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Structure of the Canola and Biodiesel Industries

Jeremy W. Mattson
William W. Wilson
Christopher Duchsherer

Center of Excellence for Agbiotechnology: Oilseed Development
Department of Agribusiness and Applied Economics
North Dakota State University
Fargo, North Dakota 58105-5636

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Highlights

The biodiesel industry in the United States has grown significantly in recent years. Production increased from 25 million gallons in 2004 to an estimated 250 million gallons in 2006, and many new plants are being built. Like the ethanol industry, much of the growth in the biodiesel industry can be attributed to government support at both the federal and state levels. This support includes a $1 per gallon blenders tax credit for biodiesel. There is considerable potential for demand to grow since the 250 million gallons produced in 2006 equaled just 0.5% of total U.S. diesel consumption.

The National Biodiesel Board reported that as of January 31, 2007 there were a total of 105 biodiesel plants operating in the United States with a total capacity of 864.4 million gallons per year. By the end of 2007, it is expected that 77 new plants will have been constructed and 8 facilities will have expanded. It is anticipated that these new and expanded plants will increase U.S. annual production capacity by 1.7 billion gallons. The plants are located throughout the United States, although the largest concentrations are in the Midwest and East. Iowa and Texas had the largest capacities in early 2007. The states experiencing the greatest growth in biodiesel production in 2007 include Iowa, New Jersey, Texas, Indiana, Washington, and North Dakota. Biodiesel production in Canada has been limited to a few small plants, but the new government incentives for biofuel production could spur some growth in the Canadian biodiesel industry. The world's largest producer of biodiesel, by a significant margin, has been the European Union. Biodiesel production is also emerging in Asia and South America.

Soybean oil is currently the dominant feedstock for biodiesel production in the United States. In Europe, on the other hand, the primary feedstock is rapeseed oil. Canola, which is a variant of rapeseed grown in Canada and the northern United States, is emerging as a feedstock for biodiesel production in the United States and Canada. There are plants under construction in Canada and the northern United States that plan to use canola oil as the primary feedstock, including a large plant in Velva, North Dakota that is planned to begin operations in the summer of 2007.

Canola production in the United States increased throughout the 1990s. Area planted to canola increased from about 150 thousand acres in the early 1990s to 1.56 million acres in 2000. Production rose from 191 million pounds in 1991 to 2.0 billion pounds in 2000 and 2001. Acreage peaked in 2000 and 2001 in the United States, however. Yields have increased over the 15-year period from 1991 to 2005, but the rate of increase is rather slow, and there has been variation from year to year. The lowest yield during this period was 1,197 pounds per acre in 2002, and the highest yield was 1,618 pounds per acre just two years later in 2004. The greatest concentration of canola production in the United States is in northern and central North Dakota. In fact, approximately 90% of U.S. canola production is in North Dakota. Canola production in Canada dwarfs that in the United States. With the exception of a few years, Canadian production has steadily increased over the last several decades, reaching a of 21.3 billion pounds in 2005. Acreage in Canada peaked in 1994 at 14.2 million acres planted and has since ranged from 8.0 to 13.7 million acres.

Returns from canola must compete with those from traditionally grown crops such as spring wheat and durum wheat, and an important factor to consider is the production risk associated with each of these crops. An area of concern with canola production is shattering. Shattering occurs in canola naturally when the pods which hold the canola seed get too dry and break open. The major factors associated with variability in returns to labor and management for canola are crop yields, shattering, market price, and the green count levels. Results from a budget simulation model show that while canola is risky, it is no more risky than major competing crops. Results also show that if shattering is reduced from the current level of 25% to 5%, the return to labor and management nearly triples, and the per acre yield would be over 300 lbs greater than the current averages. Based on this analysis, the value of reducing shattering could be valued at up to $50 per acre, but it is highly variable.

Consumption of canola oil in the United States has grown steadily over the last 20 years, from 93 million pounds in 1985/86 to 1.90 billion pounds in 2005/06. The growing demand has been met by increases in both domestic production and net imports of canola oil. Consumption should continue to grow with the recent qualified health claim from the FDA and increasing consumer awareness of the health benefits of canola oil. Canola oil is now touted as a healthy cooking oil because it has a low level of saturated fat (7%), a high level of monounsaturated fat, no trans fats, and a relatively high level of omega-3 fatty acids compared to other vegetable oils.

The characteristics of canola oil also make it a favorable feedstock for biodiesel production. The higher oil content of canola results in a higher oil yield per acre. The average canola yield in North Dakota for 2004-2006 was about 1,480 pounds per acre. With this yield and a 41% oil content, one acre of canola would produce 607 pounds of canola oil, which could produce 81 gallons of biodiesel. A soybean yield of 42 bushels per acre would yield about 454 pounds of soybean oil, which could produce 60 gallons of biodiesel per acre.

The characteristics of canola oil also make it a favorable feedstock for biodiesel production. A major quality factor for biodiesel is its cold weather performance, which is directly related to the level of unsaturation of the feedstock oil. Because of its low saturated fat content, biodiesel produced from canola oil exhibits better cold flow properties. Sources high in saturated fat such as palm oil or animal fats perform well in some areas, but they have the worst cold flow properties, which could make them undesirable for biodiesel in many regions of the country. Canola oil also performs as well or better than soybean oil in every important factor for biodiesel production.

While there may be many benefits from producing biodiesel, the growth of the industry will depend on its profitability. Feedstock cost is a substantial expense for biodiesel production, so the choice of feedstock affects profitability. Animal fats are the cheapest feedstock, but they are more expensive to process. Soybean oil is generally the cheapest of the virgin vegetable oils. A comparison of wholesale canola and soybean oil prices since 2000 shows that soybean oil prices are lower than canola oil prices by an average of about 5 cents per gallon, and more recently that price gap has risen to about 8 cents.

Results from a simulation model show that the higher cost of canola oil leads to a higher cost of production for biodiesel. We find that the average per gallon production cost for a 30 million gallon per year (MMGy) biodiesel plant is $2.16 for soy biodiesel and $2.45 for canola biodiesel. The results also show, as previous studies have found, that economies of scale exist. The production costs for a 15 MMGy plant are $2.46 and $2.75, respectively, for soy and canola. However, as prices of soy and canola oil have increased recently, so has the cost of production for biodiesel. When the 2005 prices are used in the model, the average cost of production in a 30 MMGy plant is found to be $2.29 for soy biodiesel and $2.89 for canola biodiesel. These results demonstrate the importance of feedstock price on biodiesel profitability. Soybean and canola oil prices have continued increasing in 2006 and 2007.

The main limiting factor for biodiesel production is the available supply of affordable feedstock. The majority of U.S. biodiesel production will likely continue to be from soybeans because it is the most abundant feedstock. The next most available vegetable oils are domestically produced corn oil, domestically produced and imported canola oil, imported palm oil and coconut oil, and domestically produced cottonseed oil. With demand increasing for biodiesel and for healthy vegetable oils for food use, canola production may not be able to keep pace with the demand. The potential for soybean-based biodiesel production is also limited by feedstock availability. Continued increases in soybean oil and other vegetable oils could push up prices and cause biodiesel production costs to increase. To meet the demand, the United States may need to increase imports of vegetable oils. Some alternative feedstocks that could be used for biodiesel production include corn oil, sunflower oil, palm oil, animal fats, used cooking oil, waste grease, camelina, jatropha, and algae, among others.

Abstract

The biodiesel industry in the United States has grown significantly in recent years. Production increased from 25 million gallons in 2004 to an estimated 250 million gallons in 2006, and many new plants are being built. Most biodiesel in the United States is produced from soybean oil, but canola offers characteristics which make it a favorable feedstock for biodiesel production. Characteristics of canola oil also make it an increasingly popular choice for human consumption. This study examines the structure of the biodiesel and canola industries. Specifically, the study describes changes in the biodiesel industry, trends in canola production in the United States and Canada, profitability and production risk for canola, the characteristics of canola oil for both human consumption and biodiesel production, the profitability of biodiesel production, and the potential to meet the demand for biodiesel production in the United States.

Key words: canola, biodiesel, vegetable oil

Structure of the Canola and Biodiesel Industries

Jeremy W. Mattson, William W. Wilson, and Christopher Duchsherer[1]

Introduction

The biodiesel industry in the United States has grown significantly in recent years. Production increased from 25 million gallons in 2004 to an estimated 250 million gallons in 2006, and many new plants are being built. Like the ethanol industry, much of the growth in the biodiesel industry can be attributed to government support at both the federal and state levels. This support includes a $1 per gallon blenders tax credit for biodiesel. Support for biofuels, including biodiesel, is driven by a desire to reduce U.S. dependence on foreign oil, the environmental benefits of the renewable fuels, and the economic benefits for farmers and rural communities. Growth in the industry is expected to continue.

Biodiesel can be produced from a number of potential feedstocks. Most feedstocks can be divided into one of three categories: vegetable oils, first use animal fats, and waste greases (Kotrba 2006). Virgin vegetable oils, which are available in consistently high quality form, are easiest to process into biodiesel (Kinast 2003). Vegetable oils include those derived from soybeans, sunflowers, canola/rapeseed, etc. Largely because of its wide availability, most biodiesel in the United States has been produced from soybean oil. Rapeseed oil is the most common feedstock used in the European Union (EU), where most of the world's biodiesel has been produced. Rapeseed, or its North American variant canola, offers characteristics which make it a favorable feedstock for biodiesel production. New biodiesel plants are being built in the United States and Canada which plan to use canola oil as its primary feedstock.

In addition, characteristics of canola oil also make it an increasingly popular choice for human consumption. The U.S. Food and Drug Administration (FDA) (2006) recently authorized a qualified health claim touting the health benefits of canola oil. As a result of increasing consumer awareness of these health benefits, demand for canola oil could grow. The increasing demand for canola for both food and fuel could spur a growth in production in the United States. However, the United States is already a net importer of canola and canola oil, and these imports could increase as production may not be able to keep pace with demand.

The objective of this study is to examine the structure of the biodiesel and canola industries. Specifically, the study describes changes in the biodiesel industry, trends in canola production in the United States and Canada, profitability and production risk for canola, the characteristics of canola oil for both food use and biodiesel production, the profitability of biodiesel production, and the potential to meet the demand for biodiesel production in the United States. Simulation models are developed to analyze risks in canola production and cost of production for biodiesel.

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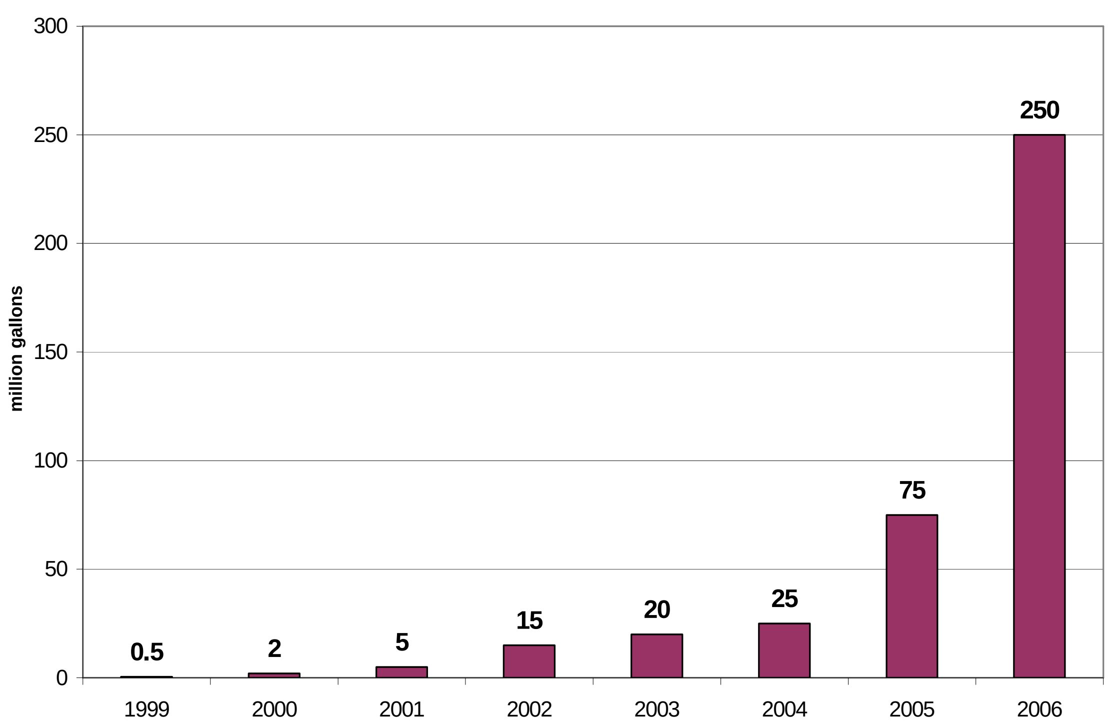
[1]Research Assistant, Professor, and Graduate Student in the Department of Agribusiness and Applied Economics, North Dakota State University.

The Growth of the Biodiesel Industry

The biodiesel industry in the United States is a young and growing industry. Sales of biodiesel in the United States increased from just 0.5 million gallons in 1999 to 25 million gallons in 2004, before tripling to 75 million gallons in 2005 and then growing to an estimated 250 million gallons in 2006 (Figure 1) (National Biodiesel Board 2007). The industry lags considerably behind the corn ethanol industry, which produced 4.9 billion gallons in 2006, but it has grown quickly over the last five years, and it is expected to continue increasing as a number of new plants are in the construction or planning stages. There is considerable potential for demand to grow since the 250 million gallons produced in 2006 equaled just 0.5% of total U.S. diesel consumption, which was 49.2 billion gallons. To capture just 2% of the current market for diesel would require annual biodiesel production to increase to 1 billion gallons.

Figure 1. U.S. Biodiesel Production



Source: National Biodiesel Board

Government Support

Much of the growth in the biodiesel industry is driven by government support, both at the federal and state levels. Cost of production for biodiesel is higher than that for conventional diesel, but subsidies reduce the cost disadvantage and improve the profitability of biodiesel. The

U.S. Congress created a volumetric-based tax incentive for biodiesel (VEETC) which provides a $1.00 per gallon tax credit for biodiesel produced from virgin oils derived from agricultural products and animal fats (Palmer 2006). The credit is actually $0.01 per percent blended into conventional diesel fuel, so it must be blended to receive the tax credit, but it is essentially equivalent to a $1.00 per gallon subsidy. The tax credit was implemented in 2005 and was later extended through 2008 as part of the Energy Policy Act of 2005. The Energy Policy Act of 2005 also provides a small producer income tax credit of $0.10 per gallon for the first 15 million gallons produced by a biodiesel plant.

The federal government is also supporting biofuel production through a renewable fuels standard created in the Energy Policy Act of 2005. This legislation mandates a level of U.S. biofuel consumption that will increase each year to 7.5 billion gallons in 2012. Most of this mandate, though, will be achieved from ethanol, and there is no specific requirement for biodiesel use.

Most states have their own incentives to promote the production and use of biodiesel (Table 1). Minnesota, for example, mandated 2% biodiesel use on September 29, 2005. Producers of biodiesel in North Dakota may be eligible for property tax or sales tax exemptions, an income tax credit, or tax credits for investing in an agricultural processing facility or for developing a facility to produce or blend biodiesel (Schumacher 2006). North Dakota also provides a biodiesel loan program, a biodiesel income tax credit equal to $0.05 per gallon, which is available to suppliers that blend biodiesel into petroleum fuel at a blend of 5% or greater, and a reduction in the state excise tax from the standard rate of $0.23 to $0.2185 if the fuel is at least 2% biodiesel (Schumacher 2006). A number of states considered mandates and incentives in the 2007 state legislative session which may not all be represented in Table 1.

Biodiesel production is also subsidized in Europe. The EU currently has non-binding targets for its member-countries to replace 5.75% of petrol and diesel consumption with biofuels by 2010, and the European Commission has recently unveiled new targets for a minimum of 10% biofuels within vehicle fuels by 2020 (Smith 2007). Documents available from the European Biodiesel Board (2007a) report the types of subsidies used by individual EU countries. Germany is the world's leading producer of biodiesel, accounting for more than half of the EU's biodiesel production. Germany had been promoting biofuel production by exempting these fuels from the petroleum tax. A small partial tax on vegetable oil based fuels was introduced, though, on August 1, 2006. The German government also requires a certain level of biofuel sales in an effort to achieve the EU target. The next largest producers of biodiesel in the EU are France and Italy. Germany, France, and Italy accounted for nearly 80% of EU biodiesel production in 2006. Italy has a six-year program running from 2005 through 2010 that provides an exemption from the excise duty for an annual quota of 200 thousand metric tons (about 60 million gallons) of biodiesel. Other EU countries also provide tax exemptions and other means of support for the biodiesel industry.

The tax breaks in Europe are different from those in the United States because they are generally available only at the point of sale, whereas U.S. tax breaks are received when the biodiesel is blended with diesel. The intent of the U.S. tax credit may have been to encourage U.S. production of biodiesel derived from domestic feedstocks, but the tax credit can also be applied to biodiesel produced from imported feedstock, such as palm oil, and even to imported biodiesel itself if it is blended in the United States (Palmer 2006). This tax incentive, combined with the relatively low import duty on biodiesel, may attract imports of biodiesel into the United States. Another concern is the possibility of biodiesel being re-exported from the United States. There are allegations that traders are taking advantage of a loophole in the U.S. subsidy system by shipping biodiesel to the United States, mixing it with diesel to receive the tax break, and then re-exporting it to Europe (The Independent April 29, 2007; National Biodiesel Board April 25, 2007). The National Biodiesel Board has stated that this type of re-exporting activity is an inappropriate use of the tax credit, and they are committed to closing this loophole (National Biodiesel Board April 25, 2007). There has been some movement within the U.S. Congress in 2007 to remove this loophole.

The biodiesel industry in Canada has been slower to develop. The Canadian government has just recently started to subsidize and provide incentives for biodiesel. In December 2006, Canada mandated a 5% renewable fuel content for transportation fuels by 2010 and a 2% content mandate for diesel and heating oil by 2012. The government also implemented a C$345 million program in 2007 to encourage biofuel production, of which C$200 million will go to help agricultural producers construct or expand biofuel production facilities, and C$145 million will go towards research. The federal government in Canada announced plans in early 2007 to invest C$2 billion (US$1.7 billion) over 7 years to boost ethanol and biodiesel production. This would include a $0.20/liter ($0.76/gallon) incentive for producers, though this incentive could be scaled down over time. The province of Alberta is providing a Renewable Energy Producer Credit Program that will be in effect from April 2007 to March 2011. This program provides tax credits to biofuel manufacturers in Alberta, with the minimum credit equal to the Alberta Fuel Tax, which is currently $0.09/liter ($0.34/gallon). A large biodiesel facility being planned for Innisfail, Alberta will receive a $0.14/liter ($0.53/gallon) subsidy through this program (Scotton 2007).

Table 1. State Biodiesel Incentives

State	Incentive
Arkansas	$0.50/gal tax refund to suppliers of biodiesel fuel. Expires June 30, 2007. Income tax credit to biodiesel suppliers for up to 5% of the costs of the facilities and equipment used in the wholesale or retail distribution of biodiesel fuels. Grants of up to $0.10/gal for the production of biodiesel, up to 5 million gallons per producer per year, for a period not to exceed 5 years.
California	San Francisco has mandated that diesel vehicles used by San Francisco's public agencies must use at least a 20 percent biodiesel (B20) blend by the end of 2007.
Colorado	All state-owned diesel vehicles and equipment must be fueled with B20, subject to the availability of the fuel and so long as the price is no greater than $0.10 more per gallon than the price of conventional diesel.
Delaware	Grants equal to 25% of the cost of a project which demonstrates the market potential of Renewable Energy Technology in Delaware, including biodiesel. Taxes imposed on alternative fuels used in official vehicles for the U.S. or any governmental agency are waived.
Florida	Through July 1, 2010, the sale or use of materials used in the distribution of biodiesel (B10-B100), including refueling infrastructure, transportation, and storage, is exempt from the state sales, rental, use, consumption, distribution, and storage tax, up to a maximum of $1 million in total taxes each year. A credit against the state sales and use tax is available for costs incurred between July 1, 2006, and June 30, 2010 for 75% of all capital costs, operation and maintenance costs, and R&D costs incurred with an investment in the production, storage, and distribution of biodiesel in the state, up $6.5 million.
Iowa	Through 2011, retailers whose diesel sales are at least 50% biodiesel are eligible for a $0.03/gal tax credit on each gallon of B2 or higher blend sold. Biodiesel blenders may apply for a cost-share grant for terminal distribution facilities; grants could cover 50% of the total project up to a maximum of $50,000. The goal of the Iowa Renewable Fuels Standard is to replace 25% of gasoline in the state with biofuels by Jan 1, 2020. All state agencies must ensure that all bulk diesel fuel procured contains at least 5% renewable content by 2007, 10% by 2008, and 20% by 2010
Idaho	For 2007 through 2011, qualified refueling infrastructure is eligible for up to a 6% tax credit. Grants for up to 50% of the cost of installing new refueling infrastructure dedicated to offering biofuels for retail sale. Tax deduction to licensed motor fuel distributors based on the renewable content of the fuel.
Illinois	Sales and use taxes apply to 80% of the proceeds from the sale of biodiesel-blended fuels containing between 1% and 10% biodiesel made between July 1, 2003, and December 31, 2013, and these taxes do not apply to the proceeds from the sale of biodiesel blends containing more than 10% biodiesel. All government, school, university, and mass transit diesel vehicles are required to use a biodiesel blend that contains at least 2% biodiesel. An energy independence plan will invest in renewable biofuels by providing financial incentives to build 5 new biodiesel plants.
Indiana	$1.00/gal tax credit to producers of biodiesel at a facility located in Indiana that is used to produce blended biodiesel, Tax credit of to $0.02/gal of blended biodiesel to producers in Indiana of blended biodiesel. Tax credit of $0.01/gal of blended biodiesel to retailers through December 31, 2010. Governmental entities are required to fuel diesel vehicles with biodiesel whenever possible.
Kansas	A biodiesel fuel production incentive is available in the amount of $.30 per gallon of biodiesel fuel sold by a qualified Kansas biodiesel fuel producer. The state offers an income tax credit for refueling stations placed in service after January 1, 2005; the tax credit may not exceed $160,000. A 2% or higher blend of biodiesel must be purchased for use in state-owned diesel powered vehicles and equipment, where available, as long as the price of is not more than $0.10/gal greater than the price of diesel fuel.
Kentucky	$1.00/gal income tax credit for biodiesel producers and blenders, up to an annual biodiesel tax credit cap of $1,500,000.
Louisiana	Certain property and equipment used in the manufacture, production, or extraction of unblended biodiesel, as well as unblended biodiesel used as fuel by a registered manufacturer, are exempt from state sales and use taxes. Within 6 months after monthly biodiesel production in the state equals or exceeds an annual production volume of 10 million gallons, 2% of the total diesel sold by volume in the state must be biodiesel produced from domestically grown feedstock.

Table 1 continued

State	Incentive
Maryland	Biodiesel producers may apply for production credits as follows: a) $0.20/gal of biodiesel produced from soybean oil (the soybean oil must be produced in a facility or through expanded capacity of a facility that began operating after Dec 31, 2004), and b) $0.05/gal for biodiesel produced from other feedstocks (including soybean oil produced in a facility that began operating on or before Dec 31, 2004). Credits are limited to 5 million gallons per calendar year, of which at least 2 million gallons must be from soybean oil produced in a facility as described in above. At least 50% of state vehicles must use a minimum biodiesel blend of B5 beginning in fiscal year 2008.
Maine	State income tax credit of $0.05/gal for the commercial production of biofuels. Tax credit for the construction or installation of, or improvements to, any refueling or charging station for the purposes of providing clean fuels. The qualifying percentage is 25% for expenditures made from 2002 through 2008. Direct loans and subsidies available to a business or cooperative for the design and construction of a facility to produce agriculturally derived fuel Diesel containing at least 2% biodiesel is taxed at a rate of $0.200/gal, compared to $0.279/gal for regular diesel.
Michigan	Taxes are reduced from $0.15/gal to $0.12/gal for diesel containing at least 5% biodiesel. A tax exemption may apply to industrial property which is used for the creation or synthesis of biodiesel fuel. Grants to owners and operators of service stations to convert existing, and install new, fuel delivery systems designed to provide biodiesel blends.
Minnesota	All diesel fuel sold or offered for sale in the state for use in internal combustion engines must contain at least 2% biodiesel fuel by volume.
Missouri	Monthly grant to qualified Missouri biodiesel producers, provided that 1) at least 51% of the production facility is owned by agricultural producers who are residents of the state and who are actively engaged in agricultural production for commercial purposes or 2) at least 80% of the feedstock used by the facility originates in-state. All of the feedstock must originate in the U.S. The value of the grant is $0.30/gal for the first 15 million gallons produced in a fiscal year and $0.10/gal for the next 15 million gallons produced in a fiscal year, up to a total of 30 million gallons and for 60 months maximum per producer. This incentive expires December 31, 2009. Through the 2011-12 school year, school districts are allowed to establish contracts with nonprofit, farmer-owned new generation cooperatives to purchase biodiesel blends of 20% biodiesel or higher for use as bus fuel. School districts will receive an additional payment through its state transportation aid payment to offset the incremental cost of purchasing the biodiesel. At least 75% of the MoDOT vehicle fleet and equipment that use diesel must be fueled with B20 or higher, if such fuel is commercially available.
Mississippi	$0.20/gal direct payments to biodiesel producers located in Mississippi, up to 30 million gallons per year per producer, for a period of up to 10 years. No payments will be made for production that occurs after June 30, 2015, and the maximum total annual payment to a single producer is $6 million.
Montana	Tax credit for up to 15% of the cost of storage and blending equipment used for blending biodiesel. The credit can only be claimed in the year in which the taxpayer begins blending biodiesel for fuel or sale. Tax credit is available for up to 15% of the cost of constructing and equipping a facility to be used for biodiesel production. The credit must be claimed in the tax year in which the facility begins production, and the facility must be in operation before January 1, 2010. Additionally, a tax credit is available for property used to crush oilseed crops for purposes of biodiesel production. A licensed distributor who pays the special fuel tax on biodiesel may claim a refund equal to $0.02/gal of biodiesel sold during the previous quarter if the biodiesel is created entirely from biodiesel ingredients produced in Montana. The owner or operator of a retail motor fuel outlet may claim a refund equal to $0.01/gal of biodiesel purchased from a licensed distributor if the biodiesel is created entirely from biodiesel ingredients produced in Montana. Tax incentive payable to biodiesel producers for increases in annual biodiesel production for 3years in the amount of $0.10/gal for each gallon of increased production over the previous year, available until July 1, 2010.

Table 1 continued

State	Incentive
North Carolina	A biodiesel provider that produces at least 100,000 gallons of biodiesel during the taxable year is allowed a credit equal to the per gallon excise tax the producer paid in accordance with motor fuel excise tax rate. The credit may not exceed $500,000 and is effective for 2008 and 2009. Tax credit for the processing of biodiesel equal to 25% of the cost of constructing and equipping the facility. Tax credit equal to 35% of the cost of constructing and equipping the facilities for a taxpayer that constructs and places in service in North Carolina 3 or more commercial facilities for processing renewable fuel and invests a total amount of at least $400,000,000. Tax credit equal to 35% of the cost of the property for taxpayers who constructs, purchases, or leases renewable energy property. Tax credit for qualified refueling facilities that dispense biodiesel equal to 15% of the cost of construction and installation. The retail sale, use, storage or consumption of alternative fuels is exempt from the state retail sales and use tax.
North Dakota	A 5-year corporate income tax credit for equipment that enables a facility to sell diesel fuel containing at least 2% biodiesel. The tax credit is worth up to 10% per year, for up to 5 years, limited to a cumulative amount of $50,000. A corporate income tax credit of 10% per year for 5 years of the direct costs incurred to adapt or add equipment for the purpose of producing or blending diesel fuel containing at least 2% biodiesel fuel by volume, limited to a cumulative amount of $250,000. Income tax credit to licensed fuel suppliers who blend biodiesel equal to $0.05/gal of fuel containing at least 5% biodiesel. Fund established to buy down the interest rate on loans used for the purchase of property and equipment; facility expansion; working capital; and inventory. Equipment purchased by a facility to enable the sale of diesel fuel containing at least 2% biodiesel is exempt from sales tax. The state excise tax of $0.23/gal imposed on all special fuels is reduced by $0.0105/gal for the sale or delivery of diesel fuel that contains at least 2% biodiesel.
Nebraska	Motor fuels sold to a biodiesel production facility and motor fuels manufactured a biodiesel facility are exempt from certain motor fuel tax laws.
New Jersey	The state can reimburse eligible local governments, state colleges and universities, school districts, governmental authorities, and farmers for the incremental costs of using biodiesel fuel in lieu of petroleum diesel.
New Mexico	A tax credit against the special fuel excise tax is available for each gallon of blended biodiesel fuel, available 2007 through 2012 and phased out as follows: $0.03/gal from 2007-2010; $0.02/gal for 2011; and $0.01 /gal for 2012. Biodiesel blending facility tax credit for up to 30% of the purchase cost and installation cost of equipment, limited to $50,000 per facility. After July 1, 2010, and before July 1, 2012, all diesel fuel sold to state agencies, political subdivisions of the state, and public schools for use in motor vehicles must contain B5. After July 1, 2012, all diesel fuel sold to consumers for use in motor vehicles operating on streets and highways must contain B5. By 2010, all cabinet-level state agencies, public schools, and institutions of higher education are required to take action toward obtaining 15% of their total transportation fuel requirements from renewable fuels such as ethanol and biodiesel. The City of Albuquerque fleet must be fueled with a minimum of 20% non-petroleum based fuels within 5 years.
New York	By 2007, at least 2% of fuels used in the state fleet must be biodiesel; this percentage will continue to increase annually to 10% by 2012.
Ohio	The Ohio DOT’s fleet must use at least 1 million gallons of biodiesel and 30,000 gallons of ethanol blends in fleet vehicles each year.
Oklahoma	For 2005 through 2011, a biodiesel production facility shall be allowed a credit of $0.20/gal of biodiesel produced. The credit shall be allowed for 60 months beginning with the 1st month for which the facility is eligible to receive the credit and ending not later than Dec 31, 2011. Eligible facilities can also receive a credit of $0.20/gal for biodiesel produced in excess of the original nameplate design capacity which results from expansion of the facility. Beginning Jan 1, 2012, a biodiesel facility shall receive a credit of $0.075/gal of biodiesel for new production for a period not to exceed 36 consecutive months.
Oregon	All Portland city-owned diesel vehicles must use a minimum B20 biodiesel blend. Effective July 1, 2007, all diesel fuel sold in the Portland city limits must contain a minimum of 5% biodiesel, which will increase to 10% on July 1, 2010.
Pennsylvania	The PennSecurity Fuels Initiative aims to replace 900 million gallons of the state’s transportation fuels with alternative sources over the next decade.

Table 1 continued

State	Incentive
Rhode Island	A tax credit (effective until Jan 1, 2008) is offered equal to 50% of the capital, labor, and equipment costs incurred for the construction of, or improvement to, any refueling or recharging station providing domestically produced alternative fuel. Corporations that sell alternative fuels are allowed a deduction from the gross earnings from sales, effective 1998-2007. Organically produced biodiesel fuels are exempt from motor fuel tax.
South Carolina	A $0.05 incentive payment is available to biodiesel retailers for each gallon of B20 fuel sold. For 2006 through 2014 there is tax credit for biodiesel facilities. To qualify, the facility must be placed in use after 2006 and in production at the rate of at least 25% of its name plate design capacity by Dec 31, 2009. The credit equals $0.20/gal of biodiesel produced and is allowed for up to 60 months, ending in Dec 2014. A biodiesel facility eligible for this tax credit is also eligible to receive $0.20/gal of biodiesel produced in excess of the original name plate design capacity which results from expansion of the facility completed after 2006 and before 2009. Beginning Jan 1, 2014, a biodiesel facility is eligible for a credit against the tax imposed in the amount of $0.075/gal of biodiesel, before denaturing, for new production for a period not to exceed 36 consecutive months. Tax credit for 25% of the cost for constructing or installing equipment for a qualified commercial facility that distributes or dispenses biodiesel. Alternative fuels and alternative fuel blends are exempt from the state sales and use tax. However, all fuels are subject to a state fuels tax.
South Dakota	A tax refund is available for contractors' excise taxes and sales or use taxes paid for the construction of a new agricultural processing facility, which includes an expansion to an existing soybean processing facility it will be used for biodiesel production. The project cost must exceed $4.5 million to qualify. The South Dakota DOT and state employees using state diesel vehicles are directed to stock and use a minimum of B2. Biodiesel and biodiesel blends are defined as 'special fuels' and are taxed at the special fuel excise tax rate of $0.22.
Tennessee	Grants are offered to county governments for the installation of biodiesel infrastructure that can be used to provide biodiesel fuel for county/city owned vehicles. Grant funding will be provided for 50% of total project costs, but not more than $12,000 may be awarded per individual grant.
Texas	Biodiesel is exempt from the diesel fuel tax.
Virginia	A biofuels producer is eligible for a grant of $0.10/gal of neat biofuels sold in Virginia on or after Jan 1, 2007. To qualify, a biofuels producer must produce at least 10 million gallons of neat biofuels in the calendar year in which the incentive is taken. If a producer began selling neat biofuels prior to Jan 1, 2007, a grant is available only if its production of neat biofuels for the given calendar year exceeds its production in the 2006 calendar year by at least 10 million gallons and is maintained at a minimum of that level in future years. Each producer is only eligible for 6 calendar years of grants. Effective July 1, 2007, a biofuels producer must produce at least 2 million gallons of neat biofuels in the calendar year in which the incentive is taken, or exceed its 2006 production by at least 2 million gallons.
Washington	A tax deduction is available for the sale or distribution of biodiesel. Additionally, fuel delivery vehicles and machinery, equipment, and related services that are used for the retail sale of a biodiesel are exempt from state retail fuel sales and use taxes. Until July 1, 2009, investments in buildings, equipment and labor for the purpose of manufacturing biodiesel or biodiesel feedstock are eligible for the deferral of state and local sales and use taxes and are also exempt from state and local property and leasehold taxes for a period of 6 years. A reduced Business & Occupation tax rate of 0.138% applies to persons engaged in manufacturing of biodiesel fuel or biodiesel feedstock. At least 2% of the diesel sold in Washington must be biodiesel, beginning Nov 30, 2008 or when a determination is made by the Director of the State Dept of Ecology that feedstock grown in Washington State can satisfy a 2% fuel blend requirement. The biodiesel requirement would increase to 5% once in-state feedstocks and oil-seed crushing capacity can meet a 3% requirement. 20% of the diesel used by state agencies must be biodiesel beginning on June 1, 2009
Wisconsin	The state may provide aid to school districts that use biodiesel fuel for school bus transportation to cover the incremental cost of using biodiesel as compared to the cost of petroleum diesel fuel.
West Virginia	Any county that uses an acceptable alternative fuel for the operation of all or any portion of its school bus system is eligible for a reimbursement of up to 95% of the county’s transportation cost for maintenance, operation, and related costs incurred by the use of the alternatively fueled school buses.

Source: U.S. Department of Energy, http://www.eere.energy.gov/afdc/progs/all_state_summary.cgi?afdc/0 , Accessed March 2007.

Motivation for Supporting Biodiesel

Federal and state governments are promoting and consumers are increasingly demanding development of domestically-produced renewable energy sources such as biodiesel because these sources of energy are viewed as being better for the environment, decreasing dependence on foreign energy sources, creating jobs in rural areas, and increasing income for farmers. Biodiesel significantly reduces emissions of three pollutants: carbon monoxide, hydrocarbons, and particulate matter. Carbon monoxide is a poison; hydrocarbons cause formation of ozone, a serious air pollutant; and particulate matter refers to aerosols or fine particles that can be detrimental to human health. On the other hand, the U.S. Environmental Protection Agency (EPA) (2002) found that emissions of nitrogen oxides, which also cause formation of ozone, increase slightly from burning biodiesel. Pure 100% biodiesel has been found by the EPA (2002) to decrease hydrocarbon emissions by two-thirds and carbon monoxide and particulate matter emissions by close to one half while increasing nitrogen oxide emissions by about 10%.

Biodiesel also significantly reduces emissions of carbon dioxide, a greenhouse gas, on a net lifecycle basis. Replacing petroleum diesel with biodiesel reduces total carbon dioxide emissions since the plants used to produce biodiesel absorb carbon dioxide from the atmosphere while growing, whereas the carbon dioxide emitted from petroleum diesel had been sequestered below the earth's surface. The study from the National Renewable Energy Laboratory estimates that biodiesel reduces carbon dioxide output by 78.5% (Sheehan et al. 1998).

Soybean-based biodiesel has been found to have a net energy balance of approximately 3.2, meaning that for every one unit of energy used in the production of biodiesel, which includes the production of the soybeans, 3.2 units of energy are produced (Sheehan et al. 1998). This is significantly better than the net energy balance of approximately 1.3 for corn-based ethanol (Shapouri et al. 2002), which indicates that biodiesel has greater environmental benefits than corn-based ethanol and can contribute greater to the reduction in the demand for petroleum-based fuels on a per gallon basis. Research has not been conducted to estimate the net energy balance for canola-based biodiesel. The higher oil yield for canola could improve the net energy balance, but the fact that canola production requires much greater use of fertilizer could have a negative impact.

It is a widely held goal among policy makers to reduce U.S. dependence on foreign energy sources. Over the last couple decades, the United States has become increasingly dependent on foreign oil. U.S. crude oil production peaked in 1970 at 3.5 billion barrels and has been steadily declining since the mid-1980s, dropping to 1.9 billion barrels in 2005. As production has dropped, crude oil imports have increased substantially to meet the demand for petroleum, and the ratio of foreign oil to domestic oil has grown. About two-thirds of U.S. oil consumption is currently imported, compared to less than 15% before the early 1970s and just 30% in the early and mid-1980s. Also of concern is the fact that U.S. petroleum imports are concentrated among a small number of countries. Domestically-produced biofuels such as biodiesel and ethanol can reduce U.S. consumption of petroleum, but the ability to replace a significant portion of oil imports with these alternative fuels is limited due to the large supply of feedstock needed to produce them. It is also possible that domestic biofuels production is replacing domestic oil production rather than foreign oil, since U.S. oil costs more than imported oil, and oil refineries will replace the highest-cost input first (Pates 2007).

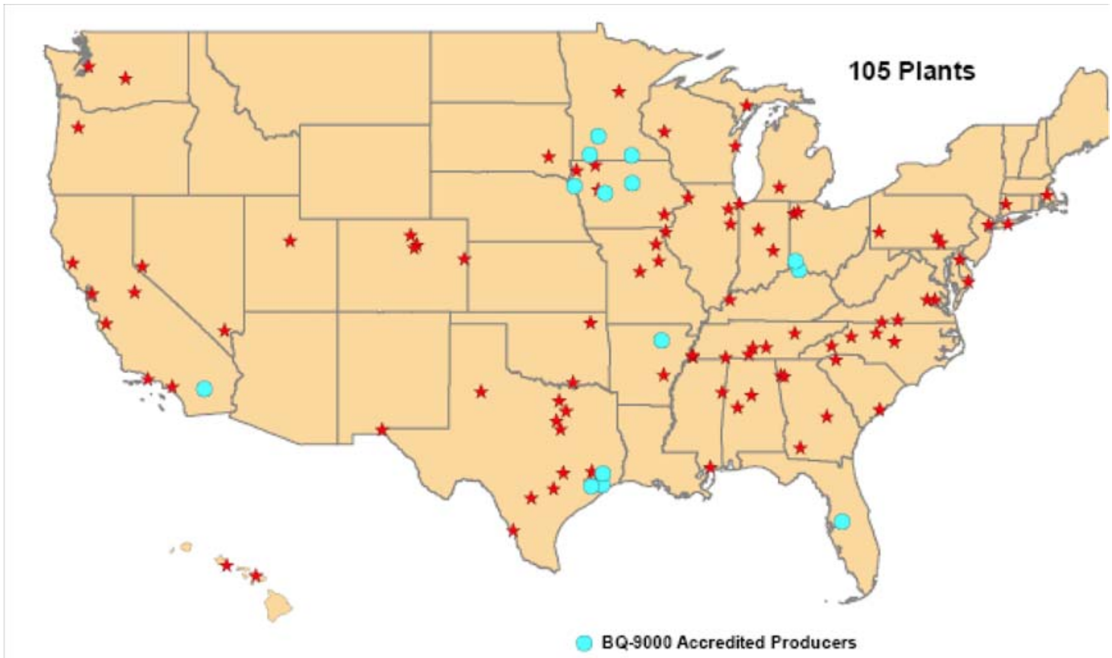
The economic benefits of domestic biofuel production is also often touted in support of the industry. These benefits include the creation of jobs in rural areas where the plants are constructed and increased income for farmers. Studies have shown that the increased demand for corn stemming from the rapid growth in the ethanol industry has a significant positive impact on the price of corn received by farmers, resulting in increases in farm income (Otto and Gallagher 2001, FAPRI 2005, McNew and Griffith 2005, Taylor et al. 2006).

Biodiesel Plants

The National Biodiesel Board (2007) reported that as of January 31, 2007 there were a total of 105 biodiesel plants operating in the United States with a total capacity of 864.4 million gallons per year. By August 2007, the number of plants in operation grew to 165, with an annual production capacity of 1.85 billion gallons, and an additional 1.37 billion gallons of capacity could be added within the following 18 months. The capacity level does not necessarily reflect the actual production amount. The industry actually carries a significant idle capacity. There are some concerns that the industry may be overbuilding. The CEO of Bunge North America, Carl Hausmann, projects that annual U.S. biodiesel consumption will probably peak at about 1 billion gallons in the next five years due to an insufficient supply of vegetable oil and low consumer demand for diesel fuel, leaving much of the nation’s capacity idle (Bloomberg News 2007).

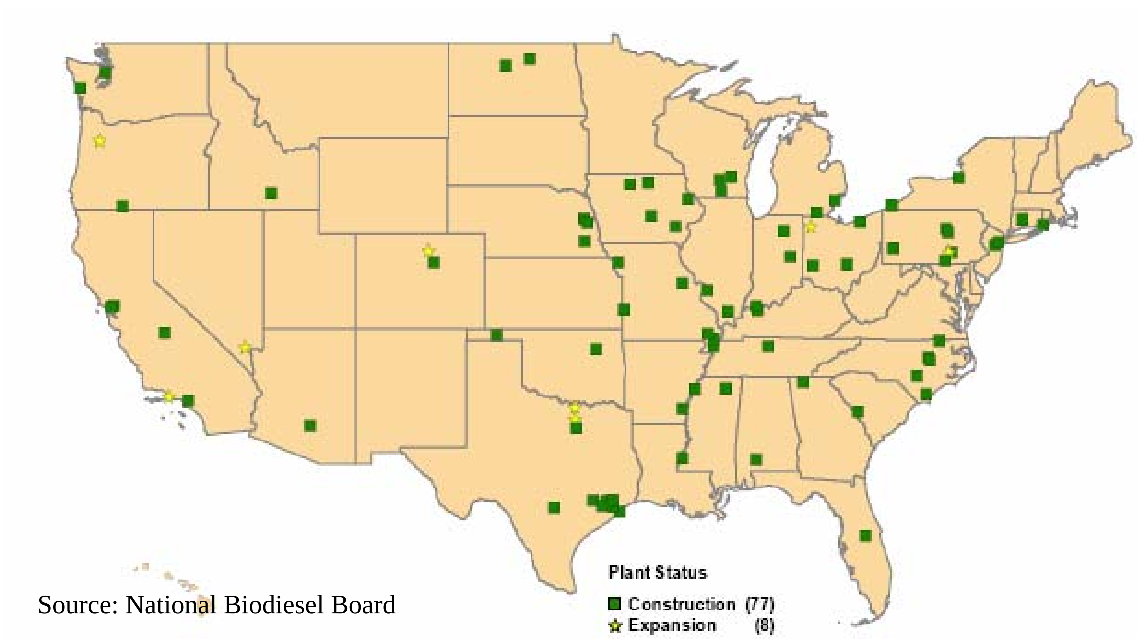
The plants are located throughout the United States, although the largest concentrations are in the Midwest and East (Figure 2). Iowa and Texas had the largest capacities in early 2007. The states experiencing the greatest growth in biodiesel production in 2007 include Iowa, New Jersey, Texas, Indiana, Washington, and North Dakota (Figure 3). Figure 4 shows the total capacity by state, including plants currently in operation and those under construction or expansion. Iowa’s total capacity will increase to 318.5 million gallons per year after construction and expansion, increasing its lead in the industry. North Dakota did not have any plants in operation as of the end of 2006, but an 85 million gallon plant (MMGy) that Archer Daniels Midland Co. (ADM) is constructing in Velva, North Dakota will be one of the largest plants in the industry. There are two 100 MMGy plants that will surpass the Velva, North Dakota plant as being the largest U.S. plants. One is owned by Bio Energy of America in Edison, New Jersey, and the other is owned by Imperium Renewables in Grays Harbor, Washington.

Biodiesel production in Canada has been limited to a few small plants, but the new government incentives for biofuel production could spur some growth in the Canadian biodiesel industry. A very large biofuel plant, the largest in North America to date, is planned for Innisfail, Alberta. This plant, which could be operational by mid-to-late 2008, is planned to produce 100 million gallons of ethanol and 100 million gallons of biodiesel per year (Reuters April 12, 2007).



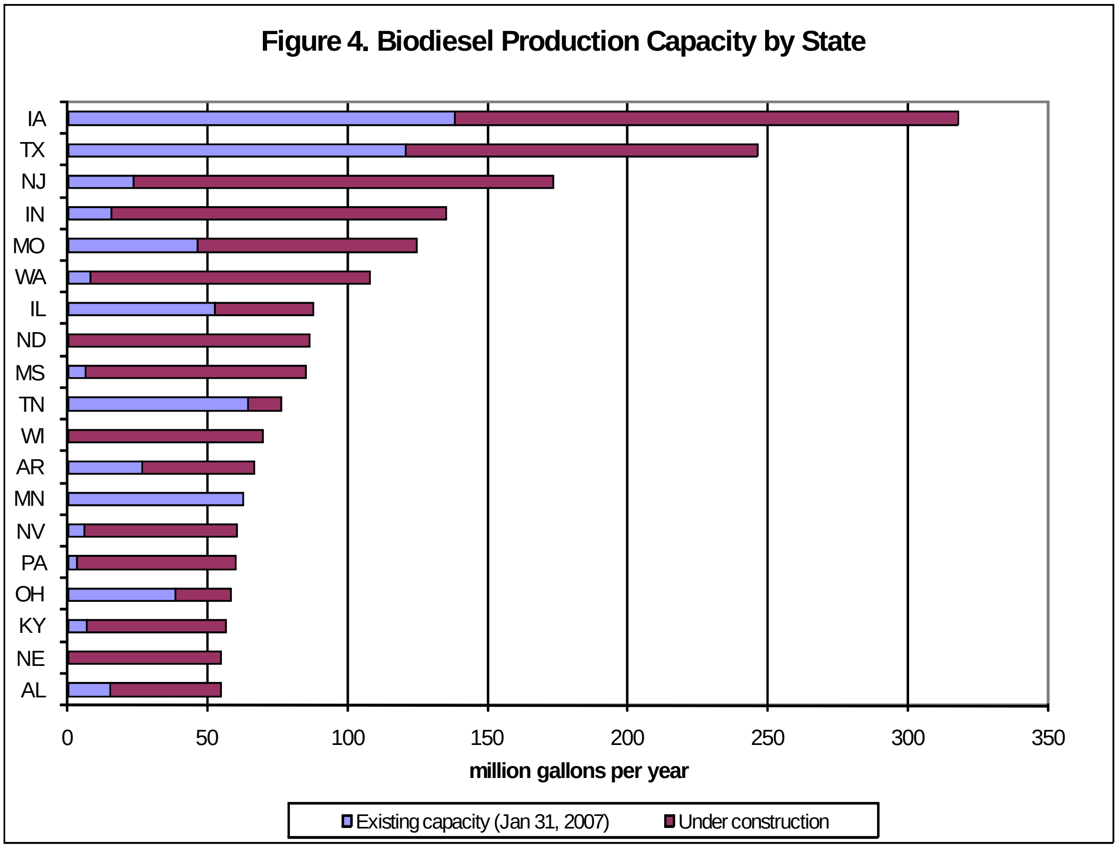
Source: National Biodiesel Board

Figure 2. Commercial Biodiesel Production Plants, January 31, 2007



Source: National Biodiesel Board

Figure 3. Biodiesel Plants under Construction or Expansion, January 31, 2007



Source: National Biodiesel Board

The world's largest producer of biodiesel, by a significant margin, is the European Union. The EU produced over 80% of the world's total in 2006 (Reidy 2007). According to the European Biodiesel Board (2007b) there were 185 operational plants in the EU in 2006. EU biodiesel production increased from 3.2 million metric tons (935 million gallons) in 2005 to 4.9 million metric tons (1.4 million gallons) in 2006. Germany produced 2.7 million metric tons (780 million gallons) of biodiesel in 2006. EU biodiesel production capacity has risen from 6.1 million metric tons (1.8 billion gallons) in 2006 to 10.3 million metric tons (3.0 million gallons) in 2007 (European Biodiesel Board 2007b).

Biodiesel production is also emerging in Asia and South America. Malaysia and Indonesia are building plants to produce biodiesel from palm oil. Brazil could become a significant biodiesel producer as it has an ambitious plan to increase its production, including a mandate for 2% biodiesel use by 2008 and 5% by 2012 (Johnson 2005). By 2009/10, Brazil and Malaysia could be challenging the United States has the world's second largest producer of biodiesel (Reidy 2007). China is also trying to build its biodiesel industry. Total production capacity in China at the end of 2005 was 300 thousand metric tons, or about 90 million gallons, but this is growing as private Chinese and foreign investors and state-owned energy firms are building or planning plants using a variety of feedstocks (Dow Jones Energy Service, Sept. 13, 2006; Reuters, Feb. 7, 2007).

Soybean oil is currently the dominant feedstock for biodiesel production in the United States. In Europe, on the other hand, the primary feedstock is rapeseed oil. Canola, which is a variant of rapeseed grown in Canada and the northern United States, is emerging as a feedstock for biodiesel production in the United States and Canada. There are plants under construction in Canada and the northern United States that plan to use canola oil as the primary feedstock, including the plant in Velva, North Dakota that is planned to begin operations in the summer of 2007 (Table 2). A 50 MMGy canola biodiesel plant had been planned for Minot, North Dakota, but its development has been suspended indefinitely. The Hallock, Minnesota plant will emphasize food-grade oil but will also produce some biodiesel. The 100 MMGy plant in Grays Harbor, Washington plans to use a combination of soybean, canola, and palm oil (McClure 2007). A 100 MMGy plant in Innisfail, Alberta plans to use 900 thousand metric tons of canola per year, and it also includes a 100 MMGy canola crush facility.

China, a major producer of rapeseed, is also starting to produce biodiesel from this source. Chinese production of rapeseed biodiesel, which currently totals about 30 million gallons per year, is limited because of less advanced technology, but scientists are working at improving technologies in China to increase their biodiesel production from rapeseed oil (Xinhua News Agency, April 2, 2007).

Table 2. Canola Biodiesel Plants Planned or Under Construction in North America

Location	Owner	Biodiesel Capacity (MMGy)	Status
Velva, ND	Archer Daniels Midland Co.	85	Operational in Summer 2007
Minot, ND	Dakota Skies Biodiesel LLC	50	Development Suspended Indefinitely
York, ND	All-American Biodiesel	2[a]	Operational in Early 2007
Munich, ND	Northern Prairie EnviroFuels LLC	30	Feasibility study
Hallock, MN	Northstar Bioenergy	2[b]	Construction to start in August 2007
Grays Harbor, WA	Imperium Renewables	100[c]	Operational Summer 2007
Ellensburg, WA	Central Washington Biodiesel	3[d]	Began operation in Early 2007
Arborg, MB	Biofrost Bio-blends	2	Operational
Regina, SK	Canadian Green Fuels	40[e]	Operational February 2007
Innisfail, AB	Dominion Energy Services, LLC	100	Construction to start in Summer 2007
Vegreville, AB	Biostreet Canada	48	Construction to start in Early 2008
Ft. Saskatchewan, AB	Canadian Bioenergy Corp.	30	Planning stage
Mayerthorpe, AB	Cansource CGF Mayerthorpe	2.6-10.6[f]	Planning stage

[a]Will use a combination of soybean and canola oil.

[b]Expected to produce 40 MMGy of food-grade vegetable oil and 2 MMGy of biodiesel.

[c]Will use a combination of palm, soybean, and canola oil.

[d]Uses a combination of Washington-based feedstocks, including canola oil.

[e]Capacity is planned to eventually reach this level.

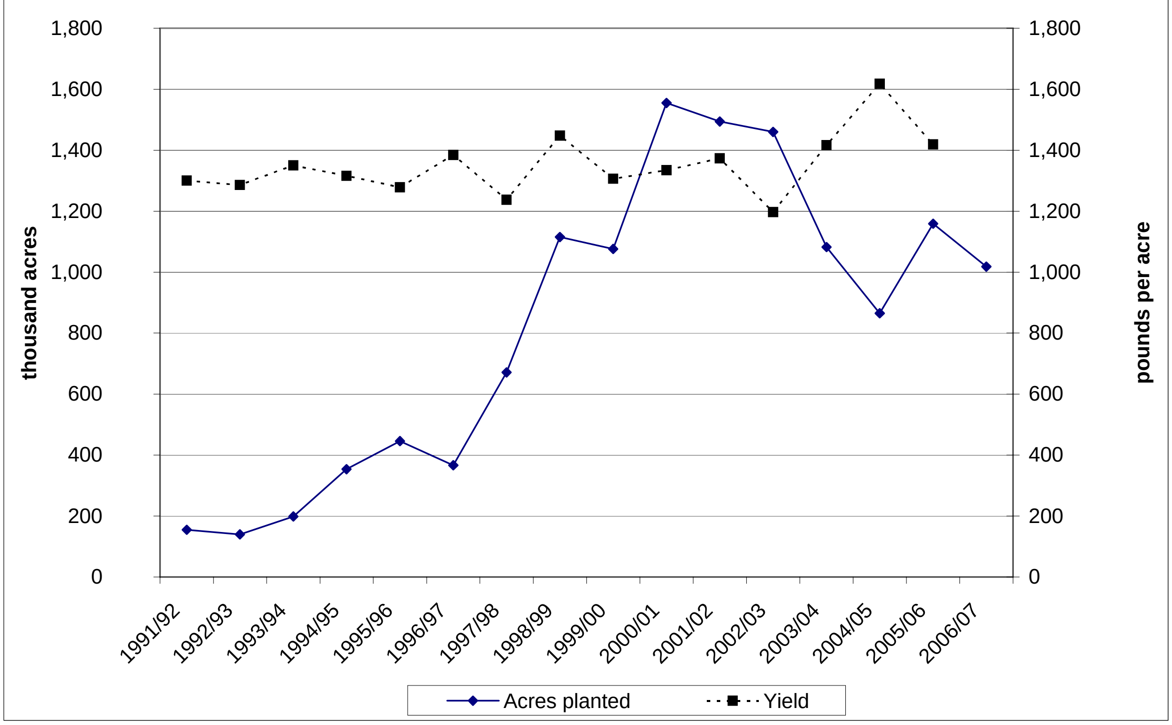
[f]Capacity will initially be 2.6, increasing to 10.6 by 2010.

Canola Production

Trends in Production

Canola production in the United States increased throughout the 1990s. Area planted to canola increased from about 150 thousand acres in the early 1990s to 1.56 million acres in 2000 (Figure 5). Production rose from 191 million pounds in 1991 to 2.0 billion pounds in 2000 and 2001. Acreage peaked in 2000 and 2001 in the United States, however. Lower yields also hurt production in 2002. Planted acreage dropped nearly in half to 865 million acres in 2004, and then increased to about 1.1 million acres in 2005 and 2006. Yields have increased over the 15-year period from 1991 to 2005, but the rate of increase is rather slow, and there has been variation from year to year. The lowest yield during this period was 1,197 pounds per acre in 2002, and the highest yield was 1,618 pounds per acre just two years later in 2004. The Northern Canola Growers Association has a ‘5 by 15' goal of increasing U.S. canola production to 5 million tons (10 billion pounds) by 2015, which they hope to achieve by increasing average yields to 2,000 pounds per acre and canola area to 5 million acres (Coleman 2007). Expanding canola production to 5 million acres would be a 450% increase. Coleman (2006) estimates that in North Dakota alone, acreage could increase to 3.5 million to 4 million acres based on a 4-year rotation.

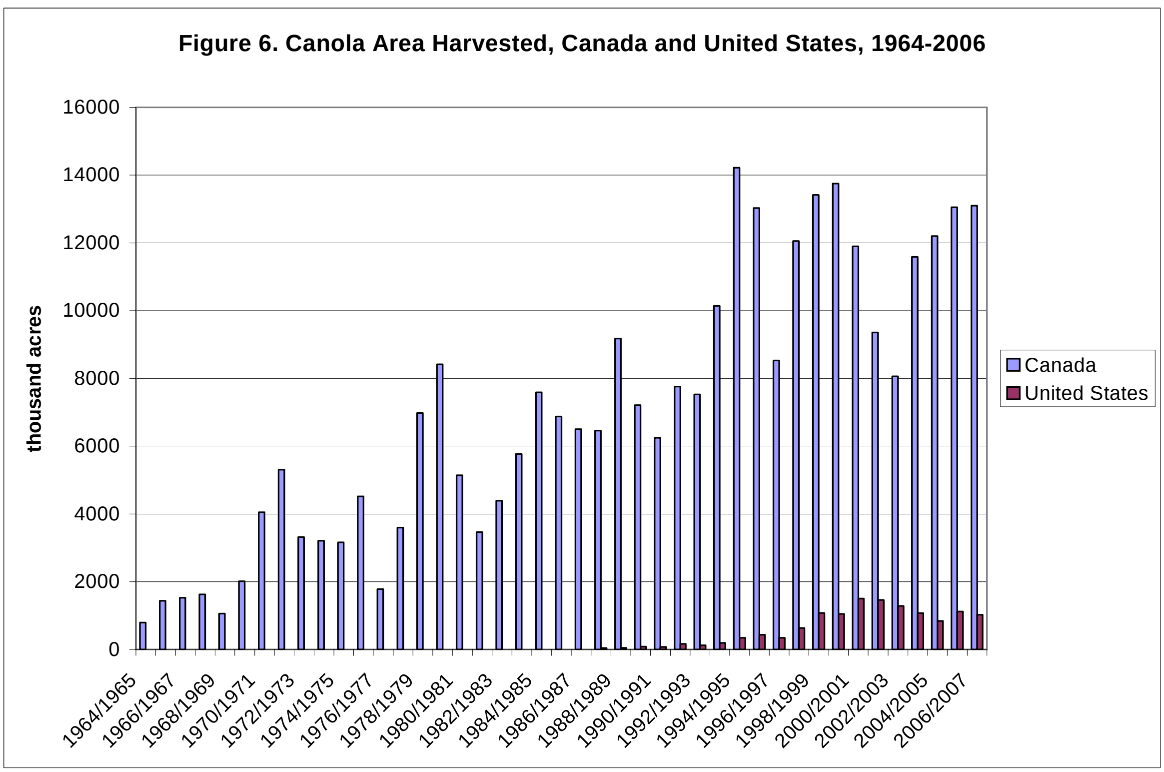
Figure 5. Canola Planted Acreage and Yield in the United States, 1991-2006



Source: Oil Crops Yearbook, ERS/USDA

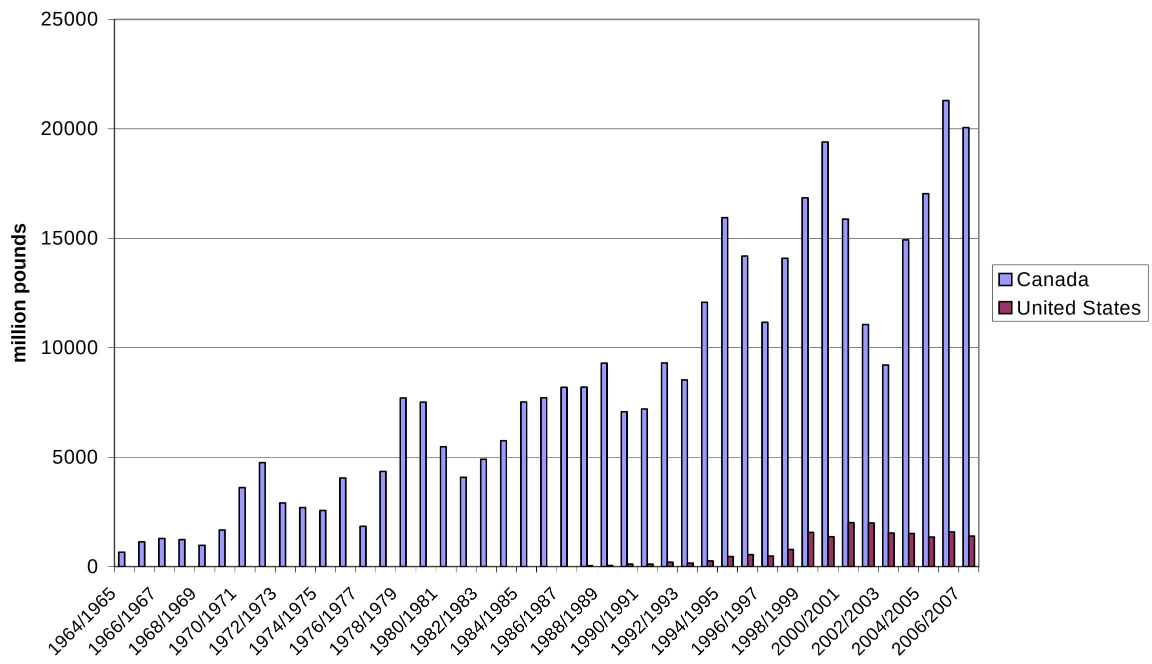
Canola production in Canada dwarfs that in the United States (Figures 6 and 7). With the exception of a few years, Canadian production has steadily increased over the last several decades, reaching a high of 21.3 billion pounds in 2005. Acreage in Canada peaked in 1994 at 14.2 million acres planted and has since ranged from 8.0 to 13.7 million acres. Yields in Canada are similar to those in the United States. They have followed a long-term upward trend and also vary from year to year. Over the last five years, yield has ranged from a low yield of 1,143 pounds per acre in 2002 to a record high yield of 1,631 pound per acre in 2005. Due to the variations in yields and acres planted, canola production in Canada fluctuated rather significantly over the last decade, from a low of 9.2 billion pounds in 2002 to more than 20 billion pounds in 2005 and 2006. The Canola Council of Canada has announced a goal of producing 15 million metric tons, or about 33 billion pounds, of canola by the year 2015, which they expect to reach by increasing acres 30% and yield 35% from 2006 to 2015 (Canola Council of Canada March 2007).

Canada ranks third in total canola, or rapeseed, production behind the EU and China. The EU-27 collectively produced 15.8 million metric tons in 2006/07, and China produced 12.7 million metric tons. In comparison, Canada produced 9.1 million metric tons and the United States produced 633 thousand metric tons. India produced 6.2 million metric tons.



Source: PS&D Database, FAS/USDA

Figure 7. Canola Production, Canada and United States, 1964-2006



Source: PS&D Database, FAS/USDA

Production Areas

The greatest concentration of canola production in the United States is in northern and central North Dakota (Figure 8). In fact, approximately 90% of U.S. canola production is in North Dakota. North Dakota produced 1.46 billion pounds of canola in 2005 on 1.04 million acres planted. The largest canola crop in North Dakota was 1.80 billion pounds in 2001 on 1.30 million acres planted. The main competing crops in North Dakota are spring wheat, durum wheat, soybeans, barley, sunflowers, and corn. While there were 1.04 million acres of canola planted in North Dakota in 2005, there were 6.80 million acres of spring wheat, 2.95 million acres of soybeans, 1.98 million acres of durum wheat, 1.41 million acres of corn, 1.20 million acres of barley, and 1.14 million acres of sunflowers. In 2006, canola area planted declined to 940 thousand acres while spring wheat, soybean, and corn acres increased to 7.3 million, 3.9 million, and 1.69 million, respectively; and durum, barley, and sunflower acres dropped to 1.3 million, 1.1 million, and 0.9 million, respectively (NASS 2007a). Soybean and corn acreage have been increasing in North Dakota, while barley acreage has followed a long-term downward trend, and durum and sunflower acreage have decreased since the late 1990s. Canola production in North Dakota is concentrated in the northern part of the state. The main competing crops in this part of the state are spring wheat, barley, durum wheat (mostly in the northwest), and sunflowers. Soybean and corn acreage are greatest in the eastern, and especially southeastern, parts of the state where canola is not a significant crop, though soybeans have become a competing crop in the northeastern and north central parts of the state.

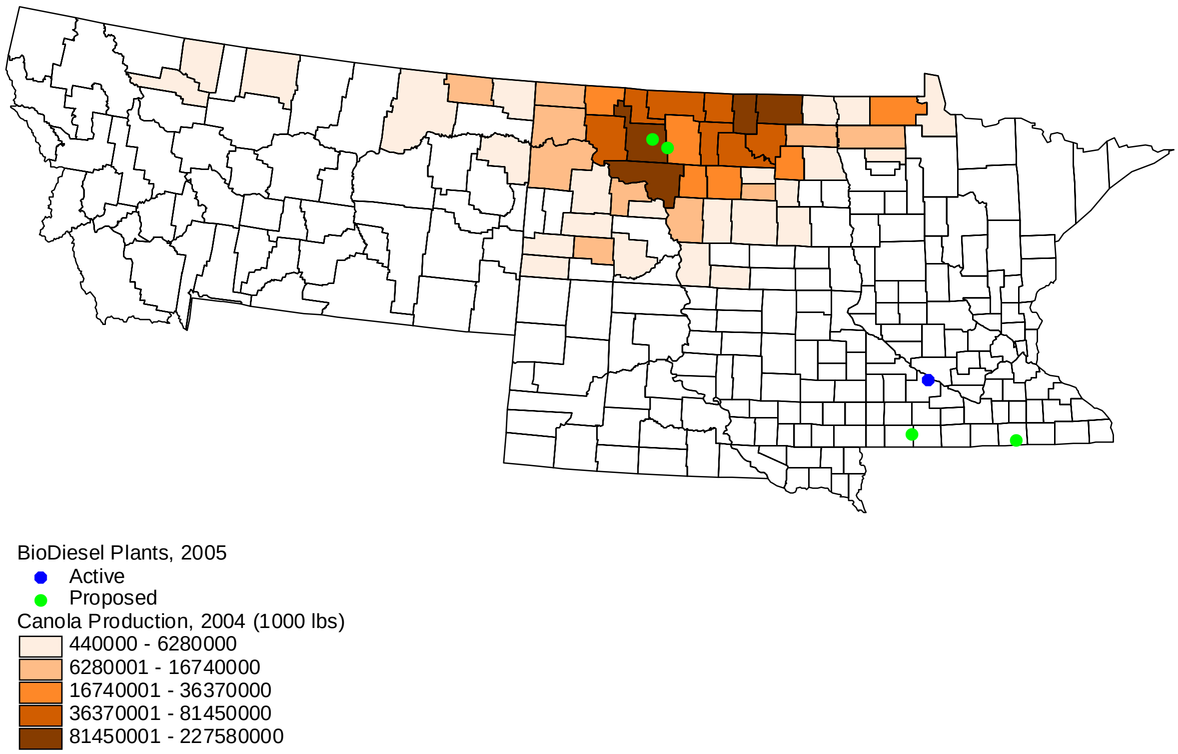


Figure 8. U.S. Canola Production Map

Some canola is also planted in northwestern Minnesota, northern Montana, and a few other northern states. The canola grown in the northern United States and Canada is spring canola. The recent development of winter canola varieties could expand the production region to the southern plains and elsewhere. Winter canola varieties have been introduced in Oklahoma, Kansas, and a few other states. These varieties of canola offer potential as a rotation crop for winter wheat in the southern plains. Rotating winter canola with winter wheat would improve the quality and consistency of the wheat, aid in the management of weeds, interfere with wheat diseases, potentially improve the yields of wheat, and provide farmers in the southern plains an opportunity to spread out their risk (Boyles, Peeper, and Medlin 2004). Winter canola acreage has increased from 25 thousand acres in 2004/05 to an estimated 60 thousand acres in 2005/06 (Hegeman 2006). Transportation costs for canola are higher in Kansas and Oklahoma than they are in North Dakota because of a lack of crushing facilities in the southern plains. The opening of crushing facilities in the southern plains could encourage the expansion of winter canola production. A winter canola and sunflower processing plant is planned to open in Oklahoma City in 2008 (Stafford 2007), and there are tentative plans for a crushing facility in Kansas (K-State Extension Agronomy 2006).

Profitability

Projected crop budgets for 2007 from the North Dakota State University Extension Service show that canola production is profitable in most parts of North Dakota (Table 3). Return to labor and management is projected to be $23.38 per acre in the north central part of the state, $17.39 per acre in the northeast (not including the easternmost counties in the Red River Valley), $17.34 in the northwest, and $15.48 in the south central. Yields are the highest in the northern parts of the state. Production is also projected to be profitable in the southwest and east central parts of the state, though less so. Return to labor and management, on the other hand, is projected to be negative in the Red River Valley and the southeast where costs, especially land costs, are the highest. In the northern part of the state, with the exception of the Red River Valley, return to management and labor for canola is projected to be higher than that for many other major crops such as soybeans, hard red spring wheat, and durum wheat (Table 4). Soybeans are shown to be much more profitable in the Red River Valley and the southeastern parts of the state, as are corn and barley. Canola is at a cost disadvantage compared to soybeans, largely because fertilizer costs are much lower for soybeans.

Table 3. 2007 Projected Crop Budgets for Canola in North Dakota, by Region

	North West	North Central	North East	North Red River Valley	South West	South Central	South East	East Central
Market Yield (lbs/acre)	1370	1380	1440	1320	1210	1290	1200	1330
Market Price + LDP ($/acre)	0.136	0.138	0.14	0.133	0.14	0.14	0.133	0.136
Market Revenue ($/acre)	186.32	190.44	194.40	175.56	163.35	174.15	159.60	180.88
DIRECT COSTS	---$/acre---							
-Seed	18.15	18.15	18.15	18.15	18.15	18.15	18.15	18.15
-Herbicides	20.50	17.50	17.50	17.50	20.50	17.50	17.50	17.50
-Fungicides	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-Insecticides	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
-Fertilizer	37.63	33.61	38.66	31.76	24.48	29.61	28.92	33.96
-Crop Insurance	8.50	8.30	10.30	10.90	8.90	9.00	10.00	9.70
-Fuel & Lubrication	9.64	10.78	10.82	12.35	9.54	10.72	12.67	12.75
-Repairs	9.33	9.75	9.76	10.44	9.29	9.72	10.82	10.86
-Drying	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
-Miscellaneous	5.00	1.00	1.00	1.00	5.00	1.00	1.00	1.00
-Operating Interest	4.77	4.38	4.67	4.50	4.24	4.24	4.38	4.58
SUM OF LISTED DIRECT COSTS	120.52	110.47	117.86	113.60	107.10	106.94	110.44	115.50
INDIRECT (FIXED) COSTS								
-Misc. Overhead	3.26	3.34	3.35	3.49	3.22	3.34	3.60	3.66
-Machinery Depreciation	11.87	12.16	12.19	12.76	11.78	12.23	13.19	13.40
-Machinery Investment	6.83	7.09	7.11	7.64	6.78	7.16	8.04	8.17
-Land Charge	26.50	34.00	36.50	51.00	26.00	29.00	45.00	36.50
SUM OF LISTED INDIRECT COSTS	48.46	56.59	59.15	74.89	47.78	51.73	69.83	61.73
SUM OF ALL LISTED COSTS	168.98	167.06	177.01	188.49	154.88	158.67	180.27	177.23
RETURN TO LABOR & MGMT	17.34	23.38	17.39	-12.93	8.47	15.48	-20.67	3.65

Source: NDSU Extension

Table 4. Projected 2007 Return to Labor and Management for Major North Dakota Crops, by Region ($ per acre)

	North West	North Central	North East	North Red River Valley	South West	South Central	South East	South Red River Valley	East Central
HRSW	-5.65	-3.56	0.47	1.06	1.83	8.32	20.09	1.49	5.94
Durum	6.02	2.86	-9.93	-17.89	19.49	18.62	4.53	-21.57	-6.04
Barley	29.66	37.95	23.28	13.68	39.71	46.28	33.79	8.64	33.55
Corn	21.11	9.88	12.17	13.06	29.59	10.80	39.49	33.37	17.9
Soybeans		11.83	12.75	39.73		16.50	46.72	36.76	33.48
Canola	17.34	23.38	17.39	-12.93	8.47	15.48	-20.67		3.65

Source: NDSU Extension

Production Risk

Returns from canola must compete with traditionally grown crops such as spring wheat and durum wheat, and an important factor to consider is the production risk associated with each of these crops. This risk can come from the environment, the markets, or inputs, with each affecting the goal of a positive return to labor and management. Discounts and premiums are other sources of risk in agricultural production which are frequently not considered in producers' crop budgets. In the case of canola, green count, a problem occurring when the chlorophyll in the seed does not have a chance to be broken down properly, is a factor which is normally tested for and can discount the value of the canola. The discount is not applied unless the green count is greater than 2% (ADM). From ADM in Velva, North Dakota, the discount is $5 per metric ton per percentage point up to 5%. The discount is $10 per metric ton per percentage point above 5%. Discounts and premiums are also incorporated into the wheat data.

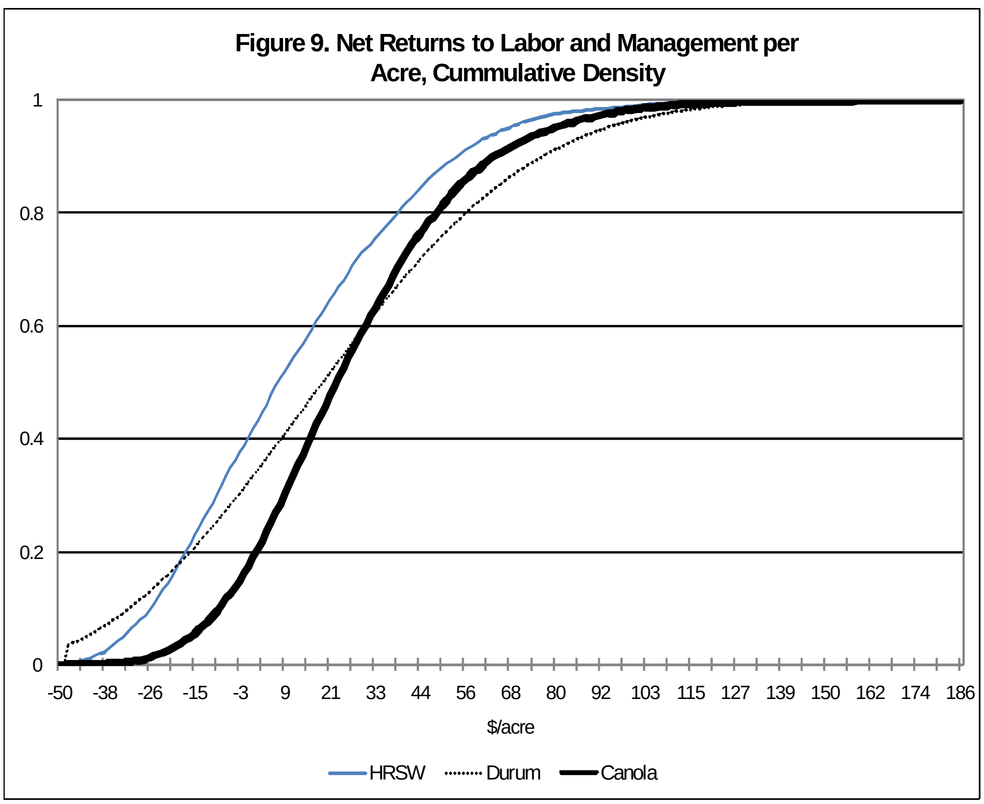
A budget simulation model was developed for canola, hard red spring wheat (HRSW), and durum wheat. The details of the model are presented in Appendix A. The returns for canola are found to have a lower standard deviation than the returns from hard red spring wheat or durum wheat (Table 5). These results indicate that while canola is risky, it is no more risky than major competing crops. Figure 9 shows a cumulative density function of the returns to labor and management for hard red spring wheat, durum wheat, and canola, respectively. Another method to quantify risk is Value-at-Risk (VaR). The VaR measure indicates the maximum loss at a given probability measure, in this case 5%, 10%, or 20%. The results indicate that the maximum loss that could occur for canola at the 10% level is $10.03 per acre, which is less than that for hard red spring and durum wheat. Another analysis can be done by examining the probabilities of having a loss. Canola has a 21% chance of having a negative return, while spring wheat and durum wheat have probabilities of a negative return in the 30th percentile (Table 6). Based on this analysis, a producer would choose to plant canola rather than wheat, but other factors like crop rotations, past disease and insect pressure, and land properties might make a producer choose a more traditional small grain.

Table 5. Estimated Returns to Labor and Management, $ per Acre

	HRSW	Durum	Canola w/ Shattering	Canola w/o Shattering
Mean	17.89	18.89	22.15	72.93
Std. Dev.	30.82	44.79	27.47	267.93
Minimum	-41.75	-59.14	-49.21	-56.78
Maximum	186.75	198.63	172.19	10,450.12

Table 6. Value-at-Risk of Returns to Labor and Management, $ per Acre

	HRSW	Durum	Canola w/ Shattering	Canola w/o Shattering
5%	-25.57	-51.67	-16.79	-8.44
10%	-18.60	-39.05	-10.03	-0.86
20%	-9.65	-21.69	-0.79	9.32
Prob. Return < $0	32.66%	36.40%	21.03%	10.67%



The major factors associated with variability in returns to labor and management for canola are crop yields, shattering, market price, and the green count levels. For both HRSW and canola, yield has a high positive correlation with the return per acre for each crop. Many of the other factors are also correlated with the return per acre, but not as strongly as the yield. For canola, higher prices lead to higher profits while higher green count levels yield lower returns, and for HRSW, the amount of protein above 15% and below 14% and associated premiums and discounts also affect returns. Factors which affect durum wheat returns, beside price, are the durum yield and the percentage of #1 hard amber durum (HAD) that the farmer raises.

An area of concern with canola production is shattering. Shattering occurs in canola naturally when the pods which hold the canola seed get too dry and break open. Some of the pods will break open naturally, but many pods break open when they are disturbed. Some of the disturbances are caused by natural occurrences like hail, wind, animals, or rain or by the methods of harvesting the seed like swathing and combining.[2] The seed then spreads over the field and cannot be harvested, reducing yield. McKay et al. (2005) and McKay and Novak (2006) have determined shattering rates for canola production in North Dakota under various harvest techniques. Based on these two studies, the average shattering rates are in excess of 25% of the yields calculated in the field trials. Without shattering, the average total yield from an acre of canola increases from 1,393 pounds per acre to 1,769 pounds per acre.

Researchers are attempting to reduce shattering in canola (Tan et al. 2007, Tys et al. 2007). We simulated the impacts of eliminating shattering and found that the mean return to labor and management more than triples (Table 5). This return would induce nearly all farmers into producing canola whenever and wherever it is possible, relating to crop rotations, disease and insect pressure, seed availability, etc. The standard deviation is larger, but this is due to the potential for large positive returns. (The maximum return of $10,450/acre shown in Table 5 is the rare occurrence where yields and other factors are all in the upper 3rd standard deviation.) Eliminating shattering reduces the 5% VaR for canola by half, and it makes the crop much less riskier than HRS and durum wheat.

Reducing the amount of shattering from 25% to zero would be unrealistic due to the plant's growth habits. To account for this fact, we simulate impacts of reducing the shattering to 5%. This reduction results in a return to labor and management of approximately $10 per acre less than that with no shattering, but still almost triple the return with shattering over 25%. The yield with 5% shattering would be over 300 lbs greater than the current averages and only approximately 75 lbs less per acre than canola without any shattering. Based on this analysis, the value of reducing shattering could be valued at up to $50 per acre in 2007, but it is highly variable.

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[2]Canola has traditionally been swathed and combined due to concerns about increased shattering from straight combining, but recent studies have shown that when harvested at the optimal time, straight combining can result in yields equal to or higher than those from traditional harvesting methods (NDSU Agriculture Communication 2007). The researchers stress, though, that when straight combining, it is very important that canola is harvested at the optimal time.

North American Canola Crushing Industry

Canola crushing plants process the canola seed into canola oil and meal. The crude oil then is refined to improve the flavor, color, and shelf life. Crushing facilities are typically located near the major oilseed producing regions to minimize transportation costs. There are three canola crushing plants in North Dakota and one in Montana. These include a plant in Velva, North Dakota and multi-seed crushing facilities in West Fargo and Enderlin, North Dakota and Culbertson, Montana (Agriculture and Agri-Food Canada 2004).

A majority of the North American crushing capacity is located in Canada. The annual crushing capacity for all the plants in Canada is approximately 4.0 million metric tons of canola seed, which produces about 1.6 million metric tons of canola oil and 2.4 million metric tons of canola meal (Canola Council of Canada June 2007). There are currently 13 crushing and refining/packaging plants in Canada. The locations of the major Canadian crushing facilities are located as follows, with the owners' names in parentheses: Lloydminster, Alberta (ADM); Watson, Saskatchewan (ADM); Windsor, Ontario (ADM); Ste. Agathe, Manitoba (Associated Proteins); Fort Saskatchewan, Alberta (Bunge); Nipawin, Saskatchewan (Bunge); Harrowby, Manitoba (Bunge); Altona, Manitoba (Bunge); Lethbridge, Alberta (Canbra); and Clavet, Saskatchewan (Cargill) (Canola Council of Canada June 2007). The crushing capacities of these plants range from 700 metric tons per day at Fort Saskatchewan to 3.6 thousand metric tons per day at the multiseed plant at Windsor. The largest canola-only facility at Clavet has a capacity of 2.4 thousand metric tons per day (Agriculture and Agri-Food Canada, June 22, 2006).

Canadian canola crush totaled 3.42 million metric tons (7.54 billion pounds) in 2005/06, which compares to 1.03 million metric tons (2.27 billion pounds) crushed in the United States. U.S. canola crushing has been greater than U.S. canola production the last two years due to net imports of canola. Canada, on the other hand, exports more canola than it crushes. Less than half of Canada's canola production has been crushed domestically.

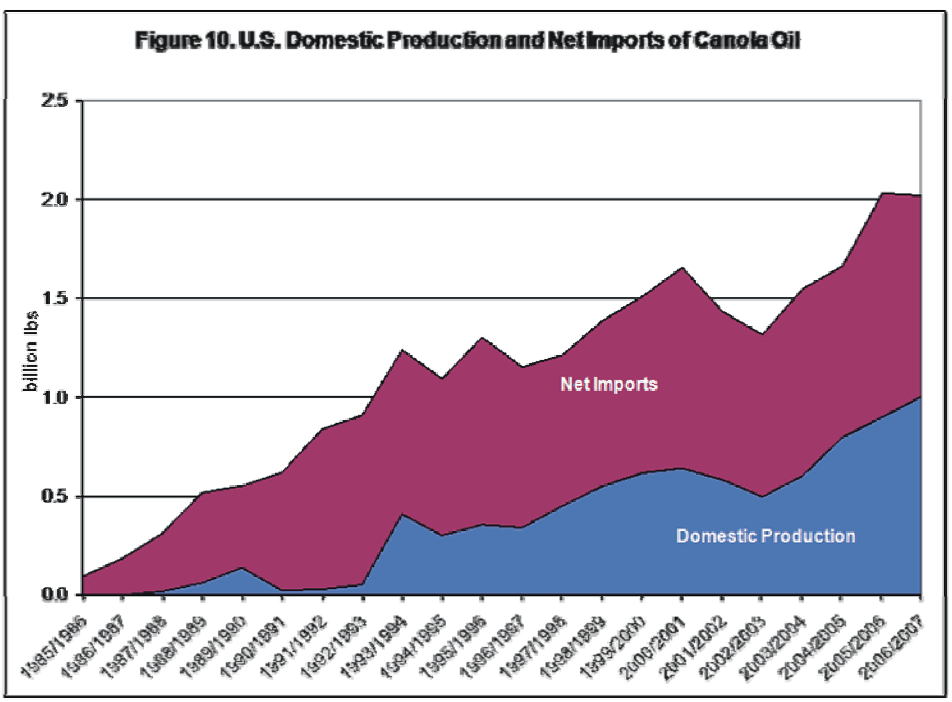
Crushing capacity in Canada, though, is increasing. In September 2006, two companies, James Richardson International (JRI) and Louis Dreyfus Canada, independently announced that they would build crushing facilities in Yorkton, Saskatchewan, capable of processing 840 thousand metric tons and 850 thousand metric tons of canola per year, respectively. Meanwhile, the plants in Clavet and Nipawin, Saskatchewan are expanding. The biodiesel plant planned for Innisfail, Alberta includes a crushing facility that will use 900 thousand metric tons of canola per year. The result of these projects would be to increase Canadian crushing capacity from 4.0 to about 7.0 million metric tons (Agriculture and Agri-Food Canada, Nov. 30, 2006).

Crushing capacity is also increasing in the United States. ADM's crushing facility in Velva is expanding, and new plants are being built or planned. Northstar Bioenergy LLC is building a plant in Hallock, Minnesota that plans to process 340 thousand tons of canola annually. Northern Prairie EnviroFuels LLC is proposing a crushing facility and biodiesel plant for Munich, North Dakota that would consume about 275-300 thousand tons of canola per year.

Canola Trade

Consumption of canola oil in the United States has grown steadily over the last 20 years, from 93 million pounds in 1985/86 to 1.28 billion pounds in 1995/96 to 1.90 billion pounds in 2005/06. The growing demand has been met by increases in both domestic production and net imports of canola oil (Figure 10). A majority of the demand has been met by imports, but domestic production of canola oil has increased to account for just under 50% of domestic consumption the last three years. A certain percentage of the domestically produced canola oil depicted in Figure 10, though, is processed in the United States from imported canola. The ratio of U.S. produced canola to canola crushed in the United States has ranged over the last decade from 0.55 in 1996/97 to 1.21 in 2002/03, and it equaled 0.70 in 2005/06.

The United States is a net importer of canola in many but not all years. Over the 5-year period from 2001/02 to 2005/06, U.S. domestic canola production averaged 1.59 billion pounds, domestic crushing averaged 1.71 billion pounds, and canola imports and exports averaged 684 million pounds and 487 million pounds, respectively (Table 7). Canola imports reached a high of 1.1 billion pounds in 2005/06 as domestic crushing rose to 2.3 billion pounds. U.S. production of canola oil during this period averaged about 671 million pounds and consumption averaged more than twice that at 1.56 billion pounds. U.S. canola oil imports and exports averaged 1.21 billion pounds and 286 million pounds, respectively, during this period. U.S. imports of canola and canola oil are almost exclusively from Canada, although there are some small quantities of rapeseed oil imported from Europe.



The canola that the United States exports is shipped mostly to Canada and, to a lesser extent, Mexico. The United States exports canola oil mostly to Canada, Germany, Italy, Mexico, and the Netherlands. Canada and Mexico have been the traditional markets for U.S. canola oil exports, but a few European countries, especially Germany, have emerged as significant export markets within the last few years. The EU became a net importer of rapeseed oil for the first time in recent history in Oct/Dec 2005, and this trend is expected to continue (Foreign Agricultural Service, March 2006).

Demand for rapeseed oil in the EU is growing rapidly because of new biofuels requirements, which call for 5.75% of petrol and diesel consumption to be replaced with biofuels by 2010. Biodiesel represents about 80% of the biofuels in the EU, and approximately 80% of its biodiesel is produced from rapeseed (Foreign Agricultural Service, December 2006). EU rapeseed production is reaching record levels, and new crushing facilities are being built to increase EU production of rapeseed oil, but production is not keeping pace with demand. Large biodiesel plants are being built in Germany, France, and the Netherlands, and rapeseed oil is the primary feedstock. The main sources for EU rapeseed/canola oil imports are Canada, the United States, and China, and the principle suppliers of EU rapeseed imports are Australia, Ukraine, Russia, Romania, and Croatia. It is estimated that 95% of the increase in demand for rapeseed oil in the EU is due to the new biofuels requirement, and two-thirds of rapeseed produced in the EU is used for biodiesel (Foreign Agricultural Service, December 2006).

Table 7. U.S. Canola and Canola Oil Supply and Use

	2001/02	2002/03	2003/04	2004/05	2005/06	5-year Avg
Canola	---------- Million pounds ----------					
Production	1,999	1,533	1,512	1,340	1,581	1,593
Imports	276	434	537	1,030	1,143	684
Exports	480	633	671	308	342	487
Crush	1,665	1,267	1,385	1,976	2,272	1,713
Canola Oil						
Production	582	496	601	776	899	671
Imports	1,108	981	1,223	1,134	1,604	1,210
Exports	255	161	278	264	471	286
Domestic Consumption	1,493	1,284	1,539	1,609	1,898	1,565

Source: Oil Crops Yearbook, ERS/USDA

Product Characteristics

The characteristics of canola oil make it a favorable feedstock for biodiesel production. Canola has a higher oil content than soybeans, yielding more oil per acre, and the performance characteristics of canola oil for biodiesel production compare favorably to those of other possible feedstocks. Many of the favorable characteristics for canola oil also make it a popular choice for human consumption. Canola meal is used as animal feed.

Oil Content

Canola has an oil content of about 40-43%, compared to 18% for soybeans. The higher oil content of canola results in a higher oil yield per acre (Table 8). The average canola yield in North Dakota for 2004-2006 was about 1,480 pounds per acre. With this yield and a 41% oil content, one acre of canola would produce 607 pounds of canola oil, which could produce 81 gallons of biodiesel. (It takes 7.5 pounds of vegetable oil to produce a gallon of biodiesel.) A soybean yield of 42 bushels per acre would yield about 454 pounds of soybean oil, which could produce 60 gallons of biodiesel per acre. Sunflowers also produce a high oil content, providing for about 75 gallons of biodiesel per acre, depending on the yield. Some areas of North Dakota achieve higher yields for canola, and future yield increases are likely. According to Johnson (2007), the potential crop yield for canola is 1,500 to 3,500 pounds per acre. Per acre canola yields of 2,000 pounds and 3,000 pounds would produce 107 gallons and 160 gallons of biodiesel per acre, respectively. Increases in oil content would also increase biodiesel yields. A yield of 2,000 pounds per acre with oil content of 43-45% would yield 115-120 gallons of biodiesel per acre.

Table 8. Oil Yields of Major Oilseeds

	yield/acre[1]	oil content	oil/acre (lbs)	biodiesel/ acre (gal)
Canola	1480	41%	607	81
Soybean	42	18%	454	60
Sunflower	1300	43%	559	75

[1]Measured in lbs. for canola and sunflowers and bu. for soybeans.

Canola and soybeans, however, both yield considerably fewer gallons of fuel and less energy per acre than corn, despite the higher net energy balance for biodiesel. An acre of corn can produce over 400 gallons of ethanol (Table 9). Therefore, Tokgoz et al. conclude that producers targeting energy crops would chose corn.

Table 9. Comparison of Energy Yields for Biofuels

	gallons/acre*	BTUs/acre**
Canola Biodiesel	81	9,708,800
Soy Biodiesel	60	7,257,600
Corn Ethanol	405	30,780,000

*Assuming yields of 1480 lbs/acre for canola, 42 bu/acre for soybeans, and 155 bu/acre for corn; oil content of 41% for canola and 18% for soybeans; 7.5 lbs of soy or canola oil per gallon of biodiesel; and 2.7 gallons of ethanol per bushel of corn.
**Assuming 120,000 BTUs per gallon of biodiesel and 76,000 BTUs per gallon of ethanol.

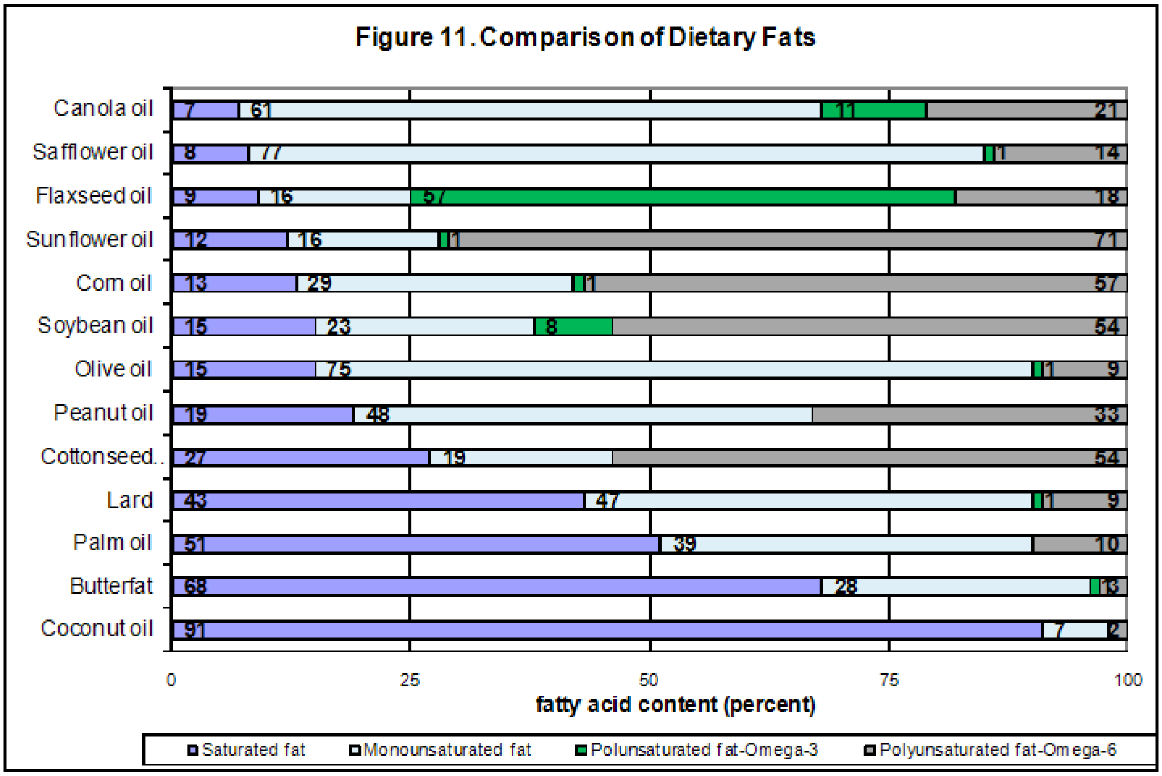
Oil Characteristics for Human Consumption

Prior to the 1970s, rapeseed oil was considered unfit for human consumption in the United States because it contained a high level of erucic acid, in the range of 30 to 60%, which is believed to have negative health effects (FDA 1988). Beginning in the 1960s, however, breeders in Canada developed rapeseed varieties low in erucic acid. By 1978, all Canadian rapeseed produced for human use contained less than 2% erucic acid, a level deemed acceptable for human consumption. The Canadian government officially named this variety of rapeseed canola. The U.S. FDA approved canola oil as "generally recognized as safe" for food use in 1985 (FDA 1988).

Canola oil is now touted as a healthy cooking oil because it has a low level of saturated fat, no trans fats, and a relatively high level of omega-3 fatty acids compared to other vegetable oils (Figure 11). Fats are an important part of the human diet, but consuming too much can be harmful, and some fats are better than others. The American Heart Association (2007) reports that saturated fat is the main dietary cause of high blood cholesterol, and they recommend that you limit your saturated fat intake to 7-10% of total calories (or less) per day. Monounsaturated and polyunsaturated are two broad categories of unsaturated fats. Both monounsaturated and polyunsaturated fats may help reduce your blood cholesterol level when used in place of saturated fats (American Heart Association 2007).

Canola oil has a 7% saturated fat content, which is the lowest of all the dietary fats (Figure 11). Soybean oil and olive oil, by comparison, both have a saturated fat content of 15%, and sunflower oil is 12%. The U.S. Canola Association filed a qualified health claim petition with the U.S. FDA in January 2006 that would acknowledge the health benefits of the low saturated fat content of canola oil. In October 2006, after reviewing the scientific evidence, the FDA approved the qualified health claim which states as follows:

> *"Limited and not conclusive scientific evidence suggests that eating about 1 ½ tablespoons (19 grams) of canola oil daily may reduce the risk of coronary heart disease due to the unsaturated fat content in canola oil. To achieve this possible benefit, canola oil is to replace a similar amount of saturated fat and not increase the total number of calories you eat in a day. One serving of this product contains [x] grams of canola oil."* (FDA 2006)



Source: canolainfo.org

Growing consumer awareness of trans fats could also increase demand for canola oil. Unsaturated fatty acids can take the "cis" or "trans" form. The cis form is far more common in natural oils. Some trans fat occurs naturally, but most trans fatty acids are formed during the process of hydrogenating vegetable oils. Partially hydrogenating vegetable oils is beneficial to food manufacturers because it increases shelf-life and creates a semi-solid fat that can be used in place of animal fats. The health risks from this process, however, have recently come to light. Trans fat consumption tends to increase bad cholesterol and decrease good cholesterol, and it may be more of a health risk than consumption of saturated fat (American Heart Association 2007).

Increased awareness of the dangers of trans fat has led to food manufacturers and restaurants to reduce or eliminate the trans fat content in their foods. Since January 2006, the FDA has required trans fats to be included on the nutrition label. New York City recently banned restaurants from using oils and spreads containing trans fats, and other cities and states are considering similar measures (Hagen 2007). Demand for non-hydrogenated canola oil could increase since it is a trans-fat free alternative. This is especially true for a variety of canola oil known as "high-stability" canola oil. High-stability canola oil contains a higher percentage of oleic acid, a monounsaturated fatty acid, which increases its stability at high temperatures, giving it a longer fry and shelf life. Oleic acid is increased from 61% in traditional canola oil to 70% in high-stability canola oil, and alpha-linolenic acid (an omega-3), which makes oil unstable, is decreased from 11% to 3% (Hagen 2006a). Restaurants such as Taco Bell in the United States and KFC in Canada have recently adopted high-stability canola oil in place of partially-hydrogenated vegetable oils to reduce or eliminate trans fat in their products (U.S. Canola Association, December 2006).

Polyunsaturated fats include omega-3 and omega-6 fatty acids. Western diets are generally high in omega-6 fatty acids and low in omega-3 fatty acids, and studies have shown that decreasing the omega-6 to omega-3 ratio in a person's diet will reduce the risk of many chronic diseases, including cardiovascular diseases and cancer (Simopoulos 2002). With the exception of flaxseed oil, canola oil has the highest amount of omega-3 fatty acids and the lowest omega-6 to omega-3 fatty acid ratio among the vegetable oils.

Polyunsaturated fats, however, are not well suited to cooking at high temperatures because they are vulnerable to heat damage. Monounsaturated fats are more stable at high temperatures, making them better suited for use as a cooking oil. Safflower oil, olive oil, and canola oil, especially high-stability canola oil, are high in monounsaturated fats. In comparing the relative stability of fatty acids, saturated fat is the most stable, then monounsaturated fat, then omega-6 fatty acids, and then omega-3 fatty acids.

Other factors that affect the quality of canola oil for food use include the chlorophyll content, or green count, total glucosinolates, and free fatty acid content. Oilseeds contain large amounts of chlorophyll when they are developing which are metabolized when the seed matures. Fully ripe seeds contain very little chlorophyll. Seeds with excessive levels of chlorophyll will result in an undesirable taste and color in the refined oil. A high level of glucosinolates in canola creates an undesirable odor and flavor. Breeding efforts have reduced the level of glucosinolates in canola. Free fatty acids are the portion of the oil that has been broken down due to chemical or microbiological activity, and they must be removed during the refining process as they reduce the smoke point in frying fats and rapidly oxidize to give rancid flavors (Northern Canola Growers Association 2001).

U.S. consumption of canola oil has been steadily rising (Figure 10). Consumption should continue to grow with the recent qualified health claim from the FDA and increasing consumer awareness of the health benefits of canola oil. Prior to the FDA's authorization of a qualified health claim for canola oil, the agency had granted only four such claims related to health disease. These claims were for nuts, walnuts, long-chain omega-3 fatty acids, and olive oil, and in each case, the FDA's authorization has had a positive effect on sales (Hagen 2006b).

Oil Characteristics for Biodiesel Production

The characteristics of vegetable oils are also important for the production of biodiesel. The cold weather performance, cetane rating, lubricity, nitrogen oxide emissions, and other characteristics of biodiesel are determined by the oil used to produce it. The low level of saturated fat and high level of monounsaturated fat in canola oil which makes it desirable for human consumption also makes it a favorable feedstock for biodiesel production.

A major quality factor of biodiesel is its cold weather performance, which is directly related to the level of unsaturation of the feedstock oil. A decrease in the saturated fat content improves the cold weather performance of the biodiesel. Cold flow properties of biodiesel can be measured by its cloud point, pour point, and cold filter plug point. Cloud point is the temperature at which a clear distillate fuel becomes hazy or cloudy because of the appearance of wax crystals; pour point is the lowest temperature at which a fuel will pour or flow when tested under standard conditions; and cold filter plug point is the temperature at which fuel crystals cause a fuel filter to plug. By each measure, the cold flow properties of biodiesel produced from canola oil compares favorably to those of biodiesel produced from other feedstocks. The cold flow properties of canola and soybean biodiesel are substantially better than those from coconut oil, palm oil, grease, lard, and tallow (Table 10). The high saturated fat content of these alternative feedstocks makes them undesirable for biodiesel use in northern climates. Canola biodiesel exhibits the best cold weather performance. It has a cloud point of 24.8˚F and a pour point of 12.6˚F, compared to 31.1˚F and 25.2˚F, respectively, for soybean biodiesel. The pour point is 48.2˚F and 60.8˚F for biodiesel produced from tallow and palm oil, respectively.

Table 10. Fuel Properties of Biodiesel as a Function of Feedstock and Comparison to Petroleum Diesel

Feedstock	Cloud point (˚F)	Pour point (˚F)	Cold Filter Plugging Point (˚F)	BOCLE (g)	Cetane number
Soybean oil	31.1	25.2	24.1	6100	50.9
Canola oil	24.8	12.6	38.5	7000	52.9
Tallow	57.0	48.2	51.8		58.8
Sunflower oil		19.4			49
Cottonseed oil		37.4			51.2
Palm oil		60.8			50
Petroleum Diesel					
Diesel #1	-40	-40			
Diesel #2	5	-27	-4 to 14	4200	44

Source: Graboski and McCormick

Despite canola's superior cold weather performance, it is still markedly worse than petroleum diesel. Number 2 diesel has a cloud point and pour point of about 5˚F and -27˚F, respectively, while Number 1 diesel has cloud and pour points of -40˚F or lower. The cold flow properties presented in Table 10 are for neat, or 100%, biodiesel. However, biodiesel is normally blended with petroleum diesel. To prevent gelling or wax formation, biodiesel can be blended at a lower percentage in colder weather. Additives can also be used to improve cold flow properties (Graboski and McCormick 1998). A survey of state transportation agencies found that concerns about cold weather behavior was one of the most common deterrents in the adoption of biodiesel blended fuel in state Department of Transportation (DOT) fleets (Humburg et al. 2006). However, the cold weather behavior of biodiesel-blended fuel was not found to be a widespread problem among the state agencies that have adopted the fuel. They did report, though, that North Dakota discontinued use of the biodiesel blend during the winter months. Other studies have found that a 10% biodiesel blend can be used in North Dakota in the winter without any problem (Red River Valley Clean Cities).

Liu et al. (2007) noted that another concern about biodiesel is its oxidative stability, especially with fuels containing polyunsaturated fatty acids. Their study found that while biodiesel with higher levels of unsaturated fatty acids had better low temperature fluidity, the oxidative stability improved with higher levels of saturated fatty acids. The polyunsaturated fats lead to instability more so than monounsaturated fats. Liu et al. found that high monounsaturated fat content improved both oxidative stability and low temperature fluidity. Canola oil is low in saturated fat but high in monounsaturated fat, compared to soybean oil which is higher in saturated fat but also higher in polyunsaturated fat. Liu et al. studied biodiesel from rapeseed oil, soybean oil, palm oil, and waste frying oil, and they concluded that biodiesel from rapeseed oil had the best cold weather properties and relatively good anti-oxidation performance.

An important benefit from the use of biodiesel is the increase in lubricity, a measure of the extent to which liquid diminishes friction. According to the two primary tests used to measure it, biodiesel has greater lubricity than conventional diesel (Strong et al. 2004). This is true regardless of the feedstock used. One test of lubricity is the Ball on Cylinder Lubricity Evaluator (BOCLE). Table 10 shows the BOCLE results for conventional diesel, soybean biodiesel, and canola biodiesel. Fuels with a good lubricity give BOCLE results in the 4500-5000 g range (Graboski and McCormick 1998). The BOCLE results reported by Graboski and McCormick are 4200-4250 for conventional diesel, 6100 for soybean biodiesel, and 7000 for canola biodiesel.

The benefit from increased lubricity is even more important as EPA regulations are requiring changes in diesel fuel. The EPA is mandating a substantial reduction in the sulfur content of diesel from 500 ppm to 15 ppm. New regulations for sulfur content began in 2006, and by June 1, 2010, all highway diesel in the United States must be ultra-low sulfur diesel (ULSD) fuel. ULSD is being mandated because it will significantly reduce emissions of particulate matter and nitrogen oxides. ULSD, however, has a lower level of lubricity (Knothe and Steidley 2005). Biodiesel, therefore, could become an attractive additive to improve lubricity. Knothe and Steidley show that blending even a small percentage (1-2%) of biodiesel can significantly improve the lubricity of ULSD.

Biodiesel also has a higher cetane number than conventional diesel. The cetane number is a measure of the self-ignition quality of fuel. Higher-speed diesels operate more effectively with fuels that have a higher cetane number. No. 2 diesel fuel in the United States usually has a cetane number between 40 and 45 while the values for biodiesel have been shown to be from 45 up to 67 (Van Gerpen 1996). The cetane number for biodiesel varies depending on the fatty acid composition of the feedstock oil. Saturated fats provide the highest cetane number, while polyunsaturated fats provide the lowest, and monounsaturated fats are in between. Studies have estimated a cetane number ranging from 45 to 67 for soy biodiesel and from 48 to 65 for canola biodiesel (Van Gerpen 1996). Graboski and McCormick (1998) found that the average reported cetane number is 50.9 for soy biodiesel and 52.9 for canola biodiesel (Table 10). These cetane numbers indicate that it is easier to start and quieter to operate vehicles fueled with soy or canola biodiesel compared to conventional diesel.

The effect on exhaust emissions from use of biodiesel is another important factor. Studies have shown that emissions of particulate matter, carbon monoxide, and hydrocarbons are reduced substantially when biodiesel is used in place of petroleum diesel, but emissions of nitrogen oxides increase (EPA 2002, Graboski and McCormick 1998). A study conducted by the EPA (2002) compared the emissions from soybean-based biodiesel, canola/rapeseed-based biodiesel, and animal-based (i.e., grease, tallow, lard) biodiesel. They found that nitrogen oxide emissions increase the most with soybean-based biodiesel and the least with animal-based biodiesel; the reductions in particulate matter and carbon monoxide emissions are the greatest with animal-based biodiesel; canola-based biodiesel reduces carbon monoxide emissions at a greater rate and particulate matter emissions at about the same rate as soybean-based biodiesel; and hydrocarbon emissions decrease at about the same rate for all three sources. The increase in nitrogen oxide emissions is found to be smaller than the decreases in other emissions.

Regardless of the feedstock used, quality control is the number one concern. Biodiesel must meet the American Society for Testing and Materials (ASTM) D6751 standard to officially be called biodiesel. ASTM D6751 includes a number of quality specifications for factors such as total glycerin, free glycerin, moisture content, cloud/pour point, acid number, oxidative stability, sulfur, flash point, cetane number, and others. Failure to meet any of these specifications would result in poor quality biodiesel. Minnesota had to temporarily suspend its biodiesel mandate in early 2006 after some poor quality biodiesel got into the market and caused fuel filters to clog.

The characteristics of canola oil indicate that it is a favorable feedstock for biodiesel production. Canola oil performs as well or better than soybean oil in every important factor. In many aspects, biodiesel performs better than petroleum diesel, regardless of the feedstock used, but the inferior cold flow properties are a limiting factor for biodiesel, requiring a lower blend in cold weather. Because of its low saturated fat content, biodiesel produced from canola oil exhibits better cold flow properties. Sources high in saturated fat such as palm oil or animal fats perform well in some areas, but they have the worst cold flow properties, which could make them undesirable for biodiesel in many regions of the country. Canola growers in the United States and Canada are attempting to capitalize on the beneficial properties of canola. The North Dakota based Northern Canola Growers Association is attempting to trademark the name “Biola” for canola-based biodiesel. The intent is to promote canola as the premier feedstock for biodiesel production.

Biodiesel is often blended at just 2% or 5%, and at these blends, the choice of using canola or soy makes minimal difference. Despite the superior qualities of canola biodiesel, it does not command a premium in the market over soy biodiesel. It is possible that the better cold flow properties and higher cetane rating could give canola biodiesel a slight premium over soy biodiesel, but the difference between canola and soy biodiesel might not be great enough to obtain a premium, especially when it is blended at low rates.

Canola Meal

Canola meal also provides value as a protein source in beef cattle, dairy cattle, poultry, and swine diets. The protein content in canola meal, however, is lower than that in soybean meal. The crude protein content for canola meal is approximately 41% of dry matter, compared to about 50-53% for soybean meal (Lardy 2002, Walker 2007). Canola meal also has a lower digestible energy content than soybean meal. The net energy of maintenance (NEM), net energy of gain (NEG), and total digestible nutrients (TDN) for canola meal are 0.73 Mcal/lb, 0.45 Mcal/lb, and 69%, respectively, while those for soybean meal are 0.94 Mcal/lb, 0.64 Mcal/lb, and 84% (Walker 2007). The energy content for canola meal, though, is slightly better than that for sunflower meal.

As production of canola has increased, so has the production and use of canola meal. U.S. canola meal use increased from 640 thousand tons in 1992/93 to about 2.3 million tons in 2005/06. In comparison, domestic soybean meal use totaled 33.2 million tons in 2005/06. Lardy (2002) reviewed the studies conducted on using canola meal in beef cattle diets and concluded that it appears to be a good source of supplemental protein. He commented that the decision to use canola meal should be based on cost and availability of competing protein supplements.

Variety Release Requirements

There are significant differences between the procedures and requirements necessary to release a new variety in Canada and those in the United States. In Canada, new canola varieties must be evaluated in field trials for three years before they can be considered for registration, though a variety could be eligible after the first two years of trials if it scores high enough. The procedure includes a number of specific rules for test location, number of tests, test size and design, and the requirements for acceptance are very stringent. There are three different species grown in Canada: B.napus (Argentine), B.rapa (Polish), and B.juncea, and there are specific requirements for each. Each candidate must meet a number of minimum criteria, and failure to meet any of these criteria will result in automatic rejection.

There are also acceptable criteria which a candidate should meet. If a candidate meets the minimum criteria but fails to meet any or all of the acceptable criteria, the committee will consider all attributes of the candidate in deciding whether or not to recommend registration. The candidate cultivars are tested for oil content, protein, erucic acid, glucosinolates, total saturates, and blackleg and white rust resistance, among other characteristics, and the results are compared to those of selected cultivars, referred to as checks, that are already commercially available in the class and zone for which the candidate is being considered. For example, the oil content must not be lower than 1.2% below the mean of the designated unadjusted checks for B.napus species, and it must be greater than or equal to the mean of the checks for B.rapa and B.juncea species. The minimum and acceptable criteria for the candidates are detailed in Table 11.

The registration requirements for new varieties are much less stringent and more market oriented in the United States. New varieties in the United States require seed certification and plant variety protection (PVP). The North Dakota State Seed Laboratory is the official certification laboratory for North Dakota. This laboratory provides a broad range of testing, including tests of germination and purity. Canola is tested for blackleg resistance. There are some federal requirements such as blackleg resistance that new varieties much attain. PVP provides legal intellectual property rights protection to developers of new varieties. The U.S. system is more market oriented than that in Canada. Instead of requiring minimum levels of certain characteristics such as oil content and protein content, the system allows the market to decide which characteristics and which varieties are most desirable.

Table 11. Requirements for Variety Recommendation in Canada

Characteristic	Specie	Requirement
		Minimum criteria
Characteristic	Specie	Requirement
Merit score (described below)	All	Must be greater than zero for the zone for which it is being considered.
Erucic acid	All	Must be less than 0.5% of the total fatty acids.
Glucosinolates	All	The seed must either contain not more than 12.0 µmoles total glucosinolates/g whole seed at 8.5% moisture content or contain levels of glucosinolate not more than the mean of the designated checks for regular B.napus, plus 0.5 for early B.napus, and plus 0.3 for B.rapa, whichever is higher.
Oil content	B.napus and low linolenic B.napus	Must not be lower than 1.2% below the mean of unadjusted designated check(s).
	B.rapa	Must be greater than or equal to the designated unadjusted check(s).
	B.juncea	Should not be below the mean of the checks.
Protein content	B.napus and low linolenic B.napus	Must not be lower than 1.5% below the mean of the designated unadjusted check(s).
	B.rapa	Must not be lower than 0.3% below the mean of the designated unadjusted check(s).
	B.juncea	Should not be lower than 3.5% below the mean of the checks.
Days to maturity	early B.napus	Must be earlier than the mean of the early B.napus checks plus 1 day.
Yield	B.rapa	Candidate entries exceeding the mean yield of the checks by 10% or more can be below the checks by .3 %oil-dry basis and .5 % protein-dry basis.
Total saturates	B.juncea	Should not be above the mean of the designated checks.
	B.napus	Must not exced the mean of the checks by 0.1 for regular B.napus and 0.2 for early B.napus.
Oleic acid	B.juncea	Must be a minimum 55%.
Blackleg rating	B.juncea	Should be MR (lower than Defender) or better.
White rust resistance	B.rapa	Must be at least equal to Tobin in resistance to white rust race 7a.
	B.napus	White rust susceptibility of B. napus candidates must be less than 10% of the plant population.
		Acceptable criteria
Characteristic	Specie	Requirement
Erucic acid	All	Erucic acid content of the harvested seed should not exceed 1%.
Blackleg rating	All	Should not be more blackleg susceptible than the designated checks.
	B.juncea	Should have an MR rating or better.
		Calculation of Merit Score
B.napus	=Y*1.13-100+7.5*(OIL-(OILC-0.9))+2.5*(P-PC)+3.6*(BC-B)+1.35*EM	
B.rapa	=Y*1.0-100+6.0*(OIL-(OILC+0.3))+4.0*(P-PC)+3.6*(BC-B)+1.35*EM	
Early B.napus	=Y*1.5-100+6.0*(OIL-(OILC-2.4))+2.5*(P-PC)+3.6*(BC-B)+1.35*EM	
where	Y=mean yield of the candidate cultivar as a % of the mean yield of the checks	
	OIL=oil content of the candidate cultivar	
	OILC=mean oil content of the checks	
	P=protein content of the candidate cultivar	
	PC=mean protein content of the checks	
	BC=mean blackleg severity of the checks measured on a 0-5 scale	
	B=blackleg severity of the candidate cultivar measured on a 0-5 scale	
	EM=number of days the candidate cultivar matures earlier than the mean of the 2 earliest checks	

Notes: Designated check cultivars for each class and testing zone are selected from among commercially available cultivars grown in the testing zone.
Cultivars with 80.0% greater oleic acid and 3.0% or less linolenic acid may be put through either specialty and contract registration of the public coop (breeder's choice).

Source: Procedures of the Western Canada Canola/Rapeseed Recommending Committee Incorporated for the Evaluation and Recommendation for Registration of Canola/Rapeseed Candidate Cultivars in Western Canada, 2006

Profitability of Biodiesel Production

While there may be many benefits from producing biodiesel, especially canola biodiesel, in terms of the environment, energy security, rural economics, and even engine performance, the growth of the biodiesel industry will depend on its profitability. The higher cost of production puts biodiesel at a disadvantage compared to petroleum diesel. VanWechel et al. concluded in 2003 that with the existing technology and no subsidy, biodiesel production in North Dakota would not be competitive with petroleum diesel. Higher diesel prices since 2003 and the $1.00 per gallon tax credit implemented in 2005, however, improve the profitability of biodiesel. Wholesale diesel prices per gallon have increased from $0.73 in 2002 to $1.75 in 2005 and $2.02 in 2006. The tax credit is currently scheduled to end after 2008, although there will likely be pressure and political desire to extend it. Higher vegetable oil prices in 2006 and 2007, on the other hand, make biodiesel production less profitable.

VanWechel et al (2003) estimated that, using soybean oil prices of 17 cents to 25 cents per pound, the cost of producing soy biodiesel in southeastern North Dakota (where soybeans are a major crop) would range from $2.02 to $2.64 per gallon for a plant that produced 5 MMGy. Paulson and Ginder (2007) estimated a production cost of $2.233 per gallon for a 30 MMGy plant and $2.219 per gallon for a 60 MMGy plant, and if they include the annual cost of capital, the total annual cost is $2.351 per gallon and $2.315 per gallon, respectively, for the 30 MMGy and 60 MMGy plant. Haas et al. (2005) estimated production cost at $2.00 per gallon for a 10 MMGy plant, and Fortenbery (2005) estimated per gallon production cost at $2.86 for a 4 MMGy plant and $2.65 for a 10 MMGy plant. These studies assumed soybean oil would be the feedstock used, but the cost of production for a canola-based biodiesel plant should be roughly the same at a given feedstock price.

The results from these studies indicate that increasing returns to scale exist in the industry, i.e., decreases in average costs with increases in plant size. As of the end of 2006 there were a few 30 MMGy plants, but most were no larger than 10 MMGy. The new plants, however, are larger. Many of the plants under construction in 2006 and 2007 are 30 MMGy or larger, including the 85 MMGy canola biodiesel plant in Velva, ND and the 100 MMGy plant in Grays Harbor, WA. These larger plants should be able to take advantage of increasing returns to scale. Paulson and Ginder estimated that these scale returns come from savings in marginal labor costs and capital costs.

Table 12 summarizes the cost of production estimates from the previous studies. Paulson and Ginder attribute the differences in cost estimates to differences in the feedstock cost, energy costs, and byproduct prices. They estimate that the feedstock cost represents 85% of total operating costs. The per pound feedstock costs used in these studies are 17-25 cents by VanWechel et al., 23.6 cents by Haas et al., 25 cents by Paulson and Ginder, and 33 cents by Fortenbery. Paulson and Ginder estimated that with an oil price of 33 cents per pound, the operating costs would be $2.833 for a 30 MMGy plant and $2.819 for a 60 MMGy plant. The cost of the feedstock oil has a significant effect on the profitability of the plant. Paulson and Ginder found that a change of 2 cents per pound in the price of the feedstock affects the expected return on investment by more than 3.5% at a given biodiesel price. Fortenbery estimated that production costs for 4 MMGy and 10 MMGy plants that used the cheaper yellow grease (17 cents per pound) would be $1.74 per gallon and $1.54 per gallon, respectively.

Table 12. Cost of Production Estimates from Previous Studies

Oil Cost (cents per pound)	Size of Plant (million gallons per year) 4	5	10	30	60
	---------- production cost per gallon ($)----------				
17		2.02[a]			
19		2.18[a]			
22		2.41[a]			
24			2.00[b]		
25		2.64[a]		2.23[d]	2.22[d]
33	2.86[c]		2.65[c]	2.83[d]	2.82[d]

[a]VanWechel et al. 2003, assuming no credit for glycerin, $0.14/lb paid for methanol
[b]Haas et al. 2006, assuming $0.15/lb received for glycerin, $0.13/lb paid for methanol
[c]Fortenbery 2005, assuming $0.40/lb received for glycerin, $0.13/lb paid for methanol
[d]Paulson and Ginder 2007, assuming $0.05/lb received for glycerin, $0.15/lb paid for methanol

Paulson and Ginder (2007) calculated breakeven feedstock prices at a given biodiesel price (Table 13). For example, for a 30 MMGy plant, with the biodiesel price at $2.80 per gallon, the breakeven feedcost cost would be 31.8 cents per pound for the operating margin and 28.8 cents per pound for net income. These breakeven costs are estimated to be higher for a 60 MMGy plant, and they increase, naturally, as the price of biodiesel rises. Carriquiry (2007) estimated that as feedstock prices exceed 30 cents per pound, the per gallon price of biodiesel needs to be above $2.80 for operating returns for a 60 MMGy plant to be positive and $3.00 for the plant to make a profit.

Table 13. Breakeven Feedstock Prices

	30MMGy Plant		60 MMGy Plant	
Biodiesel price	Operating Margin	Net Income	Operating Margin	Net Income
$/gallon	-------------------------$/lb-------------------------			
$2.40	$0.266	$0.237	$0.268	$0.245
$2.60	$0.292	$0.263	$0.294	$0.270
$2.80	$0.318	$0.288	$0.320	$0.296
$3.00	$0.344	$0.314	$0.346	$0.322
$3.20	$0.370	$0.339	$0.372	$0.347
$3.40	$0.396	$0.365	$0.399	$0.373

Source: Paulson and Ginder

Since feedstock cost is a substantial expense for biodiesel production, the choice of feedstock affects its profitability. Animal fats are the cheapest feedstock, but they are more expensive to process. Soybean oil is generally the cheapest of the virgin vegetable oils. A comparison of wholesale canola and soybean oil prices since 2000 shows that soybean oil prices are lower than canola oil prices by an average of about 5 cents per gallon (Figure 12). The price gap rose in 2005 when soybean oil averaged 23.0 cents per pound and canola oil averaged 30.7 cents per pound. Canola oil and soybean oil prices averaged 32.6 and 24.4 cents per pound, respectively, in 2006, though the prices of both rose throughout the year to 38.4 and 27.6 cents per pound, respectively, in December 2006. Sunflower oil prices had been similar to canola oil prices until they increased substantially in 2005. Sunflower oil prices averaged 44.5 cents per pound in 2005.

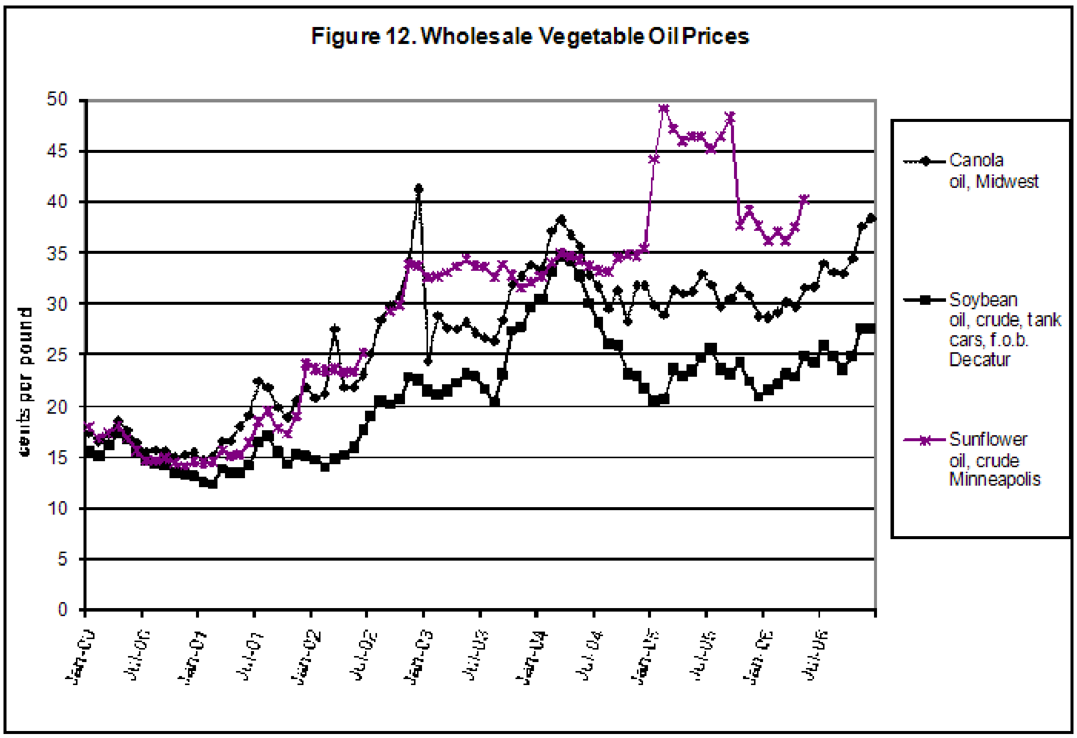


Figure 12. Wholesale Vegetable Oil Prices

Source: Oil Crops Yearbook, ERS/USDA

Tokgoz et al. (2007) estimate that soybean oil prices could continue to rise due to the rapidly expanding corn ethanol industry, which would limit growth in the biodiesel industry. Corn acreage is expected to increase to meet the growing demand for ethanol, largely at the expense of soybean acreage. Tokgoz et al. estimate a decrease in soybean acres which will lead to increased soybean prices and a long-run soybean oil price of 35 cents to 39 cents per pound, making biodiesel production less profitable.

Another factor to consider when choosing a feedstock is the availability and transportation logistics. Soybean oil is the most abundant feedstock available in the United States, which makes it an obvious choice for biodiesel production. In some areas, though, alternative feedstocks could be feasible. The canola biodiesel plants under construction in northern North Dakota and Minnesota are in an area where canola is more abundant. U.S. canola production is concentrated in this area. The emergence of winter canola could expand production into new regions which could possibly support biodiesel production.

There is some difference in the cost of production estimates due to differences placed on the value of byproducts. Glycerin is the main byproduct of biodiesel production. The value of glycerin is important because it accounts for 10% of what is produced from biodiesel production. Glycerin has a wide number of applications including food, pharmaceuticals, and cosmetics, but it is costly to refine the crude glycerin (Pachauri and He 2006). Biodiesel producers have received between 5 and 15 cents per pound for crude glycerin (Tyson et al. 2004). Increased biodiesel production, however, could have a negative effect on glycerin prices as supplies would increase substantially. Glycerin prices have dropped, in fact, since biodiesel production has expanded in Europe (Tyson et al. 2004). Finding new uses for glycerin could provide important value for biodiesel producers. Research has shown that it could be used as a dietary supplement for chickens (Simon et al. 1997).

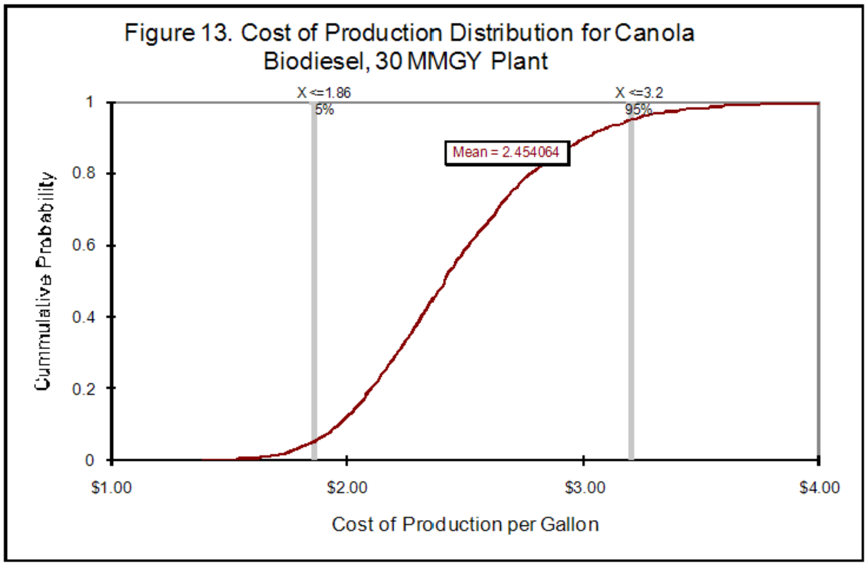
Modeling Cost of Production for Canola Biodiesel vs. Soy Biodiesel

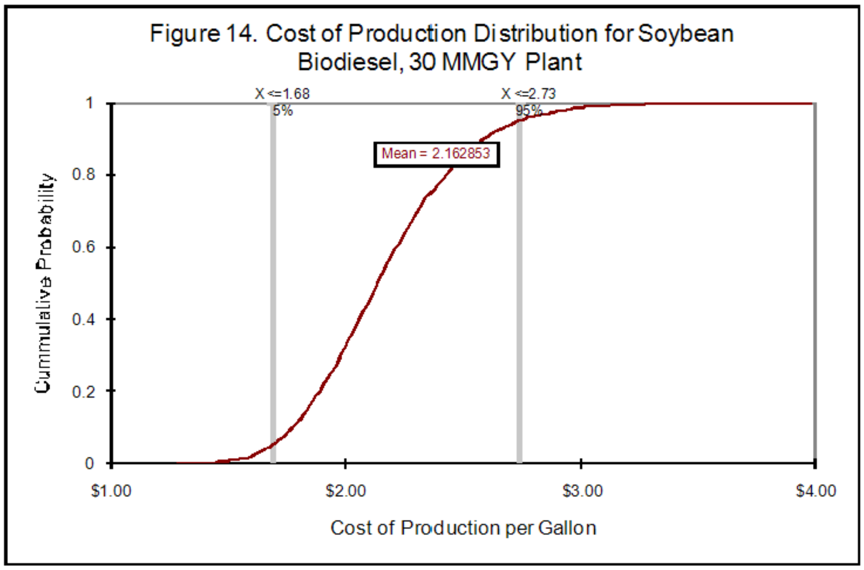
Previous studies have estimated the cost of producing biodiesel from soybean oil considering soybean oil prices and different plant sizes, but very few of the studies have determined the cost of producing biodiesel from canola oil. An important factor which has not been investigated in the literature is the risks associated with producing biodiesel. Since 2000, oilseed oil prices have been steadily increasing, but there is great volatility in each of the markets (Figure 12). Other factors in biodiesel production are risky as well. Methanol, a key product in the biodiesel production process, has been increasing significantly since 2002 (Methanex). The energy required to produce biodiesel is also quite volatile. One of the more volatile energy inputs in the process is natural gas. Natural gas or some other fuel is required to heat water to steam for the biodiesel production process.

To illustrate these factors, we analyzed the cost and risks of biodiesel production. The details of the model are presented in Appendix B. We assume no glycerin is sold as a byproduct and no production subsidies, tax credits, or government incentives are included in the model. The results are similar to those from previous studies for each respective plant size, 30 MMGy and 5 MMGy (Table 14). The results show that the cost of production for the smaller plants is about $0.30 per gallon higher than that for the larger plants, and the production of biodiesel from canola oil is $0.29 per gallon higher than that from soy oil because of the higher feedstock cost. Canola biodiesel is also riskier than soy oil biodiesel. This can be seen for 30 MMGy plants in Figures 13 and 14. The difference between the cost of production for canola biodiesel and that for soy biodiesel increases as the premium for canola oil increases. For a 30 MMGy plant, the 90% confidence interval for cost of production ranges from $1.68 to $2.73 for soy biodiesel and $1.86 to $3.20 for canola biodiesel.

Table 14. Biodiesel Production Cost Output Results

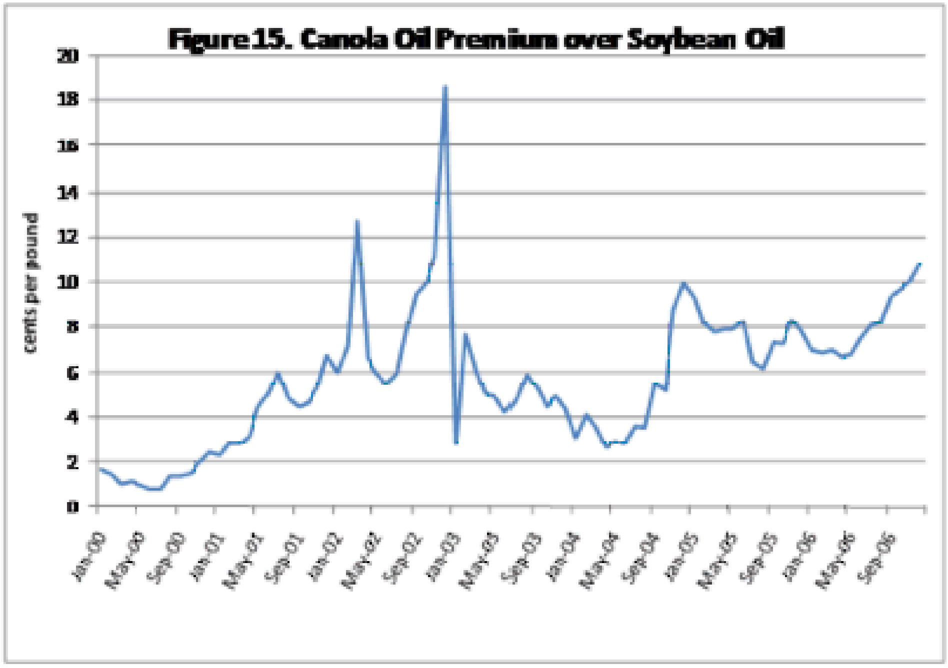
		Mean	Std. Dev	Minimum	Maximum
		----------------------$/gallon----------------------			
30 MMGy	Soybean Oil	2.16	0.32	1.28	3.98
	Canola Oil	2.45	0.41	1.39	4.55
5 MMGy	Soybean Oil	2.46	0.32	1.59	3.97
	Canola Oil	2.75	0.41	1.69	4.87





Many factors influence the cost of biodiesel production. By far, the most important factor in biodiesel production is the cost of the feedstock since it accounts for 70% - 80% of the cost of biodiesel production (Biodiesel Workshop Series). Methanol prices also have a significant impact on the cost of biodiesel production. As the cost of methanol increases, the cost of producing biodiesel will no doubt increase as well. The cost of the fuel, in this case natural gas, is influential in determining the cost of production. As natural gas prices increase, the cost of production will also increase. Lastly, management and quality control costs for the biodiesel plant help determine the cost of the biodiesel being produced.

Since 2000, the average price of canola oil has been 5-6 cents per pound above the soybean oil price, but since 2005, the premium has averaged around 8 cents per pound for canola oil (Figure 15). The results in Table 14 and Figures 13 and 14 are calculated based on price data since 2000. Over this period, the average soy and canola oil prices are $0.21 and $0.26 per gallon, respectively. Prices have been much higher recently, however. To estimate the effect of higher prices, we reran the model using prices from 2005. In this scenario, average soy and canola oil prices are $0.24 and $0.32 per pound, respectively. When these prices are used in the model, the results show that the average production cost for canola biodiesel is $0.60 per gallon higher than that for soy biodiesel, instead of $0.29 per gallon higher as in the base case. The average cost of production in a 30 MMGy plant for soy biodiesel in this scenario is $2.29 per gallon compared to $2.89 per gallon for canola biodiesel. The higher prices for soybean oil and canola oil in 2005 and 2006 and the greater premium for canola oil make the production of biodiesel, especially canola biodiesel, more costly. These results demonstrate the importance of feedstock price on biodiesel profitability. Soy and canola oil prices have continued increasing in 2006 and 2007, which has led to a slowdown in biodiesel plant construction (Reidy 2007).



Feedstock Availability for Biodiesel Production

Long-run projections for biodiesel production range from Tokgoz et al.'s (2007) estimate of about 500 million gallons per year to Soyatech's (2006) projection of 2.15 billion gallons by 2015, which would be approximately 4% of total diesel consumption. The main limiting factor would be the available supply of affordable feedstock. Bunge North America CEO Carl Hausmann projects biodiesel production will peak at 1 billion gallons due mainly to insufficient feedstock supply (Bloomberg News 2007).

The majority of biodiesel production will likely continue to be from soybeans because it is the most abundant feedstock. The next most available vegetable oils are domestically produced corn oil, domestically produced and imported canola oil, imported palm oil and coconut oil, and domestically produced cottonseed oil (Table 15). As described above, canola oil has many advantages over these alternative oils.

Table 15. U.S. Supply and Use of Vegetable Oils, 2004/05-2006/07 Average

	Beginning Stocks	Production	Imports	Exports	Domestic Consumption
	-----------------------	million pounds	-----------------------		
Soybean oil	1,932	19,972	30	1,326	18,148
Corn oil	154	2,421	55	795	1,690
Cottonseed oil	95	924	1	83	845
Canola oil	160	904	1,452	449	1,897
Sunflowerseed oil	39	470	52	163	352
Peanut oil	61	168	81	10	265
Olive oil		2	555	23	534
Palm oil	172	0	1,209	27	1,172
Coconut oil	177	0	994	15	948
Palm kernel oil	74	0	523	2	518

Source: PS&D Database, FAS/USDA

With demand increasing for biodiesel and for healthy vegetable oils for human consumption, canola production may not be able to keep pace with the demand. The United States is already a significant net importer of canola oil, and the biodiesel plants under construction will consume a large quantity of canola oil. If all the canola oil that was domestically produced and imported by the United States during the 2004/05-2006/07 time period was used for biodiesel production, it would have yielded about 315 million gallons of biodiesel per year. Domestic production could increase as a result of the growing demand, but since much of the canola oil will continue to be used for food use, imports will have to increase to meet the demands of the canola biodiesel plants. The ADM plant in Velva will require canola from about 1 million acres, which is roughly equal to the entire production in North Dakota. To meet this demand, ADM announced it will import canola from Canada.

The potential for soybean-based biodiesel production is also limited by feedstock availability. Biodiesel production accounted for 8% of total U.S. soybean oil use in 2005/06 and is estimated to account for 2.6 billion pounds of soybean oil, or 13% of total U.S. soybean oil use, in 2006/07 (Collins 2007). The 2.6 billion pounds of soybean oil used for biodiesel in 2006/07 equals the amount of oil extracted from 229 million bushels of soybeans, which is 7% of U.S. soybean production (Collins 2007). Continued increases in soybean oil and other vegetable oils could push up prices and cause biodiesel production costs to increase. To meet the demand, the United States may need to increase imports of vegetable oils. Soyatech (2006) estimates that U.S. net imports of vegetable oils will increase from 4.8 billion pounds in 2006 to 20.5 billion pounds in 2015. Hausmann believes there is not sufficient supply of feedstock to support more than 1 billion gallons of biodiesel per year (Bloomberg News 2007).

Some alternative feedstocks that could be used for biodiesel production include corn oil, sunflower oil, palm oil, animal fats, used cooking oil, waste grease, camelina, jatropha, and algae, among others. The use of sunflower oil is limited by its supply and cost. Corn oil, though, is cheaper and in greater supply. The growing ethanol industry, in fact, could lead to a greater supply of corn oil for biodiesel production. New technology is available that extracts corn oil as a byproduct in a dry-mill ethanol plant. The company that is attempting to patent this technology is signing agreements with ethanol plants to extract the corn oil, which was previously not being recovered, and its sister company is building the first commercial-scale biodiesel plants that use corn oil as the feedstock (Jessen 2006).

Palm oil also has some potential as a feedstock. The United States does not produce palm oil, but the worldwide supply of the oil is large and growing. Palm oil recently surpassed soybean oil as the most-produced vegetable oil in the world, and it has long been the most-traded vegetable oil. Worldwide production of palm oil has more than doubled in 10 years, from 17.6 million metric tons in 1996/97 to 39.0 million metric tons in 2006/07, which is greater than the 35.8 million metric tons of soybean oil produced. Palm oil is a highly traded commodity, as more than 70% of the world's production is traded. Production is concentrated in Indonesia and Malaysia. These two countries account for approximately 85% of the world's production, and they produce the oil largely for export. Production of palm oil has been increasing in the southeast Asian countries as a result of the increased worldwide demand for vegetable oil and the great productivity of the oil palm tree. The oil palm is the most productive oilseed in the world because of its high oil content. An acre of oil palm can produce 635 gallons of biodiesel, compared to 60 gallons from an acre of soybeans and 81 gallons from an acre of canola. Imported palm oil is cost-competitive with soybean and canola oil as a feedstock for biodiesel production in the United States. The price of palm oil, though, has increased significantly in 2006 and 2007 as demand for the oil is soaring (Aglionby 2007). Supply of the oil is expected to increase to meet the demand, especially from Indonesia, as the Indonesian government is predicting that production in the country will increase from 17 million metric tons to 27 million metric tons by 2015 (Aglionby 2007). The rapid growth of palm oil production has led to concerns among environmentalists that vast areas of tropical forest land are being cleared for oil palm plantations. To combat some of these concerns, a Dutch commission has proposed a system to ensure that crops used to create biofuels do not do more harm, such as deforestation, than good (Corder 2007). The potential for palm oil the United States is also limited by its inferior cold flow properties.

Jatropha and algae are two potential future feedstocks for biodiesel. Jatropha is a high oil yielding shrub which can be grown in poor soils. There has been some research into using very high oil yielding algae for biodiesel production (Briggs 2004). Algae could yield more than 5,000 gallons of biodiesel per acre, but it is not widely produced, and there are difficulties and cost disadvantages to overcome before widescale production is a possibility. Used cooking oils are a cheap feedstock, but they cost more to process into biodiesel and are limited in supply. Camelina, another option, is an oilseed in the same family as canola that producers in Montana have begun growing. Camelina generally has lower yields than other oilseeds crops, but it also has lower input costs (Johnson 2007). Montana producers grew 14 thousand acres of camelina in 2006, and production is expected to increase significantly (McMenamin 2007).

Conclusions

The biodiesel industry is a young but rapidly expanding industry. Much of the growth in the industry is due to government support. The primary incentive is a $1.00 per gallon blenders tax credit. Soybean oil is the primary feedstock for biodiesel production in the United States, but canola oil is an attractive alternative. A few biodiesel plants currently under construction plan to use canola oil as a feedstock.

The characteristics of canola oil make it a favorable feedstock for biodiesel. Biodiesel in general has some favorable qualities compared to petroleum diesel, such as greater lubricity and a higher cetane number. The main limiting factor, however, is the inferior cold flow properties of biodiesel. The cold flow properties are determined by the fat content of the feedstock oil, and since canola oil has the lowest saturated fat content, it has the best cold weather performance. Canola is also a favorable feedstock for biodiesel because it has an oil content of about 40-43%, compared to 18% for soybeans, so it yields more oil, and therefore more biodiesel, per acre.

Approximately 90% of U.S. canola production is in North Dakota. U.S. production, though, is small compared to that in Canada. The canola biodiesel plant under construction in Velva, North Dakota alone will demand about as much canola as what is currently produced in the entire state. U.S. production will likely expand as a result of this increased demand, but much of the demand may have to be met with imports from Canada.

Demand for canola oil for human consumption is also expected to grow because of its health benefits, since it is low in saturated fat, relatively high in omega-3 fatty acids, and trans-fat free. There has been debate on the use of agricultural products for food versus fuel. If agricultural products are increasingly used to produce energy, then the supply available for food decreases. Commodity prices would increase in response, and food prices could rise. Meanwhile, demand for agricultural products to feed a growing world population is also increasing. Runge and Senauer (2007) argued that increasing biofuel production is likely to exacerbate world hunger.

Demand for vegetable oils, in general, has been increasing throughout the world and in the United States, and demand for canola oil, specifically, has been growing. Agriculture’s primary goal will continue to be the production of food, so demand increases for food production could limit the potential of biofuel production. In the past when there has been concerns that agricultural production would not be able to keep pace with growing demand, agriculture was more than able to supply the growing need for food through increases in yields and productivity. Future technological advancements, such as advancements in yields and oil content, could improve the potential for oilseed production to provide for both food and fuel.

The limiting factors for the use of canola for biodiesel could be the available supply of canola and the demand for canola oil for food. The increased demand for canola oil and the limited supply could push its price up to the point where it may not be profitable to produce biodiesel. Biodiesel production is largely dependent on the feedstock cost and the price received for biodiesel, and there have been great variations in both of these over the last few years. Prices of both soybean and canola oil have increased since 2005, which significantly affects cost of production. The advantages for soybean oil are that it has greater availability and is a cheaper feedstock. Soybean oil will likely continue to be the main biodiesel feedstock, but there should be many opportunities for canola oil for either food or fuel.

References

@Risk Professional. Palisade Corporation. Version 4.5, 2003.

ADM. Personal Communications. April 2007.

Aglionby, John. "Palm Oil Bull Run Likely to Continue," Financial Times, May 2, 2007.

Agriculture and Agri-Food Canada. "Canada: Primary Processing of Grains and Oilseeds." Bi-weekly Bulletin, Vol. 19, No. 9, June 22, 2006.

Agriculture and Agri-Food Canada. "Canola: Situation and Outlook." Bi-weekly Bulletin, Vol. 19, No. 17, November 30, 2006.

Agriculture and Agri-Food Canada. "The United States Canola Industry: Situation and Outlook." Bi-weekly Bulletin, Vol. 17, No. 4, February 27, 2004.

American Heart Association. "Know Your Fats," http://www.americanheart.org/presenter.jhtml?identifier=532 Accessed March 2007.

Biodiesel Workshop Series. "Sensitivity Analysis." Presented at the Biodiesel Workshop Series in Ames, Iowa, October 16-20, 2006.

Bloomberg News. "U.S. biodiesel is overbuilding, Bunge CEO Hausmann says," Omaha World-Herald, May 13, 2007.

Boyles, Mark, Tom Peeper, and Case Medlin. "Producing Winter Hardy Canola in Oklahoma," F-2130, Oklahoma Cooperative Extension Service, Division of Agricultural Sciences and Natural Resources, Oklahoma State University, 2004.

Briggs, Michael. "Widescale Biodiesel Production from Algae," UNH Biodiesel Group, Physics Department, University of New Hampshire, August 2004. http://www.unh.edu/p2/biodiesel/article_alge.html

Canola Council of Canada. "Canola growing great 2015." March 2007.

Canola Council of Canada. "Overview of Canada's Canola Industry." http://www.canola-council.org/ind_overview.html Accessed June 2007.

Carriquiry, Miguel. "U.S. Biodiesel Production: Recent Developments and Prospects," Iowa Ag Review, Center for Agricultural and Rural Development, Spring 2007.

Coleman, Barry. "Canola: An Excellent Feedstock for Biodiesel," Biodiesel Magazine. January 2006.

Coleman, Barry. “Canola: Biodiesel Impacts,” Presented at the North Dakota Biodiesel Workshop hosted by the Energy and Environmental Research Center, University of North Dakota, March 29, 2007.

Collins, Keith. Statement of Keith Collins, Chief Economist, U.S. Department of Agriculture, Before the U.S. Senate Committee on Agriculture, Nutrition and Forestry. January 10, 2007.

Corder, Mike. “Dutch Propose Rules on Biofuel Importation,” Associated Press, May 4, 2007.

Dow Jones Energy Service. “Big Boys Starting to Eye Biodiesel,” China Institute, University of Alberta, September 13, 2006.

Economic Research Service, United States Department of Agriculture. Oil Crops Yearbook. “Prices: Farm, Wholesale, and Index Numbers of Wholesale Prices, by Month, 2001-2006.” Accessed May 2007.

Energy Information Administration, Department of Energy. “Average Retail Price of Electricity to Ultimate Customers: Total by End-Use Sector.” Accessed May 2007.

Energy Information Administration, Department of Energy. “Natural Gas Prices.” Accessed May 2007.

European Biodiesel Board. 2007a. Legislation. http://www.ebb-eu.org/legislation.php Accessed May 2007.

European Biodiesel Board. 2007b. Statistics: The EU Biodiesel Industry. http://www.ebb-eu.org/stats.php Accessed August 2007.

Food and Agricultural Policy Research Institute. “Implications of Increased Ethanol Production for U.S. Agriculture.” FAPRI-UMC Report #10-05. August 22, 2005.

Foreign Agricultural Service, U.S. Department of Agriculture. “EU-25 Oilseeds and Products: Changes in the EU Oilseed Situation 2006,” GAIN Report No. E36051, March 24, 2006.

Foreign Agricultural Service, U.S. Department of Agriculture. “EU-25 Oilseeds and Products Update 2006,” GAIN Report No. E36146, December 20, 2006.

Foreign Agricultural Service, U.S. Department of Agriculture. Production, Supply and Distribution Online Database. http://www.fas.usda.gov/psdonline/psdHome.aspx Accessed March 2007

Foreign Agricultural Service, U.S. Department of Agriculture. U.S. Trade Internet System. http://www.fas.usda.gov/ustrade/ Accessed March 2007.

Fortenbery, T. Randall. “Biodiesel Feasibility Study: An Evaluation of Biodiesel Feasibility in Wisconsin,” Staff Paper No. 481, Department of Agricultural & Applied Economics, University of Wisconsin-Madison, March 2005.

Graboski, Michael S., and Robert L. McCormick. “Combustion of Fat and Vegetable Oil Derived Fuels in Diesel Engines,” Prog. Energy Combust. Sci. Vol 24. 126-164, 1998.

Haas, Michael J., Andrew J. McAloon, Winne C. Yee, and Thomas A. Foglia. “A Process Model to Estimate Biodiesel Production Costs,” Bioresource Technology. Vol. 97, 671-678, 2006.

Hagen, Katie. “High Stability Canola Oil: A Solution to Reducing Trans Fat in the Food Supply,” U.S. Canola Digest, Vol. 1, No. 3, 14-17, September/October 2006a.

Hagen, Katie. “The Power of a Qualified Health Claim: What Claims Have Done for Nuts, Walnuts, Omega-3s and Olive Oil,” U.S. Canola Digest, Vol. 1, No. 4, 6-8, November/December 2006b.

Hagen, Katie. “The Fight to Ban Trans Fat: Regulators 1, Industry 0: Demand for Canola Oil to Increase,” U.S. Canola Digest, Vol. 2, No. 1, 5-7, January/February 2007.

Hegeman, Roxana. “Winter canola growing in popularity,” Associated Press, June 16, 2006.

Humburg, D. S., T. J. Hansen, L. G. Schumacher, A. K. Mahapatra, G. L. Taylor, B. T. Adams. “Biodiesel Use and Experience Among State DOT Agencies,” Applied Engineering In Agriculture. Vol. 22(2): 177-84, 2006.

Jessen, Holly. “The Matchmaker,” Biodiesel Magazine, November 2006.

Johnson, Burton. “Oilseed Crops for Biofuels,” Presented at the North Dakota Biodiesel Workshop hosted by the Energy and Environmental Research Center, University of North Dakota, March 29, 2007.

Johnson, Elizabeth. “Brazil’s Biodiesel Rush,” Biodiesel Magazine. August/September 2005.

K-State Extension Agronomy. e-Updates No. 44, August 11, 2006.

Kinast, J.A. Production of Biodiesels from Multiple Feedstocks and Properties of Biodiesels and Biodiesel/Diesel Blends. National Renewable Energy Laboratory. Golden, CO., March 2003.

Kotrba, Ron. “Everything Under the Sun,” Biodiesel Magazine, February 2006.

Knothe, Gerhard, and Kevin R. Steidley. “Lubricity of Components of Biodiesel and Petrodiesel: The Origin of Biodiesel Lubricity,” Energy & Fuels. Vol 19, No. 3, 1192-1200, 2005.

Lardy, Gregory P. “Canola Meal in Beef Cattle Diets.” Animal and Range Sciences Department, North Dakota State University. 2002.

Liu, Changheng, Mei Yang, Jiangwei Wang, Mingxia Wang, and Fenghong Huang. “Effects of Fatty Acids on Oxidation Stability and Low Temperature Fluidity of Biodiesel,” Proceedings of the 12th International Rapeseed Congress, Vol V, 350-353, Wuhan, China, March 26-30, 2007.

Manfredo, Mark R. and Raymond M. Leuthold. “Market Risk Measurement and the Cattle Feeding Margin: An Application of Value-at-Risk.” Agribusiness 17(3), 333-353, July 2001.

McClure, Robert. “Biodiesel fuels enthusiasts vowing a ‘revolution,’” Seattle Post-Intelligencer, May 6, 2007.

McKay, Kent, and Lee Novak. “Canola Harvest Method and Timing Trial.” North Central Research Extension Service, North Dakota State Extension Service, 2006.

McKay, Kent, Lee Novak, Shanna Mazurek, and Gary Willoughby. “Canola Harvest Method and Timing Trial.” North Central Research Extension Service, North Dakota State Extension Service, 2005.

McMenamin, Helen. “New Crops Look Promising,” Farm Business Communications, April 18, 2007.

McNew, Kevin, and Duane Griffith. “Measuring the Impact of Ethanol Plants on Local Grain Prices.” Review of Agricultural Economics 27-2 (2005):164-180.

Methanex. Methanex Monthly Average Regional Posted Contract Price History. http://www.methanex.com/products/methanolprice.html Accessed May 2007.

National Agricultural Statistics Service, U.S. Department of Agriculture. *North Dakota Annual Statistics Bulletin.* 2007.

National Agricultural Statistics Service, U.S. Department of Agriculture. Quick Stats. “North Dakota County Data – Crops.” Accessed April 2007.

National Biodiesel Board. “Biodiesel Tax Advisory Notice.” Jefferson City, MO, April 25, 2007.

National Biodiesel Board. Fuel Fact Sheets. http://www.biodiesel.org/resources/fuelfactsheets/ Accessed May 2007.

NDSU Agriculture Communication. “Studies Show Canola Can be Straight Combined.” North Dakota State University Extension Service, 2007.

North Dakota State University Extension Service. Farm Management Planning Guides. http://www.ag.ndsu.edu/pubs/ecguides.html Accessed March 2007.

Northern Canola Growers Association. "2001 U.S. Canola Quality Report." Bismark, ND, 2001.

Otto, Daniel, and Paul Gallagher. "The Effects of Expanding Ethanol Markets on Ethanol Production, Feed Markets, and the Iowa Economy." A Report Submitted to the Iowa Department of Agriculture and Land Stewardship Office of Renewable Fuels. Iowa State University Department of Economics, Ames, IA. June 30, 2001.

Pachauri, Naresh, and Brian He. "Value-added Utilization of Crude Glycerol from Biodiesel Production: A Survey of Current Research Activities," Written for presentation at the 2006 American Society of Agricultural and Biological Engineers Annual International Meeting, Portland, OR, July 9-12, 2006.

Palmer, Mark M. "U.S. Biodiesel Policy Fueling Loopholes: How and When Can They be Closed?" U.S. Canola Digest, Vol. 1, No. 4, 12-13, November/December 2006.

Pates, Mikkel. "Experts question economics of biofuels," AGWEEK, April 30, 2007.

Paulson, Nick D., and Roger G. Ginder. "The Growth and Direction of the Biodiesel Industry in the United States," Working Paper 07-WP 448, Center for Agricultural and Rural Development, Iowa State University, May 2007.

Red River Valley Clean Cities, University of North Dakota Energy and Environmental Research Center. "Biodiesel Performs - Summer and Winter." http://www.undeerc.org/programareas/renewableenergy/cleancities/localsuccess/biodiesel.asp Accessed March 2007.

Reidy, Susan. "Biofuels Market Review: Biodiesel," *Biofuels Business*. June 2007.

Reuters. "China to open 200 million acres woodland for bioenergy," China Institute, University of Alberta, February 7, 2007.

Reuters. "N.A.'s biggest biofuel plant to be built in Alberta." April 17, 2007.

Runge, C. Ford, and Benjamin Senauer. "How Biofuels Could Starve the Poor," Foreign Affairs. 86-3 (May/June 2007):41-53.

Schumacher, Joel. "Oilseed, Biodiesel and Ethanol Subsidies & Renewable Energy Mandates: U.S. Federal & Selected State Initiative," Agricultural Marketing Policy Paper No. 16, Agricultural Marketing Policy Center, Montana State University, November 2006.

Scotton, Geoffrey. "Massive biofuel plant slated for Alberta: To be the largest in North America," CanWest News Service. April 17, 2007.

Shapouri Hosein, James A. Duffield, and Michael Wang. "The Energy Balance of Corn Ethanol: An Update." U.S. Department of Agriculture, Office of the Chief Economist, Office of Energy Policy and New Uses. Agricultural Economic Report No. 814. July 2002.

Sheehan, John, Vince Camobreco, James Duffield, Michael Graboski, Housein Shapouri. "An Overview of Biodiesel and Petroleum Diesel Life Cycles." National Renewable Energy Laboratory, U.S. Department of Energy. Golden, CO. May 1998.

Simon A., M. Schwabe, and H. Bergner. "Glycerol Supplementation in Broiler Rations with Low Crude Protein Content," Arch Tierernahr. Vol. 50, No. 3, 271-282, 1997.

Simopoulos, A.P. "The Importance on the Ratio of Omega-6/Omega-3 Essential Fatty Acids," Biomedicine and Pharmacotherapy. 56(8) 365-79, October 2002.

Smith, Jeremy. "EU biofuel targets draw imports, food crops safe," Reuters. January 18, 2007.

Soyatech. Biofuels 2006: Production, Supply and Reality. Soyatech LLC and HighQuest Partners. September 2006. http://www.soyatech.com/pdf/06biofuels.pdf

Soyatech. "U.S. Oilseeds: Supply, Distribution and Price." Soyatech LLC. http://www.soyatech.com/oilseed_statistics.htm, Accessed May 2007

Stafford, Jim. "Oilseed processing plant to open in 2008." NewsOK.com July 20, 2007.

Strong, Christopher, Charlie Erickson, and Deepak Shukla. "Evaluation of Biodiesel Fuel: Literature Review." Western Transportation Institute, College of Engineering, Montana State University – Bozeman, Prepared for the Montana Department of Transportation, January 2004.

SunPrairie Grain. "Daily Markets." http://www.sunprairiegrain.com/. Accessed April 2007.

Tan, Xiaoli, Jiefu Zhang, Zhiyan Zhang, Jia Zhou, Song Jiang, Cunkou Qi, Jianyang Li. "Quantitative Determination of the Strength of Rapeseed Pod Dehiscence," Proceedings of the 12th International Rapeseed Congress, Vol. V, 280-283, Wuhan, China, March 26-30, 2007.

Tapasvi, Dhruv. "Evaluating the Economic Feasibility of Canola Biodiesel Production in North Dakota." Unpublished Master's Thesis, North Dakota State University, Fargo, North Dakota, 2006.

Taylor, Richard D., Jeremy W. Mattson, Jose Andino, and Won W. Koo. "Ethanol's Impact on the U.S. Corn Industry," Agribusiness & Applied Economics Report No. 580, Center for Agricultural Policy and Trade Studies, North Dakota State University, March 2006.

The Independent. “Europe threatens trade war over U.S. biodiesel subsidies.” Independent News and Media Limited, London, UK. April 29, 2007.

Tiffany, Douglas G. and Vernon R. Eidman. “Factors Associated with Success of Fuel Ethanol Producers.” Staff Paper P03-7, Department of Applied Economics, University of Minnesota, 2003.

Tokgoz, Simla, Amani Elobeid, Jacinto Fabiosa, Dermot J. Hayes, Bruce A. Babcock, Tun-Hsiang Yu, Fengxia Dong, Chad E. Hart, and John C. Beghin. “Emerging Biofuels: Outlook of Effects on U.S. Grain, Oilseed, and Livestock Markets,” Staff Report 07-SR 101, Center for Agricultural and Rural Development, Iowa State University, May 2007.

Tys, Jerzy, Henryk Stasiak, Andrzej Borychowski, and Roman Rybacki. “Crack Resistance of Pods in Some Varieties of Winter Rapeseed, Proceedings of the 12th International Rapeseed Congress, Vol. I, 420-423, Wuhan, China, March 26-30, 2007.

Tyson, K. Shaine, Joseph Bozell, Robert Wallace, Eugene Petersen, and Luc Moens. Biomass Oil Analysis: Research Needs and Recommendations. NREL/TP-510-34796. National Renewable Energy Laboratory, U.S. Department of Energy. Golden, CO. June 2004.

U.S. Canola Association. “High-Stability Canola Oil Excellent Trans Fat Alternative: Can Help New York City Restaurants Comply With Trans Fat Ban,” Press Release, December 5, 2006.

U.S. Environmental Protection Agency. A Comprehensive Analysis of Biodiesel Impacts on Exhaust Emissions: Draft Technical Report. Assessment and Standards Division, Office of Transportation and Air Quality, U.S. Environmental Protection Agency. EPA420-P-02-001, October 2002.

U.S. Food and Drug Administration, Department of Health and Human Services. “Canola Oil (Updates Talk Paper - T85-10),” http://www.fda.gov/bbs/topics/ANSWERS/ANS00198.html November 14, 1988.

U.S. Food and Drug Administration, Department of Health and Human Services. “Qualified Health Claims: Letter of Enforcement Discretion - Unsaturated Fatty Acids from Canola Oil and Reduced Risk of Coronary Heart Disease (Docket No. 2006Q-0091),” October 6, 2006.

U.S. Wheat Associates. “Crop Quality Reports.” Various Issues. http://www.uswheat.org/. Accessed April 2007.

Van Gerpen, Jon. “Cetane Number Testing of Biodiesel,” In Liquid Fuels and Industrial Products from Renewable Sources, Proceedings of the 3rd Liquid Fuel Conference, edited by J.S. Cundiff, E.E. Gavett, C. Hansen, C. Peterson, M.A. Sanderson, H. Shapouri, and D.L. VanDyne, American Society of Agricultural Engineers, St. Joseph, MI, 1996, pp. 197–206.

VanWechel Tamara, Cole R. Gustafson, and F. Larry Leistritz. "Economic Feasibility of Biodiesel Production in North Dakota," Paper prepared for presentation at the American Agricultural Economics Association Annual Meeting, Montreal, Canada, July 27-30, 2003.

Walker, Julie. "Oilseed Crops in Beef Cattle Rations," The BeefSite, January 2007, http://www.thebeefsite.com/articles/823/oilseed-crops-in-beef-cattle-rations

Xinhua News Agency. "Oil-thirsty China turns to farmland for diesel oil," China Institute, University of Alberta, April 2, 2007.

Appendix A. Production Risk Model

Budgets were simulated for canola, hard red spring wheat (HRSW), and durum wheat using @Risk. Production risk was analyzed for the North Central Region according to the North Dakota State University Extension Service projected crop budgets. This region includes the counties of Ward, Renville, McHenry, McLean, Pierce, Benson, Rolette, and Bottineau. Adding risk into the crop budgets for HRSW, durum wheat, and canola is done by using historical yield data, which were collected from the National Agricultural Statistics Service (NASS). The county average yield was used for each county from 1999 to 2006; prior to 1999, data on county average canola yields were not reported. A summary of the crop yield and quality data is in Table A1.

Table A1. Crop Budget Base Data: Agronomic Variables

	HRSW		Durum		Canola	
	Yield (bu)	Protein %	Yield (bu)	% #1 HAD	Yield (lbs)	Green Count %
Mean	33.13	14.36	30.05	36	1393	0.61
Std. Dev.	6.23	0.83	8.70	17	178	0.39
Minimum	22.50	11.80	12.10	69	1052	0.20
Maximum	46.80	18.60	54.10	18	1930	1.60

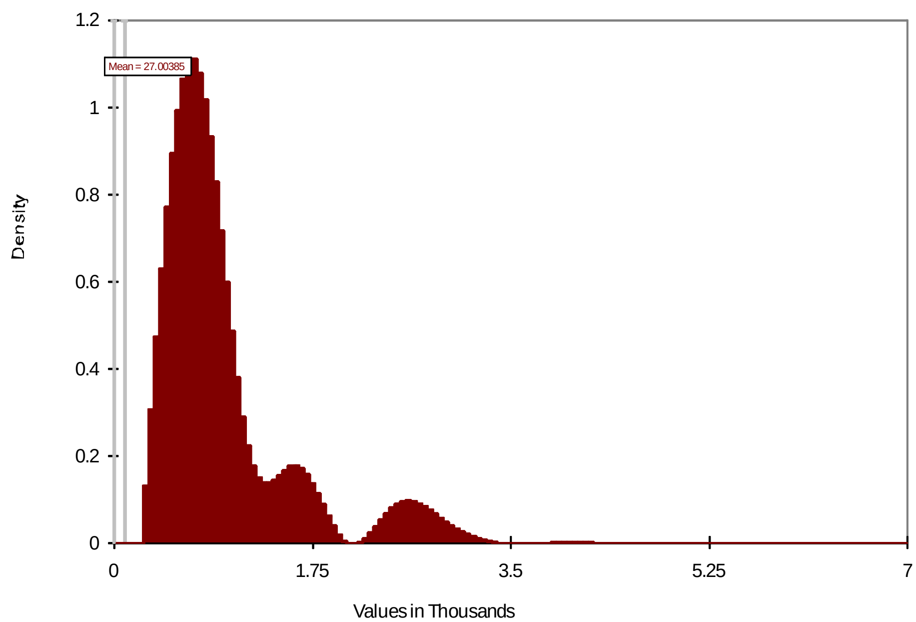
New crop canola prices for 2007 are greater than they have been for several years. Similarly high prices are occurring in the durum wheat and spring wheat markets. It was assumed with high commodity prices, producers would lock in new crop commodity prices to hedge price risk for the 2007 growing season. Another justification for using the 2007 new crop prices is the input costs for production of grains. With record high fuel and fertilizer prices, the markets must adjust to provide an incentive for farmers to raise a particular commodity.

Data for the prices of durum wheat and spring wheat for the region were from SunPrairie Grain in Minot, an elevator which has locations in nearly all the counties in the region. Canola prices were determined based upon the 2007 new crop value of canola at ADM in Velva, where much of the canola produced in this region will be sold. To analyze green count values, data were used from canola harvest method and timing trials at the North Central Research Extension Service in Minot, North Dakota (McKay et al).

Data for spring wheat protein and the percentage of durum wheat graded # 1 were taken from Crop Quality Reports (U.S. Wheat Associates). The durum wheat not meeting U.S. #1 Hard Amber Durum (HAD) standards is assumed to be U.S. #2 Hard Amber Durum and would be priced at a $1.20 discount below the new crop 2007 durum price (SunPrairie Grain). Protein premiums and discounts were determined from the Minneapolis Grain Exchange with 14% protein as the base. Below 14%, the producer would receive a discount while hard red spring wheat with protein above 15% would receive a premium.

The data collected in McKay et al (2005) and McKay and Novak (2006) were used to determine a distribution for shattering. In each year, the shattering was measured from one variety using different harvesting techniques, i.e., swathing, straight combining, swathing with a desiccant, etc. This is the only data available on canola shattering at the current time and we feel it gives fairly realistic values for the purpose of this analysis. Using Best Fit in @Risk, it was determined the best distribution to estimate the percentage of shatter was a Log Normal distribution with a skew to the right (Figure A1). Since the NASS county yield data is the average after shattering has occurred, the base yield was multiplied by one plus the percentage of shatter from the distribution.

Figure A1. Distribution for Shattering



Appendix B. Biodiesel Cost of Production Model

The stochastic simulation software @Risk was used to determine distributions for various prices, such as soybean oil, canola oil, methanol, natural gas, and electricity prices. The spreadsheet is setup similar to Tiffany and Eidman's (2003) model for ethanol production in Minnesota. The characteristics for biodiesel production inputs and outputs were derived from VanWechel et al. (2003) and Fortenbery (2005); plant equipment prices and labor requirements were taken from Tapasvi (2006); data for soybean oil and canola oil prices were retrieved from Soyatech (2007); methanol prices were acquired from Methanex while catalyst prices were determined from the Biodiesel Workshop Series presentations (2006); and electricity and natural gas prices were acquired from Energy Information Administration using the United States industrial annual average prices. Information on the base case data values are in Table B1.

Table B1. Descriptive Statistics for Biodiesel Production Model

	Soybean Oil ($/lb)	Canola Oil ($/lb)	Methanol ($/gal)	Electricity ($/kwh)	Natural Gas ($/MMBtu)
Mean	0.21	0.26	0.87	0.05	6.08
Std. Dev.	0.05	0.06	0.33	0.01	1.70
Minimum	0.14	0.17	0.37	0.05	4.02
Maximum	0.30	0.34	1.80	0.06	8.56

Other base assumptions of the production spreadsheet include an interest rate of 7% on 60% of the initial capital. The other 40% is capital raised through investors which require a 20% return on investment. Seven and a half gallons of biodiesel are acquired from one pound of canola or soybean oil and no glycerol or soapstock are refined and sold to other industries as a byproduct. In addition, to determine the actual cost of production, no production subsidies, tax credits, or government incentives are included in the model. The complete budget is in Table B

Table B2. Biodiesel Production Budget

	Cost/ Gal. Biodiesel			Plant Totals
Production Capacity	30,000,000		Fixed Capital	$ 15,862,699
Investment Cost per Gal	$ 0.62		Working Capital	$ 2,823,560
Production Factor	100%	70% - 150%	Total Capital Investment	$ 18,686,259
Debt/Equity Assumptions				
Factor of Debt	60%		Total Debt	$ 11,211,755
Factor of Equity	40%		Total Equity	$ 7,474,504
Interest Rate on Debt	7%			
Return Required by Investors	20%			

Annual Production	
Pounds Required	**Gallons Produced**
225,000,000	30,000,000
-	

Conversion Factors	Distribution	High	Low
Gal Biodiesel Extracted/ lb Canola Oil	Uniform	8	7
Gal Biodiesel Extracted/ lb Soybean Oil	Uniform	8	7
Glycerol	Uniform	0.7	0.6
Soapstock	Uniform	0.45	0.35

Establishment of Gross Margin	Distribution	Mean	Std. Dev	Per Gallon	Totals
Biodiesel (gal)	Log Normal	2	1	$ -	$ -
Glycerol (lb)	Log Normal	0.75	1	$ -	$ -
Soapstock (lb)	Log Normal	0.2	1	$ -	$ -
State Subsidy (gal)	$ -			$ -	$ -
Federal Subsidy (gal)	$ -			$ -	$ -
Revenue per Unit				**$ -**	**$ -**
	Distribution	Mean	Std. Dev		
Soybean Oil (lb)	Log Normal	$ 0.2202	$ 0.0414	$ 1.65	$ 49,535,158
Canola Oil (lb)	Log Normal	$ 0.2590	$ 0.0541	$ -	$ -
Gross Margin				**$ (1.65)**	**$ (49,535,158)**
Operating Costs Per Gallon	Distribution	Mean	Std. Dev		
Natural Gas	Log Normal	7.2411	1.8546	$ 0.05	1,629,248
Electricity	Log Normal	0.0419	0.0013	$ 0.00	$ 4,400
		High	Low		
Nat Gas Required	Uniform	0.005	0.01		
KWH Required	Uniform	0.002	0.005		
Total Energy Costs				**$ 0.05**	**$ 1,633,647**
Water	Uniform	0.0025	0.004	$ 0.00	36,562.50
Water Required	Uniform	0.35	0.4		
Catylist - .08 per gal - 1% Sodium Hydroxide	0.42			$ 0.03	$ 1,008,000
Methanol (per lb)	0.13			$ 0.10	$ 3,143,891
Methanol Required	0.8				
Total Process Requirements				**$ 0.14**	**$ 4,188,454**
Maintenance and Repairs (per gallon)	7%			$ 0.04	$ 1,110,389
Waste Removal	$ 35.00	600		$ 0.00	$ 21,000
Water Treatment	Uniform	0.01	0.015	$ 0.00	140,625
Marketing				$ 0.03	$ 900,000
Depreciation				$ 0.07	$ 2,183,078
Interest Expense	7%			$ 0.03	$ 784,823
Inventory Costs	0.02			$ 0.02	$ 600,000
Labor				$ 0.04	$ 1,259,893
Management and Quality Control	Uniform	0.01	0.02	$ 0.02	$ 450,000
Real Estate Taxes				$ 0.00	$ 50,000
Liscenses, Fees, and Insurance	1%			$ 0.01	$ 158,627
Misc. Expenses	Uniform	0.01	0.015	$ 0.01	$ 375,000
Total Other Costs				**$ 0.27**	**$ 8,033,435**
Total Costs				**$ 0.46**	$ 13,855,536
Net Margin per Unit				**$ (2.11)**	$ (63,390,693)
Investor Required Rate of Return	20%			$ 0.05	$ 1,494,901
Excess/Shortage after Capital Paid				**$ (2.16)**	$ (64,885,594)