CREDITING SYSTEM FOR RENEWABLE FUELS: FUNCTIONALITY & BENEFITS

Report prepared for Neste

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EXECUTIVE SUMMARY

The EU legislative framework on fleet targets for new road vehicles focuses on tailpipe emissions in a so-called “tank-to-wheel” approach, which does not differentiate between fossil and renewable fuels. Car manufacturers (OEMs) can basically only reduce their fleet emissions by selling more electric vehicles into the market.[1] If they do not succeed – as is currently the case with OEMs on average missing the necessary share of electric vehicles (EV) by more than 40% in the first half of 2020 – OEMs have to pay significant penalties.

Frontier has proposed a crediting system for renewable fuels in a recent study[2] which would allow OEMs to voluntarily finance additional renewable fuel (on top of the volumes mandated under RED II) and count the corresponding emission reductions against their fleet targets.[3] The system avoids double counting of OEM’s and fuel supplier’s efforts, provides the necessary coordination along the value chain and thus induces additional GHG emissions reductions by converting penalty payments without any environmental benefits into higher emission reductions.

Neste has asked Frontier to develop potential road transport sector scenarios after implementing such a renewable fuel crediting scheme and to explain how such a crediting scheme would impact different stakeholder groups and the environment. Such a crediting scheme generates benefits for consumers, OEMs and fuel suppliers while allowing for **additional, effective, and faster** emission reductions (Figure 1).

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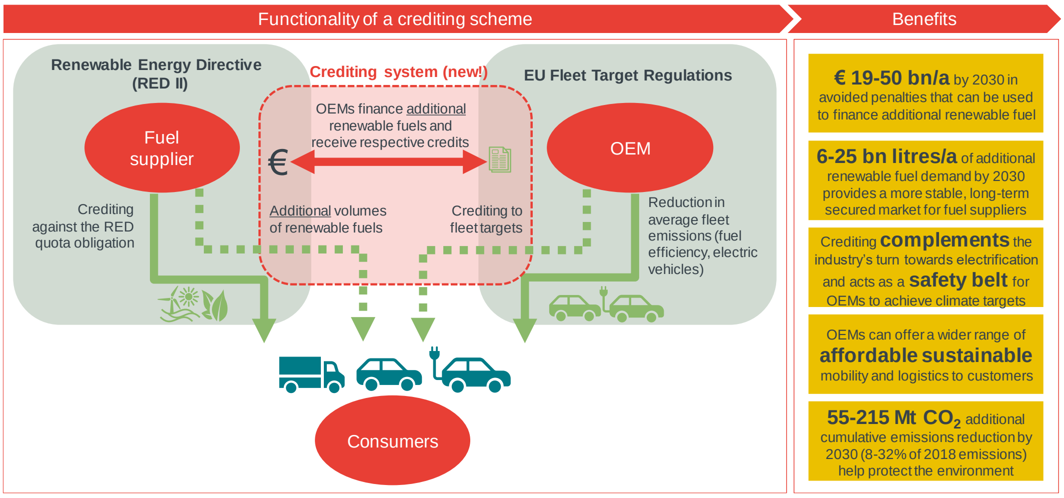
1 The scope for fuel efficiency improvements of internal combustion engines, which provides a second option, is rather limited.

2 In May 2020, Frontier Economics Ltd. (“Frontier”) published a study on behalf of the German Federal Ministry for Economic Affairs and Energy (BMWi) where we develop a crediting system for renewable fuels, available online https://www.bmwi.de/Redaktion/DE/Downloads/C-D/crediting-system-for-renewable-fuels.pdf?__blob=publicationFile&v=4.

3 The EU currently applies a strictly split approach to tackle greenhouse gas (GHG) emissions in Road Transport. While fuel suppliers are required to provide an increasing share of renewable fuels, OEMs are addressed through an EU legislative framework on EU emission standards for new road vehicles (‘fleet targets’) that focuses on tailpipe emissions (so-called “tank-to-wheel” emissions).

Figure 1 Stack of shareable benefits for OEMs, fuels suppliers, consumers and the environment



Source: Frontier Economics

The benefits are summarised below in more detail (please refer to the main body for further details on the functionality of the system).

OEM could invest in additional GHG measures instead of paying billions in penalties

OEMs may miss their fleet targets, which could result in tens of billions of euros in penalties by 2030 – money which is lost for climate protection.

Car OEMs are expected to miss their 2020-targets, with a gap in EV of more than 40% in the first half of 2020. At the same time, fleet targets will get further tightened in the next decade which could result in € 30 bn penalties in 2030 for passenger cars alone (fleet targets for trucks start only in 2025).[4]

€ 19-50 bn

penalties in 2030

If passenger car OEMs miss the required EV share by 10-40%

A voluntary crediting scheme allows OEMs to **achieve true emission savings** instead. OEMs can offer their customers carbon-neutral combustion engine (and hybrid) cars and trucks which complements the industry's turn towards electrification and acts as a **safety belt** for OEMs.[5]

[4] "*We are talking about a potential €30 bn penalty for the industry*," warned Volkswagen chief executive Herbert Diess in 2019, see https://www.ft.com/content/74c04dc2-5b9c-11e9-9dde-7aedca0a081a.

[5] OEMs have already taken huge investments into e-mobility and policy makers are paving the way for charging infrastructure. In our crediting system proposal, we have also included an optional cap on emission reductions from crediting to address concerns that direct electrification could be crowded out.

Fuel suppliers can benefit from a more stable, long-term secured market for renewable fuels

To avoid penalties, OEMs could buy credits from additional renewable fuel from fuel suppliers to reduce their average fleet emissions.

A crediting system could therefore boost demand for renewable fuels by several billion litres per year. This provides a more stable, long-term secured market for renewable fuel suppliers and could lead to additional investments renewable fuel production facilities and new solutions like e-fuels.

6-25 bn ltr

additional renewable fuels by 2030

to achieve targets for passenger cars and fill a 10-40%-gap in EV sales

In 2020, 4.5 bn litres of green fuels would be needed to fill the gap in EV (based on sales in the first half year) to meet the targets – this number could rise to up to 25 bn litres by 2030 for passenger cars alone.

Consumers gain freedom of choice to find affordable low-emission vehicles that fit their mobility needs

Consumers are today only left with one choice for sustainable mobility – electric vehicles. A crediting system could provide more affordable and broader choice for sustainable low-carbon mobility and logistics.

Crediting avoids billions in **penalties, which could otherwise drive new vehicle prices up**. In the proposed crediting system, OEMs have the option to sell carbon-neutral combustion engine (and hybrid) cars and trucks if they counterbalance the entire lifetime emissions with additional renewable fuel before such a new vehicle is sold (‘frontloading’). For some consumer groups combustion engine vehicles are the most suitable – or possibly the only – option for sustainable mobility, in particular in sparsely populated areas and for heavy duty vehicles. Consumers do not see higher prices at the filling station nor do they suffer from a devaluation of their existing vehicles (which is often one of the more major investments of a household). Retaining broad public approval is extremely important for the feasibility of ambitious climate targets in transport, a sector which represents almost a quarter of Europe’s GHG emissions.

Additional, effective, and faster emission reductions help protect the environment

A crediting system leads to **additional, effective, and faster emission reductions** compared to a world where OEMs miss their targets and pay a penalty.

If OEMs participate in the voluntary crediting system, they have to buy certificates for the entire lifetime emissions of a new vehicle ('frontloading'). Using the RED II sustainability and tracing scheme ensures effective emission reductions (not just on paper) and prevents double counting. A crediting scheme with frontloading (i.e. offsetting lifetime emissions before the sale of a new vehicle) could reduce annual emissions from new vehicles by tens of millions of tonnes by 2030 – these savings accumulate to up to ca. 215 Mt until 2030 for passenger cars (~32% of all road transport emissions in 2018).

55-215 Mt

additional emissions reduction cumulatively by 2030

From additional renewable fuel which have to cover the entire lifetime emissions before a new vehicles is sold

These additional emission reductions can be achieved at the same or lower costs than without a crediting scheme since OEMs could invest in additional GHG measures instead of paying billions in penalties.

A crediting system is a first step towards more holistic regulation, considering the lifecycle impact from different technologies

Credible and effective climate protection requires a **more holistic view** on the climate impact of different mobility options – a full life-cycle perspective which reveals true emissions along the **whole value chain** (from battery and vehicle production, power and fuel mix to recycling). A crediting system – bridging the gap between the "well-to-tank" sphere of fuel provision and the "tank-to-wheel" focus of OEM's regulation – would be a first step towards a more holistic system as it links and coordinates climate protection efforts by fuel suppliers and car manufacturers.

We cannot afford to exclude technologies – the focus on a single technology in road transport would be too risky

The climate challenge is significant and time is short – the remaining global emission budget to limit the temperature increase to 1.5°C may be exhausted in less than two decades if we do not drastically reduce emissions.[6] We **cannot afford to exclude technologies** (such as combustion engines with renewable fuels) and put all our eggs in the one basket. Otherwise we risk failing climate targets which can have irreversible long-term damage. Instead we need regulations that provide a level playing field for a wide-ranging set of technologies.

[6] https://www.ipcc.ch/sr15/chapter/chapter-2/, see Figure 2.3.

1 MOTIVATION – REFINING EUROPEAN FLEET TARGETS

In this section we set out:

- **Background** (**Section 1.1**) – We have proposed a crediting system (in our "BMWi study"[7]) to create a level playing field for renewable fuels to reduce emissions from road transport;
- **Scope** (**Section 1.2**) **–** In this paper we build on our proposal and further clarify the workings and possible benefits of such a crediting scheme; and
- **Approach** and structure of this report (**Section 1.3**).

1.1 Background – Proposed crediting system to create a level playing field for renewable fuels

Today, the EU applies a strictly split approach to tackle greenhouse gas (GHG) emissions in Road Transport. While fuel suppliers are required to provide an increasing share of renewable fuels, the OEMs are addressed through an EU legislative framework on EU emission standards for new road vehicles ('fleet targets') that focuses on tailpipe emissions (so-called "tank-to-wheel" emissions). This approach assigns zero emissions to electric vehicles, does not differentiate between fossil fuels and renewable fuels and thus provides strongly skewed incentives towards electrification. This regulatory inconsistency/artificial regulatory barrier creates obvious coordination problems and is likely to prevent an efficient and effective technology mix for a de-fossilised road transport in future.

The European Commission (EC) is currently reviewing the scope to credit the climate-neutrality of renewable and low-carbon fuels (in the following "renewable fuels") in EU emissions performance standards for passenger cars and vans.[8] In May 2020, Frontier Economics Ltd. ("Frontier") published a study on behalf of the German Federal Ministry for Economic Affairs and Energy (BMWi). In this study ("BMWi study") we propose a crediting system for renewable fuels which can underpin the methodology to be developed by EC in the 2021/2020 review of fleet targets.

Neste Oyj ("Neste"), as a producer of renewable diesel and renewable jet fuel refined from waste and residues, actively engages in providing road transport with a sustainable perspective for combustion engines beyond the use of fossil fuels. Neste therefore wants to further engage industry members and policy makers in discussing how a crediting system for renewable fuels[9] can benefit the industry, customers, and climate protection.

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[7] https://www.bmwi.de/Redaktion/DE/Downloads/C-D/crediting-system-for-renewable-fuels.pdf?__blob=publicationFile&v=4

[8] https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12655-CO2-emissions-for-cars-and-vans-revision-of-performance-standards. The EC will review emissions performance standards for heavy-duty vehicles by December 2022, see Art. 15 of EU Regulation 2019/1242.

[9] As for the BMWi study the aim is to potentially include all sustainable renewable fuel options like biogas and other solutions.

1.2 Scope – Workings and possible benefits from a crediting scheme

Neste has asked Frontier to develop potential road transport sector scenarios after implementing a renewable fuel crediting system and explain how such a crediting system would impact on different stakeholder groups and on the environment. The basic building blocks for the crediting scheme are thereby taken from our proposal, as developed in our study commissioned by the BMWi[10].

In this study, we address the following questions:

- How could a crediting system for renewable fuels work in practice, from the perspective of different stakeholders?
- What are the potential benefits of a crediting system for different stakeholders (fuel suppliers, OEMs, and mobility consumers) as well as for the climate?
- How much additional GHG emissions might be saved by applying such a crediting system?
- How could the use of renewable fuels interact with the ramping up of electric vehicles (battery-electric vehicles (BEV), fuel cell electric vehicles (FCEV)) and efforts to reinforce electricity charging infrastructure?
- What would be the potential additional benefits of a more technology-open approach in tackling climate change in road transport – both for society and individual companies?

All views expressed in this document are the views of Frontier, based on our own calculations and publicly available information.

1.3 Approach and structure of this report

Thanks to various stakeholder workshops, in-depth industry knowledge and our work for policymakers from different member states, we are aware of questions and concerns regarding a renewable fuel crediting system.

In this study, we:

- Use a **question-answer style** to illustrate how a crediting system might work in practice from the perspective of different stakeholders; and
- Develop **example scenario calculations** until 2030 to demonstrate the potential impact of a crediting system on different stakeholders and the environment.

Our report is structured as follows:

- **Section 2 –** Building blocks for a crediting system that includes renewable fuels in the European fleet target regulation;

[10] https://www.bmwi.de/Redaktion/DE/Downloads/C-D/crediting-system-for-renewable-fuels.pdf?__blob=publicationFile&v=4

- **Section 3** – Potential implementation of a crediting system for renewable fuels in practice;
- **Section 4** – Value creation from a crediting system for different stakeholders;
- **Section 5** – Impact on climate protection in the transport sector;
- **Section 6** – The value from a technology-open approach to tackle climate change in road transport.

2 A CREDITING SYSTEM TO INCLUDE RENEWABLE FUELS IN FLEET TARGETS

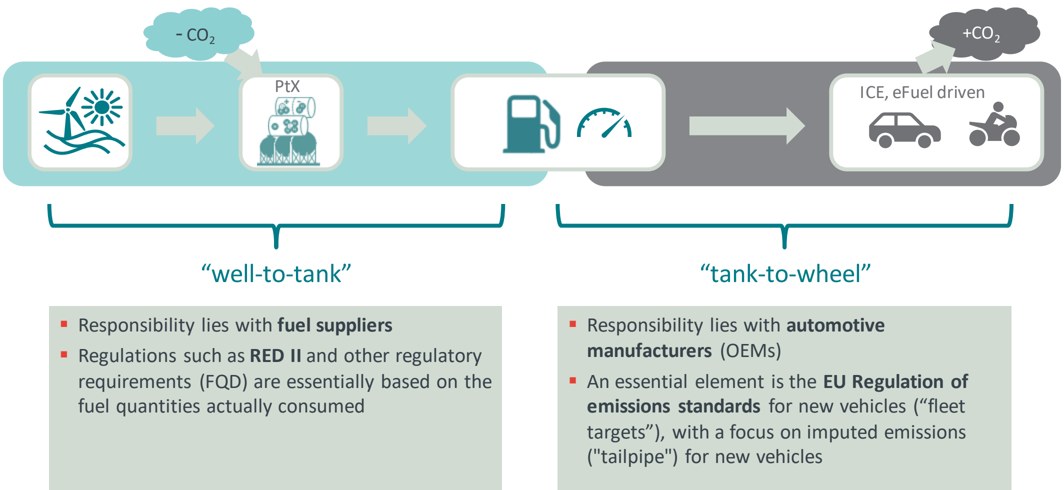
In this section we outline:

- The fact that the current EU fleet target regulation only considers tailpipe emissions and thus does not recognise renewable fuels (**Section 2.1**); and
- The basic building blocks of our proposed crediting system[11] that accounts for emissions savings from renewable fuels in fleet targets (**Section 2.2**).

2.1 The current EU fleet target regulation does not consider renewable fuels

The EU legal framework for reducing CO_2 emissions in the road transport sector separates responsibility along the supply chain (Figure 2):

Figure 2 Schematic overview of the regulatory separation along an exemplary e-fuel supply chain



Source: *Frontier Economics (2020): “Crediting System for renewable fuels in EU emission standards for road transport”, report for the German Federal Ministry for Economic Affairs and Energy (BMWi).*

Fuel suppliers are responsible for emissions from transport fuels from the original energy source (“well”) to the vehicle (“tank”). They are subject to regulations such as the revised Renewable Energy Directive[12] (“RED II”) and further regulatory requirements[13] that essentially focus on the quantities of fuel consumed.

Vehicle manufacturers (often referred to as Original Equipment Manufacturers, “OEMs”) are responsible for direct emissions from the vehicle, i.e. on the way from the tank to the wheels. The main element regulating emission reductions are the

[11] Origination from a study for the BMWi, see https://www.bmwi.de/Redaktion/DE/Downloads/C-D/crediting-system-for-renewable-fuels.pdf?__blob=publicationFile&v=4.

[12] Directive (EU) 2018/2001.

[13] Such as Directive 2009/30/EC (Fuel Quality Directive) and the German Federal Pollution Control Act (BImSchG).

set of emission performance standards for new vehicles (also referred to as “fleet targets”, see textbox below).

EU FLEET TARGET REGULATION

The two EU Regulations[14] that govern the fleet targets for light duty vehicles (passenger cars / vans) and heavy-duty vehicles share the following features:

- **Tank-to-wheel approach (“tailpipe” emissions) –** Therefore, only the vehicle tailpipe emissions are relevant in the current context, regardless of the origin and CO_2 intensity of the fuel used.
- **Single annual EU-wide fleet target for each OEM –** For each OEM, a single EU-wide fleet target applies for each of the segments (cars, vans, and heavy-duty vehicles). Fleet targets are set annually and comprise all new vehicles registered in the same year.
- **Targets are tightened over time –** The basic idea is that all OEMs should lower the Europe-wide average CO_2 emissions of their new vehicles each year below an increasingly stringent fleet limit value:

	2020/21	2025 onwards	2030 onwards[15]
Cars	95 g CO_2/km [NEDC[16]]	-15% vs. 2021	-37.5% vs. 2021
Vans	147 g CO_2/km [NEDC]	-15% vs. 2021	-31% vs. 2021
Heavy-duty vehicle	Not applicable	-15% vs. reference period	-30% vs. reference period

  Fleets of heavy-duty vehicles will be regulated from 2025 onwards, with the initial CO_2 target emission-reduction levels to be set relative to a reference period (July 1, 2019 – June 30, 2020).

  On 17 September 2020, the EC presented its plan to accelerate emissions reductions significantly in the next decade.[17] This will most likely imply even stricter fleet targets.

- **Significant penalties for underperformance –** OEMs must pay a penalty per vehicle if their average emissions exceed the fleet target:
  - For **cars and vans**, OEMs must pay a ‘penalty’ of 95 EUR/g CO_2/km times the number of new vehicles.
  - For **heavy-duty vehicles**, failure to comply with emission targets will result in a penalty of €4,250 per g CO_2/tkm in 2025 and €6,800 per g CO_2/tkm in 2030.

[14] Regulation (EU) 2019/631 (passenger cars / vans) and Regulation (EU) 2019/1242 (heavy-duty vehicles).

[15] Existing targets/further tightening of 2030 targets is currently under discussion/announced.

[16] Target will be converted into WLTP values from 2021 onwards with a conversion rate equal to the ratio between WLTP and NEDC emissions in 2020 (yet to be determined).

[17] https://ec.europa.eu/clima/sites/clima/files/eu-climate-action/docs/com_2030_ctp_en.pdf

Fleet targets focus on **imputed** ("tailpipe") **emissions from fuel consumption**, which has key implications on how imputed emissions are determined for different drivetrain technologies:

- **Internal combustion engines** – Emission values for each vehicle type are determined according to standard test procedures (e.g. WLTP for cars and vans), measuring tailpipe emissions. **No differentiation is made between fossil and renewable fuels** consumed during actual operation.
- **Electric vehicles** – Emissions from electric vehicles are **set to zero, irrespective of the fossil fuel content in the electricity mix**.

These aspects of fleet regulation have at least two important implications:

- **Single technology focus:** Fleet targets primarily incentivize electrification and do not consider fuel-based emission reduction technologies – **irrespective of their climate protection contribution**.
- **Lack of coordination along the fuel value chain:** It also creates a coordination challenge, as the introduction of new vehicles **should obviously include planning for the fuel supply side** as well to achieve the most efficient solutions.

This artificial split of responsibilities before/after the tank with incompatible incentive structures **could be costly while also not delivering effective climate protection**.

In the next subsection, we explain the basic building blocks of a crediting system that could be a first step to overcome these shortfalls.

2.2 Basic building blocks of a crediting system reflects renewable fuels in fleet targets

In our BMWi study[18], we therefore propose a crediting system for renewable fuels (**Figure 3**) which serves as the starting point for this study.

Our proposed crediting system builds on the existing sustainability certification scheme for transport fuels under RED/RED II and provides a level playing field for different emission-reduction options. The aim is to provide effective and cost-efficient climate protection in the transport sector while maintaining affordable individual mobility and logistics.

[18] https://www.bmwi.de/Redaktion/DE/Downloads/C-D/crediting-system-for-renewable-fuels.pdf?__blob=publicationFile&v=4

Figure 3 Main building blocks of a crediting system

Principle 1 – Building on existing sustainability certification scheme for transport fuels under RED/RED II

Principle 2 – Level playing field among emission-reduction options for road transport

Principle 3 – Effective climate change contribution in the transport sector

Principle 4 – Maintaining **affordable mobility and logistics**

	Aspect	Design proposal
General features	Participation conditions	**Voluntary participation** for OEMs (no minimum quota for renewable fuels)
	Geographical scope	**EU-wide harmonised** crediting system and sustainability criteria for renewable fuels
	Volumetric scope	**Optional cap** on max. reduction (in g/km for LDV and g/tkm for HDV per fleet and year)
	Admissible fuels	All **RED II compatible** transport fuels (further provisions in national RED II implementations)
	Tradability	**Yes** – sustainability credits for transport fuels transferable
	Banking	**Yes** – within the valid scope of sustainability proofs according to RED II
	Borrowing	No – **no additional scope** for borrowing
Origin side	Double counting	No – sustainability credits can only be **credited once** against a legal obligation
	Sustainability criteria	RED II **sustainability criteria** and delegated acts apply (regards renewable content and additionality)
	Country of origin	**Worldwide** (if tracked and comprised reliably in accordance with RED II)
	Blending	**Blending** with fossil fuels admissible
Use side	Link to transport sector	Yes – Either **direct use or indirect use** for fuels fed into cross-sectoral infrastructure
	Link country of use	No – admissible fuel can be supplied to final customers **in all Member States**
	Crediting options	**Crediting to individual** new vehicles (as 'low-emission vehicle') possible
	Link to OEM fleet	For crediting to individual new vehicles – only credits from fuels **compatible with powertrain technology** admissible
	Timeframe fulfilment	**Front loading** (credits for lifetime emissions to be surrendered at time of registration)

Source: Based on Frontier Economics (2020): "Crediting System for renewable fuels in EU emission standards for road transport", report for the German Federal Ministry for Economic Affairs and Energy (BMWi).

In the next section, we explain how such a crediting system would work in practice.

3 HOW COULD A CREDITING SYSTEM WORK IN PRACTICE?

In this section, we outline the basic concept of a crediting system (**Section 3.1**) and illustrate how a crediting system would work in practice from the perspective of different stakeholders:

- OEM (**Section 3.2**);
- Fuel producer/supplier (**Section 3.3**); and
- Consumer (**Section 3.4**).

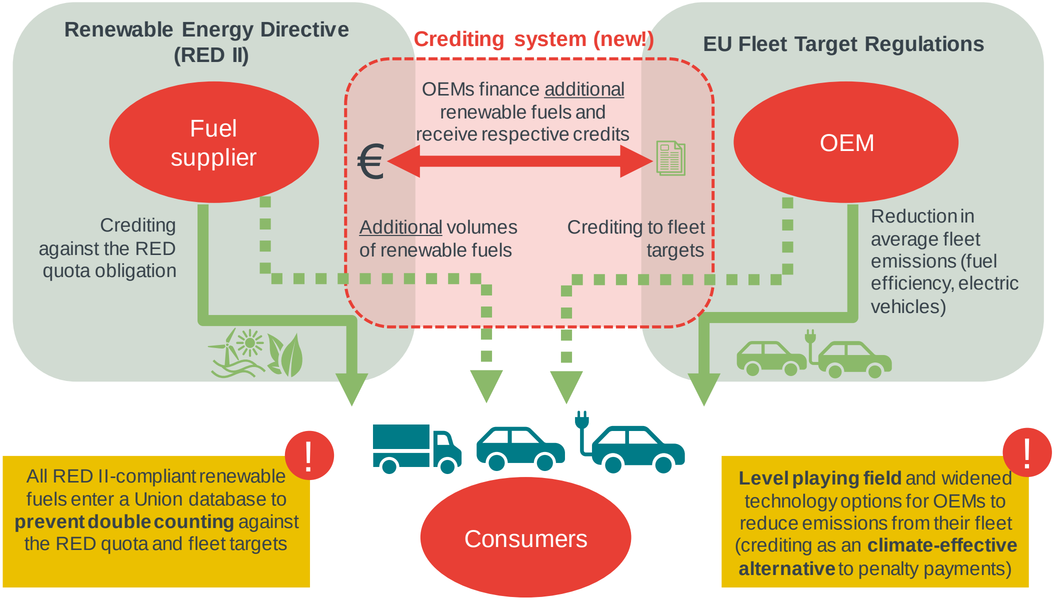
It is important to note, that while we differentiate the various stakeholder groups along their function in the process, stakeholder types could be integrated in a single corporation, e.g. the logistic portion of fuel suppliers are fuel consumers.

3.1 Basic concept of a crediting system for renewable fuels

Figure 4 illustrates the basic concept of a crediting system for renewable fuels, which applies to both light- and heavy-duty vehicles (LDV and HDV):

- **Fuels suppliers** sell renewable transport fuels into the market, which are then credited against their RED II renewable fuel quota.
- **Fuels suppliers** sell **additional** RED II-compliant renewable transport fuel volumes beyond their own renewable fuel quota. These volumes are purchased by **OEMs**, which receive credits in return. All RED II-compliant renewable fuels enter a single Union-wide database (in accordance with RED II, Art. 28 (2)) to prevent double counting against the renewable fuel quota (of the fuel supplier) and the fleet target (of the OEM).
- **OEMs** use these credits from additional renewable fuel volumes – which would otherwise not have been supplied to the market – for counting toward the emissions of new vehicles in their fleet. The crediting system is designed to provide a level playing field and widen technology options. It also provides a climate-effective alternative to penalty payments if fleet targets are not met.

Figure 4 Flow chart of accounting renewable fuels in fleet targets



Source: Frontier Economics

In the following subsections, we illustrate how the crediting would work in practice from the perspective of different stakeholders in question-answer style.

3.2 How could it work in practice for an OEM?

Below we explain when, where and how a credit must be procured and used by an OEM and how credits are surrendered. We also address any implied risks for an OEM.

Marketplace for credits – Where and how can I procure credits?

New credits are generated whenever renewable fuels are supplied to end customers in the EU and can be transferred between fuel suppliers and OEMs:

- In a crediting system, OEM would not enter the fuel sector directly but only get involved in the trading credits that reflect the "green" property of fuels. Credits can be traded between fuel suppliers and OEMs until they are surrendered and deleted from the database.
- We assume such transfers would initially take place based on bilateral contracts, where the contracting parties would be tasked with negotiating appropriate terms and prices for credits. Medium to long term, such transactions might become increasingly standardised and eventually move to broker platforms or exchanges. Since there will be multiple potential sellers and buyers on the market, we expect the emerging market for such credits to be sufficiently liquid. Intermediaries (e.g. financial institutions) could also play a role in this market. They would boost liquidity and provide instruments to mitigate market risks (e.g. by offering forward contracts that allow to lock in credit prices longer term).

Admissible fuels – Can I only use credits from fuels that are used in new cars?

No, in principle any admissible credits from renewable fuels can be credited towards average fleet emissions. Restrictions may apply for crediting against individual vehicles.

- For example, an OEM can buy credits generated from renewable diesel produced and consumed in Finland, even if there are only petrol cars in the fleet which are sold in Southern Europe. This reflects the concept of uniform EU-wide fleet targets and Europe-wide scope to reduce emissions.
- A restriction applies only if an OEM actively opts to credit against an individual vehicle. In this case, for credibility reasons a direct link might be established between the powertrain technology of new vehicles in the year in which the crediting takes place. This means an OEM can only attribute credits from renewable fuels to individual new vehicles that are technically usable in these vehicles. For example, if a diesel car is sold as low-emission vehicle, the corresponding credits must come from renewable diesel (but still irrespective of the member state where these fuels are sold).

Credits assignable to individual vehicles – What is the impact on average fleet emissions?

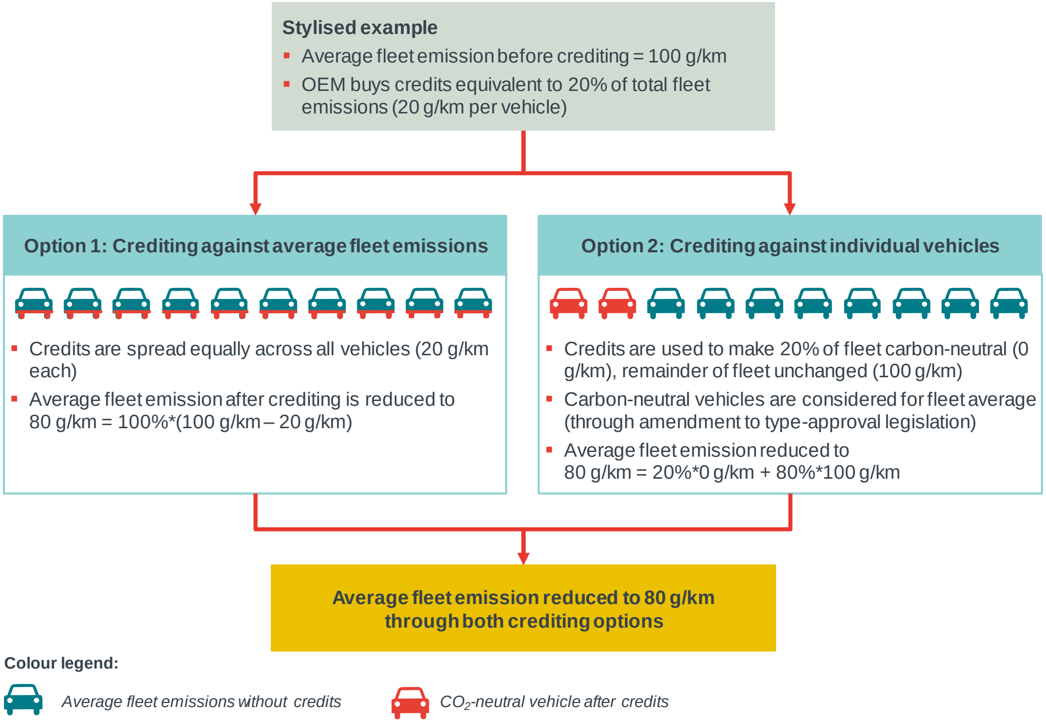
Both proposed crediting options against vehicles have the **same end impact on average fleet emissions** (Figure 5).

Under a crediting system, OEMs buy and surrender a certain volume of sustainability declarations equivalent to a certain CO_2 reduction in tonnes. OEMs can use credits in two ways:

- **Option 1 – Reduction of average fleet emissions**: The CO_2 reduction amount is subtracted from the average fleet emissions of an OEM (see Section 5.2 of our BMWi study for a calculation formula). Under this option, the OEM realises a benefit from avoiding a penalty payment if it would otherwise exceed its fleet target. The final customers who buy the vehicles nevertheless experience no difference between an OEM using renewable fuels to meet its targets or not.
- **Option 2 – Crediting against individual vehicles (optional for OEM)**: The emission reduction through crediting renewable fuels can be attributed to individual vehicles (by amending the European type-approval regulation, see Section 6.2 of our BMWi study for a legal implementation). OEMs can attribute the low-emission properties in registration documents, which makes the emission reduction visible (and transferable) for final customers. This option may appeal to policy makers (and also logistics companies) as part of ramping up a clean transport sector, e.g. if low-emission vehicles are granted an exemption in the context of taxes or tolls, there will be a need to identify vehicles "earmarked" as low-emission.

The example in Figure 5 shows that both approaches entail the same reduction in average fleet value. The main difference regards the timing when credits must be surrendered (see below).

Figure 5 Different crediting options – stylised example (LDV)



Source: *Frontier Economics*

Note: *Note that this is a stylised example. In practice, vehicles can be partly or fully set CO_2 neutral in Option 2 (low- or carbon-neutral vehicle respectively) and credits can be split (for example 50:50) between Options 1 and 2, resulting in the same average fleet emission after crediting (80g/km).*

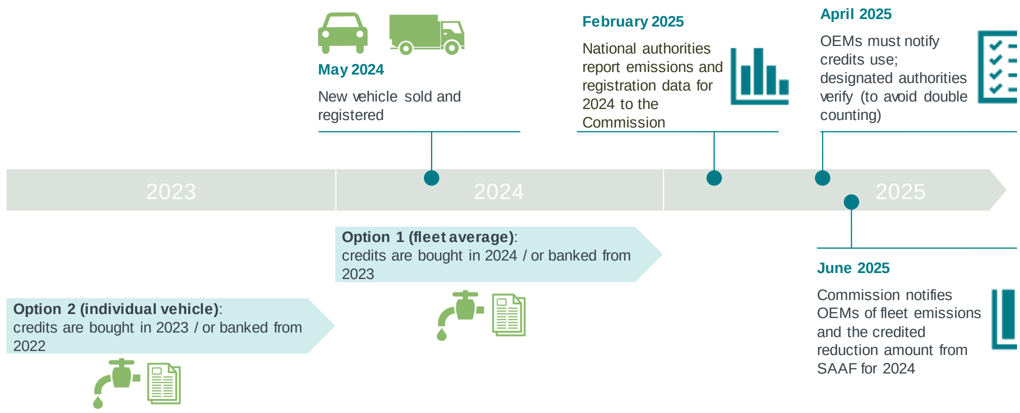
Timeline – When do I buy and use credits?

We illustrate the timing, using the example of a new vehicle that is sold and registered in May 2024. In this example, we assume that an annual verification procedure exists for submitting credits.[19]

The timing of credits depends on whether they count towards average fleet emissions (option 1) or are assigned towards an individual vehicle (option 2).

[19] Alternatively, an ongoing verification procedure intra-year could be implemented where credits must be surrendered and verified year-round (and not the following year) when low/zero-carbon vehicles are sold. This approach generates additional administrative efforts but lets the OEM offer low-emission vehicles immediately after credits have been verified.

Figure 6 Timeline from an OEM perspective



Source: Frontier Economics

Note: This timetable currently applies only to LDV since the process for HDV has not yet been determined.

The main feature is that credits must be procured ***before*** they can be used. This ensures that credits are verified before use and prevents double counting against other legal obligations (such as the RED II-quota for suppliers).

The timing depends on the crediting option chosen by an OEM:

- For **individual crediting** (option 2), only credits from the previous year 2023 are assignable to individual vehicles since they have already been verified (by April 2024).
- If credits are assigned against **average fleet emissions** (option 1) in 2024, credits can be purchased at any time until the end of the same year (**2024**). Verification and accounting against fleet targets.
- **By the end of February 2025**, national authorities (e.g. the KBA in Germany) must report emissions and new registration data for the preceding year to the Commission.[20]
- **By mid-April 2025**[21]**,** after reporting the registration data to the Commission, OEMs must notify the designated national authorities for renewable fuels (for example, in Germany the Main Customs Office) about the number of renewable fuel credits they intend to credit against their fleet emissions for the preceding year. The designated national authorities verify that OEMs have procured sufficient admissible credits.
- **By the end of June 2025**, the Commission notifies OEMs of the average specific CO_2 emissions, target emissions and the credited reduction amount from renewable fuels for the preceding calendar year.

Volume risks – What happens if I bought too many or too few credits?

OEMs can mitigate the volume risk by short-term trading (potentially also with intermediaries), banking or signing longer term contracts with fuel suppliers:

[20] Regulation (EU) 2019/631, Art. 7.

[21] This is the date set in German law (BImSchG) by which quota trading contracts for the previous year must be submitted to the main customs office in Cottbus to be counted against the fuel supplier quota.

- If **too many credits** are procured (e.g. when the number of sold vehicles is lower than expected), credits can be either traded to other OEMs or banked for use next year (subject to limitations on validity for credits from RED II and national laws).
- OEMs can avoid buying **too few** credits (to avoid penalty payments): They can buy credits in the same year they sell new vehicles (unless the individual crediting option is chosen, see above). Towards the end of a year, an OEM should be able to determine whether a target gap exists (either insufficient ZLEV have been sold or insufficient credits procured). In this case, the missing number of credits can be procured short term.[22] Alternatively, OEMs can sign long-term contracts (possibly over several years) with fuel suppliers, which guarantee a certain number of credits.

In an unlikely event of a short-term shortage of credits (e.g. due to an end-of-year rush), **the worst case is falling back to the penalty – the only option for an OEM today without a crediting system**.

Price risks – What happens if credit prices surge unexpectedly?

OEMs can hedge against extreme price spikes since the crediting system is optional. If credit prices rise unexpectedly, it might be more economical to pay the penalty or sell additional zero- and low-emission vehicles (ZLEV) at a discount. The penalty serves as a backstop and implicitly caps credit prices (except when crediting low-emission vehicles would result in them being sold at such a high premium that OEMs would be willing to pay beyond the penalty). **In any such circumstances, OEMs would be better off than in the current situation without a crediting system.**

OEMs have relative certainty about the credit price before selling an internal combustion engine vehicle (ICEV) which enables them to appropriately price in additional costs:

- For individual crediting (selling a low-emission ICEV), OEMs must buy the necessary credits first before selling the vehicle.
- For counting towards the fleet target, credits can be either bought before or within the same year, offering OEMs sufficient flexibility to manage the price risk they want to take.

OEMs may also be able to hedge long-term price risks in contracts with fuels suppliers or intermediates (presumably against a premium).

3.3 How could it work in practice for a fuel supplier?

Generation of credits – How can I generate a credit?

Credits are generated by selling admissible renewable fuels to final customers anywhere in the EU. The country of origin is not linked to the country of use for the credits (i.e. where an OEM eventually sell new vehicles) since the location where

[22] Such short-term procurements might be only possible at a price premium but we would expect a free market regime to develop appropriate risk mitigation instruments (options or forward contracts).

emissions are saved does not matter for climate protection (which is why there is a single European transport sector target and a single European-wide fleet target). A system that requires a direct link could also only be implemented at high administrative cost.[23]

A designated national authority will verify the generation of new credits and the information will be instantly passed on to a Union-wide database (which must be set up as part of the RED II implementation).

Admissible fuels – Does the crediting only target synthetic fuels and hydrogen?

No. In principle, OEMs should be able to use all synthetic, biological and non-biological liquid and gaseous transport fuels produced with renewable energy that meet the sustainability and greenhouse gas emissions saving criteria in RED II and that comply with the national RED II implementation in those Member States where the renewable fuel is sold.

A broad set of admissible fuels ensures wide-ranging biofuels and synthetic fuels that can be used to generate credits.

Market place for credits – How can I trade credits?

Credits can be traded between fuel suppliers and OEMs until surrendered and invalidated in the database (see **Section 3.2**). Credits are procured in bilateral contracts between the supplier and OEM – it is up to the contracting parties to negotiate appropriate terms and prices.

Medium to long term, credit transactions might become more standardised and eventually move to broker platforms or exchanges.

Price risks – Will the credits I need to fulfil my own renewable quota become costlier?

The price for credits (reflecting the value of the green property of the underlying fuel) will depend on the dynamics of the wider renewable fuels market. However, we would not expect soaring price hikes affecting renewable fuels under the crediting system since:

- Renewable fuels come from a global market;[24]
- In the short term, demand from OEM will be moderate in comparison to the overall market size (see **Section 4.3**); and

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[23] Firstly, credits have to be generated before an OEM sells the new vehicles. Secondly, the default option is to count credits against the fleet average – it is hard to imagine that a system would work that required pro-rata credits from each country where vehicles are sold.

[24] See USDA (2019), EU Biofuels Annual 2019, available online: https://apps.fas.usda.gov/newgainapi/api/report/downloadreportbyfilename?filename=Biofuels%20Annual_The%20Hague_EU-28_7-15-2019.pdf

- In the long term, higher prices will attract new investments (including new synthetic fuel supplies from the MENA region[25]) and additional fuel supply which will dampen the price increase.

Investment risks – Will I be able to amortise investments into new production facilities for renewable fuels?

Generally, the risk for a renewable fuel producer resembles that of conventional fuel production:

- Producers must amortise a significant upfront investment over a long pay-back period (decades);
- Investors are thus subject to long-term price and volume risks.

The main difference with investments in conventional fuels is that renewable fuels cost more to produce and profitability depends on scope to remunerate the renewable property (e.g. through a crediting scheme).

3.4 How could it work in practice for a consumer?

What changes for me as a consumer?

A crediting system for renewable fuels provides benefits when buying a new vehicle and may also have positive side effects for existing vehicle owners with a combustion engine.

A crediting system provides a broader choice among sustainable low-carbon mobility options when buying a new vehicle:

- Currently only plug-in hybrid vehicles (PHEV), battery-electric vehicles (BEV) and fuel cell electric vehicles (FCEV) are considered zero- and low emission vehicles (ZLEV) under the EU regulation.[26]
- Under a crediting system, OEMs can also sell new low-carbon ICEVs if they finance the corresponding emission reductions for the life emission through a crediting scheme. Credits costs are incurred by the manufacturer and do not affect the fuel price at the filling station.

The system is voluntary for OEM, so the emergence of a green version of your preferred model or brand will depend on OEMs offering such a vehicle.

A crediting system for renewable fuels does not directly affect the existing fleet of cars, vans, and trucks in the EU. However, there might be attractive side effects on existing vehicle owners:

- The availability and choice of renewable fuels at fuelling stations might further increase. This is because the crediting scheme will boost available volumes of

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[25] See Agora Verkehrswende, Agora Energiewende and Frontier Economics (2018): The Future Cost of Electricity-Based Synthetic Fuels, available online https://www.agora-energiewende.de/fileadmin2/Projekte/2017/SynKost_2050/Agora_SynKost_Study_EN_WEB.pdf.

[26] A ZLEV is defined in the Regulation as a passenger car or a van with CO_2 emissions of between 0 and 50 g/km. In practice, most ICEV cannot achieve this threshold since they would need to consume less than 2 litres of fuel per 100 km.

renewable fuels (also in their neat form), which will then, in turn, be largely consumed by the existing vehicle fleet.

- A long-term perspective for ICEV combined with the increased availability of renewable fuel could boost the value of existing vehicles on a secondary market.

Do I have to go to a designated fuelling station for biofuel if I buy a new vehicle that is sold as a low-emission vehicle under the crediting scheme?

No. The crediting system is accounting-based: the OEM who sells a new vehicle has already procured the required credits from renewable fuels sold to other customers in the EU. Consumers can go to their normal fuelling station and need not pay any premium for renewable fuels or incur any additional investment costs.

Accounting-based renewable systems are already well established (e.g. for electricity) and help limit administrative cost.

How can I be sure that a low-emission internal combustion vehicle is good for the environment?

The crediting system is set up such as to ensure that low-emission internal combustion vehicles provide real, effective and immediate climate protection (see also Section 5):

- **Established RED II sustainability framework** – The crediting system builds on the existing RED II framework which sets out strict sustainability requirements and a certification schemes that allows to trace admissible renewable fuels along the entire fuel chain.
- **No double counting with other targets** – The proposed crediting system is based on strict additionality. That is only where it is proven, that an additional litre of fossil fuels is replaced by renewable fuels (on top of all other obligations), a credit can be claimed. In this regard our proposal is even stricter than e.g. the requirements for electric vehicles, which are treated as zero-emission even in situations where they are run on fossil-generated electricity.
- **Effective emission reductions** – Renewable fuels that generate the necessary credits replace conventional fuels and therefore avoid real emissions. It is not an accounting trick where emissions are only seemingly reduced but reappear elsewhere.
- **Accelerated emissions reductions** – OEMs, *before* selling a new vehicle, must – via credits – cover *all lifetime* emissions (so-called ‘frontloading’). This means that a **low-emission ICEV starts with a negative emission balance**, which is only later reduced to zero during operation.

Will new vehicles become costlier?

No. We expect new vehicle prices to *decline* after a crediting scheme is introduced, since OEM will avoid higher cost from penalty payments if they miss their emission targets – although they might pass on these costs to their customers, pushing up vehicle prices. A crediting system provides an additional *option* to avoid such penalties and vehicle prices will be no higher (and likely lower) than without a crediting scheme.

A low-emission vehicle with an internal combustion engine will be costlier than its conventional counterpart (without crediting) since an OEM must finance renewable fuels which are costlier than conventional fuels. These costs can be offset by the significant benefits buyers of such vehicles receive, since the low-emission property will enter the registration documents (subject to national regulations):

- Exemption or lower toll costs (trucks) and tax benefits for low-emission vehicles (cars); and
- Higher price for low-emission vehicles on the secondary market.

4 WHAT IS THE POTENTIAL MAGNITUDE OF BENEFITS FOR OEMS, FUEL SUPPLIERS AND CONSUMERS?

In this section we will illustrate – using scenarios until 2030 (**Section 4.1**) – the value creation/impact from a crediting system for different stakeholders:

- **OEMs** (**Section 4.2**) may miss their fleet targets, which could result in tens of billions of euros in penalties by 2030 – money which is lost for climate protection. A **voluntary** crediting scheme allows OEMs to achieve true emission savings instead. OEMs can offer their customers carbon-neutral combustion engine (and hybrid) cars and trucks which complements the industry's turn towards electrification and acts as a safety belt for OEMs.[27]
- **Fuel suppliers** (**Section 4.3**) – A crediting system could boost demand for renewable fuels by several billion litres per year. This could help to establish a more stable, long-term secured market for renewable fuel suppliers and could lead to additional investments in new renewable fuel production facilities. It also provides an automatic coordination of efforts from the fuel and vehicle sector.
- **Consumers** (**Section 4.4**) benefit from more affordable and broader choice for green mobility and logistics. Crediting could avoid billions in penalties, which could otherwise drive new vehicle prices up. Carbon-neutral combustion engine (and hybrid) cars and trucks are for some consumers the most suitable – or possibly the only – option for sustainable mobility, in particular for consumers in rural areas and heavy duty vehicles. Retaining broad public approval is extremely important for the feasibility of ambitious climate targets in transport, a sector which represents almost a quarter of Europe's GHG emissions.

The corresponding **environmental benefits** are analysed in **Section 5**.

4.1 Methodical approach – Using scenarios until 2030 to illustrate benefits from the crediting system

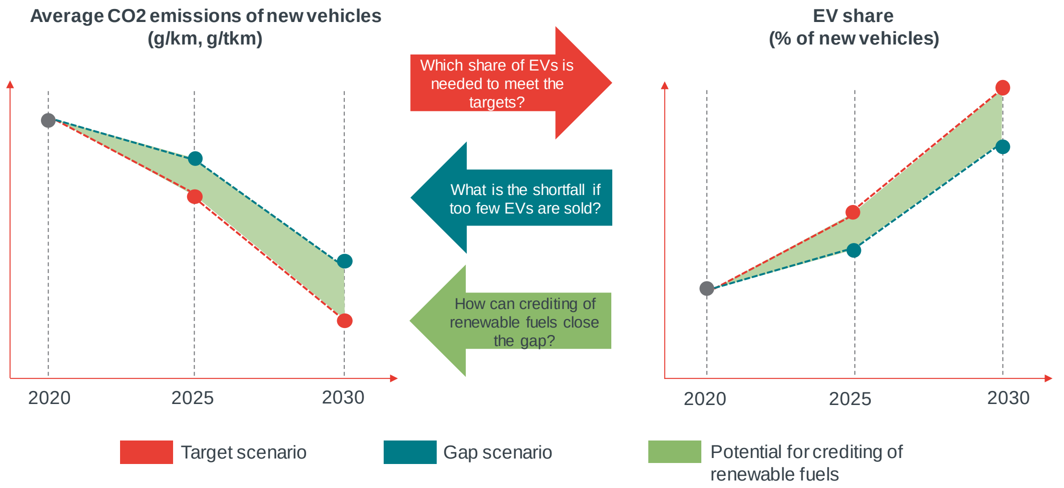
Gap scenarios to illustrate the scope and benefits for a crediting scheme

To estimate the benefits of a renewable fuel crediting system on OEMs, fuel suppliers and final customers we use scenario analyses until 2030. These are not projections of the future – they illustrate the causal relationships transparently and shed light on the order of magnitude of key aspects and their relativity to the overall car fleet, new registrations or fuel market.

Two scenario types are shown: "target" and "gap" (**Figure 7**).

[27] OEMs have already taken huge investments into e-mobility and policy makers are paving the way for charging infrastructure. In our crediting system proposal, we have also included an optional cap on emission reductions from crediting to address concerns that direct electrification could be crowded out.

Figure 7 Using target and gap scenarios until 2030 to illustrate the potential scope for a crediting system



Source: Frontier Economics

Note: EV includes BEV, PHEV and FCEV. We abstract from details such as super credits in early years, ZLEV factor >1 and different types of PHEV.

- **Target scenario** – In the target scenario, we assume that OEMs achieve their fleet targets by combining fuel efficiency improvements and placing sufficient electric vehicles on the market. We do not consider a contribution from a crediting scheme in this scenario. We consider tighter future targets in line with the current discussion on the EU level:
  - *Passenger cars:* A stricter fleet target of "-50% by 2030 compared to 2021" as proposed by the European Commission[28]. It seems unlikely in an environment with a more ambitious climate policy that fleet targets will remain unchanged. (see Figure 8 for an overview of the emission reductions under the various scenarios)
  - *Trucks:* A stricter fleet target "-40%" instead of "-30%" by 2030 (note that the review of HDV targets is scheduled for 2022, this is only an assumption).
- **Gap scenarios** – We consider scenarios where fleet targets without the implementation of a crediting scheme are missed because too few EVs[29] are sold into the market. On average, car OEMs are expected to miss their 2020 targets (see textbox below) despite significant financial incentives for EV in many countries, for example Germany – missing the necessary EV share is therefore a real risk.

The difference between the target and gap scenarios is used to quantify a possible emission gap and the corresponding penalty payments for the automotive industry.

[28] EC COM(2020) 562 - Stepping up Europe's 2030 climate ambition.

[29] We abstract from different EV technologies (BEV, FCEV, and hybrids) and not yet established technology options (such as hydrogen-ICEV). Instead we express the developments in electrification in terms of the equivalent EV share with zero tailpipe emissions. This means that if part of the EV fleet comprises hybrids, we need more vehicles to achieve equivalent tailpipe fleet emission reductions. Take a simple example: 50% EV (@0 g/km) + 50% ICEV (@100g/km) = 25% BEV (@ 0g/km) + 50% hybrids (@50g(km) + 25% ICEV (@100g/km).

Figure 8 Emission reductions achieved under various scenarios by 2030

	Passenger cars (compared to 2021)	**Trucks** (compared to 2020/21)
Target scenario	-50% (stricter target)	-40% (stricter target)
Gap scenario(s)	Different scenarios* (with OEMs missing the target because of a gap in the required EV share): ▪ Gap (10%): -45% (optimistic) ▪ Gap (25%): -38% (baseline) ▪ Gap (40%): -32% (pessimistic*)	-30% (current target)

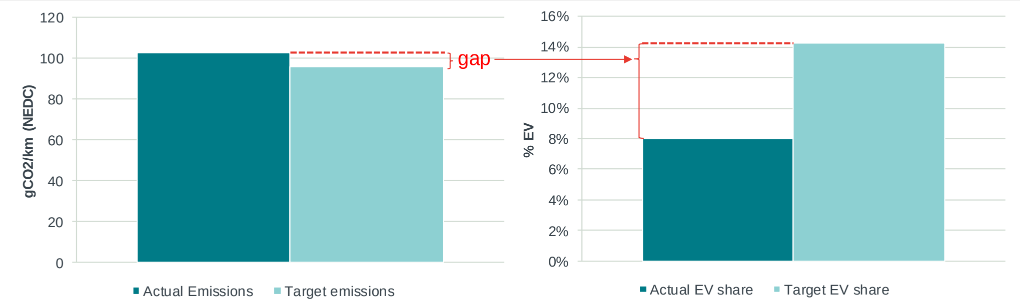
Source: Frontier Economics

*Note: *) The largest considered gap of 40% is still below the expected gap in 2020, see textbox below.*

OEM ARE EXPECTED TO MISS THEIR 2020 FLEET TARGETS – THERE IS A 44%-GAP IN EV

According to current market data, OEMs are expected to miss their 2020 targets by 7g/km year-to-date (~7% compared to the target of 95 g CO_2/km). To meet their targets, OEMs would have to increase the share of electric vehicles from currently 8% to more than 14% (Figure 9).[30] In other words, there is a 44%-gap in EV sold today, equal to 670,000 additional new EVs.

Figure 9 OEMs are expected to miss their fleet targets in 2020 by 7g/km – this equates to an EV gap of 44%



Source: Frontier Economics based on data from ICCT (2020), Market Monitoring September 2020.

Note: According to ICCT, the average emissions from new vehicles in 2020 (until July) equals 103 gCO_2/km (in NEDC terms), missing the weight-adjusted 2020-target of 96 g/km by 7%. From 2021 on, targets will be set on a WLTP basis, based on a conversion rate from NEDC to WLTP yet to be determined in 2020 in accordance with Annex XXI to Regulation (EU) 2017/1151.

The notional 95g/km target in 2020 is softened by transitory mechanisms:

- 'Super credits' for ZLEV – ZLEV are multiplied by a factor of 2 in 2020, i.e. one EV with zero-tailpipe emissions counts as two vehicles in the fleet average. Super credits will be gradually phased out until 2023.
- For 2020 only, OEMs can omit the top 5% of new cars with the highest CO_2 emissions when calculating the fleet average.[31]

This suggests a widening of the gap unless OEMs can significantly accelerate new EV sales.

Expecting about 20 million new cars by 2030, a 25% gap in new electric vehicles seems realistic given tighter fleet targets

As mentioned, we compare the target scenario (OEM meet their targets, no penalties paid) and show how challenging this will be. For the gap scenarios we start off from a situation where the OEMs on average already miss the 2020 target by 7% although some special rules apply in their favour. Over time the targets will be tightened significantly by 2030: by -37.5 % under existing LDV regulation but given the latest statements from Brussels most likely by -50% in 2030. A gap of

30 $EV_{target} = 1 - \frac{target_{NEDC}}{actual_{NEDC}} * (1 - EV_{actual}) \rightarrow 14.3\% = 1 - \frac{96}{103} * (1 - 8\%)$. Note that the $target_{NEDC}$ is equal to 96 instead of 95 [gCO_2/km]. This is done to approximate for the weight of the average fleet, which increases the target for heavier fleets.

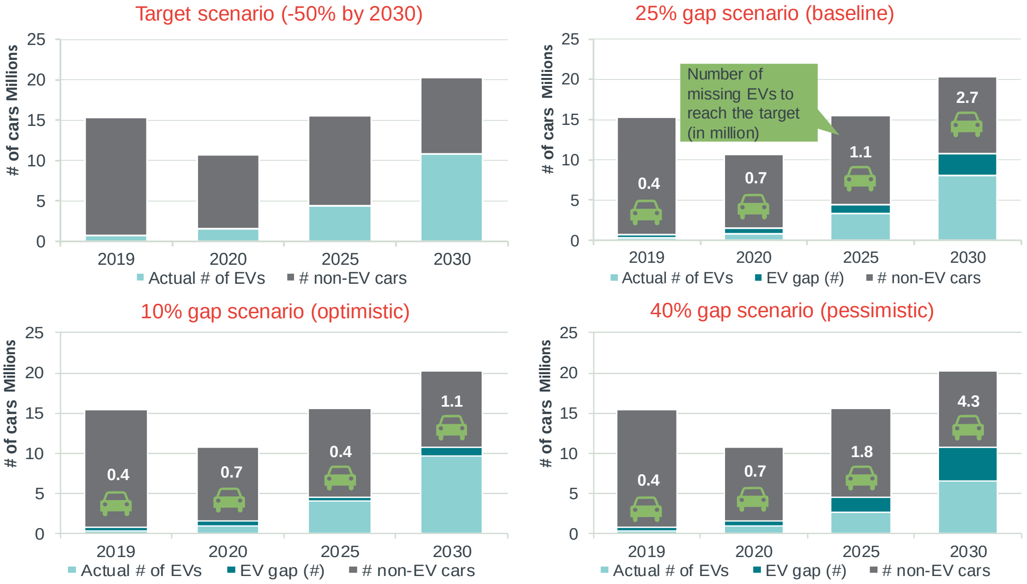
31 ICCT estimates that this lowers the average fleet emissions by 3g/km in 2020.

25% therefore seems realistic and still assumes significant growth of EVs and additional fuel efficiency improvements in new ICEVs.

For each gap scenario, we derived the composition of the new vehicle fleet for the snapshot years 2020, 2025 and 2030:

- For **passenger cars**, we assume a linear increase in new EU car registrations to 20 million in 2030.[32] This equates to an annual growth rate of 2.6% compared to 2019 before the COVID-19 crisis hit the industry.
- This results in the following composition of new passenger cars registered each year until 2030 (**Figure 10**). The shortfall in EV sales in 2030 ranges between 1.1 million (10%-gap scenario) and 4.3 million vehicles (40%-gap scenario).
- For **trucks**, we focus on long-haul vehicles (5-LH in HDV fleet regulation) which comprise ~63% of the total subject to fleet targets. We also assume a constant total of 220,000 new trucks/a (in line with historical data provided by ACEA).[33]

Figure 10 Assumed evolution of the annual stock of new passenger cars in Europe until 2030



Source: *Frontier Economics*

Note: *See Annex A for further detailed assumptions and parameters. Note that there are no super credits for EV from 2023 onwards.*

4.2 OEM could invest in additional GHG measures instead of paying billions in penalties

OEMs can benefit from a crediting system in several ways:

- OEMs may miss their targets, which could result in up to € 50 bn in penalties by 2030 (trucks and passenger cars combined);

[32] Based on EC (2018): Non-paper on Cars/Vans CO_2 Regulation proposal.

[33] For the total number of trucks sold see https://www.acea.be/statistics/tag/category/by-country-registrations. For the share of 5-LH in total trucks see https://www.acea.be/uploads/publications/ACEA_preliminary_CO2_baseline_heavy-duty_vehicles.pdf.

- OEMs (and consequently consumers) can save on costs and – even more important – achieve additional and faster emission savings instead of paying a penalty under a crediting scheme;
- OEMs can offer their customers carbon-neutral combustion engine cars and trucks; and
- Crediting complements the industry's turn towards electrification – it acts as a safety belt for OEMs and prevents disruptions of the market for new vehicles.

OEMs must pay significant penalties if they miss their fleet targets

As mentioned, OEMs must pay a per-vehicle penalty if their average emissions exceed the fleet target:

- For **Cars and vans**, OEMs must pay a 'penalty' of 95 EUR/g CO_2/km times the number of new vehicles, which equates to a CO_2 price of ca. 475-600 EUR per tonne CO_2, depending on the assumed lifetime mileage.[34]
- For **trucks**, failure to comply with the specific emission target will result in a penalty of €4,250 per g CO_2/tkm in 2025 and €6,800 per g CO_2/tkm in 2030. The penalty in 2030 equates to a CO_2 price of ca. 280-600 EUR per tonne CO_2, depending on the assumed lifetime.[35]

These penalty payments can reach several thousand euros per new vehicle, depending on by how much OEMs exceed their fleet targets.

OEMs may miss their targets, which could result in up to € 50 bn of euros in penalties by 2030

Rather than examining the "hidden" cost from the penalty on each newly registered vehicle, we can also examine the total sum of penalties payable by OEMs that sell vehicles in Europe. The following considerations effectively indicate the penalties at risk for the sector:

- If the 2020-trend continues, this could result in total penalties of ~7bn/a for the industry already today in 2020,[36] despite a decline in vehicle sales[37] from 15.4 m in 2019 to 10 m in 2020 and despite phase-in provisions.[38]
- By 2030, penalties for passenger cars alone could range between 10 and 40 bn/a if OEMs are unable to boost the share of EVs sold to achieve the -50%

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34 95 EUR/g/km divided by an average lifetime mileage of 160,000 – 200,000 km multiplied by 10^6 (g/tonne). Assuming a longer lifetime mileage would result in a lower CO_2 price and vice versa.

35 €6,800 per g CO_2/tkm divided by 1,605,672 (annual tonne-kilometre for 5-LH) and divided by an assumed lifetime of 7-15 years, multiplied by 10^6 (g/tonne). Assuming a longer lifetime in years would result in a lower CO_2 price and vice versa.

36 According to ICCT (Market Monitor, September 2020), the current gap (Jan-Aug) is 7 g CO_2/km in NEDC terms). If this continues in 2020, penalties = 7 g/km * 95 €/(g/km) * 10.7 m vehicles = € 7.1 bn.

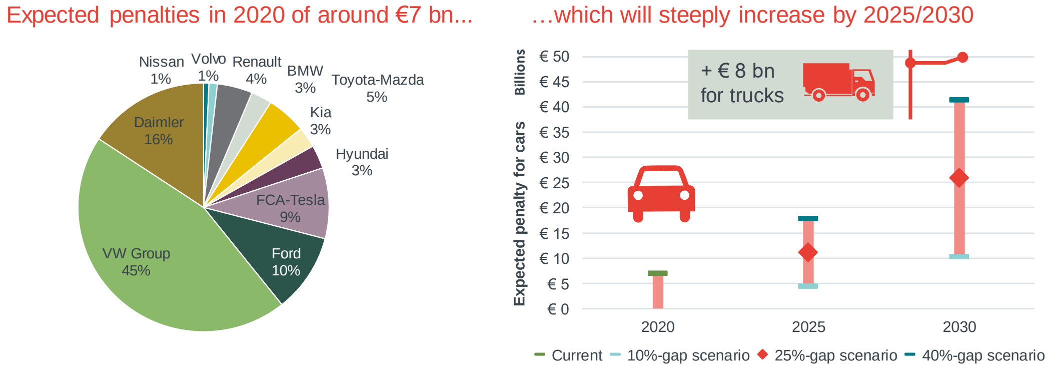
37 In 2019 (before Covid-19), PA Consulting estimated that the top-13 car makers could face penalties of €14.5 bn in 2021, see https://www.paconsulting.com/insights/2019/co2-emissions-are-increasing/.

38 For 2019 vehicle sales, see https://www.acea.be/statistics/tag/category/by-country-registrations. For 2020, we scale up the YTD (August) values from ICCT (2020): Market Monitor, September 2020, Fact Sheet Europe.

emission target. "*We are talking about a potential €30 bn penalty for the industry*," warned Volkswagen chief executive Herbert Diess already in 2019.[39]

Our penalty calculation tends to underestimate actual penalties since we assume perfect pooling of the industry (to minimise the aggregate penalty payments) and since we use NEDC targets which will to be converted into WLTP from 2021 onwards with a conversion rate equal yet to be determined.[40]

Figure 11 Penalty payments for OEMs might increase from € 7 billion to € 50 billion by 2030



Source: Frontier Economics

Note: Penalties in 2020 are based on data from the ICCT Market Monitoring 2020 which considers the impact of the 95%-rule for 2020 NEDC targets and super credits for ZLEV. (see Annex B for further details).

OEMs (and consequently consumers) can save on costs and – even more importantly – achieve additional and faster emission savings instead of paying a penalty under a crediting scheme

In a crediting system, OEMs can buy credits from fuel suppliers generated through **additional** renewable fuel volumes (in excess of their own obligation from RED II) – which would otherwise not have been supplied to the market. These credits (reflecting true emission savings *before* credits are issued) can be counted towards the average emissions of new vehicles in their fleet to avoid the penalty (referred to as "Option 1 – Reduction of average fleet emissions").

High penalties mean OEM's willingness-to-pay significantly exceeds the cost of producing additional renewable fuels for fuel suppliers, which creates a potential **win-win** renewable credits market for both parties. In the textbox below, we show that the expected range of expected credit prices is below the penalty for passenger cars and trucks which creates a **business case OEM for fleet crediting (option 1)**. The net benefits can also be shared with consumers (see **Section 4.3**).

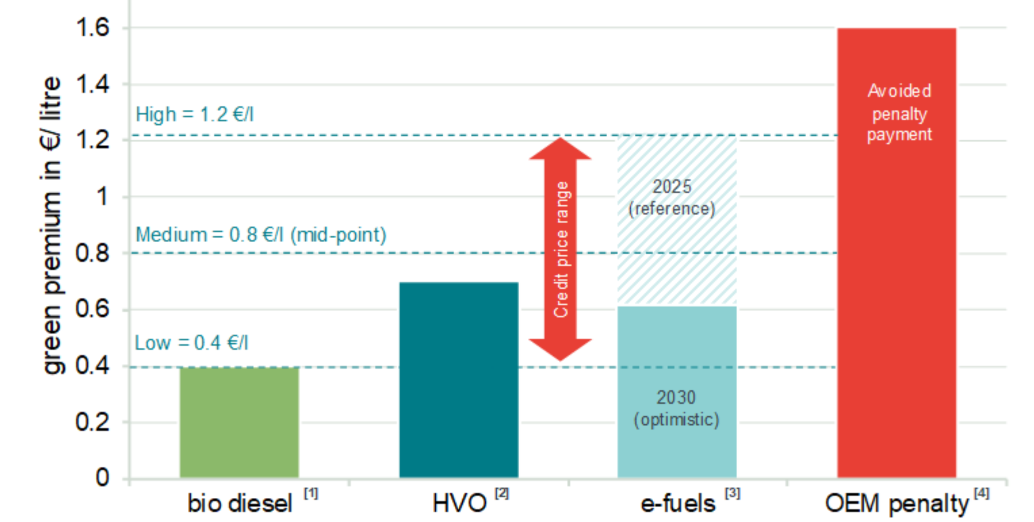
39 https://www.ft.com/content/74c04dc2-5b9c-11e9-9dde-7aedca0a081a

40 Current market data suggests that the conversion rate will be 1.2, i.e. both targets and average fleet emission would increase by 20% from NEDC to WLTP, and any target gap would increase by 20% accordingly. This means that penalties in € per vehicle could increase by 20% by the mere change from NEDC targets to WLTP targets.

A MARKET FOR RENEWABLE FUEL CREDITS

- **OEMs could be willing to pay up to 1.6 €/l for credits** – Converting the penalty from fleet regulation (in € per g/km or g/tkm) into € per litre of renewable fuel shows that an OEM would be willing to pay up to app. 1.6 €/l for credits.[41]
- **The production cost premium for renewable fuels is between 0.4 and 1.2 €/l** – Renewable fuels are typically costlier to produce than conventional fuels (as reflected in higher wholesale prices). This cost difference must be compensated by the credit price (reflecting the green property of the fuel).
  - The cost premium for biodiesel vs. conventional diesel is ~0.4 €/l at a wholesale level;
  - The cost premium for HVO is estimated ~0.7 €/l at a wholesale level;
  - The cost premium for e-fuels may decline from ~1.2 €/l to ~0.6 €/l by 2030.
- If the cost premium translates into prices for credits, this results in a possible price range for credits (expressed in € per litre renewable fuel) of 0.4-1.2 €/l. At these credit prices, OEMs would be willing to buy credits and fuel suppliers would be willing to supply additional renewable fuels (generating the credits).

Figure 12 OEM penalty exceeds the possible price range for credit



Credit price	Low	Mid	High		Penalty (2030)
€/l	0.4	0.8	1.2	<	1.4-1.6
g/km (LDV)	24	48	73	<	95
g/tkm (HDV)	1,957	3,995	6,032	<	6,800

Source: [1] https://www.ufop.de/biodiesel-und-co/biodiesel-preis; [2] Derived from publicly available financial statements from Neste Oyj (2019); [3] e-fuels production based in MENA region and transported to the EU, Source: Frontier Economics (2020); [4] Based on LDV penalty of 95 € per g/km excess emission (Regulation (EU) 2019/631, Art. 8), converted into €/l based on a 175,000 km lifetime mileage and 85% CO_2 savings factor.

Note: Green premium = green fuel wholesale price – conventional fuel wholesale price. The price calculations are made independently by Frontier Economics based on publicly available information. Neste does not suggest that this would be the future nor correct pricing.

Financing additional renewable fuels helps accelerate climate protection in road transport (see **Section 5** for further details) – while paying a penalty would not help the climate.[42]

OEMs can offer their customers carbon-neutral combustion engine cars and trucks

Using "Option 2 – individual crediting", OEMs can sell carbon-neutral cars and trucks if emission reductions through the crediting of renewable fuels are attributed to individual vehicles (individual crediting). If the carbon-neutral property is listed in registration documents (via an amendment to the European type-approval regulation, see **Section 3.2**), emission reductions are visible (and transferable) for final customers.

This has significant net benefits, depending on the future price for renewable fuel credits, which can be shared by OEMs and their customers (**Figure 13**):

- **Credit costs** – OEMs must pay for credits up front, equal to the (assumed) lifetime emissions of the vehicle. Credit costs increase proportionally with lifetime fuel consumption and the credit price (see textbox above). Accordingly, credit costs for trucks may go up to € 300,000 if credit prices are high, while passenger cars only require credits of up to € 8,000 per vehicle in 2030.
- **Avoided penalty** – OEMs can count the corresponding emission reductions against their average fleet emissions (see Section 3.2). The avoided penalties from selling a carbon-neutral ICEV with crediting compared to selling a new ICEV without crediting equals the emissions times the penalty per excess emission [€ per g/km or g/tkm]. The avoided penalty in 2030 equals around 10,500 € per carbon-neutral car and around 350,000 € per carbon-neutral truck.
- **Possible additional tax/toll benefits** – Low-emission vehicles enjoy significant benefits from car tax and toll exemptions. For example, in Germany, electric passenger cars are tax-exempt for the first 10 years and electric trucks (BEV, FCEV and PHEV) are fully exempt from toll payments. If the same exemptions were to apply to carbon-neutral combustion engines, truck owners would save significant payments over the vehicle lifetime.

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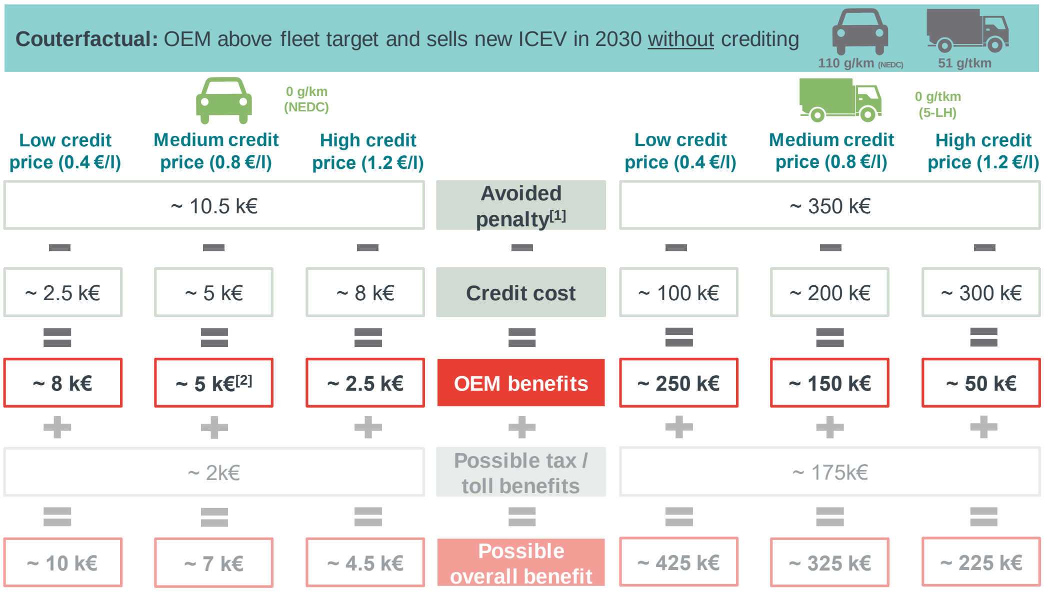
41 The willingness-to-pay depends on new parameters for a crediting system, which would need to be introduced in the amended fleet regulation. For cars, this is the lifetime mileage and for trucks the lifetime in years as set by the respective regulation to determine the required credits, see BMWi study, Section 5.2. 1.6 €/l is based on a car with a lifetime mileage of 175,000 km and an emission savings factor of 85%. The willingness-to-pay for a 5-LH truck with a lifetime of 9 years (corresponds to a total mileage of ~ 1 million km) would be slightly lower at 1.4 €/l at 2030-penalties. Assuming a longer lifetime would result in a lower willingness-to-pay, since more credits would need to be procured to reduce emission by 1 unit and vice versa.

42 The penalty is revenue for the general EU budget, see HDV fleet target regulation, recital 35 and LDV fleet target regulation, recital 45.

Figure 13 Net benefits from the sale of a carbon-neutral car/truck with renewable fuel crediting in 2030



Source: *Frontier Economics*

Note: *Assumption and detailed calculation see Annex B. [1] Includes impact on reduced fleet average from ZEV; Cars: penalty of €95 per gCO2 /km, Trucks: €6,800 per g CO2/tkm in 2030; [2] Numbers do not add up due to rounding.*

Although the extra payments for OEM from buying credits appear high at first glance, **OEMs benefit from selling carbon-neutral vehicles, even if they cannot charge more for them, since credit costs are lower than the penalties avoided in most cases**. As mentioned, OEMs can always choose whether to buy a credit or continue paying the penalties. Depending on overall market dynamics, OEMs might be able to share benefits with their customers (particularly for trucks) by agreeing on a higher vehicle price (to partly compensate for credit costs).

The business case for carbon-neutral trucks with combustion engines will also depend on whether OEMs can sell sufficient EV trucks to avoid any penalties. This might be a huge challenge for OEMs if targets are tightened, since long-haul trucks – which comprise ~63% of the vehicles subject to fleet targets – require a far-developed charging infrastructure, longer drive ranges than cars and high load capacities (in tonnes).

Crediting provides a complement to the industry's turn towards electrification – it acts as a safety belt for OEMs and prevents disruptions of the market for new vehicles

In our scenarios, electrification is and remains the backbone for reducing road transport emissions. A crediting system for renewable fuels is not designed to undermine the importance of electric vehicles but **complement the emission reduction efforts**, given increasingly stringent targets.

Currently EVs are more or less the only technology option – given the limited fuel efficiency improvements for ICEV – to reduce (tailpipe) emissions from new vehicles. The crediting system will therefore also help to **act as a "hedge" for OEMs** and an additional option to react if future risk emerges, e.g.

- if EU fleet targets were increased at relatively short notice (as announced recently);
- if regulation moves towards life cycle analysis, resulting in a less favourable treatment of EVs;
- if countries change their mobility sector policies (see recent trends in China[43]), or
- if the take-up of EVs by customers is limited (e.g. perceived lack of charging infrastructure, long distance applications, image/brand issues around rare materials, etc.).

Without an additional "tool" to react to materialized risks the only realistic option for OEMs will be to pay the penalty. Apart from EU regulation and the EU market, a broader technology portfolio is important for OEMs operating in global markets with different environmental policies.

The focus on a single technology might also disrupt the "new vehicle" market, in particular in years when fleet targets are tightened (2025 and 2030):

- If OEMs expect to fail their targets, they have two options: pay a significant penalty or sell electric vehicles at a significant discount.
- If customers can anticipate this behaviour, they might delay the purchase of a new electric vehicle to benefit from significant future discounts.

A delayed uptake of electric vehicles would increase fleet emissions. **Crediting could avoid such disruptions** since OEMs can buy renewable fuel credits (at lower costs than the penalty) as an alternative to meet their targets and achieve effective emission savings.

Note: In our crediting scheme proposal, we have proposed an optional cap on emission reductions from crediting in g/km or g/tkm to address concerns that direct electrification could be crowded out by a crediting system.

4.3 Fuel suppliers can benefit from a more stable, long-term secured market for renewable fuels

A crediting system could boost demand for renewable fuels by several billion litres per year which provides a more stable, long-term secured market for renewable fuels.

Fuel suppliers as well as OEMs could benefit from the crediting scheme (not to mention consumers and the environment). The additional market potential for renewable fuels (**Figure 14**) equals the gap between fleet-targets and achieved (computational) fleet-emission reductions through EV sales and ICE efficiency gains.[44]

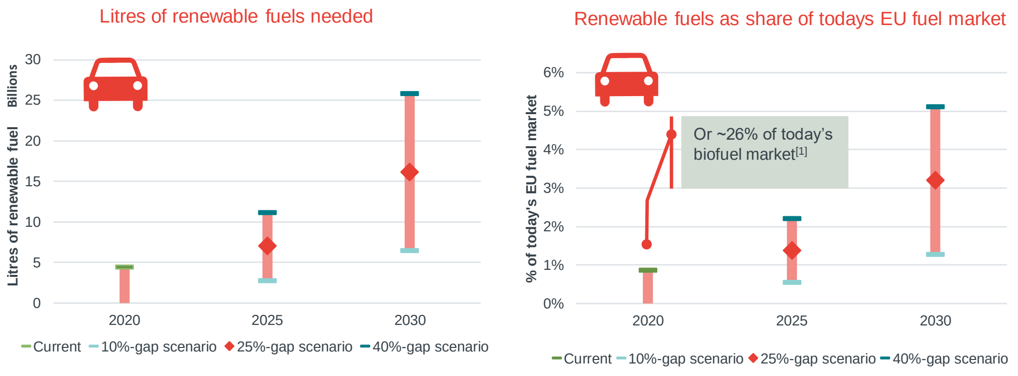
[43] China, the world's largest car market, is adopting a more open technology approach (see textbox) where highly efficient ICEV and hybrid vehicles have a long-term future. European OEMs might lose their technological advantage if unable to sell low-carbon ICEVs in their home markets.

[44] Due to front loading, this equates to the equivalent volume of green fuels over the entire lifetime of a vehicle before credits are counted towards individual vehicles or fleet targets. For example, if emissions from 1 million passenger cars with a lifetime of 15 years were to be offset, this would require the fuel consumption equivalent to 15 million vehicles per year.

From a fuel supplier's perspective, the following considerations on market potential are relevant:

- The short-term market volumes for credits are expected to be small compared to the current biofuel market size (which is driven by the renewable fuel obligation of suppliers) – we do not expect this to trigger a shortage of renewable fuels. In 2020, 4.5 bn litres of green fuels would be needed to meet the targets, which equates to ~26% of today's biofuel market and less than 1% of the total fuel market.[45]
- In the longer run, the required volumes for passenger cars can rise up to around 25 billion litres of renewable fuels by 2030 for passenger cars. This corresponds to around 5% of the total fuel market in the EU (see right hand side of **Figure 14**). We expect that successfully introducing a crediting scheme would lead to additional investments in new fuel production facilities. The European Commission's impact assessment on Stepping up Europe's 2030 climate ambition[46] shows that an increase in the renewable share in the transport sector can be achieved. We therefore expect that the European market for renewable fuels can accommodate additional demand from a crediting system, considering that additional synthetic fuels could also be imported from outside of Europe.[47]

Figure 14 Potential additional renewable fuel in road transport from a crediting system (example: passenger cars, 25%-gap scenario)



Trucks: additional 6 bn litres by 2030 (scenario: OEMs reach 30%-target, but target set to -40%)

Source: Frontier Economics

Source: Results for passenger cars from 25% gap scenario (i.e. OEMs sell 25% less EVs than needed to achieve their fleet target).

[45] Road fuel demand in the EU in 2018 was around 375 m tonnes (see Fig. 8 in FuelsEurope: Statistical Report 2018); Biofuel market size was around 13 m tonnes in 2019 (see Table 9 at https://apps.fas.usda.gov/newgainapi/api/report/downloadreportbyfilename?filename=Biofuels%20Annual_The%20Hague_EU-28_7-15-2019.pdf). Note that we use a conversion factor of 1,345 litres per tonne of fuel.

[46] See part 2, page 56; available online: https://eur-lex.europa.eu/resource.html?uri=cellar:749e04bb-f8c5-11ea-991b-01aa75ed71a1.0001.02/DOC_2&format=PDF.

[47] See Agora Verkehrswende, Agora Energiewende and Frontier Economics (2018): The Future Cost of Electricity-Based Synthetic Fuels, available online https://www.agora-energiewende.de/fileadmin2/Projekte/2017/SynKost_2050/Agora_SynKost_Study_EN_WEB.pdf.

4.4 Consumers gain freedom of choice to find affordable low-emission vehicles that fit their mobility needs

Consumers are practically today only presented with one option for green mobility – electric vehicles. A crediting system could provide more affordable and broader choice for green mobility and logistics:

- Crediting avoids billions in penalties which could otherwise lead to higher prices for new vehicles.
- In the proposed crediting system, OEMs have the option to sell carbon-neutral combustion engine cars and trucks if they offset the entire lifetime emissions with additional renewable fuel. For some consumer groups combustion engine vehicles are the most suitable – or possibly the only – option for green mobility, in particular for heavy duty vehicles. It can also unlock additional tax and toll benefits if tax and toll regulations focus on climate impact, and not on the drivetrain technology.

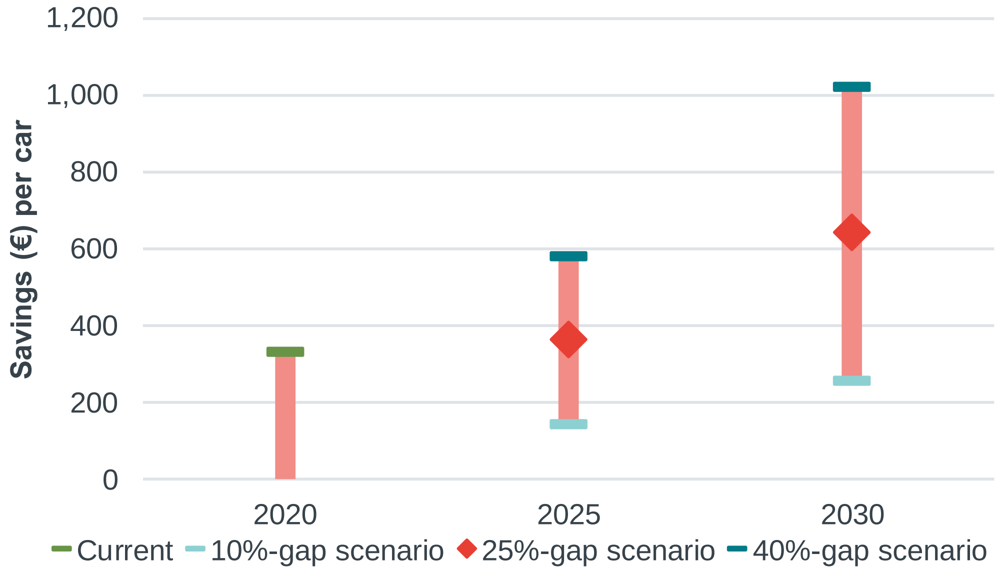
Retaining public approval is extremely important for the feasibility of ambitious climate targets in transport, a sector which represents almost a quarter of Europe's GHG emissions.

Crediting avoids billions in penalties, which might otherwise drive new vehicle prices up

Broadening the scope of emission-reduction options for OEMs will reduce the cost of achieving fleet targets and ultimately drive new vehicle prices down.

OEMs can save up to € 50 bn in penalty payments by 2030 (see **Section 4.2**). Even after deducting the cost for credits (needed to finance additional renewable fuels), this could lead to significant cost savings per vehicle (**Figure 15**).

Figure 15 Consumer can save up to 1,000 € per new passenger car if savings are passed on to them



Source: Frontier Economics

Note: This is based on our medium estimate on credit prices of 0.8 €/l. Cost savings are allocated to all vehicles, including electric. If savings were only allocated to combustion engine vehicles, total savings would reach up to ~€ 2.000 per new ICEV by 2030.

Individual vehicle crediting provides a broader choice of green mobility options and can unlock additional tax/toll benefits

The transition of the transport sector cannot be achieved without the broad public acceptance and the customer take-up of sustainable transport technologies. If customers can no longer get the mobility they want, this can cause massive acceptance problems which ultimately jeopardise the success of the overall climate protection efforts. Therefore retaining customers' support might be an important side-effect of offering alternative options for a de-fossilised individual mobility to private individual.

For some consumer groups combustion engine vehicles are the most suitable – or possibly the only – option for green mobility, in particular for heavy duty vehicles. With individual crediting, OEMs can offer these customers zero- and low emission combustion engine vehicles through individual crediting.

Acknowledging emission reductions from renewable fuels can help in two areas:

- It would keep mobility affordable (see above). This is particularly important for low and medium income households.
- A vehicle is often one of the more major investment of a household. The existing fleet of ICEV therefore poses a significant share of individual's property. A crediting system would provide a longer-term perspective for green internal combustion engines and help to retain the secondary market value of existing vehicles. This prevents a significant devaluation of individual wealth.

Zero- and low emission through individual crediting can also unlock additional benefits for consumers if tax/toll regulation is based on the CO_2 intensity of a vehicle (rather than the drivetrain technology). Electric vehicles are subject to tax and toll exemptions in several EU Member States.[48] If the same exemptions were to apply to carbon-neutral combustion engines, truck owners in particular could save significant toll payments over the vehicle lifetime (**Figure 13**).

[48] See ACEA (2020), Electric vehicles: tax benefits & purchase incentives, available online: https://www.acea.be/uploads/publications/Electric_vehicles-Tax_benefits_purchase_incentives_European_Union_2020.pdf

5 WHAT'S IN IT FOR THE ENVIRONMENT?

A crediting system leads to **additional, effective, and faster** emission reductions[49] in the transport sector compared to a world where OEMs miss their targets.

- OEMs can mitigate more emissions overall – they can reach more ambitious targets (instead of missing them and paying the penalty);
- A crediting scheme with frontloading can reduce annual emissions from new passenger cars by up to 57 Mt CO_2 in 2030 (~ 8% compared to road sector emissions in 2018);
- Crediting with frontloading would reduce the cumulative emissions of new passenger cars until 2030 by up to 215 Mt CO_2 (~ 32% of total road sector emissions in 2018).

A crediting system can help achieve more ambitious climate targets for road transport

The **challenge** to meet emission-reduction targets for the road transport sector is huge – there are real and material risks of OEMs being unable to meet them:

- OEMs are expected to miss their 2020 fleet targets (see **Section 4.2**), despite a strong increase in the share of electric vehicles sold (8%, up from 3% in 2019) and transitional measures[50] which ease the pressure on OEMs.
- At the same time, targets are expected to be increased significantly until 2030 in line with the European Commission's ambitions to reduce EU greenhouse gas emissions by at least 55% by 2030.[51]

There is a real and material risks of **electromobility alone being insufficient** to achieve ambitious transport sector targets in 2030:

- E-mobility requires an accelerated expansion of renewable electricity sources, but this is at risk due to public resistance against more wind turbines and power grid expansions, limitations to suitable sites, grid stability issues, competing use for renewable electricity, etc.
- Some use cases in road transport, for example long-haul trucks, have specific infrastructure needs and are difficult (or expensive) to electrify.
- Geographic and climatic limitations, such as long distances in sparsely populated areas and cold winters.

Additional renewable fuels from a **crediting system can** therefore **complement electromobility** to meet the climate challenge for road transport.

[49] The fossil fuel comparator and emission saving factors for renewable fuels used to calculate emission reductions are taken from RED II. RED II considers not only the climate impact from CO_2 but also takes other GHG emissions (N_2O and CH_4) into account. To reflect the combined climate benefit from renewable fuels, GHG emissions are expressed as CO_2 equivalence (CO_2eq, see RED II, Annex V). In the remainder of the report, we simply refer to CO_2 equivalence as "CO_2" when we calculate GHG emission reductions from renewable fuels.

[50] 'Super credits' for ZLEV (multiplier of 2 for electric vehicles) and the 95%-rule which allows OEMs to omit the top 5% of new cars with the highest CO_2 emissions for calculating the fleet average.

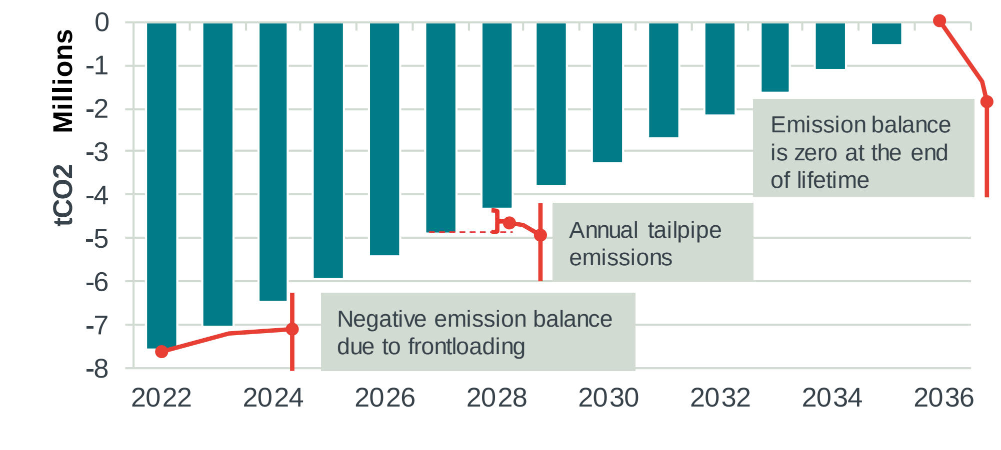
[51] https://ec.europa.eu/commission/presscorner/detail/en/ip_20_1599

A crediting system would also significantly **accelerate climate protection** due to frontloading of emission reductions. In our BMWi study, we propose frontloading of credits: OEMs must surrender the renewable fuel credits covering the full lifetime emissions of new vehicles. Before year 1 of the life of a new passenger car, emissions over the entire lifetime of ten years or more had to be taken out of the atmosphere. This creates a **negative emissions balance** which is slowly reduced over the vehicle lifetime (see textbox below). Frontloading is possible since most road vehicles in Europe are still running on conventional fuels, which can be replaced with renewable fuels.

FRONTLOADING SIGNIFICANTLY ACCELERATES EMISSION REDUCTIONS IN ROAD TRANSPORT

- In year 1, there is a net negative impact on emissions since the lifetime emissions (15 years in our example) are already bound up in the production of synthetic fuels or biofuels. This net impact equals 15 times the annual tailpipe emissions of new passenger cars;
- These emission savings are reduced over the lifetime of 15 years when vehicles release CO_2 back into the atmosphere;
- Net emissions only reach zero at the very end of the lifetime[52] – this is a significant advantage over zero-tailpipe emission technologies (EV).

Figure 16 Frontloading leads to a net negative emission balance in early years – example for the new passenger car cohort 2022



Source: Frontier Economics

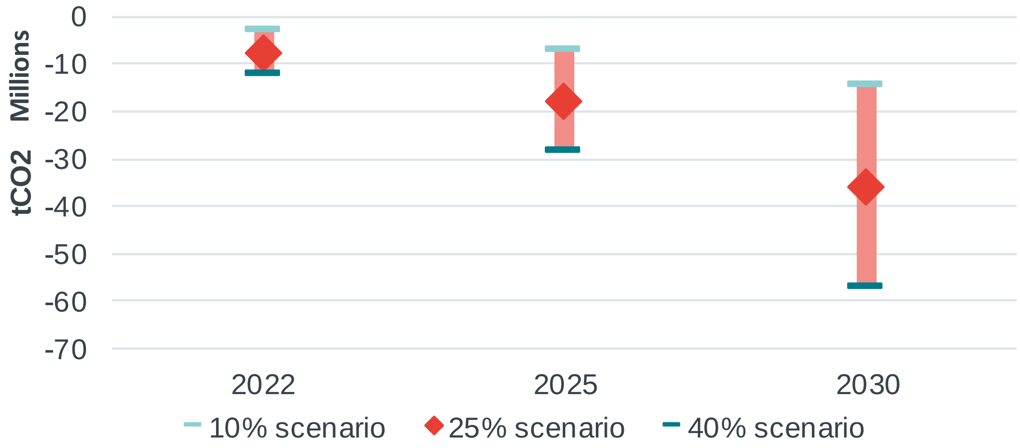
Note: This example is based on our 25% gap scenario, which means ~420,000 cars were offset by frontloading their lifetime emissions in 2022.

52 'Lifetime' (in km) is a new parameter which has to be defined in Fleet Regulation as part of the crediting scheme. The parameter is set such that the average car reaches net zero emission at end of its lifetime. Individual vehicles might emit more (above-average lifetime) or less (below-average lifetime). For the calculations in this report we assume a lifetime mileage for new passenger cars of 175,000 km (equivalent to 15 years at 11,667 km/a).

A crediting scheme with frontloading can reduce annual emissions from new passenger cars by up to 57 Mt CO_2 in 2030

Figure 17 shows the annual emission reductions from a crediting system if OEMs would otherwise miss their targets by not selling sufficient EVs.[53]

Figure 17 A crediting scheme with frontloading can reduce annual emissions from new passenger cars by up to 57 Mt Mt CO_2 in 2030



Source: Frontier Economics

Each year, the lifetime emissions of sufficient passenger cars are offset by additional renewable fuel credits to reach the fleet target. Emission reductions increase over time, reflecting an increase in the total number of cars and targets.

By 2030, emissions savings amount to up to 57 Mt CO_2 in 2030, ~8% of total road transport emissions in 2018.[54]

A crediting scheme with frontloading would reduce cumulative emissions by up to 215 Mt CO_2 until 2030

To limit global warming, only a certain amount of greenhouse gases can be released into the atmosphere (i.e. a certain emission budget), which means cumulative emissions are relevant, not just annual emissions in the target year.

The cumulative emission reductions achieved through a crediting system build up substantially over time – up to 215 Mt CO_2 in 2030 (**Figure 18**):

- In 2022, the entire lifetime emissions of the first cohort of passenger cars are offset and only released back (as tailpipe emissions) over the lifetime (15 years in our example).
- In 2023, a second cohort is offset, while cohorts one and two are emitting their yearly emissions.

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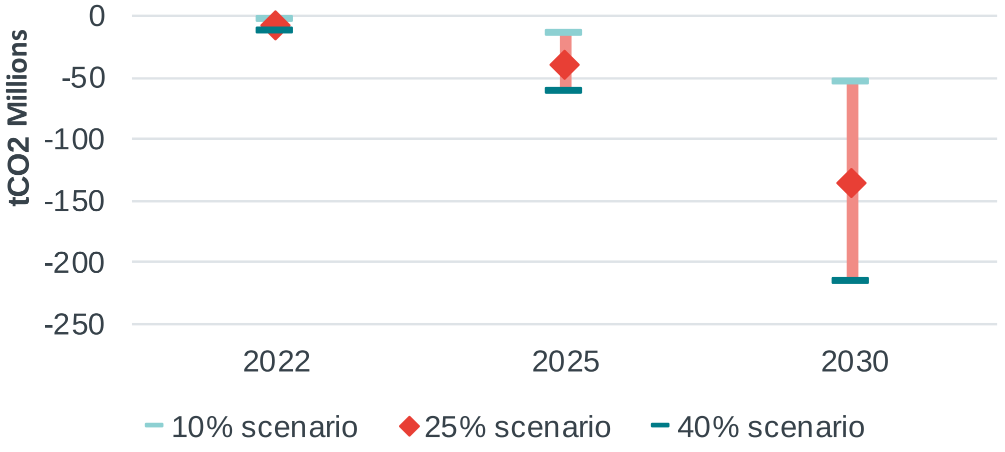
[53] Note that the amount of emissions saved depends on the difference between actual emissions and the emission target. In our scenarios, we define this gap through the missing share of EVs that would have had to be sold to reach the target in any given year.

[54] Total transport emissions are 947 Mt, road transport has a share of 71.7% (= 679 Mt), see https://www.eea.europa.eu/data-and-maps/indicators/transport-emissions-of-greenhouse-gases/transport-emissions-of-greenhouse-gases-12.

- This continues until 2030, by which time the lifetime emissions of nine cohorts have been offset while only a fraction is released back in the form of annual tailpipe emissions.

Even if eventually, all GHGs bound in the production process of the renewable fuel, are released back in the atmosphere, faster emission reductions provide more time for adaptation and greater ability to withstand climate change.

Figure 18 Introducing a crediting system by 2022 could reduce cumulative road transport emissions by 135 Mt until 2030



Source: Frontier Economics

Note: This example is based on our 25% gap scenario, which means that between 2022 and 2030 the lifetime emissions of around 10 m cars were offset by frontloading.

6 CONCLUSION – A CREDITING SYSTEM COULD BENEFIT THE INDUSTRY, CONSUMERS AND OUR CLIMATE

A crediting system can boost the efficiency and effectiveness of de-fossilising road transport. It creates a significant stack of sharable benefits for consumers, OEMs and fuel suppliers while generating **additional, effective, and faster** emission reductions!

- **OEMs** (**Section 4.2**) may miss their fleet targets, which could result in tens of billions of euros in penalties by 2030 – money which is lost for climate protection. A **voluntary** crediting scheme allows OEMs to achieve true emission savings instead. OEMs can offer their customers carbon-neutral combustion engine (and hybrid) cars and trucks which complements the industry's turn towards electrification and acts as a safety belt for OEMs.[55]
- **Fuel suppliers** (**Section 4.3**) – A crediting system could boost demand for renewable fuels by several billion litres per year. This could help to establish a **more stable, long-term secured market** for renewable fuel suppliers and could lead to additional investments in new renewable fuel production facilities. It also provides an automatic coordination of efforts from the fuel and vehicle sector.
- **Consumers** (**Section 4.4**) benefit from **more affordable and broader choice** for green mobility and logistics. Crediting avoids billions in penalties, which could otherwise drive new vehicle prices up. Carbon-neutral combustion engine (and hybrid) cars and trucks are for some consumers the most suitable – or possibly the only – option for green mobility, in particular for heavy duty vehicles. Retaining broad public approval is extremely important for the feasibility of ambitious climate targets in transport, a sector which represents almost a quarter of Europe's GHG emissions.
- A crediting system leads to **additional, effective, and faster emission reductions** compared to a world where OEMs miss their targets and pay a penalty. Using the RED II sustainability and tracing scheme ensures effective emissions reductions (not just on paper) and prevents double counting. A crediting scheme with frontloading (i.e. offsetting lifetime emissions before the sale of a new vehicle) could reduce annual emissions from new vehicles by tens of millions of tonnes by 2030 – a multiple even looking at cumulative emissions until 2030. These additional emission reductions can be achieved at the same or lower costs since OEMs could invest in additional GHG measures instead of paying billions in penalties.

Credible and effective climate protection requires a **more holistic view** on the climate impact of different mobility options – a full life-cycle perspective which reveals true emissions along the whole value chain (from battery and vehicle production, power and fuel mix to recycling). A crediting system – bridging the gap

[55] OEMs have already taken huge investments into e-mobility and policy makers are paving the way for charging infrastructure. In our crediting system proposal, we have also included an optional cap on emission reductions from crediting to address concerns that direct electrification could be crowded out.

between the "well-to-tank" sphere of fuel provision and the "tank-to-wheel" focus of OEM's regulation – would be a first step towards a more holistic system as it links climate protection efforts by fuels suppliers and car manufacturers.

The climate challenge is significant and time is short – the remaining global emission budget to limit the temperature increase to 1.5°C may be exhausted in less than two decades if we do not drastically reduce emissions.[56] There are certain transport applications where renewable fuels are the only feasible green option (e.g. mobile machines, aviation, shipping) and we need to develop and maintain an appropriate fuel infrastructure. We **cannot afford to exclude technologies** (such as highly-efficient combustion engines with renewable fuels) and put all our eggs in the one basket. Otherwise we risk failing climate targets which can have irreversible long-term damage. Instead we need regulations that provide a level playing field for a wide-ranging set of technologies.

[56] https://www.ipcc.ch/sr15/chapter/chapter-2/, see Figure 2.3.

ANNEX A ASSUMPTIONS AND PARAMETERS

Figure 19 provides the underlying parameters for the passenger car calculations in our three scenarios. We assume a target of -50% emission reduction to 2021.

Figure 19 Key parameters – passenger cars (-50% target, all three gap scenarios)

Assumption	Value	Unit	Comment/Source
Target in 2019 (NEDC)	120	gCO_2/ km	Regulation (EU) 2019/631
Target in 2020 (NEDC)	96	gCO_2/ km	ICCT Market Monitoring Sept 2020
Target in 2021 (NEDC)	95	gCO_2/ km	Regulation (EU) 2019/631
Reduction of target in 2025	-20%	to. 2021 in %	Tighter targets (EC stepping up)
Reduction of target in 2030	-50%	to 2021 in %	Tighter targets (EC stepping up)
Penalty for non-compliance	95	€/ gCO_2/ km /car	Regulation (EU) 2019/631, Art. 8
Actual emissions 2020 (NEDC)	103	gCO_2/ km	Average NEDC (after credits, 2020YTD value) from ICCT Monitoring Sept 2020
Lifetime mileage per car	175,000	km	See Frontier BMWi study
Yearly mileage per car	11,667	km/ a	Lifetime mileage divided by 15 years of operation
# newly registered cars in 2020	10,719,547	cars	YTD new vehicle registrations from ICCT Market Monitoring September 2020, scaled up to full year
# newly registered cars in 2030	20,300,000	cars	EC, Technical update of the non-paper (Sept 2018) on Cars/Vans CO2 Regulation proposal, November 2018
Achieved share of EVs 2020	8%	%	Average of EU (2020YTD value, ICCT Market Monitoring Sept 2020)
Fuel efficiency improvement	1%	% p.a.	Assumed decrease of non-EV emission intensity (p.a.)
Credit price_low	0.4	€/ litre	Green premium for biodiesel above the wholesale price for conventional fuel
Credit price_medium	0.8	€/ litre	Mid-point between low and high credit price
Credit price_high	1.2	€/ litre	Green premium for e-fuel (Frontier estimate 2025) above the wholesale price for conventional fuel
Biofuel market size in EU_2019	17,380	m litres	USDA, EU Biofuels Annual 2019, Figure 9
Road fuel demand in the EU	375	m tons	FuelsEurope, Statistical Report 2018, Fig. 9
Litres per tonne (of above)	1,345	litres per tonne	
CO2 reference value	94	gCO_2/ MJ	Fossil fuel comparator from RED II, Annex VI (CO_2 equivalent)
CO2saving(k)	85%	%	RED II, Annex V
Energy content RE fuel	44	MJ/ kg	

Source: Frontier Economics

Figure 20 highlights the relevant parameters for our HDV calculations. Here we assume that the current target of -30% emission reduction to 2020 is achieved, but that the target is tightened to -40%.

Figure 20 Key parameter – trucks (-40% target scenario, 30% achieved)

Assumptions	Value	Unit	Comment
Fuel efficiency gains (p.a.)	1%	% p.a.	1% p.a. fuel efficiency
Average emissions 2020 (baseline)	56.5	gCO2/ tkm	2020 = preliminary baseline ACEA for 5-LH, 1% p.a. fuel efficiency
Reduction of target in 2025	-20%	to ref period in %	Tighter targets (compared to -15% in current regulation); reference period July 2019 – June 2020
Reduction of target in 2030	-40%	to ref period in %	Tighter targets (compared to -30% in current regulation); reference period July 2019 – June 2020
Annual transport	1,605,672	tkm/a	for 5-LH, see ANNEX A of HDV Fleet Regulation
Annual mileage	116,000	km/a	see ANNEX A of HDV Fleet Regulation
Lifetime	9	a	New parameter; 7 (from Euro 6) to 15 years (more realistic)

Source: Frontier Economics

ANNEX B DETAILED RESULTS

In this annex we provide further details on:

- Overview of scenario results;
- Possible OEM and consumer benefits from a crediting scheme; and
- Example of crediting one million litres of renewable fuel on fleet targets.

B.1 Overview of scenario results

Figure 21 provides an overview of the results of all three gap scenarios we calculated. The gap is defined as the difference to the amount of electric passenger cars that would have to be sold in order to meet the fleet emission target, as percent of total electric passenger cars sold. All other parameters are equal across the scenarios.

Figure 21 Overview of results for all three gap scenarios in 2030 (all values p.a. in 2030)

Variable	Unit	25%-gap scenario	10%-gap scenario	40%-gap scenario
Achieved share of EVs in new sales	% .p.a.	40%	48%	32%
Achieved number of EVs in new sales	cars	8,082,511	9,699,013	6,466,009
Gap to target EV share in new sales	%	13%	5%	21%
Gap to target EV number in new sales	cars	2,694,170	1,077,668	4,310,673
Number of non-EV cars	cars	9,523,318	9,523,318	9,523,318
Emissions	gCO2/ km	60.94	52.88	69.00
Yearly emissions of new fleet	tons of CO2	14,432,118	12,522,597	16,341,639
Allowed emissions	tons of CO2	11,249,583	11,249,583	11,249,583
Surplus of emissions	tons of CO2	3,182,535	1,273,014	5,092,056
Excess lifetime emissions	tons of CO2	47,738,026	19,095,210	76,380,841
Penalty cars	€	25,914,928,169	10,365,971,267	41,463,885,070
Penalty trucks	€	8,444,716,000	8,444,716,000	8,444,716,000
Litres of renewable fuel needed to fill the gap	litres	16,165,372,291	6,466,148,916	25,864,595,665
Litres_trucks	litres	6,077,104,965	6,077,104,965	6,077,104,965
Total costs of credits for OEM_low	€	6,466,148,916	2,586,459,567	10,345,838,266
Total costs of credits for OEM_medium	€	12,932,297,833	5,172,919,133	20,691,676,532
Total costs of credits for OEM_high	€	19,398,446,749	7,759,378,700	31,037,514,799
Savings for costumers per passenger car_low credit costs	€	958	383	1,533
Savings for costumers per passenger car_medium credit costs	€	640	256	1,023
Savings for costumers per passenger car_high credit costs	€	321	128	514
Savings for costumers per ICEV_low credit costs	€	2,042	817	3,268
Savings for costumers per ICEV_medium credit costs	€	1,363	545	2,181
Savings for costumers per ICEV_high credit costs	€	684	274	1,095

Source: Frontier Economics

B.2 Possible OEM and consumer benefits from a crediting scheme

Figure 22 and

Figure 23 provide the detailed calculations on possible benefits that consumers might incur from a crediting system, for cars and trucks respectively.

Figure 22 Net benefits from the sale of a carbon-neutral car with renewable fuel crediting – detailed results (mid credit price)

Couterfactual: OEM above fleet target and sells new ICEV in 2030 without crediting

110 g/km (NEDC)

Medium credit-price scenario (0.8€/l premium)

Passenger car	Unit	2021	2025	2030	Source / Comment
Emission new ICEV before crediting	g/km (NEDC)	120	115	110	1% fuel efficieny p.a.
Lifetime mileage	tkm/a	175,000	175,000	175,000	based on historical mileage
Total emissions	t CO2	21	20	19	Imputed lifetime CO2 emissions
Penalty	€/g/km	95	95	95	LDV Fleet Regulation
Avoided penalty	**€/ vehicle**	**11,400**	**10,951**	**10,414**	Penalty avoided by ZEV if OEM is above target
CO2 savings RES fuel	gCO2/l	2,953	2,953	2,953	based on renewable fuel with 85% CO2 savings acc. to RED II
RES fuel credits required	l	7,111	6,831	6,496	
RES fuel credit cost	€/l	0.8	0.8	0.8	Mid-point of credit cost range (0.4-1.2 €/l)
RES fuel credit cost	**€/ vehicle**	**5,689**	**5,465**	**5,197**	
OEM benefits	**€/vehicle**	**5,711**	**5,486**	**5,217**	Avoided penalty - credit cost
Car tax	€/a	200	200	200	MWV publication 2019
Exemption	a	10	10	10	German tax authorities
Tax benefit	**€/vehicle**	**2,000**	**2,000**	**2,000**	Tax benefits over lifetime (no discounting)
Possible overall benefits	**€/vehicle**	**7,711**	**7,486**	**7,217**	Avoided penalty + toll benefits - credit cost

Source: Frontier Economics

Figure 23 Net benefits from the sale of a carbon-neutral truck with renewable fuel crediting – detailed results (mid credit price)

Couterfactual: OEM above fleet target and sells new ICEV in 2030 without crediting

51 g/tkm

Medium credit-price scenario (0.8€/l premium)

Long haul truck (5-LH)	Unit	2020	2025	2030	Source / Comment
Emission new ICEV before crediting	g/tkm	57	54	51	2020 = preliminary baseline ACEA for 5-LH, 1% p.a. fuel efficiency
Annual transport	tkm/a		1,605,672	1,605,672	for 5-LH, see ANNEX A of HDV Fleet Regulation
Annual mileage	km/a		116,000	116,000	see ANNEX A of HDV Fleet Regulation
Lifetime	a		9	9	New parameter; 9 a ~ 1,000,000 km total mileage
Total emissions	t CO2		776	738	Imputed lifetime CO2 emissions
Penalty	€/g/tkm	-	4,250	6,800	HDV Fleet Regulation
Avoided penalty	**€/ vehicle**		**228,356**	**347,464**	Penalty avoided by ZEV if OEM is above target
CO2 savings RES fuel	gCO2/l		2,953	2,953	based on renewable fuel with 85% CO2 savings acc. to RED II
RES fuel credits required	l		262,933	250,047	
RES fuel credit cost	€/l		0.8	0.8	Mid-point of credit cost range (0.4-1.2 €/l)
RES fuel credit cost	**€/ vehicle**		**210,346**	**200,037**	
OEM benefits	**€/vehicle**		**18,010**	**147,426**	Avoided penalty - credit cost
Toll cost	€/km		0.187	0.187	toll for Euro 6 truck > 18t in Germany in 2019 from Toll Collect
Share of toll km	% of km		90%	90%	Reasonable assumption for long-haul truck
Exemption	% of toll		100%	100%	BMVI
Toll benefit	**€/vehicle**		**175,705**	**175,705**	Toll benefits over lifetime (no discounting)
Possible overall benefits	**€/vehicle**		**193,715**	**323,131**	Avoided penalty + toll benefits - credit cost

Source: Frontier Economics

B.3 Example of crediting one million litres of renewable fuel on fleet targets

For light duty vehicles, fleet targets are expressed in average CO_2 emissions in grams per kilometre of mileage (gCO2/km). The contributions to emission reduction from credited renewable fuel quantities (in litres) must therefore be converted into the same unit. **Figure 24** shows the parameters and the formula to calculate the contributions to emissions reductions from a given amount of renewable fuel.

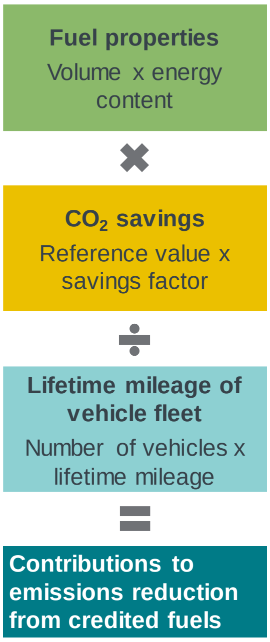
To calculate the value of the emission reduction for fleet i we must first calculate the total CO_2 savings induced by the renewable fuel and then divide by the total lifetime mileage of the fleet:

- For each type of renewable fuel, we multiply the amount of fuel by the CO_2 reference value for the fossil fuel comparator (according to RED II[57]).
- Subsequently, we multiply the CO_2 reference value for the fossil fuel comparator with the emissions saving factor of the respective renewable fuel, also specified in RED II[58], to get the total emission reduction that can be counted against the fleet target.
- To determine the equivalent CO_2 reduction amount, next we divide the emission savings by the total expected mileage of the newly registered fleet, for which we multiply the number of newly registered vehicles of OEM i, with their assumed lifetime mileage.
- An OEM that introduces 1,000,000 litre HVO diesel into the market would generate a total of 0.02 gCO_2/ km contribution to emission reductions.

57 Directive (EU) 2018/2001, *Annex V No. 19.* For biofuels, the fossil fuel comparator is set to 94 g CO_2eq/MJ. This value reflects the GHG content of petrol and diesel which is higher than for natural gas. The fossil fuel comparator is expressed as CO_2 equivalence (CO_2eq) and also takes other GHG emissions (N_2O and CH_4) into account to reflect the combined climate impact from fossil fuels.

58 Ibid, Annex V.

Figure 24 Contributions to emissions reduction from crediting 1 million litres of renewable fuel



Variable	Value	Unit	Comment / Source
Type of renewable fuel	HVO		Hydrotreated oil from waste cooking oil
Renewable fuel in litres	1,000,000	Litre	Assumed for this example
Energy content per litre of renewable fuel	34.4	MJ/ l	Neste renewable diesel handbook, table 3
CO2 reference value	94	gCO2eq/ MJ	CO2 value of the replaced fuel, see Directive (EU) 2018/2001 Annex V
CO2saving(k)	83%	%	See Directive (EU) 2018/2001 Annex V for list of relevant savings factors
Number of vehicles	1,000,000		Assumed for this example
Lifetime mileage	175,000	km	See Frontier BMWi study
Contributions to emissions reduction from credited fuels	**0.02**	**g/ km**	

Source: Frontier Economics

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