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Decarbonising Road Freight Transport

Today, 96.9% of heavy-duty freight vehicles operate on diesel fuel[1], posing a major challenge for the transition toward low-carbon solutions. EdEn reviews the current situation and, in particular, assesses the role that electric trucks are expected to play in the coming years.

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1. On January 1st, 2025. Source: SDES (French Ministry of ecological transition).

Heavy-duty freight vehicles account for more than 86% of total freight transport in France (measured in tonne-kilometres in 2023). In 2024, as in 1990, they were responsible for 26.6 Mt of CO_2 emissions[2]. While efforts to expand maritime and rail freight and to improve overall logistics efficiency remain essential, decarbonising road freight transport is a necessity. Transition toward biomethane (BioNGV) is still in infancy and vehicles using this fuel represent only 2% of the active fleet. Bio-diesels also provide a possible solution, but trucks running on B100[3] or HVO100[4] currently account for just 1% of the total fleet. Hydrogen was also considered as an alternative[5], but its development has faced significant delays. Each of these solutions faces substantial constraints that limit its large-scale deployment.

By contrast, battery-electric solutions are gaining momentum, driven in particular by declining battery costs and spillover effects from the electrification of light-duty vehicles.

European Regulation 2024/1610 of 14 May 2024 establishes a clear roadmap for reducing CO_2 emissions from new heavy-duty vehicles registered in the European Union[6]: a 45% reduction by 2030 (up from the previous 30% target) and 90% by 2040. Through this regulation, the European Commission explicitly aims to stimulate the emergence of a zero-emission heavy-duty vehicle market, based on battery-electric and hydrogen trucks. Achieving the 2030 target would require at least 35% of newly registered heavy-duty vehicles to be zero-emission by that date.

Charging equipment compliant with the Megawatt Charging System (MCS) standard is now entering the market. The first MCS charging stations are expected to be deployed in France in 2026–2027, enabling electric trucks to recharge during the mandatory 45-minute breaks.

Photo 1: MCS Alpitronic charging station presented at the Solutrans 2025 trade fair.

Five criteria for assessment

The heavy road freight sector is therefore entering a phase of **deep structural transformation**. EdEn conducted a comprehensive assessment of heavy-duty vehicle decarbonisation across five complementary dimensions:

1. availability of a technically mature zero-emission truck offering, with proven and operationally validated performances;
2. adequacy of charging infrastructure to support the expected large-scale uptake of zero-emission heavy-duty vehicles;
3. potential impacts of zero-emission solutions on working conditions and operational practices, including fleet management and logistics constraints;
4. economic viability of the transition, in a highly fragmented sector comprising approximately 40,000 companies, 73% of which operate fleets of only one to four vehicles;
5. capacity of companies to finance the required investments, particularly in vehicles and associated infrastructure.

The study does not intend to produce new well-to-wheel CO_2 balance assessments, given that extensive literature already exists on this topic, often with divergent conclusions. It simply recalls that the CO_2 regulation for heavy-duty vehicles focuses exclusively on tailpipe emissions and explicitly prioritises zero-emission vehicles, whether electric or hydrogen-powered.

Key Assumptions

Starting from the 2025 baseline, the analysis leads to results for 2030, 2035, and 2040, based on a set of explicit assumptions.

Energy prices before taxation are assumed to remain constant relative to 2025 levels. Most of the assumptions therefore relate to taxation and parafiscal charges. In particular, it is assumed that taxation on biofuels will be harmonised by 2030 at the latest, in line with the French loi Climat et résilience (*Climate and Resilience Law*).Conservative

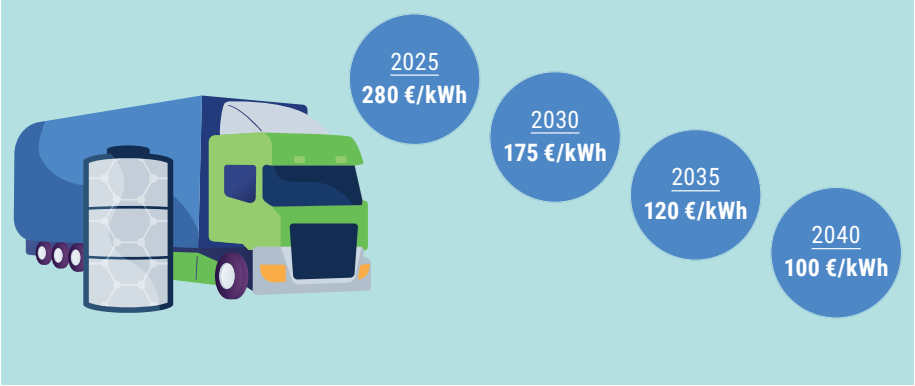

Table 1: **Assumptions on the evolution of battery prices for heavy-duty vehicles (in euros per kWh of gross capacity).**

2. *Source : CITEPA (Secten) report.*
3. *B100 is a biodiesel fuel composed entirely of fatty acid methyl esters (FAME).*
4. *HVO : Hydrotreated Vegetable Oil.*
5. *See the publication by EdEn "L'hydrogène dans le transport routier de marchandises (Hydrogen in road freight transport)" (October 2021).*
6. *These objectives apply to road freight transport as well as to buses and coaches.*

Tractor-type heavy-duty vehicle	2025	2030	2035	2040
Average cost of a diesel heavy-duty vehicle	€120,000	€126,000	€126 ,000	€126,000
Average cost of an electric heavy-duty vehicle, excluding batteries and comfort options	€150,000	€136,700	€110,000	€110,000
Battery cost	€149,500	€93,400	€ 64,100	€53,400
Net purchase cost of the electric heavy-duty vehicle, including batteries and after subsidies(*)	€238,000	€168,700	€143,400	€163,400

** Comfort options are taken into account, amounting to €20,000 in the TCO calculations presented later.*

Table 2: **Assumptions on the evolution of the price of a battery-electric tractor unit, excluding comfort options, equipped with a battery with a gross capacity of 534 kWh.**

assumptions were adopted regarding the impacts of both the TIRUERT[7] being replaced by the IRICC[8] as of 1 January 2027 and the potential extension of the European emissions trading system to road transport (EU-ETS 2) from 1 January 2028. As EU-ETS 2 has not yet been transposed into French law, its net impact in 2030 was assumed to correspond to an additional carbon cost of only €30 per tonne of CO_2, equivalent to approximately €0.08 per litre of diesel.

Vehicle costs remain a central issue. Electric heavy-duty vehicles require a substantial upfront investment, with purchase prices currently 2.5 to 3 times higher than those of diesel trucks. This cost differential – largely mitigated at present by public support schemes – is primarily driven by the still-high cost of batteries. In this regard, Chinese manufacturers are already reporting significantly lower battery and vehicle prices as early as 2025. It was therefore assumed that European prices would progressively converge toward these levels, in line with the trajectories presented in Tables 1 and 2.

Given intense international competition, particularly from Asian manufacturers, such cost convergence could materialise more rapidly than assumed. The industrial and strategic stakes for the European automotive and battery sectors are therefore considerable.

As for public support (energy savings certificates and tax deductions), it was assumed that it would be reduced beyond 2030, as investment costs for electric heavy-duty vehicles decline.

Three Families of Use Cases

The study distinguishes three families of use cases:

- **Urban transport**, represented by a family-owned company operating four 16-ton rigid trucks, each traveling 35,000 km/year, i.e. an average of 160 km/day. The trucks return to the depot every evening, where charging stations are supposed to be installed;
- **Regional transport**, illustrated by another family-owned company

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7. TIRUERT: Taxe incitative relative à l'utilisation de l'énergie renouvelable dans les transports (French tax incentivising the use of renewable energy in transports).
8. IRICC: instrument incentivising to reduce carbon intensity in transports (draft of new tax aiming to replace the TIRUERT from 1st of January 2027).

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operating four 19-ton rigid trucks, each traveling 66,000 km/year, or 300 km/day. The trucks' range allows them to return to the depot every evening;

- **Long-distance transport**, illustrated by a company operating at least several dozen 44-ton tractor units, each traveling 110,000 km/year, or an average of 500 km/day. The company operates one or more depots to which around twenty trucks return every evening. The depots are equipped with 50 kW charging stations as well as a minimum number of 150 kW stations. However, given the distances involved, a share of en-route recharging along major corridors is assumed, set at 25% in the study.

Conclusions

Availability of Vehicles and Equipment

An electric heavy-duty vehicle offering covering a now very wide range of needs has emerged in France. This evolution, foreshadowed by developments observed in the United States and China, is now a reality, benefiting from progress achieved in passenger vehicles and batteries. Technical progress – widespread adoption of electric axles, declining battery costs, and improved battery performance – will continue to develop, as confirmed by recent announcements from Chinese manufacturers.

By contrast, hydrogen trucks have made little progress to date. The market offering remains limited, while hydrogen prices remain very high.

Availability of Infrastructure

CCS (Combined Charging System) has become the baseline standard for passenger vehicles and is also relevant for heavy-duty vehicles. MCS is the standard that will enable trucks to recharge at power levels of up to 800 kW during the mandatory 45-minute break after 4.5 hours of driving.

The key issue is infrastructure deployment. The study clearly highlights that, for both operational and economic reasons, most truck charging will take place at company depots, preferably at night. However, companies are not currently equipped and remain reluctant to invest. Continued incentives and support are therefore required. Shippers, logistics platforms, and ports also have a role to play.

Charging along major corridors is an essential complement for long-distance transport. The European AFIR regulation must be translated into an implementation strategy. This requires addressing land-use issues by leveraging existing capacity at rest areas, service areas, or secure parking facilities. The creation of public charging hubs near motorway exits and logistics centers will provide an additional solution for certain use cases.

Operating Conditions

Operational issues have not appeared to be critical. Feedback from drivers who have already adopted electric vehicles is positive, and provided that charging infrastructure is in place, the issue of – central for passenger cars – is less compelling for heavy-duty vehicles, given regulatory constraints on driving time and mandatory rest periods.

Economic and Financial Aspects

The central challenge in shifting freight transport toward low-carbon solutions lies in economic viability and investment financing.

Detailed Total Cost of Ownership (TCO) analyses were conducted for 2025, with projections for 2030, 2035, and 2040 (expressed in €2025).

At present, there are no realistic prospects for large-scale deployment of hydrogen solutions, which remain far outside the economic envelope. While niche applications may persist, hydrogen is not a viable option for mass freight transport.

By contrast, the outlook for electric heavy-duty vehicles is increasingly favorable, in light of anticipated technical and economic improvements in both batteries and vehicles. The results indicate that electric solutions could become dominant as early as 2030 across all three use cases examined. Long-distance transport remains the most challenging segment today, primarily due to high charging prices along motorways (around €0.40/kWh). Electric trucks are nevertheless expected to benefit from the progressive increase in diesel costs, driven by the Euro 7 standard and the implementation of EU-ETS2. In addition, reduced motorway tolls could accelerate the deployment of electric trucks by several years.

These findings do not call into question the decarbonisation targets for new heavy-duty vehicles set by the CO_2 regulation, even though meeting the first milestone in 2030 may prove challenging. Some flexibility mechanisms may be necessary, but there is no justification at this stage for revising the overall trajectory.

The critical issue is ensuring a successful market take-off. Vehicle supply exists, but prices remain high. Public support has so far played a decisive role, enabling electric trucks to achieve TCOs that are often comparable to – or even slightly more attractive than – those of diesel trucks. However, this advantage remains fragile and recent.

Local transport	2025	2030	2035	2040
16-ton rigid truck with three battery packs	1.11 €/km	0.94 €/km	0.88 €/km	0.93 €/km
Urban diesel	1.12 €/km	1.20 €/km	1.27 €/km	1.35 €/km
Urban CNG	1.20 €/km	1.35 €/km	1.38 €/km	1.38 €/km
Urban HVO	1.22 €/km	1.26 €/km	1.29 €/km	1.34 €/km
Urban B100	1.06 €/km	1.25 €/km	1.29 €/km	1.34 €/km
Urban hydrogen	2.25 €/km	1.98 €/km	1.58 €/km	1.58 €/km

Evolution of total cost of ownership in the case of local transport.

Regional transport	2025	2030	2035	2040
19-ton rigid truck with four battery packs	0.83 €/km	0.70 €/km	0.65 €/km	0.68 €/km
Urban diesel	0.85 €/km	0.92 €/km	0.97 €/km	1.03 €/km
Urban CNG	0.92 €/km	1.02 €/km	1.05 €/km	1.05 €/km
Urban HVO	0.90 €/km	0.93 €/km	0.95 €/km	0.99 €/km
Urban B100	0.81 €/km	0.93 €/km	0.96 €/km	1.00 €/km
Urban hydrogen	1.74 €/km	1.46 €/km	1.19 €/km	1.21 €/km

Evolution of total cost of ownership in the case of regional transport.

Long-distance transport	2025	2030	2035	2040
44-ton rigid truck with six battery packs	0.83 €/km	0.71 €/km	0.67 €/km	0.70 €/km
Urban diesel	0.79 €/km	0.85 €/km	0.90 €/km	0.96 €/km
Urban CNG	0.88 €/km	0.96 €/km	0.99 €/km	0.99 €/km
Urban HVO	0.87 €/km	0.90 €/km	0.91 €/km	0.95 €/km
Urban B100	0.79 €/km	0.90 €/km	0.91 €/km	0.95 €/km
Urban hydrogen	1.54 €/km	1.30 €/km	1.07 €/km	1.08 €/km

Evolution of total cost of ownership in the case of long-distance transport.

From a public policy perspective, it is therefore essential to maintain momentum toward large-scale deployment.

- Public support should be secured at least until 2030, and strengthened in key areas, particularly charging infrastructure.
- Taxation – or equivalent mechanisms – on diesel fuels must also be adjusted. This is a sensitive issue. EdEn advocates for a gradual and coordinated implementation of the instruments currently under discussion - EU-ETS2, IRICC, the re-normalisation of biofuel taxation, and the sixth phase of energy savings certificates – to avoid disruptive deadlock situations, such as those experienced during the carbon tax debate in 2019.
- Access to financing remains a major obstacle for small transport companies. Guarantee mechanisms, potentially funded through the Social Climate Fund, could be established, as allowed under Article 7 of Regulation 2023/955.
- Electricity pricing also warrants close attention. While it is largely determined by contractual relations between suppliers and companies, tax policy should better support the competitiveness of electric solutions. Moreover, differentiated motorway tolls for zero-emission heavy-duty vehicles – authorised by the Eurovignette Directive (2022/362) and already implemented in Germany and Switzerland – could further accelerate deployment.
- From an industrial perspective, the influx of very low-cost Chinese vehicles could significantly undermine Europe's manufacturing base. The most effective response is likely to be a rapid scaling-up of electric truck deployment, allowing European manufacturers to amortise fixed production costs quickly and strengthen their competitiveness.
- Finally, electric road systems should not be overlooked. Currently under experimentation, they could significantly reduce the need for large onboard battery capacities in long-distance applications.
- While electric heavy-duty vehicles are set to become a central pillar of the broader electrification strategy, their deployment will inevitably be gradual, despite the urgency of reducing greenhouse gas emissions and dependence on imported fossil fuels. Biodiesels and BioNGV therefore have a legitimate role as transition fuels, and may continue to serve certain market segments where electrification is not feasible. However, their role must not delay the deployment of electric trucks. Technological neutrality implies a gradual reduction in support for these fuels, particularly to avoid locking in the use of limited biomass resources in applications where electric solutions are already available.
- Biomass resources are critically needed in sectors such as aviation and maritime transport, where electrification is not an option. In this respect, the industrial trajectory of HVO100 will be important to monitor—and regulate if necessary. As a precursor to sustainable aviation fuels, it can serve as a launchpad for that sector, provided that, over time, demand shifts from road transport to aviation in line with decarbonisation priorities.