Financing the transition to electric trucks

Subject: **Framing paper for the start of a dialogue**

Date: March 2023

Contents

Executive Summary

The road freight sector is responsible for 20% of greenhouse gas emissions globally. In recent years, battery electric and hydrogen fuel cell electric trucks have become market ready with successful pilots being deployed in multiple regions. New policies in California and European Union force a significant ramp up by obliging OEMs to accelerate the transition, and international shippers have committed to significantly reduce scope 3 emissions in their supply chains this decade. We see a huge latent demand for electric trucks. However, there are still several structural barriers for fast-tracking the ramp up of electric trucks, including infrastructure build-out, carrier engagement and finance. .

This framing paper discusses how financing is affecting the transition towards electric trucks and how it can be part of the solution. It is part of a series of discussions on financing the transition to electric trucks.

Some of the largest financing challenges towards electric truck deployments are:

- **The total cost of ownership and the initial investment costs are significantly higher than status quo.** Given freight and logistics are commercial operations, it is anticipated that once TCO parity is there the transition will move swiftly.
- **Deployment of charging infrastructure is expensive, has a long lead time, and is not (yet) profitable.** Private and/or public charging infrastructure are essential to support the operations of electric trucks, but will require significant capital investment costs towards the equipment and to upgrade the grid connections.
- **Compensation models between freight buyers and carriers do not incentivize emissions reduction.** While more than 60% of freight buyers have developed a decarbonization strategy, 45% of freight buyers do not engage with carriers to reduce emissions in their operations. Freight operations often have multilayered contracting with intermediaries. Fleet owners are faced with the risk of taking on the electric truck on their balance sheet, without understanding the business value of the vehicle and how that may change, even in the next years as the market and technology improves.

In short, the transition to electric trucks is hampered by high deployment costs, the lack of charging infrastructure, and the challenge of adapting existing business models to reward sustainable transport. New and improved financial solutions will go a long way towards enabling a virtuous cycle of electrification that can:

- **Level the financial impact of using and providing electric road freight services.** Only structural solutions that address the financing challenge of the upfront cost differential between electric trucks and combustion engine trucks, in particular for SME carriers, can help bend the curve. Several OEMs are already expanding their “truck as a service” and “advanced leasing” models, but their balance sheets will be stretched if access to private capital markets cannot be included.
- **Incentivize the market development of innovative truck ownership models and charging.** Freight buyers need to revise their contractual arrangements with fleet operators to provide the confidence to make the transition and guarantee revenues. Attracting private capital will require de-risking the investment, by mitigating risks such as residual value revenue and utilization. There may be a space for advanced financial structures that would establish “asset ownership” corporations that hold e-truck assets with de-risking measures jointly undertaken by major shippers and OEMs.
- **Support the education of the industry to navigate the transition to electric trucks**. The ramp up of e-trucking will not happen synchronously across the network. The beachhead model[1], through which local delivery trucks electrify first, followed by regional medium duty delivery and finally by heavy duty truck networks may provide a pathway forward. OEMs, freight buyers and fleet owners need to collaborate to make the transition. This requires altering their procurement practices, shifting towards collaborative relationships with carriers, incorporating carbon pricing in their supplier evaluations, and providing education and training to their carriers.

1 Introduction

1.1 Road transport role in greenhouse gas emissions

The transport sector is responsible for about one-fifth of greenhouse gas emitted globally[2]. A major contributor is the road freight sector. The road freight sector accounts for 20% of the freight activity but 75% of the total energy consumed. Most of this is consumed in the heavy- and medium-duty segments. Considering that about 96% of the energy comes from fossil sources[3], the road freight sector faces a difficult although not impossible challenge to decarbonize in keeping with the 1.5-degree pathway. Unless fossil fuel consumption can be decoupled from the sector, the sector is expected to lead to a 15% increase of global CO2 emissions by 2050[4].

In recent years, battery electric and hydrogen fuel-cell electric trucks are gaining traction as solutions to this problem[5]. Lifecycle analysis of battery-electric and hydrogen fuel-cell-electric truck operations show that they have the best potential for decarbonization provided that the upstream emissions from electricity and hydrogen production is low[6]. While this may not necessarily be the case now, it is clear that the electricity sector is making strides towards that goal. In most parts of Europe, a battery-electric truck has a significantly lower emissions profile than an equivalent diesel truck. It is expected that these trucks will also be financially competitive in the next 5 years[7]. The supply chain for low-emission hydrogen is less energy-efficient, more expensive and more complicated, which makes it a longer-term challenge that is being addressed from multiple angles in the industry.

The priority for road freight decarbonization in the next decade is to replace a predominantly fossil-fueled fleet with electric freight vehicles. While there are signs that the second part of this decade will see a rise in the availability of electric medium- to heavy-duty trucks, accelerated by CO_2 regulations and mandatory sales targets, **the adoption of these e-trucks in the road freight sector will depend strongly on demand-side policies and financing**. Failure to redirect investment towards the sector would risk a slower than expected transition as well as misalignment with other commitments and policies. Ultimately, this slow uptake would jeopardize the 1.5-degree pathway, as agreed in the Paris agreement.

2 State of road freight electrification

While it is tempting to simplify the problem of electrification as simply a matter between the vehicle market and fleet owners, our experience in the logistics sector informs us that the challenge can be traced to other actors in the ecosystem, such as shippers, logistics service providers (LSPs) and carriers. In this section, we briefly highlight the relationship between the different actors and the barriers they face to work towards road freight electrification.

2.1 Supply Chain Actors: Shippers and LSPs

Supply chain actors consist of shippers and receivers of goods, as well as logistics intermediaries, such as third-party logistics service providers. The profile of these actors is diverse. While most operate only domestically, many operate globally, with activities, and therefore, freight transport demand, spanning different continents. These actors are under increasing pressure to reduce their greenhouse gas emissions, not only produced directly by them (i.e., Scope 1 emissions), but also those produced indirectly from their activity (i.e., Scope 3). As transport activity is often undertaken by a third-party, their emissions often fall under Scope 3.

While a complex task, international shippers, such as Unilever, IKEA and Inditex, have already committed to reduce scope 3 emissions in their supply chains as part of their Science Based Target commitment. As they only have an indirect relationship towards freight vehicle ownership and operation, any influence on electrification will come primarily from engagement and collaboration with their logistics and transport service providers. Carrying out this task effectively and efficiently is set to be the key challenge they must overcome in the coming years, especially as there seems to be a clear difference between the alternative fuel priorities of shippers and carriers. The results of the Decarbonizing Freight 2022 survey[8] showed that the majority of shippers prioritized battery electric vehicles, while carriers overwhelmingly prioritized biodiesel and liquified natural gas. Such a discrepancy only serves to highlight how the wishes of shippers do not necessarily or easily get translated into action by carriers.

2.2 Supply Chain Actors: Carriers

Carriers operate freight vehicles on behalf of shippers or logistics service providers to actually perform the transport service. The structure of the market overwhelmingly leans towards small enterprises[9] (e.g., micro enterprises, with less than 10 employees, comprise 92% of enterprises in the land transport sector in the EU in 2020) with small fleet sizes (e.g., one third of fleets in the UK in 2020 operate 10 or less trucks, and only 32% operate more than 50). It is also common for smaller carriers to be subcontracted by larger carriers for certain routes or one-off consignments.

As such, the majority of fleet operators have a less than strong market position and are therefore sensitive to the signals by their clients to decarbonize, beyond regulatory requirements. Most also do not identify environmental sustainability as a business opportunity[10], but do identify the lack of shipper engagement as a barrier to reduce emissions in operations. Another unique aspect of small carriers is that, in contrast to larger businesses, only a small percentage lease or hire-purchase vehicles[11]. They tend to purchase the vehicles outright but prefer not to be externally financed. In most cases, this leads to a preference for secondhand trucks rather than new ones, likely due to the difference in upfront costs. Hence, we can expect that for the time being the purchase of electric trucks will not be a key priority for most small fleet owners.

2.3 State of the e-truck market

Truck manufacturers are steadily stepping up the research, production, and sales of ze-trucks, primarily in response to mounting regulatory pressure. Policies, such as the Advanced Clean Truck regulation in California[12], will require manufacturers to achieve a sales target of 40% zero-emission truck sales by 2035. In Europe, a revision to the CO_2 emissions standards for HDVs stipulates a 43% reduction target for trucks by 2030 and 90% reduction target by 2040[13], targets only reasonably achieved by zero-emission truck sales. Elsewhere, we see an ambition by 27 countries around the world to have zero-emission medium- and heavy-duty vehicles represent at least 30% of new sales in 2030, and 100% by 2040 at the latest[14].

Major manufacturers have made bold announcements with respect to vehicle model variety[15] (i.e., varying size, payload capacity and driving range) and their own 2030 sales targets[16], which coincide with the targets set by EU legislation. CALSTART's Global Drive to Zero ZETI tool provides details on current and announced models[17]. As manufacturers scale up production and battery technology improves, the supply of electric trucks can be expected to ramp up. The market is particularly dynamic in China, where zero-emission truck and bus manufacturers are developing and commercializing new models to satisfy domestic and international demand[18].

Despite signs of interest from both shippers and truck manufacturers to increase the sales of e-trucks, we are still in the early stages of e-truck adoption. The IEA Global EV Outlook 2022[19] indicates that in the past three years (2019 to 2021), annual electric truck sales have been less than 1% of total global truck sales, approximately 15 thousand new units sold in 2021. While there is indication that the sales shares are increasing and are forecasted to increase further, it is clear that the speed of adoption is insufficient to meet the climate targets set by both policy makers and the aspirations of supply chain actors.

3 Key hurdles to e-truck adoption

Electric truck adoption represents not only a shift in powertrain technology but a shift of the transport operation is designed, managed and carried out. From fleet owner's perspective, key barriers are primarily to do with the infrastructure availability and a still unfavorable total cost of ownership[20]. Other barriers mentioned are model and volume availability, and initial capital investment[i]. Note that while some of these issues, such as model availability, are not as prohibitive as they used to be, many fleet owners still retain this perception. Vehicle manufacturers and charging service providers understand these issues well but express the inability to meet the purchaser requirements at scale, at least in the short term. This vicious cycle of poor market offering, insufficient market demand, low penetration of charging infrastructure, low production volumes and high vehicle prices has led to a slow incremental growth of electric trucks, beyond those encouraged by policy mandates and incentives.

[i] As electric truck production volumes go up, it is expected that this will decrease significantly. However, according to an internal study, conducted by McKinsey, on behalf of the Sustainable Freight Buyers Alliance, at present, the fixed costs are seven times higher than for a diesel truck production. It is mainly due to conversion of production and assembly lines, and research and development.

While much is moving on the policy side to encourage the supply market to grow, there is less of a coherent approach to encouraging the demand side to actively scale-up their purchase and operation of these trucks. From this perspective, the primary hurdle to address is **the financial impact of the electric truck on the profitability of the transport business**. If we can effectively address this issue, we can break the vicious cycle, and perhaps even initiate a virtuous cycle leading to the complete electrification of the road freight sector.

The three main aspects of profitability that need to be addressed here are listed below.

- The total cost of ownership of the vehicle and operations
- The availability and costs of charging infrastructure and services
- The monetary and contractual terms between fleet operator and their clients

3.1 The total cost of ownership and the initial investment costs are significantly higher than status quo.

On the balance sheet of a profitable transport business, the incoming revenue, often a multiplication of the freight tariff and the volume or consignment distance, must exceed the total cost of owning and operating the transport assets. An indicator that is decisive in determining the profitability of the business, is the total cost ownership (TCO), and is the primary consideration in strategic fleet decisions[21]. The TCO includes all the costs incurred over the use duration of the assets, both the capital and operating expenditure. The challenge presents itself in the low profit margins of the business model, which is a defining characteristic of the transportation industry. This makes companies very sensitive to the TCO, as even a marginal increase can result in an unprofitable operation. Figure 1 illustrates how the increased cost of ownership can push the TCO to cut into the profit margins or even result in a loss-making operation.

While in some markets and for certain segments the TCO of the electric truck has already reached price parity with their diesel equivalent[22], current projections point to a lower electric truck TCO than a diesel truck in a considerable share of medium- and heavy-duty segments only after about 2024 in Europe[23], that is, only if the most favorable conditions are maintained. In China, all heavy- duty segments can be expected to reach TCO parity by 2024, depending on the regions of operation[24].

In the next paragraphs, we breakdown some of the key components of the electric truck TCO and the factors that influence them. These financially impact the business models and cost structures of fleet owners and operators, truck leasing companies, and indirectly supply chain actors, who purchase road freight services.

- **Purchase price of the truck**: The price of the truck can be up to three times that of a comparable diesel truck. While fast charging infrastructure is not yet in place, the tendency is for operators, who are as yet lack confidence in the vehicles, to purchase trucks with driving range more than necessary, while deploying them in less intensive routes. While these prices are expected to continually reduce, due to streamlining production and lower battery pack costs, the prices will still remain at least 25% more than diesel trucks in 2030. Note also that purchase price is also related to the financing costs of the capital and vehicle insurance premiums.
- **Residual value of the truck**: The depreciation cost, which is the loss in value of the truck, is associated with how the truck is dealt with at the end of the ownership period, whether sold to be reused or disposed of for recycling. As opposed to the stable used-diesel-truck market, the used-electric-truck market does not exist and it is uncertain when, where and how the used-electric-truck market will develop. This makes it difficult to estimate its resale value. Further, it is certain that the battery, which makes up a significant portion of the price of the truck, will degrade over time and therefore would not retain its full value after 6 to 8 years of use. It is expected that these batteries could be repurposed for stationary energy storage.

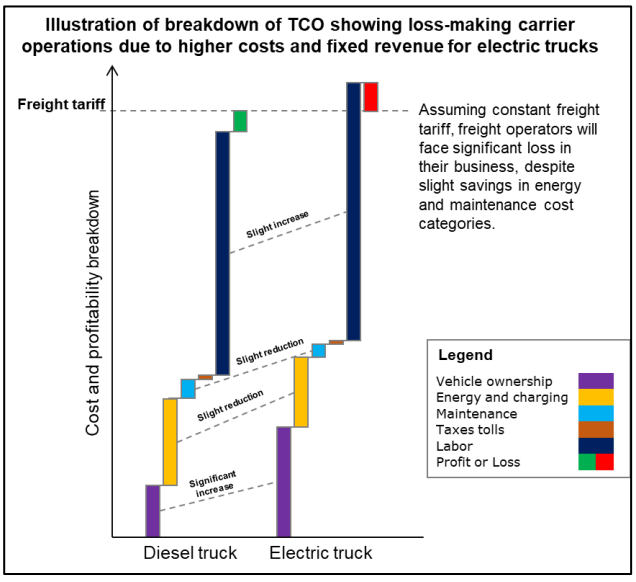

Figure 1 An illustration of the challenge of maintaining profitability in a financially unfavorable setting. (Source: own)

For now and largely due to uncertainty regarding battery life, the potential battery reuse applications, and used vehicle market dynamics, electric trucks thus have significant risks regarding residual value with compared to diesel trucks which are on average used up to 14 years in the EU.

- **Energy costs**: Electric trucks are expected to have a significant advantage over diesel trucks in the matter of energy costs. However, this advantage depends on the policies and electricity market in the operating country. For instance, the total energy cost of the diesel truck is expected to be less than the electric truck in Germany under current their policy framework[25]. Furthermore, even though renewables are increasing as a share of the energy matrix, the price of electricity continues to be strongly linked to the natural gas prices[26,27], which implies that any price increase or volatility of natural gas will lead to a similar electricity price behavior. Note also that the costs for charging infrastructure deployment will have to be bundled in with the energy cost.
- **Battery replacement and major repairs**: While regular maintenance costs are expected to be half compared to the diesel truck, any major repairs and battery replacement can be expected to be significantly high. For one, a significant portion of the truck price is attributed to the high cost of the traction battery, which can have a limited lifespan of 8 years before secondary uses. Further, as there is currently very little collective experience about the reliability of the parts of the truck, the uncertainty and risk captured in vehicle insurance schemes are estimated as high.
- **Operating productivity**: The operating productivity, i.e., how much work an e-truck can do, strongly depends on how well the trucks can be efficiently integrated into the transport operations. For instance, productivity may suffer as a result of the time spent when recharging or needing to take alternate routes to reach charging stations, which will hamper the adoption of e-trucks. If significant enough, additional (or backup) trucks may be needed to cover the same transport demand. This is anticipated to be a material risk in the early stages of adoption where operating ranges are limited and charging infrastructure is not yet widely available.

The high overall costs have spurred the need for truck-as-a-service businesses, which go beyond traditional leasing models to bundle maintenance and charging services in a recurring fee. This reduces the pressure of companies to put upfront investment. Nevertheless, as mentioned, this is not currently the preferred method for most SMEs, as it reduces the depth of the value offering of these carriers and their (at least perceived) earning potential.

3.2 Deployment of charging infrastructure is expensive, has a long lead time, and not profitable.

Charging infrastructure, whether privately or publicly accessible, is essential to support the operation of the electric truck. Not only should they be available, where and when needed, the type and quality of the charging services should match the needs of electric truck operations. At the very least, charging infrastructure needs to be provided at long duration truck parking locations (e.g., depots). If we really want to support the entire sector, especially the long-haul operations, to electrify, infrastructure for charging on-the-go locations (e.g., at truck stops along highways) should be strategically deployed. While depot charging systems can be relatively slow (up to 150 kW), on-the-go locations will need to be faster, even reaching up to the megawatt charging range[28].

Deployment of charging infrastructure will incur significant capital investment regardless of where it is deployed. This will include the equipment purchase, construction and installation, which by itself may cost as much as an electric truck itself. It is expected that the fleet operator must provide charging infrastructure at their parking locations for overnight, or more generally, downtime charging for each electric truck they operate. For the charging infrastructure located at truck stops, the costs mentioned above are in addition to the cost of land, concessions, permitting and commissioning.

Furthermore, the existing electric grid infrastructure at the logistics and parking sites are in many geographies not suitable to support high-powered high-capacity charging infrastructure. The two key aspects that need upgrades are the facility's electrical connection to the local grid, as well as the local or regional grid distribution system. For the former, the costs are borne by the facility owner. For the latter, the costs are borne by the distribution system operator. Both of which directly or indirectly (through raised grid tariffs) increase the cost of operating the charging infrastructure. In case the lead time for these necessary upgrades is too long[ii], workarounds grid congestion mitigations (e.g., smart charging, energy storage systems, on-site generators) could be

[ii] Upgrades to take place, depending on the specifications, on average 2 years and up to 10 years.

implemented in the short term. This is both an additional investment cost, but also an increase in the facility's electricity network costs and facility maintenance costs. These costs may be unitized as a charging service or access cost in the TCO calculation and are often included in the energy cost category.

Despite policy targets to deploy charging infrastructure along major highways, building an on the go charging service business remains a major and risky undertaking. Especially as we do not yet see the vehicles in sufficient numbers, the business case for truck stop charging remains elusive. Yet, as we keep hearing, large-scale fleet electrification will only happen, if there are convincingly enough sufficient charging infrastructure.

3.3 Compensation models between freight buyers and carriers do not incentivize emissions reduction.

As highlighted before, there is a significant disconnect between the low carbon aspirations of shippers and the signals they are sending towards carriers. While more than 60% of freight buyers have developed a decarbonization strategy, 46% do not engage with carriers to reduce emissions in their operations and 64% do not evaluate their emission performance. And while a significant majority (90%) of carriers believe that environmental sustainability is a business opportunity, many (37%) perceive the lack of realistic expectations to provide low carbon a significant barrier. For instance, in the shipping sector, a majority (65%) of customers expressed their willingness to pay a green premium for 'zero-carbon' marine shipping. However, most were only willing to pay between 0.1 and 5% extra – a percentage insufficient to cover even half the transition costs.

Useful market signals identified by carriers as exceptionally important are shippers willing to pay a premium for low carbon transport, as well offering longer term contracts. But it goes beyond that. Shippers can provide incentives in other forms, both financial and non-financial. The effect can level the playing field, by penalizing the evaluation of poor carbon performance or improving the terms for carriers that provide low carbon transport services. However, unless companies make sustainability criteria (e.g., emissions performance or percentage of electric trucks in fleet) a part of the procurement process, carriers, especially the SMEs will be hesitant to truly electrify.

But the challenge here is that carriers are often subcontracted by freight intermediaries, such as third-party logistics service providers or large carriers, and not directly by the shipper (or receiver). This contractual disconnect, and thereby financial disconnect, can restrict shippers from effectually (i.e., in the contracting) expressing their desire to reduce emissions or more specifically to adopt electric trucks. Book and claim offerings[29], if conducted in accordance with a stakeholder-consensus-backed framework, may help overcome this particular challenge but the market is only beginning to move towards this direction.

When it comes down to it, the biggest risk and barrier faced by fleet owners is the willingness to take on the electric truck on their balance sheet, without understanding the business value of the vehicle and how that may change, even in the next years as the market and technology improves. Current compensation models leave the fleet owner to deal with the complexity, making the transition too inconvenient and not worth the effort. Shippers should be challenged to support asset owners in shouldering a part of that risk. Some ideas used in other sectors are, such as being guarantors for financing, or including buyback or asset swaps terms in the contract for when the better electric trucks appear on the market. This is a significant change in their role: moving away from being a client towards being a collaborator.

4 Financing the transition

To summarize, the transition is hampered by financial costs, the availability of supporting infrastructure, and the challenge of adapting existing business models to reward sustainable transport. New and improved financial solutions will go a long way towards enabling a virtuous cycle of electrification to begin. The strategic aims are to:

- Level the financial impact of using and providing electric road freight services.
- Incentivize the market development of new business models
- Support the education of the industry to navigate the transition.

The trucking sector will need to collaborate to bring this forward, this includes in particular:

- Public authorities by setting long-term policy, underwrite selected risks, and incentivize the market,
- Private investment sector by providing short term and long term investment capital, taking potential

balance sheet and selected calculated risks in the transition
- Vehicle manufacturers by ramping up supply of trucks, provide performance guarantees, provide (new) financing products and educate/guide the use cases of trucks,
- Charging providers by installing and connecting charging infrastructure, provide performance guarantees, provide (new) financing products for charging, and educate/guide the use cases of electric trucks) and
- Freight buyers sector providing adequate guarantees towards revenue, incentivize/mandate usage of zero-emission trucks.
- Fleet operators by adopting their business operations suited towards new electric operations and invest in training and skills to maintain their (new) operations.

4.1 Level the financial impact of using and providing electric road freight services

Under the assumption that business will make the transition if the business case is viable, it is important financing seeks to reduce the TCO and therefore increase investments in the transition.

Current effort have focused on reducing the CAPEX of the vehicle, (e.g., EU Member States[30] and the US have implemented subsidies and fiscal incentives to subsidize purchase) there are more opportunities to address other TCO risks.

- Public authorities and Institutional Investors may also play a role to provide attractive loans on behalf of asset purchasers thereby allowing financing solutions to **reduce the financing costs of the vehicles**. Similar funds can be made available to **reducing insurance premiums**. This will require a targeted effort to large investors (equity investors and commercial banks) to invest directly or underwrite corporations who invest in the assets. This will require also **aggregation of demand** to ensure a viable transaction size (>50m USD) and a relative stable long-term policy environment.
- Ensuring **a guarantee on the (minimum) residual or resale value** of the vehicle and charging assets[31] could be helpful to curb the uncertainty of the residual value, especially for the 1st generation electric trucks vehicles purchased in the short term. This can take shape in the form of a financial "first loss protection" offered by institutional investors or green banks. Supportive policy action would be to stimulate and generate a secondary market for used electric vehicles which can develop over time.
- The legislation, like RED II and the EU ETS for Road, will **address the energy costs** of electricity or increase the cost of fossil fuels. Charging infrastructure subsidies will **reduce the charging service costs**. These fleet operators or charging service buyers are not direct recipient of subsidies but are indirect recipients of these benefits. Example suggestions have been made to increase the cost of fossil fuels every year, whilst maintaining or reducing the cost for electricity.
- Public financing should be made available to upgrade the grid, as well as streamline and speed up the process of adapting the infrastructure to charging needs. While the supporting road freight electrification is an enormous business opportunity for grid operators, the upgrade project costs are substantial and can hamper adoption if charging infrastructure does not follow the investments.

4.2 Incentivize the market development of innovative truck ownership models and charging

Current subsidies and fiscal incentives, while extensive, may still be insufficient to convince SMEs with low profit margins. The question for SMEs is who takes the risk of acquiring a vehicle and operating charging infrastructure. New electric truck ownership models or value-added services, such as truck-as-a-service, truck leasing, and battery financing, could play a role to undertake the asset risk and remove the associated anxiety.

Several successful leasing mechanism in other markets (for example from infrastructure, aviation and rail) are now emerging for the truck market as well. These include a capital or operating lease (dry and wet) of the vehicle, leasing of the battery pack are all considered.

However, this is a small market with currently only a few players. The situation for public charging services and depot charging-as-a-service is similar. One solution could be that **public funding and private investments may be earmarked for these new sustainable transport enablers**. These have to support business models that may be classified as high-risk investments but are essential for wide-scale adoption.

Supportive to reducing the TCO is to create certainty of revenue streams by freight buyers in zero emission logistics services. Here, freight buyers needs to be considering their **contractual arrangements with the fleet operators**. Solutions are to procure longer term contracts (e.g. 2-3 year contracts with options for

longer term to create TCO parity in contrast to short term spot market), provide lease of buyback solutions after the contract to overcome the higher upfront capital investment costs or provide vehicles to fleet operators directly. On top of this, deterring investments by introducing carbon pricing mechanisms where freight buyers– directly or indirectly – pay for the carbon emitted have seen to be a successful market mechanism if carbon costs are high enough.

4.3 Support the education of the industry to navigate the transition

There is a significant gap in awareness of the benefits and challenges of electric truck, which is hampering the transition. Several OEMs provide consultancy services to help fleets transition and there are peer-to-peer learning groups for fleets both in North America and Europe[32] but more work needs to be done educate and provide guidance for carriers who are just in the exploring stage. SME carriers with an aversion to external financing should be specifically engaged to help address their barriers. To some extent, this is a role played by public-funded organizations (e.g., Nationale Agenda Laadinfrastructuur) and non-profit organizations (e.g., Smart Freight Centre and CALSTART). Funding should be made available to these organizations with effective charters and scope to carry out the awareness and training needed.

Another aspect is the training of skilled workers, both for the truck supply market but also to train or retrain repair and maintenance technicians working directly in the fleets. Significant reskilling will need to take place to prepare the ecosystem for the transition.

In addition, as mentioned above, freight buyers have to play a much larger role in this transition. There are a variety of ways they can directly influence carriers to transition but they need to be challenged and trained into carrying them out. These range from altering their procurement practices, shifting towards collaborative relationships with carriers, incorporating carbon pricing in their supplier evaluations, to providing education and training to their carriers. It is expected that as freight buyers convincingly configure the demand-side of the market, the freight supply-side will follow accordingly, cascading the changes towards the vehicle market.

4.4 Stabilizing the energy transition towards a sustainable and equitable future

It is no surprise that the energy transition, especially in the next 20 years, will be disruptive globally. In fact, the aim of the measures we have proposed seeks to disrupt the current fossil-fuel- and internal-combustion-engine dependent transport sector and to significantly scale up a low- to zero-lifecycle-emissions transport system, a prerequisite to meet 1.5 degree trajectory. This will require that organizations with significant economic power and political influence play a role in absorbing the shocks, mitigating unintended outcomes, and executing course correction until we reach a truly sustainable and equitable future for the entire world. While this is traditionally a role that policy makers play, the collaborative future we imagine will require the proactive support of other economic actors and NGOs.

As we move towards a net-zero transport sector, we must ensure that the vehicle, charging infrastructure and energy market remains competitive and technologically innovative. Competition in the market can ensure that the value proposition to price ratio continues to improve. **Policy should ensure that the markets are not restrictive to new entrants**, with new and potentially better products or service offerings. Further, it should also seek to avoid painting itself into a corner by overreliance on a single supplier of battery or charging technology. We must ensure that global supply chains of battery technology or critical minerals that are being built now are resilient in the face of disruptions or industrial protectionism. Furthermore, we should continue to valorize research programs to provide society with dramatically improved technologies that can leapfrog what we have now. For instance, solid-state batteries have been touted as a game changer compared to current lithium-based batteries. Similarly, electric road systems may replace the need for stationary charging systems roll-out and provide benefits in terms of cost, driving range, and issues surrounding battery scarcity and sustainability.

Another aspect to safeguard is the impact of the costs of the energy transition on the transport sector, supply chains, the economy and society. Recently, we have seen the impact of fossil fuel prices on the transport sector leading to significant price inflation around the world. There are tremendous social costs related to inflation that local governments are still trying to mitigate using subsidies, tax reductions, and price controls. The electric truck adoption, at least in the short term, while prices remain high, may have a similar disruptive impact. These impacts have to be monitored and dealt with accordingly.

Further, we should ensure that the low carbon transition in developing economies are also

supported. The road freight sector in these markets may be too vulnerable to safely transition without external funding and knowledge exchange. Ultimately, these markets must also be free to develop in a way which fits their geopolitical and economic structure to ensure a robust transition, rather than an externally imposed one. Initiatives, such as the Global Memorandum of Understanding on Zero-Emission Medium- and Heavy Duty Vehicles build a network of countries that mutually commit and support the transition, including smaller countries. Their work should continue to develop to provide local governments with the support to build capacity and make socially and politically sustainable policies.

5 Conclusion: the call for an institutional solution

The whitepaper has tried to lay out the structural barriers for fast-tracking the ramp up of e-trucks. While policy in California and EU force a significant ramp up by obliging OEMs to accelerate the transition, the traction in the market so far is limited with infrastructure build-out lagging and carrier engagement limited.

Taking into account the pledge of international shippers to reduce scope 3 emissions in their supply chains as part of their Science Based Target commitment, the latent demand for e-trucks is huge and the gap to communicated orders and announced production plans gigantic. It is expected that once TCO parity and infrastructure availability are reached there will be a quick uptake in the market.

Only structural solutions that address the financing challenge for the upfront cost differential between e-trucks and combustion engine trucks in particular for SME carriers can help to bend the curve. Several OEMs already expand the “truck as a service” and “advanced leasing models”, but their balance sheets will be stretched if access to private capital markets cannot be included.

Private capital in the form of equity and debt financing will ask for de-risking of those elements that have been listed before.

- Residual value of battery may be guaranteed by OEMs, battery suppliers, potentially with battery-as-a service model.
- Payment risks for SME suppliers could be mitigated by shippers for their core carriers, also including longer term contract periods and higher contract values in exchange of procurement contracts with e-truck delivery.
- Shippers and logistics service providers´s may engage in guaranteeing utilization for regional depot charging (proprietary) and “On-the-go” charging. In Europe OEM´s have jointly founded high voltage charging networks on key corridors also leveraging public subsidies for initial capex.

There may be a space for advanced financial structures that would establish “asset ownership” corps that holds e-truck assets with de-risking measures jointly undertaken by major shippers and OEMs. The railway industry has been exploring structures for the lease of locomotives and rolling stock incl. freight wagons, as the railway undertakings also lack financial power to take them on their balance sheet or guarantee utilization long term given variable contract durations. This has led to a thriving and profitable industry offering a variety of lease and contract models (short and mid-term; wet and dry lease). A similar industry structure may be feasible for the trucking industry.

Obviously, the ramp up of e-trucking will not happen synchronously across the network. The beachhead model[33] where local delivery trucks spread towards regional medium duty delivery network use case and evolve towards heavy duty truck networks may be easier to implement. In particular in industrial and densely populated regions with high utilization of assets and a regional charging network including depot charging, the local and medium duty use case can cover 65% of today´s demand for medium duty trucking solutions and already 49% of heavy duty trucking solutions[34]. This acts as a starting points alongside high volume trunk routes with bi-directional profile. This may be even more the case as the drivers still favor back to garage rosters with limited overnight stays away from home.

While structural barriers are paramount, the share of volume that could be tackled with a significant structural solution including distributed guarantees, asset holding companies and the focus for those use cases of limited complexity may be growing rapidly.

6 References

[1] Calstart, the Beachhead Strategy: A Theory of Change for Medium- and Heavy-Duty Commercial Transportation
[2] IEA. 2017. "The Future of Trucks - Implications for Energy and the Environment."
[3] IEA (2022), Trucks and Buses, IEA, Paris https://www.iea.org/reports/trucks-and-buses, License: CC BY 4.0
[4] ITF. 2018. "Towards Road Freight Decarbonisation Trends Measures and Policies." ITF Policy Papers. Paris: OECD Publishing.
[5] IEA. 2017. "The Future of Trucks - Implications for Energy and the Environment."
[6] ICCT. 2023. "A Comparison of the Life-Cycle Greenhouse Gas Emissions of European Heavy-Duty Vehicles and Fuels.".
[7] Basma, Hussein, Arash Saboori, and Felipe Rodríguez. 2021. "Total Cost of Ownership for Tractor-Trailers in Europe: Battery Electric versus Diesel.".
[8] Transporeon, Smart Freight Centre, & Kuhne Logistics University. 2022. "Decarbonizing Freight 2022: Where Shippers and Carriers Stand on the Road to Net Zero." https://www.transporeon.com/en/reports/decarbonizing-freight-2022.
[9] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Businesses_in_the_transportation_and_storage_sector
[10] Tölke, Moritz, and Alan McKinnon. 2021. "Decarbonizing the Operations of Small and Medium-Sized Road Carriers in Europe."
[11] Allen, Julian, Maja Piecyk, and Mengqiu Cao. 2023. "Road Freight Transport SMEs: Trading, Operational and Decarbonisation Perspectives." ENG-TR.030.
[12] https://ww2.arb.ca.gov/resources/fact-sheets/advanced-clean-trucks-fact-sheet
[13] https://theicct.org/eu-co2-hdv-standards-explained-feb23/
[14] https://globaldrivetozero.org/mou-nations/
[15] The vehicle models announcements by OEMs vary by size, payload capacity and driving range. See Calstart's Zero-Emission Truck and Bus Market Update published October 2022 at https://globaldrivetozero.org/site/wp-content/uploads/2022/10/ZE_TruckBus_update.pdf.
[16] Transport & Environment. 2022. "Addressing the Heavy-Duty Climate Problem."
[17] CALSTART (2022): Drive to Zero's Zero-Emission Technology Inventory Data Explorer. Version 1.0. Available online at: https://globaldrivetozero.org/zeti-data-explorer/
[18] ICCT. 2021. "Race to Zero: How Manufacturers Are Positioned for Zero-Emission Commercial Trucks and Buses in China."
[19] IEA. 2022. Global EV Outlook 2022, IEA, Paris https://www.iea.org/reports/global-ev-outlook-2022
[20] ICCT. 2022. "Road Freight Decarbonization in Europe: Readiness of the European Fleets for Zero-Emission Trucking.".
[21] Bain. 2022. "European Truck Market Outlook 2022." https://www.bain.com/insights/european-truck-market-outlook-2022/
[22] ICCT. 2021. "Total Cost of Ownership for Tractor-Trailers in Europe: Battery Electric versus Diesel."
[23] TNO. 2022. "Techno-Economic Uptake Potential of Zero-Emission Trucks in Europe."
[24] ICCT. 2021. "Total Cost of Ownership for Heavy Trucks in China: Battery-Electric, Fuel Cell Electric, and Diesel Trucks."
[25] Basma, Hussein, Arash Saboori, and Felipe Rodríguez. 2021. "Total Cost of Ownership for Tractor-Trailers in Europe: Battery Electric versus Diesel."
[26] US EIA- https://www.eia.gov/electricity/monthly/update/wholesale-markets.php
[27] https://www.rabobank.com/knowledge/d011318792-the-basics-of-electricity-price-formation
[28] ICCT. 2022. "Charging Solutions for Battery-Electric Trucks." https://theicct.org/publication/charging-infrastructure-trucks-zeva-dec22/
[29] https://www.mckinsey.com/industries/travel-logistics-and-infrastructure/our-insights/driving-decarbonization-accelerating-zero-emission-freight-transport
[30] https://www.transportenvironment.org/discover/how-to-buy-an-electric-truck/
[31] Tesla introduced for a short time, at the nascent passenger EV market, a resale value guarantee. https://www.tesla.com/sites/default/files/pdfs/rvg/RVG_Agreement_R20160318_en_US.pdf
[32] https://sustainablefleets.org/
[33] Calstart, the Beachhead Strategy: A Theory of Change for Medium- and Heavy-Duty Commercial Transportation
[34] RMI, Electric Trucks reach a tipping point. Electric Trucks Reach a Tipping Point - RMI