

POSITION PAPER: CLIMATE POLICY FRAMEWORK FOR NON-ROAD MOBILE MACHINERY (NRMM)

MAIN ARGUMENTS

- **High Energy Demand of NRMM:** Non-Road Mobile Machinery (NRMM) is crucial in agriculture, construction, and other sectors, consuming large amounts of energy due to their long lifespans and extensive use in remote areas.
- **Importance of Energy-Dense Fuels:** NRMM operations often require energy-dense fuels to ensure reliability and operational flexibility, particularly in off-grid locations where electrification is impractical.
- **Limited Electrification Potential in NRMM:** Even by 2050, only 40% of the existing NRMM fleet is expected to be electrified, meaning renewable fuels like advanced biofuels and eFuels (RFNBOs) are essential for defossilizing the remaining fleet. Battery production contributes significantly to lifecycle emissions, making renewable fuels and hydrogen more favorable for some NRMM applications, especially those requiring high energy density and flexibility.
- **GHG Reduction Potential of Renewable Fuels:** Renewable fuels are critical to achieving significant GHG reductions, particularly in sectors where electrification is not feasible.

POLITICAL REQUESTS

- **Deploy ambitious supply quotas for renewable fuels:** Establish supply quotas for renewable fuels such as advanced biofuels and renewable fuels of non-biological origin (RFNBOs) in the Renewable Energy Directive (Directive (EU) 2023/2413) and national transposition, encompassing NRMM among other sectors to create a strong demand signal and incentivize investment in these sustainable fuel sources.
- **Supply-Side Support through Funding and Energy Taxation:** Provide financial support through programs like the EU Hydrogen Bank and Innovation Fund, and revise European Energy Taxation (Directive 2003/96/EC) to favor renewable fuels over fossil fuels, accelerating their market competitiveness.
- **Leverage Public Procurement to Promote Renewable Fuels:** Include NRMM propelled by renewable fuels in public procurement policies, similar to the Clean Vehicle Directive (Directive (EU) 2019/1161), to lead by example and stimulate broader market demand for low-emission NRMM solutions.

- **A Multi-Technology Pathway:** Deploy a technology-neutral approach that integrates advanced biofuels, RFNBOs hydrogen, and electrification, recognizing that different types of machinery have unique operational needs that cannot all be met by electrification alone.

GENERAL REMARKS

Non-Road Mobile Machinery (NRMM) includes a wide range of machinery used in industrial, agricultural, and construction sectors, such as tractors, excavators, cranes, chainsaws, and other power tools. These machines play a vital role in infrastructure development, agriculture, law enforcement, defense, and logistics. **Figure 1** highlights the significant global stock, annual registration numbers, and substantial energy demands of two key NRMM segments. The data was collected in a joint research project with Porsche Consulting and demonstrates that these various machinery types, operating across the globe with differing stock and lifespans, consume a considerable amount of energy. The energy demand in conjunction with long lifespans of the equipment highlight the need to address GHG reductions in the existing fleet of NRMM machinery.








	 Agriculture Machinery	 Construction Machinery
	New Registrations 158,000 vehicles	155,550 vehicles
	Global Stock 33-44 million tractors	13-19 million construction machines
	Lifespan approx. 18 years	approx. 15 years
	Calculated Stock EU 3.04 million vehicles	2.47 million vehicles
	Energy Demand DE 66 PJ (KTBL) → calculated for the EU: 353 PJ (DE fleet = 19% of the EU fleet)	44 PJ (Federal Statistical Office) → calculated for the EU: 184 PJ (DE fleet = 24% of the EU fleet)

Figure 1: Overview about new registrations, global stock and lifespan of different NRMM applications

NRMM operations are often characterized by high energy consumption and the need for mobility across diverse terrains and distances. The demands of NRMM – particularly long-distance transport and operation in remote areas – require an energy-dense fuel source that delivers reliability, portability, and sufficient range without frequent refueling or extended downtime.

THE ROLE OF RFNBOs IN NON-ROAD MOBILE MACHINERY

Despite NRMM's substantial contribution to global emissions – accounting for more than 2% of total GHG emissions – there is currently no dedicated climate regulatory framework for vehicle manufacturers in this

sector. This situation is similar to the global shipping industry, which contributes a comparable share of global emissions but got subject to both regional and global regulations aimed at reducing its environmental impact in the European Green Deal. While regulations exist for pollutants and non-CO2 emissions, NRMM is also indirectly impacted by heavy-duty industry regulations since components are often developed for both sectors, as well as by fuel regulations and taxation.

To assess the potential of renewable fuels for NRMM, we conducted a study with Porsche Consulting, focusing on agriculture and construction machinery. The study explores Total Cost of Ownership (TCO), the most important criterion for operators, and includes assumptions about the availability of different powertrain technologies. For instance, internal combustion engines remain the only viable option for tractors with more than 148 kW due to long-range and high operational demands, while smaller applications are more suited to electrification. According to the study, even in 2050, only 40% of the existing fleet will be electrified. The remaining fuel demand must be met by sustainable sources such as advanced biofuels or eFuels to meet climate targets.

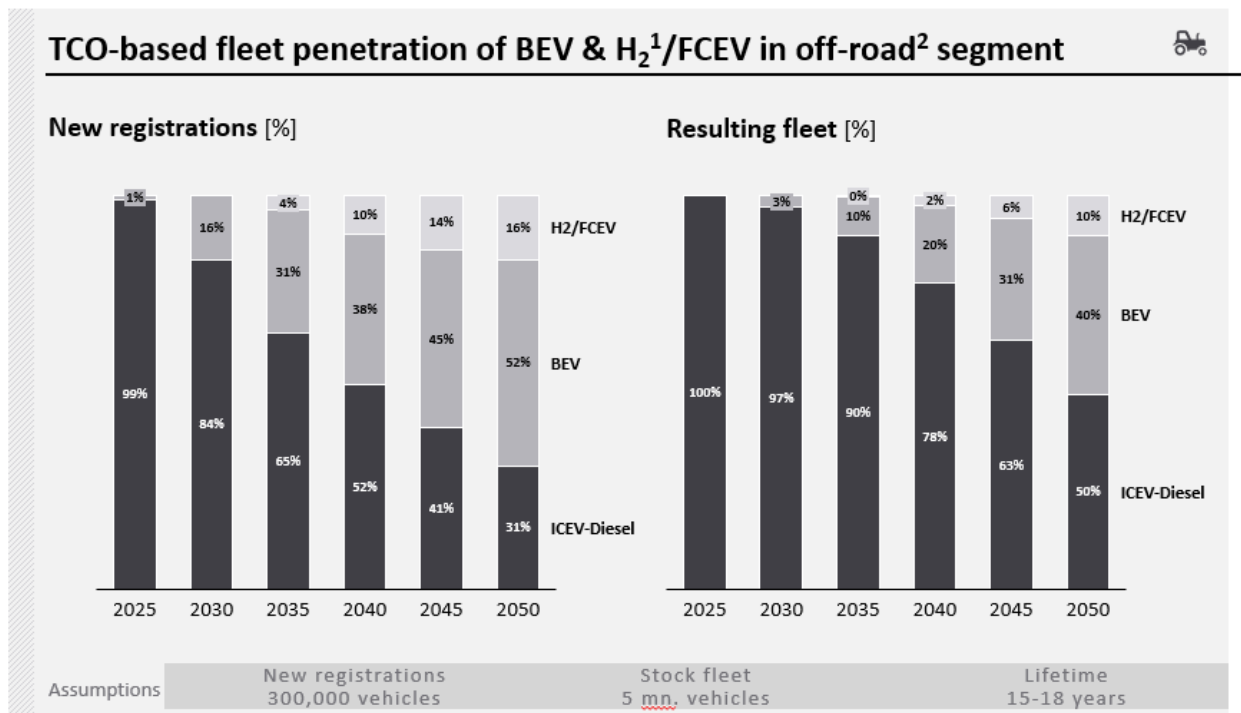


Figure 2: Fleet Penetration of BEV and H2 FCEV in NRMM

The same study found that although energy demand in this sector will decrease by 22% due to electrification and efficiency improvements, a significant portion of the remaining energy needs will be met by low-carbon diesel, biofuels, biomethane, Hydrotreated Vegetable Oil (HVO), or RFNBOs. The majority of fuel demand, equivalent to approximately 7 billion liters of gasoline equivalent, will primarily be supplied by hydrogen and

RFNBOs. Therefore, the immediate market uptake of synthetic fuels is crucial for decarbonizing the NRMM sector.

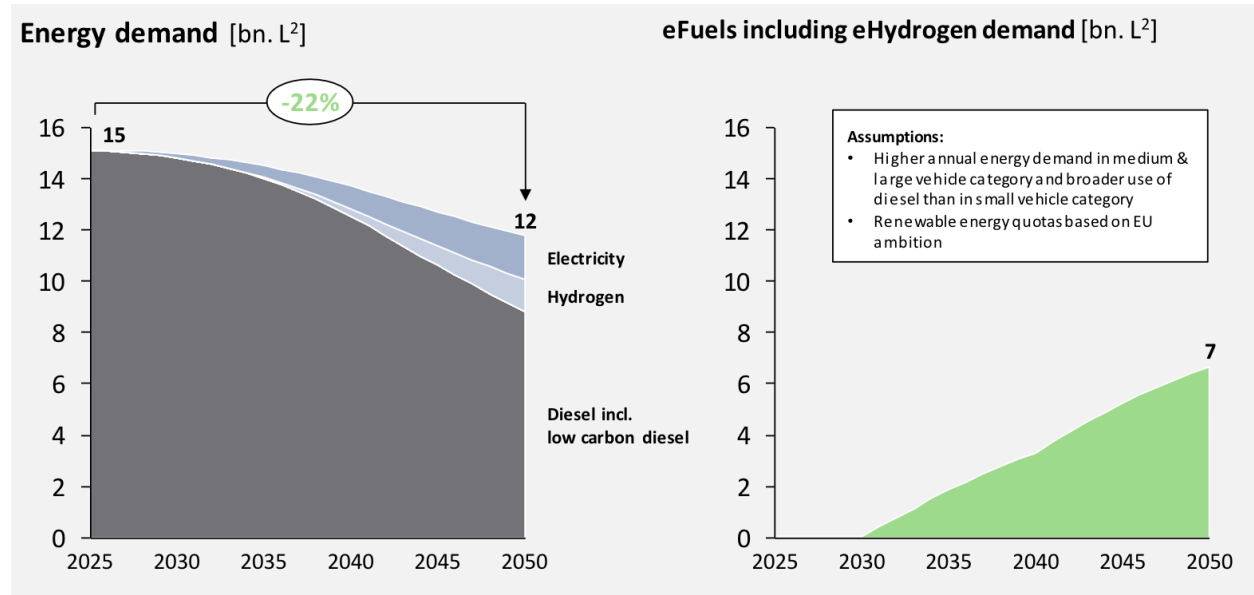


Figure 3: Development of fuel demand in the NRMM applications

While advanced biofuels are already being utilized in the NRMM sector to mitigate GHG emissions, scaling these efforts and making them more affordable necessitates the adoption of a comprehensive climate policy framework. Ensuring access to scalable and sustainable energy carriers, at prices that support competitive agriculture and industry, requires unlocking the potential of renewable fuels through well-structured policies. Both RFNBOs and advanced biofuels present viable solutions for reducing the GHG intensity of the NRMM sector, but their development and deployment depend heavily on active regulatory support.

Existing NRMM regulations primarily target air quality, focusing on reducing pollutants like nitrogen oxides (NO_x) and particulate matter. However, broader climate impacts, such as GHG emissions, are only indirectly addressed through other regulations previously discussed by the eFuel Alliance, including the Renewable Energy Directive (RED), which influences the availability of low-carbon fuels. Given NRMM's critical role in infrastructure development, industrial capacity, and the wider economy, it is essential to implement climate policies aimed at reducing the GHG intensity of this sector.

Furthermore, NRMM is not only vital for today's infrastructure projects but also plays a key role in building the renewable energy infrastructure required to achieve future climate goals. Machinery such as diggers, excavators, cranes, and wheel loaders are indispensable in constructing solar farms, wind turbines, and other clean energy projects. Especially for the defense and military sector NRMM and its secure and

independent availability of fuels plays a major role. Therefore, continuing to overlook the GHG emissions from this sector undermines broader efforts to meet global climate targets.

WHY WE NEED A MULTI TECHNOLOGY PATHWAY FOR NON-ROAD MOBILE MACHINERY?

A technology-neutral approach, including the use of RFNBOs – liquid and gaseous synthetic fuels produced from renewable energy – is crucial to reducing GHG emissions from NRMM. These fuels offer high energy density, making them well-suited for machinery requiring long operational hours in remote locations. They can be easily stored and transported, making them adaptable to various NRMM applications, particularly in areas where access to electric charging infrastructure is limited. **Figure 4** illustrates how different machines require distinct alternative drive technologies depending on operational time, distance to energy infrastructure and power needs. Smaller machines with lower power demands are ideal for battery-electric drives, while larger machines with higher power requirements and long distance to recharging/refueling infrastructure depend on combustion engines or hybrid solutions. This highlights the importance of considering the specific operational profiles of each machine when adopting alternative energy sources for NRMM.

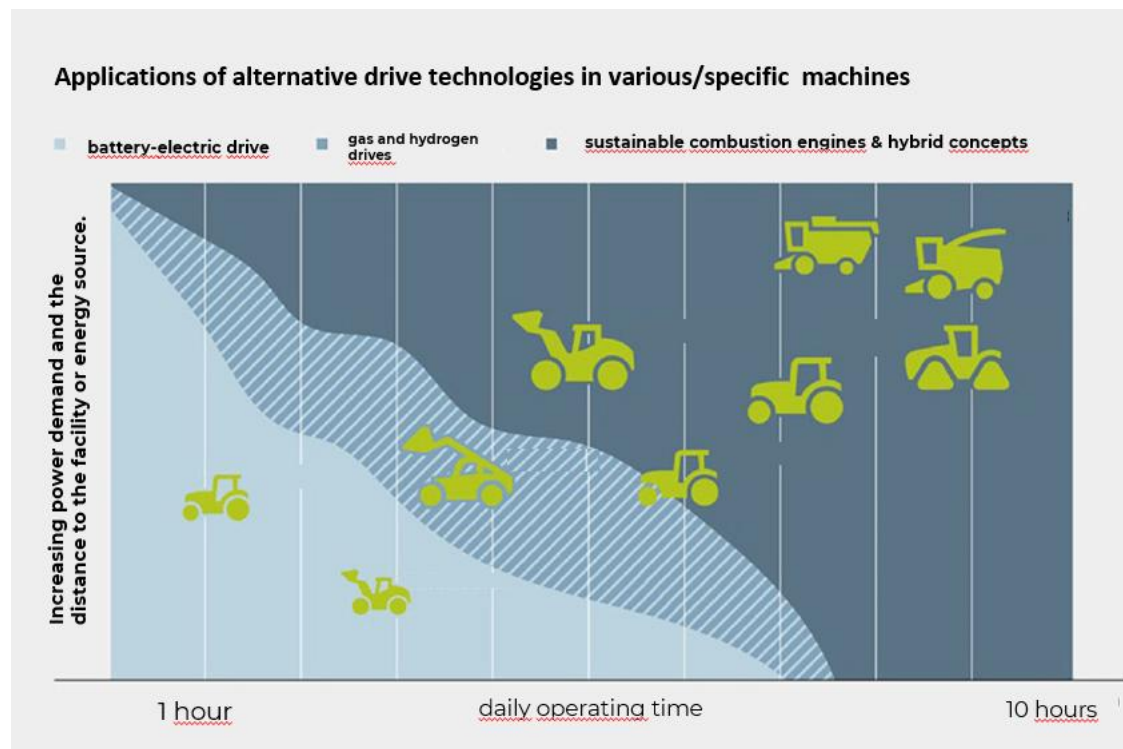


Figure 4: NRMM alternative drive technologies depending on operational time and power requirements.
Source CLAAS (2023)

Furthermore, the energy-intensive nature of NRMM operations, coupled with varied working conditions

(e.g., extreme weather, heavy loads, and continuous operation), presents challenges for the use of large batteries, which can be impractical due to space and weight constraints. This is especially true for handheld power tools like chainsaws, where battery size and weight negatively impact usability and efficiency. In contrast, liquid fuels provide a compact, energy-dense solution that offers operational flexibility without compromising performance.

LIFE CYCLE CARBON FOOTPRINT

To achieve meaningful GHG reductions across the entire lifecycle, the NRMM sector needs solutions that address emissions from cradle to grave. Large batteries, although beneficial in several sectors, have significant environmental costs associated with their production, particularly in terms of raw material extraction, manufacturing, and disposal at the end of their life cycle. A recent [study by Frontier Economics](#) examined the lifecycle emissions of various NRMM with different propulsion technologies. The study is available on request. It found that for NRMM, the production of batteries remains a significant source of emissions. For example, even battery-electric mobile cranes operating entirely on renewable electricity emit more GHGs over their lifetime than a crane powered by RFNBOs or a hybrid crane using green hydrogen.

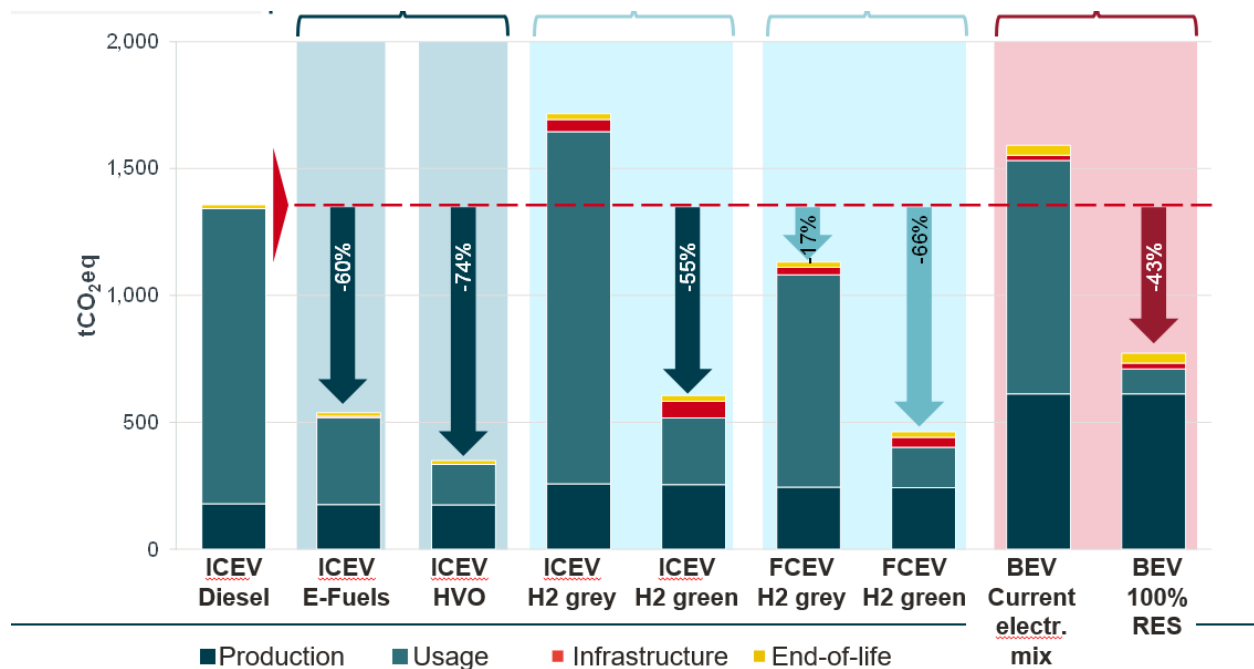


Figure 5: Lifecycle analysis of 60-ton heavy mobile crane with 25 years lifespan, 1,000 operating hours and 10,000 km mileage per year. 15 years in Germany and 10 years in third country. Data taken from 2020.

Similar findings were reported for wheel loaders. A wheel loader powered by an internal combustion engine (ICE) running on renewable fuels can achieve similar environmental benefits as an electric wheel loader operating on green electricity. This is because renewable fuels significantly reduce greenhouse

gas emissions compared to fossil fuels, while also providing high energy density and operational flexibility, especially in off-grid or heavy-duty applications.

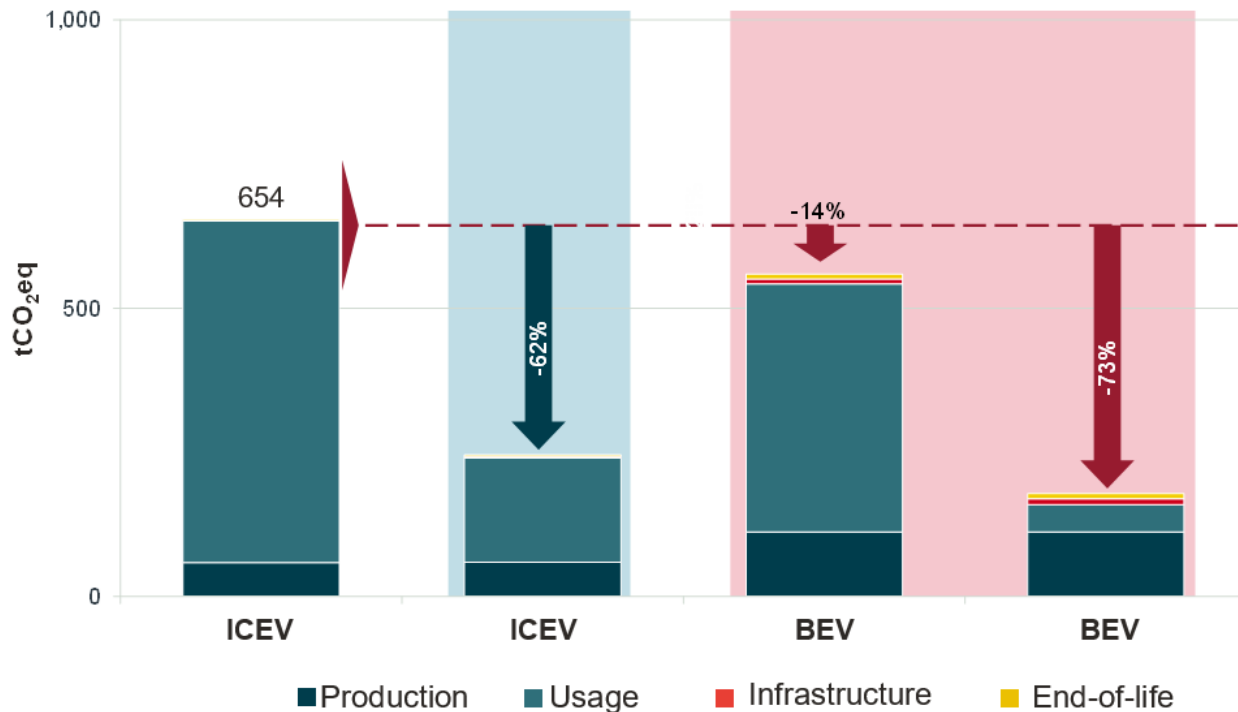


Figure 7: Lifecycle analysis of wheel loader with 10 year service time, 1,500 operating hours with an average diesel consumption of 12l/hour year.

RECOMMENDATIONS – INTEGRATING RENEWABLE FUELS INTO THE NRMM SEGMENT

To ensure that renewable fuels can play a central role in defossilizing the NRMM sector, the eFuel Alliance proposes the deployment of a climate policy framework composed of the following factors:

1. **Demand Signaling Through Renewable Fuel Quotas:** Establishing clear supply quotas for renewable fuels encompassing NRMM sector is essential for creating a market for these fuels. Such quotas would serve as a demand signal to fuel producers and suppliers, ensuring that there is a clear business case for the production and distribution of fuels tailored to the unique needs of NRMM. This would also provide certainty to machinery operators and industries that rely on NRMM, encouraging them to transition from conventional fuels to carbon neutral propulsion. As indicated in [our position paper](#) concerning the implementation of the latest revision of the Renewable Energy Directive (RED), we recommend raising the GHG reduction target to at least 20% to encourage investments in the eFuel value chain, without singling out or cancelling any particular mobility



segment. In addition, we propose a dedicated RFNBO quota of 5% for the whole transport sector. Member states have to transpose the RED in national legislation by May 2025.

2. **Supply-Side Support for carbon neutral fuels in NRMM via funding scheme and revision of the energy taxation:** To promote the use of carbon neutral fuels in the NRMM sector, it is essential to provide supply-side support through existing funding mechanisms. Programs like the EU's Hydrogen Bank and the Innovation Fund, which are designed to support the development and deployment of low-carbon technologies, should explicitly include NRMM as a potential application area for carbon neutral fuels. By doing so, these programs can stimulate research, development, and commercialization efforts, helping to bring RFNBOs to market at a competitive price. The biggest lever to close the price gap between fossil and renewable fuels is the European Energy Taxation. Currently, renewable fuels like HVO, biomethane or RFNBOs are taxed like fossil fuels. That makes no sense if climate-friendly technologies should be promoted. The EU Commission has proposed quite attractive low tax rates for advanced biofuels and RFNBOs. Due to unanimous vote in the Council being a prerequisite, [revision of the energy taxation](#) has seen less progress. It is definitely time to accelerate this process.
3. **Incorporating CO2 neutral fuels for NRMM in Public Procurement:** Public procurement is a powerful tool for driving market change, and the adoption of clean technology standards in procurement policies has been effective in other sectors. By incorporating eFuel-enabled NRMM into public procurement criteria – similar to how the Clean Vehicle Directive promotes the use of low-emission vehicles – governments and public institutions can lead by example. This would not only create demand for renewable fuels in NRMM but also encourage private sector adoption, further reinforcing the market for sustainable fuels.

CONCLUSION

The NRMM sector plays a vital role in global infrastructure and industry, with significant potential for the integration of renewable fuels. Given its critical societal function, it is essential that the NRMM sector is considered within the framework of broader climate policies. Renewable fuels present a viable, scalable solution to the sector's unique energy challenges, offering high energy density, flexibility, and sustainability.

By implementing the recommendations outlined in this paper—such as demand signaling through eFuel quotas, supply-side support via existing funding mechanisms, and public procurement criteria—the NRMM sector can transition toward a more sustainable future while continuing to support global infrastructure and industrial development. Adopting renewable fuels in this context is not only an environmental necessity but also a practical, industry-friendly solution that ensures both economic and operational continuity while achieving significant reductions in GHG emissions.



ABOUT THE eFUEL ALLIANCE

The eFuel Alliance is a stakeholder initiative committed to promoting the political and social acceptance of eFuels (RFNBOs) and to securing their regulatory approval. We represent more than 170 companies, associations and consumer organizations along the value chain of eFuel production. We stand for fair competition and a level-playing field for all relevant emission reduction solutions. We are committed to more climate protection and aim to win broader recognition of the significant contribution eFuels can make in the drive for sustainability and climate protection. Our goal is to facilitate the industrial production and widespread use of renewable fuels.