International District Energy Association

June 2019

Case Studies Converting Existing Boilers to Liquid Biofuels to Meet Sustainability Goals

By Dan Wallace, PE
I. Motivation
II. Liquid Biofuel Solutions
III. Case Studies
Central Plant GHG Emissions Reduction

• Concern for the effects of Carbon Emissions has never been higher.
• Many Facilities are looking to reduce fuel usage and benefit from the positive PR of also reducing emissions
• American College & University Presidents' Climate Commitment (ACUPCC)
Central Plant GHG Emissions Reduction Options

• Increase efficiency of existing operations (high efficiency burners, modern controls and/or VFDs)
• Convert from oil or gas to a biogenic fuel like landfill gas or digester gas.
• Convert from oil or gas to a biogenic fuel like wood waste.
• Other options are available - convert to biogenic renewable liquid fuels.
Typical GHG “life cycle“ GHG Factors for Combustion

<table>
<thead>
<tr>
<th>Energy Component</th>
<th>GHG emission factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil</td>
<td>207 #/MMBTU</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>141 #/MMBTU</td>
</tr>
<tr>
<td>Electricity</td>
<td>0.7 to 1.6 #/kwh</td>
</tr>
<tr>
<td>Typical Liquid Biofuel</td>
<td>5-30 #/MMBTU</td>
</tr>
</tbody>
</table>
Liquid Biofuel Options

- RFO™ – Produced by Ensyn Fuels
  Typically priced lower than Natural Gas and other fossil fuels. Requires higher capital cost for equipment retrofit than other liquid fuels.

- BRO™ – Produced by Renewable Energy Group
  Typically competitively priced with liquid fossils fuels such as #2 and #6 oil. Requires relatively low to no equipment modifications to burn.

- Others – B100, B20, etc...
What is RFO™?

- RFO is a homogeneous, organic liquid obtained from the thermal conversion of biomass
- Has the appearance of motor oil
- It is polar in nature and does not readily mix with hydrocarbons
- pH >2.5, specific gravity of 1.2
- Contains less metals and sulfur than petroleum liquids
- Accepted as a biogenic fuel

### RFO Specification Sheet

<table>
<thead>
<tr>
<th>Property</th>
<th>Analytical Method</th>
<th>Typical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Content</td>
<td>ASTM D203 (Karl Fisher titration)</td>
<td>&lt;24 wt%</td>
</tr>
<tr>
<td>pH</td>
<td>ASTM E70-07</td>
<td>&gt;2.5</td>
</tr>
<tr>
<td>Density @ 15 °C</td>
<td>ASTM D4052</td>
<td>10.0 lb/USgal</td>
</tr>
<tr>
<td>Specific Gravity @ 15 °C</td>
<td></td>
<td>1.20</td>
</tr>
<tr>
<td>Kinematic Viscosity @ 40 °C</td>
<td>ASTM D445</td>
<td>25 cSt</td>
</tr>
<tr>
<td>Higher (Gross) Heating Value, Moisture Free</td>
<td>ASTM D240</td>
<td>9905 Btu/lb</td>
</tr>
<tr>
<td>Higher (Gross) Heating Value, As-Is</td>
<td>Calculated</td>
<td>7528 Btu/lb</td>
</tr>
<tr>
<td>Lower (Net) Heating Value</td>
<td>Calculated</td>
<td>6842 Btu/lb</td>
</tr>
<tr>
<td>Solids Content</td>
<td>ASTM D7579</td>
<td>0.1 wt%</td>
</tr>
<tr>
<td>Pour Point</td>
<td>ASTM D97</td>
<td>-13 °F</td>
</tr>
<tr>
<td>Elemental Analysis (moisture &amp; ash free)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbon</td>
<td>ASTM D6291</td>
<td>54.87 wt%</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>ASTM D6291</td>
<td>6.67 wt%</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>ASTM D6291</td>
<td>0.16 wt%</td>
</tr>
<tr>
<td>Sulphur</td>
<td>ASTM D4294</td>
<td>&lt;0.05 wt%</td>
</tr>
<tr>
<td>Oxygen</td>
<td>Calculated, by difference</td>
<td>38.25 wt%</td>
</tr>
<tr>
<td>Ash</td>
<td>ASTM D482</td>
<td>&lt;0.15 wt%</td>
</tr>
</tbody>
</table>
Typical RFO Conversion

• Virtually any firetube or watertube boiler can be converted to fire RFO.
• Firing RFO is similar to any fuel oil requiring pre-heating (No. 6 oil or No. 4 oil)
• Cost per Btu is less than No. 2 oil, but typically more expensive than natural gas.
• Greenhouse gas emissions from RFO are 88% lower than heavy oil, and 81% lower than natural gas.
• NOx and CO emissions are similar to natural gas and typically less then No. 2 oil.
Current RFO Users

- Memorial Hospital
- Youngstown Thermal
- Bates College
What is BRO™?

- Bio Residual Fuel produced from vegetable and animal fats.

- Produced during the process of making Biodiesel.

- Drop in replacement for other liquid fuels such as #2 - #6 oil. Competitively priced with these fuels.

- Requires heating and evaluation of equipment to ensure compatibility (e.g. seals, burner nozzle, etc…)

PREFERRED UTILITIES MFG CORPORATION
Objective was to reduce costs and be “green”

Contract for long term supply of RFO signed April, 2014, first deliveries began summer of 2014.

Designed to operate on RFO with #4 oil backup. Provides fuel optionality

First winter was coldest Feb. on record, and RFO was exclusive fuel.

RFO has been the primary fuel since August of 2014

Annual RFO use is approximately 300,000 gallons. First year target savings of $160,000 realized
4 boilers - nominal 120,000 MMBTU hour heat input
- 3 coal, 1 natural gas
- Converted natural gas boiler to dual fuel- Nat gas/ RFO

Retrofit includes
- 40,000 gallon single wall SS storage tank, with containment
- 2 nominal 60 MMBTU/hr dual fuel burners
- Fuel delivery skid

Marked efficiency improvement - low CO levels
Full commercial operations - savings being realized
Youngstown Thermal Retrofit
Youngstown Thermal Fuel Delivery System
Youngstown Thermal Dual Fuel Burners

- Burners designed for natural gas and RFO - any combination
- Two burners fired into one furnace – each with a nominal capacity 60 MMBTU/hr
- Third party source tested at 65 ppm NOx, 0.2 ppm SO2, 3.1 ppm CO, and 0.1 ppm VOC
Youngstown Thermal MCC, BMS, and Boiler Controls
Bates College
Lewiston, Maine

- Signed ACUPCC pledge May 16, 2007
- Pledge date for Carbon neutrality 2020
- Scope 1 GHG emissions were approximately 40% of total of Scope 1-3
- Central steam plant represents approximately 70% of the Scope 1 emissions
- Achieved carbon neutrality ahead of schedule in 2019 with the most impactful step of switching to a liquid biofuel (RFO™)

- Resulted in an annual reduction of Central Plant GHG emissions of 3080 MTCO2e.
- Burns liquid biofuel exclusively in central plant to realize GHG emissions reduction with emergency backup of natural gas.
- Bates will additionally save > $600,000 over the life of the contract
Bates College

- 3 x 700 HP boilers, natural gas and oil fired
  - Conversion of 1 boiler initially to burn biofuel in 2016, with second conversion in 2018.
  - 20,000-gallon double wall SS tank
  - Steam to hot water exchanger
  - Biofuel transfer and heater skid

- Operational plan is to run one boiler on RFO, and one boiler on standby on RFO. The third boiler is an emergency backup.

- Fully operational < 4 ppm CO - running at 85%+ efficiency
The existing controls and VFDs were re-used for the RFO burner.

The boilers were converted to be able to burn both RFO and Natural Gas (emergency backup).

Operators can use the same easy touchscreen interface they have used for years.
Burner Assembly – 29.4 MMBTU per hour
Fuel Delivery Skid & Storage Tank

- Duplex pumps & strainers
- Heat exchanger
- Motor control center
- Instrumentation
- Recirculation valving
- Separate fuel unloading skid

- Double wall storage tank (20,000 gallon of capacity)
- High- and low-level alarms
- Flame Arrestor
- Conservation vent
Preferred Utilities Manufacturing Corp.
Danbury, CT – BRO™
Case Study

- Started burning BRO™ in 2018.
- Switched from Natural Gas.
- Existing equipment was available that previously burned #6 oil.
- No modifications were required to Preferred’s equipment for burning the liquid biofuel.
- Reduced CO2 emissions by >70% compared to previously burning Natural Gas.
- Reduced fuel cost compared to burning #6 oil.
- Delivered 6000 gallons of liquid biofuel into a fuel oil storage tank that already had 1000 gallons of #2 oil. Handled and burned the fuel without issue.
- Utilized a Preferred burner and boiler that are 40+ years old with no modifications required.
- Achieved 3% Excess O2 in the stack with <5 ppm CO. Burned the fuel while heated to only 140F.
Preferred Utilities Manufacturing Corp. Danbury, CT – BRO™ Case Study

Utilized existing fuel oil storage tank and handling system.
2019 IDEA Renewable Oil Summary

I. Motivation
   • Greenhouse gas emissions

II. Solutions
   • RFO™ –liquid fuel
   • BRO™ –liquid fuel

III. Case Studies
   • Bates College
   • Youngstown Thermal
   • Memorial Hospital
   • Preferred Utilities Manufacturing
Thank You

Questions?

Dan Wallace, PE
Vice President,Preferred Utilities Manufacturing Corporation
dwallace@preferred-mfg.com
Preferred Utilities Manufacturing Corp

For more info, contact...

PREFERRED UTILITIES MFG CORP

31-35 South St. • Danbury • CT
T: (203) 743-6741 • F: (203) 798-7313
www.PREFERRED-MFG.com