

Report

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**Impact of the Fit for 55
package on energy demand
of the EU transport sector
up to 2050**

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Impact of the Fit for 55 package on energy demand of the EU transport sector up to 2050

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KEYWORDS

Transport, Road transport, Electrification, Energy Demand, CO₂ Emissions, RED III, Well-To-Tank, Well-To-Wheels, Alternative Fuels, ETS 1, ETS 2.

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This report explores two illustrative scenarios assessing the potential impact of the Fit for 55 package on the EU transport sector up to 2050. These scenarios are intended solely for analytical and comparative purposes. They do not represent forecasts, nor do they imply any assessment of the likelihood or feasibility of the underlying assumptions. The analysis does not evaluate implications for economic competitiveness, affordability for consumers or industries, or other macroeconomic effects. Concawe makes no claim that the selected configurations are uniquely appropriate or hold greater validity than other possible approaches. The scenarios presented are not exhaustive; alternative pathways, including those dependent on successful technological scale-up, could require different assumptions to achieve similar outcomes. Economic parameters have not been incorporated into the modelling. Consequently, the results should not be interpreted as indications of whether such outcomes are achievable in practice.

In December 2025, the European Commission proposed new targets for the CO₂ emissions for newly sold light duty vehicles as of 2035. The previous internal combustion engine sales ban is replaced by a 90% reduction of CO₂ emissions in a tank-to-wheel perspective in comparison to the sales mix in 2021. The effects of this proposal has not been considered within this study.

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EXECUTIVE SUMMARY

Purpose

The Fit for 55 (FF55) legislative package will drive significant changes in the EU transport system over the coming decades. This study assesses the implications across road, aviation, maritime, rail and off-road transport with regard to energy demand and fuel mix, liquid fuel requirements, and compliance with the Renewable Energy Directive (RED III) and the EU Emissions Trading Systems (ETS 1 and ETS 2) through to 2050.

Methodology

The assessment is based on an in-house transport energy demand model that covers road transport (passenger cars, light commercial vehicles, buses/coaches, and light- and heavy-duty trucks), aviation, maritime, rail and off-road transport. For road transport, the model represents fleet evolution and energy demand by combining (i) new vehicle sales and stock turnover (scrappage), (ii) activity (passenger- and tonne-kilometres), (iii) powertrain mix, and (iv) powertrain energy efficiency. Compliance with the EU CO₂ standards for new cars and vans, and for new heavy-duty vehicles, is represented on a tailpipe (tank-to-wheel) basis through changes in the assumed new-sales powertrain mix.

For aviation and maritime, final energy demand is set using two alternative demand trajectories and the fuel mix is adjusted to meet ReFuelEU Aviation and FuelEU Maritime requirements.

The analysis uses two illustrative scenarios (low and high) to show how the combined policy package could shape energy demand and fuel mix, which differ as follows:

- Behavioural assumptions and activity trends: declining passenger-car activity (-1.5%/year) and increasing bus and coach activity (+0.75%/year) over 2030-2050 in the low scenario, whereas the high scenario follows European Commission projections.
- Fleet turnover: intensified scrappage of older internal combustion vehicles—replaced by battery-electric or fuel-cell electric vehicles—from 2031 in the low scenario.
- Aviation and maritime demand: Two demand growth scenarios for maritime and aviation over 2030-2050 were evaluated, one based on reaching the 2050 demand of A Clean Planet for All, and the other one based on a continuation of the growth rate observed over 2014-2019 until 2050.

Key results

Transport energy demand and ETS 1/ETS 2 implications

Road transport electrification causes a rapid decrease in energy demand, with fossil liquid fuel demand reaching zero in 2050 in the low scenario and close to zero in the high scenario. Road transport energy demand falls to 193 Mtoe (million tonnes of oil equivalent) in 2030 and further to 77-93 Mtoe by 2050 (low and high scenario respectively), as electricity and hydrogen progressively replace liquid fuels and deliver higher end-use efficiency. Despite this rapid transition, road transport emissions exceed the 2030 ETS 2 target.

Across the two scenarios, aviation energy demand is assumed to range between 57-87 Mtoe by 2050 and maritime demand between 52-74 Mtoe by 2050. CO₂ reductions in these sectors are therefore achieved primarily by replacing fossil fuels with renewable fuels, consistent with the ReFuelEU Aviation and FuelEU Maritime targets. Neither maritime nor aviation meets the ETS 1 emission target in 2030 in the scenarios assessed.

In 2050, the ReFuelEU Aviation and FuelEU Maritime targets imply a demand for advanced biofuels of 47-67 Mtoe and renewable fuels of non-biological origin (RFNBOs) of 39-58 Mtoe. In addition, the 2050 energy demand for the road, off-road and rail sectors amounts to electricity of 54-65 Mtoe and hydrogen of 28-29 Mtoe. Across all transport modes, total energy demand declines by a range between 18 and 39% between 2019 and 2050, reaching 198 to 266 Mtoe in the low and high scenario respectively. The renewable fuels, electricity and hydrogen listed above substitute fossil liquid fuels, the demand for which decreases by 85-86% compared with 2019 levels.

RED III Compliance assessment

The analysis indicates that compliance with the EU vehicle CO₂ emission performance standards and the ReFuelEU Aviation and FuelEU Maritime requirements is not sufficient on its own to meet the 2030 Renewable Energy Directive (RED III) target for transport. Two illustrative pathways are therefore modelled to bridge the remaining gap:

- Bridging the gap with increased renewable fuel consumption: In the first pathway renewable fuel demand amounts to: 14.1 Mtoe of food- and feed-crop biofuels, 5.4 Mtoe of Annex IX B fuels, 2.1 Mtoe of Annex IX A fuels, and 6.9 Mtoe of renewable fuels of non-biological origin (RFNBOs). Within the RFNBO total, 0.6 Mtoe is assumed as sustainable aviation fuels and 6.3 Mtoe as intermediate e-hydrogen used in refining, produced via electrolysis powered by renewable electricity. This is considered the most market ready alternative to bridge the gap in 2030. For these calculations, the renewable share of the electricity grid is assumed to be 58%, aligned with the trajectory towards zero emission intensity in 2040.
- Bridging the gap with increased electricity consumption: In the second pathway, the gap is addressed through higher electricity use in road transport, equivalent to an additional 0.26 Mtoe of electrification relative to the baseline. This corresponds to around 1 million additional battery-electric vehicles beyond the projected 29 million battery-electric vehicles 2030 stock. Even with this additional electrification, compliance still requires renewable fuel volumes: 13.5 Mtoe of food-based biofuels, 5.2 Mtoe of Annex IX B fuels, 2.1 Mtoe of Annex IX A fuels and 4.8 Mtoe of RFNBOs.

Note: Values are shown as absolute energy volumes; RED accounting multipliers are not applied here.

In the RED III cases investigated, intermediate e-hydrogen produced via refinery electrolyzers operating on renewable electricity is considered a comparatively technology-ready option to support compliance with the 2030 target, by substituting hydrogen currently produced via steam methane reforming.

Concluding remarks

Overall, the analysis highlights both the scale of the transformation of European transport and the significant challenges associated with delivering sufficient volumes of compliant energy carriers through to 2050. The results underline the need for large-scale technology deployment across vehicle fleets and the energy system, including electricity generation and distribution, electrolysis capacity, and renewable fuels value chains.

Note: Results are presented for analytical comparison and are not forecasts. The modelling does not assess feasibility or economic impacts and does not evaluate fuel supply availability. The European Commission's December 2025 proposal to revise the EU CO₂ emission performance standards for new cars and vans is not considered in this study.

1. INTRODUCTION AND METHODOLOGY

The EU legislative framework for the transport sector has been rapidly changing over the last decade. The European Green Deal, aiming at net zero GHG emissions in 2050 and the decoupling of economic- and resource growth, impose strict targets for the period 2030-2050. The Fit for 55 (FF55) framework is a set of legislations aiming at reducing greenhouse gas emissions by 55 % in 2030. As these legislations are interlinked, it is necessary that an integrated assessment is carried to determine the impact of regulatory compliance with regards to energy demand and mix. In this report we assess the combined requirements for the transportation sectors, covering road, off-road, rail, maritime and aviation.

The considered legislation is:

- Regulations for CO₂ emissions from newly sold passenger cars and vans with the more detailed impact assessment; (1) along with the amended regulations (2).
- Regulation for CO₂ emission from newly sold heavy duty vehicles along with the impact assessment; (3) along with the amended regulations (4).
- Fuel EU Maritime; (5).
- Refuel Aviation; (6).
- The Renewable energy directive (RED III); (7).
- The emission trading system and sectoral CO₂ emissions; ETS (8) and ETS 2 (9).

Eurostat (10) has been used as the primary data source regarding new vehicle sales, vehicle stock, annual mileage segmented by vehicle age, and vehicle load factors – expressed in vehicle-kilometre (vkm), passenger-km (pkm) and tonne-km (tkm). Background data up until 2024 have been used whenever available, however this is explained in detail in the coming chapters. EU regulations, other than the above mentioned, that impact the transport sector, are referenced in the appropriate chapters or alternatively cross-referenced in (11).

Vehicle energy consumption information is derived from the Well-to-Wheels analysis developed collaboratively by JRC, EUCAR, and Concawe (12) together with expert opinion (13) and (14).

The activity for the road sector is based on EU Commission estimates (15); while for aviation and maritime, scenarios have been derived from A Clean Planet for All (16) in combination with historical trends from (17).

1.1. SCOPE AND OBJECTIVE

The study scope entails the energy demand and CO₂ emissions from the EU27 transport sector and considerations with respect to renewable energy demand ratio.

The scope is separated into:

- **Foreground:** the portion of the study that is specific to the system being modelled.
- **Background:** the parts that are included in the model but are not explicitly detailed with regards to data (not specified in the objective) are the background.

Both the background and foreground are based on best available data and when not available, our assumptions have been referenced as clearly as possible.

THE SCOPE FOREGROUND:

- Estimations of the EU27 **energy demand from the transport sector** towards 2050. This is broken down per segment namely road, off-road, rail, aviation and maritime. The road segment is analysed for the subcategory's passenger cars, light commercial vehicles, buses & coaches and trucks.
- The road fleet model focus:
 - 1) Aligning the activity in terms of pkm and tkm to the projections from (18).
 - 2) The impact of sales targets to meet CO₂ emission standards of newly sold vehicles for alternative powertrains and energy efficiency measures.
 - 3) The impact on energy demand for the respective transport sectors.
- For the aviation and maritime sectors, final energy demand has been modelled in a low and high scenario.
- The ratio of sustainable aviation fuels, e-fuels and fossil kerosene in the aviation sector.
- The maritime fuel emission intensity in 2030, 2040 and 2050 based on fuel ratio.
- The total renewable, fossil and global (electricity and H₂) energy demand in the EU27 transport sector.
- The assessment of required measures to ensure compliance with RED III and ETS 1 & 2 and, in case of non-compliance, show the gap to attain compliance.

THE SCOPE BACKGROUND:

- The road transport stock size, EU27 population expectation, vehicle sales volumes other than to maintain constant stock, road activity, vehicle energy efficiency, vehicle load factor, aviation and maritime fuel demand other than expressed in the scenarios.
- CO₂ standards for new sales of passenger cars and light commercial vehicles have been applied in accordance with the powertrain shares provided in the (19). The period prior to 2030 is provided for reference as background results, without intention to provide detailed estimation of energy demand in this period.
- Final energy demand for the aviation, maritime, off-road and rail sectors. These were based on activity growth assumptions with consideration to improvement in energy efficiency, or matching final energy demand to scenarios from A Clean Planet for All (16).
- The renewable energy share in a specific segment. These were assessed on aggregate level, to determine compliance with RED-III, Refuel Aviation and Fuel EU Maritime.
- The fuel emission intensities were based on the JEC Well to Wheels study (12).
- The ratio of renewable/fossil share for natural gas and hydrogen. These are based on trends and forecasts of emissions from the power sector in the EU (20). Note that the road segment and the ETS only considers the tank to wheel perspective, therefore the ratio of renewable to fossil does not impact the study results. Diesel and gasoline are assumed to have constant emission intensity in the period 2030-2050.

- The gasoline to diesel sales ratio in the PC segment.
- The blending share of FAME and ethanol in diesel and gasoline respectively.

OUT OF SCOPE:

- Fuel supply or balance of refined products is not considered.
- The technical or economic feasibility of producing the required fuels, such as e-fuels or lignocellulosic biofuels. Additionally, we have not examined the availability of the necessary feedstocks or the logistics involved in mobilising them to meet projected energy demand.
- For the heavy-duty vehicle (HDV) and light commercial vehicle (LCV) segments, battery electric vehicles (BEVs) are assumed to be functionally equivalent to internal combustion engine (ICE) vehicles with respect to key operational parameters such as driving range, daily operating hours, climate suitability, and charging/refuelling time. This assumption facilitates a direct comparison between powertrain technologies and is necessary given the current state of technical development and the limited commercial deployment of BEVs in these segments.

1.2. REGULATORY FRAMEWORK

The regulatory frameworks considered will be described further.

The activity reference scenario is based on Transport in Numbers (15).

1.2.1. Regulations in road transport

The CO₂ emission targets for new sales are considered in a tank-to-wheel (TTW) perspective. The assessment of CO₂ emissions occurring outside of the TTW perspective or for ICE vehicles operating exclusively on zero-emission fuels is not considered in this study.

1.2.1.1. Newly sold Light-Duty Vehicle CO₂ emissions

CO₂ emissions from vehicles are regulated via obligations on OEMs (original equipment manufacturers, i.e. vehicle manufacturers) via vehicle CO₂ emissions targets (21) per km driven in a standardized driving cycle. This affects fleet CO₂ emissions of newly sold vehicles shown in the following tables.

Table 1 CO₂ Emissions of newly sold passenger cars and vans in EU27

	Passenger cars	Light commercial vehicles
2020	95 g/km	147 g/km
2025	-15%	-15%
2030	-55%	-50%
2035	-100%	-100%

Based on (22). The 100 % CO₂ reduction in Tab. 1 refers to the sales ban on internal combustion engine (ICEV) i.e., zero emissions in a tailpipe perspective. The sub-sales targets per powertrain for passenger cars and light commercial vehicles are provided in Tables 2 and 3 respectively and are indicative to meet the Table 1 requirements.

Table 2 Indicative sub-sales target stratified per PC powertrain to achieve Tab. 1 requirements

PC	ICEV	PHEV	BEV	FCEV
2030	44%	15%	40%	1%
2035	0%	0%	91%	9%
2040	0%	0%	88%	12%

Based on (19). The ICEV category includes hybrid-electric vehicles (HEV). Battery-electric vehicles (BEV) and fuel cell electric vehicles (FCEV) emit zero CO₂ emissions in a tank to wheel perspective. Plug-in hybrid-electric vehicles (PHEV) emit zero CO₂ emissions in a tank to wheel perspective while operating in electric mode.

Table 3 Indicative sub-sales target stratified per LCV powertrain to achieve Tab. 1 requirements

LCV	ICEV	PHEV	BEV	FCEV
2030	47%	4%	48%	1%
2035	0%	0%	94%	6%
2040	0%	0%	89%	11%

Based on (19). The specific emission targets for vehicle manufacturers to comply with for each year are based on the EU fleet-wide targets, taking into account the average test mass of a manufacturer's newly registered vehicles.

1.2.1.2. Newly sold Heavy-Duty Vehicle CO₂ emissions

In 2019, Europe adopted the first-ever EU-wide CO₂ emission standards for new heavy-duty vehicles (HDVs), the Regulation (EU) 2019/1242. An updated regulation was adopted by the European parliament in May 2023 (4) covering also a 100% sales targets for city buses in 2030.

HDV manufacturers are required to meet the targets set for the fleet-wide average CO₂ emissions of their new vehicles registered as of 2025, with stricter targets from 2030 and onwards. For the purpose of this study heavy duty vehicles have been stratified into the following sub-segments:

- Gross vehicle mass of less than or greater to 12 tonnes for trucks
- Gross vehicle mass over 7,5 tonnes for buses and coaches.

A sub-mandate of new sales of zero emission city buses taking effect in 2030 have been agreed and is included in the HDV target. The targets in Table 4 are expressed as a percentage reduction of emissions compared to the sales for EU27 in 2021.

Table 4 Emission reduction for newly sold HDV in EU 27

	2025	2030	2035	2040
Reduction normalised to the reference emissions in 2021	15%	45%	65%	90%

Based on (23). The sub-sales targets per powertrain for all HDV sub-segments, Buses & Coaches, Trucks>12t, and Trucks<12t are provided in Tables 5, 6, 7, and 8 respectively and are indicative to meet the Table 4 requirements.

Table 5 Indicative sub-sales HDV target per powertrain to achieve Tab. 4 requirement

All HDVs	Diesel	NG	PHEV	BEV	H2
2030	54%	10%	7%	19%	11%
2035	32%	10%	8%	30%	22%
2040	9%*	3%	3%	45%	41%

*Note that when considering the HEV share in ICE, a total 90% emission reduction is achieved by 2040

Table 5-8 are based on (23).

Table 6 Indicative sub-sales Bus & Coach target per powertrain to achieve Tab. 4 requirements

Buses & Coaches above 7,5 t					
	Diesel	NG	PHEV	BEV	FCEV
2030	32%	2%	2%	48%	18%
2035	17%	2%	2%	52%	27%
2040	4%	1%	1%	50%	44%

Table 7 Indicative Trucks>12t sub-sales target per powertrain to achieve Tab. 4 requirements

Trucks > 12t					
	Diesel	NG	PHEV	BEV	FCEV
2030	61%	11%	1%	12%	16%
2035	36%	11%	0%	22%	32%
2040	9,5%	3,5%	0%	28%	59%

Table 8 Indicative Trucks<12t sub-sales target per powertrain to achieve Tab. 4 requirements

Trucks < 12t					
	Diesel	NG	PHEV	BEV	FCEV
2030	46%	9,5%	14%	28%	4%
2035	37%	9%	12%	36%	7%
2040	8%	3%	4%	68%	18%

The monitoring and reporting Regulation (3) require that, as of 1 January 2019, Member States monitor and report to the Commission information on the heavy-duty vehicles registered for the first time in the Union; and lorry manufacturers monitor and report to the Commission CO₂ emission and energy consumption data as determined pursuant to the certification Regulation for each new vehicle produced for the EU market. This information will be calculated using the Vehicle Energy Consumption Calculation Tool (VECTO)¹.

1.2.2. Worldwide Harmonized Light Vehicles Test Procedure WLTP

In 2020, the Worldwide Harmonized Light-Duty Vehicles Test Procedure (WLTP) replaced the New European Driving Cycle (NEDC). The WLTP uses a more realistic drive cycle which aimed to reduce the gap between CO₂ emissions certified in the laboratory and those experienced under real driving conditions. For the purposes of this study for the passenger car segment, we assume 10% higher energy consumption for all powertrains compared to the estimated WLTP values to account for real-world driving variations (24). However, a more recent study (25) shows 20 % higher CO₂ emissions compared to the WLTP for ICE gasoline and ICE diesel under the particular real-world driving conditions considered. Other studies showed considerably higher CO₂ emissions compared to the WLTP results for plug-in hybrid vehicles (PHEVs), when running in largely charge depleted conditions i.e., vehicles running solely on the ICE engine more often as the user chooses not to charge the battery. These results represent a use case behaviour that has most likely arisen as a result of company car policies applicable in some EU countries where staff might have to pay for electrical charging but that the company covers fuel costs, as included in the company car package. This result may be measured, but this unintentional use case can simply be rectified by financial policy. It is therefore not considered representative of the energy consumption of the technology if used in the intended economical way, where the driver pays for the fuel used and is incentivised to charge the vehicle. This emphasises that the real-world factors are heavily behaviour-related and extreme cases are difficult to simulate from a technical perspective. For the purposes of this study, we consider reasonable use cases that more closely align with the WLTP drive cycle for the typical European motorist long-term, especially as some company car and mobility policies have already changed. We consider the WLTP values as a lower baseline and that the default addition of 10 % represents a realistic behaviour sensitivity long-term.

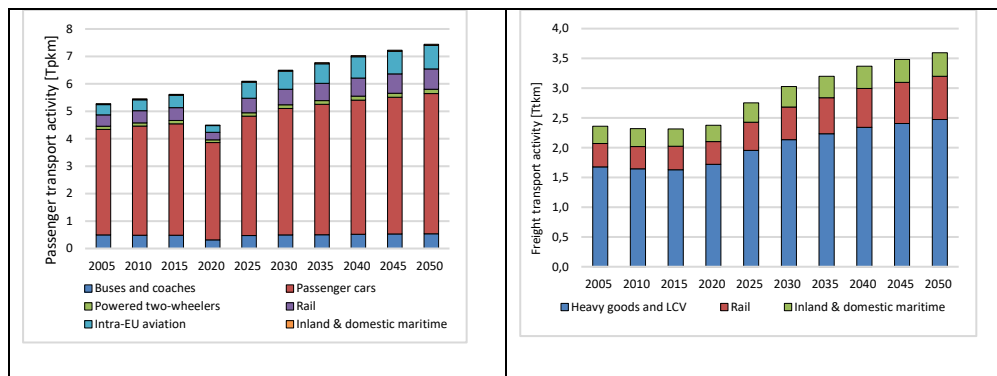
¹ VECTO is a simulation software that can be used cost-efficiently and reliably to measure the CO₂ emissions and fuel consumption of heavy-duty vehicles for specific loads, fuels and mission profiles (e.g. long haul, regional delivery, urban delivery, etc.), based on input data from relevant vehicle components.

1.2.3. Transport activity

This section specifies the activity in terms of transportation work for the respective sectors. The activity for the road sector is based on EU Commission projections (15).

The road sector is separated in vehicles that perform passenger and goods transportation: buses, coaches and passenger cars perform passenger km (pkm) whereas lorries, road tractors and light commercial vehicles perform tonne-km (tkm).

Figure 1 Projected transport activity- all modes



Source: (15)

The pkm and tkm demand projections represent an economic aspect but is of importance as it is fundamental to the model objective i.e., not simulating vehicles but the desire for transportation.

2. TRANSPORT ENERGY DEMAND MODEL

Concawe has an excel-based model previously used in (26) that have been further enhanced for the following segments:

- Road transport
 - Light Duty Vehicles (passenger cars and light commercial vehicles)
 - Heavy Duty Vehicles (buses and coaches, light- and heavy trucks)
- Off-Road transport (for instance mining and agriculture)
- Rail transport
- Aviation (separated in International and Domestic)
- Maritime (separated in International and Domestic)
- Fuel and electricity Emission Intensity.
- RED III compliance assessment (chapter 6).
- Total CO₂ emissions covering ETS 1 (for aviation and maritime) & ETS 2 (for road transport).

The model simulates a low- and a high- scenario that are described in chapter 3.2.

2.1. METHODOLOGY

2.1.1. Aviation, maritime, Off-road & Rail

Aviation and maritime modelling follow final energy demand projections specified in chapter 1.2.3. The fuel mix is then adjusted to comply with ReFuelEU Aviation and FuelEU Maritime, as referenced in (6) and (5) respectively. The rail sector final energy demand considers the ongoing electrification trend and final energy demand align with (15). The off-road sector is modelled according to (27) with assumptions of steady fuel demand in the period 2030-2050.

2.1.2. Road transport

The road transport segment is based on vehicle sales data (17) for all road vehicle categories, updated with 2024 data if available as of August 2025. On the rare occasions that member state data is incomplete or not reported, the latest available data for that country was used. Vehicle survival rates were adjusted to align the simulations to the stock according to (17) for passenger cars and harmonizing for the other categories. Road transport activity aligns with (15) but differs in the scenarios introduced in chapter 3. Historic energy demand is simulated and have been verified to (15).

The methodology utilised to assess the **fuel supply and demand** in the EU road transport sector up until 2050 is shown in the figure below:

Figure 2 Hierarchical model and methodology overview

1. Road transport		2. Non-road & Sum-up		3. Iteration & Compliance	
Input EU27 population # vehicles / capita Yearly new sales Powertrain sales ratio Vehicle energy demand/km Activity (pkm & tkm) Load factor PHEV battery utilization Emission intensity	Assumptions Scrappage rate Efficiency improvement ICE fuel sales ratio Load factor PHEV battery utilization Initial vehicle milage Mileage decline /year	Rail & Off-road Diesel engine efficiency improvement 2030-2050	Aviation & Maritime Energy demand assumptions until 2050	Iteration & sensitivity Scrappage rate Activity shift between transport modes PHEV utilization rate Banning year ICE/PHEV	
	Simulations Future sales Vehicle stock Energy demand	3. Total energy demand Aggregated demand per transport mode Well-to-tank CO ₂ intensity			
					Compliance RED III ETS 1 & 2

2.1.3. Road fleet projections

The fleet modelling tool covers the road vehicle fleet development and the resulting fuel demand for 27 European countries. The model stratifies demand for passenger cars (PC), light-duty commercial vehicles (LCV) and heavy-duty vehicles (HDV). HDV are stratified into buses and coaches, and trucks over and under 12 tonnes of gross mass respectively. Each category captures demand per fuel type (including biofuel breakdown) that are linked to greenhouse gas (GHG) emissions and share of renewable energy demanded. The modelling methodology is described in Figure 3 and further described in Table 9.

Table 9 Important sources and variables

Variable/model input	Source/applied method
Stock	<p>Historical stock figures based on (17), (24), (28), (29) and (30).</p> <p>The high scenario assumes constant number of vehicles per capita in EU27 for the period 2019-2050.</p> <p>The low scenario assumes a decreased ratio of PC per capita and increased ratio of the Bus & Coach per capita (described in chapter 3.2 -low scenario).</p>
Scrappage rate	Scrappage rates for each vehicle segment fitted to historical trend based on (31), (15) and (17). See also Figure 18.
Relative vehicle mileage	<p>For PC the relative yearly mileage differs depending on powertrain based on (13) and supported by (32).</p> <p>Extrapolation of historical trend (17) explained in the relevant subsections.</p>
Mileage as per vehicle age	Yearly driven distance declines along with vehicle age. Assumption of extrapolation of historical trend based on (17) explained in relevant subsections.
Efficiency of new sales	<p>For the PC gasoline and diesel ICE, the weighted values for new registrations in 2022 is based on (33) based on WLTP average plus 10% real world factor (1).</p> <p>The energy efficiency of new sales for other PC powertrains are based on (26) that have been harmonized with weighted estimates of popular model sales in EU27 in 2024.</p> <p>For the respective heavy duty vehicle categories, the efficiency of new sales is based on VECTO by simulation of (34) using a representative driving cycle and payload.</p> <p>For HDV the VECTO energy consumption have been historically assumed to have improved energy efficiency of 0,5 % for the period 2000-2019 (35).</p>
Vehicle powertrain sales ratio	Linear trend to meet sales targets for respective vehicle categories as described in Tables 1-5 (2).
Activity in yearly pkm/tkm	Aggregate values from reference scenario (15) broken down for the stock considering vehicle age and transport mode.
Vehicle load factor	Constant over the simulated period based on (17)
Powertrain utilization rate	Historical data from (36) also published in (27)
PHEV electric mode utilization rate	Based on (12)

Table 9 is explained below:

- Passenger car (PC):
 - PC yearly desired stock is calculated as a function of the EU27 population and passenger cars per capita (assumed constant 0,56 PC per capita 2025-2050) with considerations to yearly scrapping.
 - Vehicle scrappage rate is assumed to follow an alpha-beta function with survival rate of $\frac{1}{1+\alpha\beta t}$ where $t = t_{\text{current year}} - t_{\text{year sold}}$. The *alpha* and *beta* coefficients are derived on historical stock and sales in EU27 (see fig 5).
 - Relative driven distance per powertrain is based on assumptions described in (26), (13) and supported by (32). The ratios intend to simulate a typical usage of the different powertrain, as an example diesel cars have 80% higher yearly mileage compared to gasoline cars (32).
 - Relative driven distance as a function of age is based on historical data (17).
 - Yearly new sales per powertrain type is based on the EC sales targets (Table 2). Assumed linear trend between historical data (up to 2024) and the respective sales targets.
 - Fleet average annual mileage is calculated based on the activity (15) with consideration of load factor (10), and stock age. Assumption of load factor moderate increase from 1,49 pkm/vkm in 2020 to 1,55 pkm/vkm in 2030 based on (10) and then constant until 2050.
 - In terms of Vehicle fleet energy efficiency per km and CO₂ efficiency (3)²:
 - For the PC gasoline and diesel ICE, the weighted values for new registrations in 2022 (considering car size) is based on (33) based on WLTP average plus 10% real world factor (1). Assumptions of yearly improvement until 2030 from which constant efficiency is assumed i.e., no improvement after 2030 due to the ICE sales ban in 2035.
 - The energy efficiency for the LPG and CNG vehicles, HEV gasoline, HEV diesel, PHEV diesel & gasoline, BEV and FCEV are based on is based on (26).
 - Ratio of HEV in ICE along with gasoline to diesel ratio is described in (26).
- Light commercial vehicles (LCV) or vans is identical to the PC with the following exceptions:
 - It is assumed that the relative driven distance is the same for different power trains.
 - Activity is based on (15) and modelled as a share of the tkm performed by the road transport segment, together with the truck category.
- Heavy-duty vehicles (HDV) differ to PC with the following exceptions/notifications:
 - Activity expressed as tkm for the truck categories and as pkm for Buses & Coaches.

² For PHEV there is a proportion for the combustion engine efficiency and a proportion for the EV, scaled for the amount of driving in EV mode.

- Data derived from (14) considering load factor (representative load) and yearly mileage. Assumption that heavy trucks (>12t) perform 95 % of the ton-km and light trucks (<12t) perform 4,8 % of the ton-km supported by (14) and (17). 0,2 % of the tkm is assumed to be performed by LCV. The load factor for light trucks is constant at 3,02 tkm/vkm and 12 tkm/vkm for heavy trucks (37). A historical review of load factor, tonne-km and vehicle-km can be found in the respective chapters.
- The pkm performed by the Buses & Coaches are provided by (15) and in the low scenario, activity is shifted from the PC to the Buses & Coaches category. An assumption based on (14) is that the load factor for Buses & Coaches is 16,5 in 2020 and increase linearly up to 25,1 in 2050, in line with the increased utilization of buses & coaches (figure presented in chapter for buses & coaches).
- Hydrogen-powered heavy-duty vehicles are assumed to use fuel cell technology for the purpose of this study. It is recognised that hydrogen internal combustion engine (ICE) vehicles may also be viable; however, an evaluation of their relative merits falls outside the scope of this study. This assumption should not be interpreted as expressing any preference regarding the two technologies.

Motorcycles are excluded from this modelling, as they only contribute to less than 1% of road transport GHG emissions in EU27 in 2022 (38).

2.2. FLEET COMPOSITION AND MODEL CALIBRATION

2.2.1. PASSENGER CARS (PC)

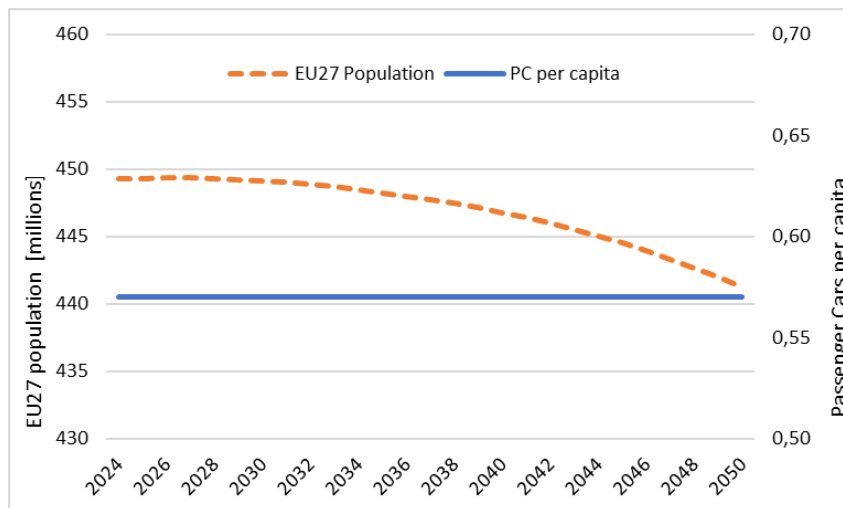
The model input is summarized as follow:

- 1) Desired stock (based on Year-on-Year) growth.
- 2) New registrations/sales quota (complying with the regulation),
- 3) Scrappage rates assumed to be similar for ICE cars and BEV/FCEV.
- 4) PC relative driven distance as function of age (based on (17) supported by Figure 5 and powertrain on (36) (26) (32)),
- 5) Fuel emission intensity in g CO₂/vehicle km,
- 6) Share of diesel and gasoline of new registrations (26),
- 7) Sales share of hybrid-electric (HEV) of the ICE for the respective fuel types (26),
- 8) Alternative fuel types in new registrations (2):
 - Compressed Natural Gas (CNG),
 - Liquefied Petroleum Gas (LPG),
 - Battery Electric Vehicles (BEVs) and Plug-in Hybrids (PHEVs),
 - Fuel Cell Electric Vehicles (FCEV)
 - Share of battery-electric mode utilization (e-driving with power charged from the grid) for PHEV.

2.2.2. Population, stock and new registrations

The EU27 population is forecasted in (15). For the high scenario, it is assumed that the ratio of number of passenger cars per capita up to 2050 remains unchanged at 0,57 which is the 2019 ratio. For the low scenario, it is assumed that this ratio decreases in the period 2030--2050 as a consequence of activity shift to other transport modes (description in chapter 3.2). This ratio enables an estimated a stock on a year-to-year basis. The relationship for the high scenario is expressed in the figure below that also shows that the EU27 population is forecasted to peak in 2030 and gently declines until 2050.

Figure 3 EU27 population and number of passenger cars per capita (high scenario)



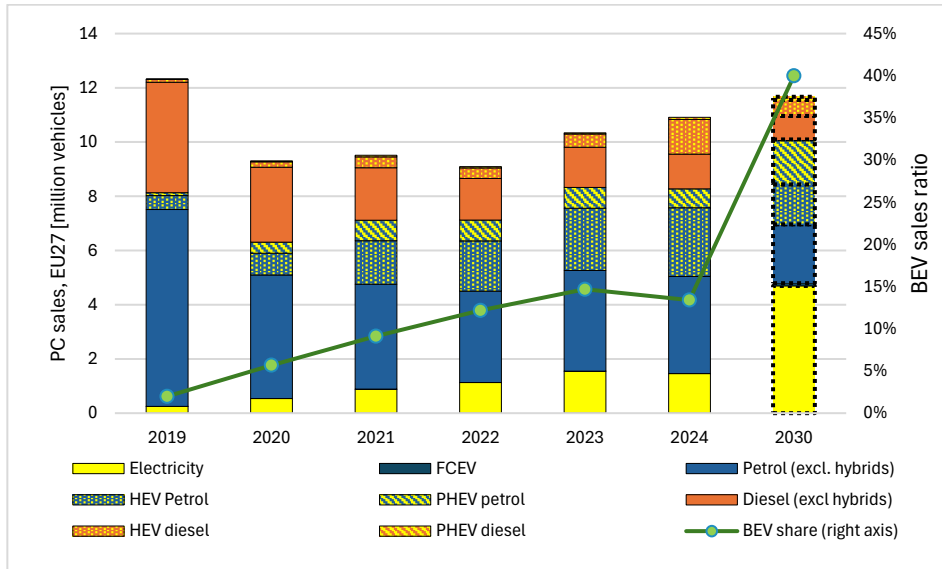
Source: Population from (39)

2.2.3. PC New registrations & stock

Figure 4 shows the historical PC new sales in the EU27, specified per powertrain. It is observed that since 2019, there has been a significant increase in the sale of electric power trains including BEV's, petrol & diesel HEV³'s and petrol PHEV's (17).

³ HEV considered to be mild or full hybrid electric.

Figure 4 Passenger car new sales in EU27



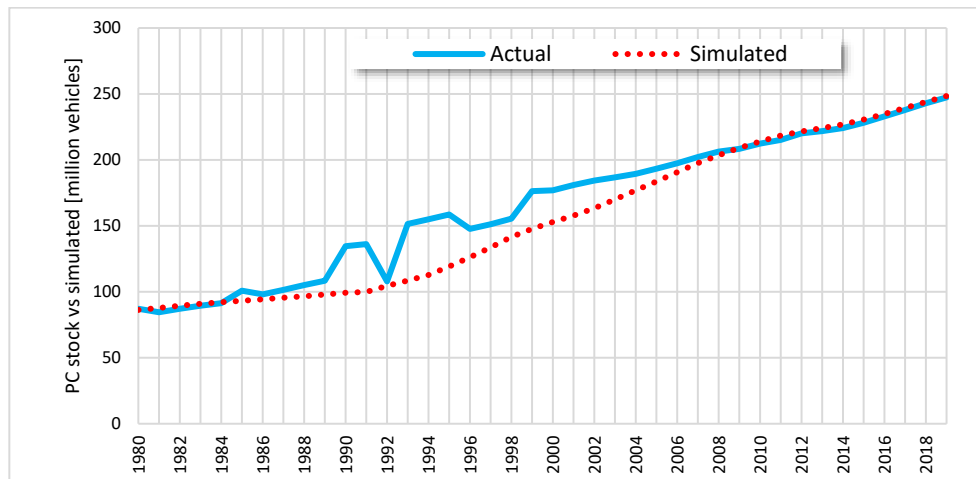
Source: Historic values up to 2023 based on (17), with 2024 data from ACEA, and modelled values for 2030 to meet vehicle sales targets

It is worth mentioning that the BEV sales ratio in 2024 were at 13,5 % whereas the target in 2030 is 40 %.

2.2.4. PC scrappage rate

The PC scrappage rate have been extrapolated based on historical trends (40).

Figure 5 Passenger cars scrappage rate; simulated vs actual



A scrappage method based on an alpha/beta- function was applied:

$$P(\text{survival, year } n) = \frac{1}{(1 + \alpha\beta^n)}$$

The parameters of the alpha-beta function that simulates the scrappage rate are adapted to match the historical scrappage function from (40).

Figure 6 Passenger car survival rate

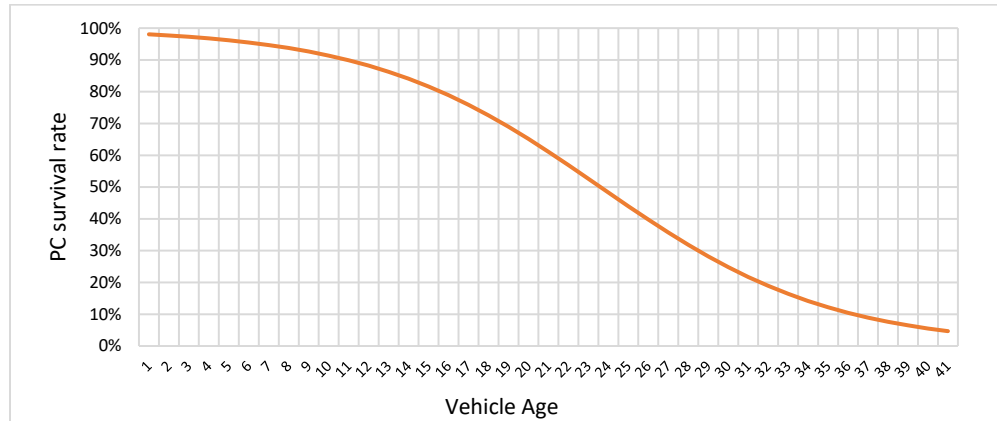
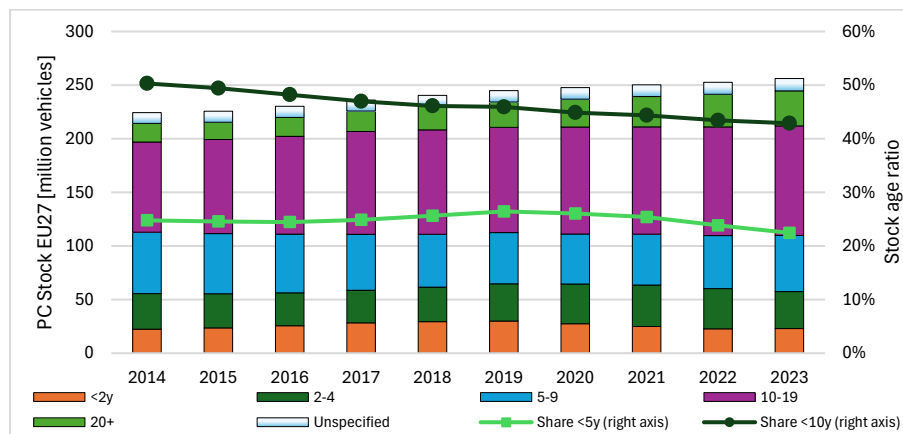


Figure 6 shows the modelled survival function for ICE PC. Average PC scrapping age is suggested by (41) to 20 years. Note that this is not the same as average stock age which can be estimated at the median of the survival curve. The EEA estimated the average stock age of 12.3 years in 2022 (24). The scrapping function is based on data analysis from (17) that is supported by the figure below.

Figure 7 PC stock as per age group



Source: (17)

The figure shows passenger cars stock age separated per age group along with the stock ratio that is less than 5 years (22,4% in 2023) respectively less than 10 years (42,9% in 2023).

2.2.5. Relative mileage per powertrain & vehicle age

New vehicles account for a higher share of yearly mileage than older vehicles which is also reflected in in terms of energy demand. Table 10 also show the relative mileage based on powertrain. Diesel ICE has highest relative yearly mileage whereas HEV gasoline has the lowest (42) supported by (32).

Table 10 Passenger car mileage depending on age and powertrain relative mileage

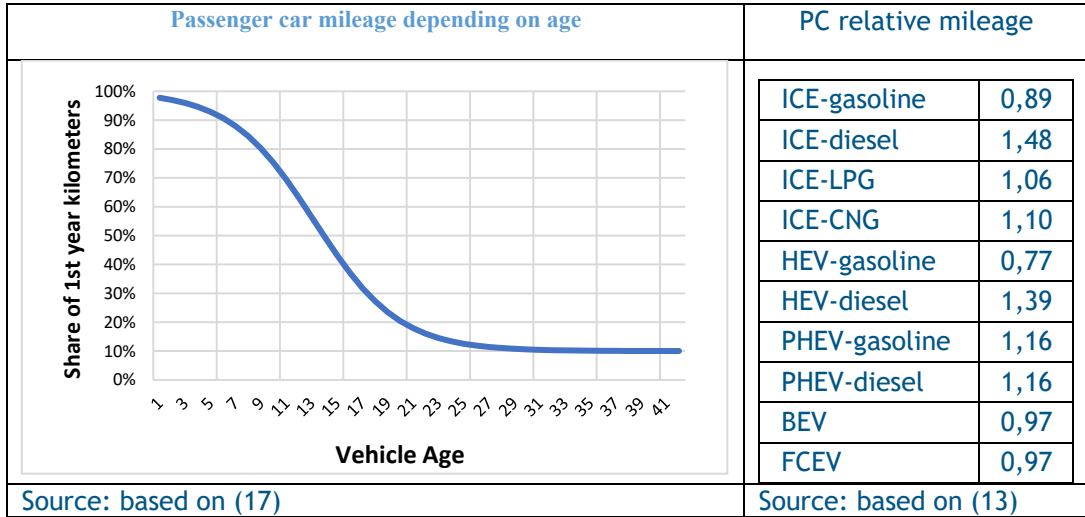
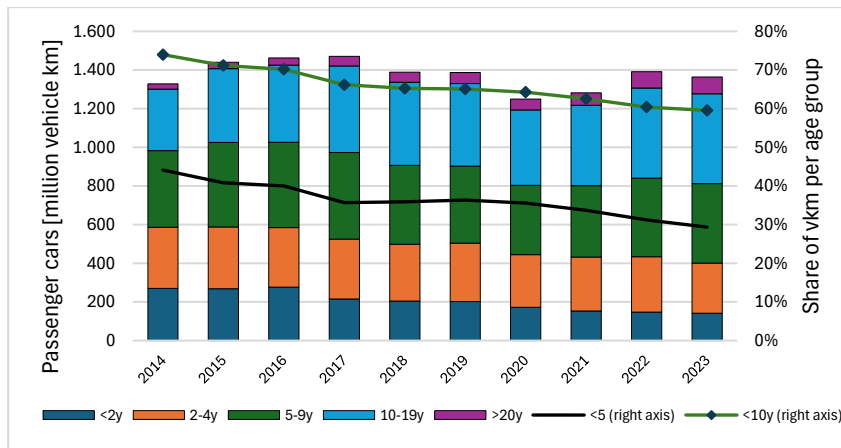


Table 10 harmonized with (17) and Figure 8 and is adjusted so that cumulated 50 % of the mileage of a fully functioning PC around seven years of age.

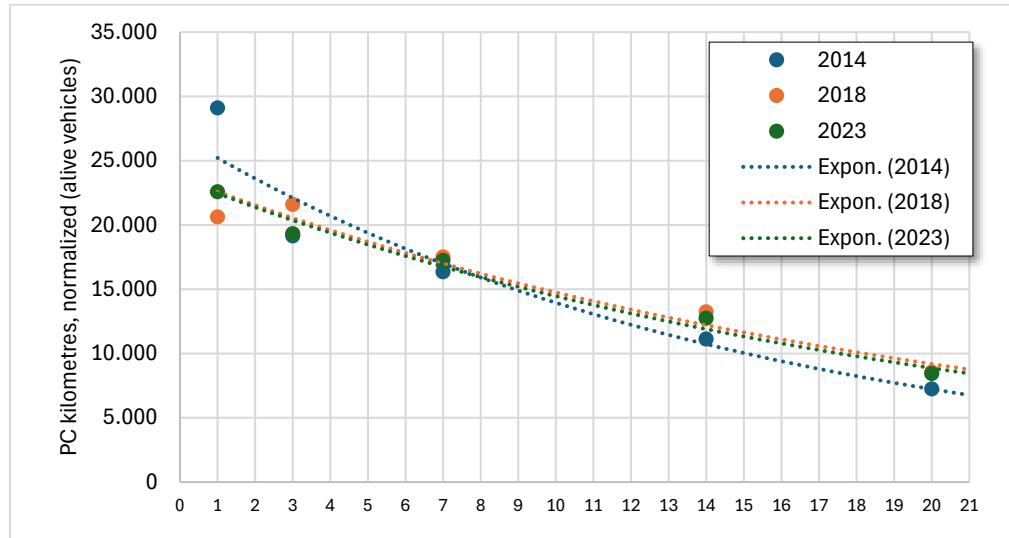
Figure 8 Passenger car mileage vs vehicle age



Source: (17)

We assume that PC mileage decrease along with vehicle age based on (40) and (17) illustrated in Figure 8 and also presented normalized in Figure 9.

Figure 9 Passenger car mileage as function of age

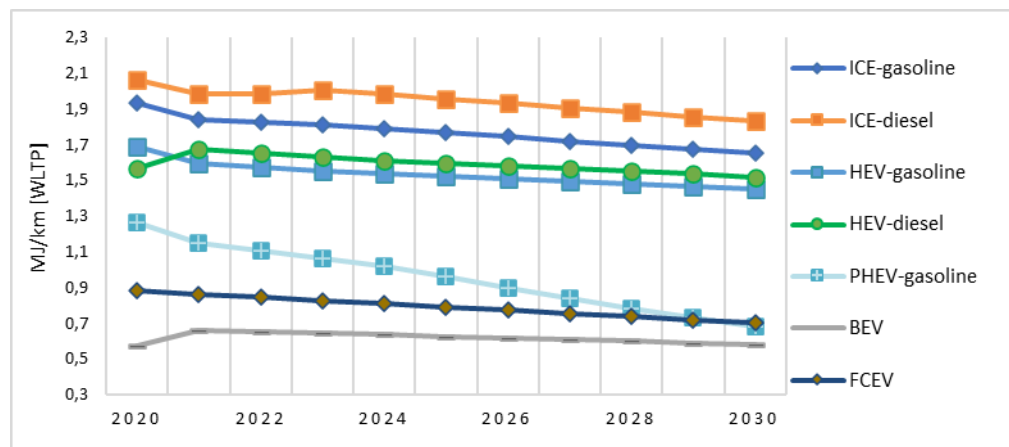


Source: (17) data from Germany, France, Malta and Sweden.

Eurostat data for PC vkm stratified per age group is unfortunately only available for a limited number of member states. Figure 8 is weighted according to stock for the corresponding age groups. Figure 9 show that PC mileage is concentrated to the early years of vehicle life.

2.2.6. Vehicle energy efficiency

Figure 10 New sold PC average energy efficiency (MJ/km) based on WLTP



Source: For LPG/CNG (26). For HEV, PHEV, BEV and FCEV (26) has been used to assess historical sales. For 2024, energy consumption is harmonized with sales of top models in EU 27 and illustrated in Figure 74 in the annex. For ICE Gasoline and ICE diesel, the fuel consumption is based on (24) with consideration to weighted new sales in EU27 (considering car size).

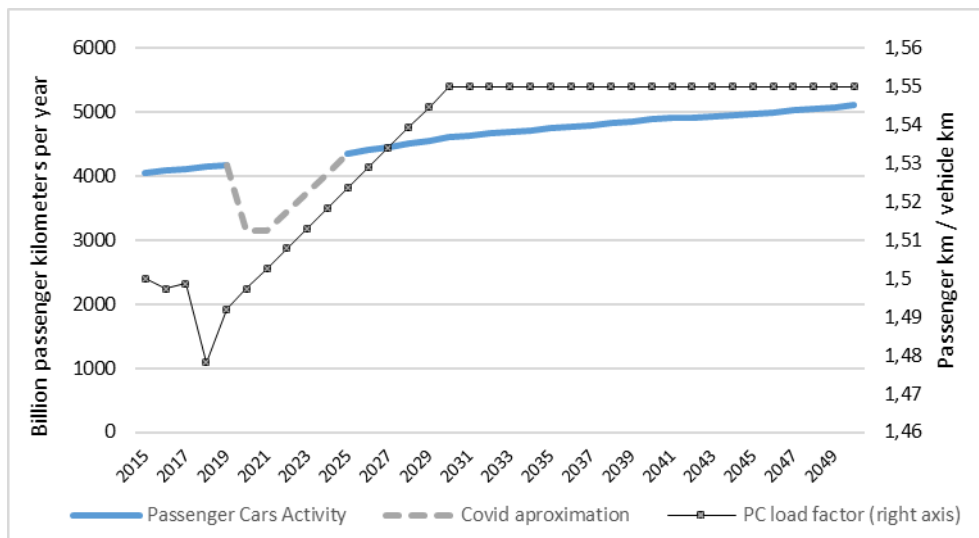
Figure 10 shows the evolution of the energy efficiency for the average new sales for the PC category. Note that the energy consumption per km is higher for diesel than gasoline as the average engine size is larger for the new sales. It is assumed that energy consumption per km reduces annually by 1,2% from 2023 to 2030. The ratio

of HEV to ICE sales in 2030-2035 is assumed at 40 % thereafter the ICE engine is not allowed as per the FF55 regulations. PHEV utilization rate is assumed at 45% in 2020, increasing linearly to 75% in 2030 (constant for the period 2030-2050) (12).

2.2.7. PC activity & load factor

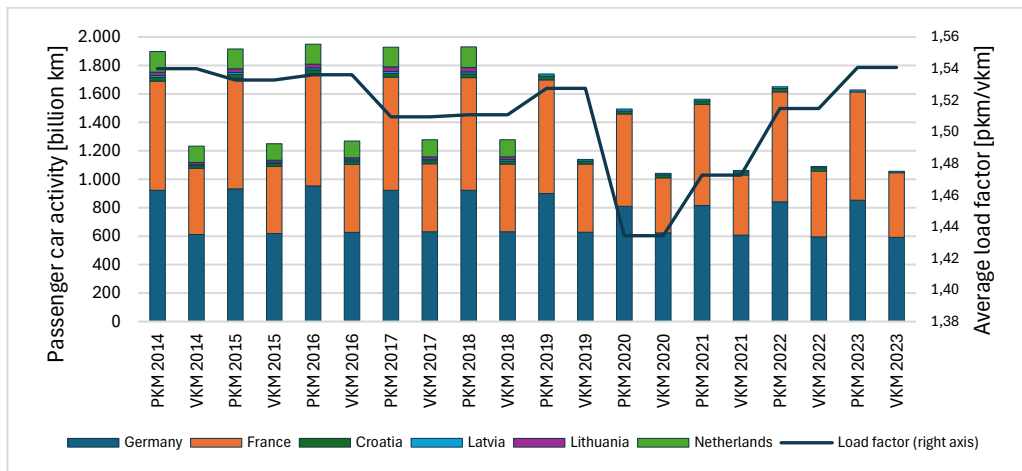
Figure 11 show our assumption of load factor for passenger cars pkm/vkm along with the baseline activity for the PC segment, expressed as billions of pkm (activity for the covid-19 years are indicative).

Figure 11 Passenger car activity (billion pkm) & load factor (pkm/vkm) (High scenario)



Source: (17) for load factor, (39) for activity

Figure 12 Passenger car load factor historical data



Source: (17)

Germany, France, Croatia, Latvia, Lithuania and the Netherlands report data for passenger cars both in terms of vkm and pkm. For the said countries the load factor has been calculated to 1,54 pkm/vkm.

2.2.8. PC sales (High Scenario)

Figure 13 Passenger cars new sales (High Scenario)

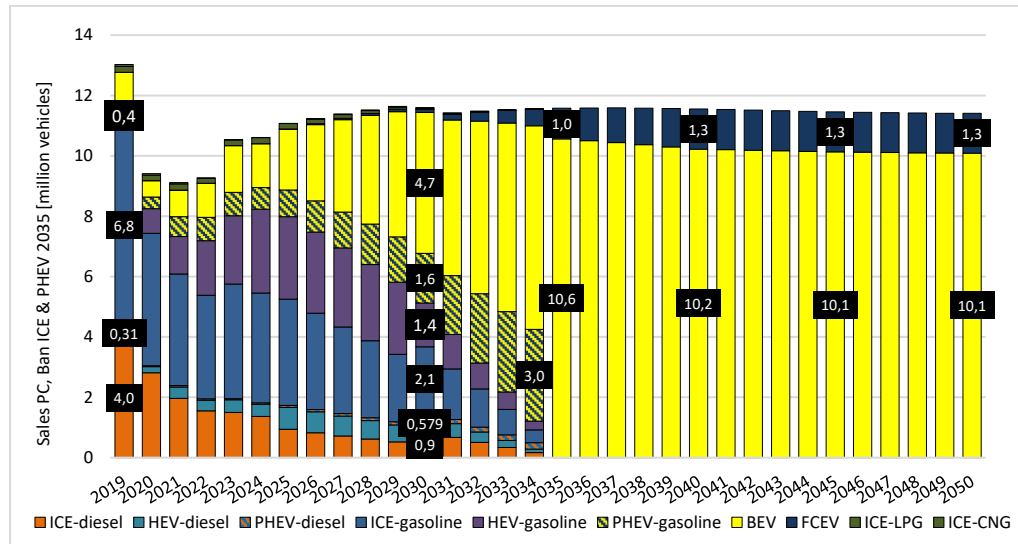


Figure 13 show the sales for the PC segment based on the legislative powertrain sales targets combined with the expected stock. Historical sales data is used up to 2024, and forecasted thereafter up to 2050. Note that an increased sales share of PHEV gasoline vehicles from 2030 to 2035 is assumed, in anticipation of consumers reaction to the ICE ban in 2035.

2.2.9. PC stock (High Scenario)

Figure 14 Passenger car stock (High Scenario)

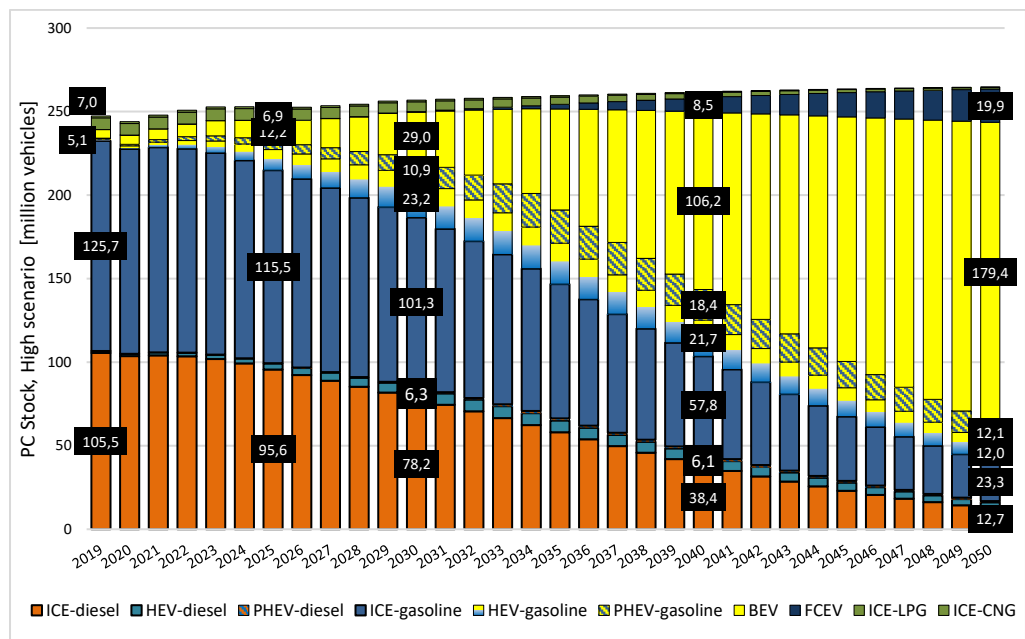


Figure 14 illustrates the considerable lag with which the new sales impact the stock due to the relative long life span of passenger cars. It is observed that despite the 2035 ICE ban, more than 55 million ICE passenger cars (including PHEV) are projected to remain in the vehicle stock in 2050.

2.2.10. PC energy demand (High Scenario)

Figure 15 Passenger car energy demand (High Scenario)

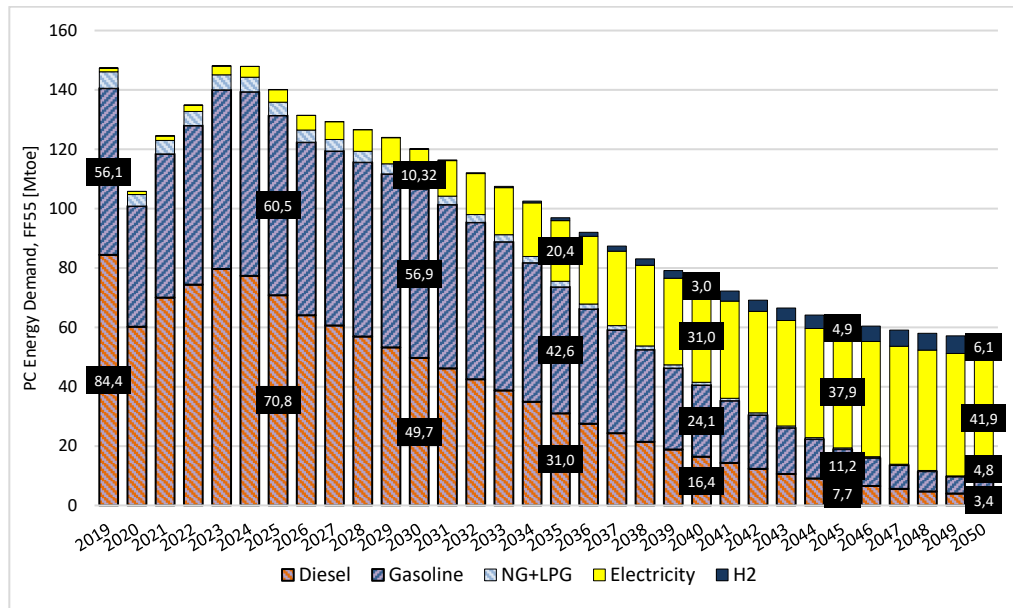


Figure 15 and Table 11 shows the modelled fuel demand from the passenger car segment in EU27. Demand in 2023 have been adjusted to align with 2019 levels, while demand for the covid-19 years is indicative.

The decreasing fuel demand which is a combined effect of:

- 1) The higher energy efficiency of the battery-electric powertrain compared to the internal combustion engine.
- 2) The expected reduction in energy consumption of the averaged newly sold vehicles compared to the existing stock, as older vehicles are expected to drive considerably less than newer ones.

Liquid fuel and energy demand compared to 2019 is shown in table form below.

Table 11 PC decrease in energy and liquid fuels demand compared to 2019 (high)

	2030	2040	2050
Liquid fuels decrease vs 2019	24,9%	71,6%	93,2%
Total energy decrease vs 2019	18,5%	48,8%	61,2%

2.3. PASSENGER CAR SENSITIVITY - BUILDING THE LOW- & HIGH SCENARIO

A sensitivity analysis showed that some parameters were highly impacting final energy demand.

Table 12 High- and low impact variables for passenger cars

High impact variables	Low impact variables
Activity	PC per capita and/or stock
Vehicle load factor	Energy consumption of ICE - in particular if coupled with additional ICE scrapping
Scrappage rate of ICE along with replacement of new cars	Total yearly sales

Table 12 is based on observations of some variables impact on fleet energy consumption and is expressed in relative terms. The number of passenger cars per capita has lower impact as it affects the total number of vehicles but not the total activity, thus more PC per capita will simply reduce the mileage per vehicle. ICE energy consumption (here in the context of 2050) has also been identified as a low impact variable due to the ICE ban in 2035 resulting in high scrapping combined with decreased mileage per annum based on vehicle age.

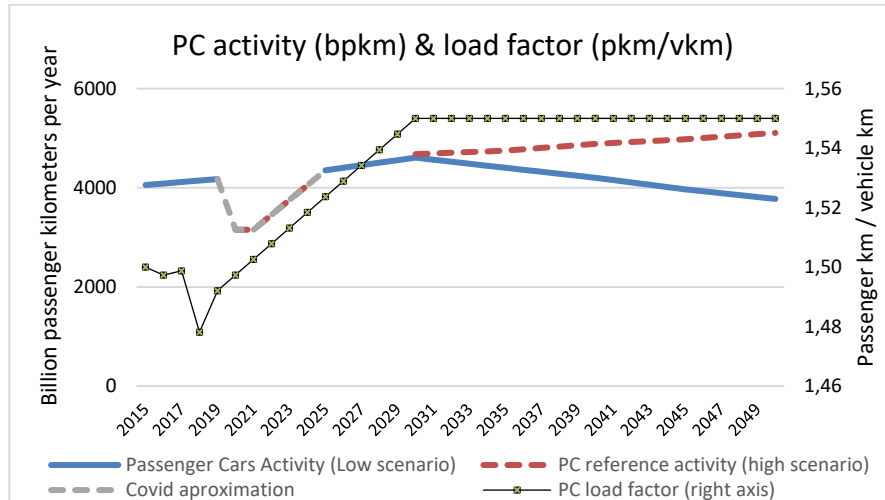
Due to the high impact of the activity for passenger cars energy consumption, and given the uncertainty the EU population transport pattern in the future, two scenarios were developed based on two sets of hypothetical activity:

- The “**high scenario**”, based on the set of hypotheses detailed previously;
- The “**low scenario**” obtained by:
 - decreasing the PC activity annually by 1,5 % for the period 2030-2050 of which 0,75 % is shifted to the bus & coach segment,
 - increased scrapping of ICE PC over 20 years of age coinciding with the ICE ban taking effect in 2035 and
 - a reduction of the of the number of PC per capita for the period 2030-2050.

2.3.1. Reduced activity, low scenario

Figure 16 shows the effect of decreased activity in the PC segment whereas the average pkm per vkm is identical to the high scenario. This is meant to reflect a shift to other means of transport away from the passenger car segment, for instance to buses & coaches, pedestrians, bicycling or similar. When such a shift occurs to the bus & coach segment it has been coupled with increased sales of vehicles.

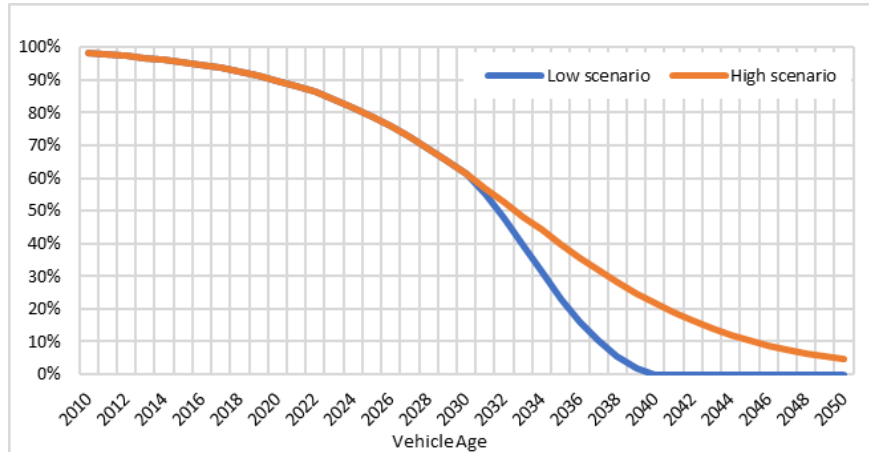
Figure 16 Passenger car activity in low- & high scenario



Source: (17) for load factor, (39) for activity

2.3.2. Increased scrapping of old ICE PC post 2035, low scenario

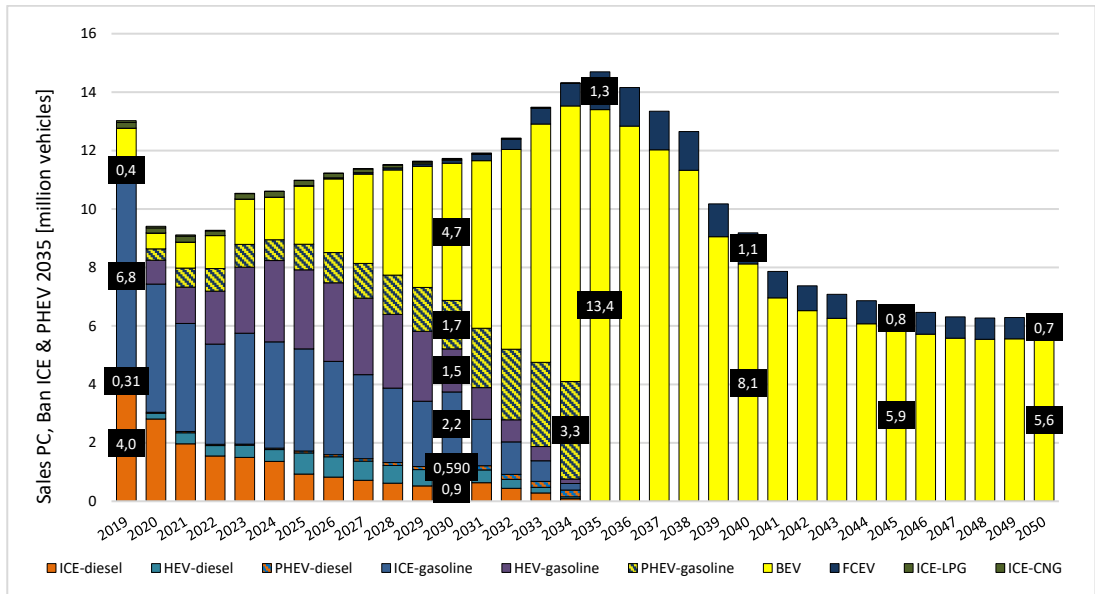
Figure 17 Illustrative additional scrapping of 20 year+ ICE vehicles from 2035



The low scenario is further defined by an additional yearly scrapping of 15% of ICE vehicles older than 20 years, for the period of 2035-2050. Figure 17 show the scrappage rate in the baseline/high scenario (orange curve) and in the low scenario the increased scrapping (the blue curve).

2.3.3. PC sales (Low Scenario)

Figure 18 Passenger car sales (Low Scenario)



The PC sales are identical to the high scenario until 2030 after which scrapping of ICE vehicles 20+ years are initiated in anticipation of the 2035 ICE ban (shown in Figure 17). The additional scrapping of older ICE vehicles has been coupled with increased BEV/FCEV sales ratio to avoid replacement of old, with new ICE. During 2040-2050 yearly sales have been reduced to reflect the reduced activity in the PC segment. This effect is present also during 2030-2040 though the increased new sales due to replacement of scrapped old ICE PC is stronger in terms of volume.

2.3.4. PC stock (Low scenario)

Figure 19 Passenger car stock (Low Scenario)

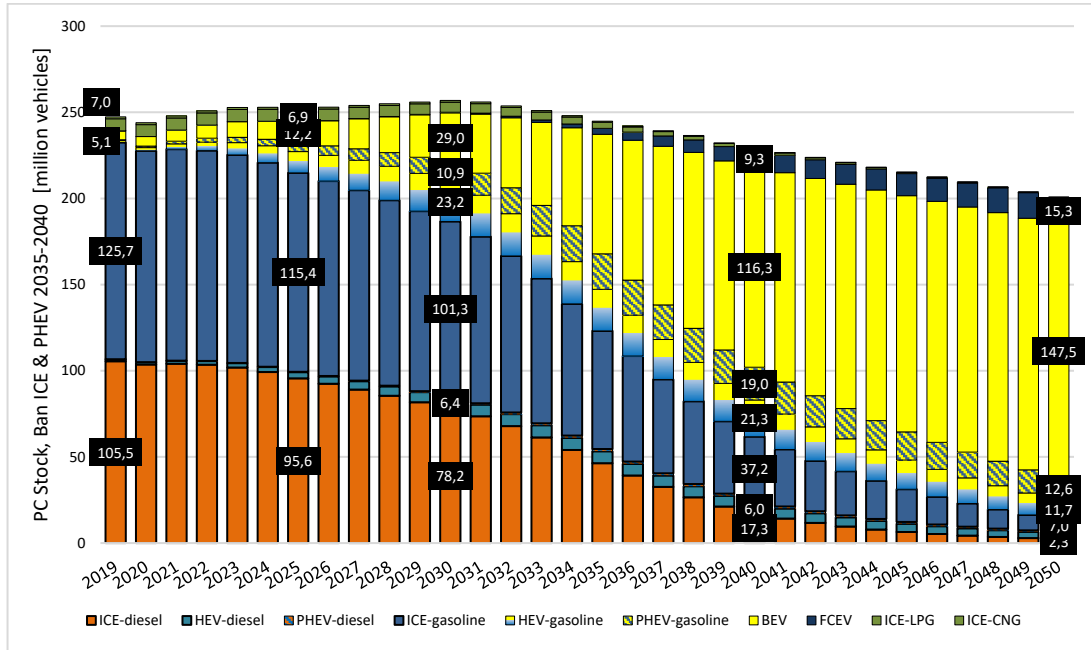


Figure 19 show a shorter lag between sales and stock compared to the high scenario. This is due to scrapped ICE vehicles being replaced by BEV and FCEV.

2.3.5. PC energy demand (Low scenario)

Figure 20 Passenger car energy demand (Low Scenario)

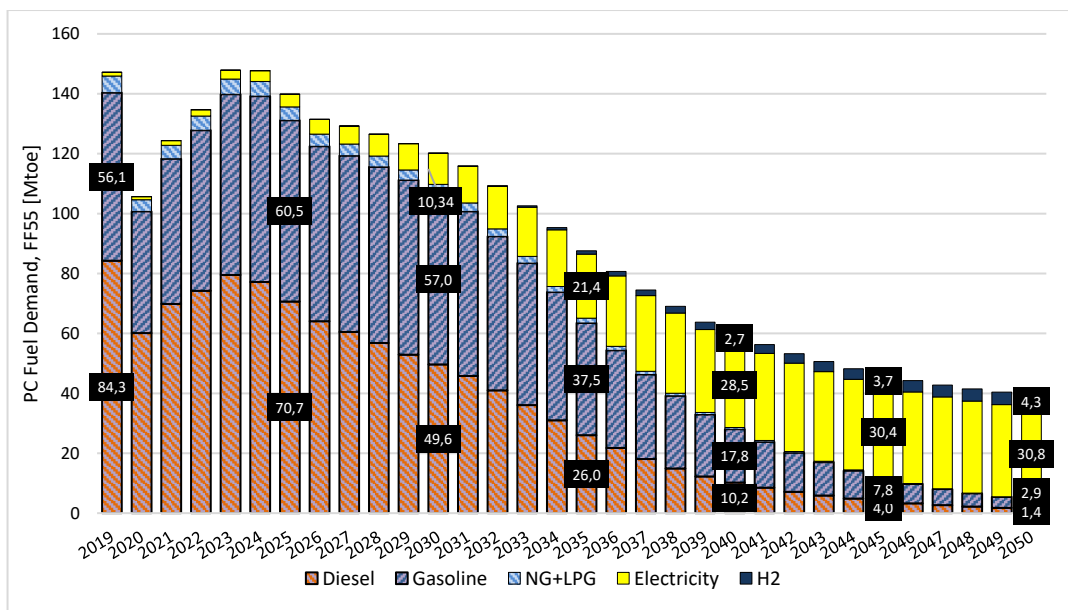


Figure 20 and table 13 show the modelled energy demand from the passenger car segment in EU27 in the low scenario. Demand in 2023 have been adjusted to align with 2019 levels, while demand for the covid-19 years is indicative. The decreased energy demand compared to the high scenario is an effect of:

- 1) The reduced PC category activity.
- 2) Increased scrapping of ICE vehicles older than 20 years for the period 2031-2050, that are replaced with BEV and FCEV.

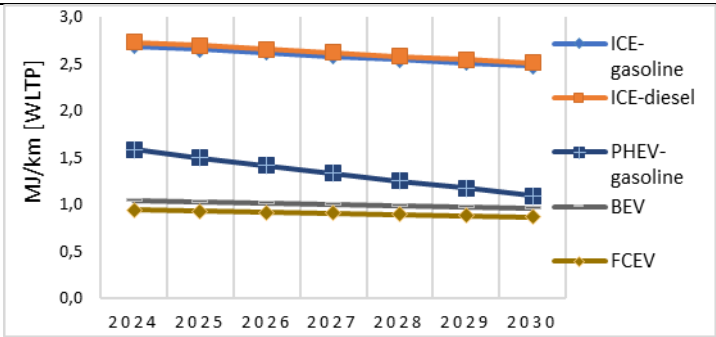
Table 13 Passenger cars energy & liquid fuel demand decrease compared to 2019 (low)

	2030	2040	2050
Liquid fuels decrease vs 2019	24,8%	80,4%	96,3%
Total energy decrease vs 2019	18,3%	59,4%	72,5%

2.4. LIGHT COMMERCIAL VEHICLES (LCV)

The light commercial vehicles modelling follows the same methodology as the passenger cars. The differences are summarized in Table 14:

Table 14 LCV key parameters

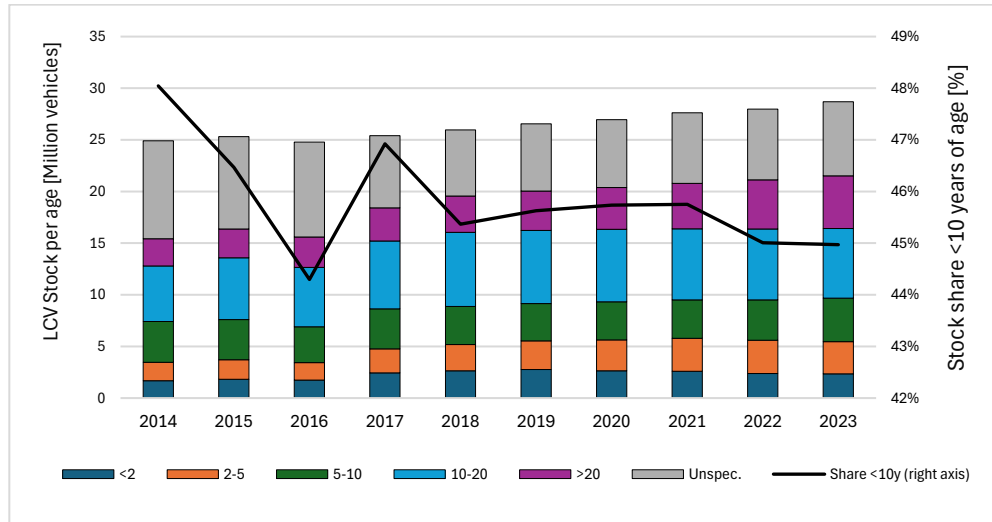
LCV per capita 2050	0,063 (constant to 2020)																																																
Average scrapping age	19 years																																																
Average stock age	<9 years																																																
Half total vehicle mileage performed	<7 years																																																
Vehicle energy efficiency	 <table border="1"> <caption>Estimated data from Table 14 chart (MJ/km [WLTP])</caption> <thead> <tr> <th>Year</th> <th>ICE-gasoline</th> <th>ICE-diesel</th> <th>PHEV-gasoline</th> <th>BEV</th> <th>FCEV</th> </tr> </thead> <tbody> <tr> <td>2024</td> <td>2.7</td> <td>2.8</td> <td>1.6</td> <td>1.0</td> <td>0.9</td> </tr> <tr> <td>2025</td> <td>2.6</td> <td>2.7</td> <td>1.5</td> <td>1.0</td> <td>0.9</td> </tr> <tr> <td>2026</td> <td>2.5</td> <td>2.6</td> <td>1.4</td> <td>1.0</td> <td>0.9</td> </tr> <tr> <td>2027</td> <td>2.4</td> <td>2.5</td> <td>1.3</td> <td>1.0</td> <td>0.9</td> </tr> <tr> <td>2028</td> <td>2.3</td> <td>2.4</td> <td>1.2</td> <td>1.0</td> <td>0.9</td> </tr> <tr> <td>2029</td> <td>2.2</td> <td>2.3</td> <td>1.1</td> <td>1.0</td> <td>0.9</td> </tr> <tr> <td>2030</td> <td>2.1</td> <td>2.2</td> <td>1.0</td> <td>1.0</td> <td>0.9</td> </tr> </tbody> </table>	Year	ICE-gasoline	ICE-diesel	PHEV-gasoline	BEV	FCEV	2024	2.7	2.8	1.6	1.0	0.9	2025	2.6	2.7	1.5	1.0	0.9	2026	2.5	2.6	1.4	1.0	0.9	2027	2.4	2.5	1.3	1.0	0.9	2028	2.3	2.4	1.2	1.0	0.9	2029	2.2	2.3	1.1	1.0	0.9	2030	2.1	2.2	1.0	1.0	0.9
Year	ICE-gasoline	ICE-diesel	PHEV-gasoline	BEV	FCEV																																												
2024	2.7	2.8	1.6	1.0	0.9																																												
2025	2.6	2.7	1.5	1.0	0.9																																												
2026	2.5	2.6	1.4	1.0	0.9																																												
2027	2.4	2.5	1.3	1.0	0.9																																												
2028	2.3	2.4	1.2	1.0	0.9																																												
2029	2.2	2.3	1.1	1.0	0.9																																												
2030	2.1	2.2	1.0	1.0	0.9																																												

Source: (24) for ICE gasoline and diesel, (26) with regards to energy consumption for remaining powertrain that have been harmonized with declared WLTP values for the top sales in EU27.

The energy consumption per km of the average newly sold LCV is assumed to decline until 2030 and then remain constant until 2050 due to a combination of improved powertrain efficiency and vehicle size in the new sales.

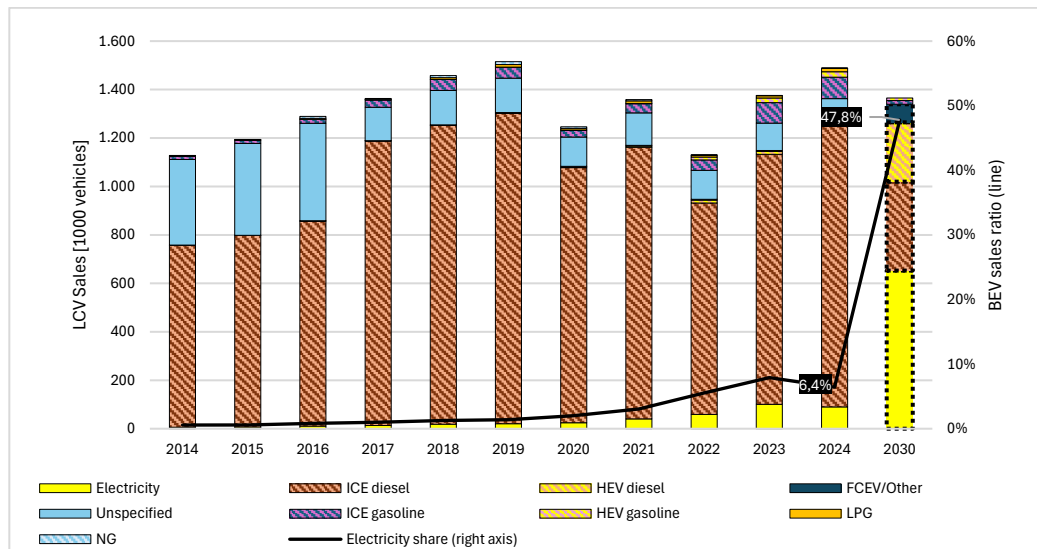
The scrapping function is based on data from (31) illustrated in Figure 21 regarding the average stock age.

Figure 21 Light commercial vehicle stock per age category



Source: (17)

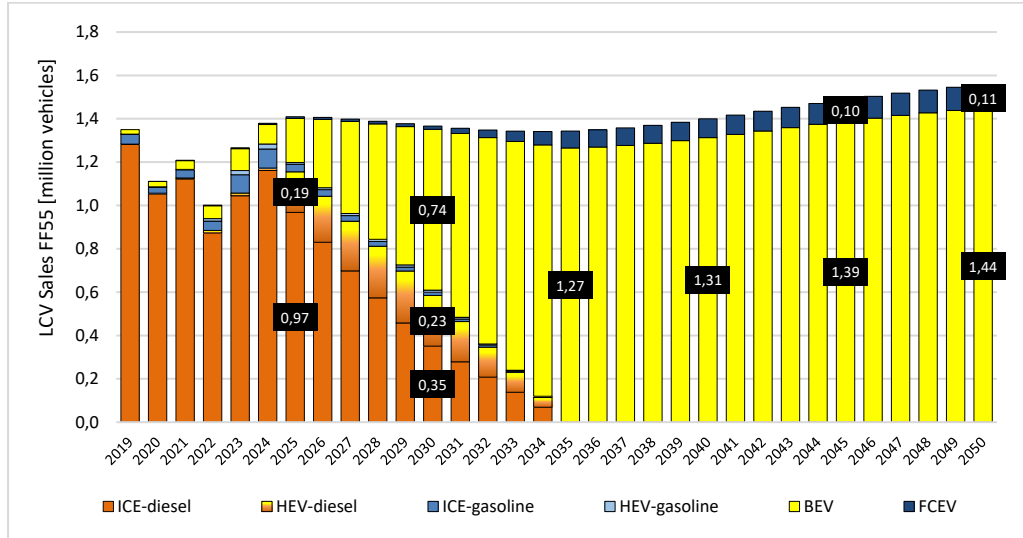
Figure 22 New sold LCV with regards to powertrain



Source: Historic values based on (17) and modelled values for 2030 to meet sales targets

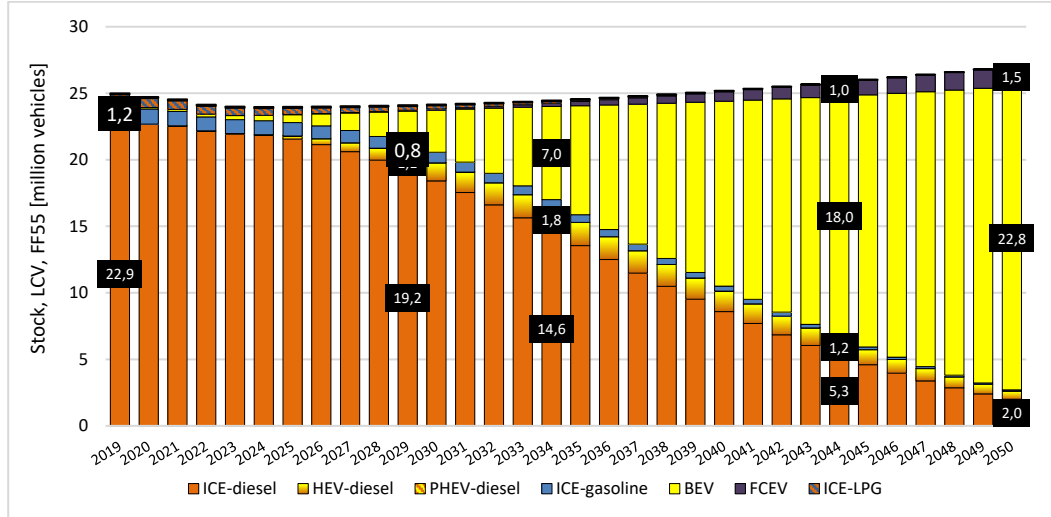
Figure 22 shows that BEV are increasing though ICE diesel is still dominant. The BEV target for 2030 is 48 %.

Figure 23 LCV sales



As of 2035, in conjunction with the ICE sales ban, BEV account for 94 % of sales and FCEV of 6 % (Table 3).

Figure 24 LCV stock



The lag of the BEV penetration in the stock is caused by the relative long-life span of the LCV (compared to heavier trucks described in chapter 2.5).

Figure 25 LCV energy demand

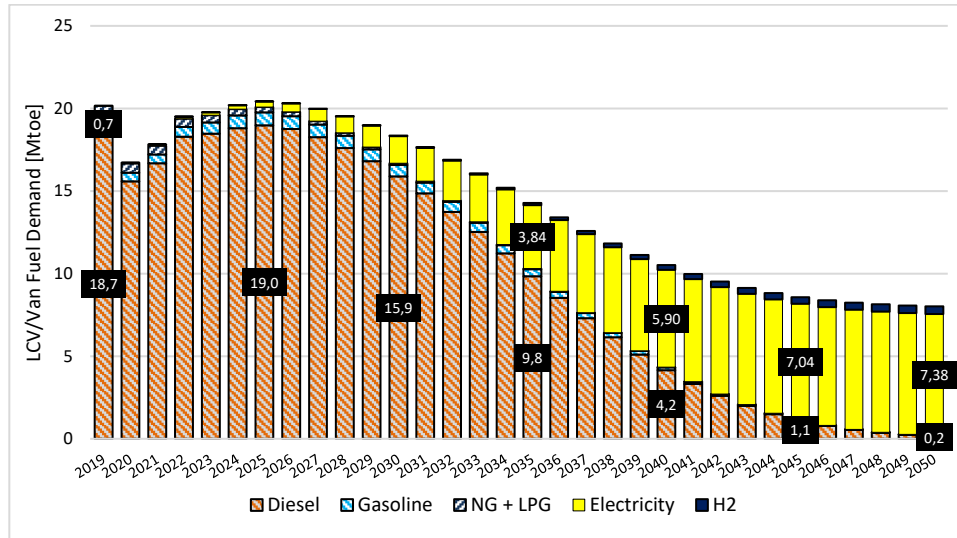


Fig. 25 and Table 15 show the modelled energy demand from the LCV segment. Demand in 2023 have been adjusted to align with 2019 levels, while demand for the covid-19 years is indicative.

Table 15 LCV decrease in energy and liquid fuels demand compared to 2019

	2030	2040	2050
Liquid decrease vs 2019	17,2%	78,5%	99,1%
Total decrease vs 2019	9,1%	47,9%	60,3%

Liquid fuel demand decreases by 17 % in 2030 compared to 2019, with 79 % in 2040 and 99 % in 2050 which is a consequence of the new vehicles higher yearly mileage.

2.5. HEAVY-DUTY VEHICLES (HDV)

The HDV stock is segmented into:

- 1) Trucks under 12 tonnes,
- 2) Trucks from 12 tonnes and over (including all road tractors),
- 3) Buses and Coaches.

The truck categories are identical in the high- and low scenario and the activity follows the forecast from (15) illustrated in Figure 1.

2.5.1. Trucks lighter than 12 tonnes

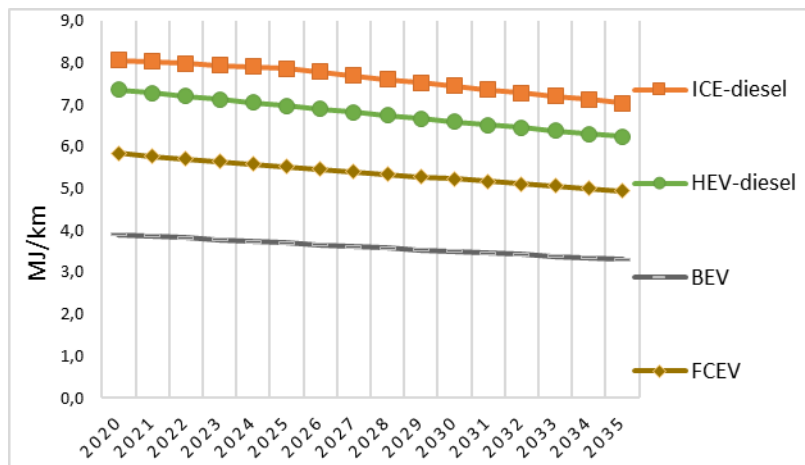
The light truck category consists of lorries with registered gross weight less than 12 tonnes. In occasions where Eurostat lorry data is not stratified other than 10-20 tonnes, 20% are considered for the <12t category and 80% for the >12t category.

Table 16 Key modelling parameters for trucks lighter than 12 tonnes

Number of <12t trucks per capita in 2050	0,003*
Average scrapping age	18 years
Average stock age	9 years
Half total vehicle mileage performed	<6,5 years

* Slightly decreasing stock of vehicles per capita (from 0,0038 in 2023 to 0,003 in 2050).
 Source: based on analysed data from (17).

Figure 26 Energy consumption of newly sold trucks <12t

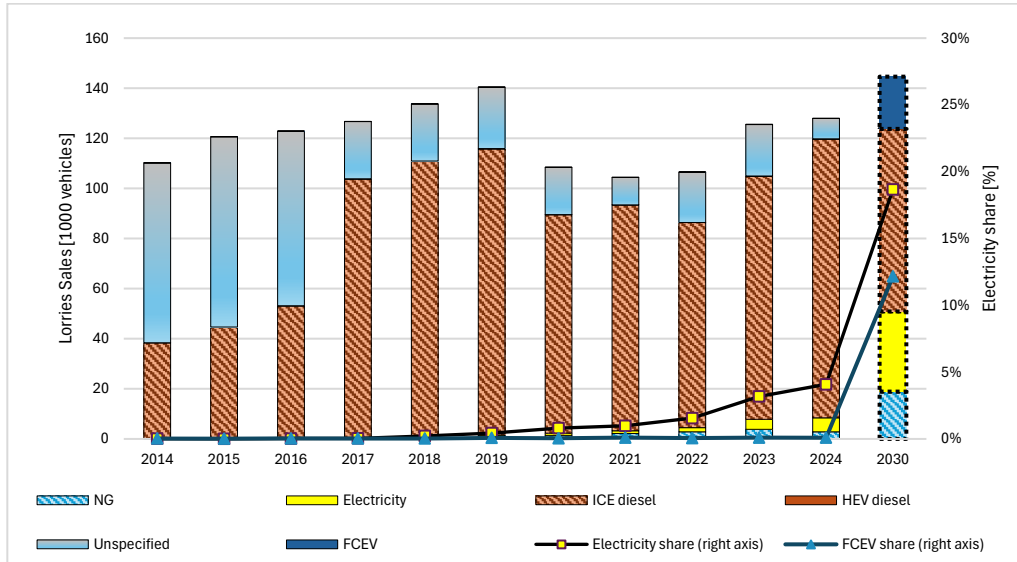


Source: Energy consumption per km is based on (26), (13) and (34).

Data from (17) have been used for assumptions of yearly distance, vehicle stock and usage pattern. We have applied assumptions of decreasing energy consumption per km by 1,2% per annum for the period 2025-2050.

Trucks are typically used in a more highway-dominated duty cycle compared to buses, PC and LCV. Trucks are optimized for fuel efficiency (aerodynamics, rolling resistance, down-speeded diesel engines, etc.) contrary to PC where aspects such as comfort and design are of greater significance. Under those conditions, comparative analyses find that battery electric heavy-duty trucks are roughly 2x more energy efficient than diesel trucks which is lower than the 3x shown for PC or LCV (43).

Figure 27 New sold Lorries (both the light and heavy category) by Powertrain

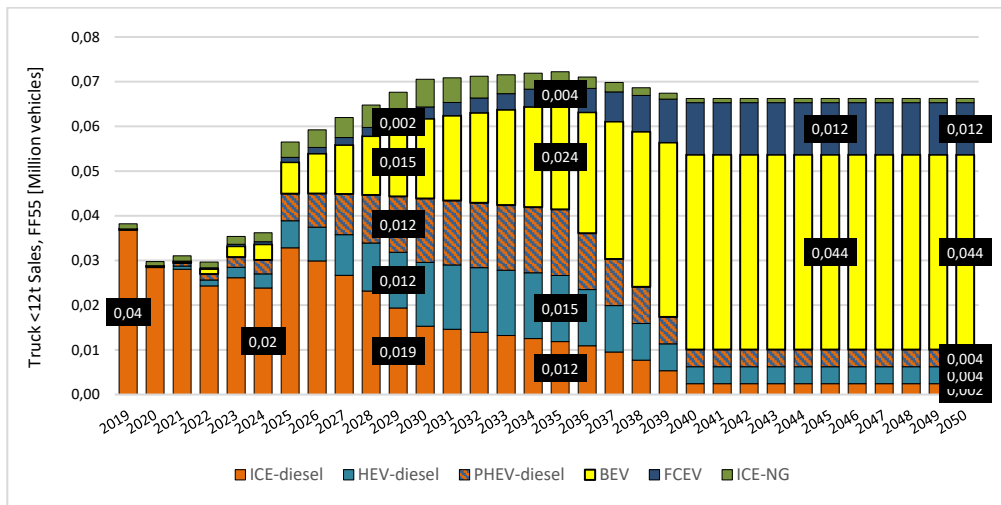


Source: Historic values based on (17) and modelled values for 2030 to meet vehicle sales targets

The BEV segment is increasing from very low levels whereas ICE diesel remains dominant. However, the required sales increase of BEV to comply with the 2030 target of 28 % for trucks <12t and 12 % for trucks >12t, will be challenging.

The scrapping curve for Lorries have been estimated same as for PC, however of a lower accuracy due to the difficulty in modelling the COVID years combined with unavailability of data prior to 2013 for all the EU27 member states.

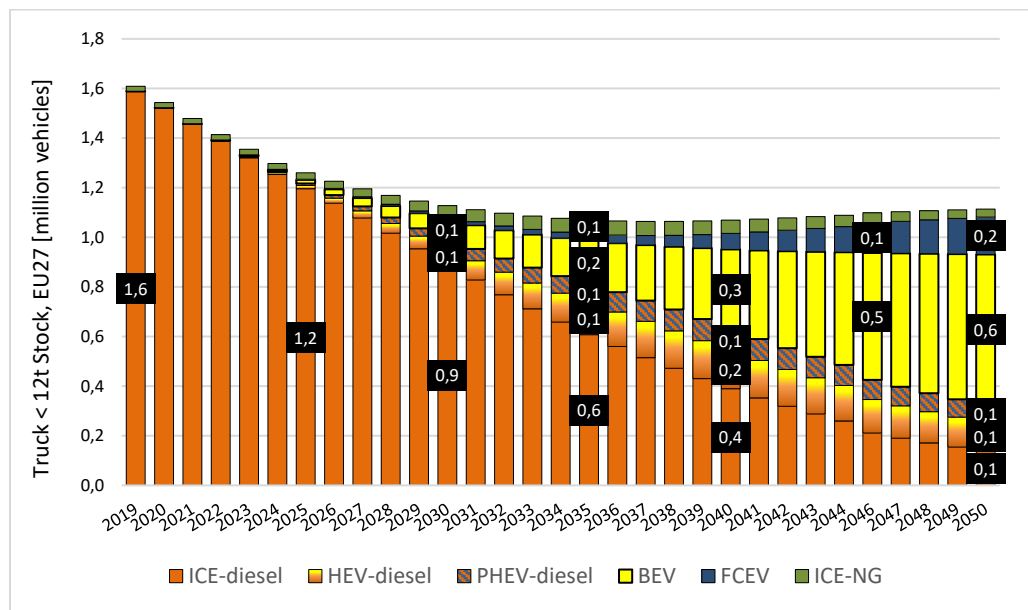
Figure 28 Truck < 12t new sales



Compared with pre-COVID levels, new sales rise significantly as of 2025. This is a modelling choice as Eurostat stock data indicate very large fleet compared to what would be consistent with sales. At the same time, EC survey evidence shows that a significant share of lorries is not in use.

To reconcile these discrepancies, we are modelling a higher scrappage rate that in turn require increased sales to mitigate a rapidly declining stock. This adjustment brings stock levels closer to Eurostat reporting and avoids maintaining an unrealistically large vehicle pool that includes a high proportion of unused units. As a consequence, the model shifts slightly more weight onto new sales (increasingly dominated by BEV), which we consider a more realistic representation of market dynamics than retaining a high stock figure.

Figure 29 Truck < 12t stock



The relative long-life span of trucks < 12t increase the lag for BEV to penetrate the vehicle stock. By 2040, BEV and FCEV reach 36 % share of the stock and in 2050, this will rise to 68 %.

Figure 30 Truck < 12t energy demand

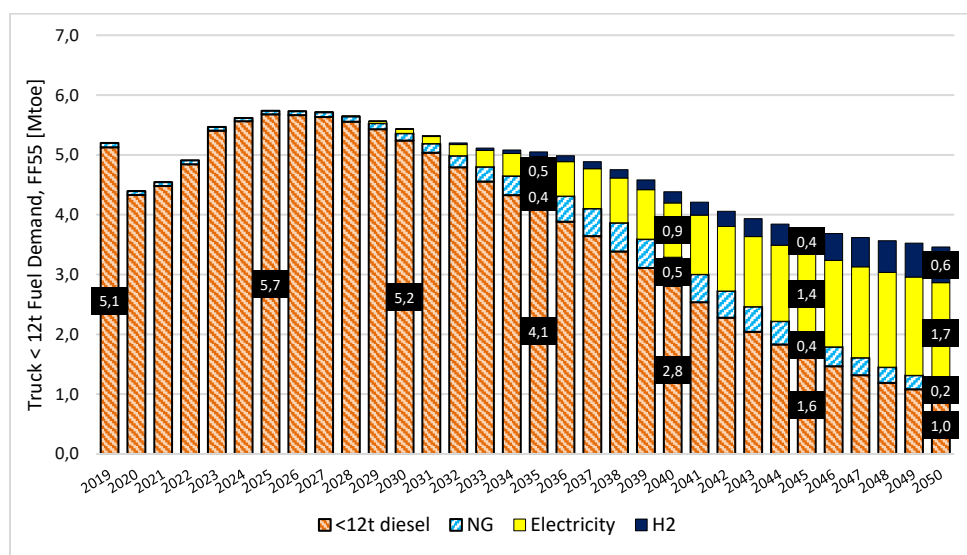


Fig. 30 and table 17 show energy and liquid fuel demand from trucks < 12t.

Table 17 Trucks <12t decrease in energy and liquid fuels demand compared to 2019

	2030	2040	2050
Liquid decrease vs 2019	-7,1%	38,4%	78,8%
Total decrease vs 2019	-15,4%	7,1%	32,2%

Both energy and liquid fuel demand increase in 2030 compared to 2019 due to increased activity of <12t trucks and increase in newly sold vehicles combined with the low stock replacement rate. In 2040 and 2050 fuel demand decrease even though activity increase which is a consequence of the higher energy efficiency of the battery electric powertrain compared to the diesel ICE. Note that the activity (based on (39)) for the light truck increase with 67 % between 2019 and 2050 which explain the relative high diesel consumption in 2050 (even though the number of trucks is drastically reduced).

2.5.2. Trucks heavier than 12 tonnes

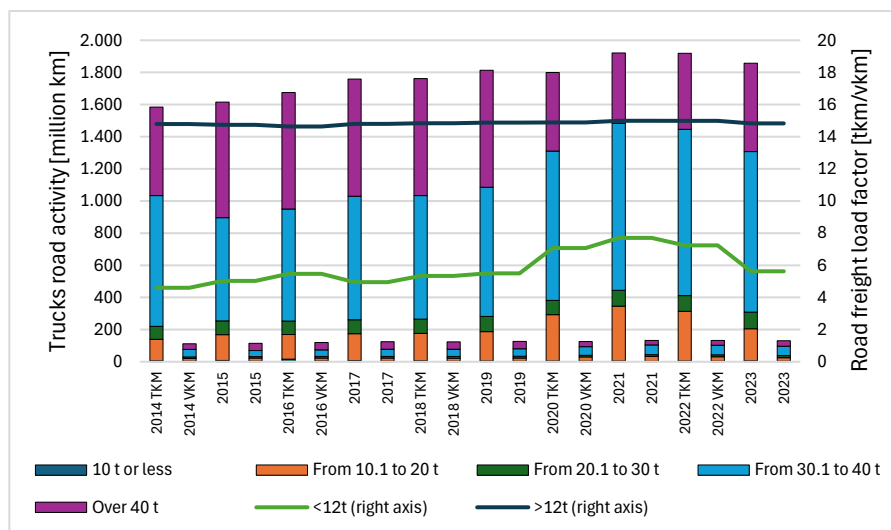
The category trucks >12t consists of lorries with gross weight over 12 tonnes and road tractors (in this study 100% of road tractors assumed to have a gross weight over 12 tonnes). The trucks >12t category is characterized by higher yearly mileage and higher stock replacement turnover than trucks <12 tonnes.

Table 18 Modelling parameters for heavy trucks (Lorries >12 tonnes and road tractors)

Number of >12t trucks per capita in 2050	0,01 (17)
Average scrapping age	13 years
Average stock age	6,5 years
Half total vehicle mileage performed	<4 years of age (17)

Source: Constant number of vehicles per capita over the period. Remaining figures own assessment based on analysed data from (17).

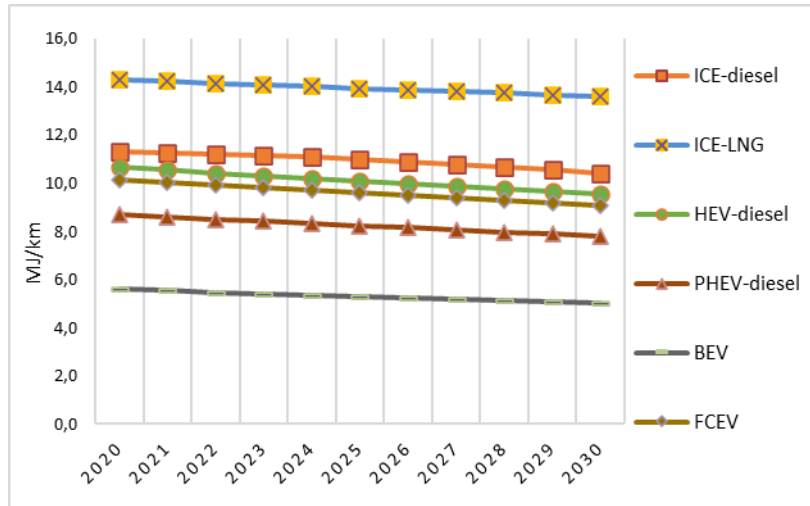
Figure 31 Activity data & load factor for lorries and road tractors



Source: based on compiled data from (17).

See also Figure 72 in the appendix for illustration of decreasing mileage (and tonnage) per vehicle age.

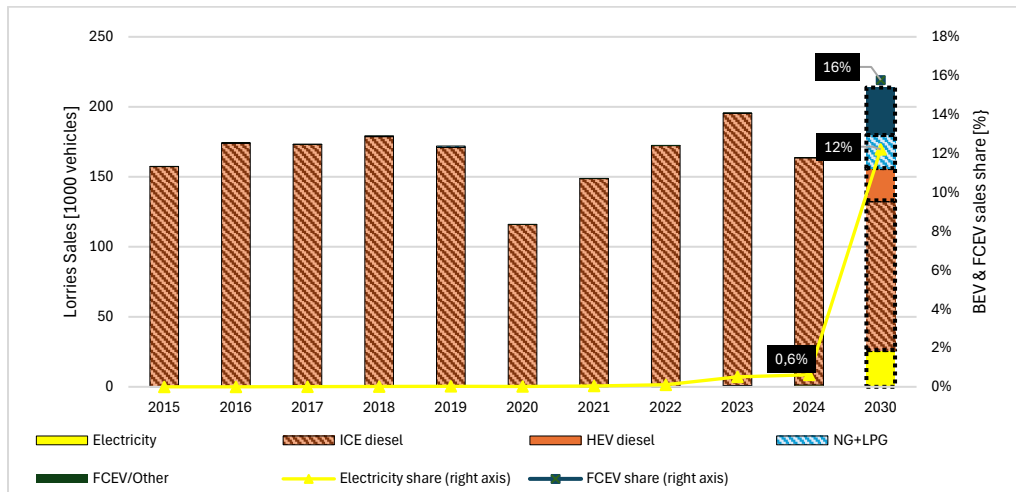
Figure 32 Truck > 12t newly sold energy consumption per km



Source: Energy consumption per km is based on (26), (13) and (34).

Consistent with (26), a reduction of energy consumption per km by 1,2% per annum is assumed also for the period 2030-2050.

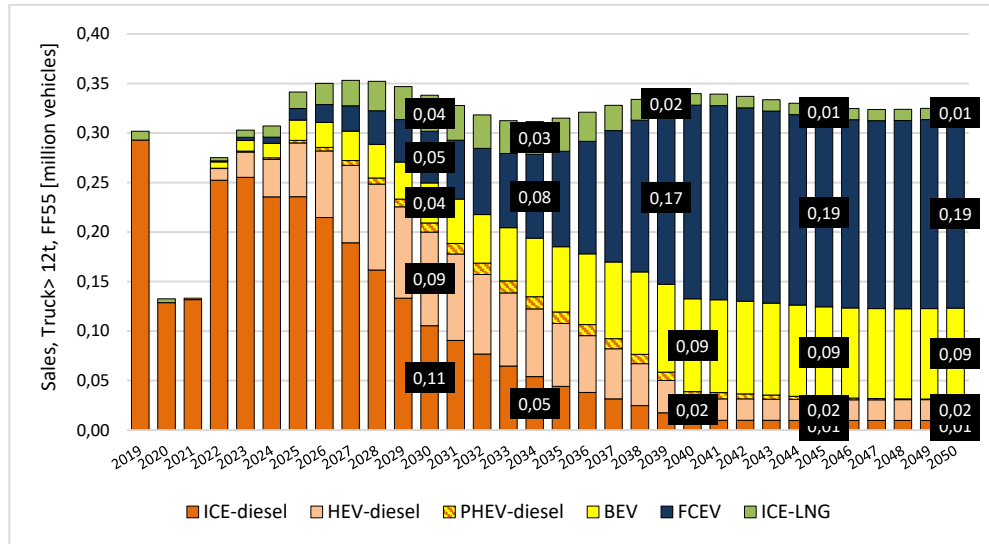
Figure 33 New sold Road Tractors (>12t)



Source: Historic values based on (17) and modelled values for 2030 to meet vehicle sales targets

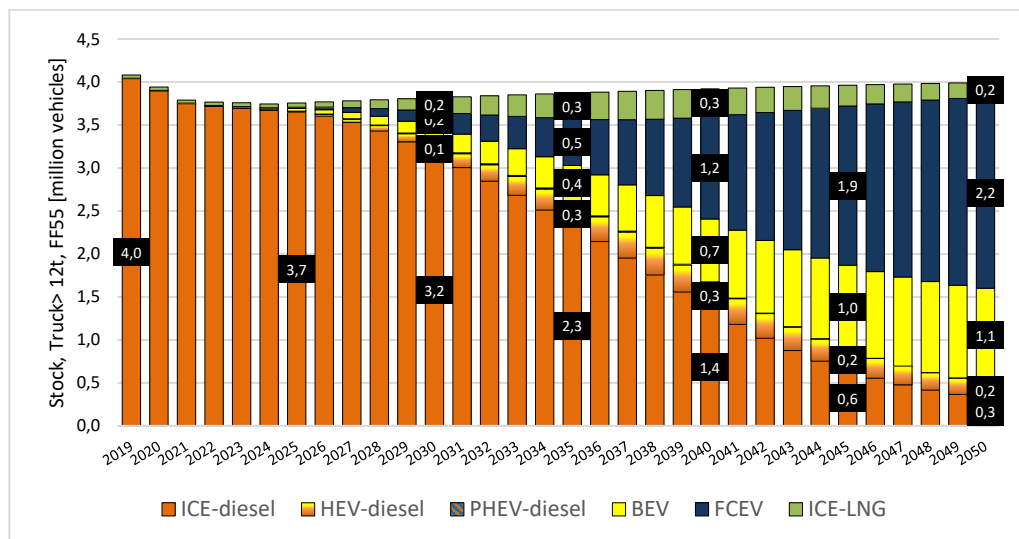
Figure 33 show historic values up to 2024 and modelled values for 2030 that meet the vehicle sales targets. Not surprisingly the new sales of BEV are insignificant for road tractors although with an increase in 2024.

Figure 34 Trucks > 12t new sales



In line with the sales targets to meet emission reductions, FCEV are expected to be the preferred powertrain even though BEV account for approximately 30 % sales share after 2040. In this study, hydrogen-powered vehicles for the heavy-duty vehicles are assumed to be based on fuel cell technology rather than hydrogen ICE. It is acknowledged that hydrogen ICE vehicles could also be suitable, albeit at a lower level of technology maturity, however it is beyond the scope of this study to compare these technologies nor to evaluate their respective advantages.

Figure 35 Truck > 12t stock



The assumptions of future stock for the light and heavy trucks differ with regards to the very high utilization rate for the long haulage category compared to trucks < 12t as indicated in Figure 32. The shorter life span and higher yearly mileage of the long haulage trucks enable a more rapid stock transition of powertrain. By 2040, BEV and FCEV reach 58 % share of the stock and 86 % in 2050.

Figure 36 Truck > 12t energy demand

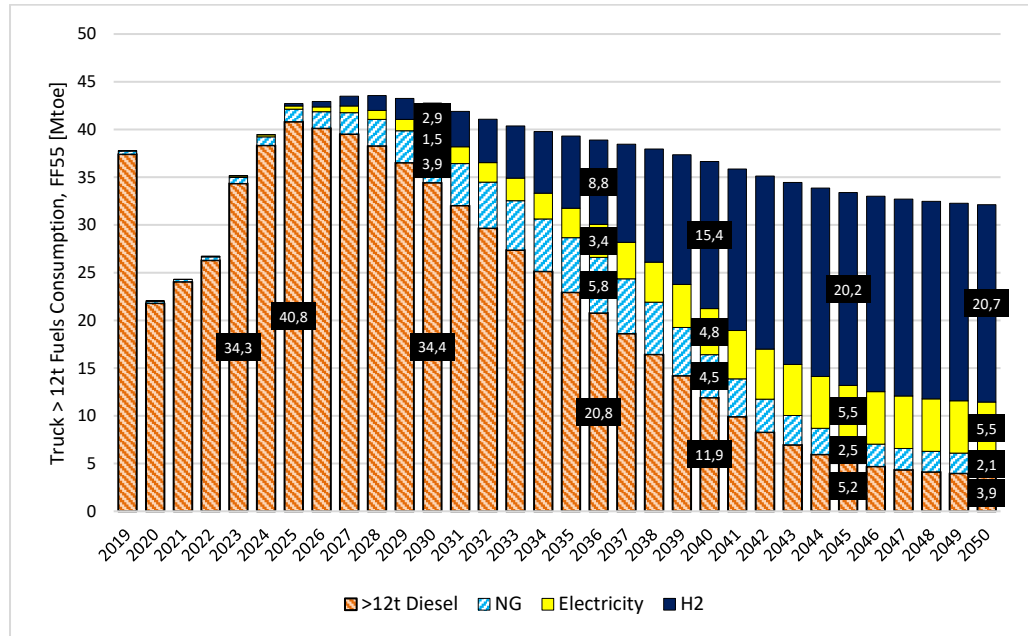


Figure 36 and table 19 show energy and liquid fuel demand that decrease considerably despite increased activity over the period considered. The comparatively high replacement rate results in higher impact of the more efficient powertrain options of FCEV and BEV.

Table 19 Trucks >12t decrease in energy and liquid fuels demand compared to 2019

	2030	2040	2050
Liquid fuel demand decrease vs 2019	-1,6%	56,5%	84,2%
Total energy demand decrease vs 2019	-13,2%	3,0%	15,0%

FCEV compared to ICE diesel are expected to be 31 % more energy efficient for trucks >12t in 2030 whereas H₂ ICE are assumed to have 5 % higher energy consumption (44). Therefore, the use of hydrogen ICE is expected to increase the total energy demand relative to the use of FCEV.

Note that though diesel demand in 2050 is 8 times that of the trucks < 12t although 95 % of the total ton-km activity are performed by the heavy truck segment. The significant reduction in energy demand is due to the higher efficiency of the FCEV and BEV powertrains. Due to the relatively shorter life span of these vehicles, this trend occurs at a higher rate than with other freight segments. Further, over time, the older diesel vehicles drive less.

2.5.3. Buses & Coaches

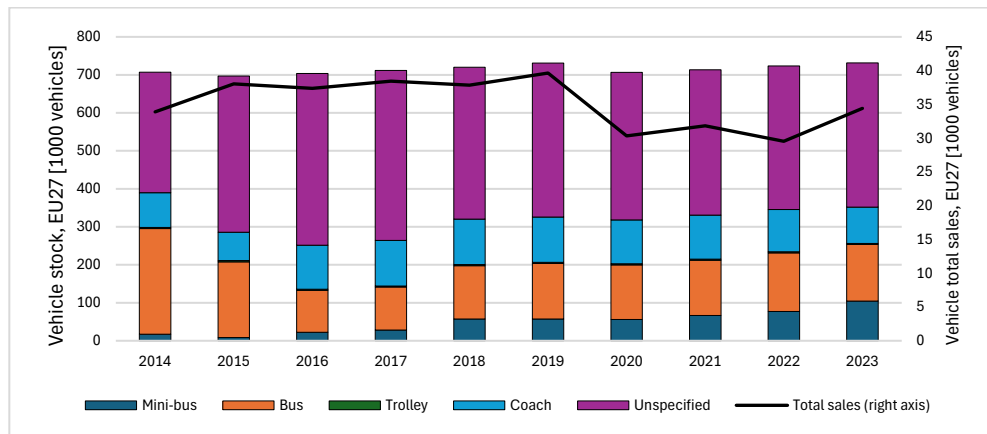
The Buses & Coaches stock is segmented into:

- 1) Buses < 7,5 tonnes
- 2) Buses > 7,5 tonnes
- 3) Coaches

We have chosen to merge the segments with the coaches representing half and the buses the other half. The bus stock exceeds the coach stock that in turn have higher yearly driving distance and hence energy demand. This is consistent with (17), which indicates that the bus stock in EU 27 in 2022 were 57,5 % (Figure 27).

A proposal (45) is that new sales of city buses in 2030 have zero emission in a tank-to-wheel perspective. However, the sales share of city buses is small relative the total bus and coach sales.

Figure 37 Buses & Coaches stock, EU27



Source: (10)

As shown in Fig. 37, the number of buses exceeds that of coaches. However, since coaches typically cover greater annual mileage per vehicle than buses, we have chosen to approximate the data by merging both categories on a 50/50 basis.

Table 20 Buses & Coaches modelling parameters

Number of buses & coaches per capita in 2050	0,00145 (High Scenario) 0,002 (Low Scenario)
Average scrapping age per vehicle	15 years
Steady state average stock age	< 7 years
Half total vehicle mileage performed	< 6 years

Source: Number of vehicles per capita constant and depending on scenario. Remaining figures own assessment based on analysed data from (17).

Figure 38 Bus & Coach load factor and performed pkm

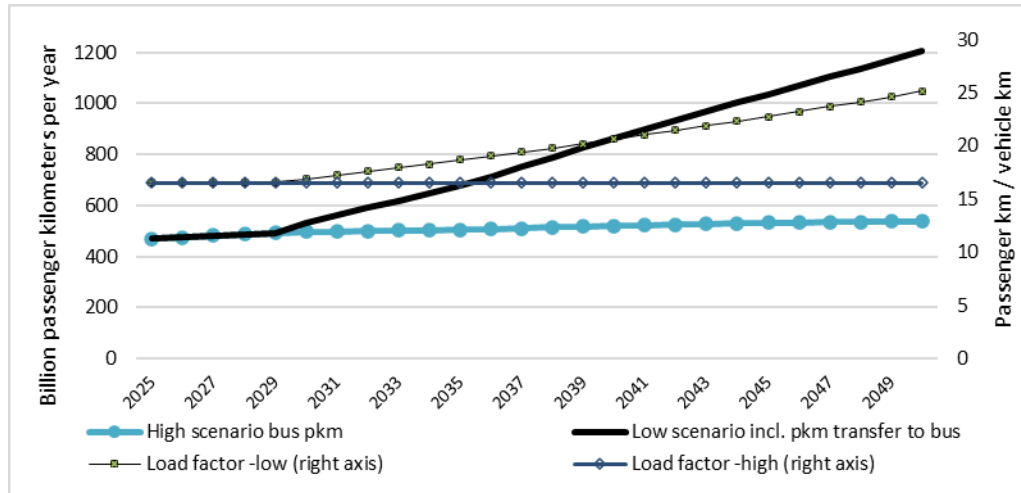
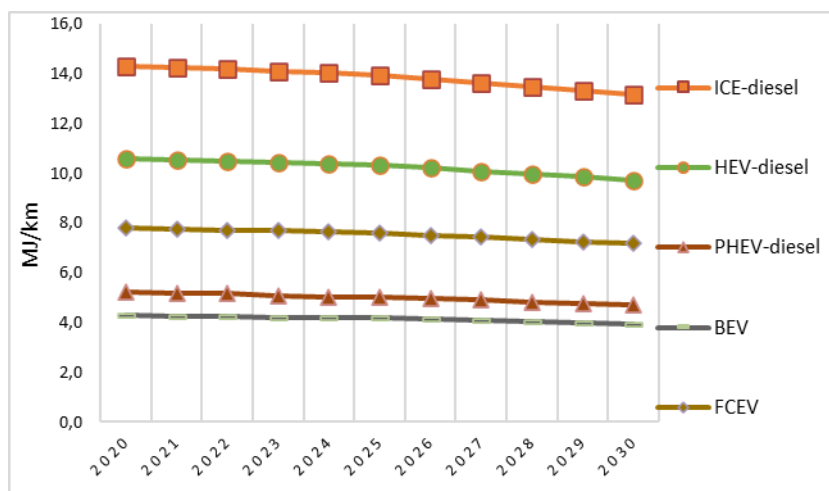


Figure 38 shows the total activity for buses & coaches in the low and high scenario where the low scenario more than double the pkm in 2050 compared to the high scenario.

The assumption of increase in load factor reflects a harmonisation to (14) that apply the load factor for city buses: low= 15 pkm/vkm; representative= 42 pkm/vkm; max= 90 pkm/vkm. The expected increase of pkm/vkm for the coach category is linked to the decline in ICE diesel PC sales, where it is assumed that some of the activity is transferred to coaches. While a portion could also be transferred to rail, no increased energy requirement is assumed. The supporting data regarding load factor is provided in Appendix I.

Figure 39 Energy consumption per km for newly sold buses & coaches

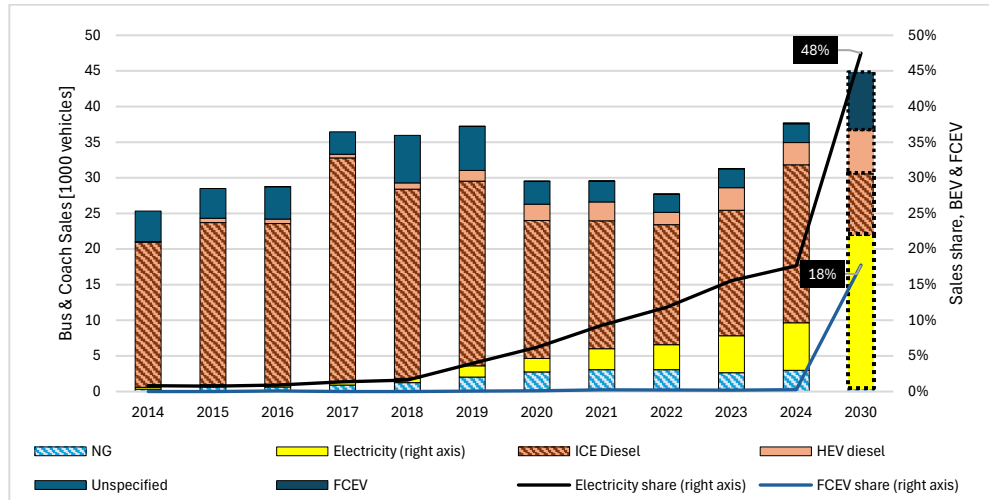


Source: Energy consumption per km is based on (14), (26), (13) and (34).

Consistent with (26) , a reduction of energy consumption per km by 1,2% per annum is applied. A consequence of our merging of buses and coaches considering that some powertrain options will be more preferable in one of the segments, we have chosen to use the energy consumption for BEV to represent buses whereas FCEV represent coaches. This reflects the benefit of BEV if the driving cycle has low

average speed with several start/stop whereas coaches would benefit from the lower refuelling time of a FCEV combined with higher ratio of highway driving.

Figure 40 New sold Buses & Coaches per powertrain

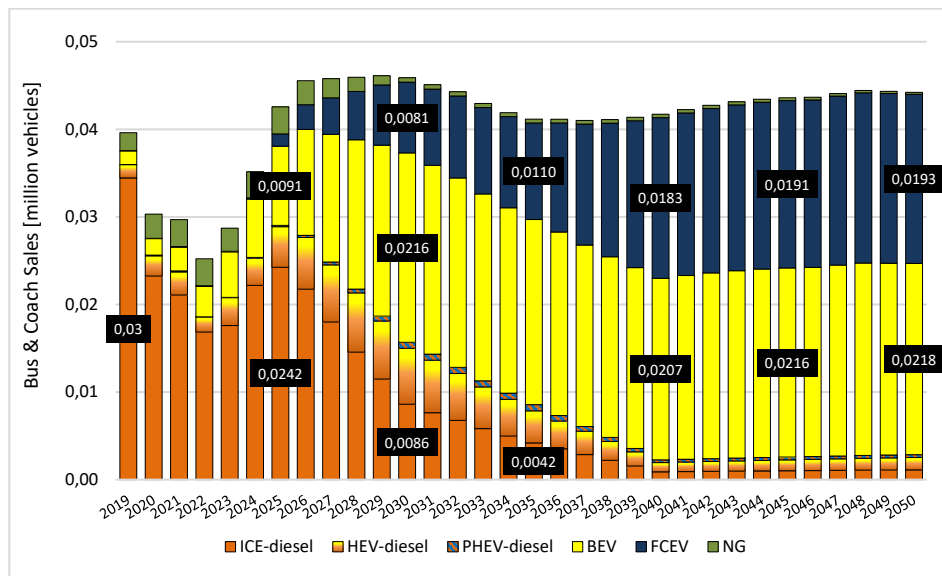


Source: (17)

The new sales of buses have noticeable share of BEV which may signal a build up towards the target of 100 % zero emission city buses in 2030. Also, HEV diesel and natural gas-powered vehicles make significant shares of the new sales. We have assumed that BEV and PHEV are predominantly buses whereas FCEV are predominantly coaches.

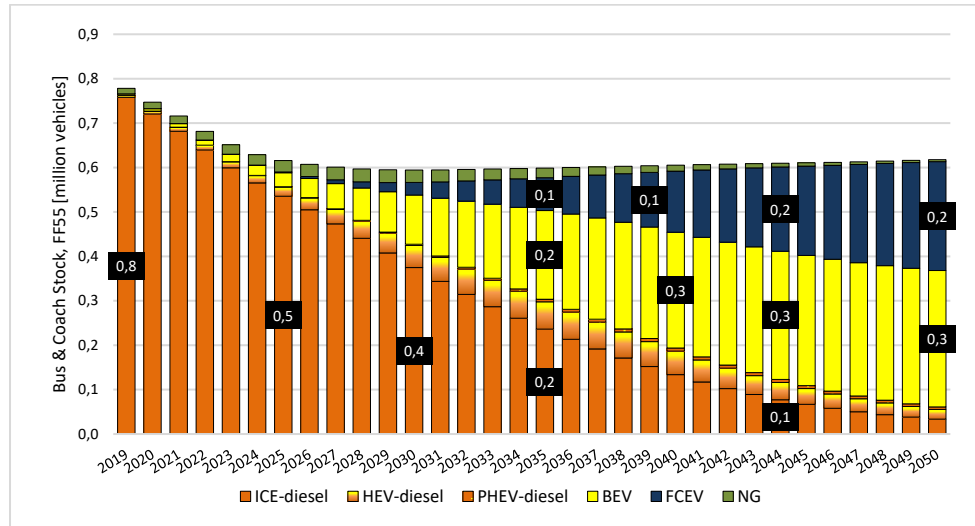
2.5.3.1. Buses & Coaches - High scenario

Figure 41 Bus & Coach sales per powertrain (High Scenario)



As of 2040, sales of diesel engines are marginal and city buses are dominantly BEV whereas coaches are predominantly FCEV.

Figure 42 Bus & Coach stock per powertrain (High Scenario)



The stock change is lagging due to the high bus & coach life span. However, the penetration of BEV and FCEV is fairly rapid so that less than 15 % of the fleet is diesel powered in 2050. By 2050, approximately 0.3 million BEV's and 0.2 million FCEVs are expected in the bus and coach segments.

Figure 43 Bus & Coach energy demand (High Scenario)

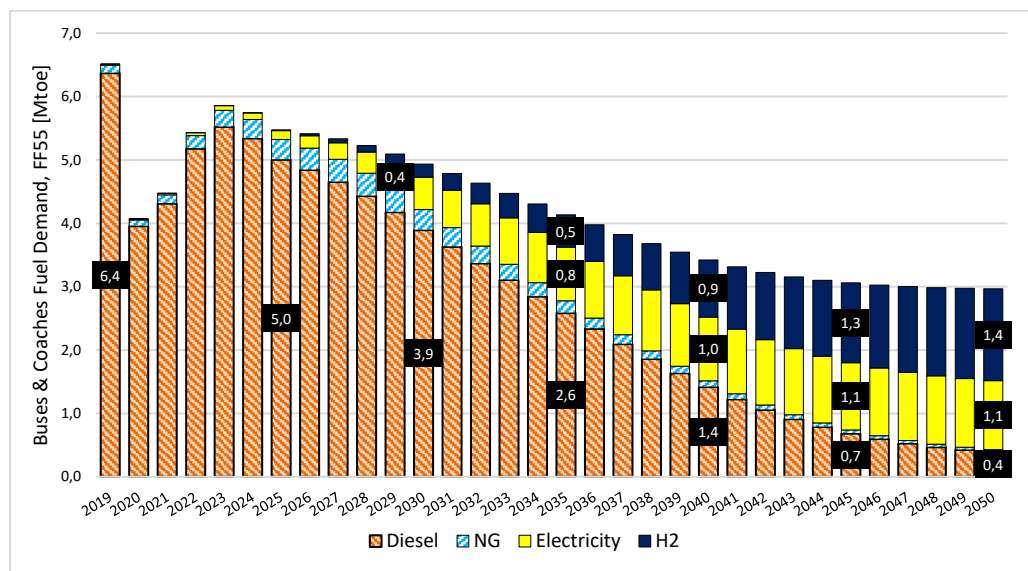


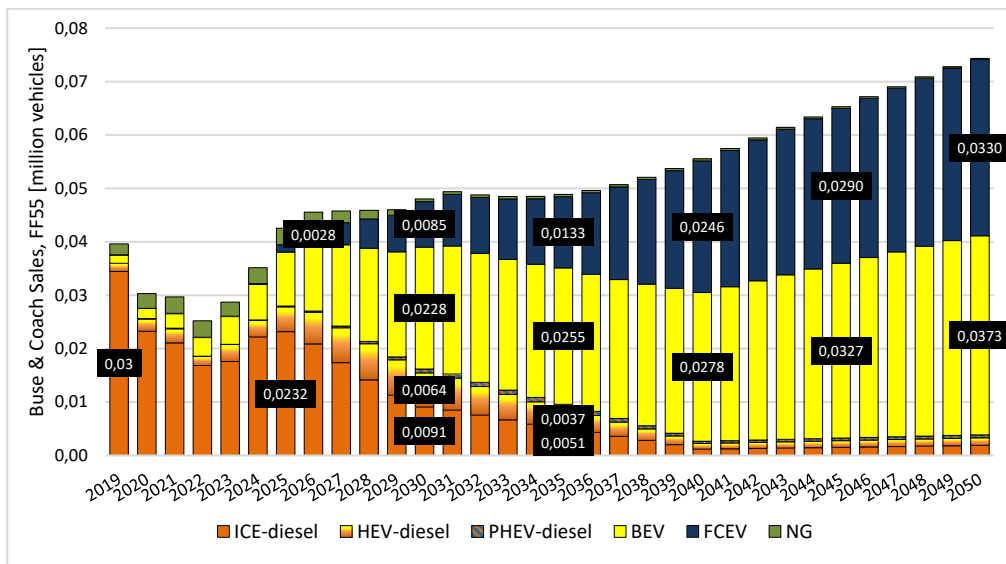
Fig. 43 and Table 21 show that diesel demand decrease due to improvement of energy consumption per km and due to the powertrain transition to BEV and FCEV.

Table 21 Bus & Coach decrease in energy and liquid fuels demand compared to 2019 (high)

	2030	2040	2050
Liquid fuels demand decrease vs 2019	35,1%	76,7%	93,4%
Total energy demand decrease vs 2019	24,2%	47,4%	54,4%

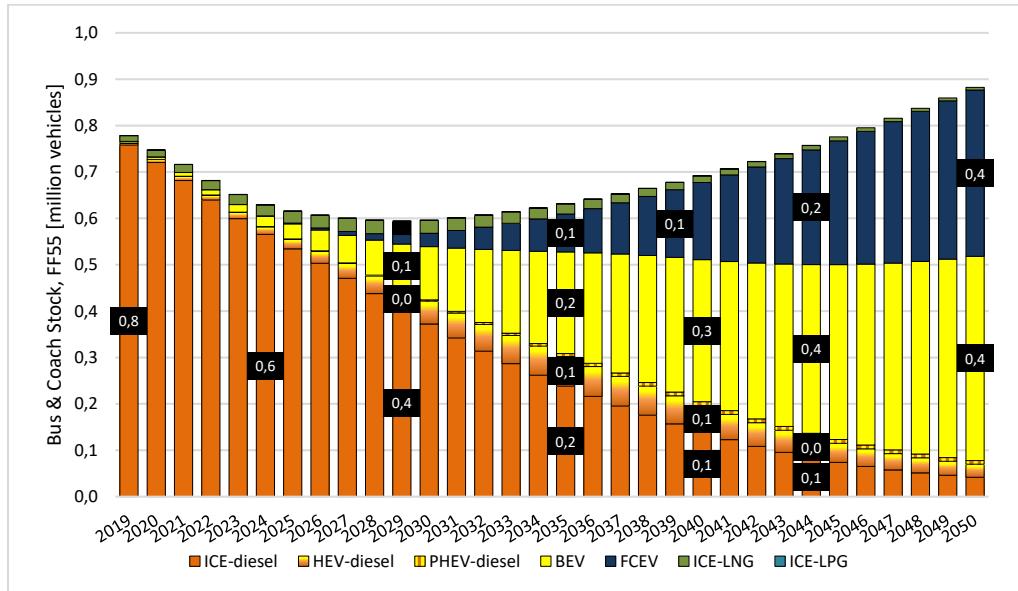
2.5.3.2. Buses & Coaches - Low scenario

Figure 44 Buses & Coaches new sales per powertrain (Low Scenario)



Similar to the high scenario but the sales are higher to simulate the increased activity. The Bus & Coach load factor is increasing from 16,55 pkm/vkm to 25 pkm/vkm over the period 2030-2050 to accommodate the activity shift away from passenger cars.

Figure 45 Buses & Coaches stock (Low Scenario)



Due to the increased activity, we have correspondingly increased sales in the low scenario while maintaining identical scrapping intensity. Due to the increased sales, a larger share of vkm is performed by BEV and FCEV compared to the high scenario.

Figure 46 Buses & Coaches energy demand (Low Scenario)

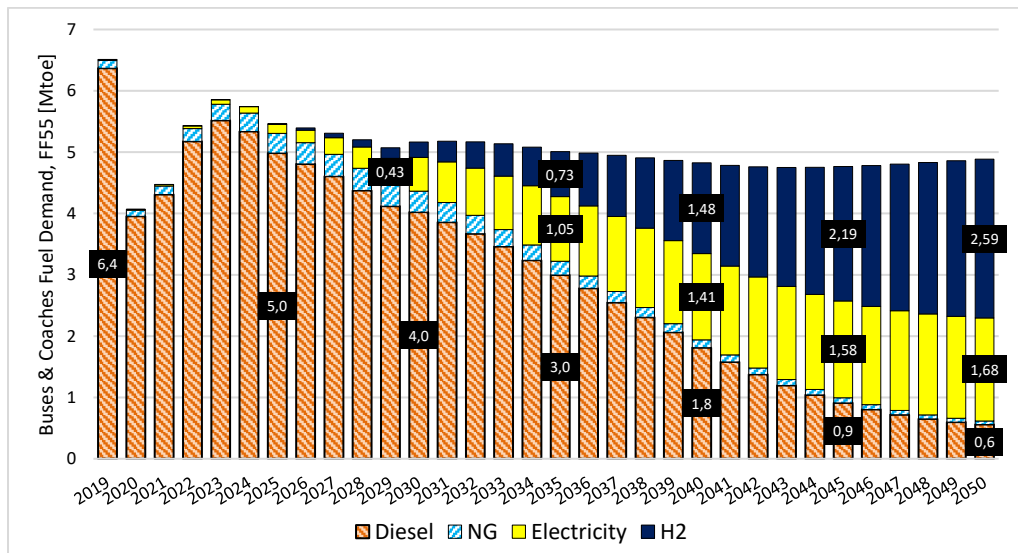


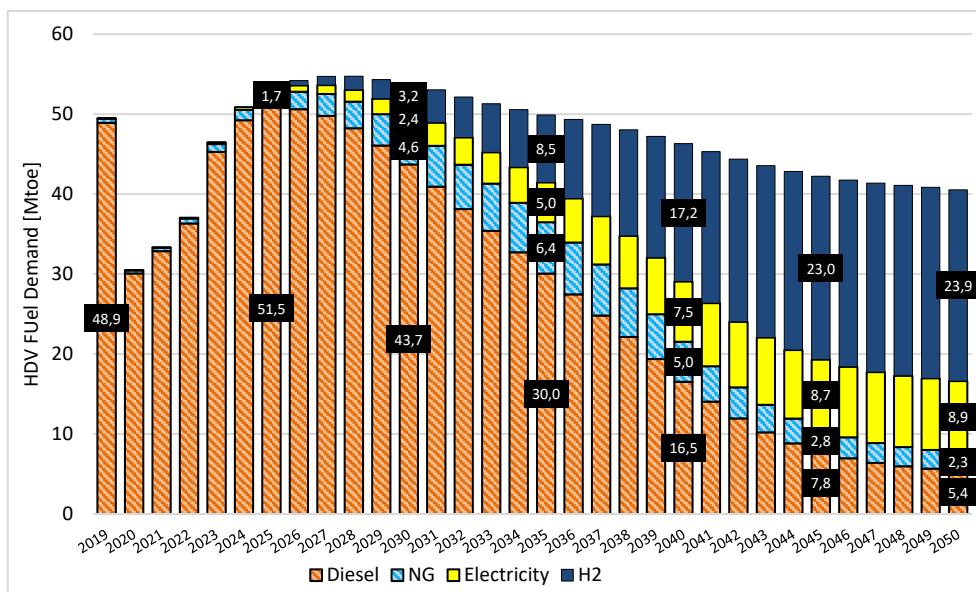
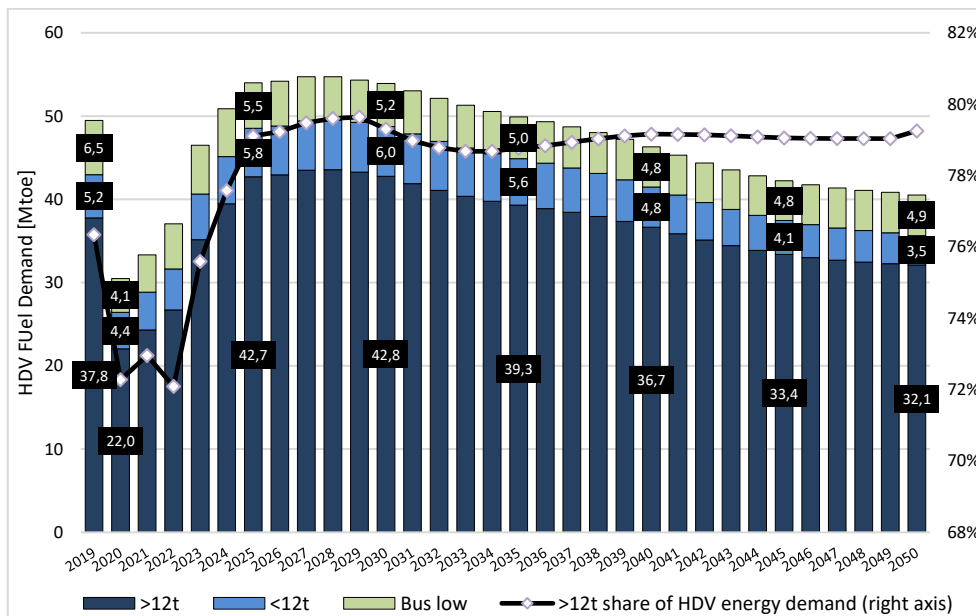
Figure 46 and Table 22 show energy and liquid fuel demand from Bus & Coach in the low scenario. Compared to the high scenario, fuel demand in the low scenario is indeed higher, though due to higher sales in the low scenario, the vkm share of BEV and FCEV, the difference is comparably small.

Table 22 Bus & Coach decrease in energy and liquid fuels demand compared to 2019 (low)

	2030	2040	2050
Liquid fuel demand decrease vs 2019	32,8%	70,2%	90,5%
Total energy demand decrease vs 2019	20,7%	25,9%	24,9%

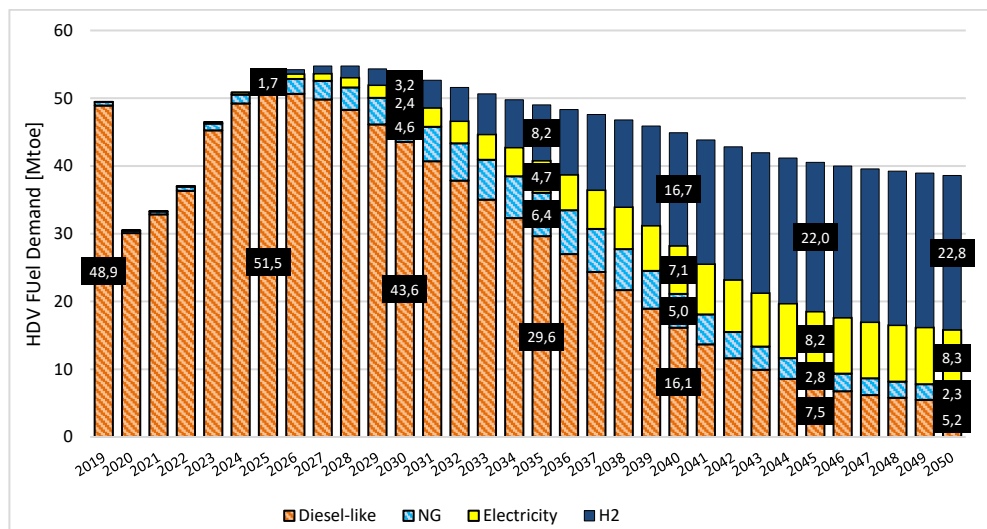
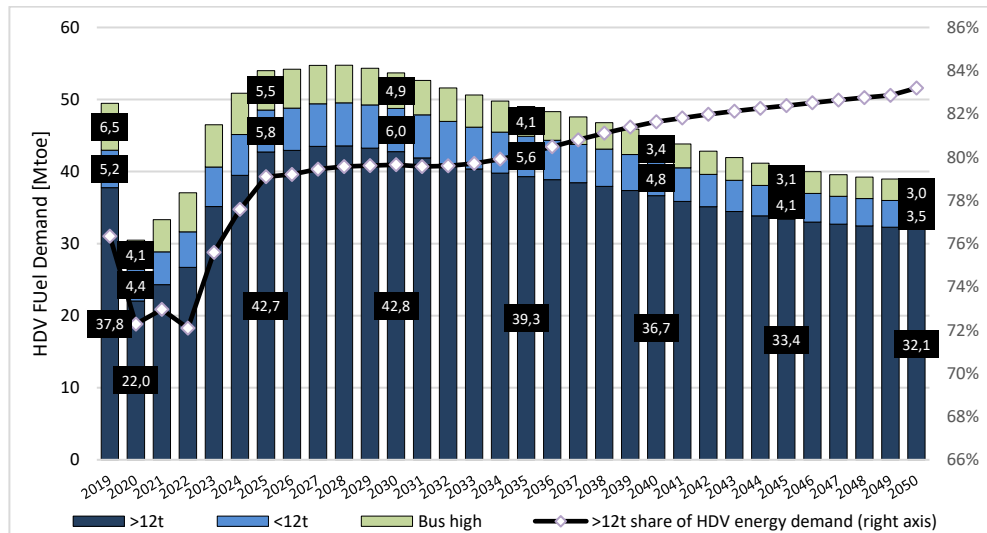
2.5.4. Heavy-Duty Vehicles (Trucks over & under 12 tonnes, Buses & Coaches)

Figure 47 HDV Energy demand, low scenario



The low scenario exhibits a transition from liquid fuel demand to electricity and hydrogen. Due to the high ratio of tkm performed by the >12t trucks, a category dominated by FCEV, hydrogen is dominant in 2050, followed by electricity.

Figure 48 HDV energy demand, high scenario



As already mentioned, fuel demand for HDV in the high scenario is lower than the low scenario due to the pkm in the PC segment following the baseline assumption rather than transferring to the buses & coaches in the low scenario.

2.6. ROAD TOTAL (PC, LDV AND HDV)

Figure 49 Road fuel demand in FF55 modelling, EU 27

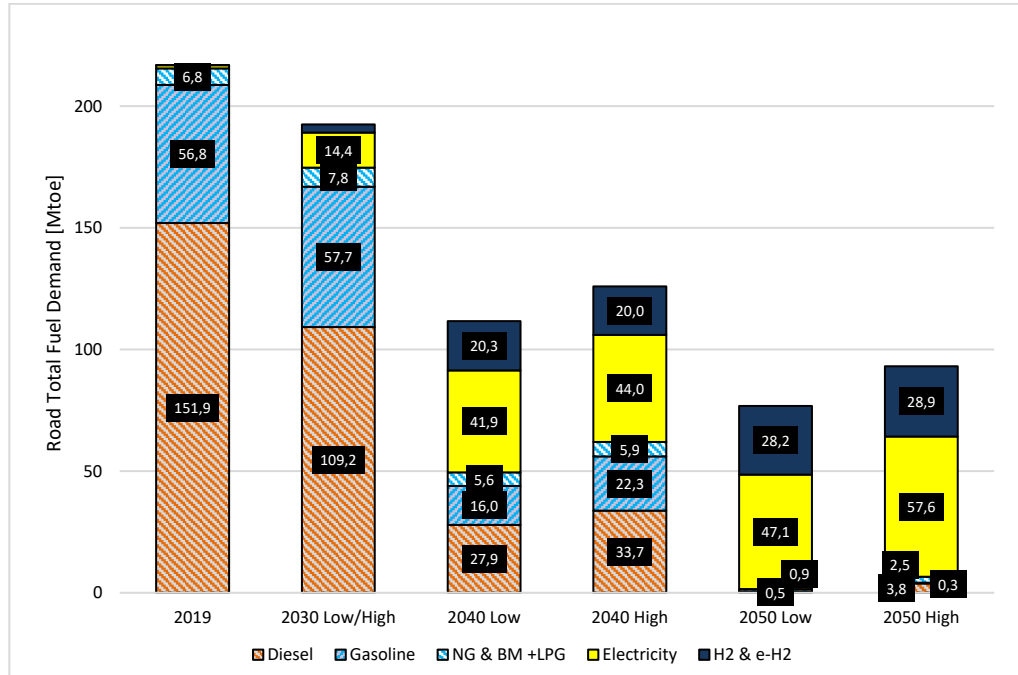


Figure 49 shows the energy demand evolution for road transport in the low and high scenarios. Note that the figure considers the impact of the Combined Transport Directive by a reduction of liquid fuels corresponding to 5 Mtoe in 2040 and 10 Mtoe in 2050 (see chapter 6.1.1 for explanation). As a consequence, liquid fuel demand is almost eliminated in the low scenario although it remains for the different road segments on a separate basis.

The decreased fuel demand in road transport is mainly due to the transition from internal combustion engine to battery electric and fuel cell electric powertrains. As previously shown, this trend is comparatively strongest in the passenger car segment (especially when coupled with increased scrapping of old ICE vehicles in the low scenario) though it is also considerable in the heavy truck segment (due to short vehicle life span). As described in chapter 2, vehicle mileage decreases with vehicle age, which means that although PC/LCV ICE vehicles are present in the vehicle stock in 2050, they contribute marginally to energy demand in 2050.

In the low scenario, the amount of pkm is decreased in the PC segment out of which half is transferred to the bus & coach segment (with a considerably lower fuel demand per pkm than passenger cars). Also, starting in 2035, the additional scrapping of old ICE passenger cars that are replaced with either BEV or FCEV, results in a sharply decreased energy demand. The liquid fuel demand decrease relative to 2019 is shown in Table 16 for the high and low scenarios for 2030, 2040 and 2050.

Table 23 Relative Road energy and liquid fuel demand compared to 2019

	Energy decrease vs. 2019	Liquid fuel decrease vs. 2019
2030	11,2%	20,8%
2040 Low	48,5%	79,5%
2040 High	42,0%	73,8%
2050 Low	63,4%	100,0%
2050 High	57,1%	99,2%

2.7. OTHER TRANSPORT MODES

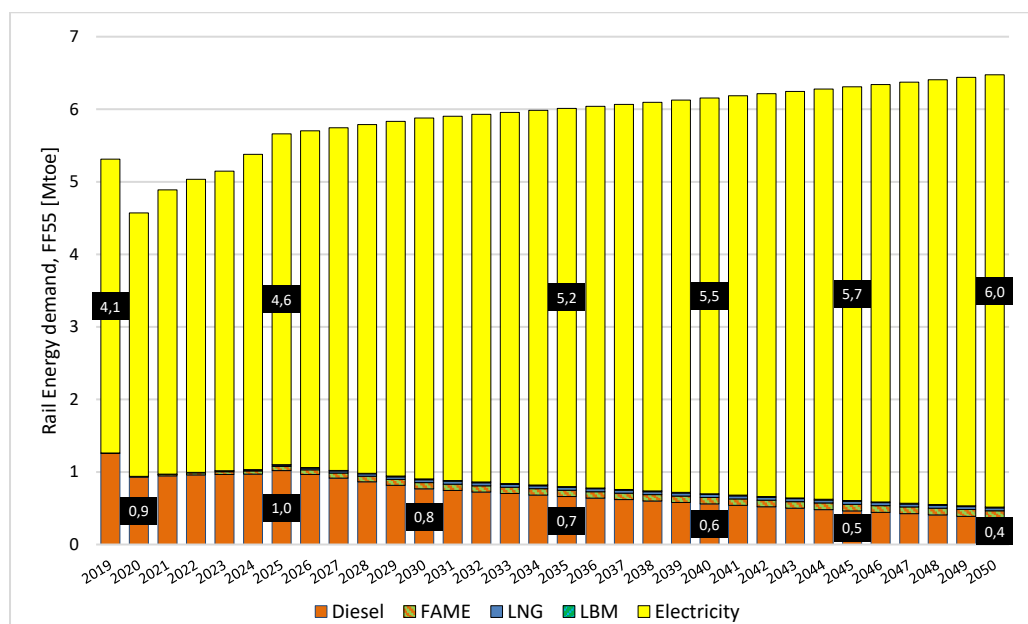
Other modes, including off-road, aviation, maritime and railway, have been also modelled in a simplified way to provide an estimate of the total fuel demand mix towards 2050.

2.7.1. Rail & Off Road

Rail transport is predominantly powered by electricity, though diesel remains necessary for non-electrified routes, accounting for around 16% of the sector’s energy demand by 2050 (European Commission, 2021). While efficiency gains in passenger rail are relatively modest compared to road and aviation - due to already substantial past improvements - ongoing policy efforts continue to promote the transition from diesel to electricity. In freight rail, energy efficiency is also improving steadily, supported by the broader push for railway electrification. These developments mirror the trends in road freight, where CO₂ standards and technological advancements are driving significant efficiency gains.

Figure 50 is based on rail activity from (15) with projected energy demand of 6 Mtoe in 2030.

Figure 50 Rail energy demand

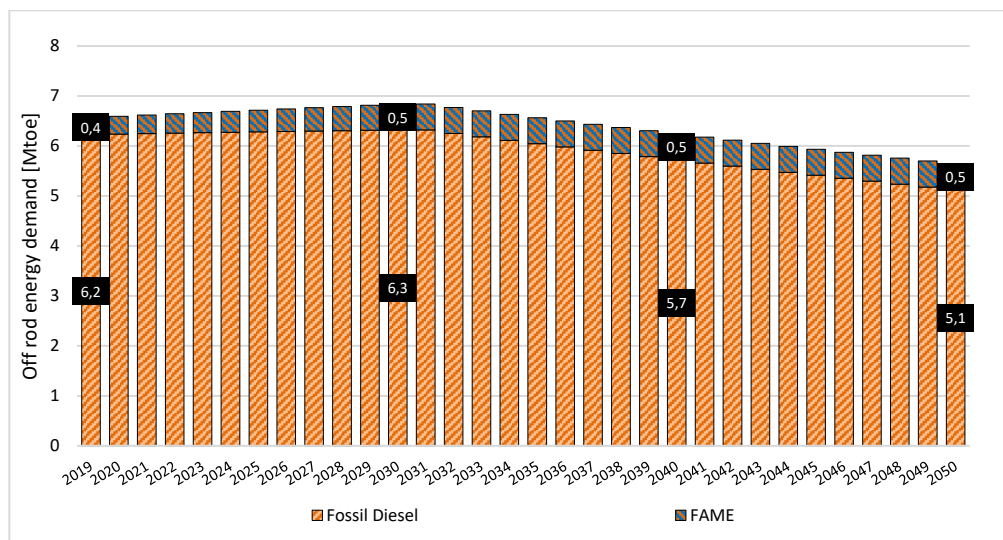


Though there is expectancy of a modal shift of passengers from the road to the rail segment, partly due to the definition of the low scenario and partly due to the proposal on the Combined Transport Directive (46), we have not accounted for the resultant increased energy demand in rail, however we do not expect this to have a significant impact on liquid fuel demand due to the high electrification level.

We assume an improvement in energy efficiency for the diesel engine of 1,4 % /year, due to renewal of the fleet and following the evolution for HDV diesel efficiency improvement. This assumption rests on the engine manufacturer being the same entity. This simplified assumption has a minor impact as the diesel to electricity ratio is decreasing over the period. The ratio of electrified rail transport in 2030-2050 is expected to be 0,3 % /year which is half compared to the period 2020-2030 with around 0,6 % /year.

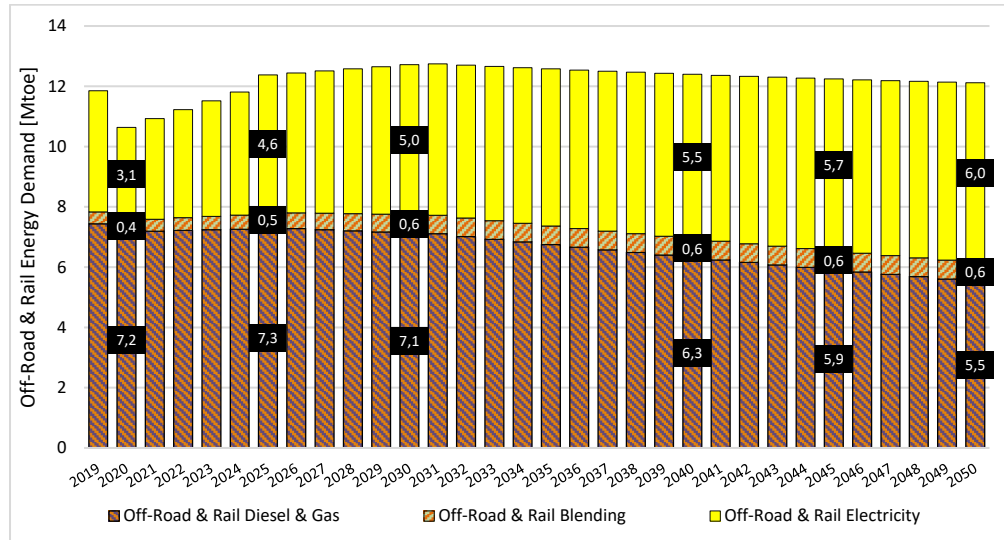
For the off-road segment we assume an energy demand of 6,6 Mtoe in 2019 that increase to 6,8 Mtoe in 2030 based on (27). Diesel completely dominates the off-road sector and we expect constant activity for the period along with same efficiency improvement as for the rail diesel segment.

Figure 51 Off-road energy demand, FF55, EU27



The mining industry makes a considerable part of the off-road energy demand and electrification as a means to improve efficiency and reduce CO₂ emissions, are on the agenda for several companies. However, since there are little initiatives within the FF55 regulation targeting the mining industry, we have not included this transition in the scope of this study.

Figure 52 Rail and off-road fuel demand, EU 27



The two sectors combined show a modest decrease in energy demand up until 2050 with a total energy demand of 12 Mtoe in 2050.

2.7.2. Aviation sector

2.7.2.1. Background information

The aviation sector showed a rapid growth until the COVID years: the total number of passengers travelling by air to, from and within the European Union in 2018 were 1,1 billion. The net energy demand has grown by 2,6 % /year during the period 2014-2018 (17). The number of flights in EU27 + EFTA in 2019 were 9,3 million that sharply declined to 4,12 in 2020 and 5,07 in 2021 (47). Longer-term estimations are that 12,2 million annual flights will be performed in the region by 2050 (47).

Despite the radical decrease in activity over the COVID years, the aviation sector continued the pace of improved energy efficiency. The (48) concludes:

“From 2010 to 2019, average fuel efficiency per revenue passenger kilometre (RPK) improved by over 2.5% /year. On a revenue tonne kilometre (RTK) basis, which includes passengers, their luggage, and freight, fuel efficiency improved by 1.7%, nearly reaching ICAO’s aspirational goal of 2% per annum (measured per RTK) through 2050. However, efficiency improvements have not kept up with demand growth to date, with RPK growing at an average rate of more than 6% annually between 2010 and 2019.”

For the period up until 2050, EU aviation is subject to the Refuel Aviation regulation (6) that sets targets for the ratio of *Sustainable Aviation Fuel* (SAF) with sub-targets for the e-fuels ratio.

2.7.2.2. Fuel demand outlook

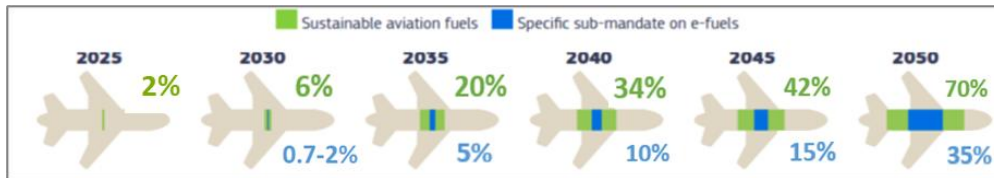
Anticipating the potential medium-long term impact of COVID is challenging for the sake of this report (which follows a simplified estimate for non-road transport). We have assumed an increase in fuel demand of 2,6 % /year for the period 2025-2030 totalling an increased demand of +7,4 % in 2030 compared to 2019. The estimate in 2024 is from (49) the growth figure for 2025-2030 and beyond is in line with (50)

based on activity growth rate for 2014-2018 of 4,6 % coupled with energy efficiency improvement of 2,0 % /year (with the resulting energy demand growth 2,6% /year).

The evolution of aviation activity and consequent fuel demand beyond 2030 is difficult to predict. This report follows two scenarios: the 2030-2050 fuel demand evolution is assumed to either follow the net fuel demand growth rate observed between 2014-2018 (high scenario) or that total fuel demand in 2050 matches the 1.5 Tech scenario in the Clean Planet for All (16). Thus, the net fuel demand increase is 2,6 % /year in the high scenario and 0,5 % in the low scenario (matching the 1.5 Tech final fuel demand of 57,4 Mtoe in 2050).

2.7.2.3. Expected alternative fuel penetration

Figure 53 Aviation fuel ratio in the Refuel Aviation

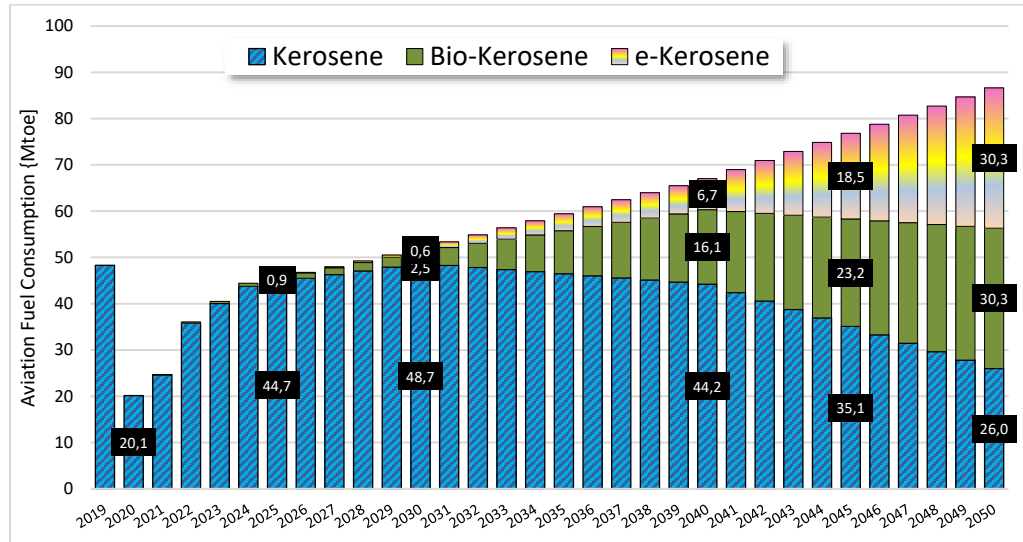


The Refuel Aviation regulation sets mandates for Sustainable Aviation Fuels (SAF) in percentage of aviation fuel demand from 2025 with sub-mandates of e-fuels for the period 2030-2050. For 2030 we have assumed a e-kerosene requirement of 1,2 %, which will be challenging to meet given the absence of current projects having passed Final Investment Decision.

Table 24 Aviation modelling parameters

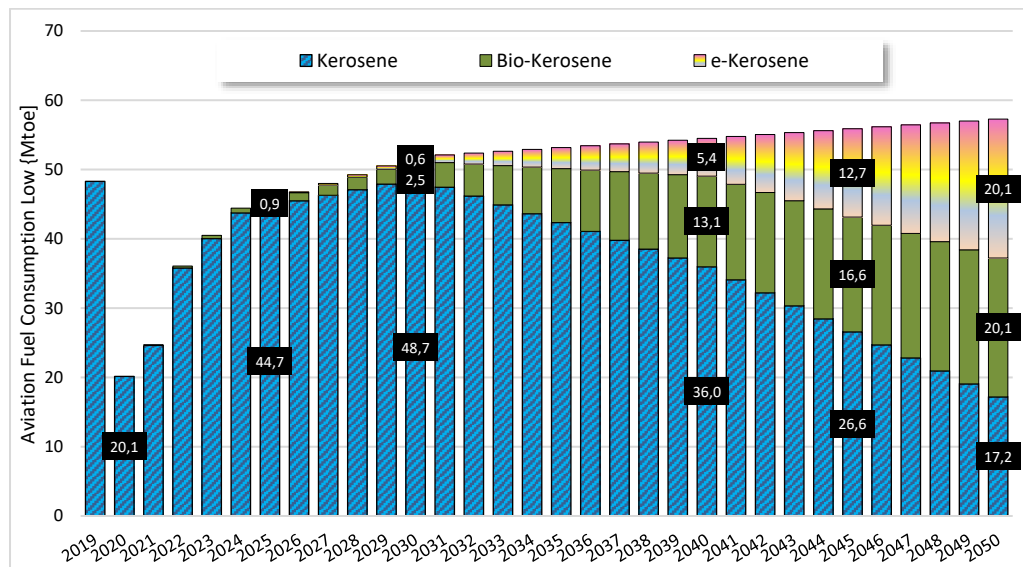
Parameter	EU27 Domestic + International
Total demand 2019	48,3 Mtoe (17)
Efficiency improvement 2019-2030	2%/year (51)
COVID 19 impact	Activity recovery in 2024, fuel demand recovery ~ 2028
Activity demand growth 2014-2018	4,6 %/year
2030 energy demand estimate	51,8 Mtoe
High scenario - Fuel demand net growth 2030-2050	2,6 %/year
High scenario - 2050 estimated demand	86,6 Mtoe
Low scenario- Fuel demand net growth 2030-2050	0,5 %/year
Low scenario- 2050 estimated demand	57,4 Mtoe

Figure 54 Total Aviation fuel demand, High scenario, EU 27



Total jet fuel demand in the high scenario would increase by 79 % compared to 2019 to reach 86,6 Mtoe in 2050. In line with the Refuel Aviation targets the demand for fossil kerosene will be 26 Mtoe in 2050 (decrease of 44 % compared to 2019), whereas demand for bio-SAF will be 30,3 Mtoe and demand for e-kerosene will be 30,3 Mtoe.

Figure 55 Total Aviation fuel demand, Low scenario, EU 27



In the low scenario, fossil Kerosene demand would decrease by 64 % in 2050 compared to 2019 whereas overall fuel demand increases with 19 %. The respective demand for fossil kerosene, bio-SAF and e-kerosene would be limited to respectively 17,2; 20,1 and 20,1 Mtoe in 2050 in such case.

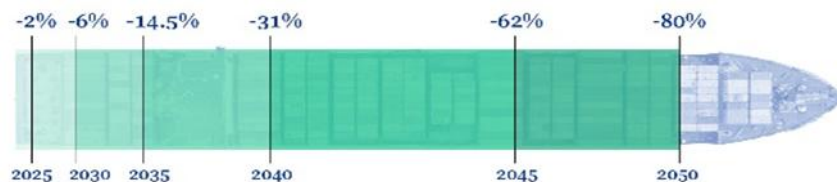
2.7.3. Maritime and waterways

Heavy fuel oil (HFO) dominates the oceangoing maritime segment. A regulation aimed at improving environmental performance was implemented in 2020, commonly referred to as IMO 2020 (International Maritime Organization). The regulation caps the fuel sulphur content to 0,5 wt% encompassing all international waters. In dedicated emission control areas such as in coastline proximity, in ports, in the North Sea, the Baltic Sea and the English Channel, the sulphur limit have been restricted to 0,1 wt% 2015. High sulphur fuel oil (HSFO) can still be used by ships equipped with an exhaust gas cleaning unit (scrubber). Other options are very low-sulphur fuel oil (VLSFO) with sulphur limit lower than 0,5 wt%, marine gasoil (MGO) or alternative fuels (e.g. LNG or methanol). For the purpose of this report, we have assumed a blending ratio of 22 % MGO and 78 % heavy fuel oil in the marine fuel oil based on 5-year average for international maritime during 2015-2019 (17).

The FuelEU Maritime regulation within (5) requires to reduce fuel emission intensity compared to base year 2020 with an emission intensity of 91,16 g CO_{2eq}/MJ on a well to wake basis. As shown in Figure 56, the maritime target is to reduce fuel emission intensity with 6 % in 2030, 31 % in 2040 and 80 % in 2050 compared to the 2020 average for international shipping 91,16 gCO_{2eq}/MJ. The reduction of fuel emission intensity is achieved through introduction of biofuels in the form of FAME, HVO and advanced biodiesel, e-fuels (e-ammonia, e-methanol, Fischer-Tropsch diesel) and through increased use of electricity (in this context considered fully renewable with zero emission intensity) from the grid while at port. As multiple pathways are currently being developed, it is difficult as this stage to predict which would be the share the different technologies. The ratios of the respective fuels have therefore been arbitrarily set to obtain the desired fuel emission intensity reduction. It is highly improbable that the final energy consumption would follow such pattern. Safety aspects have not been considered nor the time lag needed for deployment of technologies and infrastructure.

In April 2025 the IMO adopted the draft Net-Zero Framework, combining a fuel emission intensity standard and a carbon-pricing mechanism for large ships (≥ 5,000 GT). However, during the October meeting, it was instead decided to postpone the vote to 2026. As a result, the binding CO₂-reduction and pricing rules will not enter into force as originally scheduled and the regulatory framework remains subject to further inter-sessional drafting and political agreement (52).

Figure 56 Fuel emission intensity reduction targets for the maritime sector



Reductions vs fuel intensity of 91,16 gCO_{2eq}/MJ

Similar to aviation, the evolution of the maritime activity is difficult to predict up to 2050. We therefore developed 2 scenarios for maritime sector segmented as per domestic and international shipping, based on different net growth in fuel demand for the period 2030-2050. The low scenario is designed to have identical fuel demand as in the 1.5 LIFE scenario in the Clean Planet for All initiative (16) featuring a -0,4 % yearly growth rate for the period. The high scenario applies a yearly growth

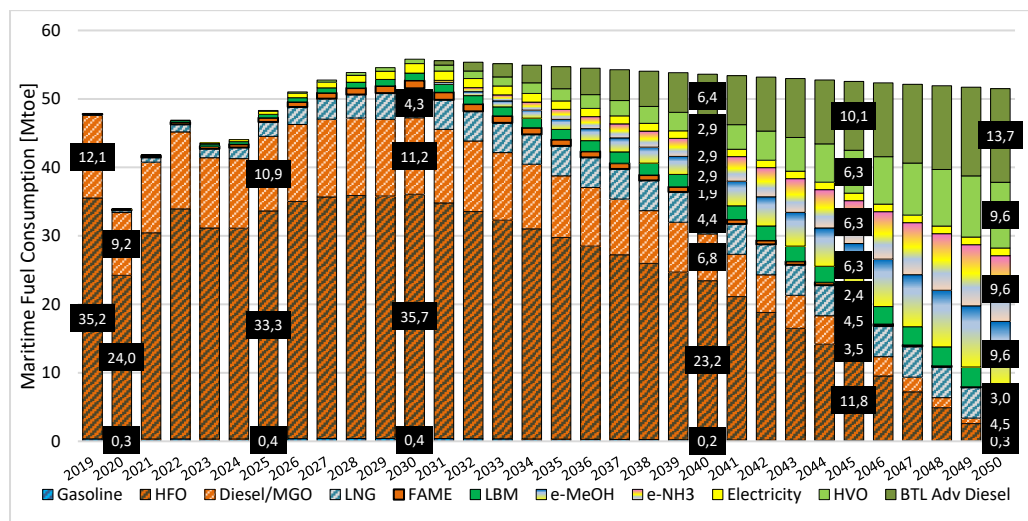
of net fuel demand of 1,4 % for the period 2030-2050 which correspond to the yearly increase for the period 2014-2019 (53).

Table 25 Maritime modelling assumptions and scope, Low scenario

	Domestic Navigation	International navigation
Total demand 2019	4,2 Mtoe*	43,6 Mtoe*
COVID 19 impact	Total demand 2020: 3,4 Mtoe	Total demand 2020: 30,5 Mtoe
2030 estimated demand	5,0 Mtoe*	50,8 Mtoe*
Historical emissions	EEA database	EEA database
2050 estimated demand	4,6 Mtoe (-0,4%/year)	46,9 Mtoe (-0,4%/year)

*Based on (16) total 60 Mtoe maritime demand split according to (17) 91 % share for international maritime and applying an adjustment factor of 93 % to account for EU27 rather than EU28.

Figure 57 Maritime Fuel Demand - International & Domestic, Low scenario



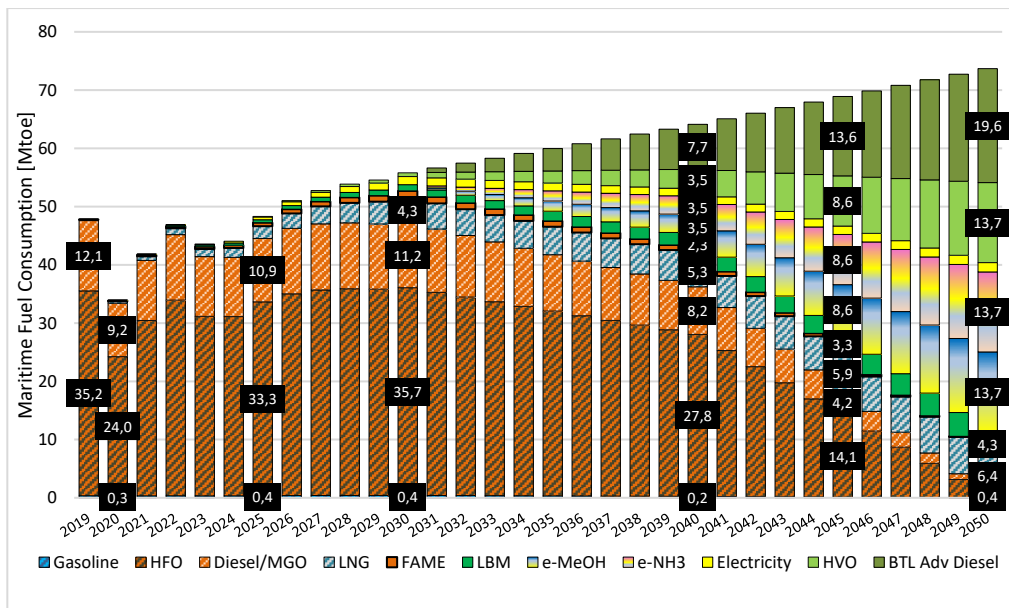
Demand of fuel oil, diesel, gasoline and LNG amounts to 5 Mtoe in 2050 which is a reduction of 9 % compared to 2019.

Table 26 Maritime modelling assumptions and scope, High scenario

Scope	Domestic Navigation	International navigation
Total demand 2019*	4,2 Mtoe	43,6 Mtoe
COVID 19 impact	Total demand 2020: 3,4 Mtoe	Total demand 2020: 30,5 Mtoe
2030 estimated demand**	5,4 Mtoe	50,8 Mtoe
Historical emissions	EEA database	EEA database
2050 estimated demand	6,6 Mtoe (1,4%/year)	67,1 Mtoe (1,4% /year)

*Based on (16) total 60 Mtoe maritime demand split according to (17) 91% share for international maritime and applying an adjustment factor of 93% to account for EU27 rather than EU28.

Figure 58 Maritime Fuel Demand - International & Domestic, High scenario



While total fuel demand increases for the maritime segment, demand of fuel oil, diesel, gasoline and LNG amounts to 7 Mtoe in 2050 which is a reduction of 85 % compared to 2019.

3. TOTAL ENERGY DEMAND - ALL TRANSPORT MODES

Figure 59 Total energy demand for all transport modes

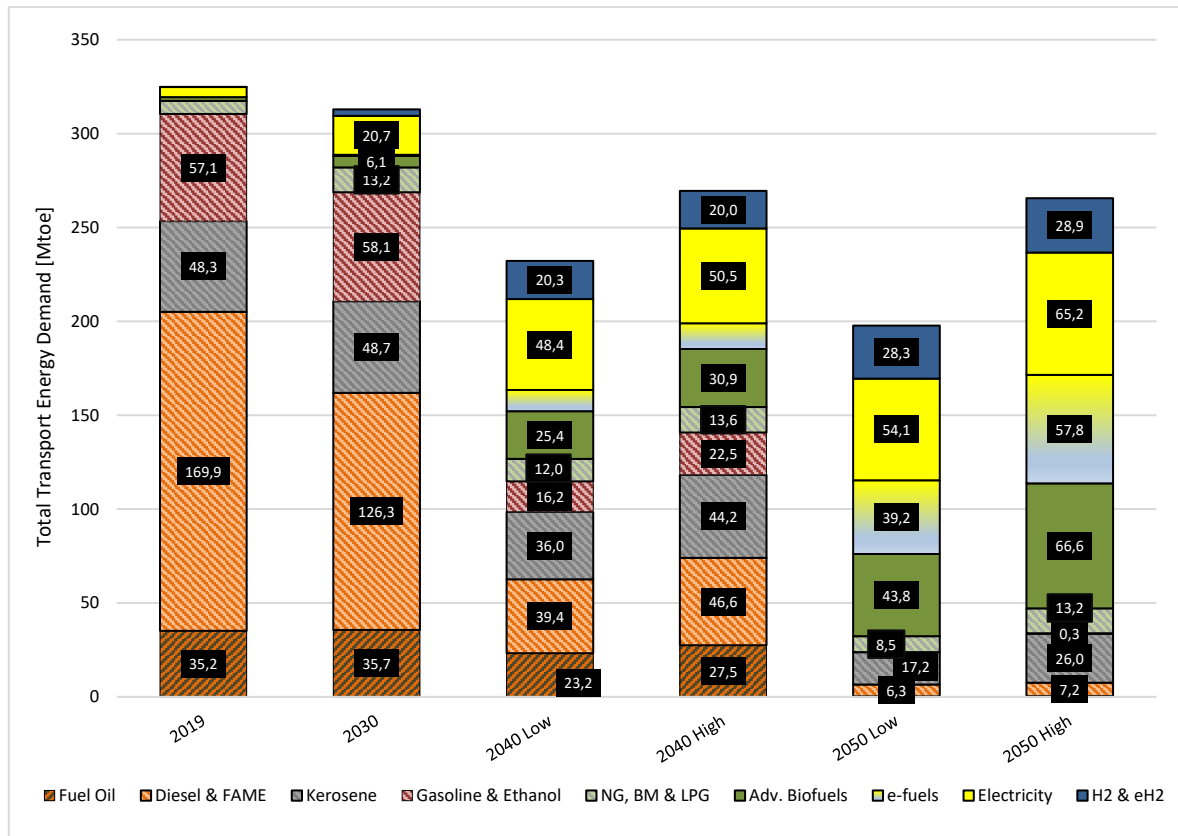


Figure 59 shows the total energy demand evolution in all transport modes in the high and low scenarios up to 2050. A single scenario was assessed for 2030 due to the insignificant difference between the low- and high scenario due to early effects of scrapping and shift of activity from PC to public transport.

The powertrain switch from ICE to BEV and FCEV in the road segment is the main reason for the decrease in final energy demand. This decrease in energy demand in road transport is obtained despite the increase in pkm and tkm, as indicated in Figure 1.

The powertrain switch in the road segment is a consequence of the sales targets that are most prominent for passenger cars and light commercial vehicles with the ICE ban taking effect in 2035 (incl. PHEV). The vehicle fleet powertrain transformation depends on the vehicle replacement rate that are a function of scrappage rate and the regulated sales ratio. The increased scrapping of old ICE passenger cars (that are replaced by new BEV/FCEV) starting in 2031 coupled with an activity shift from passenger cars to buses & coaches, have a strong impact on energy demand. The consequences are shown also in Table 27. Note that the liquid fuels contain bio-components.

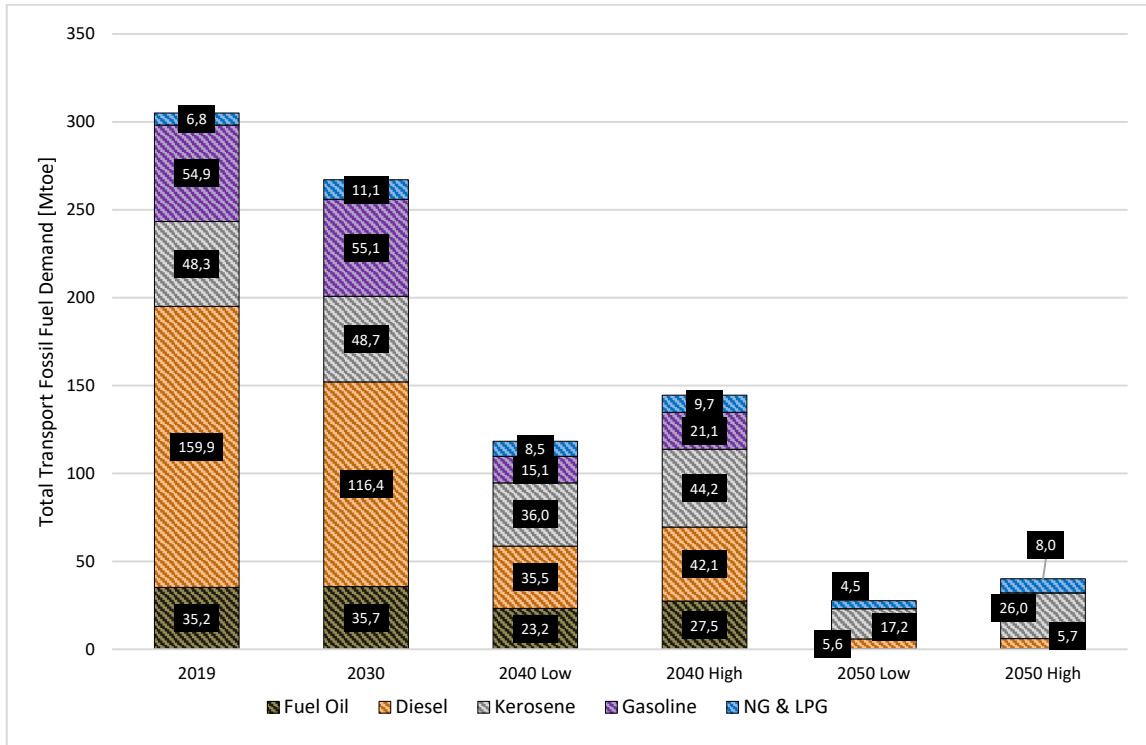
Table 27 shows total energy demand reduction compared to 2019, the ratio of fuel oil, diesel (including marine gasoil), kerosene, gasoline, LPG and NG (the fossil ratio), the ratio of electricity and H₂ and the e-fuels ratio. The fuel demand in 2030 is utilized as the baseline for the RED III compliance assessment (see chapter 6.2).

Table 27 Total transport energy demand; change relative 2019 & current energy share

	Energy demand reduction comp. to 2019	Fuel Oil, Diesel, Kerosene, Gasoline, NG & LPG ratio reduction	Biofuels ratio vs current	E-fuels ratio vs current	Electricity & H ₂ share of total
2019 [Mtoe]	325	305	14,4	0,0	5,4
	Demand relative 2019 [%]		Share of current year total [%]		
2030	96,3%	84,5%	6,7%	0,2%	7,7%
2040 Low	71,5%	50,8%	14,6%	4,9%	29,6%
2040 High	83,0%	53,4%	15,1%	5,1%	26,2%
2050 Low	60,9%	14,0%	24,5%	19,8%	41,7%
2050 High	81,8%	15,0%	27,7%	21,8%	35,4%

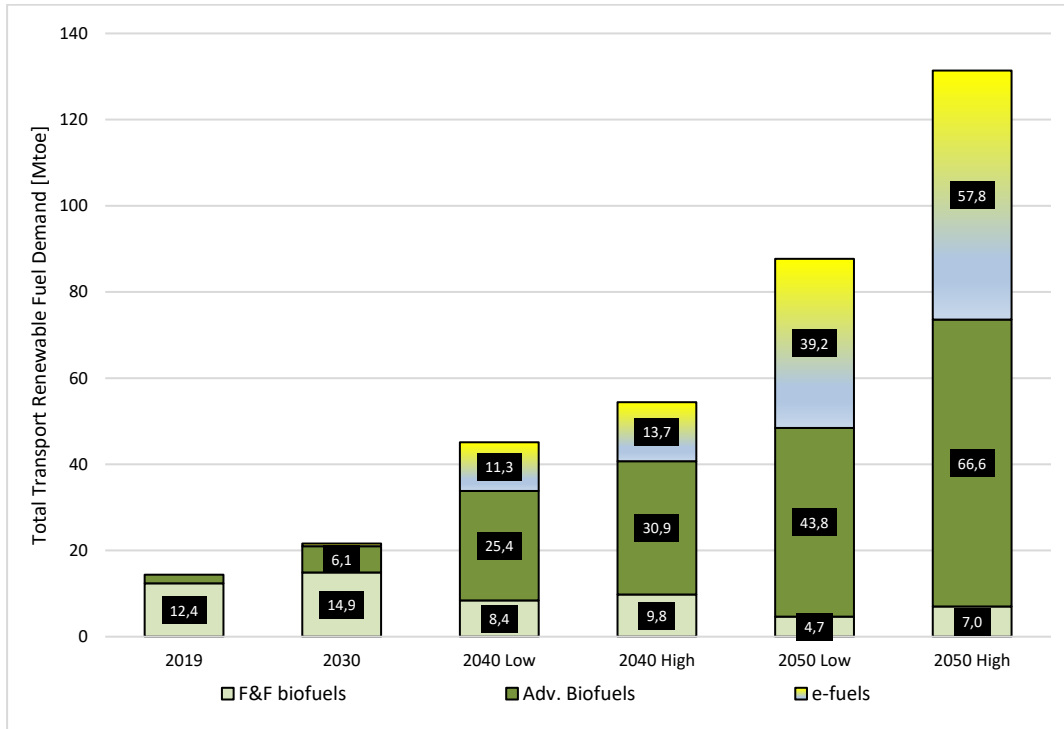
Based on expectations of activity increase, moderated by improved efficiency, fuel demand in the maritime and aviation sectors increase for the period 2019-2050. We have not considered a powertrain switch in those transport modes, thus any transition in these known hard-to-abate sectors takes place through a switch from fossil to renewable fuels. In 2040, for aviation and maritime, the quantities required of advanced biofuels are between 23 and 28 Mtoe and of e-fuels of 11 and 14 Mtoe. While in 2050, a demand for these advanced biofuels from the two sectors is between 43 and 64 Mtoe and 39 and 58 Mtoe of e-fuels. The supply of these renewable fuels represents a significant challenge, due to the nascency of these technologies.

Figure 60 Fossil fuel demand for all transport modes



Figures 60 and 61 show the demand of fossil fuels and renewable liquid fuels up to 2050 respectively. Fossil fuel demand reduces by 86-91 % by 2050 relative to 2019. F&F biofuels refer to food- or feed-based biofuels that are part of the blending stock for diesel or gasoline. The renewable fuels are substituting fossil fuel counterpart on a 1:1 energy basis. Note that these scenarios have been simulated from a demand perspective and should not be considered as suggestions of supply feasibility taking into account industrial scale-up or economical aspects.

Figure 61 Renewable liquid fuel demand



4. EMISSION INTENSITY

It should be noted that alternative fuels have been considered fully interchangeable with their fossil counterparts (with consideration of energy content). Thus, the renewable fuels have been allocated to the respective sectors to obtain compliance with the sector specific targets. The considered fuels are shown in Table 27.

Table 28 Fossil & renewable fuel alternatives considered in this study

Liquid	Gaseous	Electricity
<ul style="list-style-type: none"> • Ethanol • Gasoline (containing blend of ethanol) • Hydrotreated vegetable oils (HVO) • Fatty acid methyl esters (FAME) • Diesel (containing blend of FAME) • Advanced renewable diesel (adv. BtL) • Liquefied Natural gas (LNG) - containing blends of LBG. • Liquefied petroleum gas (LPG) • Liquefied upgraded biomethane (LBG) • Liquefied synthetic methane from biomass gasification (LBG) • Liquefied synthetic methane via Power-to-Gas routes (LBG) • Fuel oil • E-Methanol • E-ammonia • Kerosene • E-kerosene • Sustainable aviation fuels (SAF) produced from renewable biogenic feedstock. 	<ul style="list-style-type: none"> • Hydrogen (fossil or e- H₂) • Compressed natural gas (CNG) • Compressed upgraded biomethane • Compressed bio-methane from biomass gasification • Compressed synthetic methane via Power-to-Gas • DME 	<p>Electricity</p>

4.1. FUEL EMISSION INTENSITY

The emission intensity values are based on (54), (42), (12), (55) and (27). Aligned with the CO₂ emission standards in road transport, carbon intensity is based on TTW values for road transport, and thus the contribution from renewable fuels is not considered. For the maritime sector, the WTW perspective is considered as per FuelEU Maritime requirements. The values are compiled in the tables below.

Table 29 Fuel emission intensities, Tank-to-Wheel (TTW)

TTW (g CO _{2eq} /MJ)	Other Sectors	
		Reference
Fossil Gasoline	73,4	JEC
Fossil Diesel	73,2*	JEC
Fuel Oil	78,2	JEC
LPG	65,7	JEC
CNG	56,2	JEC
CBM	56,2	JEC
LNG	56,2	JEC
LBM	56,2	JEC
Ethanol	71,4	JEC
FAME**	76,2	JEC
HVO**	70,8	JEC
e-MetOH	1,8	JEC
Kerosene	70,8	ICAO
Bio-Kerosene	70,8	ICAO
e-Kerosene	70,8	ICAO
BTL Adv Diesel	73,2	JEC
Synthetic Low-carbon fuels	70,8	EC

*Based on different specifications affecting carbon and sulphur content the fossil diesel, BTL Adv diesel and synthetic low-carbon fuels used in Maritime is considered to have emission intensity of 76,4 g CO_{2eq}/MJ.

**Assumed feedstock mix, that may impact carbon and emission intensity, detailed in (12).

Table 30 Fuel emission intensity, Well-to-Tank (WTT)**

WTT (g CO _{2eq} /MJ)	2019	2030	Ref.
Fossil Gasoline	17,0	17,0	JEC
Fossil Diesel	18,9	18,9	JEC
Fuel Oil	13,5	13,5	EC
LPG	7,8	7,8	JEC
CNG	12,0	12,0	JEC
CBM	23,2	23,5	CW Outlook
LNG	16,6	16,6	JEC
LBM	27,8	28,1	JEC
Ethanol	52,0	44,0	JEC
FAME	39,0	39,0	JEC
HVO	30,0	27,0	JEC
e-MetOH	1,8	1,8	EC
H ₂	132,0	132,0	EC
e- H ₂	3,6	3,6	EC
e- NH ₃	3,3	3,3	EC
Electricity	81,0	49,0	EC
Kerosene	18,2	18,2	JEC
Bio-Kerosene (SAF)	11,9	11,9	ICAO
e-Kerosene	0,8	0,8	ICAO
BTL Adv Diesel	9,7	9,7	JEC
Synthetic Low-carbon fuels	0,8	0,8	JEC

* The maritime diesel values refer to marine gasoil (MGO)/ Fossil diesel are considered to have emission intensity in WTT perspective of 14,4 gCO_{2eq}/MJ.

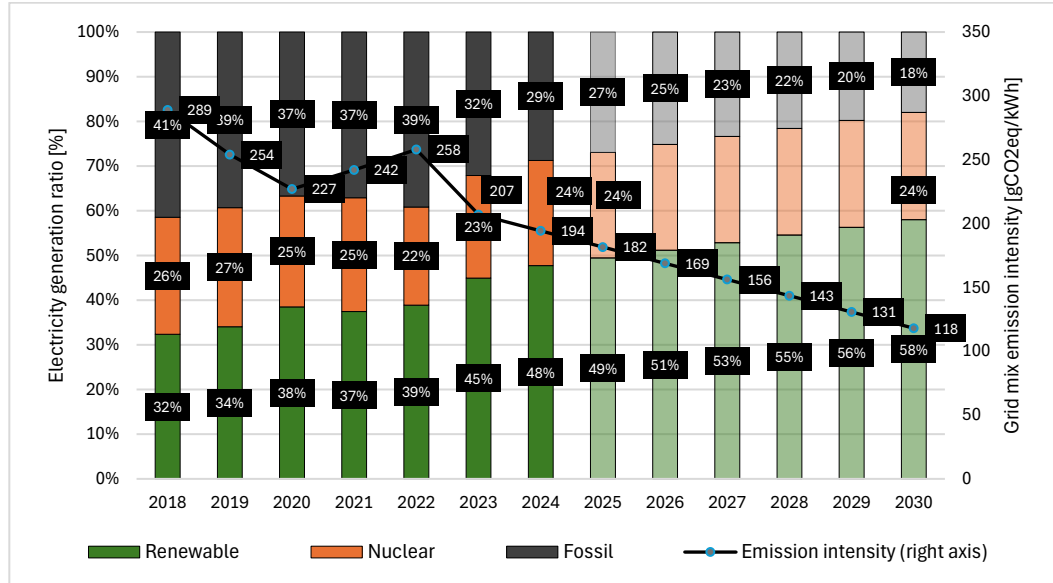
** In the JEC study where there is a range for the fuel emission intensities, the representative value has been selected.

4.2. ELECTRICITY EMISSION INTENSITY

Electricity cause zero emissions from a Well-to-Tank (WTT) perspective, which - apart from the maritime sector and the RED III calculations - is the only perspective applied in this report. The WTT emission intensity for electricity are assumed to decrease over time, from 81 gCO_{2eq}/MJ in 2019 to 49 gCO_{2eq}/MJ in 2030, extrapolating linearly to 1 gCO_{2eq}/MJ by 2050, when emissions are expected to be near zero or even negative. Complementary projections (33) indicate a faster decarbonisation trajectory, suggesting electricity emission intensity could reach zero as early as 2040.

For consistency with the assumptions used in the Renewable Energy Directive (RED III) compliance calculations (see Chapter 5), the share of renewable electricity in the 2030 grid mix has been set at 58 % (56) which is in line with the trajectory towards 0 emission intensity in 2040. This aligns with the observed 2023 renewable electricity share of 44 %, associated with a grid emission intensity of 58 gCO_{2eq}/MJ (56).

Figure 62 Electricity generation in EU27



Source: Electricity share 2018-2024 based on (57), emission intensity based on (56).

The respective energy shares for the period 2025-2030 is based on the following assumptions:

- Fossil sources at constant proportional ratio with constant emission intensity.
- Nuclear generation ratio constant (24%).
- Overall emission intensity decreases 194 - 118 gCO_{2eq}/kWh between 2024-2030 and reach zero in 2040.

5. THE RENEWABLE ENERGY DIRECTIVE (RED III)

RED III compels the individual Member States to achieve 29 % minimum renewable energy content in the transport sector in 2030. This target considers potential multipliers of prioritized fuels/energy types in specified sectors. Alternatively, Member States may choose to reduce GHG emissions by 14,5 % compared to a fossil baseline (assuming default emissions benchmark of 94 CO_{2eq}/MJ for liquid fuels and 183 CO_{2eq}/MJ for electricity). However, in the second alternative, no multipliers are applied. As modelling of this latter alternative reveals it is slightly less favourable to Member States than reporting energy shares, the following analysis will be restricted to calculating an energy mandate. Our analysis treats Europe as a single homogeneous entity (27 Member States are treated as one).

The sectoral sub-targets e.g., no food or feed (F&F) based biofuels in maritime, have been considered. The F&F-based fuels are not permitted to exceed 7 % in 2030. Should F&F-based fuel demand be lower than 7 %, the total target level of the Member State is discounted accordingly. Consistent with Eurostat's SHARES statistics, we have assumed an average 4,5 % F&F-based biofuel demand in 2030, bringing the compliant target level for consideration to 26,5 %.

Advanced biofuels as defined in (7) are here considered in two categories:

- Annex 9A consisting of lignocellulosic materials and other non-food, non-feed feedstocks, including agricultural and forestry residues, wastes, and certain biogenic fractions of municipal waste. These fuels are prioritised under RED III because they deliver high greenhouse-gas savings and do not compete with food or feed production.
- Annex 9B consisting of waste- or by-products, primarily used cooking oil and animal fats in the form of tallow. This feedstock is considered low-risk in the context of causing indirect land-use change (ILUC) (58).

The 2030 sub-mandates and multipliers of specific renewable fuels and uses in RED III are summarized below:

- The share of Annex 9A and e-fuels/RFNBOs (renewable fuel of non-biological origin) must reach a combined minimum of 5,5 % of energy content after multipliers, in 2030.
 - An additional sub-mandate of minimum 1 % RFNBOs is applicable.
 - Advanced biofuels are double counted (x2) based on energy content. When consumed in the aviation and maritime sectors it receives an additional incentive multiplier of 1,2 (i.e. 1,2 x 2 = 2,4)
 - RFNBOs are double counted (x2) based on energy content. When consumed in the aviation and maritime sectors it receives an additional incentive multiplier of 1,5 (i.e. 1,5 x 2 = 3)
- Annex 9B biofuels are capped at 3,4 % after double counting.
- F&F biofuels and other renewable fuels are single-counted (x1)
- Renewable electricity in road transport is quadruple-counted (x4).
- Renewable electricity in rail transport is multiplied by 1,5.
- Renewable electricity in other transport modes is not awarded any multipliers.

We have based the RED III calculations on the low scenario as the targets appear already ambitious and challenging even under these most favourable conditions. We reiterate that in 2030 (the RED III year of evaluation) the difference in energy demand in transport between the two scenarios is less than 1 Mtoe or 1%.

The refining industry is expected to have an aggregated demand of up to 7,1 Mtoe of intermediate H₂ in 2023 (59). The existing and announced electrolyser capacity in the EU refining industry is expected to be 1,46 GW in 2030 (60) (59). For the coming calculations we assume 5000 operating hours per year at 75 % efficiency. We have chosen to cover potential gaps by additional e-H₂ in refining as this option have a high technological maturity and the time from decision to market is short production pathways of finished fuels of RFNBO or Annex 9A fuels.

5.1. RED III COMPLIANCE, CASE 1: BASELINE

Compliance with the legislations described in the previous chapters (PC, LCV, & HDV standards, Refuel EU aviation and Fuel EU Maritime) provide a 2030 baseline energy demand. When not prescribed by previous scenarios we assumed the most affordable compliance layers were prioritised and saturated:

- F&F crops capped at 4,5 % or 14,1 Mtoe (reducing the total target to 26,5 %)
- Annex 9B saturated at 3,4 % or 10,6 Mtoe after double counting.

Adherence to the other legislations reviewed establish baselines demand as follows:

- RFNBO: at 0,6 Mtoe single counted energy, consisting of 0,6 Mtoe of e-kerosene (after multipliers 1,9 Mtoe), required by the Fuel EU Aviation target. We reiterate that this is a highly challenging target given the current development/announcements of projects. We have assumed an additional 0,5 Mtoe of intermediate e-H₂ in refining for manufacturing conventional fuels corresponding to 1,1 Mtoe after multipliers. This is obtainable with announced e-H₂ electrolyser capacity of 1,46 GW (59) providing an e-H₂ to H₂ refining ratio of 8 %. The total RFNBO energy supply would then be 3,0 Mtoe (1,0%) after all applicable multipliers i.e. attain the 1 % sub-mandate.
- Annex 9A (composing of anaerobic digested bio-methane) renewable fuels of 2,1 Mtoe or 5 Mtoe after multipliers (considered to be used in maritime). This corresponds to 0,7 % on energy basis and 1,6% after multipliers.

Together, Annex 9A and RFNBO amount to 2,6 % and fall short of RED III's combined 5,5 % requirement.

Table 31 RED III compliance, Case 1: baseline

2030 Baseline - Energy content			
Fuel or energy carrier	Unit	Absolute values - no multipliers	Absolute values - with multipliers
Total Ren. Electricity	Mtoe	12,1	38,7
Ren. electricity in road transport (x4)	Mtoe	8,4	33,5
Ren. electricity in rail transport (x1.5)	Mtoe	2,9	4,4
Ren. electricity in all other transport modes (x1)	Mtoe	0,814	0,814
Compliant biofuels	Mtoe	21,5	29,7
Food-crop (x1)	Mtoe	14,1	14,1
Annex IX-B (x2)	Mtoe	5,3	10,6
Annex IX-A (and biomethane) (x2)	Mtoe	2,1	5,0
RFNBO (x2)	Mtoe	1,2	3,0
as final fuels (e-fuels / e-H2)	Mtoe	0,6	1,9
as intermediate (e-H2) for fossil fuel production	Mtoe	0,5	1,1
RCF (x1)	Mtoe	0,0	0,0
Total RES-T numerator (all transport)	Mtoe	34,8	71,4
Total RES-T denominator (all transport) - Baseline	Mtoe	312,9	312,9
2030 Energy Shares by Energy Carrier (% energy on REDIII basis)			
Fuel or energy carrier	RED III Target/cap (with multipliers)	% energy (no multipliers)	% energy (with multipliers)
Total Ren. Electricity	N/A	3,9%	12,4%
Ren. electricity in road transport (x4)		2,7 %	10,7%
Ren. electricity in rail transport (x1.5)		0,9 %	1,4%
Ren. electricity in all other transport modes (x1)		0,3 %	0,3%
Compliant biofuels		6,9 %	9,5%
Food-crop (x1)	Max 7% energy (Cap)	4,5 %	4,5 %
Annex IX-B (x2)	Max. 3.4% energy (Cap)	1,7 %	3,4 %
Annex IX-A (and biomethane) (x2)	5,5% combined (incl. Min. 1% RFNBO)	0,7 %	1,6 %
RFNBO (x2)		0,4 %	1,0 %
as final fuels (e-fuels / e-H2)		0,2 %	0,6 %
as intermediate (e-H2) for fossil fuel production		0,2 %	0,3 %
RCF (x1)		0,0%	0,0%
Total RES-T (all transport sectors)		11,1 %	22,8 %
			vs.
Overall RED III Targets	29%-2,5%=26.5%	----->	26,5%

Overall, the outcome of previous described legislations results in a renewable energy share of 22,8 % after multipliers and thus fall short of the 26,5% target by 3,7 percentage points.

5.2. RAMP UP OF ADVANCED BIOFUELS AND RFNBO'S (CASE A)

The RED III case A scenario increases Annex 9A and RFNBO shares to comply with the 5,5 % sub-mandate in a manner that we consider to be highest technological readiness. It can be summarized as follows:

- F&F crops capped at 4,5 % (bringing the total target down to 26,5 %), representing 14 Mtoe in 2030 (no multiplier applicable).
- Annex 9B saturated at 3,4 % after double counting, representing 10,8 Mtoe.
- RFNBO at 3,9 % after multipliers, representing 12,2 Mtoe consisting of 0,6 Mtoe of e-kerosene and 5,2 Mtoe of intermediate e-H₂ in refining for manufacturing conventional fuels. The intermediate e-H₂ in refining requires an installed capacity of 16 GW electrolyzers supplying a e-H₂ refining share of 73 %.

- Annex 9A biofuels remain at 0,7 % on energy basis, 1,6 % after all multipliers, representing 5,0 Mtoe.

The realisation of such scenario in 2030 is evaluated as very challenging given the current low production capacity of Annex 9A fuels and, although announced electrolyser projects are increasing, insufficient financial investment decision for additional capacity of RFNBO's.

Table 32 RED III compliance, Case A: ramp-up of advanced biofuels and RFNBOs

2030 Case A - Energy content			
Fuel or energy carrier	Unit	Absolute values - no multipliers	Absolute values - with multipliers
Total Ren. Electricity	Mtoe	12,1	38,7
Ren. electricity in road transport (x4)	Mtoe	8,4	33,5
Ren. electricity in rail transport (x1.5)	Mtoe	2,9	4,4
Ren. electricity in all other transport modes (x1)	Mtoe	0,814	0,814
Compliant biofuels	Mtoe	21,5	29,8
Food-crop (x1)	Mtoe	14,0	14,0
Annex IX-B (x2)	Mtoe	5,4	10,8
Annex IX-A (and biomethane) (x2)	Mtoe	2,1	5,0
RFNBO (x2)	Mtoe	5,8	12,2
as final fuels (e-fuels / e-H2)	Mtoe	0,6	1,9
as intermediate (e-H2) for fossil fuel production	Mtoe	5,2	10,3
RCF (x1)	Mtoe	0,0	0,0
Total RES-T numerator (all transport)	Mtoe	39,4	80,7
Total RES-T denominator (all transport) - Baseline	Mtoe	313,9	313,9
2030 Energy Shares by Energy Carrier (% energy on REDIII basis)			
Fuel or energy carrier	RED III Target/cap (with multipliers)	% energy (no multipliers)	% energy (with multipliers)
Total Ren. Electricity	N/A	3,9%	12,3%
Ren. electricity in road transport (x4)		2,7 %	10,7%
Ren. electricity in rail transport (x1.5)		0,9 %	1,4%
Ren. electricity in all other transport modes (x1)		0,3 %	0,3%
Compliant biofuels		6,8 %	9,5%
Food-crop (x1)	Max 7% energy (Cap)	4,5 %	4,5 %
Annex IX-B (x2)	Max. 3.4% energy (Cap)	1,7 %	3,4 %
Annex IX-A (and biomethane) (x2)	5,5% combined (incl. Min. 1% RFNBO)	0,7 %	1,6 %
RFNBO (x2)		1,8 %	3,9 %
as final fuels (e-fuels / e-H2)		0,2 %	0,6 %
as intermediate (e-H2) for fossil fuel production		1,6 %	3,3 %
RCF (x1)		0,0%	0,0%
Total RES-T (all transport sectors)		12,6 %	25,7 %
			vs.
Overall RED III Targets	29%-2,5%=26.5%	----->	26,5%

Table 32 show that the RED III overall renewable energy requirement, although close, is still not met with a renewable energy share of 25,7 % after multipliers, falling short by 0,8 % of the overall 26,5 % target.

5.3. RED III RENEWABLE ENERGY COMPLIANCE BY ADDITIONAL RAMP-UP OF ANNEX 9A BIOFUELS AND RFNBO (CASE B)

In order to comply with the RED III renewable energy share requirement of 26,5 % this case increases the share of RFNBO's to cover the gap identified in case A. It requires the following renewable fuels production:

- F&F crops capped at 4,5 % (bringing the total target down to 26,5 %), representing 14,1 Mtoe in 2030 (no multiplier applicable).
- Annex 9B saturated at 3,4 % after double counting, representing 10,8 Mtoe.
- RFNBO at 4,6 % after all multipliers, or 14,5 Mtoe consisting of 0,6 Mtoe of e-kerosene, and 6,3 (12,6 after multipliers) Mtoe of intermediate e-H₂ in refining for manufacturing conventional fuels. This case reaches 88 % of intermediate e-H₂ refining demand requiring an installed capacity of 19 GW electrolyzers which is extremely ambitious considering currently announced capacity of 1,46 GW.
- Annex 9A biofuels remain at 0,7 % or 1,6% after multipliers corresponding to 5,0 Mtoe.

Table 33 RED III compliance, Case B: additional of advanced biofuels and RFNBOs

2030 Case B - Energy content			
Fuel or energy carrier	Unit	Absolute values - no multipliers	Absolute values - with multipliers
Total Ren. Electricity	Mtoe	12,1	38,7
Ren. electricity in road transport (x4)	Mtoe	8,4	33,5
Ren. electricity in rail transport (x1.5)	Mtoe	2,9	4,4
Ren. electricity in all other transport modes (x1)	Mtoe	0,814	0,814
Compliant biofuels	Mtoe	21,6	29,9
Food-crop (x1)	Mtoe	14,1	14,1
Annex IX-B (x2)	Mtoe	5,4	10,8
Annex IX-A (and biomethane) (x2)	Mtoe	2,1	5,0
RFNBO (x2)	Mtoe	6,9	14,5
as final fuels (e-fuels / e-H2)	Mtoe	0,6	1,9
as intermediate (e-H2) for fossil fuel production	Mtoe	6,3	12,6
RCF (x1)	Mtoe	0,0	0,0
Total RES-T numerator (all transport)	Mtoe	40,6	83,1
Total RES-T denominator (all transport) - Baseline	Mtoe	314,1	314,1

2030 Energy Shares by Energy Carrier (% energy on REDIII basis)			
Fuel or energy carrier	RED III Target/cap (with multipliers)	% energy (no multipliers)	% energy (with multipliers)
Total Ren. Electricity	N/A	3,9%	12,3%
Ren. electricity in road transport (x4)		2,7%	10,7%
Ren. electricity in rail transport (x1.5)		0,9%	1,4%
Ren. electricity in all other transport modes (x1)		0,3%	0,3%
Compliant biofuels		6,9%	9,5%
Food-crop (x1)	Max 7% energy (Cap)	4,5%	4,5%
Annex IX-B (x2)	Max. 3.4% energy (Cap)	1,7%	3,4%
Annex IX-A (and biomethane) (x2)	5,5% combined (incl. Min. 1% RFNBO)	0,7%	1,6%
RFNBO (x2)		2,2%	4,6%
as final fuels (e-fuels / e-H2)		0,2%	0,6%
as intermediate (e-H2) for fossil fuel production		2,0%	4,0%
RCF (x1)		0,0%	0,0%
Total RES-T (all transport sectors)		12,9%	26,5%
			vs.
Overall RED III Targets	29%-2,5%=26.5%	----->	26,5%

Table 33 shows the volumes and shares of renewable fuels required to achieve RED III compliance, which highlight the demand RFNBOs to a total of 5,8 Mtoe over the 2030 baseline scenario. We re-emphasise that, considering existing and announced new-builds of electrolyzers and finished RFNBO production facilities, and with consideration that 2030 is merely 4 years away, this is a highly ambitious target.

Regarding the advanced biofuels, the level of investment announcements for industrial-scale advanced biofuel plants is insufficient. Also, the supply chains for feedstocks such as crops cultivated on severely degraded land or inter-seasonal energy crops still need to be established along with the other production pathways for advanced biofuels feedstock.

5.4. RED III RENEWABLE ENERGY COMPLIANCE BY RAMP-UP OF ELECTRICITY IN THE ROAD SECTOR (CASE C)

The lastly analysed compliance method is to increase the share of electricity consumption in the road sector. This scenario assumes compliance of the 5,5 % RFNBO and Annex 9A and 9B fuels, as in case A but also obtain the 26,5 % renewable energy share by increasing electricity demand in the passenger car segment where it substitutes liquid fuels previously used in ICE vehicles.

Table 34 Case C- reaching RED III with additional electricity (increased RES grid ratio)

2030 Case C - Energy content			
Fuel or energy carrier	Unit	Absolute values - no multipliers	Absolute values - with multipliers
Total Ren. Electricity	Mtoe	12,3	39,3
Ren. electricity in road transport (x4)	Mtoe	8,5	34,1
Ren. electricity in rail transport (x1.5)	Mtoe	2,9	4,4
Ren. electricity in all other transport modes (x1)	Mtoe	0,814	0,814
Compliant biofuels	Mtoe	20,8	28,9
Food-crop (x1)	Mtoe	13,5	13,5
Annex IX-B (x2)	Mtoe	5,2	10,3
Annex IX-A (and biomethane) (x2)	Mtoe	2,1	5,0
RFNBO (x2)	Mtoe	5,5	11,6
as final fuels (e-fuels / e-H2)	Mtoe	0,6	1,9
as intermediate (e-H2) for fossil fuel production	Mtoe	4,8	9,7
RCF (x1)	Mtoe		
Total RES-T numerator (all transport)	Mtoe	38,5	79,8
Total RES-T denominator (all transport) - Baseline	Mtoe	301,5	301,5
2030 Energy Shares by Energy Carrier (% energy on REDIII basis)			
Fuel or energy carrier	RED III Target/cap (with multipliers)	% energy (no multipliers)	% energy (with multipliers)
Total Ren. Electricity	N/A	4,1%	13,0%
Ren. electricity in road transport (x4)		2,8%	11,3%
Ren. electricity in rail transport (x1.5)		1,0%	1,4%
Ren. electricity in all other transport modes (x1)		0,3%	0,3%
Compliant biofuels		6,9%	9,6%
Food-crop (x1)	Max 7% energy (Cap)	4,5%	4,5%
Annex IX-B (x2)	Max. 3.4% energy (Cap)	1,7%	3,4%
Annex IX-A (and biomethane) (x2)	5,5% combined (incl. Min. 1% RFNBO)	0,7%	1,7%
RFNBO (x2)		1,8%	3,8%
as final fuels (e-fuels / e-H2)		0,2%	0,6%
as intermediate (e-H2) for fossil fuel production		1,6%	3,2%
RCF (x1)		0,0%	0,0%
Total RES-T (all transport sectors)		12,8%	26,5%
			vs.
Overall RED III Targets	29%-2,5%=26.5%	----->	26,5%

The additional required electricity in the road sector is 0,26 Mtoe. This demand corresponds to an additional 1 million PC BEVs expanding the previous estimated stock of 29 million PC BEVs in 2030. Assuming a BEV average battery capacity of

60 kWh, this corresponds to an aggregate 0,06 TWh of battery demand on top of an already ambitious baseline while also placing additional requirements on charging infrastructure and the electricity grid.

In addition to the above-mentioned increases in electricity demand, case C requires:

- F&F crops capped at 4,5 % (bringing the total target down to 26,5 %), representing 13,5 Mtoe in 2030 (no multiplier applicable).
- Annex 9B saturated at 3,4 % after double counting, representing 10,3 Mtoe.
- RFNBO at 3,8 % after all multipliers, or 11,6 Mtoe consisting of 0,6 Mtoe of e-kerosene, and 4,8 Mtoe of intermediate e-H₂ in refining for manufacturing conventional fuels. This case requires 68 % of intermediate e-H₂ refining demand which could be supplied by 15 GW electrolyser capacity.
- Annex 9A biofuels remain at 0,7 % or 1,7 % after multipliers corresponding to 5,0 Mtoe.

5.5. RED III SUMMARY

The 4 cases are summarized in Fig. 63.

Figure 63 RED III compliance with different fuel alternatives

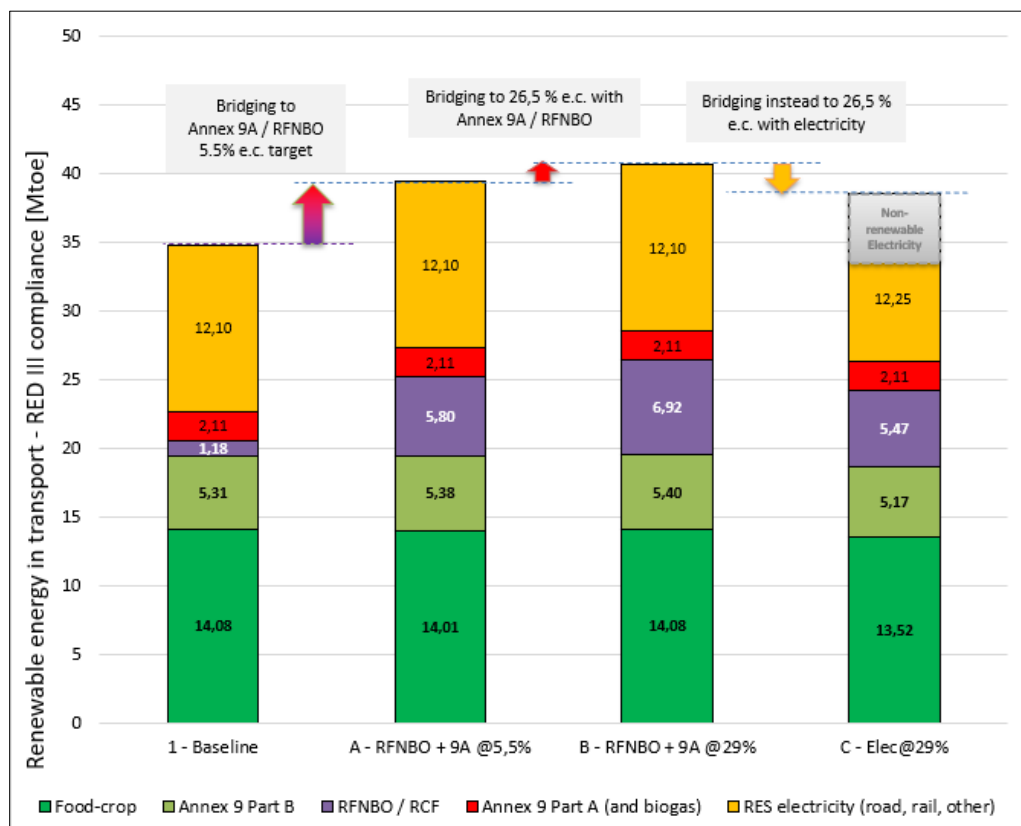


Figure 63 summarize the RED III compliance options where case B & C complies with the 26,5% target based on a ramp-up of renewable fuels or electricity respectively. Figure 63 also shows that the intermediate e-H₂ electrolysing capacity is sufficient

in the baseline scenario to comply with the 1 % RFNBO target whereas case A remains ambitious in terms of RFNBO supply. Given the limitations identified for both Case B and C, meeting the RED III objective by 2030 is likely to be highly challenging.

Table 35 Summary of absolute energy (NO multipliers)

Absolute Energy (no multipliers)	Unit		Baseline	Case A RFNBO & 9A @5,5%	Case B RFNBO & 9A @29%	Case C Electricity @29%
Total Ren. Electricity	Mtoe	No Multipliers	12,1	12,1	12,1	12,3
Ren. electricity in road transport (x4)	Mtoe		8,4	8,4	8,4	8,5
Ren. electricity in rail transport (x1.5)	Mtoe		2,9	2,9	2,9	2,9
Ren. electricity in all other transport modes (x1)	Mtoe		0,814	0,814	0,814	0,814
Compliant biofuels	Mtoe		21,5	21,5	21,6	20,8
Food-crop (x1)	Mtoe		14,1	14,0	14,1	13,5
Annex IX-B (x2)	Mtoe		5,3	5,4	5,4	5,2
Annex IX-A (and biomethane) (x2)	Mtoe		2,1	2,1	2,1	2,1
RFNBO (x2)	Mtoe		1,2	5,8	6,9	5,5
as final fuels (e-fuels / e-H2)	Mtoe		0,6	0,6	0,6	0,6
as intermediate (e-H2) for fossil fuel production	Mtoe		0,5	5,2	6,3	4,8
RCF (x1)	Mtoe		0,0	0,0	0,0	0,0
Total RES-T numerator (all transport)	Mtoe		34,8	39,4	40,6	38,5
Total RES-T denominator (all transport)	Mtoe		312,9	313,9	314,1	301,5

Table 36 Summary of absolute energy (with multipliers)

Absolute Energy (with multipliers)	Unit		Baseline	Case A RFNBO & 9A @5,5%	Case B RFNBO & 9A @29%	Case C Electricity @29%
Total Ren. Electricity	Mtoe	With Multipliers	38,7	38,7	38,7	39,3
Ren. electricity in road transport (x4)	Mtoe		33,5	33,5	33,5	34,1
Ren. electricity in rail transport (x1.5)	Mtoe		4,4	4,4	4,4	4,4
Ren. electricity in all other transport modes (x1)	Mtoe		0,814	0,814	0,814	0,814
Compliant biofuels	Mtoe		29,7	29,8	29,9	28,9
Food-crop (x1)	Mtoe		14,1	14,0	14,1	13,5
Annex IX-B (x2)	Mtoe		10,6	10,8	10,8	10,3
Annex IX-A (and biomethane) (x2)	Mtoe		5,0	5,0	5,0	5,0
RFNBO (x2)	Mtoe		3,0	12,2	14,5	11,6
as final fuels (e-fuels / e-H2)	Mtoe		1,9	1,9	1,9	1,9
as intermediate (e-H2) for fossil fuel production	Mtoe		1,1	10,3	12,6	9,7
RCF (x1)	Mtoe		0,0	0,0	0,0	0,0
Total RES-T numerator (all transport)	Mtoe		71,4	80,7	83,1	79,8
Total RES-T denominator (all transport)	Mtoe		312,9	313,9	314,1	301,5

Table 37 Summary of energy shares (with multipliers)

RED III Compliance after Multipliers	Unit	RED III Target/cap (with multipliers)	Baseline	Case A RFNBO & 9A @5,5%	Case B RFNBO & 9A @29%	Case C Electricity @29%
Total Ren. Electricity	%	N/A	12,4%	12,3%	12,3%	13,0%
Ren. electricity in road transport (x4)	%		10,7%	10,7%	10,7%	11,3%
Ren. electricity in rail transport (x1.5)	%		1,4%	1,4%	1,4%	1,4%
Ren. electricity in all other transport modes (x1)	%		0,3%	0,3%	0,3%	0,3%
Compliant biofuels	%		9,5%	9,5%	9,5%	9,6%
Food-crop (x1)	%	Max 7% energy (Cap)	4,5%	4,5%	4,5%	4,5%
Annex IX-B (x2)	%	Max. 3.4% energy (Cap)	3,4%	3,4%	3,4%	3,4%
Annex IX-A (and biomethane) (x2)	%	5,5% combined (incl. Min. 1% RFNBO)	1,6%	1,6%	1,6%	1,7%
RFNBO (x2)	%		1,0%	3,9%	4,6%	3,8%
as final fuels (e-fuels / e-H2)	%		0,6%	0,6%	0,6%	0,6%
as intermediate (e-H2) for fossil fuel production	%		0,3%	3,3%	4,0%	3,2%
RCF (x1)	%		0,0%	0,0%	0,0%	0,0%
Total RES-T (all transport sectors)	%		22,8%	25,7%	26,5%	26,5%
			vs.	vs.	vs.	vs.
Overall RED III Targets	%	29%	26,5%	26,5%	26,5%	26,5%

Table 35-37 summarize the three cases investigated where case B and C comply with the RED III 2030 energy target. It should be noted that the volumes of renewable fuels or additional BEV/PHEV in the road segment to comply with the RED III targets are additions to already considerable adaptation in the form of i) additional amounts of renewable fuels, ii) ambitious sales targets for the road segment and iii) the increase of the renewable electricity grid mix.

5.6. RED III ESTIMATES IN 2040

There are currently no announced overarching targets for renewable energy share in transport for 2040 other than what has already been announced per sector. For informative purposes, we show the baseline renewable energy demand and shares based on compliance with Refuel Aviation, Fuel EU Maritime, the respective sales targets for the road segments, the combined transport directive and other projections explained in chapter four.

Table 38 Summary of absolute energy in a fictive 2040 Low RED III context

2040 Baseline for Energy target calculations [Mtoe]				
Fuel or energy carrier	Abs. values (NO mult.)	Abs. values (NO mult.)	Abs. values (with mult.)	Abs. values (with mult.)
	LOW	HIGH	LOW	HIGH
Total Ren. Electricity	36,8	38,5	134,8	141,3
Ren. electricity in road transport (x4)	32,0	33,6	127,9	134,2
Ren. electricity in rail transport (x1.5)	4,1	4,1	6,2	6,2
Ren. electricity in all other transport modes (x1)	0,667	0,797	0,667	0,797
Compliant biofuels	33,8	40,7	81,9	99,6
Food-crop (x1)	7,2	8,1	7,2	8,1
Annex IX-B (x2)	4,0	4,8	8,0	9,6
Annex IX-A (and biomethane) (x2)	22,5	27,8	66,7	81,9
RFNBO (x2)	31,5	33,7	74,3	81,0
as final fuels (e-fuels / e-H2)	26,5	28,7	64,3	71,1
as intermediate (e-H2) for fossil fuel production	5,0	5,0	9,9	9,9
RCF (x1)	0,0	0,0	0,0	0,0
Total RES-T numerator (all transport)	102,0	112,9	291,0	321,9
Total RES-T denominator (all transport) - Baseline	232,4	269,7	232,4	269,7

Table 38 summarize the energy demand from the transport sector in the baseline scenario in 2040 in the Low and High scenario. The renewable electricity share is explained in chapter 4 but is assumed to be at 76 % in 2040 (complemented by 24% nuclear) i.e., grid emission intensity is assumed to be zero. Note that the baseline energy demand differs significantly between the Low and High due to difference in electrification, scrapping of ICE PC and activity.

The relative share of intermediate e-H₂ in refining is based on (61) and here set at 70 % of the total H₂ demand of 7,1 Mtoe (constant as of 2030) to a total of 5 Mtoe in both scenarios. Note that this is in conjunction with the expected increase of e-H₂ as road fuel of around 15 Mtoe (total H₂ road demand of 20 Mtoe).

In the Low scenario aviation 9A demand amounts to 12,7 Mtoe, 9B demand to 0,4 Mtoe and e-SAF to 5,4 Mtoe. Maritime 9A demand consists of 7 Mtoe of advanced BTL diesel and 1,9 Mtoe of liquified biomethane blended in LNG, 9B demand consists

of 2,9 Mtoe of HVO. RFNBO demand consists of 2,9 Mtoe of e- NH₃ and 2,9 Mtoe of e-MetOH, respectively.

In the High scenario aviation 9A demand amounts to 15,5 Mtoe, 9B demand to 0,5 Mtoe and e-SAF to 6,7 Mtoe. Maritime 9A demand is 8,4 Mtoe of advanced BTL diesel and 2,3 Mtoe of liquified biomethane blended in LNG, 9B demand of 3,5 Mtoe of HVO. RFNBO demand of 3,5 Mtoe of e- NH₃ and 3,5 Mtoe e-MetOH, respectively.

Table 39 Summary of absolute energy in a fictive 2040 Low RED III context

2040 Baseline Energy Shares by Carrier (% energy)				
Fuel or energy carrier	% energy (NO mult.)	% energy (NO mult.)	% energy (with mult.)	% energy (with mult.)
	LOW	HIGH	LOW	HIGH
Total Ren. Electricity	15,8%	14,3%	58,0%	52,4%
Ren. electricity in road transport (x4)	13,8 %	12,4%	55,0%	49,8%
Ren. electricity in rail transport (x1.5)	1,8 %	1,5%	2,7%	2,3%
Ren. electricity in all other transport modes (x1)	0,3 %	0,3%	0,3%	0,3%
Compliant biofuels	14,5 %	15,1%	35,2%	36,9%
Food-crop (x1)	3,1 %	3,0 %	3,1 %	3,0 %
Annex IX-B (x2)	1,7 %	1,8 %	3,4 %	3,6 %
Annex IX-A (and biomethane) (x2)	9,7 %	10,3 %	28,7 %	30,4 %
RFNBO (x2)	13,6 %	12,5 %	32,0 %	30,0 %
as final fuels (e-fuels / e-H2)	11,4 %	10,6 %	27,7 %	26,4 %
as intermediate (e-H2) for fossil fuel production	2,1 %	1,8 %	4,3 %	3,7 %
RCF (x1)	0,0%	0,0%	0,0%	0,0%
Total RES-T (all transport sectors)	43,9 %	41,9 %	125,2 %	119,4 %

Table 39 show that without multipliers the Low scenario reach 44 % renewable energy share in transport in 2040 whereas if multipliers are considered in similar fashion as in 2030, the renewable energy share is 125 %.

In 2040 in the High scenario the renewable energy share is 42 % without multipliers and 119 % if multipliers are applied in similar fashion as in 2030.

6. GREENHOUSE GAS EMISSIONS FROM TRANSPORT

Greenhouse gas emissions from the transport sector are here considered in a tank-to-wheel (tailpipe) perspective. If emitted within EU, the WTT emissions are accounted in other legislation. Renewable fuels are those that comply with the GHG-saving and sustainability criteria as per RED III which are considered as zero emissions in ETS 1 and ETS 2.

6.1. IMPACT OF THE COMBINED TRANSPORT DIRECTIVE AND RED III COMPLIANCE

On the 7th of November 2023 the European Commission announced an update to the Combined Transport Directive (46). The objective is to, among else, reduce environmental impact and fuel demand by increased utilization of rail transport by shifting activity from more energy intensive transport modes. The impact of a recent proposal from the European Commission referred to as the Combined Transport Directive have been modelled in the following manner:

- Reduced road fuel demand corresponding to 5 Mtoe of diesel in 2040, due to activity shift to other transport modes.
- Reduced road fuel demand corresponding to 10 Mtoe of diesel in 2050, due to activity shift to other transport modes.

The impact of RED III case B has been considered in Figure 64 by substituting fossil fuel demand of 5,7 Mtoe of renewable fuels corresponding to decreased emissions of 18 Mt CO_{2eq} from the road segment.

6.2. ETS 2 & ETS 1 COMPLIANCE

Figure 64 2030 CO₂ emissions from transportation & ETS ambition

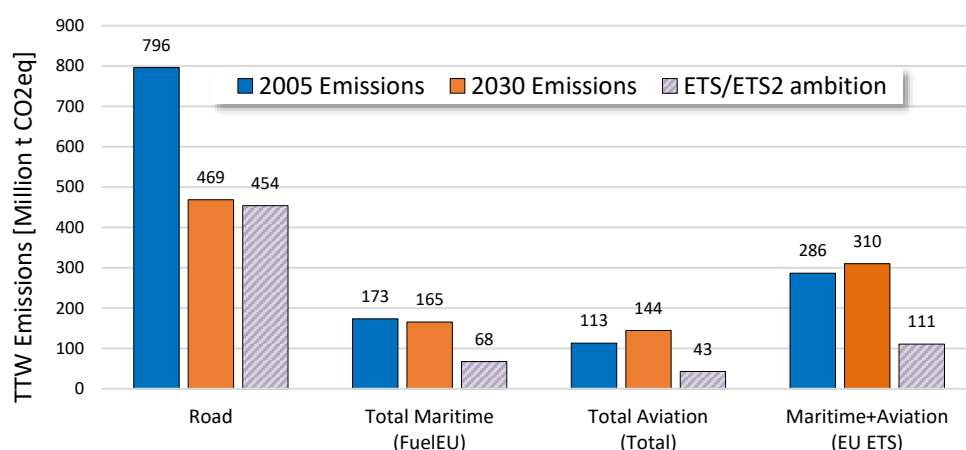


Figure 64 show that the road sector decreases CO₂ emissions by 41 % compared to the 2005 levels if including the additional RED III case B fuels. The shared ETS 2 goal in 2030 (covering the road, the residential and additional sectors) is a 43 % reduction compared to 2005 levels. Efforts to reduce emissions is not comparable between sectors. Reductions are expected to be easier in residential compared to road and thereby it is not possible to conclude if our road projections are sufficient to reach the ambition. Despite efforts to reduce fuel emission intensity and to increase the

share of renewable fuels, only marginal changes are seen in aviation and maritime compared to 2005 levels because of anticipated total fuel demand.

Figure 65 2040 CO₂ emissions from transportation

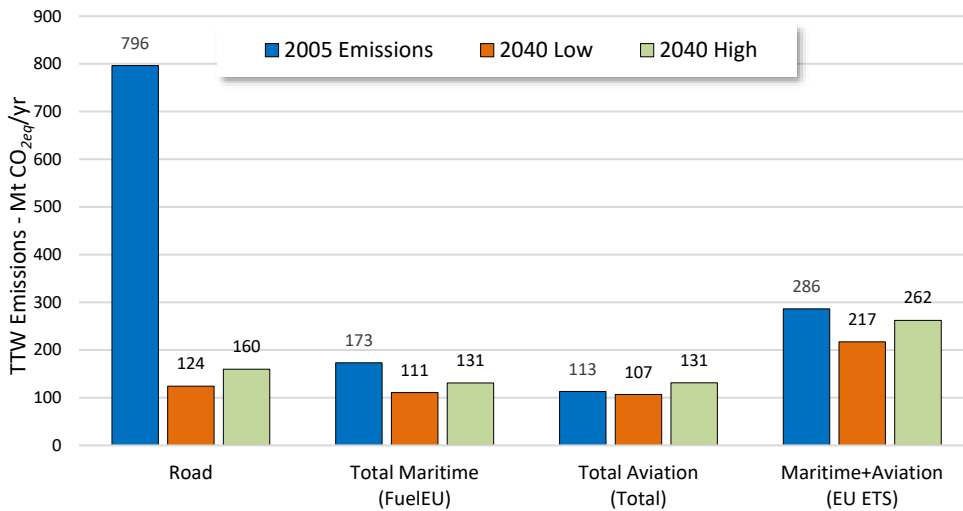


Figure 65 show that emissions in the road segment are 73 - 65 % (low to high scenario) below the 2030 ETS goal and a reduction of 84 - 80 % compared to 2005 in 2040. The ETS directive is expected to be reviewed shortly to take into account the 2040 climate target. Demand from the road segment has been reduced with 5 Mtoe of liquid fuels in consideration of the Combined Transport Directive.

Figure 66 2050 CO₂ emissions from transportation

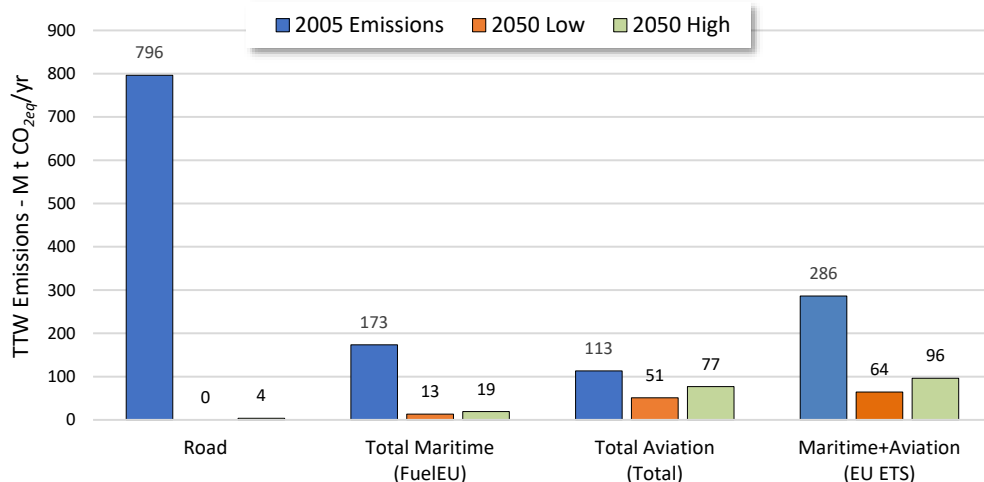


Figure 66 show that emissions in the road segment reach zero in the Low scenario and are close to zero in the High scenario. Maritime emissions have decreased 92 - 89 % since 2005 whereas aviation has decreased 32 - 55 % compared to 2005. Demand from the road segment has been reduced with 10 Mtoe of liquid fuels in consideration of the Combined Transport Directive.

7. CONCLUSIONS

The impact of the regulations directed at the road transport sector cause a decline in liquid fuel demand despite activity is increasing in terms of performed tonne-km and passenger-km. The main reason for decreasing energy demand is transition from internal combustion engine to battery-electric powertrain.

Our analysis of the regulatory impact of the FF55 is separated in two scenarios. Both comply with the powertrain sales targets from the road sector, the SAF blending targets in aviation as well as the fuel emission intensity decrease in the maritime sector. However, the low scenario shifts passenger transport from the passenger cars to the Bus & Coach segment with 1,5 % /year for the period 2030-2050. Consequentially, the low scenario has lower activity for the period of 2031-2050 whereas the high scenario increases passenger transportation along with the projection (39). In response to this decreased activity from the PC segment, we decrease passenger car new sales and increase scrapping and replacement of ICE cars older than 20 years with BEV and FCEV, which occurs gradually as of 2031.

The aviation and maritime projections are based on yearly growth figures from the pre covid period alternatively aligning with final energy demand with scenarios from A Clean Planet for All. Maritime energy demand grows 1,4 % /year (high scenario) or decrease -0,4% /year (low scenario) for the same period. The low scenario in maritime aligns with final energy demand to the 1.5 Life scenario in the Clean Planet for All in 2050, while the high scenario applies a yearly growth of net fuel demand of 1,4 % for the period 2030-2050 which correspond to the yearly increase for the period 2014-2019 (17). Corresponding figures for aviation are 2,6 % /year (high scenario) or 0,5 % /year (low scenario). The final energy demand of aviation in 2050 aligns with the net fuel demand growth rate observed between 2014-2019 (high scenario) whereas total fuel demand in 2050 complies with the 1.5 Tech scenario in the Clean Planet for All (low scenario) (16).

Energy demand from the road sector decreases 11 % in 2030 compared to 2019 whereas fossil liquid fuel demand decrease 21 %. In 2040, energy demand decreases between 49 % and 42 % (low resp. high scenario) and fossil liquid fuel demand decrease between 80 % - 74 %. In 2050, energy demand decreases between 65 % - 57 % (low resp. high scenario) and fossil liquid fuel demand decrease between 100 % - 99 %. The drastic reduction in liquid fuel demand is caused by a fleet transition to battery-electric and H₂ powertrain that also reduces total fuel demand as the electric powertrain is more energy efficient. The low scenario has a higher transition rate towards BEV starting in 2030 (due to increased ICE scrappage rate) and also lower vehicle km compared to the high scenario, due to reduced activity.

In the low and high scenarios respectively, fuel demand in aviation increases respectively by 19 % and 79 % for the period 2019-2050 whereas fossil kerosene demand decrease by 46 % and 64 %. Correspondingly, fuel demand in maritime increase respectively by 8 % and 54 % for the period 2019-2050 whereas fuel oil and marine gasoil demand decreases to less than 1 %.

The combined energy demand from all transport sectors declines 4 % in 2030 whereas fossil fuel demand decrease 15 %, compared to 2019. In 2040, energy demand decreases between 28 % - 17 % whereas fossil liquid fuel demand decrease 49 % - 47 % compared to 2019. In 2050, energy demand decreases 39 % - 18 % whereas fossil liquid fuel demand decrease 86 % - 85 % compared to 2019. The decrease in total energy demand is primarily caused by the decrease in the road sector (small contribution also from rail and off-road). The decrease in fossil liquid fuel demand

is mainly attributed to the road and maritime whereas aviation decrease between 46 % - 64 % due to compliance with ReFuel EU Aviation targets.

Meeting the requirements of the Renewable Energy Directive III (RED III) by 2030 is expected to be challenging. Compliance would demand substantial volumes of Annex 9A biofuels (5,0 Mtoe after multipliers) and renewable fuels of non-biological origin (RFNBOs, 14,5 Mtoe after multipliers), compared to 5,0 Mtoe of Annex 9A and 3,0 Mtoe of RFNBOs in the baseline scenario. This would come in addition to 14,1 Mtoe of food- and feed-based biofuels and 10,8 Mtoe of Annex 9B fuels after multipliers.

An alternative route to compliance could involve a significant increase in electricity use in the road segment, while maintaining baseline levels of liquid renewable fuels. In this scenario, electricity demand from the road sector would need to rise from 14,2 to 14,5 Mtoe, requiring the deployment of approximately 1 million additional BEV passenger cars on top of the 29 million BEVs already in the 2030 stock.

Our RED III scenarios assume a 58 % renewable electricity share in 2030 following the trajectory of (56) reaching zero emission intensity in 2040 with a renewable share of 76 %. Also, the feasibility of the compliance pathways for the respective segment remains uncertain, given the limited progress as of 2025 and the substantial additional investments needed beyond those already planned.

The renewable energy share in all transport modes in 2040 is between 44 % to 42 % in the low and high scenario although total energy demand differs between 232 Mtoe to 270 Mtoe. If multipliers are considered in similar fashion as in 2030, the renewable energy share is 119 % respectively 125 %.

Emissions of CO₂ decline rapidly but none of the sectors reach the ETS ambition in 2030. Emissions in 2040 decline further, again due to electrification in the road segment whereas both maritime and aviation increase total fuel demand but decrease fuel emission intensity. Due to the increased activity in aviation and maritime, however, emissions still exceed the 2030 ETS ambition. In 2050, CO₂ emissions in the road sector reach zero in the low scenario due to the impact of electrification and the combined transport directive that shifts activity from the road segment to other means of transport. The primary cause of the decrease in CO₂ emissions are the transition from ICE to BEV in the road sector along with rapid introduction of renewable alternatives in aviation and maritime.

8. GLOSSARY

BEV	Battery Electric Vehicle
B7	Fuel with max 7% (volume) blending of FAME into diesel
CNG	Compressed Natural Gas
CO _{2eq}	Carbon dioxide equivalent (converted via global warming potential)
E10	Fuel with 10% (volume) blending of ethanol into gasoline
E5	Fuel with 5% (volume) blending of ethanol into gasoline
e-diesel	Synthetic diesel fuel made from carbon dioxide, water, and electricity
EV	Electric Vehicle (BEV+PHEV)
FAME	Fatty Acid Methyl Ester
FCEV	Fuel Cell Electric Vehicle
GHG	Greenhouse gas
H ₂ - fossil	Hydrogen from fossil sources
H ₂ - renewable / e-H ₂	Hydrogen from electrolyzers powered by renewable electricity
HDV	Heavy-Duty Vehicle
HEV	Hybrid Electric Vehicle
HFO	Heavy Fuel Oil
HSFO	High Sulphur Fuel Oil
HVO	Hydrotreated Vegetable Oil
IMO	International Maritime Organization
JEC	Joint Research Centre, EUCAR, CONCAWE
ktoe	kilo tonnes oil equivalent
LBM	Liquid bio-methane
LCV	Light Commercial Vehicle
LDV	Light-Duty Vehicle
LNG	Liquified natural gas
LPG	Liquefied petroleum gas
MGO	Marine Gas Oil
Mtoe	Million tonnes oil equivalent
NEDC	New European Driving Cycle
PC	Passenger Car
PHEV	Plug-in Hybrid Electric Vehicle
RED-III	The Renewable Energy Directive III
RFNBO	Renewable Fuel from Non-Biological Origin
SAF	Sustainable Aviation Fuel
SNG	Synthetic Natural Gas

TTW	Tank-to-Wheel
UCO	Used Cooking oil
WLTP	Worldwide Harmonised Light Vehicle Test Procedure
WTT	Well-to-Tank
WTW	Well-to-Wheel

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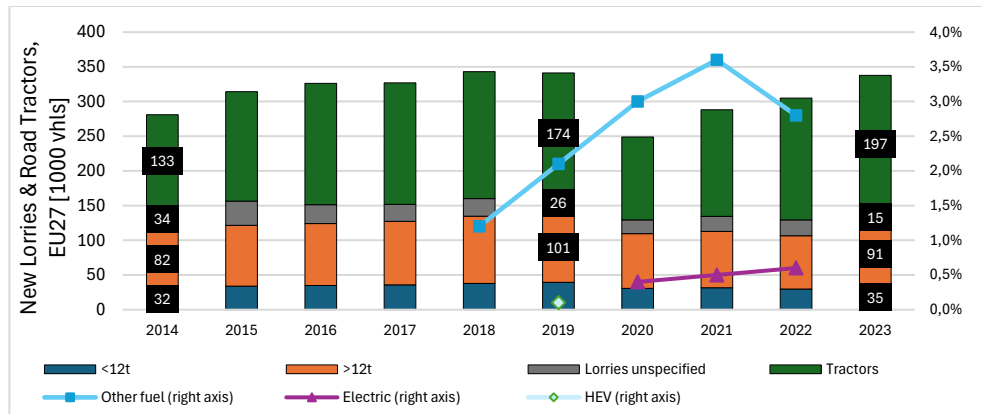
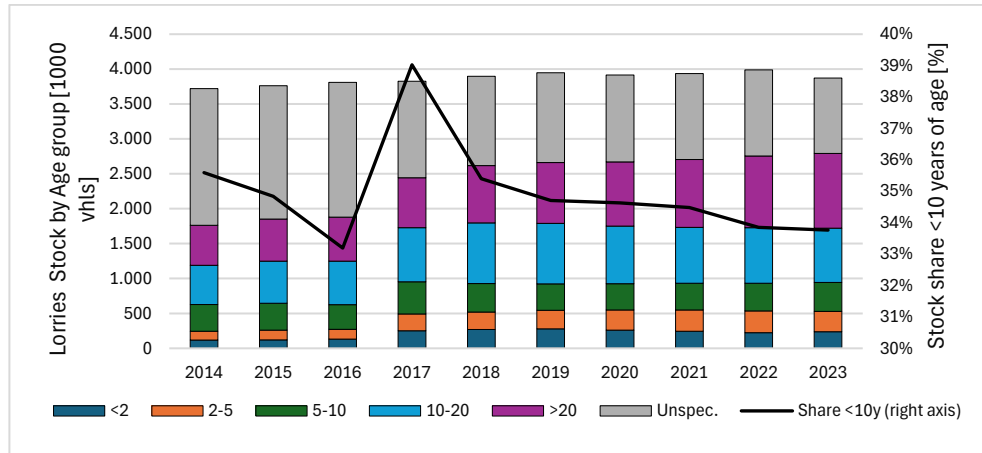
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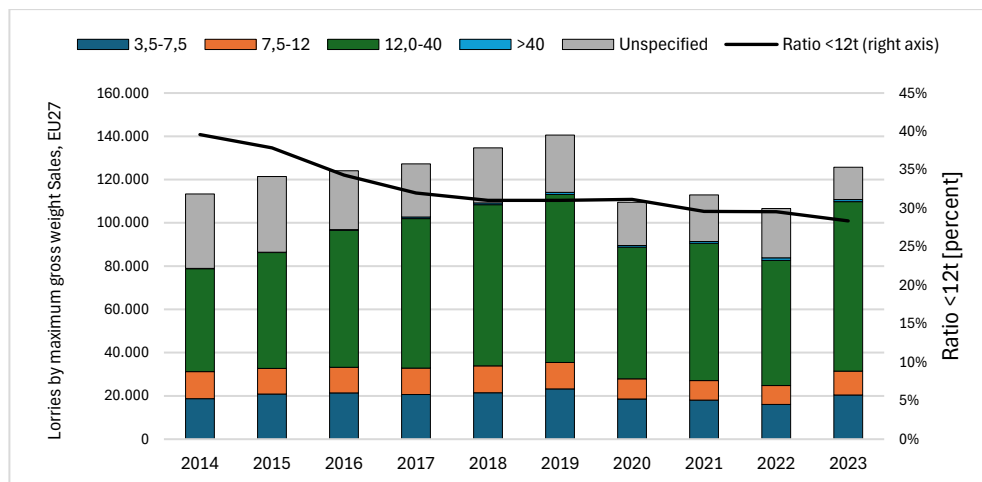
APPENDIX

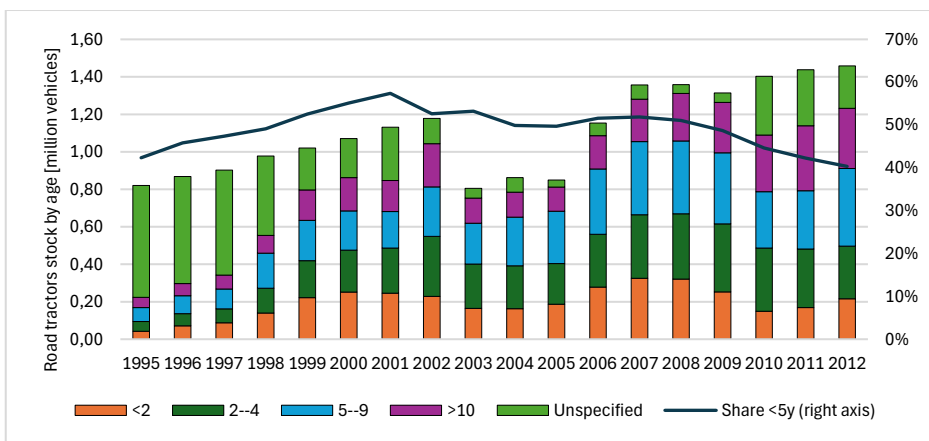
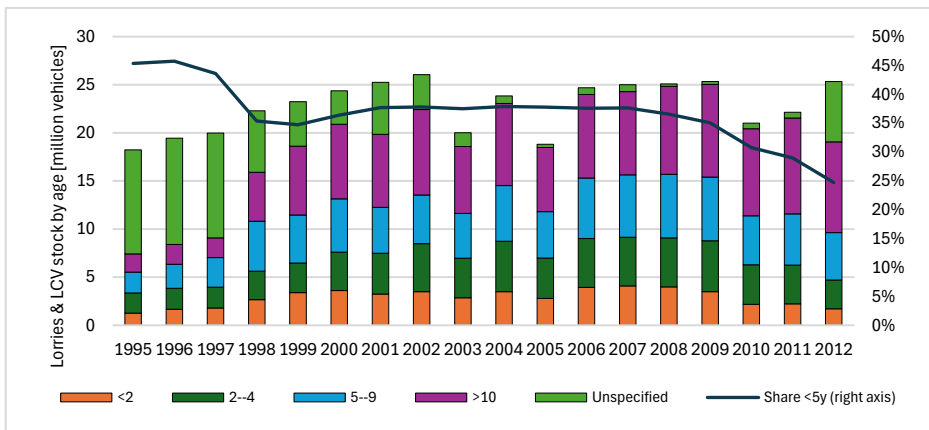
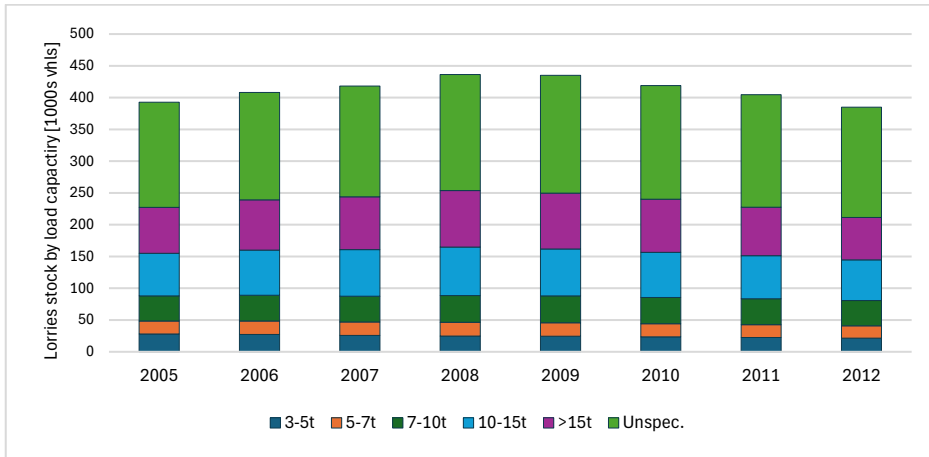
The below figures support our modelling choice regarding stock size, sales, scrappage rate and vehicle mileage depending on age.

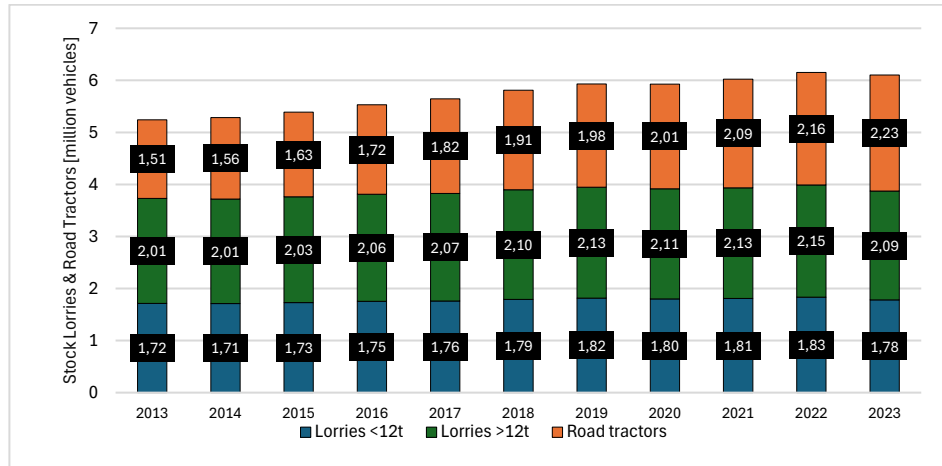
Figure 67 Supporting data for lorries and road tractors



*Share of alternative powertrain from ACEA

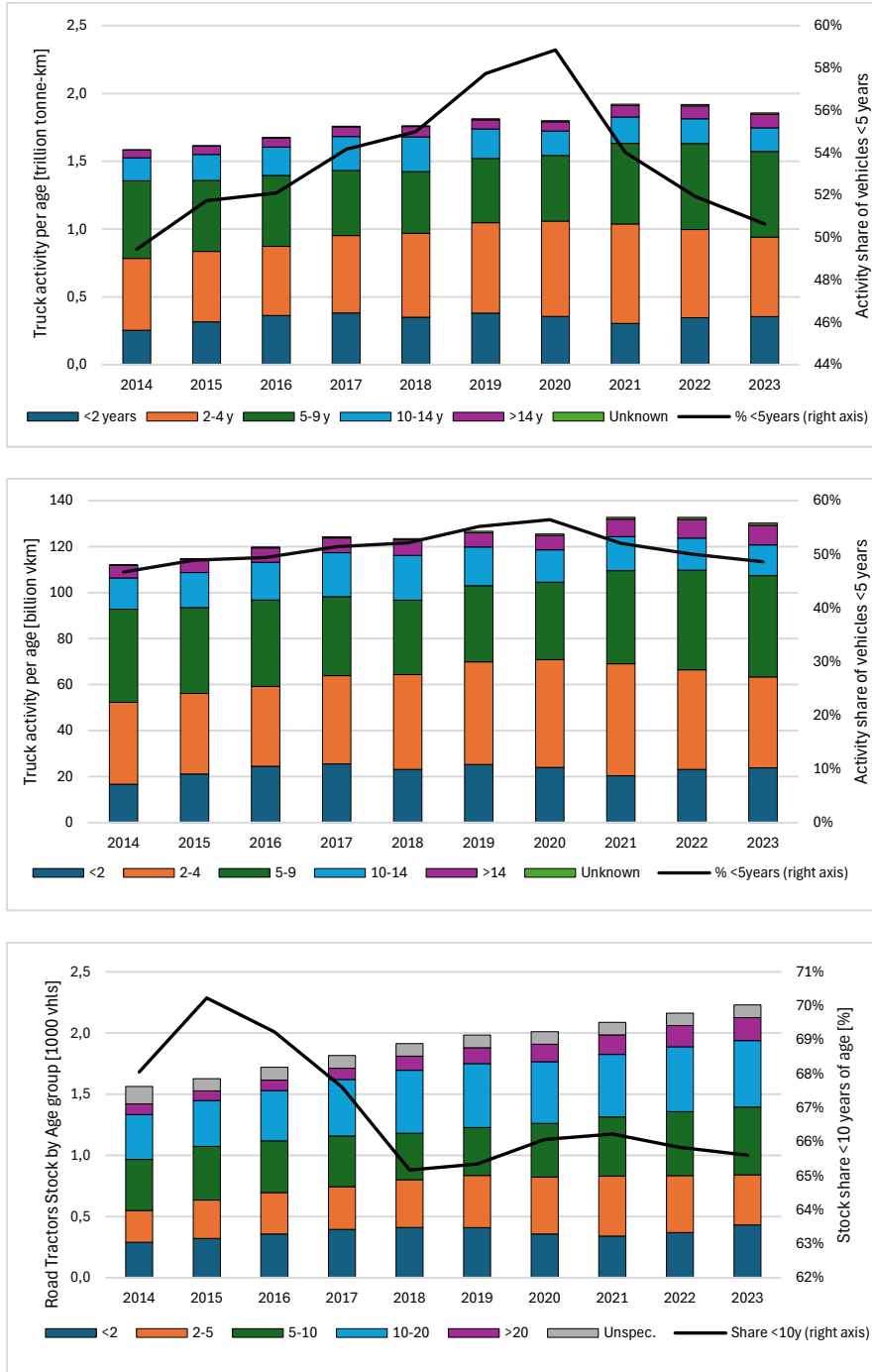






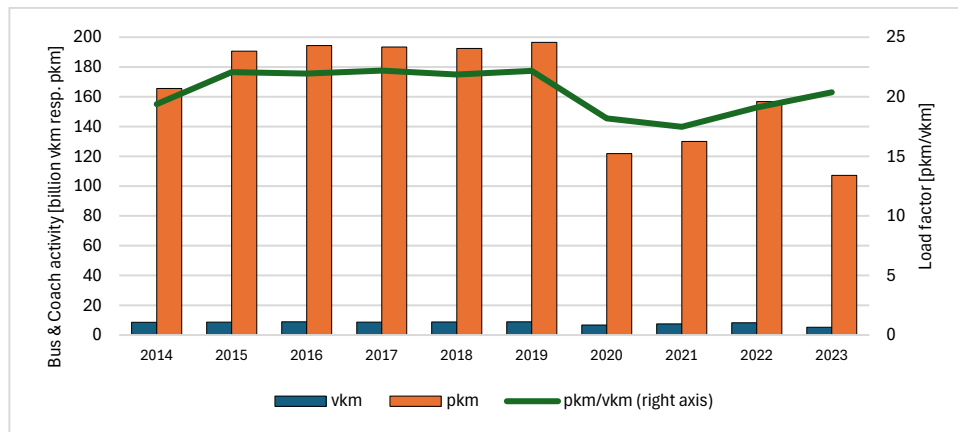
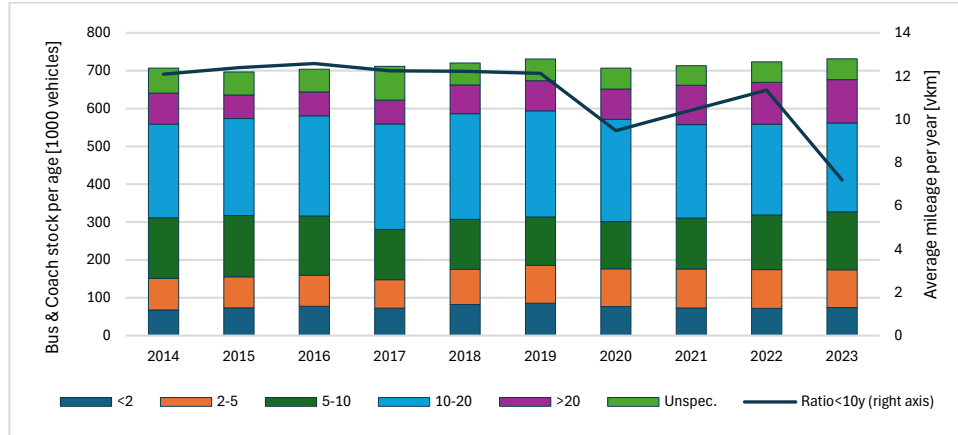
Source: (17)

Figure 68 Supporting data for Trucks

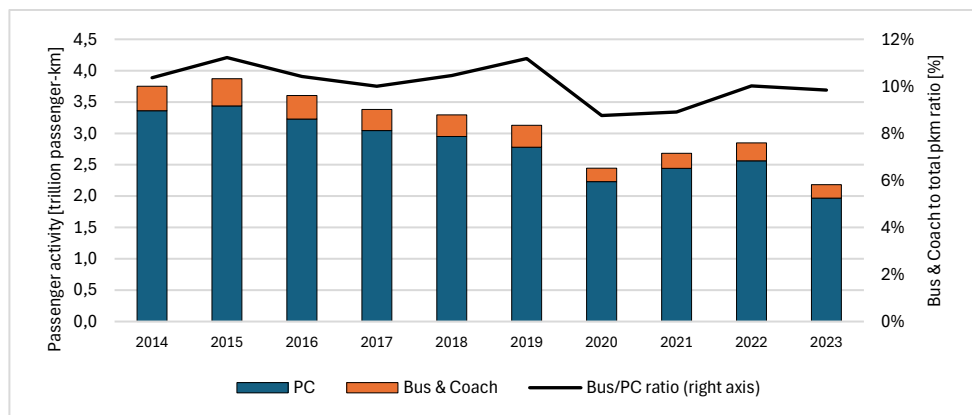


Source: (17)

Figure 69 Supportive data for Buses & Coaches

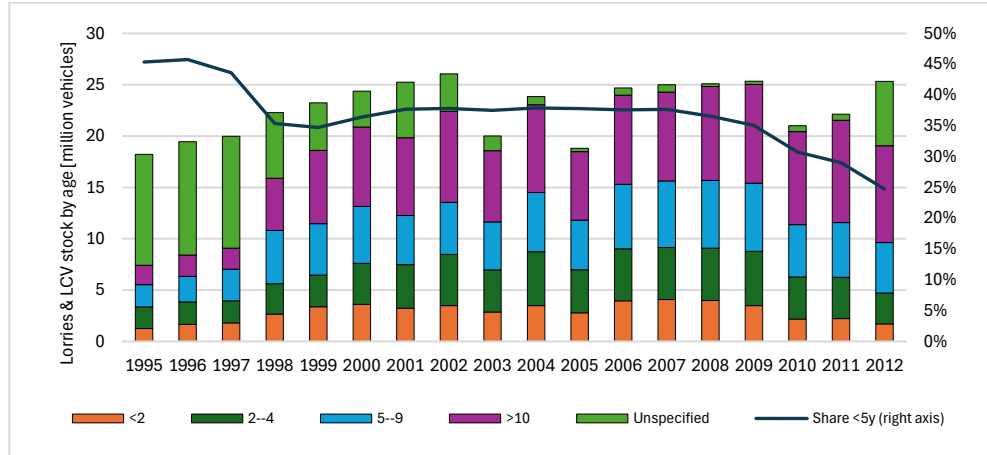


Data from Bulgaria, Denmark, Germany, Estonia, Ireland, France, Croatia, Lithuania, Malta and Portugal.



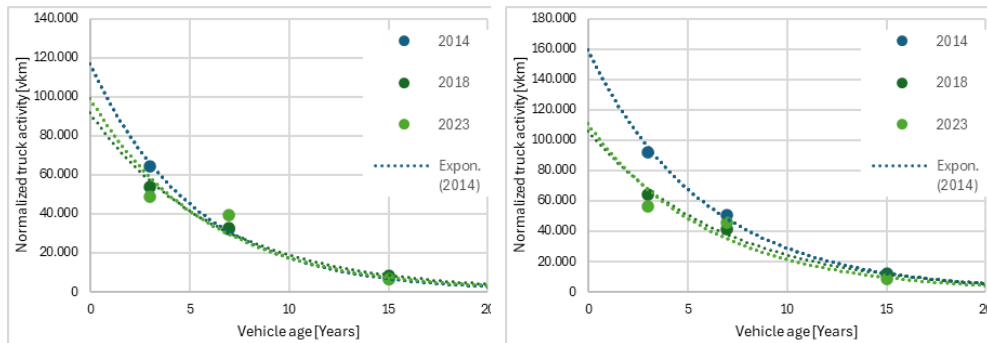
Source: (10)

Figure 70 LCV supporting data



Source: (17)

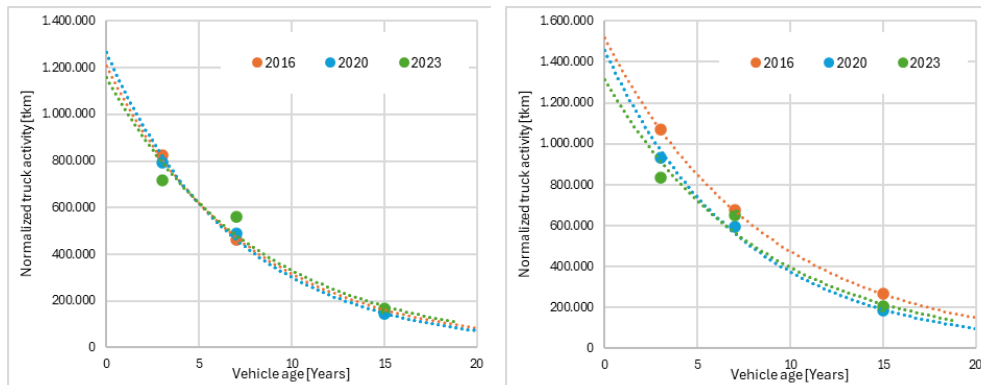
Figure 71 Truck activity (vkm) per year as function of vehicle age, normalized



Source: (17)

Left figure considers the entire EU27 vehicle stock, i.e. also vehicles of unknown vehicle age. Right figure only considers vehicle of known age.

Figure 72 Truck activity (tkm) per year as function of vehicle age, normalized



Source: (17)

Left figure considers the entire EU27 vehicle stock, i.e. also vehicles of unknown vehicle age. Right figure only considers vehicle of known age.

Table 40 Share of HDV powertrain in the new sales from EC Reference scenario (15)

Buses over 7,5 tonnes	Diesel (including hybrid)	Gas-powered vehicles	PHEV	BEV	Hydrogen-powered vehicles
2030					
Baseline	56%	6%	2%	34%	2%
TL_Low	21%	3%	3%	70%	3%
TL_Med	15%	2%	3%	77%	3%
TL_High	7%	1%	3%	85%	4%
2035					
Baseline	45%	7%	2%	40%	6%
TL_Low	16%	3%	4%	68%	8%
TL_Med	9%	2%	4%	76%	9%
TL_High	4%	1%	3%	83%	9%
2040					
Baseline	27%	10%	3%	45%	16%
TL_Low	7%	2%	3%	70%	18%
TL_Med	3%	1%	3%	73%	20%
TL_High	0%	0%	0%	71%	29%

Coaches over 7,5 tonnes	Diesel (including hybrid)	Gas-powered vehicles	PHEV	BEV	Hydrogen-powered vehicles
2030					
Baseline	87%	2%	0%	4%	8%
TL_Low	70%	2%	0%	8%	19%
TL_Med	61%	2%	0%	11%	26%
TL_High	43%	2%	0%	17%	38%
2035					
Baseline	77%	2%	0%	7%	13%
TL_Low	50%	2%	0%	17%	31%
TL_Med	35%	2%	0%	22%	41%
TL_High	21%	1%	0%	28%	50%
2040					

Baseline	63%	3%	0%	10%	24%
TL_Low	25%	2%	0%	23%	50%
TL_Med	14%	1%	0%	26%	58%
TL_High	0%	0%	0%	30%	70%

Lorries between 5 and 7,5 tonnes (as in scope 1)	Diesel (including hybrid)	Gas-powered vehicles	PHEV	BEV	Hydrogen-powered vehicles
2030					
Baseline	76%	14%	6%	4%	1%
TL_Low	66%	13%	12%	7%	1%
TL_Med	61%	12%	15%	10%	1%
TL_High	48%	10%	24%	16%	2%
2035					
Baseline	65%	20%	7%	7%	1%
TL_Low	50%	16%	19%	13%	2%
TL_Med	40%	13%	25%	19%	4%
TL_High	28%	9%	29%	29%	5%
2040					
Baseline	53%	25%	7%	12%	3%
TL_Low	32%	11%	23%	28%	6%
TL_Med	21%	8%	22%	40%	9%
TL_High	0%	0%	0%	80%	19%

Lorries between 7,5 and 16 tonnes (as in scope 1)	Diesel (including hybrid)	Gas-powered vehicles	PHEV	BEV	Hydrogen-powered vehicles
2030					
Baseline	69%	14%	6%	9%	2%
TL_Low	57%	12%	10%	18%	3%
TL_Med	52%	11%	12%	22%	3%
TL_High	39%	8%	15%	33%	5%
2035					
Baseline	57%	19%	5%	15%	4%
TL_Low	40%	13%	11%	30%	6%
TL_Med	31%	11%	12%	39%	8%
TL_High	21%	7%	11%	50%	10%

2040					
Baseline	44%	23%	4%	22%	7%
TL_Low	24%	9%	10%	46%	12%
TL_Med	16%	6%	8%	57%	14%
TL_High	0%	0%	0%	78%	22%

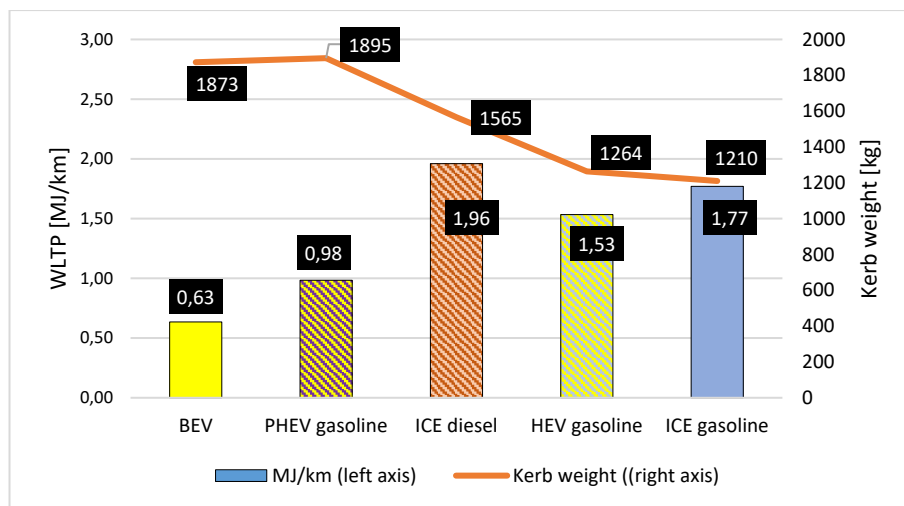
Lorries above 16 t (as in scope 1)	Diesel (including hybrid)	Gas- powered vehicles	PHEV	BEV	Hydrogen- powered vehicles
2030					
Baseline	66%	20%	0%	7%	7%
TL_Low	64%	16%	0%	9%	11%
TL_Med	63%	13%	1%	10%	13%
TL_High	58%	9%	0%	14%	18%
2035					
Baseline	52%	26%	0%	10%	13%
TL_Low	45%	18%	0%	15%	21%
TL_Med	39%	14%	0%	19%	28%
TL_High	32%	8%	0%	24%	35%
2040					
Baseline	35%	30%	0%	13%	21%
TL_Low	27%	12%	0%	21%	40%
TL_Med	19%	7%	0%	25%	48%
TL_High	0%	0%	0%	31%	69%

Table 41 New cars and vans in 2030, 2035 and 2040 from EC Reference scenario (15)

	Cars				Vans			
	ICEV*	PHEV	BEV	FCEV	ICEV*	PHEV	BEV	FCEV
2030								
Baseline	61,5%	13,3%	24,5%	0,6%	71,6%	14,7%	13,4%	0,3%
TL_Low	56,1%	12,8%	30,5%	0,6%	66,9%	13,6%	18,9%	0,7%
TL_Med	48,0%	16,1%	35,1%	0,8%	61,9%	16,0%	21,3%	0,7%
TL_High	39,4%	14,3%	45,3%	1,0%	51,3%	13,3%	34,7%	0,7%
2035								
Baseline	56,0%	16,8%	25,3%	1,8%	58,2%	18,4%	22,0%	1,3%
TL_Low	38,7%	20,1%	38,8%	2,4%	43,4%	21,2%	32,7%	2,6%
TL_Med	28,0%	21,8%	46,8%	3,4%	28,7%	21,8%	47,4%	4,2%
TL_High	0,0%	0,0%	90,2%	9,8%	0,0%	0,0%	94,2%	5,8%
2040								
Baseline	46,7%	17,6%	32,4%	3,2%	50,1%	20,8%	26,8%	2,3%
TL_Low	18,5%	19,2%	55,1%	7,2%	17,7%	22,9%	52,3%	7,2%
TL_Med	0,0%	0,0%	87,0%	13,0%	0,0%	0,0%	85,6%	14,4%
TL_High	0,0%	0,0%	89,9%	10,1%	0,0%	0,0%	93,0%	7,0%

* including HEV and gas fuelled vehicles

Figure 73 Kerb weight & energy consumption for top sold PC in EU 27



Source: (62) combined with vehicle manufactures certified values.

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