Abstract

This report was prepared to respond to the European commission's request to industry, OEMs and fuel companies, to present technological options that can prove and monitor the use of CO2 neutral fuels in new vehicles and contribute to the European Commission's commitment to present a methodology for registering after 2035 vehicles running exclusively on CO2 neutral fuels.

Monitoring CO2 neutral fuels implies the tracking and tracing the fuel from the production or entry point, in case of imports, all the way down to the final use in a given vehicle. The Working Group on Monitoring Methodologies (WGMM) therefore features a broad sectorial representation including OEMs and their suppliers, fuel producer and fuels suppliers, fuel retailers and their equipment suppliers, in order to ensure that the TCMV's proposed methodology fits the requirements of all sectors of the automotive and fuels value chain for a robust and reliable proofing and reporting methodology.

A technology neutral, inclusive and consistent definition for CO2 neutral fuels to avoid over-complexity of the EU regulation

The work of the WGMM started with an assessment of the compromise agreed between the Germany and the Executive Vice-President Timmermans in March 2023, and the Commission's briefing to the member state experts in the TCMV, the proposed fuels definition and the pre-suggested methodologies identified by the Commission services.

The Commission proposal of September 2023 only included e-Fuels, also labelled RFNBOs, in its definition of CO_2 neutral fuels and required these fuels to have a 100% GHG emission savings based on a Well-to-Wheel (W-t-W) basis. This approach is evaluated by the experts in the WGMM as technically very difficult to achieve currently and inconsistent with the overall EU Green deal goals defined as "net-zero", recognizing GHG emissions and also absorption/storage by either biogenic or industrial means. The Working Group's proposal aims to correct this inconsistency, and proposed an alternative definition "***CO2 neutral fuel' means all fuels defined by the Renewable Energy Directive (EU) 2018/2001, provided that they meet the sustainability criteria of that Directive and associated delegated acts, where the same amount of CO2 from biomass, ambient air or recycled carbon sources is bound in the fuel production as is released during combustion in the use phase. Those fuels shall include renewable and/or synthetic fuels, such as biofuel, biogas, biomass fuel, renewable liquid and gaseous transport fuel of non- biological origin (RFNBO) or a recycled carbon fuel (RCF)***."

There should be one unique definition of CO2 neutral fuels for all EU legislative acts and this definition should be aligned with RED.

CO2 neutral fuels complementary to electrification in road transport

The report furthermore shows that the inclusion of CO2 neutral fuels in road transport does not weaken the new vehicle CO2 reduction targets, but instead, would be a complement to battery-electric and hydrogen-powered vehicles with the potential of accelerating the phase-out of fossil fuels.

Road transport is the lead market to create a long-term investment case for CO2 neutral fuels for the benefit of all transport sectors.

Road transport can be the ideal for scaling up the uptake of CO2 neutral fuels, enabling industrial scale production and cost reduction for businesses and citizens. The size of the market and investments resources, economies of scale, the significant taxation share of fuels in road transport, and the need for a market access for the co-products stemming for instance Sustainable Aviation Fuels (SAF).

The role of biofuels

Biofuels represent today 90% of renewables in road transport and they can continue to meet a large part of future increased energy demand. Biofuels are currently commercially available and delivered in sufficient amounts and thus available to accelerate the decarbonization of the transport sector significantly.

Fuelling Technologies for Vehicles & Retail

The report's main objective is to provide the Commission, TCMV experts and their administration in Member States with a comprehensive, objective, neutral and technical assessment of all identified fuel monitoring options.

The members of the WGMM, and the experts who contributed to the work have no intention to recommend any of the proposed methodologies, the final decision remaining the sole responsibility of the legislator.

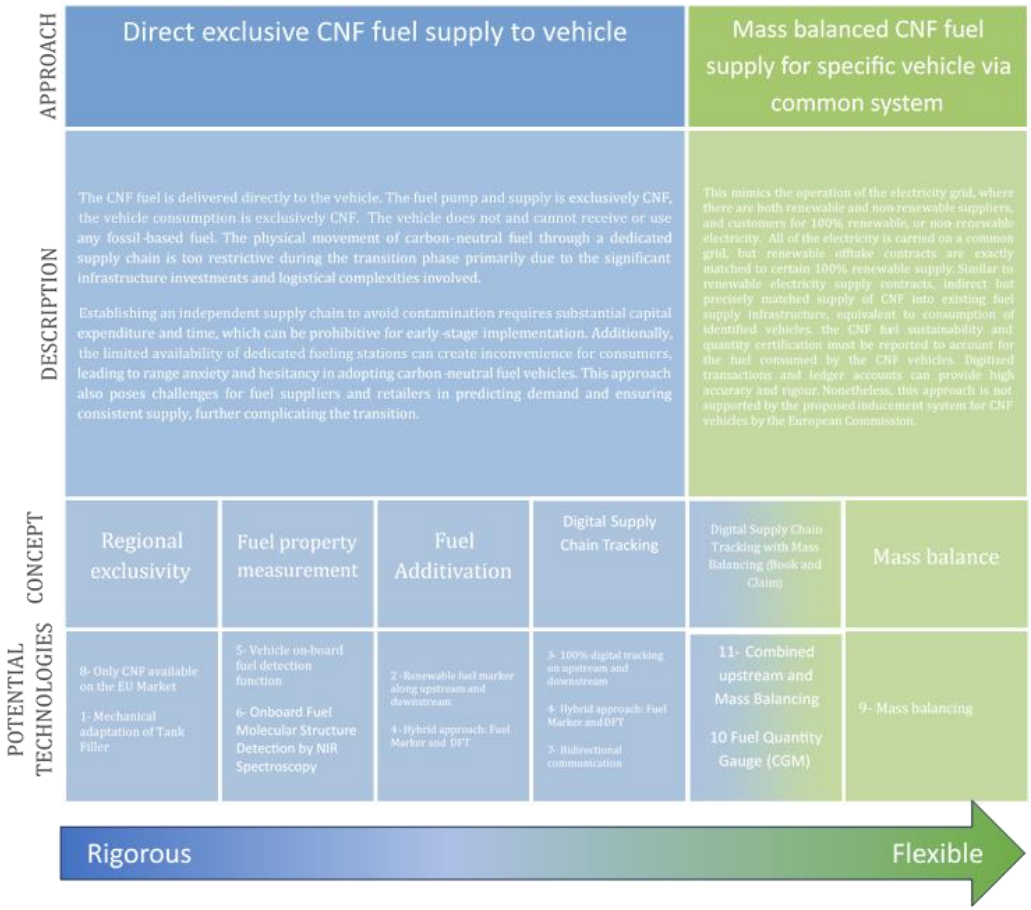
Two potential approaches, and 11 technology options to monitor CO2 neutral fuels

The assessment performed by the experts of the WGMM concluded that, in the current stage of technology development, two main approaches can be considered for the use and monitoring of CO2 neutral in a new vehicle class after 2035:

- **Direct and exclusive CO2 neutral fuel supply** to the vehicle where the fuels is delivered through a dedicated and isolated infrastructure end-to-end, in an exclusive manner, through fuel pumps that only supply 100% CO2 Neutral Fuel, with 4 possible concepts for direct exclusive CNF supply to the vehicle:
    - **Fuel Marking**: well-established fuel identifier technology that uses a distinct physical marker additive, which can now be used to prove CNF throughout the supply chain.

- **Digital Fuel Tracking System (DFTS):** already used in industrial safety systems, this technology enables secure digital tracking and ledger accounting of CNF across fuel supply system and vehicle operation.
- **Onboard Detection**: vehicle-based group of technologies that can immediately detect presence or absence of CNF during fuelling by chemical or physical tests, and enable/disable vehicle operation.
- **Physical security of fuel connections** to enable CNF but prevent fossil-based fuel throughput.

– **CO2 neutral fuel supply for specific vehicle via the overall fuel supply system**, where the CO2 neutral fuel is delivered via the current fuel infrastructure currently shared with petroleum fuels. This approach is particularly adapted for gaseous fuels. The fuel requirements of the vehicle are exactly matched with the same quantity of CNF supplied into the overall fuel supply system and securely monitored and matched with the vehicle through a digital tracking system.



The table below summarises the type of methodology, its detection method, potential inducement systems and the compatibility with the fuel type.

#	Methodology	Tracking method	Detection method	Inducement system	Fuel compatibility
1	Mechanical adaption of tank filler / nozzle	Physical	Mechanical	Not required	Gaseous and Liquid fuels
2	Fuel marker along upstream and downstream (sensor in vehicle)	Physical	Sensor	YES	Liquid fuels
3	100% digital tracking from upstream to downstream (DFTS w/ digital handshake)	Physical	Electronic by re-using existing data	YES	Gaseous and Liquid fuels
4	Hybrid approach - upstream: fuel marker & sensor until EU border - downstream: DFTS w/ digital handshake	Physical	Sensor & Electronic	YES	Liquid fuels
5	Vehicle On-Board Fuel Detection Function	Physical	Sensor	YES	Liquid fuels
6	Vehicle Onboard Fuel Molecular Sensor	Physical	Existing Engine Sensor	YES	Liquid fuels
7	Bidirectional Communication between vehicle and gas station	Physical	Electronic	YES	Gaseous and Liquid fuels
8	EU market exclusively supplied with CNF	Physical	NR	Not required	Gaseous and Liquid fuels
9	Mass-Balanced CNF supply to each CNF vehicle	Virtual	None	NO	Gaseous and Liquid fuels
10	Fuels Usage Balancing - FUB	Virtual	Electronic	YES	Gaseous and Liquid fuels
11	Combined mass balancing - DFTS w/ digital handshake	Virtual	Electronic	YES	Gaseous and Liquid fuels

Outcome of the Evaluation Matrix

Option 1- Mechanical adaption of tank filler / nozzle: Mechanical adaption of the filler neck and the nozzle would physically prevent that wrong fuel is filled but in practice it is prone to

tampering and might not considered as robust enough when used alone. Additionally, it will incorporate high efforts for the development of new standards and hardware at both filling station and vehicle, including additional integration efforts.

Option 2 - Fuel Marker along upstream and downstream: A fuel marker and sensor in the vehicle physically tracks the CNF. This methodology is already used for heating oil, but there is currently no off-the-shelf automotive sensor is available. New developments for automotive requirements (e.g. robustness, selectivity, sensitivity) are expected. With regards to tampering robustness, marking the fossil fuel may be a more robust solution.

Option 3 - 100% digital tracking from upstream to downstream DFTS w/ digital handshake): The DFTS (digital fuel tracking system) is a 100 % digital solution along the entire delivery chain, completely based on the existing data and infrastructure of the different stakeholders. Via a digital handshake, the reliable pairing of vehicle and nozzle is enabled and allows flexible inducement reaction. Manipulation robustness is assured by reliability checks within a multi trust centre approach (stakeholder – cloud - vehicle). The solution needs technical adaptations in the vehicle, logistics and fuelling stations.

Option 4 - Hybrid approach – upstream fuel marker & sensor until EU border – downstream: DFTS w/ digital handshake: A potential means to improve the sensor & marker approach could be a hybrid approach in combination with the DFTS. Within this solution, the lack of automotive ready sensors could be bypassed by performing a digital handshake with filling station, based on a sensor signal which measures the fuel marker in the filling station itself. Less stringent requirements for such a sensor could therefore apply, which leads to lower integration efforts at OEM side and faster time to market.

Option 5 - Vehicle Onboard Fuel Detection Function: On board fuel detection by processing the existing Engine Control Unit (ECU) signals is a pragmatic software solution which is based on data already available in the vehicle. The solution may work for CNF fuels with properties which are different to conventional ones such as HVO and Diesel. However, currently no solution for gaseous fuels is known.

It might require calibration to include possible future fuels, since the actual measurement value (correlating with property) may change from one fuel source to another, resulting in additional deployment efforts in field.

Option 6 – Vehicle Onboard Fuel Molecular Sensor: A molecular structure sensor is another option which directly tracks the fuel type in the vehicle. It is not a marker as proposed in Option 2. The onboard sensor is available in series production and fulfils the standards outlined in EN590 and EN228.

It is capable of providing the onboard, real-time final verification required by the EU, as it already does in bus and truck applications to detect fossil fuels. CNF fuel detection has been

successfully implemented for standards such as EN14214 and EN15940, and new databases are currently being developed for e-fuel molecules.

Option 7 - Bidirectional communication between vehicle and filling station: Bidirectional communication between the vehicle and the filling station provides a tamperproof approach which could be used as a 1-to-1 pairing solution between nozzle and vehicle.

Next to the secure authentication process, the solution provides a filling monitoring and a blockage device in the filler neck, which can inhibit filling with conventional fuel. However, to fulfil tampering requirements, the solution needs technical adaptations.

Option 8 - CNF exclusively available in EU market. While this scenario is unrealistic to be considered for 2035, it is one that is certainly possible in the longer-term and so is worthy of considering as part of the overall transition strategy for transport in the EU. This assumes that CNF is exclusively available, likely some years away, and would be the result of substantial scale up of CNF fuels for road transport alongside the needs of other sectors, and also the reduction of overall liquid and gaseous fuels demand, achieved by efficiency and electrification.

Option 9 - Mass-Balanced CNF supply to each CNF vehicle. Mass-balancing is an indirect solution which focuses on an input-output approach, controlled by booking and claiming of certificates. Trading markets such as electricity and gaseous fuels in pipelines are efficiently controlled by such an approach. This means for a potential CNF application, that the fuel may not be physically consumed in the claiming CNF vehicle. But the fuel supply system reliably assures that the CNF fuel amount is introduced in average elsewhere into the market. Such a solution would benefit from high system efficiency, fast ramp-up of fuel production and fuel supply chain whilst enabling that in the introduction phase filling stations do not need to have a dedicated CNF pump.

Option 10 - Fuel Usage Balancing: Fuel Usage Balancing solution uses a mass-balancing approach based on tracking of fuel energy in the vehicle tank without a handshake between filling station and vehicle. Instead of the filling station, the responsibility of certificate handling is transferred to the motorist, who is directly connected with a certificate marketplace, which may be an efficient solution for fleet customers in commercial vehicle segment.

However, for average end-customer in passenger car segment, the solution might be a burden by transferring too much responsibility to the motorist for certificate handling.

Option 11– Digital Tracking with Mass balancing: Since mass-balancing (ption 9) is based on a certificate handling mechanism which incorporates average reporting of the stakeholders to an authority, a hybrid solution in combination with a DFTS (see option3) is proposed. This system benefits from a fast accumulation of certificates on single vehicle level since it can include the DFTS as monitoring platform and performer of the digital handshake between

the vehicle and the filling station. So, accurate and in-time certificate handling could be assured per individual vehicle.

Methodology assessment from customer and retailer perspective

The report also focuses on the requirements and considerations for customers and retail sectors to ensure the successful integration and acceptance of CNF powered vehicles, and the enabling technologies (Chapter 6). It addresses the technology requirements for a successful CNF rollout and monitoring. To this end, it evaluates the identified technology options from various angles including availability, costs implications, ease of use, security of monitoring and inducement technologies.

These technologies also have potential applications beyond the European Union, thereby laying a robust foundation for the widespread adoption of CNF. It is important to ensure that CNF- dedicated vehicles can operate beyond EU boundaries and to establish control mechanisms that prevent the use of non-CNFs. Options for this issue are also addressed.

The report furthermore provides an analysis of the effective inducement system required for supporting the EU's CO2 Neutral Fuel (CNF) requirements. The experts recommend the incorporation a fuelling monitoring system to track CNF use to ensure the vehicle is exclusively fuelled with CNF, an inducement system in the form of a mechanism that reacts if non-CNF fuel is detected, enforcing compliance through various responses.

Finally the report explores the issue of regulatory geofencing which is a direct consequence from the inducement systems chosen to ensure compliance with CNF requirements. Regulatory geofencing influences how vehicles function outside EU borders and affects the resale value of used vehicles in non-EU regions. The analysis describes the implications for vehicle usability, enforcement, and potential misuse outside the EU, and the impact on customers.

Regulatory evaluation

The report is completed by a detailed analysis of all regulations to identify adaptations that may be required to recognise individual CNF monitoring methodologies (Chapter 7).

The report describes the advantages, disadvantages and impacts from a regulatory perspective, which includes an assessment of the prospect and time duration for potential implementations, and formulates brief amendments where possible.

The report "*monitoring the use of CO2 neutral fuels in road transport – a cross-sectoral industry assessment*" is available in digital version and will be complemented with factsheet type information for all monitoring methodologies described in the report.

Conclusion

This comprehensive report is the outcome of a cross sectoral industry cooperation, with individual companies and trade associations from various sectors such as OEMs, OEM suppliers, fuel producers and suppliers, fuel retailers and retail equipment suppliers.

The report materialises the members' engagement to respond positively to the Commission's request to industry to propose a methodology to prove the use of the CO2 neutral fuels.

The experts of the WGMM have performed this overall assessment of all identified monitoring methodologies to provide to the Commission and Member States experts the best overview and technical input to enable an informed decision in this regulatory process. The WGMM experts are furthermore ready to support the work of the TCMV with complementary technical advice and clarification.

Moreover, the WGMM members also issued a series of recommendation regarding the definition of CO2 neutral fuels and the consistency of this definition throughout European regulations. This is an important aspect to consider when designing the methodology for the recognition of zero-emission vehicles running exclusively on CO2 neutral fuels.