

Decarbonizing the European Truck Fleet: Policies, Technologies, and Infrastructure

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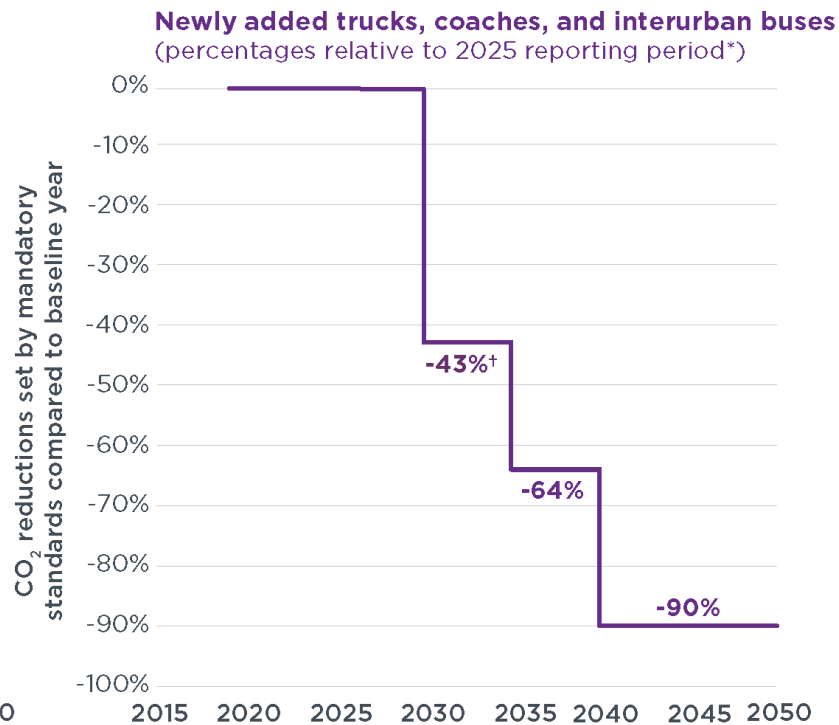
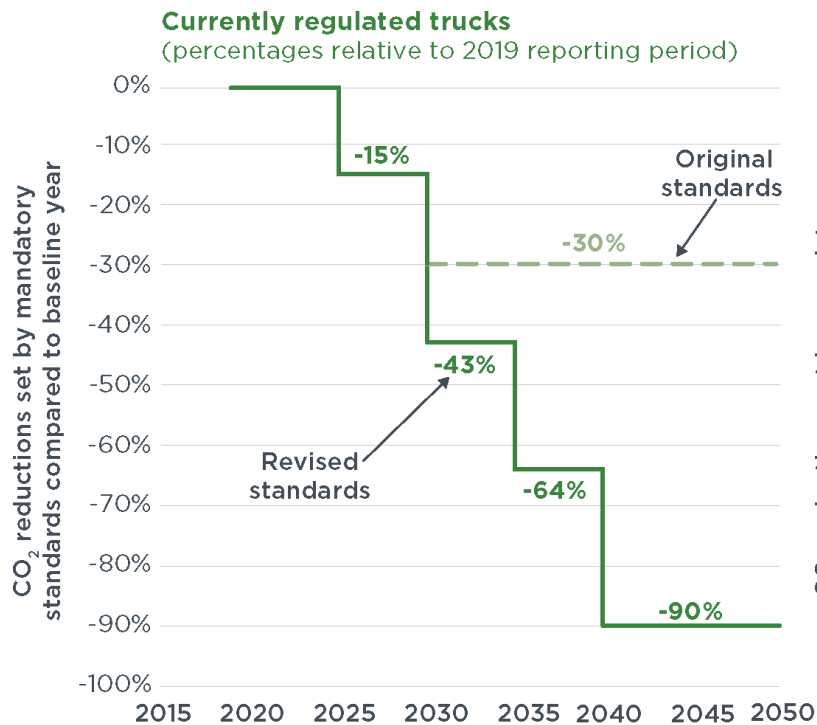
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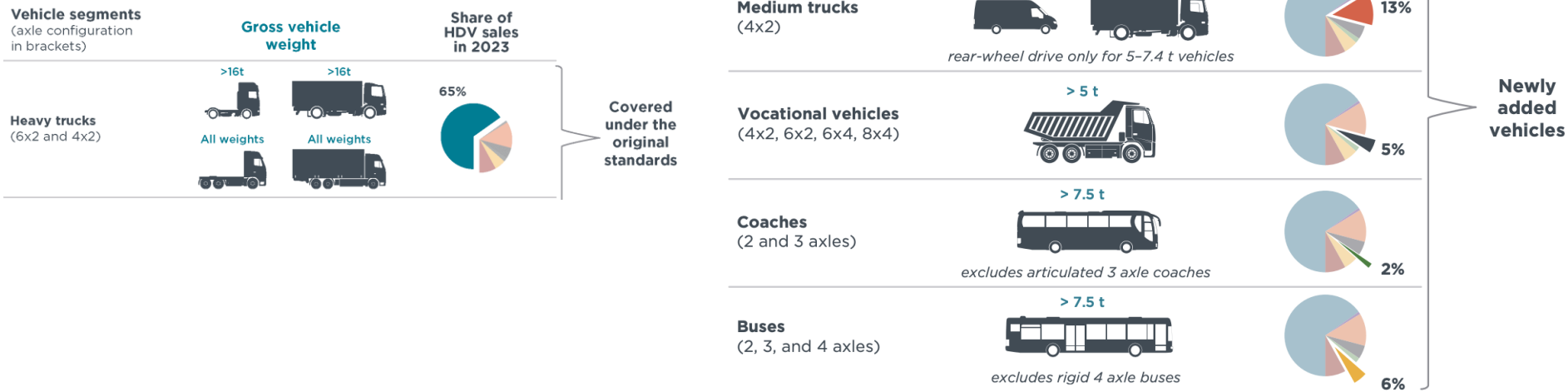
Heavy-duty Vehicles CO₂ Policy Scene



CO₂ Reduction Standards for Heavy-duty vehicles in the EU.

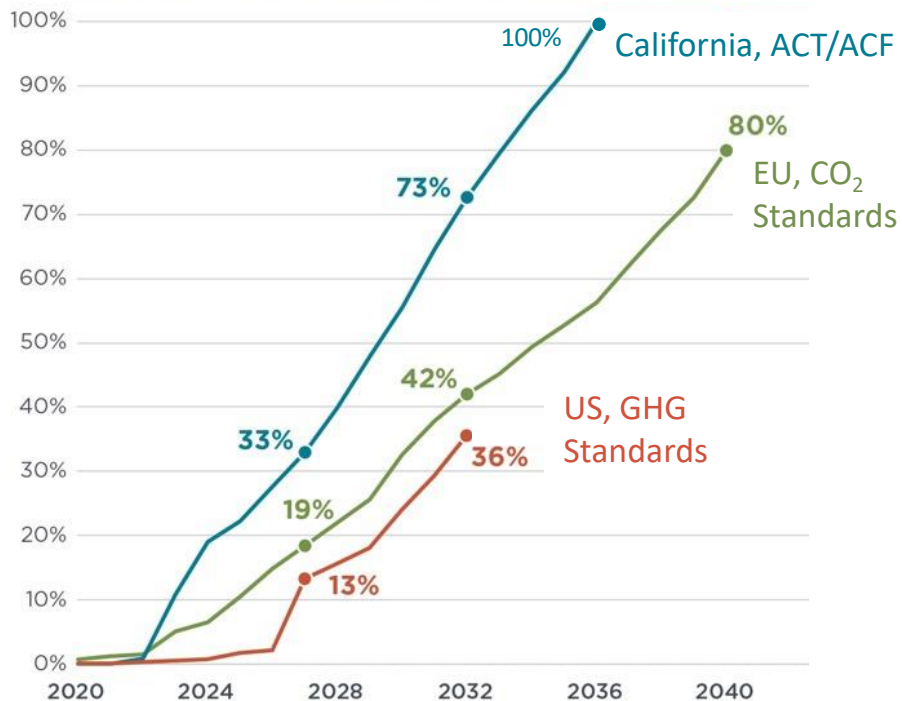


Scope of Vehicles Covered Under the EU CO₂ Standards



Fuel Economy Standards in the US. Comparison Based on Expected Fleet Electrification

ZEV sales shares in Class 4-8 HDVs by market



Policies driving zero-emission vehicles:

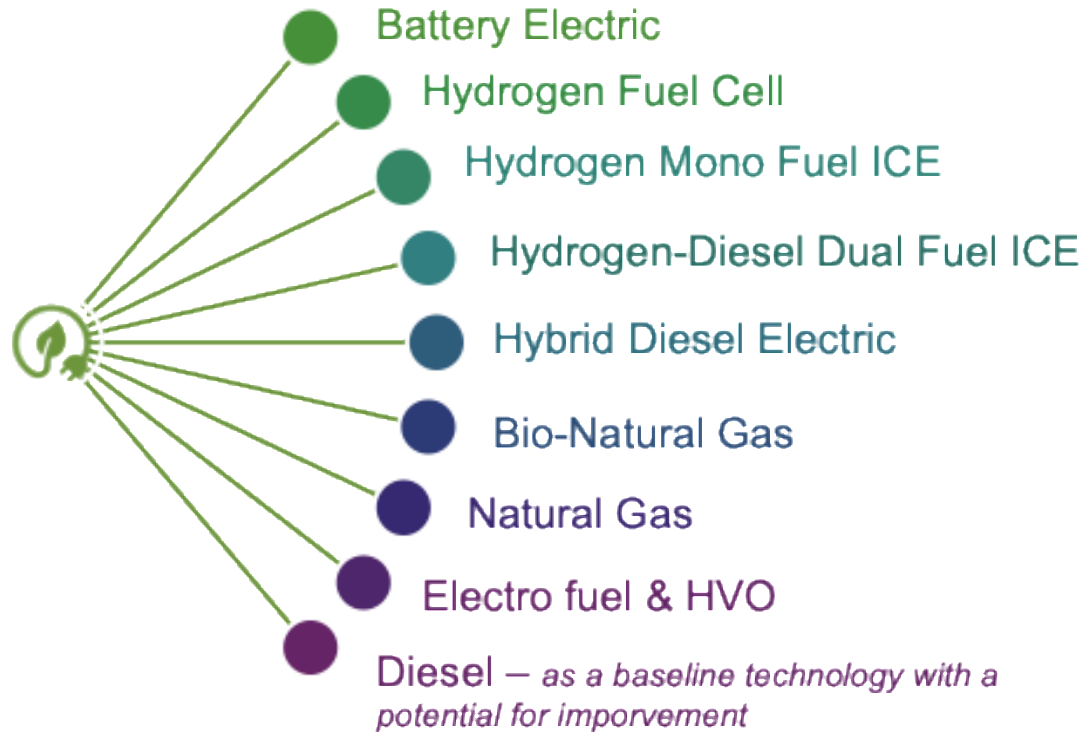
- California
 - ACT: ZEV sales requirement
 - ACF: ZEV purchase requirement
- European Union
 - CO₂ Standards
- United States
 - Phase 3 GHG Emissions | Fuel Economy Standards

ZEV: Zero-emission vehicle

Alternative Truck Technologies



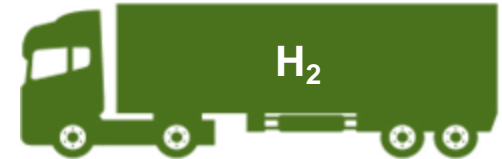
Truck Decarbonization Technologies



Battery-electric



Hydrogen-powered



*Fuel Cells
Hydrogen Combustion Engines*

Battery-electric Trucks Have Come a Long Way!

- **Increase in model offerings**
 - All legacy OEMs are offering a wide range of electric trucks, including for long-haul applications.
- **Driving ranges reaching 600km on a single battery charge**
 - Up to 300 km in 2023
 - 150-200 km back in 2021-2022
- **Purchase cost ~ 2.5x more than diesel for long-haul**
 - ~ 5x more than diesel in 2022-2023
- **Total cost of ownership outlook is very promising**
 - Light and medium commercial vehicles already show a favorable TCO







Hydrogen Fuel Cell Trucks are Still Struggling to Catch up!





- **Fewer model offerings than battery-electric**
- **Diesel-like driving ranges and refueling time**
 - Up to 1,000 km
 - 20-30 mins refueling time
- **Purchase costs are significantly higher than diesel and battery-electric**
 - Expensive fuel cell stacks and hydrogen tanks
- **Total cost of ownership outlook is very challenging**
 - Hydrogen fuel cost is a key challenge
- **Technology is expected to play a secondary role**
 - Battery-electric trucks are expected to dominate the market for most segments, including long-haul.



Hydrogen Internal Combustion Engine Technology is Gaining Momentum!

- Legacy OEMs publicly announced their plans to develop this technology

Location	Stakeholders	Announcement
	Scania and Westport Fuel Systems	Demonstrating HPDI hydrogen ICE (2023)
	Volvo Trucks	Plans for more hydrogen ICE laboratory testing (2023)
	DAF	Prototype 26-tonne hydrogen ICE rigid truck (2022)
	KEYOU	Testing hydrogen ICE 18-tonne rigid truck (2023)

Location	Stakeholders	Announcement
	MAN	Testing 16.8-liter hydrogen ICE (2021 - 2023) – Small series production to start in 2025 (2024)
	Daimler Trucks AG	Testing hydrogen ICE multipurpose truck (2023-2024)
	Renault Trucks and Université d'Orléans	'H ₂ -PL' Demonstration Project (2021-2023)
	IVECO and FPT Industrial	Demonstrating hydrogen ICE for trucks (2023)

More Zero-emission trucks are Registered Every Quarter, Mainly Battery - electric

FIGURE 2.1

Sales of heavy trucks by powertrain

96.2% Diesel
2.6% Natural gas
1.2% Battery electric



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FIGURE 3.1

Sales of light and medium commercial vehicles by powertrain

88% Diesel
2% Natural gas
10% Battery electric

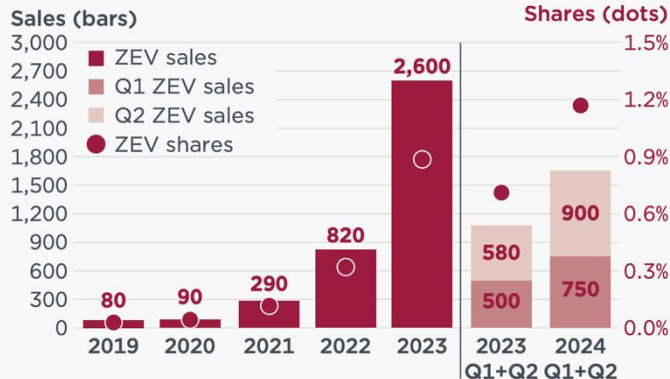


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Registration data until Quarter 2 - 2024

FIGURE 2.2

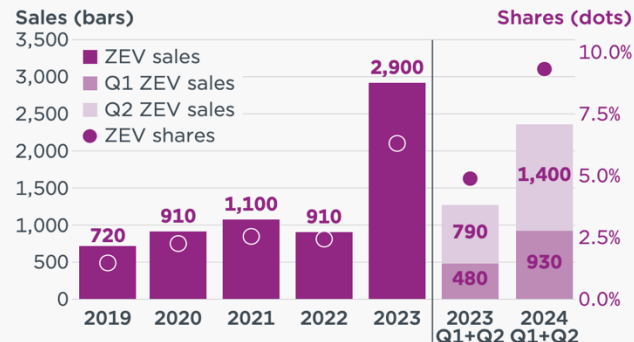
Sales of zero-emission heavy trucks



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FIGURE 3.2

Historic sales of zero-emission light and medium commercial vehicles



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Infrastructure



Enabling Conditions for Freight Decarbonization | Infrastructure is a Key Factor



EU Alternative Fuels Infrastructure Regulation – Public Charging

Target date	Scope	Minimum capacity requirement	Minimum distance requirement
December 31, 2025	15%* of core and comprehensive TEN-T	One recharging pool with 1,400 kW of aggregated power	Every 120 km* in each direction of travel
	Urban node	One recharging pool with 900 kW of aggregated power	-
December 31, 2027	50% of core and comprehensive TEN-T	One recharging pool with 2,800 kW of aggregated power in the core TEN-T and 1,400 kW in the comprehensive TEN-T	Every 120 km* in each direction of travel
December 31, 2030	TEN-T core	One recharging pool with 3,600 kW of aggregated power	Every 60 km in each direction of travel
		One hydrogen refueling station	Every 200 km
	TEN-T comprehensive	One recharging pool with 1,500 kW of aggregated power	Every 100 km in each direction of travel
	Urban node	One recharging pool with 1,800 kW of aggregated power	-
		One hydrogen refueling station	-

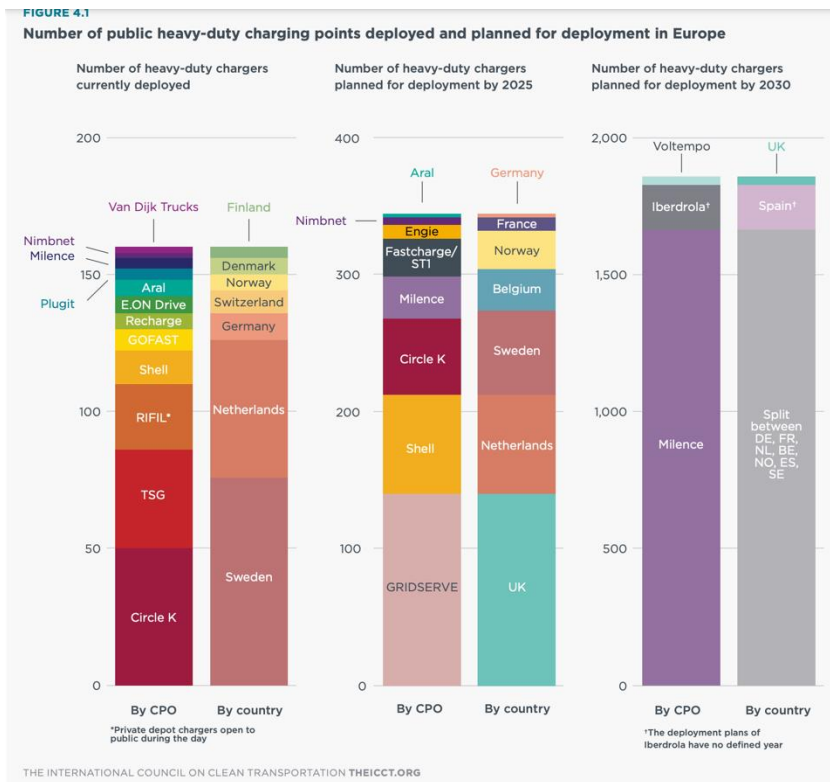
The regulation also requires Member States to ensure the installation of at least **two publicly accessible 100 kW** charging stations at all safe and secure parking areas by **December 31, 2027**, and **four by December 31, 2030**.

Fast and Ultra-fast Charging is Crucial to Enable Long-haul Electrification

- TSG charging plaza has 36 charging points for trucks and off-highway vehicles in the Netherlands.

- **Milence: a joint venture between Daimler Trucks, Traton Group, and the Volvo Group.**

- Investment plan of 500 million euros to build 1,700 public charging points by 2027
- Including megawatt chargers, spread out across Germany, the Netherlands, France, Belgium, Spain, Sweden, and Norway.
- Milence opened its first 4 charging points in October 2023.



Private or Semi-Public Depot Charging Has a Big Role to Play!

- **Majority of trucking energy needs can be supplied at depots.**
 - Including ~ 80% of a typical long-haul truck's daily energy needs.
 - Cross-boarder trucks will rely on public fast charging stations.
- **Depot charging (private facilities) is expected to be cheaper than public charging.**
 - Due to Higher utilization and longer available charging duration
 - This is a key enabler for favorable TCO for electric trucks
- **Semi-public depots (shared depots) can further increase utilization and reduce costs.**
 - Due to Higher utilization

Fleet Electrification - Grid Integration | Short- and Long-term Challenges

- **Limited existing grid capacities in urban areas to accommodate truck charging demand**
 - All legacy OEMs are offering a wide range of electric trucks, including for long-haul applications.
- **Long permitting process to expand the depot's power capacity**
 - Complex bureaucracy across different local administrations
 - Waiting times to access higher depot power can reach up to 5 years

Key Takeaways



Summary

- European regulations are paving the way for the decarbonization of the road freight sector.
- More zero-emission trucks are being registered each quarter, and OEMs are offering an increasing number of zero-emission truck models.
- Positive economic outlook for battery-electric trucks, even for the challenging long-haul segment.
- More public charging infrastructure must be deployed, and private charging has a big role to play.
- Grid capacity is a challenge in some areas.

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