PRODUCING BIODIESEL FROM CANOLA IN THE INLAND NORTHWEST: AN ECONOMIC FEASIBILITY STUDY

PROBLEM STATEMENT

The problem dealt with in this report consists of two parts:

1. Can rapeseed and canola be produced economically in eastern Washington and northern Idaho?
2. Under what conditions could their oils be used as a feedstock for biodiesel used in urban bus systems?

The study area is that served by the Spokane Transit Authority, and our data are partially based on a test period in which a biodiesel blend was used in several buses. Production costs were estimated for a simulated plant used to process the oil. The canola seed market price was used for feedstock cost. This cost, added to the costs of extracting the oil and processing the oil into biodiesel, determined the estimated cost of producing biodiesel for the Spokane Transit Authority.

CANOLA AND BIODIESEL PRODUCTION

Canola Production Costs in the Inland Northwest

Several studies have assessed production costs for rapeseed and canola in the Inland Northwest. Estimated costs have ranged from about 10 cents to nearly 20 cents per pound (Melfi and Withers [1993], Smathers and Withers [1993], Smathers and Foltz [1993], Hinman et al [1991]).

Variation in production cost per pound has resulted from different in climate and soil conditions, from different production practices, and from comparing winter canola with spring canola. Estimated typical yield for spring canola was 1,300 pounds per acre (Smathers and Foltz, 1993) and for winter canola was about 2,000 pounds per acre (Smathers and Withers, 1993). In these studies, winter canola was seeded in late summer on fallow land, while spring seeded canola did not require fallow. Fallow costs were included in the winter canola crop estimate. The cost per pound of seed produced was 15 cents for winter canola and 19 cents for spring canola. In these estimates, all costs except management and risk were charged to the crop. Hinman et al. (1991) estimated costs a little lower, 10 cents to 12 cents per pound, in Lincoln and Adams Counties of eastern Washington in a wheat, barley, fallow, canola rotation.

ENVIRONMENTAL SENSITIVITIES AND BENEFITS

Ethyl ester of rapeseed oil used as a fuel is made from renewable ethanol and rapeseed oil. The resulting product is biodegradable, has a high flash point and has been shown in emission tests to reduce HC and CO emissions. NOx and PM emissions depend on engine design.

The esterification process using ethanol has little effect on the environment. The glycerol can be sold as is or purified. The wastewater from this plant is approximately 175 gallons per day which should have little or no impact on local sanitation facilities. Ethanol is not a Resource Conservation & Recovery ACT (RCRA) hazardous waste. The high number of dilutions and any residual catalyst that is present in the washwater need to be considered if this waste were to be processed commercially. The Moscow City Waste Treatment plant has given approval for direct disposal of the wastewater into their plant.

PROJECT ECONOMICS

Fixed Costs		
Building	$170,000	
Equipment	$ 60,500	
		$/Per Gallon
Annual Cost (8% interest) $63,804		$0.64
Insurance and Taxes (2%)		$0.05
Variable Costs		
Oil@$0.06/lb to $0.29/lb		$0.46 to $2.23
Ethanol@$1.05/gal		$0.34
KOH@$1.56/lb		$0.15
Labor@$245/day		$0.49
Maintenance and repairs (3% of fixed Costs)		$0.02
Utilities		$0.04
Total		$2.19 to $3.96

Potential Income

- Sale of Ethyl Ester Fuels
- Sale of Crude Glycerol

A capitol recovery factor was used for 5 years and 8%. There is no estimation of the potential income from the final product.

Canola Markets

Once canola seed has been produced, it can be sold on the domestic market or exported. Oil and meal are produced by crushing the seed. Canola oil competes with soybean, sunflower, peanut, and other vegetable oils. U.S. canola also competes with Canadian canola. As soybean oil is most widely used in the United States, canola oil prices are somewhat tied to soybean oil prices. In other words, canola oil prices tend to rise and fall with soybean oil prices. The same can be said for canola meal as it tends to follow soybean meal prices. Canola can be exported as whole seed or as oil and meal. Schermerhorn (1986) concluded that Japan would be the major importer of whole rapeseed and that U.S. access to this market would be difficult because of production in Canada, France, and Denmark. Eastern European countries could also be players in the Japanese market. However, domestic consumption of canola oil far exceeds our current production.

Vegetable Oil as a Fuel

Considerable work has been done on using vegetable oil as a fuel for combustion engines. Peterson (1986) found that power output, torque, and brake thermal efficiency in engines fueled with vegetable oil were equal to or very close to those using diesel. However, engine deposits, coking, and other problems resulted from long-term use.

Engine problems associated with vegetable oil fuel can be eliminated by modifying the oil into vegetable oil esters called biodiesel. Ethanol or methanol can be used for this purpose. Methanol is derived from petroleum, while ethanol is a renewable resource produced from grains and other farm products.

Peterson et al. (1992) found that ethanol and methanol are quite similar in their effects on engine performance. Ethyl esters have a slightly higher viscosity than methyl esters, however, and the cloud and pour points are lower. These properties could reduce ethyl ester usability in cold weather. Fuel consumption is the same with either fuel. Ethyl esters are lower in smoke opacity and have lower exhaust temperature, lower injector coking, and fewer combustion chamber deposits.

When comparing the two esters (biodiesel fuels) with diesel (2-D), Peterson et. al. found that the gross heat units of biodiesel were 9 to 13 percent lower than those of 2-D. The viscosities of biodiesel were almost twice that of 2-D, and 2-D had lower cloud and pour points than biodiesel. Biodiesel fuels produced lower power and torque than 2-D. Injector coking was similar for both ethyl ester and 2-D, but the methyl ester showed a slightly higher coking index. The smoke opacities of biodiesel were one-third that of 2-D, and the exhaust temperature of biodiesel was always at least 50°C lower than 2-D (Peterson et al., 1992).

Van Dyne and Raymer (1992) first looked at the environmental implications of biodiesel and found that the two most important factors in biodiesel's future use may be its low levels of exhaust emissions and its biodegradability. These factors may override cost considerations and performance concerns in certain niche markets such as wetlands, wilderness areas, national forests, oceans, and other environmentally sensitive areas. Biodiesel is lower than diesel fuel in three out of four categories listed in the 1993 European Economic Community emissions limits.

Biodiesel Production Costs

Caringal (1989) performed an economic analysis of rapeseed methyl ester and found that the cost could be broken down into the following parts: raw material cost (91.52 percent), operating cost (3.12 percent), and capital cost (5.337 percent). Due to this breakdown, Caringal determined that rapeseed methyl ester is not sensitive to either operating or capital costs because the raw materials made up the majority of the costs.

Weber (1993) determined that both feedstock and meal prices are extremely important in the cost of biodiesel. He concluded that economic competitiveness of a cooperative plant depends enormously on localized variables. Areas that offer low electrical rates, existing facilities, and large oilseed acreage would be good locations. Weber also found that without farm program benefits to minor oilseeds such as canola and soybeans were the most economic feedstocks for a biodiesel facility.

Bam (1991) compared the economic viability of rapeseed ethyl ester with that of rapeseed methyl ester. He assumed that the process for making ethyl ester is essentially the same as that used for making methyl ester, so only the difference in the cost of the alcohol was considered. He found that the break-even price of the ethyl ester was $2.00 per gallon as compared to $1.85 per gallon for methyl ester.

These studies and reports indicate that biodiesel can be used as a substitute for diesel fuel but is more expensive to produce than diesel fuel. Up to the present, the high cost of production has prevented biodiesel from becoming a more widely used alternative fuel. In Europe, where petrodiesel is more expensive than in the United States, biodiesel has had substantial use.

A calculation of oil cost must also consider the value of meal and glycerine. When oil is extracted from canola, a protein meal is produced that can substitute for soybean meal in livestock rations. Glycerine is a by-product of biodiesel production from producing biodiesel. These by-products help to offset the cost of biodiesel production.

THE COST OF CANOLA FOR PROCESSING

In northern Idaho, canola was introduced as an alternative crop to peas and barley. These are crops grown in rotation with winter wheat, which is the major crop in the area. Farmers grow as much wheat as they can within the limits of rotation requirements and government programs. This means about one-half of the crop acres are seeded to wheat each year with the other half producing peas, barley, and, in some cases, lentils. It was hoped that canola would be more profitable than these traditional crops.

Crop budgets prepared by the University of Idaho Cooperative Extension System were used as a basis for estimating the profitability of canola as compared with peas and feed barley (Table 3-1). All crops had a small return over variable costs, but when fixed costs were added, all had a negative return to risk and management. Canola experienced a loss per acre slightly greater than barley and was at an even greater disadvantage with peas. Higher prices or larger yields will be required to make canola a profitable crop. In some cases, where canola could be produced on program acres where deficiency payments could be received along with canola income, it was profitable. Also a few growers produced farm yields considerably above average for the area and enjoyed a positive net return.

The recent market price of 13 cents per pound of canola seed was used to estimate fuel costs even though this was below estimated total production costs. It was assumed that an adequate supply of seed would be available of the processor at this price.

Table 3-1. Estimated economic costs and returns for selected crops northern Idaho, 1993.

	Canola	Peas	Feed Barley
Yield per acre	1,300 lb	1,700 lb	1.5 ton
Price per unit	$0.13	$0.09	$91.00
Gross receipts per acre	$169.00	$148.75	$136.50
Total variable costs	$149.37	$131.91	$128.55
Return above variable costs	$19.63	$16.84	$7.95
Total fixed costs	$106.18	$91.28	$89.10
Total costs	$255.55	$223.19	$217.65
Return to risk and management	$(86.55)	$(74.44)	$(81.15)
Price needed to cover all costs	$0.20	$0.13	$145.10
Yield per acre needed to cover all costs	1,966 lb	2,551 lb	2.39 ton

FEASIBILITY OF RAPESEED OIL AS A FEEDSTOCK FOR BIODIESEL

All three varieties of rapeseed (spring canola, winter canola, and winter rapeseed) grown in the study area could be used for biodiesel because of their high oil content. The largest portion of the cost to produce biodiesel is the feedstock cost. The cost of producing feedstock has been the major obstacle to economic feasibility of biodiesel.

The Clean Air Act of 1990 established stricter emissions regulations for urban transit systems (Caro, 1994). Urban transit directors may have to find ways to reduce emissions either with cleaner engine operation or with pollution reducing fuels. Some alternative fuels competing with biodiesel include compressed natural gas, electricity, ethanol, methanol, and others. The expense of converting buses to use other alternative fuels or of purchasing new fleets to meet the federal emissions standards imposes a financial hardship for urban transit systems. Biodiesel can be used in existing diesel engines without expensive conversion changes. One merely changes form diesel fuel to biodiesel. Therefore, Spokane Transit Authority and other transit systems have been looking into biodiesel as a viable alternative to diesel fuel. The Spokane Transit Authority system was chosen for this feasibility study as it serves the urban center of the northern Idaho and eastern Washington region, and has tested biodiesel blended with diesel fuel.

Spokane Transit Authority Fuel Use

Spokane Transit Authority (STA) is the urban transit system for Spokane, Washington and the surrounding area in Spokane County. STA serves a 371 square mile area that has a population of about 331,000 people. STA operates several services including 36 bus routes, paratransit services for persons with disabilities, car pool and vanpool matching, as well as transportation consulting services (Spokane Transit Authority, 1993).

Eighteen buses were used for a biodiesel experiment from September 1993 to February 1994. These buses ran on a blend of 70 percent diesel and 30 percent biodiesel. The biodiesel used soybean oil as a feedstock and was supplied by the Iowa Soybean Association. At the end of the six month experiment, STA reported reduced fumes, lower particulate levels, and increased fuel economy for the buses using the blend.

At the time of this study, STA utilized 157 coaches each of which used about 1,100 gallons of diesel per month (Caro, 1994). This is a total of 172,700 gallons of diesel required per month or 2,072,400 gallons per year for the fleet of coaches alone. Considering that Spokane is a major center in the Inland Pacific Northwest, it would be reasonable to look at area rapeseed/canola producers as a source of fuel for the STA.

Plant Site Analysis

A linear programming model was used to select an optimal plant site based on the transportation cost of moving seed and the three co-products of meal, biodiesel, and glycerine to and from the plant. Regional trucking firms were contacted for custom hauling rates between possible plant sites, canola producing areas, and product markets.

Six possible plant sites were selected. The sites include five seed-producing areas (Moscow and Craigmont Idaho, Steptoe, Ritzville, and Dayton Washington) and Spokane, Washington. The five cities were chosen as possible sites because they are located in canola or rapeseed producing areas and are accessible to Spokane by major highways. Spokane was chosen as a possible site since it was the target market for both biodiesel and glycerine (Figure 3-1).