ROAD FREIGHT ZERO

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WORLD ECONOMIC FORUM

In partnership with
McKinsey & Company

Road Freight Zero: Pathways to faster adoption of zero-emission trucks

INSIGHT REPORT

OCTOBER 2021

Images: Getty Images

Contents

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Foreword

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Achieving a sustainable zero-emission freight transport economy by 2050 requires cohesive action now. Road freight is the primary CO_2 emitter of global trade-related transport, with an emissions share projected to grow from 53% to 56% by 2050.[1] This trajectory is far from Paris-compatible, despite positive technology momentum. Accelerating investment in assets and infrastructure to ensure a zero-emission future requires enabling policy, financing and adoption at scale within this decade.

The World Economic Forum's Road Freight Zero (RFZ) initiative, established in September 2020, engages industry leaders across the value chain who endorse the need for collaboration to accelerate the transition to a zero-emission transport future. This includes demand- and supply-side actors, such as leading manufacturers, consumer goods giants, logistics majors, fleet operators, energy, tech and infrastructure firms, innovators, finance companies, academia and civil society.

While decarbonization of transportation has made great strides in many parts of the world – with zero-emission cars, buses, light commercial vehicles and various forms of micro-mobility – progress has been slow for medium- and heavy-duty trucks. As governments launch ambitious climate goals, such as the European Union's "Fit for 55" package, whose objective is to reduce emissions by at least 55% by 2030, companies and policy-makers are recognizing that major reductions will be needed across all forms of transport.

Given the pace of advancement, with more cost-effective and higher-performing batteries, improved fuel-cell technology, greater availability of zero-emission trucks and improved infrastructure, a low-carbon truck future is well within reach. In isolation, however, these technological improvements will be insufficient to scale deployment in line with global climate goals by 2050 and will not meet EU Green Deal objectives in the immediate future. Coordination across the entire value chain is required to synchronize large-scale fleet and infrastructure finance with transport demand, truck deployment and infrastructure build-out.

The Road Freight Zero community is addressing challenges related to infrastructure, capital financing and the policy levers required to define clear pathways to accelerate roll-out of zero-emission freight vehicles. To maximize impact, the community is working closely with leading programmes and organizations with a shared vision. The Mission Possible Partnership, which addresses seven hard-to-abate sectors including medium- and heavy-duty trucks, the ZEFV ACTion Group, the European Clean Trucking Alliance and academia are actively collaborating.

When we look at the numerous pilots underway, the decarbonization goals set by transport buyers, the product pipelines of truck makers and recent policy announcements, the industry appears to be on the cusp of significant progress. The engagement, energy and dedication of the RFZ community has been inspiring. The report that follows captures some key findings about the state of the market in Europe and what it will take to accelerate zero-emission truck transport.

We gratefully acknowledge the guidance and financial support of the European Climate Foundation and the contributions of our leading knowledge partners – the McKinsey Center for Future Mobility (MCFM), Material Economics and Kühne Logistics University.

Executive summary

Moving road freight to a faster pace of zero-emission truck adoption is feasible, but requires coordinated action to overcome tough challenges

Road freight currently generates 15% of European CO_2 emissions.[2] About **70% of those emissions come from medium- and heavy-duty trucking** (MDT/HDT) – the hardest-to-abate segments.[3]

Nevertheless, there is a growing consensus that the zero-emission (ZE) truck industry is on course to deliver competitive business cases for the decarbonization of these fleets – through battery electric vehicles (BEVs) and hydrogen fuel cell electric vehicles (FCEVs) that could eventually be powered by renewable energy.

McKinsey modelling suggests that by 2030, 37% of new MDT and HDT sales could be zero-emission in Europe, corresponding to around 150,000 vehicles.[4] However, **at its current pace, the industry would need another 120,000 zero-emission trucks on the road annually by 2030 to achieve the 1.5°C target** – **equivalent to two-thirds of total trucks sold.**[5] Reaching this target may require €4 billion in additional investment in ZE trucks by 2030[6] and €30-40 billion for zero-emission refuelling/recharging infrastructure over the period up to 2030.[7]

Drawing on our analysis of multiple reports,[8] RFZ's leadership concludes that **two barriers are having an outsized effect on the pace of adoption:**

1. **Lack of infrastructure for ZE truck fleets**

2. **Gaps in vehicle and infrastructure financing** for fleet owners to address increasing capital expenditure

RFZ also found that multiple solutions can be applied, but these will need to happen through coordinated collaboration across the value chain. Determined to go a level deeper, RFZ leaders and partners explored the pathways needed to implement these solutions effectively through specific contexts and how these can be scaled.

This report draws from a large body of modelling, research and **direct RFZ partner engagement, including multiple workshops with over 40 companies, a dedicated survey to assess barriers and solution pathways, numerous deep-structured interviews** with RFZ partners to analyse specific archetypes of ZE truck adoption and **quantitative use-case modelling utilizing a large database of truck transport data compiled for decarbonization analysis.**

The outcome of this year of work and analysis confirms initial research on key barriers facing the industry, but also **reveals three solution domains that require greater emphasis**:

1. **Policy framework:** Long-term stable policies and incentives to improve the total cost of ownership (TCO) for truck operators and infrastructure providers

2. **Innovative financing:** Leasing models to help truck operators transition to zero-emission trucks more quickly, and actions to reduce the uncertainty of residual values

3. **Coordinated roll-out:** Deploying market-ready zero-emission vehicles and corresponding infrastructure in a coordinated way along numerous corridors

RFZ's modelling of solution pathways and use cases provides additional quantitative support for these findings and enables the application of select levers to specific truck use cases. **This serves as a practical set of data and a toolkit for transporters, truck makers, policy-makers and infrastructure players to better understand zero-emission TCO economics and which actions have the largest impact on adoption.**

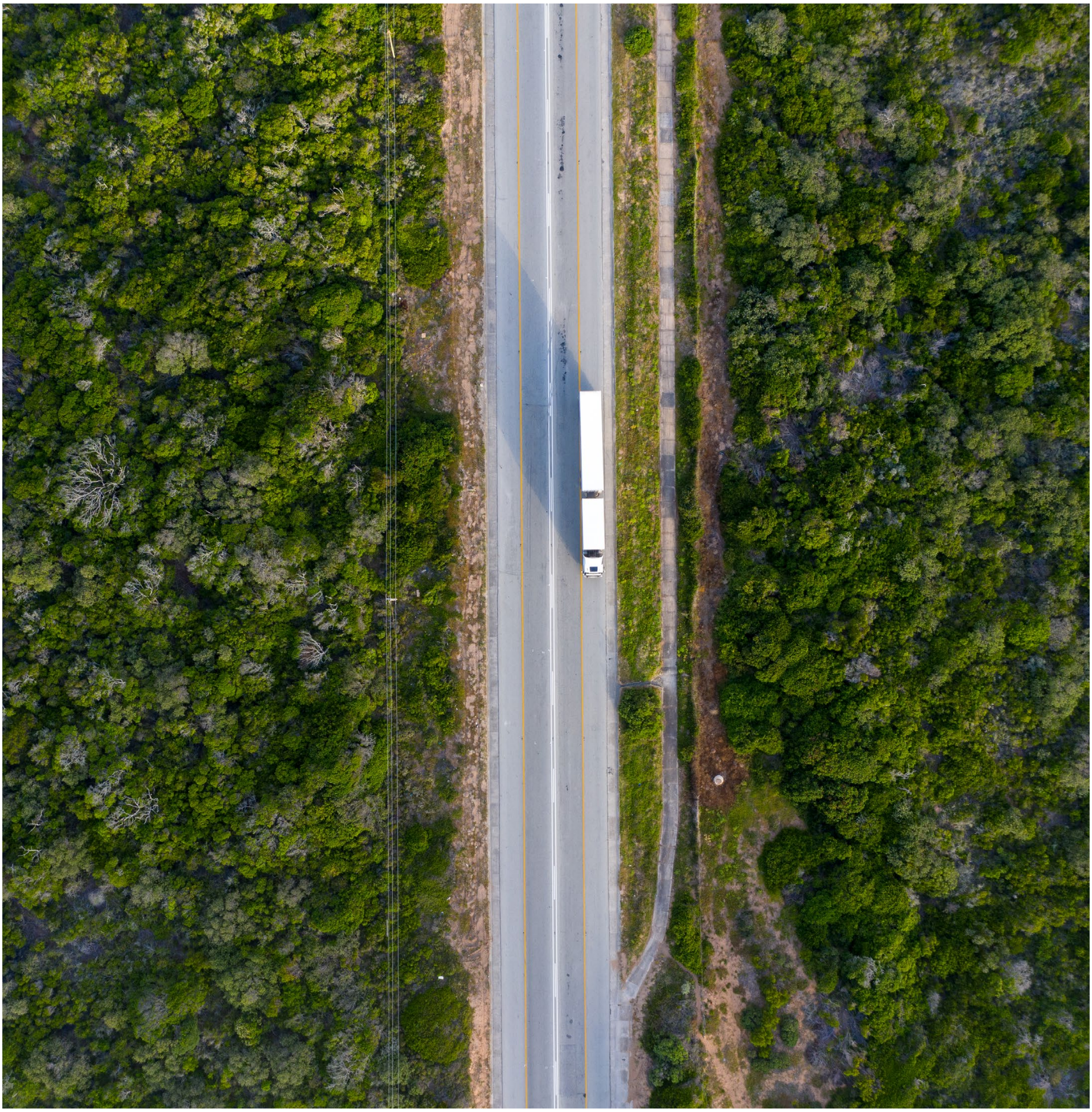
As demonstrated here, the Road Freight Zero initiative, led by the World Economic Forum and supported by its partners, including the McKinsey Center for Future Mobility, will continue to be well-positioned to convene stakeholders, define collaborative solutions and expand ZE truck use.

Accelerating truck transport towards a 1.5°C trajectory and meeting the "Fit for 55" EU goals will not be easy, but each actor in the value chain has a role to play. Road Freight Zero is committed to play its role in supporting the full value chain succeed in the race to zero.

1

Context and current trajectory

Trucks powered by both batteries and hydrogen fuel cells are on track to increase – but even with both options, current zero-emission truck sales projections fall short of a 1.5°C scenario



A growing consensus agrees that the truck industry can achieve longer-term decarbonization using zero-emission (ZE) truck technologies (battery and fuel cell), but sales today remain limited.

The industry's decarbonization trajectory suggests that around 37% of sales could be ZE trucks by 2030, rising to nearly all sales by 2050. While this 2030 projection is higher than the truck manufacturers' current regulatory obligations, the modelling of expected emissions from medium- and heavy-duty trucks (MDTs/HDTs) suggests this will not be sufficient to align with a 1.5°C pathway by 2030. Accelerating the transition beyond current projections can move the industry closer to a 1.5°C scenario – considered by scientists to be the maximum recommended amount of warming above pre-industrial levels to limit the most dangerous effects of climate change.

BOX 1

Road Freight Zero (RFZ) and the Mission Possible Partnership (MPP)

MPP is a coalition of public and private partners working on the industry transition to set heavy industry and mobility sectors on the pathway towards net-zero emissions by mid-century.

RFZ is MPP's high-ambition global industry platform for trucking, led by the World Economic Forum, in close collaboration with knowledge partners.

While this report focuses on Europe's truck sector, many of the solutions identified and discussed in this report will apply to markets globally.

1.1 Scope of report

This report focuses on MDTs and HDTs in one geography, Europe, but many of the solutions identified and discussed in this report will also apply to markets globally. A key source of insight for this report was a unique transport database of truck and lane-level information from major European fleets, provided by Forum partners. For each lane and truck, a total cost of ownership (TCO) calculator was applied to estimate the cost of decarbonization. The tool is open to additional RFZ partner contributions and provides in-depth insights for fleet operators, freight buyers, truck makers, infrastructure players and policy-makers on overall emissions, by lane and respective abatement costs. Selected truck use cases were analysed in further detail to define decarbonization pathways, which were validated in larger workshops with stakeholders across industry segments.

1.2 Current trajectory

> Additional investments of €25-30 billion by 2030 will be needed to cover a faster roll-out of higher capex ZE trucks.

In Europe, heavy vehicles account for 5-6% of total CO_2 emissions.[9] The overall road freight sector will potentially double by 2050, with medium- and heavy-duty trucks accounting for close to 70% of road transport emissions.[10]

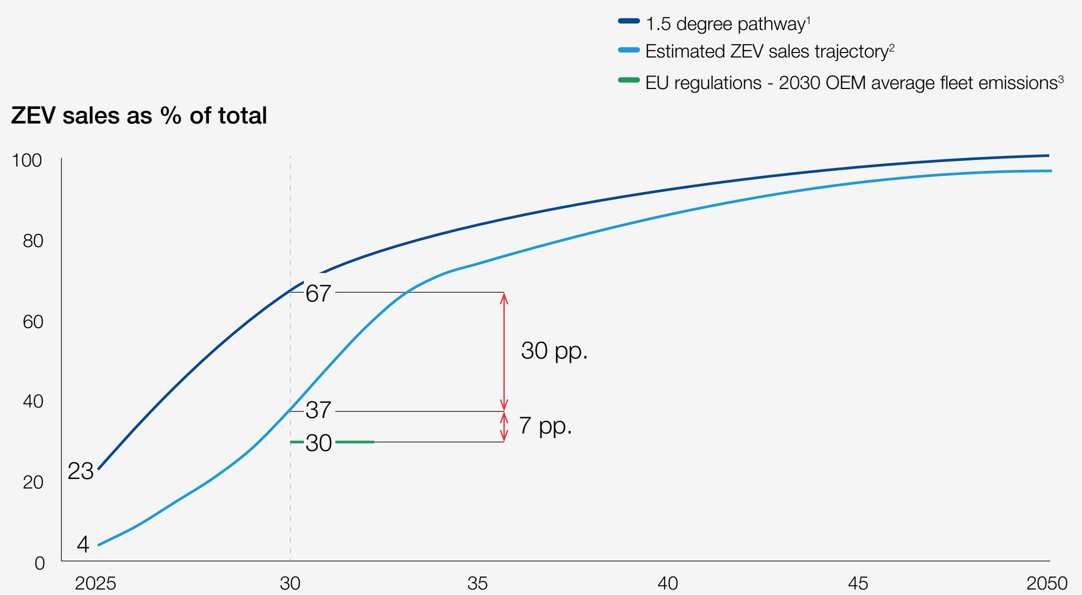
Transition to zero-emission technologies has already begun. Recent research by the McKinsey Center for Future Mobility suggests that by 2025, 4% of all MDT and HDT sales in Europe will be ZE vehicles, with the ZE share growing to 37% by 2030 (see Figure 1). This roll-out will need to be supported by 140,000 public and destination charging points and 1,500 compatible hydrogen fuelling stations by 2030.[11]

However, reaching a 1.5°C pathway by 2030 will require even more investment in both ZE trucks and infrastructure than currently projected, given the high capital expenditure (capex) costs.

Additional investments of €25-30 billion[12] by 2030 will be needed to cover a faster roll-out of higher capex ZE trucks. Supporting a much larger ZE fleet in a 1.5°C pathway could also require €50-60 billion in additional infrastructure investments (above current projections) by 2030, equating to approximately 1,000-1,500 additional hydrogen fuelling stations and 150,000-200,000 additional charging points for trucks.

FIGURE 1

Projected market share of ZE trucks, % of new sales



1 1.5 degree pathway corresponds to the maximum level of warming above pre-industrial levels that could limit the most dangerous and irreversible effects of climate change determined by the IPCC

2 McKinsey expected case - July 2021

3 EU regulations are expressed as a percentage reduction of emissions compared to EU average in the reference period (1 July 2019–30 June 2020). 2030-2050 target extrapolated – 2035 and 2040 targets to be determined 2022

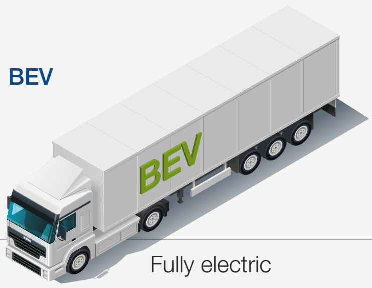
Source: McKinsey Center for Future Mobility

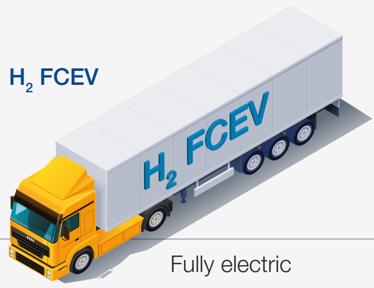
1.3 Zero-emissions trucking technology

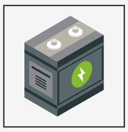
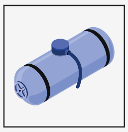
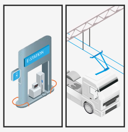
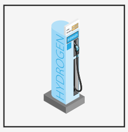
Two main technologies currently vie for road freight ZE truck acceptance – battery electric vehicles (BEVs) and hydrogen fuel cell electric vehicles (FCEVs). Both feature electric powertrains with batteries and electric motors, but they use different energy storage systems. While a broad offering of BEV trucks will become available prior to 2025, most original equipment manufacturers (OEMs) are also investing in FCEV technology, with large-scale market entries planned post-2025. Hence, the future market will most likely include a mix of both BEV and FCEV powertrain technologies.[13]

The backers of both BEV and FCEV technologies assume that future tipping points, including regulatory policy changes, will occur to close the TCO gap between these technologies and the alternatives (diesel vehicles or other ZE truck solutions). Leading truck makers, including Daimler Trucks and Volvo Group, are making substantial investments in both BEV and FCEV technologies, with BEV models set to launch first, followed by fuel-cell trucks. In 2020, Daimler Trucks and Volvo Group formed a joint venture to co-develop and commercialize the fuel-cell powertrains underlying FCEVs.[14]

FIGURE 2 **ZE truck technology comparison**





	BEV	H_2 FCEV
Powertrain	Fully electric	Fully electric
Main energy storage system	 Battery	 Liquid or gaseous Hydrogen
Main energy supply system	 – Electric chargers – Catenary charging	 – Hydrogen fill stations
Availability	Several (<10) models currently available	Only 1 model available commercially
Main advantages	– Currently widely available – Compelling TCO when battery size can be minimized	– High energy density of hydrogen – easier to design for long distance – Fast refueling
Main drawbacks	– Size weight and cost of battery – more pronounced for long range vehicles – Longer recharging times	– Current lack of availability of vehicles – Current high price of hydrogen – Lack of hydrogen infrastructure in Europe

Which technology has the best TCO for a specific use case will depend on many factors and potentially change over time
Many in the wider ZEV industry expect the future market to include a mix of both technologies

Technology advances are improving the efficiency of both battery and fuel-cell solutions, which will drive down prices and improve widespread adoption:

– **BEV:** Technology advances can make batteries cheaper, more capable of fast-charging and more energy-dense (leading to lower size and weight). These innovations could accelerate BEV market penetration. The battery industry expects battery pack cost reductions of about 60-70% by 2030, from around \$250/kWh to \$80-\$100/kWh.[15]

– **FCEV:** Hydrogen pump prices could fall significantly, from over €10/kg in 2020 to around €4/kg in 2030, as scale ramps up.[16]

> Given the level of uncertainty around battery and fuel-cell performance, a multi-technology approach can help de-risk the decarbonization pathway.

This process will be driven not only by transportation demand, but also the decarbonization of other industries such as steel and cement. The use of hydrogen combustion engines as a diesel alternative could also help accelerate fill-station investment. In addition, recent modelling shows a 70% reduction potential in fuel-cell system costs due to increased production scale.[17]

Transportation is already a multi-technology market, with petrol, gas and diesel engines co-existing (although diesel captures a disproportionate share).

In the future, we will also see a multi-power ZE truck market, as global truck makers develop both BEV and FCEV solutions, while in the near term looking to lower-carbon fuel options, such as synthetic fuels and biofuels, as part of the transition to zero-tailpipe-emissions powertrains. Furthermore, major energy and infrastructure players are running pilots on hydrogen fuelling and high-speed charging for trucks.[18] Given the level of uncertainty around battery and fuel-cell performance, nascent demand signals and major infrastructure challenges, a multi-technology approach can help de-risk the decarbonization pathway.

1.4 Important nuances along the decarbonization journey

The focus of this report is road freight with *zero on-road emissions*. However, full decarbonization depends on the entire value chain. For example, BEV trucks run on electricity from the grid, but the carbon intensity of national electrical grids varies by country. In the EU, about 60% of electricity comes from carbon-free sources,[19] so renewable energy supplies need to expand in-sync with BEV truck demand.

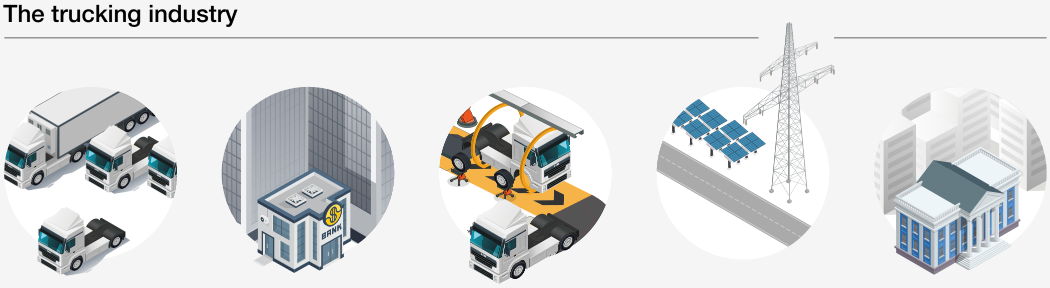
Currently a mix of blue (low-carbon) and early pilots of green (renewable) hydrogen are available commercially. To achieve the full decarbonization impact for FCEV trucks, the hydrogen must come solely from green sources. Other industries (e.g. steel) could start competing for green hydrogen, but different sectors could also work together to improve demand signals and economies of scale.

In addition to BEV and FCEV, the industry can help reduce net carbon emissions using alternative fuels. While options such as liquid natural gas (LNG) or compressed natural gas (CNG) allow for moderate carbon savings, synthetic fuels and newer biofuels – such as bio-LNG, bio-CNG and hydrotreated vegetable oil (HVO) biodiesel – are becoming viable lower-carbon options. As these alternative powertrains use internal combustion engines, they can play a relevant role as bridging solutions. However, all of these alternative fuels generate tailpipe emissions (greenhouse gases, particulate matter etc.), which makes them less attractive for regulators in the long run, especially in cities.

Moreover, biofuels and synthetic fuels are limited in supply and carry a price premium compared with regular fuels. Other hard-to-abate sectors such as aviation may also turn to these lower-carbon biofuels or synthetic fuels to decarbonize. RFZ acknowledges the role that these fuel alternatives may play, but the initiative is focused predominantly on accelerating the industry towards the ultimate destination of fully zero-emission trucks on the road.

FIGURE 3 **Trucking value-chain simplified**

The trucking industry



Fleet operators | **Financial institutions** | **Truck makers** | **Energy and infrastructure players** | **Governments**

\+

In addition, a number of other players will also have roles to play in the transition, from trailer manufacturers to telematics companies and beyond.

Source: McKinsey Center for Future Mobility

1.5 Six criteria to evaluate decarbonization of trucking

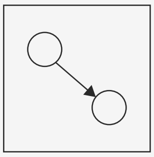
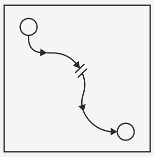
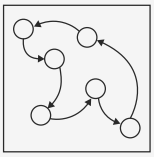
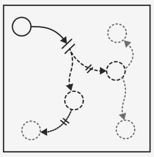
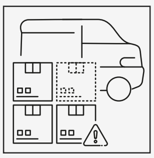
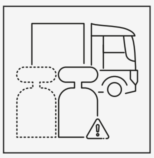
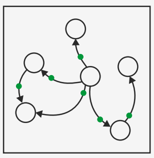
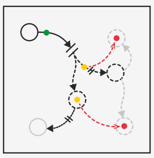
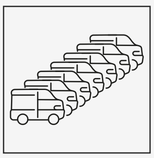
Six criteria will define how we evaluate different trucking segments for decarbonization (see Figure 4):

- Route length
- 1 or 2 driver routes
- Depot-based or “floating” routes
- Payload
- Operator structure
- Size of fleet by company

Based on common system archetypes, these feature different decarbonization profiles. For example, one of the easiest archetypes to decarbonize is likely a large captive fleet covering short, well-defined routes where the fleet operator can install its own infrastructure at all shipping points.

Among the most difficult archetypes involves on-demand, long-haul transportation not operating on pre-planned routes, making it the most cost-sensitive and highly reliant on the greatest number of small, often underfunded, independent companies. Furthermore, while long-haul accounts for about 15% of medium- and heavy-duty trucks in Europe, this use case generates around 47% of all trucking emissions.[20]

FIGURE 4 **Decarbonization profiles across trucking archetypes**

Simpler to decarbonize				More complex to decarbonize
Short haul Shorter ranges, potential for smaller batteries		Route length		**Long haul** Longer distances, reliable refuelling/recharging infrastructure required
1 driver Mandatory breaks and overnight stops enable downtime charging/refuelling		1 or 2 driver routes		**2 drivers** 24-hr operation reduces down-time, but fewer refuelling opportunities and longer trip durations
Depot-based (incl. some LTL) Routes begin and end at depots, giving more control over infrastructure		Depot-based or “floating” routes		**Floating routes** Uncertain destination infrastructure drives higher enroute charging needs
Volume limited Fewer consequences of vehicle weight		Payload		**Weight limited** Every tonne of vehicle powertrain weight reduces hauling capacity
Private fleet Complete control over matching trucks to routes; more predictability		Operator structure		**3PL – 3rd party logistics provider** Routes subject to daily demand; must match truck availability to trip
Large fleet More economical due to scale; can test in small proportion of fleet		Size of fleet by company		**Small fleets** High risk transition; lower access to capital

Source: McKinsey Center for Future Mobility

2 Unlocking key barriers to decarbonize trucking

Top barriers to overcome include the roll-out of infrastructure and financing of trucks and infrastructure – but these issues are becoming better understood

Based on a formal survey and deep dive interviews of Road Freight Zero partners, the two most challenging barriers to zero-emission truck adoption in the 2021-2030 timeframe were identified by a strong majority as the lack of charging/refuelling infrastructure and the financing of trucks and infrastructure. Other concerns were also discussed, including gaps in total cost of ownership (TCO) between ZE and diesel trucks, a lack of available ZE truck models to buy and challenges in adjusting fleet operations to ZE trucks. However, RFZ partners believe these concerns are on more positive trajectories, whereas the two most challenging barriers require more intervention to solve.

2.1 Infrastructure roll-out challenges

Zero-emissions trucks will require new infrastructure in the forms of charging or hydrogen refuelling stations. For some use cases, charging and refuelling operations can take place in depots using infrastructure built specifically for the user. However, to increase route flexibility and to serve the full set of use cases, stakeholders need to build public on-the-go infrastructure. Such infrastructure typically requires high investment levels that need strong business cases, as well as effective execution.

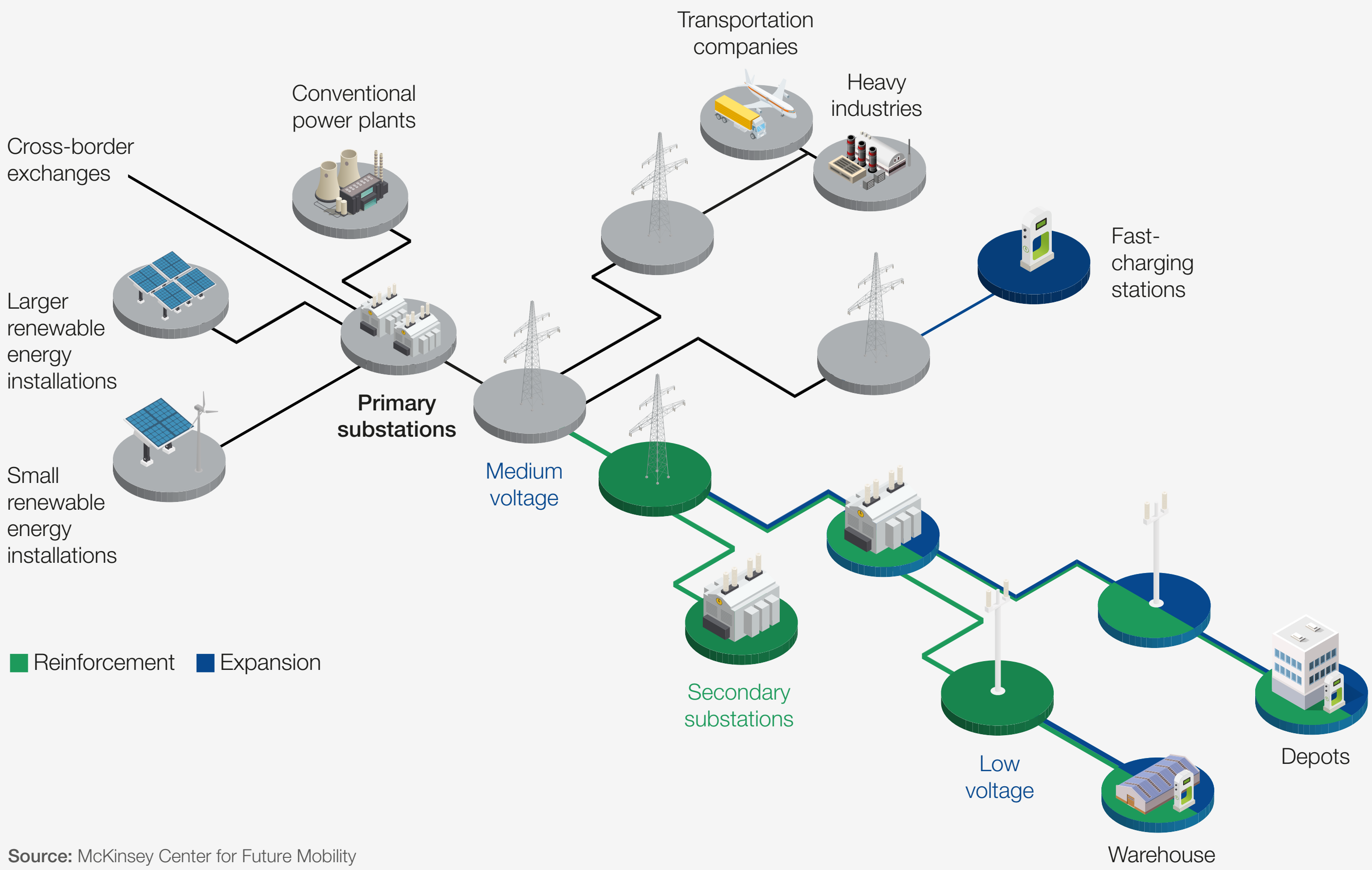
Demand uncertainty with large capex outlays

In a classic "chicken or egg" scenario, players may hesitate to invest in charging and refuelling infrastructure until enough ZE trucks are on the road to achieve profitable utilization. For BEVs, mid-route charging requires substantially more power and more costly infrastructure than overnight charging. For example, to charge an average 400kWh[21] battery fully in 45 minutes (the mandatory break time under EU law for long-haul drivers) requires charging infrastructure rated 750kW or higher. This technology is currently under development and could cost between €200,000 and €350,000 per charge point.[22] The capex for hydrogen fuelling stations can range from €2-€3 million for a 1,000 kg/day station, depending on the output pressure. For both BEV and FCEV, infrastructure costs are expected to drop by up to 60% by 2030, driven by advances in technology and scale of operations.[23]

Grid capacity and planning

Infrastructure may require additional grid upgrades, such as expanded transmission and distribution capacity (see Figure 5). Public upgrades can face lengthy bureaucratic delays. Each European country differs, but recent examples show upgrades can take up to five years. Furthermore, utilities and regulators may adjust electricity tariffs and rate structures to include higher peak or standing charges to recoup costs, further complicating ZE truck business-case economics.

FIGURE 5 **Required reinforcement/expansion for grids**



Source: McKinsey Center for Future Mobility

Depot infrastructure issues

Initially, truck operators will most likely install charging/refuelling infrastructure at or close to their depots, since experts believe 60-90% of truck charge points will be at hubs and destinations.[24] This has clear upfront capex implications for fleet operators. Some players are already working to solve these challenges, for example Hitachi ABB Power Grids has launched Grid-eMotion Fleet, which is designed for depot chargers from 50-600kW of power and is intended to reduce space requirements and installation costs at depots.[25]

2.2 Vehicle financing challenges

ZE truck financing models will require a significant overhaul, as financial institutions need to adapt from traditional models – developed for diesel depreciation and operating costs – to ZE trucks.

Finance companies must adapt the depreciation and operating cost curve models of traditional trucks to ZE truck technology. Vehicle depreciation related to TCO depends on the purchase price, residual value and duration of ownership – an equation core to the development of TCO, financing costs and leasing prices. High capex and uncertain residuals result in higher depreciation and high truck costs. RFZ carried out some primary research and analysis to inform this process (see Box 2).

BOX 2

Road Freight Zero use-case evaluation using the TCO model

To understand the current economics and potential solutions for ZE trucks and transporters, the Forum coordinated the collection of trip data from five major European transporters and freight buyers to compile a database covering over 18,000 trucks and more than 200,000 individual shipments across Europe. This database was created for the sole purpose of analysing decarbonization pathways.

Analysts aggregated the transport data into over 10 archetype truck use cases in collaboration with study participants. For each archetype use case, they carried out a detailed total cost of ownership (TCO) analysis to evaluate the key drivers of TCO as well as projected ZE truck parity, to inform decarbonization pathways.

Forum partners provided critical input on the analyses in a series of workshops that identified solutions for accelerating the future of ZE trucking in Europe.

Large upfront capex and residual value questions

“ While ZE trucks will eventually offset higher capex with lower operating expenses (opex), during the transition period fleets face the issue of expanding capex spending plus the higher opex of running mixed fleets.

While ZE trucks will eventually offset higher capex with lower operating expenses (opex), during the transition period fleets face the issue of expanding capex spending plus the higher opex of running mixed fleets. Leasing and financing models remain uncertain due to the unclear residual values for ZE trucks, which result from three main risk factors:

– **Battery or fuel cell degradation.** Replacing a worn-out battery or fuel cell during a vehicle's second ownership cycle lowers its estimated residual value floor. Long-haul, heavy-duty trucks tend to stress EV batteries due to their high energy throughput. While fuel cell stacks should operate for up to one million km, they could still fail, costing approximately 7% of the upfront hydrogen truck capex.

– **Second-hand vehicle market demand.** Lessors and financiers lack the information needed to predict residual values. Likewise, used truck purchasers may take longer to transition to ZE trucks than new truck purchasers do. For instance, sales to Eastern Europe, Africa or South America could lag because of the lack of charging/refuelling infrastructure, reducing residual values.

– **Technology risk.** Unclear rates of technology development, such as declining battery costs or hydrogen fuel prices, could quickly reduce the resale value of older ZE trucks.

2.3 Positive momentum in other key areas

In addition to the barriers described above, RFZ is working to accelerate progress in other areas including closing TCO gaps, expanding ZE truck offerings and sharing fleet operation learnings.

Closing the total cost of ownership (TCO) gap to diesel

“As the industry gains scale, the high cost of delivering energy is falling as the capex for the substantial infrastructure required also falls.

In the case of electric trucks, while some factors driving TCO are improving, overall TCO gaps with diesel still exist. As the industry gains scale, the high cost of delivering energy is falling as the capex for the substantial infrastructure required also falls. Battery costs – the biggest cost for BEV trucks – should continue to fall, as the chemistry improves and the scale of production increases. The penalties imposed by heavy batteries, in the form of a truck’s carrying capacity and range, should also reduce, as battery density improves and as policies change to allow higher on-road vehicle weights.

In the case of fuel-cell trucks, the largest TCO barriers today are the cost of hydrogen itself and the cost of on-board H_2 systems (e.g. electrolyser, tank etc.). However, multiple factors, including the rise in demand for H_2 across other hard-to-abate sectors (e.g. steel, shipping, air transport) should help spur greater supply, improve H_2 infrastructure and reduce H_2 costs as a result. Larger-scale production and technology advances in electrolysers and tanks will improve the TCO for FCEV trucks.

Innovative partnerships are also helping to improve R&D economics and accelerate infrastructure roll-out. For example, IVECO, FPT Industrial and Nikola Corporation formed a joint venture in 2019 to co-develop FCEV and BEV trucks, with the goal of improving speed to market and reducing R&D investments for each individual player, thus reducing TCO for all.[26]

Although RFZ may not directly influence these factors, it can deliver use-case analyses (including those in this report) to build confidence around the trajectory and speed for TCO parity in different scenarios.

Boosting ZE truck offerings

To date, OEMs have launched a small number of medium- and heavy-duty electric and fuel-cell trucks for wide distribution to fleets in Europe and other markets. The BEV market, in particular, needs trucks with a variety of ranges and battery capacities to fulfil different use cases. Many truck makers are gearing up for new launches, with over 20 new zero-emission MDT and HDT models launching production in the next three years. RFZ will continue to foster greater transparency between transport operators/ buyers and OEMs, with the goal of improving demand signals for key decarbonization use cases. Several forward-thinking transport buyers are already sending strong demand signals including IKEA, which has a stated goal to become “climate positive by 2030” and move to zero-emission home deliveries by 2025.[27]

Learning how to run a ZE truck fleet

Today, the early ZE truck adopters are changing several aspects of their operations, including retraining staff (especially maintenance technicians), adjusting routes to best fit ZE truck capabilities and range, and upgrading physical depot layout to accommodate charging for H_2 fill stations. This period of transition represents a steep learning curve initially, but these fleets can apply early learnings from pilots across their networks. RFZ serves as a forum for sharing best practice across industry players to help streamline operational changes and to help reap the benefits of ZE technologies, such as potentially lower maintenance costs and longer vehicle lifetimes.

3

Priority solutions to accelerate ZE truck rollout

Three key solutions combined in use case-specific decarbonization pathways could bridge the total cost of ownership gap

Based on our survey of Forum partners, discussions with industry partners and a review of the latest published reports, the RFZ initiative has identified three groups of solutions to accelerate road freight decarbonization:

1. **Policy frameworks** to improve ZE truck TCO and de-risk infrastructure
2. **Innovative leasing products** and reduced residual value uncertainty
3. **Industry consortia** to aggregate demand and de-risk infrastructure roll-out

These solutions can be applied to different use cases (see chapter 4). This report explores two main types:

– **Depot charging**: this includes many distribution use cases. This area should break even first but could still benefit from acceleration.

– **Highway infrastructure:** this includes line-haul cases (consistently travelled point-to-point trucking routes between cities or other distribution locations). Line-haul use cases generate substantial carbon emissions and their solutions will involve many stakeholders.

3.1 Policy frameworks to improve ZE truck TCO and de-risk infrastructure

The industry would benefit from a stable, long-term policy framework.

A coordinated EU policy framework could help mobilize increased investment. The current patchwork of regulation and incentives across different countries and the forthcoming update of the *Regulation (EU) 2019/1242 reducing CO_2 Emissions from Heavy duty vehicles* makes ZE trucks an uncertain space for operators, especially regarding the profitability of their business models. The industry would benefit from a stable, long-term policy framework, in the spirit of the "Fit for 55" package recently announced by the European Commission, which covers passenger and light commercial vehicles. Heavy vehicle regulation will only be reviewed in 2022. This upcoming review is likely to include multiple aspects such as the Alternative Fuels Infrastructure Regulation (AFIR), Energy Tax Directive (ETD), Renewable Energy Directive (RED) and Emission Trading System (ETS), each of which could have wide-ranging impacts on the speed of ZE truck adoption and the consequent pace at which the TCO gap with diesel narrows. Given the different industry structure for heavy trucking and the sector's greater decarbonization challenges, a more stable and industry-supportive roadmap could potentially include the following:

Policies that boost the ZE truck business case by improving TCO
The policies below could improve the relative TCO of a zero-emission versus diesel truck by between 10% and 20%:[28]

– Purchase subsidies for ZE trucks

– Carbon taxes or credits on vehicle emissions (indirectly impacting truck operators)

– Road toll exemptions for ZE trucks or penalties for diesel trucks, such as increased taxes or driving bans/fines in city centres (assuming appropriate ZE truck alternatives are available)

Policies that reduce the risk of infrastructure deployment
These types of policies can decrease the upfront capital needed through subsidies and grants or provide some form of future revenue certainty. Currently, most take the form of subsidies or credits for infrastructure capex. Examples include:

– Grants that cover up to 75% (or €200,000) of infrastructure purchase and installation costs[29]

– Tax reductions on electricity rates for companies that provide commercial EV charging[30, 31]

– Additional policies that could indirectly guarantee infrastructure revenue or operating expenses; for example, governments could guarantee utilization l evels in the early stages of the transition

3.2 Innovative leasing products and reducing residual value uncertainty

Two major impediments to financing ZE trucking occur at the beginning and end of the ownership period – acquisition and end-of-life. Unlocking the following solutions can lead to breakthroughs:

Acquisition solutions

Innovative vehicle-leasing models delivered by groups of key industrial players can support the deployment of ZE trucks at scale (see Box 3). Ecosystem participants can collaborate to deliver solutions, sharing risk across stakeholders.

BOX 3

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

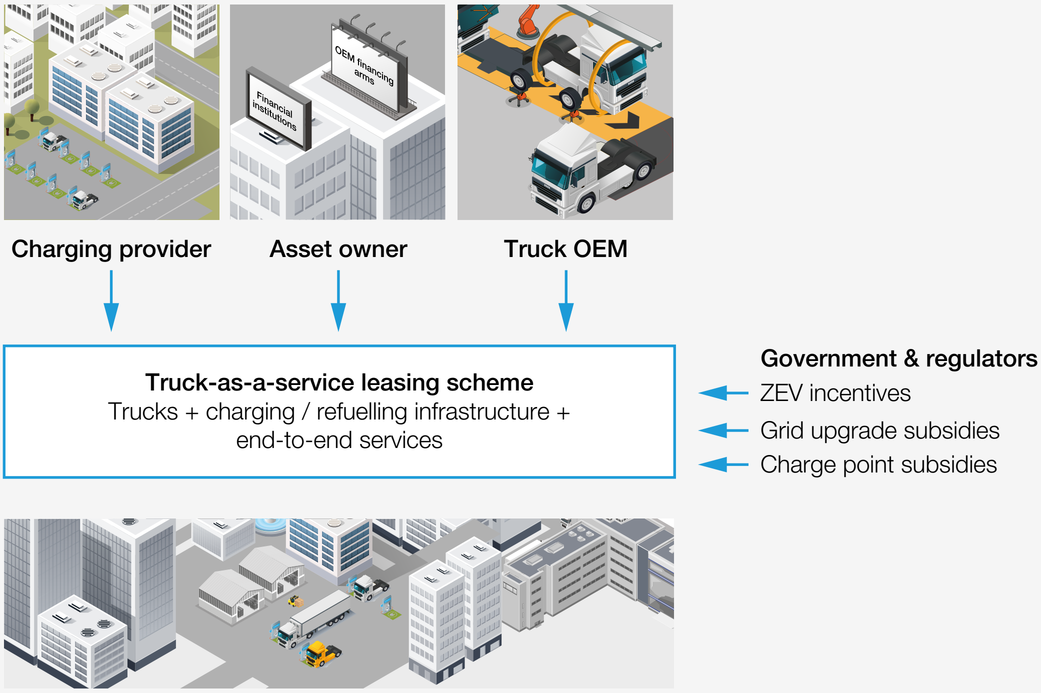
Institutional investor partnerships with forward-thinking OEMs and transport players can also be established in the form of Special Purpose Vehicles (SPVs) to help provide significant long-term financing options. The SPV would employ investor capital to purchase vehicles and infrastructure assets and lease an all-in-one solution to fleet operators. Governments can de-risk the investment for investors by, for example, offering guarantees. From a fleet operator perspective, capex becomes opex and stakeholder risk becomes more diversified. Other Forum/MPP initiatives on transition finance are focused on linking major pools of capital to transportation decarbonization efforts.

The industry assumes leasing will grow in the transition to ZE trucks, since few fleets will willingly take on resale risk through direct truck ownership. A variety of innovative models could emerge, including dynamic pay-per-mile leasing schemes and truck-as-a-service offerings:

Dynamic pay-per-mile leasing schemes reduce the risk for fleet operators, as the leasing payment (partially) reflects usage. Low utilization will not result in losses in the same way that a monthly leasing fee would, potentially helping smaller fleets move to ZEV technologies. Daimler Trucks, for example, is currently providing dynamic leasing options, linked to their goal of growing services revenues from 30% today to 50% by 2030.[32]

Truck-as-a-service offerings enable fleet transitions by providing full-service cover on maintenance, repairs and other operational changes, in addition to vehicle and infrastructure investments (see Figure 6). Partnerships between energy players and global truck makers would source and deliver renewable hydrogen to power fuel cell trucks leased by the truck makers via pay-per-use contracts. For battery-electric trucks there already are offerings on the market. For example, Volta Trucks, a start-up in the medium-duty urban truck market, is promoting their truck-as-a-service solution where "for a single monthly fee, customers will have access to the vehicle, charging infrastructure and all of its servicing, maintenance, insurance and training requirements".[33]

FIGURE 6 | Truck-as-a-service for distribution use cases



Source: McKinsey Center for Future Mobility

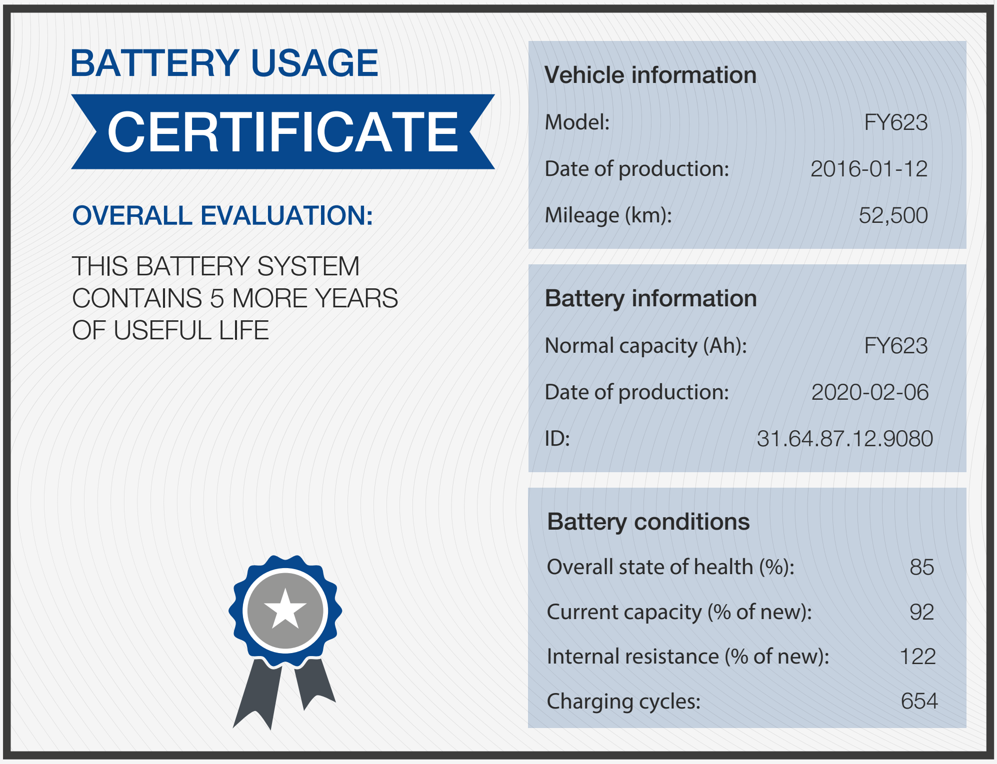
End-of-life solutions

Move the risk of failure away from asset owners by offering extended battery or fuel cell stack warranties to cover replacement costs over the initial ownership period. The light commercial vehicle segment is currently experimenting with this model. Alternatively, truck makers and financial investors could provide a battery-as-a-service (BaaS) offering for end-customers on a monthly subscription basis. Today, companies are trialling BaaS schemes for EV passenger cars based on annual mileage.

Increase the end-of-life value of batteries to raise their residual value floor and give truck makers and their financing arms greater confidence when setting lease prices at competitive levels. Several vehicle makers are collaborating with battery suppliers and others to boost end-of-life battery values, with several launching their own recycling ventures.

Applied battery usage data and analytics can extend battery life and provide more accurate residuals. Fleet data collection and analytics on driving and charging behaviour can help mitigate battery degradation. Standardized battery condition and ageing assessments, provided as certificates, are ideal for determining residual value for warranty management and resale (see Figure 7).

FIGURE 7 | **Example of a battery usage certificate**



Source: McKinsey Center for Future Mobility

3.3 Industry consortia to aggregate demand and de-risk infrastructure roll-out

Reduce capex and focus on future economics to improve infrastructure economics

Industry consortia should plan and deploy ZE trucks and infrastructure – a model already being applied in over 25 ZE truck pilots across Europe. For example, the Port of Rotterdam/Air Liquide-led consortium announced the development of a hydrogen corridor with 25 refuelling stations and 1,000 trucks by 2025 to connect Netherlands, Belgium and West Germany.

In another 2021 example, Daimler Truck, TRATON and Volvo formed a joint venture to create a high-performance public charging network for heavy trucks with the stated goal of investing €500 million to deploy 1,700 charging points across major highways and key logistics destinations.[34]

Such pilots serve as models for larger deployment as TCO improves. RFZ aims to codify learnings to enhance effective replication and scalability across other corridors.

Speeding up infrastructure deployment through faster planning and permitting

Governments can streamline permitting processes to enable rapid ZE truck infrastructure upgrades and purchase land for infrastructure in strategic locations. Grid capacity and permitting for EV charging should become fast-tracked to accelerate grid extension and reinforcement projects.

For near-term hydrogen refuelling, trucks will ship H_2 to refuelling stations from centralized hydrogen production facilities. Longer-term, pipeline infrastructure will most likely follow, requiring coordination at the EU and international levels. For example, in 2021, IVECO, Nikola and OGE followed this with a second agreement to support the creation of hydrogen pipeline networks and fill-station build-out in Europe.[35]

4 Priority pathways to accelerate ZE truck rollout

The challenges in decarbonization vary greatly by use cases - two pathways were identified for greatest near-term impact

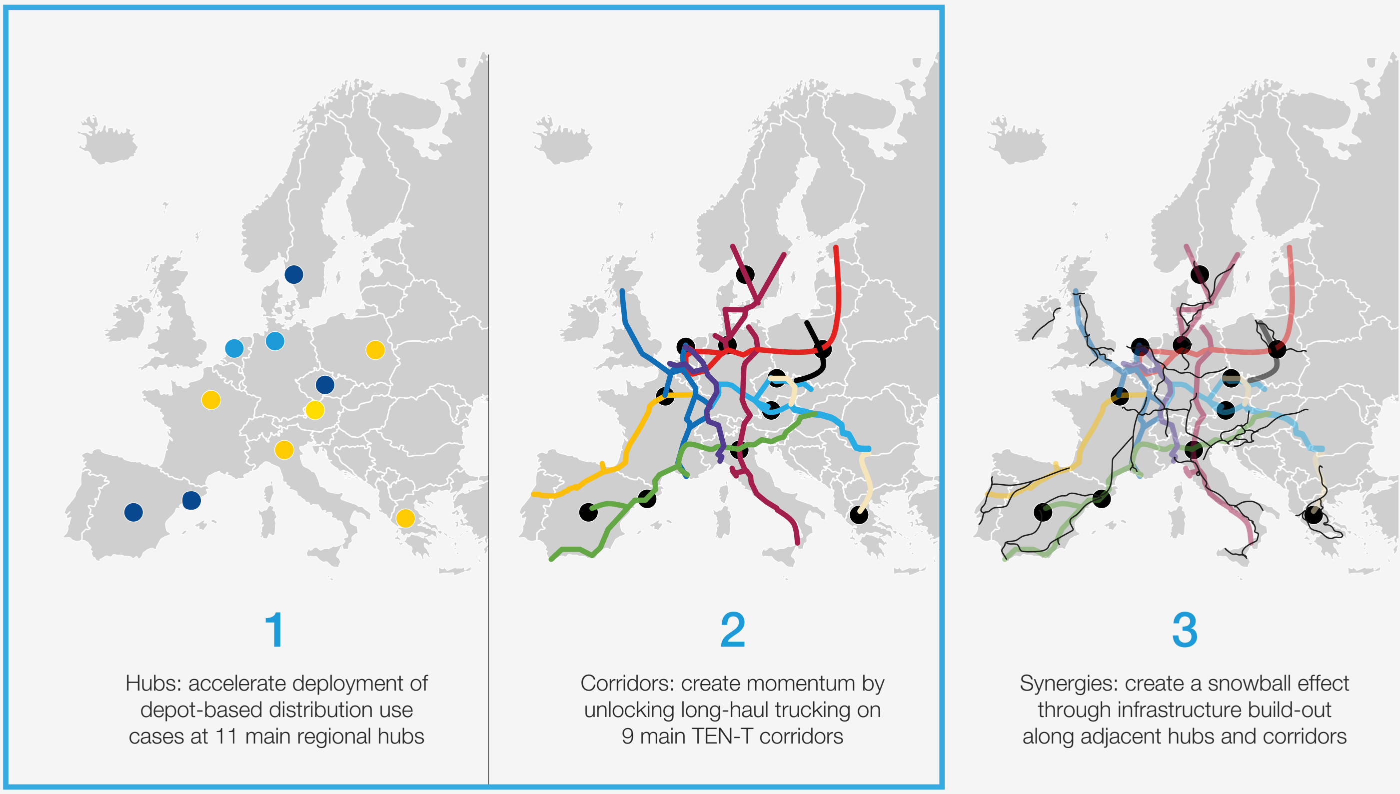
While the TCO tool allowed a comprehensive quantitative analysis of the transport database provided by Forum partners, RFZ sought to understand which priority use cases would have the greatest near- to mid-term applicability and decarbonization impact. Based on prioritization by Forum partners, with input collected through in-depth discussions, workshops and an online survey, RFZ partners selected the two highest priority use cases or pathways, which offered both the top barriers and opportunities (see Figure 8):

1. **Short-haul routes around regional hubs:** depot-based distribution using medium-duty trucks around 11 main regional hubs

2. **Long-haul routes along high-traffic corridors:** long-haul freight using heavy-duty trucks, along nine principal European corridors

These two priority pathways are explored in more detail below.

FIGURE 8 **Priority pathways selected by RFZ partners**



Source: McKinsey Center for Future Mobility and World Economic Forum

As represented in image 3 of Figure 8, although our analysis treats these use cases separately, there are substantial synergies or "snowball effects" to be gained by prioritizing both these opportunities simultaneously, such as:

- Decarbonizing depot-based distribution with competitive TCOs will lead to the creation of more decarbonized hubs across Europe

- Such hubs can build operator experience and confidence in the use of ZE trucks and spur the build out of significant depot infrastructure

- The next routes slated for decarbonization will most likely be long-haul corridors along the main Trans-European Transport Network (TEN-T) highways, which will begin to link hubs together

- Once stakeholders decarbonize many long-haul routes, they will have deployed significant infrastructure that can help facilitate on-demand use cases to decarbonize

As noted above, the European Automobile Manufacturers Association (ACEA) has analysed how infrastructure build-out may evolve in EU. Based on their research, charging infrastructure will mostly consist of 350kW DC at fleet hubs and along key corridors up to 2025. By 2030, there could be further differentiation, with a combination of high-power (>500kW) public and destination chargers and lower-power (100 kW) chargers for overnight charging. ACEA estimates that by 2030, there should be a charger for roughly every three BEV trucks and an H_2 fill station for roughly every 60 FCEV trucks.[36]

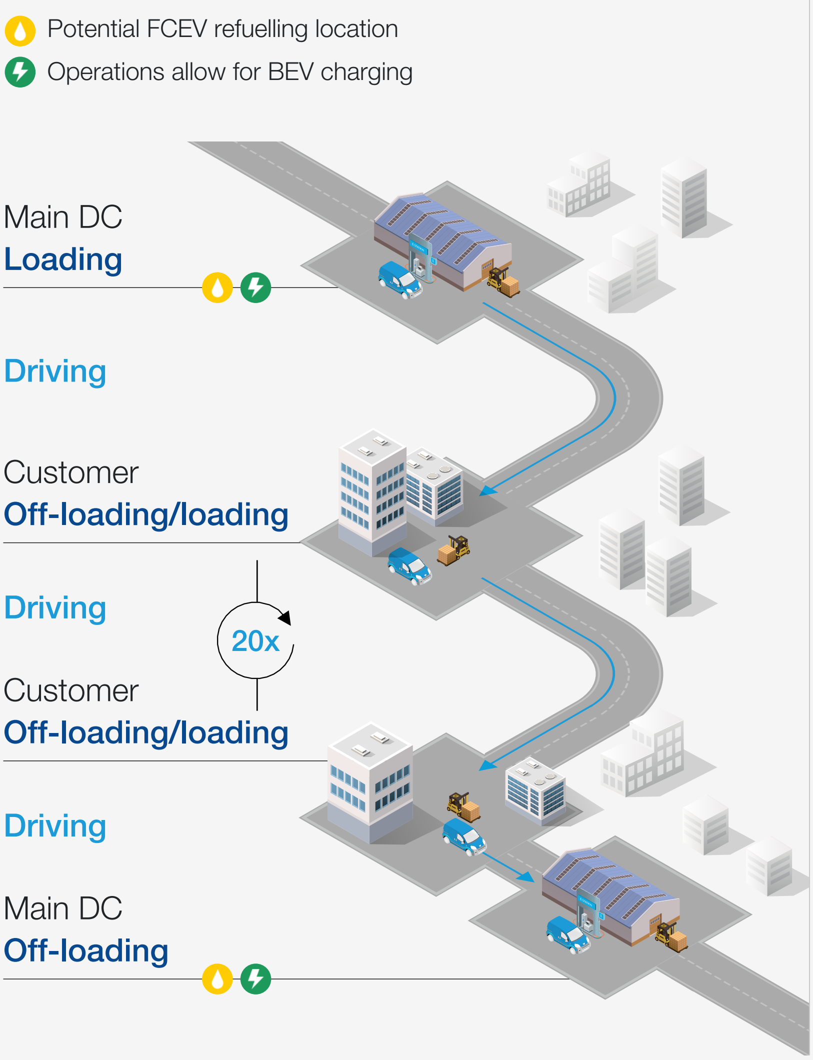
4.1 Short-haul routes around regional hubs

This first priority pathway focuses on accelerating the deployment of zero-emission trucks and infrastructure on local and regional delivery routes. This “sure thing” use case is the closest to near-term economic viability, but still requires transition support to achieve sufficient acceleration.

Typically these are short-haul deliveries using medium-duty trucks operating out of regional depots up to a daily range of about 200km. The trucks return to the same depots each day with high route predictability (see Figure 9). This reduces demand uncertainty for both infrastructure and trucks. The upfront capex investment for the trucks themselves will be lower than for long-haul trucks, due to their lower payload and range requirements, allowing the use of smaller batteries.

FIGURE 9 **Activity pattern and operations of depot-based short-haul distribution**

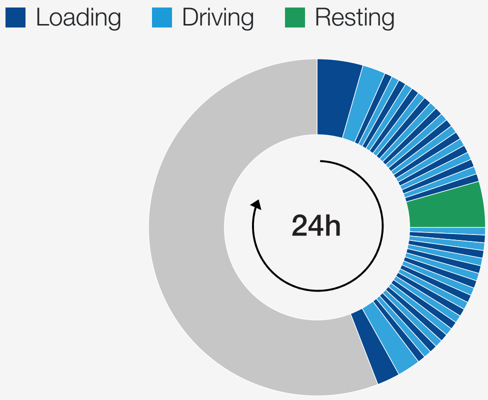
Activity pattern



Details on operations

Typical usage pattern

~11h operations per day (1 driver)



Route description	Pick-up and delivery, milk-runs High predictability
Typical payload	5-8 tonnes
Vehicle spec.	Rigid box truck (16 tonne GVW)
Typical goods	Consumer goods, industrial goods
Operator structure	Private fleet

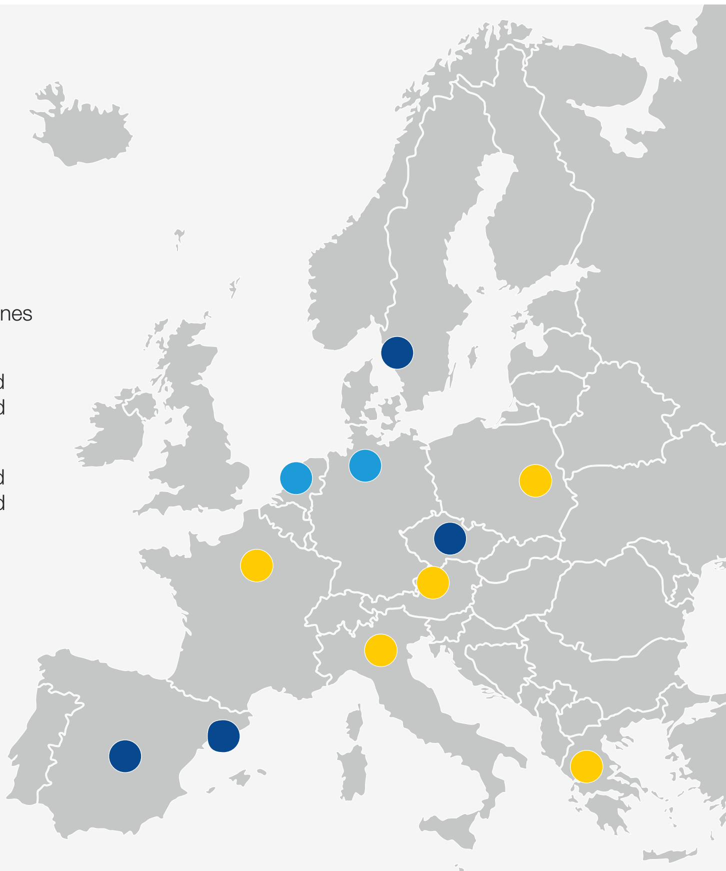
Source: McKinsey Center for Future Mobility and World Economic Forum

In the case of Europe, we have identified 11 major European regional distribution hubs around which the deployment of zero-emission trucks and infrastructure could be accelerated (see Figure 10).

FIGURE 10 **Road freight load around 11 European regional distribution hubs**

Hub[1]	Annual national freight load, road transport 2030 tonnes (million)
Barcelona, Spain	95 - 96
Madrid[2], Spain	76 - 77
Stredoceský kraj, Czech Republic	56 - 57
Västra Götalands län, Sweden	50 - 51
Groot-Rijnmond, Netherlands	46 - 47
Hamburg, Germany	42 - 43
Warsaw, Poland	34 - 35
Paris, France	31 - 32
Grevena, Kozani, Greece	30 - 31
Milan, Italy	24 - 25
Linz, Austria	24 - 25
Total	**500 - 520**

- Hubs with > 50 million tonnes of road freight transport
- Hubs with > 40 million and < 50 million tonnes of road freight transport
- Hubs with > 20 million and < 40 million tonnes of road freight transport



1 Top hub selected for 10 most active European countries in national road freight, plus Madrid and excluding the UK as not part of EU
2 Madrid added on top of Barcelona as it aggregates important fleet hubs of the country and has a key strategic positioning for road freight
Source: McKinsey Center for Future Mobility and World Economic Forum

Pathway for transition to zero-emission trucks in medium-duty segment (short-haul)

A key challenge in decarbonizing road freight is to reduce the total cost of ownership for zero-emission trucks. Figure 11 illustrates one potential pathway for ZE truck deployment in distribution use cases for 16-tonne trucks by 2022, using battery electric vehicles (BEVs) as the example technology.

Below are four possible levers or solutions to bridge the TCO gap in this use case for short-haul MDTs:

1. **City governments incentivize local fleet owners and operators to switch to BEV trucks**

– Governments give a €24,000 subsidy per truck on the purchase/lease price

– Governments give BEVs a 50% discount on road tolls

– Low-emission zones (LEZ) ban diesel trucks or charge entry fees (e.g. €60 per day) for access to defined urban areas

2. **Truck OEMs, financial institutions, infrastructure developers and energy providers partner to form a bundled leasing scheme for fleet operators**

– Pay-per-mile and truck-as-a-service offerings can rapidly drive scale, as fleet operators implement BEV technologies for their highly predictable routes

3. **Local governments and planning authorities coordinate with energy providers to finance and roll out grid capacity upgrades for charging depots**

– Governments provide a subsidy of €30,000 per truck towards the capex of charge-point infrastructure

– Governments finance electricity grid upgrades at charging depots

4. **End-of-life batteries are replaced, covered by warrantee, and enter circular recycling or refurbishment programmes**

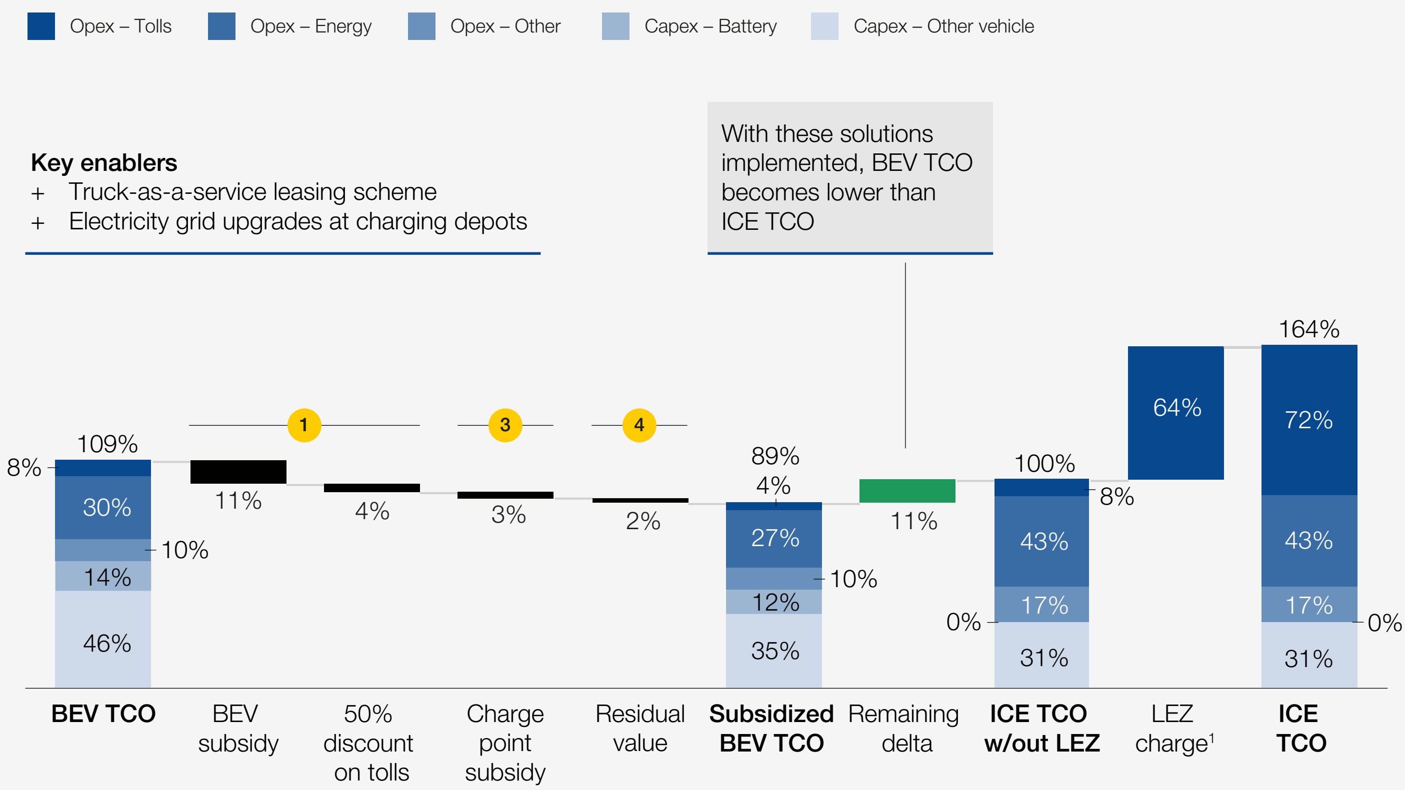
– BEV lessor makes an agreement with a company purchasing used batteries at favourable prices

– Recycling/repurposing companies receive tax breaks to incentivize scaling

– Dedicated battery refurbishment schemes will increase expected battery residual value by 10%

This combination of four moderate TCO levers (at levels already seen) can move the total cost of owning a BEV truck by 20 percentage points, from 9% more expensive than an internal combustion engine (ICE) truck to 11% cheaper by 2022 – for short-haul depot-based distribution. As can be seen in Figure 11, an LEZ charge for diesel or petrol vehicles alone would significantly swing the TCO case in favour of BEVs.

FIGURE 11 **Measures to tip the total cost of ownership in favour of battery electric trucks for short-haul depot-based distribution**



1 London style LEZ charge, charging additional daily fees for high-emission vehicles

Source: McKinsey Center for Future Mobility and World Economic Forum

4.2 Long-haul routes along high-traffic corridors

The second priority pathway focuses on accelerating the roll-out of ZE trucks and infrastructure to tackle the “big” emissions of heavy-duty trucks along major long-haul transit corridors. These high-traffic routes show potential to abate a significant portion of heavy trucking CO_2 emissions. However, to achieve results will require a greater level of stakeholder coordination.

These long-haul corridors generally involve two types of use cases:

– On-demand freight that involves unpredictable trips across various routes

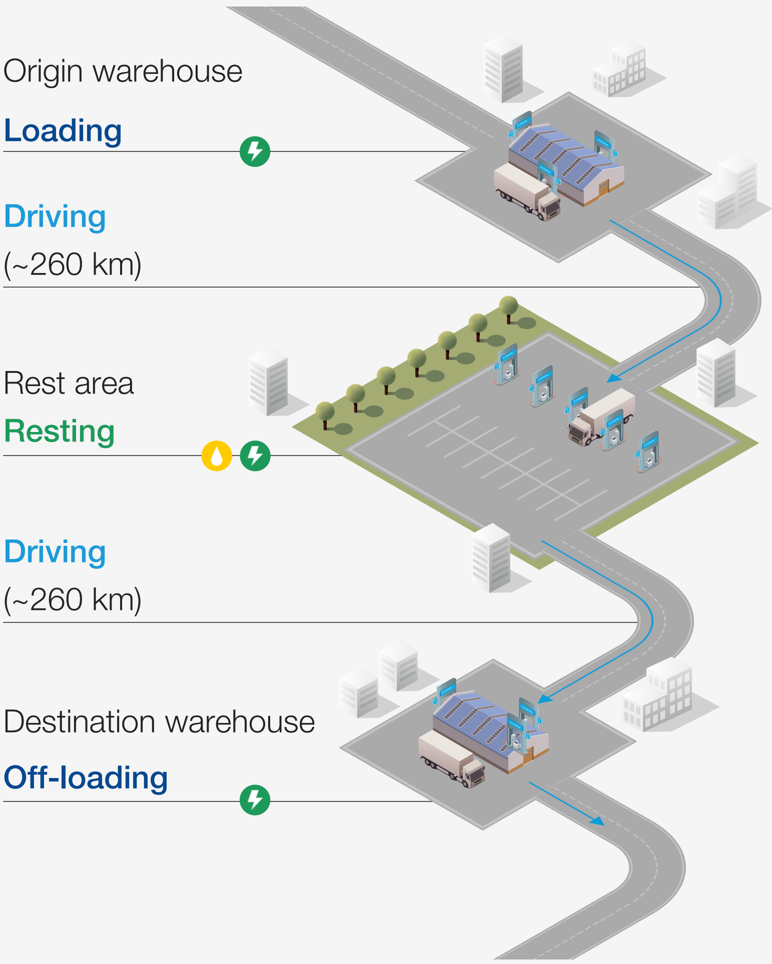
– Line-haul freight that involves predictable point-to-point trips along set routes

Due to its predictability, line-haul is easier to decarbonize and is therefore the subject of this analysis. Typically, line-haul freight covers an approximate daily range of 500km, along predictable highway routes (see Figure 12).

FIGURE 12 **Activity pattern and operations of long-distance line-haul road freight**

Activity pattern

Potential FCEV refuelling location
Potential for BEV charging location

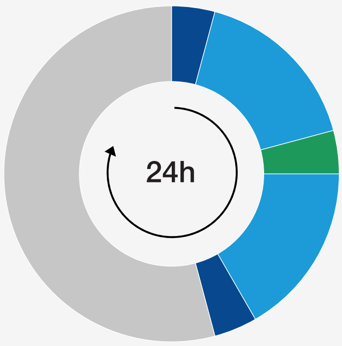


Details on operations

Typical usage pattern

~10h operations per day (1 driver)

Loading Driving Resting



Route description	Point-to-point trip, mostly on highway High predictability
Typical payload	25 tonnes
Vehicle spec.	Heavy-duty tractor with semi-trailer (40 tonne GVW)
Typical goods	Consumer goods, industrial goods
Operator structure	Mostly third-party logistics (3PL)

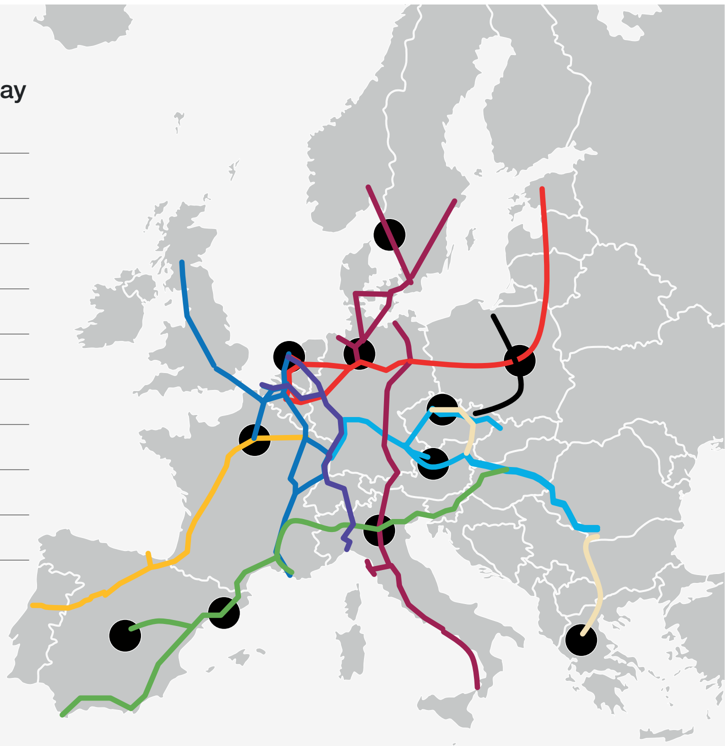
Source: McKinsey Center for Future Mobility and World Economic Forum

By focusing on the top nine European long-haul corridors, fleets can cover 20% of the TEN-T road network (see Figure 13). Decarbonizing these lanes could serve as the major starting point for achieving ZE truck status more broadly for all European road freight. However, these networks span a much larger group of stakeholders and therefore require more coordination for deployment.

FIGURE 13

Road freight load along nine main European TEN-T corridors

	Length km	HDT movements per day #
Scandinavian-Mediterranean	~4,650	11,500 - 12,500
Mediterranean	~3,370	9,500 - 10,500
North Sea-Baltic	~2,500	9,500 - 10,500
North Sea-Mediterranean[1]	~2,480	13,000 - 14,000
Rhine-Danube	~2,070	11,500 - 12,500
Atlantic	~1,900	9,000 - 10,000
Rhine-Alpine	~1,600	13,000 - 14,000
Baltic-Adriatic	~960	6,500 - 7,000
Orient-East Mediterranean	~690	9,500 - 10,500
Total	**~20,200**	



1 Although the UK is not part of the EU and of the TEN-T network anymore, the corridor was kept on the map as it draws a very high density of long-haul HDTs.

Source: McKinsey Center for Future Mobility and World Economic Forum

Pathway for transition to zero-emission trucks in heavy-duty segment (line-haul)

The following analysis looks at one potential pathway for the deployment of zero-emission heavy-duty (40-tonne) trucks in line-haul road freight by 2025, using both BEVs and FCEVs as the example technologies (see Figure 14).

There are five possible levers or solutions to bridge the TCO gap in this use case:

1. **Governments incentivize fleet owners and operators to switch to ZE trucks**

– Governments give €24,000 subsidy per truck on the purchase/lease price

– Governments give ZE trucks a 50% discount on road tolls

2. **Key corridors and lanes are identified for ZEV roll-out through industry consortia**

– Customers and fleet operators facilitate aggregation and public sharing of logistics route plans

– Governments augment this via binding targets for roll-out of hydrogen refuelling/electric charging infrastructure

3. **Infrastructure developers plan and deploy required hydrogen refuelling/electric charging stations**

– Governments and planning authorities establish fast-track permission process and pre-purchase land ready for infrastructure

– Governments provide subsidy towards infrastructure capex (e.g. €30,000 per truck towards charge point/fill station)

4. **In parallel with infrastructure planning, fleet owners jointly make binding purchase agreements on ZE trucks**

– Several ownership models (e.g. pay-per-mile, truck-as-a-service offering) can facilitate this

– Bundling subscriptions to ZE charging/refuelling infrastructure can also help reduce the demand risk for infrastructure developers

5. **End-of-life batteries are replaced, covered by warrantee and enter circular recycling or refurbishment programmes**

– BEV lessor makes an agreement with a company purchasing used batteries at favourable prices

– Recycling/repurposing companies receive tax breaks to incentivize scaling

– Dedicated battery refurbishment schemes will increase expected battery residual value

This combination of five moderate TCO levers (at levels already seen) can move the total cost of owning a BEV truck by 21 percentage points, from 12% more expensive than an internal combustion engine (ICE) truck to 9% cheaper. For an FCEV truck, the swing is 20 percentage points, from 19% more expensive than an ICE truck to 1% less. This data is for line-haul road freight applications, by 2025.

FIGURE 14

Measures to tip the total cost of ownership in favour of BEVs or FCEVs for heavy-duty trucks in line-haul road freight

1 Infrastructure subsidy assumed on a per-truck basis, for consistency with BEV. In practice, potential incentives for hydrogen infrastructure will likely be directed at energy providers, with truck operators benefitting indirectly through lower hydrogen costs.

Source: McKinsey Center for Future Mobility and World Economic Forum

5 Recommendations for key actors

Decarbonizing road freight requires support from the whole trucking ecosystem

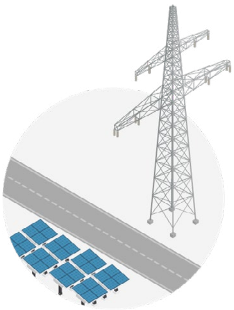
The goal of decarbonizing the road freight transport sector at the speed and scale required by the science of climate change can only be achieved with a multi-stakeholder approach in which all sectors and actors collaborate to play their part. Based on a year of research and analysis conducted with our RFZ partners, we would like to make the following recommendations for action by key sectors.

Policy-makers

Policy-makers could design a structured – and proactively communicated – **policy framework** for the roll-out of ZE trucking in Europe and other markets globally. Industrial and financial stakeholders would benefit from greater clarity and certainty on the direction of government policies that will inform calculations around total cost of ownership (TCO) economics. For long-haul use cases across priority TEN-T corridors, policy will serve a critical role in cross-border infrastructure coordination.

Building on the European Commission's "Fit for 55" decarbonization goals, member states could prepare to set **binding targets** on infrastructure build-out and enact supporting measures to push ZE truck sales, adjust road tolls and consider low-emission zones within urban areas.

Policy-makers could also create visible **funding mechanisms** for hydrogen production and distribution, electricity rates, and primary and secondary infrastructure build-out, to move the needle early on TCO parity and create industrial consortia for a ZE truck roll-out.



Energy and infrastructure companies

Energy and infrastructure companies should forge partnerships with truck makers, financial institutions, logistics operators and local governments to plan and **deploy primary infrastructure** as well as grid upgrades across key emissions-intensive corridors. They should create the right rebates and rate structures to facilitate this deployment.

They could also capitalize on new business opportunities and **technology developments** in cell chemistry and packaging to help resolve some residual value uncertainties.

Financial institutions

Captive and independent financing companies should accelerate the development of **innovative leasing models** to support fleets across the transition period, through the provision of vehicles, infrastructure and end-to-end support services. They should collaborate with truck OEMs, energy and infrastructure providers, logistics operators and governments to offer compelling returns, distribute risk and explore pay-per-mile and truck-as-a-service leasing schemes to allow for transition flexibility.

Financial institutions could also create **environmental, social and governance (ESG) funds** focused primarily on supporting the expansion of ZE trucking and infrastructure.

Truck makers

Truck manufacturers should invest in solutions to **mitigate ZE truck residual risk**, via battery-as-a-service offerings, refurbishment programmes and other approaches. They should collaborate with financing arms and financial institutions, as well as with energy and infrastructure players, to offer consolidated leasing packages.

They can develop **common standards for high-power charging** and establish or support the creation of such charging networks along critical high-use routes. It also makes sense for truck makers to push product-optimization initiatives around energy consumption and energy throughput to support lighter batteries (addressing TCO) and battery lifetime mileage (addressing residual value concerns).

Transport customers

We expect that a large incentive to decarbonize will come from transport customers demanding more sustainable shipping methods. Transport customers should **clarify their commitments to decarbonize** and compel their transport providers to follow suit. One effective approach involves cascading sustainability targets down to suppliers to ensure brokers and fleet owners feel pressure to decarbonize.

Logistics players and fleets

Logistics companies with large fleets should **pilot ZE truck adoption** in clusters, regions and transport lanes, working jointly with others to participate in vehicle and infrastructure financing schemes. Shippers can market low-cost CO_2 abatement to end-customers. Freight forwarders can differentiate products to new and existing customers, creating demand for pooled ZE truck fleets. Likewise, fulfillment and parcel players can incorporate sustainability into their planning processes, which can then be mostly driven by cost and quality considerations.

The public and consumers

Like-minded members of the public can push decarbonization through their **purchasing decisions** (e.g. opting for carbon-neutral shipping) and supporting infrastructure projects to enable ZE truck adoption.

World Economic Forum

The World Economic Forum will continue to build strong **cross-stakeholder engagement** and commitment to drive these initiatives. Overcoming most of the infrastructure and financing barriers will require synchronized effort across actors. The Forum will also build synergies between the work of the Road Freight Zero initiative, the Financing the Transition to a Net Zero Future platform, our Mission Possible partners, and Material Economics, one of RFZ's knowledge partners, to integrate the approaches to road-freight decarbonization discussed here.

Conclusion

After nearly one year of work with Road Freight Zero partners, conducting numerous surveys, market research and workshops, RFZ concluded the following:

- While there is significant action on ZE trucks, the EU needs significantly more trucks deployed to meet climate goals by 2030, compared to the current course and speed of roll-out
- The need for infrastructure roll-out of charging points and H_2 fill stations is significant and requires major acceleration
- Today`s financing offerings are not sufficient for the sector transition to ZE trucks and related infrastructure - but this can rapidly change with the right coordinated effort
- More collaboration is needed to pave the way forward beyond pilots, into mass deployments, which can be scaled up even more by 2030 and beyond, with each player in the value chain playing a critical role

Furthermore, RFZ's solution pathways modelling provides an excellent fact-based approach to explore the nuances of these use cases and engage directly with transport companies to map out decarbonization journeys, with the goal of cracking some of the most difficult "chicken or egg" issues.

Achieving ambitious truck-related decarbonization goals set by policy-makers and the ZE truck deployment goals set by public sector players will require a coordinated response across stakeholders. The good news is that these actions can happen right now, including:

- Advocating for a stable and ambitious policy framework for MDT and HDT
- Ensuring financiers are aware of long-term plans and redefine how capital can be geared towards ZE truck and infrastructure deployment goals
- Engaging with like-minded business partners, sharing best practices and sponsoring innovative projects that improve coordination of trucks, infrastructure and demand

The time to act boldly is now, with the opportunity to move beyond pilots to full-scale operational deployments, to strengthen demand signals across all transport buyers, to incentivize faster truck and infrastructure investments and to create financial models that can drive a step-change in capital deployment to decarbonize truck transport.

Collectively, all players must make concrete plans to support these zero-emission trucking pathways. The World Economic Forum and its partners have observed early action plans starting to emerge and the Road Freight Zero initiative will strive to accelerate these in year two of its work programme.

The Forum encourages all readers of this report to join these ambitious and important efforts!

Acknowledgements

World Economic Forum

Shannon Engstrom
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RFZ partners

We would like to express our appreciation to all of our RFZ partners and in particular to those who contributed valuable use-case analysis for this report:

AB InBev

IKEA Supply

Kuehne + Nagel

Sennder

Unilever

Editing and design

Jonathan Walter
Editor

Laurence Denmark
Designer

Special mention

Special thanks go to Dr Christoph Wolff, a key contributor in his former role as Head of the Platform for Shaping the Future of Mobility at the World Economic Forum. His vision and guidance on the future of trucking led to the launch of the Road Freight Zero initiative. His expertise, critical feedback and thoughtful inputs to this report are sincerely appreciated.

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