



## **Intelligence** Briefing.

Alternative vs traditional truck  
powertrains in the EU:

Total cost of ownership 2024





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## Glossary

### A

#### AdBlue

A diesel exhaust fluid used in selective catalytic reduction systems to reduce diesel engines' nitrogen oxide emissions.

#### Alternative Fuels and Efficiency Model (AFEM)

IRU proprietary model to assess energy consumption, efficiency potential and alternative fuels' ease of use based on transport operators' own operations.

#### Axle

A central shaft for rotating wheels or gears. In vehicles, it supports the weight and facilitates wheel rotation.

### B

#### Battery electric vehicle (BEV)

A vehicle powered entirely by electricity stored in rechargeable battery packs, with electric motors replacing traditional combustion engines.

### C

#### Capital expenditure (CapEx)

Funds used to acquire, upgrade or maintain physical assets such as property, industrial buildings or equipment.

#### Carbon emission factor (CEF)

A coefficient representing CO<sub>2</sub> emissions per unit of activity, such as per unit of fuel consumed or distance travelled.

#### Carbon dioxide emissions

The release of carbon dioxide into the atmosphere from the burning of fossil fuels.

#### Compressed natural gas (CNG)

Natural gas compressed to less than 1% of its volume at standard atmospheric pressure.

### D

#### Depreciation

The reduction in the value of an asset over time due to wear and tear, obsolescence or ageing.

#### Diesel

A type of fuel derived from crude oil used in compression-ignition engines.

### E

#### Energy cost

The expense incurred from consuming energy resources, such as electricity, fuel or gas, for operating equipment or vehicles.

#### EUR/km

Euros per kilometre is a cost metric expressing the expense incurred for every kilometre travelled.

#### EUR/kg

Euros per kilogram is a pricing measure indicating the cost per unit weight of a product/fuel.

#### EUR/kWh

Euros per kilowatt-hour is a unit of energy cost indicating the price for consuming one kilowatt-hour of electricity.

#### EUR/L

Euros per litre is a common unit for pricing liquids like fuel, indicating the cost per litre.

### F

#### Fuel cell electric vehicle (FCEV)

A vehicle that generates electricity through a fuel cell powered by hydrogen that emits only water vapor as a byproduct.

### G

#### Gross combination weight (GCW)

Maximum authorised weight for a vehicle to run on public roads.

### gCO<sub>2</sub>/km

Grams of carbon dioxide emitted per kilometre is a measure of a vehicle's emissions intensity.

### gCO<sub>2</sub>/tkm

Grams of carbon dioxide emitted per tonne-kilometre is the emissions per unit of freight transported over a distance.

### H

#### Hydrotreated vegetable oil (HVO)

A renewable diesel fuel produced by hydrotreating vegetable oils or animal fats. It serves as a sustainable alternative to fossil diesel.

### I

#### Inflation

Inflation is the rate of increase in prices over a given period of time.

#### Insurance

A contractual agreement in which an individual or entity receives financial protection or reimbursement against losses from an insurance company.

#### Internal combustion engine (ICE)

An engine burning a fuel to produce mechanical energy.

### K

#### kgCO<sub>2</sub>/km

Kilograms of carbon dioxide emitted per kilometre is used for larger-scale emission measurements such as heavy-duty vehicles.

#### kgCO<sub>2</sub>/tkm

Kilograms of carbon dioxide emitted per tonne-kilometre is a metric for assessing the carbon intensity of freight transport.

**L****Liquefied natural gas (LNG)**

Natural gas cooled to a liquid state at about -162°C for ease of storage and transport used as a fuel for heavy-duty vehicles.

**Liquefied petroleum gas (LPG)**

A mixture of propane and butane gases stored under pressure in liquid form. It is commonly used as fuel for heating, cooking and vehicles.

**M****MJ/kg**

Megajoules per kilogram is a unit of energy density indicating the amount of energy stored per kilogram of a substance.

**N****N2 & N3**

European vehicle categories for goods vehicles. N2 refers to vehicles weighing between 3.5 and 12 tonnes, while N3 includes vehicles weighing over 12 tonnes.

**O****Operating expense (OpEx)**

The ongoing expenses for running a business or system, including costs like utilities, rent, salaries and maintenance.

**Ownership tax**

Taxes levied on the ownership of assets like vehicles or property, often based on the value or type of the asset.

**P****Payload**

The carrying capacity of a vehicle, referring to the weight of the passengers or cargo that it can transport.

**R****Registration fee**

A mandatory charge paid to government authorities to register a vehicle, legally authorising it for use on public roads.

**Residual value (RV)**

The amount that an asset is worth after it has been used for a particular period.

**Road freight**

The transport of goods and cargo via roadways using trucks or other commercial vehicles.

**Road tractor**

Road motor vehicle designed, exclusively or primarily, to haul other road vehicles which are not power-driven (mainly semi-trailers).

**S****Semi-trailer**

A trailer without a front axle designed to be attached to a tractor unit (road tractor), with a significant portion of its weight supported by the towing vehicle.

**T****T2S3**

Acronym describing an articulated vehicle made of a two-axle road tractor pulling a three-axle semi-trailer.

**TCO (Total cost of ownership)**

The comprehensive total of all costs associated with owning an asset over its entire lifecycle, including acquisition, operation, maintenance and disposal expenses.

**Toll**

A fee charged for the use of certain roads, bridges or tunnels. It is typically used to fund maintenance and infrastructure projects.

**Tonne-kilometre (tkm)**

This is a unit of freight transport measure which represents the transport of one tonne of goods (including packaging and tare weights of intermodal transport units) by a given transport mode (road, rail, air, sea, inland waterways, pipeline, etc) over a distance of one kilometre.

**V****VECTO (Vehicle Energy Consumption Calculation Tool)**

A simulation software used in the EU to certify CO<sub>2</sub> emissions and fuel consumption of heavy-duty vehicles.

**W****Well-to-wheel (WTW)**

An analysis approach that evaluates all CO<sub>2</sub> emissions for a fuel, from its extraction (well) to consumption (wheel).

**Z****Zero-emission vehicle (ZEV)**

A vehicle that produces no tailpipe emissions from its onboard source of power, such as electric or hydrogen fuel-cell vehicles.

# Introduction

The road freight sector is known for its operational efficiency, providing reliable, fast and low-cost solutions to its customers, including shippers and freight forwarders. A key factor influencing operators' strategic investment decisions is the total cost of ownership (TCO) for a vehicle. For a new vehicle technology, such as a new alternatively fuelled powertrain, to be successful, it should lower the TCO. In addition, with the sector's commitment to reach carbon neutrality by 2050, another key indicator is gaining momentum: carbon emissions (CO<sub>2</sub>). This raises

several important questions for road transport operators about the costs and benefits of adopting new technologies, such as battery electric vehicles (BEVs) and fuel cell electric vehicles (FCEVs), to reduce emissions.

The combined TCO-CO<sub>2</sub> indicator is also of interest for other actors in the road transport ecosystem, such as shippers and policymakers, to design new tenders or to meet their own targets. A comprehensive economic impact assessment is thus necessary to evaluate the feasibility of the green transition. Without a clear understanding of the TCO for alternative powertrains compared with current diesel solutions, making informed decisions is challenging.

This IRU Intelligence Briefing compares the TCO-CO<sub>2</sub> of different powertrains. It offers insights on the expected TCO and carbon dioxide reduction capacities of new powertrains. The analysis covers five types of powertrains: diesel, hydrotreated vegetable oil (HVO), gas, BEV and FCEV for the five biggest EU road freight countries (Poland, Germany, France, Spain and Italy). The Intelligence Briefing will be updated every semester to reflect the latest market and industry developments.



Chapter 1

# Context: Road freight performance and truck fleet compositions

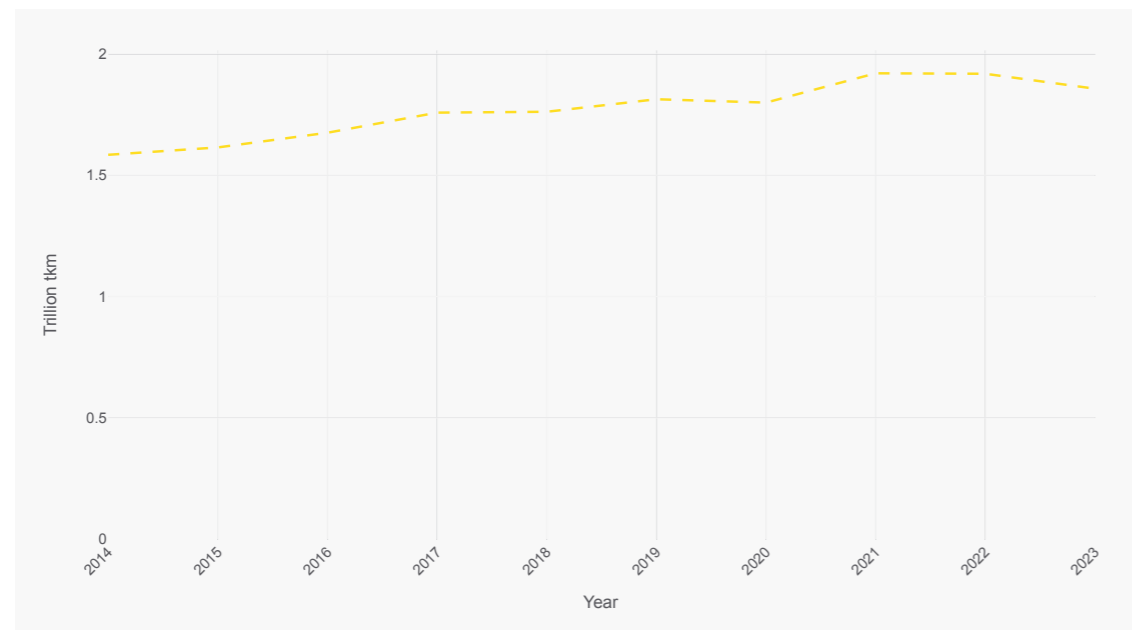
## 1.1. Road freight performance

Fuel consumption is the key indicator linking TCO and CO<sub>2</sub>, as the cost of energy is the most sensitive TCO component, and CO<sub>2</sub> emissions are a by-product of fuel combustion for a diesel engine. The relevant freight performance indicator to compare fuel consumption across different powertrains is “tonne-kilometres”, as it accounts for the difference in payloads and distances. A geographical perspective is also important. TCO components vary due to the diversity of fuel prices,

incentives and tax differences, and the carbon intensity of different energy sources.

EU road freight volumes have increased over the last decade, peaking at 1.92 trillion tonne-kilometres in 2022. In 2023, road freight volumes fell due to the economic downturn in the EU. Road freight is highly dependent on both economic (trade, manufacturing, consumption, etc) and geopolitical (oil shocks, uncertainty, etc) factors.

EU road freight volume



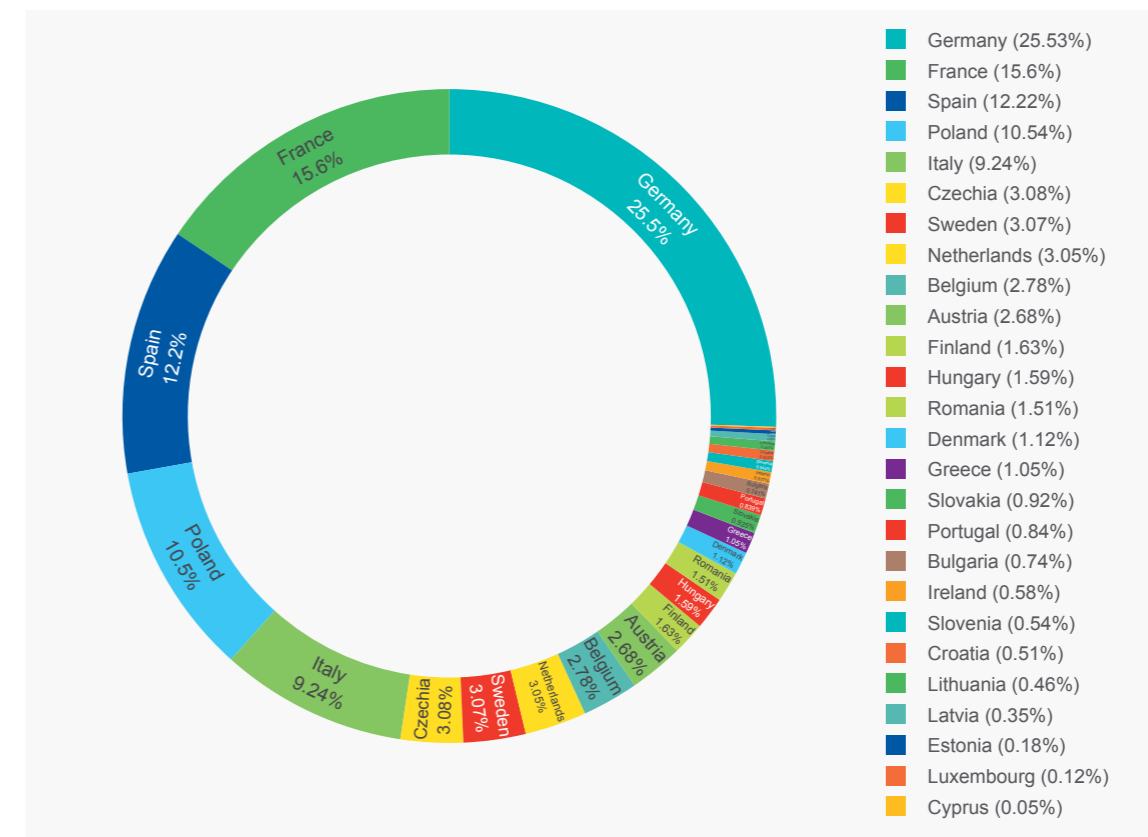
Source: Eurostat ([road\\_go\\_ta\\_totl](#)) extracted on 2024-10-23

There are two important road freight volume metrics:

- The national road freight volume reflects the volume of goods transported within a particular country or transited along its national roads, regardless of the truck’s country of origin. This metric closely reflects the fuel needed for road goods transport per country.
- The road freight volume by national fleet looks at the road freight volume performed by a national fleet, which can operate in different countries. This metric helps to capture the specific characteristics that affect transport operators.

The following infographics present the distribution of EU national road freight volumes per country in 2022 (latest available data). Germany, followed by France and Spain, has the greatest volume of national road freight volumes in the EU, due to its economic weight, central geographical location, seaports, advanced transport infrastructure, and manufacturing capacity. Over the past decade, road freight volumes have been increasing for all countries, indicating sustained economic growth.

Total road freight volume per country in 2022 (tkm)



Source: Eurostat ([road\\_tert\\_go](#)) extracted on 2024-10-23

### Chapter 3

## TCO comparison

TCO is a crucial performance indicator for transport operators and shippers, but it is complex to handle as a single value does not provide the full picture. Despite the extensive research in this Intelligence Briefing, the TCO values should be considered in the stated use case and assumptions used based on the time period considered. For example, the Intelligence Briefing assumes a constant workload, payload and external conditions for vehicles over their first six years. As a result, the values do not factor in the effects of weather or empty

trips. Moreover, the TCO values do not fully reflect the risk transport operators face with greater capital investment in their fleets, particularly in cases of major breakdowns or low transport activity. New powertrains tend to offset their higher capital expenditure (CapEx) through lower operational expenditures (OpEx). Nevertheless, a TCO analysis remains relevant as it illuminates the current standing of technologies in today's market conditions.

This Intelligence Briefing assumes that the enabling conditions exist for all fuels, giving transport operators access to HVO, CNG, LNG, H2 and electric chargers suitable for articulated vehicles. However, these enabling conditions are not yet in place for LNG, H2 and electric charging. Regarding HVO, it is important to note that production levels will be limited compared to the needs of road transport (including cars and vans), maritime and aviation. To put it in perspective, the total HVO production forecast for 2050 would cover less than a third of truck and bus needs, and only if all European production was consumed.

TCO will be presented in two units: EUR per kilometre for a given payload, and EUR per tonne-kilometre.



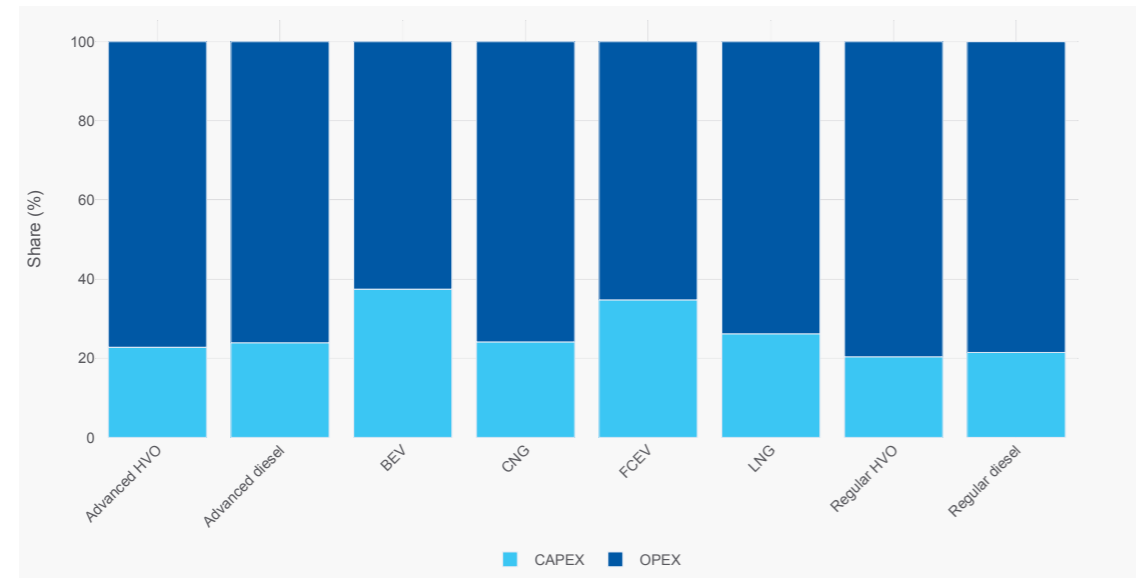
### 3.1. TCO decomposition (CapEx and OpEx) for a given payload

This section breaks down TCO's cost structure by powertrain and country for a given payload. The payload is assumed to be 15 tonnes for long-haul operations (EU average payload for articulated vehicles).

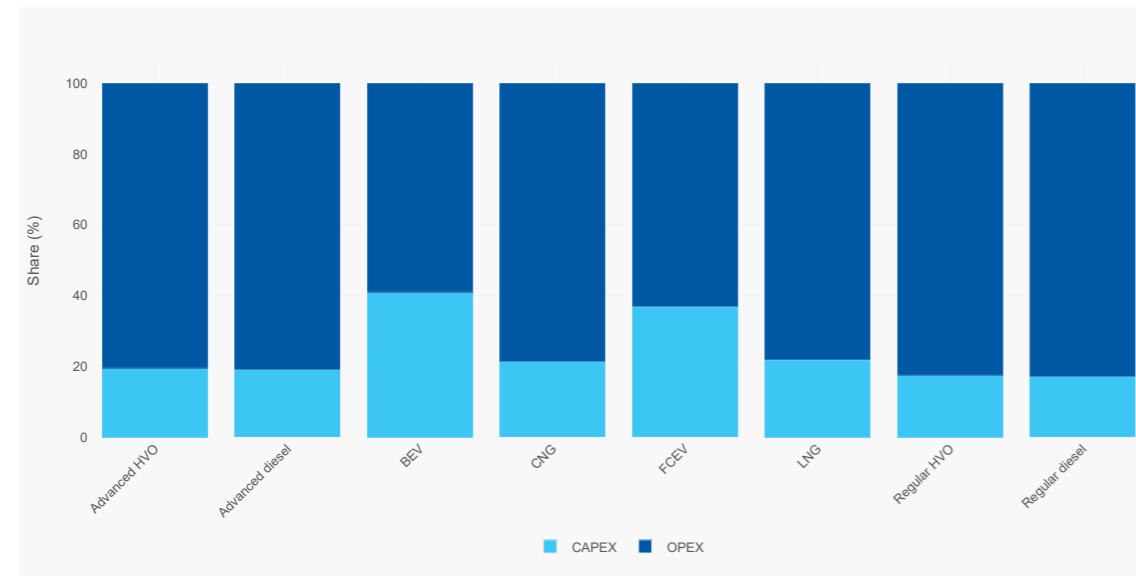
Starting by looking at the weight of CapEx and OpEx in the TCO, it should be noted that the regular diesel truck (class 1 on CO<sub>2</sub> emissions) is the least CapEx-intensive powertrain. BEV and

FCEV trucks have a more CapEx-intensive TCO, with FCEV being the most CapEx-intensive on average, apart from Germany, Poland and France, where the weight of CapEx is greater for battery, since FCEVs' OpEx are significantly higher than that of BEVs. OpEx are the main TCO cost component (more than 60-80% on average) for all powertrains and all countries.

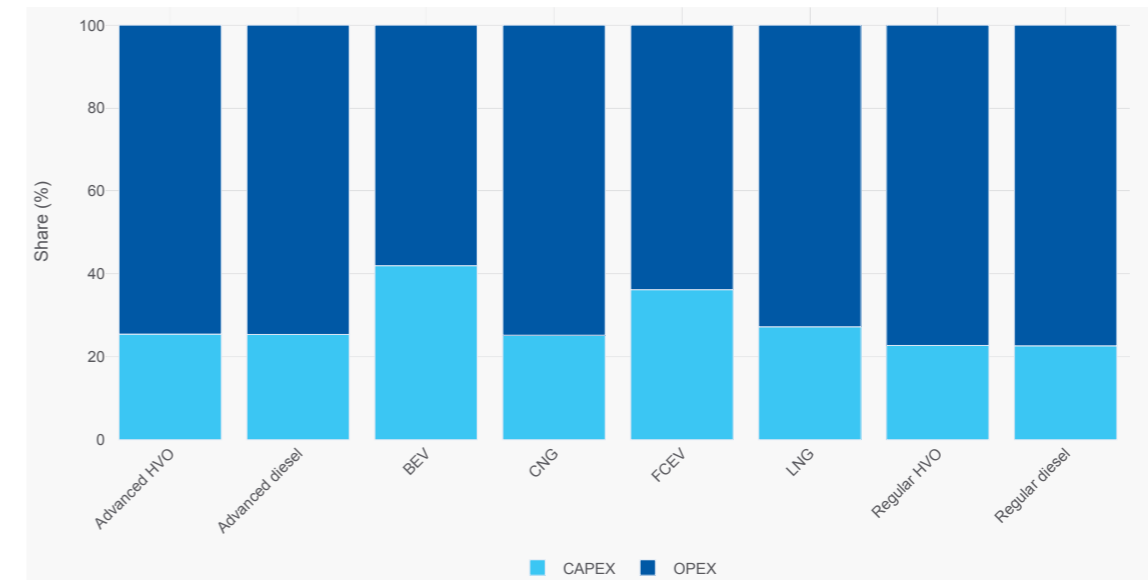
Cost structure by powertrain for 15-tonne payload in France



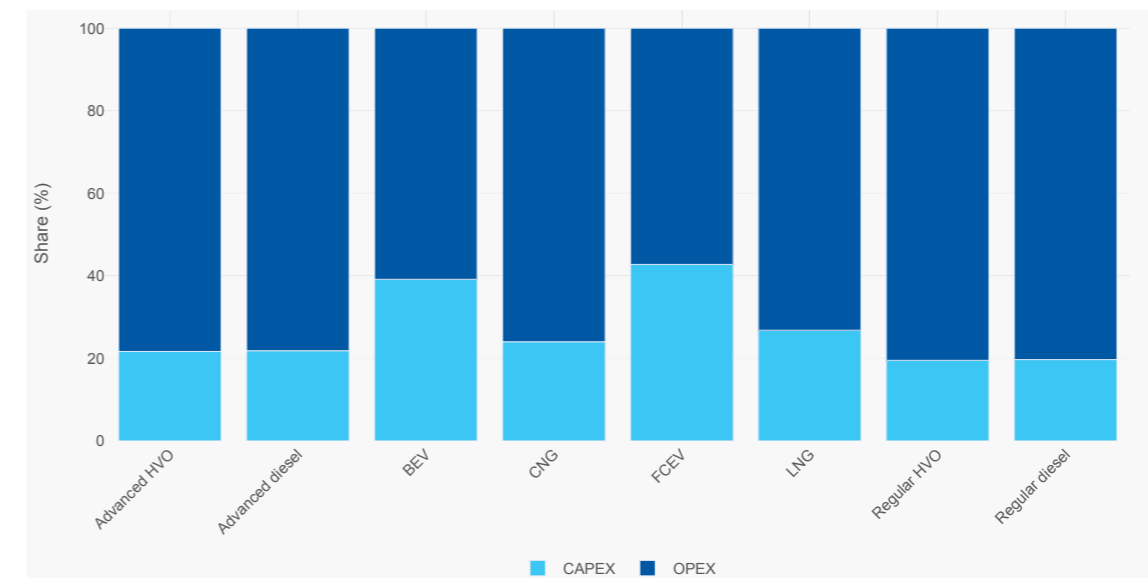
Cost structure by powertrain for 15-tonne payload in Germany



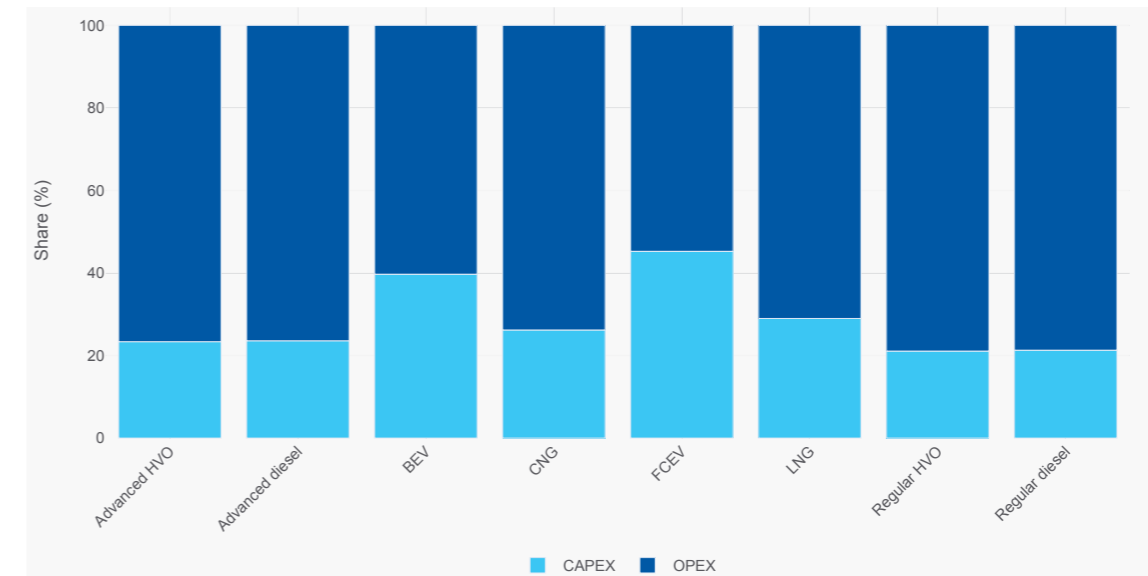
Cost structure by powertrain for 15-tonne payload in Poland



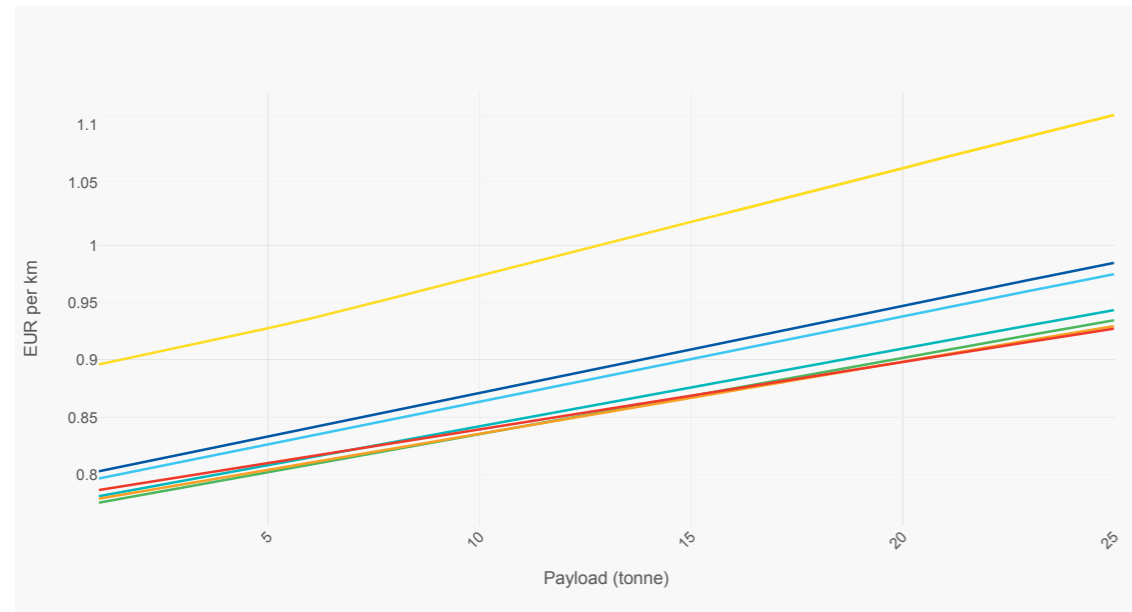
Cost structure by powertrain for 15-tonne payload in Spain



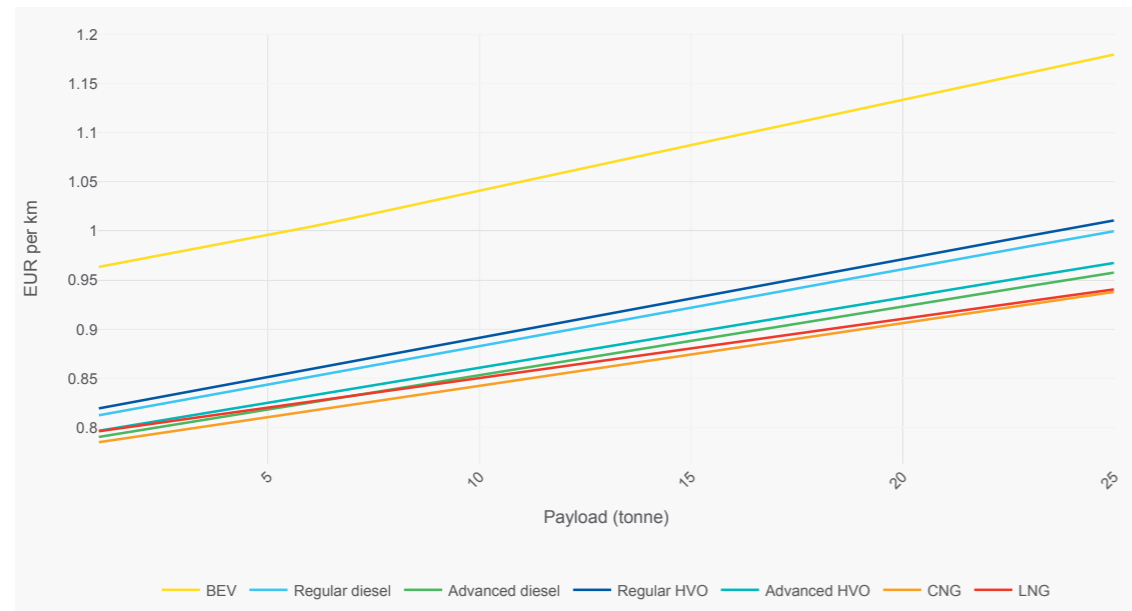
Cost structure by powertrain for 15-tonne payload in Italy



TCO in Spain



TCO in Italy

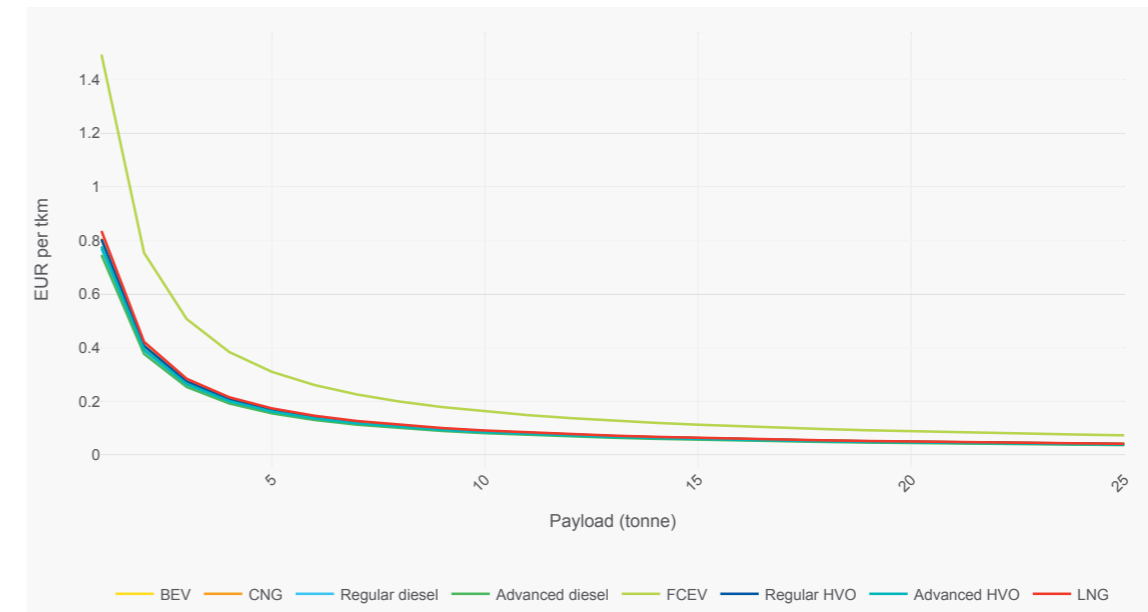


It is apparent that the BEV powertrain is the most expensive in all countries except Germany and France, due to lower electricity costs, and lower toll fees for BEVs in Germany. In France, the ranking, in EUR per kilometre, between powertrains evolves according to payload increases. The higher the payload, the more efficient the internal combustion engines are on average compared to BEVs. Excluding BEVs, the TCO of different powertrains are almost equally spread in Spain and Italy, while other countries have substantial differences

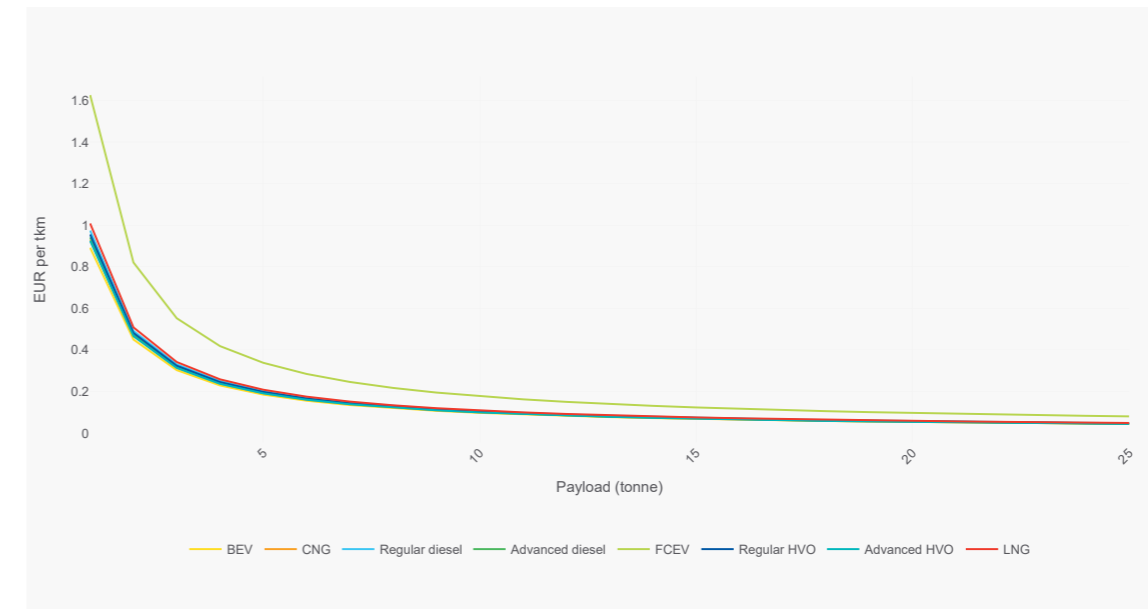
due to variations in cost structures, as previously demonstrated.

Another perspective emerges when examining the TCO in EUR per tonne-kilometre rather than just per kilometre. This view reveals that TCO variations between powertrains become less significant compared to TCO variations across payload values (except for FCEVs). This TCO intensity demonstrates that, regardless of the powertrain, increasing payload is a powerful lever for minimising transport costs.

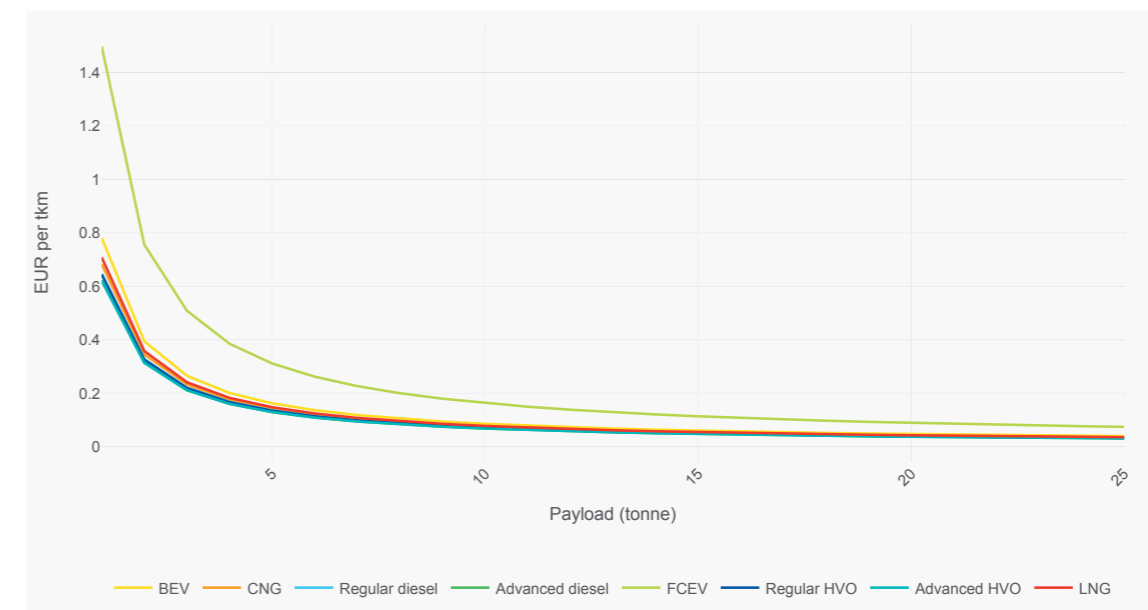
TCO in France



TCO in Germany



TCO in Poland



  
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