Working Group on Monitoring Methodologies of CO_2-Neutral Fuels

WGMM

SUMMARY REPORT

The availability of sustainable feedstocks for the production of CO_2-neutral fuels in Europe

Supporting the decarbonization of the road transport sector

2026

(selection of logos)

The Working Group on Monitoring Methodologies of CO_2-Neutral Fuels (WGMM), a voluntary platform that brings together stakeholders from across the entire automotive and fuel value chain, developed in its 2024 report a technology-neutral definition of CO_2-neutral fuels, which it recommends for a consistent application across all EU legislative acts.

The proposed definition is as follows:

'CO_2-neutral fuel' means all fuels defined under the Renewable Energy Directive (EU) 2018/2001, provided that they meet the sustainability criteria of that Directive and its associated delegated acts. Such fuels must ensure that the same amount of CO_2 from biomass, ambient air or recycled carbon sources is bound during production as is released during combustion in the use phase. These fuels include renewable and/or synthetic fuels such as biofuels, biogas, biomass fuels, renewable liquid and gaseous transport fuels of non-biological origin (RFNBOs), and recycled carbon fuels (RCFs).'

The WGMM 2024 report further demonstrates that integrating CO_2-neutral fuels into road transport would complement battery-electric and hydrogen-powered vehicles and has the potential to accelerate the transition to climate neutrality.

This *Executive summary* introduces a new WGMM report (hereafter referred to as the '2025 WGMM report') that considers the European availability of sustainable feedstocks for the production of CO_2-neutral fuels, and aims to give policymakers and stakeholders a clear picture of how those feedstocks can be used to produce different types of fuels and contribute to the decarbonization of the road transport sector.

Summary report

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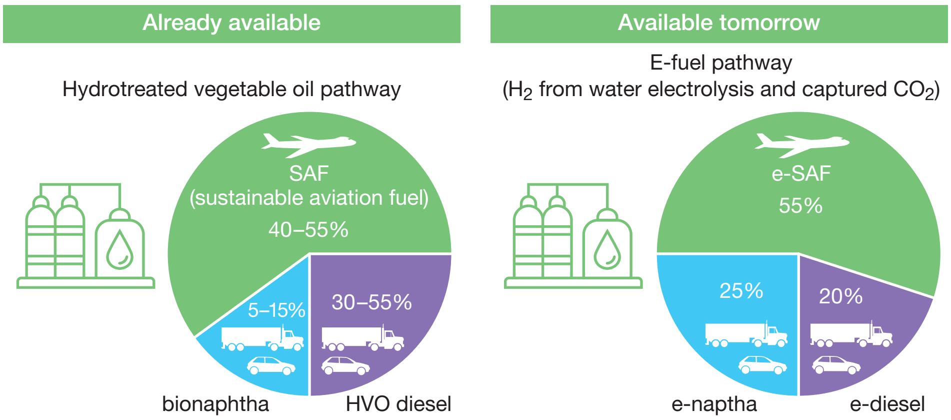
Introduction

The 2025 WGMM report[1] provides an assessment of the availability in Europe of sustainable feedstocks[2] that can be used to produce CO_2-neutral fuels, and considers how these resources can support the decarbonization of the road transport sector. The objective of the report is to give policymakers and stakeholders a clear picture of how sustainable feedstocks can be used to supply different types of fuels, and how they can contribute to this transformation.

The merit order principle[3] does not apply to renewable fuels as it does to electricity because the production of renewable fuels involves multiple synergies. Fuel production plants that use HEFA[4] and PtL/FT[5] processes specifically to produce high-quality aviation (jet) fuel also co-produce road-suitable naphtha (15–25% of output), bio-LPG (10–15%) and diesel (20–25%) alongside SAF[6] (60%)/e-SAF[7] (55%). Using these co-products for road transport fuels (for both light- and heavy-duty vehicles) takes nothing away from the aviation sector, but actually helps its decarbonization. Valorizing SAF and e-SAF co-products in road transport helps to reduce the production costs of SAF and e-SAF, making these sustainable fuels more economically competitive than fossil fuels, which in turn helps towards accelerating the decarbonization of the aviation sector.

Figure 1: SAF and e-SAF plants always co-produce renewable road-suitable naphtha and diesel (values are illustrative)



[1] *The availability of sustainable feedstocks for the production of CO_2-neutral fuels in Europe. Supporting the decarbonization of the road transport sector*. This report was closed on 9 December 2025 and is pending publication.

[2] Includes conventional and advanced feedstocks

[3] The 'merit order' system is a ranking system used to determine the order in which power plants provide electricity to the market based on their marginal costs, i.e. the cheapest sources are used first, and the more expensive sources brought online as demand increases. Electricity prices are dictated by the cost of the most expensive sources required to meet demand at a given time.

[4] Hydroprocessed esters and fatty acids

[5] Power-to-liquids/Fischer Tropsch

[6] Sustainable aviation fuel

[7] Synthetic aviation fuel derived from renewable energy

Sustainable feedstock availability and biofuel demand up to 2050

Multiple studies (European Commission 2017, 2019; Concawe/Imperial College London, 2021) have concluded that Europe possesses substantial potential for sustainable biomass production for use in road transport even after competing uses have been accounted for. Agricultural and forestry residues represent the dominant contributors to biomass production, while biowastes play a supplementary role. Methodological assumptions regarding the mobilization of feedstocks, yield improvements, and land use restrictions explain the variation between conservative and more ambitious estimates from these studies.

The Concawe/Imperial College London study estimated that the potential availability of advanced and waste-based biofuels could reach up to 79 million tonnes of oil equivalent (Mtoe) by 2030, and increase to 137 Mtoe by 2050. These figures were estimated after deducting the potential biomass availability required to meet the projected demand from non-transport sectors. The 2024 update of Annex IX under RED[8] III (2023), which integrates intermediate crops and crops grown on severely degraded lands, increases the theoretical potential of feedstock availability for biofuel production. The publication of certification guidelines for these newly-integrated categories is eagerly awaited and, if these sources are to be utilized effectively, will need to ensure pragmatism and predictability while contributing to the creation of new value chains that deliver benefits across all sectors involved. The availability of conventional biofuels[9] is expected to be around 15 Mtoe in 2030 (6.6 Mtoe of bioethanol and 8.5 Mtoe of FAME[10]), and 28 Mtoe in 2050 (13 Mtoe of bioethanol and 14.5 Mtoe of FAME) based on European production capacities and imports (via trade agreements).

When these feedstock potentials are compared with the demand for biofuels of 19–42 Mtoe (2030) and 35–94 Mtoe (2050) estimated in several studies (S&P Global, European Commission 2017, 2019), the analysis shows that Europe could satisfy the expected road transport renewable fuel requirements in 2030 and remain within feasible supply ranges in 2050. This suggests that, under the right enabling conditions, sufficient feedstock could be available to support both liquid and gaseous renewable fuel production over the long term.

The central challenge, therefore, is not the existence of feedstock, but the degree of mobilization and the cost-effectiveness of collection, transport and processing systems. Assessing and developing cost-effective supply chains for biofeedstocks will be essential to realizing this potential and meeting future biofuel demand.

8 European Union's Renewable Energy Directive

9 As defined in the Renewable Energy Directive, that is 'starch-rich crops, sugar crops or oil crops produced on agricultural land as a main crop'.

10 Fatty acid methyl esters

Overall findings

The evidence indicates that Europe has sufficient sustainable feedstock to underpin a robust portfolio of renewable fuels for road transport, provided that enabling conditions are in place. The main constraint is not the availability of feedstocks, but the ability to account for biofuels from a broader range of raw materials, including imports, within mandatory targets and incentive schemes, as well as the extent to which collection, transport and processing systems can be mobilized cost-effectively. Moreover, diversity across fuel types reduces risk by spreading reliance across different feedstocks. Co-product synergies such as the use of biogenic CO_2 for RFNBOs[11] and bioLPG from HVO[12] also enhance system efficiency. The following chart summarizes the potential contribution of different biofuels to the decarbonization of the road transport sector.

Table 1: The potential contribution of different renewable fuels to the decarbonization of the EU road transport sector
(Source references for this table can be found at the foot of page 5)

Feedstock type	Renewable fuel type	Current supply for transport (Mtoe)	Potential supply for transport in 2050 (Mtoe)	Demand for transport in 2050 (Mtoe)[a]
Crop-based feedstocks	Bioethanol, bio-maritime fuels, bio-SAF	4.6[b]	12–14 (domestic)[c]	35–94
	HVO, FAME, bio-maritime fuels, bio-SAF	5.3[d]	14.5 (domestic)[e]	
Annex IX B feedstocks	HVO, FAME, bio-SAF and bio-maritime fuels	3.3[f]	9–33+ (domestic)[g]	
Annex IX A feedstocks	Bio-based renewable diesel (HVO, FAME, lignocellulosic biomass and waste-based), bio-based renewable gasoline/bioethanol, bio-SAF and bio-maritime fuels	4.2	32–137 (domestic)[h]	
Allowable H_2 and CO_2 sources	RFNBOs	0	151 (global)[i]	39–64
Gases from renewable feedstocks	Renewable liquid gas (eLPG, eDME)	0.2	3.8 (domestic)	6–12[j]
	Renewable methane (biomethane)	0.5[k]	16–32 (domestic)[l]	
	TOTAL RENEWABLE FUELS	18.2	238.8–386	80–170[m]

[11] Renewable fuels of non-biological origin
[12] Hydrotreated vegetable oil (renewable diesel)

Conclusions

The 2025 WGMM report confirms that Europe's sustainable feedstock base is broad and sufficient to support the scaling of renewable fuels in road transport through to 2050. FAME and HVO will support the decarbonization of diesel fleets, while bioethanol and renewable gasoline molecules decarbonize the petrol pool. Scaling lignocellulosic biomass and waste-based renewable fuels will be critical to unlock higher volumes of renewable fuels and deepen emissions reductions. RFNBOs represent a scalable electricity-linked option, renewable liquid gases provide flexibility for autogas users, and biomethane offers a highly effective solution for heavy-duty fleets. Together, these fuels can complement electrification, ensuring a resilient, balanced and sustainable pathway to CO_2 neutrality in the European road transport sector, as there is an opportunity to further increase their use.

Source references for Table 1 on page 4:

[a] Based on two potential demand scenarios: 'Scenario 3' for 2050 in the EU's impact assessment on 'Europe's 2040 climate target and path to climate neutrality by 2050', which foresees that renewable fuels will be utilised firstly in the maritime and aviation sectors with a supporting role in road transport, and the 'More Molecule Scenario' from the S&P Global study (2025) which demonstrates a higher ambition for renewable fuels by relaxing the requirements of the LDV and HDV vehicle standards and allowing sales of some new internal combustion engine cars and vans after 2035, and postponing any electrification in the aviation and marine sectors until after 2050.

[b] Source: ePURE, 2024.

[c] Source: ePURE (based on estimates of capacities and ethanol quotas via free trade agreements).

[d] Source: Shares and EBB 2024 statistical report.

[e] Source: EBB (based on European production capacities and imports via trade agreements).

[f] Source: Shares and EBB 2024 statistical report.

[g] For the Annex IX B feedstocks for FAME and HVO, we indicate a figure of 33 Mtoe+ for the potential supply for transport, but intermediate crops can count in both Annex IX A and B. The potential for intermediate crops (indicated by the '+') is based on a European Commission study undertaken in 2024.

[h] Source: Concawe/Imperial College London, 2021.

[i] Estimated availability for the EU from global e-fuel/RFNBO availability.
Source: Porsche Consulting, 2024.

[j] The demand for renewable methane for transport in 2050 is derived from the Eurogas 2050 scenario, assuming that 10% of the HDV fleet would be powered by renewable methane.

[k] Source: Shares.

[l] Potential production in 2050 = 165 bcm = 142 Mtoe, of which the share attributed to transport is 23% (current share of biomethane for transport).
Source: Gas For Climate study, 2022. Available at:
https://gasforclimate2050.eu/wp-content/uploads/2023/12/Guidehouse_GfC_report_design_final_v3.pdf

[m] Projection (real balance will be defined by markets, production, etc.)

ANNEX

Biodiesel (FAME) and renewable diesel (HVO[1])

FAME biodiesel and HVO are both well-established alternatives to fossil-derived diesel fuel. They are compatible with existing vehicles and distribution systems, and are essential for decarbonizing the current diesel fleet. Both biodiesel (FAME) and renewable diesel (HVO) are expected to remain significant contributors to the fuel pool in 2030 and 2050.

Biodiesel (FAME)

In the European Union (EU), FAME is produced from a mix of crop-based and waste-based feedstocks. Rapeseed oil remains the dominant crop-derived input, accounting for 34% of the total. Among waste-based sources, used cooking oil (UCO) is the largest contributor at 24%, followed by other residues and wastes. It is produced via biomass esterification, where fats are broken down and then reacted with methanol to produce a final product that is similar to fossil diesel fuel but with a higher oxygen content. Like conventional diesel, biodiesel must comply with CEN[2] standard EN 14214. This ensures a standard quality and performance when FAME is used in diesel engines, whether as pure biodiesel or as a part of a diesel/biodiesel blend, with maximum 7% (v/v) FAME (designated B7) according to standard EN 590, and 10% (v/v) FAME (designated B10) specified in standard EN 16734. In addition, the European Commission's Fuel Quality Directive (FQD) provides for both 7% and 10% (v/v) blends (7% being the 'protective grade', i.e. to protect the integrity and operational safety of certain vehicles and machinery, particularly older engines or those not specifically adapted for higher FAME blends). Biodiesel is currently in widespread use in the form of B7 and B10+ blends, with higher concentrations, such as B20, reported in fleets throughout several EU member states. The GHG reduction of FAME depends on several factors including the feedstock utilized, the related processing phase and the process energy, but can be more than 80% when waste or residues are used.

Renewable diesel (HVO)

HVO is a paraffinic renewable diesel produced by hydrotreating fatty acids and lipid feedstocks such as UCO, and other waste residue oils and fats. It can be used in pure form as a fully drop-in fuel, and co-produces renewable LPG,[3] naphtha and SAF. Its greenhouse gas (GHG) reduction potential depends on the feedstock, the process energy and hydrogen source, but is generally substantial when waste and residue-based feedstocks are used. The EEA reports that, in 2022, the HVO used in the EU provided on average an 89% GHG emissions saving compared to fossil fuel.[4] HVO production has been expanding steadily, and the resulting paraffinic fuel may be blended with fossil diesel, limited by the blend meeting the minimum density specification in CEN standard EN 590. Depending on the density of the base fuel, the maximum HVO content is typically around 35% (v/v) for temperate climates and up to 65% (v/v) for severe winter grades. HVO can also be sold on the market as a neat fuel (100% HVO) in compliance with CEN standard EN 15940. In the long term, HVO has significant potential to decarbonize the heavy-duty vehicle (HDV) sector.

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1 Hydrotreated vegetable oil
2 European Committee for Standardization
3 Liquefied petroleum gas
4 EEA (2024). *Greenhouse gas intensities of transport fuels in the EU in 2022. Monitoring under the Fuel Quality Directive.* ETC CM Report 2024/04. European Environment Agency (EEA).

Lignocellulosic biomass and waste-based renewable diesel

Beyond HVO, renewable diesel can be produced from lignocellulosic biomass (such as forest and agricultural residues and dedicated energy crops) and biowastes. This is achieved via thermochemical conversion followed by upgrading (i.e. reacting with hydrogen and a suitable catalyst to remove oxygen and other impurities to create a fuel that is chemically similar to fossil diesel). The principal pathways are: gasification with FT synthesis; fast pyrolysis with subsequent upgrading; hydrothermal liquefaction (HTL) with upgrading; and alcohol-to-distillates (AtD).

The resulting paraffinic fuel meets CEN standard EN 590 when blended, and EN 15940 when used neat, and is fully compatible with existing fuel transportation and storage logistics, as well as with diesel engines in passenger, heavy-duty and off-road applications. Depending on feedstock management and logistics, the process energy and its source, and the hydrogen source, this type of fuel has the potential to provide GHG savings of 82–89% relative to the EU's fossil diesel comparator (in RED III) over a typical life cycle. Today, commercial production remains modest, with several routes progressing but not yet widely deployed.

Bio-based renewable gasoline/bioethanol

Gasoline decarbonization relies on two complementary factors:

(i) the continued use and increased capacity for production of bioethanol; and

(ii) the introduction of renewable hydrocarbon gasoline molecules, often produced as a co-product of HVO and FT processes, ethanol-to-gasoline (EtG), methanol-to-gasoline (MtG) or FT synthesis processes.

Bioethanol fuel blends

Bioethanol is already widely deployed in Europe, blended in grades such as E5[5] and E10, with E85 available at more than 5,500 stations as of 2025. E20 has been approved as a technical specification at CEN with publication expected in January 2026. However, the FQD currently sets a maximum limit of 10% ethanol in gasoline, which prevents countries in the EU from implementing this grade. A revision of the FQD would be required if this grade is to be used in the EU-27. National standards bodies in Norway, UK and Switzerland can, however, adopt this as a national standard. On average, bioethanol delivers GHG savings of around 79% compared with fossil petrol.[6] Feedstocks for bioethanol production are primarily European crops such as maize, wheat and sugar beet, with less than 10% of today's bioethanol being produced from RED Annex IX advanced feedstocks.[7] Ethanol's co-products, such as high-protein animal feed and biogenic CO_2 streams, offer additional benefits and synergies with future e-fuel production.

[5] E5, E10, etc. = designation for petroleum fuel blends containing up to 5% ethanol (E5), 10% ethanol (E10), etc.

[6] Source: ePURE, 2025.

[7] The EU is working to increase the use of a wider range of feedstock sources as listed in RED III, Annex IX; currently, these sources are used in less than 10% of bioethanol production due to challenges relating to their availability, collection, processing and associated costs.

Future demand for bioethanol is expected to rise as E10 becomes universally available and E20 adoption expands. Capacity could reach 13 million cubic metres by 2035, with E85 representing a major opportunity for use in hybrid and plug-in hybrid fleets. This would ensure a substantial and cost-effective contribution to gasoline pool decarbonization.

Renewable gasoline from biomass

Renewable hydrocarbon gasoline produced from biomass via EtG, MtG and FT, among other processes, is a further option. These processes can produce 100% renewable gasoline fuel components, which could be further processed or blended with other renewable fuel components to produce renewable gasoline meeting CEN standard EN 228. This 100% renewable gasoline fuel would be fully compatible with petrol vehicles and existing fuel transportation and storage logistics systems, and have very low life-cycle GHG intensities. However, their scale will depend on the pace of project deployment because, unlike other fuels, automotive gasoline is difficult to use in applications other than passenger cars. For that reason, the regulatory framework is a key element in promoting the increase in renewable gasoline production capacity, through continued investment in technology and the use of new feedstocks and production processes.

Renewable fuels of non-biological origin/e-fuels

Renewable fuels of non-biological origin (RFNBOs), commonly referred to as e-fuels, are produced from renewable hydrogen and sustainable CO_2. For road transport, they encompass e-diesel, e-gasoline, e-LPG, eDME[8] and e-methane. Their sustainability depends on the use of renewable electricity, additionality requirements,[9] temporal and geographic correlation, and the supply of CO_2 from biogenic or direct air capture pathways (EU regulations currently require industrial CO_2 streams to be phased out by 2041). RFNBOs can achieve GHG reductions of 70–95% compared with fossil fuels, depending on the source of electricity and CO_2 inputs. They are fully compatible with existing vehicle systems and fuel transportation and storage logistics, making them attractive options for a smooth transition to low-carbon fuels.

RED III sets binding RFNBO targets for the transport sector across EU member states. Based on these targets, and the requirements of FuelEU Maritime and ReFuelEU Aviation targets, at least 0.9–1.0 Mtoe of RFNBOs would be required by 2030. Many member states are implementing more ambitious RFNBO quotas; for example, Finland plans to introduce a minimum mandate for RFNBOs of 4% of total transport fuels by 2030, while Spain have suggested 2.5%, Belgium 2%, and France and Germany 1.5%.

Demand is expected to grow significantly after 2030, particularly as regulations support RFNBO production while industrial scaling drives cost reductions. The EU's impact assessment on 'Europe's 2040 climate target and path to climate neutrality by 2050' foresees a demand of liquid and gaseous e-fuels of 40 Mtoe in 2040 (Scenario S3) and 45 Mtoe in 2050.

According to the International Energy Agency (IEA), more than 200 e-fuel projects are currently under development around the world, although most of these are still in the early stages. According to a study undertaken by Porsche Consulting in 2024,[10] the maximum global supply potential for e-fuels will be 60 Mtoe in 2035 and 43.3–130 Mtoe in 2040. Assuming that the road transport sector accounts for around 80% of the overall fuel demand, the supply of 34.6–104 Mtoe required by this sector by 2040 is deemed to be achievable.

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[8] Renewable dimethyl ether

[9] Requirements for hydrogen producers to use only electricity sourced from new, dedicated renewable sources.

[10] *With eFuels to a Greener Future: The Way Forward to Create a New Industry*, 9 October 2024.

E-fuels rely on renewable electricity, water and CO_2, and large-scale production will occur mainly in regions with abundant renewable energy, e.g. in sunny and windy areas. According to Fraunhofer IEE (2021),[11] around 7,300 Mtoe of electricity-based liquid fuels could be produced outside Europe—far exceeding global transport sector needs—allowing the diversification of supply sources beyond traditional fossil fuel exporters. By harnessing green hydrogen and captured carbon, e-fuels will broaden Europe's renewable fuel options alongside biofuels. In order to unlock this capacity, it will be necessary to scale renewable electricity generation capacity in tandem with biofuels production, while at the same time considering the decarbonization needs of all sectors.

Renewable liquid gas (rLPG and rDME)

Renewable liquid gas includes renewable propane, butane and DME. Renewable LPG (rLPG, also known as bioLPG) is often produced as a by-product of HVO and FT processes, while e-LPG is produced from renewable hydrogen and CO_2 through a synthetic process. Both are chemically and operationally compatible with existing vehicle autogas technologies. rDME can be produced as a biofuel via gasification of various biomass sources with subsequent synthesis, or as an e-fuel. GHG reductions of more than 80% are achievable for both rLPG and rDME compared with the EU's fossil fuel comparator (in RED III), depending on the feedstock and production pathway. A 2025 report commissioned by Liquid Gas Europe projects that renewable liquid gas could reach a total production capacity of 8 Mtoe by 2040 and 30 Mtoe by 2050, with about 20% of this volume available for the transport sector. This would allow renewable gas to decarbonize significant segments of the autogas market where it offers a cost-effective solution.

Renewable methane (biomethane and e-methane)

Renewable methane, whether biomethane or e-methane, provides another drop-in solution compatible with existing CNG[12] and LNG[13] vehicle fleets and infrastructure. Biomethane is produced by upgrading biogas from anaerobic digestion of agricultural residues, manures, biowaste and sewage sludge, or by gasifying lignocellulosic feedstocks followed by methanation.[14] E-methane is synthesized via the Sabatier process[15] using renewable hydrogen and CO_2.

Biomethane delivers very low, and in some manure-based cases even negative GHG emissions compared with fossil methane. The use of digestate (a nutrient-rich by-product of the biomethane production process) as a biofertilizer further improves the environmental life-cycle performance, both through the avoidance of emissions associated with synthetic fertilizer production, and also by returning important organic matter and nutrients to the soil. Europe produced about 4.4 Mtoe of biomethane in 2023, and technical potential estimates suggest around 40 Mtoe could be available by 2030, rising to 149 Mtoe by 2050. The road sector currently consumes around 23% of biomethane, mainly in HDVs.

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[11] Fraunhofer IEE (2021). *PTX-ATLAS: Weltweite Potenziale für die Erzeugung von grünem Wasserstoff und klimaneutralen synthetischen Kraft- und Brennstoffen*. Teilbericht im Rahmen des Projektes DeV-KopSys. Fraunhofer-Institut für Energiewirtschaft und Energiesystemtechnik.

[12] Compressed natural gas

[13] Liquefied natural gas

[14] Methanation of lignocellulosic feedstocks refers to biological anaerobic digestion, where microbes convert complex biomass into biogas (a mixture of methane (CH_4) and CO_2) through multistage biochemical pathways.

[15] The Sabatier process is a specific type of methanation which involves a catalytic thermochemical reaction in which purified CO_2 reacts with H_2 over a metal catalyst at elevated temperature and pressure to produce synthetic methane (e-methane) and water.

WGMM

Working Group on Monitoring Methodologies of CO_2-Neutral Fuels (WGMM)

The WGMM is a voluntary platform that brings together stakeholders from across the entire automotive and fuel value chain to monitor and assess the use and development of CO_2-neutral fuels in road transport.

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