FEASIBILITY OF A 5,000,000 GALLON PER YEAR

BIODIESEL PRODUCTION FACILITY USING

CANOLA, SOYBEANS, AND

SUNFLOWERS AS

FEEDSTOCK

By

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Bachelor of Science in Agribusiness

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Stillwater, Oklahoma

2007

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
MASTER OF SCIENCE
December, 2008

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Acknowledgements

First, I would like to thank my advisor, Dr. Phil Kenkel, for the support and guidance given to me throughout this process. Sincere thanks are due to my other committee members Dr. Rodney Holcomb, Dr. Tim Bowser and Dr. Nurhan Dunford for their intuition, encouragement, and friendship throughout the research process.

I would like to genuinely thank the friends I have acquired over the past year and half. Special thanks go out to all of the members and visitors of the "506," you know who you are.

Next, I would like to thank my family for their never ending support and guidance throughout my entire academic process. I would like to thank my parents and grandparents, especially, for instilling values and a work ethic which I will use for the rest of my life. Special thanks go out to my brother and sister who have never failed to lend a helping hand whenever I needed one. Special thanks also go out to my girlfriend whose never ending support has lifted me even when the situation seemed dim.

Finally, thank you to the entire faculty of the Agricultural Economics Department who worked hard with me and pushed me to get an education second to none. I have made many friends in the department and am grateful for such.

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CHAPTER I

INTRODUCTION

Due to record oil prices, alternative sources of fuel are increasingly being studied as a means to power the country. Furthermore, as oil prices increase, the incentive to produce alternative fuels increases. According to the Energy Information Administration, crude oil, as of January 2008 topped $90 a barrel (Energy Information Administration, 2008). Public pressure to create a more environmentally friendly fuel adds further to the possible feasibility of this existing technology. Petroleum based fuels consist primarily of gasoline and diesel. As gasoline burning engines are more common than diesel burning engines, many studies have been performed regarding the feasibility and cost competitiveness of ethanol, a substitute for gasoline. However, diesel engines work off the principle of compression combustion in which fuel is compressed so that its temperature rises to a point that when oxygen is added combustion occurs.

Ethanol is not suitable for conventional diesel burning engines as its properties mimic gasoline and need a spark to ignite. Biodiesel, on the other hand, will work in conventional petroleum based diesel burning engines. Biodiesel can be created using any type of combustible oil. Potential oil feedstock includes animal fats and vegetable oils. Currently, the most commonly used feedstock is soybeans accounting for nearly 90% of biodiesel production (Butzen, 2006). However, crops

such as canola also show potential as being a suitable feedstock and are more adapt

to the dry, non-irrigated conditions of Oklahoma. Furthermore, crops such as canola

have the ability to fit in well as a rotational crop with winter wheat. A winter canola

and wheat rotation has the possibility to improve the marketability of wheat for

Oklahoma producers by improving the quality of grain sold by better managing

mixed infestations of weeds and other unwanted intruders (Boyles, Peeper, Medlin,

2008). Other oilseed crops suitable for biodiesel production also show promise for

production in Oklahoma. These include cotton, sunflowers, peanuts, etc., all of

which are traditional dryland crops.

Due to the limited research of biodiesel production using Oklahoma grown

oilseed crops for feedstock, the following question emerges. Is a biodiesel production

facility using oilseed crops that can be grown in Oklahoma a feasible venture taking

into account costs of capital, labor, feedstock, and acquisition of feedstock in

comparison to economies of scale? The purpose of this research is to answer the

preceding question so that information is available to aspiring plant owners and

managers before large investments are undertaken.

Objectives

The overall objective of this research is to determine whether a biodiesel

production facility using Oklahoma grown oilseed crops is economically feasible.

The specific objective of this research is to:

1. Develop a decision aid tool for future investors by determining variable and fixed costs of production and revenues from processing oilseed crops and selling refined biodiesel, and refined glycerin and meal feed by-products.

2. Use the previously described template to analyze the costs and returns of representative oilseed crushing and biodiesel manufacturing operations. The analysis considers four scenarios: crushing and processing 100% canola, crushing and processing 100% soybeans, crushing and processing 50% canola and 50% sunflower, and a stand alone biodiesel production facility supplied from purchased oil feedstocks.

3. Determine sensitivity of the profitability of a biodiesel production facility for the same four scenarios using varying prices for inputs and outputs.

Review of Literature

Biodiesel is fuel that is created using oilseed crops such as soybeans, canola, cottonseed, peanuts, flaxseed or any other oilseed crop. It can also be created using excess waste fat from slaughtered livestock (Butzen, 2006). Biodiesel is not a recent discovery. Rather, the technology to produce and consume it was available before the invention of the automobile. Rudolph Diesel, inventor of the diesel engine, originally designed his engine to run off of vegetable oil. When on display at the World Fair in Paris in 1900, Diesel's new compression combustion engine did so. However, due to lobbying efforts by petroleum companies and its cheap and extensive availability, petroleum became the primary source to fuel the diesel engine by 1920. Due to its limited use over the past century, biodiesel infrastructure is still at its infancy in the United

States. However, the industry is growing faster now than ever before. Butzen writes, "The biodiesel industry is growing rapidly in the U.S. and continued rapid growth is expected over the next decade. Current biodiesel production capacity of about 350 million gallons per year is expected to double within the next 18 months. If capacity eventually reaches one billion gallons, this would represent almost 2% of the total diesel consumption in the U.S., which is near 55 billion gallons (Butzen, 2006)."

Biodiesel Production Process

Biodiesel can be created using numerous processes. However, the most widely used process is referred to as transesterification. Transesterification involves mixing alcohol, an oil feedstock, and a catalyst to form biodiesel and a byproduct, glycerol. Glycerol is unrefined glycerin which means that excess methanol and water have not been extracted. The most commonly used alcohol is methanol and is used in excess of approximately 1.6 times the amount of oil feedstock used. Excess methanol is recovered from the reaction and reused. The ratio of raw oil to useable biodiesel is approximately 1:1 (Van Gerpen, 2004). Figure I-1 is a flow diagram showing the complete process including the recovery of unused methanol.

This research deals with the use of oilseed crops as this is a source of renewable resources which is the most easily accessible to Oklahoma and the most beneficial to its producers. Regional research has focused on the feasibility of biodiesel production facilities in various parts of the country. Although the methods of research are very similar, the inputs and input prices vary somewhat across regions.

Methanol

Methanol   Catalyst

Mixed

Oil → Reactor

Separator → Glycerol & Water → Acid → Separator → Waste

Ester

Acid

Water → Washing

Glycerol → Neutralizer ← Noon

Separator → Glycerol & Water

Esters

Glycerin – H_{20}

Dryer → Vapor

Distillation

Methanol

Biodiesel

Water → Evaporator

Glycerin
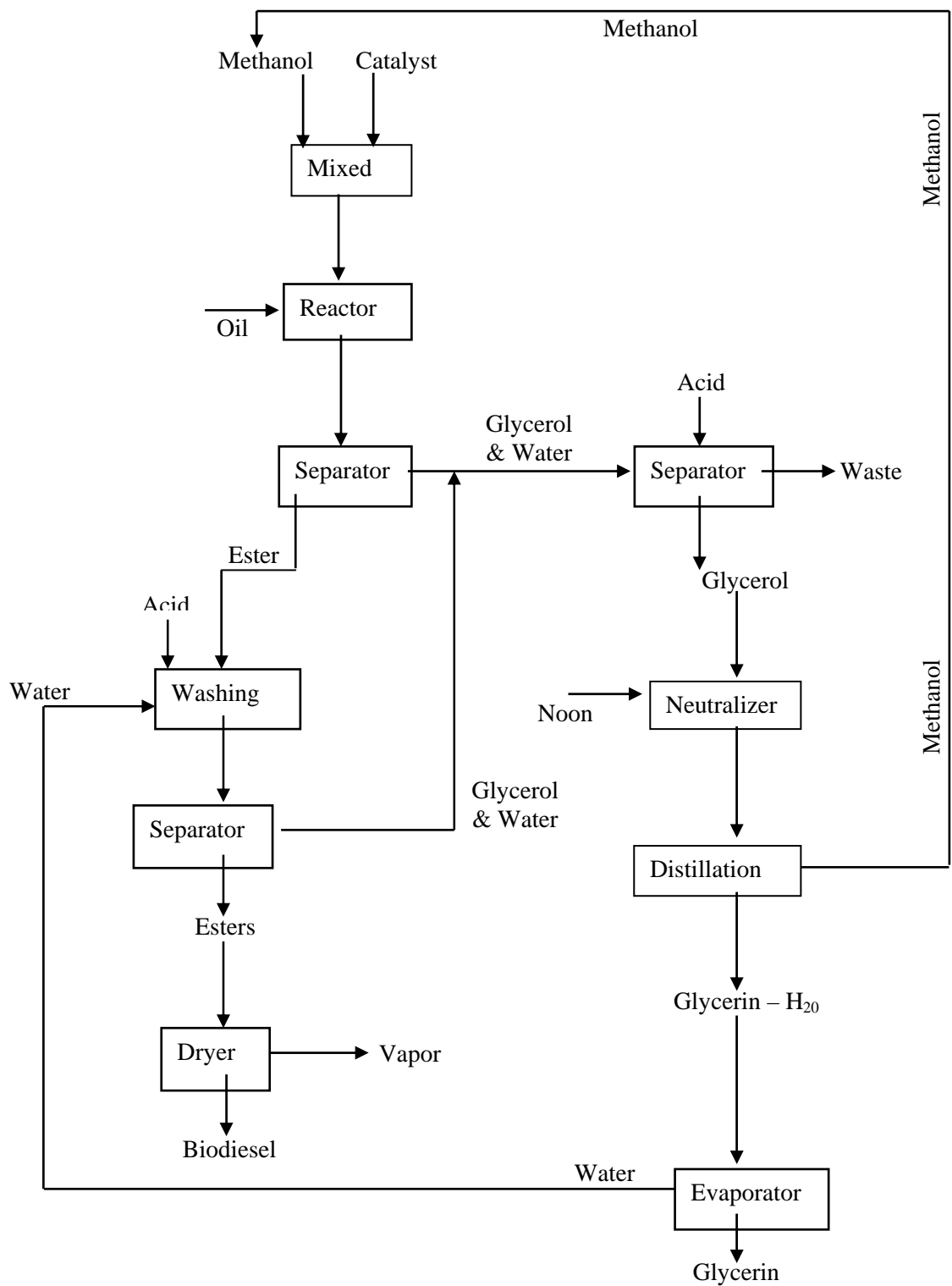
Source: Kenkel, Phil. "Feasibility of a Biodiesel Production Facility as Part of a Canola Crushing Operation," January 2006.

Figure I-1.   Biodiesel Production Process using Transesterification.

Economic Engineering and Feasibility Analysis

Economic engineering uses engineering data to estimate facility, equipment, labor and utility requirements. The economic component of the model determines the fixed and variable costs associated with operating the facility (Criner and Jacobs). A feasibility study can be defined in many ways. A feasibility study is a combination of a market study and an economic analysis that provides potential investors with knowledge of both the environment where a project exists and the expected return on the investment to be derived from the project (Northstar Economics). A feasibility study is further defined as the disciplined and documented process of thinking through an idea from its logical beginning to its logical end to determine its practical viability potential, given the realities of the environment in which it is going to be implemented. A complete feasibility study is conducted at three levels: technical, operational, and economic. The technical feasibility asks: "Can it be built?" The operational feasibility asks: "Will it work?" The economic feasibility brings the operational and technical levels together to determine if the project can generate enough net economic benefits to justify investments in it. It asks: "Will it make economic sense if it works and it is built?" (Amanor-Boadu)

Regional Feasibility Analysis

Research indicates that many variables need to be taken into account when examining the feasibility of producing and processing vegetable oil into useable biodiesel. Bender examined the economic feasibility and impact of biodiesel production to the refineries and the producers of the commodities. A review of twelve economic feasibility studies showed that projected costs for biodiesel using oilseeds and animal fats

ranged from $0.30-0.69 per gallon with the assumption that facilities would be

constructed alongside traditional grain storage and processing facilities which would

lower initial capital investment costs. This is compared to pre-tax diesel production costs

of $0.18 per gallon. The study found that biodiesel production was not yet feasible for not

only the refineries but to the producers as well (Bender, 1999). Further, more localized

research was conducted by Crockett, Peterson, and Mann. The study focused on the

feasibility of a 1,000,000 gallon per year production facility in Idaho. It examined

statewide demand for the product and the projected costs and revenues of producing and

refining. Some of the plant requirements listed include: storage capacity facilities of

85,000 gallons of vegetable oil and 20,000 gallons of methanol or if a crushing facility

was included, 10,000 tons of 40% oil seeds. According to the author's estimates, if

operated 300 days per year, the plant would need to process approximately 3,500 gallons

of vegetable oil/animal fat per day. The output side would require an 85,000 gallon

storage tank in which to store biodiesel for 30 days or shorter. Other requirements for

water, methanol, etc. were discussed. More detailed cost estimates were discussed,

including capital cost per gallon of biodiesel to be $2.00 for a 500,000 gallon annual

production facility, $2.00/gal for a million gallon production facility, $1.25/gal for a 5

million gallon production facility and $1.00/gal for a 20 million gallon production

facility. Processing cost assumptions included $0.15/lb for oil seeds, $50/ton for crushing

and filtering, $0.14/gal of biodiesel for methanol, $0.073/gal of biodiesel for catalyst

(NaOH), $0.06/gal of biodiesel for high FFA (free fatty acid) processing, $0.05/gal of

biodiesel for freight and $0.20-$0.30/gal of B100 biodiesel. Revenues included

estimating the price of biodiesel to be $2.20/gal, glycerin, if refined, to be $0.05 and any

additional meal at $125/ton. Furthermore, sensitivity analysis of an 11 million gallon per

year plant compared to a 21.5 million gallon per year plant were performed showing that

seed cost per pound needed to lie below $0.06 for an 11 million gallon facility to be

profitable and below $0.08 per pound for a 21.5 million gallon facility. This research

shows that oil seed costs must be low for biodiesel processing to be profitable which does

not bode well for producers in the area (Crockett, Peterson, and Mann, 2006). A further

feasibility analysis was conducted by Fortenbery in the state of Wisconsin. This study

examined the advantages and disadvantages of producing biodiesel in the state of

Wisconsin by modeling a 4 million and a 10 million gallon per year facility using either

soybean oil or yellow grease. Capital requirements for the 4 million and 10 million gallon

per year facilities were $6,627,540 and $8,820,760, respectively. Operating costs per

gallon for the 4 million gallon per year facility using yellow grease or soybean oil for

feedstock were $1.74 and $2.86, respectively. Operating costs per gallon for the 10

million gallon per year facility using yellow grease or soybean oil for feedstock were

$1.54 and $2.65, respectively.   Included in this discussion is the availability of potential

feedstocks, market access, required physical plant characteristics and other capital,

operating costs of the production facility, cost competitiveness of the final product,

possible pant locations, and community impacts of plant development (Fortenbery,

2005). Further, more detailed research was conducted by Haas, McAloon, Yee and Foglia

in order to create a model to estimate production costs. The model estimated the capital

and operating costs of a moderately-sized industrial biodiesel production facility. Annual

production capacity of the plant was set at 37.85 million gallons. Facility construction

costs were calculated to be $11.3 million. The largest contributors to the equipment cost,

accounting for nearly one third of expenditures, were storage tanks to contain a 25 day

capacity of feedstock and product. Total biodiesel production costs were $2.00/gal with

oil feedstocks accounting for nearly 88%. Crude glycerol recovery and the sale of

decreased production costs by approximately 6% (Haas, McAloon, Yee, Foglia, 2006).

Tax Incentives

Government aid in the form of tax credits and subsidies further affects biodiesel

returns. The USDA has offered grants for biodiesel production through the Commodity

Credit Corporation (CCC). The CCC provided payments for the expansion of biodiesel

production in the fiscal years 2004-2006. The 2006 payment for a new or expanded

facility was $1.47 per gallon for soybean oil biodiesel. Average subsidies per gallon

from 2001 to 2005 ranged from $1.43 to $.61 (Kenkel, 2006). A blender's credit is also

available to retailers who sell blended biodiesel at the pump. Passed and signed in

October, 2004, the American JOBS Creation Act of 2004 is a biodiesel tax incentive that

gives 1 cent per percentage point of first-use biodiesel to the fuel blender. First-use

biodiesel includes any virgin non-recycled oil. A gallon of B20 gives the blender at retail

twenty cents. Second-use biodiesel, which includes any recycled oil, gives the blender a

half-cent per percentage point. A gallon of B20 will give the blender at retail ten cents

(Biodiesel Magazine). Hard to determine, however, is the tax incentive passed on to the

wholesaler of biodiesel. Wassell and Dittmer attempted to answer the question as to

whether subsidies for biodiesel production were economically efficient. According to

Wassell and Dittmer, "An efficient subsidy scheme would set the per gallon biodiesel

subsidy equal to the external benefits of biodiesel. This would result in biodiesel being

produced and marketed only in those situations in which the added costs of producing

and marketing biodiesel are less than the external benefits." They concluded that

subsidies would be beneficial and would increase production of biodiesel. Although

biodiesel would gain a foothold in the fuel market, at approximately 2.2%, conventional

diesel would still hold a strong market share (Wassell, Dittmer, 2005).

The research discussed in this review provide a summation of previous research

completed in this field. Overall, they show an industry that has some potential to become

a player in the energy market. Data collected in this review show that regional biodiesel

production facilities can be feasible. However, many important variables to its success

have to be favorable in each region. Two, in particular, regional climate and environment,

play a crucial role. The articles discussed show a wide range for favorable conditions.

Wherever suitable farm land exists to produce the crops necessary for the biodiesel

production process, a reasonable chance for success is possible. The big question, like in

many agricultural markets, is how to balance prices of raw materials with that of the

refined product. The producers of the commodity used in this process need prices that are

high enough to make production feasible. Furthermore, the processing and refining

industry need raw material prices that are low enough to reduce costs so that the final

biodiesel product can be priced so that it can compete with conventional diesel. It is this

balance that needs to be researched further so that larger infrastructure can be built with

out the added risk of uncertainty. My research will closely follow previous research but

will focus on the industry in the area of Oklahoma and the resources and infrastructure

available here. Also, due to recent volatility of prices in 2007 and 2008, research prior to

this cannot reflect feasibility with complete accuracy. My research will reflect updated

prices of inputs and outputs of the production process.

CHAPTER II

METHODOLOGY

The Biodiesel Production Facility Template

The primary objective of this study was to perform an economic feasibility analysis of an "average" sized biodiesel production facility in Oklahoma. A template was constructed using Microsoft Excel with the objective of providing a user-friendly means about which to examine numerous input values and quickly develop analysis of the corresponding revenue and cost structures. The structure of the feasibility template was based off of a previous template developed by Drs. Kenkel and Holcomb of Oklahoma State University. Basic engineering calculations, utility calculation methods, and the equipment list including steam usage, horsepower, and natural gas specifications were provided by a proprietary study on a biodiesel production plant performed by Drs. Bowser and Holcomb of Oklahoma State University. Sources of equipment, specific models, and associated cost estimates were withheld for reasons of confidentiality.

The Microsoft Excel workbook consists of twelve worksheets. Four worksheets require the user to input values. Input information includes basic production inputs, feedstock prices, capital structure, biodiesel production size and capacity, equipment scheme, and personnel expenses. Model assumptions along with the user-supplied information are then used in financial calculations. These calculations include market and

expense projections, loan amortization, operations summary, and return on investment, all of which are calculated over a ten year period. Each of the worksheets is described in more detail.

User-Supplied Data and Assumptions

Most of the basic input information supplied by the user is located on the "Input Value" worksheet. This information includes percent of capital financed, long term and short term interest rates, property tax rates, percent payroll tax and benefits, transportation rates and distances, utility rates, working capital, biodiesel tax credits, and maintenance and insurance as a percentage of plant, property, and equipment.

Also located on the "Input Value" worksheet are inputs relating to feedstock used. The template provides for up to three different feedstocks to be used on a percentage basis. Information required for each feedstock includes raw material prices in dollars per unit, oil prices per pound, meal prices per ton, hull prices per ton (if applicable), and corresponding inflation rates for each.

Further input cells are provided so that prices and inflation rates of inputs and outputs of the production process can be entered. These include the prices for any additional oil needed for production, methanol, catalyst (NaOH), glycerin, and the wholesale price of the biodiesel produced.

Input cells are also provided to specify production size and capacity of the plant. A cell is provided for the entry of gallons of biodiesel to be produced in a year. The plant capacity and operating time assumptions are contained in a the "Operational Assumption" section of the input sheet. In order to calculate yearly plant capacity, input

cells for tons crushed per hour are multiplied by hours of operation per day and days of operation per year, both input cells.

The template allows the user to select whether or not the biodiesel facility would incorporate a crushing facility alongside or buy the pre-crushed and processed oil feedstock and whether the facility will refine the glycerin by-product. This feature is implemented using "if statements" in Microsoft Excel. "If statements" are commands in Microsoft Excel that test a condition and decide whether the condition is true or false. A value is programmed if the condition holds and an alternative value is programmed if the condition is false. For ease of use, the user enters "1" in the corresponding cell if he/she wishes to use the crushing facility or "0" if they do not. Inputs are available if the user wishes to crush a feedstock and sell the processed oil rather than use it for biodiesel.

Biodiesel facilities also have the option of refining the glycerol co-product. (The terms glycerol and glycerin are sometimes used synonymously to refer to C3H8O3, a syrupy, sweet, colorless or yellowish liquid, obtained from fats and oils as a byproduct of the transesterfication process. The term glycerol is commonly applied to the unrefined product which may include methanol and other impurities, while glycerin is used to describe the refined product which is widely used in food, soap and pharmaceutical manufacturing.) A list of glycerol refining equipment list is included in the template. The option for glycerol refining can be selected by the user. Deselecting the glycerol refining option removes the glycerol refining equipment from the project cost and depreciation calculations and adjusts the utility and production cost calculations appropriately. If the user wishes not to sell refined glycerin, he/she should also adjust the glycerin price entry to reflect the appropriate price for a non-refined product. Users anticipating a disposal

cost for glycerol (unrefined glycerin) should enter the appropriate negative number in the cell entry for glycerin price.

Input cells are also provided to allow the user to specify the percentage each feedstock used in the crushing operation. The total crush volume is determined by the specified hourly capacity and hours of operation. The crush volume for each feedstock is calculated from the feedstock percentages and total crush volume.

In order to calculate oil supplied from crushing, the user must input the oil content percentage of each feedstock used, the hulls percentage, and the percentage of the available oil that will be extracted (extraction percentage). Standard industry benchmarks for common oilseed crops are provided in the template. The calculations supplied from these crushing assumptions are used to determine the oil supplied from crushing and the amount of oil that must be purchased from outside sources or can be sold on the open market while meeting the specified volume of biodiesel. The "Equipment" worksheet allows the user to specify the equipment used throughout the crushing and production process and the associated purchase and installation costs. The horsepower and steam requirements for each piece of equipment are also specified on the "Equipment" worksheet. The total horsepower and steam usage for the entire production process, with and without the crushing operation, is also summarized on the "Equipment" sheet.

Although the template is designed for users to specify their particular equipment compliment, equipment costs, utility usage estimates, estimated new prices and manufactures specifications of design capacity and horsepower were provided as baseline estimates. All of the baseline estimates were based on a proprietary study of a biodiesel

production facility conducted by Drs. Bowser and Holcomb of Oklahoma State University.

Further inputs are required on the "Depreciation", "Personnel Expense", and "Return on Investment" worksheets. Information on cost and useful life of plant and equipment are entered on the "Depreciation" worksheet. Personnel information including a list of positions, base salaries, wage rates, overtime rates, and benefits are entered on the "Personnel Expense" worksheet. Finally, a discount rate for present value and internal rate of return analysis is entered on the "Return on Investment" worksheet.

Intermediate Calculations

The user-supplied data provide a basis for intermediate calculations. These calculations are in turn used to calculate the return on investment and profit analysis. Utility usages and associated costs are calculated using rates from the "Input Value" worksheet and manufacturers' specifications regarding horsepower, steam usage, and natural gas usage from the "Equipment" page. Calculated on the "Utility" page are electricity, natural gas, water, and sewage. Electricity is calculated by totaling horsepower usage for equipment at 80% connected horsepower and multiplying the sum by a fixed input rate of kilowatt/horsepower. The totaled kilowatts per year are multiplied by the electricity cost rate to find total electricity cost per year. Natural gas is calculated by totaling natural gas usage from the "Equipment" page by a corresponding natural gas rate from the "Input Value" page. Water is calculated by totaling steam pounds used from the equipment page, dividing by pounds per gallon of water (a fixed input), and

multiplying by the corresponding water rate. Sewer is calculated by totaling wastewater from the conversion process and multiplying by the corresponding sewage rate. Finally, solid waste is calculated by multiplying number of hauls by the cost per haul, both estimates. Each utility is estimated on a per year value and totaled to form a total cost of utilities estimate.

In order to determine the quantities of oil supplied from crushing and any excess or deficit oil needed to produce the desired amount of biodiesel in a year, a series of calculations are included on the "Input Value" worksheet. The user simply enters the percentage amount he/she wishes to crush of each feedstock (up to three feedstocks) and the program calculates tons crushed, oil supplied from crushing by each crop, any excess oil supplied from crushing, and any additional oil needed to be purchased, or available for sale, in order to produce the desired amount of biodiesel. Gallons of oil supplied from tons crushed are calculated under "Crushing Assumptions" section in the "Input Value" worksheet. Oil supplied from crushing may be slightly overstated because the template does not model oil lost during degumming. Tons of meal are also calculated under the "Crushing Assumptions" program.

Once quantities provided by crushing are established the corresponding values of feedstock grains, oil, biodiesel, glycerin and meal products are calculated using the prices are supplied by users and entered on the input page. Quantities of the production process including methanol, sodium hydroxide, and glycerin were established by using assumptions on the "Engineering Calcs" page. The engineering assumptions were based on a proprietary study of a biodiesel production facility performed by Drs. Bowser and Holcomb of Oklahoma State University. The physical quantities of feedstocks and final

products are summarized on the "Market Projection" worksheet for a ten year period at allocated inflation rates. The dollar amount of sale and purchase volumes and dollars are also provided for each feedstock's grain, oil, and meal, as well as, biodiesel, glycerin, methanol, sodium hydroxide, or any additional purchased oil. A gross margin is then calculated for each of the ten years.

Depreciation expense is calculated on the "Depreciation" worksheet. Four categories of buildings and equipment are summed. Buildings are depreciated on a straight line basis over 39 years. Special purpose buildings are depreciated on a straight line basis over ten years. Equipment and heavy rolling stock are depreciated over 7 years using MACRS (modified accelerated cost recovery system) while light trucks and vehicles are depreciated over 5 years using MACRS.

Loan principle and interest payments are calculated on the "Loan Amortization" worksheet. Loan terms and the percentage of financing come from the user and are entered on the "Input Value" worksheet. Working capital is also amortized on this worksheet and uses values entered on the "Input Value" worksheet which include the amount of working capital and the short term interest rate.

The "Expense Projection" worksheet projects yearly expenses for ten years based on the calculations in the previously described worksheets. Labor is categorized as "Fixed" or "Operational" and salaries, benefits, and overtime are totaled for each. Each subtotal is then added to find total labor expense. Trucking expenses are calculated by multiplying varying trucking rates for each input and output by quantities hauled. Finally, variable overhead, including utility expense, is summed and all variable expense categories are combined to find total variable expense. Fixed expenses of maintenance, insurance, and property tax are

calculated using rates from the "Input Value" worksheet. Other fixed expenses include depreciation, interest, and protection and safety. All fixed expenses are summed to find total fixed expenses. Other categories of expenses are simply estimates and can be entered by the user. These include a category for "other expenses" and "miscellaneous". Variable, fixed, and "other" expenses are combined to find total expenses.

Projected Income and Expense Statements

The template summarizes total income and expenses for a ten year period on the "Operations Summary" worksheet. Gross sales and cost of goods sold are provided from the "Market Projection" worksheet and expenses from the "Expense Projection" worksheet. A simple projection of cash flows from operations is also created by adjusting the annual after tax profits for the cash flow impacts of depreciation expenses (a non-cash expense) and loan principle payments (a cash flow requirement not categorized as an expense).

Return on Investment and Feasibility Measures

The "Return on Investment" worksheet summarizes the feasibility of the biodiesel production facility. Six feasibility measures are calculated including the net present value, the internal rate of return, benefit to cost ratio, payback period, average return to assets, and average return to equity. Net present value measures an investment's ability to generate sufficient income to cover cash expenses and the opportunity cost of capital. A positive net present value indicates that the investment has the ability to do so and a negative present value does not. The benefit to cost ratio simply measures the the

investments earnings over its costs. The internal rate of return evaluates cash flows over the life of a project. An investment is feasible if its internal rate of return is greater than the interest rate paid on capital plus a risk premium. The payback period is a simple profitability measure that gives the number of years an investment takes to pay for itself. Obviously, a smaller payback period is preferred. Payback period is calculated by dividing the cost of the investment by the cash flows generated by the investment. Finally, return to assets and return to equity are measures that indicate the ability of assets and owned assets (equity) to generate income. They are calculated by dividing net income by either total assets or total equity.

Sensitivity Analysis

Like any other pro forma or budgeted analysis, variable costs and revenues cannot be estimated with complete accuracy. A degree of error will always be associated with any estimate. However, responsiveness can be calculated by changing input and output prices. One of the key objectives of the feasibility template is to calculate sensitivity of the production facility with respect to prices for inputs and outputs or any other variable aspect. The feasibility template allows users to analyze the impact of sales price, raw material costs, energy and utility costs and other assumptions on the profitability of their project.

Baseline Model Assumptions

The baseline model was based on a five million gallon (18,927,059 liters) biodiesel production facility to be based in Oklahoma using feedstock available to the

region. Four feedstock scenarios are examined. The first, 100% canola, the second, 100%

soybeans, and a third, a blend of 50% canola and 50% sunflowers crushed and used for

production of biodiesel. Lastly, a scenario of a biodiesel production facility without a

crushing facility is examined. Unlike the previous three, the last scenario assumes the

biodiesel production facility purchases previously refined oil feedstock for transformation

into biodiesel. The canola and combined canola and sunflower scenarios were selected

because these oilseed crops are agronomically suited to Oklahoma's climate. Canola and

sunflower also have relatively high oil content. The soybean scenario was used to provide

a comparison to other studies of biodiesel feasibility which have been based on soybean

oil feedstocks. Also, soybeans are the major oilseed crop in the U.S. and have historically

been the primary feedstock used for biodiesel production. Feasibility measures and

sensitivity analysis are compared for each scenario. Raw material and final product

pricing are based upon USDA reports and price quotes from regional grain markets.

Equipment costs are based upon a proprietary study conducted by Bowser and Holcomb.

Baseline crushing operating capacity is based on a crushing facility operating 325 days

per year, 24 hours a day with a crushing capacity of six tons per hour. An uptime

percentage of 95% is assumed. Baseline oil content of canola was estimated to be 35.1%.

This percentage was based on average oil contents from results obtained at Kansas State

University's 2004 National Winter Canola Variety Trial in Goodwell, OK (Kansas State

University Agricultural Experiment Station and Cooperative Extension Service). Baseline

oil content of soybeans was estimated to be 18.7%. The soybean oil content was based

on the average annual oil contents from 1986 to 2007 supplied by the USDA's National

Agriculture Statistics Service in cooperation with Iowa State University and the

University of Minnesota (United States Department of Agriculture). Finally, baseline sunflower oil content was estimated to be 43.1%, based on the 2007 average as determined by the 2007 U.S. Sunflower Crop Quality Report (National Sunflower Association).

The basic financing assumption for the model includes a loan for 50% of the total cost of plant, property, and equipment at 7.5% APR for a term of ten years. Monthly working capital to finance feedstock demands was estimated at $500,000 at a short-term interest rate of 7.5%. Additional working capital of 2% of annual sales was assumed. Property tax was estimated to be .5% of the total cost of plant, property, and equipment. Payroll tax to salaries was assumed to be 5% salary expense, and retirement expenses were estimated at 15% of salary. Workers compensation expense was 10% of salary expense. Utility rates for electricity, telephone, gas, and water were estimated to be $0.11/kW, $2000/year, $15/MCF, and $2.00/1000 gallons, respectively. Maintenance was estimated to be 5% of total plant, property, and equipment value and insurance was estimated to be 1% of total plant, property, and equipment value. While the template includes the option to model an inflation rate, no inflation was assumed in the baseline scenario. Finally, a discount rate of 10% was used to in the net present value calculations.

Trucking expense rates were estimated to be $4.50/mile for meal and grain and $5.00/mile for oil and glycerin (Long, 2008). Each truck was assumed to haul 24 tons of material. Average distance for canola and sunflower grain delivery was assumed to be thirty and sixty miles respectively. Trucking distance for outbound meal was assumed to be thirty miles and trucking distance for outbound oil and glycerin were assumed to be 100 miles.

Representative prices for oilseed inputs and biodiesel and co-product outputs are hard to determine with certainty due to the lack of volume in regional markets and recent price volatility. It is therefore important to perform sensitivity analysis over a range of prices around the baseline price. Because of the recent volatility of price movement for oilseed commodities and byproducts, a one year average of recent prices were used to determine the baseline input and output prices Monthly prices provided by the USDA's Oil Crops Outlook handbook from May 2007 to April 2008 were averaged (United States Department of Agriculture, 2008). Canola grain price was calculated to be $18.82/cwt or about $0.19/lb, soybean grain price was calculated to be $9.24/bu., and sunflower grain price was calculated to be $19.88/cwt or $0.20/lb. Meal prices for canola, soybeans, and sunflowers were calculated the same and were $213/ton, $276/ton, and $139/ton respectively. Canola, soybeans, and sunflower oil were calculated at $0.56/lb, $0.43/lb, and $0.78/lb respectively. Finally, soybean hulls were quoted at $120/ton (University of Missouri Extension, 2008). For the baseline model, prime bleachable summer yellow (PBSY) cottonseed oil was the assumed choice of additional oil needed to reach production goals of 5,000,000 gallons (18,927,059 liters). The price of PBSY cottonseed oil was estimated to be $0.53/lb based on the USDA Oil Crops Outlook data.

Biodiesel price was estimated by averaging the price of retail biodiesel from March 2007 to January 2008 (U.S. Department of Energy, 2008). The retail to wholesale margin was calculated by subtracting the average of wholesale prices of No. 2 diesel from April 2007 to March 2008 by the average retail prices of No. 2 diesel from March 2007 to January 2008 (U.S. Energy Information Administration, 2008). The estimated retail to wholesale margin was then subtracted from the estimated biodiesel retail price to

find a wholesale biodiesel price of $2.93. A $0.50 (assumed 50% of retail tax credit passed on to wholesaler) biodiesel tax credit was then added to this estimated price to find a final wholesale biodiesel price estimate of $3.43.

Methanol, an input of the transesterification process, was quoted at $2.75 (Utah Biodiesel Supply, 2006). Sodium hydroxide (catalyst), also an input of the production process was estimated at $350/ton. This cost was based on public bids by regional water treatment plants. Finally, glycerin, a byproduct of the transesterification process was quoted to be approximately $0.19/lb (Crockett, Peterson, and Mann, 2006).

A biodiesel production facility has the choice to either buy previously crushed oil or incorporate a crushing facility alongside the production facility. Three of the four baseline scenarios are based on the operation of an integrated oilseed crushing and biodiesel production facility. For comparison purposes all of the scenarios are standardized at 5M gallons of biodiesel production. Because of the differences in oil content, the amount of additional oil feedstock purchased varied across scenarios. The baseline scenario assumed that the biodiesel operation refined the glycerin co-product. For a detailed summary of the baseline assumptions used in the models refer to Table II-1.

Table II-1.   **Biodiesel Assumptions**

Consumables	Price/Costs
Plant Cost (Integrated)	$5,230,592
Plant Cost (Stand Alone Biodiesel Production Facility)	$2,128,966
Personnel Expense (Integrated)	$725,540
Personnel Expense (Stand Alone Biodiesel Production Facility)	$563,300
Annual Capacity (tons crushed)	44,460
Biodiesel Price (gal)	$3.43
Glycerin Price (lb)	$0.19
Methanol Price (gal)	$2.75
NaOH Price (ton)	$350.00
Soybean Grain Price (bu)	$9.24
Canola Grain Price (lb)	$0.19
Sunflower Grain Price (lb)	$0.20
Soybean Oil Price (lb)	$0.43
Canola Oil Price (lb)	$0.56
Sunflower Oil Price (lb)	$0.78
PBSY Cottonseed Oil Price (lb)	$0.53
Soybeans Meal Price (ton)	$276.43
Canola Meal Price (ton)	$213.00
Sunflowers Meal Price (ton)	$139.00
Natural Gas cost/MCF	$15.00
Electricity/kW	$0.11

The following sections list the equipment used and are categorized by process.

Again, equipment used, associated costs, and generic descriptions were based on a

proprietary study of a biodiesel production facility performed by Drs. Bowser and Holcomb. Specific descriptions, models used, cost estimates and corresponding sources in the proprietary study are withheld in order to protect confidentiality. However the equipment cost and utility assumptions are thought to be representative of a typical 5M gallon/year operation.

Receiving and Preparation Area Equipment

This includes equipment used for storage and cleaning of incoming grain. First the grain is dumped into a pre cleaner with a capacity of approximately 50,000 lbs per hour. Next, the cleaned grain is carried by a belt system to a storage bin with a three day storage capacity. Bulk storage tanks for methanol and additional purchased oil, each with a three day storage capacity, cost $29,600 and $50,820 respectively.

Preparation area equipment consists of additional grain cleaning equipment. The grain first enters an additional aspirated cleaner. Then, a magnet removes any tramp metal present. Once cleaned, the grain is dried and heated to prevent shattering before rolling using a dryer. Finally, the grain is rolled using a roller mill at a cost of $72,006. Total cost for equipment used in the receiving and preparation area is $691,194. For a more detailed description of receiving and preparation area equipment costs and quantities refer to Appendix Tables 1 and 2.

Oil Extraction and Oil Processing Area Equipment

After grain is cleaned and rolled, it is then ready to be crushed. The primary equipment needed for crushing of grain is an oil press and an extruder. For the model an

oil press at a cost of $154,625 is used to the press the grain. The extruder used has a cost of $99,525.

After the oil is extracted from crushing the grain, the oil enters an oil processing area to be cleaned and degummed. First, the oil is filtered and then degummed using hot water degumming to remove impurities in the oil. The oil enters a centrifuge and is flash dried to remove excess water. Total equipment cost for the oil extraction area is $2,107,029. Total equipment cost for the oil processing area is $128,250. The oil processing area equipment is quoted as a whole. For a more detailed description of oil extraction costs and quantities refer to Appendix Table 3.

Conversion Equipment (Actual Production)

The conversion process includes the actual production process of biodiesel by transesterification. The oil is mixed with a catalyst and methanol and enters a heat exchanger. After the reaction is complete, the mixture enters another heat exchanger to vaporize any excess methanol and water. The mixture then enters a vacuum tank and is flash dried. Two settling tanks collect biodiesel and a mixture of glycerol, water, and methanol. Excess methanol is separated through another vacuum system and settles in a tank to be recycled and used in the process again. Water is also recycled and used again in the process for washing. Primary equipment for the process includes heat exchangers, vacuum tanks, and settling tanks. Total cost of equipment for the conversion process is $487,793. For information regarding costs and equipment used refer to Appendix Table 4.

Meal Processing and Packaging Equipment

Meal left over from rolling and crushing the grain can be sold to feed area livestock. Meal is bagged and prepared for shipping. Total costs for meal processing and packaging are $140,193. For a more detailed description of meal processing and packaging costs refer to Appendix Tables 5 and 6.

Store and Ship Equipment

The final products, biodiesel and glycerin are stored in tanks with costs of $57,135 and $29,610 respectively. For the model, two biodiesel storage tanks are used. Each biodiesel storage tank has a two day capacity (about 40,000 lbs) and includes a ladder and $9,000 for insulation and heat pipe. The glycerin storage tank has a four day capacity and includes a ladder and $6,000 for insulation and heat pipe. Transfer pumps to transport the products from wash to tanks are also included and associated filters. Total costs for equipment to store and ship the final products are $320,262. For a more detailed description of equipment used to store and ship product refer to Appendix Table 7.

Glycerin Refining Equipment (Optional)

Glycerin refining is not an integral part of the biodiesel production operation but is rather an optional production option that can be used to increase the value of the glycerol co-product. Equipment used to refine glycerol and remove any excess water include filter, surge tank, metering pump, static mixer, heat exchanger, ion exchange purifier, and vacuum distillation. Total equipment cost associated with glycerin refining

is $95,000 and are reflected in the model whether glycerol is refined or not. Glycerin refining equipment is reflected as a single price quote.

Quality Control Equipment

The American Society for Testing and Materials (ASTM) provides biodiesel producers with quality standards for production. The quality control is voluntary but if met will yield the production facility a BQ-9000 accredited status by the National Biodiesel Accreditation Commission. Tests for flash point, viscosity, purity and cloud point are performed here. Quality control equipment costs total $113,337 and are summarized on Appendix Table 8.

Office Equipment

Office equipment cost estimates were obtained from area office supply stores and include chairs, desks, other furniture, file cabinets, and a small refrigerator. Total costs are $6,400 and are summarized in Appendix Table 9.

Sanitation Equipment

Primary costs for sanitation include a dry vacuum system and pressure wash system each valued at $5,500 and $15,000 respectively. Total costs for sanitation equipment are $46,575 and are summarized in Appendix Table 10.

Facility and Other Equipment

Other equipment costs, including costs for the boiler, building shell, piping and electrical switchgear total $999,600. A detailed summary of costs is available in Appendix Table 11.

Total Plant, Property, and Equipment

Installation and freight of each process is calculated using a rate of 35%. When total equipment costs along with associated installation and freight costs are totaled, the value is then used to calculate depreciation costs. The cost of land is valued at $10,000 and added to the final equipment and building costs to find a final value of plant, property, and equipment. Total value of plant, property, and equipment for the integrated (biodiesel and crushing) model is $5,220,592. For the stand alone biodiesel production facility model, total value of plant, property, and equipment is $1,016,391. For a summary of the total equipment list for the integrated model and stand alone biodiesel production facility model refer to Appendix Tables 12 and 13 respectively.

CHAPTER III

FINANCIAL PROJECTIONS FOR THE BASELINE SCENARIOS

The previously described feasibility template was used to develop a ten year projection of income and expenses for each scenario in the baseline assumptions. The template also provided a return on investment analysis for each of the four scenarios. The internal rate of return, return on assets, and return on equity were compared across a range of prices for each scenario in order to examine the sensitivity of the projected rate of return to changes in feedstock and final product prices. Breakeven analysis was also performed by determining the level of the variable of interest that generated breakeven (or zero) average ten year cash flow. Finally, the net present value and break even biodiesel and feedstock prices were compared across scenarios to determine which feed stock scenario provided the maximum return on investment at the baseline assumptions.

100% Canola Crushed Scenario

For the first scenario, 100% of feedstock to be crushed was canola. At an annual capacity of 44,460 tons, the crushing facility supplied 3,252,506 gallons (12,312,074 liters) of oil. Therefore, 13,280,951 pounds (1,747,494 gallons or 6,614,984 liters) of excess oil (PBSY cottonseed oil) was needed to complete annual production goals of 5,000,000 gallons (18,927,059 liters) of biodiesel.

Projected Income and Expenses

For the scenario involving 100% of canola to be crushed, average total biodiesel sales for a ten year time frame accounted for $17,942,695 per year. Total glycerin sales averaged $718,989 per year. Finally, average meal sales totaled $7,054,358 per year. Because no excess oil was supplied from crushing, the plant had no sales of oil. Average total sales of products and byproducts were $25,716,042 per year. Average cost of goods sold totaled $28,043,729 per year which included average cost of canola feedstock at $17,508,245, additional supplied oil at $7,364,251, methanol at $3,164,819, and sodium hydroxide at $67,106.

Average fixed labor including administrative and overhead totaled $200,351 per year. Average operational labor totaled $558,724 per year. Average fixed and operational labor totaled $759,075 per year. Average trucking expenses including hauling of grain, oil, meal, and glycerin totaled $466,331 per year. Average variable overhead including utilities, chemicals and water additives, and sewage treatment and disposal totaled $1,006,260 per year. The previously mentioned totals sum for a total average variable expense for the ten year time frame of $2,231,666 per year. Average fixed overhead including maintenance, insurance, property tax, depreciation, interest, and protection and safety totaled $891,308 per year. An average of other expenses including supplies and miscellaneous totaled $48,600 per year. Average total expenses including fixed and variable for the ten year time frame were $3,171,574 per year. For a more detailed summary of the first scenario's expenses refer to Table III-1.

Table III-1. **Expense Projections for 100% canola (Average of annual costs for 10 years)**

	Average Expense	Percent of Total Average Expense
Administrative and Overhead	$200,351	6.32%
Operational	$558,724	17.62%
Total Labor	**$759,075**	**23.93%**
Trucking-grain	$250,088	7.89%
Trucking-Oil	$0	0.00%
Trucking-Meal	$178,064	5.61%
Trucking-glycerin	$38,179	1.20%
Total Trucking	**$466,331**	**14.70%**
Electricity	$687,689	21.68%
Natural Gas	$270,391	8.53%
Water	$10,561	0.33%
Chemicals and Water Additives	$8,250	0.26%
Sewer and Treatment	$16,269	0.51%
Solid waste removal	$11,100	0.35%
Telephone	$2,000	0.06%
Total Utilities	**$1,006,260**	**31.73%**
Total Variable	**$2,231,666**	**70.36%**
Maintenance	$227,580	7.18%
Insurance	$52,206	1.65%
Property Tax	$52,306	1.65%
Depreciation	$423,484	13.35%
Interest	$130,732	4.12%
Protection and Safety	$5,000	0.16%
Total Fixed	**$891,308**	**28.10%**
Supplies	$48,600	1.53%
Miscellaneous	$0	0.00%
Total Other Expenses	**$48,600**	**1.53%**
Total Expenses	**$3,171,574**	**-**

When total expenses are subtracted from gross margin, average earnings before taxes of ($5,449,362) per year are calculated for the ten year time frame. Oklahoma tax credits total $1,000,000 a year for the first five years but because after tax profits were negative, no credit can be accounted. After taxes were subtracted from initial earnings, an

average after tax profit of ($5,449,362) per year was calculated. For a more detailed

summary of the first scenario's operations summary refer to Table III-2.

Table III-2.   **Summary of Income and Expenses for 100% Canola (Baseline Scenario- Average of 10 Years)**

Accounting Entry	Average of Ten Years
Gross Sales	$ 25,716,042
COGS	$ 28,043,729
Gross Margin	$ **(3,164,819)**
Biodiesel Tax Credits	$ 50,000
Total Gross Margin	$ **(2,327,688)**
Variable Expenses	$ 2,231,666
Fixed Expenses	$ 891,308
Other Expenses	$ 48,600
Total Expenses	$ **3,171,574**
Earnings Before Taxes	$ **(5,449,362)**
Tax	$ **-**
After Tax Net Profit/Loss	$ **(5,449,362)**

Average projected cash flows were calculated by adding in depreciation of

$423,484 and subtracting principle payments of $261,530 to find average projected cash

flows of ($5,287,307) per year.

Return on Investment Analysis

A net present value of ($89,805,039) was calculated for 100% of canola to be

crushed over a ten year period. This value indicates that at the selected baseline prices

and discount rate, the scenario of crushing canola and manufacturing biodiesel does not

generate sufficient cash flow to cover expenses and cover the 10% opportunity cost of the

invested capital. In fact, the negative projected cash flows indicate that the project's

income does not cover the projected cash expenses and loan payments associated with the project.

Sensitivity Analysis

In order to test sensitivity, certain prices were allowed to vary across a range while other variable prices remained constant. Changes in the scenario's internal rate of return, return on assets, and return on equity were then calculated for each change in the variable being tested. Table III-3 shows the change in each of the previously mentioned sensitivity measures for the first scenario across a range of biodiesel wholesale prices.

Table III-3. **Sensitivity of Canola Processing Return to Biodiesel Value**

	Biodiesel Price					
Economic Variable	$4.30	$4.40	$4.50	$4.60	$4.70	$4.80
Internal Rate of Return	Neg	Neg	4.49%	18.53%	30.36%	41.25%
Return on Assets	-17.19%	-7.20%	2.80%	12.80%	22.79%	32.79%
Return on Equity	-34.39%	-14.39%	5.60%	25.59%	45.59%	65.58%

Baseline biodiesel price for the model is assumed to be $3.43.

Results show that at the given baseline variable prices for inputs and byproducts, the breakeven biodiesel wholesale price is approximately $4.50. Furthermore, a ten cent increase in the price of biodiesel increases the IRR by approximately 14%, ROA by approximately 10%, and ROE by approximately 20%.

Table III-4.   Sensitivity of Canola Processing Return to Canola Feedstock Value

Canola Grain Price (lb)

Economic Variable	$0.125	$0.13	$0.135	$0.14	$0.145	$0.15
Internal Rate of Return	23.77%	12.49%	-1.67%	Neg	Neg	Neg
Return on Assets	17.08%	8.19%	-0.70%	-9.59%	-18.47%	-27.36%
Return on Equity	34.16%	16.38%	-1.39%	-19.17%	-36.95%	-54.73%

Baseline canola feedstock price for the model is assumed to be $0.19.

The first scenario also seems to be highly sensitive to feedstock prices as is indicated in Table III-4.

Results indicate that the breakeven price for canola feedstock when other variable prices are held constant at the baseline assumptions is approximately $0.13 to $0.14. Furthermore, a $0.005 increase in the price of canola feedstock decreases IRR by approximately 12%, ROA by approximately 9%, and ROE by approximately 18%. Sensitivity results may be overstated as meal prices are linked to grain prices, but the template does not allow for a simultaneous change in the corresponding meal price.

100% Soybeans Crushed Scenario

The second scenario assumed that, 100% of feedstock to be crushed was soybeans. It was anticipated that this scenario would provide lower returns because soybeans have lower oil content in comparison to other feedstocks used. Soybeans low oil content led to a lower portion of more valuable oil supplied by crushing. All additional oil needed to meet production goals was supplied by oil at the baseline price for additional oil purchased. Therefore, baseline additional purchased oil price supplied by PBSY cottonseed oil weighed more heavily in this scenario compared to the other scenarios in the model. At an annual capacity of 44,460 tons, the crushing facility

supplied 1,627,798 gallons (6,161,885 liters) of oil. Therefore, 25,628,738 pounds (3,372,202 gallons or 12,765,173 liters) of excess oil (PBSY cottonseed oil) was needed to complete annual production goals of 5,000,000 gallons (18,927,059 liters) of biodiesel.

Projected Income and Expenses

Average total biodiesel sales per year for a ten year time frame accounted for $17,942,695. Total glycerin sales averaged $718,989. Finally, average meal and hull sales per year totaled $10,169,143 and $334,908 respectively. Because no excess oil was supplied from crushing, the plant had no sales of oil. Average total sales of products and byproducts per year were $29,165,735. Average cost of goods sold totaled $37,708,918 per year which included average cost per year of soybean feedstock at $14,326,619, additional supplied oil at $14,211,065, methanol at $3,164,819, and sodium hydroxide at $67,106. Average fixed labor including administrative and overhead totaled $200,351 per year. Average operational labor totaled $558,724 per year. Average fixed and operational labor totaled $759,075 per year. Average trucking expenses including hauling of grain, oil, meal, and glycerin totaled $751,147 per year. Average variable overhead including utilities, chemicals and water additives, and sewage treatment and disposal totaled $1,006,260 per year. The previously mentioned totals sum for a total average variable expense for the ten year time frame of $2,516,482 per year. Average fixed overhead including maintenance, insurance, property tax, depreciation, interest, and protection and safety totaled $891,308 per year. An average of other expenses per year including supplies and miscellaneous totaled $48,600. Therefore, average total expenses including fixed and variable for the ten year time frame

were $3,456,390 per year. For a more detailed summary of the second scenario's expenses

refer to Table III-5.

Table III-5. **Expense Projections for 100% soybeans (Average of annual costs for 10 years)**

	Average Expense	Percent of Total Average Expense
Administrative and Overhead	$200,351	5.80%
Operational	$558,724	16.16%
Total Labor	**$759,075**	**21.96%**
Trucking-grain	$500,175	14.47%
Trucking-Oil	$0	0.00%
Trucking-Meal and hulls	$212,792	6.16%
Trucking-Glycerin	$38,179	1.10%
Total Trucking	**$751,147**	**21.73%**
Electricity	$687,689	19.90%
Natural Gas	$270,391	7.82%
Water	$10,561	0.31%
Chemicals and Water Additives	$8,250	0.24%
Sewer and Treatment	$16,269	0.47%
Solid waste removal	$11,100	0.32%
Telephone	$2,000	0.06%
Total Utilities	**$1,006,260**	**29.11%**
Total Variable	**$2,516,482**	**72.81%**
Maintenance	$227,580	6.58%
Insurance	$52,206	1.51%
Property Tax	$52,306	1.51%
Depreciation	$423,484	12.25%
Interest	$130,732	3.78%
Protection and Safety	$5,000	0.14%
Total Fixed	**$891,308**	**25.79%**
Supplies	$48,600	1.41%
Miscellaneous	$0	0.00%
Total Other Expenses	**$48,600**	**1.41%**
Total Expenses	**$3,456,390**	**-**

When total expenses are subtracted from gross margin, average earnings before

taxes of ($5,949,572) per year are calculated for the ten year time frame. Once again,

Oklahoma tax credits total $1,000,000 a year for the first five years but because after tax profits were negative, no credit can be accounted. After taxes were subtracted from initial earnings, an average after tax profit per year of ($5,949,572) was calculated. For a more detailed summary of the second scenario's operations summary refer to Table III-6.

Table III-6.   Summary of Income and Expenses for 100% Soybeans (Baseline Scenario- Average of 10 Years)

Accounting Entry	Average of Ten Years
Gross Sales	$ 29,165,735
COGS	$ 31,708,918
Gross Margin	**$ (2,543,182)**
Biodiesel Tax Credits	$ 50,000
Total Gross Margin	**$ (2,493,182)**
Variable Expenses	$ 2,516,482
Fixed Expenses	$ 891,308
Other Expenses	$ 48,600
Total Expenses	**$ 3,456,390**
Earnings Before Taxes	**$ (5,949,572)**
Tax	**$ -**
After Tax Net Profit/Loss	**$ (5,949,572)**

Average projected cash flows were calculated by adding in depreciation of $423,484 and subtracting principle payments of $261,530 to find average projected cash flows of ($5,787,618) per year.

Return on Investment Analysis

A net present value of ($97,872,143) was calculated for 100% soybean crushed scenario indicating that average returns discounted over ten years were negative. Once again, the calculated NPV indicated that the crushing biodiesel manufacturing process

does not generate sufficient cash flow to cover expenses and cover the 10% opportunity cost of the invested capital. In fact, the gross margins and net earnings were negative for each of the ten years modeled.

Sensitivity Analysis

Like the previous scenario, sensitivity to changes in biodiesel and feedstock price were tested using varying prices for each. All other variable prices were held constant in order to measure the effect both biodiesel and feedstock price had on the scenario's internal rate of return, return on assets, and return on equity. Table III-7 shows changes for each of the previously mentioned measures of return as prices of wholesale biodiesel change.

Table III-7.   **Sensitivity of Soybean Processing Return to Biodiesel Value**

Economic Variable	Biodiesel Price					
	$4.40	$4.50	$4.60	$4.70	$4.80	$4.90
Internal Rate of Return	Neg	Neg	5.14%	18.98%	30.72%	41.56%
Return on Assets	-16.76%	-6.76%	3.23%	13.23%	23.23%	33.22%
Return on Equity	-33.52%	-13.53%	6.47%	26.46%	46.45%	66.45%

Baseline biodiesel price for the model is assumed to be $3.43.

Results show that a biodiesel production facility with a combined crushing facility using soybeans for feedstock has a breakeven price, holding constant to baseline assumptions, between $4.50 and $4.60. When biodiesel price is increased by $0.10, internal rate of return increases by approximately 13%, return on assets increases by approximately 10%, and return on equity increases by approximately 20%.

Feedstock prices also seem to affect returns by significant amounts. Table III-8 shows changes in measurements of return in response to changes in feedstock prices.

Table III-8.   **Sensitivity of Soybean Processing Return to Soybean Feedstock Value**

	Soybean Grain Price (bu)					
Economic Variable	$5.00	$5.50	$6.00	$6.50	$7.00	$7.50
Internal Rate of Return	17.31%	Neg	Neg	Neg	Neg	Neg
Return on Assets	11.90%	-2.91%	-17.73%	-32.54%	-47.36%	-62.17%
Return on Equity	23.81%	-5.82%	-35.45%	-65.08%	-94.71%	-124.34%

Baseline soybean feedstock price for the model is assumed to be $9.24.

Results show significant negative returns across much of the price range. The breakeven feedstock price is approximately $5.24 a bushel. Furthermore, a $0.50 increase in feedstock decreases internal rate of return by approximately 20%, return on assets by approximately 14%, and return on equity by approximately 30%. Sensitivity results may be overstated as meal prices are linked to grain prices in the market. However, the template does not allow for a simultaneous change in the corresponding meal price.

50% Canola and 50% Sunflowers Crushed Scenario

The third scenario assumed that the crushing facility processed 50% canola and 50% sunflowers. An annual crushing capacity of 44,460 tons, 22,230 tons of canola feedstock yielded 1,626,253 gallons (6,156,037 liters) of oil per year and 22,230 tons of sunflower feedstock yielded 1,875,884 gallons (7,100,993 liters) of oil per year. Total oil supplied from crushing was 3,502,138 gallons (13,257,034 liters) per year. Therefore, additional oil (PBSY cottonseed oil) supplied of 11,383,754 pounds (1,497,682 gallons or 5,669,343 liters) was needed to meet 5,000,000 gallon (18,927,059 liters) annual production goals.

Projected Income and Expenses

Average biodiesel sales for a ten year time frame accounted for $17,942,695 per year. Total glycerin sales per year averaged $718,989. Finally, average meal sales totaled $5,497,036 per year. Like the first and second scenarios, because no excess oil was supplied from crushing, the plant had no sales of oil. Average total sales of products and byproducts were $24,158,719 per year. Average cost of goods sold totaled $27,484,798 per year which included average cost per year of canola and sunflower feedstock at $8,754,122 and $9,247,181 respectively, additional supplied oil at $6,312,261, methanol at $3,164,819, and sodium hydroxide at $67,106.

Average fixed labor including administrative and overhead totaled $200,351 per year. Average operational labor totaled $558,724 per year. Average fixed and operational labor totaled $759,075 per year. Average trucking expenses including hauling of grain, oil, meal, and glycerin totaled $578,536 per year. Average variable overhead including utilities, chemicals and water additives, and sewage treatment and disposal totaled $1,006,260 per year. Total average variable expense for the ten year time frame was $2,343,871 per year. Average fixed overhead including maintenance, insurance, property tax, depreciation, interest, and protection and safety totaled $891,308 per year. An average of other expenses including supplies and miscellaneous totaled $48,600 per year. Average total expenses including fixed and variable for the ten year time frame were $3,283,779 per year. For a more detailed summary of the third scenario's expenses refer to Table III-9.

Table III-9.   **Expense Projections for 50% canola and 50% sunflowers (Average of annual costs for 10 years)**

	Average Expense	Percent of Total Average Expense
Administrative and Overhead	$200,351	6.10%
Operational	$558,724	17.01%
Total Labor	**$759,075**	**23.12%**
Trucking-grain	$375,131	11.42%
Trucking-Oil	$0	0.00%
Trucking-Meal	$165,226	5.03%
Trucking-Glycerin	$38,179	1.16%
Total Trucking	**$578,536**	**17.62%**
Electricity	$687,689	20.94%
Natural Gas	$270,391	8.23%
Water	$10,561	0.32%
Chemicals and Water Additives	$8,250	0.25%
Sewer and Treatment	$16,269	0.50%
Solid waste removal	$11,100	0.34%
Telephone	$2,000	0.06%
Total Utilities	**$1,006,260**	**30.64%**
Total Variable	**$2,343,871**	**71.38%**
Maintenance	$227,580	6.93%
Insurance	$52,206	1.59%
Property Tax	$52,306	1.59%
Depreciation	$423,484	12.90%
Interest	$130,732	3.98%
Protection and Safety	$5,000	0.15%
Total Fixed	**$891,308**	**27.14%**
Supplies	$48,600	1.48%
Miscellaneous	$0	0.00%
Total Other Expenses	**$48,600**	**1.48%**
Total Expenses	**$3,283,779**	**-**

Average earnings before taxes totaled ($6,559,858) per year. Again, no taxes were realized by the plant because taxes are passed through to investors and because after tax profits were negative, no credit could be accounted for. After taxes were subtracted from initial earnings, an average after tax profit per year of ($6,559,858) was calculated. For a more detailed summary of the third scenario's operations summary refer to Table III-10.

Table III-10.   Summary of Income and Expenses for 50% Canola and 50% Sunflowers (Baseline Scenario- Average of 10 Years)

Accounting Entry	Average of Ten Years
Gross Sales	$ 24,158,719
COGS	$ 27,484,798
Gross Margin	$ (3,326,078)
Biodiesel Tax Credits	$ 50,000
Total Gross Margin	**$ (3,276,078)**
Variable Expenses	$ 2,343,871
Fixed Expenses	$ 891,310
Other Expenses	$ 48,600
Total Expenses	**$ 3,283,779**
Earnings Before Taxes	**$ (6,559,858)**
Tax	**$ -**
After Tax Net Profit/Loss	**$ (6,559,858)**

Average projected cash flows were calculated by adding in depreciation of $423,484 and subtracting principle payments of $261,530 to find average projected cash flows of ($6,397,903) per year.

Return on Investment Analysis

A net present value of ($107,687,926) was calculated for the mix of 50/50 canola and sunflower to be crushed. Like the previous scenarios, the negative net present value

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indicates that earnings are negative for each of the ten years and the production facility

has no possibility of paying back the initial investment.

Sensitivity Analysis

Again, returns appear to be highly sensitive to changes in biodiesel price. Changes

in measurements of return to changes in biodiesel price are summarized in Table III-11.

Table III-11.   Sensitivity of Canola and Sunflower Processing Return to Biodiesel Value

Economic Variable	Biodiesel Price					
	$4.50	$4.60	$4.70	$4.80	$4.90	$5.00
Internal Rate of Return	Neg	Neg	2.43%	16.93%	28.92%	39.88%
Return on Assets	-18.43%	-8.43%	1.57%	11.56%	21.56%	31.56%
Return on Equity	-36.85%	-16.86%	3.14%	23.13%	43.12%	63.12%

Baseline biodiesel price for the model is assumed to be $3.43.

Results indicate that the breakeven returns lie between biodiesel prices of $4.60 to

$4.70. A $0.10 increase in biodiesel price increases internal rate of return by

approximately 11%, increases return on assets by approximately 10%, and increases

return on equity by approximately 20%.

Changes in feedstock prices appear to affect returns significantly as well. Changes

in return measurements in response to changes in feedstock prices are summarized in

Table III-12.

Table III-12. Sensitivity of Canola and Sunflower Processing Return to Canola and Sunflower Feedstock Value

Economic Variable	Canola and Sunflower Grain Price (lb)					
	$0.12	$0.125	$0.13	$0.135	$0.14	$0.145
Internal Rate of Return	8.31%	-7.90%	Neg	Neg	Neg	Neg
Return on Assets	5.28%	-3.61%	-12.50%	-21.39%	-30.28%	-39.17%
Return on Equity	10.56%	-7.22%	-25.00%	-42.78%	-60.55%	-78.33%

Baseline canola and sunflower price for the model is assumed to be $0.19 and $0.20 respectively.

Results show that the breakeven feedstock price when both feedstocks are assumed the same price is $0.12 to $0.125. When sunflower and canola feedstock price each increases by $0.005, internal rate of return decreases by 16%, return on assets decreases by 9% and return on equity decreases by 18%. Sensitivity results may be overstated as meal prices are linked to grain prices in the market. However, the template is not structured to reflect correlations between feedstock and meal price variables

Stand Alone Biodiesel Production Facility Scenario (No Crushing)

The last scenario tested involved a production facility without a coinciding crushing facility. Therefore, the oil processed into biodiesel was assumed to be purchased from an outside source. Due to its favorable price with respect to the other oil prices at the time of this study, PBSY cottonseed oil was selected for the oil feedstock in the "Stand Alone Biodiesel Production Facility" scenario. Like the previous three scenarios, the production facility was to produce 5,000,000 gallons (18,927,059 liters) of biodiesel annually. No meal sales were accounted for due to the exemption of the crushing facility.

Projected Income and Expenses

Average total biodiesel sales per year for a ten year time frame accounted for $17,942,695. Total glycerin sales averaged $718,989. Average total sales of products and byproducts per year were $18,661,684. Average cost of goods sold per year totaled $24,242,129 which included average cost per year of PBSY cottonseed oil at $21,070,896, methanol at $3,164,819, and sodium hydroxide at $67,106.

Average fixed labor per year including administrative and overhead totaled $200,351. Average operational labor per year totaled $516,289. Average fixed and operational labor per year totaled $716,641. Average trucking expense per year totaled $38,179. Average variable overhead including utilities, chemicals and water additives, and sewage treatment and disposal totaled $450,195 per year. The previously mentioned totals sum for a total average variable expense for the ten year time frame of $1,205,014 per year. Average fixed overhead including maintenance, insurance, property tax,
depreciation, interest, and protection and safety totaled $331,745 per year. An average of other expenses per year including supplies and miscellaneous totaled $48,600. Therefore, average total expenses including fixed and variable for the ten year time frame were $1,585,359 per year. For a more detailed expense summary of the biodiesel production facility only refer to Table III-13.

Table III-13.   Expense Projections for the stand alone biodiesel production facility (Average of annual costs for 10 years)

	Average Expense	Percent of Total Average Expense
Administrative and Overhead	$200,351	12.64%
Operational	$516,289	32.57%
Total Labor	**$716,641**	**45.20%**
Trucking-Glycerin	$38,179	2.40%
Total Trucking	**$38,179**	**2.40%**
Electricity	$147,472	9.30%
Natural Gas	$254,543	16.06%
Water	$10,561	0.67%
Chemicals and Water Additives	$8,250	0.52%
Sewer and Treatment	$16,269	1.03%
Solid waste removal	$11,100	0.70%
Telephone	$2,000	0.13%
Total Utilities	**$450,195**	**28.40%**
Total Variable	**$1,205,014**	**76.01%**
Maintenance	$74,248	4.68%
Insurance	$21,190	1.34%
Property Tax	$21,290	1.34%
Depreciation	$150,364	9.48%
Interest	$59,653	3.76%
Protection and Safety	$5,000	0.32%
Total Fixed	**$331,745**	**20.93%**
Supplies	$48,600	3.07%
Miscellaneous	$0	0.00%
Total Other Expenses	**$48,600**	**3.07%**
Total Expenses	**$1,585,359**	**-**

When total expenses are subtracted from gross margin, average earnings before taxes

of ($7,115,805) per year are calculated for the ten year time frame. Once again, Oklahoma

tax credits total $1,000,000 a year for the first five years but because after tax profits were

negative, no credit can be accounted. After taxes were subtracted from initial earnings, an

average after tax profit per year of ($7,115,805) was calculated. For a more detailed

operational summary of the biodiesel production facility only refer to Table III-14.

Table III-14.   Summary of Income and Expenses for Stand Alone Biodiesel Production Facility (Baseline Scenario- Average of 10 Years)

Gross Sales	$ 18,661,684
COGS	$ 24,242,129
Gross Margin	$ (5,580,446)
Biodiesel Tax Credits	$ 50,000
Total Gross Margin	$ (5,530,446)
Variable Expenses	$ 1,205,014
Fixed Expenses	$ 331,745
Other Expenses	$ 48,600
Total Expenses	$ 1,585,359
Earnings Before Taxes	**$ (7,115,805)**
Tax	**$ -**
After Tax Net Profit/Loss	**$ (7,115,805)**

Average projected cash flows were calculated by adding in depreciation of

$150,364 and subtracting principle payments of $105,948 to find average projected cash

flows of ($7,115,805) per year.

Return on Investment Analysis

A net present value of ($115,912,576) was calculated for the stand alone biodiesel

production facility scenario indicating, once again, that returns were significantly

negative over the ten year time frame. As the net present value calculation is much lower

for the final scenario, a combined crushing facility appears to lessen the loss realized by a

biodiesel facility alone.

Sensitivity Analysis

When prices of biodiesel and purchased oil are allowed to vary, changes in measures of return can be calculated. Table III-15 summarizes the changes in measures of return when biodiesel prices are allowed to vary holding all other baseline assumptions constant.

Table III-15.   Sensitivity of Stand Alone Biodiesel Production Facility Return to Biodiesel Value

	Biodiesel Price					
Economic Variable	$4.75	$4.80	$4.85	$4.90	$4.95	$5.00
Internal Rate of Return	Neg	0.73%	20.39%	35.75%	49.67%	62.93%
Return on Assets	-9.94%	2.35%	14.63%	26.91%	39.19%	51.47%
Return on Equity	-19.87%	4.69%	29.25%	53.81%	78.37%	102.93%

Baseline biodiesel price for the model is assumed to be $3.43.

Results indicate that the breakeven price of biodiesel is about $4.81. A $0.05 increase in the price of biodiesel results in approximately a 15% increase in the internal rate of return, a 12% increase in return to assets and a 25% increase in return to equity.

Changes in additional purchased oil prices show similar results and are summarized in Table III-16.

Table III-16.   Sensitivity of Stand Alone Biodiesel Production Facility Return to Additional Purchased Oil Value

Economic Variable	Additional Purchased Oil Price					
	$0.14	$0.18	$0.22	$0.26	$0.30	$0.34
Internal Rate of Return	-1.50%	Neg	Neg	Neg	Neg	Neg
Return on Assets	-0.61%	-11.23%	-21.85%	-32.47%	-43.09%	-53.71%
Return on Equity	-1.22%	-22.46%	-43.70%	-64.94%	-86.19%	-107.43%

Baseline PBSY cottonseed oil price for the model is assumed to be $0.53.

Although the model used PBSY cottonseed oil and corresponding prices, sensitivity results can represent any oil feedstock used. Results indicate a breakeven oil feedstock price of approximately $0.13. A $0.04 increase in oil feedstock decreases return to assets by approximately 10% and return to equity by approximately 20%.

Summary

Each scenario shows negative returns across the ten year time frame. Furthermore, each scenario shows significant negative net present values. This indicates that none of the baseline scenarios generated sufficient income to cover cash expenses and cover the 10% opportunity cost of invested capital. In fact, none of the scenarios generated sufficient returns to cover the costs of feedstock purchase and production costs. Table III-17 compares the net present values and breakeven biodiesel and feedstock prices for each scenario.

Table III-17.   Net Present Value and Breakeven Prices for each Scenario

	NPV	Breakeven Biodiesel Price	Breakeven Feedstock Price
100% Canola	$(89,805,039)	$4.50	$12.85/cwt
100% Soybeans	$(97,872,143)	$4.59	$5.24/bu
50% Canola & 50% Sunflowers	$(107,687,926)	$4.70	$12.20/cwt
Stand Alone Biodiesel Production Facility	$(115,912,576)	$4.81	$0.13/lb

When compared with the other three scenarios, the first scenario of 100% canola crushed appears to be the best choice, by a considerable margin, when net present value and breakeven prices are considered. The second best alternative by the model's calculations appears to be the second scenario involving 100% soybeans crushed followed by the third scenario of 50% canola and 50% sunflowers crushed and finally, the fourth scenario appears to be the least optimum choice in which no crushing facility is combined with the biodiesel production facility.

CHAPTER IV

CONCLUSION

As oil prices continue to reach all time highs, the opportunity of alternative sources of energy will increase. Biodiesel appears to be a favorable alternative fuel due to its ease of use in existing conventional diesel burning engines. Although its energy content is less than conventional diesel, its lubricity exceeds that of conventional diesel making it a favorable fuel to increase engine life. Although, 100% biodiesel is not in use today, its lubricity and environmental benefits are being used as a sort of additive with conventional diesel. Blends of diesel containing 2% all the way to 20% of biodiesel are not uncommon today and may be much more common in the near future.

Research was performed to show the economic feasibility of a biodiesel production facility using four scenarios, three integrated crushing/biodiesel production facilities and a stand alone biodiesel production facility, in order to show potential investors the financial costs and benefits a production facility would incur before large investments were undertaken. The feasibility study was performed using a template constructed in Microsoft Excel in which any user could input their own estimates of prices, both cost and output, to form cost structures and a related summary of income.

Specific Conclusions

1. The first objective of the research was to develop a decision aid which could be

    used to analyze the feasibility of oilseed crushing and biodiesel manufacturing

    operations. The feasibility template was constructed in Microsoft Excel. The

    template allows users to input their own estimates of raw material and final

    product prices, and to select manufacturing options and equipment compliments

    representative of their planned operation. The oilseed processing and biodiesel

    production feasibility template which was described in detail in this study proved

    to be very useful in projecting the profitability of typical processing scenarios.

2. The second objective of this study was to use the template to determine the

    feasibility of representative processing operations. Four scenarios were tested.

    The first involved an integrated crushing/biodiesel production facility using

    canola feedstock. At the baseline assumptions, the first scenario did not appear to

    be feasible. Calculations showed a negative net present value and internal rate of

    return. The second scenario, involving an integrated crushing/biodiesel production

    facility using soybeans as feedstock. Under the estimated baseline assumptions,

    the second scenario also showed a significant negative net present value and

    internal rate of return. Furthermore a negative gross margin indicated that the

    facility could not cover its initial production costs. The third scenario involving an

    integrated crushing/biodiesel production facility using 50% canola and 50%

    sunflowers for feedstock. The scenario also showed a negative net present value

    and internal rate of return. Like the second scenario, gross margin was negative

    for each of the projected ten years showing, once again, showing the inability to

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cover basic input costs of feedstock and materials needed for production. The

final scenario in which biodiesel is produced from purchased vegetable oil

showed the most unfavorable rate of return. At the time of this study, vegetable

oils prices were at historically high levels. This unfavorable price ratio between

vegetable oil and wholesale biodiesel contributed to the low projected returns.

Without the luxury of being able to sell meal byproducts offered by a combined

crushing facility, the stand alone biodiesel production facility has a lower

projected rate of return relative to any of the integrated crushing and biodiesel

production facilities that were modeled. As with the previous two scenarios, the

stand alone biodiesel scenario could not cover costs of production which was

indicated by a negative gross margin.

The third objective was to examine the sensitivity of the results of each scenario to

changes in feedstock and biodiesel prices. Sensitivity analysis of the first scenario

showed a breakeven biodiesel price of approximately $4.50 and a feedstock breakeven

price of approximately $0.13 per pound. The breakeven biodiesel price appears to be

attainable given the current market price of conventional diesel at the time of this report.

However, the baseline assumptions were based on the average prices for the most recent

year for both oilseeds and biodiesel. At the time of this report Oklahoma canola prices

are over $.25/lb. If this price level were to continue, the breakeven biodiesel price would

exceed the level based on the $.19/lb canola price assumption. The rate of return for the

first scenario is also sensitive to both biodiesel and feedstock prices. A ten cent increase

in biodiesel increases internal rate of return by 14% and a $0.005 increase in feedstock

decreases internal rate of return by 12%. With feedstock, especially, the high sensitivity adds very high risk to the investment.

Sensitivity of the second scenario showed that the breakeven price of biodiesel was $4.59. Keep in mind, that the model's baseline assumption of soybean price was $9.24. At the time of this report, current prices for soybeans exceeded $10.00/bu. Higher feedstock prices would increase the breakeven biodiesel price. The breakeven feedstock price of $5.24 showed even less promising results. It appears unlikely that soybean prices will return to this level. The second scenario also appeared to be highly sensitive to both biodiesel and feedstock prices. A ten cent increase in biodiesel increases internal rate of return by 13% and a $0.50 increase in feedstock decreases internal rate of return by 20%.

Breakeven prices for the third scenario were similar to the second. Breakeven biodiesel and feedstock prices were $4.70 and approximately $0.12 respectively showing very poor chance of the scenario to break even with current prices. The breakeven price assumed that both feedstocks were priced at the same level. This assumption (which was made to simplify the presentation of the results) is not unreasonable as both canola and sunflowers are priced at similar levels and the prices tend to be highly correlated. The canola and sunflower scenario also appears to be highly sensitive to feedstock and biodiesel prices. A ten cent increase in the price of biodiesel increased internal rate of return by approximately 11% and a $0.005 increase in the price of feedstock decreased internal rate of return by approximately 16%. Although price risk might be lowered by employing two feedstocks, the loss of return by crushing 50% sunflowers is too significant to overlook.

Breakeven biodiesel and feedstock prices of the fourth scenario, a stand alone biodiesel production facility, had the lowest projected rate of return of any of the scenarios examined. Biodiesel breakeven price was estimated at $4.81 and oil feedstock breakeven price was estimated at $0.13. The final scenario appeared to be the most highly sensitive investment once again indicating the risk benefit of a combined crushing facility.

When all scenarios are compared, the first scenario involving an integrated crushing/biodiesel production facility appears to be the most favorable. This is possibly due to the high oil content and ease of extraction of canola feedstock. The breakeven price of biodiesel for this scenario appears to be low enough to possibly compete with diesel or at the very least be a fairly cheap fuel additive.

The benefits of using a combined crushing facility appear to be significant. Not only does it increase revenue but it also decreases risk by providing the plant with the advantage of being able to sale their processed oil instead of using it for production if the market warrants such.

Because of an inadequate margin between input prices and final product prices, a biodiesel production facility using canola, soybeans, or sunflowers does not appear to be a feasible investment at this time. If the ratio of oil feedstock to biodiesel becomes more favorable and more technologically advanced production methods occur in the future, a different opinion may be made.

Limitations and Suggestions for Further Research

The study has provided a comprehensive model for assessing the feasibility of an integrated crushing/biodiesel production facility. The model has accounted for an array of varying input prices and rates. However, recently, commodity grain prices have shown extreme volatility, many of which have reached and surpassed all time highs. Baseline assumptions for the model were calculated by averaging monthly prices for the last year for many of the inputs, particularly feedstock. Historical data of any feedstock price does not reflect current conditions due to this recent volatility. Further study may be warranted within the next few years to give the economy as a whole time to adjust to the recent spike and determine whether the recent commodity spikes are permanent or temporary.

Because biodiesel has not been used extensively for many years like conventional diesel, a suitable market and infrastructure does not exist. Therefore price determination proved hard to calculate. Wholesale prices were especially hard to determine as tax credits were hard to allot between wholesalers and retailers and at retail, biodiesel is commonly sold as blends of 20% or less with conventional diesel. Furthermore, assumptions were made that all of the marketed biodiesel was sold. Future research would seem reasonable to determine consumer willingness to pay for the product so that salability could be measured and added to the model.

Finally, the model showed that a combined crushing facility would dramatically reduce costs of the biodiesel production facility. Further research regarding a crushing facility alone would be recommended.

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APPENDIX

Appendix Table 1.   Receiving Area Equipment

Equipment	Value of Each		Quantity	Value	
Pre cleaner	$	10,000	1	$	10,000
Day storage for grain	$	52,000	1	$	52,000
Bulk storage, methanol	$	29,600	1	$	29,600
Bulk storage, purchased oil	$	50,820	1	$	50,820
Installation and freight				$	49,847
			Total	**$**	**192,267**

Appendix Table 2.   Preparation Area Equipment

Equipment	Value of Each		Quantity	Value	
Grain cleaner	$	10,000	3	$	30,000
Magnet	$	6,324	3	$	18,972
Dryer	$	78,340	3	$	235,020
Dryer discharge screw	$	0	3	$	0
Roller mill	$	24,002	3	$	72,006
Bucket elevator	$	4,516	3	$	13,548
Installation and freight				$	129,341
			Total	**$**	**498,887**

Appendix Table 3.   Oil Extraction Area Equipment

Equipment	Value of Each		Quantity	Value	
Oil press	$	154,625	2	$	309,250
Press discharge screw	$	5,896	2	$	11,792
Oil screening tank	$	31,238	2	$	62,476
Bucket elevator	$	6,717	1	$	6,717
Surge bin	$	4,560	1	$	4,560
Extruder	$	99,525	1	$	99,525
Discharge screw	$	4,659	1	$	4,659
Vented screw conveyor	$	8,025	1	$	8,025
Vent fan w/hood	$	2,500	1	$	2,500
Oil press spare parts kit	$	3,150	1	$	3,150
Extruder spare parts kit	$	7,600	1	$	7,600
Installation and freight				$	546,267
			Total	**$**	**2,107,029**

Appendix Table 4.   Conversion (Actual Production) Equipment

Equipment	Value of Each		Quantity	Value	
Metering pump system	$	39,264	1	$	39,264
Static mixer	$	688	1	$	688
Heat exchanger	$	13,778	1	$	13,778
Tubular reactor	$	7,500	1	$	7,500
Back pressure valve	$	4,231	1	$	4,231
Heat exchanger, two phase	$	7,873	1	$	7,873
Vacuum tank	$	41,664	1	$	41,664
Settle tank A	$	59,215	1	$	59,215
Settle tank B	$	59,215	1	$	59,215
Condenser coil	$	3,068	1	$	3,068
Vacuum system	$	18,815	1	$	18,815
Methanol tank	$	15,638	1	$	15,638
Static mixer	$	535	1	$	535
Methanol dehydration	$	51,174	1	$	51,174
Methanol recirc. Tank	$	6,000	1	$	6,000
Vacuum tank pump	$	39,264	1	$	39,264
Settle tank biodiesel pump	$	688	2	$	1,376
Settle tank glycerin pump	$	13,778	2	$	27,556
Acid injection pump	$	7,500	2	$	15,000
Methanol pump	$	2,280	2	$	4,560
Installation and freight				$	126,465
			Total	**$**	**487,793**

Appendix Table 5.   Meal Processing Equipment

Equipment	Value of Each	Quantity	Value
Elevator	$ 6,799	1	$ 6,799
Roller mill	$ 24,002	1	$ 24,002
Drum cooler	$ 24,255	1	$ 24,255
Cooler discharge conveyor	$ 4,659	1	$ 4,659
Installation and freight			$ 20,900
		Total	**$ 80,615**

Appendix Table 6.   Meal Packaging Equipment

Equipment	Value of Each	Quantity	Value
Bulk storage	$ 5,121	3	$ 15,364
Bag filler	$ 15,609	1	$ 15,609
Palletize	$ 8,500	1	$ 8,500
Meal transfer conveyor	$ 4,659	1	$ 4,659
Installation and freight			$ 15,446
		Total	**$ 59,578**

Appendix Table 7.   Store and Ship Equipment

Equipment	Value of Each	Quantity	Value
Biodiesel Tank A	$ 57,135	1	$ 57,135
Biodiesel Tank B	$ 57,135	1	$ 57,135
Gylcerine tank	$ 29,610	1	$ 29,610
Biodiesel transfer pump	$ 4,650	1	$ 4,650
Glycerin transfer pump	$ 2,985	1	$ 2,985
Biodiesel filter	$ 9,469	1	$ 9,469
Biodiesel heater	$ 3,465	1	$ 3,465
Water wash system	$ 15,638	1	$ 15,638
Dehydration	$ 51,174	1	$ 51,174
Transfer pumps	$ 2,985	2	$ 5,970
Installation and freight			$ 83,031
		Total	**$ 320,262**

Appendix Table 8.   Quality Control Equipment

Equipment	Value of Each	Quantity	Value
D 93 Flash Point	$ 10,300	1	$ 10,300
D 93 Flash Point	$ 2,200	1	$ 2,200
D130 Corrosion	$ 3,700	1	$ 3,700
D130 Corrosion	$ 661	1	$ 661
Viscosity	$ 22,500	1	$ 22,500
Viscosity	$ 2,900	1	$ 2,900
Viscosity	$ 3,400	1	$ 3,400
Viscosity	$ 120	5	$ 600
D 664 Acid value	$ 7,000	1	$ 7,000
D 874 Sulfated ash	$ 2,500	1	$ 2,500
D 2500 Cloud point	$ 5,500	1	$ 5,500
D 2709 Water and sediment	$ 6,600	1	$ 6,600
D 6584 Total and free glycerol	$ 18,000	1	$ 18,000
Inflation (10%) for instrument prices since last estimate			$ 8,586
Installation, training, and freight at 20%			$ 18,889
		Total	**$ 113,337**

Appendix Table 9.   Office Equipment

Equipment	Value of Each	Quantity	Value
Chair	$ 150	3	$ 450
Computer system	$ 1200	2	$ 2400
Desk	$ 500	2	$ 1000
File cabinets	$ 200	4	$ 800
Furniture	$ 1500	1	$ 1500
Refrigerator, small	$ 250	1	$ 250
		Total	**$ 6,400**

Appendix Table 10.   Sanitation Equipment

Equipment	Value of Each	Quantity	Value
Chemical cabinet (cleaning)	$ 500	1	$ 500
Cleaning utensils	$ 1,000	1	$ 1,000
Foam generator	$ 2,500	1	$ 2,500
Hose station	$ 1,500	4	$ 6,000
Sink, hand wash	$ 250	4	$ 1,000
Sink, mop	$ 250	1	$ 250
Trash cans	$ 250	1	$ 250
Dry vacuum system	$ 5,500	1	$ 5,500
Waste receptacles	$ 2,500	1	$ 2,500
Pressure wash system	$ 15,000	1	$ 15,000
Installation and freight			$ 12,075
		Total	**$ 46,575**

Appendix Table 11.   Facility, Other Equipment

Equipment	Value of Each	Quantity	Value
Boiler	$ 85,000	1	$ 85,000
Hot water heater	$ 2,500	2	$ 5,000
Air compressor	$ 6,900	1	$ 6,900
Piping (product, water, air, steam)	$ 35	3000	$ 105,000
Water softener	$ 5,200	1	$ 5,200
Building shell	$ 73	8000	$ 584,000
Maintenance shop equipment	$ 25,000	1	$ 25,000
Evaporative water cooler	$ 27,500	1	$ 27,500
Chiller	$ 74,500	1	$ 74,500
HVAC for offices	$ 6,500	1	$ 6,500
Electrical switchgear	$ 50,000	1	$ 50,000
Condensate return system	$ 25,000	1	$ 25,000
		Total	**$ 999,600**

Appendix Table 12.   Total Equipment Cost and Installation (Integrated)

Equipment	Value
Receiving Area	$ 142,420
Preparation Area	$ 369,546
Oil Extraction	$ 520,254
Oil Processing	$ 95,000
Conversion	$ 361,328
Meal Processing	$ 59,715
Meal Packaging	$ 44,132
Store and Ship	$ 237,231
Glycerol Refining (Optional)	$ 95,000
Quality Control	$ 94,447
Office	$ 6,400
Sanitation	$ 34,500
Facility, Other	$ 999,600
Total Equipment Cost	**$ 5,135,592**

Appendix Table 13.   Total Equipment Cost and Installation (Stand Alone Biodiesel Production Facility)

Equipment	Value
Conversion	$ 361,328
Store and Ship	$ 237,231
Glycerol Refining (Optional)	$ 95,000
Quality Control	$ 94,447
Office	$ 6,400
Sanitation	$ 34,500
Facility, Other	$ 999,600
Total Equipment Cost	**$ 1,016,391**

VITA

Joshua Wayne Parks

Candidate for the Degree of

Master of Science

Thesis: FEASIBILITY OF A 5,000,000 GALLON PER YEAR BIODIESEL
PRODUCTION FACILITY USING CANOLA, SOYBEANS, AND
SUNFLOWERS AS FEEDSTOCK

Major Field: Agricultural Economics

Biographical:

Personal Data: Born in Enid, Oklahoma, on September 24, 1983, the son of Mat
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Education: Completed the requirements for the Master of Science in Agricultural
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Experience: Graduate Research Assistant, Department of Agricultural Economics,
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Name: Joshua Wayne Parks   Date of Degree: December, 2008

Institution: Oklahoma State University   Location: Stillwater, Oklahoma

Title of Study: FEASIBILITY OF A 5,000,000 GALLON PER YEAR BIODIESEL
PRODUCTION FACILITY USING CANOLA, SOYBEANS, AND
SUNFLOWERS AS FEEDSTOCK

Pages in Study: 66   Candidate for the Degree of Master of Science

Major Field: Agricultural Economics

Scope and Method of Study: The rate of consumption of oil over the past few decades has
skyrocketed and recently, the price has as well. It becomes necessary to explore
alternative sources of energy in order to curb rising oil prices and develop a fuel
which is more environmentally friendly. One fuel in particular, biodiesel, which is
made from plant oils and animal fats, shows enormous potential to compete with
conventional petroleum fuels. However, before massive investments are
undertaken to build a production infrastructure, an analysis of the feasibility of
production is necessary. In order to do so, a template was constructed using
Microsoft Excel to estimate costs and revenues of a 5,000,000 gallon per year
production facility in order to form a budget and give potential entrepreneurs and
the like more information about their investments.

Findings and Conclusions: Both an integrated crushing/biodiesel production facility and a
stand alone biodiesel production facility under baseline assumptions and estimates
show negative net present values and internal rates of return. Sensitivity analysis
reveals that breakeven prices for varying scenarios range from approximately
$4.50 to $4.80. Results reveal that an integrated crushing/biodiesel production
facility using canola, soybeans, or sunflowers would not be a feasible investment
taking into account cost of capital, labor, and feedstock at current prices for inputs
and outputs.

Advisor's Approval _____