



FINAL PROJECT REPORT

The Vermont Biodiesel Project Building Demand in the Biofuels Sector

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The Vermont Biodiesel Project is a collaboration between:

**Vermont Biofuels Association
Vermont Department of Public Service
Vermont Fuel Dealers Association
Vermont Sustainable Jobs Fund**

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Building Demand in the Biofuels Sector

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This report represents the collaborative efforts of the Vermont Biofuels Association (VBA), Vermont Fuel Dealers Association (VFDA), Vermont Sustainable Jobs Fund (VSJF), Vermont Department of Public Service (DPS), Vermont Department of Buildings and General Services (BGS), Vermont Department of Environmental Conservation (DEC) and more than a dozen private companies engaged in building the renewable fuels sector in the state.

The Vermont Biodiesel Project (VBP) was funded by a grant to DPS from the US Department of Energy State Energy Program with additional funding from the Vermont Sustainable Jobs Fund via the State of Vermont. The VBP is the first phase of the Vermont Biofuels Initiative, a public/private partnership intended to grow the biofuels sector in Vermont. We would like to thank Chuck Ross, state director from the Office of Senator Leahy, whose insights and advice helped bring this initiative and its many follow up activities to fruition. We would also like to recognize the leadership of Lt. Governor Brian Dubie for his on-going interest in biodiesel as an alternative fuel for Vermont. Special thanks to Richard Smith, Deputy Commissioner from DPS for his assistance with inter-agency coordination.

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EXECUTIVE SUMMARY

The future and security of Vermont's energy supply, coupled with concerns about economic development and environmental protection, led a group of leaders to form the Vermont Biodiesel Project (VBP). This two-year venture, funded by the US Department of Energy State Energy Program and the Vermont Sustainable Jobs Fund, set out to develop a market for biodiesel in the state through an integrated set of pilot programs and market building activities.

The VBP was a collaboration between the Vermont Biofuels Association (VBA), Vermont Fuel Dealers Association (VFDA), Vermont Sustainable Jobs Fund (VSJF), Vermont Department of Public Service (DPS), Vermont Department of Buildings and General Services (BGS), Vermont Department of Environmental Conservation (DEC) and more than a dozen private companies engaged in building the renewable fuels sector in the state. This project is the first phase of the Vermont Biofuels Initiative (VBI), a public/private partnership intended to grow the biofuels sector in Vermont that received major support from the Office of Senator Leahy.

According to the Energy Information Administration, Vermonters used more than 678 million gallons of petroleum in 2004 including 63 million gallons of diesel for transportation and over 183 million gallons for home heating, all purchased from outside the state. The premise of the VBP was that by stimulating in-state demand for biodiesel, a market would form that fuel dealers, entrepreneurs and farmers could supply with locally manufactured products.

The goal of the VBP was to create a two-year, commercial-scale program involving large buyers that would initiate local use of biodiesel for heating and fleet transportation. The project was designed to test the feasibility of using renewable fuel in institutional and commercial settings, help peers to educate one another about the fuel, and demonstrate the economic viability of biodiesel in the state's energy market.

Objective One: Build Demand – Increase demand for Vermont-provided biodiesel by organizing the commercial-scale purchase of five million gallons of domestically produced biodiesel by 2006

Objective Two: Increase Supply – Increase the supply of domestic biodiesel available from Vermont-based businesses to five million gallons over two years from a 2004 baseline of 27,000 gallons, and increase in-state biodiesel production capacity to 450,000 gallons over two years from the 2004 baseline of 2,500 gallons.

The VBP work plan consisted primarily of pilot projects and educational activities designed to inform parties interested in the use or production of biodiesel.

PILOT PROJECTS

The VBP focused on generating new knowledge in two large scale pilot projects: use of biodiesel for heating when blended with No. 6 heating oil conducted by the Vermont Department of Buildings and General Services (BGS) at their Waterbury facility; and biodiesel in snowmaking operations conducted by Smugglers' Notch Resort.

Subsequently, the partners leveraged their resources to develop an additional set of pilot projects for residential heating called the Vermont Bioheat Program. During the project duration, VSJF used its own funds to sponsor a set of small biodiesel pilot tests at the Vermont Law School for institutional heating and Sugarbush Resort for snow grooming machines.

All together, these VBP related pilot projects used more than 78,500 gallons of blended biodiesel for heating, snow making, and off-road vehicles reducing greenhouse emissions by an estimated 179 tons. All the projects used biodiesel successfully in real world conditions, thus contributing to the knowledge of how to introduce biodiesel in Vermont settings. As intended, the commercial scale demand for the product sent a market signal to suppliers who responded with biodiesel deliveries.

The BGS pilot developed detailed data that helped the state gain insights into the emissions profile of biodiesel when blended with heavy heating oil. The Smugglers' Notch project yielded specific information about how to use biodiesel in cold weather conditions for snow making. Both organizations expressed continued interest in using biodiesel in the future. The bioheat pilots generated concrete experience with fuel dealers who are beginning to sell biofuels in the residential market. The projects at Vermont Law School and Sugarbush similarly yielded information that contributed to the overall development of the market signal and distribution system.

WORKSHOPS AND EDUCATIONAL ACTIVITIES

During the project, the Vermont Biofuels Association and Vermont Fuel Dealers Association collaborated on a range of workshops that helped fuel dealers, fuel users, agricultural producers and state leaders to learn more about biodiesel. Attendance at these events totaled more than 1,000 individuals including the Governor of Vermont, fuel dealers, farmers, institutional purchasers, investors, regulators, advocacy organizations, students and citizens.

The VBP also included development of detailed case studies posted on the Vermont Biodiesel Project website (www.vtbiodieselpoint.org), surveys that helped document interest in biodiesel, and the formation of purchase/distribution networks to deliver product to customers.

PROJECT OUTCOMES

Demand for Biodiesel Established

The partners and participants of the VBP helped stimulate the consumption of 275,000 gallons of biodiesel in 2005, up from 9,000 gallons in 2003. Current projections show that more than one million gallons will be consumed in the state by the end of 2006, which is 20 percent of the project goal of five million gallons by 2006. The partners anticipate that the in-state consumption of biodiesel will rise to five million gallons by the end of 2007. Of the volume used in the state, VBP partners and participants in VBP-related pilots consumed more than 78,500 gallons of blended biodiesel.

In-State Production on the Rise

At the beginning of the VBP in 2004, in-state biodiesel production stood at 2,500 gallons and rose to 10,000 gallons in 2005. Current projections show that volume heading toward more than 50,000 gallons by the end of 2006. This volume is less than the project goal of 450,000 gallons. However, a recent announcement by a newly formed biodiesel production company shows that this volume will rise considerably in 2007.

In August 2006, Biocardel Vermont—a new joint venture between two Canadian firms—announced plans to site a biodiesel production facility in Swanton using soy oil as a feedstock to meet the emerging local biodiesel demand. The company plans to manufacture four million gallons per year initially, rising to eight million gallons in the future. The 21 anticipated jobs at Biocardel combined with the jobs that emerged in the sector since 2004 will put the VBP over its anticipated outcome of 10 new jobs in the biodiesel sector by the end of 2006. The announcement by Biocardel Vermont to produce biodiesel in the state demonstrates that the innovative Vermont Biodiesel Project market conditioning program accomplished its objectives.

Biocardel Vermont plans to produce over 4 million gallons of biodiesel in the state with 21 new jobs as a result. This decision demonstrates that the innovative Vermont Biodiesel Project market conditioning program accomplished its objectives.

Fuel Dealers are Selling Biodiesel; Farmers are Producing Oil Seed

As a result of the increased demand for biodiesel, the number of fuel dealers selling biodiesel rose from two in 2004 to 17 in 2006. In addition, several farm operations are now either producing biodiesel or exploring on-farm production of oil seed from such crops as soy, canola, sunflowers and mustard. The interest among farmers continues to grow as the economics for on-farm production become clear.

Air Pollution and Greenhouse Gas Reductions

Biodiesel yields lower atmospheric emissions of pollutants and greenhouse gases than petroleum fuels. The VBP pilot projects at Smugglers' Notch, the Vermont Department of Buildings and General Services combined with VSJF-funded biodiesel pilot projects at the Vermont Law School and Sugarbush Resort led to the reduction of an estimated 179 tons

of greenhouse gas emissions. Based on the overall use of biodiesel in the state since 2004, more than 564 tons of greenhouse gas reductions have helped the state respond to concerns about global warming.

The project participants formed what turned out to be a highly effective collaboration that fulfilled the purpose of the project. The public/private cooperation exemplified during the VBP provides a model for sustainable development for others to emulate.

FINDINGS

The Vermont Biodiesel Project generated several key findings.

Finding #1: Biodiesel Works in Vermont

The foremost finding is that biodiesel blends work in a wide variety of institutional and commercial applications in Vermont's cold climate. In the three years since project leaders began introducing biodiesel into the state, many people have experimented with the fuel to learn its properties. Biodiesel has been vetted in a wide array of uses such as snow making compressors, snow groomers, farm equipment, commercial and institutional boilers, residential heating systems, trucks and diesel cars. With the exception of the rare case where the operators did not anticipate the cleansing properties of biodiesel that moves diesel sludge from storage tanks into engines, biodiesel users report few issues with the fuel.

Finding #2: Institutional and Commercial Demand for Biodiesel Now Exists

A second key finding is that the demand for fuel from institutions and large commercial users is attracting larger volume fuel producers such as Biocardel Vermont. The market signal established by the Vermont Biodiesel Project shows that local consumers are aware of the fuel and willing to use it to meet their heating or transportation needs given that the product meets their standards for quality, reliability and affordability.

Finding #3: Biodiesel is Available in Vermont, but Not Widely

The growth of the biodiesel market is a sign of real progress. However, many parts of the state are not currently served by companies that offer biodiesel either for transportation or heating purposes.

Finding #4: The VSJF Market-Building Model Works

The VSJF market building model formed the foundation under the Vermont Biodiesel Project. This method shows that modest public investments using a strategic approach that connects purchasers with suppliers in an emerging market works. Many other aspects of the state's transitioning economy would benefit from this innovative, efficient and cooperative market-driven approach to sustainable economic development.

Finding #5: The Market is Poised for Traditional Economic Players to Enter

After three years of establishing the utility and economics of biodiesel in Vermont, it is now possible for traditional financial entities to confidently work with prospective

biodiesel producers. They now know that there is a highly networked, integrated system in place for answering their questions on biodiesel production scaled to Vermont's size.

Finding #6: Attention on Biodiesel is Growing

When the VBP began in 2003, there was little discussion about biodiesel on the state or national scene. Now, many people from the U.S. President and state legislatures down to individual users are aware of the fuel and are trying it in many applications. The increased attention is building pressure to develop effective policies that will support the sector, remove market barriers, and generate necessary investments in production and distribution infrastructure.

Finding #7: Develop Policies to Support Biofuel Production in the State

As demand for biodiesel grows, the state will need more biodiesel, both from within and outside its borders. The state needs coherent policies for biofuels production and programs designed to bring greater volumes of high quality fuel to the market place, as well as a mechanism to continually implement and evaluate the policies as conditions change. This will be a key requirement for the next level of commercial production to emerge in Vermont.

Finding #8: Focus on Biodiesel Blends that Work for the State

The Vermont Agency of Natural Resources stated that blends up to B100 can be used in direct-fired industrial or commercial boilers, and that the agency would have no objection to a small percentage of biodiesel being used in home heating oil (up to B5) until more information becomes available that supports a larger percentage. ANR also stated that for use in transportation, biodiesel blends at or below B20 present no problem from an air quality standpoint. However, the agency has questions about emissions from higher blends of biodiesel in transportation that will require further attention.

Finding #9: Further Progress Will Require Strong Leadership

The collaborative process developed by the VBP partners accelerated the advancement of a market for biodiesel in Vermont. To capitalize on these advancements and to further develop this emerging market opportunity, the state needs continued strong leadership and coordination among state agencies and between public and private partners.

Finding #10: Continued Need for the Vermont Biodiesel Project

The success of the first two years have led to many new questions and demonstrated the need for continued efforts to sharpen the economic picture for biodiesel development at the farm scale, with cooperatives, and for larger commercial-scale ventures in the state. The VBP team retains both capacity and desire to further extend the group's work into currently unexplored parts of the emerging biofuels terrain.

The full VBP report concludes with a set of recommendations for follow-up activities.

I. INTRODUCTION

Growing concern about rising oil prices, instability in the Middle East, climate change and the fate of family farms, coupled with excitement about local economic revitalization helped fuel the emerging biodiesel industry in Vermont over the past three years. These concerns and opportunities formed the starting point for a venture intended to accelerate the development of the biodiesel sector in the state.

In early 2003, the Vermont Sustainable Jobs Fund (VSJF) worked with the Office of Senator Patrick Leahy to form the Vermont Biofuels Initiative (VBI), a public/private partnership intended to build the emerging biofuels market, develop new networks in the renewable fuels sector, and invest in biodiesel production capacity and supply infrastructure in the state.

Beginning in November 2003, a partnership between VSJF, the Vermont Department of Public Service (DPS), the Vermont Biofuels Association (VBA) and the Vermont Fuel Dealers Association (VFDA) led to the Vermont Biodiesel Project (VBP). As the first component of the VBI, this two-year market conditioning program was designed to foster growth of viable biodiesel businesses in the state through education and pilot projects.

This report reviews the activities and results from the Vermont Biodiesel Project.

BACKGROUND

During the 1990's, many Vermonters began to recognize the state's vulnerable position as a major importer of goods and services, including oil from outside the state.¹ In April 2000 a group of leaders from the state's largest institutions partnered with the Vermont Sustainable Jobs Fund (VSJF) and the Office of Senator Patrick Leahy to form an import substitution project to support local, sustainable economic growth. Called the *Cornerstone Project*, this public/private partnership focused on purchasing key goods and services from Vermont businesses beginning with the forest products sector.

Upon successful demonstration of VSJF's *Cornerstone* approach with wood products, the participating institutions indicated their desire to obtain locally supplied energy—biodiesel in particular—if the market could provide quality products at affordable prices. With the interest from institutions such as the Vermont Department of Buildings and General Services, Vermont State Colleges, Middlebury College, the University of Vermont, the Vermont Law School and many others in 2003, VSJF identified a demand that would appeal to potential suppliers. In conjunction with the Office of Senator Leahy, VSJF then formed the Vermont Biofuels Initiative.

At the same time, disparate and uncoordinated activities in the nascent biodiesel sector began to emerge. For example, VSJF had made an initial grant to Dog River Alternative

¹ *The Vermont Job Gap Study, Phase 6: The Leaky Bucket*. Doug Hoffer and Ellen Kahler. July 2000.

Fuels Co. to explore the potential for biodiesel production in the state. The University of Vermont and Vermont's Alternative Energy Corporation had begun assessing the potential for biodiesel production in the state under a USDA grant. A few companies sold biodiesel in the state. Home producers were turning waste grease into fuel for their diesel vehicles and one commercial fueling operation dispensed "bio" at its pumps in Brattleboro. A new industry network, the Vermont Biofuels Association, formed in Middlebury. And Lt. Governor Dubie began extolling the virtues of biodiesel as a part of the state's emerging energy picture in his regular speeches.



Rick Fleming, President of Fleming Oil Co., Brattleboro, Vermont was one of the first to sell biodiesel in Vermont.

In November 2003, VSJF convened suppliers and potential producers of biodiesel from Vermont to discuss the prospects for a market conditioning process. Under the collaborative leadership of VSJF, the newly formed Vermont Biofuels Association (VBA), the Vermont Fuel Dealers Association (VFDA), the Department of Public Service and the Biorenewables Education Center (BEC)², the Vermont Biodiesel Project was born. The project received \$75,000 from the US Department of Energy State Energy Programs with a match of \$50,000 from VSJF via its appropriation from the Legislature in September 2004. Along with in-kind contributions from project partners, the budget stood at \$187,000.

A steering committee composed of project manager Edward Delhagen (Deputy Director, VSJF), Shane Sweet (Director, VFDA), Netaka White (Director, VBA), Sabrina Trupia (Director, BEC) plus Chris

Owen followed by Kelly Launder from the Department of Public Service led the venture. VSJF contracted with Greg Strong as project coordinator. Other participating partners included the Vermont Department of Buildings and General Services, Agency of Natural Resources Air Pollution Control Division, Smuggler's Notch Resort, Vermont State Colleges, Dog River Alternative Fuels, Global E Industries, Long Trail Biofuels, and Vermont's Alternative Energy Corporation. The VBP kicked off its work plan in October 2004 for a two-year program to jumpstart the biodiesel industry in the state. Together, this group formed what turned out to be a highly effective collaboration through which the partners achieved a wide array of outcomes.

² The Biorenewables Education Center closed in April 2005.

VERMONT'S OIL PREDICAMENT AND OPPORTUNITY

Like the rest of the nation, Vermont's annual liquid energy consumption comes from an array of sources predominantly petroleum produced out of the state's borders. Of the more than 678 million gallons of petroleum consumed in Vermont in 2004, 343 million gallons was gasoline, 63 million gallons was diesel for transportation, 183 million was heating oil with the remaining portion covering all other uses (aviation fuel, kerosene, etc.). Because of the small size of the state, Vermont ranks last among states in overall petroleum usage.³

Using September 2006 pricing of \$2.50 per gallon of diesel, 75 percent of this value, or about \$460 million left the state for crude oil and refined diesel products alone.

What would happen if Vermont developed a means to recapture a portion of the money spent on fuel that leaves the state? What kinds of economic and environmental benefits would the state enjoy by replacing a portion of petroleum distillate imports with a domestically produced biofuel?



Local canola crop grown for oil seed production; Stateline Farm, Shaftsbury, Vermont

The Vermont Biodiesel Project began with the premise that renewable biodiesel⁴ made from waste grease or crops such as canola or soy beans could be produced using the state's agricultural lands and consumed to meet a portion of the state's energy needs. Substituting one percent of the diesel and heating oil consumed in the state would require about two and a half million gallons of biodiesel (B100). Using an agricultural multiplier of 2.3 derived from a similar region in New York, biodiesel from Vermont farm producers would generate over \$14 million in economic benefit from the dollars that would be spent in the local economy. Using an employment multiplier of 1.5, every primary job created in the biofuel sector related to agricultural production has the potential to create another one and a half full time positions in the state's economy.⁵

³ Energy Information Administration, State Energy Data 2004.

⁴ *Biodiesel* is the name of a clean burning alternative fuel, produced from domestic, renewable resources including plant oils (e.g., soy oil), waste grease or animal fat. Biodiesel contains no petroleum, but it can be blended at any level with petroleum diesel to create a biodiesel blend. See *Biodiesel Basics* at the National Biodiesel Board website URL: www.nbb.org/resources/biodiesel_basics/default.shtm.

⁵ See *Economic Multipliers and the New York State Economy*, Policy Issues in Rural Land Use. Vol. 9, No. 2, Dec. 1996. Department of Agriculture, Resource and Managerial Economics: Cornell University Extension.

II. THE VERMONT BIODIESEL PROJECT

GOALS AND OBJECTIVES

As the first part of the Vermont Biofuels Initiative, the goal of the ***Vermont Biodiesel Project*** was to create a two-year, commercial-scale program involving large buyers that would initiate local use of biodiesel for heating and fleet transportation. The project was designed to test the feasibility of using renewable fuel in institutional and commercial settings, help peers to educate one another about the fuel, and demonstrate the economic viability of biodiesel in the state's energy market.

By doing so, the VBP partners envisioned a process that would establish market "pull" to which entrepreneurs could respond, thus building out the market. The partners assumed that as institutions or large businesses established commercial-scale tests, the supply side would respond by developing the infrastructure to meet fuel needs. Biodiesel education, services and products would then be made available to an increasingly wider circle of institutions and businesses to support the emerging biofuels sector.



Green Mountain Power fuels up on B20.

Specific VBP Objectives included:

Objective One: Build Demand – Increase demand for Vermont-provided biodiesel by organizing the commercial-scale purchase of five million gallons of domestic biofuels by 2006.

Objective Two: Increase Supply – Increase the supply of domestic biodiesel available from Vermont-based businesses to five million gallons over two years from a 2004 baseline of 27,000 gallons and increase in-state biodiesel production capacity to 450,000 gallons over two years from the 2004 baseline of 2,500 gallons.

To accomplish these goals and objectives, the VBP partners developed a work plan consisting of the following components:

- Biodiesel pilot projects with fuel purchase assistance in two Vermont commercial-scale facilities (Smugglers' Notch Resort and the Vermont Department of Buildings and General Services)
- Workshops and trade shows on institutional/commercial usage, agricultural supply, and related issues such as bio-based technologies and bio-refineries

- Communication of the benefits and practicalities of biodiesel usage to a range of institutional fuel users through case studies, project reporting, websites, and media coverage
- Surveys regarding attitudes toward biodiesel among stakeholders
- Emissions testing from use of biodiesel in heating and other commercial systems
- Statewide biodiesel purchase and distribution network development

In 2004, the partners leveraged their resources to develop an additional set of pilot projects for residential heating called the Vermont Bioheat Program. In addition, VSJF used its own resources in 2004 to fund a set of small biodiesel pilot tests at the Vermont Law School for institutional heating and at the Sugarbush Resort for snow grooming machines.

PROJECT OUTCOMES

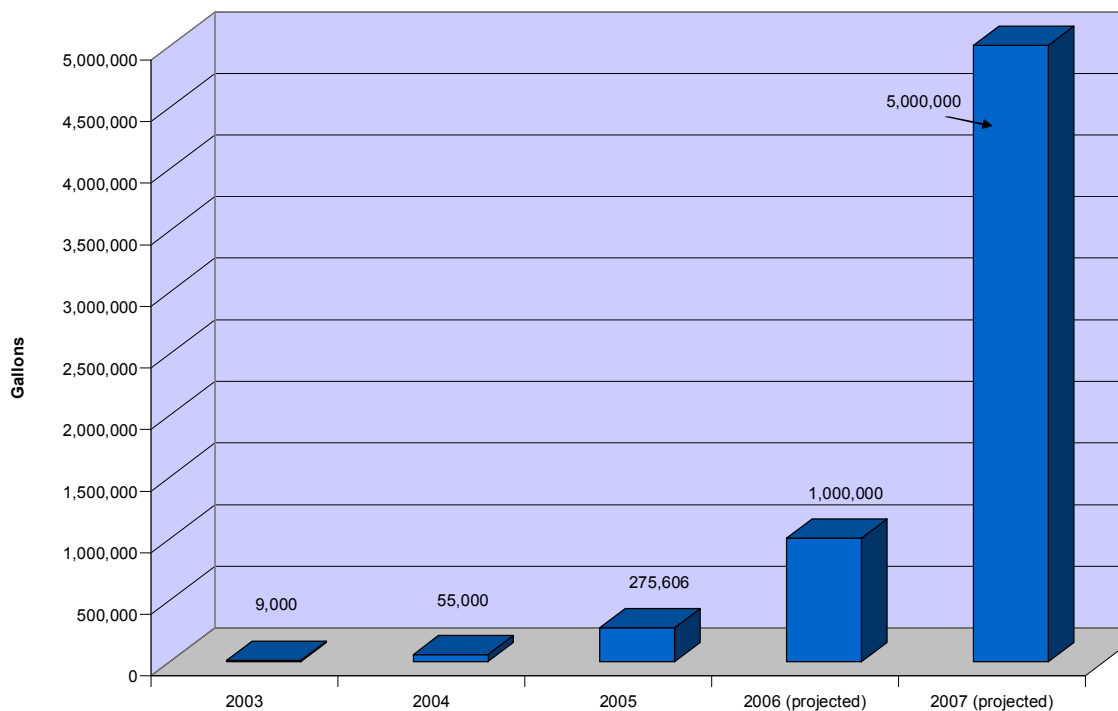
At the beginning of the project, participants anticipated a range of ambitious outcomes:

- 1) The purchase of five million gallons of domestically produced biodiesel supplied by Vermont businesses over two years from a 2004 baseline of 27,000 gallons
- 2) Increase the in-state capacity to make biodiesel to 450,000 gallons annually from the 2004 baseline of 2,500 gallons
- 3) The creation and/or retention of 10 full-time equivalent jobs in the Vermont biodiesel industry
- 4) An institutional/commercial market segment prepared to purchase locally supplied biodiesel on a commercial-scale
- 5) Vermont biodiesel suppliers prepared to serve institutional and commercial customers
- 6) Increased awareness of biodiesel among institutional stakeholders, the general public, and Vermont public officials
- 7) Improved air quality through reduced pollution and greenhouse gas emissions
- 8) Collection, analysis, and dissemination of biodiesel emissions test data

Building Biodiesel Demand (Outcome 1)

The VBP set out to stimulate the use and production of biodiesel in Vermont with ambitious targets. Consumption of biodiesel amounted to approximately 9,000 gallons in 2003 from a variety of small-scale sources (e.g., back yard production) and modest imports from commercial sources outside the state. VBP partners assumed there would be 27,000 gallons of consumption as a baseline in 2004; however the actual volume consumed that year rose to 55,000 gallons. By 2005, the aggregate in-state usage quintupled to over 275,000 gallons. The current projections show that more than one million gallons will be used in the state by the end of 2006.⁶ While this volume is only 20 percent of the initial objective for the project, the VBP partners anticipate that the volume will grow to five million gallons by the end of 2007 (see next section).

⁶ Data from the Vermont Biofuels Association, January 2006.



Consumption of Biodiesel Blends in Vermont

The VBP activities along with participants in the Vermont Bioheat Program and VSJF biodiesel pilot projects account for over 78,500 gallons of the biodiesel used from 2004 to mid year 2006. This demand contributed to the increase nation-wide demand for biodiesel over the same period.⁷

Biodiesel Supply and Production (Outcomes 1 & 2)

The initial in-state production baseline for this project was 2,500 gallons in 2004. By 2005, more than 10,000 gallons of locally produced biodiesel had entered the market, primarily for off-road vehicle use or heating. Preliminary data for 2006 show the level of in-state production heading toward 50,000 gallons of B100 with the potential to go much higher in the years to come. This volume was less than the 450,000 gallons of in-state production anticipated by August 2006, but still presented a measurable supply.

With demand on the rise in the state, a new commercial joint venture of two Quebec firms named ***Biocardel Vermont*** is planning to open the state's first large scale commercial biodiesel plant in Swanton, Vermont. On July 28th, 2006 the Vermont Economic Development Agency approved a \$645,355 loan to Biocardel Vermont to construct their

⁷ National Biodiesel Board: URL: www.nbb.org/pdf_files/fuelfactsheets/Production_Graph_Slide.pdf
 Figures from the National Biodiesel Board show that annual production of domestic biodiesel grew from 20 million gallons in 2003 to 75 million gallons in 2005

facility that will use soy bean oil as a biodiesel feedstock to meet local demand.⁸ The company intends to import oil from Canada initially, with Vermont farmers given the opportunity to supply oil at a later date. Subsequently, the company received \$534,522 in tax credits authorized by the Vermont Economic Progress Council.⁹ Representatives from the business indicated that biodiesel demand is a key factor in their decision about where to locate. Assuming the company receives the required permits, the facility will begin producing four million gallons per year in 2007 rising to eight million gallons over time.

The entrance of Biocardel is a clear indication that the demand exists for the company's product. Biocardel is the first among a growing list of potential suppliers interested in meeting the demand developed via the VBP.

New Jobs in Biodiesel (Outcome 3)

Biocardel intends to employ 21 workers.¹⁰ These jobs combined with the others that emerged in the sector since 2004 will put the VBP well over its goal of 10 new jobs by 2006. Using the economic multipliers for agriculture described previously, the primary employment in biodiesel production has the potential to yield more than 30 additional jobs in agriculture and other related sectors. Clearly, the VBP intent to build demand for biodiesel leading to new in-state production and employment has been fulfilled.

Institutions Prepared to Use Biodiesel (Outcome 4)

The Department of Buildings and General Services and Smugglers' Notch used about 12,125 gallons of commercial B100 during their pilots. These partners along with the Vermont Law School, Sugarbush Resort, and the fuel dealers (e.g., Patterson) involved with the bioheat program consumed over 22,000 gallons of B100 (see Table One). These institutions developed the systems, capacity and leadership needed to introduce a new product into on-going operations. The fact that none of the pilot projects sponsored by the VBP encountered any substantive difficulties points to the level of preparedness at each institution.

The VBP outreach activities conducted by VBA and VFDA reached a wider group of Vermonters than the formal pilot projects. Given the range of workshop participants, many other organizations learned how to use biodiesel, and who to contact for answers to questions leading up to introduction of the fuel into a system.

⁸ *Firm Ponders Biodiesel Fuel Plant for State*, Brattleboro Reformer, Tuesday, August 15, 2006. URL: www.reformer.com/headlines/ci_4183275

⁹ *Governor Douglas Welcomes Biocardel Vermont Biodiesel Plant*. Press Release, Office of Governor Douglas, State of Vermont. September 7, 2006. URL: <http://www.vermont.gov/tools/whatsnew2/index.php?topic=GovPressReleases&id=2065&v=Article>

¹⁰ *Canadian companies hope to build biodiesel plant in Vermont*, Vermont Public Radio, August 29, 2006. URL: www.publicbroadcasting.net/vpr/news.newsmain?action=article&ARTICLE_ID=960495

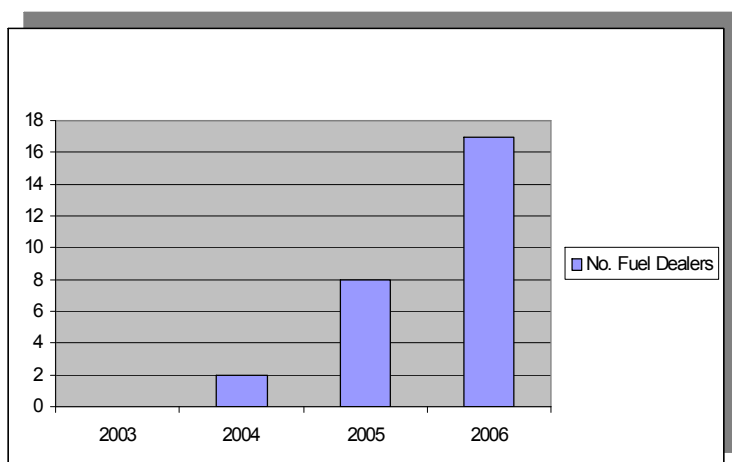
Table One: Vermont Biodiesel Project Fuel Use

VBP Pilot User	Bio-blend (gallons)*	Blend (Bx%)	Conversion: B100
BGS			
<i>Brattleboro Office (No.2)</i>	3,000	46.7	1,401
<i>Brattleboro Office (No.2)</i>	984	100	984
<i>Brattleboro Office (No.2)</i>	1,200	100	1,200
<i>Waterbury Powerhouse (No. 6)</i>	695	100	695
<i>Waterbury Powerhouse (No. 6)</i>	920	100	920
<i>Waterbury Powerhouse (No. 6)</i>	2,426	100	2,426
Smugglers' Notch Resort	22,500	20	4,500
Patterson (Bioheat Program)	5,000	20	1,000
Champlain Valley Plumbing and Heating (Bioheat Program)	15,000	20	3,000
Sub-Total	51,725		16,126
VSJF Pilots			
Vermont Law School	10902	20	2,180
Vermont Law School	900	100	900
Sugarbush Resort	15006	20	3,001
Sub-Total	26,808		6,081
TOTAL	78,533		22,207

* Volumes as reported by end users.

Commercial Sector Development (Outcome 5)

When the VBP began, there were only two commercial fuel dealers selling biodiesel in the form of B100 and B20 for the on-road market in Vermont. This changed dramatically during the course of the VBP. The pilots at BGS and Smugglers' Notch Resort, Sugarbush



Fuel Dealers Selling Biodiesel in Vermont (Source: VBA)

Resort, the Vermont Law School, and the bioheat program participants helped expand the number of fuel dealers selling biodiesel from two to 17. This total includes several of the state's largest fuel dealers such as Champlain Oil Company, Jack F. Corse, Inc., Fleming Oil and the Evans Group of Vermont. In addition, several farm operations are now exploring on-farm production of oil seed from

such crops as soy, canola, flax, sunflowers and mustard. With funding provided by Senator Leahy through the Vermont Biofuels Initiative, the University of Vermont is working with farmers to clarify the economics of oil seed production in the state. As the economic case for oil seed and biodiesel production solidifies, this new farm activity will expand the potential of the biodiesel sector.

Education Leads to Public Awareness and Acceptance (Outcomes 4,5 & 6)

WORKSHOPS

One of the key goals for the VBP was to help companies interested in selling biodiesel or bioheat to learn about the fuel. The Vermont Biofuels Association and Vermont Fuel Dealers Association collaborated to lead more than a dozen workshops and two trade shows during the period of the project for a variety of audiences. Attendance at these events totaled more than 1,000 individuals including the Governor of Vermont, the Office of Senator Leahy, fuel dealers, farmers, institutional purchasers, investors, regulators, advocacy organizations, students and citizens. Events included:

- Agency of Transportation central garage training
- The 1st and 2nd Annual Biodiesel Workshops including sessions designed for fuel users, farmers, producers and suppliers tracks
- Bio-based Products Workshop
- Renewable Energy Vermont's Annual Conference
- Agriculture and the Environment Conference (sponsored by the VT Environmental Consortium)
- Presentations at the Rutland and Grand Isle Conservation Districts
- Vermont Fuel Dealers Association oil heat service technicians workshop
- Biodiesel workshops at Solarfest
- Biodiesel seminars for fuel dealers, purchasers, and Vermont Highway and Road Supervisors
- Northeast Organic Farmers Association workshop
- Annual Spring Conference for the Vermont Fuel Dealers Association

The breadth and scope of workshops conducted by the VBA and VFDA for these respective audiences reflects the partners' awareness that peer-to-peer learning provides the quickest route for fuel users and sellers to educate one another. By tapping the experience of people interested in piloting the use of biodiesel in a variety of settings, these two partners succeeded in rapidly spreading the word about biodiesel in fleets, oil heat systems, off-road vehicles, and farm equipment.



Vermont Biodiesel Workshop at Vermont Law School, June 2006.

The VBP built explicit links between fuel users—the demand side—and biodiesel suppliers. The project created feedback loops that allowed both sets of interests to learn about biodiesel availability, performance in various equipment, warranty issues, reliability, cold weather storage, regulatory issues, farm production, blending and delivery, and many other key concerns. The hallmark of these workshops was the attention paid to the needs of both biodiesel or bioheat users and fuel suppliers. When issues came up with one set of audiences (e.g., questions about the performance of biodiesel in large machinery), the VBP was able to connect users with one another to share their experiences. The lessons learned in one arena were transferred to others, which enabled customers to gain confidence in biodiesel and the companies that offered the product.

CASE STUDIES

To better understand the trends and opportunities occurring within the industry, the VBP documented key lessons learned by early adopters in the Vermont biodiesel sector. The case studies profile individuals and businesses from four distinct but related groups; biodiesel entrepreneurs, fuel dealers, commercial scale users of biodiesel, and members of the agricultural community.

These case studies have been instrumental in providing the VBP with valuable information to gauge progress, assess emerging development needs, and inspire others who are considering entering this growing market.

The following case study reports have been organized by market group and are available in narrative format at the VBP website (www.vtbiodieselproject.org):

Agriculture

- Cate Farm, Plainfield
- Ekolott Farm, Newbury
- Borderview Farm, Alburgh
- State Line Farm, Shaftsbury
- Foster Farm, Middlebury

Commercial Users

- Green Mountain Power, Colchester
- Town of Norwich
- Smuggler's Notch Resort, Cambridge
- Sugarbush Resort, Warren
- Vermont Dept. Buildings & General Services, Montpelier

Entrepreneurs

- Algaepower, Montpelier
- BioQuantum, Inc., White River Jct.
- Dog River Alternative Fuels, LLC, Berlin
- Green Technologies, LLC. Winooski

Fuel Dealers

- Champlain Oil Company, S. Burlington
- Fleming Oil Company, Brattleboro
- Jack F. Corse Inc., Cambridge
- Patterson Fuels, Richmond

Surveying the Public (Outcome 6)

The VBP conducted a set of surveys in 2005-2006 to assess interest in biodiesel. The target audiences included customers of Vermont Fuel Dealers Association members, the Vermont Sugar Makers Association, and the general public. While not set up to be statistically valid due to cost constraints, the surveys revealed a high level of awareness in the marketplace about the fuel. Respondents completed a total of 228 surveys in 2005.

- 95 percent of the respondents knew what biodiesel was in 2005.
- Most of the respondents (82 percent) use between 500 and 5,000 gallons of No.2 oil for home heating annually.
- 39 percent of the respondents already use biodiesel.
- 156 respondents indicated interest in buying biodiesel, 67 remained undecided, and two were uninterested.
- When asked what factors were important when making fuel choices, environmental impact rated the highest (187), followed by energy independence (172), benefits to the local economy (167), price (123), improved equipment performance (111) and convenience (96).
- Fuel users indicated a preference for home delivery (169) and availability within a five-mile radius (146) as key factors.

The data show that many customers had learned about biodiesel by 2005 and were using the product. The fact that most of the fuel dealers who now sell biodiesel began to offer the product in the second year of the VBP indicates that they perceived an adequate market into which they could offer a biodiesel product. The fact that most respondents placed environmental attributes and energy independence as key factors in their thinking may reflect that the audience was already predisposed to the potential benefits of biodiesel. Given the fact that the survey was not designed to be statistically significant, the data suggest that it would be beneficial to conduct a random survey to further establish the awareness of biodiesel and determine what new information and services will be the most essential.

Air Pollutants and Greenhouse Gas Reductions (Outcomes 7 & 8)

The National Biodiesel Board provides the following information about biodiesel's environmental impacts:

"Biodiesel is the only alternative fuel to have fully completed the Tier 2 health effects testing requirements of the Clean Air Act specified by the US EPA. The use of biodiesel in a conventional diesel engine results in substantial reduction of unburned hydrocarbons, carbon monoxide and particulate matter compared to emissions from diesel fuel. In addition, the exhaust emissions of sulfur oxides and sulfates (major components of acid rain) from biodiesel are essentially eliminated compared to diesel.

“Of the major exhaust pollutants, both unburned hydrocarbons and nitrogen oxides are ozone or smog forming precursors. The use of biodiesel results in a substantial reduction of unburned hydrocarbons. Emissions of nitrogen oxides are either slightly reduced or slightly increased depending on the duty cycle of the engine and testing methods used. Based on engine testing, using the most stringent emissions testing protocols required by EPA for certification of fuels or fuel additives in the US, the overall ozone forming potential of the speciated hydrocarbon emissions from biodiesel was nearly 50 percent less than that measured for diesel fuel.”¹¹

A 1998 biodiesel life cycle study sponsored jointly by the US Department of Energy and the US Department of Agriculture concluded that biodiesel reduces net CO₂ emissions by 78 percent compared to petroleum diesel.¹² Unlike petroleum, which contains carbon from plant matter locked under ground millions of years ago, biodiesel is a renewable resource produced from plant matter that uses current solar gain to store energy. Plants absorb carbon through photosynthesis then release it when plant matter (e.g., biodiesel) is burned. Thus, biodiesel is essentially a carbon neutral fuel.

Consequently, the pilot projects had direct and measurable greenhouse gas emissions reductions. Using data established by US EPA, the pilot activities used 22,207 gallons of B100, which translates into an estimated **179 tons of avoided greenhouse gas emissions**.¹³ Based on an estimated 350 thousand gallons of biodiesel blends consumed in Vermont during the two year project period, **biodiesel users reduced greenhouse gas emissions by 564 tons**. Although this is a tiny portion of the state's overall greenhouse gas contribution (estimated at 7 million metric tons carbon equivalent¹⁴), it demonstrates the potential for greenhouse gas reductions from investments that harness the power of the market.

Unfortunately, the project's human health impact assessment was not completed within the time line of the project. This phase of the work, conducted at Smugglers' Notch, will resume in 2007 and detail the improvements in human health risk due to the decreased volumes of hazardous constituents in diesel emissions from the use of biodiesel in snow compressors. Should this be the case, these data will lend another reason to why consumers and the State of Vermont should expand the biodiesel market.

¹¹ *Biodiesel FAQ Sheet*, National Biodiesel Board. URL: www.biodiesel.org/resources/faqs/default.shtm

¹² *Life Cycle Inventory of Biodiesel and Petroleum Diesel for Use in an Urban Bus*. USDA and US DOE. 1998 URL: www.nrel.gov/docs/legosti/fy98/24089.pdf#search=%22biodiesel%20lifecycle%20study%201998%20%22USDA%22%22

¹³ Estimated using the Emissions Calculator based on US EPA data, National Biodiesel Board: URL: [www.biodiesel.org/\(X\(1\)S\(xgzeueqwdyxkfgqc1tw1pj45\)\)/tools/calculator/default.aspx?AspxAutoDetectCookieSupport=1](http://www.biodiesel.org/(X(1)S(xgzeueqwdyxkfgqc1tw1pj45))/tools/calculator/default.aspx?AspxAutoDetectCookieSupport=1)

¹⁴ Vermont Fuel Use: US Department of Energy, Energy Information Administration. URL: www.eia.doe.gov/emeu/states/sep_use/total/pdf/use_vt.pdf; Fuel coefficients: see URL: www.eia.doe.gov/oiaf/1605/coefficients.html

PILOT PROJECTS: LEADERS STEPPING UP TO THE PLATE

VBP pilot projects at Smugglers' Notch Resort and the Department of Buildings and General Services coupled with the VSJF pilots at Sugarbush and Vermont Law School created a dialogue based on experience with biodiesel and bioheat. The subsequent Vermont Bioheat Program expanded the reach of the VBP by conducting tests in the residential sector.

Early in the VBP, staff from the Air Pollution Control Division of the Department of Environmental Conservation (DEC) raised concerns about the emissions from biodiesel in transportation. Data from the US EPA indicated that while pollutants such as sulfur dioxide and particulates decrease with use of biodiesel, nitrogen oxides presented a mixed picture.¹⁵ Under the testing performed by the EPA, use of biodiesel in diesel engines registered increases in NO_x emissions.¹⁶

At the beginning of the project, DEC officials agreed that use of biodiesel in heating applications would not create increases in NO_x. Others outside the project, however, continued to use biodiesel in transportation settings. The partners realized that state and federal governments would need to address issues related to NO_x emissions from transportation both within and beyond Vermont's borders. The VBP was given clearance by staff from the DEC to conduct tests with blends up to 20 percent biodiesel (B20) in non-transportation applications.

At the end of the project, DEC officials reiterated their concern for biodiesel blends above B20 for use in transportation, but stated that biodiesel blends at or below B20 present no problem from an air quality standpoint. ANR also stated that blends up to B100 can be used in direct-fired industrial or commercial boilers, and that until more information becomes available that supports higher percentages, the agency would have no objection to a small percentage of biodiesel being used in home heating oil (i.e., up to B5).¹⁷

Pilot #1: Smugglers' Notch

The first large volume test entailed use of biodiesel at Smugglers' Notch Resort, which is a year-round facility comprised of three interconnected mountains with snow making on 62 percent of the terrain. This pilot was designed to establish biodiesel performance in snow making compressors during winter under field conditions, and better understand its emissions profile.

Under the leadership of Tom McGrail, environmental compliance manager from Smugglers' Notch Resort, a team worked with Pat Mayo from the Jack F. Corse, Inc. fuel

¹⁵ See *A Comprehensive Analysis of Biodiesel Impacts on Exhaust Emissions*. US EPA 2002. EPA420-P-02-001. URL: www.epa.gov/otaq/models/analysis/biodsl/p02001.pdf

¹⁶ Subsequent analysis by DOE indicates that NO_x emissions from biodiesel vary depending on the type of diesel engine and how the emission testing is conducted. See: *Effects of Biodiesel on NO_x Emissions*. Bob McCormick, National Renewable Energy Lab. URL: www.nrel.gov/vehiclesandfuels/nrbf/pdfs/38296.pdf

¹⁷ Email correspondence from Jeff Wennberg, Commissioner, Department of Environmental Conservation. October 16 & 17, 2006.

dealership to develop the pilot testing program. The year round resort wanted to increase its familiarity with biodiesel delivery, storage and handling; learn about maintenance issues associated with biodiesel; learn about changes in emissions; and generate positive public impressions about the company's efforts to reduce greenhouse gases.

Like other pilot projects around the country, the resort's early trials with tractors, back hoes and other heavy equipment indicated that the company could obtain biodiesel and use it reliably in this set of machinery. Using biodiesel to run key snow making apparatus with its potential to gel in cold conditions required additional levels of planning. McGrail's team developed a set of contingency plans and spoke with the owners of the compressors that lease to Smugglers. They also set up emissions tests to determine exposures to various pollutants by employees who work around the compressors.



Netaka White, Terry Wescom, and Tom McGrail (L-R) filling a front-loader with B20 at Smugglers' Notch Resort.

The snow making equipment consists of 14 Atlas Copco compressors with 400 hp Detroit Diesel generators that burn approximately 230,000 gallons of petroleum diesel during the snow making season. The project managers had no difficulty obtaining biodiesel from the local fuel dealer. However, the fuel dealer did have occasional difficulty obtaining biodiesel from their supplier due to shortages in Montreal at the time. The resort used 22,500 gallons of B20 during its pilot. The VBP offset a portion of the added fuel costs with a grant of \$5,000.

The grounds managers and fuel technicians reported that the experience was "very positive," that they did not experience any failures, and that the equipment runs better on biodiesel than on straight diesel. The only significant issue that emerged was with sludge deposits that had previously accumulated in their storage tanks from storing regular diesel. Biodiesel, which acts as a detergent, can move sludge into fuel lines where it can block fuel filters and nozzles. The Resort staff prepared for this issue and replaced fuel filters as needed. Once the sludge was cleaned from a system, it no longer posed a problem.

The pilot air emissions component was designed in conjunction with researchers from Keene State University who intended to help quantify occupational health exposures to emission from diesel exhaust near the compressors. Under the direction of Melinda Treadwell, the research team successfully conducted baseline tests in January 2006. However, warm weather and logistical difficulties precluded completion of the biodiesel portion of the emissions evaluation. The team intends to return during the 2007 ski season to finalize the biodiesel analysis, and will subsequently report their findings.

As a result of the positive experience with biodiesel at Smugglers' Notch, the resort management intends to continue using biodiesel. This pilot project used the demand from

one large user to make it possible for the local fuel dealer to enter the biodiesel market. As a result of the experiences selling biodiesel products to Smugglers' Notch, Jack F. Corse Inc. now markets biodiesel to others in the Lamoille County region.

Pilot #2: Department of Buildings and General Services

As the state's purchasing agent and keeper of properties, BGS plays a major role in piloting new products or processes for the state. BGS' commitment to supporting the local economy stretches back many years, including the department's commitment to supporting local forest products through the Cornerstone Project. As a Cornerstone partner and a state agency charged with reducing green house gas emissions per the state's Climate Change Action Plan enacted by Executive Order 10-28, BGS stepped forward to pilot the use of biodiesel in state facilities.

BGS maintains offices in Montpelier, Waterbury, Brattleboro and over 100 other locations around the state. In FY03, the state used 170,000 gallons of No.2 heating oil statewide in about 300 buildings. The Montpelier complex used 250,000 gallons of No.6 heating oil and the Waterbury offices used another 300,000 gallons. The pilot project manager, Teigh Southworth from BGS, chose the Waterbury complex for testing biodiesel since this one facility alone would consume a significant amount of fuel, had redundant fuel systems and boilers, and would require considerably less logistical hassle in getting the fuel to the facility.

When BGS could find no information on commercial applications of biodiesel with No.6 heating oil, the staff decided to focus the state's project on this heavy grade fuel. The fact that the powerhouse at the Waterbury complex could easily be modified to facilitate emissions testing further augmented the decision by BGS to use this facility.

In addition to determining the performance of biodiesel with No.6 heating oil, this pilot project also intended to establish pollution profiles. In consultation with the Air Pollution Control Division of DEC, BGS designed a pilot program using standard US EPA testing protocols and contracted with Air Quality Testing Services (AQTS) from Essex Junction to study carbon monoxide, nitrogen oxides, and sulfur dioxide emissions.

The pilot project consisted of testing straight No.6 and blends of B5, B10 and B20 in the industrial boilers of the powerhouse. This facility provides steam to about 600,000 sq. ft. of building space throughout the winter. The steam is used for space heating, domestic hot water production, in autoclaves in laboratories, and in the kitchen for cooking. The powerhouse consists of two No.6 oil fired B&W BHP watertube boilers, a 400 BHP woodchip fired IBC firetube boiler, and a 125 BHP No.2 oil fired Hurst scotch marine summer boiler. BGS conducted the tests beginning with the baseline test on February 7th and concluded with B20 on February 21st, 2006. BGS took samples at each of the dilutions and sent them to a laboratory to determine each sample's composition. Delivery and blending of biodiesel was coordinated with No. 6 deliveries to ensure the correct dilution at all times. Table 2 provides the data from the tests.

Table 2: Summary of Test Results on No.6 Oil and Biodiesel Blends

Test	Method	No.6 Oil Result	B5 Result	B10 Result	B20 Result	Units
Gravity °API @ 60°F	ASTM D-4052	12.4	12.4	14	15.6	@60 °F
Sulfur	ASTM D-4294	1.83	1.86	1.64	1.5	Wt%
Viscosity, Kin @ 122.0°	ASTM D-445	416.6	273.8	164.9	81.23	cSt
Viscosity, SFS @ 122.0	ASTM D-2161	196.8	129.5	78.5	40.1	Sec
Nitrogen	ASTM D-5762	3402	3531	2881	2795	ppm
B.T.U. Value (Gross)	ASTM D-240	18333	18259	18353	18223	Btu/lb
B.T.U. Value (Gross)	ASTM D-240	150129	149523	148641	145984	Btu/gal
Ultimate Analysis						
Carbon	ASTM D-5291	86.88	86.28	86.09	85.06	Wt%
Hydrogen	ASTM D-5291	10.58	10.5	10.31	10.64	Wt%
Oxygen	calculation	0.36	1.05	1.76	2.47	Wt%

Air Quality Testing Services Emissions Tests Results:						
NO _x		126.9	134.9	122.9	124.5	ppm
Emission Rate		0.403	0.314	0.313	0.274	lb/MMBtu
CO		329.6	139.1	160.9	122.8	ppm
Bias Adjusted		304.7	114.2	135.8	97.9	ppm
Emission Rate		0.594	0.163	0.212	0.132	lb/MMBtu
SO ₂		383.1	484.2	472.9	509.4	ppm
Emission Rate		1.691	1.568	1.672	1.557	lb/MMBtu

The test results indicate three key findings:

1. The emissions rates for nitrogen oxides and carbon monoxide dropped as the concentration of biodiesel increased.
2. The amount of sulfur in the fuel mix dropped markedly as biodiesel concentration increased; however this did not translate into changes in sulfur emissions rates, which stayed relatively constant.
3. Boilers required less maintenance after using blended biodiesel.

Due to funding constraints, the pilot project did not measure particulate matter—another key pollutant. The data suggest that biodiesel leads to a more efficient burn, thus reducing the amount of particulates in the emissions but increasing the concentration of sulfur dioxide even as the overall amount of sulfur in the fuel dropped. The project left some key questions unanswered, such as changes in particulate concentrations. These questions can form the basis for future analysis to further develop our understanding of biodiesel.

From a practical point of view, the BGS project demonstrated the viability of using biodiesel mixed with No.6 fuel oil. The equipment showed no operational issues and functioned without any noticeable problems. The benefits of using biodiesel mixed with No.6 oil include easier measurement of fuel in tanks, easier routine cleaning of the burners and strainers, lower emissions, and reduction of fossil CO₂ emitted. The only apparent

downside to burning biodiesel blended with No.6 oil currently is the cost of the fuel, which remains more expensive than straight No.6 fuel oil.

For the complete BGS pilot project report, see *Emissions Testing of Biodiesel Blends with No.6 Fuel Oil*, Vermont Department of Buildings and General Services (September 2006).

Pilot #3: Vermont Bioheat Program

In 2005, the VBP partners expanded their efforts to build markets for biodiesel. In the fall, the Vermont Biofuels Association, Vermont Fuel Dealers Association and the Vermont Sustainable Jobs Fund created the Vermont Bioheat Program (VBHP). *Bioheat* is an industry-accepted term for any blend of pure, plant-derived biodiesel with conventional high- or low-sulfur petroleum home heating oil. *B20 bioheat* is a common blend of 20 percent biodiesel and 80 percent No.2 fuel oil.

This venture leveraged the resources of the Vermont Biodiesel Project and contributed to the understanding and acceptance of this relatively new product entry 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 better understand how the fuel will perform once introduced into residential heating systems. Success in showing how to use bioheat further contributed to achieving the goals of the VBP.

The development of bio-based fuels presents an opportunity to utilize a domestically produced, more environmentally benign means of home heating. During the course of the VBP, Vermont fuel dealers received 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 various 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.
- **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 percent. In open-flame heating applications, other air emissions are reduced, as well, including NO_x, sulfur, smoke and particulate matter.¹⁸
- **Price Stability** – Assuming that domestically produced bioheat customers can obtain the product via contracts, the bio portion may better insulate consumers from price fluctuations associated with pure petroleum fuels.

¹⁸ C.R. Krishna, *Biodiesel Blends in Space Heating Equipment*, December 2001, BNL-68852.

With increasing usage comes several important questions regarding fuel and equipment performance, supply reliability, cost and environmental characteristics.

The objective of the VBHP was to introduce bioheat as a viable source for home heating applications in Vermont. Specific VBHP research goals included:

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 0.7 percent 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, reductions in CO₂ 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 is possible that accumulated soot and scale build-up on the system heat exchangers accounts for some or all of the drop in combustion efficiency.¹⁹

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 for further testing. Nonetheless, reduced combustion efficiency values of less than one percent 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 percent when B20 bioheat is used. Cad cells are electronic sensing devices that shut burners off under certain conditions. The higher resistance 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

¹⁹ 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.

burner. However, no such behavior was observed in the 19 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.

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.

For the complete report, see *Laboratory and Field Testing of Biodiesel in Residential Space Heating Equipment* Final Project Report, Vermont Bioheat Project, Vermont Biofuels Association (September 2006).

III. FINDINGS

The Vermont Biodiesel Project generated several key findings.

Finding #1: Biodiesel Works in Vermont

The foremost finding is that biodiesel blends work in a wide variety of institutional and commercial applications in Vermont's cold climate. In the three years since project leaders began introducing biodiesel into the state, many people have experimented with the fuel to learn its properties. Biodiesel has been vetted in a wide array of uses such as snow making compressors, snow groomers, farm equipment, commercial and institutional boilers, residential heating systems, trucks and diesel cars. With the exception of the rare case where the operators did not anticipate the cleansing properties of biodiesel that moves diesel sludge from storage tanks into engines, biodiesel users report few issues with the fuel.

Finding #2: Institutional and Commercial Demand for Biodiesel Now Exists

A second key finding is that the demand for fuel from institutions and large commercial users is attracting larger volume fuel producers such as Biocardel Vermont. The market signal established by the Vermont Biodiesel Project shows that local consumers are aware of the fuel and willing to use it to meet their heating or transportation needs given that the product meets their standards for quality, reliability and affordability.

Finding #3: Biodiesel is Available in Vermont, but Not Widely

The growth of the biodiesel market is a sign of real progress. However, many parts of the state are not currently served by companies that offer biodiesel either for transportation or heating purposes.

Finding #4: The VSJF Market-Building Model Works

The VSJF market building model formed the foundation under the Vermont Biodiesel Project. This method shows that modest public investments using a strategic approach that connects purchasers with suppliers in an emerging market works. Many other aspects of the state's transitioning economy would benefit from this innovative, efficient and cooperative market-driven approach to sustainable economic development.

Finding #5: The Market is Poised for Traditional Economic Players to Enter

After three years of establishing the utility and economics of biodiesel in Vermont, it is now possible for traditional financial entities to confidently work with prospective biodiesel producers. They now know that there is a highly networked, integrated system in place for answering their questions on biodiesel production scaled to Vermont's size.

Finding #6: Attention on Biodiesel is Growing

When the VBP began in 2003, there was little discussion about biodiesel on the state or national scene. Now, many people from the U.S. President and state legislatures down to individual users are aware of the fuel and are trying it in many applications. The increased attention is building pressure to develop effective policies that will support the sector, remove market barriers, and generate necessary investments in production and distribution infrastructure.

Finding #7: Develop Policies to Support Biofuel Production in the State

As demand for biodiesel grows, the state will need more biodiesel, both from within and outside its borders. The state needs coherent policies for biofuels production and programs designed to bring greater volumes of high quality fuel to the market place, as well as a mechanism to continually implement and evaluate the policies as conditions change. This will be a key requirement for the next level of commercial production to emerge in Vermont.

Finding #8: Focus on Biodiesel Blends that Work for the State

The Vermont Agency of Natural Resources stated that blends up to B100 can be used in direct-fired industrial or commercial boilers, and that the agency would have no objection to a small percentage of biodiesel being used in home heating oil (up to B5) until more information becomes available that supports a larger percentage. ANR also stated that for use in transportation, biodiesel blends at or below B20 present no problem from an air quality standpoint. However, the agency has questions about emissions from higher blends of biodiesel in transportation that will require further attention.

Finding #9: Further Progress Will Require Strong Leadership

The collaborative process developed by the VBP partners accelerated the advancement of a market for biodiesel in Vermont. To capitalize on these advancements and to further

develop this emerging market opportunity, the state needs continued strong leadership and coordination among state agencies and between public and private partners.

Finding #10: Continued Need for the Vermont Biodiesel Project

The success of the first two years have led to many new questions and demonstrated the need for continued efforts to sharpen the economic picture for biodiesel development at the farm scale, with cooperatives, and for larger commercial-scale ventures in the state. The VBP team retains both capacity and desire to further extend the group's work into currently unexplored parts of the emerging biofuels terrain.

IV. CONCLUSION

Biodiesel in Vermont is here to stay. As more people become aware of biodiesel's performance and local benefits, more consumers will use biodiesel. With more commercial producers offering quality product in the market, and farmers diversifying their operations into oil seed crops, the market will continue to grow.

The Vermont Biodiesel Project represents an innovative, collaborative market building process that helped make it possible for a new, commercial scale production company to enter the state (i.e., Biocardel Vermont in 2006). The participants in the VBP acknowledged the effectiveness of the interactions between government, non-profit and business partners in working to achieve the goals of the venture. The VBP highlights the fact that public/private partnerships which span the political divide can emerge and succeed even in times of duress and transition. As testimony, the members of the steering committee are working on plans to expand the program in a new iteration that involves a wider array of participants in the coming years.

The Vermont Biodiesel Project also demonstrated that Vermonters are both interested in using biodiesel and capable of producing it for their own use in a small rural state. Demand for specific environmentally and economically beneficial products can indeed lead to new economic ventures that make those products. The market building model pioneered by the Vermont Sustainable Jobs Fund provides an example of sustainable development for others to emulate.

While there are many questions yet to be answered about the economics of producing biodiesel in the state, there is a clear demand for cleaner, renewable fuels that support Vermont's economy and keeps dollars within the state. The next level of work will entail fleshing out the costs of biodiesel production at farm-scale, cooperative and commercial scales.

When Vermonters decide to work together toward common ends, as they did during the VBP, many opportunities emerge that benefit all. While the state looks at how to meet the considerable demand for liquid fuels to meet our needs in this new century, they can now have confidence that a set of Vermonters are capable of developing viable alternative fuels that can run machinery, heat buildings and fuel the economy in years to come. How much of this liquid energy demand can be met locally will be a function of market demand, public policy initiatives, and the economics of energy at the local, regional and global levels. The question is whether more players—public or private, progressive or conservative—will work together

effectively as energy economics impact traditional petroleum markets. We have made a good start but there is much work left to do.

V. RECOMMENDATIONS

Based on their experience in the past two years, the participants in the VBP developed the following recommendations to build a broader biofuels sector in the state.

1. Develop full and regularly updated economic data analysis for the cost of biodiesel production in Vermont for the small scale, on-farm market and larger, commodity scale users. Clarifying the differences between these two cases will help financiers better understand the opportunities and risks for local biodiesel production.
2. Continue developing pilot projects that explore the boundaries of biofuel production in Vermont. Pilot projects provide a way for Vermonters to learn from one another, share information and see new technologies in action. Further efforts that expand beyond biodiesel to include ethanol production and other related components of liquid fuel production deserve support.
3. Allocate funding for renewable liquid fuels from the new Clean Energy Fund to support public/private investments and pilot projects in the emerging biofuels sector. The legislature identified biofuels as one of the potential activities in the law that established this fund that DPS now administers.
4. Develop a senior level agency coordinating group to iron out differences and build stronger working relationships between the Agency of Natural Resources, the Agency of Commerce and Community Development, Agency of Transportation, Agency of Agriculture, and the Department of Public Service with regard to biofuels.
5. Now that the Agency of Natural Resources clarified its standing on biodiesel for transportation and other uses, the agency should be instructed to expedite permitting for facilities that involve biodiesel. Continue to develop new studies that inform the agency's understanding of biodiesel for use in heating and transportation.
6. Expand the Vermont Biodiesel Project to focus on other closely-related aspects of the emerging biodiesel sector. The collaboration between private and public partners in the VBP can include more players from the biofuel world to hasten the development of clean, renewable energy supplies to meet more of the state's energy demand.
7. Complete the environmental health monitoring project at Smugglers' Notch and further develop the quantitative emissions tests at BGS for particulates.
8. Educate senior officials from the state's economic development sector regarding the opportunities, risks, benefits and challenges with biofuels. Organizations such as the state's regional development corporations, Vermont Economic Development Authority, commercial banks, and private investors would benefit from the considerable experiences of the private and public partners that are building the biofuels markets in the state.



Partners

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Vermont Biofuel Association

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