ZERO-EMISSION ROAD FREIGHT TRANSPORT

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This document is a summary in English of the report *"Potential options and technology pathways for delivering zero-carbon freight in Spain"* by the consultancy firm Cambridge Econometrics, which can be found at: https://www.camecon.com/what/our-work/zero-emission-road-freight-transport-in-Spain/

The entities that have contributed to the preparation of the above-mentioned report have carried out, in a series of meetings held throughout 2021, a constructive and transparent exchange of views with Cambridge Econometrics on the technical, economic and environmental issues related to the development of low-carbon technologies for vans and heavy goods vehicles.

The aim of this collaborative project has been to assess the limits within which vehicle technologies can contribute to mitigating carbon emissions from road freight vehicles in Spain.

The following entities have participated in the project by contributing data and their knowledge, experience and vision on the subject. These contributions have been taken into account by the authors of the report, but the study should in no way be considered as reflecting the positions or opinions of these organisations.

- **Dirección General de Transporte Terrestre, del Ministerio de Transportes, Movilidad y Agenda Urbana**
- **IKEA España**
- **Instituto para la Diversificación y Ahorro de la Energía (IDAE), Ministerio para la Transición Ecológica y el Reto Demográfico**
- **Irizar e-mobility**

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Contents

Acronyms and abbreviations

	ABBREVIATION	DEFINITION
POWERTRAIN TYPES		
Internal combustion engine	ICE	These are conventional fossil-fuel powered vehicles with an internal combustion engine. In the various scenarios modelled there is variation in the level of efficiency improvements to the ICE. Efficiency improvements cover engine options, transmission options, driving resistance reduction, tyres and hybridisation.
Battery electric vehicle	BEV	This category refers to fully electric vehicles, with a battery but no internal combustion engine.
Fuel cell electric vehicle	FCEV	FCEVs are hydrogen fuelled vehicles, which include a fuel cell and a battery-powered electric motor.
Electric road system	ERS	Refers to electrified infrastructure to supply EV vehicles with a constant power supply across portions of the road network. BEV-ERS are vehicles with the required pantograph to enable them to draw charge from ERS.
Zero emissions vehicle	ZEV	Includes all vehicles with zero tailpipe emissions (e.g. FCEVs and BEVs).
Electric vehicles	EV	All vehicles which are fuelled directly via electricity (i.e. BEVs and PHEVs).
VEHICLE TYPES		
Light Heavy goods vehicles	LHGVs	Heavy goods vehicles with a gross vehicle weight of 3.6-7.5 tonnes.
Medium Heavy goods vehicles	MHGVs	Heavy goods vehicles with a gross vehicle weight of 7.6-16 tonnes.
Heavy Heavy goods vehicles	HHGVs	Heavy goods vehicles with a gross vehicle weight greater than 16 tonnes.
Heavy goods vehicles	HGVs	Goods vehicles with a gross vehicle weight greater than 3.6 tonnes. This acronym is used to refer to LHGVs, MHGVs and HHGVs altogether.
OTHER ACRONYMS		
Original equipment manufacturers	OEMs	Equipment manufacturers of motor vehicles and their components.
Total Cost of Ownership	TCO	Total cost of purchasing, owning, and operating (fuel, maintenance, etc.) a vehicle over its lifetime.
Operating expenses	OPEX	Expenses a business incurs through its normal business operations.
Capital expenditures	CAPEX	Funds required to acquire and install a certain physical asset.
Operations and maintenance	O&M	The category of expenditure covering the operations and maintenance to provide a good or service.
Hydrogen refuelling station	HRS	Infrastructure for the dispensing of hydrogen for motor vehicles.

Table 1. Acronyms and abbreviations used in the study.

Executive summary

This study explores the potential options and technological pathways to deliver zero carbon road freight transport in Spain in 2050.

Its objective has been to assess the techno-economic potential of different powertrains to decarbonise road freight transport, taking into account the specific characteristics of this sector in Spain, in terms of its nature as well as the infrastructure requirements to support the emerging fleet powered by advanced zero emission technologies (e.g. electric charging and hydrogen refuelling infrastructure needs).

The Cambridge Econometrics (CE) analytical team, with the support of the European Climate Foundation (ECF) and Transport & Environment (T&E), has worked throughout 2021 with a panel of experts, comprising representatives from a range of entities involved in the road freight transport sector, to understand, in the specific case of Spain, what the possible decarbonisation pathways are, as well as its relevant costs (in terms of vehicle, infrastructure costs and total cost of ownership) and the environmental benefits of their deployment (in terms of CO_2 emissions and air pollutants).

The study shows that a rapid transition to zero-carbon powertrains can substantially reduce the CO_2 emissions associated with the road freight fleet. As the electricity sector will decarbonise and hydrogen will be able to be produced by electrolysis using renewable energy sources, well-to-wheel CO_2 emissions will decrease substantially. However, there is a large gap in Spain between current policies and a consistent trajectory towards zero-carbon road freight transport.

In addition, the deployment of vans (vehicles with a gross weight of up to 3.5 tonnes) and zero-carbon trucks requires the simultaneous development of an adequate charging and refuelling infrastructure to support the growing fleet of such vehicles. For heavy-duty vehicles, the scenarios dominated by hydrogen fuel cell vehicles require the largest total investment in infrastructure, followed by the scenario dominated by vehicles equipped with pantographs for battery recharging via catenary (Electric Road System, ERS scenario). Investment in charging infrastructure is substantially lower in an equivalent scenario dominated by pure battery electric vehicles. There is also an important issue around the speed with which some of these infrastructures could be deployed. Thus, the need to anticipate investments for the ERS scenario is likely to mean that any transition favouring this technology will take place more slowly than a switch to battery electric or hydrogen fuel cells, implying higher cumulative emissions in the interim.

The analysis of the total cost of ownership of the different options examined shows that zero-emission trucks are likely to be cheaper than internal combustion engine trucks in the coming years. Thus, battery electric trucks will reach cost parity with internal combustion engine vehicles by 2025. Similarly, battery electric trucks with pantographs are also expected to be cheaper than internal combustion engine vehicles by that date. Hydrogen fuel cell-powered trucks will be cost-competitive with respect to ICE ones by 2030 as hydrogen prices fall. The cost of these technologies will fall over time as economies of scale are achieved and low electricity and hydrogen prices allow vehicles with advanced propulsion technologies to become more cost-effective. Zero emission trucks may further benefit from additional policies that reduce the cost of these technologies or increase the costs of diesel vehicles.

However, in the scenarios considered in the report where any of the advanced - i.e. non-internal combustion engine - powertrains dominate, phasing out the sales of new internal combustion engine vans in 2035 and new heavy-duty internal combustion engine vehicles in 2040 alone does not achieve total decarbonisation of the fleet in 2050, as a number of these internal combustion engine vehicles sold before will still be part of the fleet in 2050. Therefore, an earlier phase-out of internal combustion vehicles and other additional policies would be needed to achieve sector-wide zero emissions in 2050. It is important to note that conventional internal combustion engine vehicles will become increasingly uncompetitive over their lifetime compared to their electric equivalents, with the likely result that hauliers will rely less and less on them. This latter fact has the potential to precipitate a shift from the use of existing internal combustion engine vehicles to zero-emission mobility models more rapidly than is reflected in this study.

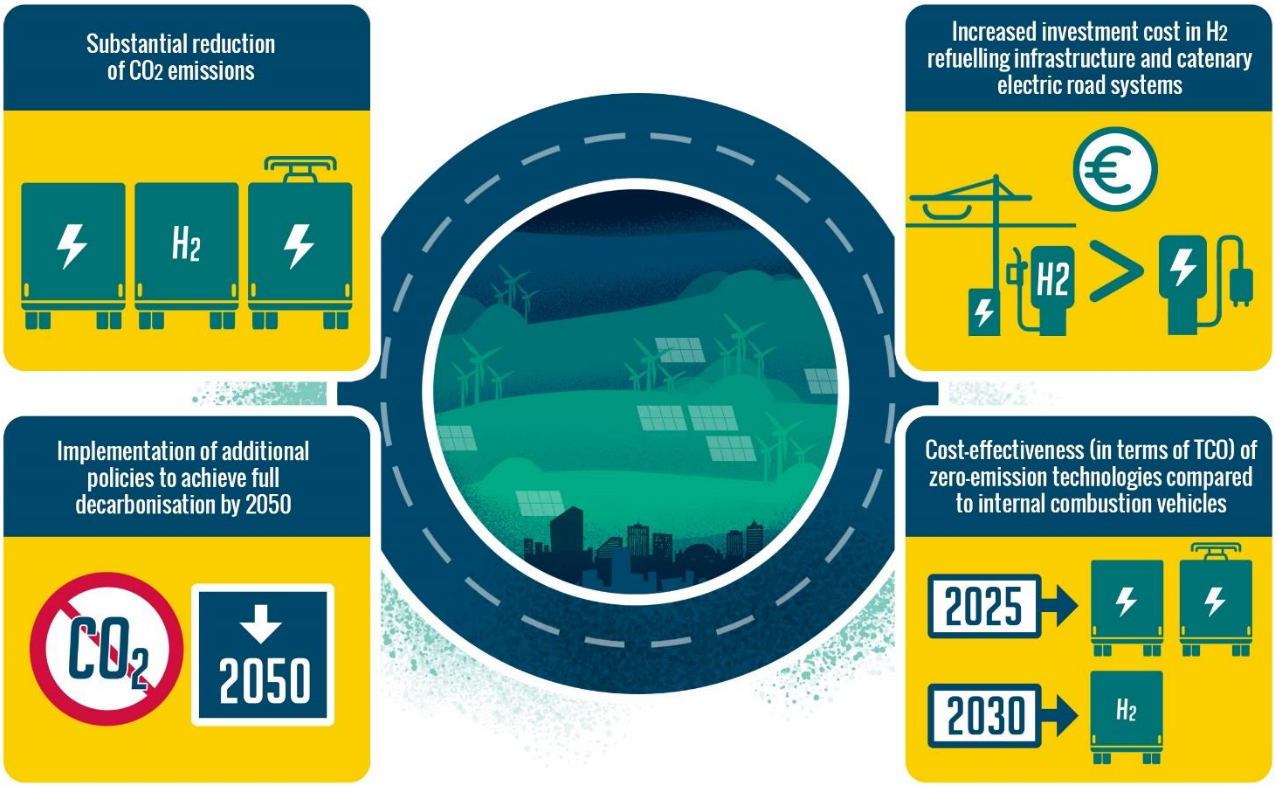

Figure 1. Main conclusions

Introduction

Transport is the sector that contributes most to greenhouse gas (GHG) emissions in Spain. According to data from the Ministry for Ecological Transition and the Demographic Challenge (MITERD), included in the Spanish National Greenhouse Gas Inventory Report[1] (March 2021), this sector accounted for 29.1% of total emissions in terms of CO_2 equivalent in 2019.

Thus, in order for Spain to meet its energy and climate targets and commitments adopted at state, European and international level, the transport sector must be decarbonised as a priority.

Road transport is the largest contributor to GHG emissions, being responsible, according to the same source, for 26.8% of the national total, which is not surprising since in Spain this is the predominant mode of transport, both in terms of passengers and goods (representing more than 80% of total mobility).

As for freight transport (97% of which is by road in Spain), according to the same MITERD report 8.19% of total national GHG emissions came from heavy goods vehicles (trucks) and 1.63% from light vehicles (vans), the vast majority of which still run on fossil fuels.

Spain has the third highest volume of road freight transport (in million tonne-km) of any EU Member State, behind Poland and Germany. In Spain and Poland, more than 50% of the fleet travels more than 500 km per day. Both countries lead in the number of international journeys (12% and 30% respectively) in the EU. Thus, Spain is one of the countries with the highest volume of goods transported by road and with the highest daily mileage among EU countries.

In Spain, according to data from the Statistical Portal of the Directorate General of Traffic (DGT), belonging to the Ministry of the Interior, at the end of 2019 there were 2,783,153 trucks of any maximum authorised mass (MMA). As for vans, according to the DGT, there were 2,467,487 of these vehicles in Spain at the same time. In total, 5,250,640 vehicles of both classes[2].

As for trucks, 2,205,647 of them were of <3.5t MMA and the rest, i.e. 577,506, were trucks of >3.5 t MMA and industrial tractors. Thus, still according to DGT data, the sum of vans and light trucks of <3.5 t MMA amounted in 2019 to a total of 4,673,134 vehicles.

According to DGT data for 2020, 96.42% of all trucks (2,514,750) were running on diesel, 3.21% on petrol and 0.36% in the category "other fuels/technologies".

With regard to the age distribution of the fleet of trucks in Spain, 13.5% were <5 years old; 9.3%, 5 to 10; 29.5%, 10 to 15; 25%, 15 to 20; 22.6%, >20, resulting in 47.6% of the total being over 15 years old.

As for trucks over 16 tonnes, the DGT figure for 2020 is 276,511, 89.39% of which are in the 30.1 to 40.0 tonne range.

European Union CO_2 emission standards

In 2019, the European Union agreed Regulation (EU) 2019/1242, which sets CO_2 emissions standards for heavy-duty vehicles until 2030. New vehicles sold in 2025 and 2030 will have to emit an average of 15% and 30% less, respectively, compared to the EU average CO_2 emissions per tonne-kilometre of new vehicles sold during the period from 1 July 2019 to 30 June 2020. Initially, the rules apply only to larger trucks, but their scope is expected to be extended as part of the revision of the rules scheduled for 2022.

As seen above, there is a substantial proportion of older trucks operating in Spain, and rapid decarbonisation requires that these are phased out and replaced by zero-carbon alternatives.

Similarly, with respect to vans, also in 2019 the EU adopted Regulation (EU) 2019/631 setting CO_2 emission performance standards for new passenger cars and new light commercial vehicles. This regulation requires

[1] *Informe de Inventario Nacional de Gases de Efecto Invernadero.* Ministerio para la Transición Ecológica y el Reto Demográfico (MITERD) (2021).

[2] At the end of 2020, according to DGT data, there were a total of 2,514,750 trucks and 2,516,177 vans, i.e. a total of 5,030,927 vehicles of both classes. There is therefore a slight decrease in the number of trucks and a slight increase in the number of vans compared to the previous year.

reducing CO_2 emissions from the average EU vehicle fleet from new passenger cars and vans by 15% for the period 2025-2029, and by 37.5% for new passenger cars and 31% for new vans from 2030 onwards.

These CO_2 emission standards are a key element of the broader objective of fully decarbonising freight transport across Europe by 2050, which in turn is part of the overall objective of climate neutrality (i.e. zero net greenhouse gas emissions) by that date.

Indeed, we should bear in mind that the European Union has committed to achieve climate neutrality by 2050. In order to achieve this goal, it will be necessary, among other measures, to accelerate the transition of the road freight vehicle fleet to zero emissions more quickly than that resulting from the above-mentioned regulations.

Although the Integrated Energy and Climate Plan 2021-2030 (PNIEC) states that modal shift measures must be taken to shift freight transport from road to rail (the latter represents only 2% of the total in Spain, compared to an EU average of 17%), the truth is that it will not be possible to achieve the total decarbonisation of this activity without committing to zero emission technologies in trucks and vans.

Given this evidence, it is pertinent to answer a series of key questions in this area, such as: what are the environmental benefits associated with decarbonisation technological pathways in Spain; how will the total cost of ownership of the different powertrains evolve over time and what impact will this have on Spanish hauliers; and what are the investment needs in infrastructures associated with decarbonisation routes in Spain? The aim of this study is to answer these questions.

Methodology

The illustration below summarises the process followed in the collaborative project for the development of the study with all stakeholders.

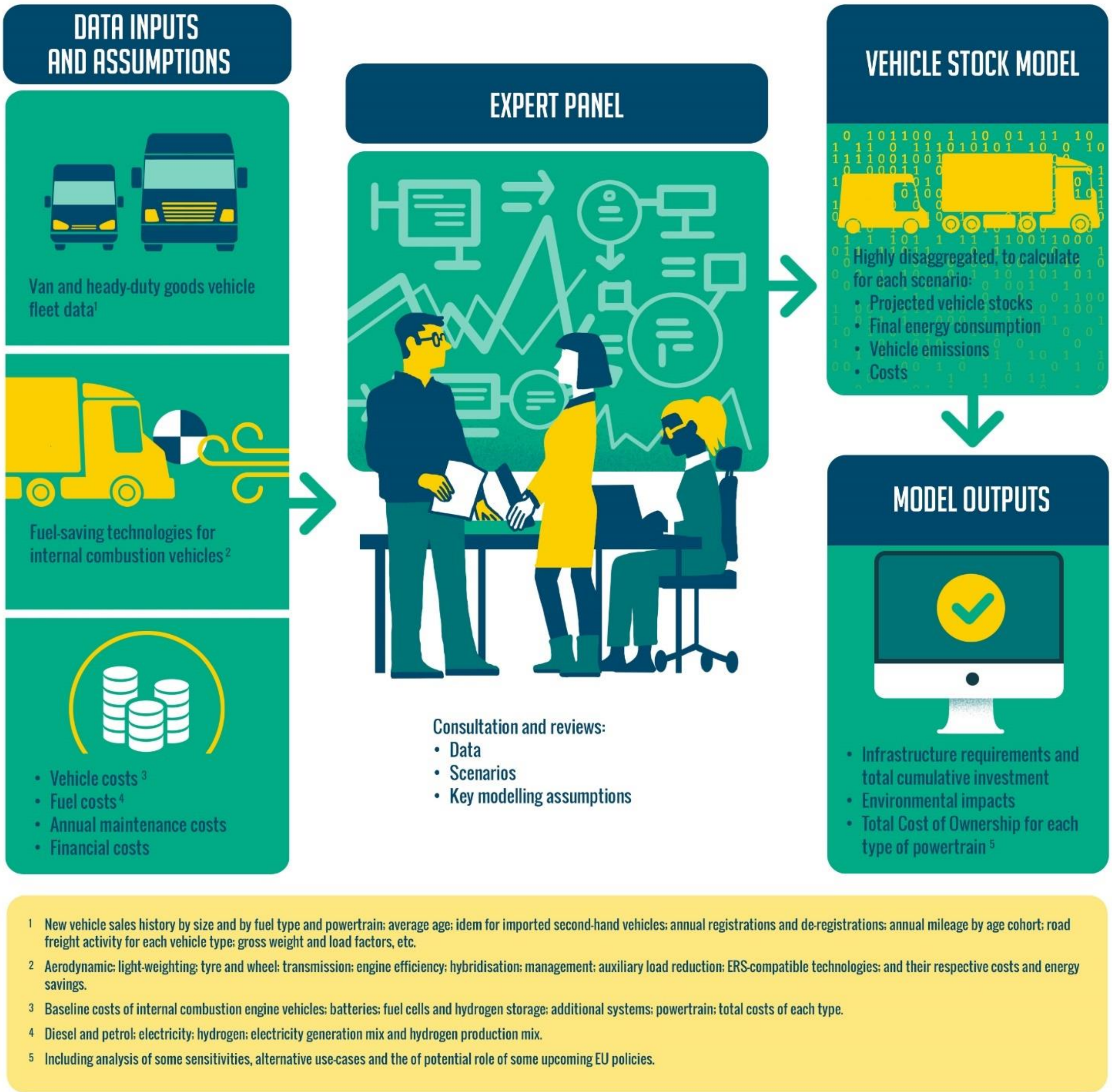

Figure 2. General description of the approach used in the modelling of the project.

In the process, five meetings were held with the expert panel, starting with a first meeting to discuss preliminary ideas on the scenarios to be considered, define them properly and agree on the main modelling assumptions.

The integrated modelling framework included: (a) the application of the Cambridge Econometrics vehicle stock model to assess the impact of various combinations of zero-carbon vehicle sales on energy demand, CO_2 emissions, vehicle prices and technology costs; and (b) a total cost of ownership (TCO) analysis to assess all costs faced by hauliers in purchasing, operating and maintaining vehicles over their lifetime.

The interim results were discussed in a series of meetings with the expert panel where there was a fruitful exchange of information and views, as well as further comments from the parties, received through other channels.

For the study, a set of scenarios were defined (see table 2) defined by: (a) the mix of new vehicle sales by powertrain type, (b) the adoption of energy efficient technologies, and (c) CO_2 emission reduction policies.

Scenarios considered

SCENARIO	SCENARIO DESCRIPTION
REF (Reference)	• No change in the deployment of energy efficiency technology or powertrains in sales from 2020 onwards. • Some improvements in the fuel-efficiency of the vehicle stock, due to stock turnover.
CPI (Current Policy Initiatives)	• Deployment of fuel-efficient technologies[3] in all new vehicles over the period to 2030 (e.g. light-weighting) and advanced powertrains, to meet the CO_2 emission performance standards targets in 2025 and 2030 for vans and HGVs. • No further changes after the year 2030.
TECH BEV (High Technology, BEVs dominate)	• Ambitious deployment of fuel-efficient technologies in all new vehicles over the period to 2030 (e.g. light-weighting). • Deployment of advanced powertrains, predominately BEVs for both vans and HGVs). • Phase-out of sales of new ICEs by 2035 for vans and 2040 for HGVs.
TECH ERS (High Technology, ERS system dominates)	• Ambitious deployment of fuel-efficient technologies in all new vehicles over the period to 2030 (e.g. light-weighting). • Deployment of advanced powertrains (predominately BEV for vans and BEV-ERS for HGVs). • Phase-out of sales of new ICEs by 2035 for vans and 2040 for HGVs.
TECH FCEV (High Technology, Fuel cell vehicles dominate)	• Ambitious deployment of fuel-efficient technologies in all new vehicles over the period to 2030 (e.g. light-weighting). • Deployment of advanced powertrains (predominately BEVs for vans and FCEVs for HGVs). • Phase-out of sales of new ICEs by 2035 for vans and 2040 for HGVs.

Table 2. Description of the five main modelling scenarios.

[3] Fuel-saving technologies for internal combustion vehicles: aerodynamic; light weighting; tyre and wheel; transmission; engine efficiency; hybridisation; management; auxiliary load reduction; and ERS-compatible technologies.

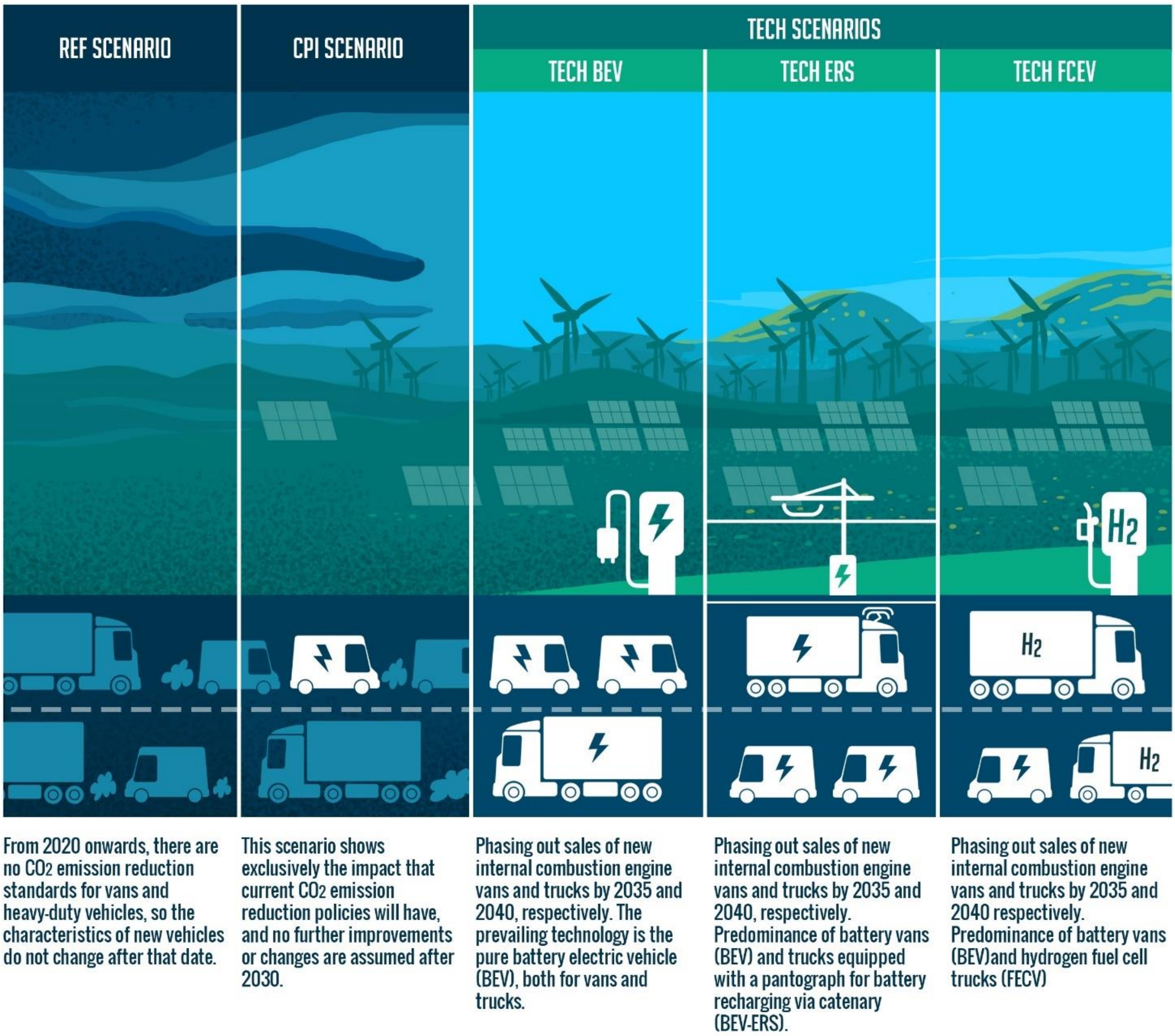

Figure 3. Summary of scenarios used in the study.

Much of the technical analysis presented in this report focuses on the van (0-3.5 t) and heavy-duty truck (HHGV, > 16 t) segments; however, similar analysis has been carried out for the light-duty truck (LHGV) and medium-duty truck (MHGV) segments. The main focus is on vans and HGVs because they constitute the most relevant part of the Spanish fleet of road freight vehicles and, consequently, carry the vast majority of the tonne-kilometres of freight. They therefore have a major influence on the overall costs and environmental impact of the sector.

Cost considerations

As shown in Figure 2, a number of input data and assumptions have been taken into account for the modelling, based on the latest scientific and technical literature. With regard to the estimation and projection of costs, it is useful to go into a little more detail than is provided in the figure above.

In the model, the **capital cost of each vehicle** is derived by combining projections of the cost of the powertrain and slider (by market segment) with estimates of the cost of fuel-saving technologies fitted to the vehicle (including low rolling resistance tyres, aerodynamic improvements and weight reductions).

The cost of technologies that reduce CO_2 emissions from road freight transport will reduce over time as economies of scale are achieved, but the cost faced by hauliers will increase as more technologies are added to meet increasingly stringent CO_2 limits required by legislation. By 2030, the purchase price of battery and fuel cell electric vehicles is still expected to remain higher than that of diesel and petrol vehicles. Over the following decades, the difference in purchase price will narrow as the price of diesel vehicles increases and zero-carbon vehicles become cheaper as they will be produced at scale. By 2050, the purchase price of BEVs will be even lower than that of internal combustion vehicles.

Battery price projections up to 2030 are based on historical prices and forecasts published in the specialist media. For the remainder of the period, a smoothed curve was applied to project prices up to 2050. According to the estimates, battery pack prices will continue to decrease from 2030 onwards, but at a more moderate pace than in the previous period, reaching approximately 30 euros/kWh in 2050. These prices also include a 40% premium that was added to reflect other additional costs (e.g. battery management system, spread in raw material costs, research and development costs as well as profit margins) to estimate the retail cost of the battery pack.

Both **fuel cell and hydrogen storage** costs are expected to more than halve between 2020 and 2040, but due to uncertainty no further cost decreases are assumed beyond 2040. The prices considered include hydrogen distribution costs.

In addition, powertrain costs for internal combustion engine vehicles are expected to increase slightly due to the future introduction of Euro VII standards which, according to sources consulted, are likely to result in a cost increase of between 2% and 5% compared to the current price of a new Euro VI truck. In contrast, powertrain costs for BEVs, BEV-ERS and FCEVs are expected to decrease due to future mass production. The costs for FCEVs also include the compressed hydrogen gas tank and the costs for BEV-ERS include the pantograph and the on-board connection system, in addition to the components mentioned above. According to the modelling, BEV costs are expected to decrease the most, falling below FCEV costs in 2030 and BEV-ERS costs in 2040.

In summary, **the total cost of the vehicle** can be broken down into 8 components, namely: the tractor unit, the trailer, the electric motor, the battery pack, the fuel cell, the compressed hydrogen tank, the additional system requirements and the active pantograph. The estimated contribution of the components to the cost of HHGVs can be seen in the figure below.

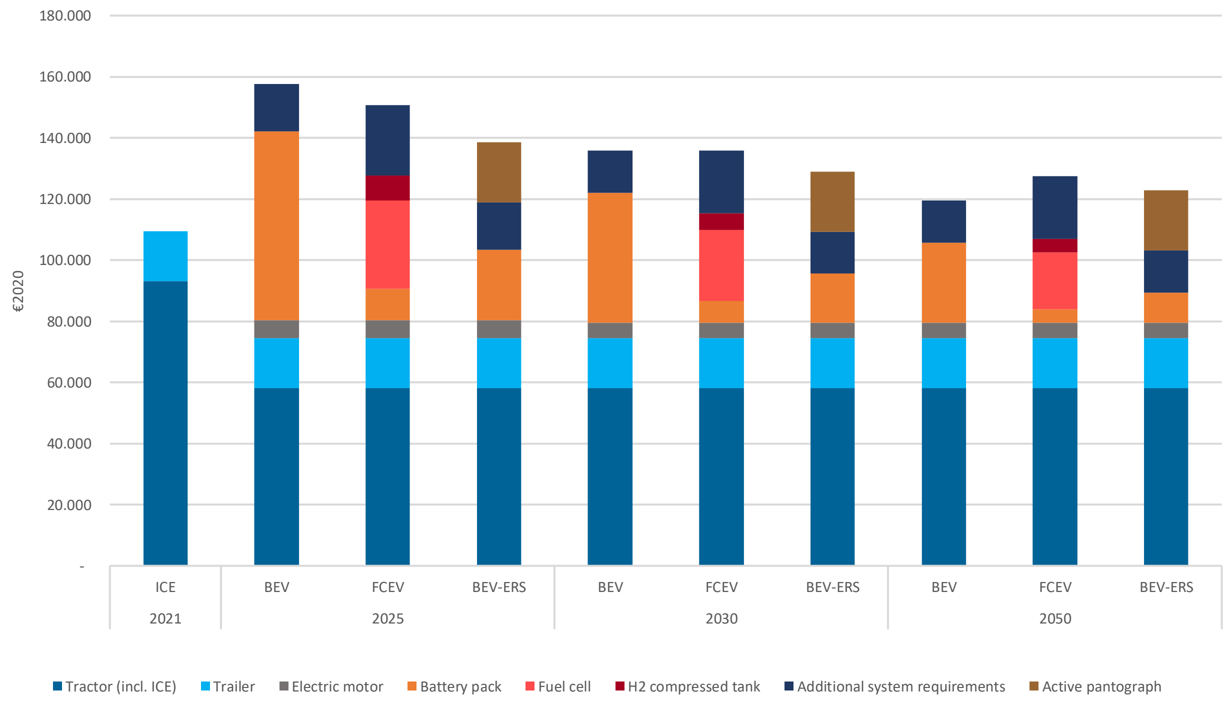

Figure 4. Breakdown of HHGVs powertrain costs (€, 2020)

With regard to **fuel costs** (conventional fossil, electricity, hydrogen) the following considerations should be taken into account.

For **ICE vehicle** fuels, the future price of oil is a key uncertainty in the zero-carbon transport scenarios and changes in the oil price are likely to greatly affect the economic outcomes of the scenarios. For the model, petrol and diesel prices were projected assuming the same price increase as in the IEA World Energy Outlook 2020 oil price projections.

For **electricity generation**, two scenarios were considered. On the one hand, the "conservative" scenario, with a generation mix in line with that forecast by the PNIEC until 2030. From then on, it is assumed that the percentage of renewable energies is increased until a 100% renewable generation mix, totally carbon neutral, is reached in 2050. On the other hand, in the "green" scenario, electricity is always sourced from renewables, generated locally at the charging station or through power purchase agreements. Therefore, electricity generation in the "green" scenario is completely carbon neutral in all years.

With respect to **hydrogen**, it is estimated that its production in Europe will increase significantly in the coming years, which will bring down the price. There are currently two main technologies for producing hydrogen: steam methane reforming (SMR) and electrolysis. Although SMR has significantly lower costs, the related carbon dioxide emissions are substantial. In contrast, hydrogen production by electrolysis with renewable electricity (green hydrogen) produces no CO_2 emissions. Hydrogen prices have been taken from industry forecasts up to 2030. After that date, it has been assumed that the price remains constant, as there is still a strong uncertainty about the evolution of hydrogen prices thereafter. These values cover production, preparation, distribution and refuelling station costs.

As in the case of electricity generation, two hydrogen production scenarios have been considered, both using electrolysis. Initially, in the "conservative" scenario, hydrogen is obtained primarily from grid electricity (yellow hydrogen). Then production gradually ramps up to 100% green hydrogen. On the other hand, in the "green" scenario, all hydrogen is produced locally from renewable electricity at hydrogen filling stations.

Regarding **maintenance costs**, in the TCO analysis, different annual maintenance costs are assumed for vehicles depending on their size and powertrain type. In general, EVs have fewer components than conventional powertrains and therefore their maintenance costs are lower.

For **financing costs**, it is assumed that new vehicles purchases are fully financed by a loan with an average interest rate of 6.5% in our central scenario to amortise the capital costs over the lifetime of the vehicle. Payments are made monthly and the finance costs are the difference between the amount of the total payments and the purchase price of the vehicle.

Vehicle fleet model consideration

The vehicle fleet model calculates vehicle fuel demand, vehicle emissions and vehicle prices for a given mix of propulsion technologies in each scenario. The model uses information on new vehicle efficiency and vehicle survival rates to assess how changes in new vehicle sales affect stock characteristics. The model also includes a detailed technology sub-model to estimate how the efficiency and price of new vehicles are affected by changes in the adoption of fuel-efficient technologies. The vehicle stock model is highly disaggregated, modelling 16 different technology types in four different classes of commercial vehicles (vans, LHGVs, MHGVs, HHGVs).

Total Cost of Ownership (TCO) Analysis Considerations

The results of the vehicle stock model (including fuel demand and vehicle prices) are used as input for the TCO analysis. The TCO analysis provides an in-depth comparison of the different vehicle types and shows the evolution of the cost components for each vehicle type. The cost components considered in the central case are: depreciation, fuel cost, maintenance cost, infrastructure (private and public) and financing cost.

Considerations in relation to vehicle sales in the different scenarios

The combination of sales for each propulsion system deployed in each of the scenarios has been considered for both vans and trucks.

The REF scenario does not include the deployment of advanced powertrains, so the dominance of internal combustion engines is maintained throughout the projection period. Internal combustion engines account for the totality of heavy-duty vehicle sales and stock until 2050, and only 0.65% of new vans are electric vehicles.

The CPI scenario reflects the achievement, by 2025 and 2030, of the current emission reduction targets for newly registered vehicles set at European level. To meet the 31% CO_2 emission reduction target for new vans in 2030, energy efficient technologies are introduced and BEVs reach 27% of annual new sales in 2030. Furthermore, in this scenario, BEVs and FCEVs are assumed to play a more prominent role in the heavy-duty vehicle sales mix, reaching respectively 13% and 6% of new sales in 2030. This period also sees moderate improvements in the energy efficiency of heavy-duty vehicles. As no further targets have been formally announced or introduced, no additional deployment of advanced powertrains or efficiency improvements of new vehicles are assumed beyond 2030. See figure 5 below.

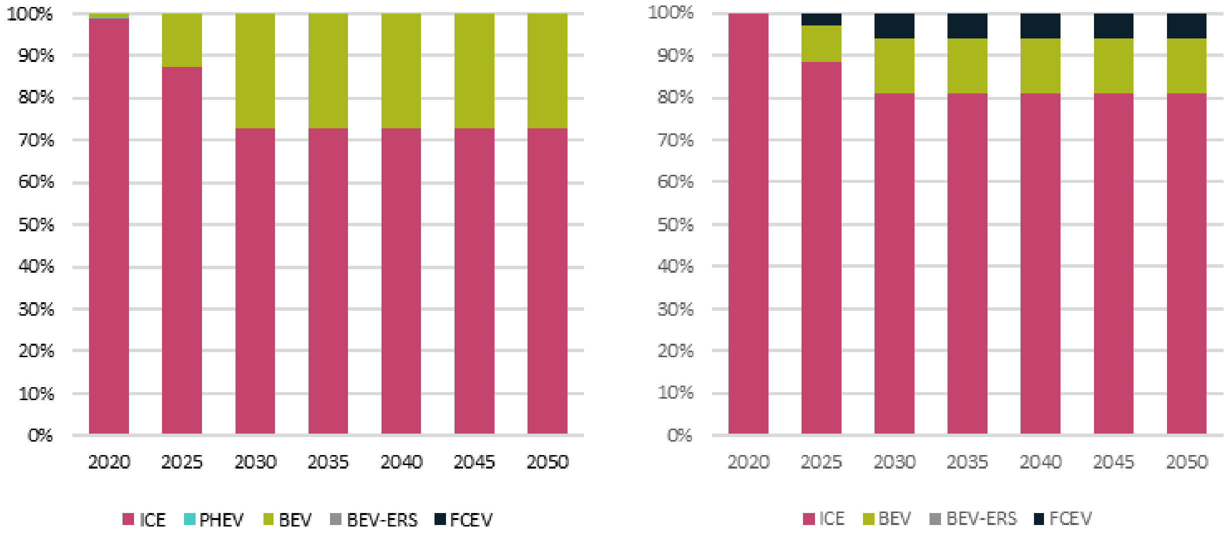

Figure 5: Sales mix of vans (left) and HGVs (right) in the CPI scenario (% of annual new vehicle sales)

In the TECH scenarios, battery electric vans become the dominant propulsion system in all scenarios. Thus, BEVs reach 75% of new sales in 2030, and ICEs are eliminated from new sales from 2035 onwards. All new vans are electrified thanks to improved battery technology and the deployment of an adequate charging infrastructure. FCEVs and BEVs with ERS are not taken into account in this scenario, as the vans are used for distances which are feasible with battery technology.

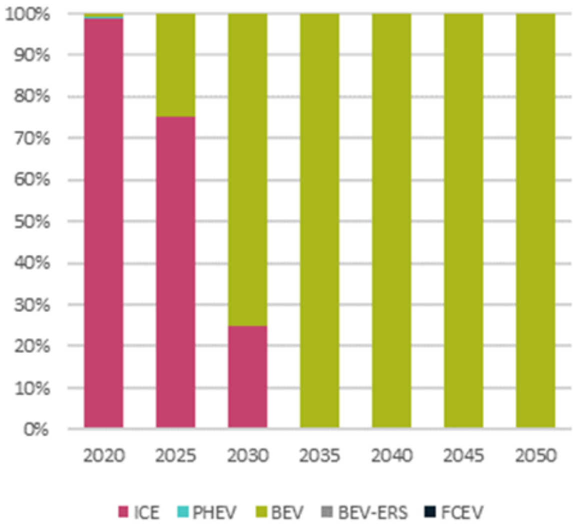

Figure 6: Sales mix of vans in all the TECH scenarios (% of annual new vehicle sales)

Figure 7: Sales mix of HGVs in the TECH BEV scenario (% of annual new vehicle sales)

The situation is different for trucks. Thus, in the TECH BEV scenario, 16% of new sales are BEVs in 2025. Those who buy BEVs do so because the technology is sufficient to meet their current needs (e.g. autonomy between distribution centres can be met with a full charge of a BEV). BEVs will reach 100% of new sales by 2040 (up from 35% in 2030 and 80% in 2035) due to continuous technology improvements and reduced battery pack costs.

In the TECH ERS scenario, vehicles with ERS systems become the dominant technology, but take some time to emerge due to their dependence on the prior existence of an ERS infrastructure. BEV-ERS vehicles only account for 20% of new sales in 2030; however, their market share expands rapidly thereafter, reaching 90% in 2040. As the deployment of ERS on the roads increases, vehicles with ERS become more attractive to hauliers. Vehicle costs are relatively low (compared to the other zero-carbon powertrains: BEVs and FCEVs), because ERS models do not need large batteries. In this scenario, a certain percentage of BEVs is maintained to cover short distances on roads without catenary.

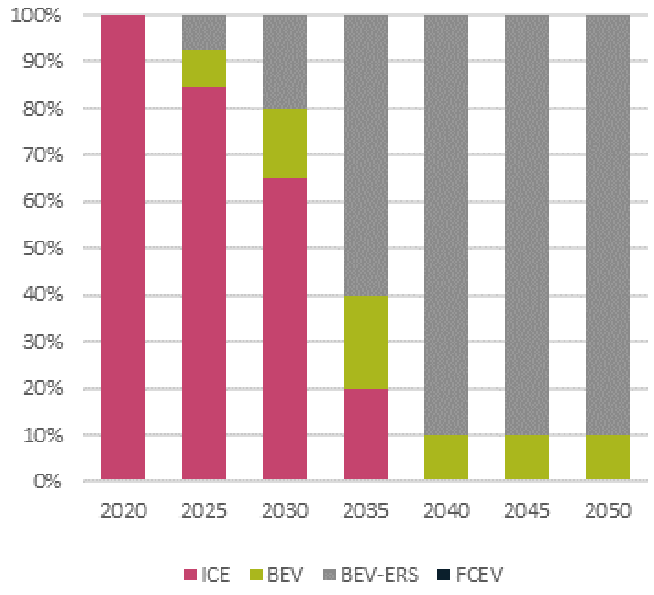

Figure 8: Sales mix of HGVs in the TECH ERS scenario (% of annual new vehicle sales)

In the TECH FCEV scenario, FCEVs become the dominant powertrain and in 2040 account for 100% of new sales. The deployment of FCEVs in this scenario coincides with that of BEVs in the TECH BEV scenario. FCEVs achieve rapid deployment thanks to the expected cost reductions.

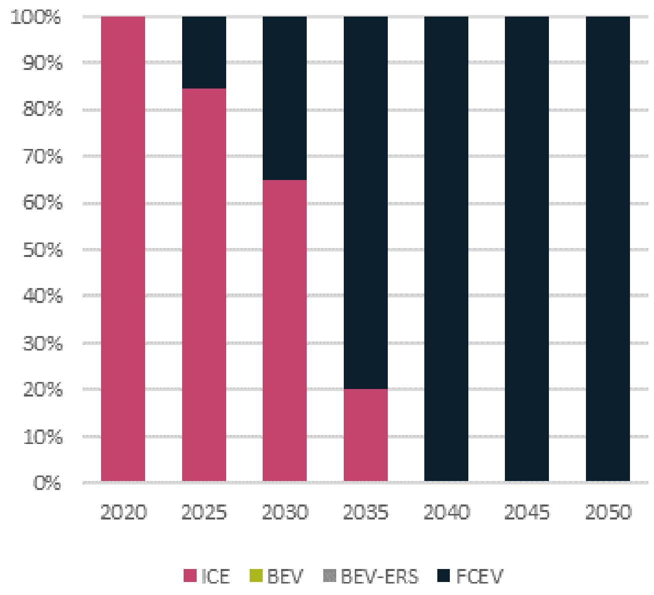

Figure 9: Sales mix of HGVs in the TECH FCEV scenario (% of annual new vehicle sales)

Projected structure of the fleet of vans and trucks to 2050

The evolution of the Spanish fleet of road freight vehicles in 2050 in each scenario and the corresponding estimate of fuel demand and CO_2 emissions were calculated using the model developed by Cambridge Econometrics.

Breakdown of the powertrain in the different scenarios

- Vans

In the CPI scenario, in 2040, the share of BEVs in the total van fleet reaches 18% and reaches 24% in 2050 (Figure 10).

In the TECH scenarios, the situation changes drastically. Thus, assuming a phase-out of the sales of new ICE vans with an end date for their commercialisation in 2035, the deployment of BEV powertrains in the TECH scenarios is rapid. The share of BEVs in the total van fleet continues to increase after 2035, reaching 58% in 2040 and 85% in 2050, thanks to improved battery technology and the deployment of an adequate charging infrastructure (see Figure 11). However, carbon neutrality will still not be achieved by 2050, as there will still be a remaining stock of ICE vehicles in circulation.

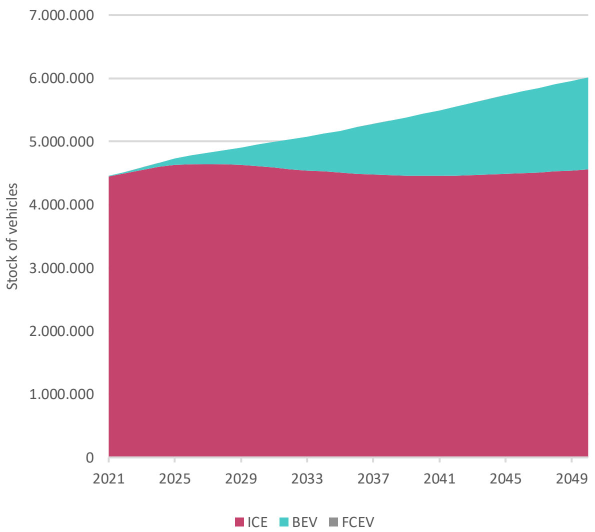

Figure 10. Stock composition for vans in the CPI scenario

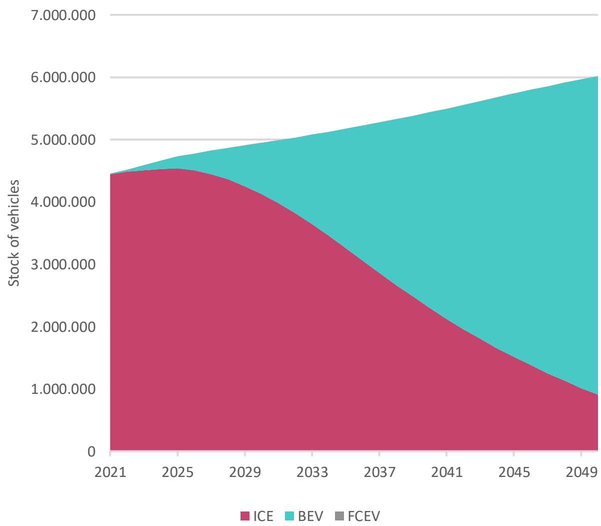

Figure 11. Stock composition for vans in the TECH scenarios

- Trucks

In the CPI scenario, less than 12% of the heavy-duty vehicle fleet in 2040 has an advanced powertrain, with BEVs contributing 8%. In 2050, BEVs represent 11% of the total HGV fleet and FCEVs just 5% (Figure 12).

In the TECH BEV scenario, BEVs reach 100% of new sales in 2040, which translates into 81% of the fleet in 2050 (compared to almost 10% of the fleet in 2030) (Figure 13).

Regarding the deployment of the heavy-duty vehicle powertrain in the TECH ERS scenario, due to the slow development of the predominant BEV-ERS technology, because of the need to deploy the necessary infrastructure early, only 32% of the vehicle fleet is ERS-enabled in 2040, and the fleet is still dominated by internal combustion engines at this point. However, in 2050, ERS-enabled vehicles are more than 68% of the fleet, and ICEs have been reduced to 19%. See figure 14.

In the TECH FCEV scenario, the development of FCEVs is identical to the deployment of BEV-ERS powertrains in the TECH ERS scenario. Due to the relatively high upfront costs of the technology, FCEVs achieve rapid deployment from 2035 onwards, reaching 43% of the stock in 2040 and 81% in 2050. See Figure 15.

As in the case of vans, the heavy-duty vehicle fleet in the three TECH scenarios is not fully decarbonised by 2050, and the zero-carbon target for the sector is not reached.

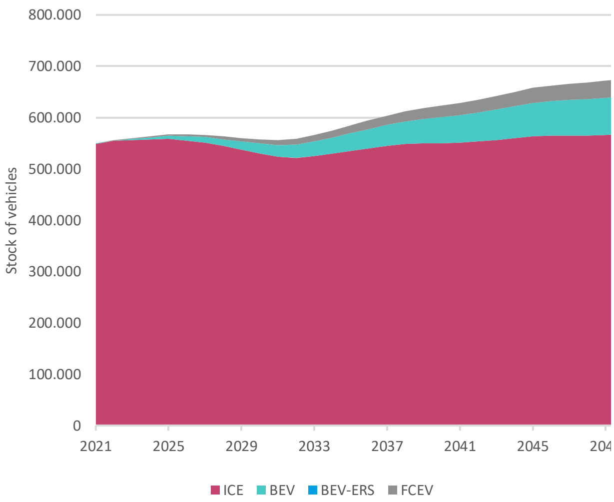

Figure 12. Stock composition for HGVs in the CPI scenario.

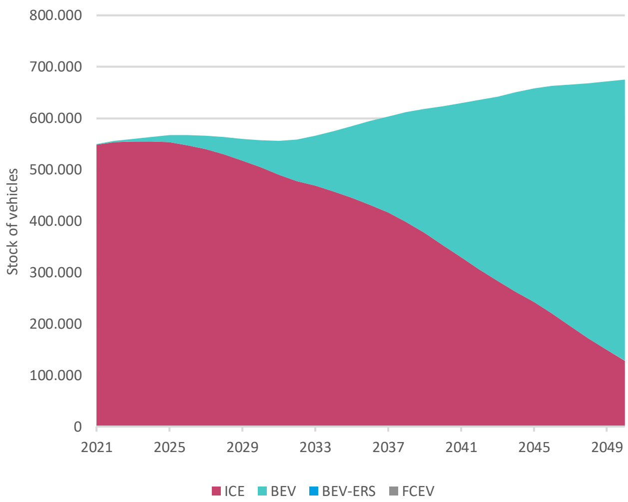

Figure 13. Stock composition for HGVs in the TECH BEV scenario

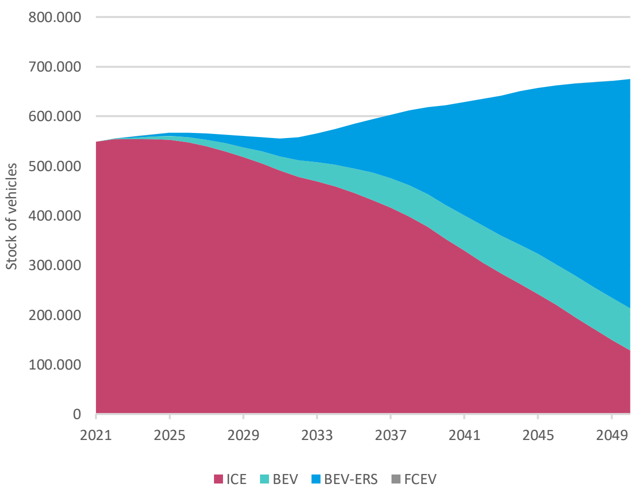

Figure 14. Stock composition for HGVs in the TECH ERS scenario

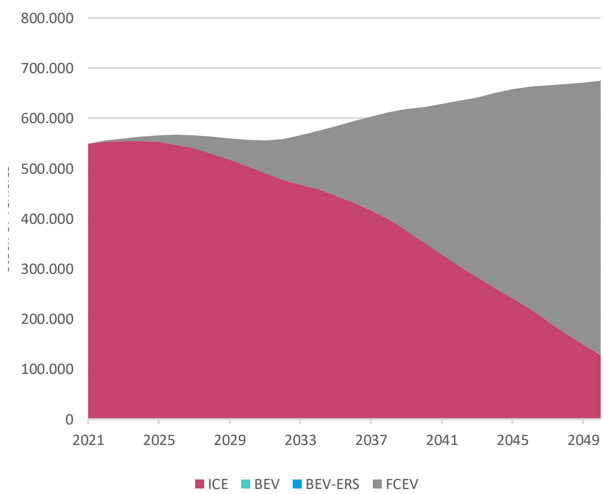

Figure 15. Stock composition for HGVs in the TECH FCEV scenario

Final energy consumption

The deployment of advanced powertrains and the combined adoption of fuel-efficient technologies substantially increase the efficiency of the vehicle fleet and consequently reduce the associated energy consumption. As shown in Figure 16, the fuel consumption of the vehicle fleet is modestly reduced in 2030 in the TECH scenarios compared to the CPI scenario. However, in 2050, as the share of vehicles with advanced powertrains increases, annual fuel demand is reduced by more than 56% in the TECH BEV and TECH ERS scenarios and by 41% in the TECH FCEV scenario compared to the reference scenario. The reduction in fuel demand in the TECH FCEV scenario is more moderate due to the lower efficiency of fuel cell technology compared to electric battery powertrains.

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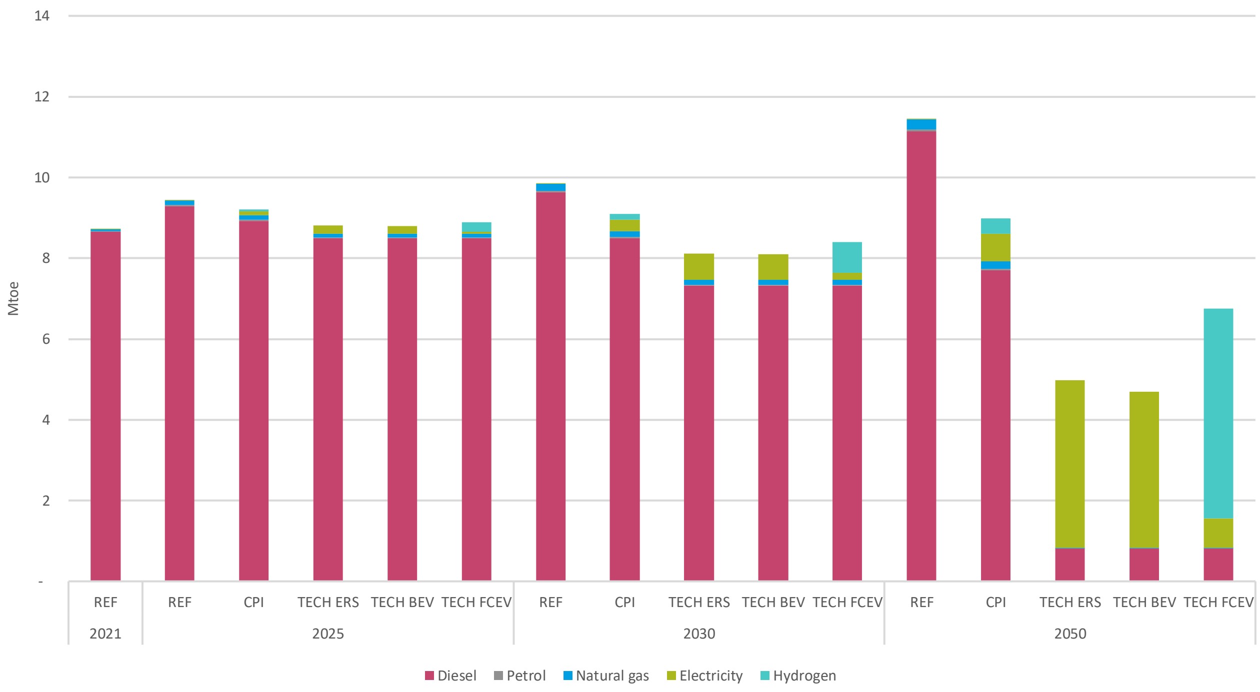


Figure 16: Stock fuel consumption of fossil fuels, hydrogen and electricity (Mtoe) in the different scenarios.

This only comprises the differences in final energy consumption, but if looking at primary energy consumption the difference between BEV/ERS and FCEV would be even bigger. This is due to the fact that final energy consumption does not factor in well-to-tank efficiency losses.

Infrastructure requirements

Just as it was once necessary to enable internal combustion engine vehicle transport, the deployment of advanced zero-carbon powertrains also requires the implementation of a dedicated infrastructure.

In this respect, the study has analysed the costs and pace of deployment of electric charging points, hydrogen refuelling stations and electric road systems, as well as the total infrastructure needs.

TECH ERS scenario

The main source of electricity for ERS-enabled vehicles will be through an electric road system with catenary. There will also be a deployment of slow chargers in depots (22 kW), to facilitate overnight charging of vehicles. As the deployment of electric road infrastructure increases, the time trucks spend in electric mode will increase, which will be reflected in increased use of this infrastructure. In order to incentivise the uptake of electric enabled vehicles, the deployment of ERS infrastructure has been concentrated in the initial phase.

Based on verified ERS installation, operation and maintenance cost data, it is assumed that installation costs decrease over time from a value of €2.41 M/km in 2020 (in the early stages of deployment) to €2.14 M/km in 2050, when the system is technologically mature, after substantial learning has taken place in the interim and given the associated cost reductions. Linear interpolation is used to derive the cost in each year between 2020 and 2050.

Based on traffic flow data from the Traffic Map of the General Directorate of Roads of the Ministry of Transport, Mobility and Urban Agenda (MITMA) for 2019, the sections of the high-capacity road network with the highest levels of use by heavy vehicles were identified, i.e. those that would most need to be equipped with ERS catenary infrastructure to allow for the dynamic loading of the progressively growing fleet of BEV ERS vehicles. Thus, such infrastructure is assumed to be deployed along a number of sections of the following roads: A-2, A-3, A-35, A-4, A-6, A-7, AP-7, N-340, SE-30, V-30 and V-31, for a total of 3,891 km.

Increasingly rapid deployment of infrastructure is assumed as learning takes place and costs decrease. Despite slow initial adoption, around 26% of the network considered is covered by ERS in 2050 (compared to 2.4% in 2030 and 11.1% in 2040).

Due to the necessary infrastructure requirements, the expected share of heavy-duty vehicles with ERS is only 5% of the HVG fleet in 2030; however, their share expands rapidly thereafter, reaching 15.5% in 2035, 32.8% in 2040 and 68.1% in 2050.

TECH BEV scenario

Based on existing documentation and announcements by various companies and governments, it is considered that battery electric heavy-duty vehicles will rely on fast charging technology for on-road charging, for which these vehicles will require a high-power charging infrastructure (700 kW chargers have been assumed in the study) installed along key transport routes (e.g., the main EU TEN-T network). It has been estimated that their manufacturing and installation cost would be 512,797 € and 398,619 €, respectively, i.e. a total cost of close to 1 M€.

It has also been assumed that lower power chargers installed in depots would be necessary to allow slow charging of vehicles during the night. For the latter, different power outputs have been considered (7 kW for vans; 22kW and 90kW for trucks) to support batteries of different sizes in the fleet. Regarding the cost, it has been assumed that the owners of these installations would buy the cheapest charger that meets their need. The estimated manufacturing and installation costs for each of these power ratings would be: €855 and €427 for 7 kW; €10,683 and €4,074 for 22 kW; and €34,186 and €10,683 for 90 kW.

The final installation cost will depend on the number of charging posts to be installed, the type of location and existing installations at the site and, most importantly, the level of grid reinforcement required to cope with the increase in local electricity demand. In terms of location, it has been assumed that depots are in existing facilities, usually located in an urban area, while sites for installing fast charging points for heavy-duty vehicles will be newly built, due, on the one hand, to the substantial additional space requirements of fast charging stations and, on the other hand, to the space limitations of the currently existing stopping and refuelling points in a large part of Spain. Thus, for the new fast charging stations, additional costs (for access roads to and from the main road, site works, professional fees, grid connection and civil works) have been estimated at between 269,218 € (initial phase, with 2 charging points) and 646,337 € (mature phase, with 8 or more charging points).

TECH FCEV scenario

To service FCEVs, the main infrastructure needed will be hydrogen refuelling stations (HRS). For this technology to take off, sufficient initial investment is also needed to incentivise hauliers to switch to heavy-duty hydrogen fuel cell vehicles.

The main components of a hydrogen refuelling station are a compressor, refrigeration equipment and a dispenser. An HRS will dispense hydrogen at 700 bar according to the performance specification set out in the international standard SAE J2601. The current level of technology and manufacturing volumes make the costs of a hydrogen refuelling container relatively high.

In the scenario for the FCEV vehicle fleet model, two different sizes of HRS capable of dispensing, respectively, 10,000 kg/day and 25,000 kg/day have been selected. The cost estimates for an HRS have been linearly scaled using the power rule of 0.6 from the cost of a 3,000 kg/day station, initially designed for hydrogen buses. A 3,000 kg/day HRS requires 5 dispensers, this ratio is used to determine the number of dispensers required for a 10,000 kg HRS (that would be 17 dispensers) and 25,000 kg HRS (42 dispensers). Given the estimated cost ranges for each dispenser (including installation and civil works, etc.) and for each combined storage and compression unit, and taking into account that for the largest HRS the costs are at the lower end of the range, total investment costs of €28 million and €48 million are assumed, respectively.

Total cumulative infrastructure investment

Figure 17 shows the cumulative infrastructure investment needs for each TECH scenario from 2021 to 2050. In the TECH scenarios, the rapid deployment of the necessary infrastructure is essential to enable the penetration of EVs in the fleet. The deployment of hydrogen refuelling stations is more capital intensive than the installation of charging or ERS catenaries. The cumulative infrastructure investment in the TECH FCEV scenario reaches almost EUR 20 billion in 2050, while in the TECH ERS scenario it is EUR 16 billion and in TECH BEV, where infrastructure costs are lower, it is EUR 12 billion.

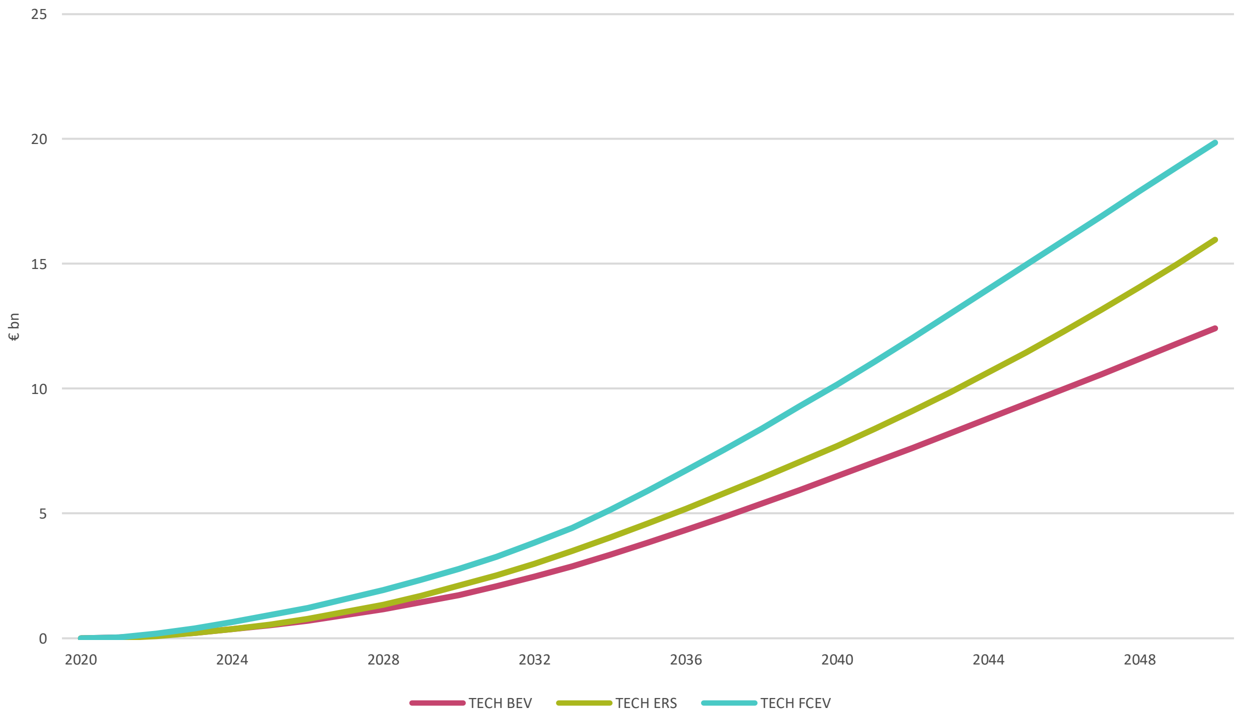


Figure 17: Total cumulative infrastructure investment by scenario (billions of euros, 2020)

Environmental benefits

Impact on CO_2 emissions

The evolution of the average tailpipe CO_2 emissions of the vehicle fleet in each scenario is shown in Figure 18 for vans and Figure 19 for HHGVs.

With the exception of the REF scenario, all other scenarios analysed meet (CPI scenario) or exceed (TECH scenarios) the CO_2 emission reduction levels of 15% by 2025 and 30% (31% for vans) by 2030 (in terms of gCO_2/km compared to the baseline) proposed by the European Commission regulation.

For vans, direct (tailpipe) emissions from new vehicles are reduced to zero after the phase-out of sales of internal combustion engine vehicles in 2035, and the same applies from 2040 for heavy-duty vehicles.

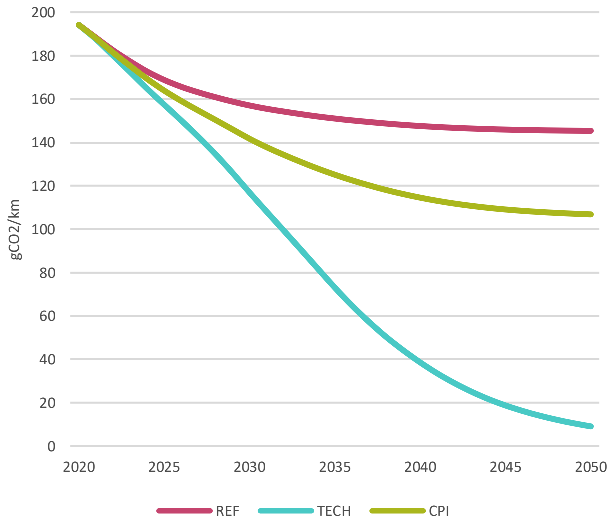


Figure 18: Average stock tailpipe CO_2 emissions of vans (gCO_2/km)

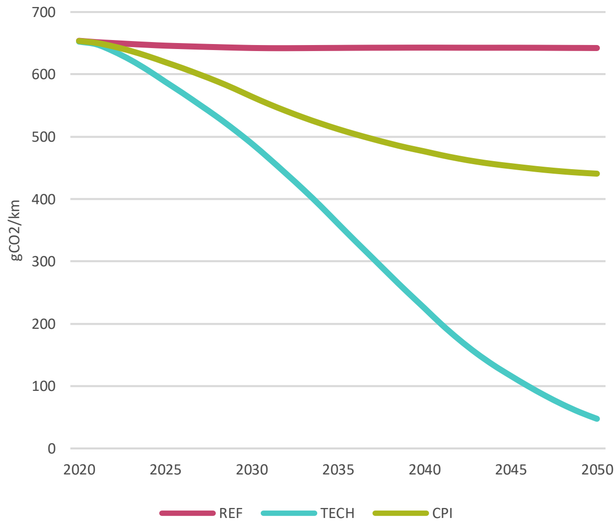


Figure 19: Average stock tailpipe CO_2 emissions of HHGVs (gCO_2/km)

Although direct emissions from new vehicles are zero after the above dates, however, as shown in Figures 18 and 14, emissions from the total vehicle fleet do not reach zero in 2050, as a percentage of internal combustion engine vehicles sold in previous years (before the phase-out) are still on the road.

Despite this, the penetration of zero emission technologies leads to a considerable decrease in direct emissions between 2030 and 2050, such that annual CO_2 emissions are almost 93% lower in 2050 in the TECH scenarios than in the reference scenario, while in the CPI scenario the reduction is only 31%.

With respect to well-to-wheel CO_2 emissions, i.e. taking into account the emissions associated with electricity generation and hydrogen used as fuel by zero-carbon vans and heavy-duty vehicles, as can be seen in Figure 20, all TECH scenarios achieve a reduction of more than 47% thanks to the combination of incorporating efficiency technologies and switching from diesel to zero-carbon powertrains.

Emission savings in the TECH scenarios are highest in the case of the "green" electricity generation and hydrogen production systems (Figure 20, left), achieving more than 49% reduction compared to the baseline. In the "conservative" electricity and hydrogen production scenario (Figure 20, right), the TECH BEV and TECH ERS scenarios outperform the TECH FCEV scenario because the use of grid electricity to produce hydrogen and power the FCEVs leads to higher implied emissions.

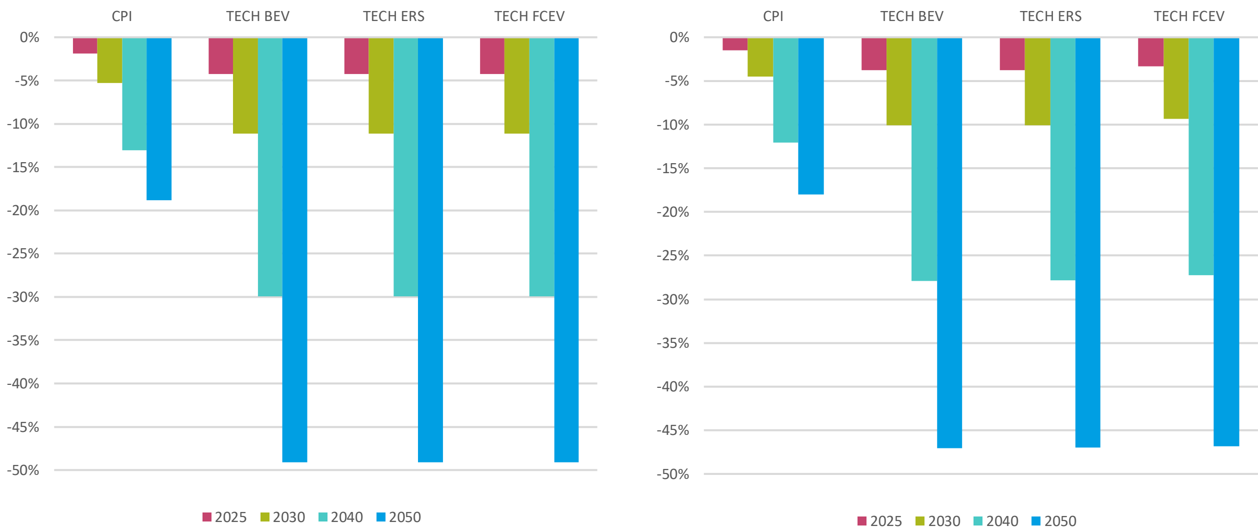


Figure 20: Cumulative CO_2 well-to-wheel emission reductions in the "green" scenario for electricity and hydrogen (left) and in the "conservative" electricity and hydrogen scenario (right) (%).

Impacts on particulate matter and nitrogen oxides emissions

Particulate matter (PM_{10}) and nitrogen oxides (NO_x) emitted by the use of fossil fuels in ICE vehicles in road transport have a substantial impact on air quality with detrimental consequences for human health, especially in many urban centres. The reduction of both pollutants is an important co-benefit of the decarbonisation of road freight transport.

In the CPI scenario, annual emissions of NO_x and PM_{10} particulate matter from vehicle tailpipes are reduced by 96% and 97% respectively in 2050 compared to 2020 levels. In the TECH scenarios the impacts are even higher for both particulate matter (almost 100% in 2050) and NO_x (99% in 2050). See Figure 21.

In the short and medium term, a large part of the reductions observed in all scenarios are related to the impact of the Euro 5/V, Euro 6/VI and Euro 7/VII emission standards on internal combustion engine vehicles. This is due to the fact that the progressive replacement of older ICE vehicles with newer vehicles subject to stricter emission control standards allows substantial reductions in annual PM_{10} and NO_x emissions. However, beyond 2030, emissions of these pollutants in the CPI scenario decrease at a slower rate compared to the TECH scenarios. This is mainly due to the transition from petrol and diesel vehicles to electricity and hydrogen that takes place in the TECH scenarios.

The modelled particulate emissions only refer to emissions resulting from combustion and thus released from the tailpipe. Particulate emissions from road transport related to tyre and brake wear and road abrasion, have not been modelled.

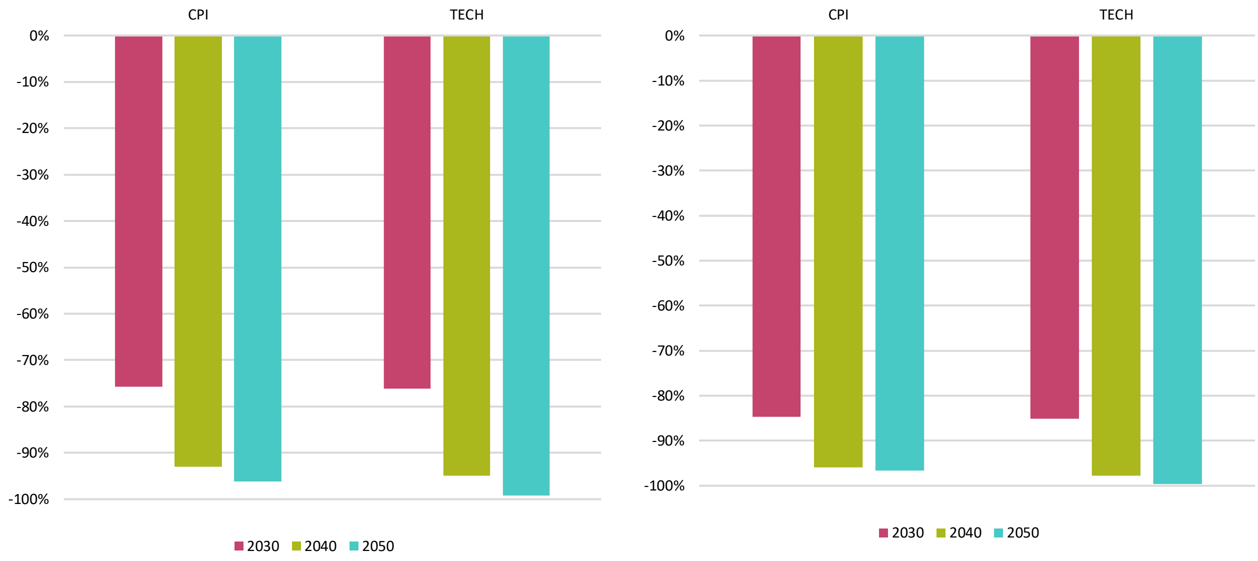


Figure 21: Tailpipe emissions of NOx (left) and PM10 (right) of the vehicle stock (% difference from baseline in 2020)

Total cost of ownership (TCO) analysis

The total cost of ownership (TCO) of the vehicle is generally the determining factor in the decision of hauliers to purchase one or another type of vehicle with which to carry out their activity.

To calculate the TCO of vans and heavy goods vehicles, the different costs associated with owning a vehicle over its lifetime were added together. The cost components considered in the central case are as follows:

- Depreciation: the purchase price of a vehicle (including VAT) minus the resale price at the end of the TCO period, i.e. the value lost between the time of purchase and the time of sale of the vehicle.

- Fuel costs: the cost of fuel/energy to cover the mileage travelled during the TCO period.

- Maintenance costs: the cost of maintaining and repairing the vehicle.

- Infrastructure costs: for electric vehicles, the CAPEX and OPEX of a deport charger over the TCO period and a contribution per vehicle to the total costs of the rapid charging infrastructure network; for hydrogen vehicles, a contribution per vehicle to the total costs of the hydrogen refuelling station network; for ERS-enabled vehicles, a per vehicle contribution to the total costs of the catenary infrastructure network.

- Financial costs: the cost of financing the vehicle purchase cost.

In addition, the effect on TCO of certain changes in assumptions regarding fuel and electricity prices, mileage and period of ownership have been analysed, as well as the impact of possible future regulations currently under discussion, as is the case of the new Eurovignette Directive.

TCO results: central case for vans and HHGVs

First, based on recent technical literature, archetypes of vans and HHGVs were developed that would represent the average vehicle in each of these classes, which facilitates the calculation of the cost components in the TCO analysis. These archetypes have been updated using informed feedback from the expert panel to consider the latest developments and trends in the Spanish (and European) road freight vehicle market.

The archetypal van in the case of ICE vehicles is equipped with a 90 kW diesel engine; for a BEV it consists of a 90 kW electric motor and a 70 kWh battery; and finally, in the case of a FCEV, a 45 kW fuel cell, a 90 kW electric motor, a 45 kWh battery and a tank capable of storing 3 kg of hydrogen.

As for the archetypes for HHGVs, the powertrain characteristics are: for ICE trucks, a 350 kW diesel engine; for BEVs, a 350 kW electric motor and a 600 kWh battery; for a BEV-ERS, a 350 kW electric motor and a 225 kWh battery; and finally, in the case of an FCEV, a 250 kW fuel cell, a 350 kW electric motor, a 100 kWh battery and a tank for 24 kg of hydrogen.

The TCO for each of the archetypes was then calculated, taking into account all the above-mentioned costs.

For the vans, Figure 22 shows the estimated TCO over a 14-year ownership period for each of the studied powertrains (ICE-diesel, BEV and FCEV).

As can be seen, based on the results, BEVs will become the cheapest vehicle type to own in 2025, although only marginally cheaper than an ICE. The main factors explaining the difference in their respective TCOs are lower fuel/energy costs, due to the higher efficiency of BEVs compared to ICEs and FCEVs, and lower maintenance costs, which offset higher depreciation and finance costs. FCEVs become competitive with diesel vans in 2030, as hydrogen prices fall due to the economies of scale associated with their mass production, while BEVs are substantially cheaper than ICEs already at that date. In 2050, BEVs are much cheaper than either of the other two technologies, but the TCO of FCEVs is already significantly lower than that of diesel vans.

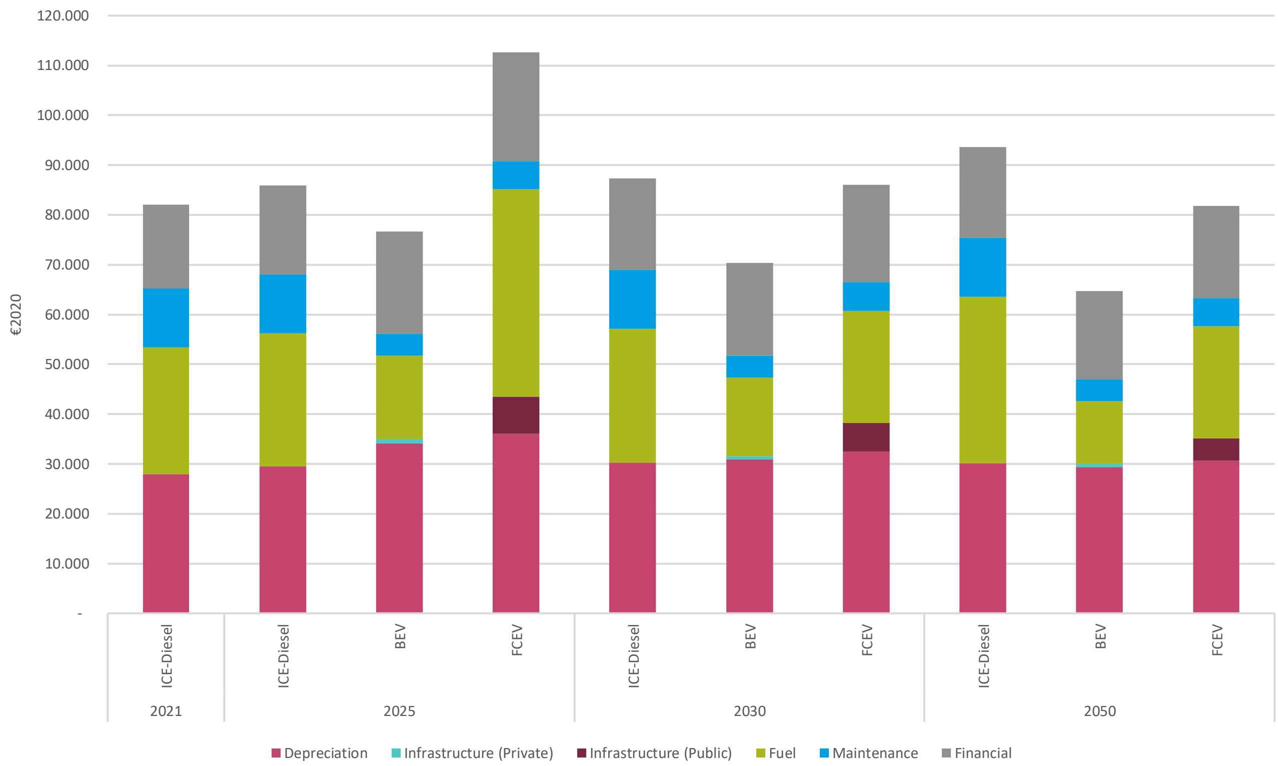


Figure 22: Total cost of ownership for vans over 14 years (€, 2020)

For heavy-duty trucks (HHGVs), the TCO was calculated for the four powertrains (ICE-diesel, BEV, FCEV and BEV-ERS) over a 12-year lifetime (Figure 23).

The evolution of the TCO cost components for HHGVs follows similar patterns as for vans. BEVs and BEV-ERS will already be cheaper in 2025 than ICEs. FCEVs are cost competitive with ICEs from 2030 onwards thanks to the reduction in hydrogen prices, although their TCO is significantly higher than that of BEVs and BEV-ERS.

The main conclusion from the TCO analysis is that the lower operating costs of BEV-based powertrains (due to lower fuel costs on the one hand and the higher efficiency of the electric motor on the other) more than offset the higher capital costs. In the case of FCEVs, these vehicles also reach cost competitiveness with ICEs in 2030 due to the substantial decrease in hydrogen prices.

Overall, the comparative TCO analysis of each powertrain shows that the adoption of zero emission vehicles should not increase total costs for hauliers. However, there are other issues that need to be addressed to ensure the adoption of these more efficient, zero-emission vehicles. Thus, the transport sector in Spain has many small and medium-sized enterprises that lack the capacity to finance the purchase of zero-emission vehicles.

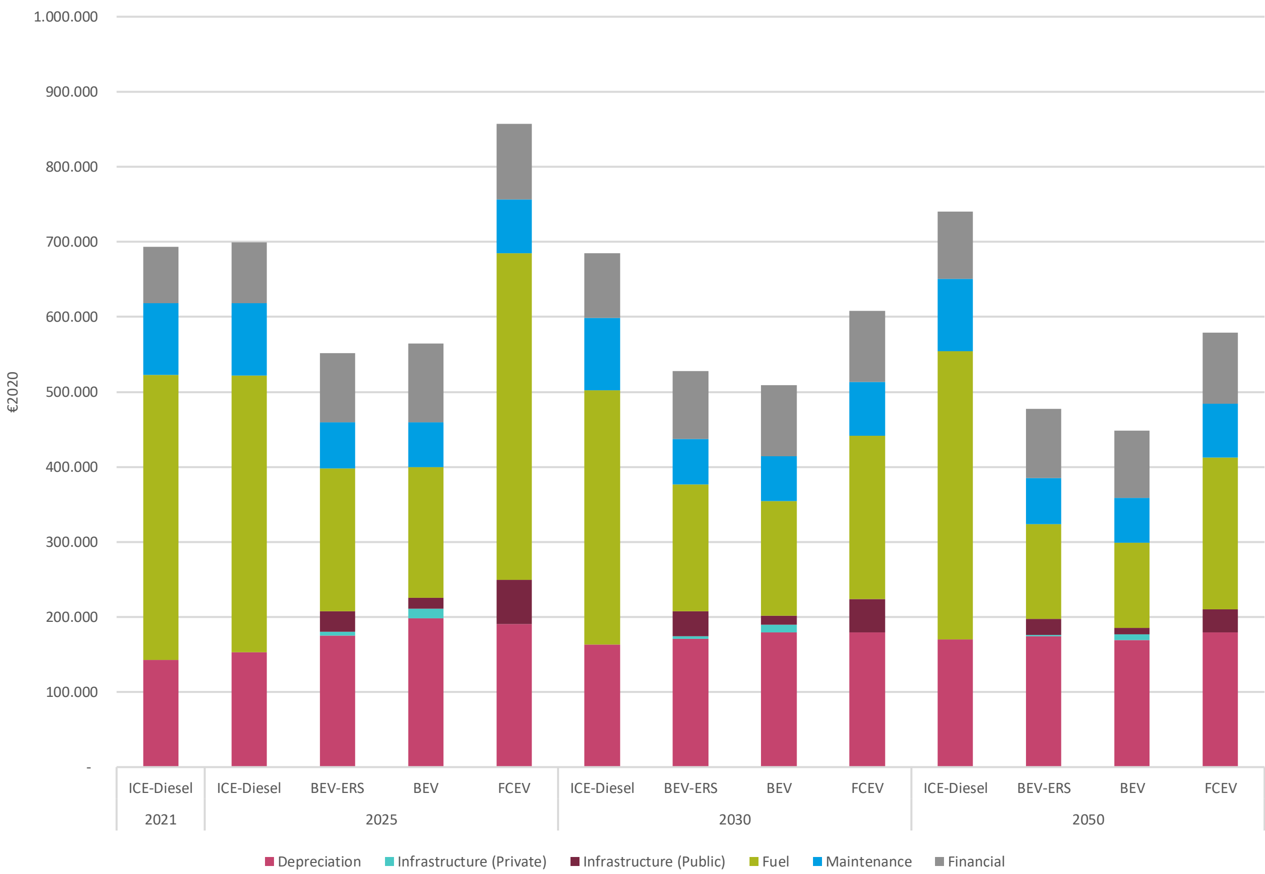


Figure 23: Total cost of ownership for HHGVs over 12 years (€, 2020)

Sensitivities

To explore the impact of possible variations of the different elements that are part of the TCO calculation, sensitivity analyses have been carried out, varying each element one by one and extracting the potential implications.

The **cost of fuel/energy** is the main component in the analysis of the TCO of goods transport vehicles, so variations in its price could have a significant impact on the total cost. Therefore, the impact of a +/- 25% change in fuel prices in 2030 has been analysed. The result is that fuel/energy price changes do not affect the basic trends of the TCO analysis. Only in the case where diesel is 25% cheaper than in the central case and hydrogen prices are 25% more expensive, the TCO of ICEs would become slightly lower than that of FCEVs.

The TCO evolution of trucks also depends to a large extent on how much trucks are used. Therefore, a sensitivity analysis was carried out considering **mileage variations** of +/- 25%. The result is that the more trucks are used, the more profitable vehicles with a zero-carbon powertrain will be. This is a logical consequence of the fact that vehicles travelling longer total distances use more energy, and the cost of the energy required is much lower for electric vehicles than for their diesel equivalents. This effect is particularly significant for BEVs and BEVs with ERS due to the lower cost of electricity than hydrogen.

In order to find out how the TCO is affected by the fact that the vehicle **holding period** was shorter than considered in the central case, the TCO has been calculated for 4 years. This could be the case for a large fleet operator who buys and uses new vehicles for a limited number of years before reselling them. With a short holding period, the relevance of the depreciation cost component increases compared to fuel, maintenance and infrastructure costs. Although the purchase price of vehicles with zero emission powertrains is higher, even with a shorter holding period the total cost of ownership is higher for conventional internal combustion engine vehicles, with the exception of a hydrogen fuel cell van (FCEV) in 2030.

Influence on TCO of certain regulations

Some of the regulations currently under discussion in the European Union to move towards climate neutrality by 2050 may influence the costs of hauliers. Two of them have been considered, in order to analyse how they could influence the total cost of ownership.

One is the **new Eurovignette Directive**. To incentivise cleaner transport, this regulation mandates a minimum 50% discount on distance-based road charges for zero-carbon trucks by 2023, as part of an overhaul of tolls in Europe. As these payments represent a substantial part of hauliers' costs, owners of zero-carbon trucks stand to benefit greatly from this discount. This rebate could even be increased to a maximum of 75%.

Tolls greatly increase the TCO of heavy-duty vehicles and the 50% discount widens the difference in total cost of ownership between zero-emission and internal combustion vehicles, as shown in Figure 24. The effect is similar for vans, although to a lesser extent as they are mainly used for urban transport. [4]

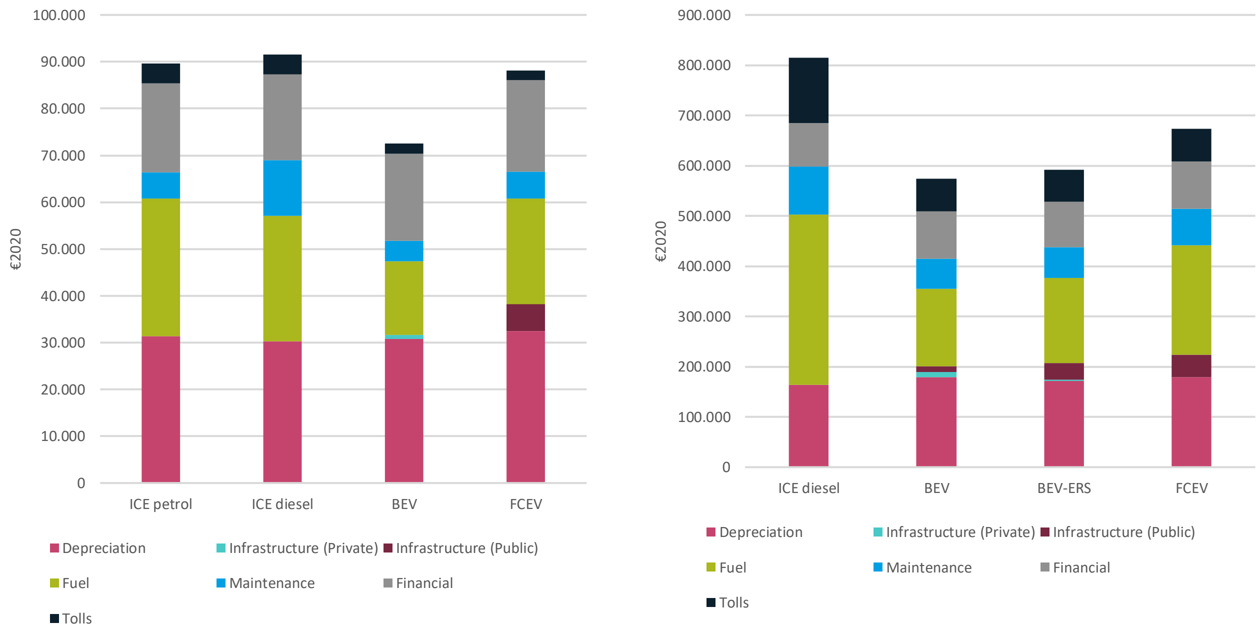
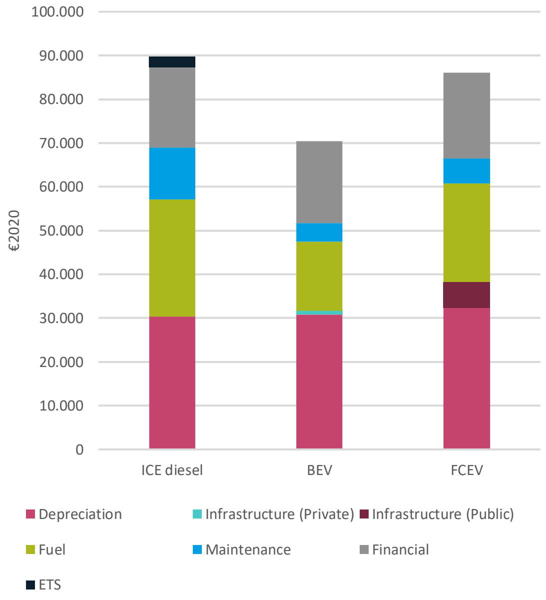


Figure 24: Total cost of ownership with tolls for vans (left) and HHGVs (right) in 2030 (€, 2020)

Another proposal under discussion, in this case in the framework of the European Commission's "Fit for 55" legislative package on energy and climate, is the **extension of the Emissions Trading Scheme (ETS) to the road transport sector**, probably through a scheme separate from the general system currently in place. Putting a price on carbon emitted from road freight transport would increase the cost of fuels such as petrol and diesel and provide an incentive for companies in the sector to reduce their fuel costs by switching to more efficient powertrains such as EVs.

Under the assumption of a separate ETS for transport in parallel to the current ETS, the impact on TCO of a carbon price of 50 euros, in line with the average allowance price observed in 2021, was calculated (Figure 25). This cost of the ETS for transport is only relevant for vehicles with internal combustion engines, whose TCO logically increases, as the tailpipe CO_2 emissions of vehicles with advanced powertrains are zero. Given the increasing ambition of climate policies at European and global level, the carbon price of the EU ETS is likely to continue to increase compared to current levels, and the impacts on the TCO of ICE diesel engines could be even more significant.

[4] Vans make only 28% of the distance travelled on roads, compared to 63% for HGVs, according to the driving profiles used in this study.



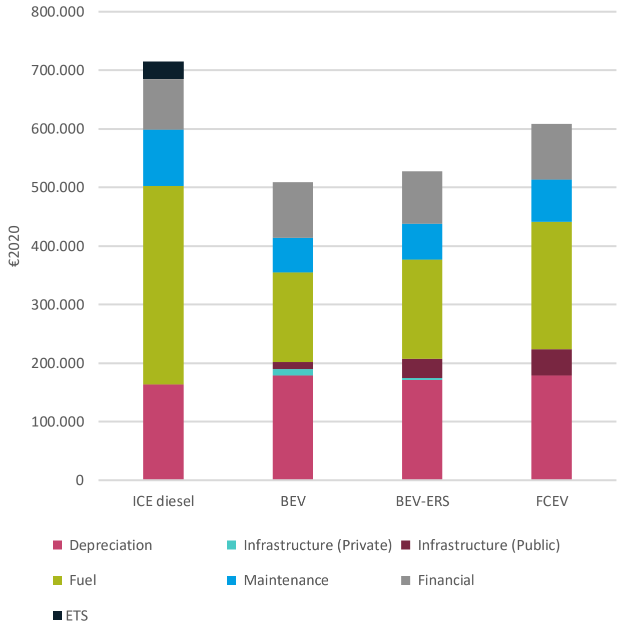


Figure 25: Total cost of ownership with Transport ETS for vans (left) and HHGVs (right) in 2030 (€, 2020)

Policy recommendations

The climate emergency forces us to act urgently to curb climate change in all areas of our economy, including the transport sector, the vast majority of which still runs on fossil fuels, the use of which is the fundamental cause of global warming.

In Spain, this sector is the largest contributor to greenhouse gas emissions (29.1% of the total in 2019), with road freight accounting for 9.8% of the national total, therefore it is appropriate to implement new policies and measures to reduce the significant climate impact of this sub-sector.

Recommendations of the Cambridge Econometrics study

In this regard, the study prepared by Cambridge Econometrics in collaboration with the collaboration of representatives of various entities in the sector, has concluded that **a rapid transition to propulsion systems based on zero emission technologies can substantially reduce CO_2 emissions from the road freight fleet.**

However, the study warns that**, in order to ensure that the** 2050 **climate neutrality target for this sector is met**, it will not be sufficient to ensure the end of sales of internal combustion engine vans by 2035 and of internal combustion engine trucks by 2040, but either an earlier phase-out or **additional measures focused on early reduction of the use of such polluting vehicles will be needed.**

The Total Cost of Ownership analysis presented in this study concludes that in both the van and truck markets, **pure battery electric vehicles and electric trucks ready for electric road use will be competitive by the middle of the current decade** with respect to ICE ones and that hydrogen fuel cell vehicles will be by 2030.

However, to achieve this, **substantial supporting infrastructure would be needed to support all available zero-emission technologies.**

In this respect, the deployment of high-power charging infrastructure for zero emission trucks needs to be acted upon without delay and the planning process for such infrastructure needs to be initiated immediately in order not to encounter bottlenecks in the deployment of charging points in the second half of this decade.

On the other hand, **the main uncertainty in determining a possible lead time for the results of the study** with respect to the different scenarios **is the speed at which zero carbon technologies** (batteries, electric road systems and fuel cells) **and fuels** (green hydrogen) **can be brought down in cost**, as well as the evolution of the expected increase in the costs of fossil fuels (diesel, petrol, natural gas) used by internal combustion engine vehicles.

Adequate regulation at European and national level is crucial to move more quickly and safely on the road freight transport decarbonisation path, contributing to improve the total cost of ownership of zero emission technologies and, consequently, to bring forward the date when cost parity with conventionally fuelled vehicles is reached.

A framework is now in place to make significant progress in this area. On the one hand, as part of the "Fit for 55" legislative package presented by the European Commission on 14 July 2021, both the revision of Regulation (EU) 2019/631 setting CO_2 emission performance standards for new passenger cars and new light commercial vehicles and the Alternative Fuels Infrastructure Regulation (AFIR) are under discussion. In addition, in 2022, the Commission is expected to present a proposal for a revision of Regulation (EU) 2019/1242, which revise and set new CO_2 emission standards for new heavy-duty vehicles. On the other hand, the discussion of the future Sustainable Mobility Law in Spain opens up a wide range of possibilities for improvement in this area.

Additional recommendations on vehicle emission reduction standards

In relation to the regulation of **truck emission standards**, recent studies[5,6] by organisations such as Transport & Environment (T&E) and the International Council on Clean Transportation have concluded that the current

[5] Transport & Environment (2021). *Easy Ride: why the EU truck CO_2 targets are unfit for the 2020s.* Retrieved from https://www.transportenvironment.org/wp-content/uploads/2021/10/202108_truck_CO2_report_final.pdf

[6] International Council on Clean Transportation (2021). *CO_2 emissions from trucks in the EU: An analysis of the heavy-duty CO_2 standards baseline data.* Retrieved from https://theicct.org/publications/eu-hdv-co2-standards-baseline-data-sept21

level of regulatory ambition is too low to drive the CO_2 emission reductions needed to achieve the EU's climate targets and, in particular, is insufficient to drive a relevant supply of zero-emission vehicles in the 2020s. Therefore, the revision of the CO_2 standards in 2022 should significantly increase the level of ambition and improve the design of the regulation.

In that respect, T&E has proposed to set an ambitious intermediate CO_2 target of at least 30% by 2027 and a significant increase of the 2030 CO_2 reduction target of around 65% should be set in order to ensure a significant reduction of emissions in the whole market by that date and to ensure that the supply of zero emission vehicles ramps up already in the 2020s.

Also, as is already being considered for vans and cars, this organization proposes the convenience of stablishing a 100% CO_2 reduction target for 2035 should be considered for the vast majority of new heavy-duty vehicles including long-haul trucks to enable the road freight sector to play its part in the climate framework of the EU Green Deal.

In terms of **CO_2 emission reduction standards for vans**, it is recommended, in order to ensure the expected market evolution, to set CO_2 emission reduction targets of 25% by 2025 (leading to 18-20% of new electric van sales by that date); 45% by 2027 (equivalent to 38% of new sales) and 80% **by 2030 (which would be equivalent to 75% of new ZEV sales) and, as the European Commission has proposed in its proposal, 100% by 2035.**

Additional recommendations on the deployment of alternative fuels infrastructure

With regard to alternative fuel infrastructure, the European Commission has proposed to replace the current directive (AFID) with a regulation (AFIR) and to set, for the first time, minimum targets for public charging infrastructure for heavy-duty vehicles on the Trans-European Transport Network (TEN-T). For the TEN-T Core Network, i.e., the main high-capacity roads in the EU, this means at least 1,400 kW of charging power every 60 km by 2025, with at least one charger with 350 kW power output. The minimum total power should increase to 3,500 kW by 2030. For the overall TEN-T (Comprehensive Network), the EU's secondary roads, the Commission proposal calls for the same power output targets, but only for every 100 km and with a delay of 5 years: 2030 and 2035, respectively. For urban nodes, the Commission suggests an installed charging capacity of at least 600 kW in 2025 and at least 1200 kW in 2030. At least one charger of 100 kW at Safe and Secure parking areas.

In addition, the proposal introduces targets for hydrogen refuelling stations with a capacity of at least 2 t/day each by 2030. These refuelling stations should be located along the TEN-T core and comprehensive networks every 150 km (for compressed hydrogen) and every 450 km (for liquefied hydrogen) by that year.

Proposing a regulation with binding targets shows the Commission's determination to finally tackle emissions from road freight transport. Focusing on the TEN-T core network is the most sensible way to do this, as 80% of all road freight transport activity (t-km) takes place on these roads.

However, market forecasts suggest that the Commission is significantly underestimating the total number of zero emission vehicles in 2030, especially for battery electric trucks.

In order to have the necessary number of zero emission battery trucks on EU roads and thus achieve the decarbonisation targets for this sub-sector in time, T&E considers that the ambition of the deployment of **heavy-duty vehicle** charging infrastructure (Article 6) should be increased so that in the TEN-T core network at least 2,000 kW of charging power per 60 km in 2025 and 5,000 kW in 2030 and in the comprehensive network, the same figures are reached five years later, i.e. in 2030 and 2035, respectively. These figures would be in line with the highest ambition case studies assessed by the EC in its proposal. Similarly, the ambition for urban nodes should also be increased to achieve a minimum charging power of at least 1400 kW in 2025 and 3500 kW in 2030. Each Safe and Secure truck parking area should have at least two 100 kW chargers in 2025 and at least five in 2030.

Although the Megawatt Charging System (MCS) standard is in development and expected to be available not before 2024, the EU should include the standard as soon as it is available in AFIR.

With regard to **vans**, it would be advisable to ensure in the AFIR regulation that Europeans can drive an electric vehicle throughout the EU in 2025 (Article 3) by making mandatory targets for light-duty vehicles for the overall TEN-T network in 2025 in order to eliminate any fears related to "range/charging anxiety".

It would be advisable to improve fleet-based charging infrastructure targets (Article 3) by linking them to the share of electric vehicles in a country's fleet and to ensure an absolute minimum target. This ensures that Member States with a relatively low share of electric vehicles in their fleet are obliged to provide sufficient infrastructure. As a safeguard mechanism, a minimum charging infrastructure requirement could be implemented in each Member State to ensure at least a 2% share of electric vehicles in 2025, 5% in 2027 and 10% in 2030.

It is also recommended that the lead times for issuing permits for the construction and installation of charging points and grid connections be reduced, and that a map of available sites, charging demand and network capacity be drawn up.