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GOVERNMENT FLEET
EXPO & CONFERENCE
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The New Alternative Fuel of Choice

Renewable Diesel

Richard Battersby | The City of Oakland – Oakland, California
Gary Lentsch CAFM | Eugene Water & Electric Board - Eugene, Oregon
What is Renewable Diesel?

Petroleum Fuels
Produced by a Fractional Distillation Process

Bio-Diesel
Utilizes a transesterification process
Renewable Diesel – is refined by a hydrotreating process

Producing RD involves hydrogenating triglycerides to remove metals and compounds with oxygen and nitrogen using existing refinery infrastructure.

It’s Made by Using Organic Materials

- Waste Animal Fat
- Wasted Fish products
- Vegetable Oil Residues
- Used Cooking Oil
- Technical Corn Oil
- Tall Oil Pitch
- Crude Palm Oil
- Camelina Oil
- Jatropha Oil
- Rapeseed Oil
- Soybean Oil
## Typical Properties of Diesel Fuels

<table>
<thead>
<tr>
<th></th>
<th>Petroleum Diesel</th>
<th>Bio-Diesel</th>
<th>Renewable Diesel</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cetane #</strong></td>
<td>40-55</td>
<td>50-65</td>
<td>75-90</td>
</tr>
<tr>
<td><strong>Energy Density, MJ/kg</strong></td>
<td>43</td>
<td>38</td>
<td>44</td>
</tr>
<tr>
<td><strong>Energy Content, BTU/gal</strong></td>
<td>129K</td>
<td>118K</td>
<td>123K</td>
</tr>
<tr>
<td><strong>Sulfur</strong></td>
<td>&lt; 10 ppm</td>
<td>&lt; 5 ppm</td>
<td>&lt; 10 ppm</td>
</tr>
<tr>
<td><strong>NOx Emissions</strong></td>
<td>Baseline</td>
<td>10</td>
<td>-10</td>
</tr>
<tr>
<td><strong>Cloud Point, C</strong></td>
<td>-5</td>
<td>20</td>
<td>-15</td>
</tr>
<tr>
<td><strong>Oxidative Stability</strong></td>
<td>Baseline</td>
<td>Poor</td>
<td>Excellent</td>
</tr>
<tr>
<td><strong>Cold Flow Properties</strong></td>
<td>Baseline</td>
<td>Poor</td>
<td>Excellent</td>
</tr>
<tr>
<td><strong>Lubricity</strong></td>
<td>Baseline</td>
<td>Excellent</td>
<td>Similar</td>
</tr>
</tbody>
</table>

As you can see from the table above, Renewable Diesel possesses properties that are similar to Petroleum Diesel and thus can be used in any quantity.
Life-Cycle Carbon Intensity Comparison

Below are Oregon Default Values - Specific Pathways and Locations can Change Values Significantly

<table>
<thead>
<tr>
<th>Feedstock</th>
<th>lbsCO2e in Diesel Gallon Equivalents</th>
<th>Bio-Diesel</th>
<th>Renewable Diesel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Used Cooking Oil</td>
<td>5.17 lbsCO2e/dge</td>
<td>5.50 lbsCO2e/dge</td>
<td></td>
</tr>
<tr>
<td>Tallow</td>
<td>10.83 lbsCO2e/dge</td>
<td>8.55 lbsCO2e/dge</td>
<td></td>
</tr>
<tr>
<td>Corn Oil</td>
<td>10.53 lbsCO2e/dge</td>
<td>9.60 lbsCO2e/dge</td>
<td></td>
</tr>
<tr>
<td>Canola</td>
<td>16.51 lbsCO2e/dge</td>
<td>14.27 lbsCO2e/dge</td>
<td></td>
</tr>
<tr>
<td>Tallow</td>
<td>10.83 lbsCO2e/dge</td>
<td>8.55 lbsCO2e/dge</td>
<td></td>
</tr>
<tr>
<td>Soy</td>
<td>16.63 lbsCO2e/dge</td>
<td>14.92 lbsCO2e/dge</td>
<td></td>
</tr>
</tbody>
</table>
Why are the Carbon Reduction numbers so important?

• Renewable Diesel is on the left-side
• Petro-Diesel is on the right-side
• The black soot are the particulates that are going in your exhaust systems

To watch the full video – go to:

https://www.youtube.com/watch?v=eww6GY45TgE
What does Particulates do to our DPF’s
The Benefits of Renewable Diesel

As a drop-in biofuel, Renewable diesel behaves exactly like fossil diesel -

- Can be used straight or blended
- No need for infrastructure change
- It meets the ASTM-D975 and CARB standards for Diesel Fuel
- Very stable – it can be stored over long periods of time with no deterioration in quality
- Year-around performance, various grades can be produced to reach cloud points -34 °C (-29°F)
- Feedstock flexibility from various sources

The environmental benefits -

- GHG Emission Reductions
- NOx - emissions -10%
- PM - emissions -30%
- CO - emissions -35%
- THC - emissions -40%
- Less regeneration cycles
- Can be used in all storage tanks
- Renewable Diesel has the potential to make all diesel powered vehicles a AFV (alternative fuel vehicle)
The Big Questions:

✓ What’s with this “new” fuel?
✓ Where does it come from?
✓ How much does it cost?
✓ What are the emission benefits?
✓ Can I store it in an Underground Storage Tank?
✓ How does it fit into sustainability plans?
✓ What else am I missing?
What's with this “new” fuel?

California’s Biodiesel and Renewable Diesel Trend

Source: Energy Commission, PIIRA Reporting, Staff Analysis
What’s with this “new” fuel?

Monthly U.S. biodiesel and renewable diesel imports (2012-15)

Source: U.S. Energy Information Administration, Petroleum Supply Monthly
## RD Producers and Future Producers

<table>
<thead>
<tr>
<th>Producer</th>
<th>Annual Production (gal)</th>
<th>Plant Location(s)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neste</td>
<td>680 Million</td>
<td>Finland, Rotterdam, Singapore</td>
<td>Finnish Petroleum Refiner</td>
</tr>
<tr>
<td>REG</td>
<td>75 Million</td>
<td>Geismer, LA</td>
<td>Large portfolio of biodiesel and renewable chemical plants</td>
</tr>
<tr>
<td>Eni S.p.A.</td>
<td>125 Million – 150 million additional in 2016</td>
<td>Italy</td>
<td>Largest petroleum refiner in Italy. Offering RD15 at 3500 stations (UOP process)</td>
</tr>
<tr>
<td>Diamond Green</td>
<td>184 Million – expanding to 275 Million start of 2018</td>
<td>Norco, LA</td>
<td>Partnership between Valero and Darling Industries (UOP process)</td>
</tr>
<tr>
<td>AltAir Paramount</td>
<td>42 Million (jet and diesel)</td>
<td>Los Angeles, CA</td>
<td>Paramount Petroleum (UOP process)</td>
</tr>
<tr>
<td>UPM Biofuels</td>
<td>32 Million (diesel and naphtha)</td>
<td>Lappeenranta, Finland</td>
<td>Feedstock crude tall oil from pulp production</td>
</tr>
<tr>
<td>ENVIA Energy</td>
<td>23 Million – in start up phase</td>
<td>Oklahoma City, OK</td>
<td>Landfill methane to RD (JV including Waste Management, Inc.) FT-Process</td>
</tr>
<tr>
<td>East Kansas Agri-Energy</td>
<td>3 Million – planned</td>
<td>Garnett, KS</td>
<td>Integrated RD/ethanol plant, under construction</td>
</tr>
<tr>
<td>UrbanX Renewables</td>
<td>75 million – in planning</td>
<td>Southern California</td>
<td>ARA/Chevron Lummus “Biofuels Isoconversion” of waste fats and oils</td>
</tr>
</tbody>
</table>

*Full scale operation*
RD Regulatory Information

• Renewable diesel is a qualified EPAct fuel
  o For RDxx blends the renewable portion of the fuel is counted as alternative fuel and receives EPAct credits (treated the same as biodiesel blends)
• RD has multiple approved pathways for Renewable Fuel Standard
• Eligible for blender’s tax credit so may actually find RD99 (if tax credit is renewed)
How much does it cost?

May 2017 (bulk drop minus fed excise)
- $1.75- $1.85 / gallon R99 Renewable Diesel
- $1.70- $1.80 / gallon ULSD
- $1.95- $2.15 / gallon B20 Bio-Diesel

Sources:
- Spot bid
- RFP/RFQ
- Piggyback/co-op- State General Services, SACOG, City of SF
What are the emission benefits?

Using Renewable Diesel produced from 100% renewable raw materials can achieve up to 80% reduction in greenhouse gas emissions over its lifecycle compared to fossil diesel. In addition, it can reduce levels of local emissions that have a negative impact on air quality.
LCFS Carbon Intensities (CI) of fuels

Bars = Method 1 values
Whiskers = min/max of Method 2 values

* Scaled by EER of 3.4. Utility values use utility specific reported carbon intensities.
** Scaled by EER of 2.2.

Data Source: http://www.arb.ca.gov/fuels/lcfs/lcfs.htm (accessed 4/23/16)

Source: SERC, 2016
What are the emission benefits?

GHG Emission Reduction

Carbon Intensities of different feedstock under CARB LCFS:

- Petroleum: 98 gCO2e/MJ
- NEXBTL: 16 gCO2e/MJ
- NEXBTL: Used Cooking Oil
- NEXBTL: Technical Corn Oil (wdg)
- NEXBTL: Technical Corn Oil (ddg)
- NEXBTL: Fish Fat
- NEXBTL: Australian Animal Fat
- NEXBTL: New Zealand Animal Fat
- NEXBTL: North American Animal Fat

- Average emission reductions with 100% NEXBTL diesel
  - NOx-emissions: -10 %
  - PM-emissions: -30 %
  - CO-emissions: -35 %
  - THC-emissions: -40 %
  - PAH compounds: reduced significantly

- Standard service interval
- No changes in fuel logistics
- No operability issues with blend or 100% NEXBTL
- Average daily low temp in 2009 was app. negative (-) 20 °C
- Winter grade NEXBTL had cloud point of negative (-) 25 °C
- There are approximately 1400 urban buses in the Helsinki area
RD Study, Knoxville, TN

- East Tennessee Clean Fuels Coalition
- 7500 gallon test batch
- $2.80/gallon delivered vs. $1.53/gallon
- 8 week testing period
- 5 truck test group, but other vehicles used the fuel
- Operators told a fuel additive was being tested
- Operators were asked to keep a manual regen log
RD Study, Knoxville, TN

Before the study:
- Manual regens required frequently
- Forced regens required up to weekly
- Oil dilution, DPF/DOC failures

During the study:
- No forced regens on any test vehicles
- Reduced manual regens on test vehicles
- No blending issues noted

After the study:
- 2 test vehicles required forced regens 8 and 10 days later
Can I store it in an Underground Storage Tank?

State of California
Edmund G. Brown Jr.

Renewable Diesel Should Be Treated the Same as Conventional Diesel

This is a joint statement by the Air Resources Board (CARB) and the State Water Resources Control Board intended to clarify questions that have been raised regarding the status of renewable diesel. As discussed below, renewable diesel should be treated the same as conventional CARB diesel for all purposes, including storage in underground storage tanks (USTs).
Mandates

MANAGEMENT MEMO

SUBJECT: DIESEL, BIODIESEL, AND RENEWABLE HYDROCARBON DIESEL BULK FUEL PURCHASES

NUMBER: MM 15-07
DATE ISSUED: DECEMBER 9, 2015
EXPIRES: UNTIL RESCINDED

REFERENCES: PUBLIC RESOURCES CODE §25722.5 (c) - (f), §25722.6 et seq.; HEALTH AND SAFETY CODE §43870; CALIFORNIA CODE OF REGULATIONS §95480 et seq.; EXECUTIVE ORDERS B-2-11 and B-32-15; ASSEMBLY BILL 692 (QUIRK)

ISSUING AGENCY: DEPARTMENT OF GENERAL SERVICES

THIS MANAGEMENT MEMO REPLACES MANAGEMENT MEMO 12-06

Purpose

This Management Memo establishes requirements for the purchase of bulk diesel, biodiesel, and renewable hydrocarbon diesel (renewable diesel) fuels.

Policy

State agencies shall purchase state-contracted renewable diesel fuel, in lieu of conventional diesel and biodiesel fuels, when making bulk purchases of fuel for diesel powered vehicles and/or equipment. Additional information on this policy can be found in State Administrative Manual (SAM) Section 3627, Diesel, Biodiesel, and Renewable Diesel Bulk Fuel Purchases.

Exemptions to this renewable diesel fuel purchasing requirement are processed through the Department of General Services (DGS) Office of Fleet and Asset Management (OFAM) and are outlined under the Exemptions to Renewable Diesel Purchasing Requirements section of SAM 3627, which includes provisions for fuel availability, timeliness of delivery in emergency response situations, cost, and operational viability.
City of Oakland Clean Fuel Fuels

- 700,000 gallons annually
- Gasoline
  - 396,000 gallons
- Renewable Diesel
  - 230,000 gallons
- Compressed Natural Gas (CNG)
  - 75,000 gasoline gallon equivalents
City of Oakland Clean Fleet Plan

Continue:
- Renewable Diesel
- Battery electric and hybrid sedans and trucks
- CNG street sweepers, refuse trucks, cargo vans

Expand:
- EV charging infrastructure
- Data capture (utilization, EV, emissions)

Explore:
- Solar EV charging
- Hydrogen fuel cell sedans
- Renewable diesel sedans
LCFS Carbon Intensities (CI) of fuels

Bars = Method 1 values
Whiskers = min/max of Method 2 values

EER Adjusted Carbon Intensity (g CO2e / MJ)

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>CI Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gasoline</td>
<td>100</td>
</tr>
<tr>
<td>Diesel</td>
<td>120</td>
</tr>
<tr>
<td>fossil</td>
<td>80</td>
</tr>
<tr>
<td>renewable</td>
<td>60</td>
</tr>
<tr>
<td>fossil</td>
<td>40</td>
</tr>
<tr>
<td>CA avg</td>
<td>20</td>
</tr>
<tr>
<td>PG&amp;E</td>
<td>10</td>
</tr>
<tr>
<td>PacifiCorp</td>
<td>80</td>
</tr>
<tr>
<td>Trinity PUD</td>
<td>60</td>
</tr>
<tr>
<td>NG</td>
<td>40</td>
</tr>
<tr>
<td>RNG</td>
<td>20</td>
</tr>
<tr>
<td>Virgin</td>
<td>10</td>
</tr>
<tr>
<td>Waste</td>
<td>0</td>
</tr>
<tr>
<td>Petro Eth</td>
<td>80</td>
</tr>
<tr>
<td>CNG</td>
<td>60</td>
</tr>
<tr>
<td>LNG</td>
<td>40</td>
</tr>
<tr>
<td>Electricity*</td>
<td>20</td>
</tr>
<tr>
<td>H2**</td>
<td>0</td>
</tr>
<tr>
<td>BD</td>
<td>0</td>
</tr>
<tr>
<td>RD</td>
<td>0</td>
</tr>
</tbody>
</table>

* Scaled by EER of 3.4. Utility values use utility specific reported carbon intensities.
** Scaled by EER of 2.2.

Source: SERC, 2016

Data Source: [http://www.arb.ca.gov/fuels/lcfs/lcfs.htm](http://www.arb.ca.gov/fuels/lcfs/lcfs.htm) (accessed 4/23/16)
What else are we missing?

- 100% renewable and sustainable
- Smaller environmental footprint
- Lower operating costs than other alternative fuels
- Easy to use
- Superior cold weather performance
- High performance
- No blending limit
- Good storage properties
- Pure hydrocarbon
- Odorless
Questions

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