University of Idaho

NIATT

Sustainable Transportation
On Campus and in the Community

Proceedings from the 2005 Conference

Workshop Track 5: September 22-23, 2005

Biodiesel Fuel Production

By

Karen Faunce

Dr. Jon Van Gerpen

Our Common Charge:
Sustainable Transportation on Campus and in the Community

Recent global events have brought into sharp focus our nation's transportation system and the energy system that underlies it. Conflict overseas and natural disasters in the U.S. have spotlighted our dependence upon foreign oil; the vulnerability of the Gulf Coast to environmental impacts; the implications of our resource dependence and land use investments in war-torn and hurricane-prone areas; issues of security and transportation with regards to emergency evacuation strategies; and the social inequities pertaining to access to resources. We are compelled to ask: Can our tightly-woven transportation-land use-energy-environmental system be sustained over the long run?

We can and should continue to examine the issues of technology, resource use and the role of education in fostering a system of sustainable transportation both locally and nationally. One chapter in this process took place in September, 2005 on the University of Idaho campus where 200 interested individuals from the community and the university addressed topics relating to sustainable transportation; including campus and local transportation, research facilities, educational programs, land use and sustainable development, and alternative fuels. These issues have relevance for universities, local communities, and the national landscape.

Many important insights emerged from the two day conference:

- ***The creation of a sustainable, multi-modal transportation system in Moscow, Idaho that links the University of Idaho to the greater community is possible through a cooperative approach between entities.*** In Workshop Track 1, national transportation experts outlined steps toward a positive shift from single occupancy vehicle dependence to a multi-modal sustainable and equitable transportation system developed in cooperation between local governments and universities.

- ***The University of Idaho has the opportunity to be a leader in research, and a model for the application of renewable energy sources.*** In Workshop Track 2, University of Idaho Architecture students facilitated a design charette, which yielded several designs for a sustainable energy lab and transit facility on campus.

- ***Student involvement is essential in the discussion of sustainable transportation.*** In Workshop Track 3, participants discussed how service learning projects can provide both university students and faculty with a more effective way to collaborate with community leaders in addressing land use and environmental issues, and engender a sense of stewardship in future generations.

- ***Community values must be brought into the discussion of land use and transportation.*** In Workshop Track 4, experts in the field of transportation helped participants identify community values, and then translate those values into attributes that the transportation system should have.

- ***Rising petroleum fuel prices and the increasing need for a decentralized fuel source make the time ripe for research and development of alternative fuels, such as Biodiesel.*** In Workshop Track 5, a group discussion took place about the advantages and impediments to producing feedstocks, to creating a Biodiesel fuel production facility, and to creating a market for the fuels on the Palouse.

The time is right for the university to embrace a spirit of community and interdisciplinary cooperation, in order to address today's transportation, energy, and environmental problems. UI President Tim White's signature on the Talloires Declaration, a commitment to environmental sustainability in higher education, behooves faculty, students, and staff to seek innovative solutions for common problems facing the university, and inevitably, the community as a whole.

Former Mayor Comstock and current Mayor Chaney both came to the conference, and affirmed the positive relationship that exists between the city and the university, as well as our common challenges. I trust that we can accept the charge to face these challenges together.

Michael Kyte

Michael Kyte
Director, National Institute of Advanced Transportation Technology
University of Idaho

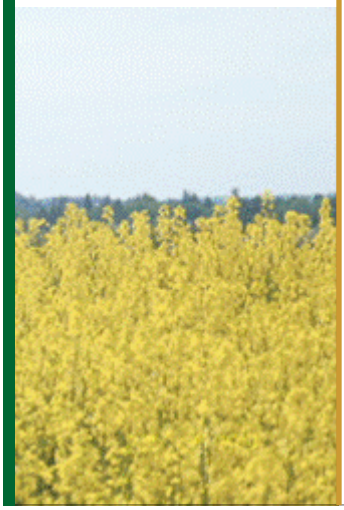
WORKSHOP TRACK 5:

Biodiesel Fuel Production

Dr. Jon Van Gerpen, chair of the Department of Biological and Agricultural Engineering

Advantages to Biodiesel Fuels

- Requires no engine modifications (except replacing some fuel lines on older engines).
- Can be blended in any proportion with petroleum diesel fuel.
- High cetane number and excellent lubricity.
- Very high flashpoint (>300°F)
- Can be made from waste restaurant oils and animal fats.



Introduction

Biodiesel fuel production and use has been of interest to University of Idaho researchers since the late 1970s. Over the years, a number of university vehicles, from pickups to farm machinery, have been operated using Biodiesel fuels. The University of Idaho Department of Biological and Agricultural Engineering is a national leader in Biodiesel fuels research.

In September, 2005, as part of the two day conference held at the University of Idaho: *Sustainable Transportation on Campus and in the Community,* agricultural and biological engineers, plant geneticists, crop specialists, farmers, students, and other interested parties attended Workshop Track 5: *Biodiesel Fuel Production* to discuss the opportunities for, and obstacles to Biodiesel production and use in northern Idaho. Dr. Jon Van Gerpen, chair of the Department of Biological and Agricultural Engineering facilitated the two day workshop, which consisted of a series of presentations, and group discussions of current issues and research pertaining to Biodiesel fuels.

Presentation: What is Biodiesel Fuel?

Dr. Van Gerpen began the session by giving an overview on Biodiesel fuel: what it is, where it comes from, the advantages and disadvantages of its use, and cost considerations. The fuel is derived from a chemical reaction between a vegetable oil or animal fat and an alcohol (ethanol or methanol), plus a catalyst, yielding alkyl monoesters meeting the ASTM standards for diesel fuel. The by-products of the fuel production include the seed meal (when the fuel is derived from a plant source), and glycerin. Biodiesel fuel can be used in combination with, or as a substitute for petroleum diesel fuel in diesel engines, without modification to the engine. Blends, such as B-20 (20% Biodiesel, combined with 80% commercial fuel) are popular in fleet vehicles and can be used to meet energy policy

University of Idaho Biodiesel fuel vehicles on display during the conference.

Dr. Paul Mann
Consultant,
JR Simplot Co.
(Photo: University of Idaho website.)

act mandates for state institutions. Recently, due to the increased costs of petroleum fuels, the use of higher concentrations of Biodiesel has become more economically viable, especially for fleet vehicles and farm equipment.

Biodiesel fuel is non-toxic, renewable, biodegradable, and emits a reduced amount of carbon monoxide, hydrocarbons, and particulates compared to conventional diesel fuel. The fuel has a very high flashpoint (>300° F), making it safe to transport. And it can be produced from waste animal fats and restaurant oils. Van Gerpen pointed out, however, that the fuel has a lower energy content compared to No. 2 diesel fuel, which means that users can expect an 8% reduction in fuel economy and power. Additionally, Biodiesel fuel crystallizes at around 0° C. making low temperature additives necessary in cold climates. And stabilizers may be needed to prolong the life of the fuel and prevent sedimentation, which can clog filter systems, or else the fuel must be filtered frequently.

Cost considerations for Biodiesel fuel are complex. Van Gerpen pointed out that feed stock costs are variable, because animal fats and wastes are inexpensive, but have a limited supply, and seed oils are marketed for other uses, creating competition for their use as fuel. And the facilities for fuel production have not yet been created in order to have wide spread availability. The current price for Biodiesel is $2.30 to $3.00 per gallon depending on the location, and the application of available subsidies for its use.

Presentation: Southern Idaho Feasibility Study

Dr. Van Gerpen then introduced Paul Mann, a consultant from J.R. Simplot Co. Dr. Mann, and Dr. Charles Peterson, Interim Dean of the College of Engineering conducted a feasibility study which researched local sources of feedstocks, marketing options for the fuel and byproducts, plant site requirements and constraints, and considerations for the technology itself, including meeting ASTM standards, and the proprietary nature of commercial Biodiesel production. The sponsors of the study included the Idaho Department of Water Resources Energy Division, The University of Idaho College of Engineering, Department of Biological and Agricultural Engineering and the National Institute of Applied Transportation Technology.

The study area comprised nine counties in the Greater Treasure Valley. The research team considered population and growth in the area for creating markets, and also production capacity for the different feedstocks. Several seed crops, including

Feedstock Production Summary (Millions of Gallons)	
Oil from Crops (25,000 to 166,000 acres at 54 to 105 gallons per acre)	**1.35 to1.74**
Oil from Waste Grease (50% of current collection)	**0.3 to 0.5**
Oil from Processing Plants (50% of estimated 3 million pounds)	**0.2**
Oil from Tallow (50% of current 56 million pounds)	**3.7**
Total Estimated Supply	**5.5 to 21.8**

Figure 1: Estimation of oil production from available feedstocks in the study area.

winter rapeseed, winter canola, yellow mustard crops, sunflower, safflower, and soy are viable feedstocks for local production. Waste oil supplies from restaurants and animal processing plants were also included in the study. Tallow is in the greatest supply, but processors are reluctant to start marketing oil to Biodiesel production when it is still in a speculative stage, and while they have other buyers for the product.

The virgin seed crops mentioned above were examined for yield, drought and climate tolerance, disease, and market availability. Winter rapeseed and winter canola are reported to be the highest yielding oil crops for Idaho, but there are Ag orders in southern Idaho that impede their production in order to control diseases of the Brassica genus, and protect the area's seed industry. However, the research in the study indicates that with a modification of the Ag order, production of these crops is possible by integrating them into an 8 or 12 year crop rotation strategy for commercial producers. Mann stated that a pessimistic estimate of crop acres for oil seed production predicts an oil yield of approximately 105 gallons per acre, for a total of 6.8 million gallons of oil per year in the Treasure Valley. His optimistic estimate predicts 17.5 million gallons. See Figure 1 for oil production estimates derived from the various sources in the Greater Treasure Valley.

Plant Size Assumptions*

Oilseeds	**$0.097 cents/pound**
Methanol	**$0.104 per gallon**
Catalyst	**$0.073 per gallon**
High FFA Processing	**$0.06 per gallon**
Freight	**$0.05 per gallon**
Crushing and Filtering	**$50.00 per ton**
Cost of Plant Operation Heat Energy, electricity, labor, depreciation, maintenance, administration	**$0.20 per gallon up to $0.30 per gallon for the smaller plant**

*Reference: Building a Successful Biodiesel Business
Actual numbers for a particular plant may vary from data used.

Figure 2: Some of the costs associated with the operation of a Biodiesel fuel processing plant.

The market for Biodiesel fuels in the area is promising due to high population centers in the valley, the Boise Clean Cities program, and a large quantity of fleet vehicles used by the state, the National Guard, federal agencies, and utility companies. Other possible consumers included public transportation agencies, the sanitation companies, city and county agencies and the school districts. Based on population and current diesel use, the study estimated that there is a market for 166 million gallons of Biodiesel fuel in the Treasure Valley. The study also looked at the uses for the seed meal and glycerol by-products in the area, including uses as livestock feed, boiler fuel, and pesticide. Mann concluded that there would be sufficient uses for the meal, especially as cattle feed, but that there were limited uses for the glycerol.

He then examined the logistics for a production plant located in southern Idaho, including size and production capacity, infrastructure and legal costs, transportation considerations, utilities, zoning, and permitting. Plant site location, he noted, would be size dependent, with a smaller plant having more potential locations. Larger plants would be constrained by transportation vectors. See Figure 2 for an analysis of processing plant cost considerations. Participants asked questions after the presentation and were interested in more information about the markets for the glycerin, for example, for kosher products, which is a high value market. However, glycerin for kosher products cannot contain animal products, or be processed in a plant with animal products, complicating access to that market.

Presentation: Processing Facility Considerations

In the Thursday afternoon session, Jim Armstrong from the Spokane Conservation District spoke to the group about logistical considerations for processing feedstocks for Biodiesel fuel. First, he said, there are two different models for a processing facility. The first is the development of a large, centrally located processing facility that could produce 50-80 million gallons of Biodiesel per year. The second is the development of several smaller plants that would be situated near the growing areas. A plant of this scale would produce around five million gallons per year, and entail a cooperative arrangement between growers. Armstrong strongly favored the smaller decentralized model for several reasons:

- This area does not have an adequate seed production industry to support a large plant
- There are enormous transportation, infrastructure and storage costs associated with centralized production on a large scale.
- Biodiesel production does not follow an economy of scale.
- Transporting and marketing large amounts of byproducts is both costly and impractical.

Armstrong went on to say that until the farming industry is on board with growing seeds, a production facility will be difficult to rationalize. According to his calculations, 100,000 crop acres are required to support a production facility that generates five million gallons of Biodiesel. Plus there needs to be a market for the meal, which is 60-70% of the product from the crusher. Farmers, he says, are very conservative, and unlikely to speculate in a market that may not yield what they get for their current crops. Some farmers are wary about using Biodiesel in their own machinery, as well, for fear of voiding the warranty on their engines. Armstrong concluded by saying that as a cottage industry, people are very interested in Biodiesel, but until there is a seed market that farmers can count on, and consequently the seed production to rationalize a plant, and therefore, a market for the fuel itself, then production will remain small scale, and that those hoping to make a leap into large scale production based on best case scenario estimates are taking a great financial risk.

Rico Cruz, who works for the Nez Perce tribe, described a pilot Biodiesel plant in Oregon.

Rico Cruz, who works for the Nez Perce tribe spoke next, agreeing with Jim Armstrong that large scale production is a risk. His experience overseas was that an adequate source of seed or used oils is necessary to support the building of a plant. "The best way is a cooperative plant," said Cruz. He told the group about a pilot plant in Oregon started by the Pendleton Grain Growers. Their plant started with 3500 acres of rapeseed and mustard and yielded 25,000 gallons of seed oil to convert to fuel. They produce B-20 for the heating oil market, and the meal goes to the dairy industry, so there is already a market for the byproducts. They use a low-heat purification system for the glycerin, in hopes of getting the USP grade necessary to sell to the pharmaceutical industry. The grain growers association already had the infrastructure to deal with transportation of the seed, heating oil, and byproducts. The group plans to expand as they develop their production and markets.

The participants were very interested in Cruz's experiences overseas, and asked questions about the different seed crops, and their potential for cultivation locally. Research is being done on crops grown in the Pacific, such as Palm- which requires pesticides and irrigation, and a lesser known plant grown in India and on the African continent which is related to the castor plant (name) and is both drought resistant and has a long production life.

Presentation: Oil Seed Production in Northern Idaho

After this discussion, Dr. Van Gerpen introduced the next speaker. Jim Davis is a research support scientist for the Department of Plant, Soils, and Entomological Sciences at the University of Idaho. His research is in Brassica production, particularly canola, and on developing pesticides from the meal from winter mustard. His presentation focused on the feasibility of local production of different seed crops for Biodiesel fuel.

Rapeseed has been grown on the Palouse since the 1930's, mustard since the Depression, maybe earlier, said Davis. Then the "Grain Revolution" occurred, and wheat replaced the Brassicas on the Palouse. Canola returned in the early 1990's, grown for oil, and was marketed to Canada. Davis considers the potential for oil seed crops in the area to be "Very good!" In his opinion, there needs to be a greater diversity of dryland crops grown in the area, with sustainability in mind: sustainability of the soil, the biosystem, and the economic system. In the Inland Northwest, which is defined as northern Idaho, eastern Washington, and northeast Oregon, soy, sunflower, and safflower crops are not sustainable, because they are not dryland crops. Brassica crops, especially canola, rapeseed and mustard grow well here. The Brassicas have already made regional adaptations here, they are familiar to farmers, and they require no specialized equipment for harvesting. They are a beneficial addition to a crop rotation system due to their ability to break a disease cycle, add biomass to the soil, and their taproot makes them drought resistant.

Winter canola, Davis said, has the highest seed and oil production (see Figure 3), and the meal from winter canola makes a suitable livestock feed. Also, the meal can be used as an organic soil amendment, and has properties to eliminate nematodes, though cannot be currently labeled to do so. Canola seed production drops dramatically however, with diminished rainfall, so in drought areas, mustard provides more consistent crop yields (See Figure 4.)

Davis believes that Brassicas are a very promising Biodiesel crop for the Inland Northwest. He did say, however, that there are some drawbacks to Biodiesel fuel use that need to be overcome for it to be widely accepted. Biodiesel fuel increases NOX emissions in the atmosphere, creating smog by accumulating in the lower atmosphere. And Biodiesel has a high cloud point temperature (see Figure 5), especially in purer mixtures, though as mentioned by Van Gerpen, additives can make the fuels less temperature sensitive.

Davis also identified some problems with Brassica production that currently impedes its use as a seed fuel. Winter wheat comprises over half of the Pacific Northwest's six million acres of cropland. Canola and mustard comprise only a very small percentage. Economic returns on the Brassica crops are low compared to wheat, and farmers do not necessarily know how to grow them. Brassica seed yield can be water sensitive and

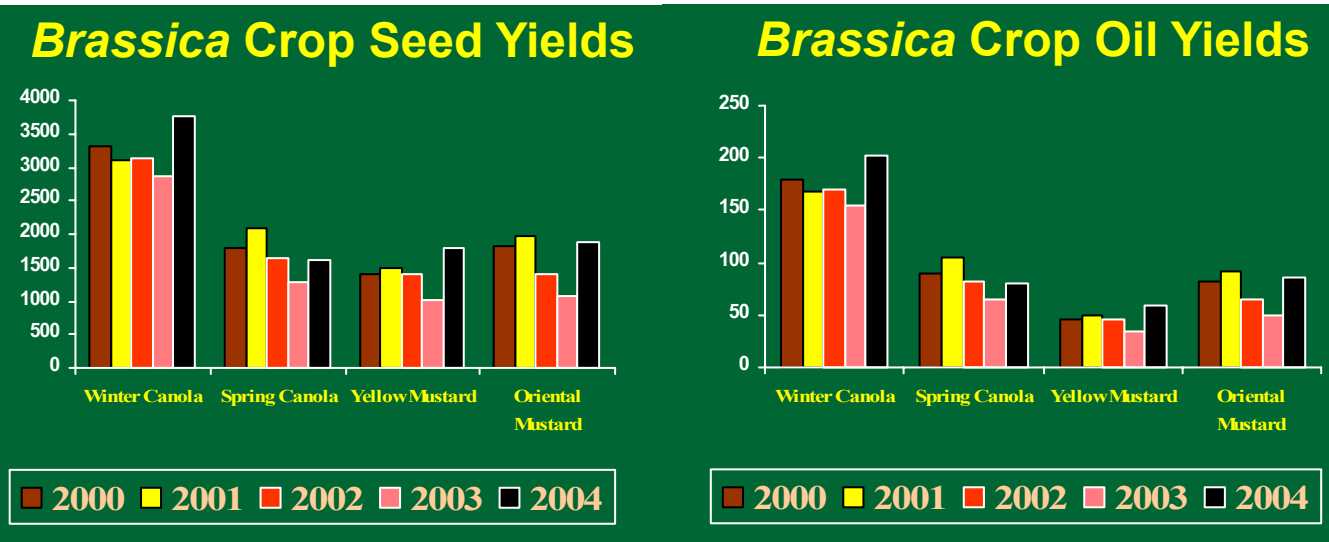


Figure 3: *Brassica* crop seed and oil yield comparison

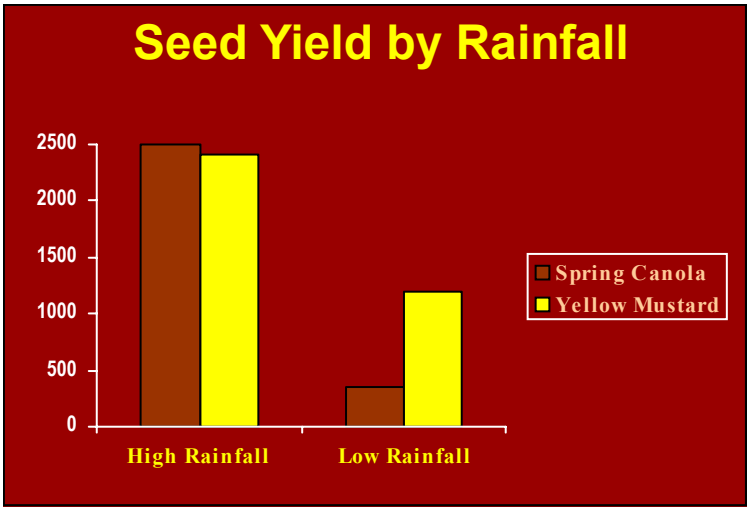


Figure 4: Seed Yield comparisons as influenced by rainfall.

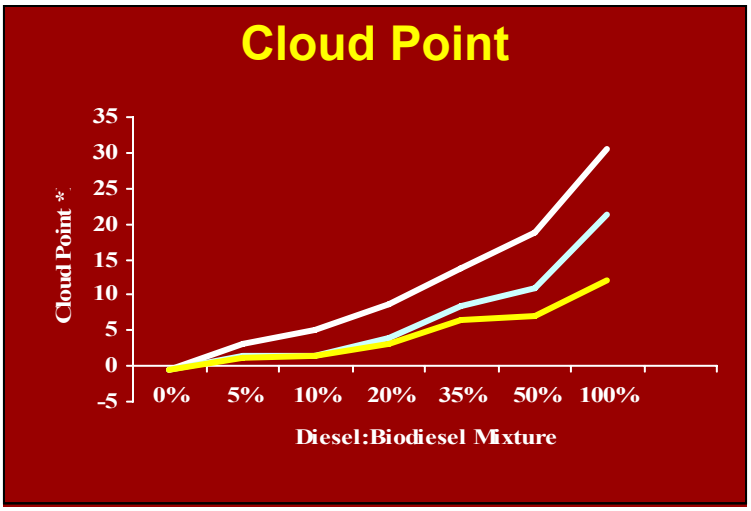


Figure 5: Cloudpoint temperature comparison for various Biodiesel mixtures.

the plants are vulnerable to a variety of pests, though there are currently several different effective insecticides on the market. Of the Brassicas, yellow mustard out-performs canola in weed competition, and requires less straw management strategies to keep seed production high. But under ideal circumstances, as shown above, canola out-produces mustard in seeds and oil. Davis concluded by discussing some of the challenges in the marketplace to supplying the Biodiesel industry with seed oil. Canola and other oils are used in established markets, such as for condiments, cooking oils, lubricants, engine oils and slip agents. The manufacture of these products from the existing supply of seed crops competes with Biodiesel production, which is a relatively new product with an uncertain market. The market potential for Biodiesel is improved however, by the increasing cost of petroleum fuels, and the potential for recovering costs through finding high value markets for the meal and glycerol byproducts, potentially lowering the price of the fuel for the consumer. The participants in the group continued the discussion by noting that better adapted varieties of seed crops would make farmers less risk averse, and incentives would further attract new interest. People also felt strongly that a decentralization of fuel production and a renewable local source were crucial components to creating a more energy secure nation.

Obstacles and Action Items

Friday morning's breakout session focused on two objectives: creating a list of obstacles to public access to Biodiesel fuel in eastern Washington, eastern Oregon and Idaho; and determining actions that could overcome these obstacles. The group divided into three teams to tackle the issues, and to create a list of action items with which to proceed. Each team came up with a list of obstacles and a list of action items. These obstacles and action items identified by the different groups can be summarized as follows:

Obstacle:

- There are government hurdles to overcome, including a lack of mandates and incentives for sustainable fuel use. But which also include competing subsidies for other crops, such as wheat.

Participants discuss obstacles and action items during the break out session.

Action Item:

- Government involvement needs to be of the right type and the right scale. Mandates for Biodiesel use in state fleet vehicles can help provide a market for the fuel. A fuel tax reduction can be used as an incentive for Biodiesel use. Federal agencies, such as USDA can provide support in creating a Biodiesel fuel crushing facility and production plant. Farm subsidies for growing the crops cannot be the only type of government support for the effort, because without assistance in production and developing the market, incentive to grow the crops will die when the subsidies expire.

Obstacle:

- There is no infrastructure in place for Biodiesel production, including crushing and processing plants, a market for the byproducts, and the transportation systems necessary for intake and output of products.

Action Item:

- The three groups all suggested ways to enhance the markets and create the infrastructure for Biodiesel fuel production. These action items included:
  - Create a demonstration plant using research grant monies.
  - Get USDA support in creating a plant and storage facility for products.
  - Enter into a lease arrangement with Washington State to access rail cars for transportation.
  - Enhance the value of the by-products through more research into various uses, such as pesticides.
  - Develop relationships with the feed industry to stimulate the market for by-products.

Obstacle:

- Farmers lack knowledge and leadership for growing the crops and finding markets for the fuel and by-products.

Action Item:

- One of the groups felt very strongly that oil seed production, not processing or marketing, was the primary step in Biodiesel fuels development. This group recommended a tri-state conference that involves the farmers, the land grant universities in Idaho, eastern Washington, and Oregon, and including other entities such as county extension, the National Biodiesel Board, and USDA's Agricultural Research Service be held to synthesize current research, identify seed oil crop varieties and growing techniques, and then introduce farmers to the techniques for successful production. This conference would have the added benefit of creating a network of interested parties and could be the beginning of cooperatives for production, marketing and transportation of Biodiesel products.

Dr. Van Gerpen presented the obstacles and action items generated by the three groups later that day in the final session of the conference.

Presentation: A Distributor's Perspective

Steve Busch, president of Busch Distributors gave the final presentation of the Track 5 workshop. He focused on current fuel distribution systems so that fuel transportation infrastructure could be included in the discussion of the development of a local Biodiesel fuel industry. Busch told the group that there are currently three pipeline systems for distributing refined oil into the area: from Montana, from Salt Lake to Boise to Spokane, and from Western Washington. Upon arriving at the loading rack, the refined product is sold to distributors. The generic gas is then blended and branded and sold at a markup to local fuel vendors. Busch then explained the differences between state regulations in Idaho and Washington and the financial implications of Washington's higher state road tax. As a distributor, Busch said, "I see Biodiesel as just another commodity. I will handle it if I can make money with it. If I can't, I won't."

Conclusions

To become a widely produced and marketed commodity, therefore, Biodiesel fuel has a long way to go to get beyond its beginning stages as a cottage industry product. Growers need to know what varieties of seed crops to grow, how to grow them, and how to integrate their production into a systems view of agriculture which includes their contribution to overall economic profitability and their contribution as a rotation crop. Infrastructure, including a transportation system, a crushing and production plant, and a market for the fuel and by-products needs to be established so that growers can be assured their risk is not too great. Government agencies need to offer their buy-in through creating a system of mandates and incentives that supports the transition to clean, sustainable fuel use. And universities must step up to the challenge of offering their research, and to educate growers and the public on the necessity and viability of sustainable fuel use. Progress in these areas will attract the entrepreneurial interest of private investors, so that alternative fuel sources, such as Biodiesel can eventually be built into a mainstream system of distribution and public access. The increasing costs and uncertain access to petroleum resources, and a beleaguered natural environment demand that progress be made in these areas for the welfare of future generations.

Recommended Links:

National Biodiesel Education Program: *http://www.uidaho.edu/bioenergy/*

Biological and Agricultural Engineering Biodiesel website: *http://www.uidaho.edu/bae/biodiesel/*

National Biodiesel Board: *http://www.biodiesel.org/*

Brassica Breeding and Research website: *http://www.ag.uidaho.edu/brassica/index.html*

Spokane County conservation District website: *http://www.sccd.org/biodiesel/*

We appreciate the support of these conference sponsors!

US DOT University Transportation Centers Grant DTRS98-G-0027

Green Sponsors

President's Office, University of Idaho

National Institute for Advanced Transportation Technology

University of Idaho Parking and Transportation Services

Gold Sponsors

University of Idaho College of Engineering

University of Idaho Finance and Administration

Idaho Transportation Department

City of Moscow, Idaho

University of Idaho College of Natural Resources

Silver Sponsors

Federal Highway Administration, Boise, Idaho

Idaho National Laboratory

Bronze Sponsors

Valley Transit–non-profit public transportation

University of Idaho Environmental Science Program

University of Idaho Environmental Biotechnology Institute

Shelley L. Bennett, Commercial Broker/Developer; Moscow, Idaho

University of Idaho College of Science

Gem Valley Appraisal (gem@moscow.com)