4 Trucking industry net-zero tracker[137]

Battery and hydrogen-powered electric trucks are considered vital for net-zero trucking, but adoption depends on region, duty cycle and supporting policies.[138]

Key emissions data[139, 140, 141]

5%
Contribution to global energy related GHG emissions

1.6 $gtCO_2e$
Operational and fuel supply chain emissions

2%
Emissions growth (2019-2022)

108 gCO_2
Emissions intensity (emitted per tonne miles, 2020)

96%
Fossil fuels in the fuel mix (2021)

2-2.5 times
Expected demand increase by 2050

Readiness key takeaways

Technology
Two key zero-emission pathways are emerging, battery electric trucks (BETs) and hydrogen-electric trucks (HETs), which can nearly eliminate tailpipe emissions. Adoption is limited to around 1% partly due to increased ownership costs (33-133%[142]).

Infrastructure
Insufficient infrastructure, less than 1% of the needed amount, hinders technology scaling. Meeting 2050 goals requires a $2-$3.2 trillion[143] in investment, primarily into clean power infrastructure.

Demand
Zero-emission vehicles (ZEVs) held 1% of the market in 2022. A B2B green premium of 10-15% may be necessary, with about 1-3% affecting consumers.[144] However, this remains untested at scale.

Policy
Public policy encourages ZEV adoption, with the EU taking the lead, but the industry is diverse and regulated at various levels. More policies are needed to support infrastructure development.

Capital
Additional capital requirements, including retrofitting the existing fleet requires a $2.1 trillion[146] in investment. However, the business case remains weak due to high costs and uncertain returns, given 6% industry profit margins and a 10% WACC.[147]

Stated energy transition goals

– Industry bodies propose an emissions reduction of 14% by 2030 and 92% by 2050.[145]

Emission focus areas for tracker

Trucking emissions can be divided into two main categories:

1. **Well-to-tank** mainly upstream emissions from production and distribution of fossil fuels.
2. **Tank-to-wake** primarily due to combustion of fossil fuels, predominantly diesel, used during trucking operations.

Sector priorities

Exisiting transport

Reduce near-term emissions intensity by:

– Accelerating the adoption of drop-in biofuels and synfuels in the interim
– Introducing standards and regulations around legacy vehicle decommissioning cycles
– Making use of efficiency and design improvement opportunities at an accelerated pace.

Next generation transport

Accelerate clean power infrastructure development, to reduce absolute emissions by:

– Investing in R&D to accelerate ultra-fast charging infrastructure deployment
– Investing in clean power infrastructure to increase access to renewable energy sources
– Accelerating development of hydrogen-electric technologies for long-haul applications.

Ecosystem

De-risk capital investment to accelerate technology adoption by:

– Increasing incentive-based policies such as tax subsidies to drive charging infrastructure deployment
– Implementing a blend of policies to incentivize accelerated fleet renewal outside BAU cycles.

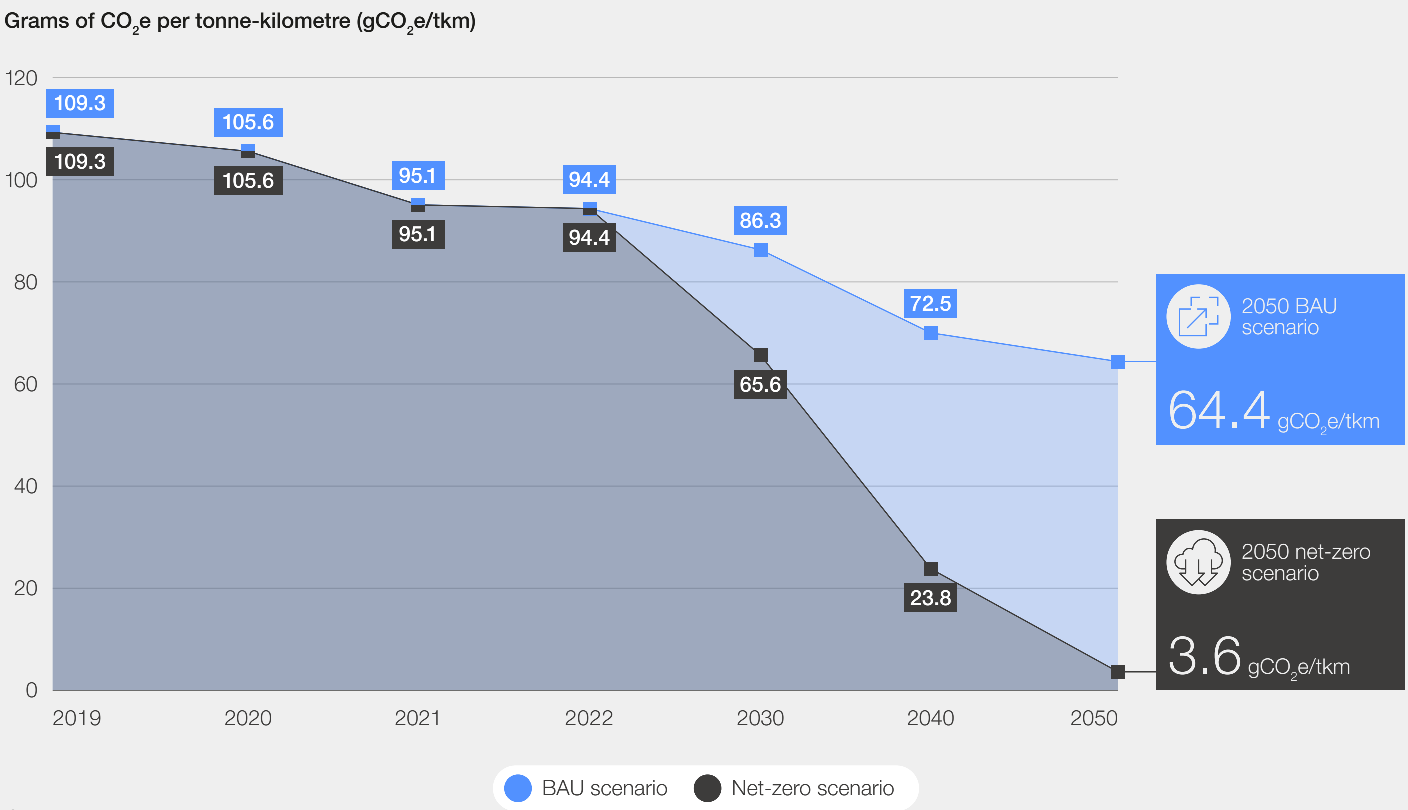
Notes: 1 The scope of analysis covers the hard-to abate aspect of the Trucking industry, primarily heavy-duty trucking **2** Regions in scope for trucking analysis, based on MPP framework; US, China, India, EU

Performance

Absolute emissions, measured by gigatonnes of CO_2 equivalent, are influenced by various factors such as fuel burn, load factors, vehicle type and route type. Currently, around 64% of the industry's total life cycle emissions arise from day-to-day operations, including vehicle use, maintenance and repair.[148] Addressing long-haul emissions could potentially decarbonize 86%[149] of the fleet in the EU. As BETs and hydrogen-electric trucks (HETs), scale up commercially, absolute emissions are expected to reduce almost equally between 2030-2040 and 2040-2050.

Emissions intensity in the trucking industry measures the amount of CO_2 released per gigajoule of energy generated through fuel combustion. This intensity is influenced by vehicle types and combustion rates. Over the last four years, emissions intensity has reduced by around 14% due in part to efficiency measures, operational improvements and an increase in biofuels in the fuel mix. Currently, BETs have a high emissions intensity due to the reliance on coal and other fossil-based fuels for power generation. However, as clean power scales up, emissions intensity is expected to approach zero by 2030. To achieve net-zero targets, the trucking sector should aim to reduce emissions intensity by roughly 30% by 2030 and approximately 80% by 2050.[150]

FIGURE 28 **Emissions intensity trajectory for trucking**



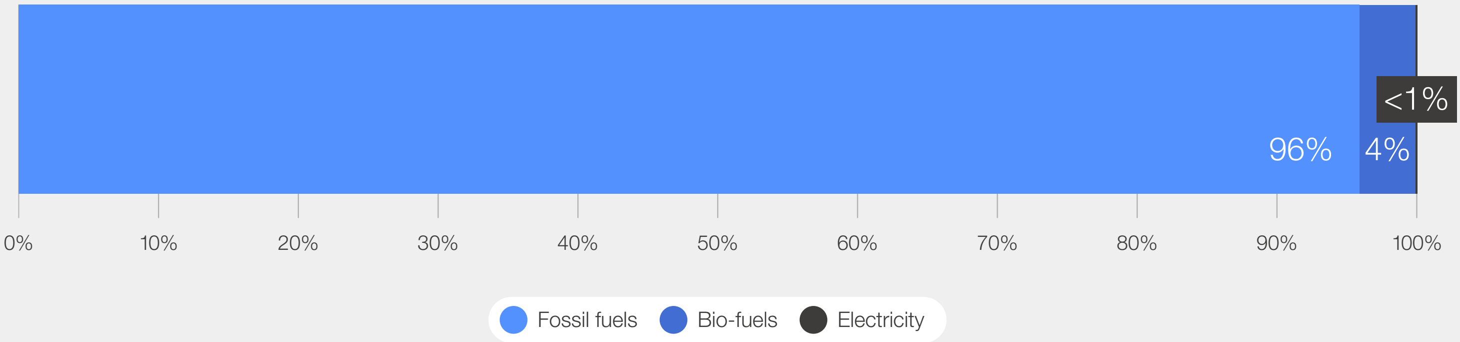
Source: IEA

Path forward

> Industry should prioritize investment in charging and refuelling infrastructure, R&D and stimulating market demand.

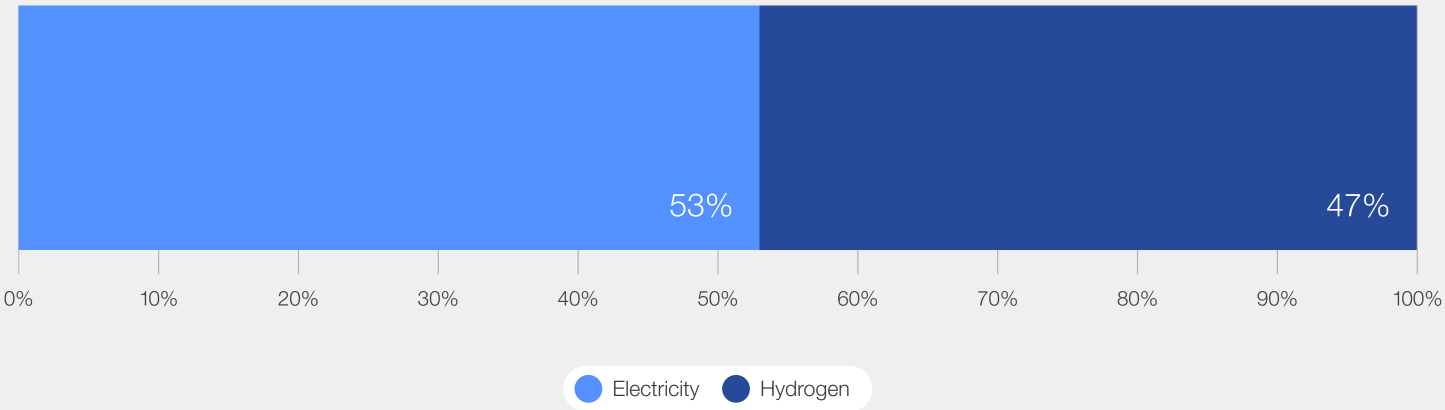
The key decarbonization strategy is to replace diesel combustion trucks with BETs, with HETs playing a smaller role. Immediate measures to accelerate emissions reduction include increased operational efficiency in transport and distribution, fuel efficiency measures and modal shift from trucking to rail. Achieving a predominantly ZEV fleet by 2050 requires collaboration among industry stakeholders, government and global advisers.[151] Priorities include investing in charging and refuelling infrastructure, advancing R&D for long-haul BETs and HETs, and stimulating market demand for zero-emission trucks (ZETs). These coordinated actions aim to accelerate infrastructure development and reduce overall ownership costs, promoting adoption throughout this decade. Despite the current dominance of fossil fuels in the fuel mix, a 53% emissions reduction is projected between 2030-2040 as commercial-scale BETs become widespread.[152]

FIGURE 29 | **2021 fuel mix**



Source: IEA

FIGURE 30 | **Proportion of new trucks sold in 2050 – MPP accelerated zero-emission scenario**



Source: MPP

TRUCKING

2 Technology

Two leading zero-emission pathways have emerged, with BETs being more advanced. HETs are expected to become commercially available by 2025. Both BETs and HETs have the potential to reduce in-transit emissions to near-zero. However, adopting these technologies could increase TCO by 33-133%,[153] depending on duty cycle and range.

The main challenges to widespread adoption include limited range, challenges in charging and refuelling infrastructure, and onboard storage restrictions, especially for long-haul applications. Consequently, adoption remains limited to around 1%.[154]

Propulsion technologies

1% of the global fleet are BETs

BETs and HETs have the potential to reduce life cycle GHG emissions by up to 84%[155] and tailpipe (tank-wheel) emissions to around zero. BET technology is currently commercially available for light and medium duty trucks, though adoption is low, at around 1%[156] of the global fleet. Hydrogen-electric trucks are not available at commercial scale, with expected availability around 2025.[157] However, sufficient onboard storage of clean hydrogen and large lithium battery capacity requires additional vehicle length, restricting the applicability to long-haul applications. While Adani Enterprises,[158] for example, signed an agreement with Ashok Leyland and Ballard Power to launch a pilot project in 2023 to develop a 55-tonne hydrogen fuel cell electric truck for mining applications, most projects are limited to the demonstration stage.

The implementation of BET and HET technologies includes a TCO increase of up to 1.3 times[159] due to the retrofitting requirements, fleet renewal requirements and necessary modifications to the existing fleet.

Charging and refuelling technologies

> Ultra-fast charging stations could reduce recharging from 8 hours to 45 minutes.

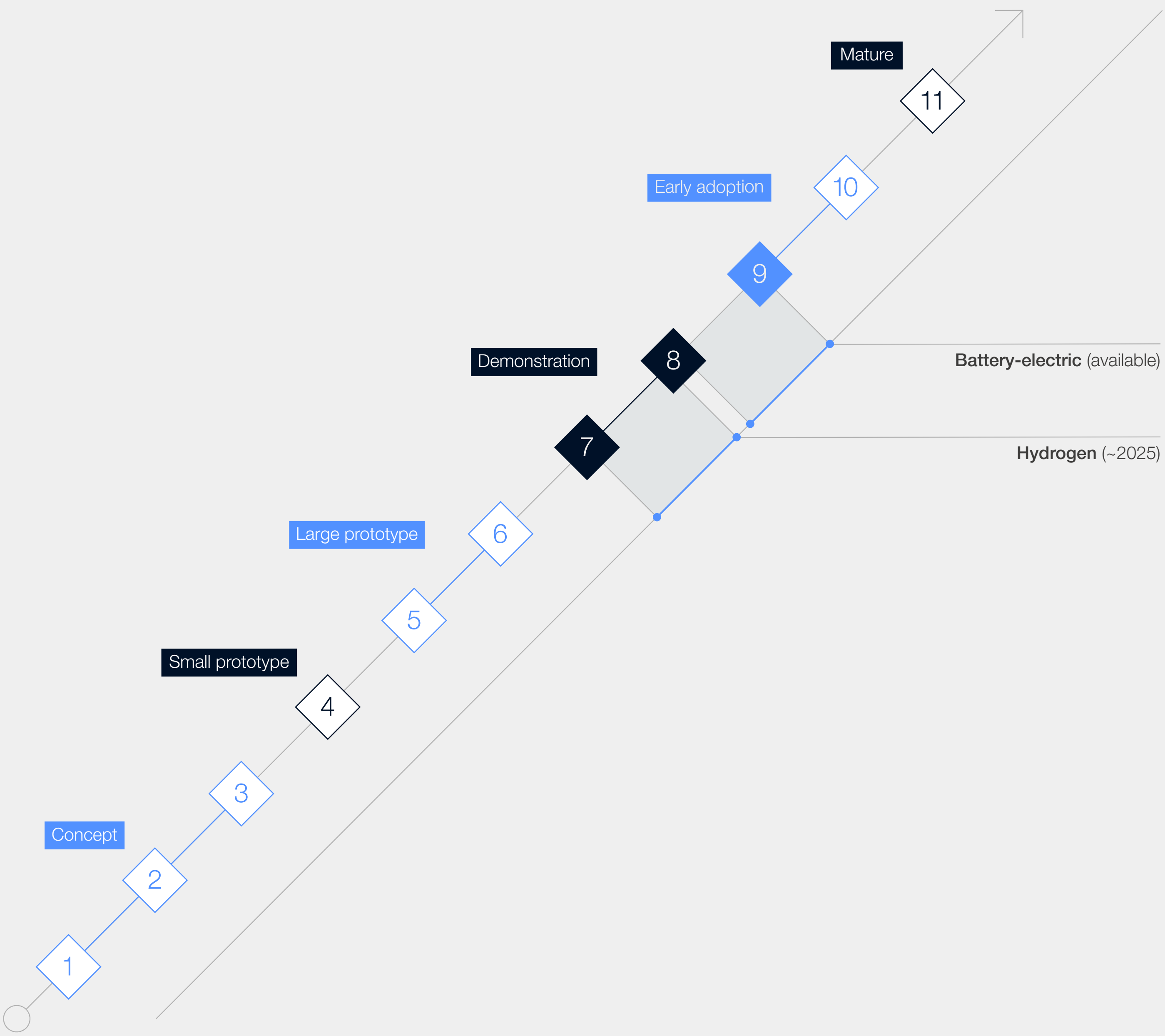
Recharging of BETs has yet to achieve commercial parity with the speed and convenience of refuelling diesel vehicles, charging can take up to 8 hours. While technology advancements have been made, with companies like bp announcing their first ultra-fast charging station aimed at recharging a heavy-duty truck (HDT) in 45 minutes, similar projects are generally limited to the demonstration stage.[160]

In comparison, refuelling with compressed hydrogen takes less than 20 minutes, which is almost comparable to existing diesel refuelling. However, applications are limited by onboard storage requirements.

Other intermediate measures

Transition fuels are less carbon intensive than legacy fuel sources, with emissions reduction potential ranging from 70-75%.[161] Renewable gas, synfuels and biofuels are commercially available today and are being adopted at a higher rate than low-emission technologies. However, these fuels are more emissive in terms of both absolute emissions and intensity than BETs and HETs, and in some cases are blended with fossil-based diesel.

FIGURE 31 **Estimated TRL and year of availability for key technology pathways**



Source: IEA

TRUCKING

2 Infrastructure

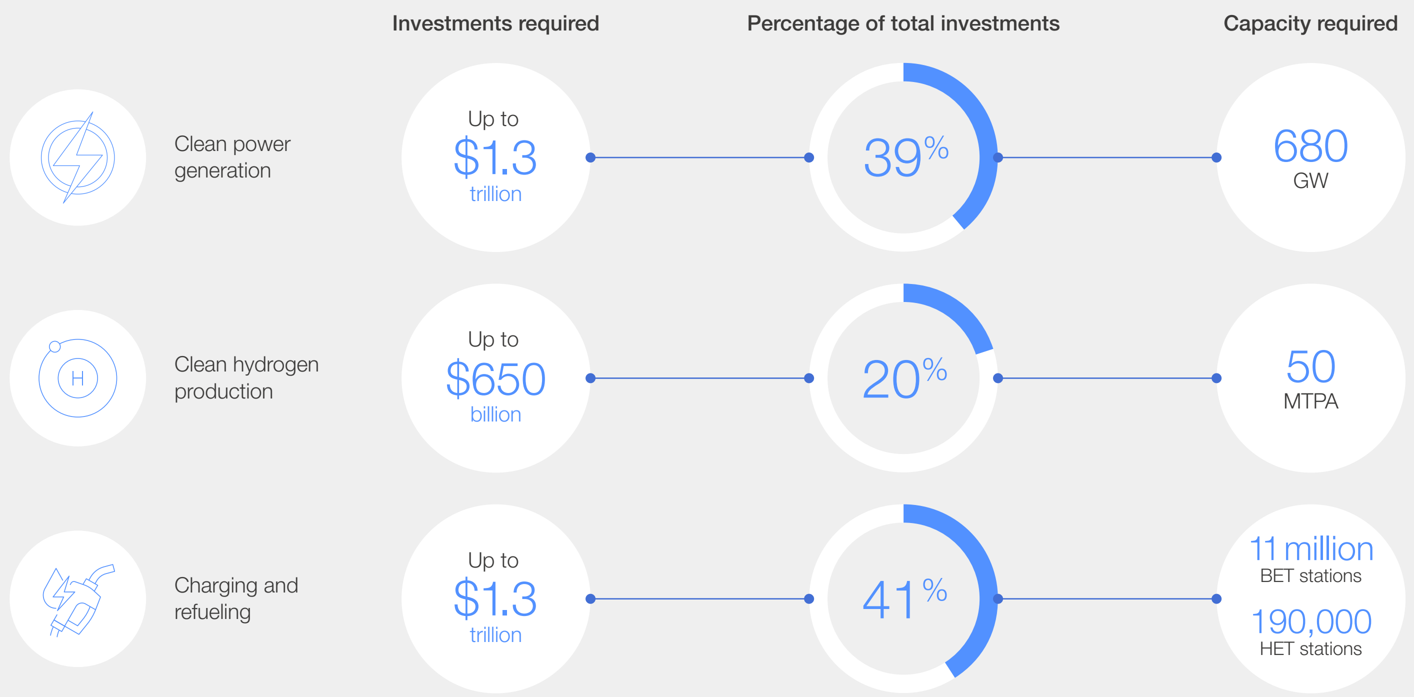
The commercial scaling of BETs and HETs hinges on the availability of crucial infrastructure. Currently, less than 1% of the necessary infrastructure is in place,[162] falling short of what's needed to enable the adoption of BETs and HETs. To enable the industry to meet 2050 targets, substantial investments ranging from $2.1 to $3.3 trillion[163] must be allocated within the trucking industry.

To support the projected target of 53% BETs and 47% HETs on the road by 2050,[164] the trucking industry will require a significant boost in clean power capacity. Specifically, this translates to approximately 8.5 times the current clean power capacity of the entire UK annually and a 54-fold increase in global clean hydrogen capacity.[165] The associated costs for this are estimated to be up to $1.3 trillion.[166]

For BETs to become feasible for medium and long-haul transport, they need access to charging infrastructure, both on-site and roadside. By 2050, an estimated 11 million charging stations will be required to meet the rising demand for BETs.[167] Some promising initiatives are under way in Europe, exemplified by Milence,[168] a joint venture between Volvo, Daimler and Traton, aiming to install at least 1,700 ultra-fast charging points across Europe by 2025. Companies like Siemens[169] are exploring alternative solutions to traditional wired charging, including overhead catenary charging and in-transit wireless charging,[170] which may provide a variety of options for future charging requirements.

HETs require access to onsite hydrogen refuelling infrastructure. To meet the demand for HETs by 2050, an estimated 190,000 refuelling stations will need to be established, incurring costs from $0.3-0.7 trillion.[171]

FIGURE 32 **Investments required for enabling infrastructure**



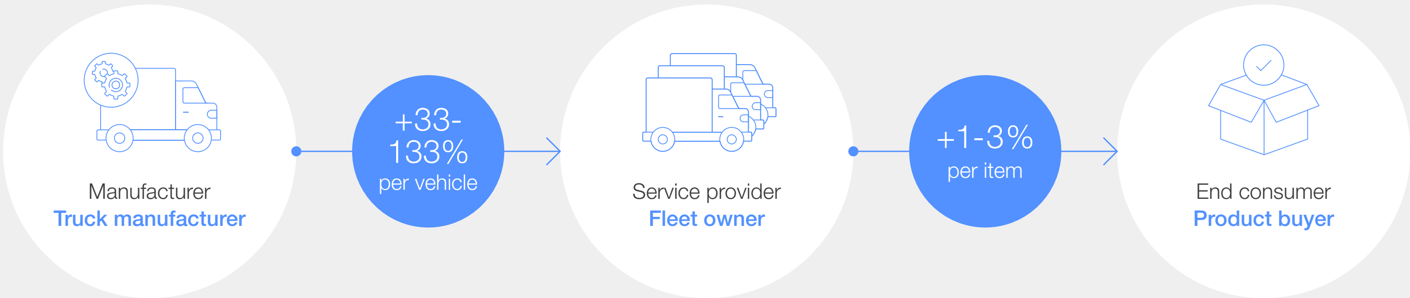
Source: Accenture analysis based on data from multiple sources to include MPP, IEA, IRENA and BloombergNEF

TRUCKING

2 Demand

In 2022, the market demand for ZETs stood at approximately 1%.[172] As such, the ability to absorb a 33-133% green premium for BETs and 100-300% HETs remains untested at scale, with HDTs attracting the higher end of this range.[173] The tight margins in logistics suggest the industry would struggle to absorb these premiums at commercial scale. Present adoption rates fall short of the industry's net-zero trajectory, where ZET sales are expected to constitute 100% of the 2050 net-zero scenario.[174] To stimulate demand, estimates suggest a green premium of 10-15% would be necessary to maintain ZETs affordability in the market. However, only a small portion of the price premium, around 1-3%, is expected to be passed to end consumers due to transport costs accounting for around 5% of a product's retail price.[175]

FIGURE 33 **Estimated B2B and B2C green premium**



Source: Accenture analysis based on MPP data

Emerging business models like TaaS and BaaS may help manufacturers create new revenue streams.

Efforts to increase demand-side market measures include near-term ZEV sales mandates in countries like China, Canada and Norway, which are anticipated to accelerate adoption towards 2030. Some major carriers, including DPD, have imposed green surcharges ranging from 14-27% on fossil fuel use.[176] However, the uneven development of clean captive and grid-based power infrastructure poses a risks of temporary emissions intensity spikes in regions where power sources primarily rely on fossil fuels, until clean power capacity catches up. Additionally, slower policy development to support the growth of charging and refuelling infrastructure, crucial for maintaining regular business operations, may result in cost penalties for fleet owners, and oversupply issues for original equipment manufacturers (OEMs). However, emerging business models like trucks-as-a-service (TaaS)[177] may help OEMs mitigate these risks, creating an additional revenue stream to ease the impact of high green premiums, while reducing CapEx and on-site charging requirements for fleet owners.

Currently, few manufacturers have successfully demonstrated models of zero-emission HDTs for long-haul application.[178] With limited availability of ultra-fast charging infrastructure, operators are exploring alternative business models such as battery-as-a-service (BaaS) to meet growing ZET demand.[179] Under the BaaS model, fleet owners purchase the truck body, while batteries are owned and maintained by service companies. Fleet owners subscribe to a monthly fee, and their drivers can quickly swap HDT batteries at charging stations in as little as 2-3 minutes.[180] The Chinese State Power Investment Company (SPIC) has already sold 10,000 BaaS-enabled trucks and established 100 charging stations.[181] Private companies like Golden Concord Group (GCL) are advancing this effort, with 10 stations along the Beijing-Shanghai highway by year-end, and an additional 175 planned stations in China.[182]

TRUCKING

3 Policy

Trucking policy has evolved to incentivize the adoption of ZEVs with sales targets and purchase subsidies, notably led by the EU. The trucking industry is highly fragmented, with a mix of both large and small players, truck types, services, duty cycles and load types. It is usually regulated at supra-national (EU), national and sub-national levels, depending on regional dynamics. While tailpipe emissions have been a focus, addressing GHG emissions is equally important.

Effective public policies should facilitate ZEV adoption by developing essential clean power, hydrogen generation and charging infrastructure. The EU stands out with comprehensive policies, while other regions also implement measures such as ZEV sales targets, fleet decommissioning incentives and purchase subsidies to drive adoption.

Existing policy landscape

TABLE 7 **Policy summary**

Enabler	Policy type	Policy instruments	Key examples	Impact
Technology	Market-based	Carbon pricing	– EU-ETS proposed expansion to include road transport[183]	Incentivizes gradual adoption of ZEVs by increasing operating costs of diesel trucks. The proposed EU-ETS expansion comes into effect only after 2027.
	Mandate-based	Fuel tax	– Canada's federal carbon tax on diesel[184]	10-13% increase in diesel costs.[185]
		Fuel efficiency standards	– India's fuel consumption standards for heavy duty vehicles[186]	Aims to reduce the consumption of diesel from the trucking sector, which contributes to 33% of India's transport sector emissions.
		Bans on new sale	– Ban on diesel truck new sales in California by 2036[187]	Gradual phase out of diesel trucks leading to reduction in 25% of transport emissions.[188]
Infrastructure	Incentive-based	Taxes and subsidies	– IRA clean power and green hydrogen production tax credits as well as alternative fuel refuelling infrastructure tax credits[189]	Incentivizes build-out of clean power and green hydrogen capacity as well as the required charging and refuelling infrastructure.
	Mandate-based	Direct regulation	– EU Alternative Fuels Infrastructure Regulation mandate for charging stations across the Trans-European Transport Network (TEN-T)[190]	Aims to equip 100% of the TEN-T core network with fast charging stations for trucks at a distance of at least 60km.[191]
Demand	Mandate-based	ZEV sales targets	– 2030 targets for countries including Canada and select EU nations like Norway[192] – 2025 target for China[193]	35% and 50% of new heavy-duty vehicle sales to be ZEV by 2030 for Norway and Canada respectively. For China, 25% of logistics stock to be ZEV.
Capital	Incentive-based	Purchase subsidies	– Complementary policies across several countries like Australia, Canada, Finland, Italy, Japan, the US etc.[194]	Incentivizes switch to ZEV fleet due to lower upfront capital costs.

1

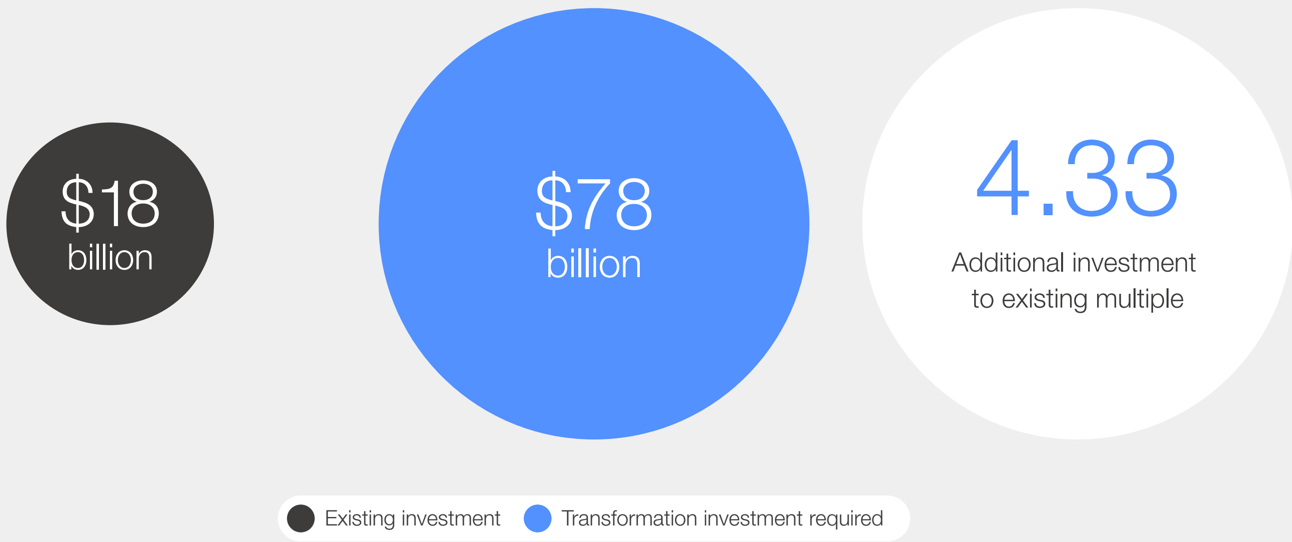
TRUCKING

Capital

The trucking industry will require an estimated $2.1 trillion by 2050,[195] requiring $78 billion in additional annual investments for fleet owners for fleet owners to retrofit their trucking fleet with battery electric powertrains. This represents four times the current annual expenditures in the trucking industry of $18 billion.[196]

Recent data suggests the business case for investing in zero-emission trucking remains weak due to high costs and uncertain returns. The industry's current profit margins of roughly 15%[197] and WACC of 10%[198] suggest it may struggle to absorb these extra costs and generate adequate returns solely from internal cash flows.[199] As technology scales and economies of scale take effect, investment requirements are expected to decrease.

FIGURE 34 **Additional investment required to existing investment ratio**



Source: Accenture analysis based on Global Drive to Zero data

Facilitating the funding necessary to support this transformation in developing nations will play a pivotal role in enabling a zero-emission trucking sector. International multilateral finance institutions should adjust their investment portfolios to align with the requirements of the trucking industry. In the United States and Europe, where internal combustion engine (ICE) trucks are substantially more expensive than in India and China, the upfront net capital investment required to achieve net zero is 25% to 30% more than continuing to use mostly diesel. However, in India and China, where ICE trucks are cheaper, the incremental costs of ZETs and their infrastructure are more significant.[200]

The existence of ZETs depends on both the supply of these vehicles and the demand for them, which are interconnected with the upstream value chains facilitating their production and use. Policy-makers should focus their attention upstream by addressing concerns like the ethical sourcing of essential raw materials for ZET components by OEMs. Additionally, investing in the infrastructure required to distribute electricity and hydrogen to areas where trucks will require these resources is crucial.

Worldwide, governments are stimulating both the desire for and availability of ZETs by enforcing more stringent emissions goals, fuel criteria or both. Prominent logistics firms and major truck purchasers are pledging to reduce carbon footprints and cut emissions, thus creating growing demand for ZETs. Established OEMs and emerging players are making substantial investments in the advancement of ZET models, while fleet operators are channelling investments into acquiring vehicles and establishing on-site infrastructure. An example of innovative ZET deployments includes Shihezi industrial park in China, a fleet of 100 BETs serve business based in the park. The trucks typically make trips of about 100km and swap batteries at a facility in the industrial park.[201]

The fragmented nature of the industry makes aggregating data on net-zero commitments by companies challenging.

“ Worldwide, governments are stimulating both the desire for and availability of ZETs by enforcing more stringent emissions goals, fuel criteria or both.

Endnotes

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