USING BIODIESEL IN MARINE OPERATIONS

Your guide to achieving more sustainable shipping today

Learn about biodiesel and best practices to maximize value from this readily available, low-carbon fuel solution.

MICHIGAN ADVANCED BIOFUELS COALITION

What is biodiesel?

Biodiesel is a low-carbon, renewable fuel that is made from sustainably produced feedstocks, including soybean oil, used cooking oil, and other fats and vegetable oils.

Compared with petroleum diesel and marine fuel oil, fueling vessels with biodiesel results in lower emissions of greenhouse gases. Biodiesel reduces CO2 by an average 74% compared to petroleum diesel. Other pollutants such as hydrocarbons, particulate matter and sulfur dioxide are also reduced when using biodiesel.

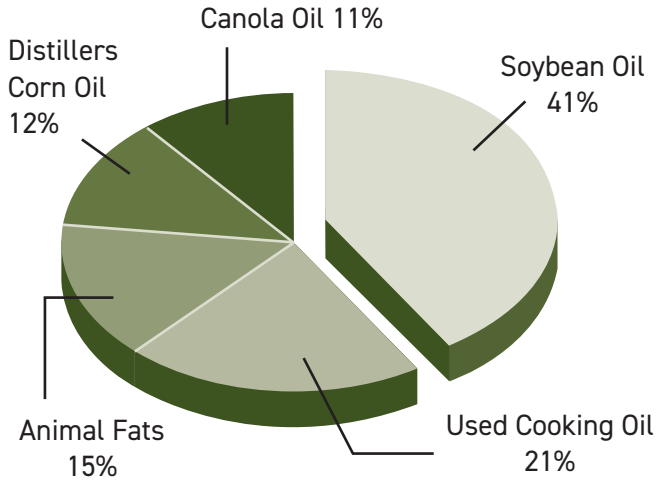
Biodiesel stands apart as a readily available, practical solution to help decarbonize the shipping industry and improve air quality for port workers, mariners, and communities. It can be used in any diesel engine with little or no modifications. Since biodiesel can use existing liquid fuel infrastructure, it can be deployed immediately without burdensome investments in new equipment. Biodiesel is made in North America, enhancing energy security by reducing dependence on imported fossil fuels.

Biomass-based diesel refers to a renewable fuel substitute for petroleum diesel and encompasses biodiesel and renewable diesel. Biodiesel is produced from the transesterification process and is technically referred to as Fatty Acid Methyl Esters (FAME). In its pure form, biodiesel meets the ASTM D6751 and ISO 8217:2024 standards. When blended, biodiesel must meet additional standards as outlined on page 6 of this guide.

Renewable diesel is typically produced through hydrotreating, the same process that converts crude oil into petroleum diesel. Renewable diesel also meets the ASTM D975 standard for petroleum diesel and is sometimes referred to as hydrotreated vegetable oil (HVO).

Renewable diesel is mostly consumed in states with low carbon fuel standards that have pricing mechanisms to bring the cost down. In the Midwest, biodiesel is more commonly used because it produced in the area and costs less than renewable diesel.

Figure 1. Feedstocks Used for U.S. Biomass Based Diesel Production



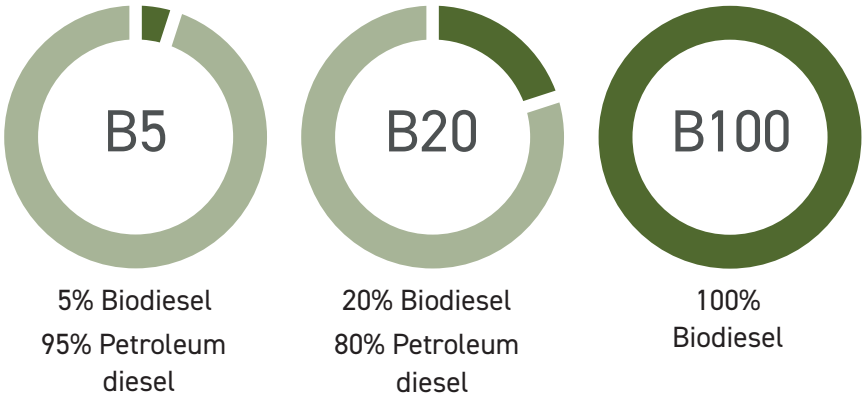
Source: U.S. Energy Information Administration, 2024 https://www.eia.gov/biofuels/update/table2.pdf

The U.S. produced over 5 billion gallons of biomass-based diesel fuel in 2024. The renewable fats and oils (feedstocks) used to produce the fuels are shown in Figure 1.

Understanding biodiesel blends

Biodiesel can be blended in any proportion with petroleum-based fuels or renewable diesel for use in marine vessels and equipment. The blends are represented with a B followed by the percentage of biodiesel blended into the base fuel. (Figure 2.)

Figure 2. Biodiesel Blends Explained



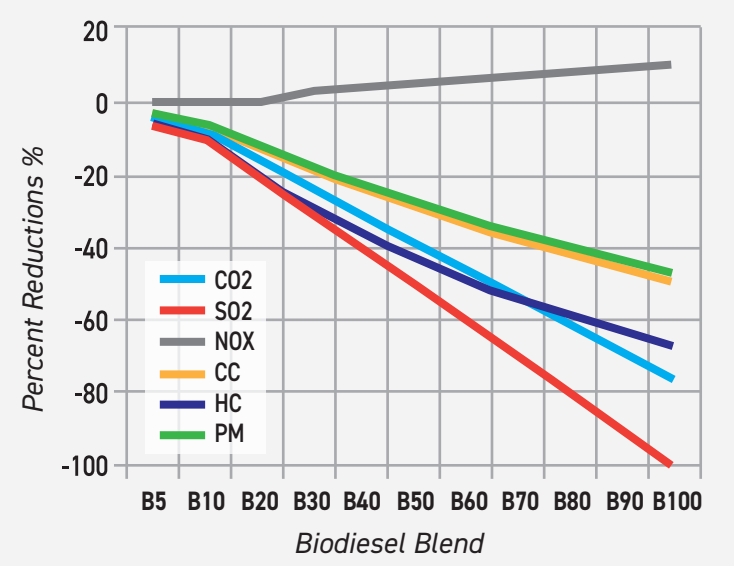
WHY CHOOSE BIODIESEL TODAY?

Transitioning marine fuel supply to biodiesel can help improve air quality for ship crews, port workers and people living in port communities.

Ship engine emissions are especially problematic for ports in metropolitan areas, where poor air quality can contribute to major health problems. For example, Detroit has the second highest prevalence of asthma among major U.S. cities and has more cases of asthma than any other Michigan municipality.[1]

Biodiesel reduces particulate matter and other harmful pollutants that cause poor lung health. While NOx emissions can rise in some engine applications, many marine trials have shown no additional NOx levels from biodiesel compared to heavy fuel oil (HFO), marine gas oil (MGO) and very low sulfur fuel oil (VLSFO)[2]

Figure 3. Engine Out Emission Reductions From Biodiesel Use



Source: https://docs.nrel.gov/docs/fy07osti/40554.pdf

Meet sustainability goals and mandates

Interest in biodiesel is growing as shipping companies and other marine fuel users seek to be more environmentally conscious. Biodiesel is an excellent low-carbon option as companies look for ways to reduce emissions and implement sustainable fuel solutions into their operations.

Cleaner air in port communities

In 2024, the International Standards Organization (ISO) updated the ISO 8217 fuel specification for marine applications, allowing for use of biodiesel blends up to 100% (B100) in marine vessels.[3] The new ISO 8217:2024 standards ensure that biodiesel meets rigorous standards for marine applications.

Improve engine performance

With its increased lubricity, biodiesel reduces engine wear. Higher cetane content contributes to smoother operation, and reduced soot production causes less wear on diesel particulate filters. Similar benefits are expected with Exhaust Gas Cleaning Systems.

Support economic development

The biomass-based diesel fuel industry supports 480 jobs in Michigan[4], and more than 107,000 jobs nationally[5]. Jobs include feedstock production and sales, refinery construction and maintenance, and fuel production, distribution and sales. The industry also delivers additional revenue for farmers by providing a market for soybean oil. In total, bio-mass based diesel adds $42.4 billion to the U.S. economy.[5]

COMPARE BIODIESEL WITH OTHER LOW-CARBON FUELS

Biodiesel has many practical advantages over other marine fuel alternatives being tested by shipping companies. (See Table 1.)

Renewable diesel (RD) is readily available but can be cost-prohibitive in the Midwest. In contrast, biodiesel blends up to B20 typically track diesel prices within a few cents per gallon and sometimes cost substantially less, depending on available incentives.

Liquified natural gas (LNG) is another viable option but requires significant infrastructure and engine investments to convert from diesel. Biodiesel works with existing liquid fueling infrastructure and engines with little or no modifications.

Other potential solutions are renewable methanol, ethanol, ammonia and green hydrogen. But these options all require new or upgraded vessels and infrastructure and are years away from reality.

Furthermore, keep in mind the volumetric density of marine fuel varies greatly, affecting onboard fuel storage needs. (Table 2.) When using biodiesel, shipping companies do not have to sacrifice fuel storage space as with some other fuels. B20 delivers energy nearly equal to low sulfur diesel fuel – and brings 15% carbon reduction.

Table 1. Low-carbon Fuels Checklist (√ = yes x = no)

	B20 Biodiesel	B100 Biodiesel	Renewable Diesel	LNG	Methanol	Ammonia	Hydrogen
Readily available now	√	√	√	√	x	x	x
Compatible with most diesel engines without modifications	√	*	**	x	x	x	x
Using existing fuel storage tanks and infrastructure	√	***	√	x	x	x	x
Pricing in Midwest comparable to ultra low sulfur diesel	√	√	x	****	x	x	x

**Compatible with most diesel engines without modifications, but some engines may require heating and other minor upgrades.*

***Compatible with most, but not all marine engines.*

****Fueling infrastructure needs to be upgraded in colder climates. Upgrades may include heated tanks, tank blankets, heated dispensers and/or heated hose cabinets.*

*****LNG is cheaper than diesel on a per energy unit basis.*

Table 2. Energy Density of Liquid Marine Fuels [7,8]

	Energy Content (BTU/Gallon)	Diesel Gallon Equivalent	Additional Fuel Storage Capacity Needed Compared to Ultra Low Sulfur Diesel
Ultra Low Sulfur Diesel	128,500	1.00	
Biodiesel (B20)	126,700	.99	1.01x
Renewable Diesel	123,710	.96	1.03x
Biodiesel (B100)	119,550	.93	1.07x
Liquid Natural Gas (LNG)	69,000	.53	1.88x
Methanol	57,250	.45	2.20x

[4] *Alternative Fuels Data Center (AFDC) Fuel Properties Comparison. Alternative Fuels Data Center: Fuel Properties Comparison (energy.gov) Accessed Nov. 9, 2023*

[5] *Michigan Department of Revenue. Alternative Fuel GGE Comparison 3.5 cpg surcharge.pdf (state.mn.us) Accessed Dec. 6, 2023.*

BEST PRACTICES FOR ADOPTING BIODIESEL

Ships seeking to use biofuels must prepare an implementation plan tailored for each vessel.

Following these best practices will ensure smooth operation and optimal performance, especially when implementing biofuels for the first time.

Understand materials compatibility
Biodiesel blends should not come in contact with metals such as brass, bronze, copper, lead, tin, and zinc. Fuel system components compatible with all blends of biodiesel are carbon steel, stainless steel, and aluminum.

Older fuel lines should be inspected for wear and compatibility before implementation of biodiesel. Natural rubber hoses and gaskets tend to swell and eventually leak with biodiesel blends. Biodiesel compatible materials include Viton, Teflon, fluorocarbon and nylon.

Maintain storage tanks and dispensers
Whether you are running on bio-based fuels or petroleum fuels, storage and dispensing systems need regular maintenance to ensure optimal fuel performance. Prepare for biodiesel implementation by testing the fuel tank(s), removing free water and applying biocides if microbial activity is detected through lab analysis. Water contamination is the biggest issue affecting fuel quality, leading to corrosion, microbial activity and fuel degradation. Sample fuel tank bottoms regularly to visually check for water contamination and repair any water intrusion issues.

Biodiesel storage considerations
Biodiesel tends to oxidize faster than petroleum diesel, meaning that fuel stored for long periods of time (6 to 12 months) should be tested for acid number and oxidation stability to ensure it still meets specifications. Check with your biodiesel supplier for an antioxidant that can be added to stored fuel to keep it from oxidizing during long-term storage.

Check OEM concerns
Checking with engine OEMs regarding biodiesel usage will highlight any potential issues that may be present. Many marine engine manufacturers have rigorously tested biodiesel and approve blends up to B100 in certain engine platforms.

Emissions evaluation
The higher oxygen content in biodiesel can cause elevated combustion temperatures which leads to increased NOx emissions in some cases. Factors that affect the NOx levels include engine type, engine load and biodiesel blend. Operators may need to consult previous emissions studies with similar vessels or verify emissions to confirm compliance with NOx regulations in certain jurisdictions. The NOx levels increases are typically minimal and can be rectified with fuel additives, exhaust gas recirculation (EGR) and selective catalytic reduction (SCR).

Fuel range
B100 contains around 7% less energy content compared to petroleum diesel. Users may see an increase in fuel consumption to maintain a certain engine load. Engines may need to be tuned to account for the energy difference at higher biodiesel blends.

Cold weather operation
Biodiesel has a higher cloud point temperature than diesel fuel which may impact cold weather operability for ships operating in winter. At high biodiesel blends, this may require heated fuel lines that are exposed to ambient conditions. Cold flow improver additives have been specifically formulated for up to B50 blends to allow cold weather operation. Testing the winter fuel blends and additive dose rates in the lab before cold weather sets in is the best way to predict cold weather operability.

Biodiesel solvency
Biodiesel has surface cleaning properties. When first introduced, biodiesel may loosen sediment and diesel sludge that can accumulate in older storage tanks. Be prepared for shorter filter change intervals when initially using biodiesel by having replacement filters on hand. Users can reduce the likelihood of plugged filters by starting with lower blends and ramping up to higher blends over time. After the fuel system is cleaned, regular filter change intervals can resume.

PURCHASING BIODIESEL

With strict ASTM fuel specifications, today's biodiesel meets even stricter quality and performance standards than petroleum diesel. The following specifications are relevant for marine vessel operators looking to use biodiesel.

- Marine specific requirements ISO 8217:2024
- ASTM D975 for biodiesel blends from 0-5%
- ASTM D7467 for B6-B20
- ASTM D6751 for B99/100

Seek a BQ-9000 certified supplier
It is important to purchase biodiesel from a fuel supplier with BQ-9000-accredited fuel producer -- your assurance of consistent, high-quality biodiesel. To achieve this accreditation, biodiesel producers are subject to third-party audits. The program verifies fuel quality and best management practices throughout the manufacturing process, including storage, sampling, testing, blending, shipping and distribution.

BQ-9000-accredited companies consistently outperform baseline industry quality standards, according to annual surveys[6] conducted by the National Renewable Energy Laboratory (NREL).

Other resources
- NREL Biodiesel Handling and Use Guide: Sixth Edition

CLEARING UP BIODIESEL MISCONCEPTIONS

MISCONCEPTION: Biodiesel clogs engine filters

TRUTH: Biodiesel has engine cleaning properties. When first used, it may loosen sediment and diesel sludge that can accumulate in storage tanks. Be prepared for shorter filter change intervals when initially using biodiesel by having replacement filters on hand. Starting with lower blends and scaling up over time can reduce the likelihood of filter plugging. After the fuel system is cleaned, regular filter change intervals can resume.

MISCONCEPTION: Biodiesel does not work in all engines

TRUTH: Biodiesel blends up to B20 that meet ASTM specifications can operate in any type of diesel-powered equipment. International Standards Organization (ISO) fuel standards allow for use of biodiesel blends up to 100% (B100) in marine fuel. Refer to your equipment manual or consult the manufacturer to confirm recommended fuels and considerations when using biodiesel.

A common misconception is that use of biodiesel voids engine or equipment warranties. In fact, the federal Magnuson-Moss Warranty Act protects buyers against companies adding this type of disclaimer to a warranty.

MISCONCEPTION: Biodiesel feedstocks compete with food sources

TRUTH: Biodiesel can be used from many different feedstocks. The most common is soybean oil. It's important to know that soybean oil is a byproduct of producing soybean meal for livestock feed and other uses. Biodiesel creates a market for this excess oil and does not divert land from food production. In fact, soybean farmers in the US have continued to achieve higher yields and produce more crops on less land year after year according to figures from the USDA. Similar to soybean oil, distillers corn oil is a byproduct of ethanol production, which also produces distillers dry grains for livestock. Used cooking oil (UCO) and animal fats are also biodiesel feedstocks that divert waste from landfills.

These marine operations rely on biodiesel

Biodiesel is a cost-effective way to achieve aggressive sustainability goals today. For vessel operators looking to lower carbon emissions, biodiesel fuel is readily available from multiple suppliers on the Great Lakes and inland waterways in the upper Midwest.

Here are examples of companies that are early adopters of biodiesel in this region:

- **CSL,** Montreal, Quebec, Canada. CSL started biodiesel trials in 2019. The company has made rapid progress and recently passed the milestone of running over 75,000 hours on B100 in eight vessels on the Great Lakes.
- **ARTCo,** a subsidiary of ADM. ARTCo operates 29 vessels that move barges up and down the Mississippi River. This fleet uses over 22 million gallons of B30 annually.
- **Algoma Central Corporation,** St. Catherines, Ontario, Canada. In a biofuel trial, Algoma ran five vessels on B100 in the Great Lakes, resulting in a 70% reduction in CO2 emissions.
- **Interlake Steamship Company,** Middleburg Heights, Ohio
- **Middle River Marine,** Mokena, Illinois. Uses B17 on the Illinois River

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WANT TO LEARN MORE ABOUT BIODIESEL?

Visit miadvancedbiofuels.com or contact Michigan Soybean Committee/Michigan Soybean Association at 989-652-3294 or soyinfo@michigansoybean.org.

The Michigan Advanced Biofuels Coalition (MiABC) promotes the use of advanced biofuels to help improve the quality of life in Michigan. Using biomass-based diesel fuels – biodiesel, renewable diesel and sustainable aviation fuel – protects our air and environment by reducing carbon and harmful emissions from diesel-powered vehicles, equipment, vessels and aircraft. Formed by the Michigan Soybean Committee, MiABC provides resources to help Michigan communities and fleets take full advantage of the benefits of using biodiesel, the most commonly available advanced biofuel. Funding for MiABC comes from Michigan farmers through the soybean checkoff program.

MICHIGAN SOYBEAN COMMITTEE

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