IDEA2019
The Energy for More Resilient Cities

International District Energy Association

June 2019

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

By Dan Wallace, PE

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2019 Case Studies Converting Boilers to Liquid Biofuels

I. Motivation

II. Liquid Biofuel Solutions

III. Case Studies

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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

Energy Component	GHG emission factor
Oil	207 #/MMBTU
Natural Gas	141 #/MMBTU
Electricity	0.7 to 1.6 #/kwh
Typical Liquid Biofuel	5-30 #/MMBTU

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

Property	Analytical Method	Typical
Water Content	ASTM E203 (Karl Fisher titration)	<24 wt%
pH	ASTM E70-07	>2.5
Density @ 15 °C	ASTM D4052	10.0 lb/USgal
Specifc Gravity @ 15 °C		1.20
Kinematic Viscosity @ 40 °C	ASTM D445	25 cSt
Higher (Gross) Heating Value, Moisture Free	ASTM D240	9905 Btu/lb
Higher (Gross) Heating Value, As-Is	Calculated	7528 Btu/lb
Lower (Net) Heating Value	Calculated	6842 Btu/lb
Solids Content	ASTM D7579	0.1 wt%
Pour Point	ASTM D97	-13 °F
Elemental Analysis (moisture & ash free)		
Carbon	ASTM D5291	54.87 wt%
Hydrogen	ASTM D5291	6.67 wt%
Nitrogen	ASTM D5291	0.16 wt%
Sulphur	ASTM D4294	<0.05 wt%
Oxygen	Calculated, by difference	38.25 wt%
Ash	ASTM D482	<0.15 wt%

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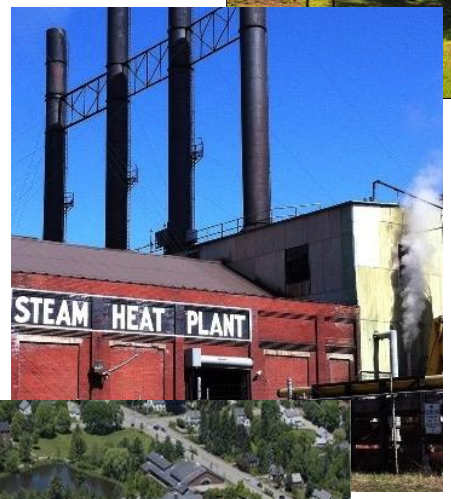
Typical RFO Conversion

- 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



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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…)

Memorial Hospital
North Conway, NH

- 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

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Youngstown Thermal

- 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

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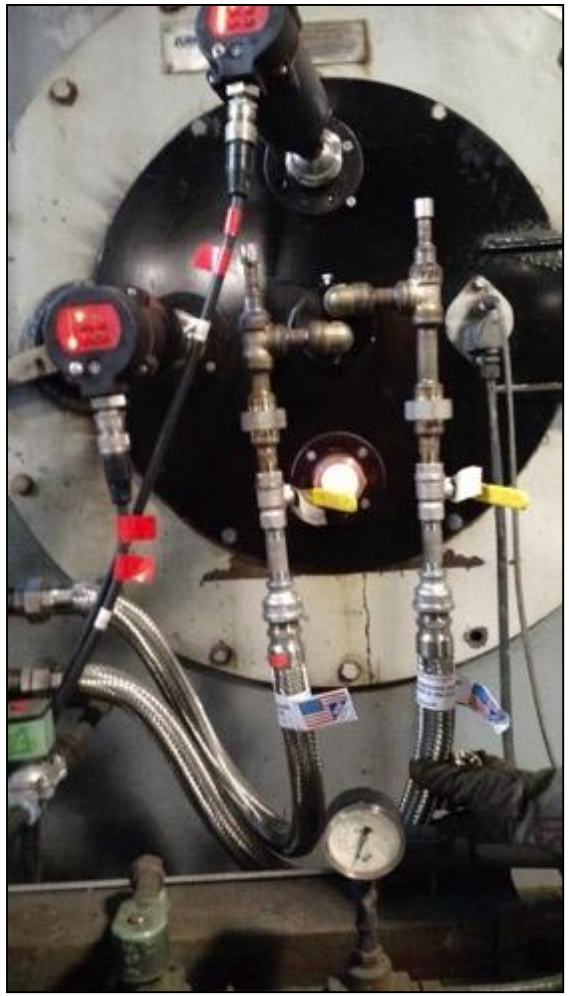
Youngstown Thermal Retrofit

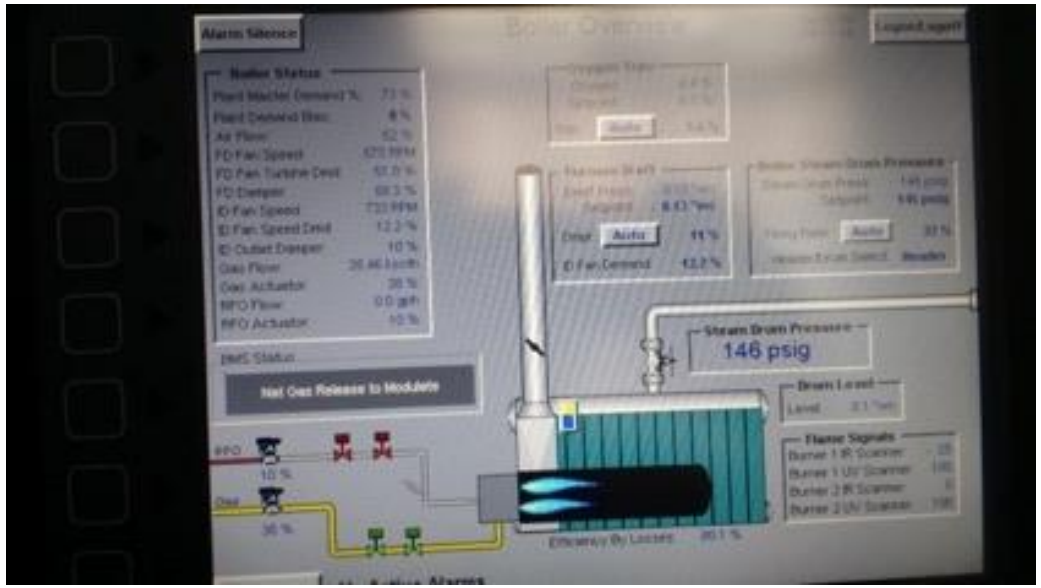
Youngstown Thermal Fuel Delivery System

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 60MMBTU/hr
- Third party source tested at 65 ppm NOx, 0.2 ppm SO_2, 3.1 ppm CO, and 0.1 ppm VOC

Youngstown Thermal MCC, BMS, and Boiler Controls



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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

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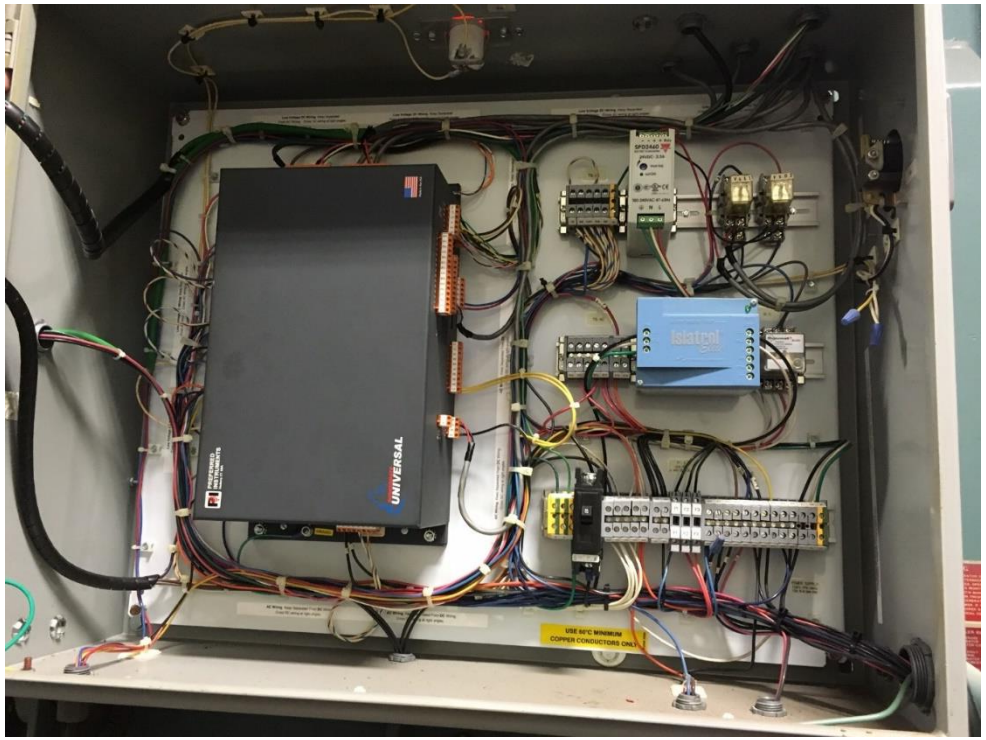
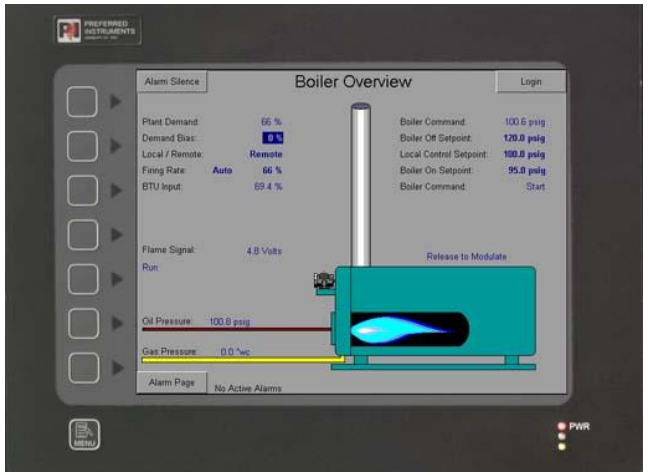
Bates College

- 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

Bates College



- 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.

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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

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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.

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Danbury, CT – BRO™ Case Study

Utilized existing fuel oil storage tank and handling system.

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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

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Thank You

Questions?

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

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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

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