

Biodiesel (FAME)

Alternative maritime fuel information sheets
Document 8 of 8

About this document

Shipowners, managers, and operators face considerable uncertainty when selecting low-emissions fuels and technologies to meet decarbonization targets and comply with regulations. Transitioning from fossil-based fuels to low-emissions alternatives is essential for shipping's decarbonization. While several fuel options can reduce greenhouse gas (GHG) emissions, each has distinct strengths and limitations in terms of emissions, scalability, technological maturity, and cost — there is no silver bullet solution.

To navigate the uncertainty around fuel selection, the Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping (MMMCZCS) has developed a set of information summaries on eight alternative maritime fuels. These summaries provide a snapshot overview of the risks and opportunities associated with e-ammonia, blue ammonia, e-methanol, bio-methanol, e-methane, bio-methane, e-diesel, and biodiesel. The shared information is based on a collation of analysis and insights from several sources, including previous MMMCZCS research projects and insights from interviews we conducted with industry experts at our partner organizations.

Readers can use these fuel snapshots to identify key aspects that deserve close attention when evaluating and comparing alternative fuels for future fleet fueling strategies.

Each information summary is organized into four main subject areas that support evaluation across the eight fuel pathways:

- [Sustainability considerations](#)
- [Fuel availability potential](#)
- [Maritime uptake](#)
- [Commercial considerations](#)

This document focuses on [biodiesel \(fatty acid methyl ester, FAME\)](#). For additional insights into alternative maritime fuels towards 2050, we encourage readers to take a look at the MMMCZCS [fuel pathway maturity map](#) on our website.

Nothing in these information sheets shall be taken as advice, predictions, or recommendations, and readers should read the disclaimer before using the information sheets.

Acknowledgements

This information sheet was prepared by the Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping (MMMCZCS) with assistance from our partners. Contributors marked with an asterisk (*) were seconded to the MMMCZCS from their home organization and contributed in a research capacity under the supervision and direction of MMMCZCS.

Writing led by Annalicia Poehler and Nikolaj Enevoldsen (both MMMCZCS); editorial review by Matilda Handsley-Davis and Jazelyn Rivas Rosende (both MMMCZCS); layout and design by Julia Garbowska (MMMCZCS); project steering by Estela Vazquez Esmerode and Christoffer Lythcke-Elberling (both MMMCZCS). Thanks to Maria Grammatikou (MMMCZCS) and Tobias Kleinke* (Hapag-Lloyd) for assistance with preparing the publications and to all colleagues at the MMMCZCS and partner organizations who contributed expert knowledge to the project.

Disclaimer

This publication has been prepared by Fonden Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping ("Center") for informational purposes only. The Center acts as a neutral facilitator. This material presents non-confidential, public-source and/or modeled information for general understanding. Nothing herein constitutes advice, a recommendation, or guidance on individual commercial strategy. The content herein is based on studies, research, and analyses conducted by the Center, as well as publicly available information as of the date of publication. While the Center has made every effort to ensure the accuracy and reliability of the information presented, it does not guarantee or warrant, either expressly or impliedly, the completeness, accuracy, or suitability of this information for any specific purpose.

This publication is not intended to serve as technical, regulatory, commercial, legal or other advice. Readers are encouraged to consult with their advisors before making any decisions or taking actions based on the information contained herein. Compliance with applicable laws, regulations, and standards, including but not limited to those related to safety, environmental protection, and design requirements, remains the sole responsibility of the reader. The Center disclaims all liability, whether in contract, tort (including negligence), or otherwise, for any damages, losses, errors, or injuries, whether direct, indirect, incidental, or consequential, arising from the use of, or reliance on, the information contained in this publication. By accessing this publication, readers acknowledge and agree to the terms of this disclaimer and release the Center from any liability associated with the use of the information provided herein.



Sustainability considerations

- Similar to other alternative fuels, FAME biodiesel is expected to be subject to sustainability compliance. However, the industry currently lacks mandatory and harmonized criteria – particularly regarding life-cycle assessment (LCA) methodologies for emerging options, including FAME.
- Besides climate impact (see 'Life cycle GHG emissions,' below), the main sustainability risks from this fuel include:
 - Significant negative impacts on direct land-use change (due to deforestation or peatland conversion) and biodiversity loss (due to the implementations of monocultures and pesticide use) if FAME is produced from edible oils such as soybean oil or palm oil.^{1, 2, 3, 4}
 - Production of FAME as a first-generation biofuel also creates food security risks, as resources (e.g., land, water, and crops) may be dedicated to fuel production instead of food production.^{1, 5}
 - FAME production can present risks to human and labor rights, based on reports of poor working conditions and forced labor on plantations.^{3, 6} Moreover, local and Indigenous communities may suffer from conflicts over land and water use rights, due to use of water for irrigation and conversion of land to large-scale agricultural production.

Life cycle GHG emissions

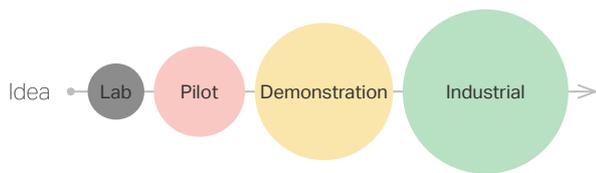
- Life cycle emissions include GHGs released across the full value chain – from feedstock and resource extraction, to transportation of the fuel to market, and final use on board the vessel.
- For FAME biodiesel, life cycle GHG emissions intensity is in the range of 1.3-70 gCO₂ eq/MJ.^a The main drivers of these emissions are linked to feedstock cultivation, particularly the carbon fluxes in soil resulting from direct land use change, along with regional agricultural practices and the use of inputs such as water and fertilizers.
 - FAME produced from used cooking oil (used cooking oil methyl ester or UCOME) generally exhibits much lower life cycle emissions than crop-based alternatives, as the feedstock is a waste material that carries minimal upstream burdens and is not associated with land use change.^{7, 8, 9}
 - FAME combustion produces carbon dioxide (CO₂). Since this carbon originates from biogenic sources, these emissions are considered carbon-neutral, as CO₂ released during combustion is roughly offset by the CO₂ absorbed during biomass growth.
- LCA is essential for evidence-based decision making, as it provides transparency on a fuel's full emissions profile. Results can vary depending on methodological choices and data sources. Accurate descriptions of the system boundaries and assumptions are necessary for comparisons.

^a g CO₂ eq/MJ = grams of carbon dioxide-equivalent per megajoule of energy



Fuel availability potential

- **Feedstock availability**
 - The feedstocks for FAME are fats, oils, and greases. These feedstocks can also be used to produce another fuel called hydrogenated vegetable oil (HVO, also known as 'renewable diesel'), which is outside the scope of this document.
 - Feedstock supply is limited by challenges including sector competition and feedstock sustainability.¹⁰
- **Industrial maturity**



● FAME production: industrial¹¹

- **Infrastructure requirements**
Collection and logistics for feedstocks such as vegetable oils, waste cooking oils, and animal fats, including pretreatment and storage; FAME production and distillation; storage, blending, and bunkering infrastructure.

Maritime uptake

Safety

- The properties of FAME closely resemble those of conventional maritime fuels.
- Best practices for safe handling of FAME are well-established.¹² Technology and safe operations are mature and not considered a challenge.¹³

Vessel technology

- FAME is compatible with many existing marine engines and has been applied in service without significant operational issues. We therefore do not expect this fuel to present new requirements for shipyards.
- However, onboard fuel systems should be specified and managed to accommodate FAME-specific characteristics, including oxidative degradation, increased risk of microbial growth, and material and sealing compatibility.^{14, 15}

Logistics, storage, and bunkering

- A framework is developing for licensing bunker suppliers to bunker FAME.¹⁶ However, the number of bunkering locations is still limited.
- Specifications for FAME concerning stability and blending levels are standardized for storage, bunkering, and onboard use.¹⁷ The long-term chemical stability of FAME is still being investigated.



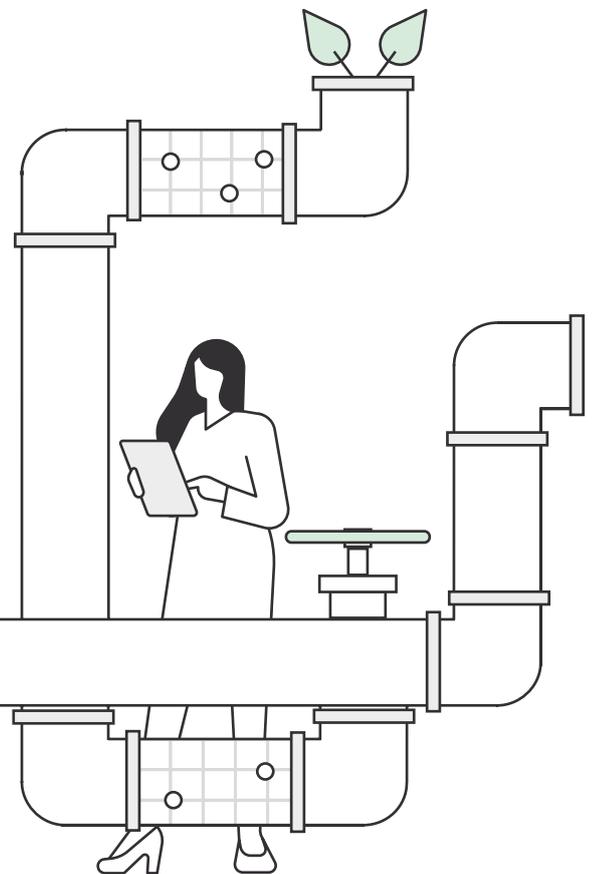
Commercial considerations

Regulatory and certification

- The IMO Net-Zero Framework is a set of technical and economic measures aimed at delivering emissions reductions according to the IMO's 2023 GHG Strategy. The timeline for the framework's adoption and implementation remains to be finalized.¹⁸
- Final guidance on quantification of well-to-wake GHG emissions from fuels and the sustainability criteria are still under development by the IMO.¹⁹ These guidelines will be combined with the development of certification schemes to ensure that the utilized alternative fuels are produced according to a set of sustainability requirements and reduce GHG emissions.
- The risk-based assessment of indirect land-use change is also under development at the IMO and will be critical to assess the environmental benefits and regulatory acceptance of FAME biodiesel.
- The 2024 update to ISO 8217 (the main international standard for marine fuels) allows for up to 100% biofuel content.¹⁷
- IMO regulations on air pollution from ships (MARPOL Annex VI) allow the use of biofuel blends on ships, with blends up to 30% treated as conventional fuels and higher blends subject to stricter NO_x and documentation requirements.²⁰ Under these regulations, biofuels that reduce GHG emissions by more than 65% compared to marine gas oil and are certified by an international certification scheme can benefit from favorable carbon intensity ratings under the IMO Carbon Intensity (CI) framework.

Cost and market development

- As FAME is already on the market today and prices are volatile, we do not present estimated costs or abatement costs in this section.
- The main cost drivers for this fuel include competition for limited sustainable feedstocks e.g., for production of automotive fuel and SAF.⁹
- The main competing markets for FAME are road transport and aviation.^{7,8,9,21} Competition with road transport may lessen over time due to growing electrification.²¹



⁹ SAF = sustainable aviation fuel



References

- ¹ [Mathew, G. M. et al. Recent advances in biodiesel production: Challenges and solutions. *Science of the Total Environment* 794: 148751 \(2021\)](#)
- ² [Chowdhury, P. et al. Biomass to biofuel: Impacts and mitigation of environmental, health, and socioeconomic challenges. *Energy Conversion and Management: X* 25: 100889 \(2025\).](#)
- ³ [Russell, M. Palm oil: Economic and environmental impacts. *European Parliamentary Research Service* \(2020\).](#)
- ⁴ [Purnama, I. et al. Environmental Impacts and the Food vs. Fuel Debate: A Critical Review of Palm Oil as Biodiesel. *Global Change Biology Bioenergy* 17:6 e70043 \(2025\).](#)
- ⁵ [Balat, M. Potential alternatives to edible oils for biodiesel production – A review of current work. *Energy Conversion and Management* 52:2 1479-1492 \(2011\).](#)
- ⁶ [BBC. US bans Malaysian palm oil producer over forced labour \(2020\).](#)
- ⁷ [Xu, H. et al. Life Cycle Greenhouse Gas Emissions of Biodiesel and Renewable Diesel Production in the United States. *Environmental Science & Technology* 56:12 \(2022\).](#)
- ⁸ [Concawe. JEC Well-to-Wheels Study version 5: a look into the carbon intensity of different fuel/powertrain combinations in 2030. *Concawe Review* 29:2 \(2021\).](#)
- ⁹ [European Parliament and Council, Directive \(EU\) 2018/2001 on the promotion of the use of energy from renewable sources \(RED II\) \(2018\).](#)
- ¹⁰ [International Energy Agency. Is the biofuel industry approaching a feedstock crunch? \(2022\).](#)
- ¹¹ [Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping. Using Bio-Diesel Onboard Vessels \(2023\).](#)
- ¹² [McCormick, R. and Moriarty, K. *Biodiesel Handling and Use Guide* \(Sixth Edition\). National Renewable Energy Laboratory \(2023\).](#)
- ¹³ [Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping. Fuel Pathway Maturity Map: bio-diesel – onboard safety and operations \(2024\).](#)
- ¹⁴ [DNV. Using biodiesel in marine diesel engines: new fuels, new challenges \(2020\).](#)
- ¹⁵ [Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping. Internal interviews with shipbrokers and ship manufacturers \(2024\).](#)
- ¹⁶ [Maritime & Port Authority of Singapore. Supply of biofuel within the port of Singapore to vessels.](#)
- ¹⁷ [International Organization for Standardization. ISO 8217:2024 - Products from petroleum, synthetic and renewable sources — Fuels \(class F\) — Specifications of marine fuels. \(2024\).](#)
- ¹⁸ [International Maritime Organization. IMO net-zero shipping talks to resume in 2026 \(2025\).](#)
- ¹⁹ [International Maritime Organization. 2023 IMO Strategy on Reduction of GHG Emissions from Ships \(2023\).](#)
- ²⁰ [International Maritime Organization MEPC.1/Circ.795/Rev.7 – Unified Interpretations to MARPOL Annex VI \(2022\).](#)
- ²¹ [Holm, M., Jameson, P. & Schack, L. Beyond Shipping: How Other Sectors Will Fuel Maritime Decarbonization. Boston Consulting Group \(2025\).](#)



Go to these links to learn about other alternative maritime fuels.

Document 1: [E-ammonia](#).



Document 5: [E-methane](#).



Document 2: [Blue ammonia](#).



Document 6: [Bio-methane](#).



Document 3: [E-methanol](#).



Document 7: [E-diesel](#).



Document 4: [Bio-methanol](#).



For more, visit
www.zerocarbonshipping.com



Mærsk Mc-Kinney Møller Center
for Zero Carbon Shipping

Copyright Notice: ©2026 Fonden Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping. All Rights Reserved. Any publication, display or reference (in whole or in part) of or to this report, shall be made conditional on inclusion of a reference to the Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping.