

# Alternative Fuel Tool Kit

## How to Implement: Biodiesel

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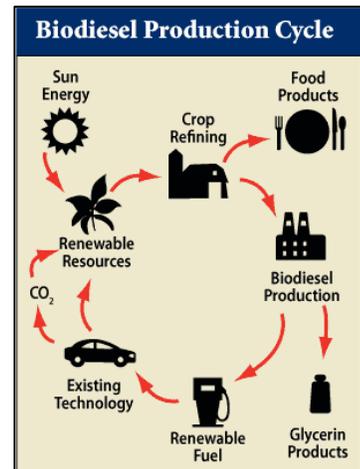
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# Introduction to Biodiesel

## What is biodiesel?

Biodiesel is a renewable diesel replacement fuel made from animal fats, vegetable oils, or recycled greases, that is similarly priced and offers significant benefits when compared to petroleum diesel. Advantages of using biodiesel include local job creation, enhanced performance, and environmental and air quality improvement. The biodiesel production process converts these oils and fats into fuel through a chemical process known as transesterification. A basic visualization of the crop-to-biodiesel production cycle can be seen in Figure 1.

Biodiesel is a registered motor fuel and diesel fuel additive with the U.S. Environmental Protection Agency (EPA). To ensure performance and fuel quality specifications biodiesel must be produced to meet ASTM International Standard D6751.<sup>1</sup>



**Figure 1.** Illustration of the crop-to-biodiesel production cycle. Biodiesel can also be produced by refining waste oil from food products. Source: <http://www.window.state.tx.us/specialrpt/energy/renewable/biodiesel.php>

### Biodiesel Feedstocks

**Animal fats:** edible, inedible, and all other variations of tallow, lard, choice white grease, yellow grease, poultry fats, and fish oils

**Plant oils:** Soy, corn, canola, sunflower, rapeseed, cottonseed

**Recycled greases:** Used cooking oils and restaurant frying oils

Biodiesel can be produced from a wide variety of feedstocks. Most of the biodiesel produced in the U.S. uses soybean, which accounts for approximately 60 percent of all biodiesel feedstocks.<sup>2</sup> In addition to the more common feedstocks for biodiesel production, significant research is underway to utilize new and novel fats and oils, such as trap grease, pennycress and field mustard, and even oils produced from algae, fungi, bacteria, molds, and yeast.<sup>3</sup> While biodiesel (B100) can be used as an unblended

fuel, its most common application is as a blend with distillate or petroleum diesel fuel. For blends, the number following the "B" indicates the percentage of biodiesel in a gallon of fuel (e.g., B50 contains 50% volume biodiesel).

B20 is the most widely used biodiesel blend. At concentrations under 5 percent, the biodiesel blend must meet ASTM International D975 diesel fuel specifications. In addition to ASTM D6751 for B100, biodiesel blends from B6 to B20 must meet ASTM International D7467 specifications.

Key characteristics of different blends of biodiesel are summarized in Table 1 below.

**Table 1: Characteristics of biodiesel by blend level, B2-B100.**

Blend	General Characteristics
B2–B5	Approved by all diesel OEM's, B5 blend common in petroleum diesel with no labeling.
B20	Most common blend, some emissions reductions.
B50	Up to B50 suitable for temperatures above 20°F.
B100	Greater emissions reductions, eliminates smoke and soot in older vehicles, winter weatherization concerns.
All	Emission reductions, and increased lubricity, which reduces engine component wear.

<sup>1</sup> ASTM stands for ASTM International, an international standardization organization that develops and publishes technical standards for a wide range of materials, products, systems and services. For additional information on ASTM standards for biodiesel fuel see: Raw or refined plant oil or recycled greases used for fuel, often referred to as straight vegetable oil, do NOT meet ASTM D6751 standards and is not biodiesel. <http://www.astm.org/Standards/D6751.htm>

<sup>2</sup> <http://www.biodieselsustainability.com/feedstocks/>

<sup>3</sup> National Renewable Energy Laboratory, [Biodiesel Handling and Use Guide, Fourth Edition](#), NREL/TP-540, Revised January 2009, Sec. 3, Pg. 15.

## How is biodiesel used?



Figure 2: Source NCCETC

Like petroleum diesel, biodiesel is used to fuel compression-ignition engines in light-, medium- and heavy-duty vehicles for both on- and off-road applications. Users include commercial fleets, government and municipal fleets, heavy machinery operators, farmers, boaters, universities and community colleges, as well as individual vehicle operators. Any diesel engine can operate on biodiesel with little to no modification while achieving similar horsepower, torque, and mileage. Additional biodiesel applications include stationary sources such as generators and boilers. When using higher-level blends, there are a few steps that must be taken to avoid issues with filters, fuel lines, and materials compatibility (see below under Infrastructure and Operational Considerations section).

## Policies, production, and consumption

Bolstered by implementation of federal policies, biodiesel demand has grown significantly over the past several years. The Energy Policy Act (EPA) of 2005 established a number of energy management goals for Federal facilities and fleets. EPA also created the Renewable Fuels Standard (RFS) which established thresholds to ensure a minimum volume of renewable fuel use in transportation. In 2007, this standard was updated through the Energy Independence and Security Act (EISA) and renamed the RFS2. The updated standard incorporated diesel (it had previously only included gasoline), increased overall usage requirements for renewable fuel, and added new categories of renewable fuel.<sup>4</sup> These standards have been a major driving force behind the growing use of biodiesel because it required “obligated parties” – the oil industry- to utilize biofuels through a system that established a Renewable Identification Number (RIN) for every gallon of renewable fuel sold into the market. In fact, though it is not labeled as such, today’s petroleum diesel sold at retail stations can contain up to a 5% biodiesel blend. In North Carolina, diesel fuel brought into the state via the Plantation pipeline can contain up to a 5% blend of biodiesel with no labeling requirement.<sup>5</sup>

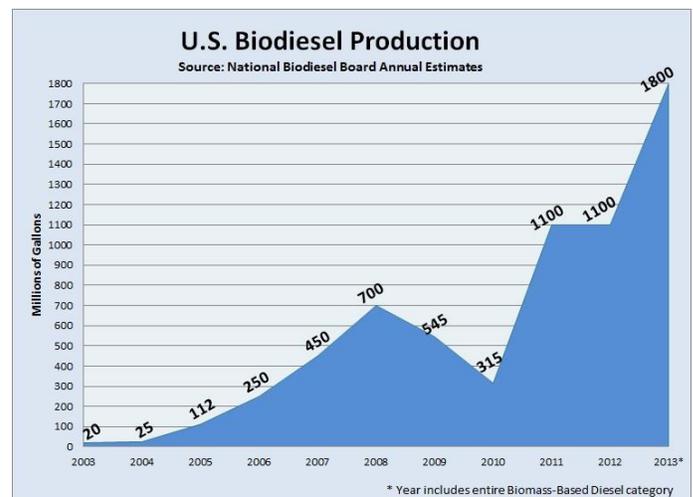


Figure 3. US Biodiesel Production, Source National Biodiesel Board

## What are the benefits of biodiesel use?

As a renewable, biodegradable, non-toxic, and non-carcinogenic diesel replacement, biodiesel offers a range of environmental, health, and performance benefits. Biodiesel has been shown to break down in soil and water up to four times faster than petroleum diesel.<sup>6</sup> When biodiesel replaces petroleum, it significantly reduces greenhouse gas and improves air quality. B20 reduces well-to-wheel emissions of CO<sub>2</sub> approximately 16% compared to petroleum diesel<sup>7</sup>, while B100 has been shown to

### Benefits of Biodiesel

- Renewable
- Safe, non-toxic, biodegradable
- Domestically grown
- Low emissions
- Ease of use, no engine modifications
- Favorable energy balance
- Cost competitive

<sup>4</sup> <http://www.epa.gov/OTAQ/fuels/renewablefuels/>

<sup>5</sup> <http://www.pipeline-news.com/feature/plantation-pipe-line-transport-biodiesel-commercial-purposes>

<sup>6</sup> Peterson, Charles and Moller, Gregory. “Biodegradability, BOD<sub>4</sub>, COD and Toxicity of Biodiesel Fuels”, University of Idaho Biodiesel Education Program.

reduce lifecycle greenhouse gas emissions by 76% compared to petroleum diesel.<sup>8</sup>

Biodiesel also reduces tailpipe emissions of particulate matter, hydrocarbons, and carbon monoxide, which varies depending on the feedstock and blend levels in 2009 and older vehicles.<sup>9,10</sup> Higher blend levels create larger offsets. There are several online tools available, such as the Argonne National Laboratory's GREET Fleet Footprint Calculator, and AFLEET Tool, that project emission reductions and petroleum fuel savings from converting to biodiesel.<sup>11</sup> Another useful resource is the Alternative Fuels User Database, where interested parties may search for fleets using alternative fuels in North Carolina.<sup>12</sup> These tools are also useful for setting fleet goals or applying for financial assistance. However, it should be noted that with the new 2010 diesel emissions standard, emissions benefits of biodiesel use in newer vehicles are not as significant as they are when using biodiesel in older diesel vehicles that predate the new standard.

In addition to environmental benefits, biodiesel improves engine operation and extends engine life. In fact, even just a B2 blend can provide up to a 65% improvement in lubricity, leading to cleaner fuel systems, longer engine life, lower maintenance costs, and less equipment downtime.<sup>13</sup> These lubricity benefits have been proven with biodiesel blend levels as low as 1%, and increase proportionally with higher level blends.

Biodiesel provides very high energy return on investment balance and increases national fuel security through the displacement of imported petroleum. Life-cycle analyses show that biodiesel contains 2.5 to 3.5 units of energy for every unit of fossil energy input in its production, and because very little petroleum is used in its production, its use displaces petroleum at nearly a 1-to-1 ratio on a life-cycle basis.<sup>14</sup> Because biodiesel is an energy efficient, renewable fuel, and can be produced locally from a range of feedstocks, it extends petroleum supplies.

Finally, one of the most significant benefits of biodiesel is its ease of use. Blends of B20 and lower can be used without equipment modifications in diesel engines. B20 blends can also utilize existing diesel fueling infrastructure including tanks and pumps. Other benefits of biodiesel include local job creation and economic impacts. In fact, it is estimated that 50,000 jobs are directly attributable to the biodiesel industry nationwide.<sup>15</sup> Biodiesel is an easy to use, safe, and a low-toxicity alternative to petroleum diesel.

### What are the common fuel properties of Biodiesel?

Biodiesel has different properties than petroleum-derived diesel fuel, and properties such as cetane number, cloud point, and stability can vary significantly by feedstock.

- **Energy Content:** Biodiesel contains slightly lower energy content (BTU's) than petroleum diesel, so the energy content of biodiesel blends and diesel fuel is proportional to the amount of biodiesel. The B20 blend contains only 1-2% less energy per gallon than diesel.<sup>16</sup> This difference is small enough that most users report no noticeable difference in fuel economy, power, and torque. There is no difference in energy content of biodiesel made from various feedstocks – biodiesel made from soybeans has the same energy content as biodiesel made from animal fats.
- **Water Solubility:** Biodiesel is not soluble with water. However, water contamination should be avoided as it accelerates oxidation, facilitates electrical conductivity, and may contain corrosive contaminants.<sup>17</sup>

#### Flammable versus Combustible

A flammable liquid has a flash point of 100°F or below.

A combustible liquid has a flash point greater than 100°F.

Source: National Fire Protection Association

<sup>7</sup> <http://greet.es.anl.gov/afleet>

<sup>8</sup> [http://www.afdc.energy.gov/vehicles/diesels\\_emissions.html](http://www.afdc.energy.gov/vehicles/diesels_emissions.html)

<sup>9</sup> National Renewable Energy Laboratory, Biodiesel Handling and Use Guide, Fourth Edition, NREL/TP-540, Revised January 2009, Sec. 2, Pg. 8.

<sup>10</sup> National Renewable Energy Laboratory, Biodiesel Handling and Use Guide, Fourth Edition, NREL/TP-540, Revised January 2009, Sec. 2, Pg. 8.

<sup>11</sup> <http://www.biodiesel.org/using-biodiesel/oem-information/oem-statement-summary-chart>

<sup>12</sup> <http://nccleantech.ncsu.edu/clean-transportation/alternative-fuels-user-database/>

<sup>13</sup> <http://www.crimsonrenewable.com/biodiesel-specifications.pdf>

<sup>14</sup> National Renewable Energy Laboratory, Biodiesel Handling and Use Guide, Fourth Edition, NREL/TP-540, Revised January 2009, Sec. 2, Pg. 7.

<sup>15</sup> <http://www.biodiesel.org/production/production-statistics>

<sup>16</sup> <http://www.biodiesel.org/docs/ffs-basics/energy-content-final-oct-2005.pdf?sfvrsn=6>

<sup>17</sup> <http://www.socalbug.org/Hodam10-08.pdf>

- **Viscosity:** While biodiesel has a viscosity similar to petroleum diesel, during cold weather it thickens more than petroleum diesel fuel and requires special systems or treatments. The temperature at which the fuel thickens or gels is called its cloud point and varies significantly with feedstock. See table 2 for cloud points of some common biodiesel feedstocks. When biodiesel nears the cloud point temperature, anti-gel additives or Number 1-D (winter diesel) fuel needs to be added to the fuel to prevent filters from clogging. Note that fuel additives that are effective for diesel may not be effective for biodiesel.
- **Conductivity:** Biodiesel has a higher conductivity than petroleum diesel. Therefore, it has greater potential for corrosion. (See material compatibility document from the National Biodiesel Board.)<sup>18</sup> Note that some conductivity is good in a fuel because it dissipates static charge which if allowed to accumulate can generate a spark causing a fire hazard.<sup>19</sup>
- **Air-Fuel Ratio:** Biodiesel has a slightly lower stoichiometric air-fuel ratio compared to diesel.<sup>20</sup>
- **Flammability:** Biodiesel is classified as a non-flammable liquid by the National Fire Protection Association.
- **Cetane Number:** Biodiesel has a higher cetane number, meaning the fuel combusts more completely.
- **Color:** Biodiesel may come in a variety of colors from water white to pale gold to dark brown. While color does not correlate with fuel quality, all fuel should be clear and bright.
- **Oxidative Stability:** Biodiesel has a lower oxidative stability than petroleum diesel. All biodiesel is treated at the point of production with commercial antioxidants to ensure adequate performance in the field. As biofuel ages, it can become acidic and form sediments and varnish.

**Table 2. Biodiesel Cloud Point Variation by Feedstock<sup>21</sup>**

<b>Biodiesel Feedstock</b>	<b>Cloud Point, °Celsius (°F)</b>
Soybean oil	1 (34)
Canola oil	0 (32)
Palm oil	17 (63)
Jatropha oil	8 (46)
Tallow	12-17 (54-63)

## **Biodiesel Availability in North Carolina**

### **Producers and Distributors**

North Carolina is home to five biodiesel production facilities. Per North Carolina state regulations, all biofuels sold must meet ASTM standards.<sup>22</sup> The BQ-9000 is an accreditation program for biodiesel producers and marketers, combining the ASTM standard for biodiesel and a quality systems program, which includes storage, sampling, testing, blending, shipping, distribution, and fuel management practices.<sup>23</sup> Piedmont Biofuels is the only North Carolina-based BQ-9000 certified producer. Blue Ridge Biofuels is currently undergoing the certification process. In addition to the five NC producers, all of whom also distribute fuel, twenty-one biodiesel distributors operate in North Carolina. For more information on distributors and retailers, refer to the North Carolina Clean Energy Technology Center's list or the National Biodiesel Board's plant list.<sup>24,25</sup>

<sup>18</sup> [http://www.biodiesel.org/docs/ffs-performace\\_usage/materials-compatibility.pdf?sfvrsn=4](http://www.biodiesel.org/docs/ffs-performace_usage/materials-compatibility.pdf?sfvrsn=4)

<sup>19</sup> [http://www.biodiesel.org/docs/ffs-performace\\_usage/electrical-conductivity-of-biodiesel.pdf?sfvrsn=4](http://www.biodiesel.org/docs/ffs-performace_usage/electrical-conductivity-of-biodiesel.pdf?sfvrsn=4)

<sup>20</sup> <http://eerc.ra.utk.edu/etfc/docs/Biodiesel-CleanGreen.pdf>

<sup>21</sup> [https://www.extension.org/pages/26611/biodiesel-cloud-point-and-cold-weather-issues#.U9\\_Wq5hOVdh](https://www.extension.org/pages/26611/biodiesel-cloud-point-and-cold-weather-issues#.U9_Wq5hOVdh)

<sup>22</sup> <http://www.biodiesel.org/using-biodiesel/fuel-quality-guide/state-fuel-quality-index/viewstate?state=North%20Carolina>

<sup>23</sup> <http://www.bq-9000.org/>

<sup>24</sup> <http://nccleantech.ncsu.edu/wp-content/uploads/Biofuel-Distributors-and-Producers-in-North-Carolina.pdf>

<sup>25</sup> <http://biodiesel.org/production/plants>

**Table 3: North Carolina Biodiesel Producers; Data based on phone interviews with each of the producers (February 2014).**

Company	Location	Nameplate Capacity (mmgy)	NC Production [1]			Feedstock
			2012	To Date	% Local [2]	
<a href="#">Blue Ridge Biofuels</a>	Asheville	1.2	500,000	1.5 mmg	50%	Waste vegetable oil
<a href="#">Foothills Bio-Energies</a>	Lenoir	5	900,000	3 mmg	5%	Multiple
<a href="#">Patriot Biodiesel</a>	Greensboro	5.2	900,000	4.5 mmg	90%	Waste Oil, Soy Oil, Fish Oil, Poultry Fat, Algae Oil
<a href="#">Piedmont Biofuels</a>	Pittsboro	1	168,000 (2012) 186,000 (2013)	N/A	30%	Recycled waste vegetable oil, fats, and greases. Collect all oil from restaurants and universities
<a href="#">Triangle Biofuels</a>	Wilson	3	1,000,000 (2012) 1,800,000 (2013)	N/A	N/A	Waste vegetable oil, Virgin Oil

<sup>[1]</sup> Annual and operation-to-date production values are approximations

<sup>[2]</sup> Represents percent of fuel sold to local market compared to bulk market

### Fueling Options and Availability

Biodiesel is widely available in North Carolina. In addition to wholesale distributors, there are more than 20 public fueling stations available for the motoring public. Whereas the majority of retail sites offer B20, nearly half of the North Carolina stations feature B50 or B99. Several biodiesel cooperatives, Bull City Biodiesel Co-op and Piedmont Biofuels Co-op also provide up to B100, on a membership basis. For public schools, municipalities, and state fleets, B20 is available through a state-purchasing contract.<sup>26</sup> The state mandates a minimum 2% use of B20 by local school districts as long as the pricing is comparable to diesel.

There are several tools available to locate your nearest biodiesel vender including the [DOE Energy Efficiency & Renewable Energy \(EERE\) Alternative Fuel Data Center Station Locator](#), [National Biodiesel Board Retail and Distributor Locators](#), [National Renewable Energy Laboratory's BioFuels Atlas](#), and the [NC Clean Energy Technology Center Biodiesel Retail Station List](#).

### Biodiesel-Ready Vehicles

According to the National Biodiesel Board, all major OEMs with diesel vehicles available for the U.S. market support the use B5 and lower blends. Similarly, more than 75% of those manufacturers now support B20 or higher biodiesel blends in certain equipment offerings. Currently, there are no on-road vehicles where the OEM supports use of greater than B20.

<sup>26</sup> [www.doa.state.nc.us/PandC/405l.htm](http://www.doa.state.nc.us/PandC/405l.htm)

**Table 4: Biodiesel OEM Support<sup>27</sup>**

OEMs Supporting B5	OEMs Supporting B20		OEMs Supporting B100
Audi	Artic Cat	Isuzu Com. Trucks (2011+)	Case IH
BMW	Buhler	John Deer	Deutz AG (B100 Europe/B20 US)
Hustler Turf Equipment	Caterpillar	Kubota	Fairbanks Morse
Mercedes Benz	Chrysler – Ram & Jeep	Mack	New Holland
Mitsubishi Fuso	Cummins	Monaco RV	
PACCAR	Daimler Trucks	Perkins	
Volkswagen	Ferris	Tomcar	
	Ford (2011+ models)	Toro	
	GMC (2011+ models)	Volvo Trucks	
	Navistar	Workhorse	
	IC Bus	Yanmar	

## Infrastructure and Operational Considerations

### Infrastructure Considerations for Biodiesel<sup>28</sup>

As a diesel replacement, biodiesel requires no new refueling equipment. Nearly all diesel infrastructure can be used for biodiesel by following basic best-practices for handling and storage. Fleets have several options when it comes to purchasing biodiesel including public refueling stations, private refueling stations, and direct delivery or in-house refueling. Selection of the optimal delivery method and infrastructure can help lower fuel costs and ensure quality.

Infrastructure and delivery mechanism often affect the total cost of biodiesel for end-users. Biodiesel prices can differ between public and private fueling stations. According to national averages, both B20 and B99 prices are higher for private refueling stations; however, that trend is reversed at the regional (Lower Atlantic) level.<sup>29</sup> Many businesses, schools, local government agencies, and other industrial consumers will purchase biodiesel in bulk directly from producers and distribution companies. Delivery size varies according to the distributor fleet. Tanker truck loads (7,500 gallons) are the most economical way to purchase biodiesel. Biodiesel is also available for direct purchase at production facilities.



**Figure 4** Source: Blue Ridge Biofuels

Transportation and storage infrastructure for B100, as with any fuel, requires compliance to local, state, and Federal regulations, and with specific conditions to avoid fuel degradation and other issues. Greater care must be used when utilizing B100. Special considerations include the following:

- Dedicated tanks should be used for the transport and storage of B100.
- All transport tanks, storage tanks, and peripheral materials (e.g., hoses and seals) must be constructed of appropriate materials. Aluminum, carbon steel, or stainless steel is recommended for transport tanks. Acceptable storage tank materials include aluminum, steel, fluorinated polyethylene, fluorinated polypropylene, Teflon®, and most fiberglass. Most transport and storage tanks designed for diesel fuel will store B100. Lead solders, zinc linings, copper pipes, brass regulators, and copper fittings should be avoided.

<sup>27</sup> [http://www.biodiesel.org/docs/default-source/ffs-engine\\_manufacturers/oem-support-summary---july-2013.pdf?sfvrsn=2](http://www.biodiesel.org/docs/default-source/ffs-engine_manufacturers/oem-support-summary---july-2013.pdf?sfvrsn=2)

<sup>28</sup> <http://biodieselmagazine.com/articles/4412/infrastructure-to-market>

<sup>29</sup> [http://www.afdc.energy.gov/uploads/publication/alternative\\_fuel\\_price\\_report\\_oct\\_2013.pdf](http://www.afdc.energy.gov/uploads/publication/alternative_fuel_price_report_oct_2013.pdf), October 2013, page 14.

- If dedicated tanks are not used transport and storage, tanks must be inspected and washed before loading to ensure there are no residual materials in the tank, other than diesel or biodiesel. If an existing tank is changed to accommodate B100 storage, it must be cleaned and flushed prior to use.
- Biodiesel must remain above a certain temperature during transportation and storage to avoid gelling and freezing. For B100, without blending or additives, heated tanks and fuel lines may be required during winter months, even in moderate climates.
- Cleanliness and the material compatibility of pumping equipment and blending systems are also critical to maintaining the integrity of biodiesel.

### State Laws

Within the state of North Carolina, regulations exist that support the use of biodiesel. First, all new government diesel vehicles are required to have a manufacturer’s warranty that allows the use of B20 in the vehicle. Second, a minimum of 2% of the total fuel purchased by local school districts is required to be at least a B20 blend, if fuel is competitively priced. Third, 75% of new state government light-duty cars and trucks weighing 8,500 pounds or less must be Alternative Fuel Vehicles or Low Emission Vehicles.<sup>30</sup>

### Biodiesel Barrier Busters<sup>31,32,33,34</sup>

The table 5 below shows some myths and facts that fleet managers should take into account as they weigh costs and benefits of using biodiesel blends.

**Table 5: Biodiesel Myths and Facts**

Myth	Fact
Major modifications are necessary to use biodiesel blends.	<ul style="list-style-type: none"> <li>• While lower biodiesel blends (up to B20) can be used in existing engines with no modifications, fuel filters and delivery systems should be monitored upon initial biodiesel use (first few tanks).</li> <li>• B100 and other high level biodiesel blends are less common than B5 and B20. Because of the solvent properties of higher level biodiesel blends, there are some operational and handling considerations.<sup>35</sup></li> <li>• Most elastomers used in vehicles manufactured after 1993 are compatible with B100 and other high level biodiesel blends.<sup>36</sup></li> <li>• For high blend use in vehicles, users should monitor hoses, gaskets and seals for degradation and replace as necessary with non-rubber or Viton. This is especially important in vehicles manufactured before 1994.</li> <li>• Most standard storage and handling procedures used for petroleum diesel can be used for biodiesel. For more information on storage, see the National Renewable Energy Laboratory’s <u>Biodiesel Handling and Use Guide</u>.<sup>37</sup></li> </ul>
Fuel quality of biodiesel is inconsistent.	<ul style="list-style-type: none"> <li>• In order to avoid operational problems and enhance operability, users should ensure all biodiesel and biodiesel blends purchased meet respective ASTM specifications. BQ-9000 certified facilities consistently produce high quality fuel, and represent over 80% of the market.</li> </ul>
Producing biodiesel takes more energy than it returns	<ul style="list-style-type: none"> <li>• Biodiesel has the highest energy balance of any alternative fuel and returns 2.5 to 3.5 units of energy for every unit of fossil fuel used to produce it.</li> </ul>
During cold weather, biodiesel doesn’t work.	<ul style="list-style-type: none"> <li>• In cold weather, biodiesel and biodiesel blends sometimes cloud and gel, leading to clogged filters and other issues. Note that in severe cold snaps, diesel fuel without biodiesel can also cloud and gel.</li> <li>• Blends of 5% or less of biodiesel generally are not impacted by cold weather</li> </ul>

<sup>30</sup> <http://www.afdc.energy.gov/laws/laws/NC/tech/3251>

<sup>31</sup> <http://www.biodiesel.org/docs/default-source/ffs-basics/biodiesel-myths-vs-facts.pdf?sfvrsn=12>

<sup>32</sup> [http://www.biodiesel.org/docs/ffs-performace\\_usage/usage-checklist.pdf?sfvrsn=6](http://www.biodiesel.org/docs/ffs-performace_usage/usage-checklist.pdf?sfvrsn=6)

<sup>33</sup> <http://www.biodiesel.org/docs/ffs-basics/biodiesel-a-better-choice-for-children.pdf?sfvrsn=4>

<sup>34</sup> [http://www.biodiesel.org/docs/ffs-engine\\_manufacturers/oem-warranty-statement-and-use-of-biodiesel-blends-over-5-\(b5\).pdf?sfvrsn=4](http://www.biodiesel.org/docs/ffs-engine_manufacturers/oem-warranty-statement-and-use-of-biodiesel-blends-over-5-(b5).pdf?sfvrsn=4)

<sup>35</sup> [http://www.afdc.energy.gov/fuels/biodiesel\\_blends.html](http://www.afdc.energy.gov/fuels/biodiesel_blends.html)

<sup>36</sup> [http://www.biodiesel.org/docs/ffs-performace\\_usage/materials-compatibility.pdf?sfvrsn=4](http://www.biodiesel.org/docs/ffs-performace_usage/materials-compatibility.pdf?sfvrsn=4)

<sup>37</sup> <http://www.nrel.gov/vehiclesandfuels/pdfs/43672.pdf>

	<p>and exhibit properties similar to petroleum diesel.</p> <ul style="list-style-type: none"> <li>• During cold weather, B20 and higher blends are manageable throughout the country with appropriate additives and handling which is typically taken care of by distributors (be sure to ask).</li> <li>• Without additives, B20 is likely to gel with prolonged exposure (multiple days) to temperatures below freezing.</li> <li>• Most biodiesel in the US is made from soy which has a cloud point temperature of around freezing, 1°C (34°F).</li> <li>• To ensure cold weather operability, biodiesel users often utilize a lower blend level during the winter months. (It is best to ask the question or obtain the batch report for assurance.)</li> <li>• Fleets can work with their fuel providers to address concerns about usage during cold weather.</li> <li>• Users interested in B100 should also reference the National Renewable Energy Laboratory's Biodiesel Handling and Use Guide, Section 3, for more detailed analysis of operational considerations for high level blend use.<sup>38</sup></li> </ul>
All vehicles experience filter plugging when using biodiesel.	<ul style="list-style-type: none"> <li>• Cleaning the fuel storage tanks and vehicle fuel systems before using biodiesel reduces the likelihood of fuel filter plugging. Fuel filter plugging is more of an issue in older diesel vehicles.</li> </ul>
Using biodiesel voids manufacturers' engine warranty.	<ul style="list-style-type: none"> <li>• All major automakers and engine manufacturers allow at least B5 blends, and the majority of engine companies allow up to B20 as long as the fuel meets ASTM specs.<sup>39</sup></li> <li>• Some recommend that biodiesel be purchased from BQ-9000 certified companies.</li> <li>• An increasing number of OEM's are accepting up to B20 blends, and several off-road applications even recommend any blend range up to B100.</li> <li>• A full OEM statement summary chart is available at the National Biodiesel Board website.<sup>40</sup></li> </ul>

## Crunch the numbers: Fuel Costs and Variability

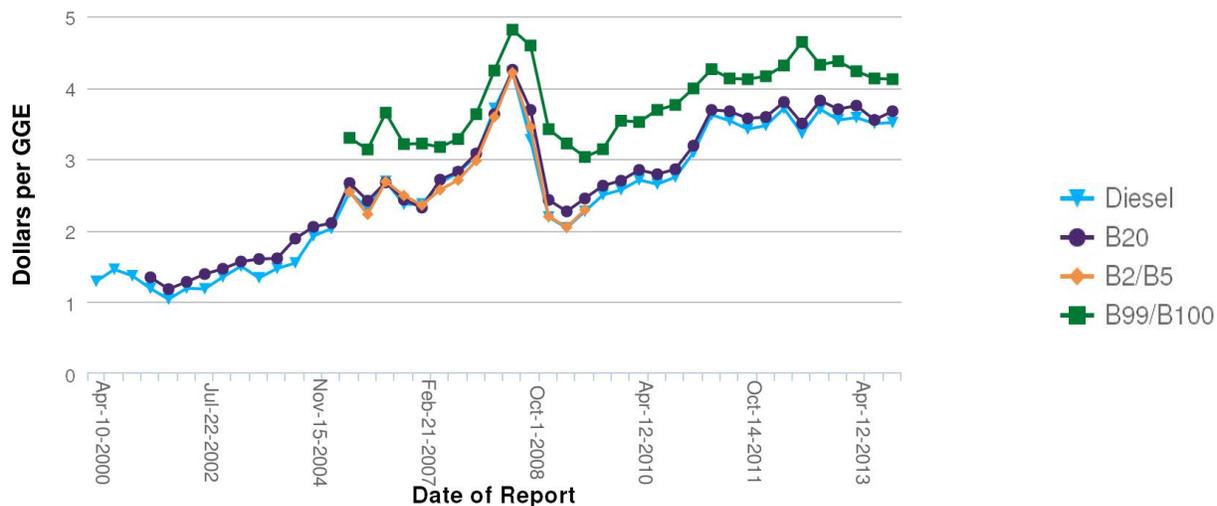
Where most biodiesel is used at blends of B20 or less, it is a cost competitive alternative fuel. Price varies across the country with typical price differences of 1-2% for B20 and less for lower blends. In April 2014 the average retail price of B20 in the Lower Atlantic region was approximately \$0.04/gallon higher than diesel. At higher blends, the price differential is slightly greater. The average regional retail price of B99 in the same time period was approximately \$0.09/gallon more expensive than diesel.<sup>41</sup> The April 2014 national average price difference between biodiesel and diesel was greater - \$0.04/gallon higher for B20, and \$0.26/gallon higher for B99. As with any fuel, pricing is a complex issue. Pricing is the result of what it costs to sustainably manufacture fuel, adjusted for a variety of market factors including global commodity markets. Like diesel, biodiesel prices also fluctuate based on location, time of year, and the political and regulatory climate such as uncertainty over the RFS. As shown in Figure 3, the price of biodiesel and diesel tends to track one another closely.

<sup>38</sup> <http://www.nrel.gov/vehiclesandfuels/pdfs/43672.pdf>

<sup>39</sup> <http://www.biodiesel.org/using-biodiesel/oem-information>

<sup>40</sup> <http://www.biodiesel.org/using-biodiesel/oem-information/oem-statement-summary-chart>

<sup>41</sup> [http://www.afdc.energy.gov/uploads/publication/alternative\\_fuel\\_price\\_report\\_oct\\_2013.pdf](http://www.afdc.energy.gov/uploads/publication/alternative_fuel_price_report_oct_2013.pdf), October 2013, pages 9-10.



**Figure 3.** Average U.S. Diesel and Biodiesel Retail Fuel Prices, 2000-2013.<sup>42</sup> Notes: GGE = Gasoline Gallon Equivalent. Though the price differential between biodiesel and diesel prices is smaller in the Lower Atlantic region than comparisons of national average prices, biodiesel prices in the Lower Atlantic still tend to track the peaks and valleys of diesel prices as seen in this graph.

## North Carolina Biodiesel Case Study

Biodiesel use is widespread throughout North Carolina by individuals, as well as private and public sector fleets. The State of North Carolina is a leading user of biodiesel. In fiscal year 2011-2012, 18 state agencies used over 7.4 million gallons of B20.<sup>43</sup> The NC Department of Transportation is using B20 in its fleet statewide and has more than 100 B20 fueling sites which all state agency vehicles can also utilize.<sup>44</sup> Duke Energy Progress has over 130 light-duty vehicles that use B20 throughout the state.<sup>45</sup> Details regarding biodiesel use by Metropolitan Sewerage District in Asheville NC, including motivation, factors tied to the decision, lessons learned and the overall experience, can be found in "[Biodiesel Case Study](#)" that is part of this toolkit.

Additional NC biodiesel users can be found online at the [Alternative Fuels User Database](#), which has a searchable map allowing website visitors to learn more about some fleets that are already using alternative fuels. Some of the North Carolina fleets in the database that use biodiesel are:

- Counties: [Chatham](#), [Henderson](#), and [Wake](#)
- Cities and Towns: [Asheville](#), [Cary](#), [Concord](#), and [Raleigh](#)
- Municipal services: [Town of Matthews & Gaston County Landfill](#), [Orange Water and Sewer Authority](#), [Buncombe County Metropolitan Sewerage District](#)
- Businesses: [Biltmore Estate](#), [Duke Energy Progress](#)
- Transit: [Chapel Hill](#), [Capital Area](#)
- Universities: [UNC-Chapel Hill](#), [North Carolina State University](#)
- Other: [Raleigh-Durham Airport Authority](#)

<sup>42</sup> Data source: [Clean Cities Alternative Fuel Price Reports](#)

<sup>43</sup> <http://www.government-fleet.com/channel/fuel-management/news/story/2013/02/north-carolina-state-agencies-displace-5-2m-gallons-of-petroleum-fuels-in-fy-2011-2012.aspx?prestitial=1>

<sup>44</sup> <http://www.government-fleet.com/channel/fuel-management/news/story/2013/02/north-carolina-state-agencies-displace-5-2m-gallons-of-petroleum-fuels-in-fy-2011-2012.aspx>

<sup>45</sup> Centralina Clean Fuels Coalition. 2012 Transportation Technology Deployment Report: Centralina Clean Fuels Coalition, January 2013.

## Trends: Looking Ahead

Biodiesel use in the U.S. has seen an upward trend as the industry has matured. Focus remains on making an industry-wide shift from first generation biofuels (made from sugars, starches or vegetable oils, often from food sources like soybeans) to advanced biofuels (made from waste material or non-food sources which reduce lifecycle carbon emissions by at least 50%).<sup>46</sup> EPA has classified biodiesel as the first (and currently only) Advanced Biofuel, making it the only commercial-scale U.S. fuel produced nationwide to meet the “advanced” criteria.<sup>47</sup> In 2013, 1.8 billion gallons of biodiesel was produced in the U.S.<sup>48</sup> Total production was significantly greater than the 2013 RFS requirement and was also nearly enough to fill the Advanced Biofuel requirement. The US Energy Information Agency predicts that through 2040 gasoline consumption will slowly decrease by approximately 25% versus current levels, while diesel consumption will slowly increase by approximately 30% versus current levels. Liquid biofuels are expected to grow, but remain in the 1-2% level of total US energy use.<sup>49</sup> It is expected that the largest markets for biodiesel will remain that of the lower blends, B5 and B20. A potential biodiesel use to maximize potential benefits is in older vehicles (pre-2010) which achieve reductions in particulates and unburned hydrocarbons. Target vehicles should include high fuel use vehicles, such as transit and school buses.



Figure 5: Source: <http://green.autoblog.com/2013/05/12/gm-thanked-by-biodiesel-groups-for-making-the-cruze-diesel-b20/>

New biodiesel feedstock and compounds are being developed. For example, research is underway at Wake Forest University to assess the feasibility of producing biodiesel more cheaply, specifically focusing on vegetable-oil waste, animal-fat waste, recycled cooking grease, and oils from municipal sewage- and water-treatment plants. If successful, these new biodiesel feedstocks could reduce production costs by up to 15 %.<sup>50</sup> In addition, an increasing number of clean diesel vehicles are entering the market. In 2013, GM became the first U.S. manufacturer to approve the use of biodiesel blends of 20% in a light-duty passenger car, the 2014 Cruze 2.0L Turbo Diesel. Other US OEM B20 approved light-duty vehicles include the Chevrolet Silverado pickup, GMC Sierra and Savana vans, and the Ford and Dodge light-duty trucks.<sup>51</sup> The Diesel Technology Forum predicts that sales of diesel vehicles could make up 10% of the market in the U.S. by 2020.<sup>52</sup> Because diesel engines are more fuel efficient than gasoline, and new clean diesel technology offers increased performance and emissions benefits, sales should increase as more vehicles become available, thus increasing opportunities for biodiesel use.

<sup>46</sup> <http://www.biodiesel.org/docs/default-source/ffs-basics/biodiesel--advanced-biofuel---here-and-now-brochure.pdf?sfvrsn=4>

<sup>47</sup> <http://www.biodiesel.org/what-is-biodiesel/biodiesel-basics>

<sup>48</sup> <http://www.biodiesel.org/news/news-display/2014/01/27/biodiesel-industry-sets-new-production-record>

<sup>49</sup> [www.eia.gov/aeo](http://www.eia.gov/aeo)

<sup>50</sup> [http://www.journalnow.com/news/local/article\\_b3646aac-39e4-11e3-9fa7-001a4bcf6878.html](http://www.journalnow.com/news/local/article_b3646aac-39e4-11e3-9fa7-001a4bcf6878.html)

<sup>51</sup> <http://www.afdc.energy.gov/uploads/publication/60448.pdf>

<sup>52</sup> <http://www.nbb.org/supportingpages/praise-gm-chevy-cruze-b20-approved>