

ECONOMICS OF SUNFLOWER OIL AS AN EXTENDER OR SUBSTITUTE FOR DIESEL FUEL

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The economics of fossil based fuels, principally gasoline and diesel, have a recent history of changing rapidly. From a national perspective, our most urgent national energy problem rests with the cost of liquid fuels, which are impacted daily by factors largely beyond U.S. control, due to our import dependence. In the early '80's, daily importation of crude oil fluctuated from 8 million barrels per day to just over 4 million barrels per day. More recently we have seen spot market prices weaken substantially from previously established highs because of an oversupply of crude oil in the world market. The current situation can lead to false expectations of a protracted period of lower prices. Given that fossil-derived liquid fuels have a finite supply, the search for alternative energy sources that are renewable has an important role to play in meeting this country's long-term energy requirements.

DIESEL CONSUMPTION IN AGRICULTURE

The ratio of diesel fuel to gasoline in agricultural production has been changing to a higher proportion of diesel. Tractors were primarily gasoline type when mechanical power was first used in agricultural production, but the introduction of diesel engines has changed the ratio toward diesel. Today nearly all farm engines are diesel, including many farm trucks. Estimated U.S. consumption of diesel fuel in agricultural production for 1978 exceeded 3.3 million gallons (Table 1). North Dakota consumed 126 million gallons of diesel. The tri-state area, of North Dakota, South Dakota, and Minnesota consumed over 378 million gallons.

TABLE 1. Estimated consumption of diesel in agricultural production and gallons of vegetable oil requirement, North Dakota, tri-state area, United States, 1978.

Area	Gallons Diesel ^a	Gallons Vegetable Oil Converted to Same Btu Equivalent as Diesel
	(000 Gallons)	
North Dakota	125,940	135,625
Tri-State	378,293	407,384
United States	3,307,747	3,562,113

^aU.S. Department of Agriculture, Economics, Statistics, and Cooperative Services, *Energy and U.S. Agriculture: 1974 and 1978*, Statistical Bulletin 632, Washington, D.C., April 1980.

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Sunflower could become an important crop to extend the diesel fuel supply or substitute for diesel. Vegetable oils are being researched by private and public agencies as an extender or substitute for diesel fuel. Diesel has a little more energy (Btu's) per gallon than vegetable oils; it takes 7.7 percent more vegetable oil to equal the same Btu's as diesel (Table 1). For example, number 2 diesel has 140,000 Btu's compared with 130,000 for vegetable oil.

OIL SEED CROPS

There are four major oilseed crops grown in the United States — soybeans, cottonseed, sunflower, and peanuts. Harvested acreage of these four oilseed crops comprise 17 percent of all cropland acres in the United States. Harvested acreage and the potential supply of vegetable oil that could be obtained from these crops exceeds 3 million gallons (Table 2). Sunflower has the highest percentage of oil in the seed (40 percent), and oil production per acre of sunflower ranks second to peanuts. Total gallons of potential oil per acre for the four crops are peanuts 107, sunflower 61, soybean 43, and cottonseed 20. The 1981 production of the four oilseed crops could supply about 86 percent of the United States fuel consumption for agricultural production at a substitution rate of 100 percent.

TABLE 2. Harvested acres, gallons of oil, percent oil in seed, and percent of diesel requirement, United States, 1981.

Oil Crop	Harvested Acres	Gallons of Oil	Percent Oil	Percent of Diesel Requirement
	(000 Acres)	(Mil Gals)		
Sunflower	2,482	154	40	4.0
Peanut	1,434	153	31	4.3
Soybean	61,833	2,634	18	73.9
Cottonseed	12,737	152	17	4.3
Total	78,486	3,093		86.5

The principal oilseed crop grown in North Dakota is sunflower. Oilseed varieties were introduced in about 1967 when 52,800 acres were grown. Acreage has increased 27-fold since the oil varieties were introduced. The highest acreage planted was in 1979 with 3.3 million acres (Figure 1). Acreage variation depends primarily on the relationship of sunflower price to the price of competing crops. The acreage trend since 1976 has been sharply upward. It is expected 1982 will show about 3.0 million acres planted to oil-type sunflower.

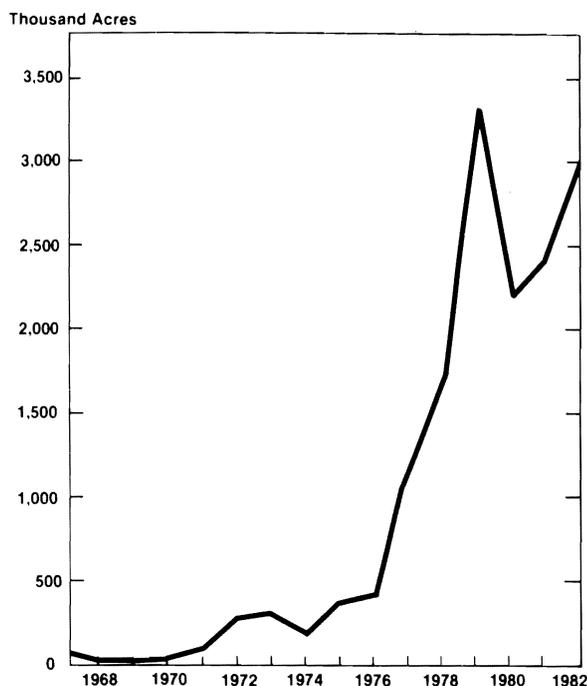


Figure 1. Trend in Planted Acreage of Oil Sunflower, 1967-1982, North Dakota.

Data in Table 3 illustrate the competitive position of sunflower with other crops in east central North Dakota. The yield and price used were the 1977-1981 average with production costs representing the average for the last three years. Sunflower ranked fourth in return to risk of the eight crops compared. It ranked better than the small grain crops and flax, and it is these crops that sunflower primarily competes with for acreage. Sunflower would rank near the top in west central and western North Dakota where soybeans, corn grain, and dry beans are not grown as extensively.

LAND RESOURCES REQUIRED FOR FUEL PRODUCTION

The land area of sunflower required to replace all diesel or a part of diesel fuel requirement is provided in Table 4. The data are based on an average North

Dakota yield of sunflower of 1,200 pounds per acre and 37.6 percent oil obtainable from the seed. Using these assumptions, an acre of sunflower would produce 58.6 gallons of oil. It would take 2,310,477 acres of sunflower to replace all the diesel fuel requirements of North Dakota agriculture. The acreage of sunflower has been large enough in three of the last 16 years to supply this amount of vegetable oil. If sunflower oil was mixed with diesel at one part sunflower oil and nine parts diesel (10%), the acreage required for North Dakota would be 231,048 (Table 4). This acreage of sunflower has been obtained in 10 of the last 16 years.

TABLE 4. Sunflower acreage required to produce sunoil to substitute for diesel fuel at varying rates.

State	Rate of Substitution			
	10%	25%	50%	100%
	-----acreage-----			
North Dakota	231,048	577,619	1,155,239	2,310,477
Minnesota	263,893	659,733	1,319,465	2,638,930
South Dakota	197,564	493,911	987,821	1,975,642
3-State Total	692,505	1,731,263	3,462,525	6,925,049
United States	6,078,691	15,196,728	30,393,456	60,786,911

If sunflower oil could be used in place of all diesel fuel in agricultural production, 60.8 million acres of sunflower would be required in the United States. This would take about 14 percent of the total cropland. A 10 percent substitution would require less than 2 percent of the total United States cropland to supply sunflower oil.

Acres of sunflower to produce oil for 10 percent substitution is less than 1 percent of the North Dakota cropland. Utilizing cropland to produce fuel would take less cropland out of food production than was required in the time of horsepower. At that time, about 20 to 25 percent of the cropland was required to produce feed for horses.

COST/PRICE RELATIONSHIP OF CRUDE SUNFLOWER OIL AND DIESEL

When considering an alternative energy source, the debate frequently centers on short- and long-term competitive relationships. This is a valid direction of focus and should be analyzed carefully before policy and investment decisions are made. Recent interest and attention has centered on the cost/price relationship of crude sunflower oil and #2 diesel prices.

TABLE 3. Estimated historical crop costs and returns per acre, east central North Dakota

Cost and Return Item	HRS					Corn Grain	Sunflower	Dry Beans
	Wheat	Barley	Oats	Flax	Soybeans			
	-----Bu.-----					-----Cwt.-----		
Yield Per Acre	35.8	58.3	69.2	14.8	25.0	70.0	14.4	15.00
Price Per Unit ^a	3.21	2.16	1.28	6.06	6.31	2.42	10.15	19.30
Gross Income	114.92	125.93	88.58	89.69	157.75	169.40	146.16	289.50
Direct Cost ^b	59.62	59.00	49.69	49.63	65.39	84.69	75.02	83.56
Return Cost								
Direct Cost	55.30	66.93	38.89	40.06	92.36	84.71	71.14	205.94
Indirect Cost ^{b,c}	68.23	65.74	64.71	60.52	79.04	77.45	67.77	80.86
Return to Risk	(12.93)	1.19	(25.82)	(20.46)	13.32	7.26	3.37	125.08
Rank	6	5	8	7	2	3	4	1

^a1977-81 average price received by North Dakota farmers.

^b1980-82 average estimated production cost for east central North Dakota.

^cIncludes costs for machinery ownership, labor, land charge, and management.

By using comparative eight-month average spot market prices for crude sunflower oil and #2 diesel fuel (bulk price) for 1979 and annual average prices for both commodities for 1980 and 1981, a cost/price ratio per Btu was calculated. Over time, this cost/price ratio has been moving steadily downward. For example, using eight-month statistics for 1979, the cost/price ratio per Btu was 4.00, meaning the crude sunflower oil price was four times higher on a per Btu basis compared to #2 bulk diesel fuel. The cost price ratio shifted downward to 2.15 for 1980 and 1.80 for 1981.

The prospects for the cost/price ratio to equalize and actually reverse is very difficult to predict with any degree of accuracy. Such factors as the level of U.S. crude oil import dependence, conservation practices, increased domestic oil production, increased agricultural production and processing costs are all linked into such a forecast. The economic incentives for developing alternatives to diesel fuel are determined by the relationship of diesel prices to the cost of producing vegetable oils. Substitutes for diesel will be produced when diesel price rises to a level equal to or above the cost of producing the substitutes.

Despite the limited time range used, the evidence does suggest these two sources of energy are moving closer together. This indicates crude sunflower oil as an alternative energy source has moved closer competitively with bulk diesel prices when compared to a recent 32-month period.

ENERGY CONVERSION

Another important relationship when evaluating an alternative energy source is to consider the energy inputs required to produce and process an alternative energy material. The conversion, using current production and processing estimates, results in an input/output ratio of 5.78 to 1 using an intermediate sized on-farm press as

TABLE 5. Energy inputs and outputs for an acre of sunflower yielding 1,450 pounds per acre, North Dakota, 1982.

	Btu/Acre
Energy Input	
Production—20.1 Gallons/Ac at 140,000 Btu/Gal ^a	2,814,000
Oil Extraction—65.3 Gallons/Ac Requiring 1,720 Btu/Gal ^b	112,316
Total	2,926,316
Energy Output	
Oil—65.3 Gallons/Ac @ 130,000 Btu/Gal	8,489,000
Meal—947 Lbs/Ac @ 8,900 Btu/Lb	8,428,300
Total	16,917,300
Ratio of Output to Input = $\frac{16,917,300}{2,926,316} = 5.78:1$	

^aCurrent inputs required to produce an acre of sunflower.

^bCurrent inputs required to process sunflower from one acre assuming an intermediate size on-farm press.

the base processing unit (Table 5). This states that for every Btu used to produce and process sunflower oil, 5.78 Btu's will be returned, assuming a 1,450-pound sunflower yield per acre. If the energy derived from only the oil is used, 2.88 Btu's are returned for every Btu used in production and processing. These ratios have

the potential for increasing with the prospects for genetic improvements and advances in cultural practices.

Advances in yield potential, assuming all other variables remain the same, would serve to make sunflower oil more competitive with diesel fuel. These on-farm processing costs may be compared to current spot market prices for sunflower oil to evaluate how competitive such operations would be with market prices a commercial plant receives for crude sunflower oil. If the average annual price received for crude sunflower oil (FOB Minneapolis) were used, the cost per gallon for crude sunflower oil in 1981 would be \$2.00. The cost per gallon for three different on-farm size processing operations ranged from \$1.74 to \$3.93 per gallon. These on-farm processing costs assume on-farm operations are run 300 days per year and are fully costed for all resources required. For more detailed cost analysis for on-farm processing see January-February, 1982 *North Dakota Farm Research*, Vol. 39, No. 4, pp. 3-7.

ALTERNATIVE PROCESSING LEVELS

Three distinct levels at which processing an alternate fuel for agriculture could take place are at the commercial level with plants ranging all the way from 800 to 2,000 tons per day.¹ Smaller, intermediate sized processing plants ranging from 25 to 150 tons per day that might be integrated with country elevator operations in rural communities is another option that might be considered. Research is currently investigating the economic advantages for these alternatives.

An attractive approach to producers for attaining a high level of self-sufficiency in their liquid fuel requirements points to on-farm processing. Three optional size operations for on-farm processing have been evaluated.

Commercial units will have the advantage of a higher oil recovery, usually recovering 99 to 99.5 percent of the oil. This differential is attributable to the processing technique employed. Prepress-solvent techniques are more complex and do not lend themselves, from an economic standpoint, to operations as small as those required for on-farm consideration.

Another important revenue generator affecting the cost of sunflower oil is the meal by-product. Considerable price variation exists depending on the protein, fiber, and residual oil content of the meal. Credits allocated to the operation for meal sales must be compared to market derived prices that take into consideration the differentials found in the meal by-product produced by each type of operation.

¹The 800 to 2,000 tons per day are the size ranges of commercial sunflower plants presently operating in the United States. There could be commercial plants operating outside these size ranges. A wider range of sizes might also hold true for intermediate size plants.

It would be extremely difficult to alter the protein, fiber, and oil residual in the meal by-product produced by an on-farm operation. This suggests that a more limited market would exist for this by-product if not totally utilized by the farm operator or within a limited geographic area where processing takes place

ON-FARM PROCESSING COSTS

Costs were analyzed for three sizes of farm presses: 0.35 tons per day, 1.67 tons per day, and 5.0 tons per day. The technology employed in the small on-farm presses incorporates techniques that are still in a developmental stage at these scales of operation. The cost curves for processing 4,800 gallons of sunflower oil annually are shown in Figure 2. The 4,800 gallons were estimated to be the amount of diesel fuel an average North Dakota farm uses annually. Processing this amount of oil would not require additional labor beyond the individual farm operator. The time required to process 4,800 gallons would be approximately 160, 31, and 10 days respectively for the three sizes of presses. The cost per gallon of sunflower oil is \$4.88 for the smallest press, declines to \$2.82 for the 1.67 ton press, and then increases to \$2.87 for the 5.0 ton press. The largest press is used only 10 days to process 4,800 gallons and the hours of use is not great enough to reduce the fixed ownership costs.

As a means of providing for a wide range of alternatives in analyzing the cost structure, it was assumed that some farmers may already have a building suitable to house the press and a zero opportunity cost was considered for the operator's labor. By deleting the building ownership cost and the labor charge, the resulting cost per gallon of crude sunflower oil is \$2.57 for the smallest press, \$2.27 for the medium press, and \$2.48 for the large press (Figure 2).

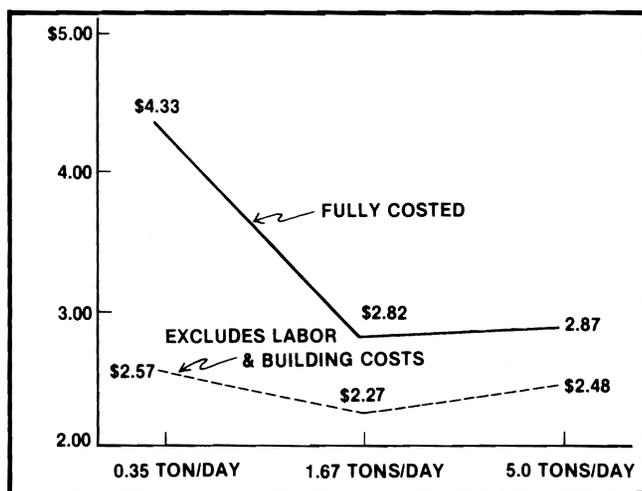


Figure 2. Estimated Costs for Processing 4,800 Gallons of Sun Oil on the Farm, (1981).

Another alternative for these small presses is to operate them full time. Costs were analyzed under the assumption that each of the presses is operated eight hours per day 300 days per year. This would require hired labor, which was included in the costs. The cost per processed gallon, when the press is operated full

time, is \$3.93 for the small press, \$2.30 for the intermediate size press, and \$1.74 for the large press. These costs include a charge for all resources used. The presses operating full time will produce more oil than most farms use annually. This volume translates into a crude oil supply that would support the requirements of 1.87 average size North Dakota farms for the small press, 9.64 average size farms for the 1.67 tons per day size, and 28.90 average size farms for the 5.0 tons per day press.

The estimated costs for the three presses operating 300 days per year capture some economies of size. Economies of size, as used here, refer to reductions in total cost per unit of production resulting from changes in the size and quantity of resources employed. The estimated cost per gallon of crude sunflower oil is reduced from \$3.93 per gallon for the small press to \$1.74 per gallon for the 5.0 tons per day press (Figure 3). Some reduction in cost per gallon is achieved when operator labor and building ownership costs are excluded as shown in the lower cost curve (Figure 3).

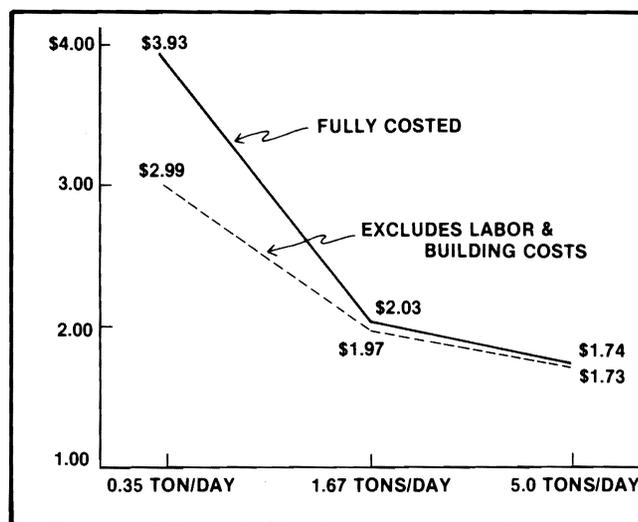


Figure 3. Estimated Costs for Processing 300 Nine-Hour Days by Three Sizes of Presses, (1981)

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