XBX EXPLORING BIODIESEL regional seminars

SEVEN CITIES. ONE VISION.

boston | philadelphia | los angeles | portland | cleveland | newport | syracuse
PADD 1A, New England
Distillate Consumption

Sales of Distillate Fuel Oil by End Use

- Diesel On Road, 1,119 BGY
- Residential HO, 1,3 BGY
- Commercial, 264K
- Industrial, 22,241K

Source: U.S. Energy Information Administration

PADD 1A - Diesel On Road, 1,119 BGY, Residential HO, 1,3 BGY, Commercial, 264K, Industrial, 22,241K
Central Atlantic, PADD 1B, Distillate Consumption

Total, 7.0 BGY, Residential, 1.447 BGY, Commercial, 589 MGY, Industrial, 135 MGH, On-Road Diesel, 4.416 BGY
U.S. East Coast, PADD 1 and Gulf Coast, PADD 3
New England

Product Supply – (PADD 1A)
- Bulk Terminal
- Product Pipeline
- Product Flows
- Marine Movements
- Urban Areas

Source: U.S. Energy Information Administration.
Preparing For Emerging Demand

- PADD 1A, Residential Heating Oil Consumption, 1.6 BGY (5% - 20% blends/81 MGY/320 MGYY

- PADD 1B, Residential Heating Oil Consumption, 1.9 BGY (5% - 20% blends, 90 MGY/360 MGYY

- PADD 1A & 1B, RHO, Consumption 3.4 BGY (5% - 20% blends, 171 MGY/680 MGYY
Biodiesel Fundamentals
Biodiesel Fundamentals

- Why Biodiesel?
- Monetizing the Benefits...
- Solid Technical Standing
What is Biodiesel?

- **Methanol** → Fatty Acid Chain
- **Oil/Fat:** Triglyceride
- **Biodiesel**
- **Catalyst**
- **Glycerol**
- Why Biodiesel?
- Monetizing the Benefits...
- Solid Technical Standing
Biodiesel Improves Distillate Properties

• High Cetane
• High Lubricity
• Ultra Low Sulfur
• Zero Aromatics
• High flash point
• Biodegradable/Non-Toxic
• Reduces PM Emissions
• Reduces Toxic Emissions
# Biodiesel Reduces Emissions from Legacy Diesel Engines

<table>
<thead>
<tr>
<th>Emission Type</th>
<th>B20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Unburned Hydrocarbons</td>
<td>-20%</td>
</tr>
<tr>
<td>Carbon Monoxide</td>
<td>-12%</td>
</tr>
<tr>
<td>Particulate Matter</td>
<td>-12%</td>
</tr>
<tr>
<td>Oxides of Nitrogen (NO$_x$)</td>
<td>+/-2%</td>
</tr>
</tbody>
</table>

Running biodiesel in legacy diesel engines that do not have exhaust after-treatment. Run on “49 state” EPA diesel.
Biodiesel Is Cleaner and Reduces Global Warming

- Closed Carbon Cycle: CO$_2$ Used to Grow Feedstock is Put Back Into the Atmosphere

→ 80% Life Cycle Decrease in CO$_2$

- Compression Ignition Platform (i.e. diesel) is 30% More Efficient Than Spark Ignition (i.e. gasoline, CNG, propane)

- LOWER Carbon Than Electricity from Coal or Natural Gas!
Biodiesel is Liquid Solar Energy
Sustainability

• 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 grown for 80% protein
  - No one grows livestock for its fat
  - No one cooks more fried food to get used oil for biodiesel
By creating a market and value for excess soybean oil, Biodiesel decreases US 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 oils and fats than we can eat.
Biodiesel Provides Energy Security

- Reduces our dependence on foreign oil
- Expands and diversifies our domestic refinery capacity
- Most economical option for turning oils and fats into usable fuel diesel applications
Boosts the Domestic Economy

• Supports over 62,000 U.S. Jobs
• Creates outlets for farm products
• Creates U.S. manufacturing jobs
• Generates over $2.5 Billion in Wages
• Generates over $15 Billion Total Economic Activity
Biodiesel Fundamentals

- Why Biodiesel?
- Monetizing the Benefits...
- Solid Technical Standing
Monetizing the Benefit$
Federal Policies

• Renewable Fuel Standard
• Biodiesel Tax Credit

State Policies

• Requirements
• Incentives
• Low Carbon Standards
The RFS, Renewable Fuel Standard

- Bipartisan policy passed in 2005
- Requires increasing volumes of renewable fuels to be blended into the U.S. fuel stream
- Two broad categories:
  - Conventional biofuels—GHG reductions of at least 20%
  - Advanced biofuels—GHG reductions of at least 50%

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Cellulosic Biofuel</td>
<td>123M</td>
<td>230M</td>
<td>311M</td>
<td>288M</td>
<td>381M</td>
<td>2.43B</td>
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<tr>
<td>Biomass-Based Diesel</td>
<td>1.73B</td>
<td>1.9B</td>
<td>2.0B</td>
<td>2.1B</td>
<td>2.1B</td>
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<tr>
<td>Advanced Biofuel</td>
<td>2.88B</td>
<td>3.61B</td>
<td>4.28B</td>
<td>4.29B</td>
<td>4.88</td>
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<tr>
<td>Conventional Ethanol</td>
<td>14.05B</td>
<td>14.5B</td>
<td>15.0B</td>
<td>15.0B</td>
<td>N/A</td>
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<tr>
<td>Total Renewable Fuel</td>
<td>16.93B</td>
<td>18.11B</td>
<td>19.28B</td>
<td>19.29B</td>
<td>N/A</td>
<td></td>
</tr>
</tbody>
</table>
Tax Credit Catalyst For Growth

• Biodiesel provides many benefits to the public—economic and job creation, environmental, energy security and U.S. competitiveness

• $1.00 per gallon federal blenders tax credit

• Tax credit helped grow the market from 100 million gallons in 2005 to nearly 3 billion gallons in 2016

• Prospects looks good for reinstallation in Fall of 2018
Statewide Requirements

Currently Implemented: CT: B20, MA: B5 (V), RI: B5, VT: B3

Consumption Incentives
Low Carbon Policies

Emerging Renewable Portfolio Standards In NE

4.5 billion total gallons
- Electric utilities purchase Renewable Energy Credits (RECs)
- Eligible sources include solar PV, wind, hydro, solid biomass, and BIODIESEL-fired power systems
U.S. Biomass Based Diesel Market

(millions of gallons)

Source: EPA EMTS*

U.S. Production Capacity, over 3.6 BGY

*Volumes reported under the RFS in the D4, DS, and D6 categories.
Biodiesel’s Future: **4 Billion Gallons/Year by 2022**
Biodiesel Fundamentals

- Why Biodiesel?
- Monetizing the Benefits...
- Solid Technical Standing
NBB Technical Program Overview

• ASTM Standards
• Biodiesel Technical Workshop and Priorities
• BQ-9000 Program Support and Activities
• Diesel Engine And Vehicle Testing
• Bioheat® Testing and Cooperative Efforts with NORA Laboratory
• Pipeline Technical Steering Committee
• Technical Efforts for New Market Development
ASTM Standards for Biodiesel

1) ASTM D6751, pure B100 prior to blending (2001)

2) ASTM D975 on/off-road diesel (2008)
   - Up to B5: No. 1 and No. 2 grades

3) ASTM D7467 on/off road diesel (2008)
   - B6-B20 grade

4) ASTM D396 heating oil
   - Up to B5: No. 1 and No. 2 grades (2008)
   - B6-B20 grade (2015)
Continuous Updates to D6751

- Originally published in 2002: ASTM D6751-02
- -03: Added 15 ppm sulfur grade
- -03a: Modified ‘middle distillate’ term, lubricity note
- -06: Reduced AV from 0.8 to 0.5; added limit on Na+K.
- -06a: Added limit on Ca+Mg
- -06b: Addition of oxidation stability
- -07: Modified language and added test methods
- -07a: Added alcohol control and modified flashpoint
- -07b: Added DCN and sulfur test methods
- -08: Addition of cold soak filterability
- Introduction of B5 into D975 and publication of D7467 (B6 to B20 Standard)
- -09: Added cloud point test methods
- -09a: Added cloud point test methods
- -10: Added EN15751 as referee method for stability
- -11: Added test methods and appendix on low temperature operability
- -11a: Replaced cold soak filterability annex with D7501
- -11b: Added new test methods
- -12: Addition of 1B Grade, updated scope, new test methods

Continuous evolution to address OEM and end-user concerns
Significant Changes With Diesel Fuel and Diesel Engines

- Ultra Low Sulfur Diesel
- High Pressure Common Rail Fuel Systems
- Engine Exhaust After-Treatment Systems:
  - Diesel Oxidation Catalysts
  - Particulate Matter Traps
  - SCR systems for NOx
Conventional Architectures for HD and LD Diesel

DOC = Diesel oxidation catalyst
DPF = Diesel particulate filter
SCR = Selective Catalytic Reduction
B20 and New Diesel After-Treatment Systems

• Biodiesel performs well with Diesel Particulate Filters and NOx SCR systems, and has some distinct advantages:
  • Less engine out particulate matter
  • Particulate burns off faster and at lower temperatures
  • May provide better performance and less maintenance vs. ULSD

• Ford Study: PM Trap Regenerations 50% longer with B20!

• New NOx after-treatment systems provide over 95% reduction in NOx with B20 and with petrodiesel
Engine and Vehicle 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

*Models equipped with Cummins engines are B20 approved. See NBB website for details.*
New in 2016:

• **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
B20 and lower blends have been successfully used in almost every engine in every application.

Key: Meeting ASTM specs!

Use of biodiesel, in and of itself, does not void an OEM parts and workmanship warranty

- Even with B100—or a blend higher than that recommended by the manufacturer
- However, any problems caused by the fuel are not engine defects and therefore would not be covered by the manufacturer
D4625 Simulated Shelf Life

Weeks at 43°C

Induction Period, Hours

1 week @ 43°C = 1 month normal storage

Weeks at 43°C
New Storage Data With B20

• With B20 Meeting ASTM Specifications in the U.S. Market today:
  • Minimum simulated shelf life of 1 year
  • Many samples over 3 years
  • Simple monitoring and re-addititzation can extend shelf life to over 4 years
Gasoline Marketing Trends
Advanced Performance & Marketing Strategies
Market Drivers

Legislation
- Exhaust Emissions
- Fuel Economy
- Sulfur Reduction
- GHG
- RFS

Engine Technology
- GDI / Turbo
- HPCR
- Lighter & Smaller
- Global Alliances

Consumer Expectations
- Performance, Durability and Reliability
- Efficiency
- Technology and Safety
- Connectivity

Regulatory Compliance
Direct Injection Gasoline Opportunities

Benefits
- More Power
- Significant Efficiency Improvements
- Greenhouse Gas Reductions

Challenges
- Injector Coking

TOP TIER
Detergent Gasoline
Global GDI Growth

- How rapidly is GDI growing?
  - Globally went from 1% to 44% of new gasoline engines in last 17 years
  - Will go to 62% in the next 5 years

Source: IHS 2014
Next Generation Gasoline Marketing

more miles per tank
TOP TIER® Overview

• Voluntary standard sponsored by equipment manufacturers

• Addresses, combustion chamber deposits and valve sticking performance

• (~2½ times) more deposit control additive required vs LAC

• Participation requires all grades, all marketing areas
Diesel Fuel 21\textsuperscript{st} Century
What’s Changed

BIG RIGS

BIG MONEY

BIG PRESSURE
**Diesel Fuel & The Future**

- Diesel technology remains a key strategy in the lineup of technologies for the future:
  - Consumers finding value in the diesel.
  - 90% of the nations freight moves on diesel.
  - Manufacturers turn to diesel options to meet economy mandates of 54.5 MPG by 2025.
- Renewable fuels are a key differentiator for diesel to compete in a low-carbon, alternative fuel future.
Ultra Low Sulfur Diesel
Removing Sulfur Chemically Changed the Fuel

- Poor lubricity
- Reduced oxidative stability
- Lower conductivity
- Changes cold flow behavior
- Less solvency – watch for injector deposits
- Lower density – lower Btu energy content per gallon
Filtration Challenges

Filter Media
- Cellulose
- Polyester

Secondary Fuel Filter
- New: 2-5 µm
- Historical: 2-15 µm

Primary Fuel Filters
- New: 7-25 µm
- Historical: 10-50 µm

How Big is a Micron?

<table>
<thead>
<tr>
<th>Micron Sizes of Familiar Particles</th>
<th>100 µm</th>
<th>80 µm</th>
<th>40 µm</th>
<th>25 µm</th>
<th>10 µm</th>
<th>8 µm</th>
<th>2 µm</th>
<th>&lt;5 µm</th>
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<tbody>
<tr>
<td>Grain of table salt</td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Human hair</td>
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<td></td>
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<td></td>
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<td></td>
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<tr>
<td>Lower limit of visibility</td>
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<td>White blood cell</td>
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<td>Talcum powder</td>
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<tr>
<td>Bacteria</td>
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<td></td>
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<tr>
<td>Silt</td>
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</table>
Extreme Temperature & Pressures
600F / 38,000 PSI

Injector Tip, Plunger Barrel and Injector Labyrinth, The “Impact Zone”

- Filter Blocking
- Power Loss
- Economy Deficits

- Shortened PMI
- Reduced Performance
- Increased Fuel Costs
Mileage Depreciation

Particles are masses of smaller, hydrogen rich carbonaceous particles
Variation In Contamination of a Filter
Microbial, Corrosion, Monoglycerides, Water, Paraffin and Thermal Instability
ULSD, Lesson’s Learned

• The industry anticipated sulfur reduction to negatively impact lubricity, BTU’s, material compatibility, and microbial growth, an increase in corrosive activity and peroxide formation was not.

• In 2010, a task force of industry leaders came together and formed the Clean Diesel Fuel Alliance, (CDFA) funding an independent study to determine the cause of accelerated corrosion in USTs containing ULSD.

• Conclusions from the study point to Microbial generated Acetic Acid, possibly exacerbated by the introduction of ethanol into ULSD tanks due to switch loading. 

  Battelle Study
Water and Microbial Growth

• Water is fuels #1 contaminant

• Activated by time & temperature in all fuels

• Microbes discharge acetic acid which drives corrosion.

• Hydrocarbons in Petro diesel or biodiesel provide the food and the water provides the oxygen.
Preparing To Store, Blend & Distribute

• Conduct a market analysis, assess mandates and incentives as possible drivers
• Product demand or terminal throughput dictates the size of the tank, piping, and pump that will be required to handle biodiesel
• Demand will ultimately be determined by price, supply and product positioning
• Ensure that you purchase fuel that meets ASTM specifications
Storage, Piping, Pumps, Blending Preparation
Biodiesel Cold Weather Baselines

Know Your Biodiesel Feedstock and Distillate Cloud & Pour Point....
Manage Operability Proactively
Preparing Diesel & Blends For Winter
Understanding Diesel Fuel Operability

Cloud Point

CFPP

Pour Point

Wax behavior WITHOUT cold flow improver

Large flat crystals block filter, no flow

Wax behavior WITH cold flow improver

Emulsified crystals flow through filter
Preparing for Winter Variables

• Monitoring future temperatures cycles and weekend downtime.

• Focus on storage tank housekeeping
  • Saddle tanks (drain water/maintain fuel separators)
  • Bulk storage (monthly fuel analysis or seasonal)

• Know what you’re buying (noted operability values)
  • FAME, (biodiesel content, fatty acid methyl esters)
  • Moisture (entrained/bottom water)
  • Paraffin content, (directly related to crude slate and refinery processing)

• Ensure fuel is properly winterized for conditions that your customer will operate in, consider fleets that travel outside your market footprint,
### Kerosene Blending Requires Oversight

<table>
<thead>
<tr>
<th>Test Protocol</th>
<th>Treatment</th>
<th>Result</th>
<th>Result, °C</th>
<th>Result, °F</th>
<th>Targets</th>
<th>Cost/Test</th>
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<tbody>
<tr>
<td>Cloud Point, °C (ASTM D7689)</td>
<td>As Received</td>
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<td>9.9</td>
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<td>CFPP, °C (ASTM D6371)</td>
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<td>3</td>
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<tr>
<td>CFPP, °C (ASTM D6371)</td>
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<td>30% #1 ULSD</td>
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<td>30% #1 ULSD</td>
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<td>CFPP, °C (ASTM D6371)</td>
<td>60% #2 ULSD</td>
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<td>40% #1 ULSD</td>
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<td>CFPP, °C (ASTM D6371)</td>
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<td>20% #1 ULSD</td>
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<td>CFPP, °C (ASTM D6371)</td>
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<td>CFPP, °C (ASTM D6371)</td>
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<td>-42</td>
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<tr>
<td>Pour Point, °C (ASTM D7346)</td>
<td>As Received</td>
<td></td>
<td></td>
<td>-11</td>
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</tr>
</tbody>
</table>
Extra Protection During Equipment Shutdown

Untreated

Top 80%
- CP: 11.7°F
- CFPP: -13.0°F

Wax fall-out line

Bottom 20%
- CP: 27.5°F
- CFPP: 6.8°F

- Keep your water fuel separators, tanks and dispensers protected.
- Consider using particulate filters only in extreme climatic conditions, and open up the filter aperture.
Wax Anti-Settling Technologies At Work

Over Night

28 Hours

Day 3

Day 7
Heating Oil Market Renaissance
Heating Oil, What We Know...

- It’s understood
- You buy it, you sell it
- It’s carbon intensive
- Policymakers loathe it
- Lacked marketability
ULSHO + Biodiesel = A Future

**Biodiesel®**
- Renewable
- Biodegradable
- High cetane
- Increased lubricity
- Safer flash point
- No nitrogen or aromatics
- Virtually sulfur free
- Contains 11% oxygen by weight

**ULSHO Bioheat®**
- Enhances fireside performance
- Helps reduce brush & vacuum intervals
- Ready for distribution now
- Compliments ULSHO
- Creates a positive consumer impression about Oilheat
- Marketable
Biodiesel blends at 20% (B-20) with ULSHO are lower in Greenhouse Gas emissions than natural gas when evaluated over 100 years, while blends of 2% (B-2) or more are lower in GHG than natural gas when evaluated over twenty years.
Thank You! Q&A

Steve Howell, President, MARC IV Consulting

Paul Nazzaro, President, Nazzaro Group, LLC