ENSYN fuels

Lafayette College – October 20, 2020

Ensyn Fuels Proposal Summary

A conversion to RFO will provide Lafayette College with:

- Increased fuel optionality and reliability
- A fuel cost savings of at least 15%
- A reduction in life-cycle greenhouse gases of at least 81%

Ensyn Corporate Summary

- Ensyn has been in business for over 30 years, producing cellulosic non-food biofuels and specialty chemicals
- Ensyn uses its patented and proprietary Rapid Thermal Processing™(RTP™) technology to convert wood residues or other cellulosic material into a renewable fuel oil, RFO™
- RFO is a refinery feedstock for production of gasoline and diesel, and is also a renewable heating fuel
- Ensyn RTP technology has been deployed in 16 facilities since 1989 and is currently operating in 8 facilities across the USA and Canada. Production to date exceeds 40 million gallons in over 160,000 hours of unit operation
- The company's technology is commercially proven in multiple industries:
- Red Arrow, a specialty food products company, has used the Ensyn technology since 1989 to produce food chemicals and heating fuels
- Ivanhoe Energy Inc (TSX: IE, NSADAQ: IVAN), an oil exploration and production company, acquired the rights for petroleum (heavy oil) upgrading in 2005 at a $100 million valuation
- Ensyn has two production facilities ready to serve Lafayette College. The Ontario facility is a 3 million gallon per year facility located in Renfrew, ON and the Cote Nord production facility is a 10 million gallon per year facility located in Port Cartier, QC.
- Ensyn is now building out capacity in a number of projects to produce significantly more RFO capacity – partially spurred on by RFS – in order to be a major supplier of RFO to the heating oil and refinery markets. There are production facilities which are in some form of development in Minnesota, Maine, New York and Georgia.

Ensyn's Ontario RFO plant in Renfrew, Ontario

Ensyn's Cote Nord RFO plant in Port Cartier, QC.

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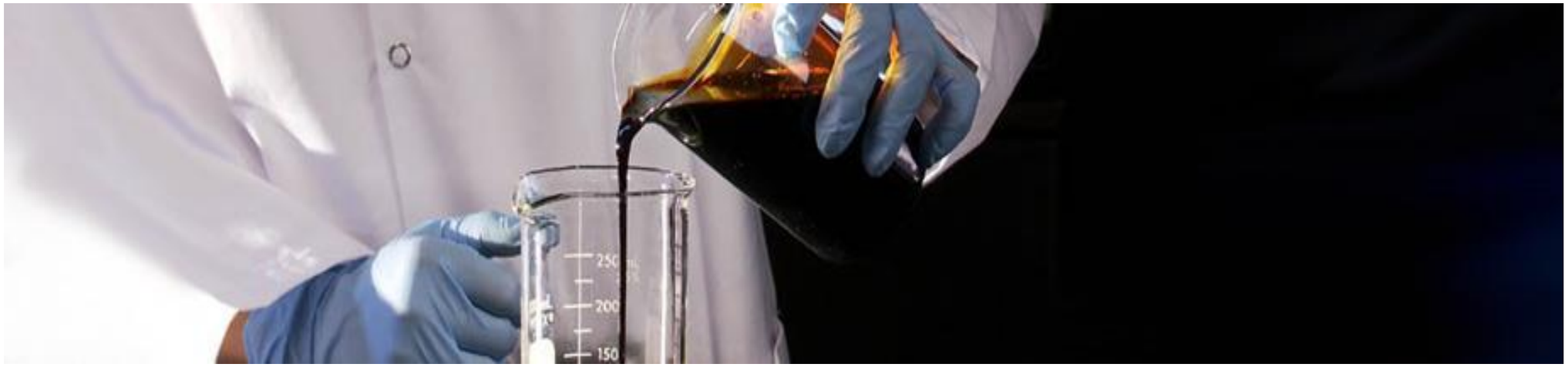
What is RFO?



- A homogeneous, organic liquid obtained from the thermal conversion of biomass
- Primarily carbon, hydrogen and oxygen
- Appearance of motor oil
- It is polar in nature and does not readily mix with hydrocarbons
- Tends to contain less metals and sulfur than petroleum liquids
- Pourable at room temperatures
- pH of 3; similar to vinegar or red wine
- Is the only known liquid fuel sourced from woody biomass that can be used for thermal operations in existing boilers

RFO Specifications

The RFO supplied by Ensyn shall comply with ASTM D7544, Standard Specification for Pyrolysis Liquid Biofuel. For ease of readership, these specifications are reproduced herein, showing both the metric units used in the ASTM standard as well as imperial units.

RFO Specification:

Parameter	Test Method	Metric Units	Imperial Units
Gross Heat of Combustion	ASTM D240	15 MJ/kg min	6450 BTU/lb min
Water Content	ASTM E203	30 wt% max	30 wt% max
Pyrolysis Solids Content	ASTM D7579	2.5 wt% max	2.5 wt% max
Kinematic Viscosity, at 40°C	ASTM D445	125 mm^2/s max	125 cSt max
Density, at 20°C	ASTM D4052	1.1 to 1.3 kg/dm^3	9.2 to 10.8 lb/US Gallon
Sulfur Content	ASTM D4294	0.05 wt% max	0.05 wt% max
Ash Content	ASTM D482	0.25 wt% max	0.25 wt% max
pH	ASTM E70	Report	Report
Flash Point	ASTM D93, Procedure B	45 °C min	113°F min
Pour Point	ASTM D97	-9 °C max	16 °F max

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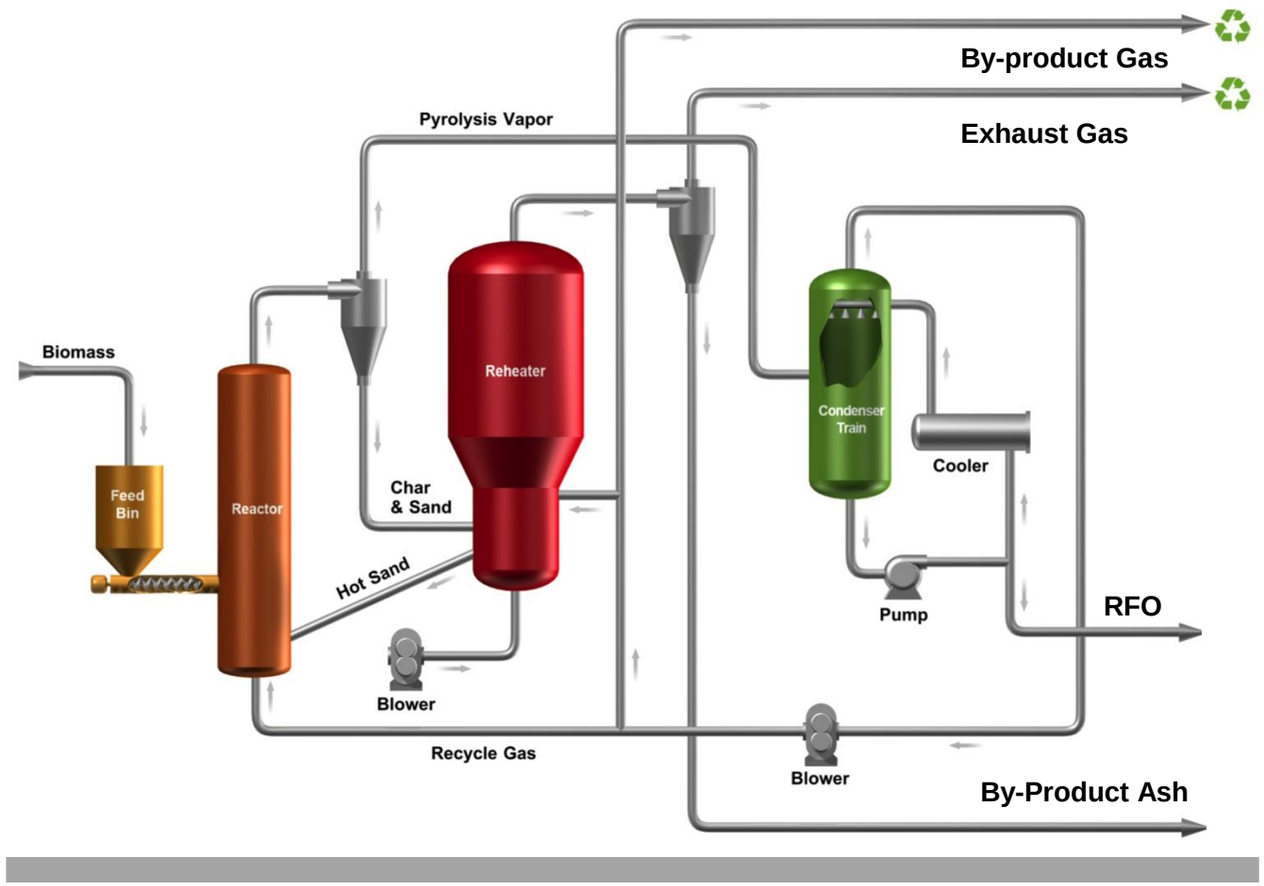
Rapid Thermal Processing (RTP™) Overview

RTP™ Diagram



RTP™ Technology Summary

- RTP™ technology is a simple scaled down version of a Fluid Catalytic Cracker (FCC)
- Sand and heat are used to thermally crack and convert biomass into renewable crude oil
- The process does not require catalysts, high pressure or hydrogen, preserving a maximum amount of carbon in liquid form
- Gas and char co-products are used as a source of energy to run the facility
- Ensyn has strong IP on its technology and bioenergy applications

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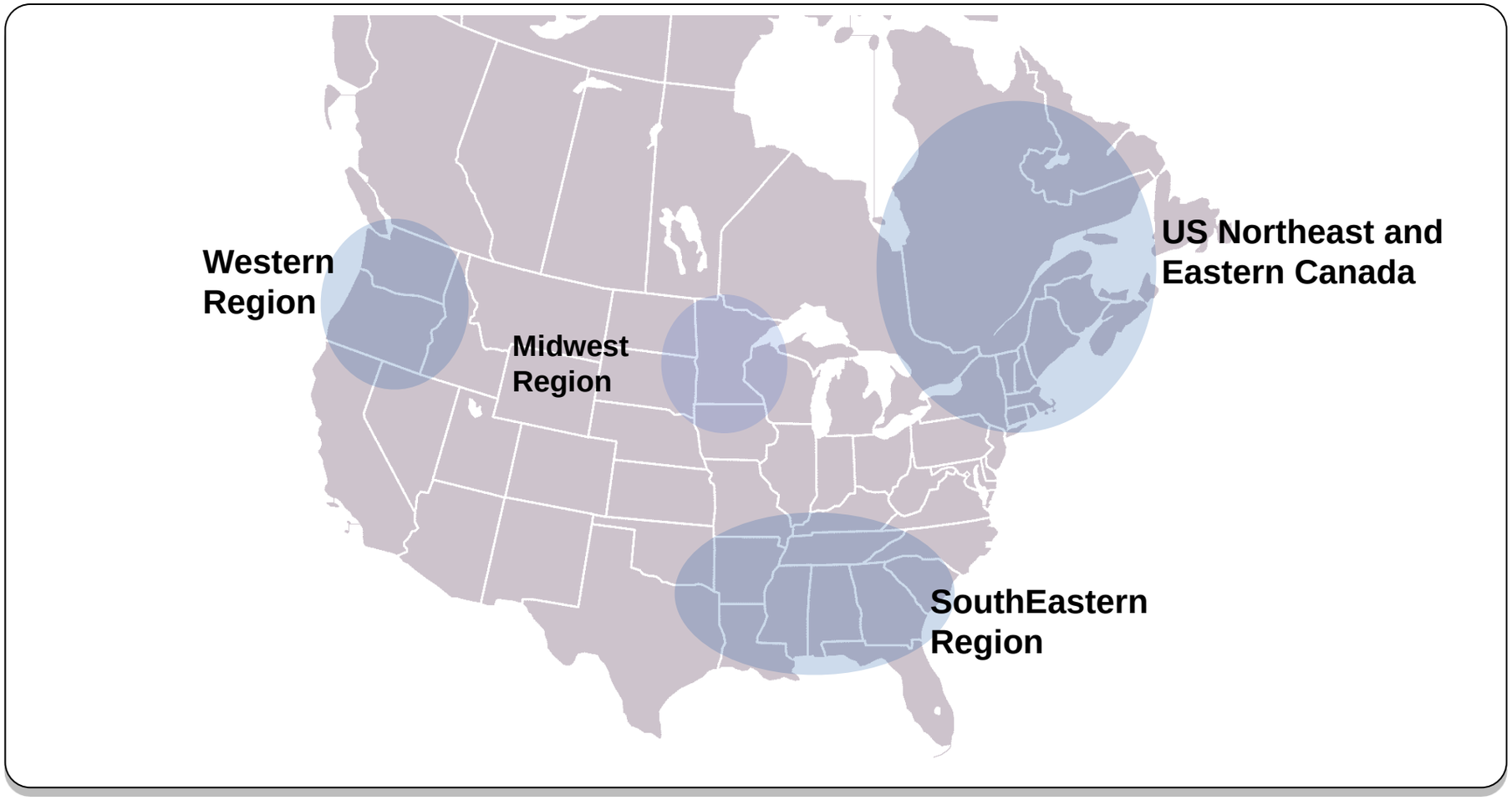
Ensyn has an attractive project pipeline of Projects

- Ensyn is engaged in development efforts and is moving forward projects across North America
- Current projects under development are located in four distinct regions - [5] states in the US and one providence in Canada
- Depending on the specific location, projects are targeted to produce renewable fuel for refinery applications and industrial and thermal applications from forest residues
- Locations are developed with strategic partners taking into account proximity to off-take and feedstock suppliers.



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Renewable Fuel Standard (RFS2)

- Passed by Congress in 2007 under the Energy Independence and Security Act (EISA).
- Increased the Renewable Fuel mandate from the 12 billion gallons in the original RFS to 36 billion gallons by 2022.
- Obligated parties under RFS2 are petroleum refineries and gasoline importers.
- All biofuels must be produced from “Renewable Biomass”.
- Of the 36 billion gallon mandate, 16 billion must be cellulosic biofuel like RFO.
- RFO must show a 50% reduction in GHGs from the fuel that it is replacing in order to qualify for a RIN (Renewable Identification Number) similar to a REC for electricity.
- Obligated parties must generate RINs to show compliance with RFS2.
- When a gallon of RFO is burned, a RIN is generated. Ensyn Fuels sells RINs to obligated parties so that they can be compliant with RFS2.
- The value of the RIN is established by the legislation. In general terms, as the cost of gasoline goes down, the value of the RIN goes up and vice-versa.

Renewable Fuel Standard Feedstock Requirements

In order to qualify under the EPA's Renewable Fuel Standard, Ensyn Fuels must use "Renewable Biomass" as defined by the RFS. The credits generated as a qualified renewable fuel are critical to Ensyn Fuels' economics so all RFO will be manufactured using feedstock that meets the "Renewable Biomass" definition. "Renewable Biomass" is defined as follows:

- Slash and pre-commercial thinnings from non-federal forest lands.
- Planted trees and tree residue from actively managed tree plantations on non-federal lands.
- Biomass obtained from the immediate vicinity of buildings, public infrastructure and areas regularly occupied by people that are at risk from wildfire.
- Other activities, including planted crops and crop residue from non-forested agricultural land that is either actively managed or fallow.

Before Thinning

After Thinning

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Can the RINs be Separated?

- RFS2 does not measure carbon reduction. The value of the RINs is based on BTUs and not GHGs.
- RINs are used for obligated parties to demonstrate their compliance with their Renewable Volume Obligation
- RINs stay with the renewable fuel until it is blended (or burned) at which point the RIN can be separated from the renewable fuel.
- The renewable attributes remain with the fuel and do not go with the RIN.
- This is the opposite of a REC where the REC actually represents the environmental attributes of the electricity.
- The EPA has confirmed that RINs are used by obligated parties to show compliance with renewable volume obligations only and not to show GHG reduction.

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RFO vs. Fossil Fuel LCA - Comparative Analyses using GHGenius Software

GHG Emissions – Wood Feedstock

Fuel	Heating Oil	Natural Gas	PyOil (i.e., RFO)
Feedstock	Crude Oil	Natural Gas	Wood Residues
	g CO_2eq/GJ		
Fuel Dispensing	402	0	874
Fuel Distribution & Storage	698	2,063	361
Fuel Production	8,412	1,376	9,555
Feedstock Transmission	1,401	0	0
Feedstock Recovery	8,081	1,708	0
Land-use Changes, Cultivation	25	0	0
Fertilizer Manufacture	0	0	0
Gas Leaks & Flares	1,900	3,540	0
CO_2, H_2S Removed from NG	0	642	0
Emissions Displaced	-128	0	0
Sub-total Fuel Production	20,790	9,330	10,790
Fuel Combustion	68,718	51,432	301
Grand Total	89,508	60,762	11,091
% Change Compared to RFO	-87.6%	-81.6%	
	208.18 lb/MMBtu	141.32 lb/MMBtu	25.8 lb/MMBtu

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Sample Cost Savings Calculation

Annual Consumption: 115,000 MMBtus
Gas Cost: $5.50/MMBtu
RFO Cost: $4.68/MMBtu
Annual Fuel Savings: $94,3000

Annual GHGs using Gas: 7,374 MTCO2eq
Annual GHGs using RFO: 1,346 MTCO2eq
GHG Reduction: 6,028 MTCO2eq

*Based on GHGenius Model on page 11

If any amount of #2 fuel oil is displaced, both the cost savings and GHG reduction are increased.

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RFO - Combustion

Emission Factors for Combustion of Renewable Fuel Oil (RFO)

Emission Factor lb/MMBtu (HHV)	NG[1]	ULSD[2]	Distillate[3]	No.4[4]	No.5[5]	No.6[6] (low S)	No.6[7] (high S)	RFO[8]
CO2	118	159	159	154	155	167	163	138
CO	0.082	0.036	0.036	0.033	0.033	0.033	0.033	0.005
NOx (Expressed as NO2)	0.098	0.14	0.14	0.13	0.37	0.37	0.37	0.175
SO2	0.0006	0.0015	0.22	1.35	1.97	0.88	4.16	0.001
Total PM	0.0075	0.024	0.024	0.055	0.077	0.083	0.27	0.075
VOC (NMTOC)	0.0054	0.0014	0.0014	0.0013	0.0019	0.0019	0.0019	0.0001

- RFO combustion emissions compare favorably with fossil fuel
- Extent of burner retrofit dependent on the burner design (new fuel gun versus complete burner assembly)
- Commercial burner package has been developed to retrofit boilers for 100% RFO use
- Official emissions test conducted at Memorial Hospital in September 2015 and Youngstown Thermal in 2016.

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What is the Difference Between Emissions and Life-Cycle GHGs?

- Biogenic carbon dioxide emissions are defined as emissions from a stationary source directly resulting from the combustion or decomposition of biologically-based materials other than fossil fuels.
- To proactively address congressional directives and stakeholder concerns specific to the use of forest biomass for energy, EPA's policy is to treat biogenic CO2 emissions resulting from the combustion of biomass from managed forests at stationary sources for energy production as carbon neutral.
- The emissions are what are actually going up the stack.
- PA DEP is concerned with the actual emissions and how those relate to the emissions permit.
- The Scope 1 GHGs that are reported to Second Nature are the life-cycle GHGs where the combustion of RFO is considered to be carbon neutral.

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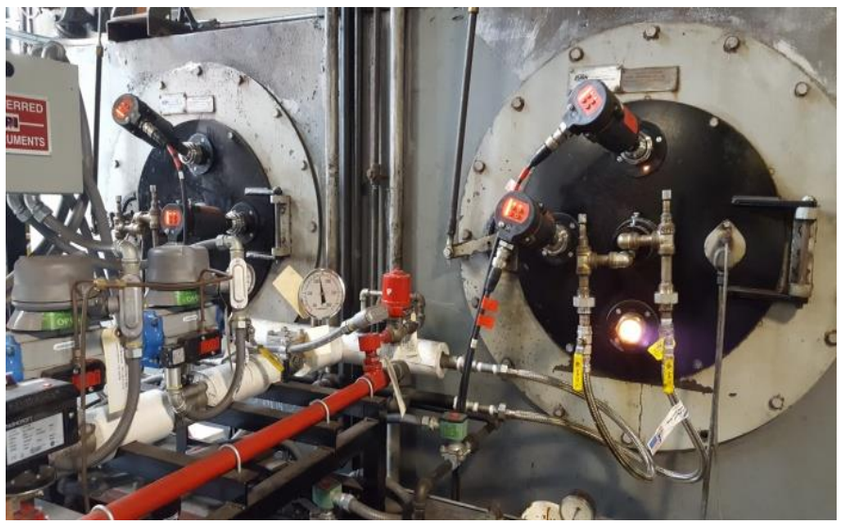
RFO Projects – Memorial Hospital North Conway, NH

- Chose RFO over solid biomass
- 2 Cleaver Brooks 200 HP boilers
- Converted in 2014
- Increased fuel optionality and reliability
- Consumed over 1.1 million gallons since 2014
- RFO has provided over 95% of the steam load

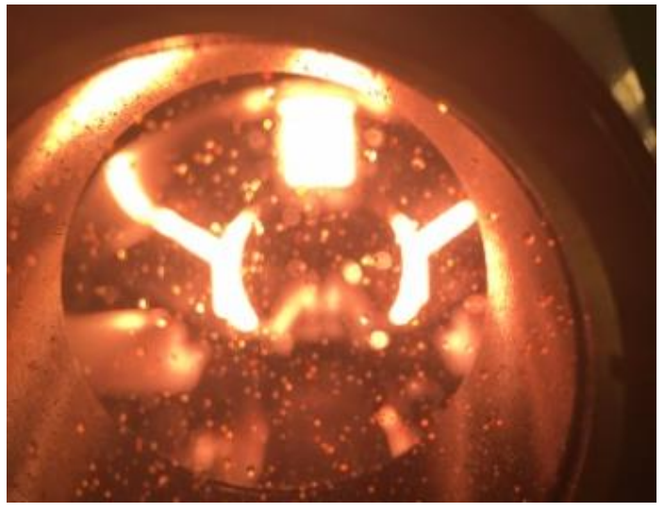
RFO Projects – Youngstown Thermal Youngstown, OH

- Converted a 100,000 lb/hr natural gas, water tube boiler to natural gas/RFO in 2016.
- The converted burner can burn gas, RFO or co-fire RFO and gas.
- Increased fuel optionality and reliability.
- YT has burned over 2 million gallons to date.
- Goal is to get to over 4 million gallons in the next year.



RFO Projects – Bates College Lewiston, ME

- 3 Cleaver Brooks 700HP boilers.
- Converted 1 boiler to RFO in 2017 and a second in January 2019
- The RFO boilers carry nearly 100% of the steam load.
- They have seen a 81% reduction in their scope 1 GHGs.
- Project had a less than 2-year payback.



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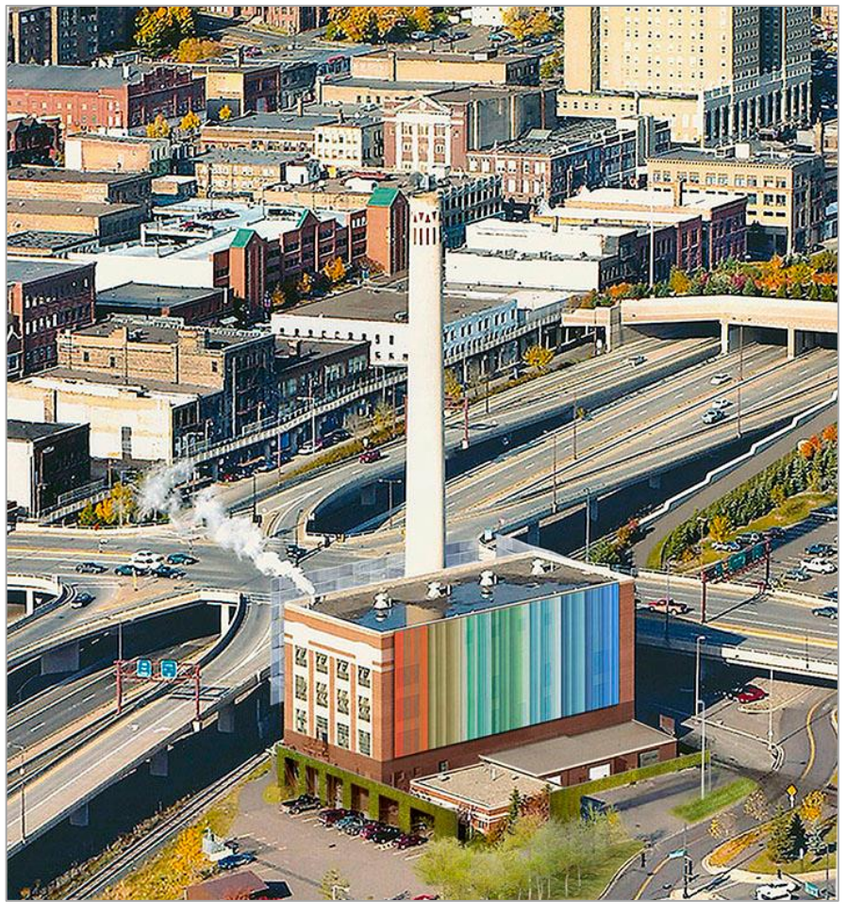
RFO Projects – Duluth Energy Systems, Duluth, MN

- Duluth Energy Systems, managed by Evergreen Energy, is the district energy system for Duluth, MN.
- DES has signed a contract with Ensyn for a minimum of 4 million gallons annually.
- Total energy use at facility is 13 million gallons of RFO equivalent.
- DES is project to grow to 7-8 million gallons of RFO annually.
- DES is price similarly to a potential proposal for Lafayette College – at a discount to natural gas.
- Projected start date is 2021.



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Production Capacity

- Ontario Facility – 4 Million gallons per year
- AECN Facility – 10.5 Million gallons per year
- Projects Under Development – 60 Million gallons per year

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RFO Production Facility in the Region

- Total capacity of 21 million gallons per year
- Will consume 400 bone dry tons of biomass per day
- Total cost of $130 million
- Will provide 126 permanent forestry jobs with an annual impact of $8 million
- Direct plant labor will be $2 million annually
- Will provide a total of 190 direct and indirect jobs annually
- Total annual economic impact of $20 million

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