways. First, a collaboration between long-term investors would provide the required funding power (€180 billion incremental capex need until 2030), which currently exceeds the capabilities of individual investors, companies or industry coalitions. Second, the long-term return expectations enable the pursuit of opportunities that would not be attractive for investor groups with shorter term interests.

Governments and regulators could de-risk the investment by providing regulatory clarity and long-term governmental master plans to reduce uncertainty and hence risk of commercial initiatives. This may attract long-term investors, who in turn can mobilize more capital. Governments and regulators also have the opportunity to facilitate an accelerated transition by introducing regulations, such as internal combustion engine (ICE) bans or zero-emission zones. These measures could go hand in hand with government-supported enablers for affected industry players, including smaller players that may struggle to conform with government-induced targets without support. Further, governments may increase the attractiveness of investments by supporting the transition via public financing, e.g. carbon gaps to positive investment cases for investors.

The bundling of the capabilities of all three stakeholders holds the potential to uniquely boost the transition and thus enable a faster trajectory to zero-emission mobility.

Mobility transition investment cases

The World Economic Forum, jointly with McKinsey & Company as a knowledge partner, has initiated a structured approach to conceptualize investment cases in close collaboration with the three stakeholder groups. The prioritized investment cases are introduced in this white paper. While each case focuses on a unique sustainable mobility area facing distinct challenges, they all share a common foundation.

Investment cases consolidate the demand side and supply side through the aggregation of demand for individual vehicles by targeting mobility fleets (including subcontractors) and aligning supply (vehicle and charging infrastructure) with demand. Investment cases are thus designed to overcome the chicken-and-egg problem, significantly reducing operating risks for industry players and risk to investors.

Investment cases are designed to lift the capex burden off individual players' balance sheets by founding a new legal entity backed by long-term investors that takes ownership of assets (including vehicles and infrastructure) and bundles them into an all-in-one leasing solution for the demand side. Thus, capex is transformed to operating expenditure (opex) for demand-side players. Demand-side players will differ among investment cases, yet the structures are designed to aid individual or small-scale fleet operators, particularly subcontractors, which often face higher switching barriers due to limited availability of financing options, as well as lower risk-taking abilities.

Investment cases are structured to become "investable" for long-term-oriented investors via securitization or structuring that satisfies global long-term investor needs, i.e. long-term stable returns with adequate risk-return profiles. Governments could further help by providing mechanisms to reduce risk by offering, for example, guarantees to reduce financial risks, such as credit and counterparty risk or financial support in the form of subsidies to ensure that the offering is economically attractive on the demand side.

Investment cases are blueprints, scalable to other locations. Investment cases are designed to overcome challenges faced by the sustainable mobility sector globally. They are also being developed in close collaboration with global industry players. Thus, while the proposed solutions should be piloted in a specific region initially, they are blueprints designed for fast roll-out to further locations, including emerging economies. Hence, a similar structure may be applicable to multiple transition cases and, importantly, the cases are not in competition. Each investment case, of course, needs to be tailored to local specifics through close collaboration with local stakeholders.

Table 1 provides an overview of the six investment cases introduced in this white paper. As all investment cases share common design foundations, the paper focuses on the unique characteristics of each sustainable mobility area and investment case in each section. Importantly, these investment cases represent initial opportunities that have been shaped with stakeholder groups (located mainly in Organisation for Economic Co-operation and Development (OECD) countries) during initial consultations. Hence, the investment opportunities presented here are not exhaustive. In particular, an accelerated zero-emission mobility transition will require a more nuanced geographic approach that includes opportunities in emerging economies and that are perceived as highly impactful and call for further analysis. Similarly, investigations should address further areas of potential high impact on mobility, such as two- and three-wheelers. Furthermore, the cases presented are still in a developmental stage and require maturing before they become investable opportunities.

TABLE 1 | Possible investment opportunities

Potential investment opportunities	Description
1. Zero-emission bus fleets in a city	SPV takes on zero-emission bus asset ownership as well as charging infrastructure ownership. Leases to bus fleet operator. Minimal upfront expense to operator
2. Zero-emission bus fleets – school buses and corporate shuttle buses	SPV takes on zero-emission school bus or corporate shuttle asset ownership, as well as charging infrastructure ownership. Leases to school bus or corporate shuttle operator. Minimal upfront expense to operator. Possible income stream to school bus operator while buses are idle through vehicle-to-grid arrangement with electricity distributor
3. Zero-emission passenger cars – shared ride vehicles (taxi fleets, platform operators)	SPV takes on zero-emission passenger vehicle ownership as well as home chargers and leases to mobility service provider-contracted drivers. Possible second SPV to take on charger asset ownership and, through partnership or arrangements with property owners (separate from government), mandate installation at strategic locations across city
4. Joint venture to create Zero-emission truck-leasing model	Joint venture between truck manufacturer, charging infrastructure provider and asset owners to establish operating company to lease zero-emission trucks to truck fleet operators
5. Joint venture to lease short-haul Zero-emission LCVs – retailers and logistic players	SPV takes ownership of zero-emission LCVs as well as chargers and leases to smaller retail and logistic truck fleet operators in a trucking-as-a -service arrangement
6. Charging infrastructure – hydrogen refuelling stations (HRS)	SPV takes ownership of HRS, partnering with governments and highway authorities to secure locations to establish HRS. SPV is both the asset owner and operating company

1 When city buses go green

Unlocking a large-scale transition to zero-emission buses in major cities

In 2021, London's bus fleet already included 200 electric buses, making it the largest electric bus fleet in Europe.

Context

With city buses on fixed routes in a confined geographical area, range anxiety[15] is seldom an impeding factor to the adoption of zero-emission vehicles for city bus fleets.[16] Centralized charging infrastructure in bus depots can allow for vehicles to be charged at the beginning or end of their route, likely not requiring extensive additional charging infrastructure build-up outside of bus depots.[17] Furthermore, Battery electric buses offer a lower total cost of ownership than comparable diesel or compressed natural gas buses, thanks to lower maintenance needs among other factors (see Box 3 Total cost of ownership (TCO) for an example using passenger cars). Therefore, their use can unlock long-term savings for fleet operators.[18] In addition, electric buses run more quietly than regular ICE buses, reducing noise pollution within cities.

In some locations, existing trolleybus infrastructure may be leveraged to electrify bus fleets, thus circumventing grid upgrades and charging requirements altogether. Trolleybuses draw power from overhead wires, a technology that had already been in decline. They are, however, on the rise again, leveraging in-motion charging technology[19] on electric vehicles. Several European cities and regions, including, among others, Switzerland and Germany, have announced plans to leverage trolleybuses in their zero-emission transition.[20]

Problem to be solved

On their own, fleet operators still face significant barriers to a zero-emission transition. Many have insufficient funds available for an accelerated transition, given their restricted financing options, particularly for public operators (e.g. government funds). Consequently, they have tended to replace fleets incrementally and at a pace likely too slow to reach government-set targets. Furthermore, in addition to their purchase, introducing electric buses often requires major grid upgrades in bus depots to enable the installation of charging infrastructure, which amplifies the complexity and capital requirements. With fixed routes and tight schedules, bus depots cannot be freely moved to locations with sufficient space and existing grid infrastructure; they would have to be extensively refurbished in existing locations, which is costly and requires a long-term commitment.

Proposed solution

A solution that mitigates roadblocks for city bus fleet operators to convert to ZEVs would unlock the potential for major CO_2 savings. For example, buses and coaches in the United Kingdom accounted for approximately 3 million tonnes of CO_2e in 2019, or 2.5% of domestic transport-related emissions.[21] London has had clean buses in operation since 2004, when the first fuel cell bus was launched into service.[22] By 2019, two city bus routes had been designated as electric only. At that time, 200 electric buses were already in London's bus fleet, making it the largest electric bus fleet in Europe, resulting in a 90% drop in nitrogen oxide (NOx) emissions.[23] As of March 2021, London's bus fleet consisted of 4,697 ICE buses (diesel), 3,884 hybrid, 485 electric, and two fuel cell buses – a total of 9,068 buses.[24]

A city similar to London could be used to pilot a large-scale zero-emission city bus transition of the remaining ICE and hybrid fleet. A special-purpose vehicle (SPV), funded by an equity or debt investment from one or more long-term investors, could be formed. The investment vehicle would acquire assets, buses and possibly bus depot charging infrastructure on its balance sheet and lease them to public and private bus fleet operators as an all-in-one zero-emission solution. The fleet operator would pay a monthly leasing fee to the SPV, thus shifting capex to opex from the bus fleet operators' perspective. This set-up would also mitigate operating risks for fleet operators by providing a solution that includes charging infrastructure. The total cost of ownership (TCO) positivity of BEVs versus ICE buses would further unlock long-term savings for fleet operators and governments.

Government support in the form of guarantees, for example, could reduce the credit risk to investors. Furthermore, subsidies – for example, vehicle purchasing subsidies – may further increase economic incentives for fleet operators to switch to ZEVs by reducing TCO and thus monthly leasing costs to operators. Governments may also consider introducing regulations that increase the cost of operating ICE buses – for example, by introducing or increasing CO_2 emissions charges, thus further facilitating the TCO positivity of BEVs. Governments could also solidify the magnitude and pace of this mobility transition through enabling environments such as zero-emission-only bus zones. In the United Kingdom, for example, the government has announced a plan to ban ICE bus sales.[25] London specifically has set the goal to add only zero-emission buses to the system from 2025 onwards, implying that the entire fleet would be zero-emission by 2037.[26]

Other industry leaders also may participate in the SPV structure, through either contractual agreements or direct (equity) participation. For example, OEMs and charging infrastructure and grid providers should be involved in the supply planning. They will likely be inclined to scale up production and unlock further savings on vehicle acquisition and charging expenses under a large-scale contract. Figure 1 summarizes a possible set-up and the interactions among various stakeholders. Operator models may vary between different cities and regions; some will, for example, have fully publicly operated bus systems. Solutions will thus need to be tailored to local specifics.

Cities globally are already undertaking similar initiatives. Bogota, for example, has established an arrangement in which third-party-owned buses are rented to bus fleet operators. This same third party has committed to building and operating bus charging terminals. Furthermore, since 2019, an Italy-based e-mobility solution provider has been renting buses and providing charging infrastructure to Bogota's public-transport system.[27]

Government support to continue with public-transport electrification is evident in Colombia's commitment to reduce GHG emissions by 51% by 2030[28] and the Electrification of Public Transportation System Law of 2019 (Law 1964/19) signed in July 2019.

In India, a publicly owned energy service company has introduced a demand aggregation model combined with a switch from capex to opex to boost EV demand for buses in nine major cities. Further, a similar concept is in the planning in the context of three-wheelers.[29] These initiatives are placed in the broader context of the Indian Government's Faster Adoption and Manufacturing of Hybrid and EV (FAME II) initiative (see Box 1 A third wheel?).[30]

BOX 1

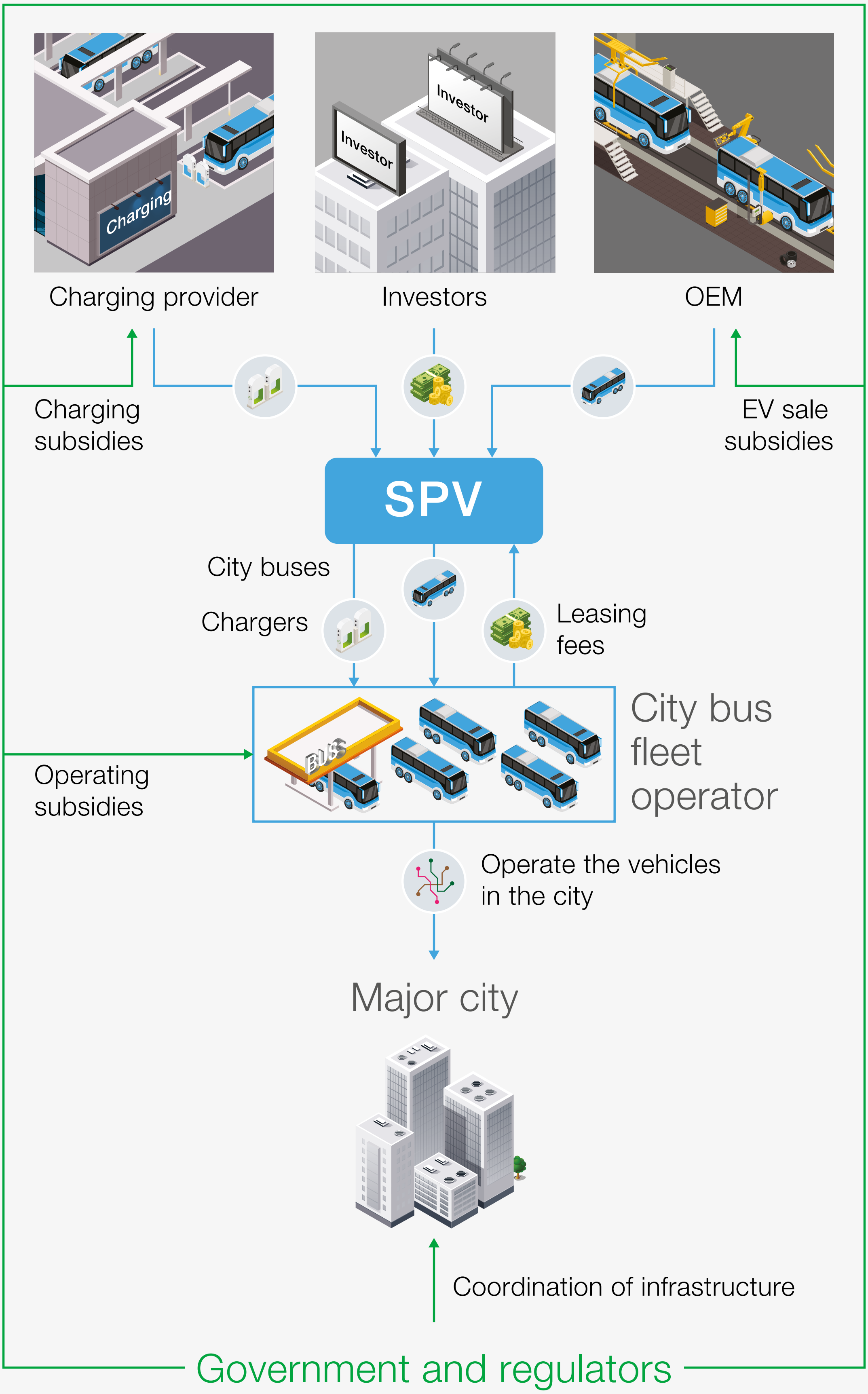
A third wheel?

Two- and three-wheelers have dominated mobility systems in some emerging economies for decades. As a result, lead acid propulsion in these vehicle classes has grown drastically, reaching a level that has triggered regulators' awareness. For example, 6 million rickshaws were on the road in India in 2018, with a compound annual growth rate of 8% between 2012 and 2018. Three-wheelers accounted for approximately 30% of the total diesel consumption of the Indian transport sector in 2018 and cause approximately 10% of total CO_2 emissions in India.

Governments and regulations have recognized the need to impose stricter rules in order to increase the safety and eco-friendliness of electric micro-mobility. In many emerging markets, extensive regulations have been introduced already, some even banning ICE two-wheelers. For example, the state of Punjab has banned the new registration of diesel/petrol-operated three-wheelers in some districts.

Despite these first efforts to achieve an eco-friendly delivery and travel system for two- and three-wheelers, a large-scale solution from infrastructure to operations is not yet available. A global large-scale zero-emission solution for two- and three-wheelers would require dedicated financing for appropriate vehicles and the corresponding charging infrastructure. While a detailed investment opportunity is beyond the scope of this paper, the opportunity is perceived as having a high impact in terms of CO_2 emissions reductions and (thus) its potential positive impact on local communities.

FIGURE 1 | **Roll out a leasing scheme for zero-emission bus fleets in a major city (including infrastructure)**



2 Fossil-free school buses

Providing a zero-emission solution for school buses and corporate shuttles

Context

More than 480,000 school buses are in service in the United States, accounting for 90% of the national bus fleet, yet fewer than 0.6% run on clean energy today.[34] The infrastructure plan from the US Government proposes a $174 billion investment in the EV market and also includes a target to electrify at least 20% of the nationwide school bus fleet.[35] Furthermore, the recently proposed Clean Commute for Kids Act authorizes $25 billion in funding through the Environmental Protection Agency (EPA) for the conversion of the ICE school bus fleet to an electric fleet over the next 10 years. The conversion to zero-emission buses under this programme could reduce GHG emissions by an estimated 5 billion tonnes each year.[36]

In the United States, there are more than 480,000 school buses in service, which account for 90% of the total nationwide bus fleet.

On a regional level, the state of Massachusetts has initiated the Massachusetts Clean Cities Coalition, aiming to support the development of alternative fuel infrastructure. Through the programme, the state has already established a partnership with schools to convert to BEVs and has allocated funds to three schools.[37] In Canada, the province of Quebec announced the investment of CA $250 million (US $200 million) over a three-year period to electrify school buses. This is expected to fund 2,600 electric school buses, replacing diesel buses, which will reduce GHG emissions by 800,000 tonnes over three years. A Quebec-based OEM is expected to supply vehicles, with other OEMs possibly fulfilling orders if demand ramps up beyond the production capabilities of a single OEM.[38] Both regions could be potential pilot regions, with further investigation needed.

Problem to be solved

A central, large-scale zero-emission transition would be challenging in the United States, given that the landscape of school bus operators is quite fragmented, with 131,000 schools and 14,000 school districts.[39] Additionally, regulatory environments differ by state. Consequently, the majority of school bus operators operate locally and have small fleets. Also, the majority of them are publicly funded; only about one-third are private operators. Public fleet operators have limited financing options because they are often bound by publicly available funds (commonly, municipal bonds), such as transportation budgets or grants. Consequently, the high capex required to transition to ZEVs and the need for an accelerated pace to reach global emissions targets are major challenges for bus operators.

In addition, the TCO of BEV school buses is not yet competitive with comparable ICE vehicles, due to the regulated market for school bus manufacturing and limited operational use cases. School bus fleets typically operate only in the morning (to take children to school) and late afternoon (to bring children home). At other times, the vehicles are usually idle. This results in a comparatively low use of school buses, which creates a challenge in recouping high upfront capital investments on EV and EVI over the asset's lifetime. Key stakeholders – fleet operators and schools – also have limited capabilities to evaluate and manage the high uncertainty resulting from the technological and operating risk of such a transition project. Given the lack of TCO advantage of school buses to date, which is expected to break even within the next four years, they also lack economic incentives to initiate a zero-emission transition on their own.

Proposed solution

To transfer the capital requirement burden away from school bus operators, a model similar to that proposed for city bus fleets could be implemented. One or several long-term investors can establish an SPV by fronting the capital to purchase school buses, which they would lease to operators. The SPV can partner with charging infrastructure providers to refurbish existing school bus depots with overnight charging equipment, which the SPV or the charging infrastructure provider would own and operate, then lease to school bus operators in an all-in-one solution. School bus OEMs also may participate, either through a large-scale contract or a direct equity share in the SPV. Service, maintenance and repair for EV and EVI also could be part of the leasing solution, thus entirely lifting operational and technological risk off public and private school bus fleet operators' shoulders.

Demand aggregation remains a challenge. A third-party could potentially step in to aggregate demand from several bus fleet operators to represent their joint interest, as with mobility service providers in the case of ride-hailing vehicles and taxis. Such a player could, for example, also offer value-added services such as fleet route planning optimization.

Government support might be beneficial to align regulations and targets at a city and regional (or even federal) level. Governments could reduce risk in the investment for shareholders, long-term investors, and possibly also industry leaders by providing guarantees on the payments from the fleet operators to the SPV, similar to the mechanisms proposed for the city bus investment case. National and regional governments could also consider providing subsidies for vehicle purchases and charging infrastructure, which could mitigate the TCO gap between electric and ICE buses, thus helping to achieve a more favourable business case for individual fleet operators. Figure 1 illustrates the potential structure of the investment opportunity as well as interactions by individual stakeholder groups using the example of city buses.

To mitigate the challenge of low school bus use as previously described, a collaboration with grid infrastructure providers could be considered to establish a vehicle-to-grid (V2G) technology agreement. The Clean Commute for Kids Act referenced earlier also promotes coordination between the US Environmental Protection Agency and Department of Energy to explore V2G.[40] With V2G technology, a bus with residual charge in its battery can plug in and feed power into the grid, selling this power to electricity distributors. School buses could feed power into the grid during idle times between pick-up and drop-off and during vacation periods. This could help balance grid demand during peak load times – for example, during middays and hot summers – benefitting grid providers and the SPV by creating an additional revenue stream, allowing for lower leasing rates and faster recouping of investments (see Box 2 The battery promise).

Furthermore, an SVP could consider retrofitting existing buses to make them electric as a way to reduce upfront capex and thus improve the TCO and leasing fee to school bus operators. This would also help prevent premature scrapping of existing school buses.

Corporate shuttles

With corporate shuttles, a similar investment case model could apply. In this case, the fleet operator would be a private corporation (whereas the school bus operator could be either public or private). An SPV could again purchase distributed generation infrastructure for zero-emission buses and lease the buses to corporate shuttle fleet operators. The SPV could also purchase chargers from a charging infrastructure provider and supply them for a lease fee to the corporate shuttle fleet operator for installation at a central (shared) or private bus depot.

BOX 2

The battery promise

Battery technology is evolving fast, improving overall BEV attractiveness. Yet the battery remains a key risk in operating electric vehicles. Batteries make up approximately 30% of a battery electric vehicle's cost today,[41] and uncertainties with regards to, among others, sufficient range, lifetime and residual value persist, creating important impediments in the decision to purchase electric vehicles for individual-vehicle and fleet owners. For example, a consumer survey indicates that about 40% of consumers consider battery and charging as a main concern when purchasing a BEV.[42]

Yet the battery should also be considered an opportunity. The sustainable mobility sector has largely recognized the battery challenge and innovations continue to emerge. This highlights the upside potential of battery-driven vehicles – the battery promise. Two strands in particular appear promising to fleet operators:

1. Range extension innovations. At the current pace. batteries will continue their rapid increase in capacity. Innovations on ever-more rapid charging technologies, the increasing density of batteries (which allows for smaller batteries), and the rising opportunities for battery swapping and wireless charging will continue to extend BEV range. Thus, the challenge of range limitations will over time be mitigated. Further, the growing numbers of options will increase the flexibility of fleet operators. Specifically, it will allow them to select the optimal battery range and charging solution for their need, thus potentially lowering EV purchasing cost while saving operating, parking and depot space.

2. Vehicle-to-grid (V2G) opportunity. With V2G technology, EVs can be plugged in and feed power into power grids. This relevant for EVs with substantial idle times (for example, school buses) and provides a second-life use case for scrapped vehicle batteries, consequently reducing batteries' residual value risk. Grid "extension" in the form of electric vehicle batteries can be used to balance the grid during peak demand times, such as mornings during winter months or afternoons during hot summers. In addition, operators such as fleet owners could sell their power supply to electricity distributors at a premium during peak demand hours, so batteries may give their owners an additional revenue stream. Recently, large OEMs have been committing to expanding into the V2G market. For example, a German automotive player has announced that its EVs will support bidirectional charging as soon as 2022.

Although batteries remain a major risk factor in EV adoption for fleets and individual-vehicle owners today, there are promising innovations that may, in a not-so-distant future, allow for the mitigation of these risks. Particularly, a growing number of innovations allow the decoupling of vehicle and battery. This may significantly reduce the risks facing fleet operators today. For example, fleet operators could keep fleets at the newest battery technology standards, thus continuously optimizing operations as battery innovations evolve. The evolution may even allow operators to extract additional value from batteries (through V2G opportunities). However, the different stakeholder groups will need to collaborate on creating mutually beneficial agreements in order to diversify the non-negligible battery risk in order to unlock the takeoff of the zero-emission mobility solution.

3 Zeroing in on automotive passenger fleets

Bundling a zero-emission solution and leasing to ride-hailing and taxi drivers in major cities

Context

An ICE non-pooled[43] ride-hailing journey is estimated to emit approximately 47% more CO_2 than an equivalent private vehicle ride.[44] Furthermore, while ride-hailing and taxi vehicles are not operated in a fleet, they are bundled under the umbrella of (platform) operators, such as mobility service providers (MSPs) and taxi fleet operators, which allows for demand aggregation. Thus, targeting the electrification of ride-hailing and taxi vehicles has potential for greater CO_2 emissions reductions than converting privately owned ICE vehicles individually.

Several MSPs and taxi operators have already committed to achieving zero emissions, with some pledging zero-emission vehicle fleets as early as 2025. Furthermore, broad national and local government support has been signalled, particularly in major urban areas, to support passenger car transition to ZEVs. A prime example is the United Kingdom, especially London. The UK Government has announced it will implement a ban on ICE vehicle sales beyond 2030.[45] The government of London has additionally introduced ultra-low-emission zones (ULEZ), requiring CO_2-emitting cars to pay £12.5 per day to enter the ULEZ, thus increasing the cost of entering the city with a non-zero-emission vehicle.[46] London has further introduced a BEV and hydrogen fuel cell vehicle discount on the London congestion charge (cleaner-vehicle discount), effective as of October 2021.[47]

Problem to be solved

MSPs operate differently from typical fleet operators in that they neither own nor operate the vehicles in the “fleet”. Rather, individual contracted drivers purchase and operate vehicles and pay a commission to MSPs and taxi operators in return for trip orders. Hence, the decision to replace an ICE vehicle with an EV lies with these individuals rather than the MSPs and taxi operators.

Enabling and incentivizing vehicle owners to switch to a BEV remains a challenge. BEVs still have a significantly higher purchase cost, representing a major hurdle for individual drivers, who may often be unable to commit to long-term financing options, such as bank loans. Furthermore, the limited availability of charging infrastructure creates an operational risk for drivers. For example, a typical driver may not have access to home charging, especially if overnight charging availability is limited within the residential area or the driver lacks a private garage to install a home charger. Fast-charging stations are already available at scale in many cities, yet they may be in unfavourable locations for individual drivers, forcing drivers to take undesirable breaks during their shifts. Moreover, the stations may be overused, given that the number of EVs in a typical urban area is growing faster than the availability of charging infrastructure.

Yet BEV passenger cars, particularly in high-mileage use cases, can already achieve TCO positivity for drivers today, unlocking long-term savings for them. A study by LeasePlan examined more than 900 scenarios in 13 European countries and found that, on average, EVs already achieve TCO positivity over ICE vehicles (by 5%, on average).[48] Figure 2 compares six TCO cost dimensions for BEV and ICE. While BEVs exhibit higher depreciation and interest costs, given their higher upfront cost, lower maintenance, taxes and energy costs largely offset the cost disadvantage.[49] It follows that, while TCO can already be favourable, the challenges of increased upfront investment and charging infrastructure availability remain key challenges for individual drivers to adopt ZEV.[50]

MSPs and taxi operators, who would be in a position to shift the capex burden away from drivers, are largely reluctant to own and operate car fleets, as this would entail a major change to their asset-light business model and require a very different set of capabilities. Yet most of them have set major zero-emission ambitions and are therefore motivated to incentivize driver ZEV take-up. While MSPs and taxi operators cannot directly enforce a switch by individual drivers, both may enable individuals by providing (financial) incentives and help establish mechanisms to reduce the switching barriers that drivers face today.

Proposed solution

To ensure that contracted drivers have access to an EV(I) solution, MSPs and taxi operators could engage with other industry stakeholders in the creation of an investment case designed to mitigate today’s adoption barriers. As for buses, an SPV could purchase BEVs and possibly charging infrastructure and lease the solution directly to drivers. While the charging infrastructure may be partially owned and operated by the SPV, charging infrastructure providers could also take up this task and enter a large-scale contractual agreement with the SPV. Furthermore, local governments may want to formulate an EVI master plan for a specific urban area and thus ensure a coordinated build-up of infrastructure throughout the urban area. Such an approach would help prevent suboptimal solutions (such as piecemeal EVI build-up or overcapacity). Hence, both the SPV and charging infrastructure provider may want to plan EVI build-up in close collaboration with local governments. Similarly, it may be helpful to involve OEMs in BEV supply planning, as they should be inclined to participate directly in the SPV, possibly through a mutually beneficial, large-scale contract. Figure 3 illustrates the proposed solution described above.

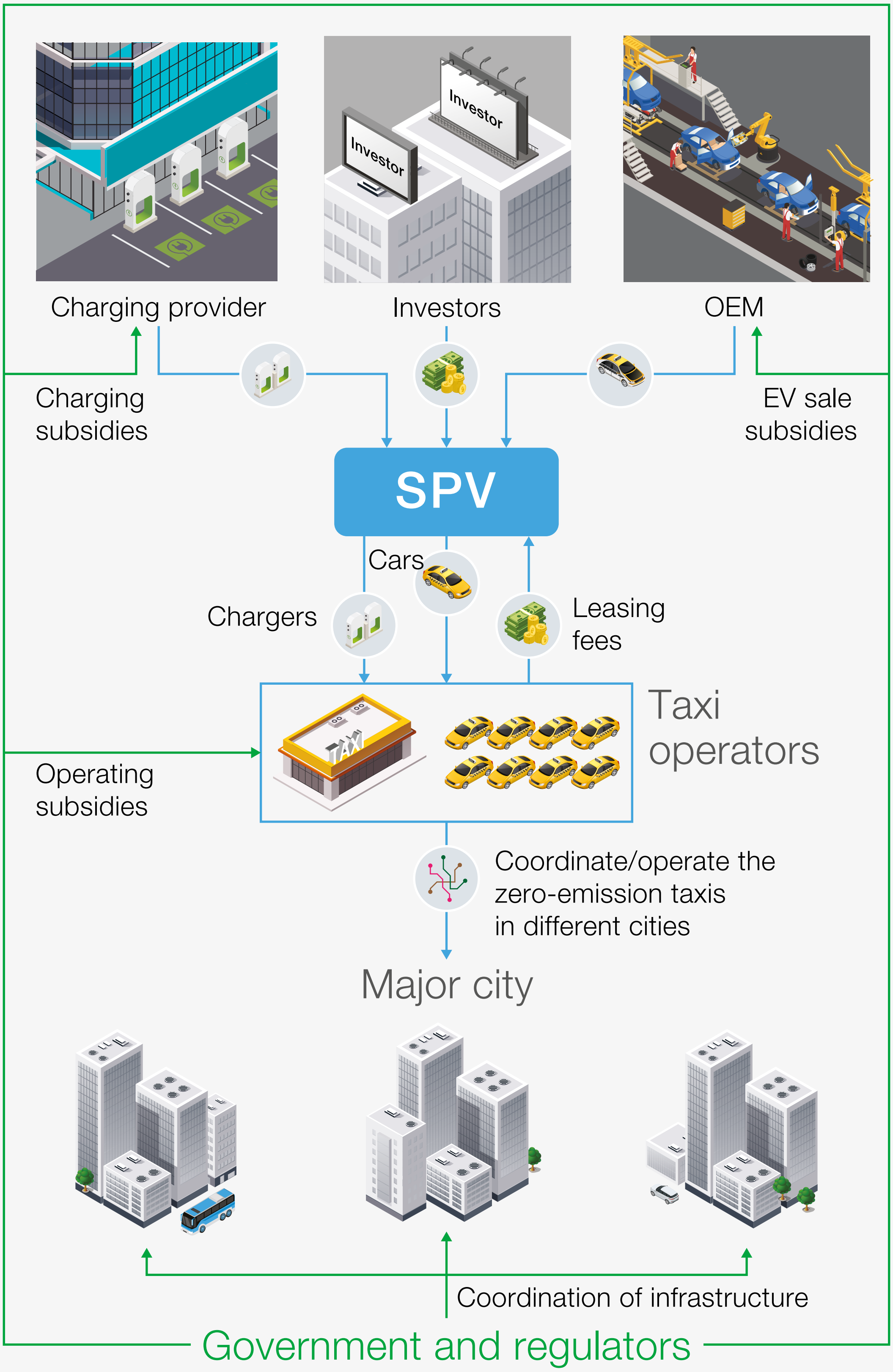
FIGURE 2 | **Total cost of ownership: Battery electric vehicles (BEVs) versus internal combustion engine (ICE) passenger cars**

Cost element	% difference with ICE vehicles	Explanation
Depreciation and interest	+17%	EVs have a higher catalogue price due to the added cost of the batteries
Maintenance	-23%	EVs have fewer moving parts compared to ICE vehicles so less maintenance is required
Tyres	+2%	EVs have, an average higher torque and weight, which results in higher wear and tear on tyres
Insurance	+6%	Insurance is often related to the catalogue price of the vehicle and therefore higher for EVs
Taxes	-88%	EVs are supported with government incentives in many countries; the effect is clearly visible in the tax costs
Energy	-54%	The average cost per kilowatt-hour of electricity is less than for traditional fuels (petrol/diesel)

Source: Leaseplan Study: The Total Cost of Ownership of Electric Vehicles Compared to Traditional Vehicles, 9 January 2019

A key risk in this arrangement would be the counterparty risk the SPV incurs when leasing directly to drivers. Counterparty risk refers to the probability that the contractee may be unable to fulfill its part of the deal. There are two potential options for mitigating the risk. First, MSPs or governments could reduce risk in the investment by providing guarantees, much as in the case of buses. Second, data-sharing collaborations could be established to improve risk prediction modelling and significantly reduce counterparty risk to the SPV over time, for example, in cooperation with insurance providers and OEMs (see Box 4 Unlocking the potential of connected-car data).

FIGURE 3 | **Replace ICE taxi fleets with BEVs in major cities (including infrastructure)**



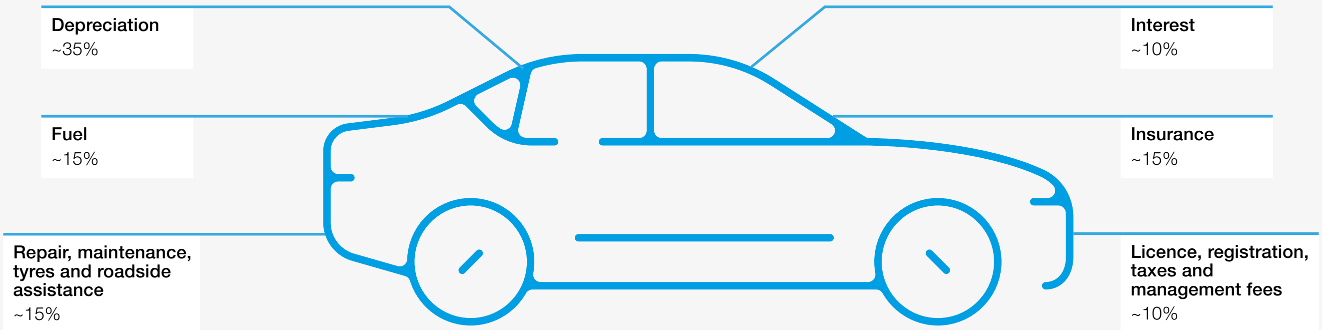
BOX 3
Total cost of ownership (TCO)

While operating costs such as electricity (versus petrol or diesel) and maintenance costs are known to be lower for an EV than for an ICE, the TCO includes the financing, leasing and depreciation cost that the driver would incur, depending on whether the vehicle is financed or leased. A TCO advantage ultimately depends on such costs for the EV being low enough to keep the TCO lower for the EV than for the ICE vehicle.

As illustrated in Figure 4, for a vehicle that is financed (including the interest cost from financing and the depreciation cost associated with owning the asset), depreciation and interest related to the asset value of the EV are the largest TCO cost component. Figure 4 also demonstrates the outsized contribution of depreciation and interest in the overall cost structure, making up approximately 45% of TCO.[51] Together, those costs are the most significant factor driving up the TCO of an EV.

In a leased vehicle (operating lease), the leasing cost would replace the depreciation and interest cost, and potentially also the cost of repair and maintenance, if a full service contract is provided as part of the leasing contract.

FIGURE 4
Average share of fleet management TCO



BOX 4
Unlocking the potential of connected-car data

The investment cases presented in this paper offer stakeholders an opportunity to double down on connected-car data and reap the full benefits of connecting the entire BEV value chain (see Figure 5).

Car data has been an important topic for OEMs, suppliers and other players in the mobility industry for many years. So far, few players have leveraged the potential that car data offers. However, a combination of earning pressure, technology development, shifting regulation, new players, and new business models now creates a favourable environment for car data monetization. If managed correctly, this could create a value pool of $290 to $490 per vehicle and year.

The investment cases presented in this white paper are well positioned to capitalize on car data, because they combine various player cases to create ecosystems. For example, a combination of OEMs, charging infrastructure providers, and mobility service providers would collect a significant amount of raw data that, if jointly leveraged, may accelerate the advancement on zero-emission mobility.

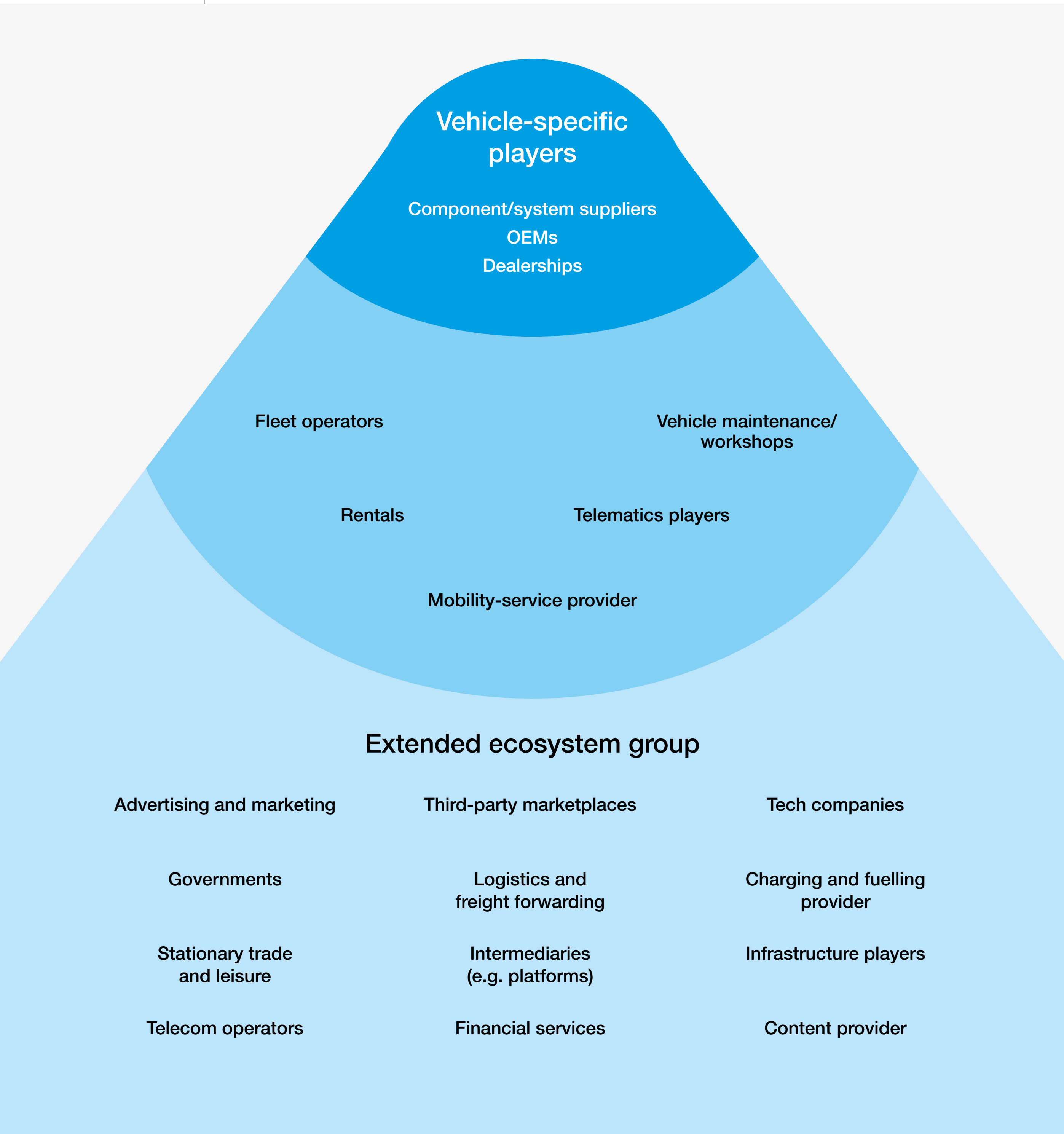
Four use cases could provide the starting point for car data monetization in these systems and help the broader mobility ecosystem reach BEV TCO positivity faster:

– **R&D optimization**. OEMs can optimize BEV hardware and software, based on real-time usage data by, such as by adjusting specifications or features, thus accelerating technological development or reducing costs and enabling BEVs to reach cost parity with ICE earlier.
– **Vehicle/fleet health and monitoring**. Predictive maintenance can significantly reduce operating costs for players such as mobility service providers (MSPs). It also can increase vehicles' residual values, thereby also benefiting, for example, leasing providers. Overall, it helps BEVs achieve TCO parity with ICE faster.

- **Vehicle-related services**. Apart from improving and managing the vehicle, data can also be used to improve the services provided to the car or its driver. For example, insurance companies may use data on driver behaviour and safety to set insurance rates more fairly.
- **Applications beyond the vehicle**. Beyond the vehicle itself (for example, infrastructure planning and optimization or monitoring), data on vehicles' driving patterns, routing and state of change can be used to optimize charging infrastructure capacity and network planning, improving the return on these assets. Similarly, sensor data from vehicles' cameras can be used to monitor infrastructure conditions or track advertising exposure, providing valuable data points to players in the extended car data ecosystem.

These are only selected examples of the possibilities that car data opens up for SPVs and investors.[52]

FIGURE 5 **Extended mobility value chain, non-exhaustive**



4 Greening the fleet: Big trucks take on zero-emission

A zero-emission leasing solution for truck fleet owners and operators

Context

The trucking industry is a pillar of the global supply chain. The US trucking industry alone is estimated to have generated $700 billion in economic activity in 2017.[53] The heavy-duty trucks that transport goods can be broken down into three segments: long-haul, regional and urban trucks.

Sales of heavy-duty trucks in China, Europe and the United States collectively totalled 1.8 million vehicles in 2020, of which 1.3 million were long-haul, 370,000 were regional, and 185,000 were urban (see Figure 6). Of these 1.8 million heavy-duty trucks, approximately 75% were sold in China, with the remainder sold in Europe and the United States. Only 1,000 of these were BEVs, and fewer than 50 were fuel cell electric vehicles (FCEVs).

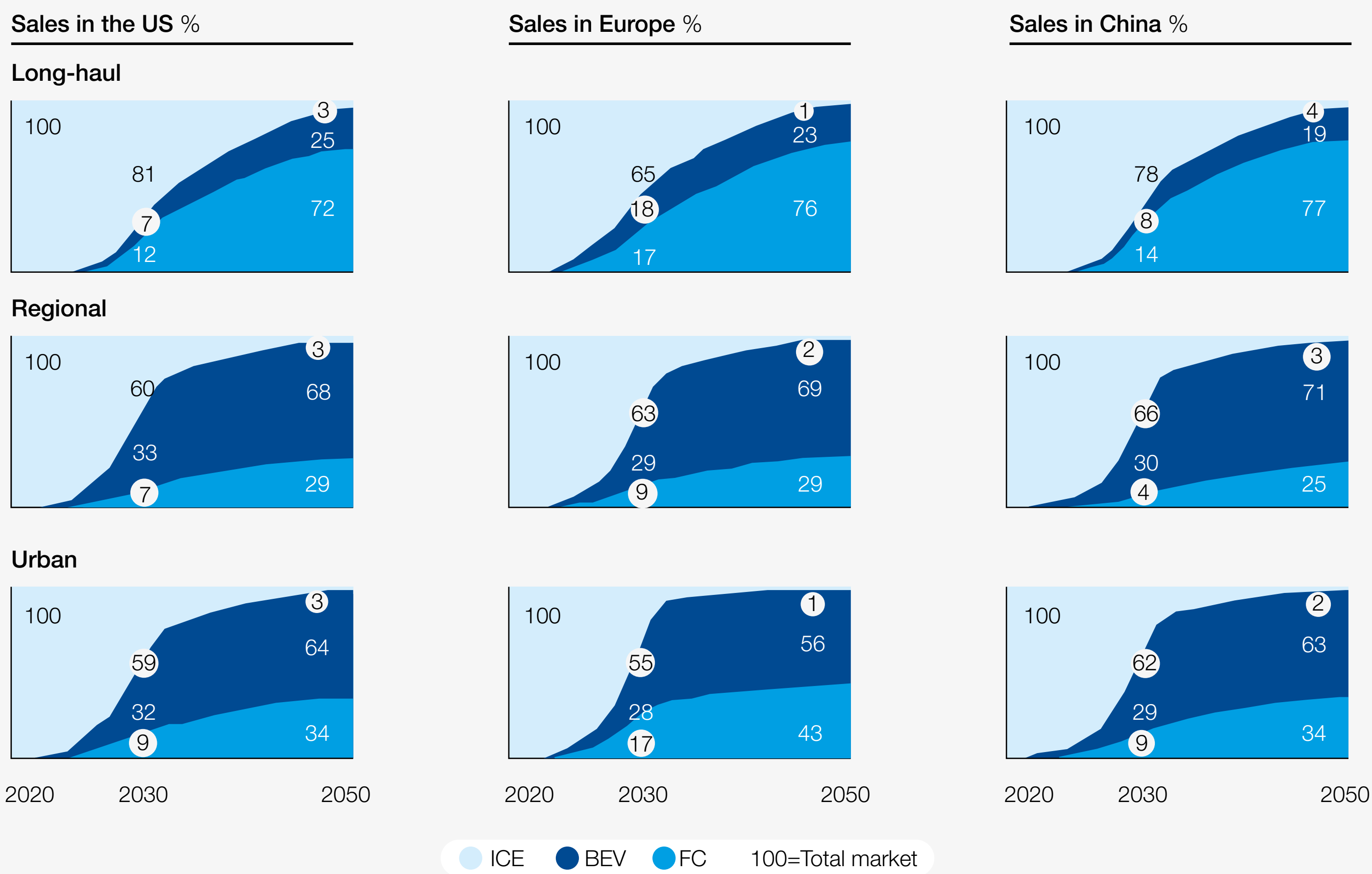
The markets, however, are expected to change significantly, and the share of zero-emission trucks (including FCEV and BEV) is expected to increase to approximately 35% by 2030, with market shares reaching 30% in China, 35% in the United States, and 40% in Europe. By 2050, as much as 98% of heavy-duty trucks sold in the three markets are anticipated to be powered by zero-emission engines in the base case scenario.[54]

Problem to be solved

With the high purchase price of heavy-duty trucks, the trucking industry typically relies on three different financing or leasing sources: the captive finance arms of OEMs, independent financing firms, and lease firms. As subsidiaries of OEMs, captive finance arms are the primary financing source, offering attractive rates on their own products, often subsidized by the parent OEM to increase sales and lease volumes. Independent finance firms are typically financial service firms (e.g. banks). The trucking operating company may already be a customer of the financial service firm and could possibly receive favourable vehicle financing rates. Leasing firms would provide vehicles to trucking companies as operating leases, relieving the asset ownership and debt burden for the truck operator, potentially covering maintenance costs as well.

A similar challenge inhibiting zero-emission vehicle adoption in other categories also exists in the heavy-duty truck space. Without adequate charging infrastructure, zero-emission heavy-duty truck adoption will not occur. Without sufficient volume of zero-emission heavy-duty trucks, a viable business case for chargers would be difficult to justify.

FIGURE 6 **Heavy-duty e-truck sales as share of total sales until 2050**



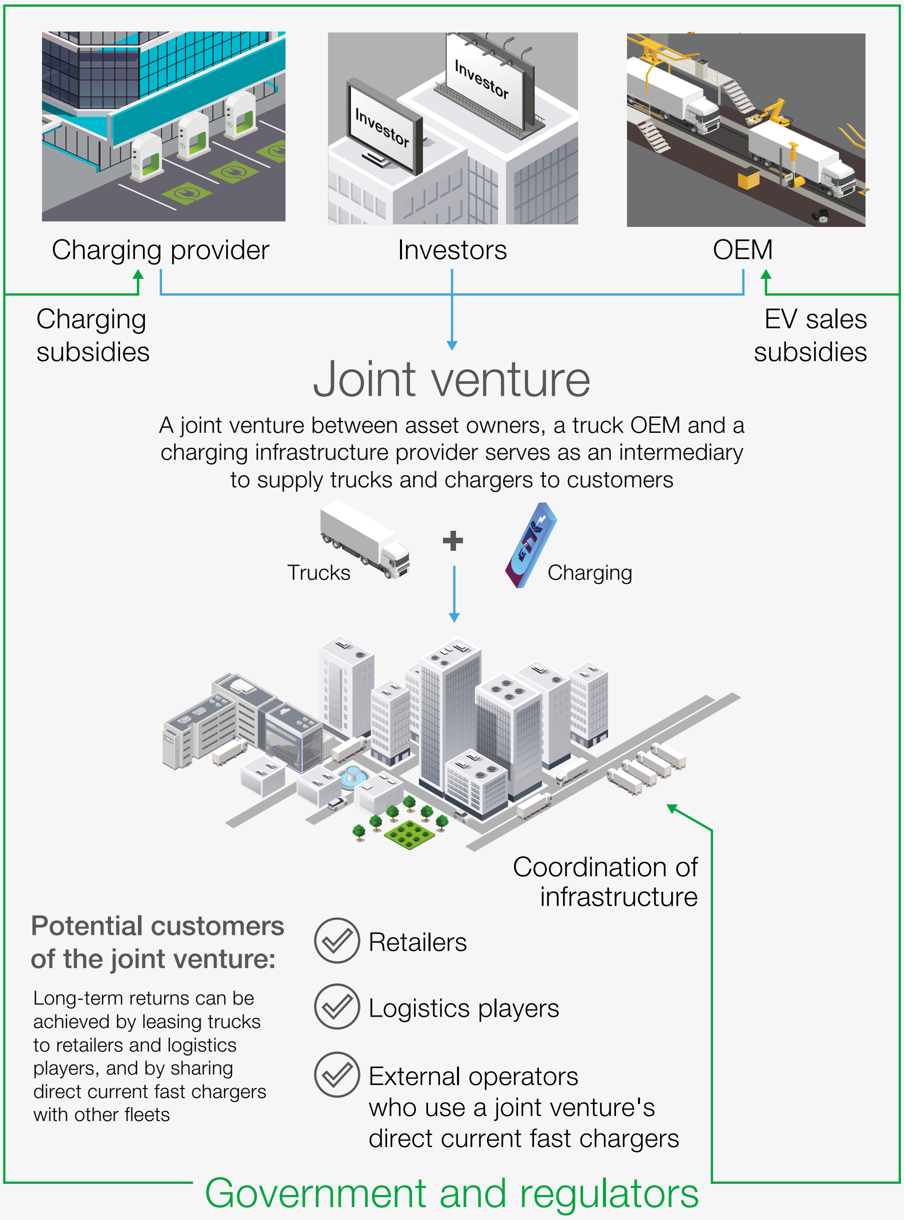
Proposed solution

A possible investment opportunity would be to create a joint venture between truck manufacturers (OEMs), charging and refuelling infrastructure providers, and long-term investors to create an operating entity that leases trucks and charging infrastructure as an all-in-one solution (see Figure 7). The joint venture could be set up as a separate legal entity similar to that of an SPV.

Two possible use cases have been shaped in initial consultations with industry partners. First, the joint venture could target selected major freight corridor legs in Europe between one or two bordering countries. Heavy-duty long-haul journeys across Europe mainly concentrate along nine main traffic corridors crossing Europe within the Trans-European Transport Network (TEN-T); these could represent suitable pilot routes. The specific routes could be selected in collaboration with major heavy-duty long-haul fleet operators, such as logistics companies. Charging infrastructure providers could then build up targeted EV infrastructure on the selected routes, and OEMs could lease BEV trucks to fleet operators and (their) subcontractors to operate on the routes.

Second, the SPV could target regional and urban heavy-duty trucks in a specific greater urban area. The joint venture would then develop a charging infrastructure concept for that area – including, for example, shared EVI at major mobility hubs – in collaboration with truck fleet operators and charging infrastructure providers. The joint venture could then lease out a zero-emission regional solution to all interested vehicle and fleet operators in that region.

FIGURE 7 **Joint venture between truck OEM, charging provider, and long-term investors (asset owners) to lease trucks and chargers to end customers**



5

Greening last-mile delivery fleets

Establishing a joint venture to lease short-haul LCVs to fleet operators

Consumer awareness of the environmental impact of these deliveries is shown by a survey demonstrating that 51% of consumers understand the environmental concerns related to e-commerce.

Context

COVID-19 lockdowns have accelerated the increase in online shopping and resulting at-home deliveries. Further increases in home deliveries from continued e-commerce growth will result in corresponding rises in CO_2 emissions if delivery vehicles remain ICE vehicles. It would therefore be essential to transition these light commercial vehicles (LCVs) or "last-mile" delivery vehicles to zero-emission vehicles to eliminate the exhaust emissions created by such deliveries.[55]

Problem to be solved

Many consumers are aware of the environmental impact of these deliveries. Recently, a survey demonstrated that 51% of consumers understand the environmental concerns related to e-commerce. Some 47% want recyclable packaging and nearly 30% would prefer carbon-neutral deliveries. [56]

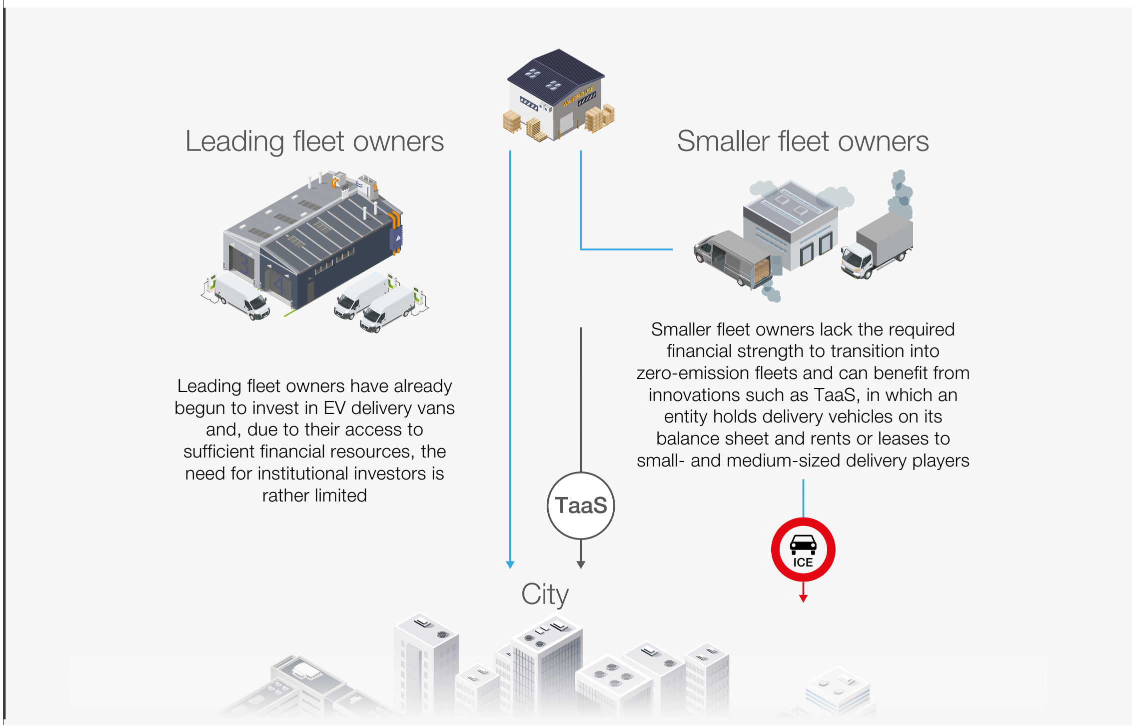
One longer-term solution to create a more carbon-neutral fleet could be a combination of last-mile solutions in the coming decades, such as drones and autonomous parcel lockers. In the immediate future, however, traditional delivery vans and trucks remain dominant. Therefore, developing clean last-mile fleets is essential to curbing CO_2 emissions. By 2030, a 78% increase in urban last-mile deliveries is estimated in the top 100 cities globally if e-commerce continues to grow as expected. This would result in the number of delivery vehicles increasing by 36% to 7.2 million vehicles, adding 6 million tonnes of CO_2 emissions.

Recent stimulus packages in the EU have increasingly incorporated decarbonization agendas by including purchase subsidies for EVs, investments in electric vehicle charging infrastructure (EVCI), and supporting local ZEV production. A commitment to banning ICE vehicles for certain applications is also evident. For example, more than 30 of the largest municipalities in the Netherlands have committed to introducing zero-emission zones for freight by 2025 as part of their national climate agreement. Other European cities have announced restrictions and regulated access to specific areas. For example, in the London Ultra-Low Emission Zone (ULEZ), fees vary depending on emission standards and time of day.

Proposed solution

High upfront costs mean zero-emission LCVs are often not affordable for smaller fleet owners. A possible investment opportunity could be structured to address last-mile trucking solutions for these smaller players as well as the limited access to charging infrastructure. An SPV could aggregate zero-emission LCVs, purchasing from OEMs and holding these assets on its balance sheet (see Figure 8). These vehicles could be leased to smaller operators in a transport-as-a-service (TaaS) arrangement, where the fleet operator pays a single bundled lease fee for the zero-emission LCV and chargers. Larger fleet operators, such as retailers and logistic companies, could engage in the SPV structuring to ensure the TaaS solution meets fleet provider needs and may also serve as a demand aggregator, given that a large share of trips is typically outsourced to smaller fleet operators (subcontractors).

FIGURE 8 **Aggregate last-mile vehicles in an SPV, with smaller fleet owners running their business on leasing arrangements**



6 Exploring fossil-free fuelling infrastructure

Doubling down on green hydrogen refuelling stations in Europe

Context

To support the adoption of FCEVs, access to hydrogen fuel is essential. FCEVs face infrastructure challenges similar to those of EVs: too few or unequally distributed refuelling stations. Unlike BEV charging, however, at-home charging of FCEVs is not possible. Therefore, promoting FCEV adoption by businesses and consumers will require a refuelling network similar to that of the existing petrol and diesel station network. While some businesses may be able to install refuelling depots at their fleet sites, long-range trucks that travel through rural areas would, in any event, require satellite refuelling locations in these areas.

Governments and companies around the globe have made commitments to invest in green hydrogen refuelling stations (HRSs). China, Europe, Japan and South Korea have set targets to create 5,000 charging stations by 2030.[57] A Chinese firm has announced it intends to build 1,000 HRSs by 2025, while the United States is expected to have more than 1,150 HRSs by 2028.

40%
potential capex reduction to HRS build-up by 2030

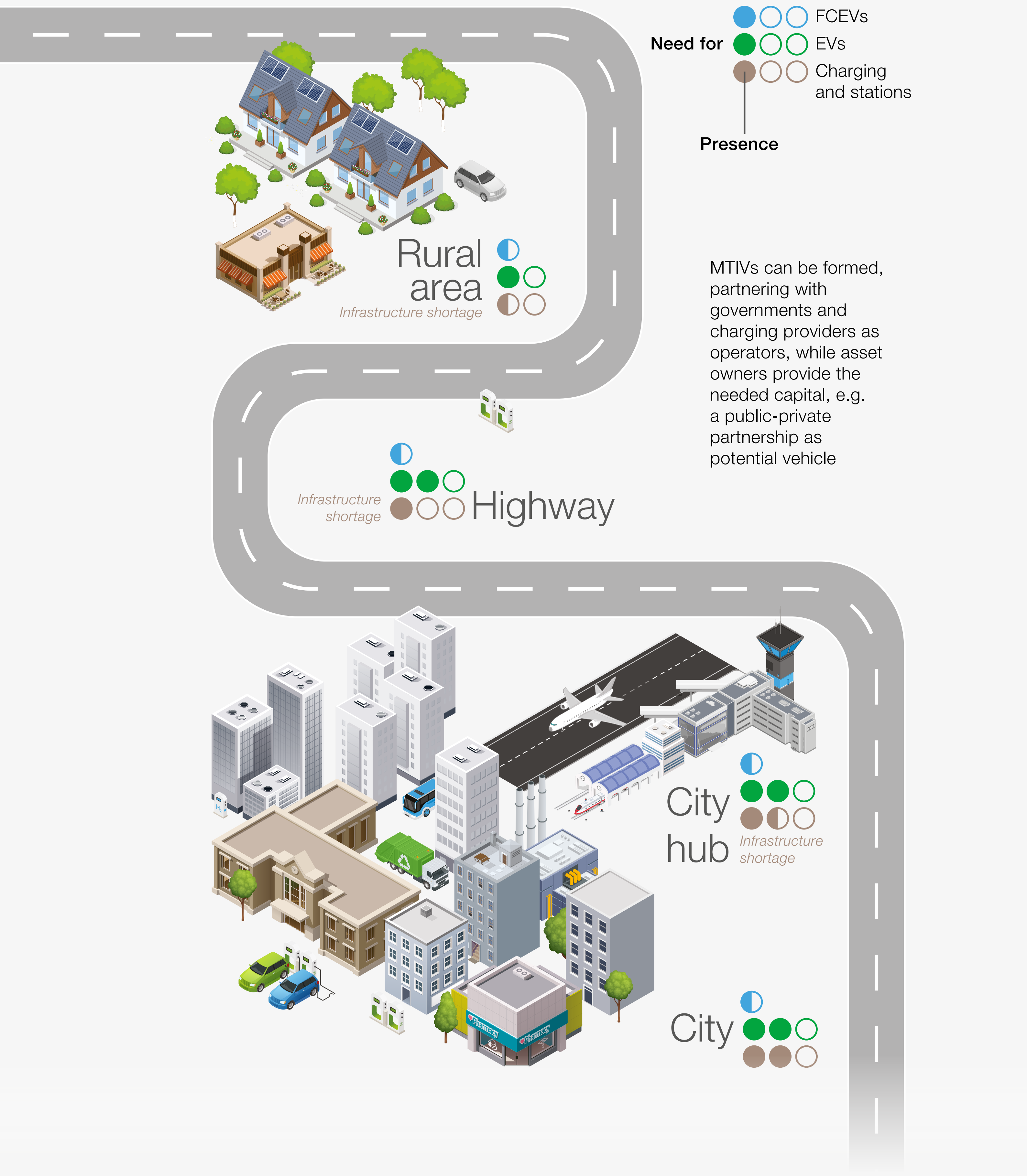
Problem to be solved

The capital cost to build an HRS can be as high as $3.5 million for a station with a capacity of 1,000 kilograms per day. Economies of scale could reduce this cost by 40% by 2030.[58] Increasing the number and coverage of HRSs will likely lead to increased demand for FCEVs, because consumers and businesses will require assurance that enough refuelling locations are available on the road.

Proposed solution

An investment opportunity to finance the roll-out of an HRS network on major highways could be established and, once implemented, would boost FCEV demand. An SPV may be founded to purchase HRSs, partnering with regional or national governments and highway authorities to secure locations for HRS installation along major highways (see Figure 9). It also could coordinate with hydrogen production firms for the delivery of green hydrogen fuel to these HRS locations. The SPV would, in this case, be the operating company as well as the long-term investor, operating the HRS and earning revenue in the sale of hydrogen fuel. Subsidies or grants would be necessary to offset the initial investment needed to construct stations and the fixed-cost overhead until FCEV adoption and customer volumes increase to a breakeven volume.

FIGURE 9 | **Charging and refuelling infrastructure in locations with infrastructure shortages**



Conclusion

The way forward

The challenges facing the sustainable-mobility sub-asset classes introduced in this paper differ, but they share common ground in two ways: significant funding would be needed to reach global climate targets and individual players will likely be unable to address these challenges alone. A collaborative solution to the unprecedented challenge faced by the sustainable mobility sector today would focus on leveraging the combined power of industry leaders, governments, regulators and global long-term investors to achieve a mutually beneficial solution. Such a large-scale effort is unique and will not come without challenges. However, if successful, it could potentially change the landscape of the mobility industry for good.

Buses

Positivity in total cost of ownership (TCO) can, in some cases, already be achieved today. Still, many bus operators are publicly operated and are thus restricted in their financing options, should a large upfront investment be required for a switch to BEVs. Major grid upgrades are costly and, if required, would add another layer of complexity for fleet operators to transition to BEVs. For school buses in particular, low use rates due to restrictive use cases create an obstacle to investments and the fragmented operator and regulatory environment makes a scaled-up solution difficult.

Passenger cars

Purchasing prices are still higher for BEVs than for ICE vehicles. With many ride-hailing and taxi drivers unable to commit to long-term financing, this upfront investment represents a major challenge. The availability of convenient charging solutions throughout the city would also be required to accelerate ride-hailing and taxi driver adoption of ZEVs, even if TCO positivity can already be reached today for high-mileage use cases.

Trucks

A shift from capex to opex combined with a targeted scale-up in charging infrastructure might unlock significant potential in the truck sectors. However, not all BEVs or fuel cell use cases are TCO-positive. Potential investment cases should be structured carefully to meet shareholder requirements.

Last-mile delivery fleet

Leading fleet owners may be able to achieve a fast-paced zero-emission transition on their own. However, smaller fleet operators, particularly subcontractors, have restricted financing options and could thus benefit from transport-as-a-service (TaaS) agreements in which they lease vehicles and perhaps charging infrastructure to overcome the financial and operational risk hurdles.

Charging infrastructure

The uptake of ZEVs in all of the proposed investment cases is essential and should be considered part of the solution in all cases. As the majority of proposed solutions focus on BEVs, green hydrogen charging infrastructure should be treated as a separate case, with a targeted scale-up needed to boost vehicle demand globally. Low use rates might be a challenge in this investment case during the scale-up; it could result in accelerated adoption and thus technological development as well.

Importantly, the six sustainable mobility investment cases presented opportunities that have been shaped in consultation with interested stakeholders. This white paper does not provide an exhaustive description of the solution space.
A broader geographic perspective, reflecting on opportunities tailored to emerging economies and expansion to other critical mobility areas, such as two- and three-wheelers, calls for further analysis, especially given the potential for great impact.

List of abbreviations

BEV	battery electric vehicle
capex	capital expenditure
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalents
DG	distributed generation
eLCV	electric light commercial vehicle
EPA	Environmental Protection Agency
EU	European Union
EV	electric vehicle
EVCI	electric vehicle charging infrastructure
EVI	electric vehicle infrastructure (charging)
FCEV	fuel cell electric vehicle
GHG	greenhouse gas
HRS	hydrogen refuelling station
ICE	internal combustion engine
LCV	light commercial vehicle
LTIO	long-term investment organization
MSP	mobility service provider
NOx	nitrogen oxide
OECD	Organization for Economic Co-operation and Development
OEM	original equipment manufacturer
opex	operating expenditure
SPV	special-purpose vehicle
TaaS	transport as a service
TCO	total cost of ownership
TEN-T	Trans-European Transport Network
ULEZ	ultra-low emission zones
V2G	vehicle to grid
ZEV	zero-emission vehicle

Contributors

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Authors

Maya Ben Dror
Sustainable Automotive and Mobility, World Economic Forum

Carolin Brückmann
Senior Associate, McKinsey & Company

Antonia Gutzler
Associate Partner, McKinsey & Company

Eric Hannon
Partner, McKinsey & Company

Bernd Heid
Senior Partner, McKinsey & Company

Tobias Schneiderbauer
Associate Partner, McKinsey & Company

Jiten Vyakarnam
Platform Curator, Automotive, Supply Chain and Transport Industries, World Economic Forum

Contributors

Gilles Duruflé
Content Director, Head of Climate Change Initiative, Long-Term Investment Organization (LTIO)

Björn König

Christian Racicot
Founder and Chief Executive Officer, LTIO

Ursula Weigl
Partner, McKinsey & Company

Christoph Wolff
World Economic Forum

Reviewers

Derek Baraldi
Head of Banking Industry, Shaping the Future of Financial and Monetary Systems, World Economic Forum

Annika Berlin
Project Manager, City Climate Finance Gap Fund

Matthew Blake
Head of Financial and Monetary System Initiatives, Member of the Executive Committee, World Economic Forum

Andrew H. Darrell
Chief of Strategy, Global Energy and Finance, Environment Defense Fund (EDF)

Ani Dasgupta
Global Director of WRI Ross Center for Sustainable Cities

Pablo Fajnzylber
Acting Vice-President and Director of Strategy and Operations, Infrastructure, World Bank (WB)

Angie Farrag-Thibault
Project Lead, Clean Trucking Initiative, World Economic Forum

Asger Garnak
Head of Partnership Program, World Resources Institute CONCITO, Seconded Advisor for Finance, COP26 High-Level Climate Champions

Jake Hiller
Senior Manager, EDF+Business, Environmental Defense Fund (EDF)

Anthony Hobley
Executive Director, Mission Possible, World Economic Forum

Holmes Hummel
Founder and Executive Director, Clean Energy Works

Uday Khemka
Managing Trustee, Nand & Jeet Khemka Foundation

Erika Myers
Global Senior Manager, Electric Vehicles, WRI Ross Center for Sustainable Cities

Lauren Pamma
Programme Director, Green Finance Institute

Shilpa Patel
Director, Mission Investing, Climate Works

Binyam Reja
Acting Global Director, Transport Global Practice, World Bank

Ankit Singhvi
Member, World Economic Forum Global Future Council on Mobility

Nigel Topping
High-Level Climate Action Champion for UN Climate Talks, COP26, UK Government

Marilyn Waite
Climate and Clean Energy Finance Program Officer, Hewlett Foundation

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Endnotes

1. United Nations, "Paris Agreement", 12 December 2015: https://unfccc.int/sites/default/files/english_paris_agreement.pdf (link as of 6 August 2021).
2. Road transport includes passenger cars and trucks, buses, and two- and three-wheeled vehicles.
3. McKinsey & Company, "Climate math: What a 1.5-degree pathway would take", 30 April 2021: https://www.mckinsey.com/business-functions/sustainability/our-insights/climate-math-what-a-1-point-5-degree-pathway-would-take (link as of 11 August 2021)
4. Fleets operate in different road transport segments, such as buses, shared mobility, freight, and delivery fleets.
5. ITF (International Transport Forum), "How Urban Delivery Vehicles Can Boost Electric Mobility", International Transport Forum Policy Papers, No. 81, OECD Publishing, Paris, 2020: https://www.itf-oecd.org/sites/default/files/docs/urban-delivery-vehicles-boost-electric-mobility.pdf (link as of 28 July 2021).
6. Domestic transport refers to the movement of people and goods within national borders and includes passenger cars, light- to heavy-duty trucks, buses, railways, domestic aviation, and domestic marine vessels.
7. McKinsey & Company, "Climate math: What a 1.5-degree pathway would take", 30 April 2021: https://www.mckinsey.com/business-functions/sustainability/our-insights/climate-math-what-a-1-point-5-degree-pathway-would-take (link as of 11 August 2021)
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9. The Paris Climate Agreement set a goal to limit global warming to well below 2 degrees Celsius, with a target of 1.5 degrees Celsius. United Nations, "Paris Agreement", 12 December 2015: https:// unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement (link as of 1 July 2021).
10. Metric tons: 1 metric ton = 2,205 pounds.
11. McKinsey & Company, "Climate math: What a 1.5-degree pathway would take", 30 April 2021: https://www.mckinsey.com/business-functions/sustainability/our-insights/climate-math-what-a-1-point-5-degree-pathway-would-take (link as of 11 August 2021)
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13. McKinsey & Company, "Net-zero Europe – Decarbonizing pathways and socioeconomic implications", 3 December 2020: https://www.mckinsey.com/business-functions/sustainability/our-insights/how-the-european-union-could-achieve-net-zero-emissions-at-net-zero-cost (link as of 3 August 2021).
14. Mobility players refers to all stakeholders in the zero-emission mobility transition, including but not limited to charging infrastructure providers, energy providers, original equipment manufacturers (OEMs) and (fleet) operators.
15. Range anxiety is what an EV driver feels when the battery charge is low and sources of electricity are unavailable. This sparks the fear of getting stranded somewhere, which adds time, inconvenience and stress to a journey. Studies show that driving range and a lack of charging infrastructure are the primary reasons people do not consider EVs when buying a new vehicle. J.D. Power, "What Is Range Anxiety with Electric Vehicles?", https://www.jdpower.com/cars/shopping-guides/what-is-range- anxiety-with-electric-vehicles (link as of 2 July 2021).
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World Economic Forum
91–93 route de la Capite
CH-1223 Cologny/Geneva
Switzerland

Tel.: +41 (0) 22 869 1212
Fax: +41 (0) 22 786 2744
contact@weforum.org
www.weforum.org