Vermont Biodiesel Project

FINAL PROJECT REPORT

**EXECUTIVE SUMMARY**

# Laboratory and Field Testing of Biodiesel in Residential Space Heating Equipment

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## 1.0 ACKNOWLEDGEMENTS

This report represents a collaborative effort between the National Oilheat Research Alliance (NORA), The Vermont Fuel Dealers Association (VFDA) the Vermont Biofuels Association (VBA), and the Vermont Sustainable Jobs Fund (VSJF).

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## 2.0 EXECUTIVE SUMMARY

The development of bio-based fuels presents an opportunity to utilize a domestically produced, more environmentally benign means of providing space heating in Vermont homes. *Bioheat* is an industry-accepted term for any blend of biodiesel (fuel derived from vegetable oil or animal fat) with conventional high- or low-sulfur petroleum home heating oil. *B20 bioheat* is a common blend of 20% biodiesel and 80% No. 2 fuel oil. This study closely examines the impact of B20 bioheat on residential oil-burning heating system performance characteristics.

Interest in bioheat continues to grow in Vermont. Fuel dealers throughout the state regularly receive inquiries from customers about this fuel and whether it might be used for heating in residential, commercial, municipal and institutional settings. At least 12 Vermont home heating fuel dealers now offer either B5 or B20 blends of bioheat. Increasing numbers of fuel dealers and their customers are exploring this fuel for several reasons, including:

- **Reduced energy dependency**. Because the vast majority of biodiesel is produced domestically, increasing its use can reduce the U.S. dependence on foreign oil sources and extend supplies of conventional (petroleum) fuel.
- **Environmental considerations**. The U.S. Environmental Protection Agency estimates that the use of B20 biodiesel reduces total hydrocarbon emissions (a major contributor to climate change) by up to 30%. In open-flame heating applications, other air emissions are reduced, as well, including $NO_x$, sulfur, smoke and particulate matter.[1]
- **Price stability**. By consuming more domestically produced biodiesel, Vermonters who use bioheat may be better insulated from the dramatic price fluctuations that have become increasingly common in the global petroleum markets.

Whatever the perceived benefits of bioheat, with increasing usage come several important questions that fall roughly into the categories of (1) fuel and equipment performance, (2) fuel supply reliability, (3) fuel cost, and (4) fuel environmental characteristics.

In the fall of 2005, the Vermont Sustainable Jobs Fund (VSJF), the Vermont Biofuels Association (VBA), and the Vermont Fuel Dealers Association (VFDA) created the Vermont Bioheat Program (VBHP) to help contribute to the understanding and acceptance of this relatively new product in the home heating fuel market. With the support of the National Oilheat Research Alliance (NORA) and the VFDA, the VBHP was designed to address questions surrounding fuel and equipment performance through a series of pilot projects and laboratory studies designed to help suppliers and users of bioheat to better understand how the fuel will perform once introduced into residential heating systems.

[1] C.R. Krishna, *Biodiesel Blends in Space Heating Equipment,* December 2001, BNL-68852.

The overarching objective of the pilot projects and laboratory studies of the Vermont Bioheat Program was to introduce bioheat as a viable source for home heating applications in Vermont. Specific VBHP research goals include:

1. Demonstrate the operational use of B20 bioheat in residential heating equipment at two laboratory locations in Vermont during the 2005-2006 heating season.
2. Demonstrate the operational use of B20 bioheat in residential settings in partnership with one or more Vermont fuel companies committed to providing B20 bioheat to their heating fuel customers during the 2005-2006 heating season.
3. Provide information to fuel distributors and service personnel on proper handling of biodiesel.
4. Document and distribute the research findings to target audiences with a stake in using bio-based heating products in the state.

Key VBHP research results indicate that there is a decrease in system combustion efficiency of up to 0.5% when B20 bioheat is used as a fuel, as compared to efficiency values when No. 2 fuel oil is used. Several performance indicators support this conclusion, including increases in net stack temperature readings, decreases in $CO_2$ emission levels, decreases in breech draft, and other factors. However, this finding does not necessarily indicate a limitation of the fuel. Because testing protocol dictated that B20 bioheat be introduced later in the heating season, it's possible that accumulated soot and scale build-up on the system heat exchangers accounts for some or all of the combustion efficiency decrease. It should be noted that most oil-burning heating systems experience a decrease in combustion efficiency over the course of a heating season as the build-up of deposits on the heat exchanger reduce its ability to absorb heat from the combustion flame.

Reduced combustion efficiency values may also be attributable to the fact that the test systems, which had been optimally tuned for the use of No. 2 fuel oil at the beginning of the season, required a re-adjustment of the fuel/air mixture to attain maximum efficiency when B20 bioheat was introduced. These findings suggest areas of further testing. Nonetheless, reduced combustion efficiency values of less than 1% are negligible in practical terms and should not discourage those considering the use of B20 bioheat.

Another key finding indicates that cad cell resistance increases by as much as 40.6% when B20 bioheat is used. This is likely attributable to the lower luminosity and different color spectrum of the B20 bioheat flame when compared to the flame produced by No. 2 fuel oil. Fuel technicians and users of B20 bioheat should be aware that higher cad cell resistances can sometimes lead to "nuisance tripping" of the burner. However, no such behavior was observed in the 26 test units included in this study.

Anecdotally, the two commercial fuel dealers that participated in this study reported no system service calls that were attributed to the use of B20 bioheat. In fact, the two participating fuel dealers had this to say about their experiences with bioheat: "*In*

*summary, we would like to say that B20 performed as well as No. 2 fuel oil in a heating application. We will recommend it to any customer currently burning No. 2 fuel oil"* and *"We were pleasantly surprised. We experienced no more problems with the boilers and furnaces at Middlebury College [using B20 bioheat] than we would expect from units running on No. 2 fuel oil."*

While there are several aspects of using B20 bioheat that warrant further research, the preliminary findings of the VBHP indicate that B20 bioheat performs as well, or nearly as well, as traditional No. 2 fuel oil in residential oil heating applications. B20 bioheat's added environmental and economic benefits suggest that this is a fuel that requires serious consideration as an alternative to traditional petroleum heating fuels.