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# Analyzing the economic competitiveness of truck decarbonization pathways in Europe

## BACKGROUND

Heavy-duty vehicles (HDV) are among the largest sources of $CO_2$ emissions in Europe, primarily due to the sector's reliance on diesel vehicles and the nascency of regulatory efforts to curb these emissions. Several alternative decarbonization pathways are being examined to replace the widely deployed diesel truck technology in Europe, including battery electric and hydrogen fuel-cell trucks, hydrogen internal combustion engine trucks, and conventional trucks powered by alternative fuels. The market development of these truck technologies and fuels will mainly depend on their economic performance.

A new ICCT study examines the total cost of ownership (TCO) for various European truck classes. The TCO analysis in the paper covers several HDV segments, including tractor trailers operating in long-haul with gross vehicle weight (GVW) reaching 40 tonnes, rigid trucks operating in regional delivery and urban delivery, and light-duty trucks operating in urban delivery. These HDV segments were chosen to ensure comprehensive coverage of the different HDV applications in Europe while focusing on the segments with the highest sales shares. The TCO includes the costs of truck acquisition, European-average fuel prices, maintenance, and European-average road tolls, taxes, and levies.

## DECARBONIZATION PATHWAYS

The study assesses the economic performance of seven decarbonization pathways:

- **Battery electric trucks** powered by the European electricity grid and assumed to charge at private depots and public fast charging stations, depending on the truck application.
- **Hydrogen fuel-cell trucks** powered by hydrogen fuel produced through renewable electrolysis, also known as green hydrogen.
- **Conventional trucks powered by hydrotreated vegetable oil (HVO)**. We consider the only low-greenhouse gas (GHG) HVO produced from waste oils in the EU, such as used cooking oil.
- **Conventional trucks powered by synthetic diesel (e-diesel)**. We consider e-diesel produced in Brazil and imported into the EU, which our analysis showed would be cheaper than producing e-diesel locally in the EU or importing from elsewhere.

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- **Conventional trucks powered by bio-compressed natural gas (bio-CNG)**. We consider bio-CNG produced in the EU from waste and residue materials, which are low-GHG but are low in availability.
- **Conventional trucks powered by hydrogen fuel**. The trucks are fueled by combusting green hydrogen fuel in an internal combustion engine (ICE).
- **Hydrogen-diesel dual-fuel trucks**. The trucks employ both diesel and hydrogen fuels but operate with at least 90% hydrogen fuel and no more than 10% diesel fuel.

## KEY FINDINGS

- **Battery electric trucks are projected to be the least-cost decarbonization pathway for most truck classes before 2030**. Medium- and light-duty urban battery electric trucks are already at TCO parity with their diesel counterparts. This is due to their lower operational expenses relative to diesel, which counterweighs their higher upfront cost. For heavy-duty long-haul trucks, TCO parity with diesel is expected to be achieved between 2025 and 2026 due to the more expensive upfront costs driven by the large batteries needed to meet high daily driving ranges (Table 1).
- **Fuel-cell trucks powered by green hydrogen are expected to become cost-competitive with diesel trucks by 2035**. Given the expected reduction in the price of green hydrogen fuel in the 2030–2040 timeframe, fuel-cell trucks will reach TCO parity with diesel trucks by 2030 for medium- and light-duty urban trucks and by 2035 for trucks operating in the long haul. In the long term, fuel-cell trucks will record a 10% to 20% higher TCO than battery electric trucks (Figure 1).
- **Conventional trucks powered by alternative low-GHG fuels such as HVO, e-diesel, and bio-CNG will struggle to match the economic performance of diesel trucks and will record a 15% to 45% higher TCO than their zero-emission counterparts by 2030.** A combination of high fuel costs and low vehicle energy efficiency results in a much higher TCO. Trucks running on e-diesel or bio-CNG are expected to record the highest TCO among all considered decarbonization pathways and across all truck classes. Trucks running on 100% HVO will record a better TCO than those powered by e-diesel and bio-CNG, but they would still be 20% to 30% more expensive than battery electric trucks (Figure 1).

## What truck technologies and fuel options cost the least?

### Ranking of total cost of ownership for various European truck classes in 2030

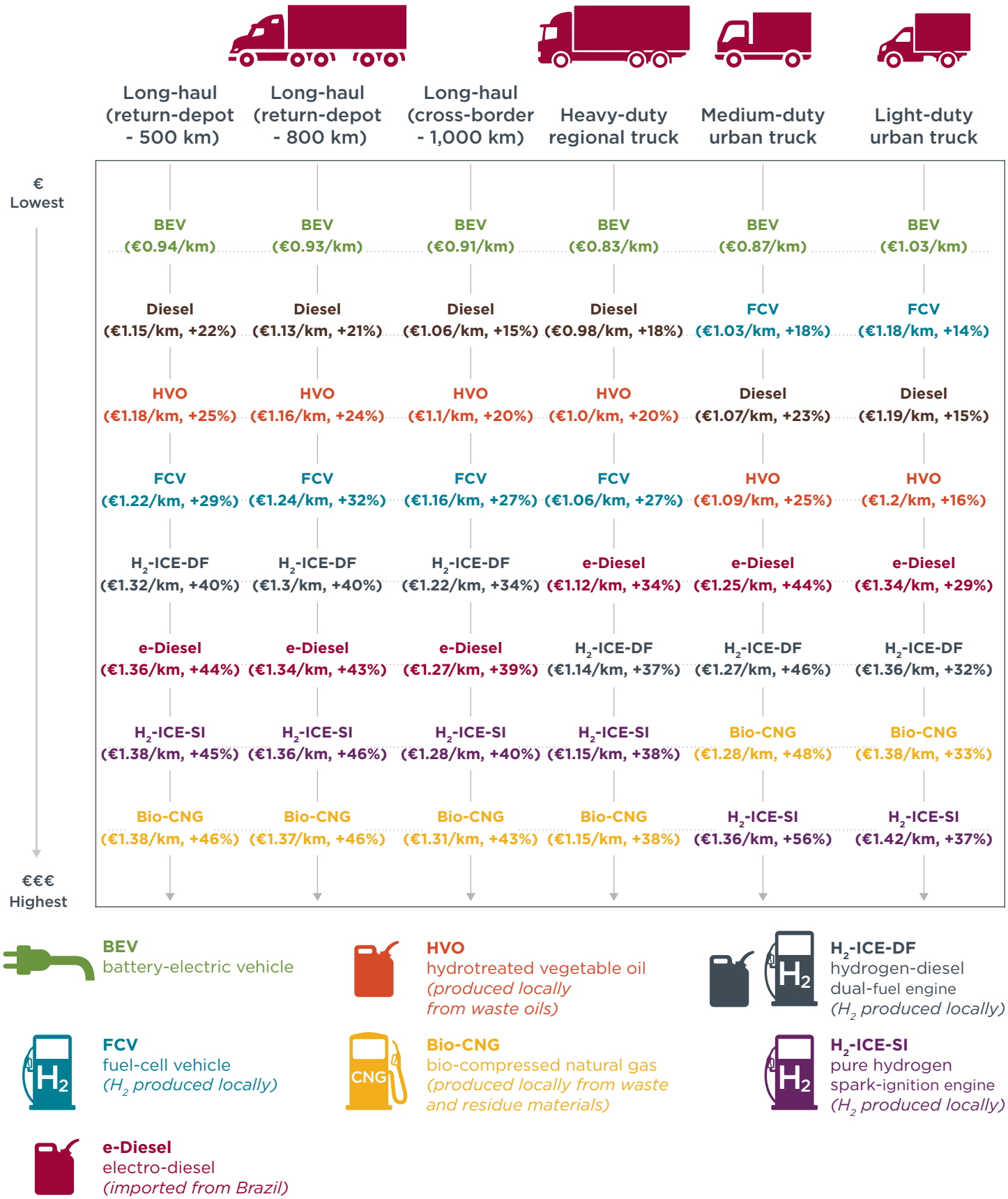


**Figure 1.** Ranking of the TCO performance of different truck classes and powertrain technologies for model year 2030. The figure shows each decarbonization pathway's TCO and truck class's percentage difference in TCO relative to the least-cost decarbonization pathway.

**Table 1.** Summary of TCO parity year for different truck classes and technologies relative to diesel trucks

| | Long-haul return-depot (500 km) | Long-haul return-depot (800 km) | Long-haul cross-boarder (1,000 km) | Regional heavy-duty truck | Urban medium-duty truck | Urban light-duty truck |
|---|---|---|---|---|---|---|
| **Battery electric** | 2025 | 2026 | 2026 | 2023 | 2023 | 2023 |
| **Hydrogen fuel cell** | 2035 | 2036 | 2036 | 2036 | 2030 | 2030 |
| **HVO** | Beyond 2040 or not at all | | | | | |
| **E-diesel** | | | | | | |
| **$H_2$-ICE-SI** | | | | | | |
| **$H_2$-ICE-DF** | | | | | | |
| **Bio-CNG** | | | | | | |

» **Trucks employing hydrogen internal combustion engines won't be able to match the economic performance of their zero-emission or diesel counterparts. However, they are expected to record a better TCO than conventional trucks powered by e-diesel and bio-CNG in the long term**. Driven by the price of green hydrogen fuel and the higher fuel consumption relative to zero-emission trucks, hydrogen combustion powertrains are expected to be 25%–45% more expensive than battery-electric trucks by 2040. However, the technology's economic performance can overcome that of conventional trucks powered by e-diesel and bio-CNG, recording up to 15% lower TCO for long-haul trucks.


## PUBLICATION DETAILS

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