Biodiesel Industry Overview & Technical Update

June 2018
Topics for Today:

- Biodiesel Industry Overview
- Benefits of Biodiesel
- Biodiesel ASTM Fuel Specifications & Quality
- Legislative Updates Impacting Biodiesel Demand
- OEM & Fleet Support for Biodiesel
- Biodiesel Resources
In North America, Diesel and Gasoline powertrains are expected to continue dominating the commercial vehicle segment in forecasts through 2025.
Diesel, HEV Diesel and PHEV Diesel Powertrains together are projected to make up nearly 62% of U.S. commercial vehicle registrations by 2025, compared to 35% gasoline and 3% all others.

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<tbody>
<tr>
<td>Gasoline</td>
<td>35.10%</td>
<td>35.19%</td>
<td>35.29%</td>
<td>35.36%</td>
<td>35.41%</td>
<td>35.45%</td>
<td>35.46%</td>
<td>35.46%</td>
<td>35.45%</td>
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<tr>
<td>Diesel</td>
<td>63.61%</td>
<td>63.34%</td>
<td>63.06%</td>
<td>62.78%</td>
<td>62.50%</td>
<td>62.21%</td>
<td>61.93%</td>
<td>61.64%</td>
<td>61.35%</td>
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<tr>
<td>HEV Gasoline</td>
<td>0.06%</td>
<td>0.06%</td>
<td>0.07%</td>
<td>0.08%</td>
<td>0.10%</td>
<td>0.11%</td>
<td>0.13%</td>
<td>0.15%</td>
<td>0.17%</td>
<td>0.19%</td>
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<tr>
<td>HEV Diesel</td>
<td>0.13%</td>
<td>0.15%</td>
<td>0.18%</td>
<td>0.22%</td>
<td>0.27%</td>
<td>0.33%</td>
<td>0.39%</td>
<td>0.46%</td>
<td>0.53%</td>
<td>0.61%</td>
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<tr>
<td>PHEV Gasoline</td>
<td>0.01%</td>
<td>0.01%</td>
<td>0.01%</td>
<td>0.02%</td>
<td>0.03%</td>
<td>0.03%</td>
<td>0.04%</td>
<td>0.06%</td>
<td>0.07%</td>
<td>0.08%</td>
</tr>
<tr>
<td>PHEV Diesel</td>
<td>0.01%</td>
<td>0.01%</td>
<td>0.02%</td>
<td>0.03%</td>
<td>0.05%</td>
<td>0.07%</td>
<td>0.09%</td>
<td>0.12%</td>
<td>0.15%</td>
<td>0.18%</td>
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<td>BEV</td>
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<td>0.09%</td>
<td>0.11%</td>
<td>0.14%</td>
<td>0.16%</td>
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<td>FCV</td>
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<td>0.00%</td>
<td>0.00%</td>
<td>0.00%</td>
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<td>0.00%</td>
<td>0.01%</td>
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<tr>
<td>CNG</td>
<td>0.56%</td>
<td>0.64%</td>
<td>0.73%</td>
<td>0.81%</td>
<td>0.90%</td>
<td>0.98%</td>
<td>1.07%</td>
<td>1.15%</td>
<td>1.23%</td>
<td>1.32%</td>
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<tr>
<td>LNG</td>
<td>0.20%</td>
<td>0.21%</td>
<td>0.22%</td>
<td>0.22%</td>
<td>0.23%</td>
<td>0.23%</td>
<td>0.24%</td>
<td>0.24%</td>
<td>0.25%</td>
<td>0.25%</td>
</tr>
<tr>
<td>PAGV</td>
<td>0.31%</td>
<td>0.34%</td>
<td>0.37%</td>
<td>0.40%</td>
<td>0.44%</td>
<td>0.47%</td>
<td>0.51%</td>
<td>0.56%</td>
<td>0.60%</td>
<td>0.65%</td>
</tr>
</tbody>
</table>

(Sources: Navigant; Fuels Institute)
Q: What if…

• ...there was a way to operate all of those diesel vehicles in a cleaner, more sustainable way without sacrificing the performance that fleets demand?

A: Good News!

• Biodiesel blends can be used in existing and new technology diesel engines without modification, and are readily available nationwide

• Renewable Hydrocarbon Diesel is also available in some markets
What is Biodiesel?

- A clean, domestic, sustainable, renewable fuel for diesel engines made from fats and oils, such as soybean oil and used cooking oil
- A high quality Advanced Biofuel
- Made through a chemical reaction called transesterification, meeting ASTM D6751 standards
- B20 and lower blends – and even B100 in some cases – have been used successfully in existing older diesel engines as well as new models coming off the production line
Biodiesel Defined

• **Biodiesel**, n. -- a fuel comprised of mono-alkyl esters of long chain fatty acids derived from vegetable oils or animal fats, *meeting ASTM D 6751*, designated B100.

• **Biodiesel Blend**, n. -- a blend of biodiesel fuel with petroleum-based diesel fuel designated BXX, where XX is the volume percent of biodiesel.

• This tightly specified definition was instrumental in achieving OEM support
Biodiesel and the RFS: Advanced Biofuel Defined

**Advanced Biofuel** - means renewable fuel, other than ethanol derived from cornstarch, that has lifecycle greenhouse gas emissions that are at least 50 percent less than baseline lifecycle greenhouse gas emissions.
What’s NOT Biodiesel?

• Raw vegetable oil/SVO
• Recycled cooking oil
• Ethanol
• Ethanol, methanol, or water blended with diesel and an emulsifier
• Other “Renewable Fuels”
Biodiesel Reaction

Reacting:

100 Lbs. Vegetable Oil or Animal Fat
+ 10 Lbs. Alcohol

100 Lbs. Vegetable Oil or Animal Fat
+ 10 Lbs. Alcohol

In the Presence of a Catalyst

Sodium Hydroxide or Potassium Hydroxide

Yields:

100 Lbs. Biodiesel
+ 10 Lbs. Glycerine

Transesterification process produces mono-alkyl esters – chemically similar to diesel fuel
2017 Biomass-Based Diesel Feedstocks

- Soybean Oil: 46%
- Distillers Corn Oil: 15%
- Canola Oil: 11%
- Yellow Grease: 15%
- Animal Fats: 13%
Biodiesel Has Expanded and Diversified Production Capacity

- Biodiesel production has expanded beyond the Midwest
- New capacity closer to other markets uses diversified feedstocks

Source: NBB
Biodiesel production increases are not constrained by available biodiesel capacity

Biodiesel Production Capacity

3.6 billion gallons

- Registered facilities producing biodiesel
- Facilities registered, but not currently producing biodiesel
- Production facilities not yet registered

Source: Biodiesel plant list 2-6-13 from Docket EPA-HQ-OAR-2013-0479; numbers are from a combination of NBB, EIA, and EPA databases.
U.S. Biodiesel & Renewable Diesel Market
(millions of gallons)
Source: EPA EMTS*

*Volumes reported under the RFS in the D4, D5, and D6 categories.
Biodiesel Production Goal: 4 Billion Gallons by 2022
Biodiesel Infrastructure

• Biodiesel and biodiesel blends available nationwide at more than 2,000 public locations

• Existing trucks, tanks, dispenser pumps and blending facilities can be used for B20 and lower
Biodiesel Production and Distribution Network Where Fuel Demand Is High

- Biodiesel is produced and widely distributed where vast majority of highway fuel is consumed
- “Thin” distribution only in states with less demand (PADD 4)

Source: USDOT (2010)
Biodiesel Is Widely Available at Bulk Terminals

- Biodiesel is available at terminals in 369 cities, compared to 453 cities with terminals providing petroleum fuels

U.S. Cities with Fuel Terminals Providing Biodiesel

Source: OPIS
Bulk Biodiesel Distributors and Jobbers Span the U.S.

- Distributors/wholesale jobbers are concentrated near demand centers
- Distributors/jobbers supplement availability of biodiesel at 2nd level of fuel distribution network

Source: NBB
Higher Blends Available Nationwide, Often Blended by Major Retailers

- Retailers nationwide sell B10 - B20 blends, esp. on main truck routes
- Large retailers often have store-level blending, by-passing terminals

U.S. Retailers Selling Biodiesel Blends of B10 to B20

Source: NBB; Company websites
Improved Pipeline Access for Biodiesel Blends

• Recent ASTM spec changes will allow increased distribution of biodiesel through multi-product pipelines

• Lower transportation costs/increased breadth of distribution

Major U.S. Petroleum Product Pipelines

Source: EIA
Top Reasons Why Smart Customers Are Using Biodiesel
Biodiesel Does Good Things:

- Provides high quality fuel from domestic, sustainable resources
- Reduces imports and power of oil cartels
- Supports 64,000 U.S. Jobs
- Generates $11.42 Billion total Economic Impact
- Reduces Particulates, Carbon Monoxide, and Unburned Hydrocarbons from Older Engines
- Reduces Green House Gas Emissions
- Best Carbon Footprint of any U.S. Produced Fuel
Emissions Reductions in Diesel Engines Without Aftertreatment:

<table>
<thead>
<tr>
<th>Emissions Reduced</th>
<th>B100</th>
<th>B20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Unburned Hydrocarbons</td>
<td>-67%</td>
<td>-20%</td>
</tr>
<tr>
<td>Carbon Monoxide</td>
<td>-48%</td>
<td>-12%</td>
</tr>
<tr>
<td>Particulate Matter</td>
<td>-47%</td>
<td>-12%</td>
</tr>
<tr>
<td>Polycyclic Aromatic Hydrocarbons</td>
<td>-80%</td>
<td>-13%</td>
</tr>
<tr>
<td>Ozone Potential</td>
<td>-50%</td>
<td>-10%</td>
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A Comprehensive Analysis of Biodiesel Impacts on Exhaust Emissions
BIODIESEL’S ON ROAD HEAVY DUTY EMISSION BENEFITS
Criteria Pollutants


<table>
<thead>
<tr>
<th>Year</th>
<th>HC</th>
<th>CO</th>
<th>PM</th>
<th>NOx</th>
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<tbody>
<tr>
<td>1998</td>
<td>1.2</td>
<td>15.5</td>
<td>0.10</td>
<td>4.0</td>
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<tr>
<td>2010</td>
<td>0.19</td>
<td>15.5</td>
<td>0.01</td>
<td>0.2</td>
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<tr>
<td>2015</td>
<td>0.14</td>
<td>15.5</td>
<td>0.01</td>
<td>0.02</td>
</tr>
</tbody>
</table>

-100% -75% -50% -25% 0%
ULSD vs B20 in SCR Systems

- No statistical difference in NOx Conversion with B20 across the entire engine map
Biodiesel is Liquid Solar Energy
Green House Gas Benefits: Biodiesel Reduces Carbon Footprint

- U.S. biodiesel on average provides an **80% Reduction in Carbon Emissions** compared to petroleum diesel
  - Full life cycle from soil to tailpipe
  - Includes latest indirect land use impacts for biodiesel used in the United States
Carbon Intensity of Fuels
grams CO2e/MJ

Based on CARB data, https://www.arb.ca.gov/fuels/lcfs/lcfs_meetings/040115_pathway_ci_comparison.pdf
• Transportation is a carbon intensive sector
• Fuel Refining captured in Industry sector
Transform the Entire Fleet

From this...
Transform the Entire Fleet

To this...
GHG Reduction Potential of EPA’s Heavy Duty Truck Rule
Plus Biodiesel - Million Tons CO2e cumulative
Biodiesel Works

In this...

Or this...

Or this...
Biodiesel Makes a Difference

3.0 Billion Gallons of Biodiesel Used in the U.S.:

• Would Reduce Carbon Emissions by more than 25 Million Metric Tons

Which is Equivalent to:

• Removing 5.4 Million Cars from America’s Roadways
• Planting 648 Million Trees
• Preserving 29.4 Million Acres of Mature Forests
Sustainability

• Biodiesel is produced from a variety of renewable resources, such as plant oils, animal fats, recycled grease, and even algae, making it one of the most sustainable fuels on the planet.

• With biodiesel, **food isn’t sacrificed for fuel.** Oils and fats for biodiesel are a minor by-product of producing food for humans and animals.
  – Soybeans are 80% protein, 20% oil
  – No one grows livestock for its fat content
  – No one cooks more fried food to get used oil for biodiesel
THE ORIGINAL MISSION

• Soybeans are grown for protein meal.
• Soybeans are 80% protein meal and 20% oil.
• Beans are crushed to separate oil and meal.
• Protein meal is consumed by humans and animals.
• There is an excess of soybean oil.
• Biodiesel uses the excess oil.
By creating a market and value for excess soybean oil, Biodiesel decreases soy protein meal prices by $20-40 per ton.
Sustainability: Food AND Fuel

A gallon of biodiesel cannot be produced without co-producing 30 lbs. of protein and 22 lbs. of carbs and dietary fiber.
When we grow protein to feed the world, we get more fat than we can eat. Those by-products can be used to make high quality biodiesel.
Biodiesel Improves Diesel Properties

- Blends with petrodiesel in any percentage
  - Once it is blended it does not separate back out
- Higher Cetane
  - Over 50 vs. average petrodiesel around 44
  - Smoother, more complete burn
- Higher Lubricity
  - 2% biodiesel ‘fixes’ even bad diesel
- Virtually Zero Sulfur
  - Meets ULSD limits of 15 ppm or less
- Zero Aromatics Reduces Toxicity and Burns Cleaner
- 11% Oxygen Provides Superior Lubricity and Reduces Black Smoke (Particulates)
- High Flash Point Makes it Safer
  - Non hazardous shipping (over 200 F)
- The particulates created by biodiesel burn off faster and at a lower temperature in a particulate trap
  - Less PM trap regenerations and lower long-term maintenance costs
ASTM Specifications and Biodiesel Fuel Quality
Biodiesel Standards:

**ASTM D6751** is the approved standard for B100 for blending up to B20, in effect since 2001
- Performance-based standard: feedstock and process neutral

**D975** – Covers petrodiesel and blends up to five percent biodiesel maximum for on/off road engines; in effect since 2008

**D7467** – Covers blends containing six to twenty percent biodiesel (B6-B20) for on/off road engines, in effect since 2008
- Designed so that if B100 meets D6751 and petrodiesel meets D975, then B6 to B20 blends will meet their specifications
- Important quality control is at B100 level
Enforcing Biodiesel Fuel Quality Standards

• 49 States have adopted ASTM D6751 as part of state law and can now legally enforce the ASTM D6751 Biodiesel Standard
  – No efforts are planned for Alaska

• NBB works actively with State Departments of Weights & Measures and other regulating entities (EPA, IRS) to help monitor and enforce biodiesel fuel quality
What is BQ-9000?

- Biodiesel Industry’s equivalent to an ISO 9000 program for biodiesel production & distribution companies as well as testing labs
- NBB implemented BQ-9000 as a means to help instill confidence in biodiesel with users and equipment companies
- There are now four BQ-9000 designations:
  - Producer (make it to spec)
  - Marketer (buy spec, keep it in spec, blend it right)
  - Certified Laboratories (test the fuel accurately)
  - Retailer (fuel quality management practices)

- Over 90% of U.S. production is by a BQ-9000 Producer
- Many OEMs are now either requiring or strongly encouraging BQ-9000
- Organizations have seen economic advantages as more bids are requiring the certification
Legislative Updates Impacting Biodiesel Demand and OEM Support
Biodiesel Policy Update

• Biodiesel qualifies as Advanced Low Carbon RFS fuel
• EPA Released Renewable Fuel Standard Volume requirements for both biodiesel eligible categories:

<table>
<thead>
<tr>
<th>Year</th>
<th>Biomass Based Diesel (actual gallons)</th>
<th>Advanced, Non-Diff. (ethanol equivalent gal.)</th>
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<tbody>
<tr>
<td>2014 (actual)</td>
<td>1.63 Billion gallons</td>
<td>2.68 Billion</td>
</tr>
<tr>
<td>2015 required</td>
<td>1.73 Billion gallons</td>
<td>2.88 Billion</td>
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<tr>
<td>2016 required</td>
<td>1.9 Billion gallons</td>
<td>3.61 Billion</td>
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<tr>
<td>2017 required</td>
<td>2.0 Billion gallons</td>
<td>4.28 Billion</td>
</tr>
<tr>
<td>2018 required</td>
<td>2.1 Billion gallons</td>
<td>4.24 Billion</td>
</tr>
<tr>
<td>2019 required</td>
<td>2.1 Billion gallons</td>
<td>Not yet published</td>
</tr>
</tbody>
</table>
Federal Legislation

Other federal legislative incentives that are important to OEMs and fleets:

- **Biodiesel Tax Incentive**
  - $1.00 per gallon blenders tax credit
  - Biodiesel Blenders Tax Credit ($1/gal) reinstated for 2015-2016, expired 12/31/16
  - Retroactive extension of blenders tax credit for 2017 was passed on 2/9/18, but did not include extension through 2018
  - Industry seeking reinstatement and multi-year extension of Biodiesel Blenders Tax Credit

- **EPACT Credits** *(Energy Policy Act)*
  - Incentive for fleets for B20+ use; most economical option for EPACT compliance
State Policies on Biodiesel
Minnesota

- B20 required statewide beginning May 1, 2018

*Note: B5 required Oct 1st through March 30th*
Consumption Incentives
Low Carbon Policies

5 billion total gallons

LCFS in Place
LCFS Potential
California LCFS - Projected Volumes

1.2 billion gallons of BMBD by 2023.

1.6 billion gallons of BMBD by 2030.

B20/R10

B20/R20

Biodiesel

Renewable Diesel
California and Biodiesel

- California Low Carbon Fuel Standard (LCFS)
  - 700MM gal/yr potential short-term market for biodiesel that provides great carbon reduction
- EPA 49 state petrodiesel can’t be used in CA
  - Has to be emissions equivalent to 48 cetane, 10% aromatic
  - “CARB Diesel”: Significant cost increase vs. EPA diesel
- B5/B10 tested with CARB diesel: NOx neutral; PM, HC, CO down
- After 2018, to sell over B5/B10, blend needs to be mitigated for small NOx increase seen in some CARB testing (~1-5%)
- B20 is NOx neutral compared to 49 state EPA diesel
- VESTA™1000 was certified by CARB to provide a small NOx reduction w/B20 (1.9% reduction) vs. CARB 48/10 petrodiesel as part of CARB’s LCFS Alternative Diesel Fuel Regulation.
- There is interest in using blends over B20 due to the added carbon reduction those blends can provide
Key Takeaways on State Policy:

• Biodiesel has strong policy support at the state and local levels
  – 1 billion+ gallon market
• State policies have induced blends in many states into the B11-B20 range
• State policies are beginning to induce blends above B20
OEM & Fleet Support for Biodiesel
OEM & Fleet support for biodiesel continues to grow due to:

- Growing volumes & availability
- Favorable policies – RFS, EPACT, Tax Credits, etc.
- GHG emissions benefits
- Vehicle performance benefits
- ASTM specifications
- BQ-9000 biodiesel quality
- Consumers and fleets want the option
- “Green” competitive advantage - easy way to green your fleet!
OEM Biodiesel Support

• In the GVW Class 5-8 vehicles that account for 92% of on-road diesel fuel, the vast majority of new diesel engines now have full OEM support for B20 and lower blends meeting ASTM standards

• For a complete listing of OEM position statements on biodiesel, visit: www.biodiesel.org/using-biodiesel/oem-information

OEMs Supporting B20
OEMs Supporting B20

*Models equipped with Cummins engines are B20 approved. See NBB website for details.
Ford: B20 Approved

Ford approves B20 in all its 2011 MY and beyond

Class 2 - 5 Super Duty &
Class 6,7 Medium Duty Trucks

And in the Ford Transit and new Transit Connect Vans

As well as the new 2018 Ford F-150 3.0L Diesel
General Motors has 20 different diesel vehicle model options available in the U.S. market in 2018 – all of which are approved for use with B20.
Fiat Chrysler: B20 Approved

- Fiat Chrysler supports the use of **B20** in the 6.7L Turbo Diesel Ram 2500/3500/4500 5500 HD pickups and in the 3.0L Ram 1500 light duty diesel pickup
- **Ram ProMaster** with 3.0L EcoDiesel I-4 Engine **Approved for B20**
- **Jeep Grand Cherokee** Approved for B20
PACCAR: B20 Approved

- **Full B20 approval** in new and legacy model PACCAR MX-11 and MX-13 engines for Heavy Duty trucks, as well as in PX-7 and PX-9 Engines for Medium Duty trucks.

- Now the entire diesel fleet of Peterbilt and Kenworth Medium and Heavy Duty trucks are approved for use with B20 Biodiesel Blends.
2018 NTEA Fleet Purchasing Outlook

According to the National Truck & Equipment Association’s 2018 NTEA Fleet Purchasing Outlook Survey:

• 75% of respondents anticipate maintaining or increasing use of diesel engine powered trucks, indicating that diesel is still the powertrain of choice among the majority of work truck fleets.

• Focus on electrification has waned in 2018, with 14% of survey participants currently using this technology as compared to 19% in 2017. Enthusiasm for this technique has returned to 2013 levels -the lowest point in recent years.

• More than 40% of fleet respondents said they are investing in alternative fuels and truck productivity technologies -a slight increase from 2017 levels. Of those currently operating alternative fueled trucks, 82% indicate that lower fuel prices will not influence their adoption of alternative fuels in 2018. In other words, their decision to make the switch is based more on the benefits of the fuels vs. price.
2018 NTEA Fleet Purchasing Outlook

• Nearly 40% of respondents indicated they currently operate alternative-fueled trucks in their fleets, up 4% from 2017 and interest is at the highest recorded level since 2014. Downward pressure on US oil prices is expected to intensify in coming months. While interest in alternative fuels may wax and wane a bit, it will likely rise steadily across time. Given the inherent volatility of oil prices, most fleets are well aware of the need to keep exploring clean energy solutions.

• **Biodiesel is the most popular alternative fuel vehicle option for 2018 at 18%**, followed by E85, CNG and Electric Hybrid. Also, this year NTEA added an option for Renewable Diesel in order to gauge directional movement in coming years. RD came in at about 4% of current alternative fuels use.

• **Looking ahead, survey respondents also indicated the most interest in biodiesel for future alternative fuels interest**, followed by E85, Electric Hybrid and CNG. Notably, energy surrounding CNG has declined year-to-year since 2014. And while Electric and Electric Hybrid powertrains are showing some growth in terms of future interest, diesel powertrains and biodiesel still outpace them significantly in the truck fleet market.

For more information on the 2018 NTEA Fleet Purchasing Outlook Survey, visit [www.ntea.com/fpo](http://www.ntea.com/fpo)
2018 NTEA Fleet Purchasing Outlook

At present, biodiesel is the most widely used alternative fuel among fleet respondents.
2018 NTEA Fleet Purchasing Outlook

Looking ahead, survey participants indicated the most interest in Biodiesel for future fleet use as well.
A Sampling of Biodiesel Fleet Users
2018: A Banner Year for Biodiesel (And for OEMs and Fleets)

- **Building on Success:** The Biodiesel industry continued on a strong path in 2017, with over 2.6 Billion gallons of biomass based diesel in U.S. despite a lapsed tax incentive.

- RFS Volumes for 2018 are in place.


- OEM & Fleet support continues to grow.

- This will provide economic opportunities for marketers, blenders and users of biodiesel, as well as for diesel vehicle/equipment OEMs and dealers.
Biodiesel Resources

- **www.biodiesel.org**
  - Biodiesel Training Toolkit
  - OEM Support Positions on Biodiesel
  - News Releases & Information Resources
  - Technical Library, Spec Sheets & Videos

- **www.americasadvancedbiofuel.com**
  - NBB’s national advertising campaign

- **www.nbb.org**
  - Official site of National Biodiesel Board

- **www.BQ-9000.org**
  - Listing of BQ-9000 Certified Companies

- **Biodiesel Now Mobile App**
  - Helps locate biodiesel retailers near you
Thank You!

Questions...?

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