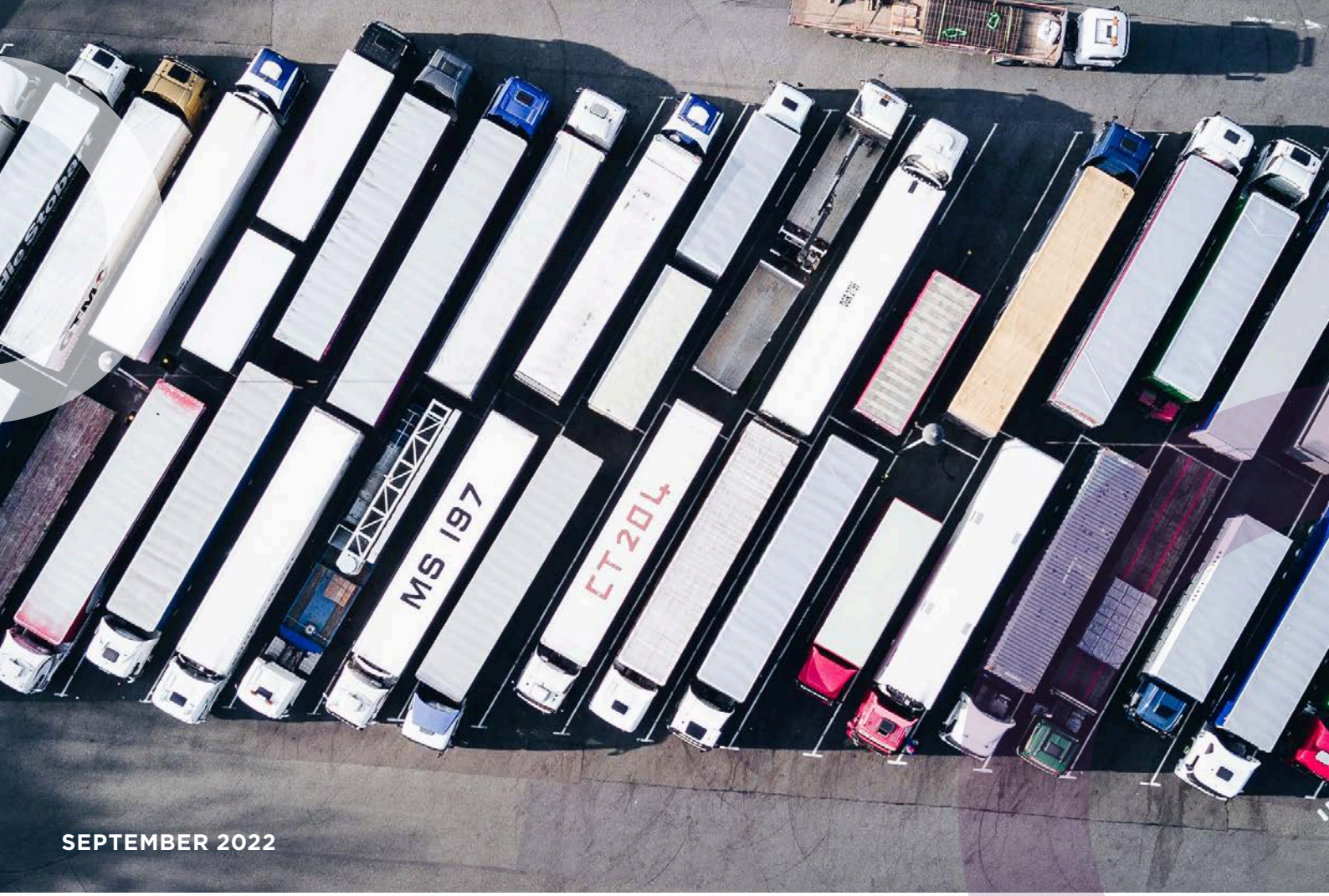

SEPTEMBER 2022

Road freight decarbonization in Europe

READINESS OF THE EUROPEAN FLEETS FOR ZERO-EMISSION TRUCKING

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icct
THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

European Clean Trucking Alliance

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ABOUT THE ICCT

The International Council on Clean Transportation (ICCT) was established in 2001 as an independent source of technical and policy expertise on clean transportation with the core mission of improving the environmental performance and energy efficiency of road, marine, and air transportation, in order to benefit public health and mitigate climate change. In the last five years, we have worked successfully with regulators and lawmakers around the world and have played a significant role in 48 distinct regulations and policies, which together are projected to reduce carbon dioxide emissions by billions of tons and prevent thousands of premature deaths over the next decade and beyond. More information can be found on our website at www.theicct.org.

ABOUT THE EUROPEAN CLEAN TRUCKING ALLIANCE

ECTA brings together more than 40 European players in the road transport of goods such as leading businesses, organisations and civil society associations that share a strong commitment to accelerate the EU's transition to zero-emissions trucks. They call for clear roadmaps and binding targets to decarbonise urban logistics and long-haul freight by 2050. ECTA business members include major hauliers, logistics and consumer goods companies in Europe and beyond. ECTA also counts some of the civil society organisations and associations with the strongest network of members and experience in transport and mobility at the European level. For more information, please visit the ECTA website: www.clean-trucking.eu

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EXECUTIVE SUMMARY

Supply chains globally are increasingly held accountable for their climate impact and are actively seeking strategies to decarbonize their operations. In Europe, the significant contribution of road freight to overall greenhouse gas emissions means there is a growing appeal to transition to fleets of zero-emission trucks. However, due to a number of perceived barriers, ambitions have not yet crystalized into a strong deployment of such vehicles.

We consulted with members of the European Clean Trucking Alliance (ECTA) to assess their readiness to transition to zero-emission freight vehicles, identify perceived barriers to the transition, and determine possible ways of accelerating the deployment of zero-emission trucks. We surveyed and interviewed fleet operators, major logistics services providers and shippers, and business associations, to better understand their business models, their general approach to sustainability, their views on the potential of different vehicle technologies, and their concerns about transitioning to zero-emission trucking. Topics covered included the availability of zero-emission truck models, financing the transition, operational constraints, and infrastructure. Due to the diversity of organizations represented in ECTA, we estimate that the results of this study are representative of the industry as a whole.

We found that the fleet of zero-emission trucks in Europe is still limited to a few pilot models showcased by progressive fleets. The lack of publicly accessible charging and refueling infrastructure dedicated to trucks is viewed as a primary roadblock to a faster transition and fleets would welcome additional support from other stakeholders to plan the build-out of infrastructure. Fleets also face limited truck availability. Some ECTA members cited an inability to secure large orders of vehicles, while others highlighted the lack of model availability and diversity, especially for long-haul trucking. Current battery-electric truck models have driving ranges limited to 250–300 km, creating significant operational challenges for high mileage use cases. Finally, the ability for carriers operating with small profit margins to finance zero-emission trucks is perceived as a major barrier to adoption. Small carriers can usually not afford the large capital investments required, and struggle to secure public and private funding. Increased financial support and alternative business models would ensure that all fleets can benefit economically from zero-emission trucking, as there is a consensus among interviewees that electric trucks can be cost competitive with their diesel counterparts.

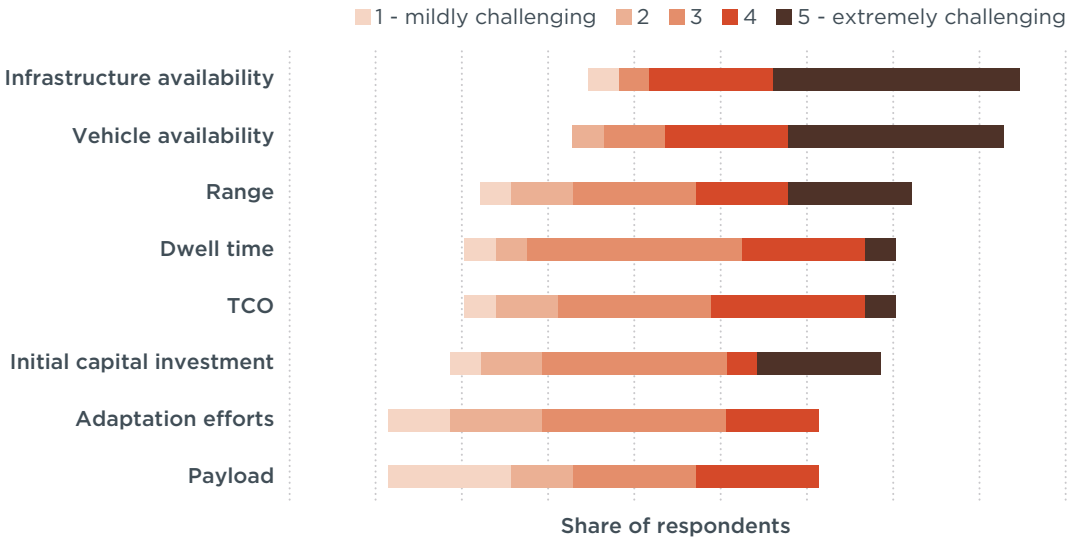

Figure ES1. Importance of key barriers to the transition to zero-emission freight vehicles as perceived by the fleets surveyed in this study.

Based on our consultation with ECTA members, we recommend the following to accelerate the deployment of zero-emission trucks in Europe:

Continue to build knowledge on zero-emission trucking technology. Several zero-emission technologies are available to decarbonize the road freight sector. More extensive knowledge about the real-world performance of zero-emission trucks, particularly as they age, is needed to increase their acceptability and facilitate the development of a second-hand market for fleet operators with less capital availability.

Increase access to charging and refueling infrastructure. Private depot chargers can contribute to a large portion of truck fleet charging needs, and their deployment should therefore be facilitated through public support and increased collaboration between fleet owners, truck manufacturers, utilities, and infrastructure providers. A network of public fast chargers is also needed, and regulation can help in securing a fast build-out of infrastructure. Detailed planning and targeting infrastructure to areas with the highest traffic can support deployment while mitigating the required investments.

Increase vehicle supply and model diversity through binding CO_2 regulation. The availability of diverse and competitive options for each truck segment is crucial for carriers, and large volumes of vehicles are required to benefit from economies of scale and reduce the cost of zero-emission trucks. The revision of the heavy-duty CO_2 emission standards planned for November 2022 is an opportunity for the EU to enshrine the ambitions of manufacturers for zero-emission trucks into binding regulation.

Support diverse business models to help overcome the financial challenges associated with zero-emission trucking. Solutions such as trucking-as-a-service and charging-as-a-service are widely perceived by the organizations interviewed to facilitate the transition to zero-emission trucking for fleet owners, as they are less capital-intensive solutions that provide support throughout the truck's lifetime. Trucking service providers can also help to aggregate demand from small fleets and catalyze development of the market in early stages.

Facilitate the access of small fleets to the zero-emission truck market. Despite their limited resources, many small fleet owners identify an opportunity in transitioning to zero-emission vehicles. Third-party organizations can provide a platform to give those companies access to the zero-emission truck market, which is otherwise reserved for large fleet owners and logistics providers. At the same time, aggregating the orders from small carriers can boost market demand and therefore reduce the risk for manufacturers to commit to zero-emission. Policies such as subsidies tailored to small fleets, and administrative support to obtain them, can ensure that all fleets have an opportunity to transition to zero-emission trucks.

Develop best practices through enhanced collaboration between stakeholders. Strategic partnerships between shippers, logistics providers, and their transport partners provide a collaborative environment that is more supportive of fleet transformations than one-off, spontaneous spot contracts. As sustainability criteria for shipping contracts become common practice, the environmental performance of the hired fleets will also become a key performance indicator for the competitiveness of shippers and freight forwarders. Knowledge gaps can be closed by sharing feedback from early adopters of zero-emission trucks to other transport partners. Early adopters therefore have a pivotal role to play in the transition to zero-emission trucking in Europe.

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INTRODUCTION

Road freight is responsible for more than 19% of the transport sector's greenhouse gas (GHG) emissions in Europe (European Environment Agency, 2020). Road freight volumes are expected to increase by 1% per year up to 2050, leading to a 36% increase compared to current levels (Tölke and McKinnon, 2021). As a result, even with current regulatory action, CO_2 emissions from the sector are expected to grow 8% by 2050 relative to 2019 (Mulholland et al., 2022).

Additionally, heavy-duty vehicles contribute significantly to ambient air pollution, accounting for 31% of Europe's transport-related emissions of nitrogen oxides (NOx), a major cause of premature deaths, especially in urban areas (Mulholland et al., 2021). To address the climate and health impacts of heavy-duty road transportation, a fast transition to zero-emission freight vehicles is needed.

Heavy-duty vehicle (HDV) manufacturers have made ambitious pledges to sell increasing numbers of battery-electric and fuel cell electric trucks, which would amount to about 40% of new vehicle sales in 2030 and close to 100% of new vehicle sales in 2040 (Basma & Rodriguez, 2021; Mulholland et al., 2022). The European Union's (EU) CO_2 standards for trucks and buses will be revised at the end of 2022, providing an opportunity to enshrine the ambitions of manufacturers for zero-emission vehicles into regulation. On the demand side, supply chains globally, and especially in the EU, are actively working to mitigate their climate impact, driving a growing demand for clean freight.

Still, despite the growing momentum around zero-emission trucks, their widespread adoption is still perceived as a challenge for financial, technical, and operational reasons. A number of barriers remain to be overcome to fully transition to zero-emission trucks. As a result, electric and hydrogen trucks represented 0.5% of the registrations of new medium- and heavy-duty commercial vehicles in 2021, mostly thanks to urban delivery vans and buses. For heavier regional and long-haul trucks, this number only reached 0.2%.[1]

To shed light on the reasons for this gap between ambitions and reality, this study explores the readiness of the European truck fleets to transition to zero-emission vehicles. We use insights from consultations with members of the European Clean Trucking Alliance (ECTA) to identify the challenges that hinder this transition and suggest possible ways of overcoming those barriers. First, we track the developments of zero-emission trucking in other markets. We then describe the consultation we led with ECTA members to obtain the information shared in this report. In the following section, we assess the extent of the current demand for zero-emission trucks in Europe and highlight the key barriers hindering the transition to zero-emission trucking as perceived by fleets. Subsequently, we describe the dynamics between key stakeholders of the road freight decarbonization to better understand how those barriers are hindering electrification. Finally, we identify avenues to accelerate the deployment of zero-emission trucks in Europe, based on feedback received from ECTA members.

1 Historical data supplied by IHS Global SA; Copyright © IHS Global SA, 2022.

INTERNATIONAL OUTLOOK

Europe is not the only region where momentum is building around electric trucks. Efforts from governments and industry worldwide to transition to zero-emission trucking can serve as good examples for transitioning the fleet of European trucks to zero-emission vehicles.

California has adopted the world's first zero-emission vehicle (ZEV) sales requirements for HDV manufacturers (California Air Resources Board, 2020a) and is now working on the Advance Clean Fleets (ACF) regulation that will mandate the purchase of increasing levels of ZEVs for truck fleets in California. The aim is to help support a full transition of the fleet by 2045, and as early as 2027 for certain applications (California Air Resources Board, 2021). To support this transition, a number of agencies are providing financial incentives. The Low Carbon Fuel Standard (LCFS) includes a program that subsidizes low carbon fuel prices, including electricity and hydrogen, and the associated infrastructure (California Air Resources Board 2020b). The Hybrid and Zero-Emission Truck & Bus Voucher Incentive Project (HVIP), which offers instant rebates on zero-emission trucks, is responsible for 60% of the zero-emission trucks deployed on Californian roads as of January 2022 and delivered $240 million worth of subsidies (California HVIP, 2021; Green Car Congress, 2022). The Volvo Lights project, which aims to demonstrate the feasibility of, and build knowledge on, zero-emission trucking, received $45 million in funding from the State of California (Volvo Group North America, 2022). Beyond direct subsidies, California passed a bill to financially support this transition through a number of tailored mechanisms including a loan loss reserve, credit enhancements, performance warranties, and sale guarantees (Environmental Defense Fund, 2021). The aim is to help fleets overcome the cost difference between zero-emission trucks and their diesel counterparts, and to simultaneously attract private capital by reducing the risk associated with investments. In this favorable regulatory context, private investment is increasing and a number of new players are entering the market, providing alternative business models such as Trucking-as-a-service (TaaS) and Charging-as-a-service (CaaS), and facilitating the transition to fleets of electric trucks.

In North America, a number of progressive fleets are piloting zero-emission trucks and driving initiatives to show their technical feasibility and economic viability. The North American Council for Freight Efficiency's demonstrator project, Run On Less – Electric, showcased thirteen fleets piloting different types of zero-emissions trucks in the United States and Canada (NACFE, 2022). More generally, the industry is developing innovative financing solutions to help customers overcome the high capital investments needed to purchase electric trucks. Manufacturers such as Volvo Group North America and Daimler Truck North America have been providing flexible payment options to their customers through dedicated subsidiaries. In Canada, Lion Electric is already providing turnkey solutions and has launched LionCapital solution, a platform that will provide flexible financing solutions and reduce the required upfront capital requirements for electric trucks (electrive.com, 2022). Independent financing institutions are also starting to get involved. The zero-emissions truck start up Nikola Corporation recently partnered with ENGS Commercial Finance to facilitate the sales of their battery-electric and fuel cell trucks. In New Jersey, the company Ideomatics focuses on helping small business acquire zero-emission vehicles through the New Jersey Zero-Emission Incentive Program.

China, the world's largest HDV market, is also the most developed market for zero-emission trucks and buses, making up 99% of the global stock (Basma & Rodriguez, 2021). Substantial subsidies for new energy HDVs, which include battery-electric, fuel cell electric and plug-in hybrid HDVs, have enabled Chinese manufacturers to develop and sell an increasing number of electric trucks. As a result, the model availability in

China is higher than in any other market, although it is largest for light trucks up to 5 tonnes (Mao & Rodríguez, 2021). In parallel, major fleets have increasing ambitions to transition to electric trucks. Shenzhen, the fourth most populated urban area in the country, electrified 77,500 of its urban logistics vehicles as of 2019 by promoting model availability and innovative business models, developing charging infrastructure, providing purchase subsidies, and giving preferential access to the city center to new energy HDVs via ten green logistics zones (Transport Decarbonisation Alliance, C40 Cities, & POLIS, 2020). Heavier trucks for regional and inter-regional transport remain almost exclusively powered by diesel combustion engines, as in other leading markets.

DATA COLLECTION WITH THE EUROPEAN CLEAN TRUCKING ALLIANCE

The European Clean Trucking Alliance (ECTA) is a coalition of over 30 leading logistics businesses and organizations that work towards zero-emission trucking in Europe. ECTA members together represent a fleet of about 380,000 vehicles (6% of the total European fleet) and have a large sphere of influence in the European logistics industry. As technical observer and advisor for the alliance, the ICCT surveyed 17 members of ECTA to better understand their operations and priorities when it comes to purchasing new heavy goods vehicles, in the context of truck electrification.

We then conducted 19 interviews with both ECTA members and other large fleets to discuss the organizations' business models, their general approach to sustainability, their views on the most suitable technologies, and their concerns about transitioning to zero-emission vehicles. Topics covered included the availability of zero-emission truck models, financing, operational constraints, and infrastructure.

We consulted 23 organizations, including fleets that operate a total of 13,400 long-haul trucks and 1,600 regional delivery trucks, as well as cargo owners, freight forwarders, large retail and consumer goods companies, and business associations. Figure 1 summarizes the profile of the consulted organizations. For confidentiality purposes, the results from these consultations were anonymized and aggregated into the key messages presented in this report.

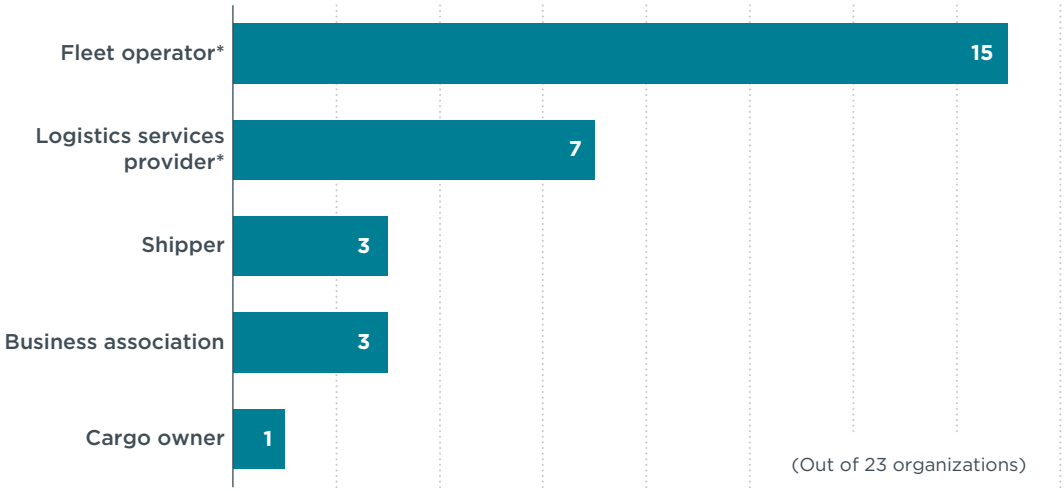


Figure 1. Profile of the organizations surveyed and interviewed for this study. *Some logistics providers only operate a fraction of their transport activities and subcontract the rest. They are therefore labeled as both fleet operators and logistics services providers.

In addition, we tracked the public announcements of other major European truck fleets on the purchase of zero-emission vehicles and compared the general level of ambition of the truck fleets to that announced by manufacturers.

DEMAND FOR ZERO-EMISSION TRUCKS IN EUROPE

The zero-emission truck market in Europe is still nascent. Up to 2020, sales of zero-emission HDVs were almost exclusively driven by electric buses (Basma & Rodriguez, 2021). Since 2021, however, there has been an increasing deployment of electric trucks enabled by increasing levels of technology readiness and a growing confidence about the economic viability of those vehicles.

The electrification of vans and light trucks for last-mile delivery is progressing quickly, with large purchase orders already being initiated. The German postal services group, Deutsche Post DHL, currently owns a fleet of around 20,000 electric vehicles from the manufacturer StreetScooter, which they formerly owned, and expects to purchase another 18,000 by 2025 (Stern.de, 2022). The logistics provider further plans to electrify 60% of its fleet by 2030 (DP DHL, 2021). Outside of ECTA, Amazon recently ordered 1,800 electric vans from Daimler for its European fleet (GreenBiz 2020). For heavier trucks, only a handful of zero-emission vehicles have been deployed on European roads to date. This contrasts with our projections of the zero-emission sales from OEM announcements, which we estimate would result in a stock of 19,000 vehicles in 2025 and 330,000 vehicles in 2030 (International Council on Clean Transportation, 2022).

Figure 2 shows examples of historical orders of zero-emission trucks with a weight above 7.5 tons as of June 2022, as recorded from public announcements and discussion with fleets.[2] To our knowledge, a total of around 3,200 trucks have been ordered to date by European fleets. The largest contributions to date have been DB Schenker's and Petit Forestier Group's orders to electric truck start-up Volta Trucks—1,470 vehicles and 1,000 refrigerated units, respectively—although those trucks are still at the design verification stage and their series production has not yet started. Fuel cell electric trucks have mostly been deployed through the pilot project led by the Hyundai–H2 Energy partnership in Switzerland. Additionally, the fleets that responded to the survey revealed procurement targets aggregating to 1,000 electric trucks in 2025 and 4,200 electric trucks in 2030.

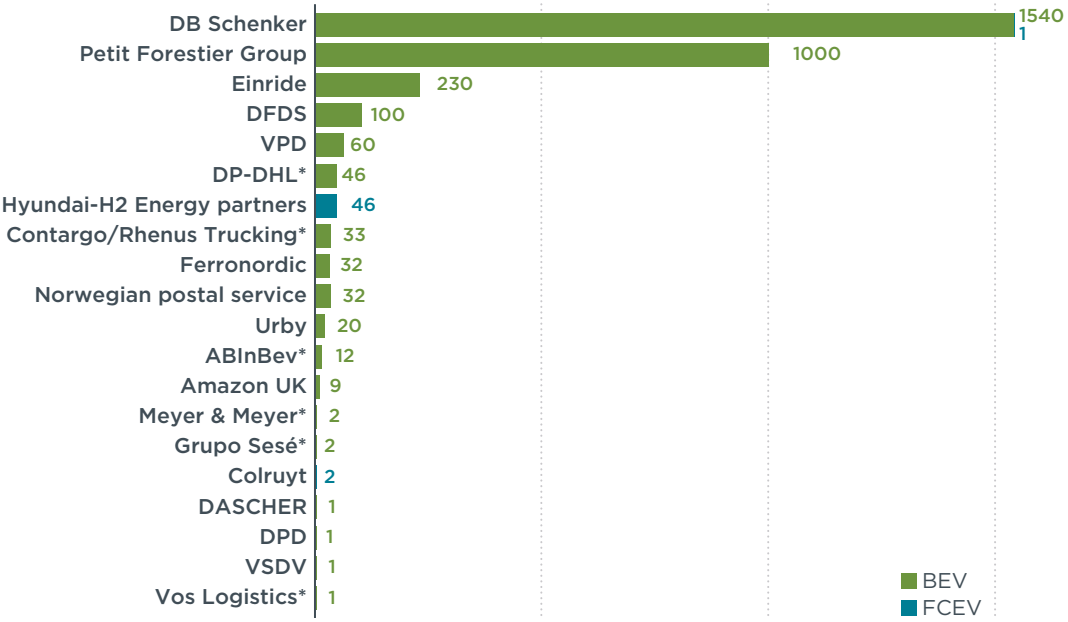


Figure 2. Zero-emission trucks deployed or ordered by European fleets as of June 2022, according to public announcements. *Members of ECTA.

2 This sample database was put together by collecting public announcements available at online ressources and is not exhaustive.

The carriers interviewed that have started to deploy zero-emission vehicles described an overall positive experience. Given their early adopter status, those organization benefit from first-rate support from truck manufacturers and infrastructure providers to incorporate zero-emission trucks in their fleets, and early feedback enables them to build expertise and develop best practices for zero-emission trucking. Moreover, early adopters can plan for the transition of their fleet at the desired pace, without imminent pressure from policies like the implementation of zero-emission zones.

Still, the demand for zero-emission trucks remains limited to a few pilot models that aim to show the technical feasibility and operational viability of those vehicles. The lack of large-scale orders highlights the lack of readiness of the freight sector to fully engage the technology transition. The current uncertainty regarding the most future-proof technologies to decarbonize freight transport is hindering the transition process by creating a number of barriers for carrier fleets, truck manufacturers, and shippers. Figure 3 shows the relative importance of key barriers as perceived by the fleets surveyed in this study.

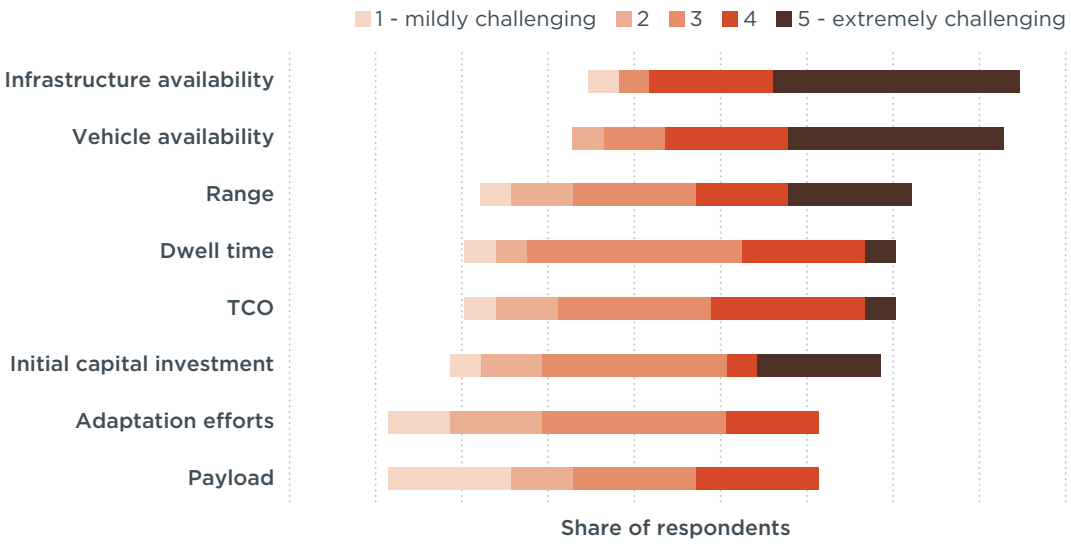


Figure 3. Importance of key barriers to the transition to zero-emission freight vehicles as perceived by the fleets surveyed in this study.

There is little publicly accessible electric charging and hydrogen refueling infrastructure dedicated to heavy-duty vehicles in Europe, which is perceived by ECTA members as the most important barrier hindering the transition to zero-emission trucking. Additionally, consensus still needs to be reached on best practices for charging and refueling. For battery-electric trucks in particular, several types of charging are available. The majority of interviewed fleets mentioned a preference to rely on a mix of private and public charging infrastructure, although it is unclear what the ideal split should be for different vehicle types and industry sectors. Planning requires financial and organizational resources, and fleets would welcome additional support from other stakeholders to develop charging infrastructure.

The ability to procure zero-emission trucks is also perceived as a significant blocking point. Despite a growing number of models developed by manufacturers, fleets highlighted that there is still little diversity of models that meet their operational needs. Current models have ranges of up to 250–300 km and there are very limited options for use cases that need more range such as long-haul trucks, which represent the largest share of freight movement and emissions. In addition, some carriers operate

specific types of vehicles for which there is no zero-emission model yet available, such as low-floor tractor units that can accommodate mega-trailers.[3]

Most importantly, several organizations cited challenges in securing large orders of vehicles. The current semi-conductor crisis has resulted in production delays in the automotive manufacturing sector, and orders of diesel trucks can take several months to be delivered. It takes significant time and effort for manufacturers to re-tool their production sites to accommodate for growing shares of zero-emission trucks. ECTA members suggested that due to the perceived uncertainty regarding both the pace of growth in demand for zero-emission technologies and the pace of infrastructure roll out, manufacturers see a risk in fully shifting their production lines. Still, a few manufacturers have started to build dedicated facilities to ramp up their production capacity, including Volvo Trucks' battery plant in Ghent, Belgium, MAN's eMobility Center in Munich, Germany, and MAN's planned battery production site in Nuremberg, Germany (Volvo Trucks, 2022; MAN Truck & Bus, 2022).

The limited range of current electric truck models is also perceived as posing operational challenges associated with charging and refueling, including a negative impact on dwell time. While some fleet operators are willing to adapt their operations to accommodate for the range limitation of zero-emission trucks, most expect those vehicles to comply with existing shipping schedules. In addition, the fleets we interviewed do not perceive the potential payload penalty gap resulting from the currently heavier electric trucks as their primary concern and, what's more, this gap is expected to be closed by the end of the decade through technology improvements in batteries (Basma, Beys, & Rodríguez, 2021).

Finally, financing the transition to zero-emission trucking is perceived as a significant challenge. Fleets expressed that they lack resources to overcome the large capital investments needed to purchase zero-emission trucks and, to a lesser extent, their higher total cost of ownership (TCO) compared to diesel trucks. To better understand how the barriers identified in our fleet survey are hindering the transition to zero-emission trucking, the next section describes the dynamics among the stakeholders of this transition.

3 Trailers with a height of 3m, while typical dry-box trailers have a height of around 2.7m.

DYNAMICS OF ROAD FREIGHT DECARBONIZATION IN EUROPE

The demand for zero-emission trucking in Europe is largely driven by the organizations that purchase and operate those vehicles—i.e., the carriers or fleet operators themselves. However, supply chains are complex systems that involve many stakeholders, and the carriers are not the only actors driving the demand for zero-emission trucks; decarbonizing the road freight sector requires support and commitment from all involved in the supply-chain. This section identifies the overarching industry dynamics and market forces acting on fleets, as reported during our consultations with ECTA members, to understand the opportunities and challenges they face to transition to zero-emission HDVs. Figure 4 summarizes the dynamics between carriers, freight customers, truck manufacturers, governments, and utility providers. Their respective roles and opportunities to overcome barriers to zero-emission trucking are discussed in more detail below.

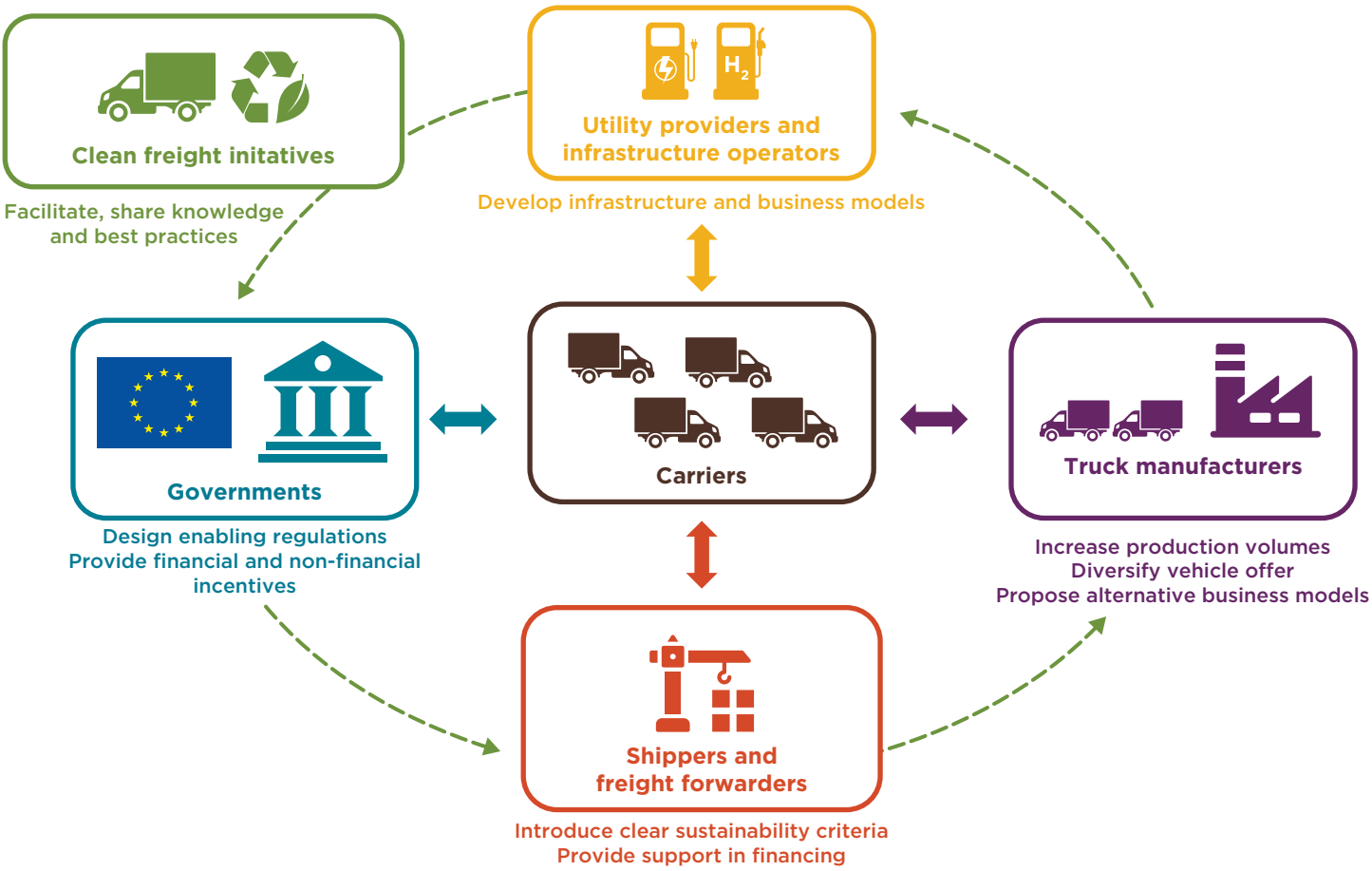


Figure 4. Schematic of the role of different actors of the supply chain in increasing carrier fleets' demand for zero-emission HDVs.

CARRIERS

Carriers are directly responsible for the CO_2 emissions from road freight and, therefore, have a pivotal role to play in decarbonizing the sector. The organizations consulted in this study are exploiting several avenues to decarbonize their operations, which follow the Avoid-Shift-Improve principle described in Figure 5.

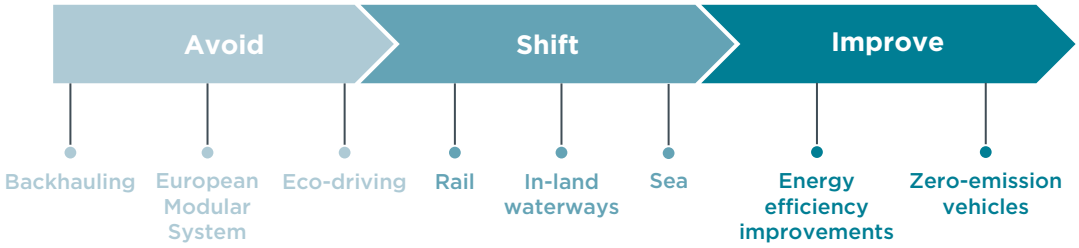


Figure 5. Schematic of the Avoid-Shift-Improve principle commonly used to reduce emissions from freight transport.

A common measure to avoid emissions across all interviewed organizations is to reduce the energy intensity of their operations via route optimization, and to reduce empty kilometers via balanced transport plans that avoid empty runs, also known as backhauling. Organizations responsible for large transport networks have greater opportunities to avoid empty runs than those only operating a few selected routes. Official EU statistics reveal that 20% of all road freight kilometers in 2020 were travelled by empty vehicles, with a higher share for national transport (24%) than for international transport (13%) (Eurostat, 2021). However, several interviewees suggested that most of the potential to reduce those empty kilometers has already been exploited, as it also results in significant economic benefits. Other mentioned avenues to avoid emissions include combining trailers according to the European Modular System and incentivizing drivers for eco-driving to reduce fuel consumption, although the savings could not be quantified by respondents.[4]

Several ECTA members are also shifting part of their operations to other modes of transport, such as rail, in-land waterways, and short sea shipping. Multi-modal transport is usually associated with both lower costs and reduced emissions. Industry associations promoting the use of multi-modal transport suggest that combined road-rail transport enables emissions savings of 60% to 90% (UIRR - International Union for Road-Rail Combined Transport, 2022). Multi-modal transport results in shorter legs for road transport of up to 250–300 km, which could be covered by already available electric truck models. However, ECTA members highlighted that significant roadblocks exist to fully exploit this potential, starting with the limited capacity of the existing European rail network. A shift to cleaner technologies is therefore required to further decarbonize the sector. As part of the survey, ECTA members ranked adoption of zero-emission trucks as their overall preferred technology area in which to invest to decarbonize truck fleets, before improvements in engine efficiency, improvements in vehicle energy efficiency, and investing in alternative fuels. Results are as shown in Figure 6.

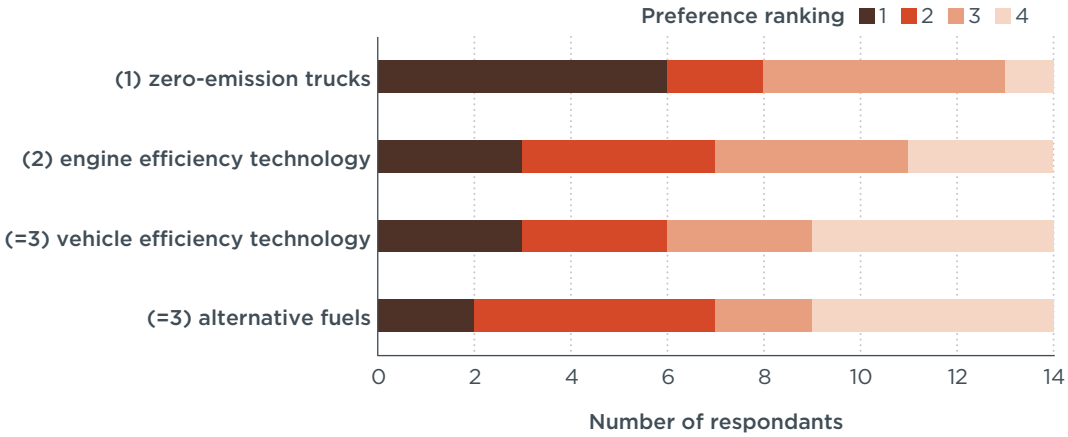


Figure 6. Preferred technology areas for fleet decarbonization according to ECTA members' response to the survey. Only 14 of the 17 survey respondents replied to this question.

4 The European Modular System regulates the use of different combinations of loading units (bodies and trailers).

In Europe, the majority of carriers are small and medium sized enterprises (SMEs). There are over 500 thousand companies providing road freight transport services (Tölke & McKinnon, 2021), and larger logistics service providers usually subcontract the majority of their operations to these SMEs. With a total stock of around 6.3 million trucks in Europe, the average truck fleet operates around 12 vehicles, with many owner-operators owning only one or two trucks (International Council on Clean Transportation, 2022). The market for carriers is under constant competitive pressure, as contracts are typically awarded to the organizations offering the lowest cost. The integration of sustainability criteria in bidding processes is a recent phenomenon that has not yet gained a strong foothold in the industry.

While ECTA members mainly consist of large carrier fleets and logistics providers, over 8,000 smaller fleets are represented through national business associations. As highlighted by those associations, small carriers usually have small profit margins of 2% to 3% and, therefore, have low capital availability to invest in technologies with higher upfront costs, even when they recognize that the technology has an attractive payback time. Due to their sizes, these carriers usually have a focus on daily operations, with limited capabilities and resources to plan for long-term transformations. Therefore, there is a need for other supply chain stakeholders to support fleets' efforts to shift to zero-emission vehicles by providing different forms of incentives and support.

SHIPPERS AND FREIGHT FORWARDERS

Progressive organizations have interest in reducing their corporate value chain emissions, also known as Scope 3 emissions, to comply with best practices and obtain a competitive advantage. In a well-functioning market, where lower value chain emissions are rewarded, freight customers would benefit from creating the right incentives for their transport partners to reduce their emissions. Incentives can take the form of clear sustainability criteria in bidding processes that truck fleets would need to meet to be awarded contracts.

The shippers and freight forwarders we interviewed either work with long-term relationships with transport partners, or with on-spot shipping agreements to cover peaks in freight demand. Due to the spontaneous and short-lived nature of spot contracts, they are generally perceived as providing less room for environmental planning. Among the interviewed logistics providers, those that rely the most on the spot market are those working in industry sectors where the demand is either unpredictable by nature or varies throughout the year. For specific shipping routes, shippers and freight forwarders sometimes have a very limited number of carrier options and cannot always make a selection based on sustainability criteria. In addition, a few organizations mentioned that the current shortage in spot market carriers in Europe, driven by the shortage in drivers, does not place them in a favorable position to include more stringent criteria in their contracts. In Europe, an estimated 14% of all truck driver positions are currently unfilled, growing from 10% in 2021 and 7% in 2020 (IRU, 2022).

Long-term contracts, on the other hand, provide an opportunity to develop strategic partnerships to help fleets decarbonize their operations and to help shippers meet their environmental goals. A number of larger shippers and freight forwarders mentioned that they already have, or are planning on introducing, clear sustainability criteria in their bidding processes for those contracts. Criteria include minimum requirements on the emissions performance of trucks, such as requiring Euro VI diesel trucks only, although none of the interviewed organizations have adopted mandates or dedicated incentives rewarding zero-emission vehicles. Respondents sometimes prioritize environmental performance over price in their bidding processes. Still, environmental performance is not yet generally considered by the interviewed carriers as a key indicator of their competitiveness.

Several ECTA members provide additional support to their transport partners, which includes assisting them in their procurement activities to identify the best available vehicles, helping with the planning and deployment of the infrastructure required to operate zero-emission vehicles, and helping overcome the operational challenges associated with charging and refueling. An area of contention across interviewed organizations, however, is whether shippers should pay higher rates for more sustainable options to help carriers bear the higher upfront costs of zero-emission vehicles. Several carriers mentioned that they would welcome a stronger signal that customers are willing to contribute financially to the transition of their fleets to zero-emission vehicles.

TRUCK MANUFACTURERS

Original equipment manufacturers (OEMs) have a key role to play in diversifying vehicle offerings, delivering significant volumes of vehicles in a timely manner, ensuring that new technologies deliver the expected environmental benefits, and that they reliably meet their performance specifications. Despite the ambitious sales targets set by manufacturers, their ability to ensure all of the above was consistently raised as a concern during our interviews.

Large carriers, freight forwarders, and shippers usually have the capacity to closely track technological developments and reassess the relative performance of different OEMs at each new procurement phase. Several ECTA members are developing strategic partnerships with manufacturers to develop truck models tailored to their needs and operational constraints. Small and medium carrier fleets, however, are usually more dependent on the willingness of OEMs to propose alternative technologies. A few interviewees recognized that this presents a challenge when it comes to transitioning to zero-emission vehicles, as they usually procure their trucks from one or a few selected manufacturers and have fewer resources to reassess the market regularly. It is also critical for fleet operators that trucks deliver the environmental performance advertised by manufacturers. According to a few interviewees, it is common to experience deviations between the advertised and real-world fuel consumption of diesel trucks.

Manufacturers can also have a key role in helping their customers finance their trucks. Most fleets still rely on a traditional ownership model, where they purchase trucks from manufacturers and re-sell them to the used vehicle market or the manufacturer. The business associations and freight forwarders that we interviewed highlighted the importance of truck ownership for small carriers, as this is usually one of the carrier's only assets. The fleets we surveyed keep their truck for an average of five years, with ownership ranging from two to seven years, before selling them—which constitutes an important source of revenue. Most manufacturers propose multiple financing options for those customers, including loans, differed payments, and leasing solutions. Finally, given to the large capital investments required to acquire zero-emission vehicles, the organizations we interviewed are open to considering alternative ways of financing the trucks. Manufacturers can therefore have an opportunity to gain a competitive edge by providing alternative business models to customers.

UTILITY PROVIDERS AND INFRASTRUCTURE OPERATORS

Access to charging and refueling infrastructure is key to enabling zero-emission trucking. Utility providers and infrastructure operators, therefore, have a key role to play in this transition by upgrading the power grid, supporting the roll out of public and private infrastructure, and providing favorable electricity rates to fleet operators. Despite a currently small market, which is essentially driven by fleets of electric buses, the ambition showcased by both manufacturers and fleets can already justify efforts from utility providers and infrastructure operators.

GOVERNMENTS

Government intervention is crucial in the early stages of road freight electrification to ensure that significant barriers are addressed. In Europe, a number of frameworks exist to promote the deployment of zero-emission trucks and the associated infrastructure.

To increase the supply of zero-emission trucks, the EU's heavy-duty CO_2 emission standards, adopted in 2019, require manufacturers to reduce the emission of their new trucks and buses by 15% in 2025 and 30% in 2030, relative to a 2019/2020 baseline. These targets can be achieved with little-to-no market penetration of zero-emission vehicles (Krause & Donati, 2018). However, the revision of the standards planned for November 2022 will provide an opportunity to lock in manufacturer production commitments and align the sector with the EU's climate goals. Accordingly, the ICCT recommends increasing the stringency of the reduction target for 2030 to at least 60%, introducing a reduction target of at least 90% for 2035, and applying a target of 100% for no later than 2040 (Mulholland et al., 2022). Sales mandates for manufacturers have also proven to be an effective way to force zero-emission vehicles into the market in other regions and could be considered as part of the proposal to revise the European heavy-duty CO_2 standards.

A number of national governments are also taking action to accelerate ZEV adoption. A global memorandum of understanding (MoU) aims to align national governments ambitions to transition to zero-emission medium- and heavy-duty vehicles (ZE-MHDVs). Signatories are expected to develop a clear strategy and provide incentives to work towards a sales share of ZE-MHDVs of 30% in 2030 and 100% in 2040. The MOU was signed by nine European countries (Austria, Denmark, Finland, Luxemburg, the Netherlands, Norway, Portugal, Switzerland, and the United Kingdom) that together represent 26% of the European MHDV market.[5] It was also endorsed by a number of sub-national governments and industry leaders, including the European Clean Trucking Alliance (ECTA) and individual members thereof (Dutch Ministry for the Environment & CALSTART, 2021). Additionally, several European signatories adopted targets for a faster transition to ZE-HDVs. As shown in Figure 5, manufacturer's ambitions go beyond the levels of ZEV market penetration that can be expected from those various frameworks.

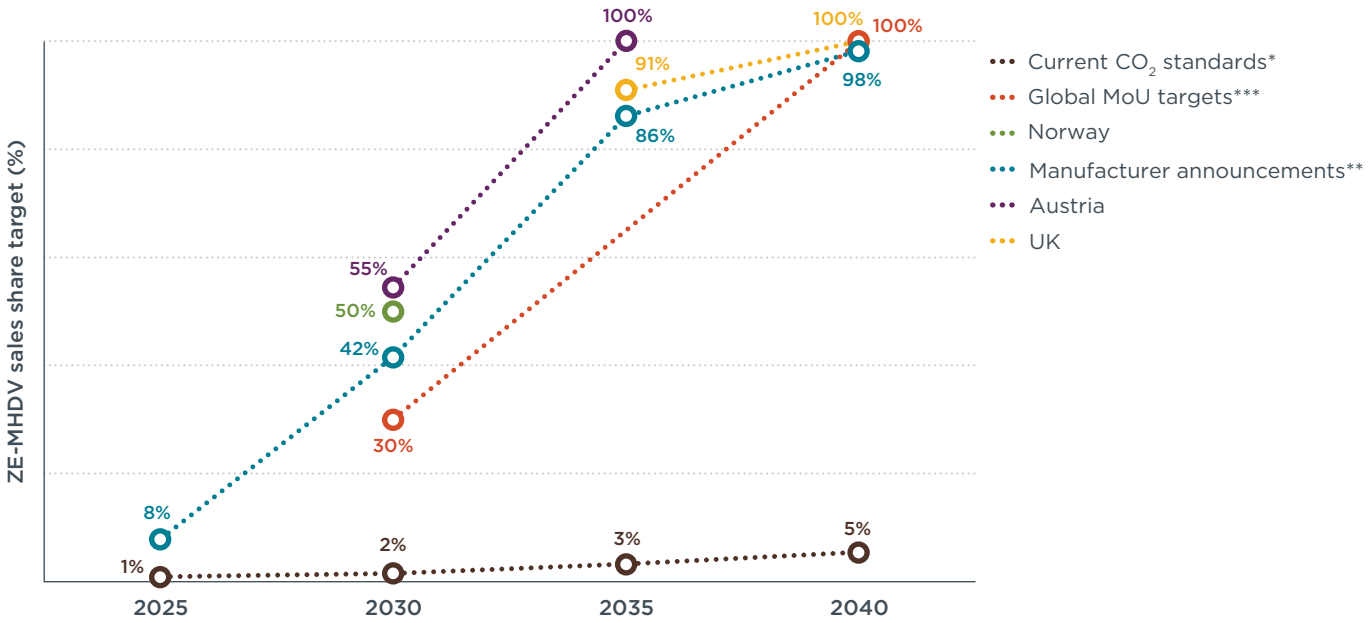


Figure 7. Non-binding sales targets for heavy goods vehicle at the European and selected national levels. *ICCT estimate based on the stringency of the targets and technology potential. **As aggregated in Mulholland et al., (2022). ***The targets of the global MOU include sales of buses

5 Historical data supplied by IHS Global SA; Copyright © IHS Global SA, 2019.

Unlike California's upcoming Advance Clean Fleets regulation, European regulators have not introduced procurement mandates to force truck fleets to purchase zero-emission trucks. However, by providing adequate policy support, governments can help maximize the economic opportunity and reduce the operational challenges associated with zero-emission trucking, hence increasing demand.

As of June 2022, purchase subsidies offered in the seven largest European truck markets—Germany, France, Italy, Spain, Poland, the Netherlands, and the United Kingdom—range from €7,000 (United Kingdom) to €550,000 (Germany) (Basma, Zhou & Rodríguez, 2022). Austria is also working on implementing a purchase subsidy covering 80% of the truck acquisition cost difference relative to an equivalent diesel truck capped at €160,000 (ORF.at, 2022) and France is providing significant fiscal support through a 60% tax exemption for zero-emission trucks, limited to €50,000, in the form of an over-depreciation scheme (AVERE France, 2022). Moreover, incentives are in place to reduce the operational costs of zero-emission vehicles. The Eurovignette directive that was recently adopted by the European Union recommends that countries apply carbon-based road toll fees and a road toll exemption of 50% for zero-emission vehicles (Goulding Caroll, 2022). Finally, introducing carbon pricing via the inclusion of the transport sector in the European Emissions Trading Systems can help the TCO performance of zero-emission trucks. The TCO impact of those policies is explored in Basma, Saboori, and Rodríguez (2021).

Regulators also have a key role to play in the development of a base infrastructure network, as the low volumes of vehicles currently on the road do not guarantee a positive business case. The EU is in the process of adopting a binding Alternative Fuels Infrastructure Regulation (AFIR) which would mandate the levels of investments coming from Member States. As of June 2022, no compromise has been found between the EU institutions on the level of ambition required for the AFIR, however the regulation is expected to contribute to establishing a base network of charging and hydrogen refueling infrastructure in the early stages of vehicle market adoption. Targeting electric charger and hydrogen station deployment to the locations where it is the most needed can help to reduce the levels of public spending to the strict minimum (Ragon et al., 2022). National governments, including Germany, France, Spain, Poland, and the Netherlands, have programs to subsidize the installation of infrastructure at private locations, such as truck depots and logistics centers. For example, the French government subsidizes up to €960,000 for projects with grid connection powers above 8,000 kVA, while Germany provides a subsidy covering 80% of the expenditure for charging or refueling infrastructure. A summary can be found in Xie and Rodríguez (2021).

Finally, at the sub-national level, a number of European cities are developing low- and zero-emission zones, restricting access to city centers to only certain vehicle technologies to address both climate and air quality issues. In the most stringent case of zero-emission zones, fleets will have to use battery-electric or fuel cell trucks for pick-ups and deliveries in city centers. Examples of already implemented zero-emission zones include London, UK and the zero-emission freight zone of Rotterdam, Netherlands, with many more European cities planning for zero-emission zones between 2025 and 2030 (Cui, Gode, & Wappelhorst, 2021). As the interviewed fleets keep their trucks five years on average, those operating urban delivery therefore have little remaining time to transition to zero-emission vehicles.

CLEAN FREIGHT INITIATIVES

Like ECTA, a number of clean freight initiatives in Europe and globally work towards knowledge sharing and the establishment of best practices to help fleets transition towards zero-emission trucking. The Road Freight Zero initiative led by the World Economic Forum has outlined a clear roadmap to overcome the obstacles to freight

decarbonization (World Economic Forum & Road Freight Zero, 2021) and will propose a transition finance framework as well as a number of de-risk initiatives. At the European level, the ENTRANCE project, financed by the EU, is providing a matchmaking platform to facilitate access to finance and increase market access of sustainable transport solutions (European Commission, 2020).

Accurate measurement of emissions from freight transport is needed to implement strategies for reduction. The Greenhouse Gas Protocol defined a standard for the determination of all corporate value chain (Scope 3) emissions, resulting in an increased level of accountability across shippers and freight forwarders. To harmonize emissions calculation across different transport modes, the Global Logistics Emissions Council developed the GLEC framework, which is now recognized as the industry standard methodology for the logistics industry. A number of organizations are building upon the GLEC framework and provide services to logistics businesses to help them determine and reduce their emissions, whether they are carriers or freight customers. The European Union is also working on a regulatory framework to determine and monitor companies' transport-related emissions. The Science Based Targets initiative provides support to logistics business to help them set emissions reduction targets for their transport-related activities, as part of their Environmental, Social and Governance activities. Several ECTA members have endorsed Science Based Targets to reduce their corporate emissions. Finally, the Sustainable Freight Buyers Alliance initiative, which was launched in May 2022, aims at matching shippers, including several ECTA members, with sustainable freight initiatives.

Table 1 summarizes select initiatives promoting an increased deployment of zero-emission vehicles from European truck fleets.

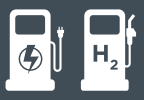
Table 1. Select initiatives promoting the demand for zero-emission HDVs in Europe.

	Leading organization	Geographical scope	Mission
European Clean Trucking Alliance	European Climate Foundation	Europe	EU-wide platform for knowledge sharing and the establishment of best practices to decarbonize road freight.
ENTRANCE project	European Commission, European Shippers Council	Europe	Matchmaking platform to facilitate access to finance and increase market access of sustainable transport solutions.
Sustainable Freight Buyers Alliance	Smart Freight Centre, Business Social Responsibilty, World Economic Forum	Global	Matches progressive shippers and freight forwarders with sustainable freight initiatives.
GLEC Framework	Smart Freight Centre	Global	Industry standard methodology for the calculation of logistics GHG emissions.
Science Based Targets Initiative	CDP, the United Nations Global Compact, World Resources Institute, the World Wide Fund for Nature (WWF)	Global	Supports logistics companies in setting corporate targets for GHG emissions reduction.
Road Freight Zero	World Economic Forum	Global	Aims at accelerating the transition to zero-emission freight by providing a clear roadmap and through the establishment of de-risk initiatives and a transition finance framework.

ACCELERATING THE DEPLOYMENT OF ZERO-EMISSION TRUCKS IN EUROPE

Based on our discussions with ECTA members, we identified six possible avenues to address the barriers identified and accelerate the deployment of zero-emission trucks in Europe. Table 2 summarizes these six zero-emission trucking facilitators and the stakeholders responsible for each. The variety of the involved stakeholders highlights the collaborative nature of the required efforts. More detail on each path is provided below.

Table 2. Avenues to accelerate the deployment of zero-emission trucking in Europe and main responsible stakeholders.

	 Carriers	 Truck manufactuers	 Shippers and freight forwarders	 Utility providers and infrastructure operators	 Governments	 Clean freight intiatives
Continue to build knowledge on zero-emission trucking technology	Run pilot programs	Run pilot programs Communicate technology developments Adapt to feedback from early-movers	Share knowledge with transport partners	Communicate technology developments		Contribute to knowledge sharing on technology options
Increase access to infrastructure	Collaborate with utility providers	Provide integrated vehicle-infrastructure solutions	Equip depots with required power grid connections	Upgrade the grid, support in planning and financing infrastructure roll out	Provide binding regulation Support financially through subsidies	
Increase vehicle supply	Clearly communicate requirements on vehicle performance	Leverage existing technology to diversify vehicle offer	Clearly communicate requirements on vehicle performance		Provide binding regulation	
Support diverse business models	Re-assess truck procurement strategies	Provide flexible payment options that reduce capial investments	Support transport partners in finding the most appropriate solution	Provide flexible payment options that reduce capial investments	Regulate third party organizations	
Facilitate the access of small fleets to the zero-emission truck market		Aggregate demand from transport partners	Aggregate demand from transport partners		Provide dedicated small fleet subsidies	Aggregate demand from transport partners
Develop best practices	Share early-mover experience	Share early-mover experience	Develop strategic partnerships with transport partners Introduce clear sustainability criteria			Share feedback from early movers Support shippers and freight forwarders in establishing sustainability criteria

CONTINUE TO BUILD KNOWLEDGE ON ZERO-EMISSION TRUCKING TECHNOLOGY

Increasing knowledge of the technologies available for zero-emission trucking is the first major step needed to address most challenges hindering fleet transition. It will reduce the risk for fleets of investing in stranded assets, inform the deployment of the supporting infrastructure, enable shippers and freight forwarders to provide adequate

sustainability criteria and support to carriers, help regulators tailor their policies and incentives, and attract private capital. The two major zero-emission truck technologies available are battery-electric trucks (BETs) and fuel cell electric trucks (FCETs). Both can be designed with various configurations to accommodate for different use cases, including different battery sizes, fuel cell powers, and charging or refueling technologies. ECTA members perceive different zero-emission technologies to be suitable for different use cases and industry sectors.

Battery-electric trucks are generally recognized to be the most immediate zero-emission technology. Due to a higher model availability (Basma & Rodriguez, 2021), they are perceived as having a higher technology readiness level. There is growing consensus in the industry that the total cost of ownership of battery-electric trucks can be favorable compared to that of their diesel counterparts given their lower operating costs, mainly driven by energy and maintenance costs. Total cost of ownership parity with diesel can already be achieved today for lighter delivery trucks, and can be achieved in a few years for heavier segments given the ongoing technology developments (Basma, Saboori, & Rodríguez, 2021; Basma et al., 2022). Most concerns regarding BETs revolve around their limited driving range, although ICCT analysis shows that a majority of trips can be achieved with current technologies (Basma, Beys, & Rodríguez, 2021).

There is also appetite from several interviewees for FCETs, although it is recognized that there is more uncertainty about their economic benefits. Fuel cell electric trucks showcase higher driving ranges than BETs, reducing their dependency to the associated refueling infrastructure. This is perceived as particularly attractive to ECTA members that operate on longer-than-average shipping routes and in remote areas where infrastructure availability is scarce. Moreover, the higher driving range of FCETs provides more flexibility than that of current BET models, which helps in overcoming the operational challenges identified in Figure 3.

A number of questions remain regarding the in-use performance of zero-emission trucks concerning aspects that are crucial to the truck ownership experience, as highlighted Figure 6. In order to effectively plan for a transition to zero-emission trucks, fleet operators need to know what the lifetime of the vehicles will be, how fast batteries and fuel cells will degrade, what the optimal ownership period for a new truck should be, their residual value in the second-hand market, and how these parameters compare to an equivalent diesel truck. To address all of these questions, early adopters will have a crucial role to play in sharing feedback to truck manufacturers and other logistics operators.

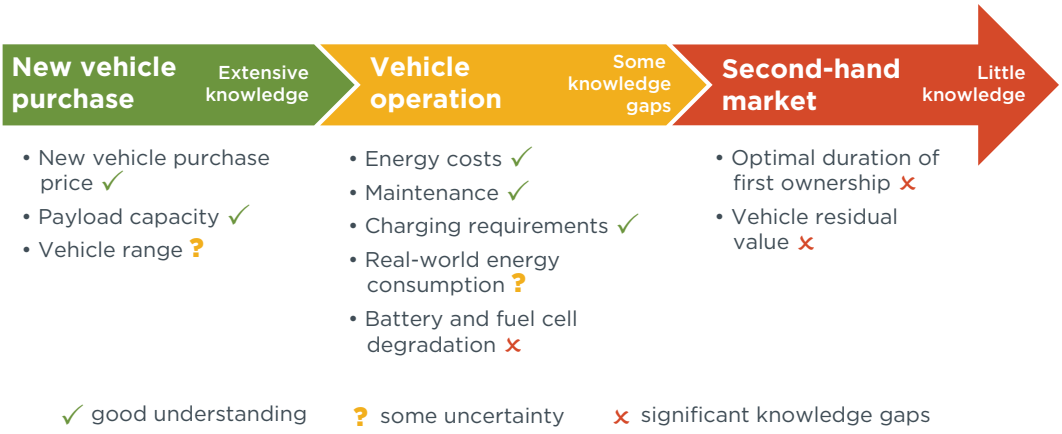


Figure 8. Knowledge gaps remaining on zero-emission trucking technology.

In the meantime, carriers need to start reducing emissions from their fleets, as a number of European cities are implementing low- and zero-emission zones. There is

therefore a demand for "transition" technologies. Despite their higher cost, alternative fuels such as biodiesel and biogas are perceived as attractive because they rely on conventional internal combustion engines, requiring less capital investment and adaptation efforts than zero-emission vehicles. However, availability of truly sustainable biofuels for the road transport sector is limited and expected to decrease in the future due to a decrease in biogenic waste availability (Carraro, Searle, & Baldino, 2021; Zhou et al., 2021). E-fuels, which are synthetic fuels produced from electricity, were also mentioned by a few ECTA members as a promising technology, although similar reservations exist regarding their future large-scale availability. Finally, a few of the interviewed organizations were also interested in exploring hybrid trucks as a transition technology.

Transition technologies are bound to become obsolete when stricter regulations, such as zero-emission freight zones, will require only zero-emission trucks. Other technologies are readily available for immediate CO_2 and pollutant emissions reduction with diesel vehicles. Improved engine design and aerodynamics, lightweighting, and lower resistance tires, can deliver up to a 39% reduction in fuel consumption (Meszler et al., 2018).[6] Additionally, advanced pollutant emissions control are readily available to meet stringent upcoming standards, while only increasing vehicle costs by less than 5% (Ragon & Rodríguez, 2021).

INCREASE ACCESS TO INFRASTRUCTURE

To accelerate the roll out of charging and refueling infrastructure, ECTA members highlighted they need a clearer understanding of what charging strategy is most suited for their fleet. In general, most of the energy needs for urban and regional delivery trucks can be satisfied with overnight charging in depots, which provides the most cost effective option and does not require fleets to adapt their operational schedules (Basma, Beys, & Rodríguez, 2021; Ragon et al., 2022). Carriers can collaborate with their customers (shippers and freight forwarders) and with utility providers to plan infrastructure deployment. Moreover, there is general agreement among fleet operators that zero-emission trucks should be able to satisfy the same operational schedules as their diesel counterparts. Therefore, for long-haul trucking, and for the most energy-demanding cases of regional transport, a network of fast chargers should also be deployed along highways for en-route charging and at destination locations for opportunity charging during truck loading and unloading.

Governments have a crucial role to play in supporting the roll out of a publicly available fast-charging and hydrogen refueling network while the volumes of vehicles are still low, as business opportunities for infrastructure operators are limited. The Alternatives Fuels Infrastructure Regulation proposed by the European Commission intends to meet the basic needs of the growing fleet and send a strong signal to the logistics industry that governments are supportive of this transition. While supportive of this initiative, ECTA argues that a much faster and larger-scale deployment of infrastructure than what is proposed is required to enable zero-emission trucking (European Clean Trucking Alliance, 2022). Prioritizing placement on roads with the highest traffic density can significantly limit the amount of public investment required to develop this base network (Ragon et al., 2022). Subsidies for private infrastructure are also recognized to be a significant help and should therefore be maintained in countries where they are in place and considered in other countries.

6 Compared to a 2015 baseline. The average tractor-trailer in 2020 (latest available data) had a fuel consumption 9% lower than that assumed in (Meszler et al. 2018).

Figure 9. Charging at the depot can cover a large portion of fleets' energy needs.

Even without a well-developed market, utility providers can diversify their offer of charging solutions, upgrade the electrical grid, cooperate with fleet owners to develop business models that are suited to their operations, and help in the establishment of best practices. Improvements in charger technology and standardization are also essential. Megawatt charging systems, which enable to charge trucks at powers of up to several megawatts, are perceived by ECTA members as a major enabler of zero-emission trucking, especially for long-haul applications. Megawatt chargers are expected to become commercially available in 2024 (Kane, 2022). Finally, a few organizations we interviewed shared concerns about the financial and workforce resources required to perform the grid connections needed to enable electric truck charging. Planning should therefore be a priority with national and sub-national governments.

INCREASE VEHICLE SUPPLY

Manufacturers do not currently produce large volumes of battery-electric and fuel cell trucks. ECTA members suggested that manufacturers see a risk in fully shifting their production lines due to the perceived uncertainty regarding the pace of growth in demand for zero-emission technologies and the pace of infrastructure roll out. Yet, large production volumes are required to benefit from economies of scale and reduce the cost of electric trucks, making them more attractive to fleets. Regulation has a crucial role to play to incentivize increases in zero-emission vehicle production by establishing a clear roadmap for the industry. The review of the CO_2 standards for trucks and buses that will take place at the end of this year is a unique opportunity to secure an increase supply of vehicles.

In the meantime, it is important that manufacturers leverage the existing technology to bring a greater diversity of models to the market. So far, the manufacturers have focused on smaller, last-mile delivery vehicles, with the model availability for heavier regional transport being more limited. ECTA members highlighted the importance of having a greater variety of options for each truck segment with different price points. Long-haul tractor-trailers represent the largest vehicle volumes and emissions share, and there is a general perception from fleets that this use case will be harder to electrify. Providing electric models for this use case is therefore crucial. This can be facilitated by an increased collaboration between truck manufacturers, fleet owners, and charger manufacturers to design solutions that are tailored to the fleets' needs. Additional use cases should also be covered, such as low-floor tractor units that can accommodate mega-trailers.

The emergence of new players in the market is seen by the majority of interviewees as an opportunity. Turning to electric truck start-ups is perceived as an interesting alternative for fleets, as they usually have business models tailored to the challenges associated with zero-emission trucking, despite the increased risk it represents. Moreover, as large Chinese manufacturers are world leaders in battery and EV production, they are gaining significant market share in the European bus market and are well-positioned to satisfy a growing demand from European fleets in the short-term (Basma & Rodriguez, 2021). Transitioning to zero-emission vehicles is therefore also critical for the traditional European manufacturers to maintain their leadership.

Finally, despite zero-emission trucks requiring less maintenance than their diesel counterparts, there is some concern among fleet operators regarding their lack of knowledge of the technology and how to maintain these trucks. Fleets that have already deployed electric trucks emphasized the importance of continuous support from the manufacturer at every stage of the deployment process. Therefore, the large-scale availability of robust maintenance services along the European road network is key to increase fleets readiness to transition to zero-emission vehicles.

SUPPORT DIVERSE BUSINESS MODELS

Despite the promising outlook of a reduced total cost of ownership with battery-electric trucks, there remains a number of economic challenges for carriers willing to transition their fleets to zero-emission. Most importantly, the capital investments required to purchase those vehicles are two- to three-fold those needed to purchase diesel trucks (Basma, Saboori, & Rodríguez, 2021). As highlighted by a few ECTA members, this comes on top of the logistics industry becoming increasingly capital-intensive, creating financial pressure on the carriers that operate small profit margins. Generous purchase premiums and other incentives are in place in several European countries, but they are often not easy to obtain due to the administrative burden they represent and do not provide a stable environment for planning, as they are usually revised on a yearly basis. Moreover, given the large public investments they represent, these subsidies are not a sustainable measure. Instead, alternatives exist to the traditional truck ownership model that can be considered to reduce the capital investments required from carriers. Table 3 provides examples of alternative business models that were discussed during our consultations with ECTA members, and how they can help to reduce the required investments. All business models listed separate asset ownership among various stakeholders.

Table 3. Examples of alternatives to the traditional truck ownership model.

	Truck ownership	Infrastructure ownership	Operational expenses	Payment
Traditional ownership	Carrier	Carrier	Carrier	One-off upfront payment
Leasing	Carrier/manufacturer	Carrier	Carrier	Fixed monthly payment
Trucking-as-a-service (TaaS)	Service provider	Service provider	Carrier	Fixed monthly payment
Pay as you drive	Service provider	Service provider	Carrier	Monthly fee based on usage
Charging-as-a-service (CaaS)	Carrier	Service provider	Carrier	Fixed monthly payment

Leasing solutions for diesel vehicles have been offered by manufacturers for a number of years. Due to the additional challenges associated with zero-emission

truck procurement, several interviews suggested that it could become increasingly popular with carriers. With leasing contracts, carriers rent a truck for a fixed period of time, either from a manufacturer or a third-party organization, and can then decide whether they want to return the truck at the end of the rental period or purchase it at its estimated residual value. This business model allows small businesses to delay and spread the required investments and is less tax intensive as part of the expenses are shifted to tax-deductible operating expenses. Leasing can include various levels of servicing for the maintenance and repairs of the vehicle, and for the charging or refueling infrastructure.

Trucking-as-a-service (TaaS) solutions are also perceived as interesting by interviewees. Beyond reducing the required capital investments, they enable an easier transition to zero-emission trucks via increased support throughout the vehicle lifetime, especially with regards to charging or refueling infrastructure management. TaaS can be provided to a carrier either directly by a truck manufacturer, or by a third-party organization. The TaaS provider is responsible for the vehicle procurement, maintenance, and insurance, as well as the deployment and maintenance of the charging or refueling infrastructure. In the most common cases, customers would pay a fixed monthly fee for the service. Alternatively, as operational expenses constitute a large portion of a truck's TCO, customers can be charged based on their usage of the truck, known as pay-as-you-drive, and therefore only pay for the energy they use.

For carriers that wish to retain ownership of their fleets, similar integrated solutions can be considered for the charging or refueling infrastructure only, referred to here as charging-as-a-service (CaaS). The CaaS provider is responsible for the deployment, installation, operation, and maintenance of the charging or refueling infrastructure. The customer is usually charged a fixed monthly fee. CaaS can be provided either by a truck manufacturer, utility provider, infrastructure operator, or by a third-party organization.

FACILITATE THE ACCESS OF SMALL FLEETS TO THE ZERO-EMISSION TRUCK MARKET

Although small carriers do not yet contribute greatly to the transition to zero-emission trucks due to their limited resources, business associations highlighted that many of them see an opportunity in transitioning their fleets, as they see a competitive advantage in being an early adopter. Several levers can therefore be activated to turn this demand into actual zero-emission truck deployment. First, platforms aggregating the demand from small fleets can help carriers gain access to the zero-emission truck market and help reduce the risk to manufacturers by accelerating the growth in demand. A few interviewed shippers and freight forwarders indicated their willingness to contribute to creating this link.

Despite the wealth of alternative business models emerging in the market, truck ownership is still perceived as an important criterion by many small carriers, as it usually constitutes their only asset. Therefore, attracting private capital to give carriers increased access to financing solutions can be decisive in accelerating the transition. ECTA members suggested that banks are lacking incentives to increase and diversify their offering of financing solutions to small carriers, including standard bank loans, as the market is still nascent and the overall volumes of sales are low. Instead, third-party organizations such as clean freight initiatives, large shippers, and freight forwarders can serve as an intermediary. By aggregating the demand for financing, they can reduce the risk to private institutions like banks in investing in supporting small fleets. Additionally, policies targeted to attract private capital can also play a major role. Examples of policies adopted in other regions include loan loss reserves and credit enhancements.

Moreover, both governments and the private sector can facilitate by helping small fleets gain access to subsidies, as several interviewees mentioned that the allocated funds are mainly dispersed to large companies that have more resources to apply for funding. Possible supporting measures from governments include tailoring subsidies to small fleets, setting aside a portion of the allocated funds, facilitating access to information, and lowering the amount administrative efforts required to obtain them. Figure 10 summarizes how third-party platforms can facilitate the access of small fleets to the zero-emission truck market.

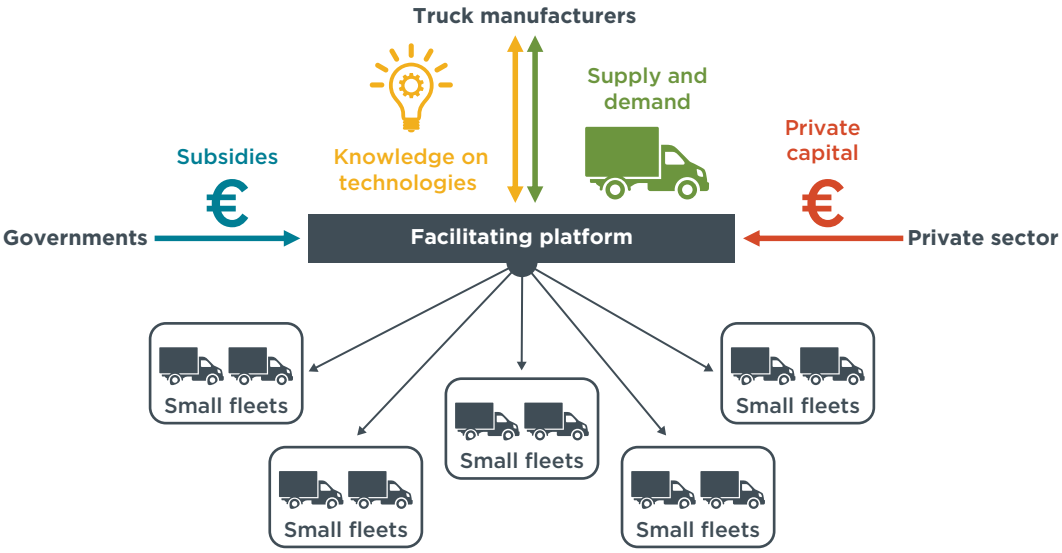


Figure 10. The role of third-party platforms, such as trucking service providers, in facilitating small fleet adoption of zero-emission trucks

Finally, purchasing second-hand zero-emission vehicles can be an attractive option for small carriers to start transitioning their fleets at a lower cost. To enable this, both regulators and manufacturers have a key role to play in the development of a used vehicle market for zero-emission trucks. In particular, securing quality data on battery and fuel cell state of health is necessary to help fleets estimate the residual value of their trucks after the first ownership. Clean freight initiatives can also help facilitate the activation of all those levers.

As small carriers represent a large majority of the European truck fleet, incentivizing and supporting their transition to zero-emission trucking can significantly accelerate the deployment of zero-emission trucks.

DEVELOP BEST PRACTICES

The transition to zero-emission vehicles is still in its early stages and knowledge gaps may be slowing down the process. However, several progressive truck fleets recognize a unique opportunity in becoming an early adopter. It is therefore important to ensure that knowledge is being shared across all stakeholders to identify where and how roadblocks can be addresses, share feedback from early adopters, and ensure that that fleets are able to make informed decisions. Sharing experience regarding financing and on how to address operational challenges such as adaptation efforts and dwell time can be key in overcoming those barriers. Best practices for zero-emission trucking should be shared not only among large logistics companies, but also with small transport companies, which are responsible for the majority of the road freight movement in Europe. Clean freight initiatives have a vital role to facilitate this knowledge sharing by connecting relevant stakeholders.

Zero-emission trucking can be enabled by long-term strategic partnerships between shippers, freight forwarders, and their transport partners. As sustainability criteria for shipping contracts becomes common practice, the environmental performance of the hired fleets will also become a key performance indicator for the competitiveness of shippers and freight forwarders.

Binding regulation can also help logistics operators determine their environmental impact more accurately and address it through an increased demand for zero-emission vehicles. This is precisely the role of the European Union's CountEmissions EU initiative, a framework to calculate and report transport-related greenhouse gas emissions (European Commission, 2021).

CONCLUSIONS

The road freight sector is increasingly accountable for its environmental impact, and stakeholders are responsible for a growing demand for zero-emission trucking. Although progressive fleets are already starting to transition to zero-emission vehicles, logistics operators still perceive a number of barriers that need to be overcome to fully engage the transition of their fleets. The lack of publicly accessible charging and refueling infrastructure dedicated to trucks, limited zero-emission truck availability, operational challenges arising from limited truck driving range, and the higher costs of those trucks are all viewed as hindering the faster deployment needed to meet the climate targets for the sector. As a result, the demand for zero-emission trucks is currently limited to a few pilot models.

Based on our consultations with members of the European Clean Trucking Alliance (ECTA), we find that several levers can be activated today to catalyze the growing demand from the logistics sector and accelerate the deployment of zero-emission trucks in Europe. These include building knowledge on available zero-emission technologies, increasing the access to charging and refueling infrastructure, increasing vehicle supply through binding CO_2 regulation, diversifying business models, promoting small fleets' access to the zero-emission truck market, and developing best practices for zero-emission trucking.

The various actors of the logistics sector all have a role to play in this transition, and enhanced collaboration between them is essential to ensure barriers are overcome. Binding regulation is particularly important to establish a clear roadmap for the decarbonization of the road freight sector. The review of the CO_2 standards for heavy-duty vehicles, planned for the end of 2022, provides a unique opportunity to achieve this.

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