

Biofuels in Heating Applications

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Market Overview

- Residential, commercial, institutional applications
- Boilers, warm air furnaces, water heaters
- 5.6 billion gallons of distillate fuel annually
- Northeast and mid-Atlantic dominate market
- “Providence Resolution” 40% - 2030, 100% biofuels 2050
- State biofuel minimum levels

New York – 10%, 20% in 2030, 50% in 2039

Connecticut – 10%, 15% in 2030, 50% in 2035

Rhode Island – 20% , 50% in 2030

Sector Technical Aspects (residential)

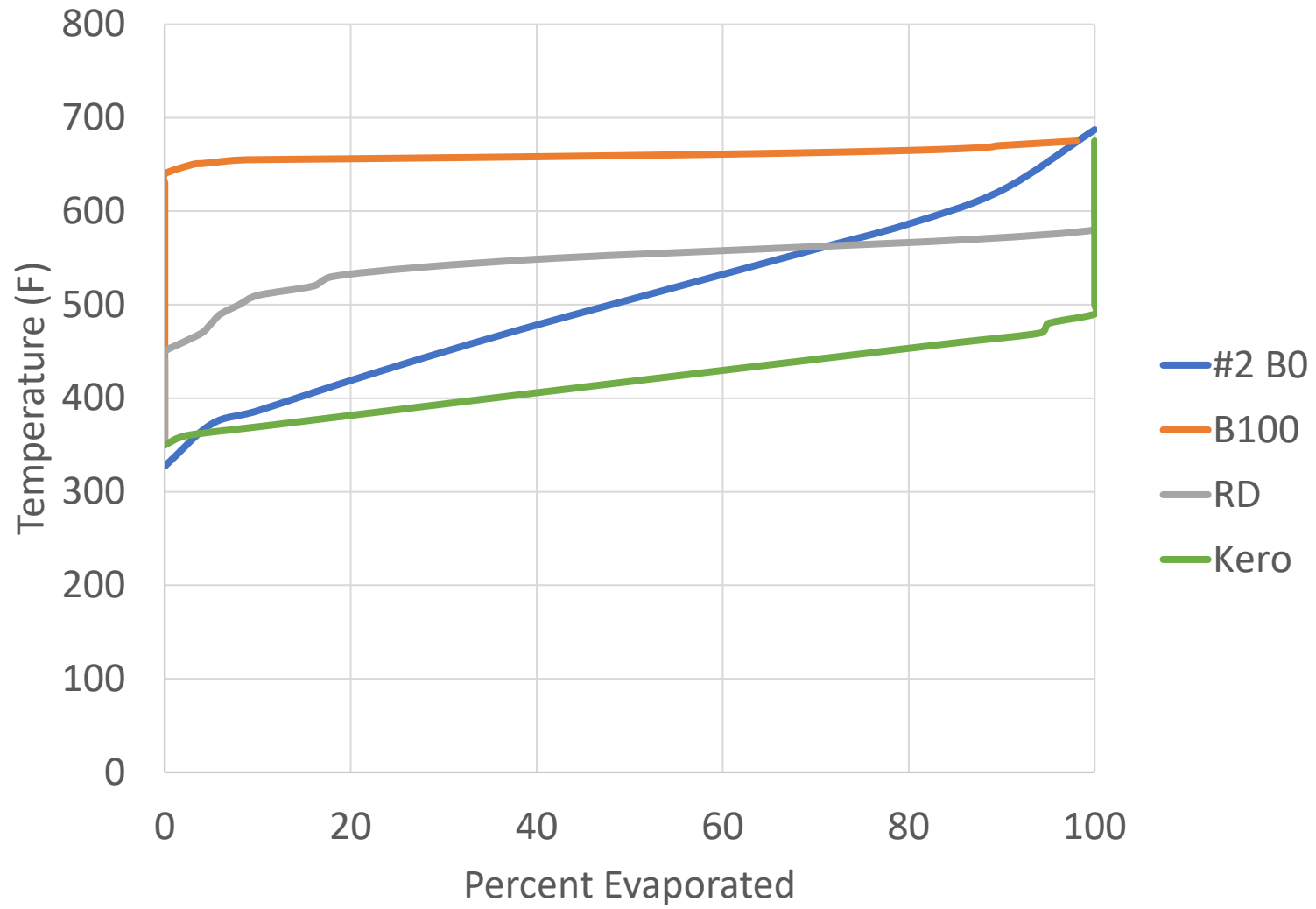
- Pressure atomization, fixed firing rates;
- 150 psi fuel pumps with integral regulators;
- 10,000 annual cycles, 5-15 minute burner on periods;
- Visible light sensing for flame safety;
- 2-4 annual fuel deliveries;
- 90% of tanks are indoors;
- Tank life can be as much as 50 years;
- Applications can be separated into “cold” and “hot” chambers.



Fuel Properties

	Petroleum No. 2 Fuel Oil	Biodiesel	Renewable Diesel (HVO)
C wt%	87	77	85
H wt%	13	12	15
O wt%	0	11	0
HHV Btu/gal	139,000	125,300	132,800
Density lb/gal	7.09	7.34	6.51
Flash Point °F	140-176	212-338	>158
Kinematic viscosity (mm ² /s @ 40C)	1.9/4.1	1.9/6.0	2.8 typical
Aromatics	20-35	0	0

Fuel Volatility



Pathway for Biodiesel

1980 Fuel use of biodiesel developed in response to surplus soy oil;

1990's Limited lab testing in heating applications;

2000s' *ASTM D6751 spec for biodiesel developed. Blend field tests started;*

2008 *B5 recognized in ASTM D396 as equivalent;*

2010's *ASTM Specs evolved based on field experience. More field studies;*

2015 *B20 defined in ASTM D396;*

2022 *UL Standards for "listing" products to B100.*

2026 *B21-B50 defined in ASTM D396.*

Biodiesel Use in Heating Oil

Current Status...

B5-10 blends are now routinely used

B20 is commonly used by fuel marketers

- Over 500,000 sites
- Major marketer has committed to B20 use in 400,000 homes

B50 is used in over 20,000 sites

B100 is routinely used in more than 250 homes

Additional B100 pilots are underway in Vermont, New York, Maryland, PA, & other locations.

Renewable Diesel now getting considerable attention



RD/BD Blend Field Study

Goals:

- Demonstrate RD80/B20 and RD50/B50 blends reliably
- Identify any equipment adjustments needed.

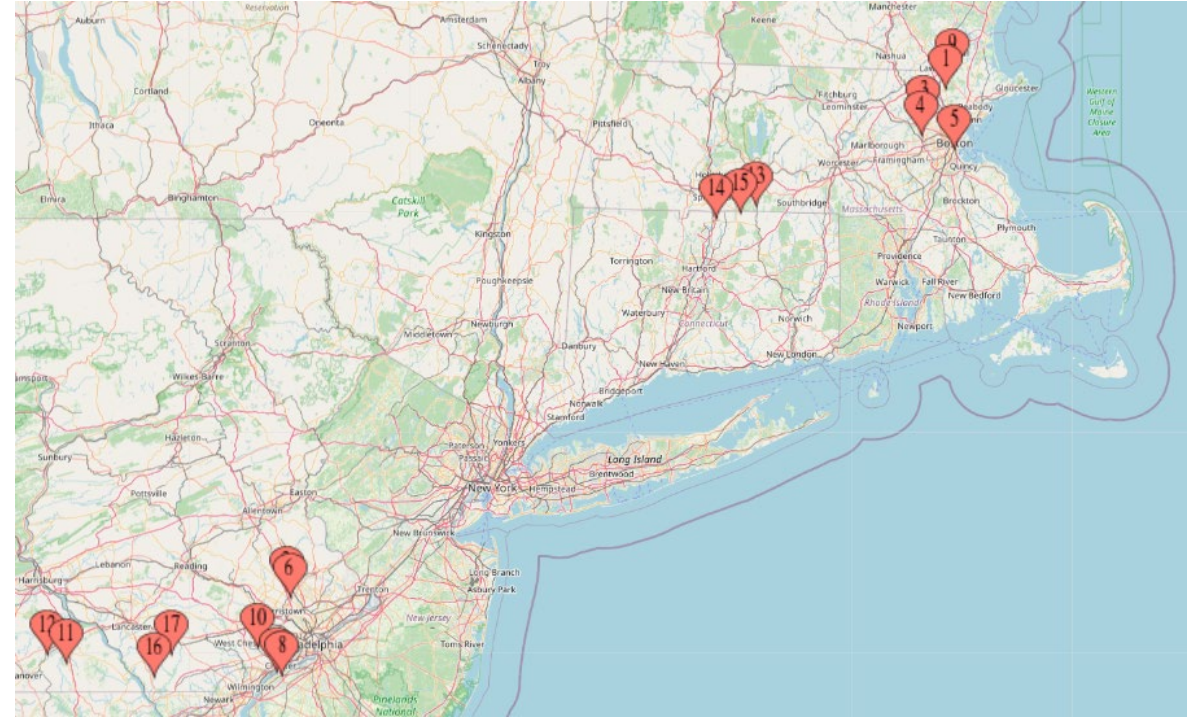
Plans:

- 121 sites in MA and PA
- Chevron supplied the fuel
- Sites divided into Level 1 (intense monitoring) & Level 2 (track service only)
- Through the 2024-2026 heating
- Target a wide variety of equipment types and manufacturers

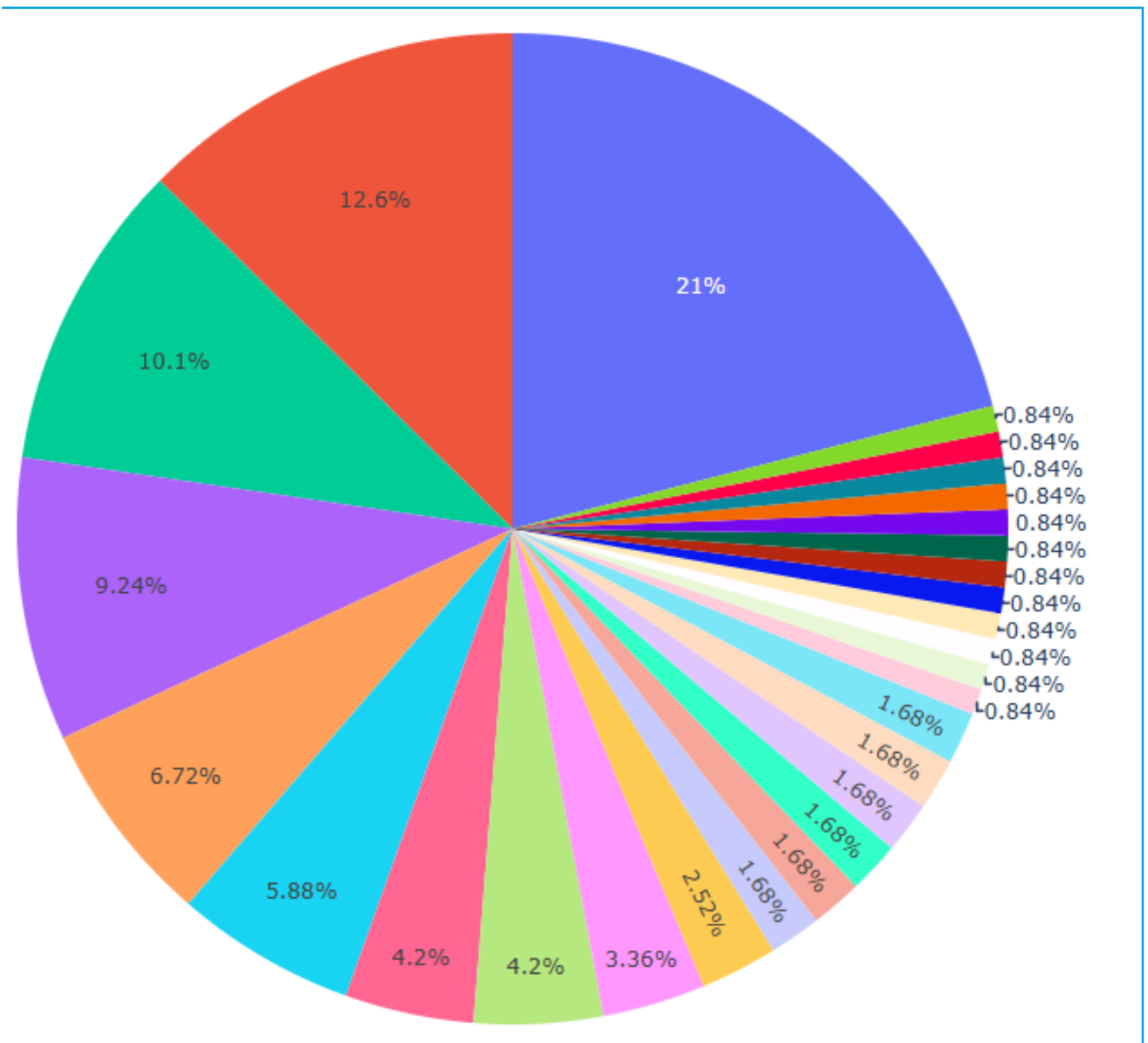


Field Study Design

- Most locations received RD80/B20; select MA sites received RD50/B50
- Sites selection emphasized finding a wide distribution of equipment:
 - 84 Boilers
 - 30 Furnaces
 - 7 Hot water heaters

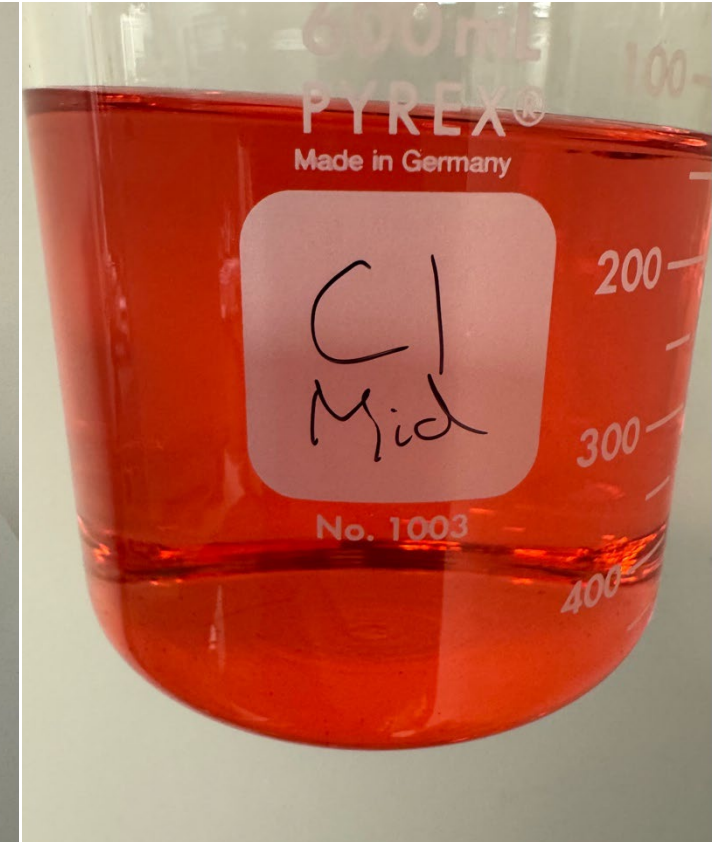


Manufacturer Distribution



Level 1 Fuel Analysis

- Oxidative Reserve
- Acid Number
- Water Content
- Biological Activity (ATP)
- Water & Sediment
- Viscosity
- Density



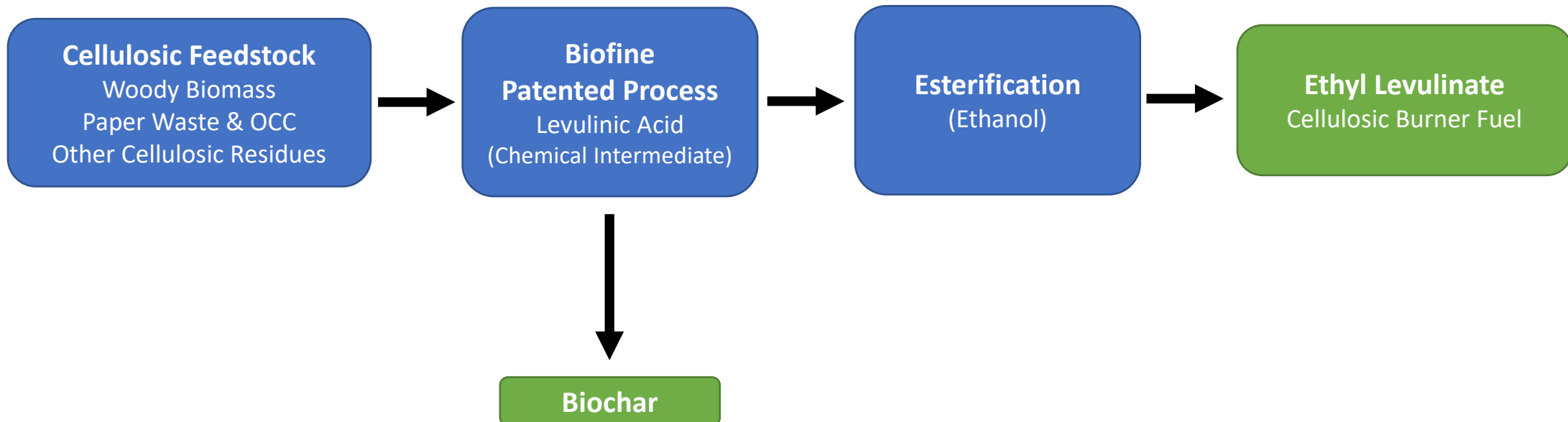
Conclusions

- Burner tuning not required;
- No increase in service required;
- Renewable fuel quality remained good throughout field operation;
- Seasonal storage affected oxidative stability and acidity, but fresh fuel restored quality.
- Storage tank condition was the dominant factor controlling:
 - water
 - sediment
 - microbial contamination
 - long-term fuel quality

The Biofine Technology

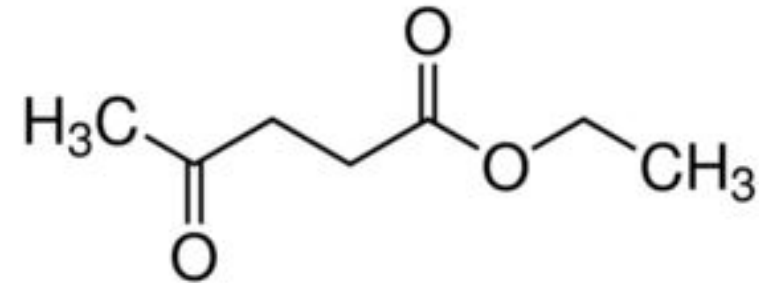


A proprietary, continuous, chemical process that enables the economic production of renewable chemicals, biochar and net-negative green-house-gas (GHG) emission biofuels from low-quality forestry waste and other cellulosic feedstocks.



Ethyl Levulinate (EL)

	Petroleum No. 2 Heating Fuel	Ethyl Levulinate (EL)
Higher Heating Value (Btu/gal)	139,000	95,500
Density (lb/gal)	7.1	8.5
C (wt %)	86.8	58.3
H (wt %)	13.2	8.3
O (wt%)	0	33.3



Freezing point < -50 C

EL Characteristics as a Burner Fuel

- Weak miscibility in petroleum;
- Good miscibility in biodiesel;
- Incompatible with common petroleum fuel elastomers;
- 8% water is solubility limit in EL;
- Freezing point -50°C;
- Good combustion performance, very low NOx.

EL Burner Fuel Development Activities

- Basic Lab Property Tests;
- Conversion of Burner Components to Compatible Elastomers (Teflon, Silicon);
- Residential and Commercial Scale Lab Combustion Tests;
- Low Blend Residential Field Test;
- EL100 Limited Residential and Commercial Field Tests;
- Development of ASTM EL Burner Fuel Specification.



Conclusions

- Heating Fuels Market is Moving Forward with Adoption of Biofuels;
- Needed Specifications and Standards Have Been Developed;
- It is a Motivated and Technically Friendly Market.