Vermont Sustainable Jobs Fund

Vermont Biofuels Initiative

Local Production for Local Use to Supply a Portion of Vermont's Energy Needs

May 2009

DOE Award Number:
DE-FG36-05GO85017

Canola field at Borderview Farm

www.vsjf.org

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ABOUT THE VERMONT SUSTAINABLE JOBS FUND

VSJF is a 501(c)(3) nonprofit created by the State of Vermont that uses **early stage grant funding** and **technical assistance** to catalyze and accelerate the development of markets for sustainably produced goods and services.

We analyze critical **market development needs** for these goods and services, including, research, technology & infrastructure, financing, technical assistance, network development, education & outreach, workforce development, sales & distribution, regulatory & public policy, and deploy our resources to meet those needs.

The products and services we support drive the green economy by **eliminating the use of fossil fuels**, **relocalizing production** (including food production, manufacturing, & the sustainable use of local resources), and **building resilience** against challenges such as peak oil & climate change.

www.vsjf.org

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Executive Summary

The Vermont Biofuels initiative (VBI) is the Vermont Sustainable Jobs Fund's (VSJF) biomass-to-biofuels market development program. Vermont is a small state with a large petroleum dependency for transportation (18th in per capita petroleum consumption) and home heating (55% of all households use petroleum for heating). The VBI marks the *first* strategic effort to reduce Vermont's dependency on petroleum through the development of *homegrown* alternatives. As such, it supports the four key priorities of the U.S. Department of Energy's Multi-year Biomass Plan:

1.) Dramatically reduce dependence on foreign oil;
2.) Promote the use of diverse, domestic and sustainable energy resources;
3.) Reduce carbon emissions from energy production and consumption;
4.) Establish a domestic bioindustry.

In 2005 VSJF was awarded with a $496,000 Congressionally directed award from U.S. Senator Patrick Leahy. This award was administered through the U.S. Department of Energy (DE-FG36-05GO85017, hereafter referred to as DOE FY05) with $396,000 to be used by VSJF for biodiesel development and $100,000 to be used by the Vermont Department of Public Service for methane biodigester projects.* The intent and strategic focus of the VBI is similar to another DOE funded organization–the Biofuels Center of North Carolina–in that it is a nonprofit driven, statewide biofuels market development effort.

DOE FY05 funds were expensed from 2006 through 2008 for seven projects: 1) a feedstock production, logistics, and biomass conversion research project conducted by the University of Vermont Extension; 2) technical assistance in the form of a safety review and engineering study of State Line Biofuels existing biodiesel production facility; 3) technical assistance in the form of a safety review and engineering study of Borderview Farm's proposed biodiesel production facility; 4) technology and infrastructure purchases for capacity expansion at Green Technologies, LLC, a waste vegetable biodiesel producer; 5) technical assistance in the form of feasibility studies for AgNorth Biopower LLC's proposed multi-feedstock biodigester; 6) technology and infrastructure purchases for the construction of a "Cow Power" biodigester at Gervais Family Farm; and 7) the education and outreach activities of the Vermont Biofuels Association.

DOE FY05 funded research, technical assistance, and education and outreach activities have helped to provide Vermont farmers and entrepreneurs with important feedstock production, feedstock logistics, and biomass conversion information that did not exist prior as we work to develop an in-state biodiesel sector. The efficacy of producing oilseed crops in New England is now established: Oilseed crops can grow well in Vermont, and good yields are achievable given improved harvesting equipment and techniques. DOE FY05 funds used for technology and infrastructure development have expanded Vermont's pool of renewable electricity and liquid fuel generation.

It is now clear that on-farm energy production provides an opportunity for Vermont farmers and entrepreneurs to reduce on-farm expenditures of feed and fuel while providing for their energy security. Meanwhile they are developing new value-added revenue sources (e.g., locally produced livestock meal), retaining more dollars in the local economy, and reducing greenhouse gas emissions.

* VSJF and the Vermont Department of Public of Service (DPS) signed a Memorandum of Understanding outlining a grant sharing arrangement. DPS administered two biogas projects, while VSJF acted as the fiscal agent.

Vermont at a Glance

- Population: **621,270**; lowest proportion of residents living in urban areas of any state[1]
- But **37%** of all jobs in Vermont are in the Burlington - South Burlington labor market[1]
- Vermont landscape: **80% forested**[1]
- **6,984 farms** in Vermont, working **1,233,313 acres**[2]
- **85%** of the market value of VT agriculture production is dairy[2]
- Vermont uses **least energy** of any state, but on a per capita basis ranks:
  18th in Petroleum consumption
  6th in Gasoline Consumption
  43rd in Diesel consumption[3]
- Farm production expenses (2007)[4]:
  Feed = $144,129,000 (44% of total)
  Fuels = $32,656,000 (10% of total)
- No in-state, commercially made liquid biofuels prior to 2004

1. Energy Use in Vermont

From 1960 to 2006, Vermont's energy consumption increased 139% (from 68.6 to 163.7 trillion Btus). During this same period Vermont's population increased only 59%. Petroleum for transportation and heating is the largest energy source used in the state, accounting for about 54% of energy consumption in 2006 (89 trillion Btus). In contrast to global trends, Vermont uses comparatively little natural gas and basically no coal. However, Vermont's reliance on natural gas increased 800% from 1966 to 2006 (equal to 5% of energy consumed, or 8.1 trillion Btus, in 2006). The bulk of Vermont's electrical baseload is supplied by Vermont Yankee, a boiling water nuclear reactor constructed in 1972 (32.5% of total energy consumption, or 53.3 trillion Btus, in 2006), and contracts with Hydro Quebec (9.2% of total energy consumption, or 15.1 trillion Btus, in 2006).

Vermont's main renewable energy resources –hydroelectricity and biomass–accounted for 9.2% and 5.9% of Vermont's energy consump-

1, 4 *Vermont in Transition: A Summary of Social, Economic and Environmental Trends*, http://futureofvermont.org/node/528
2 U.S. Department of Agriculture, 2007 Census of Agriculture
3 Energy Information Administration

tion, respectively, in 2006. The consumption of other renewables, including wind and solar, expanded 3,600%, and now equals 4.4% (7.4 trillion Btus) of total consumption (Figure 1). Finally, the activities of *Efficiency Vermont* (the state's efficiency utility) have helped Vermont eliminate 6.5% of its electricity load growth (not shown).

Vermont consumes the least amount of petroleum of any State (724,416,000 gallons in 2006), but our consumption of petroleum increased 91% from 1960 to 2006. About 79% of Vermont's petroleum dependency is spent on distillates and gasoline purchases, and the cost of diesel, No. 2 heating oil, and gas increased149%, 167%, and 140%, respectively, from 2001 to 2008. Vermont has no fossil fuel resources of its own and receives heating oil, gasoline and other fuels from terminals, or racks, in Springfield, MA, Boston, MA, Portsmouth, NH, Portland, ME, Montreal, QE, and Albany, NY.

The majority of the money that Vermonters spend on liquid fuels–over $1 billion–leaves the state to pay for crude oil purchases and refining.

Vermont consumes the *least* energy of any State (including the District of Columbia). Despite Vermont's 'green' reputation, however, on a *per capita* basis it consumes near the top of all States for both non-renewable and renewable energy sources (Table 1). That is, Vermonters consume more energy than might be expected for such a small State, and Vermont is quite vulnerable to supply disruptions of the kind anticipated to occur after peak oil.

FIGURE 1: ENERGY USE IN VERMONT, 1960-2006

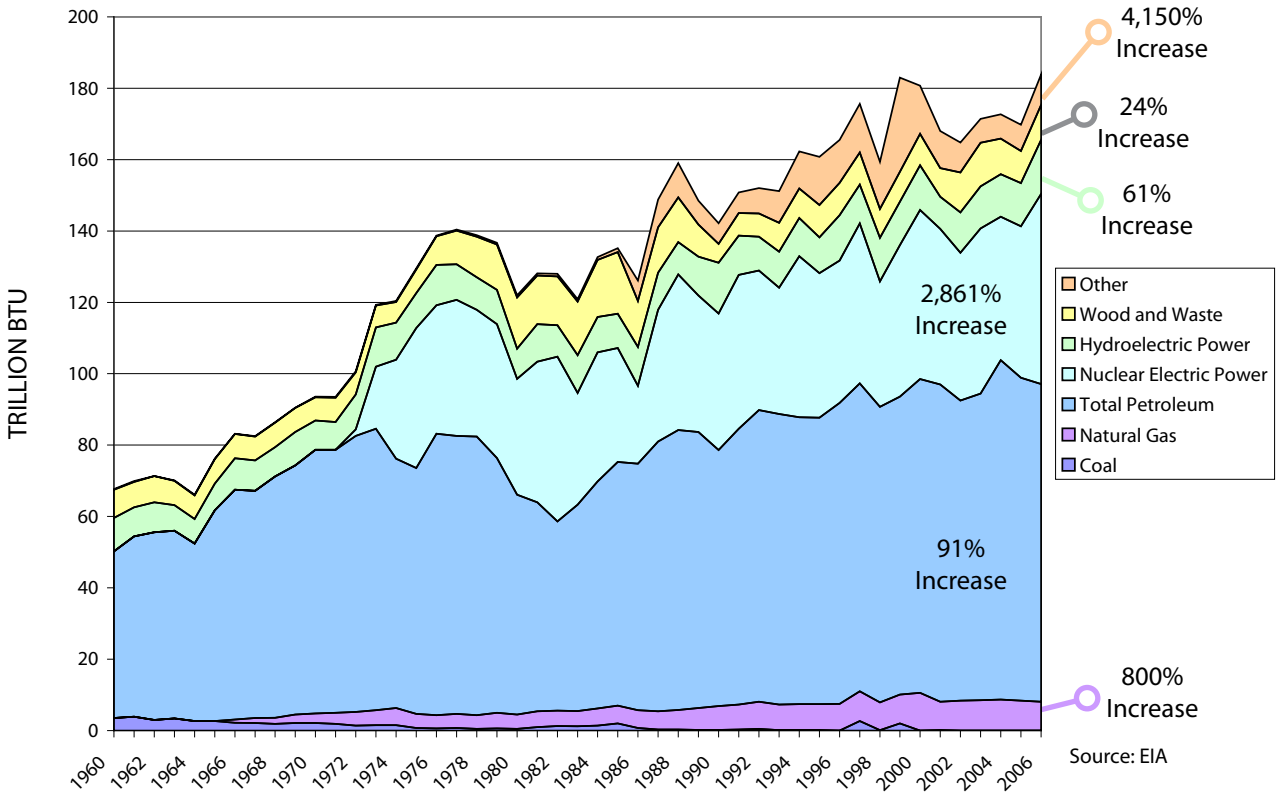


Table 1: Vermont's Per Capita Energy Consumption Ranking, 2005

Total	Petroleum	Gasoline	Diesel	Nuclear	Hydro	Biomass
41st	18th	6th	43rd	5th	10th	12th

Source: EIA

2. Biofuels in the Vermont Context

Taken together, biomass and biofuels provide the largest chunk of renewable energy used in the United States (about 3.3% of total energy consumption). As a heavily forested state, Vermont has a long history of using woody biomass for heating. Since 1981, the McNeil Generating Station (53 MW) has been using biomass to produce electricity for the Burlington Electric Department. Since then, the Ryegate Power Station (20 MW) has come online, and several "Cow Power" methane biodigesters and landfill methane generating facilities have been established. Vermont now ranks 12th in per capita biomass energy consumption.

However, at the onset of this project, Vermont had extremely limited experiences with the feedstocks, research, production processes, industry networks, and many other factors necessary to develop its *liquid* biofuels sector. The impending expiration of the State's electricity contracts with Vermont Yankee (2012) and Hydro-Quebec (2015) has pre-occupied much of the state's energy planning activities for the past several years. Since little or no public attention and investment are being made to address Vermont's petroleum dependency and the implications of peak oil, VSJF has focused on developing the in-state market for biofuels for the past four years.

Given Vermont's small scale and limited experience with liquid biofuels, VSJF started with the relatively low hanging fruit of waste vegetable oil and virgin oil (sunflower, canola, soybean) based biodiesel production. Prior to receiving Congressionally directed DOE FY05 funding, VSJF made several small grants to familiarize end users with biodiesel (e.g., Vermont Law School for heating, Sugarbush Ski Resort to fuel grooming equipment). In 2004, with DOE - State Energy Program funding (DE-PS26-04NT42068-00), VSJF and its partners ran the Vermont Biodiesel Project, a set of pilot projects and educational activities aimed at building recognition and experience with biodiesel across a variety of sectors (e.g., use in state government buildings).

DOE FY05 funding for the VBI marks our first major push to develop the supply- and demand-side of the biodiesel market (i.e., the natural oils pathway). Biodiesel consumption in Vermont increased from about 9,000 gallons in 2003 (when VSJF activities began) to about 1 million gallons in 2008.

Recent controversy surrounding commodity-scale biofuels has generated an understandable amount of concern among Vermonters, environmentalists, policy-makers and the research and agricultural community, as well as considerable debate between biofuels opponents and proponents. From day one, VSJF has promoted a local production for local use model that recognizes that oilseed crops will never come close to replacing the diesel consumed in-state. Alternatively, VSJF's natural oil pathway is aimed at replacing diesel use on-farm and small surrounding areas, while generating valuable on-farm co-products (i.e., meal).

Future VBI activities will also be aimed at new pathways or targets (e.g., grass energy for commercial thermal applications, algal biodiesel for mainstream transportation uses).

3. VSJF Market Development Approach

VSJF has created a systemic approach to developing new markets and/or strengthening and transitioning existing markets for sustainably produced goods and services. Our market development model is based on Neil Fligstein's ground-breaking work, *The Architecture of Markets* (2001). Simply put, there is no "invisible hand" guiding markets, and the "frequently invoked opposition between governments and market actors, in which governments are viewed as intrusive and inefficient, and firms as efficient wealth producers, is simply wrong" (2001: 6). Rather, consumers, governments, businesses, nonprofits, farmers, and many others interact to *regularize* and *routinize* the *structured exchange* of goods and services.

VSJF grants and technical assistance for renewable energy, sustainable forestry, and sustainable agriculture projects are geared toward overcoming market barriers and providing the *stability* necessary to support sustainably produced goods and services.

To target our limited resources most effectively, we utilize a kind of decision tree that asks the following questions:

1) What practices are undermining the sustainability of a particular market sector? We develop a problem statement that accounts for the social, environmental, and economic consequences of a particular activity. In this case, widespread societal dependence on non-renewable fossil fuels undermines all market sectors and societies.

The combustion of fossil fuels to power societal development and daily activities, as well as the clearing of carbon sinks such as forests for housing and other purposes has increased the temperature of the planet. The peaking of world oil production calls into question the progress of the past 200 years, while global climate change threatens chronic ecological and societal instability.

2) How do these problems impact Vermont? Vermont is a small player on the world's stage, but peak oil and climate change are having an impact even here.

With the projected peaking of world oil production and increasing competition from China and India, we can expect the cost of petroleum—and the amount of money leaving Vermont—to continue to rise. Despite the risk, Vermont's dependence on oil and resulting greenhouse gas emissions have continued to rise. Climatic disturbances are already visible in Vermont.

3) What are the emerging trends or opportunities for addressing these problems? The risks posed by the peaking of world oil production and climate change motivated VSJF and its partners to seek out ways of producing some amount of our transportation and thermal fuel needs locally.

Biofuels—including conventional biodiesel, methane digestion, cellulosic ethanol, algal biodiesel, grass pellets, and wood pellets and chips—are just one component of a larger suite of behavioral, technological, political, and economic transformations that will have to be made to prepare for, mitigate against, and adapt to peak oil and climate change.

4) Where is a particular market in its development trajectory? What does a particular market's supply chain currently look like? The current supply chain for fossil fuels in Vermont looks like 'petroleum in, money out'. The market and supply chain for biofuels was virtually non-existent in Vermont 4 years ago. VSJF and its partners had to start from scratch by answering the following questions:

- What are the **research** needs of this market?
- What are the **technology** and **infrastructure** needs?
- What are the **financing** needs?
- What are the **technical assistance** needs?
- What are the **network development** needs? Does a viable trade association (or business network) exist?
- What are the supply chain **education** and **outreach** needs?
- Are there **workforce development** needs that will further advance the sector?
- What are the **sales and distribution** needs of this market sector?
- What **regulatory** and **public policy** issues need to be addressed in order to advance the sector?

When cross-referenced with the biomass-to-biofuels supply chain (i.e., feedstock production - feedstock logistics - biomass conversion - biofuels distribution - biofuels end use) we end up with a 9x5 table (visualized in Table 2) that requires answering 45 types of questions (e.g., what are the feedstock production research needs?) that will create a stable market for biofuels in Vermont. **Answering these questions with grants, technical assistance, and strategic partnerships has been the overarching objective of VSJF's biofuels market development program, the Vermont Biofuels Initiative.**

Table 2: Market Development Model for Biofuels

Biomass-to-Biofuels Supply Chain

Market Development Needs

	Feedstock Production	Feedstock Logistics	Biomass Conversion	Biofuels Distribution	Biofuels End Use
Research	1	2	3	4	5
Technology / Infrastructure	6	7	8	9	10
Financing	11	12	13	14	15
Technical Assistance	16	17	18	19	20
Network Development	21	22	23	24	25
Education / Outreach	26	27	28	29	30
Workforce Development	31	32	33	34	35
Sales / Distribution	36	37	38	39	40
Regulatory / Public Policy	41	42	43	44	45

For example, what are the workforce development needs for biomass conversion in Vermont? Who can provide proper training?

4. Vermont Biofuels Initiative Strategic Goals

As an alternative to industrial-scale biofuels, VSJF believes that sustainable biofuels, specifically first generation biofuels, should be produced and used as close to the feedstock source as possible, and that local ownership of the production and distribution matters. Our 'local production for local use' market development model is premised on four interrelated strategic goals:

1) To develop alternative models to industrial-scale biofuels production that ensure opportunities for rural sustainable development through renewable energy production for local use,
2) to create opportunities for Vermonters and businesses to reduce their overall petroleum consumption and greenhouse gas emissions,
3) to buffer Vermont against disturbances in the petroleum market, and
4) to create a dynamic development model that can be applied to any form of biofuels, including biodiesel, grass energy, cellulosic ethanol, woody biomass).

The DOE FY05 Congressionally directed award was focused on three major tasks–network development, infrastructure development, and capacity building–and enabled VSJF to provide grant funding for agronomic research, network development, technology and infrastructure needs, technical assistance, and education and outreach.

Total VBI FY05 Project Cost:

DOE: $496,000
Cost share: $291,666*
$787,666

*Includes $38,002 VSJF / Vermont Department of Public Service cost share.

Task 1). Biofuels Industry Network Development

Growing the biofuels sector in Vermont requires strong connections all along the supply chain. The presence of strong, well-supported networks improves the prospects for successful business development. Networks allow businesses to share market intelligence, coordinate activities and increase the capacity of sector members to compete.

DOE FY05 funds supported the development of an industry network that encouraged cooperation within the state and among businesses, business groups and government agencies. Basic objectives included:

- Assist business associations with strategic planning, and help member businesses with market analysis, feasibility planning, environmental assessment, and/or public/private partnership formation
- Coordinate among industry businesses to establish appropriate storage and distribution capabilities
- Identify prospective research ventures that would provide biofuels from Vermont feedstocks
- Develop contingency plans to guarantee on-time deliveries of biofuels
- Coordinate with applicable regulatory agencies to ensure safe, effective development of biofuels production, distribution, transportation, and storage systems
- Expand outreach to other market segments such as the Vermont Fuel Dealers Association

Task 2). Biofuels Infrastructure Development

DOE FY05 funds were available to leverage private investment needed to stimulate development of biodiesel storage, mixing and transportation systems. This task included capital and technical assistance for existing petroleum

fuel companies (heat, transportation) to help them transition their fuel systems for delivering biodiesel to customers on a reliable, cost effective basis. A request for proposals to support the transition of current infrastructure to incorporate biofuels (e.g., mixing, storage, and distribution equipment) was released. Basic objectives of this task included:

- Provide technical assistance to existing fuel dealers and distributors that want to store and transport biodiesel and/or biofuels
- Offer grants to businesses seeking capital needed to make the transition to selling biofuels
- Mitigate risks to businesses entering the emerging biofuels market by supporting feasibility or market studies
- Leverage private investment in existing businesses necessary to advance the transition to biofuels.

Task 3). Biofuels Production Capacity

DOE FY05 funds were available to stimulate research into potential biofuel production systems, organize commercial scale production demonstrations, evaluate proposed business plans, analyze emerging markets into which products would be sold, and/or help entrepreneurs secure additional investment in proposed operations. With many potential biofuel options available for in-state production, funding in this category was aimed at learning about what will work in Vermont's cold climate.

Building capacity also included the production of crops and/or algae for plant oil. The intention was for field research to establish actual commercial production capacities, costs and margins associated with oil crops and/or algae in the state. Basic objectives included:

- Increase production capacity of Vermont biodiesel to 1,000,000 gallons and elevate production of biogas from biological sources in Vermont.
- Support development of business plans by biodiesel and/or biofuels production companies or entities for commercial scale demonstration
- Fund commercial scale demonstration field trials to determine economic feasibility for oilseed, algae and/or biogas production in Vermont
- Fund pilot biogas production demonstrations
- Leverage private investment to develop new biodiesel, biogas, and/or algae production facilities, and a oilseed crushing facility in Vermont.

Vermont Governor Jim Douglas discusses oilseed crops with John Williamson at State Line Farm in 2007.

5. Vermont Biofuels Initiative Funding Overview

DOE FY05 funds were awarded through a competitive process with both internal and external reviewers. Additional funding from the State of Vermont Agency of Agriculture, Food and Markets; the Vermont Clean Energy Development Fund; USDA Rural Development, and many other sources supplemented several of the following projects.

Biofuels Production Capacity Grants:

- **University of Vermont Extension:** A $98,089 grant was awarded to UVM Extension for oilseed crop production and logistics **research** in a northern climate context, for **technical assistance** to farmers interested in oilseed crops, and to assist State Line Farm in obtaining and installing **technology** and **infrastructure** for an on-farm biodiesel production facility.

- **Green Technologies:** A $98,000 grant was awarded to Green Technologies, Inc. to invest in **technology** and **infrastructure** to increase commercial biodiesel production from 10,000 to 50,000 gallons per year capacity (waste vegetable oil feedstock) and to purchase several pieces of quality assurance / quality control testing equipment. **Technical assistance** for business planning was also provided to Green Technologies.

- **Gervais Family Farms:** VSJF served as the fiscal agent for a $67,000 grant awarded to Gervais Family Farms (administered by the Vermont Department of Public Service) for **technology** and **infrastructure** purchases to construct a 200 kW manure biodigester.

- **AgNorth Biopower**: VSJF served as the fiscal agent for a $33,000 grant awarded to AgNorth Biopower (administered by the Vermont Department of Public Service) to obtain **technical assistance** in the form of several feasibility studies for a 1MW mixed substrate (food waste and manure) biodigester.

- **State Line Biofuels:** A $23,200 grant was awarded to State Line Biofuels ($9,200 was used for equipment and $14,000 was used to hire Callahan Engineering, PLLC to provide a safety review and engineering study) for a 284,000 gallons capacity per year biodiesel facility (Note: State Line Biofuels is not operating anywhere near capacity yet). **Technical assistance** from UVM Extension and the Farm Viability and Enhancement program were used to assist with feedstock production, logistics, biomass conversion, and business planning.

- **Borderview Farm**: A $25,000 grant was awarded for **technical assistance**, including a safety review and engineering study conducted by Callahan Engineering, PLLC and to purchase **technology** for a farm-scale oilseed to biodiesel research facility. **Technical assistance** from UVM Extension and the Farm Viability and Enhancement program were used to assist with feedstock production, logistics, biomass conversion, and business planning.

Biofuels Industry Network Grants:

- **Vermont Biofuels Association**: A $65,000 grant was awarded to the VBA to provide **technical assistance**, **education and outreach** to Vermont's nascent biofuels industry.

Biofuels Infrastructure Development Grants:

- A $49,175 grant was awarded to **Caulkins Oil and Excavating, inc.** to design a biodiesel storage and sales facility and install a dedicated biodiesel tank at their Danville location. The grant was subsequently rescinded since Dana Caulkins had difficulty obtaining permits and additional financing for the project after a lengthy period of time. Funds were re-granted out for the Borderview Farm and State Line Farm safety reviews, engineering studies, and biodiesel processing equipment purchases.

TABLE 3: SUMMARY OF DOE FY05 GRANTS

	Market Development	Feedstock Production	Feedstock Logistics	Biomass Conversion	Biofuels Distribution	Biofuels End Use	Products & Services
Natural Oils Pathway	Research	UVM Extension					Data / T.A.
	Technology Infrastructure		State Line Biofuels, Borderview Farm				-Biodiesel -Meal
				Green Tech.			
	Financing	Cross Cutting Issues: DOE and other funders.					$
	Technical Assistance	-UVM Extension -Farm Viability Program		Callahan Engineer.	L. Miller: Green Tech.		-Biodiesel -Meal
	Network Development	Cross Cutting Issues: Vermont Biofuels Association, oilseed farmer's network					Education
	Education / Outreach						
	Workforce Development						
	Sales & Distribution						
	Regulatory & Public Policy						
	Cross Cutting Issues: Vermont Biofuels Association						
Waste Processing Pathway	Research						
	Technology Infrastructure	Gervais	Gervais	Gervais	Gervais (CVPS Cow Power)	Gervais (net metered, 200kw)	-Electricity -Bedding
	Financing	Cross Cutting Issues: DOE and multiple other funders.					
	Technical Assistance	Palardy	Palardy	Palardy			
	Network Development						
	Education / Outreach						
	Workforce Development						
	Sales & Distribution						
	Regulatory & Public Policy						

6. Technical Accomplishments / Results

University of Vermont Extension

- **Grant Amount:** $98,089
- **Cost Share:** $31,984
- **Principal investigators:** Dr. Vern Grubinger and Dr. Heather Darby
- **Locations:** UVM Extension - Colchester; field trials - State Line Farm (N. Bennington), Clear Brook Farm (Shaftsbury), Borderview Farm (Alburgh)

Dr. Darby addresses farmers at Field day at Borderview Farm

- **Grant Summary:** Funds were used by UVM Extension personnel to conduct feedstock production and logistic research, to share this information with farmers and the general public, and to assist in the early stage development of State Line Farm's on-farm biodiesel facility.

UVM Extension offers a wide range of educational programs and outreach activities for Vermont farmers. The goal of UVM's project was to assess the potential for producing and processing oilseed and sugar-containing crops for small-scale on-farm energy production.

This project covers the feedstock production, feedstock logistics, and biomass conversion component of the natural oils pathway. DOE funding supported Dr. Vern Grubinger and Dr. Heather Darby's agronomic, economic, and regulatory **research** on oilseed crops, sugar beets, and sweet sorghum at several farms. DOE FY05 funding also enabled UVM Extension personnel to provide **technical assistance** to prospective energy crop farmers and provide significant assistance to the development of the processing facility at State Line Biofuels.

STATEMENT OF PROJECT OBJECTIVES

Task 1) Conduct Crop Trials: In 2006, field-scale trials were conducted at State Line Farm and Clear Brook Farm in southwest Vermont and field-scale replicated trials were conducted by Dr. Heather Darby of UVM Extension and Roger Rainville of Borderview Farm in northwest Vermont. Related work with canola and biodiesel production was also done by Dr. Peter Sexton of University of Maine, working with local farmers, and Dr. Becky Grube at the University of New Hampshire, working with farmer Dorn Cox on sunflower trials. Research from each University was shared between colleagues.

Product: A set of on-farm seed oil crop tests with data (species, varieties, seeding rates, fertility rates, harvesting methods, yields) on performance from several cultivars was

compiled. Research completed suggests that canola and sunflower have the best potential as oil producing crops in New England, due to the high oil content of their seeds and the high quality (low cloud point) of their oil. Soybeans may be part of the oilseed cropping system mix due to the high value of the soybean meal as a livestock feed, even though soybean oil yields are relatively low.

Preliminary research on sweet sorghum and sugar beets for ethanol production (as replacement for methanol in conversion to biodiesel) was compiled. Quality and profile testing of canola, flax, mustard, soybean, and sunflower meal as a livestock ration was completed. This co-product is now commonly sold to Vermont dairy farmers.

Outcome: UVM Extension concluded that oilseed crops can successfully be grown in the northern New England states. UVM Extension identified several areas for additional study and concluded that it will likely take several more years of research looking at species, varieties, seeding rates, seeding dates, fertility rates, and harvesting methods in order to make this system work well.

From a feedstock logistics perspective, UVM Extension documented harvesting and storage issues. Difficulties included scarcity of and familiarity with equipment, and having access to enough equipment to provide flexibility in using the best technique for a given crop and season.

Task 2) Collect Agronomic Data: UVM Extension documented the preliminary costs and returns for producing oil from seed on the farm, and attempted to determine the feasibility for replication of oilseed production elsewhere. Additionally, Dr. Grubinger worked very closely with State Line Farm during the development of their biodiesel processing facility.

UVM Extension Field Day at Borderview Farm

Product: Data that illustrates the findings from preliminary oilseed crop and sugar crop trials was assembled. Initial costs for crop production, harvesting, and biodiesel processing were prepared.

Outcome: Crop production, harvesting, and biodiesel production information in the Vermont context is now available to the public. Additionally, hundreds of visitors have attended Field Days and tours at State Line Farm and Borderview Farm to learn about renewable energy production and new ways of diversifying farm activities while field trials and construction of processing facilities were underway.

Task 3) Produce a Report: UVM Extension compiled all of their research into one document and have disseminated the results throughout the state.

Product: A report outlining findings from oilseed crop and sugar crop production and logistics research was compiled.

Outcome: Vermont farmers now have essential material to learn about the viability of oilseed crops for on-farm energy production and a team of technical assistance providers who can expedite and improve their projects.

State Line Biofuels

- **Grant Amount:** $23,200
- **Cost Share:** $19,103
- **Principal investigators:** John Williamson, State Line Biofuels; Chris Callahan, Callahan Engineering, LLC
- **Location:** North Bennington, Bennington County
- **Grant Summary:** Funds were used for professional engineering services to conduct a fully documented safety review and engineering study of the biodiesel processing system at State Line Biofuels. Optimization recommendations and improvements were made.

John Williamson

State Line Biofuels is Vermont's first on-farm facility making biodiesel made from oilseed crops grown on-site and from neighboring farms. The Williamson family has owned State Line Farm in Shaftsbury (Bennington County) since 1936. John and his family currently produce maple syrup, honey, sorghum syrup and hay for sale in local markets. The Williamsons had a dairy herd until 2004. For the past several years, John Williamson, with the help of Steve Plummer and many others, has been diversifying his farm operations toward biodiesel production. "It's a pretty nice feeling to have your own source of fuel", says John, "It works really well."

This project covers the biomass conversion component of the natural oils pathway. DOE FY05 funding supported **technical assistance** in the form of a fully documented safety review and engineering study of the existing biodiesel production system and enabled John to purchase new **technology and infrastructure** based on the engineer's recommendations.

STATEMENT OF PROJECT OBJECTIVES

Task 1) Safety Review: DOE FY05 funds were used to hire Callahan Engineering, PLLC to facilitate, guide and document a hazards review and failure modes and effects analysis (FMEA) of the State Line process and system.

Product: A professionally documented FMEA for State Line's biodiesel production process and overall system was completed.

Outcome: Critical safety information for State Line Biofuels and other potential on-farm biodiesel producers is now publicly available.

Task 2) Design Documentation: Callahan Engineering, PLLC was hired to prepare design documentation (e.g. prints, descriptive documents, etc.) that captures the as-built biodiesel system.

Product: Professional engineering documentation of State Line's on-farm biodiesel production system were created.

Outcome: Information that helps farmers and other potential small-scale biodiesel producers design and construct a successful and efficient production system is now publicly available.

Task 3) Technical Regulatory Review: Callahan Engineering, PLLC was hired to research and summarize applicable or relevant design code or standards associated with an on-farm, small-scale biodiesel production system.

Product: A report outlining design codes and/or standards relevant to small-scale, on-farm biodiesel production was created.

Outcome: Information that assists Vermont farmers, other potential small-scale biodiesel producers, and industry supporters determine the feasibility of–and costs and timelines associated with–developing a biodiesel production system was compiled by Callahan Engineering, PLLC. Additionally, an enterprise and operational analysis for oilseed production and processing was completed by the Farm Viability Enhancement Program and UVM Extension for State Line Biofuels using non-DOE funds.

Task 4) Aid Replication and Portability of Design: Finally, Callahan Engineering, PLLC compiled all of this material into one document to aid others with the design and fabrication of small-scale biodiesel systems based on the State Line Biofuels design.

Product: A report outlining design portability and system replication considerations for small-scale biodiesel production operations was compiled.

Outcome: Information that can assist Vermont farmers, other potential small-scale biodiesel producers, and other industry players design and construct safe and replicable biodiesel production facilities is now available on the VSJF website.

Clockwise from left: John Williamson describes biodiesel reactor during Field Day; solar grain dryer at State Line Biofuels; John takes a sample.

The State Line Biofuels safety review and engineering study is available here:
www.vsjf.org/biofuels/documents/StateLineSafetyReview_EngineeringStudy_Jan2009.pdf

Borderview Farm

- **Grant Amount:** $25,000
- **Cost Share:** $25,208
- **Principal investigators:** Roger Rainville, Borderview Farm; Chris Callahan, Callahan Engineering, LLC
- **Location:** Alburgh, Grand Isle County
- **Grant Summary:** Funds were used for professional engineering services to begin a fully documented safety review and engineering study of the proposed biodiesel processing system at Borderview Farm. Build out improvement recommendations were made.

Roger Rainville and sunflowers at Borderview Farm

Roger Rainville's Borderview Farm will be Vermont's second on-farm facility making biodiesel made from oilseed crops grown on-site and surrounding farms. Roger has been a reliable, skilled, and enthusiastic supporter of the on-farm biodiesel production concept. He has a proven track record as a farmer and businessman, and his work is highly respected among his farming peers, the agriculture organizations that he serves, and his partners and collaborators at the University of Vermont and other agricultural institutions.

This project covers the biomass conversion component of the natural oils pathway. DOE FY05 funding supported **technical assistance** in the form of a fully documented safety review and engineering study of the proposed biodiesel production system and will enable Roger to purchase new **technology and infrastructure** based on the engineer's recommendations.

STATEMENT OF PROJECT OBJECTIVES

Task 1) Safety Review: DOE FY05 funds were used to hire Callahan Engineering, PLLC to facilitate, guide and document a hazards review and failure modes and effects analysis (FMEA) of the proposed Borderview Farm process and system.

Product: A *draft* professionally documented FMEA for Borderview Farm's proposed biodiesel production process and overall system was completed.

Outcome: Critical safety information for Borderview Farm and other potential on-farm biodiesel producers is now publicly available.

Task 2) Design Documentation: Callahan Engineering, PLLC was hired to prepare design documentation (e.g. prints, descriptive documents, etc.) for the proposed biodiesel system.

Product: Professional engineering documentation of Borderview Farm's proposed on-farm

biodiesel production system are still under development. A schematic plumbing and instrumentation diagram has been made.

Outcome: Borderview and Callahan still need to confirm a suitable size of a biodiesel reactor (likely a 105 gallon batch processor), select a processor design (likely a simplification of the State Line Biofuels design), procure processor components (e.g., stainless vessels, spill containment supplies), fabricate and assemble the processor (likely assembled by Roger and hired help), formalize standard operating procedures, and make some test batches.

Task 3) Technical Regulatory Review: Callahan Engineering, PLLC was hired to research and summarize applicable or relevant design code or standards associated with an on-farm, small-scale biodiesel production system.

Product: Design codes and/or standards relevant to small-scale, on-farm biodiesel production are now documented.

Outcome: Information that assists Vermont farmers, other potential small-scale biodiesel producers, and industry supporters determine the feasibility of–and costs and timelines associated with–developing a biodiesel production system was compiled by Callahan Engineering, PLLC. Additionally, an enterprise and operational analysis for oilseed production and processing was completed by the Farm Viability and Enhancement program and UVM Extension for Borderview Farm using non-DOE funds.

Task 4) Aid Replication and Portability of Design: Finally, Callahan Engineering, PLLC compiled all of this material into one document to aid others interested in pursuing a small-scale, on-farm biodiesel production facility.

Product: A draft report outlining design portability and system replication considerations for small-scale biodiesel production operations was compiled, but the Borderview system is still under construction.

Outcome: Information that can assist Vermont farmers, other potential small-scale biodiesel producers, and other industry players design and construct safe and replicable biodiesel production facilities is now available on the VSJF website.

Task 5) Safety and Biodiesel Processing Equipment Purchase: Funds to purchase and install the necessary components (as determined in Task 1) to complete the build out of an on-farm, small-scale biodiesel production facility have yet to be expensed.

Product / Outcome: To be determined.

Borderview "biobarn" under construction.

NOTE: The small 20x40 on-farm facility was not constructed using DOE awarded funds. DOE funds were used to complete Tasks 1-4 and to identify the equipment needed to complete the the on-farm research facility.

The Borderview Farm safety review and engineering study is available here: www.vsjf.org/biofuels/documents/BorderviewFarmSafetyReview_EngineeringStudy_March2009.pdf

Green Technologies, Inc.

- **Grant Amount:** $98,000
- **Cost Share:** $49,766
- **Project Manager:** Scott Gordon, PhD, Green Technologies
- **Location:** Winooski, Chittenden County
- **Grant Summary:** Funds were used to purchase equipment to expand biodiesel production capacity, to develop a QA/QC biodiesel testing lab, provide fuel testing services, and reach ASTM fuel quality standards.

Testing equipment at Green Technologies, Inc.

As a chemistry professor, Scott Gordon brought his expertise to bear at the University of Vermont by building a 60 gallon prototype biodiesel processor in 2004. Gordon soon struck out on his own with Green Technologies, Inc., a waste vegetable oil biodiesel producer. Gordon is also interested in the bigger picture of green chemical processes and envisions developing useful products such as bioplastics, biowaxes, and soap.

This project covers the biomass conversion component of the natural oils pathway. DOE FY05 funding supported **technology and infrastructure** development (i.e., system optimization) for this project.

STATEMENT OF PROJECT OBJECTIVES

Task 1) Increase Local Biodiesel Production Capacity: Green Technologies used grant funding to research designs and equipment requirements to expand production capacity; to purchase equipment; debug tanks, pumps, and systems; and to increase production volume.

Product: Green Technologies reactors are based on a pumped mixing system design. More powerful explosion proof pumps, jet eductors and larger tanks were installed to boost production capacity.

Outcome: The main goal of this project was to reach commercial breakeven production targets (ca. 50,000 gals/yr) using inexpensive WVO feedstocks. Given Green Technologies existing WVO supply, only modest increases in WVO collection volume are needed to meet initial project goals. However, Green Technologies was only able to increase production volume from about 10,000 gals/yr in 2006, to 19,000 gals/yr in 2007 and 24,000 gals/yr in 2008. Capacity increases in the 30,000-60,000 gal/yr range require further investment in post processing (e.g. a larger filtration system).

Task 2) Develop Instrumentation and Protocols to Reduce the Costs for ASTM Testing: Green Technologies used grant funding to buy and install a gas chromatograph (GC) and other equipment; to develop GC protocols; and to provide fuel testing services.

Product: A Thermo Trace GC and Karl-Fisher coulometric autotitrator for testing water quantity were purchased. Green Technologies successfully launched a QA/QC testing program for biodiesel based on solubility, viscosity, Karl Fischer water content titration and GC determination of free and total glycerin content according to ASTM D6584.

Outcome: No dedicated affordable biodiesel testing centers existed in the Vermont region prior to this project. Increasing the market for locally produced biofuels benefits by developing low cost, in-house biofuel quality testing coupled with iterative improvements in production methods and corresponding fuel quality. Green Technologies now offers affordable biodiesel testing to local producers, including Biocardel (a new multi-million gal/yr producer).

Task 3) Evaluate the Production System for Safety, Efficiency, and Process Improvements: Green Technologies identified bottlenecks and issues in their fuel production process that impacted their ability to reach ASTM (namely better filtration/post processing).

Product / Outcome: Green Technologies identified the need for a larger fluidized bed filtration system and is now in the process of building it.

As part of this grant, Gordon also received advice from a successful businessman, a peer advisor, to update his business plan, upgrade his accounting, analysis, and reporting system, validate an action plan to meet 50,000 gallons of production, and other coaching to assist his development as an entrepreneur.

Task 4) Reach ASTM Fuel Quality Standards: For commercial use, producing ASTM quality biodiesel is essential. Few small producers, however, can afford to purchase the multi-million dollar turn-key ASTM production plants typical of large scale biodiesel production. Therefore, for a small producer, the only viable strategy for reaching ASTM quality is to start from a low capital investment platform and innovate process improvements until ASTM quality is reached. Tasks 1-3 provide a foundation for reaching ASTM quality.

Product / Outcome: Based on QA/QC testing, Green Technologies feels confident that a larger fluidized bed filtration system will enable them to reach ASTM.

Task 5) Continue Limited Research and Development on Value-added Products: Green Technologies' vision for biodiesel production is that waste (or virgin) vegetable oil comes into the plant but only useful products go out. Lacking the economies of scale that come from multi-million gal/yr biodiesel production from virgin feedstocks, Green Technologies must necessarily develop other strategies to achieve commercial success. One option is to develop the capacity to produce biodiesel related value added products such as biowaxes, bioplastics, and other products or services.

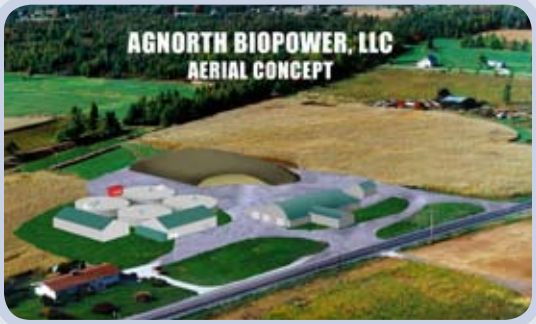
Product: Green Technologies conducted limited R&D to develop a B100 boiler kit and investigate biodiesel separation methods (e.g., cold filtering) to alter the gel-points of the fuel.

Outcome: A prototype B100 boiler kit was installed at the Green Technologies facility and has run successfully for three years. Twenty boiler kits have been sold.

The inner workings of the Green Technologies facility

AgNorth Biopower, LLC

- **Grant Amount:** $33,000
- **Cost Share:** $26,699
- **Project Managers:** Guy Palardy, Palardy Family Farm, LLC; Kelly Launder, Vermont Department of Public Service
- **Location:** Alburgh, Grand Isle County



AgNorth Biopower's concept

- **Grant Summary:** Funds were used to complete preconstruction planning, feasibility studies, an impact study, and technology selection processes for an anaerobic digester system that will utilize multiple feedstocks (e.g., forage crops and manure from the farm) to produce one megawatt (MW) of output capacity utilizing a combined heat and power generator set. The grant also helped investigate the feasibility of utilizing the extra heat generated from CHP.

Guy Palardy was a dairy farmer from 1984 to 2007. After selling his herd due to chronically unstable milk prices, Palardy began to explore the possibility of using his family's 825 acres of non-contiguous farmland, with an additional 175 acres leased from neighbors (total amount = 1,000 acres) to grow biomass and use existing 'waste' streams for a net metered on-farm energy production system.

Palardy's plan covers the entire biomass-to-biofuels supply chain, from the production of multiple feedstocks on his farm and neighboring farms (e.g., energy crops and manure) and feedstock logistics, including the delivery of waste grease from a meat processing plant in nearby Swanton, to convenient grid interconnection and interest from prospective end users. DOE FY05 funding supported the **technical assistance** phase of this proposed $6 million project.

STATEMENT OF PROJECT OBJECTIVES

Task 1) Preliminary Economic Feasibility: In June 2006 USDA Rural Development completed an environmental assessment and found no significant environmental harm would result from this project. A system impact study was conducted by Crocket Engineering, LLC of Essex Junction, VT in March 2007 and confirmed that 3-Phase Power was available at the proposed site. MWK Biomass, an international designer of anaerobic digesters, prepared an initial business plan in 2007 and North Valley Business Consulting, LLC of Swanton, VT reviewed the business plan and completed a feasibility study in May 2007. Both the MWK Biomass assessment and the North Valley Business Consulting business plan review indicated that AgNorth Biopower could be a profitable business, especially if Renewable Energy Credits were received.

Product: Four studies showed that the project is economically and environmentally feasible. The environmental assessment found that no federally protected resources would be impacted and that air quality, water quality, and solid waste management would be improved by the project. The system impact study identified an estimated $41,000 in equipment necessary to properly connect to the grid. The MWK Biomass

business plan provided estimates of material costs, price bases, revenues, investment, depreciation, cash flow, profit and loss, and capital requirements. North Valley Business Consulting judged the project feasible, with the caveat that the sale of Renewable Energy Credits is absolutely critical to the financial success of the project.

Outcome: Palardy now has all the essential documentation to demonstrate the feasibility of his project to potential investors / funders.

Task 2) System Selection: Palardy used a portion of his DOE grant (matched with $25,000 of his own money) to contract with MWK Biogas to design his project in February 2007. Vermont Agency of Agriculture, Food and Markets also supported the project with technical advice from their personnel.

Product: The MWK Biogas designed system will have three primary components: 1) six digester tanks and a biomass receiver, 2) gas collection, buffering, and cleaning subsystem, and 3) a combined heat and power (CHP) system. The site selected for the construction of the digester is less than 100 yards from the electrical grid connection point. The capacity of the line meets the requirements of the utility company. The site has easy access to a major route to handle truck traffic, and sufficient feedstock is available to supply the digester for maximum capacity output.

Outcome: The AgNorth Biopower system has now been designed, but requires an additional $6 million to build the project.

Task 3) Engineering, Funding and Permit Acquisition: With funding for project completion in place, Palardy would need to acquire appropriate permits from the State of Vermont to construct the project. The primary permit required is a Certificate of Public Good from the Vermont Public Service Board.

Guy Palardy and Netaka White review AgNorth Biopower site plans.

Product: With a line study and other engineering studies completed and site selection and system design accomplished, Palardy needs to secure additional funding to move forward.

Outcome: Palardy is pursuing additional funding from Vermont's Clean Energy Development Fund, the Food, Conservation, and Energy Act of 2008, and other sources.

Task 4) Mitigation Measures: Before final construction of the digester is complete, several mitigation measures will be required:

1) Acceptable noise levels of 65dB or less at farm property lines.
2) A Certificate of Public Good (CPG) from the Vermont Public Service Board and an Interconnect and Power Purchase Agreement for the sale of electricity to a utility.
3) An air quality permit, if required.

Product: According to the system design, mitigation of engine/generator noise will be achieved with an insulated co-generation building. Palardy has not yet applied for a CPG and it is not yet known if an air permit will be required.

Outcome: The key to the AgNorth Biopower project going forward is significant additional funding.

Gervais Family Farm Inc.

- **Grant Amount:** $67,000
- **Cost Share:** $67,810
- **Project Managers:** Gervais Family, Gervais Family Farm, Inc; Kelly Launder, Vermont Department of Public Service
- **Location:** Bakersfield, Franklin County

- **Grant Summary:** Funds were used to complete preconstruction planning and a line study, arrange utility interconnect agreements, obtain a Certificate of Public Good from the Vermont Public Service Board, and toward the construction of an anaerobic digester. The digester was operational as of February 2009 and enrolled in Central Vermont Public Service's Cow Power program. The Cow Power program charges customers a premium of 4 per kilowatt hour.

For the past 49 years Robert and Gisele Gervais and more than 20 relatives (including 15 children) have owned and operated a 2,500 acre, 1,900 cow dairy in Bakersfield, VT. The Gervais family milks about 1,000 cows in a free stall housing facility with an automated manure scraping system that delivers manure to cross alleys that flow into a storage lagoon. The Gervais family wanted to develop an anaerobic digester system to reduce odors from the manure, reduce pathogen numbers in the manure, and to produce energy for sale to the grid.

This project covers the entire biomass-to-biofuels supply chain for the manure waste pathway. DOE FY05 funding supported the **technical assistance** and **technology and infrastructure** phase of this project.

STATEMENT OF PROJECT OBJECTIVES

Task 1) System Design: The Gervais family worked with Cross Consulting Engineers in St. Albans, VT to develop an upright silo-in-silo concept with insulated concrete forms (ICF) - a new idea for digesters. They wanted to use ICF for their superior insulation factor and to save on construction costs. Cross Consulting completed structural designs for the heat exchange system; the gas delivery system; the interconnection/generation system and the manure separation system.

The original octagonal biodigester under construction in 2007.

While painting the outside of the digester with a sealing paint it was noticed that the walls appeared to be bulging (while filled at about 3/4 capacity). The structural engineer was contacted and it was determined that the outside concrete

walls of the digester had many hairline cracks. Cross Consulting concluded there was an error in the structural design and the insurance company was contacted. It was decided not to attempt to repair the structure.

Product: A replacement structure designed by GHD, Inc. (based in Wisconsin) has since been built, and the Gervais biodigester is now the sixth dairy farm enrolled in Central Vermont Public Service's Cow Power program. At a 4 cents per kilowatt hour premium, CVPS customers can choose to receive all, half, or a quarter of their electrical energy through Cow Power. According to CVPS, the premium goes to participating farm-producers, to purchase renewable energy credits when enough farm energy isn't available, or to the CVPS Renewable Development Fund. The fund provides grants to farm owners to develop on-farm generation.

Outcome: CVPS will purchase the Renewable Energy Credits associated with 780,000 kilowatt-hours generated annually at 4 cents per kilowatt-hour, while the Enosburg Village Electric Department will purchase the electricity.

Task 2) Utility Interconnection Agreement: The Gervais family negotiated with Enosburg Village Electric Department (the closest 'big' town) for the sale of the electricity from this project and reached an agreement with CVPS to sell the renewable energy credits and other environmental attributes of the power.

Product / Outcome: Contracts with both Enosburg Village Electric Department and CVPS are in place and the Gervais Family Farm has been selling electricity to the grid since February 2009.

Task 3) Certificate of Public Good and Line Study: To receive permission to interconnect a system a Certificate of Public Good must be obtained through the Vermont Public Service Board under Act 248. To do this a line study as well as other environmental criterion must be demonstrated to show that the system will be able to operate safely and in the public good.

Product / Outcome: The proper criterion were met and a Certficate of Public Good was obtained, enabling the Gervais Family Farm biodigester to go forward.

Task 4) Physical Project Completion: The structural failure of the original biodigester pushed back project completion and increased the budget. However, a new system, designed by GHD, Inc is now in place.

Product: A biodigester capable of producing 780,000 kilowatt-hours of electricity per year is now operational.

Outcome: The Gervais family now has a manure management / renewable energy system that generates electricity, money, and co-products while reducing odor, expenses, and the need for fossil fuels. The co-products in particular, are a huge bonus for the farm. Clement Gervais explains "One of our key reasons was to do something about the odor of the manure, but this also improves manure management and provides an alternative bedding source for our cows. The cost of bedding is a big thing. We've been using two and a half tractor trailer loads of sawdust a week at $2,400 per load, and we hope to replace 85 to 90 percent of that through manure solids separation. The manure, after digestion, is squeezed through rollers and the solids, low in bacteria, make good bedding. The liquids flow back to the lagoon ready for use as fertilizer. That's a big economic benefit."

The new KHD biodigester under construction in 2008.

Vermont Biofuels Association

- Grant Amount: $65,000
- **Cost Share:** $33,094
- **Project Manager:** Netaka White, Vermont Biofuels Association
- **Location:** Middlebury, Addison County
- **Grant Summary:** Funds were used to improve the capacity, efficiency, and viability of the organization, enabling the VBA to provide education and information, project leadership and coordination, fundraising, event planning and collaboration at a statewide level.

Crowd at third annual Vermont Biodiesel Conference.

The Vermont Biofuels Association (VBA) was instrumental in shepherding the development of Vermont's emerging biofuels sector. The VBA—a trade association—grew from twelve members at the end of 2004 to over eighty fuel users, fuel suppliers, farmers, researchers, renewable energy consultants, students, and individuals by the end of 2007. VBA activities included annual conferences, pilot projects, policy development, and a wide array of other efforts to connect stakeholders interested in biofuels.

This project covers cross-cutting issues for the entire biomass-to-biofuels supply chain for the natural oils pathway. DOE FY05 funding supported a wide range of **technical assistance**, **network development**, and **education and outreach** activities conducted by the VBA.

STATEMENT OF PROJECT OBJECTIVES

Task 1): Expand and Strengthen the Emerging Biofuels Network: The VBA used DOE FY05 funds to develop a three-year strategic plan for the VBA, to explore potential demand in emerging sectors (e.g., sugar makers, marine transportation, motor coach industry, etc.), and to participate in market research and development studies.

Products: A three-year strategic plan was created. New biofuel pilot projects were identified and organized (e.g., Vermont maple sugar manufacturer, Goodrich Farms, used 15,000 gallons of B20 to run an oil-fired evaporator to make maple syrup). Evolving technologies / opportunities for new processes / markets were identified (e.g., algal biodiesel).

Outcomes: As the capacity, effectiveness and viability of the VBA were improved, the organization was able to proactively respond to growing interest in the commercial and private sector, help troubleshoot and problem solve on fuel performance issues, conduct market research, and participate in policy planning with sector leaders and state government. The volume of pure biodiesel (B100) consumed in Vermont jumped from 54,000 gallons in 2005 to 364,000 gallons in 2006 and 750,000 gallons in 2007. Increased sales and distribution of biofuels resulted in reduced greenhouse gas emissions and local economic benefits to fuel dealers.

Task 2): Facilitate Communication and Education Across the Sector: The VBA worked to plan educational events to build interest and increase knowledge about biofuels, it continued to facilitate dialogue on creating effective distribution and purchase networks, and contributed to a feasibility analysis of biofuel production in Vermont in conjunction with UVM Extension and the UVM Department of Community & Applied Economics (i.e., the *Homegrown Feed, Food, and Fuel* report).

Product: Two VBA conferences and a Biodiesel Spring Workshop/Training were held; and 24 presentations to industry groups, and many other organizations were made. The *Homegrown, Feed, Food, and Fuel* report was completed. The VBA's executive director spent at least 20% of his staff time responding to calls and emails for information and referrals.

Outcome: More than 1,500 individuals attended these events. With much of the focus being on building the commercial sector (supply and demand), more than 93% of those who took part represented businesses, farms, municipalities and policy makers, with the remaining 7% made up of the general public and students. Gaps in technical knowledge among biodiesel users/producers were identified and addressed, while access to regional expertise was improved.

Task 3): Support New Biodiesel Production Opportunities in Vermont: The VBA was tasked with studying "small-scale" biofuel development projects in and outside of Vermont; studying regulatory guidelines and safety procedures for small scale and commercial production and distribution of biodiesel; and surveying Vermont fuel dealers to assess biodiesel supply networks and current capacity to store, blend and deliver biodiesel year round.

Products: A report on small-scale "micro-biofuel" development was completed by Middlebury College students. The "Best Practices" handbook was started but never completed. Alternatively, interested farmers and entrepreneurs are directed to the *Biodiesel Safety and Best Management Practices for Small-Scale Noncommercial Use and Production* report created by Pennsylvania State University. The VBA contributed to the *Homegrown, Feed, Food, and Fuel* report. A list of Vermont biofuel suppliers, storage facilities and distribution points is now online.

Outcomes: There is now greater knowledge of the opportunities available to small scale producers and the agricultural community, as well as basic safety information for persons and the environment.

In December 2007 the VBA Board of Directors decided to merge the association with Renewable Energy Vermont (REV). REV, Vermont's over-arching trade association for renewable energy since 1999, enjoys greater membership support and more sustainable funding sources, than the VBA. REV's greater size and influence will improve Vermont's ability to meet the increased demand for biofuels network development going forward. Both organizations and Vermont's renewable energy sector as a whole will benefit from this strategic consolidation.

With a new round of DOE funding in 2008 (DE-FG36-08GO88182), Netaka White was hired as the VSJF Biofuels Director to continue to develop Vermont's market for biofuels.

VBA president and author, Greg Pahl, tabling at 2007 REV Conference

7. Market Challenges and Success Factors

Market Challenge: The Novelty of Biofuels in Vermont: Liquid biofuels production is all new to Vermont and takes place within context of a traditional, well established agricultural sector based on dairy. The majority of Vermont farmers, including State Line Farm and Borderview Farm, had never grown oilseed crops prior to 2005. The small scale of Vermont farms, our region's short growing season, the lack of key pieces of equipment, infrastructure, and experience stands in marked contrast to biofuels activities in the Midwest.

The VBI's Strategic Goals (Section 4) were written broadly, with the novelty of biofuels in Vermont in mind. After conducting a competitive grant round in late 2005/early 2006, there were only seven fundable projects out of a total of nine proposals and none related to perennial grasses or algae. However, four years later, VSJF is presently slated to fund twenty grants and projects spanning a broader suite of biomass-to-biofuels projects, including algal biodiesel development. Overall, interest in biomass and biofuels technology, feedstocks and production has increased dramatically in the state.

Success Factor: VSJF's Market Development Model: The relatively rapid growth of the Vermont biofuels sector resulted from the development of key pieces of market information and resources. DOE FY05 funding enabled VSJF's grantees to research oilseed feedstock production, oilseed feedstock logistics, and biomass conversion in the Vermont context. Resources for technical assistance and equipment purchases allowed for capacity building and system optimization at new, pioneering on-farm energy production facilities for biodiesel and biogas. This research, coupled with these tangible models, became showcases for education and outreach activities for other farmers and entrepreneurs to learn from. Finally, DOE FY05 funding provided VSJF with sufficient operational capacity to scope out new grant-making opportunities and technical assistance needs to support new oilseed, algae and perennial grass projects, and to effectively manage the use of its DOE funds.

Market Challenge: The Existing Supply Chain: In Vermont's emerging biofuels industry there are several well-established organizational networks, each with its own set of social and economic relationships and dynamics and challenges. For example, Vermont's farmers (and their customers), agricultural researchers (e.g., UVM Extension), the Agency of Agriculture, and commodity feed dealers are one such network. Locally owned heating oil and fuel supply companies, their upstream distributors and their downstream customers, are another example. Technical assistance providers, consultants and funders represent a third.

Success Factor: Network Development: Much of the initial success of the VBI has evolved from an understanding of these organizational and network dynamics, intentionally building relationships with the key players across the networks, and then collaborating on market development strategies that meet the needs of this new sector.

VSJF, VBA, UVM Extension, the Center for Sustainable Agriculture, the Sustainable Agriculture Council, VT Agency of Agriculture, Vermont Fuel Dealers Association, Northeast Organic Farmers-VT, and other organizations often coordinated their research, demonstration projects and outreach events to benefit overall sector growth. This cooperative, multi-stakeholder approach was instrumental in facilitating peer-to-peer learning and the free exchange of innovative ideas, strategic information, and technical know-how that helped the industry to grow in this early stage of development. To advance the biomass-to-biofuels

sector in Vermont, VSJF has more recently been partnering with two other DOE funded projects in the state; the Biomass Energy Resource Center and the Central Vermont Recovered Biomass Facility.

Market Challenge: External Factors: Vermont is feeling the effects of federal and market controls on milk prices, and escalating feed and fuel costs to run Vermont's dairies. This "perfect storm" is taking a heavy toll on the family farm – and many are going out of business. As the price of fossil fuel and/or animal feed changes, the economic viability of growing and processing oilseed crops for fuel is also affected. In addition, the 'food vs. fuel' controversy has tarnished biofuels as a solution for many people.

Success Factor: Local Production for Local Use = Greater Local Control: Oilseeds, for example, allow farmers to substitute imported meal with homegrown alternatives, while oilseed processing for biodiesel can be used to run farm equipment, heat greenhouses and other farm buildings, making the family farm more energy and feed self-sufficent. New work on perennial grasses for commercial thermal applications and algal biodiesel for transportation will open the door for more farmers and entrepreneurs to diversify their activities and expand Vermont's green economy. Vermont activities, almost by definition, circumvent the food vs. fuel controversy by focusing on diversified agriculture and local production for local use.

8. Summary

Despite Vermont's green reputation, there had been no strategic effort to address the state's fossil fuel dependency prior to the Vermont Biofuels Initiative. As one of the few nonprofit driven, statewide biofuels market development efforts in the U.S. DOE's portfolio of projects, the VBI represents a replicable model for other small, rural states to follow. Although we are at the very beginning of a multi-year effort to transition away from fossil fuels, VSJF believes that in a relatively short amount of time–with a small staff and a relatively small budget–a lot of progress has been made.

DOE FY05 funding created an opportunity for farmers, entrepreneurs and technical assistance providers to develop knowledge and experience with a wide array of feedstock production, harvesting, and processing issues, as well as to grapple with questions of sustainability (e.g., local production for local use compared to the 'food vs. fuel' controversy). DOE FY05 funding enabled the creation of two on-farm biodiesel facilities and one new biodigester, the expansion of one waste vegetable oil biodiesel production facility, and the assembly of a team of technical assistance providers, including: Dr. Darby for oilseed crop production and logistics; Callahan Engineering, PLLC for production facility engineering; Farm Viability and Enhancement program for business planning; and the VBA/REV for cross-cutting education and outreach activities.

Over the next several years, the VSJF will focus on expanding the range of biofuel feedstocks under production, generating enterprise planning tools for commercially viable projects, and funding new innovative projects that have the capacity to reduce Vermont's dependence on fossil fuels and greenhouse gas emissions. While Vermont is a small state and we can quickly deploy needed funding and technical assistance, achieving the full social, environmental, and economic benefits of local biofuels production and a sustainable biofuels industry in Vermont, will take more time.

9. Future Vermont Biofuels Initiative Activities

In 2008 VSJF received a new Congressionally Directed Award from U.S. Senator Patrick Leahy through the U.S. Department of Energy (DE-FG36-08GO88182). A total of $984,000 was awarded and is being granted out through a competitive process for Biomass Feedstock Analysis (oilseed crops, grasses, and algae), Biomass Feedstock Production (oilseed crops, grasses, and algae), Expansion of Commercial Biofuels, and Biomass-to-Biofuels Course Development. Staff directed grants were awarded for Biomass Feedstock Analysis at the University of Vermont, for optimization of the State Line Biofuels and Borderview Farm natural oil / biodiesel production facilities, and for biomass-to-biofuels network development at Renewable Energy Vermont. Two staff directed projects, the Renewable Energy Atlas of Vermont and the Grass Energy Partnership are now underway. A map of VBI projects and three non-VBI biofuels projects is provided on page 31. A fully fleshed out VBI market development model for 2005 through 2009, including all funding sources, is provided on pages 32-33.

VBI 08 STAFF DIRECTED GRANTS

1. Biofuels Feedstock Analysis: Oilseed Crop Research and Development.

Grant Recipient: University of Vermont Extension ($67,000). Project manager: Dr. Heather Darby. Building off DOE FY05 funds and subsequent research, Dr. Darby and her assistants will be responsible for conducting field days at demonstration farms to share best practices, continuing economic analysis of oilseed crop production, and will conduct additional field trials at three farms.

2. Biofuels Feedstock Analysis: Perennial Grasses Research and Development.

Grant Recipient: University of Vermont Extension ($58,500). Project manager: Dr. Sid Bosworth. Dr. Bosworth will be responsible for conducting field days at demonstration farms to share best practices with farmers for perennial grass crop varieties, cultivation, harvesting, drying, and processing, as well as conducting perennial grasses field trials at three farms.

3. Biomass-to-Biofuels Network Development.

Grant Recipient: Renewable Energy Vermont ($28,800). Project manager: Andy Perchlik, Executive Director. Renewable Energy Vermont, a 501(c)(6) trade association, will be responsible for coordinating cross-cutting, sector-wide communication and education activities and providing technical assistance to a growing biofuels sector, including convening a Biofuels Working Group.

4. Advanced On-Farm Oilseed Processing and Biodiesel Production Methods

Grant Recipient: State Line Biofuels ($30,000). Project manager: John Williamson. State Line Biofuels will be responsible for expanding oilseed crop research (with assistance from Dr. Darby), enhanced grain and fuel processing, facility improvements, and will provide technical assistance and education to other interested farmers.

5. Safety Review, Engineering Study, and Biodiesel Equipment Purchase for On-Farm, Small-Scale Biodiesel Production Research Facility at Borderview Farm

Grant Recipient: Borderview Farm ($40,000). Project manager: Roger Rainville. Borderview Farm will complete the development of a small batch biodiesel processing facility for farm-scale research purposes, setting up standard operation procedures at the facility (with assistance from Callahan Engineering, LLC), providing process documentation (e.g., schematic drawings, FMEAs, SOPs), and providing education and outreach to other interested farmers

VBI 08 STAFF DIRECTED PROJECTS

1. Renewable Energy Atlas of Vermont: VSJF has been working closely with the Vermont Center for Geographic Information and many partners to develop a Renewable Energy Atlas of Vermont. The Atlas will be a user-friendly, GIS-based website where Vermonters can click on their town (and other spatial boundaries) and select from a range of renewable energy options. A map of existing locations and plausible new locations for renewable energy development will appear on the screen, an analysis of what is possible within the selected boundaries can be selected, and both will be printable. Phase 1 of this project includes 5 main energy categories (biomass, geothermal, hydro, solar, and wind) that splinter out into 19 data layers (e.g., biodiesel [3 oilseed crops], possible algae production locations, waste vegetable oil locations).

2. Grass Energy Partnership: VSJF has been working closely with the Biomass Energy Resource Center and Dr. Sid Bosworth at UVM Extension to explore the possibility of converting perennial grasses (e.g., switchgrass and big bluestem) into pellets (pure grass pellets and grass-wood blends) for commercial thermal applications. Phase 1 (2009/2010) of the Grass Energy Partnership will oversee field trials at Meach Cove Farm and Shelburne Farm, grass pelletizing and mixed blend pelletizing at Vermont Wood Pellets, combustion and emissions testing at All Souls Interfaith Church and Shelburne Farms, and a second Grass Energy Symposium.

VBI 08 COMPETITIVELY AWARDED GRANTS TO-DATE

1. Biofuels Feedstock Analysis: Oilseed Crop Research and Development. The VSJF sought proposals that would lead to increased acreage of oilseed crops (such as soybean, sunflower, canola or camelina) to be processed in state for fuel and livestock feed for Vermont's farms, while generating accurate data that can be used to support the feasibility of these enterprises.

Grant Recipients:

- Clear Brook Farm ($20,000), project manager: Andrew Knafel

Grantee will research the most efficient and cost effective means of growing and harvesting oilseed crops for biodiesel production, among a consortium of five Bennington County small-farms growing a total of 100 acres within a 30 mile radius from State Line Biofuels.

- Lilyquest, LLC ($20,000), project manager: Jon Satz

Grantee will gather comparative agronomic and economic data on organic and conventional methods of oilseed crop production and processing on two Vermont farms (27 acres).

- Ekolott Farm ($17,000), project manager: Larry Scott

Grantee will gather and analyze agronomic, economic and logistical data on methods of 40 acres of sunflower oilseed crop production and processing in Vermont's upper Connecticut River Valley.

- North Hardwick Dairy ($13,000), project manager: Nicholas Meyer

Grantee will gather and analyze agronomic, economic and logistical data on methods of sunflower oilseed crop production and processing on 10 acres in Northeastern Vermont.

2. On-Farm Biodiesel Facility: The VSJF sought proposals that would lead to the development of on-farm biodiesel facilities with at least 50,000 gal/year capacity and which could serve the needs of the host farm, other farms, and/or the surrounding community through the production of biodiesel and livestock meal from oilseed crops such as canola, sunflower, soy and camelina.

Grant Recipient:

- Rainbow Valley Farm ($65,000), project manager: Mark Mordasky

Grantee will be responsible for completing the following tasks, with a goal of producing 50,000 gallons (or more) of biodiesel per year:

1. Complete an enterprise operating plan
2. Renovate existing facility
3. Design system and construct processor
4. Initiate batch processing and testing

3. Biomass-to-Biofuels Course Development: The VSJF sought **workforce development** proposals that would provide students, farmers, entrepreneurs, and others with the educational foundation and technical skills necessary to develop Vermont's biomass-to-biofuels market.

Grant Recipients:

- Vermont Technical College ($20,000), project manager: Dr. John Kidder

Grantee will develop five course modules for 2010 offering: Introduction to Biomass and Biofuels; Biodiesel: Feedstock and Byproducts; Biodiesel: Fuel Production, Standards, and Regulation; Solid Biomass Fuel: Resources, Material Handling and Processing; and Solid Biomass Fuel: Combustion, Emissions, and Byproducts.

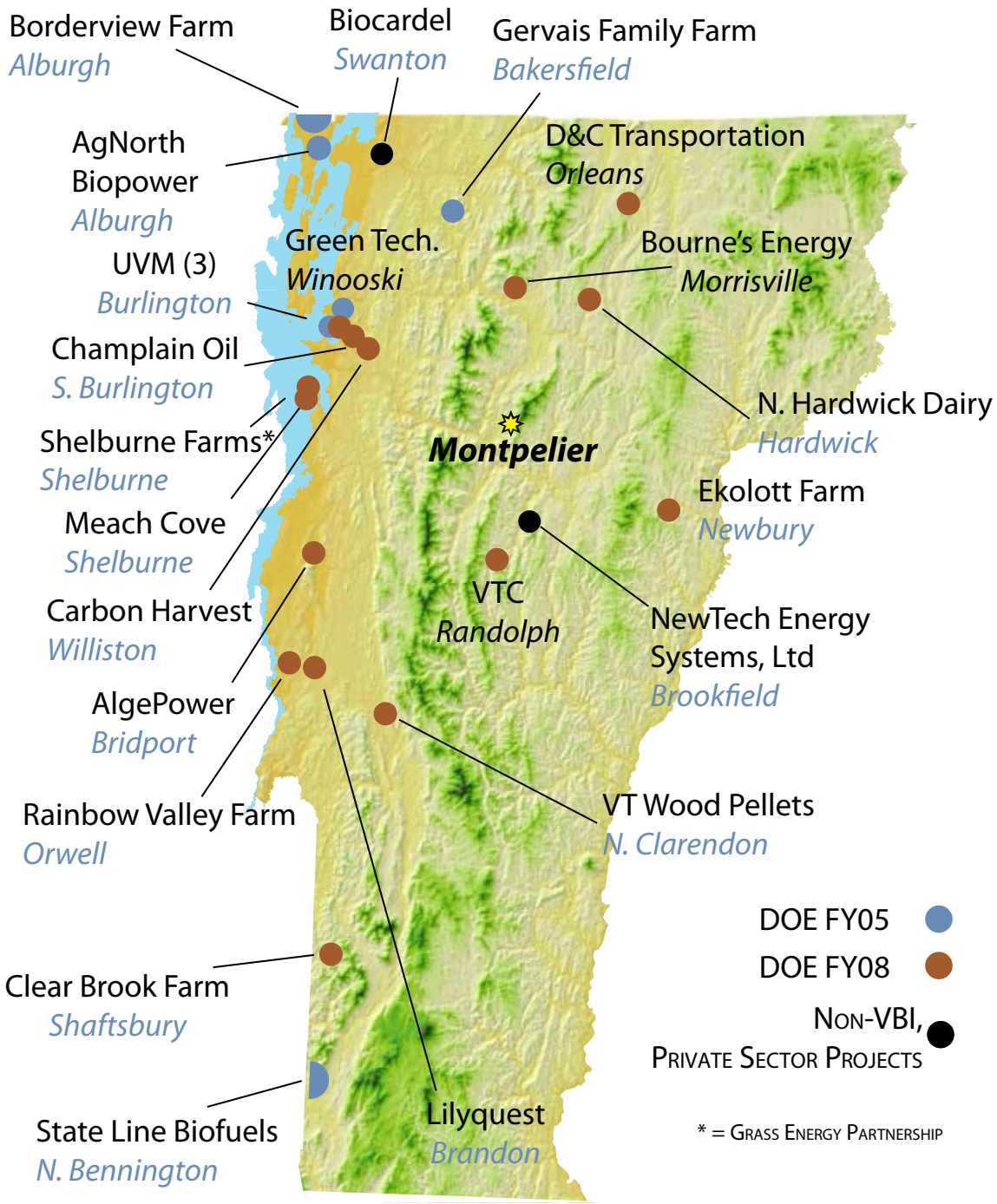
- University of Vermont ($20,000), project manager: Dr. Anju Dahiya

Grantee will develop a course at the Rubenstein School of Natural Resources and for Continuing Education credit for 2010 that will cover a wide range of feedstocks / technologies (e.g., solid wood fuel, biogas, biodiesel, algal oil, and grass pellets) as well as policy, sustainability, and economic issues.

Additional DOE FY08 requests for proposals are being conducted for the expansion of commercial biofuels (for fuel dealers) and algae production and demonstration in 2009. A second Grass Energy

Symposium, Vermont's first Algae Symposium, and additional oilseed farmer meetings will also take place.

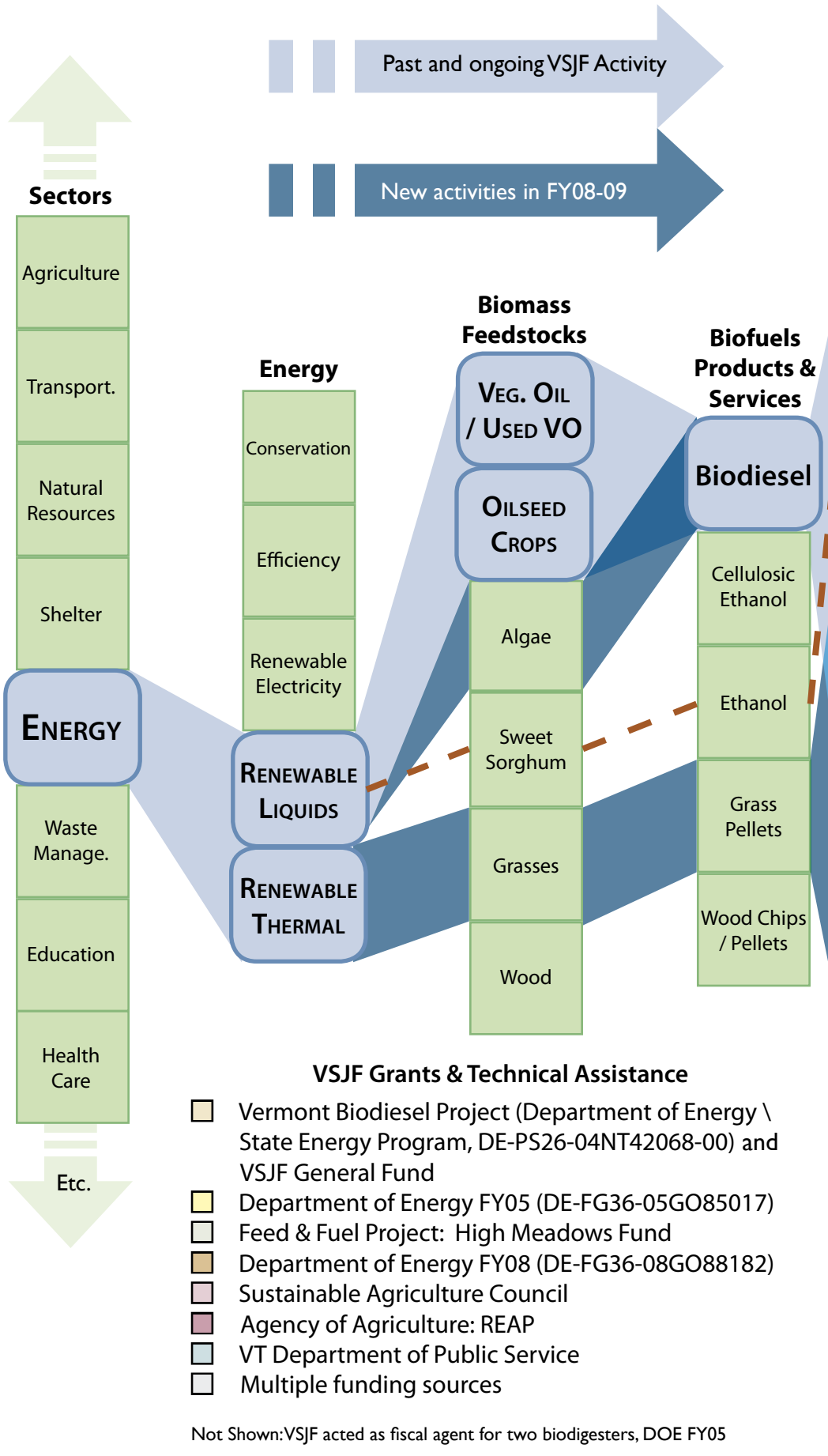
Figure 2. Vermont Biofuels Initiative Map of Projects, 2005-2009



Funding for these projects provided by U.S. Department of Energy through Congressionally Directed Awards from U.S. Senator Patrick Leahy

Vermont Sustainable Jobs Fund

VERMONT BIOFUELS INITIATIVE



VSJF Grants & Technical Assistance

- Vermont Biodiesel Project (Department of Energy \ State Energy Program, DE-PS26-04NT42068-00) and VSJF General Fund
- Department of Energy FY05 (DE-FG36-05GO85017)
- Feed & Fuel Project: High Meadows Fund
- Department of Energy FY08 (DE-FG36-08GO88182)
- Sustainable Agriculture Council
- Agency of Agriculture: REAP
- VT Department of Public Service
- Multiple funding sources

Not Shown: VSJF acted as fiscal agent for two biodigesters, DOE FY05

FEEDSTOCK PR
UVM: Oilse
Homegrown Fee
UVM: Oilseed /
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Sid Bosworth, Ve
CROSS-CUTTING: V

oduction | Feedstock Logistics | Biomass Conversion | Biofuels Distribution | Biofuels End Use

eed Production & Processing Research

Feasibility Analysis: Mobile Unit

ed, Food & Fuel: The Market Potential of Farm-Scale Oilseed Crop Products in VT

Grasss Production & Processing Research

Safety Review & Engineering: State Line & Borderview

n, Ekolott Farm, N. Hardwick Dairy, Lilyquest

gae processing & demonstration: Algepower; Carbon Harvest

UVM: GHG Lifecycle Assessment

n Biodiesel Production Facilities: State Line Farm, Borderview Farm

Bishop Fuel Dealers

Feasibility Analysis: Solar Dryer

Green Technologies: QC equipment, Pump, Tanks

Commmercial Distributors Diversification

Sweet Sorghum to Ethanol: State Line and Ekolott Farms

On-farm Biodiesel Production Facilities: Rainbow Valley Farm

S. Department of Energy through the Office of U.S. Senator Patrick Leahy ● High Meadows Fund ● State of Vermont General Appropriation● unity Foundation ● Maverick Lloyd Foundation ● McClure Foundation ● Orchard Foundation ● Sands Foundation ● Agency of Agriculture, REAP funds ● Brattleboro S&L ● Sustainable Agriculture Council

Cross-cutting: Vermont Biofuels Association ● Renewable Energy Vermont ● Oilseed farmers network

er Darby, Sid Bosworth, Vern Grubinger

Chris Callahan, Engineering

Lawrence Miller: Biz coach to Green Technologies

Cross-cutting: UVM Extension & Farm Viability & Enhancement Program: business plans and enterprise operating plans.

rmont Biofuels Association ● Renewable Energy Vermont ● Oilseed farmers network ● technical assistance providers (e.g., Heather Darby, rn Grubinger, Chris Callahan, Mike Dolce)

VBP & Pilot Projects

Vermont Biofuels Association, Renewable Energy Vermont, UVM, conferences, presentations, workshops, field days, Energy Atlas, websites

Cross-cutting issue: Worked with Sustainable Biodiesel Alliance to develop *Baseline Practices for Sustainability*

Cross-cutting issue: Biomass to Biofuels Course Development: Vermont Technical College & UVM

VT Fuel Dealers Association: Bioheat workshop at Barre Technical Center

Cross-cutting issue: Biomass to Biofuels Course Development: Vermont Technical College & UVM

Bishop Fuel Dealers

Workplan for increasing BD production & use

Commmercial Distributors Diversification

Cross-cutting issue: Worked with Sustainable Biodiesel Alliance to develop *Baseline Practices for Sustainability*

Workplan for increasing BD production & use

10. Vermont Biofuels Initiative Partners

The following organizations provided technical expertise and/or funding to the grantees and projects of the Vermont Biofuels Initiative:

Biomass Energy Resource Center: www.biomasscenter.org

Callahan Engineering, PLLC: www.callahan.eng.pro/index.htm

Farm Viability and Enhancement Program: www.vhcb.state.vt.us

High Meadows Fund: http://highmeadowsfund.org

Renewable Energy Vermont: www.revermont.org

State of Vermont Agency of Agriculture, Food & Markets: www.vermontagriculture.com

State of Vermont Department of Public Service: http://publicservice.vermont.gov

Sustainable Agriculture Council: www.uvm.edu/~susagctr

Sustainable Biodiesel Alliance: www.sustainablebiodieselalliance.com

University of Vermont Center for Sustainable Agriculture: www.uvm.edu/~susagctr

University of Vermont Extension: www.uvm.edu/~uvmext

USDA Rural Development: www.rurdev.usda.gov/VT

U.S. Senator Patrick Leahy: http://leahy.senate.gov

Vermont Biofuels Association (merged with Renewable Energy Vermont)

Vermont Community Foundation: www.vermontcf.org

Vermont Fuel Dealers Association: www.vermontfuel.com

Vermont Technical College: www.vtc.edu

11. Vermont Biofuels Initiative Reports

A. DOE FUNDED:

► **FY05 Project Reports** (DE-FG36-05GO85017)**:**

Borderview Farm Biodiesel Project, Safety Review and Engineering Study of an On-Farm, Small-Scale Biodiesel Production Facility. March 2009.

AgNorth Biopower, LLC: *Final Report to Vermont Sustainable Jobs Fund and Vermont Department of Public Service*. February 2009.

Gervais Family Farm, LLC: *Methane Biogas Project*. January 2009.

State Line Biofuels, Safety Review and Engineering Study of an On-Farm, Small-Scale Biodiesel Production Facility. January 2009.

Green Technologies: Biodiesel From Waste Vegetable Oil. December 2008.

Vermont Biofuels Association: *Building a Biofuels Industry Network*. May 2008.

University of Vermont Extension: *On-Farm Oilseed Production and Processing*. May 2007.

► **The Vermont Biodiesel Project** (DE-PS26-04NT42068-00)**:**

Building Demand in the Biofuels Sector. Final Report. October 2006.

Department of Buildings and General Services: Emissions Testing of Biodiesel Blends With #6 Fuel Oil At the Waterbury State Office Complex. September 2006.

Laboratory and Field Testing of Biodiesel in Residential Space Heating Equipment. August 2006.

B. NON-DOE FUNDED:

Feasibility Analysis: *Mobile Unit for Processing Oilseed Crops and Producing Biodiesel in Vermont*. December 2008

Feasibility Analysis: *Solar Seed Dryer and Storage Bin at State Line Farm, Bennington, VT*. October 2008.

Homegrown Feed, Food & Fuel: *The Market Potential of Farm-Scale Oilseed Crop Products in Vermont*. February 2008.

Homegrown Fuel: *Economic Feasibility of Commercial-Scale Biodiesel Production in Vermont*. September 2007.

All reports available at http://www.vsjf.org/biofuels/resources.Biodiesel.shtml.

Oilseed farmers network meeting at Cedar Brook Farm, April 22, 2009

Vermont Sustainable Jobs Fund

www.vsjf.org