Chapter 5

European Union Transition to Green Energy in the Transport Sector

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1. Introduction

During President Ursula von der Leyen's first term, the European Commission, reoriented its strategic focus, with decarbonisation as one of the major priorities. The decarbonisation strategy is set out in the Communication on the European Green Deal (EC, 2019a). This aims to make Europe the first climate-neutral continent by 2050. The European Union (EU) Climate Law (EU, 2021c) binds Europe to achieving climate neutrality by 2050 and sets an intermediate target of a 55% reduction in greenhouse gas (GHG) emissions by 2030 compared to 1990. This report was written in December 2023, therefore it relates to the relevant legislation and status of the legislative process at the time.

1.1. The Greenhouse Gas Emissions of Transport in the EU

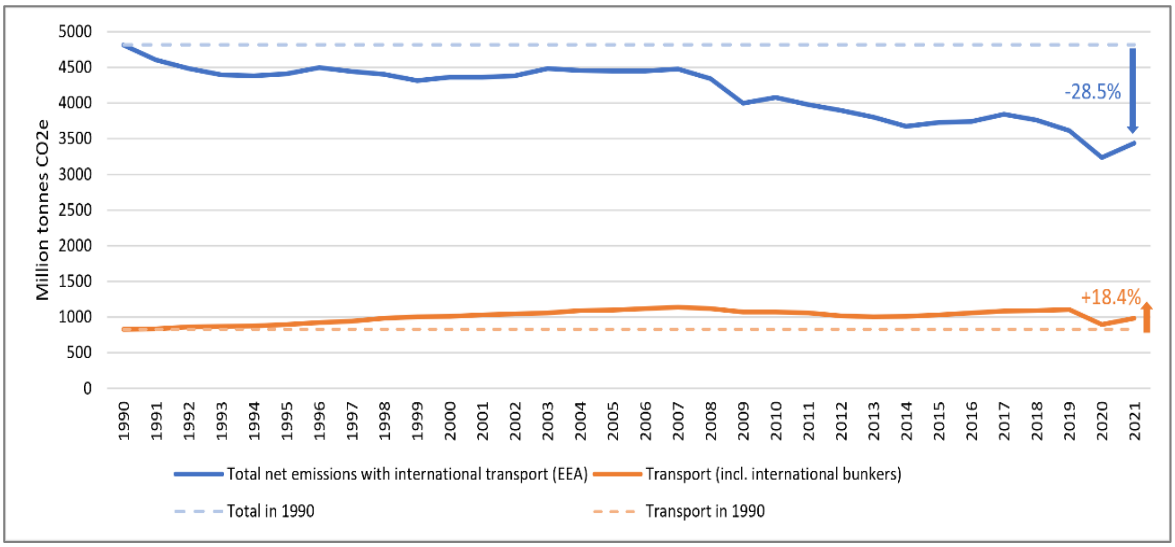
Between 1990 and 2021 overall net GHG emissions in the EU-27[1] have fallen by 28.5%.[2] In most sectors, the GHG emissions decreased. However, those of transport (including international bunkers) have risen by 18.4%. Consequently, transport's share of GHG emissions has grown. The exhaust emissions of transport (including international bunkers) were responsible for 28.5% of total GHG emissions in the EU-27 in 2021, compared to 17.2% in 1990. The transport sector is a major contributor to GHG emissions in the EU-27 because of its strong dependence on fossil fuels (Figure 5.1).

[1] EU-27 refers to the EU with its 27 Member States, as of 1 February 2020.

[2] This includes GHG emissions from land use, land use change, and forestry; indirect CO_2 emissions; and international bunkers.

Figure 5.1. Total Net Greenhouse Gas Emissions and Greenhouse Gas Emissions from Transport in the EU-27 – Million Tonnes of Carbon Dioxide Equivalent and Change between 1990 and 2021

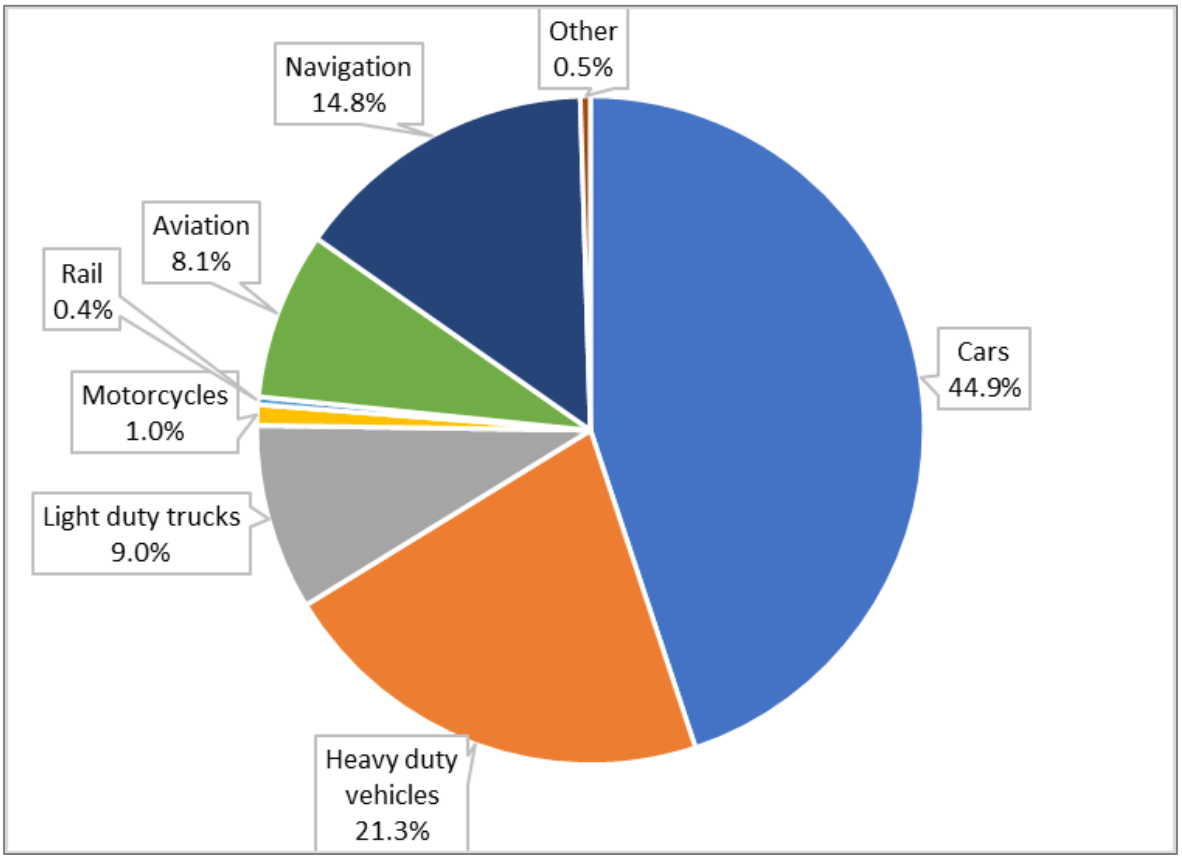
(%)



CO_2e = carbon dioxide equivalent; EEA = European Environment Agency;
Source: EEA (2023c).

Within the whole transport sector (including international aviation and navigation), car transport accounted for 44.9% of GHG emissions in 2021 (Figure 5.2). Other important modes were heavy-duty vehicles (HDVs) (21.3%), navigation (14.8%), light-duty trucks (9.0%) and civil aviation (8.1%) (EEA, 2023c).

Figure 5.2. Share of Transport Subsectors in Greenhouse Gas Emissions by Transport (Including International Bunkers) in the EU-27 during 2021



Source: EEA (2023c).

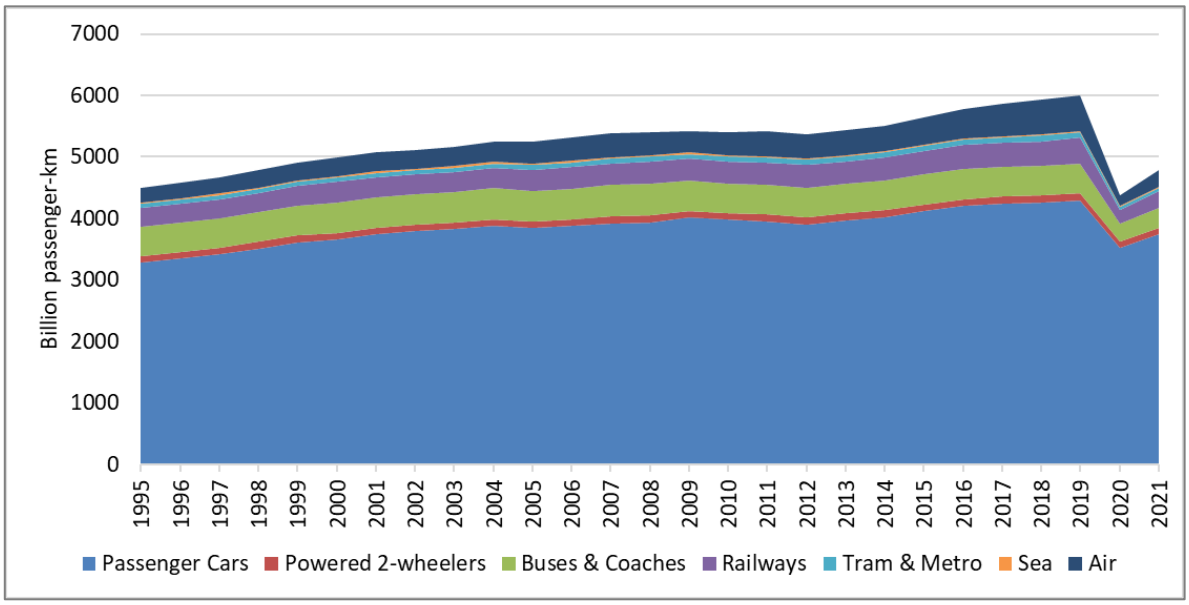
A decomposition analysis by the European Environment Agency (EEA) of the GHG emissions of passenger cars and heavy-duty trucks in 2000–2019, showed that the main driver of the increase in emissions for these two vehicle types between 2000 and 2019 was the growth in transport activity, strengthened by their growing dominance in passenger and freight transport, respectively (see Section 1.2). This outdid the positive effects on GHG emissions achieved by a higher energy efficiency and larger uptake of biofuels and led to a net increase in emissions (EEA, 2022).

1.2. The Transport Sector in the EU-27

In 2021 the demand for motorised passenger transport was estimated to be 4,780 billion passenger-km (Figure 5.3). Passenger cars were the dominant mode with a share of 78.3% (compared to 73.3% in 2000). The motorisation rate in 2021 was 597 cars per 1,000 inhabitants. Buses and coaches had a share of 6.8% and the share of heavy rail was 5.6%. Domestic and intra-EU air transport had a share of 5.7%. The share of light rail and sea transport was 1.2% and 0.3% respectively.

Figure 5.3. Passenger Transport Volumes by Mode in the European Union-27, 1995–2020

(billion passenger-km)



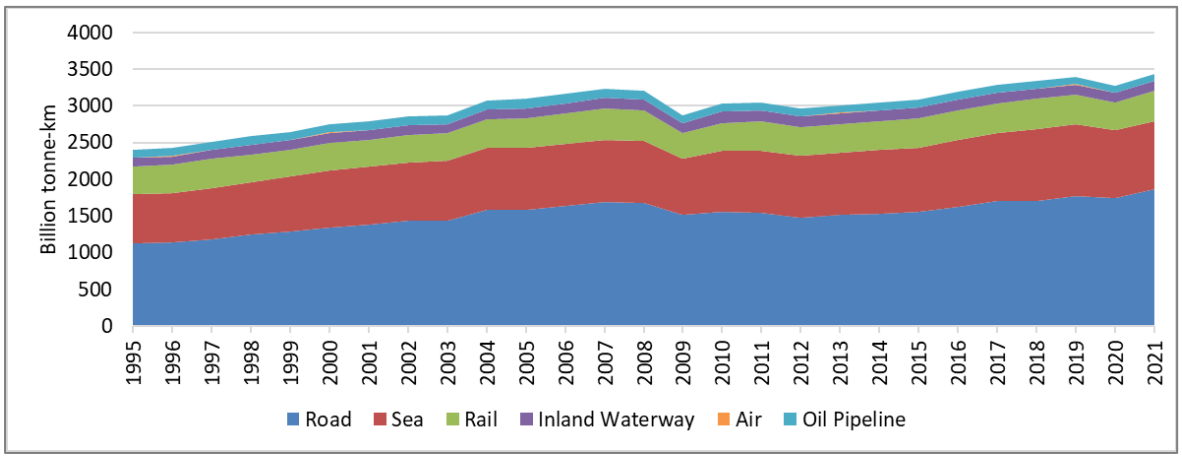
km = kilometre.

Note: Sea and air: only domestic and international intra-EU-27 transport.

Source: EC (2023b).

In 2021 3,432 billion tonne-km were transported by freight transport in the EU-27 (Figure 5.4). Road transport accounted for more than half of this (54.3%, compared to 48.8% in 2000), domestic intra-EU maritime transport had a share of 27.2%. The shares of the other modes were: 11.9% for rail, 4.0% for inland waterways, 2.6 % for oil pipelines and 0.1% for air transport.

Figure 5.4. Freight Transport Volumes by Mode in the European Union-27, 1995–2020



km = kilometre.
Note: Sea and air: only domestic and international intra-EU-27 transport.
Source: EC (2023b).

Table 5.1 presents additional information for aviation, for the flights at EU-27+European Free Trade Association (EFTA) airports.[3] In 2019 passenger and freight transport by air was considerably higher than in 2005. Passenger-km grew by 90% and tonne-km by 60%. In 2020 and 2021 the sector was affected considerably by the coronavirus disease (COVID-19) pandemic, with the largest impact for passenger transport.

[3] The EFTA consists of four countries: Iceland, Liechtenstein, Norway and Switzerland.

Table 5.1. Evolution of Air Traffic, Fuel Burn, and Net Carbon Dioxide Emissions at European Union-27 And European Free Trade Association Airports

(millions and (% change to 2005))

	2019	2020	2021
Flights	9.3 (+15%)	4.1 (-49%)	5.1 (-37%)
Passengers	818 (+71%)	229 (-52%)	304 (-36%)
Passenger-km	1484 (+90%)	389 (-50%)	509 (-35%)
Cargo (tonne-km)	8.4 (+60%)	7.3 (+39%)	n/a
Fuel burn [(i)] (tonnes)	46.5 (+34%)	20.1 (-42%)	20.4 (-41%)
CO2 emissions [(i)] (tonnes)	147 (+34%)	64 (-42%)	65 (-41%)
Net CO2 emissions [(i, ii)] (tonnes)	114 (+4%)	64 (-42%)	65 (-41%)

CO_2 = carbon dioxide; EFTA= European Free Trade Association; ETS = Emission Trading System; EU = European Union; km = kilometre.
Notes:
[(i)] The figures are for all flights departing from EU-27 or EFTA airports (flights coming from outside EU-27 or EFTA are not included);
[(ii)] The net CO2 emissions indicator takes into account emission reductions from the EU ETS.
Source: EASA, EEA, and Eurocontrol (2023).

The Climate Law does not set a separate reduction target for transport. As indicated in Section 1.1 the sector is an important source of emissions. Moreover, the EU Reference Scenario 2020 projected that without additional actions the GHG emissions of the transport sector would fall by only 22% by 2050 compared to 1990 (EC, 2021a). The European Green Deal points out that "to achieve climate neutrality, a 90% reduction in transport emissions is needed by 2050" (EC, 2019b).[4] The Sustainable and Smart Mobility Strategy (EC, 2020) sets out a roadmap for a sustainable and smart future for European transport, with an action plan towards an objective to deliver this. The following milestones are set:

- By 2030:
    - at least 30 million cars with zero emissions will drive on European roads. To put this in perspective, in 2022 the number of battery electric cars in the EU-27 numbered 3.1 million or 1.19% of the total car fleet (EAFO, 2023);

[4] Based on the EU Reference Scenario 2020 (EC, 2021a), without additional policies, the transport emissions would exceed this target by approximately 485 million tonnes of CO_2. Emissions include international aviation but exclude international maritime transport.

    - 100 European cities will be climate neutral;
    - high-speed rail travel will double;
    - scheduled collective travel for trajectories of less than 500 km should be carbon neutral;
    - automated mobility will be available at large scale; and
    - zero-emission maritime vessels will be market ready.
- By 2035:
    - zero-emission large aircraft will be market ready.
- By 2050:
    - almost all cars, light commercial vehicles, buses, and new HDVs, will be zero-emission;
    - freight transport by rail will double; and
    - a fully operational, multimodal Trans-European Transport Network will exist for sustainable and smart travel with high-speed connectivity.

The strategy indicates that to reach the climate targets "all policy levers must be pulled: (i) measures to significantly reduce the current dependence on fossil fuels (by replacing existing fleets with low- and zero-emission vehicles and boosting the use of renewable and low-carbon fuels); (ii) decisive action to shift more activity towards more sustainable transport modes (notably increasing the number of passengers travelling by rail and commuting by public transport and active modes, as well as shifting a substantial amount of freight onto rail, inland waterways, and short sea shipping); and (iii) internalisation of external costs (by implementing the 'polluter pays' and 'user pays' principles, in particular through carbon pricing and infrastructure charging mechanisms)."

The first policy lever is discussed in Sections 3.2 and 3.3. Some of the milestones defined above relate to the second policy lever – modal shift. Concerning the internalisation of external costs, the strategy states that rail and waterborne-based intermodal transport will be able to compete on an equal footing with road-only transport in the EU by 2030 (in terms of the share of external costs internalised). In addition, it specifies that all external costs of transport within the EU should be covered by transport users by 2050 at the latest.

In July 2021, the European Commission published a set of detailed legislative proposals, called the Fit for 55 or Delivering the European Green Deal package, to achieve the targets agreed in the European Climate Law. It contained new legislative proposals as well as proposals for the revision of existing EU legislation. Since the transport sector is responsible for a considerable share of GHG emissions, greening that sector is

crucial. Therefore, the Fit for 55 package also contained proposals that were aimed specifically at the transport sector. After the Russian invasion of Ukraine, the European Commission took further initiatives, including the REPowerEU proposal, with even more ambitious targets for the share of renewable energy.

This report aims to give an overview of the EU policies for the transition to green energy in the transport sector. Section 2 will present a general overview of the main EU policies for the decarbonisation of the transport sector. Section 3 will then discuss four policies in more detail, namely the EU Emission Trading System (EU ETS) and its future extension to road transport and buildings; the EU CO2 emission performance standards for cars, light commercial vehicles, and HDVs; the EU's renewable energy policy (with a focus on aviation); and the Social Climate Fund.

2. A General Overview of European Union Policies for the Decarbonisation of the Transport Sector

This section gives a general overview of EU policies for the decarbonisation of the transport sector. Table 5.2 summarises a selection of EU legislation that is currently in place or which has been adopted for the future and the strategies used to reduce GHG emissions. The first section lists regulations and directives that have a broader scope than transport but that form the general framework for decarbonisation, including that of passenger and freight transport. The second section lists selected legislation that is more specific to transport.

Table 5.2. Overview of Selected European Union Directives and Regulations for the Decarbonisation of Transport

	Type of Policy Instrument	Avoid/Shift/Improve
General directives and regulations		
Effort Sharing Regulation	General: Target setting for emission reductions	n.a.
Energy Efficiency Directive	General: Target setting for energy efficiency	n.a.
Energy Taxation Directive	Rules for taxation (market-based policy)	A/S/I: via impact of taxation on energy and electricity prices

EU Emission Trading System (current scope)	Cap-and-trade (tradeable emission permits) – market-based policy	A/S/I: via impact of price of emission permits on energy and electricity prices
Renewable Energy Directive	Blending mandate / GHG intensity reduction target	I
Social Climate Fund	Funding	n.a.
Directives and regulations with specific provisions for transport		
General		
Toll Directive	Rules for pricing road transport per km (market-based policy)	A/S/I: via toll
Vehicles		
CO2 emission performance standards	Emission standards for vehicles	I
Energy used by transport		
Future EU Emission Trading System for road transport, buildings and other sectors	Cap-and-trade (tradeable emission permits) – market-based policy	A/S/I: via impact of price of emission permits on road transport fuels
Alternative Fuel Infrastructure Directive and Regulation	Target setting for alternative fuel infrastructure provision	I

A = avoid; I = improve; n.a. = not applicable; S = shift.
Source: Author's summary.

In the case of the Effort Sharing Regulation (ESR), the Energy Efficiency Directive and the legislation regarding the alternative fuel infrastructure targets that are set must be met at EU or Member State level. In the other cases the type of policy instruments covered by the legislation is diverse. The CO_2 emission performance standards define the reduction in the CO_2 emissions per km that should be reached at fleet level for the new vehicles that are sold in the EU. The Renewable Energy Directive imposes blending mandates, or alternatively puts forward a GHG intensity reduction target. In addition, there are market-based instruments, i.e., policy instruments that use markets, prices,

or other economic variables to provide incentives to reduce the GHG emissions. The Energy Taxation Directive and the Toll Directive set rules for the taxation of energy and the charging of road use, respectively. The EU Emission Trading System and its future extension to road transport and buildings are an example of a so-called cap-and-trade scheme, with tradeable emission permits. Finally, the Social Climate Fund provides funding with the aim of ensuring that the transition is fair.

The last column of the table categorises the legislation according to the Avoid-Shift-Improve framework. This framework is based on Dalkmann and Brannigan (2007) and is frequently applied by the EEA in its classification of policy strategies. In the case of transport,

- 'avoid' strategies are directed towards reducing the number or length of trips;
- 'shift' strategies aim for a modal shift towards more environmentally friendly transport modes. Together with the avoid strategies, they address transport demand as a determinant of GHG emissions; and
- 'improve' strategies are concerned with improving vehicle and fuel technologies to be more environmentally friendly.

The market-based policy instruments have the potential to act both on transport demand, modal choice (avoid and shift), and vehicle/fuel choice (improve). The CO2 emission performance standard and the blending mandate for renewable fuels are improve strategies aimed at a better environmental performance of vehicles and transport energy.

In addition to the legislation in table 5.2, a broad range of other policies is also in place at EU level as well as Member State level to optimise transport volumes and modal choice (avoid/shift strategies). These include, financial support to sustainable modes, the removal of administrative and technical barriers for sustainable modes, the support for digital solutions and initiatives, and programmes to stimulate sustainable urban mobility (EEA, 2022).

Section 3 will discuss in more detail four policies for the decarbonisation of transport. Before turning to that discussion, Table 3 summarises the main elements of the other legislation that was presented in Table 2. This covers the policy framework before Fit for 55, and the initiatives included in the Fit for-55 package and afterwards, some of which have already been transposed in legal acts and some are still in the legislative process.

Table 5.3. Summary of the Main Elements of the Effort Sharing Regulation, the Energy Efficiency Directive, the Energy Taxation Directive, and the Toll Directive

Current Legislation or Legislation Before Fit for 55			Fit for 55 or Afterwards
Regulation/Directive	Objectives for 2030 and Main Elements	Relevance for Transport	Status Of Legislative Process (1/12/2023) And Changes Relevant for Transport
Effort Sharing Regulation Regulation (EU) 2018/842	The Regulation covers all GHG emissions that are not covered by the EU ETS or the LULUCF Regulation. The objective at EU level is as follows: GHG emission reduction in non-ETS sectors by 30% compared to 2005. Apart from the objective at EU level the regulation also sets binding emission reduction objectives per Member State.	Transport is one of the sectors covered by the regulation. There is no separate objective for transport.	Proposal for amendment (EC, 2021e) Result: Regulation (EU) 2023/857 (19/4/2023) The objective has been made more ambitious compared to the objective of Regulation 2018/842. - a reduction in GHG emissions, by 2030, of 40% compared to 2005 (EU level); and - stricter targets than in the previous regulation for the Member States. Transport continues to be covered by the amended regulation.
Energy Efficiency Directive Directive 2012/27/EU, amended by	It sets as a target an improvement in energy efficiency by at least 32.5% (compared to the energy outlook	The energy consumption by transport is part of total energy consumption.	Proposal for recast: COM(2021) 558 final After the Russian invasion of Ukraine the proposed targets were

Current Legislation or Legislation Before Fit for 55			Fit for 55 or Afterwards
Regulation/Directive	Objectives for 2030 and Main Elements	Relevance for Transport	Status Of Legislative Process (1/12/2023) And Changes Relevant for Transport
Directive (EU) 2018/2002	for 2020), at EU level. The final energy consumption(*) should be reduced by 0.8% per year in the period 2021–2030.	There is no separate target for transport. For the provisions about the energy efficiency in final energy consumption, each Member State can decide to include transport or not.	made more ambitious in the REPowerEU Plan. Result: Directive (EU) 2023/1791 (13/9/2023) - Reduction of energy consumption by at least 11.7% by 2030 (compared to the 2020 EU Reference Scenario); - Maximum final energy consumption in 2030: 763 Mtoe. - Indicative maximum primary energy consumption in 2030: 992.5 Mtoe
Energy Taxation Directive Directive 2003/96/EC	The directive determines the EU rules and minimum excises that Member States should apply to energy products and electricity.	Transport uses energy products and electricity that are covered by this directive. Most Member States apply tariffs that are well above the current minimum levels.	Proposal for recast: COM(2021) 563 final The proposal includes amongst other things: - a new structure of taxation tariffs, based on the energy content and the environmental characteristics of the fuels and electricity (highest tariffs for the most polluting fuels); - a broader tax base that includes more products in the scope of the directive and abolishes

Current Legislation or Legislation Before Fit for 55			Fit for 55 or Afterwards
Regulation/Directive	Objectives for 2030 and Main Elements	Relevance for Transport	Status Of Legislative Process (1/12/2023) And Changes Relevant for Transport
			some exemptions and rebates. Status: The legislative process is ongoing.
Toll Directive Directive (EU) 2022/362 amending Directives 1999/62/EC, 1999/37/EC and (EU) 2019/520		The directive sets the general conditions for the European toll and user charges imposed on road vehicles. It covers both light- and heavy-duty vehicles. The 2022 Directive expresses a preference for distance-based charges rather than time-based charges. The latter should be phased out. The 2022 Directive introduces the differentiation according to the CO2 emissions of the vehicles and allows for a favourable	n.a.

Current Legislation or Legislation Before Fit for 55			Fit for 55 or Afterwards
Regulation/Directive	Objectives for 2030 and Main Elements	Relevance for Transport	Status Of Legislative Process (1/12/2023) And Changes Relevant for Transport
		treatment of zero-emission vehicles.	

CO_2 = carbon dioxide; EC = European Commission; EU = European Union; GHG = greenhouse gas; LULUCF =land use, land-use change, and forestry; Mtoe = million tonnes of oil equivalent; n.a. = not applicable.
Notes:
(*) Primary energy consumption measures total domestic energy demand, while final energy consumption refers to what end users actually consume. The difference relates mainly to what the energy sector needs itself and to transformation and distribution losses (Eurostat, no date).
Source: Author's summary.

3. A Deeper Dive into Four European Union Policies

In this section the following decarbonisation policies are discussed in more detail:

- The EU ETS and its future extension to road transport and buildings;
- The CO_2 emission performance standards for cars, light commercial vehicles and heavy-duty trucks; and
- Renewable energy in transport, with a focus on aviation.

In addition, the expected role of the Social Climate Fund is discussed.

3.1. The European Union ETS and its Future Extension to Road Transport and Buildings

3.1.1. General Discussion

The EU ETS is a cornerstone of the EU's climate policy. It was introduced in 2005 with Directive 2003/87/EC. Over time, it has undergone several revisions to ensure its alignment with the EU climate policy objectives. The Fit for 55 package contained a proposal for the amendment of the EU ETS (COM(2021) 551 final) which resulted in the adoption of Directive (EU) 2023/959 on the EU ETS and Regulation (EU) 2023/957 on the inclusion of maritime transport activities in the EU ETS. The former also introduces a separate system for road transport, buildings, and other sectors – the Emissions Trading System 2 (ETS2). Table 5.4 summarises some main elements of the two systems.

Table 5.4. The European Union Emission Trading Scheme

	EU Emissions Trading Scheme	EU Emissions Trading Scheme 2 (separate system)
Sectors covered and geographical scope	1,000 heavy energy-using installations, including power stations and industrial plants in the European Economic Area (EU-27 & Iceland, Liechtenstein and Norway) Aviation (since 2012), currently only flights within European Economic Area and flights to the UK Gradual phase-in of emissions from maritime transport between 2024–2026 (certain vessels); 100% of emissions between European ports and while at berth in European ports; 50% of emissions for voyages to/from European ports Link with the Swiss ETS	Fuel distributors for road transport, buildings and additional industrial sectors
Period	From 2005 onwards, with several revisions and extension of sectors covered Provisions of Directive (EU) 2023/959 on the EU ETS and Regulation (EU) 2023/957 will apply as from 2024	From 2027 onwards (possibly 2028 in case of high energy prices)
Target reduction for 2030	-62% compared to 2005 Linear reduction factor: - 2024–2027: 4.3% - 2028–2030: 4.4%	-42% compared to 2005 Linear reduction factor: - To 2027: 5.1% - 2028–2030: 5.38%
Other aspects	Gradual phasing out of free allowances, complemented by	No free allowances Social Climate Fund

	EU Emissions Trading Scheme	EU Emissions Trading Scheme 2 (separate system)
	introduction of Carbon Border Adjustment Mechanism Strengthening of Market Stability Reserve to absorb any price shocks from the upcoming changes to the ETS	

EU = European Union, ETS = Emissions Trading Scheme.
Source: EC (no date: a); EU (2023a); and EU (2023c).

The EU ETS operates in the European Economic Area (EU-27 + Iceland, Liechtenstein, and Norway). The United Kingdom stopped participating with the end of EU membership and established its own system.[5] Since 2020 Switzerland's ETS is linked to the EU ETS (EC: no date. b).

The EU ETS currently regulates the emissions of approximately 10,000 companies and covers the electricity and heat generation plants, energy-intensive industry and commercial flights within the European Economic Area.[6] With the recent reform the system will be extended to maritime transport, for which it will be introduced gradually between 2024 and 2026. This will cover all emissions from certain vessels docking in EU harbours from intra-EU voyages and 50% of non-EU voyages.

Both the EU ETS and the ETS2 are cap-and-trade systems where a cap limits the total amount of certain GHGs that can be emitted by the actors covered by the schemes. The cap represents the total emission allowances and is reduced over time. Under the new directive the emissions should be reduced by 62% by 2030 (instead of 43% before) compared to 2005. To achieve this reduction, the number of allowances will be reduced following a linear path, with an annual reduction factor of 2.2% until 2023, 4.3% from 2024 and 4.4% from 2028. The reform also provides increased funding for decarbonising the ETS sectors.

Currently, the allowances are partly auctioned and partly distributed for free depending on the industries' risk of carbon leakage. In the future the free allowances will be

[5] This implies that the price of emission allowances can be different in the two systems. Such differences are indeed observed, as shown in Ember (2023). For example, in large part due to the different economic context in the EU-27 and the UK, on 21 September 2023, the cost per tonne of CO2 was approximately €84/tonne in the EU ETS and €39/tonne (£34/tonne) in the UK ETS.
[6] The UK ETS covers UK domestic flights, flights from the UK to the European Economic Area, and flights between the UK and Gibraltar.

gradually phased out, together with the introduction of the carbon border adjustment mechanism (CBAM). The CBAM aims to avoid carbon leakage. It is a pricing system that will apply to energy-intensive products imported into the EU.

At the end of each year, the industries must surrender enough allowances to cover their emissions, or heavy fines apply. If an installation reduces its emission and has spare allowances, it can keep them to cover future emissions or sell them to another installation. The number of allowances is limited through the Market Stability Reserve (MSR), which allows for a better matching between the supply of allowances to be auctioned and demand. The recent reform prolongs the MSR's doubled intake rate that applied until 2023 and included further refinements to it.

The future ETS2 will be a separate self-standing scheme for fuel distribution for road transport, buildings, and additional sectors. By adding ETS2 to transport, the Commission aims to contribute to the internalisation of climate externalities in transport and level the playing field between fossil fuelled vehicles and electric ones.

To minimise the transaction costs, the ETS2 will regulate fuel distributors rather than the end consumers (households, vehicle drivers, and companies in the additional sectors). The sectors covered by the ETS2 will have to reduce their emissions by 42% by 2030 compared to 2005. The linear reduction factor of the emissions cap will be set at 5.1% from 2024 and 5.38% from 2028. All allowances will be auctioned. The fuel distributors will need to obtain enough allowances and surrender them to cover the GHG emissions from the combustion of the fuel they supply to the market (EPRS, 2023). This will apply from 2027 (or at the latest in 2028 in the case of high energy prices). The financial incentive to the end users will be given by the CO2 ETS2 price which would be reflected in the fuel price depending on its carbon intensity. The intention is to provide additional financial incentives to use energy-efficient vehicles, low-carbon fuels, and to make more sustainable mobility choices. As the ETS2 is a separate system, the price of the emission allowances is likely to be different from, and higher than, that of the EU ETS. Economic theory indicates that the cost-effectiveness of two separate systems is lower than of an integrated system (Ochelen, Mayeres and Proost, 2021). However, the decision to have a separate system was taken to reduce the risk to the existing system.

3.1.2. Complementarity with Other European Union Legislation for the Decarbonisation of Transport

While currently, the EU ETS only covers part of the transport sector, namely commercial flights within the European Economic Area, it also indirectly covers part of the well-to-tank emissions of other transport modes. As the EU ETS includes power generation in its scope, it is an essential way to control the well-to-tank GHG emissions of electric trains and electric road vehicles. Driving an electric car instead of a gasoline or diesel car, avoids the CO_2 emissions of the gasoline and diesel car. This benefit is not undone

by the extra CO_2 emissions of the electricity production for the electric car, as the power generation sector falls under the EU ETS cap, and therefore these emissions will be compensated for by a reduction of CO2 emissions elsewhere in the EU ETS. With the higher uptake of EVs that is expected for the future, given the stricter CO2 emission performance standards (see Section 3.2), a larger part of transport will therefore indirectly fall under the current EU ETS, even without an extension of its scope. The EU ETS also regulates the well-to-tank emissions associated with fuel production by regulated refineries.

For aviation within the European Economic Area and, in the future, the maritime sector, the EU ETS is the main EU decarbonising policy. In the future this will be complemented by the blending mandate on renewable fuels (see Section 3.3).

The future ETS2 for road transport and buildings gives a further incentive for the decarbonisation of road transport, which will strengthen the renewable energy policy and the CO_2 emission performance standards. It will coexist with the ESR and aims to contribute to the cost-effective achievement of the targets set by that regulation.

Whereas the main instrument tackling emissions from road transport is the CO_2 emission performance standard regulation, the ETS2 should be considered as a complementary measure. Ochelen, Mayeres, and Proost (2021) discuss a number of reasons for this. Emission performance standards are expected to secure long-term emission reductions, which will come at the cost of the required investments and will, in turn, put downward pressure on ETS2 allowances prices. The standards, however, do not address all CO_2 emissions from road transport. Indeed, with the standards:

- the focus is only on the new car fleet, but they provide no incentive for drivers of the existing car fleet to change their driving behaviour;
- a rebound effect can be expected: *ceteris paribus*, drivers of new, fuel-efficient internal combustion vehicles are incentivised to use their car for more, and longer trips, as driving becomes relatively cheaper, reducing the expected environmental benefit of the fuel efficiency improvement. As the share of electric cars increases, this rebound effect on emissions will become smaller;[7]
- there is also some empirical evidence that car manufacturers have adapted to the standard as it is currently designed by making their car models heavier, which counteracts part of the CO_2 gains; and
- drivers of plug-in hybrid electric vehicles (PHEV) can still decide how much to drive in electric charge-depleting mode (given the electric range of their vehicle).

[7] It will still exist, however, for other transport externalities such as congestion, accidents, or non-exhaust emissions of air pollutants.

A carbon price via the ETS2 (or via fuel taxation[8]) contributes to curbing these problems: it gives an incentive to all vehicle users to lower their CO_2 emissions via all possible abatement options. These include reducing the number of vehicle kilometres they drive and choosing to drive more efficient vehicles, (also to scrap older unregulated vehicles) and/or to use less carbon intensive fuels. However, a similar incentive is also given by the implicit or explicit carbon pricing via fuel taxation and the CO_2 differentiation of road charges that the Toll Directive allows for. Therefore, there is an overlap between the instruments, which decreases the possible efficiency gains of the ETS2. In the case of fuel taxation this might be tackled by reducing fuel taxes when the ETS2 starts. This is, however, not foreseen currently.

3.1.3. Performance up to Now

The EEA publishes the EU ETS data viewer on its website (EEA, 2024). Each year the trends and projections in the EU ETS are also reported for the EEA. According to the edition for 2022, the emissions from stationary installations covered by the EU ETS have fallen by 36% between 2005 and 2021. This is mainly because of emission reductions in power generation, where the share of renewables has increased over time. Emissions in the largest industrial sectors (iron and steel, cement and lime, and refineries) have also fallen but at a smaller rate. There has been a reduction in the number of allowances that are allocated for free to the stationary sectors. The largest reduction took place between 2012 and 2013, with the transition from the second to the third trading period, when free allocation was no longer possible for power generation. The share of auctioned allowances has increased over time, as have the revenues from auctioning, also due to the increase in the price of the carbon permits (Nissen et al., 2022).

For aviation within the European Economic Area, the verified emissions increased between 2013 and 2019. In 2020 they decreased substantially, as the sector was hit hard by the COVID-19 pandemic. In 2021 air travel had not fully recovered, leading to emissions that were higher than in 2020 but lower than in 2019. In 2013–2019 the verified emissions were higher than the allowances for aviation, so that emission allowances needed to be bought from the non-aviation ETS sectors. In 2020 the verified emissions were below the aviation allowances, and in 2021 they were almost equal (Nissen et al., 2022).

The price of EU carbon permits has increased considerably over the past years, going from below €10/tonne in 2018 to between €80–€100/tonne in 2023 (Ember, 2023). This evolution is related to the introduction of the MSR, reforms in the ETS in the fourth

[8] The existing fuel taxes take up this role already (even if they do not perfectly reflect the carbon content of the different fuels, and they are not the same in all Member States) as in many Member States they imply relatively high carbon prices for road transport.

trading period and the adoption of the EU Climate Law, followed by the Fit for 55 package, which showed the commitment of the EU to achieve its climate goals.

3.1.4. Expected Economic and Social Impacts from the Emission Trading System 2 and the Extension to Maritime Transport

As the focus of this report lies in transport, the expected economic and social impacts are discussed for the future extension of the ETS to road transport and buildings and the extension to the emissions from the maritime sector. The discussion is based on the results of the Impact Assessment (IA) that was prepared by the European Commission for the draft reform of the ETS (EC, 2021d).

For the extension of the maritime sector, emission reduction in 2030 is expected to be 45 metric tonnes of CO_2 equivalent compared to the total emissions from the sector of 138 metric tonnes in the baseline. About one quarter is expected to be realised in the sector itself, and the rest via the buying of allowances from non-maritime ETS sectors which will consequently reduce their emissions. Within the sector itself, the IA predicts that the emission reductions will be realised mainly by improvements in energy efficiency, and not from the uptake of sustainable fuels, as the EU ETS price is not sufficiently high in 2030 to cover the price gap between conventional and sustainable fuels.

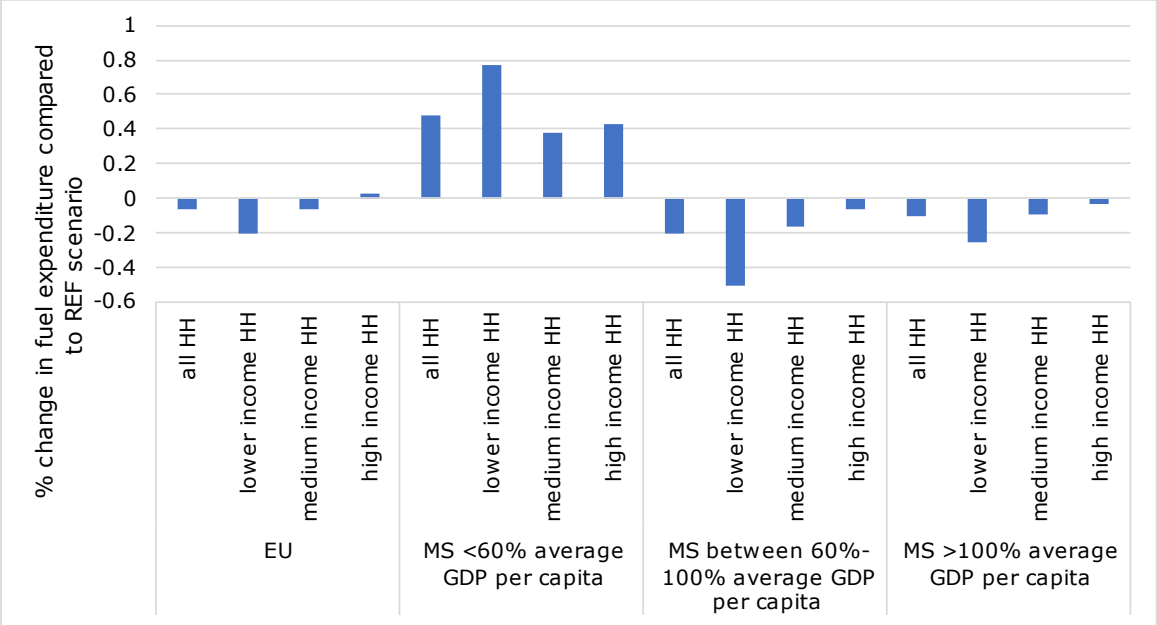
The IA projects that the net social benefit of the extension to maritime transport is positive, with a value of €1.01 billion. Shipping activities would go down by 0.9%, and costs would increase by 7.0%. The extension would generate an additional €2.4 billion in auction revenues (assuming an allowance price of €45/tonne). The impact on the different household income groups is negative but expected to be very small.

Given the emission reduction targets that are set by the Climate Law and the ESR, the ETS2 is considered to be a way to contribute to the cost-effective realisation of these targets, complementary to other policies (see also Section 3.1.2), though the incentives given will be different across Member Stares, given the range of fuel taxes across the EU. The IA points out that the ETS2 will affect individual spending on transport (and heating) fuels in the short or medium term, until the emission abating technologies fully realise their potential, and that this will have implications for social acceptability.

Figure 5.5 presents the projected change in fuel spending compared to the reference scenario per income group, for the EU as a whole and three groups of Member States: those with a gross domestic product (GDP) per capita less than 60% of the EU average, those whose GDP per capita is between 60% and 100% of the EU average, and those with an above-average GDP per capita. This is the case in the MIX scenario, that combines the ETS reform with other elements of the Fit for 55 package. Spending on fuel as a percentage of income is estimated to decrease by 0.12 percentage points on average. This is because the other measures in the MIX scenario help to reduce the

consumption of fossil fuels. The changes are unevenly distributed amongst income groups and Member States. However, in all cases they are estimated to be below one percentage point. According to the IA, the revenues raised should be sufficient to tackle the social and distributional concerns, together with other funds. Auction revenues could be used for the Innovation Fund but also to address social and distributional concerns. With the aim to shield vulnerable households, microbusinesses, and transport users from the costs of ETS2, the Fit for 55 package also includes a new Social Climate Fund (see Section 3.1.5).

Figure 5.5. Estimated Change in Fuel Expenditure as a Percentage of Household Consumption Expenditures due to Emission Trading System 2 for Transport and Buildings per Income Group, and Member State Level of Gross Domestic Product per Capita – MIX Scenario Compared to the Reference Scenario



> = greater than; < = less than; EU = European Union; GDP = gross domestic product; HH = household; MS = Member State; REF = reference.
Source: EC (2021d).

The EU ETS2 is expected to have a small impact on total employment, but to lead to changes in the sectoral composition of employment and in the skills that are needed. With a carbon price of €48/tonne, the diesel price at the pump is expected to increase by 10% to 14% based on the price in 2021, depending on the fuel tax level in the Member States, and that of gasoline would rise by 7% to 12%. According to the IA the proportion of spending on transport is typically the highest for the lower-middle- and middle-income groups, which means they would be hit the hardest on average (people in the lowest income group have less access to a private vehicle). Still, this is only indicative, as the variability in car use within the income groups is large, and even in the poorest

income group there are households who drive frequently, and who would therefore have a large increase in costs (Heyndrickx, Vanheukelom and Proost, 2021). The IA points out that 'the social impacts could be mitigated with a multi-faceted policy approach at EU and national levels.' (EC, 2021d: 129). For this purpose, the Fit for 55 package also contains a proposal for a Social Climate Fund, which will be discussed in the next section.

3.1.5. The Social Climate Fund

The Social Climate Fund was recently adopted by means of Regulation (EU) 2023/955. The fund is established for the period from 2026 to 2032. It will be mainly funded by revenue from the EU ETS2 up to a maximum amount of €65 billion, to be supplemented by national contributions. The Member States must cover at least 25% of the estimated total costs of their plans themselves. The Social Climate Fund aims to give financial support to the EU Member States for the measures and investments included in their Social Climate Plans. The regulation specifies, amongst other things, the allocation rules to divide the budget amongst the Member States, the elements that should be included in the Member States' Social Climate Plans, the principles governing the fund, the eligible measures, and the assessment of the plans by the European Commission. The Social Climate Fund is additional to other EU funds, such as the Modernisation Fund, Just Transition Fund, European Structural and Investment Funds, Recovery and Resilience Facility, and InvestEU, as well as national or regional funding. In its opinion on the Social Climate Fund, the European Court of Auditors pointed out the importance of coordination and complementarity of the various funding sources, as well as the risk of double funding (ECA, 2020).

The purpose of the Social Climate Fund measures and investments is to help vulnerable households, microenterprises, and transport users to cope with the consequences of the EU ETS2 and other climate measures in energy and transport. It focuses particularly on households in energy and/or transport poverty. The support can take the form of temporary direct income support and measures and investments to improve the energy efficiency of buildings, decarbonisation of heating and cooling of buildings, and to improve access to zero- and low-emission mobility. The purpose is not to compensate vulnerable households and microenterprises for additional costs, but to support investments to reduce emissions and relieve the CO_2-related burden. In this way, the financial consequences of the climate policies will be reduced and households will be more resilient to any future price increases.

The regulation specifies the maximum budget allocation to each Member State and considers the following variables:

- the population at risk of poverty living in rural areas;
- the CO_2 emissions from fuel combustion by households;

- the percentage of households at risk of poverty with arrears on their utility bills;
- the total population;
- the Member State's gross national income per capita, measured in purchasing power standard; and
- the share of reference emissions from road transportation, commercial and public services and the residential sector.

This mix is chosen to reduce the negative distributional consequences of the EU climate policy.

3.2. The Carbon Dioxide Emission Performance Standards for Cars, Light Commercial Vehicles, and Heavy-Duty Vehicles

3.2.1. General Discussion

CO2 emissions standards have been applied in Europe since 2008, with a voluntary agreement between the European Commission and the European Automobile Manufacturers Association (ACEA) on emissions from new cars. In 2009, this was replaced by mandatory targets for cars, which were tightened over time, and in 2011 a similar approach was introduced for new light commercial vehicles. From January 2020, Regulation (EU) 2019/631 came into force. It covered new passenger cars and new light commercial vehicles. It defined EU fleet-wide targets for 2025 and 2030 as a percentage reduction from the 2021 baseline. These are:

- for new passenger cars: a 15% reduction from 2025 and a 37.5% reduction from 2030; and
- for new light commercial vehicles: a 15% reduction from 2025 and a 31% reduction from 2030.

The binding CO_2 targets apply to the average emissions of each manufacturer's new registered vehicles across the EU, rather than to each individual new vehicle or country. The regulation also includes sales benchmarks for zero- and low-emission vehicles (ZLEVs). From 2025, a manufacturer's specific CO_2 emissions target is relaxed if its share of registered ZLEVs exceeds the benchmarks.

The system provides flexibility for manufacturers to decide how to comply and thus aims to increase the cost-effectiveness of achieving the standards. They can invest in research and development (R&D) to increase the fuel efficiency of cars with an internal combustion engine, or to make ZLEV cheaper and/or better performing; they can

increase the share of smaller and more fuel-efficient cars; or they can pool with other manufacturers.[9]

Laboratory tests are used to assess whether CO_2 emissions comply with the targets. In the past, it was found that manufacturers partially met their targets by optimising their vehicle emissions during the test cycle, rather than reducing emissions on the road. Therefore, a new test procedure, the World Harmonised Light Vehicle Test Procedure (WLTP), has been developed instead of the earlier New European Driving Cycle (UNECE, 2014). Since 2021, the assessment is based entirely on the WLTP data. To prevent the gap between tested and real emissions from evolving unfavourably, the European Commission is now also collecting data on actual CO_2 emissions and energy consumption. Implementing Regulation (EU) 2021/392 (EU, 2021a) sets out the rules for data collection by manufacturers and national authorities.

In the Fit for 55 package, the European Commission proposed a revision of CO_2 standards for cars and vans (EC, 2021e). The legislative process around this resulted in Regulation (EU) 2023/851 (19/4/2023)[10]. Under this new regulation, the 2030 CO_2 target for the entire EU car fleet is as follows: -55% for new cars and -50% for new vans, instead of -37.5% and -31% respectively in the earlier regulation. From 2035, the target for both new cars and vans is 0g/km. The credits for ZLEVs will disappear. The European Commission is required to conduct a review of the effectiveness and impact of the regulation in 2026.

Under this regulation, the Commission will also take legislative initiatives so that vehicles with internal combustion engines may still be sold new after 2035, provided they run solely and permanently on renewable fuels of non-biological origin (i.e. e-fuels or synthetic fuels produced from CO_2 and hydrogen and produced from renewable energy). These fuels are still under development and there is great uncertainty about their future availability, environmental impact, and cost (Grahn et al., 2022).

In 2019, Regulation (EU) 2019/1242a, setting the first EU CO_2 emission standards for HDVs was adopted (EU, 2019). It covers large trucks, which account for 65%–70% of all

[9] Regarding pooling, individual manufacturers in a pool are viewed as a single manufacturer for the purposes of the CO2 emission regulation. This allows those with low fleet emissions to offset the high fleet emissions of other manufacturers.

[10] After Brexit, the transitional arrangements specified that the UK remained part of the EU car CO2 regulation until 2020. Hence, cars sold in the UK in 2020 counted towards the EU target, but not after that date. Subsequently the UK legislation has been updated (UK Vehicle Certification Agency, 2021). Recently the Government of the UK announced the introduction of a zero-emission vehicle mandate. It sets minimum annual targets for the share of zero-emission vehicles in the sales of new cars and vans. For cars, these rise from 22% in 2024 to 80% in 2030 and for vans, from 10% in 2024 to 70% in 2030. This increases to 100% in 2035 (UK Department for Transport, 2023).

CO2 emissions from HDVs. The regulation sets EU fleet-wide targets for reducing the average CO2 emissions from such new trucks. The targets are:

- from 2025, a reduction of 15% compared with the reference period (1 July 2019 to 30 June 2020); and
- from 2030 onwards, a 30% reduction compared with the same reference period.

The regulation for HDVs sets targets following the same principles as the legislation for cars and light commercial vehicles. The targets concern the fleet-wide average of manufacturers' new trucks. The regulation also includes an incentive mechanism for ZLEVs.

In 2023, the Commission proposed a revision of the regulation on CO2 emission standards for HDVs. The IA for this revision points out that unless further action is taken the CO2 emissions from the HDV sector will fall by only around 14% and 70% in 2030 and 2050, respectively, compared to 2015, which is not enough to realise the climate ambitions in a cost-effective way. Therefore, the proposal introduces new, stronger CO2 emission standards for HDVs from 2030 onwards and extends the scope of the regulation to cover smaller trucks, city buses, long-distance buses, and trailers. The legislative process for this revision is still ongoing.

3.2.2. Complementarity with Other European Union Legislation for the Decarbonisation of Transport

As the new vehicles with lower emission factors penetrate the vehicle stock, the exhaust CO_2 emissions of road transport will fall. The CO_2 emissions associated with electricity production for the electric vehicles (EVs) currently fall under the scope of the EU ETS. CO_2 emissions from vehicles with an internal combustion engine will fall under the ETS2. In addition, the mix of fuels must conform with the blending mandate or GHG intensity reduction target of the Renewable Energy Directive. To support the uptake of EVs the recently adopted Alternative Fuel Infrastructure Regulation (which will apply instead of the previous Alternative Fuel Infrastructure Directive) includes specific targets for the charging capacity for EVs according to the EV fleet evolution (EU, 2023e). It also requires the installation of charging and refuelling points at regular intervals on main roads, sets targets for liquefied/compressed natural gas infrastructure, and strengthens governance for progress monitoring.

The availability of charging infrastructure is also affected by a revision of the EU Energy Performance of Buildings Directive (EPBD) (Directive (EU) 2018/844). The directive contains measures to ensure that building car parks are gradually equipped with EV charging points. The EPBD includes provisions to equip new or renovated buildings with specific infrastructure (power lines) suitable for the subsequent installation of charging points. It also requires Member States to set requirements for the installation of a

minimum number of charging points for all non-residential buildings with more than 20 parking spaces by 1 January 2025, and to simplify the installation of charging points in buildings, for example through authorisation and approval procedures. The ongoing revision of the EPBD (COM(2021) 802 final) also aims to make buildings more suitable for EVs, including smart charging requirements.

In addition to these policies at EU level, all EU Member States give additional incentives in one way or another to decarbonise road vehicles by means of tax benefits or incentives. The measures that are taken and their exact definition differ across the countries. Table 5.5 gives a general overview for the EU-27 and EFTA Member States and the UK, based on ACEA (2023)[11].

Table 5.5. Tax Benefits and Purchase Incentives for Electric Cars and Charging Infrastructure in the European Union-27 and the European Free Trade Association Member States and the UK

(Situation in 2023 as assessed by the European Automobile Manufacturers Association)

Type of Measure	Countries
Tax Benefits	
Acquisition	21 EU Member States: Austria, Belgium, Croatia, Cyprus, Czech Republic, Denmark, Finland, France, Greece, Hungary, Ireland, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain & Iceland, Switzerland.
Ownership	22 EU Member States: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Germany, Greece, Hungary, Ireland, Italy, Latvia, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Spain, Sweden & Switzerland
Company cars	16 EU Member States: Austria, Belgium, Czech Republic, Finland, France, Germany, Greece, Hungary, Ireland, Latvia, Lithuania*, Luxembourg, Netherlands, Portugal, Spain, Sweden & Switzerland, UK
Incentives	
Purchase	21 EU Member States: Austria, Belgium (2024 onwards), Croatia, Cyprus*, Czech Republic, Estonia, France*, Germany, Greece*, Hungary, Ireland, Italy*, Lithuania*, Luxembourg,

[11] The report by ACEA gives some more detail about these measures. Each year ACEA also publishes a more complete overview of taxation in Europe.

Type of Measure	Countries
	Malta*, Netherlands, Poland, Portugal, Romania, Slovenia, Spain* & Iceland, UK**
Charging infrastructure	8 EU Member States: Austria, Belgium, Czech Republic, Denmark, Italy, Poland, Spain, Sweden & Iceland, Switzerland, UK

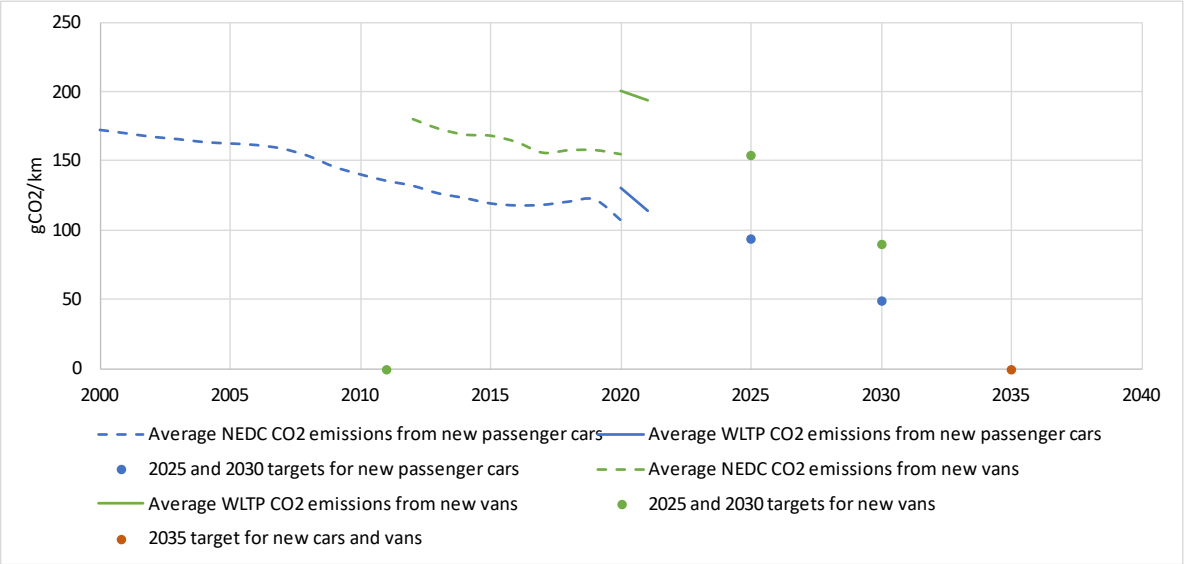
EU = European Union; UK = United Kingdom.
Notes: * including scrapping incentives; ** for conversion to wheelchair accessible vehicles
Source: ACEA (2023).

3.2.3. Performance up to Now

Figure 5.6 shows average CO_2 emission factors from new cars and vans up to 2021, as well as the targets for future years. In addition to the emission factors according to the New European Driving Cycle, the figure presents the performance based on the WLTP test cycle for 2020 and 2021. This test cycle will be used in future years. The average emission factors have fallen over time for both cars and vans. In 2021 the emission factor for cars and vans were respectively 12.5% and 3.5% lower than in 2020. This is mainly due to the larger share of EVs in new registrations, especially in the car registrations (Figure 5.7). In 2021, most car and van manufacturers and all pools of manufacturers met their binding CO_2 emission targets (EEA, 2023a, and EEA, 2023b).

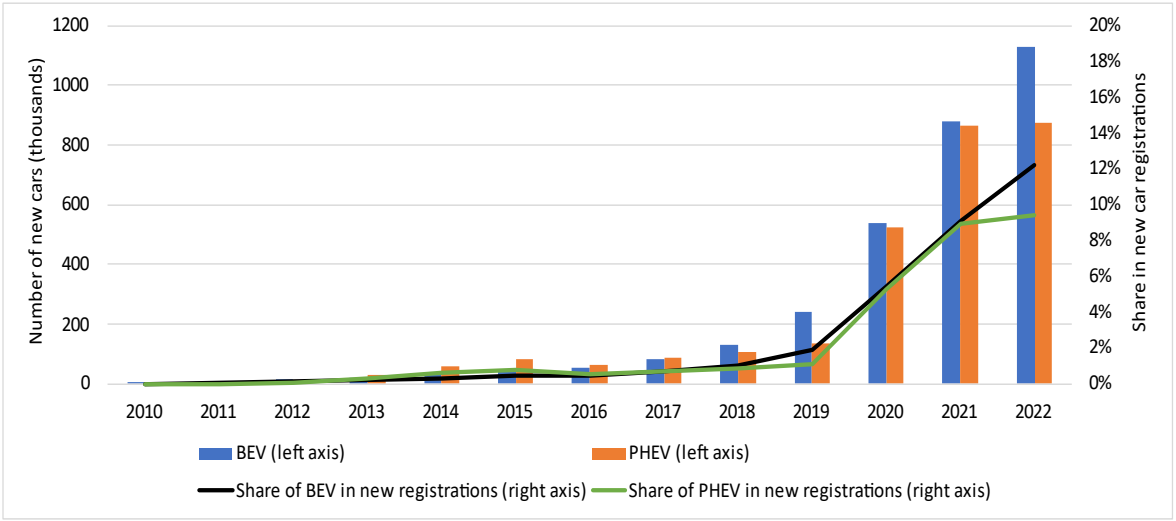
In 2022 the share of electric cars in new registrations increased compared to 2021, from 9.1% to 12.2% for battery electric cars and a smaller increase from 9.2% to 9.4% for PHEVs. As the new registrations only gradually penetrate the total car stock, the share of the electric cars in the total car stock in 2022 was still modest: about 1.2% for battery electric cars and 1.1% for PHEVs (compared to respectively 0.7% and 0.7% in 2021) (EEA, 2023d). The share of electric vans in the van stock was 0.77% in 2022, mostly consisting of battery electric vans. In that same year electric vans had a share of about 4.9% in registrations of new vans. (EAFO, 2023).

Figure 5.6. Average Carbon Dioxide Emissions from New Passenger Cars and Vans and Future Targets



CO_2 = carbon dioxide; gCO_2/km = grammes of carbon dioxide per kilometre; NEDC = New European Driving Cycle; WLTP = World Harmonised Light Vehicle Test Procedure.
Note: Country coverage: EU-27, Iceland, Norway,and the UK
Source: based on EEA (2023a and 2023b).

Figure 5.7. New Registrations of Electric Cars in the European Union-27, 2010–2022



BEV: Battery electric vehicle; PHEV: Plug-in hybrid electric vehicle
Source: EEA (2023d).

An evaluation for HDVs is not yet available. The EEA has determined that in the reference period (2019–2020), the average specific CO_2 emissions of all new HDVs

registered in the EU was 52.75g/tonne-km (reflecting total lifetime emissions) (EC and EEA, no date).

3.2.4. Expected Economic and Social Impacts

The IA for the newly accepted CO_2 emission standards for cars and light commercial vehicles put forward the significant strengthening the CO_2 targets for cars and vans as of 2030 as the preferred option (EC, 2021c). The baseline scenario for the assessment is the EU Reference Scenario 2020 which represents the legislation in place at the time. The IA considers that the strengthening of the emission standards is implemented within a scenario consistent with the other policies in the Fit for 55 package (MIX scenario).

According to the IA the strengthening of the CO2 standards, together with other policies in the MIX scenario, would allow a reduction in exhaust CO2 emissions from cars and vans of 32%–33% in 2030, 56%–66% in 2035 and 83%–89% in 2040 in comparison to 2005 levels. This is higher than the reductions in the baseline scenario (Table 5.6). The trends for the well-to-wheel CO_2 emissions are similar to those for the exhaust CO_2 emissions, taking into account the other policies in the MIX scenario, and specifically the strengthening of the current EU ETS, the introduction of a separate EU ETS for road transport and buildings, and the revision of the Renewable Energy Directive. The MIX policy scenario also includes more stringent air pollution standards for cars and vans.

Table 5.6 also presents the estimated net savings in the total cost of ownership (TCO) from the perspective of the first user (first 5 years) and second user (next 5 years), considering the residual value of the vehicles. In addition, societal savings are presented which also include the benefits from the lower well-to-wheel CO_2 emissions and are estimated over the vehicle lifetime (15 years). There are net savings for the end user in all years and for all levels of stringency of the standards considered in the IA. While the stricter emission standards imply higher upfront capital costs, this extra cost is more than compensated for by lower energy costs. There are also net savings from a societal point of view.

Table 5.6. Estimated Net Economic Savings from a Societal and End-User Perspective of Stricter Carbon Dioxide Emission Performance Standards for New Cars and Vans in the European Union, as Calculated in the Impact Assessment

	2030	2035	2040
CO_2 emissions			
Decrease in exhaust CO2 emissions from cars and vans compared to 2005 (%)	32%–33% (in baseline: 28%)	56%–66% (in baseline: 39%)	83%–89% (in baseline: 48%)
Net economic savings from societal perspective (Impact of CO2 emission performance standards only, in MIX policy scenario context)			
€/car	€860–€1,600	€1,500–€3,400	€4,600–€5,100
€/van	€1000–€1,200	€4,000–€5,100	€5,600–€6,400
TCO for first and second users of new cars and vans (Impact of CO2 emission performance standards only, in MIX policy scenario context)			
€/car	First user: €330–€600 Second user: €450–€800	First user: €970–€2200 Second user: €1,300–€2,700	First user: €2800–€3100 Second user: €2800–€3000
€/van	First user: €340–€600 Second user: €460–€880	First user: €3,400–€4,000 Second user: €2,800–€4,400	First user: €5,200–€5,500 Second user: €3,700–€3,900

€ = euro; CO_2 = carbon dioxide; TCO = total cost of ownership.
Source: based on EC (2021c).

The CO_2 emission performance standards interact with other policies in the MIX policy scenario, which leads to higher energy prices and additional capital costs for vehicles with an internal combustion engine due to stricter air pollutant emissions standards. In that case there are net costs rather than net savings in the case of CO2 emission standards with low stringency. However, with medium to high stringency of the new standards, there is a net saving, which increases with the level of stringency.

In terms of affordability (the variety of vehicle choice available per consumer group) the CO_2 emission standards are expected to mainly affect the affordability for households in the second and third quintile. For households in the lowest quintile, the set of vehicles

that are affordable to them as first and second user is already relatively limited in the baseline, and it does not change because of more stringent emission standards. For the households in the two highest quintiles there are no affordability issues, as well as for households in the third quintile as second user and for all households as third users. For the other cases, affordability issues are found for some vehicle sizes and drivetrains.

For the subjective TCO, which includes purchase price or loan payments and other group-specific parameters in the TCO, the IA shows that more stringent emission standards translate, for the lower-income groups, into higher savings relative to their annual income than for higher income groups. This is because they are more likely to be second or third users. Therefore, they can benefit from the savings in energy costs while not having to pay a high upfront capital cost. It is also the consequence of expressing the savings in terms of income, which is lower for these households. In this regard the International Council on Clean Transportation (ICCT) warns that there are still relatively few EVs on the market and many are marketed as luxury vehicles that are typically purchased by affluent households (Bauer, Hsu, and Lutsey, 2021). Goetzel and Hasnazzaman (2022), referring to the German market, also show that price parity for small cars will not be achieved before 2030 whereas luxury and midsized EVs are already close to price parity. These studies show the importance of reducing the purchase cost of used and small EVs to enable lower-income households access to the cost savings and substantial equity benefits associated with EVs.

The IA of the strengthened CO_2 emission standards also evaluates the broader economic effects. The impact on GDP is assessed to be positive and small, with the largest percentage change in 2040, of 0.28% to 0.65%. The CO_2 targets are projected to lead to more consumer expenditure, and higher investment in vehicle technology and infrastructure. The automotive and petroleum refining sector are projected to be affected negatively, while the sectors in the EV supply chain (such as electronics, metals, and electrical equipment) and the power sector are affected positively. The IA also projects a small increase in employment. The increase is largest for the most stringent standards and increases over time. The largest change is projected in 2040 with the most stringent standard – 0.3% compared to the baseline. The IA stresses the need to reskill the workforce and teach the skills required for the future to young people to facilitate the transition.

The Joint Research Centre (JRC) recently published an update of an earlier report on supply chain dependency, which also projects the demand for raw materials up to 2050 in the EU (Carrara et al., 2023). This has been done for five strategic sectors, including electric mobility. The JRC expects a huge increase in demand for raw materials for electric mobility, and this not only at European level but also in the rest of the world. It points to high dependence on regions outside the EU, and especially China. According to the JRC the supply risk is high, and for electric mobility this applies to all stages of

supply. The role of recycling depends on the volume of end-of-life products and is expected to be rather limited. In the case of batteries, the JRC estimates that – considering the known and planned mining projects for lithium, cobalt, manganese, and nickel – the demand for raw materials after 2030 will exceed the known potential supply unless investments are stepped up in time. It also highlights the importance of investing in R&D to reduce supply-side risks through the development of advanced materials, alternative technologies, or more efficient use of materials. The JRC's conclusions for e-mobility feedstocks are generally in line with those of the International Energy Agency's Global EV Outlook 2022 (IEA, 2022).

The European Commission has recently taken initiatives to reduce risks by proposing a regulation on critical raw materials (the Critical Raw Materials Act) (COM, 2023: 160). With this, it aims to be 'a comprehensive response to the risks of critical raw materials supply disruption and the structural vulnerabilities of EU critical raw materials supply chains.' (EC, 2023a). Alongside this proposal, the Commission has also prepared an outline for a Net-Zero Industry Act (COM, 2023: 161) to ensure the scale-up of production of key carbon-neutral technologies for clean energy chains.

3.3. Renewable Energy in Transport with a Focus on Sustainable Aviation Fuels

3.3.1. General Discussion

According to the current Renewable Energy Directive II (RED II) (Directive 2018/2001/EU) (EU, 2021b), in each Member State, energy from renewable sources in road and rail is at least 14% of the final consumption of energy in transport. In addition, there is a specific target for advanced biofuels, gradually increasing to 3.5% by 2030. The RED II also sets several requirements on the sustainability and GHG emissions of biofuels in transport which they must meet in order to count towards the overall 14% target and qualify for possible government financial support. The RED II sets limits for biofuels with a high risk of indirect land use change (ILUC), namely liquid biomass and fuels from biomass that significantly expand cultivation on land with high carbon storage. A phase out of these fuels is imposed between 2023 and 2030. Moreover, the share of fuels based on several feedstocks that can be processed with mature technologies (including used cooking oils and animal fats) should not exceed 1.7%.

There is no specific target for aviation, but SAFs can be taken into account when assessing the target.

The RED II is complemented by Delegated Regulation (EU) 2019/807. The regulation includes criteria for identifying feedstocks with high ILUC risk and general criteria for certifying biofuels with low ILUC risk. Criteria are proposed for improvements in agricultural practices (additionality measures) that allow for an increase in the yield of food and feed crops on land already used for this dpurpose or growing such crops on unused or abandoned land.

In the July 2021 Fit for 55 package, the European Commission included a proposal to revise the current directive (COM(2021) 557 final). Following the Russian invasion of Ukraine, the European Commission proposed the REPowerEU plan (COM(2022) 230 final), which includes a series of integrated actions to save energy, diversify and secure energy supply, boost the adoption of renewable energy, and smartly combine investment and reforms.

The resulting new directive that was signed in October 2023 (EU, 2023b) sets a target for the share of energy from renewable sources in gross final consumption of energy in the European Community of at least 45% instead of 32%. For transport, Member States must either ensure that the share of renewable energy in transport is at least 29% by 2030 or that the GHG emission intensity is reduced by at least 14.5% by 2030, compared to a baseline.

While the RED II target applied to energy consumed by road and rail transport, the new targets apply to all energy consumption by transport. Another new feature is that renewable fuels and renewable electricity count towards the emission intensity reduction target based on their GHG emission reductions.

The new directive requires that the combined share of advanced biofuels and biogas and of renewable fuels of non-biological origin in the energy supplied to the transport sector is at least 1% in 2025 and 5.5% in 2030, of which a share of at least one percentage point is from renewable fuels of non-biological origin in 2030. It also includes a credit system for the supply of renewable electricity to the transport sector through public charging stations. Private charging stations may also be taken into account here on condition that it can be proved that the renewable electricity is only supplied to EVs.

Regarding the issue of ILUC, the new directive sets limits on high ILUC risk biofuels, bioliquids, and biomass fuels with a significant expansion in land with high carbon stock. The Member States will still be able to use (and import) fuels covered by these limits, but they will not be able to include these volumes when calculating the extent to which they have fulfilled their overall renewable targets and the target share of renewables in transport. The limits impose a freeze equivalent to 2019 levels for the period 2021–2023, which will gradually decrease from the end of 2023 to zero by 2030. The new Directive also introduces an exemption to these limits for biofuels, bioliquids, and biomass fuels certified as low ILUC risk.

For aviation and the maritime sector, two separate proposals were included in the Fit for 55 package. For aviation the REFuelEU Aviation Regulation was adopted in October 2023 (EU, 2023d). It states that :

- Aviation fuel suppliers will have to ensure that all fuel made available to aircraft operators at EU airports contains a minimum share of sustainable aviation fuels (SAFs) from 2025 and from 2030, a minimum share of synthetic fuels, with both

shares increasing progressively until 2050. Table 5.7 summarises the evolution of the targets over time.

- Aircraft operators will have to ensure that the annual quantity of aviation fuel uplifted at a given EU airport is at least 90% of the annual aviation fuel required, to avoid emissions related to extra weight caused by tankering practices.

Table 5.7. REFuelEU Aviation: Minimum Share of Sustainable Aviation Fuels and Synthetic Fuels

	2025–2029	2030–2031	2032–2034	2035–2039	2040–2044	2045–2049	2050 onwards
SAF	2%	6%	6%	20%	24%	42%	70%
Subtarget synthetic fuels		On average 1.2% (min. 0.7% per year)	On average 2% (min. share of 1.2% in 2032–2033 and 2% in 2034)	5%	10%	15%	35%

SAF = sustainable aviation fuel.
Source: EU (2023d).

3.3.2. Complementarity of REFuelEU Aviation with Other European Union Legislation for the Decarbonisation of Transport

The EU aims to reduce the climate impact of aviation by means of a basket of measures. These include support for R&D on carbon-neutral aircraft, improvements in air traffic management and the inclusion of flights within the European Economic Area in the EU ETS (see Section 3.1). The proposal to revise the Energy Taxation Directive could lead to a tax on conventional jet fuel. The REFuelEU Aviation Regulation is an additional element in this basket of measures and imposes a blending mandate for SAF, with a sub target for synthetic fuels. The targets of the regulation apply to all fuel supplied at EU airports, so not only for flights within the European Economic Area. Therefore, the range of flights covered is broader than that of the EU ETS for aviation.

The regulation specifies that the following fuels are eligible:

- aviation biofuels that meet the sustainability and lifecycle emissions criteria laid down in the RED II and that are certified in accordance with the RED II. According to Article 4(5) SAF produced from the following feedstocks shall be excluded from the calculation of the minimum shares of SAF for sustainability reasons: 'food and

feed crops'[12], intermediate crops, palm fatty acid distillate and palm and soy-derived materials, and soap stock and its derivatives. However, that exclusion shall not apply to any feedstock that is included in Annex IX to Directive (EU) 2018/2001(EU, 2021b), under the conditions set out in that Annex.

- synthetic aviation fuels (also called renewable fuels of non-biological origin) and recycled carbon aviation fuels that comply with the lifecycle emissions savings threshold of the RED II.

Renewable hydrogen for aviation and low-carbon aviation fuels achieving at least the same level of lifecycle emissions savings as synthetic aviation fuels are also included within the scope of the regulation.

SAF typically have lower aromatics and sulphur content than conventional jet fuel. Therefore, the uptake of SAF also contributes to the reduction of the non-CO_2 climate impact of aviation. According to Lee et al. (2021) these non-CO_2 climate impacts are responsible globally for two thirds of the total climate impact of aviation.

3.3.3. Performance up to Now

In 2021, the share of renewable sources in transport reached 9.1% at EU level. In 2004 it was 1.6%. The share in 2021 was 1.2 percentage points lower than in 2020. In absolute terms the use of renewable energy in transport increased compared to 2020, but the share was lower than in that year because transport activities increased in 2021 with the relaxation of COVID-19 restrictions, and there was a change in methodology. The RED II sets a target of 14% in 2030, but the compromise text on its revision is more ambitious.

The share of renewable energy in transport varies substantially between EU Member States. With a share of respectively 30.4% and 20.5%, Sweden and Finland are well above the 14%. In 20 Member States the rate is below 10%.

For aviation, the share of SAFs is currently very low. In 2020 EU SAF supply was less than 0.05% of total EU aviation fuel use (EASA, EEA, and Eurocontrol, 2023).

3.3.4. Expected Economic and Social Impacts of REFuelEU Aviation

The IA of the REFuelEU Aviation Regulation considered different policy options to promote the uptake of SAF (EC, 2021b). For the policy option that was closest to the approach adopted in the final act (Option C1) the net present value (NPV) of the benefits

[12] In Article 2 of the RED II, these are defined as follows: 'starch-rich crops, sugar crops or oil crops produced on agricultural land as a main crop excluding residues, waste or ligno-cellulosic material and intermediate crops, such as catch crops and cover crops, provided that the use of such intermediate crops does not trigger demand for additional land.'

over the whole period to 2050 were found to be €67.5 billion higher than the costs. The IA indicated that the required feedstock and renewable electricity for SAF production will be available and that sufficient SAF can be supplied to the market. It also indicated that the mandate means that SAF can be introduced more quickly to the market than in the baseline scenario. This means that the use of conventional jet fuel can be reduced in line with the EU's climate ambitions. The improvement of air quality is another environmental benefit. Because of the fuel uplift obligation, the risk of tankering is estimated to be low. It indicates, however, that there is a moderate risk of competitive disadvantage with non-EU airlines on some routes.

As SAF is more costly than conventional jet fuel, the blending mandate will lead to higher fuel costs. The IA estimates that with policy option C1 in 2030 the cost of the fuel blend will be 1.4% higher than in the baseline, and almost 44% higher in 2050. As a result, ticket prices are estimated to be 0.8% higher in 2030 and 8.1% higher in 2050 than in the reference scenario. This results in less air travel (a reduction by 2% in 2030 to 5.9% in 2050), which is partly compensated by a switch to rail. The total costs for the aviation sector increase by 0.3% over the entire time horizon up to 2050. Fuel costs increase (NPV equal to €104 billion) but the capital and operational costs fall due to a lower travel demand (NPV equal to -€84 billion). The NPV of the capital investments in SAF production is estimated to be €10.5 billion. The blending mandate is expected to lead to a net job creation. This is limited in 2030 but larger in the long term. For policy option C1, the net increase in employment would be 202,000 in 2050. This is the net outcome of a loss of 46,000 jobs directly and indirectly related to the aviation sector due to lower air travel, which is expected to be more than compensated for by an increase of 248,000 jobs directly and indirectly related to SAF production.

4. Concluding Remarks

According to the EU Climate Law, Europe needs to achieve climate neutrality by 2050. For transport, the EU's Sustainable and Smart Mobility Strategy aims to deliver a 90% reduction in emissions from the transport sector by 2050. The overview in this chapter shows that in recent years, with the Fit for 55 package and other policy initiatives, the EU has made substantial efforts to improve its existing legislation as well as to introduce new legislation for the decarbonisation of transport. At the time of writing, many of the proposals have led to adopted legislation, with modifications, and others are still to follow. The IAs indicated that they would have a profound effect on the future environmental performance of the transport sector in the EU. In the future it will be important to regularly assess the progress and the economic and social impacts, to see whether they remain in line with the objectives.

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