APRIL 2018

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THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

# COMPARISON OF FUEL CONSUMPTION AND EMISSIONS FOR REPRESENTATIVE HEAVY-DUTY VEHICLES IN EUROPE

The ICCT commissioned the Institute for Internal Combustion Engines and Thermodynamics of the Graz University of Technology (TU Graz) to conduct track and chassis dynamometer testing to determine the aerodynamic drag, pollutant emissions, and fuel consumption of three European heavy-duty vehicles (HDVs). This fact sheet summarizes the key points of the study.

## BACKGROUND AND OBJECTIVE

$CO_2$ emissions from on-road freight transport, particularly those from tractor-trailers operating long-haul routes, represent a significant and growing share of global carbon emissions. HDVs are currently responsible for approximately 25% of the $CO_2$ emissions from road transportation in the EU. In the absence of regulatory measures to improve the efficiency of HDVs, the share of on-road freight in transport's $CO_2$ emissions will continue to rise due to increasing freight demand and the decreasing share of $CO_2$ emissions from the light-duty vehicle sector stemming from efficiency improvements. The United States, Canada, China, Japan, and most recently India have all adopted heavy-duty vehicle $CO_2$ standards, a significant step toward improving efficiency. The EU is contemplating similar action.

Publicly available literature on HDV fuel consumption in the EU is scarce. The vehicle testing commissioned by the ICCT seeks to fill this knowledge gap by testing three HDVs over a wide set of driving cycles and payloads in a controlled laboratory environment and following strict test procedures. The results of this study are relevant for evaluating the fuel consumption of HDVs being sold today, and for understanding the differences between average and best-performing vehicles.

## METHODOLOGY

During the testing procedures, the aerodynamic drag, pollutant emissions, and fuel consumption of the following three EU HDVs was determined.

1. A **typical** 18-tonne, Euro VI rigid truck used for mid-distance distribution
2. A **typical** Euro VI tractor-trailer used for long-haul operation
3. A **best-in-class** Euro VI tractor-trailer used for long-haul operation

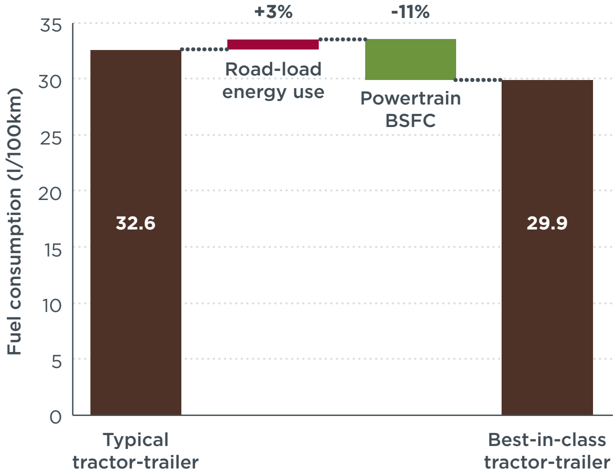
The typical trucks were identified by attempting to match the average specifications found in vehicle registration and technology adoption data. The best-in-class tractor-trailer was determined by a consultation with an original equipment manufacturer with a large market presence in the EU on the specifications of its best available model.

The testing program was designed to evaluate the fuel consumption performance of the complete vehicles, as well as to understand the differences in road-load energy demand and powertrain efficiency between the tested tractor-trailers. Special emphasis was put into the on-road measurement of the aerodynamic drag. The determination of the fuel consumption, engine, and powertrain efficiency was performed on a chassis dynamometer.

## KEY FINDINGS

**The typical tractor-trailer consumes 9% more fuel than the current best-in-class over the Long Haul cycle.** The fuel consumption in liters per 100 km was measured over the regulatory drive cycles and payloads. The typical tractor-trailer consumed 32.6 l/100km over the Long Haul cycle, while the best-in-class tractor trailer consumed 29.9 l/100km.

**The road-load energy consumption of the typical tractor-trailer was 3% lower than the best-in-class over the Long Haul cycle.** The road-load energy demand at the wheel is the combined effect of rolling resistance, aerodynamic drag, inertial forces, and road grade. Changes in road-load energy demand have a direct effect on the fuel consumption. To eliminate the influence of tire selection on the vehicle comparison, both tractor-trailers were tested with the same rolling resistance. The air drag area (i.e., drag coefficient multiplied by the frontal vehicle area) was determined following the constant-speed test stipulated in the $CO_2$ certification regulation for HDVs in the EU. The air drag area of the typical tractor-trailer was measured to be 5.21 $m^2$; 6% lower than the best-in-class tractor-trailer, which had an air drag area of 5.53 $m^2$. It was an unexpected result that the typical tractor-trailer had a better aerodynamic performance than the best-in-class. Since many aggregated design features contribute to the overall air drag, it was not possible to identify the source of the different aerodynamic performances. At 7365 kg, the curb mass of the typical tractor-truck was 5% lower than the best-in-class tractor, which had a curb mass of 7756 kg.




Comparison of the fuel consumption of the typical and best-in-class tractor-trailers over the Long Haul cycle.

The resulting road-load energy consumption at the wheel over the Long Haul cycle was 1.17 kWh/km for the typical tractor-trailer and 1.21 kWh/km for the best-in-class. These results indicate that the fuel consumption difference between typical and best-in-class tractor-trailers stems from differences in powertrain efficiency.

**The typical tractor-trailer had a powertrain efficiency 11% worse than the best-in-class.** The powertrain efficiency can be expressed as the fuel consumption, in grams, necessary to provide a unit of work at the wheel hub, in kWh, as measured by the chassis dynamometer. This metric is called the powertrain *brake specific fuel consumption* (BSFC). Changes in powertrain BSFC are reflected directly in the fuel consumption. The powertrain BSFC of the typical tractor-trailer, averaged over the Long Haul cycle, was 227 g/kWh. The best-in-class tractor trailer exhibited a powertrain BSFC of 202 g/kWh over the Long Haul cycle.

| | Fuel consumption | | Road load energy use | | Powertrain BSFC | |
|---|---|---|---|---|---|---|
| | Long Haul | Regional Delivery | Long Haul | Regional Delivery | Long Haul | Regional Delivery |
| **Typical tractor** | 32.6 l/100km | 34.3 l/100km | 1.17 g/kWh | 1.18 g/kWh | 227 g/kWh | 236 g/kWh |
| **Best-in-class tractor** | 29.9 l/100km | 31.6 l/100km | 1.21 g/kWh | 1.21 g/kWh | 202 g/kWh | 210 g/kWh |
| **Rigid truck** | 31.1 l/100km | 21.6 l/100km | 0.85 g/kWh | 0.73 g/kWh | 225 g/kWh | 238 g/kWh |

Summary of the key results for the three EU HDVs tested

## FURTHER READING

European Heavy-Duty Vehicles – Cost effectiveness of fuel efficiency technologies for long-haul tractor-trailers in the 2025-2030 timeframe. http://theicct.org/publications/cost-effectiveness-of-fuel-efficiency-tech-tractor-trailers

Fuel efficiency technology in European heavy-duty vehicles: Baseline and potential for the 2020–2030 timeframe. https://www.theicct.org/publications/fuel-efficiency-technology-european-heavy-duty-vehicles-baseline-and-potential-2020

Market penetration of fuel efficiency technologies for heavy-duty vehicles in the European Union, the United States, and China. https://www.theicct.org/publications/market-penetration-fuel-efficiency-technologies-heavy-duty-vehicles-european-union

**PUBLICATION DETAILS**

**Title:** Comparison of fuel consumption and emissions for representative heavy-duty vehicles in Europe

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**Download:** https://www.theicct.org/publications/HDV-EU-fuel-consumption-and-emissions-comparison

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