Economic Analysis of Alternative Indiana State Legislation on Biodiesel

Submitted to the Indiana Soybean Board
In completion of funded project number OFH63

Revised July 2003

Kyle Althoff, Cole Ehmke, and Dr. Allan W. Gray

Center for Food and Agricultural Business
Department of Agricultural Economics

PURDUE
UNIVERSITY

Blank for duplication.

Executive Summary

In recent years legislation supporting biodiesel has greatly expanded its market potential. A number of states have proposed and passed measures to regulate and promote the fuel, which may alter biodiesel-related markets. Promotion programs are at the core of biodiesel adoption, but the effects are not completely understood. The objective of this project is to assist the Indiana Soybean Board in understanding the economic consequences that potential legislative proposals to encourage biodiesel consumption could impose upon the diesel, agricultural, and other industry-related markets. Increased biodiesel use and the potential for in-state production of this alternative fuel would alter the current demand for petroleum-based fuels and the prices for biodiesel feedstocks. The economic consequences from such increases could ultimately reshape Indiana's diesel fuel and agricultural markets, the region's petroleum industry, and other biodiesel-related markets. Further consideration will be given to the impacts such legislation would have on Indiana consumers and the state government. The analysis looks specifically at estimating the economic impact of an Indiana state legislative mandate to incorporate a 2 percent biodiesel blend into all commercially sold diesels. The study also examines the impact of Indiana tax incentives to lower the cost of biodiesel blends.

Top line results of the study indicate that the biodiesel, soybean processing, and soybean production industries would benefit the most generating more than $38 million dollars annually for those industries. However, the corn production, agricultural input, refining, and distribution industries would lose nearly $33.5 million annually. In addition, consumers and/or taxpayers would pay nearly $21.5 million dollars annually for the mandate. The net cost to all concerned parties ranges from $15.2 to $17.2 million in losses to the Indiana economy or about 0.01 percent of gross state product.

Characteristics of Biodiesel

Biodiesel is a chemically derived renewable fuel created primarily from plant oils (soybean, canola, mustard, corn oil, etc.), animal fats (beef, pork, and poultry tallow), or used cooking oils and greases. The fuel is used as a substitute for and/or additive to diesel. During production the feedstock is separated through transesterification into liquid methyl ester compounds (biodiesel) and glycerin byproducts. Biodiesel is then shipped to distributors and supplied to customers as pure biodiesel (100 percent biodiesel known as B100) or as a blended diesel mix (typically B2 to B20) for use in powering trucks, boats, tractors, cars and other vehicles with diesel engines.

The performance of biodiesel is distinguished from regular diesel in several ways. Biodiesel benefits include lower emissions of key pollutants like carbon monoxide, unburned hydrocarbons, sulfates and particulate matter while also providing needed lubricity in a diesel engine. However, the fuel does increase nitrous oxide emissions, has possible cold-flow problems, and has a lower BTU output per gallon relative to diesel.

Despite some of its performance shortcomings, the production of biodiesel in the US has risen dramatically from 1 million gallons in 1999 to 25 million gallons in 2002. With up to 80 percent of the production costs resulting from feedstock expenses, the high costs of feedstocks such as soybean oil has constrained the growth of demand for the fuel.

The cost for feedstocks has caused the production costs of pure biodiesel to range from $1.39 to $2.52 per gallon in contrast to the $0.80 to $0.90 per gallon cost of regular #2 diesel. The higher production expenses are transferred to consumers who pay on average between $1.00 and $1.50 more per gallon at the pump for pure biodiesel compared to diesel fuel. When mixed with petroleum-based diesel fuel, the retail price for adding each additional percentage of biodiesel is estimated to cost 1 to 2 cents more per gallon.

Legislative Actions on Biodiesel

Because of the higher costs for biodiesel, demand for the fuel may be limited unless there are non-financial reasons to use the fuel. Recent emphasis on national energy security has combined with political pressure from environmental and agricultural interests to pressure federal and state governments to support renewable fuels. The US government has proposed several measures, including subsidies within the recent Farm Bill for ethanol and biodiesel production, a more restrictive sulfur emissions mandate which could increase the demand for biodiesel, and the Energy Policy Act of 1992 promoting the use of alternative fuels and alternative fuel vehicles in government agencies. Further incentives to use alternative fuels may also arise out of recent legislation within the current Energy Bill.

Biodiesel state legislation includes a variety of incentives and mandates that favor the fuel. In total there were six mandates, 11 tax incentives, five producer incentives, eight user/distributor incentives and four other state legislative actions, in 21 states. Some of these actions were passed in to law and some will be held over until the next legislative sessions. Illinois is the only state neighboring Indiana that has passed legislation regarding biodiesel. It will be important for legislators in Indiana to consider the positive and negative consequences of legislative action in Indiana relative to actions taken in neighboring states.

US Supply and Demand for Biodiesel

The US demand for biodiesel has been expanding in the past decade. Increased biodiesel production could create new markets for the feedstocks. While it has the potential to decrease US reliance on foreign oil, the constraints and costs of available biodiesel feedstocks will limit the extent of total displacement possible. Depending on the location of biodiesel production plants, local and regional economies with such sites would be impacted by increased demand for the fuel. As biodiesel production expands, it is expected that increased feedstock prices and industry development would have a multiplying affect outwards by providing benefits to a wide range of economic interests.

The following is a summary of some of the key economic factors surrounding biodiesel supply and demand in the US:

- With most development occurring in the past five years, biodiesel production is a relatively new industry within the US.
- Current production costs are substantially higher than diesel fuel. The availability of government production subsidies to encourage growth within the industry may allow the fuel to be more cost competitive with diesel fuel.

- While the majority of biodiesel production relies on soybeans as the primary feedstock, the process can be achieved using an assortment of feedstocks. The quality of feedstocks and production methods can vary depending on several factors.
- Increased demand and production of biodiesel will have a significant impact on markets for other inputs and outputs including feedstocks and glycerin products
- A number of studies have been conducted on the economic impacts of increased biodiesel production. Generally these studies have found that adding biodiesel production would benefit regional economies.
- The biodiesel industry is in a dynamic phase of growth. Many states are contemplating their government's role in supporting the industry in their state.

Results of Economic Analysis of Alternative Indiana Legislation on Biodiesel

The economic analysis of legislative proposals focuses on three potential Indiana-specific policy scenarios:

1) Mandating the blending of 2 percent biodiesel with distillate fuels
2) Subsidizing the cost of blending 2 percent biodiesel to equal the price of diesel
3) Mandating the blending of 2 percent biodiesel with distillate fuels while also including the tax credits from the recently passed Indiana HB 1001.

Each scenario assumes that biodiesel production would be located within the state. The results and analysis focus primarily on the localized impacts to Indiana's economy. Although there would realistically be market activities that cross the state's geographical borders, the analysis assumes that the demand for distillate fuel, biodiesel inputs, and other impacts would be confined to localized areas of Indiana. These limiting assumptions likely result in "best case" scenarios for the measured impacts.

The analysis was conducting using a combination of IMPLAN analysis and a partial equilibrium spreadsheet model. IMPLAN was used to illustrate the potential direct, indirect, and induced impacts to the biodiesel, soybean, and corn industries. IMPLAN also provides an estimate of the impacts on employment from the mandate. The partial equilibrium analysis focuses on the impacts of price changes within the industry and other industry consequences ignored in the IMPLAN analysis. The partial equilibrium analysis also computes the cost to consumers and taxpayers.

The figure at the end of this summary captures the net revenue effects of biodiesel legislation in the state of Indiana. The conclusions from the empirical results are:

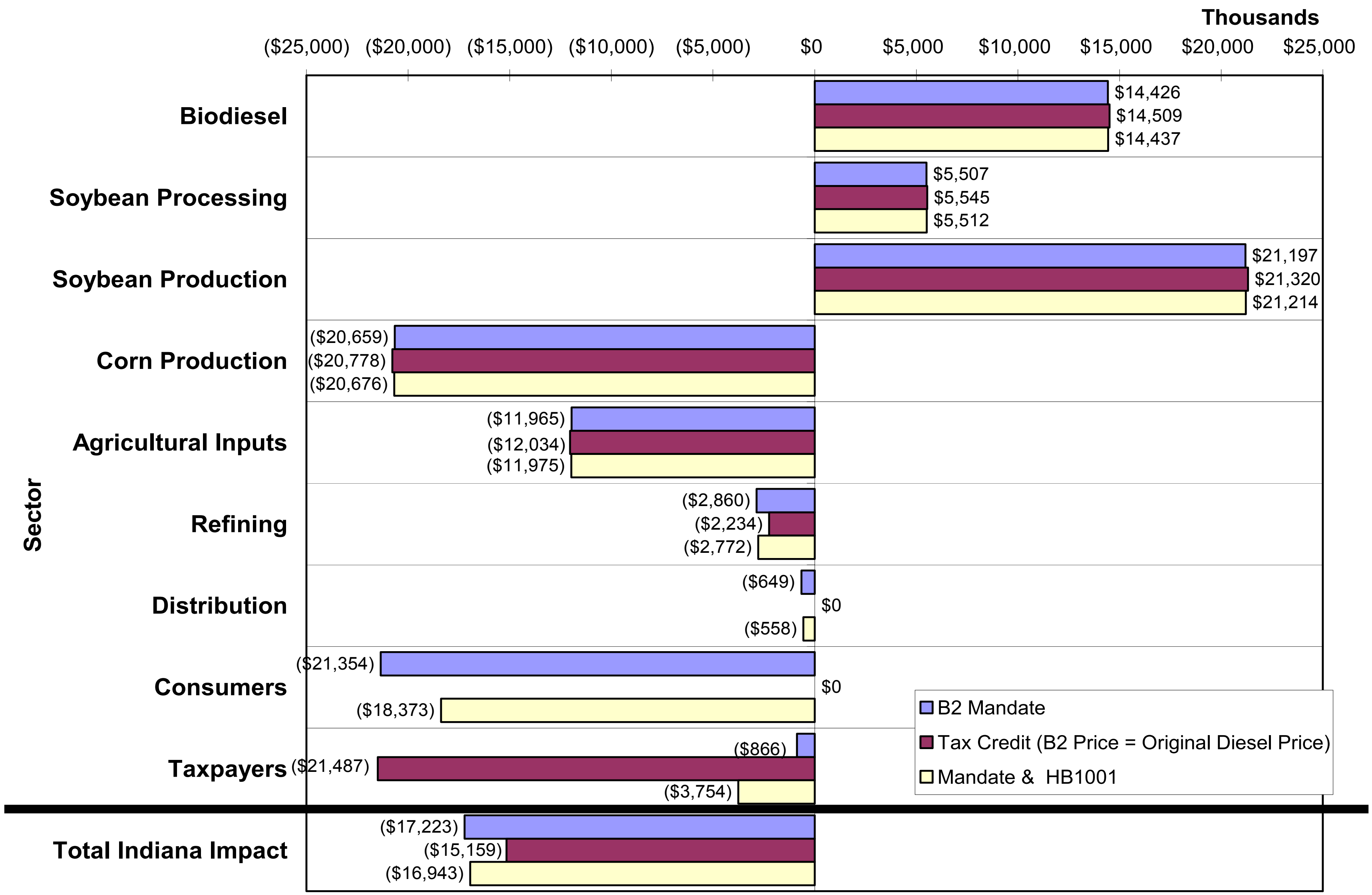
- Indiana uses approximately 1.3 billion gallons of diesel annual
- A 2 percent biodiesel blend would raise pump prices about $0.015 per gallon
- There would be a demand for 27 million gallons of biodiesel to meet a 2 percent mandate resulting in the use of:
    - 197 million pounds of soyoil
    - 18 million bushels of soybeans

- Some of the economic benefits include
  - Net value-added activity of about $13 million annually to the biodiesel and related industries,
  - As many as 133 new jobs created across the impacted sectors of the economy
  - A 3 cent per bushel increase in soybean prices, and
  - Approximately $5.5 million in new net revenue to the soy processing industry in Indiana.
- The total net revenue effects from each of the three legislative proposals, including costs to consumers and taxpayers, is a negative value ranging from a loss of $17.2 million without tax breaks to $15.2 million with tax breaks.
- The subsidy proposal, which has the least negative total net revenue impact, would benefit B2 consumers and the soy industry the most, but the state government, and therefore taxpayers, would end up paying directly for the additional cost of biodiesel.
- The corn production and agricultural input sectors would face decreased total net revenues from each of the proposals as acres of corn were shifted to soybean production.
- The refining sector would be negatively impacted under each policy because of the substitution of biodiesel for distillate fuel and the resulting reduction in consumer demand for diesel fuels.
- The fuel distribution sector would face negative net revenues because of the reduced consumer demand unless the cost of biodiesel was subsidized.
- While taxpayers will face additional burdens under all of the proposals, the impacts from mandating B2, which were derived from the decreased tax revenues due to reduced consumer demand, are significantly less than the costs of subsidizing the additional cost of biodiesel.

This analysis has revealed that the total net revenue effects from the three biodiesel proposals would be negative. While an IMPLAN analysis portrayed that adding biodiesel production could have a range of direct, indirect, and induced effects, the total “value added” may be offset by other industries that are burdened by the increase in fuel prices and shifts to soybean production. Even without these other industry effects, the $13 million in economic value added would not be enough to offset the $21 million in costs to consumers and/or taxpayers.

This analysis does not capture the value of the environmental and performance characteristics of biodiesel as well as the fuel’s renewable nature. Despite the fact that the economic analysis of the three biodiesel initiatives predicts that the total impact on net revenues within Indiana would be negative, $17 million dollars annually is less than 0.01 percent of Indiana’s gross state product of approximately $192 billion based on government figures from 1999. To the extent that environmental benefits are worth more than 0.01 percent of gross state product the biodiesel mandate would be a positive for the state of Indiana. There may also be alternative motivations for encouraging the production and use of biodiesel. It may be that short-term industry subsidization is justified to entice in-state production of biodiesel necessary to meet the increased demand for biodiesel when the new federal sulfur emissions standards are implemented in 2006.

Net Revenue Impacts of Alternative Biodiesel Legislation for Indiana



Blank for duplication.

Table of Contents

List of Tables

List of Figures

Blank for duplication.

Chapter 1. Introduction

Primary Author: Kyle Althoff and Allan Gray

Biodiesel is a chemically derived renewable fuel created primarily from plant oils or animal fats for use as a substitute for diesel. During production the feedstock is separated through transesterification into liquid methyl ester compounds (biodiesel) and glycerin byproducts. Biodiesel is then shipped to distributors and supplied to customers as pure biodiesel (B100) or as a blended diesel mix (typically B2 – B20) for use in powering trucks, boats, tractors, cars and other vehicles with diesel engines.[1]

The performance of biodiesel is distinguished from regular diesel in several ways. Biodiesel benefits include lower emissions of carbon monoxide, unburned hydrocarbons, sulfates and particulate matter while also increasing the lubricity within an engine. Some of the drawbacks to biodiesel include the potential of the fuel to increase nitrous oxide emissions, possible cold-flow problems, and a lower BTU output per gallon in contrast to diesel.[2, 33]

Despite some of its performance shortcomings, the production of biodiesel in the US has risen dramatically from 1 million gallons in 1999 to 25 million gallons in 2002. With up to 80 percent of the production costs resulting from feedstock expenses, the high costs of inputs has constrained the growth of demand for the fuel. The cost for feedstocks, which can include soybeans, mustard, canola oil, yellow grease, and animal fats, has caused the production costs of pure biodiesel to range from $1.39 to $2.52 per gallon. The higher production expenses are transferred to consumers who pay on average between $1.00 and $1.50 more per gallon at the pump for pure biodiesel compared to diesel fuel.[4] When mixed with petroleum-based diesel fuel, the retail price for adding each additional percentage of biodiesel is estimated to cost 1to 2 cents more per gallon.

Because of the higher costs for biodiesel, demand for the fuel may be limited unless there are non-financial reasons to use the fuel. Recent emphasis on national energy security has combined with political pressure from environmental and agricultural interests to pressure federal and state governments to support renewable fuels. The US government has proposed several measures, including subsidies within the recent Farm Bill for ethanol and biodiesel production, and a more restrictive sulfur emissions mandate which could increase the demand for biodiesel. Further incentives to use alternative fuels may also arise out of recent legislation within the current Energy Bill.

---

[1] Pure biodiesel fuel (100% derived from renewable oil) is commonly referred to as *neat biodiesel.* Biodiesel blend designations are based upon the proportion of pure biodiesel within the biodiesel-diesel fuel mixture (e.g. B20 contains a mixture of 20% biodiesel fuel with the other 80% comprised of petroleum diesel fuel).

[2] "Biodiesel Emissions." National Biodiesel Board.

[3] "Biodiesel Performance." National Biodiesel Board.

[4] Coltrain, David. Biodiesel: Is It Worth Considering?

Combining these federal policies with complementary state legislation may position the work for rapid growth. For example, Minnesota recently passed legislation that would require most of the diesel fuel consumed within the state to contain 2 percent biodiesel provided certain provisions are met. Several other state legislatures are trying to address the benefits and costs imposed by potential biodiesel initiatives. Evaluating the economic consequences for legislation supporting biodiesel can provide a better understanding of the potential effects the policy may have on related industries, consumers and government finances.

A. Objectives

The objective of this project is to assist the Indiana Soybean Board in understanding the economic consequences that potential legislative proposals to encourage biodiesel consumption could impose upon the diesel, agricultural, and other biodiesel-related markets. Increased biodiesel use and the potential for in-state production of this alternative fuel would alter the current demand for petroleum-based fuels and the prices for biodiesel feedstocks. The economic consequences from such increases could ultimately reshape Indiana's diesel fuel and agricultural markets, the region's petroleum industry, and other biodiesel-related markets. Further consideration will be given to the impacts such legislation would have on Indiana consumers and the state government.

The specific objectives for this study include the following:

1) Catalogue the various state initiatives regarding alternative fuels, particularly biodiesel, in terms of legislation that promotes or mandates the production and/or use of alternative fuels.

2) Estimate the economic impact of an Indiana state legislative mandate to incorporate a minimum percent biodiesel blend into all commercially sold diesels.

3) Estimate the economic effect of Indiana state legislation providing tax credits for biodiesel in Indiana, as outlined in Indiana, HB1001 (May 2003).

4) Estimate the economic impact of Indiana state legislation providing a tax reduction to consumer prices at the point of purchase that would offset the incremental cost for adding biodiesel to diesel.

Increased consumption of biodiesel within the state will have several economic effects. By analyzing a variety of potential state legislative initiatives, the project will depict the consequences that could result from each proposal.

B. Data and Methodology

To examine the consequences of increased biodiesel consumption, the appropriate demand and supply estimates will have to be calculated for diesel fuel, biodiesel fuel, and biodiesel feedstocks. Using partial equilibrium and IMPLAN modeling, the project will assess the implications of specific legislative proposals including effects on diesel consumers, state governmental resources, local soybean prices and volumes, as well as other interrelated markets. Potential Indiana legislation that would increase demand for biodiesel and/or encourage in-state production of the fuel will impact each of these markets in a significant manner.

Data will be collected from sources that include the United States Department of Energy and the Federal Highway Administration to determine prices, consumption, and demand elasticities for diesel fuel markets. Recent estimates from the United States Department of Agriculture (USDA) on the production and consumption of soybeans within the state of Indiana will be utilized along with a United Soybean Board forecasting model. Additional research into the emerging markets and prices for biodiesel within the US, including the impacts of subsidies on the markets, will also be necessary for the project. Throughout the analysis, the goal will be to estimate the impacts from potential legislative proposals using the most accurate data available. Although reliable biodiesel price and consumption figures are not readily accessible due to the emerging nature of the industry, there are several estimates and testimonies from consumers and researchers that will prove useful in determining the relevant data for the fuel.

Using the information collected, the project will proceed by developing a partial equilibrium model that can be utilized for each legislative proposal to predict the potential impacts on the various markets. By calculating the projected demand for biodiesel under the specific legislative proposals, the impacts for on-highway fuel, soybeans, biodiesel, and soy mills can be determined. The resulting models will provide estimates of the effects such legislation could have on Indiana consumers, farmers, governmental finances, and other biodiesel-related markets.

C. Report Structure

This report has been structured to first provide a description of the main drivers for the emerging biodiesel industry within the US. The renewable fuel's environmental and performance characteristics have combined with recent legislation at both the federal and state levels to spur dramatic growth in the demand for biodiesel over the past five years. The report will proceed by examining both the demand and supply components that have shaped the industry as it has proceeded through such rapid growth. These chapters will provide the background for the economic analysis of potential Indiana legislation presented in Chapter 5. As the industry continues to develop, it is important to comprehend the interrelated impacts that can arise throughout the economy from legislation to support biodiesel. The following paragraphs provide a more detailed depiction on the contents of the upcoming chapters.

<u>Chapter 2. Environmental Features and Performance Characteristics of Biodiesel</u> provides essential background into the functional attributes of the fuel. As a renewable fuel, biodiesel maintains several environmental and performances characteristics that distinguish the fuel from petroleum-based diesel.

Chapter 3. Legislative and Regulatory Review will review the federal and state policies that impact biodiesel. National regulations and legislation have included policies based on health and environmental effects, energy policy, and the expansion of agricultural markets. In addition state initiatives throughout the US have supported biodiesel; Chapter 3 will catalogue the various state initiatives for biodiesel.

Chapter 4. Economics of the Biodiesel Industry will be an assessment of the current market structure for biodiesel. It reviews both the demand and supply components that have been integral to shaping the current markets for the fuel. This chapter will also provide an overview of the constraints faced within the industry in terms of the alternative feedstocks, the production process, and other factors that impact the supply and demand of biodiesel.

Chapter 5. Economic Analysis of Alternative Biodiesel Legislation in Indiana, presents the analysis of selected legislative initiatives that could be introduced to support biodiesel. The chapter begins with a theoretical assessment of the impacts of a mandate and a tax incentive. The IMPLAN software is then used to give an initial assessment of the impact of a mandate on economic activity and employment within the state. Finally, a partial equilibrium model is used to address some of the shortcomings of IMPLAN to estimate the impacts of three legislative proposals on nine specific segments of the Indiana economy: biodiesel, soy processing, soybean production, corn production, agricultural inputs, diesel refining, fuel distribution, consumers, and taxpayers.

Chapter 2. Environmental Features and Performance Characteristics of Biodiesel

Primary Author: Kyle Althoff

Although biodiesel is a comparable substitute to petroleum diesel, biodiesel's distinctive chemical structure and renewable separates the fuel from its diesel counterpart. Additional information beyond the standard economics of diesel fuel will be helpful to comprehend the potential impacts of legislative proposals concerning biodiesel. This chapter will identify the environmental features and performance characteristics of biodiesel by including both the benefits and drawbacks that occur from the production, distribution and consumption of biodiesel. The pricing of biodiesel will be expanded on in Chapter 3. From an environmental context, biodiesel emission levels deviate significantly from those of petroleum diesel which creates both positive and negative consequences. In terms of performance, biodiesel has several distinct qualities that create a safer, more lubricious fuel than diesel. However, it can also require additional distribution infrastructure and equipment alterations to make optimal use of the renewable fuel. By examining biodiesel's emissions and performance the role these aspects as a primary driver of demand for the renewable fuel can be revealed.

A. Environmental Features of Biodiesel

The most prominent advantages to using biodiesel are the decreased levels of harmful emissions. In its pure form, biodiesel eliminates sulfur exhaust emissions.[5] This feature could become a principle stimulus for adoption as a lower mandate for sulfur emissions is enacted within the US for on-highway diesel engines starting in 2006. Blended with diesel at a low rate, biodiesel may offer a cost-competitive solution to meet this standard due to its reduction of sulfur emissions. While combustion of biodiesel produces significant decreases in the emission of sulfur oxides (SOx), it also leads to reductions in particulate matter (PM), hydrocarbons (HC), and carbon monoxide (CO) emissions. However, biodiesel combustion may also increase the tailpipe emissions of carbon dioxide (CO_2) and nitrogen oxides (NOx) in comparison to petroleum diesel fuel.

Before examining the affect of the sulfur mandate and biodiesel emissions research, a brief outline of research on the environmental features will be presented. Following the outline, biodiesel's sulfur emissions and the upcoming mandate on sulfur content in diesel fuel will be discussed in an effort to expose the potential impact the policy could have on future biodiesel demand. After describing the sulfur mandate, the related emissions data for PM, NOx, HC, CO and CO_2 from the outlined research studies will be compared and contrasted. Biodiesel's other ecological properties will also be touched on briefly. The statistics will attempt to illustrate the potential environmental consequences from biodiesel as well as indicate their influences upon demand for the fuel.

[5] Benefits of Biodiesel. National Biodiesel Board.

Introduction to Emissions Research

Although several studies have been conducted relating to the lower emissions levels from biodiesel, one of the most comprehensive, The Life Cycles Inventory of Biodiesel and Petroleum Diesel for Use in an Urban Bus, was completed by the National Renewable Energy Laboratory (NREL) in May 1998. While relying upon that study, emissions data and comparisons will be illustrated with supplemental assistance from other research. The National Biodiesel Board (NBB), a trade association for biodiesel, recently sponsored the testing of B100 for Tier 1 and Tier 2 of the Clean Air Act.[6] The information from that earlier testing along with the latest draft technical report from the US Environmental Protection Agency (EPA) titled A Comprehensive Analysis of Biodiesel Impacts on Exhaust Emissions will be contrasted with the results from the NREL study. The emissions data from each of these reports will provide a basis for this review on the potential air quality consequences from biodiesel use.[7]

The NREL study focused on the complete "life cycle" of emissions which involves an analysis of the net energy and emissions created during the entire process starting from the initial feedstock production and continuing through to the tailpipe emissions. The research also depicted the difference between net emissions that occurred from the entire life-cycle of the fuel and the emissions results that occurred only from the engine combustion of biodiesel fuel. The study was conducted using the engine emissions from an urban transport bus and the authors stressed that other engine models could create different emissions results. The NREL study also provided a comparison between pure biodiesel and potential biodiesel blends and found most emission changes to be proportional with the percent of biodiesel in the blend. It should be noted however that recent estimates from the EPA indicate that the soybean-based biodiesel used within this study may have higher concentrations of emissions in comparison to biodiesel derived from animal fats.[8]

In October 2002 the EPA released the report A Comprehensive Analysis of Biodiesel Impacts on Exhaust Emissions for public review and reference. The report provides insight on the average tailpipe emissions expected from different types of diesel and biodiesel fuels. Biodiesel fuel derived from soybean, rapeseed, and animal fats was tested and evaluated based primarily on the emissions from heavy-duty highway engines.[9] The EPA report also tested several mixtures of soybean-based B20 blends. Although the overall analysis did not attempt to consider the life cycle releases like the NREL study, the document does provide the most recent estimate of biodiesel tailpipe emissions and average fuel properties.

The EPA report revealed that emissions from the use of biodiesel provided even more benefits at B20 blend levels than initially estimated in the NREL report and other research. The reason behind this discovery was that previous studies relied upon a linear relationship between the percent of biodiesel combusted and the decrease in emissions

[6] "Fact Sheet." Clean Cities Alternative Fuel Information Series.
[7] A Comprehensive Analysis of Biodiesel Impacts on Exhaust Emissions – Draft Technical Report. EPA.
[8] A Comprehensive Analysis of Biodiesel Impacts on Exhaust Emissions – Draft Technical Report. EPA.
[9] A Comprehensive Analysis of Biodiesel Impacts on Exhaust Emissions – Draft Technical Report. EPA.

expected. The report, however, illustrated that there is a greater incremental benefit at lower blends than at higher blends of biodiesel.[10]

Sulfur Emissions

Sulfur emissions from diesel fuels such as sulfur oxides and sulfates are contributing factors to the formation of acid rain.[11] The results from the Tier 1 Health and Environmental Effects testing for biodiesel revealed that biodiesel in its pure form "completely eliminated" the emissions of sulfur oxides and sulfates from the engine exhaust.[12] The sulfur content within biodiesel is typically below 15 parts per million (ppm).[13] Consequently, fuel mixtures of biodiesel with other diesel fuels produce sulfur emissions dependent upon the percent of biodiesel within the blend and the sulfur content of the original diesel fuel. While the tailpipe emissions of B100 release zero sulfur discharges, the production process to create the fuel has been found to release more emissions than the diesel production process due to the higher levels of electricity required.[14] However, the NREL study revealed that the net life cycle sulfur emissions were found to decrease 8.03 percent for B100 and 1.61 percent for B20 blends.

Sulfur Emissions Standard

One of the most significant factors that could affect the demand for biodiesel in the next decade will be the commencement of a Federal mandate in 2006 to lower the sulfur levels in distillate fuels. The mandate, which will be explained in more detail within the next chapter, reduces the allowable sulfur content in fuel from 500 ppm to 15 ppm. Although the policy will have a staggered implementation schedule, the initial phase begins in June 2006.[15] In April 2003, the EPA also released plans to enact stricter standards for off-road vehicles, which includes agricultural and construction equipment, starting in 2008.[16] The NREL study remarked that the expected sulfur mandate regulates the sulfur content of the actual fuel combusted. The upcoming mandates are expected to require changes in diesel engines, exhaust systems and/or fuel composition.

As the mandate on the sulfur content in diesel fuel approaches, many refineries will be researching and investing in methods to reduce the overall sulfur levels within their fuels.[17] One problem that has arisen, however, is that ultra-low-sulfur diesel (ULSD) fuels tend to have lower lubricity characteristics than regular diesel fuel (e.g. No. 2 diesel).[18] The lubricity properties for diesel fuels are an integral measure of the overall impact the fuel has upon engine wear. Lower values of lubricity, typically associated with

---

[10] "EPA Releases Comprehensive Study on Biodiesel Emissions." National Biodiesel Board.
[11] "Benefits of Biodiesel." National Biodiesel Board.
[12] "Benefits of Biodiesel." National Biodiesel Board.
[13] "Biodiesel Handling and Use Guidelines." National Renewable Energy Laboratory.
[14] "Life Cycle Inventory of Biodiesel and Petroleum Diesel for Use in an Urban Bus." NREL.
[15] "EPA Gives the Green Light on Diesel-Sulfur Rule." Environmental News.
[16] "Bush Administration Proposes Dramatic Reductions of Pollution from Nonroad Diesel Engines." Environmental News.
[17] "New Diesel Fuels: They Are in Your Future for Nonroad Equipment." Association of Equipment Manufacturers.
[18] "What are Biodiesel's Advantages?" Mechanical Engineering Department. Iowa State University.

ultra-low-sulfur diesel fuel, have been shown to increase engine wear.[19] Additionally, estimates from the Department of Energy and the American Petroleum Institute predict that the incremental costs of producing ULSD to meet the mandate could range between $0.047 and $0.13 per gallon.[20] Other studies from the EPA and the American Petroleum Institute have found the associated costs to be $0.045 to $0.05 per gallon and $0.078 to $0.106 per gallon, respectively.[21]

Blending low levels of biodiesel with the reduced-sulfur fuels would increase the lubricity of the fuel which would lead to a potential decrease in engine wear. Because biodiesel does not create sulfur emissions, the mixture of biodiesel with the low sulfur fuels would not increase the total sulfur content within the fuel. Thus, biodiesel could become a substitute or mixture for future diesel fuels which would allow the fuel to meet the sulfur mandates in 2006 while still retaining the necessary lubricity to protect engines. The decision to blend biodiesel into the fuel will likely be dependent on competing lubricity additives and their respective benefits and costs.[22]

Although the reduction in sulfur emissions could be the main motivation for biodiesel demand in the future, several other regulated emissions from the renewable fuel vary significantly from their respective values in petroleum diesel fuel. The next sections will illustrate both the changes in the emissions including PM, NOx, HC, CO, and CO_2 as well as the overall lifecycle releases of these compounds when substituting biodiesel for diesel fuel.

Particulate Matter (PM) Emissions

Along with nitrogen oxides (NOx) and sulfur, particulate matter emissions are one of the principle regulated emissions from diesel engines. Particulate matter contributes to the black exhaust smoke noticed from diesel tailpipes and has been recognized as a factor in respiratory disease.[23] The EPA analysis concluded that the average decrease in PM tailpipe emissions was 47 percent for B100 and 12 percent for the soybean-derived B20.[24] In the NREL study, the tailpipe emissions from B100 were measured to be 68 percent less. The NREL study also found that total particulate matter decreased based on the proportion of biodiesel fuel within the fuel blends. The B100 fuel resulted in net life cycle releases of particulate matter that declined 32.41 percent when compared to conventional diesel fuel. This decrease was attributed directly to the decreased particulate matter released during engine combustion.[25]

---

[19] "What are Biodiesel's Advantages?" Mechanical Engineering Department. Iowa State University.
[20] "New Diesel Fuels: They Are in Your Future for Nonroad Equipment." Association of Equipment Manufacturers.
[21] Tiffany, Douglas G. "Biodiesel: A Policy Choice for Minnesota."
[22] Tiffany, Douglas G. "Biodiesel: A Policy Choice for Minnesota."
[23] "Benefits of Biodiesel." National Biodiesel Board.
[24] "EPA Releases Comprehensive Study on Biodiesel Emissions." National Biodiesel Board.
[25] Life Cycle Inventory of Biodiesel and Petroleum Diesel for Use in an Urban Bus. NREL.

Hydrocarbon (HC) Emissions

Hydrocarbons, nitrogen oxides and carbon monoxide are primary contributors to smog and ozone problems in urban areas.[26] The EPA technical analysis revealed that hydrocarbon tailpipe emissions were reduced by 67 percent using B100 and 20 percent using a B20 blend.[27] Although it differs from the EPA's guidelines, the NREL study evaluated the total hydrocarbon emissions (THC) which included methane, benzene, formaldehyde, and other hydrocarbons. While the results indicated that tailpipe emissions of THC decreased by 35 percent, the lifecycle analysis predicted a 35 percent increase in the total releases due to emissions that occur during the soybean crushing process. The NREL study alluded to the fact that the overall localized impacts of hydrocarbon emissions would thus depend upon the relative proximity of the soybean crushing processes to urban areas that typically struggle with smog problems.[28]

Nitrogen Oxides (NOx) Emissions

As a primary precursor to smog, nitrogen oxide (NOx) emissions have placed an encumbrance on the overall acceptance of biodiesel. The EPA report estimated the NOx emissions increased by 10 percent for the average B100 and 2 percent for soybean-derived B20 blends.[29] The NREL study conveyed similar estimates with the B100 results predicting an increase of NOx tailpipe emissions by 8.89 percent. Taking into consideration the complete life cycle analysis, the NREL study also concluded that the NOx emissions would rise for both B100 and B20 respectively by 13 percent and 2.67 percent. One of the proposed reasons for the increase in NOx emissions stems from biodiesel's altered chemical composition compared to petroleum diesel. The fuel's lower compressibility may combine with its higher cetane number to cause advancement in ignition timing within the engine. Researchers at the Iowa State University have predicted that adjusting the engine injection timing for different fuel mixtures as well as increasing the cetane number of the biodiesel may prevent the increase in NOx emissions. However, the costs associated with such measures may prove to be higher than the additional benefits provided. [30] Controlling NOx emissions will likely be a major challenge for the biodiesel industry as EPA regulations for NOx continue to tighten and demand for the fuel grows.

Carbon Monoxide (CO) Emissions

Carbon monoxide (CO) is a contributor to the creation of smog and ozone.[31] Carbon monoxide (CO) emissions within the EPA analysis were found to be reduced by 48 percent in the B100 fuels tested and 11 percent in the soybean-derived B20 fuels.[32] The NREL concluded that tailpipe emissions from biodiesel were reduced by 46 percent. The net life cycle emissions in the NREL study decreased by about 34.5 percent from using B100 and were lowered by 6.9 percent for B20 when compared to petroleum diesel.

---

[26] "Life Cycle Inventory of Biodiesel and Petroleum Diesel for Use in an Urban Bus:" 25 NREL.
[27] "EPA Releases Comprehensive Study on Biodiesel Emissions." National Biodiesel Board.
[28] "Life Cycle Inventory of Biodiesel and Petroleum Diesel for Use in an Urban Bus:" 23-25. NREL.
[29] "EPA Releases Comprehensive Study on Biodiesel Emissions." National Biodiesel Board.
[30] Van Gerpen, Jon H. "Biodiesel Blend Sensing."
[31] "Benefits of Biodiesel." National Biodiesel Board.
[32] "EPA Releases Comprehensive Study on Biodiesel Emissions." National Biodiesel Board.

With several non-attainment urban areas throughout the US struggling to control their CO air quality standards, the NREL study concluded that biodiesel could prove to be an "effective tool" for meeting the restrictions.[33] However, Dr. Robert McCormick from the NREL's Center for Transportation Technologies and Systems department noted that gasoline contributes considerably more to air quality concerns in terms of CO emissions than petroleum diesel.[34]

Carbon Dioxide (CO_2) Emissions

Carbon dioxide (CO_2) is recognized by the EPA as a greenhouse gas that could contribute to global warming.[35] The EPA's biodiesel report was "not able to identify an unambiguous difference in exhaust CO_2 emissions between biodiesel and conventional diesel."[36] Alternatively, the NREL study found CO_2 tailpipe emissions increased by 4.7 percent for the B100 blend.

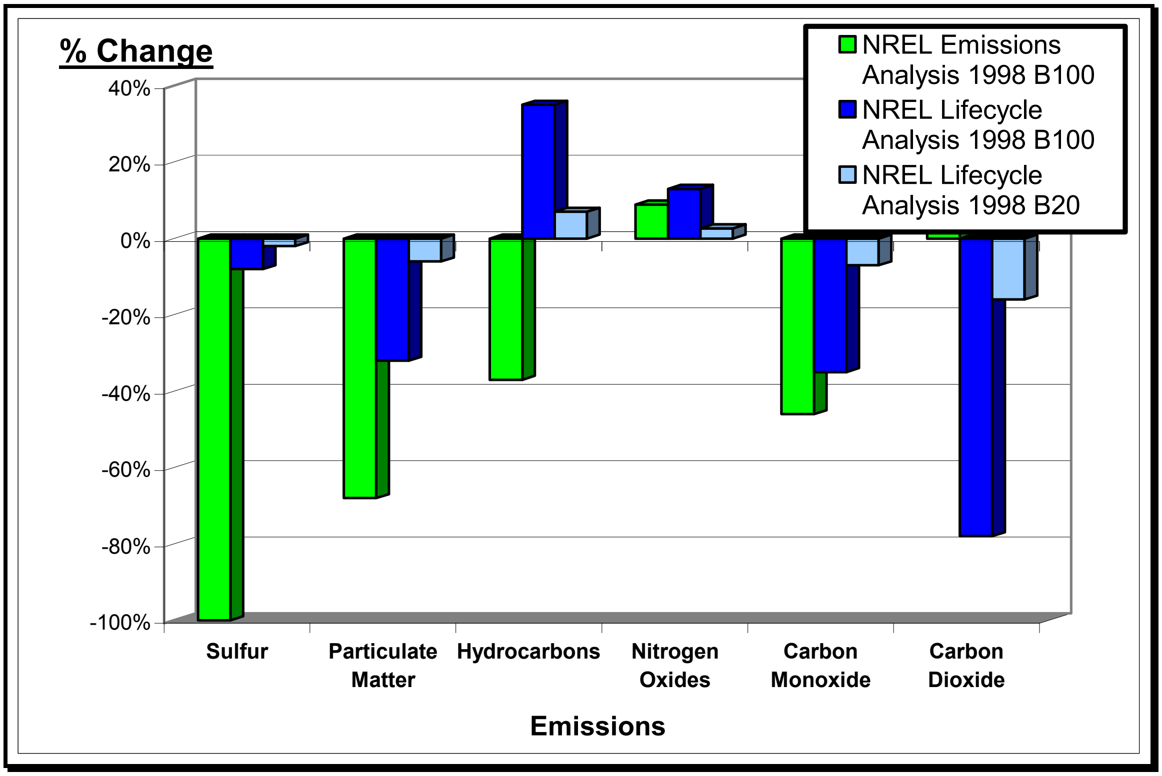
The NREL study also concluded that the net life cycle CO_2 emissions decreased 78.45 percent using B100 and by 15.66 percent using B20 in comparison to conventional diesel fuel. In determining these life cycle estimates, the NREL focused on the closed carbon cycle involved in the biodiesel production. The CO_2 tailpipe emissions from biodiesel were considered to be converted by soybean plants and recycled throughout the production process. In comparison, although the CO_2 emissions from petroleum diesel fuel could also be converted via soybean plants, the combustion of fossil fuels was assessed as an expedited conversion of stored carbon into the atmosphere which would take millions of years to be reconverted back into its original form. The study concluded that the total net CO_2 levels within the atmosphere would thus be reduced for the biodiesel life cycle when compared to the conversion of fossil fuels. Beyond that conclusion, the overall effect from the CO_2 emission changes has been concluded to be relatively minor and some researchers have claimed it "should not be overemphasized."[37]

The following charts depict the emissions results described earlier from the EPA's Draft Technical Analysis and the NREL's Life Cycle Inventory of Biodiesel. Figure 2.1 illustrates the estimates of emissions changes between the NREL's life cycle analysis for B100 and B20 blends as well as the emissions produced strictly from the tailpipe using B100 in an urban bus. Figure 2.2 offers a comparison between the tailpipe emissions from the NREL's B100 predictions and the EPA's Draft Technical Report results for its average B100 and soybean-derived B20 blends.

---

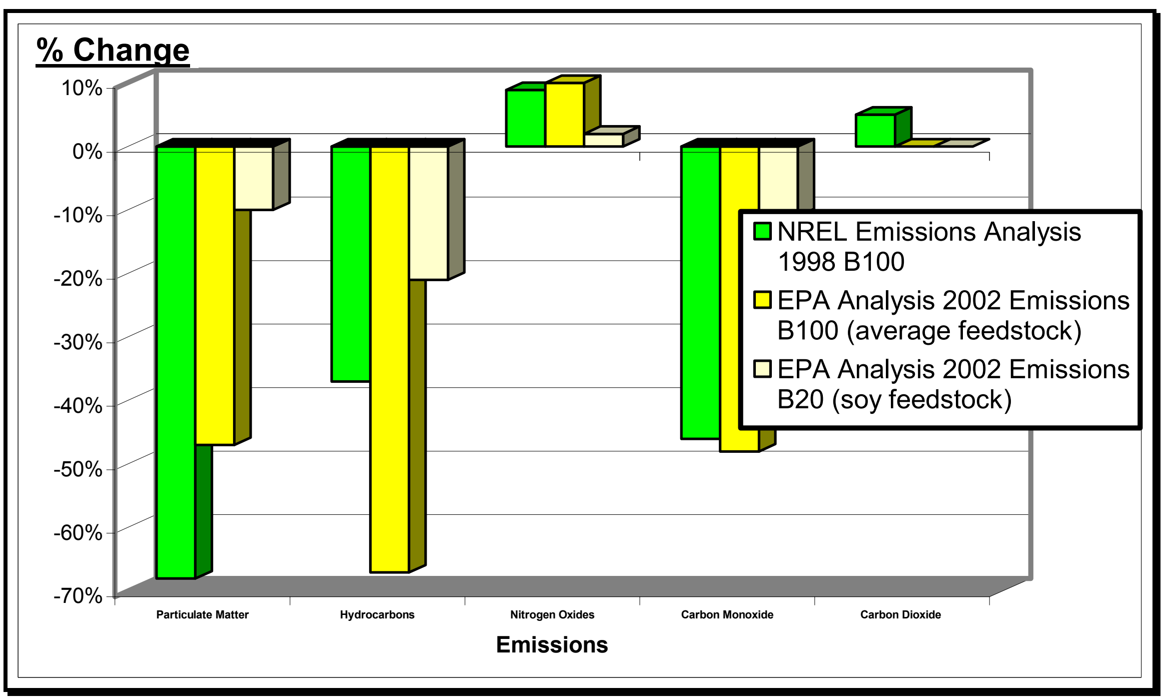
[33] "Life Cycle Inventory of Biodiesel and Petroleum Diesel for Use in an Urban Bus:" 23-25. NREL.
[34] McCormick, Robert. "Re: Biodiesel emissions."
[35] "Global Warming - Climate." EPA.
[36] "A Comprehensive Analysis of Biodiesel Impacts on Exhaust Emissions – Draft Technical Report:" iii. EPA.
[37] "What is Biodiesel?" Mechanical Engineering Department. Iowa State University.

Figure 2.1 Change in Biodiesel Emissions Compared to Diesel Fuel Emissions.



Source: Life Cycle Inventory of Biodiesel and Petroleum Diesel for Use in an Urban Bus

Figure 2.2 Change in Biodiesel Tailpipe Emissions Compared to Diesel Fuel.



Sources: "Life Cycle Inventory of Biodiesel and Petroleum Diesel for Use in an Urban Bus," 1998, and "A Comprehensive Analysis of Biodiesel Impacts on Exhaust Emissions - Draft Technical Report," 2002

Other Ecological Features of Biodiesel

The Office of Transportation Technologies (OTT), Department of Energy, has cited emission values similar to NREL's tailpipe emissions data for biodiesel. The OTT has also noted that biodiesel "can reduce the carcinogenic properties of diesel fuel by 94 percent."[38] The Tier 1 testing by the NBB for the Clean Air Act Amendments revealed that the mutagenicity properties, the propensity to cause mutations within mammals, were significantly lower for biodiesel.[39] Research conducted by other entities has also referenced the reduction of harmful aromatics from biodiesel as an increased health benefit from the fuel.[40]

While its emissions benefits alone are notable, biodiesel's chemical properties also tend to make the fuel safer than petroleum-based fuels. The National Biodiesel Boards lists several environmental measures including acute oral toxicity, skin irritation in humans, aquatic toxicity, and biodegradability which highlight the safety properties for the fuel.[41] Compared with the respective properties for petroleum diesel, each of these safety and health factors becomes integral to the product's overall value especially when considered throughout the fuel supply chain.

The most prominent of these factors could likely be biodiesel's biodegradability properties. Pure biodiesel has been tested and proven to decompose up to 88 percent in a 28 day timeframe, four times faster than regular diesel fuel. Furthermore, blends of biodiesel and diesel tend to dissolve faster than regular diesel.[42] Thus, stationary and transport fuel tanks which contain pure or partial mixes of biodiesel fuel would pose a decreased environmental risk in contrast to conventional diesel fuel if a spill or leak occurred.

The NREL's life cycle study also emphasized the net energy produced from the life cycles of different fuel products. Throughout the complete life cycle, pure biodiesel generates "3.2 units of fuel product energy for every unit of fossil energy consumed."[43] In comparison, "B20 yields 0.98 units of fuel product energy for every unit of fossil energy consumed," and petroleum diesel generates 0.83 units. Consequently, the NREL report concluded that pure biodiesel fits the renewable classification with its net energy value above regular diesel. Another distinction can be made for net energy values using corn-based ethanol, which has been reported to have a net energy ratio of 1.24 in its pure form.[44] Considerable debate has occurred over the net energy ratio and the relative value of ethanol fuel in comparison to its substitute petroleum-based gasoline. Such debate could have restricted the historical demand and governmental support for ethanol. While both ethanol and biodiesel exhibit net energy ratios greater than one, biodiesel's energy ratio of 3.2 is significantly greater than ethanol. Thus, it could be more likely that the debate over biodiesel's net energy balance would not be as intense.

---

[38] "Just the Basics: Biodiesel." Transportation for the 21st Century.
[39] "Benefits of Biodiesel." National Biodiesel Board.
[40] Williamson, Dave. "Biodiesel in Berkeley."
[41] "Environmental & Safety Information." National Biodiesel Board.
[42] "Environmental & Safety Information." National Biodiesel Board.
[43] "Life Cycle Inventory of Biodiesel and Petroleum Diesel for Use in an Urban Bus:" v. NREL.
[44] Manning, P., Popp, and Cochran. Biodiesel:"Potential and Possibilities for the Arkansas Economy."

From emission standards to energy ratios, biodiesel has been proven to be an environmentally-beneficial fuel. Biodiesel has several chemical properties that promote the fuel's safety and stability. Because of such benefits, several sources have suggested marketing and distributing biodiesel in environmentally sensitive areas including waterways, non-attainment air quality regions, and national parks. The fuel is also considered to be an improved substitute in areas where humans are prone to inhaling higher levels of fuel emissions or suffer health problems from air quality. Combined with the performance enhancements from the fuel, biodiesel has several properties that contribute to the demand for the fuel as an alternative or additive to petroleum diesel.

In summary, the emissions tests from biodiesel reveal that tailpipe emissions of sulfur, particulate matter, hydrocarbons, and carbon monoxide all decrease while nitrogen oxides increase and carbon dioxide remains relatively unchanged when compared to petroleum diesel. If the net life cycle values are considered, the aggregate discharges from the entire production processes reveal that some values such as carbon dioxide decrease while others such as hydrocarbons increase. Biodiesel also reduces air toxics, aromatics, and mutagenicity effects in comparison to conventional petroleum diesel. Biodiesel is more biodegradable and has a substantial net energy gain in regards to diesel fuel which should aid in the promotion of the fuel.

As the push for renewable fuels and cleaner-burning engines continues, these features will combine to induce the demand for biodiesel within the US. Although each of these factors is important from an environmental perspective, the upcoming sulfur mandate and the ability to control or reduce NOx emissions from biodiesel will likely have the largest impacts on the future demand for the fuel.

B. Performance Characteristics of Biodiesel

Biodiesel's chemical composition and biological origin create some unique consequences for users and distributors of the fuel. Although the renewable fuel is a comparable substitute for petroleum diesel within diesel engines, biodiesel maintains several distinct attributes that are reflected in the fuel's performance. The focus of this section is to describe some of the performance characteristics. While there are several advantages attached to biodiesel's performance attributes, there are also some properties that require additional equipment and costs to handle the fuel. The tradeoffs associated with these performance characteristics will affect both distributors' and consumers' demand for biodiesel.

Handling Characteristics

This section will analyze some of the distribution and handling issues associated with biodiesel. The fuel has distinct chemical properties in contrast to diesel that may require changes to storage and transportation practices. Biodiesel can be integrated into the current distribution and retail facilities with fewer equipment conversions than most other diesel fuel alternatives. The fuel can be distributed in its pure or blended form depending on the consumer demand for the various blends as well as logistics involved in the mixture of biodiesel. However, the renewable nature of the fuel has created some concerns about the long term stability of biodiesel.

Blending and Storage

Biodiesel requires similar storage, handling and operation procedures as regular diesel fuel with some exceptions. Current distributors and retailers typically rely on the same facilities including storage tanks and pipes for biodiesel fuel as were previously used for petroleum diesel. Nevertheless, vehicle users and storage facilities must be informed and prepared for cold flow problems as well as biological growth that can occur within biodiesel fuel tanks.[45]

Splash blending is utilized as a procedure to mix biodiesel with regular diesel fuel. Biodiesel, which has a specific gravity of 0.88, is typically added to the top of a tank of diesel fuel (specific gravity of 0.85) to prepare a blend.[46] Each batch of fuel thus has its own specific qualities based on the properties and proportions of biodiesel and diesel fuel in the mix. Minimum blending temperature recommendations for the fuel have also been prescribed.[47] Depending on demand for specific blends (B2-B100), suppliers of the fuel may need to maintain more than just one specific blend of fuel. This can create an increased cost for mixing and storing the fuel blends.

Stability

Biodiesel's long-term stability also presents problems for the storage of the fuel. There is general concern within the biodiesel industry about the fuel's extended storage capabilities due to the potential for water contamination, bacterial growth, and oxidative difficulties.[48] Most recommendations assert that biodiesel or blends of biodiesel should not be stored for more than six months in storage facilities or vehicle tanks.[49] The fuel's higher oxygenate value contributes to an expedited breakdown of the fuel in comparison to diesel fuel. This could result in the development of residues and varnishes that would cause plugging or failure of pumps, filters, and injectors.[50] Additives can be supplemented to biodiesel to reduce such problems but this introduces an additional cost for the fuel.

Interrelated Handling and Engine Performance Characteristics

Several performance issues affect both the handling and engine operating performance of biodiesel. Cold flow, solvency, and flashpoint characteristics are all properties that create additional burdens for distributors and consumers of the fuel. This section will describe these characteristics while also providing insight on how some users have found solutions for dealing with the cold flow and solvency problems that arise.

---

[45] "Biodiesel Handling and Use Guidelines:" 11. National Renewable Energy Laboratory.
[46] "Biodiesel Handling and Use Guidelines." National Renewable Energy Laboratory.
[47] "Biodiesel Handling and Use Guidelines:" 8. National Renewable Energy Laboratory.
[48] "Fuel Stability." Mechanical Engineering Department. Iowa State University.
[49] Howell, Steve. "Rigorous Standards Ensure Biodiesel Performance."
[50] "New Diesel Fuels: They are in Your Future for Nonroad Equipment." Association of Equipment Manufacturers.

Cold Flow

The demand for biodiesel has been constrained by concerns about the fuel's cold flow potential. Petroleum diesel and biodiesel will begin to gel, or solidify, at low temperatures in the absence of special fuels, additives, or other precautionary measures. This can create problems for blending, pumping, and engine operation. While No. 2 diesel fuel typically will incur gelling problems at about -9° C, soybean based biodiesel has been found to suffer from gelling around 0° C and biodiesel from animal fats around 20° C.[51] The cold flow properties of biodiesel blends will vary depending on the proportion of diesel fuel within the mixture. Two methods for measuring the cold flow properties include the cloud point and the pour point. The University of Iowa has defined the two gelling classifications as: "The cloud point is the temperature at which a cloud of wax crystals first appears in a fuel sample," and "The pour point is the lowest temperature at which movement of the fuel sample can be determined."[52] Table 2.1 illustrates the cold flow data including the cloud and pour points for different blends of soy-based biodiesel tested in Minnesota in mid-2001.

Table 2.1 Cold Flow Properties from Different Blends of Soy-based Biodiesel with No. 2 Diesel.

% Biodiesel	Cloud Point (° F)	Pour Point (° F)
0.0	-2	-23
2.0	-1	-18
5.0	0	-13
10.0	1	-8
20.0	4	-3
100.0	34	32

Source: Dr. Shaine Tyson, National Renewable Energy Laboratory (NREL)

Some of the preventative techniques utilized in the industry to reduce cold-flow problems include adding tank heaters, insulating tanks, using fuel additives, and blending biodiesel with diesel to lower the cold flow properties. Although several users have professed to using B20 blends at temperatures down to -28° F with only a block heater and fuel filter heater, many potential consumers remain wary of the problems that could arise from biodiesel's cold flow properties.[53, 54]

Solvency

Biodiesel's chemical structure makes the fuel a mild solvent. Most potent in its pure form, biodiesel can have an impact on storage tanks and fuel system components.[55] Biodiesel will dissolve sediment and other impurities that have built up from diesel fuel deposits within storage tanks and fuel lines. The result can lead to the dissolved particles plugging fuel filters and causing fuel injector failure. Although biodiesel was criticized in

[51] "Diesel Fuel Cold Flow Properties." Mechanical Engineering Department. Iowa State University.
[52] "Diesel Fuel Cold Flow Properties." Mechanical Engineering Department. Iowa State University.
[53] Howell, Steve. "Rigorous Standards Ensure Biodiesel Performance." 7-8.
[54] "Biodiesel Beats the Cold." National Biodiesel Board.
[55] "Biodiesel Handling and Use Guidelines:" 12. National Renewable Energy Laboratory.

the mid-1990s for such problems, many of the difficulties experienced were the result of lower fuel quality standards. Current B100 consumers have noticed problems with degradation of cellulose based filters and some rubber seal components when using the fuel.[56] Educating future consumers on the necessity of making engine alterations may be helpful as the demand for biodiesel grows.

Flashpoint

The flash point for a fuel is used to indicate the temperature at which it may combust when exposed to ignition. Neat biodiesel has an estimated flash point ranging from 242° to 338° Fahrenheit (F) depending on the feedstock type.[57] In comparison, several other types of fuel including diesel have significantly lower flash point levels.[58] Petroleum based fuels typically have flashpoints between 122° F and 176° F.[59] Consequently, biodiesel maintains a safety benefit over petroleum diesel especially in areas where unintended ignition during storage and handling is a concern.

Engine Performance Characteristics

In comparison to other alternative fuels, consumers are able to alternate between diesel and biodiesel without requiring major changes in most engines. For example, the physical structure costs associated with trial and adoption of biodiesel have been found to be much lower in comparison to converting such vehicles as urban buses in comparison to using compressed natural gas or methanol fuels.[60] Along with the cold flow, solvency, and flashpoint issues discussed earlier, the lubricity, cetane and net energy properties of biodiesel also impact the overall engine performance. This section will highlight these latter two properties and also summarize how manufacturer warranties have dealt with the renewable fuel.

Lubricity

Biodiesel has been found to provide enhanced lubricity benefits during engine combustion. Research by Stanadyne Automotive Corp, a diesel fuel injection equipment manufacturer, has demonstrated that even a 1 percent mixture of biodiesel with diesel fuel can improve the overall lubricity in engines by 65 percent. Thus, there is a potential for biodiesel to be marketed as a lubricity additive for consumers demanding increased engine protection.

As explained earlier, some types of petroleum diesel must have reduced sulfur levels starting in 2006 in order to meet the federally mandated 15 ppm standards. However, one of the consequences for decreasing sulfur levels within diesel is that the original lubricity properties of the fuel diminish. To satisfy the requirement of decreased sulfur emissions, biodiesel could be mixed as an additive or supplied in a blend while

[56] Tyson, K. Shaine. National Renewable Energy Laboratory (NREL). Personal interview.
[57] Duffield, James, et al. "US Biodiesel Development: New Markets for Conventional and Genetically Modified Agricultural Products."
[58] Howell, Steve. "Rigorous Standards Ensure Biodiesel Performance." 7.
[59] "What are Biodiesel's Advantages?" Mechanical Engineering Department. Iowa State University.
[60] Ahouissoussi, Nicolas and Michael Wetzstein. "A Comparative Cost Analysis of Biodiesel, Compressed Natural Gas, Methanol, and Diesel for Transit Bus Systems."

simultaneously providing the lubricity desired to combat excessive wear and maintenance requirements.[61] As engine manufacturers and petroleum refineries aim to comply with the upcoming sulfur mandates, biodiesel may provide a solution for the future fuel composition dilemmas.

Cetane Number

The cetane number provides a description of a fuel's ignition delay properties. A higher cetane number indicates a shorter delay between the time when the fuel is injected and when it is ignited. Having a higher cetane number can result in less noise, but it also tends to increase the cost of a fuel.[62] Regular No. 2 diesel has a cetane number ranging from 40 to 52.[63] Pure biodiesel tends to have a higher cetane number "between 46 and 60 depending on the feedstocks used to make the biodiesel." Biodiesel created from animal fats or reusable greases has been found to have a higher cetane number than soybean derived biodiesel. [64]

Net Energy

In comparison to petroleum diesel, biodiesel has a lower net energy balance which affects engine output. Biodiesel has been tested to have about 16,000 Btu (British thermal units) per pound in contrast to diesel's 18,300 Btu/lb. Because of biodiesel's higher density, this translates to 118,170 Btu/gallon for biodiesel versus 129,050 Btu/gal for diesel fuel.[65] Several studies have been conducted to analyze the impact that the energy content of biodiesel has on fuel economy. The results have concluded that there is between a 10 percent reduction to and 12.5 percent increase in fuel economy for switching to pure biodiesel.[66, 67] Other research on blends with 20 percent or less biodiesel have concluded that any changes to engine performance from using the fuel are indistinguishable.[68] Nevertheless, the assortment of estimates on the impact of biodiesel's energy content may leave consumers questioning the potential costs and benefits to their overall fuel economy.

Warranties

Several engine manufacturers have stated that their warranties will remain valid if blends of B20 or lower are used within the engines.[69] Others, such as Caterpillar, have warrantees on B100 that restrict the fuel composition to a standard the meets specific company or industry values. John Deere appears to have warranties for B100 on some

[61] Biodiesel: On the Road to Fueling the Future. Nazzaro, Paul.
[62] "What are Biodiesel's Advantages?" Mechanical Engineering Department. Iowa State University.
[63] Duffield, James, et al. "US Biodiesel Development: New Markets for Conventional and Genetically Modified Agricultural Products." p. 18.
[64] " What are Biodiesel's Advantages?" Mechanical Engineering Department. Iowa State University.
[65] "What Do You Need to Know?" Mechanical Engineering Department. Iowa State University.
[66] "Just the Basics: Biodiesel." US Department of Energy. Office of Transportation Technologies. Energy Efficiency and Renewable Energy.
[67] "What Do You Need to Know?" Mechanical Engineering Department. Iowa State University.
[68] "New Diesel Fuels: They Are in Your Future for Nonroad Equipment." Association of Equipment Manufacturers.
[69] "New Diesel Fuels: They Are in Your Future for Nonroad Equipment." Association of Equipment Manufacturers.

equipment while limiting other engines to blends that contain only up to 5 percent biodiesel (B5) due to long-term storage concerns.[70, 71] Thus, there is general inconsistency among engine manufacturers on the limitation of warranties based on the blends of biodiesel that can be used as well as the actual feedstocks involved in producing the biodiesel.[72] The National Biodiesel Board (NBB) tracks the positions of several of the major engine manufacturers relating to different blends of biodiesel. In summary, consumers of the fuel must remain attentive not only to the type of engine used but also the quality of the biodiesel fuel purchased in order to meet the manufacturer warranties.

Review of Biodiesel Characteristics

In addition, biodiesel's performance characteristics have the potential to create added value for the producers, distributors, and consumers of the fuel. Unlike other diesel fuel substitutes such as natural gas, biodiesel is able to be integrated into the current diesel retail market and used in the same engines. There are, however, potential timing alterations, handling issues, filter problems and other components that may need to be addressed to improve the overall performance of biodiesel. While the fuel's chemical structure promotes safer storage and transport practices, it also creates some drawbacks with respect to cold flow, solvency, and stability factors. Although the actual fuel economy of the fuel remains contested, biodiesel does provide an increased cetane number and lubricity benefits for engines. The weight of each of these factors can be affected by the proportion and origin of the biodiesel blended with diesel at any particular time. As consumers and distributors of biodiesel become more acquainted with the performance benefits and drawbacks of the fuel, their preferences for each of these factors will be reflected in the overall demand for biodiesel.

[70] "US Interest in Biodiesel Growing." New York Times.
[71] "Biodiesel Handling and Use Guidelines:" 14. National Renewable Energy Laboratory.
[72] "Biodiesel Handling and Use Guidelines:" 14. National Renewable Energy Laboratory.

Chapter 3. Legislative and Regulatory Review: Biodiesel

Primary Author: Cole Ehmke

A primary drawback of biodiesel is that the high price of the feedstocks used to make the fuel it to be more expensive than conventional diesel. To counter this, Federal and state regulations have created incentives for development and adoption of the fuel. Some of the Federal incentives include the Clean Air Act Amendments of 1990 which promote cleaner fuels, the Energy Policy Act (EPACT) of 1992 which encourages the use of alternative fuels as a means to reduce petroleum imports, and the energy portion of the Farm Bill. State legislation sources include a variety of incentives and mandates that favor the fuel.

This chapter will review the relevant federal legislation (the Clean Air Act, the EPACT and the Farm Bill), then the variety of state measures that have been proposed and adopted.

A. Federal Regulation

Environmental concerns and energy security issues have prompted legislation and regulatory actions designed to increase use of alternative fuels such as biodiesel. The US Congress has passed a number of legislative actions to address both issues. The Clean Air Act Amendments of 1990 *(*CAAA*, P.L. 101-549)* were enacted to address environmental concerns. The regulatory programs address the emissions output of urban buses and the exhaust emissions of engines. Thus these regulations have created a demand for cleaner burning fuels.

An interest in domestically produced renewable fuels that reduce fuel imports while possibly building markets for agricultural products, led to the comprehensive national Energy Policy Act of 1992 (EPACT*, P.L. 102-486*). This law was intended to strengthen the nation's energy trade balance by displacing imported petroleum through promotion of alternative fuels and alternative fueled vehicles. EPACT requires federally and state controlled vehicle fleets to purchase alternatively fueled vehicles, or use alternative fuels. The Farm Bill is oriented more to bioenergy production than consumption. It primarily provides economic incentives to expand biodiesel production.

Clean Air Act Amendments of 1990

The Clean Air Act Amendments created a significant opportunity for biodiesel. The law requires the US Environmental Protection Agency (EPA) to identify and regulate air emissions from all significant sources. Two emission control programs, for oxygenated fuels and reformulated gasoline, have increased demand for alternative fuels. Recent regulations may do the same for biodiesel. In January 2001, the EPA passed a rule that requires significantly lower emissions from heavy-duty vehicles using on-road diesel. It required a reduction in the sulfur content of diesel fuel from the current level of 500 parts per million (ppm) to 15 ppm, starting in mid-2006.

Burning biodiesel fuel effectively eliminates sulfur oxide and sulfate emissions, which are major contributors to acid rain. Unlike petroleum-based diesel fuel, biodiesel is free of sulfur impurities. Reducing sulfur in conventional diesel reduces the lubricating ability of the fuel. Without a high-lubricity additive to lubricate the engine and fuel system, engines running on low-sulfur diesel fuel could be subjected to premature wear or malfunction. Biodiesel can address this lubricity problem as a component in ultra low-sulfur diesel fuel because it has no sulfur and currently meets the 2006 standard. Even at low blend rates biodiesel can supply needed the lubricity. For example, a 1 percent blend of biodiesel can improve lubricity of diesel fuel by as much as 65 percent according to tests completed by Stanadyne Automotive Corp.[73] Alternatives to biodiesel as a lubricity agent would be petroleum-derived additives. These may be comparable, or lower, in cost to biodiesel. However, there is a possibility with petroleum based additives that too much can be added to a fuel batch, and thus engine create problems. Overdosing is not a problem with biodiesel since it can be used neat.[74]

The ultra low sulfur requirement will take effect in June 2006. By this date, refiners must meet a 15 parts per million (ppm) standard for at least 80 percent of the highway diesel fuel produced, with a 500 ppm cap on the remaining 20 percent of their production. Refiners may have to produce fuel with lower sulfur levels to cover the possibility of pipeline commingling with higher sulfur fuel.[75]

An EPA rule is currently proposed that would extend the desulphurization of diesel into non-road fuel. This proposal, released April 15, 2003, implements a 500 ppm sulfur limit by 2007 and 15 ppm by 2010, a reduction of 99 percent.[76] Application of the rule primarily affects construction, agricultural and industrial equipment.

The Clean Air Act Amendments create opportunities for market expansion, if certain requirements have been met. In order for a fuel to be commercialized, manufacturers of the fuel and its blends must meet EPA requirements for fuel-property definitions and satisfy health effects requirements, which have been previously completed for biodiesel, as outlined below.

Fuel Property Definition

In the United States, diesel fuel is controlled according to the American Society for Testing and Materials Standard (ASTM). ASTM is the premier standard-setting organization for fuels and additives in the US.[77] This standard describes a limited number of performance properties that diesel fuels must meet. In December 2001, the ASTM issued a specification (D6751) for biodiesel fuel. The EPA has adopted the ASTM standard and state divisions of weights and measures currently are considering its

[73] Nazzaro, Paul. “Biodiesel Is Lubricity.”
[74] Tiffany, Douglass. “Biodiesel: A Policy Choice for Minnesota.”
[75] Kaufman, Joe. “Ultra Low Sulfur Diesel Delivery Challenges.” Presentation.
[76] “Bush Administration Proposes Dramatic Reductions of Pollution from Nonraod Diesel Engines.” US Environmental Protection Agency.
[77] “ASTM Issues Biodiesel Fuel Standard” National Biodiesel Board.

adoption. This development was crucial in standardizing fuel quality for biodiesel in the US market. It is important to note that the feedstock used to create the fuel is not mandated, only the specific performance related requirements demanded of a fuel for a diesel engine.

Industry Quality Management

A project the NBB has been coordinating is the adoption of industry quality standards for producing, marketing, distributing and selling biodiesel. The ability for individuals to make home-brewed batches of the fuel coupled with the emerging nature of the industry has caused concern throughout the supply chain on the consistency of biodiesel and the derived blends. In an effort to combat those concerns and accelerate the adoption of biodiesel by consumers, an industry-wide quality management system titled BQ-9000 is being established. The requirements for the program stipulate that an organization must be able to document or demonstrate that the biodiesel meets ASTM D 6751 standards. Although acceptance of the standards is voluntary, the goal of the process is to provide an assurance on the quality of the biodiesel to distributors, marketers, retailers, and consumers.[78]

Health Effects Registration

The most significant obstacle to registering the fuel is that producers are required by the Clean Air Act Amendments to submit data that show the health effects associated with the use of their product in an engine. In recent years, regulators and policy-makers have become concerned about the potential effect of exhaust emissions on human health. As a result of this concern, the EPA has developed strict regulations for the amount of carbon monoxide, unburned hydrocarbons, oxides of nitrogen and particulate matter that an engine is allowed to emit. This has resulted in large reductions in the amount of these compounds entering the atmosphere.

The Clean Air Act Section 211(b) and (c) specifies three tiers of research data to evaluate the health effects of fuel emissions. Tier 1 is the first step of data collection. It is comprised of a literature review and an emissions characterization. Tier 2 consists of a toxicology test of laboratory animals that are exposed for 90 days to the exhaust of engines fueled with the fuel (subchronic inhalation). [79,80]

The National Biodiesel Board (NBB) undertook Tier 1 and Tier 2 testing of biodiesel emissions under EPA regulations governing the introduction of new fuels and fuel additives (40 CFR part 79). These programs include stringent emissions testing protocols. The NBB submitted the final results from the Tier 1 testing programs to the EPA in March 1998. In May 2000 biodiesel completed Tier 2 testing.

The first tier of health effects testing was conducted by Southwest Research Institute and involved a detailed analysis of biodiesel emissions. Tier 2 was conducted by

[78] Henderson, Paul. "OEM's – Building OEM Support: Biodiesel Quality."
[79] "Tier 2 Testing of Biodiesel Exhaust Emissions: Final Report."
[80] "Registration of Fuels and Fuel Additives." US Environmental Protection Agency.

Lovelace Respiratory Research Institute, where a 90-day sub-chronic inhalation study of biodiesel exhaust with specific health assessments was completed. The results of these tests are discussed in Chapter 2.

Because the costs for producing the required data can be prohibitive, the EPA included several provisions intended to ease the burden of the program. These provisions include the ability for manufacturers to group together and share costs. A manufacturer may make use of jointly-submitted testing and analysis for a product that conforms to the same grouping criteria as the tested product.

To further ease the impact of the testing costs on small producers, the fuel and fuel additives regulations state that fuel manufacturers of baseline and non-baseline (oxygenated) fuels with annual sales of less than $50 million, only need to submit the basic registration data. These companies are not required to submit Tier 1 and Tier 2 data. However, since the EPA does not consider biodiesel to be a non-baseline fuel, small biodiesel producers are not eligible for this exemption.

Small producers of atypical fuels (fuels not meeting ASTM standard) can also qualify for an exemption but the limiting size is only $10 million. These producers are also still required to submit Tier 1 data although Tier 2 can be waived. Collecting Tier 1 data can be quite expensive, requiring between $100,000 and $250,000.[81]

Fuels that are not sold into on-road markets are exempt from 40 CFR Part 79. These include fuels sold as heating oil, farming, construction, marine, power generation, and other off-road uses. To qualify for this exemption, a biodiesel producer can never provide biodiesel to anyone using it in a licensed vehicle used on-road all or part of the time. Cooperatives or producers using biodiesel in their own vehicles must register their fuels.

Tier 3 is additional testing that the EPA may require (decided on a case-by-case basis) after the results of Tier 1 and Tier 2 tests have been submitted. If the EPA believes that additional testing is needed to confirm the results of Tier 2 and Tier 2, or if new testing is justified, they can require it as part of Tier 3.

Nonattainment Areas

An opportunity provided by the Clean Air Act Amendments lies in the classification the EPA must give to each county in the United States as to whether the area has met the required ambient air quality standards. The classifications correspond to the level of conformance with the National Ambient Air Quality Standards (NAAQS). The three classifications are “Attainment" (pollutants are not at unacceptable levels), "Non-attainment" (pollutants are at unacceptable levels), or "Maintenance" (pollutants been unacceptable, but are not currently). Regulated pollutants are the following:

- ozone (O_3),
- sulfur dioxide (SO_2),

[81] National Biodiesel Board.

- nitrogen dioxide (NO_2),
- carbon monoxide (CO),
- lead (Pb), and
- PM10 (particulate matter under 10 microns in diameter).

Air pollutants that transportation projects effect are carbon monoxide (CO), ozone (O_3), and fine particulate matter (PM-10).[82]

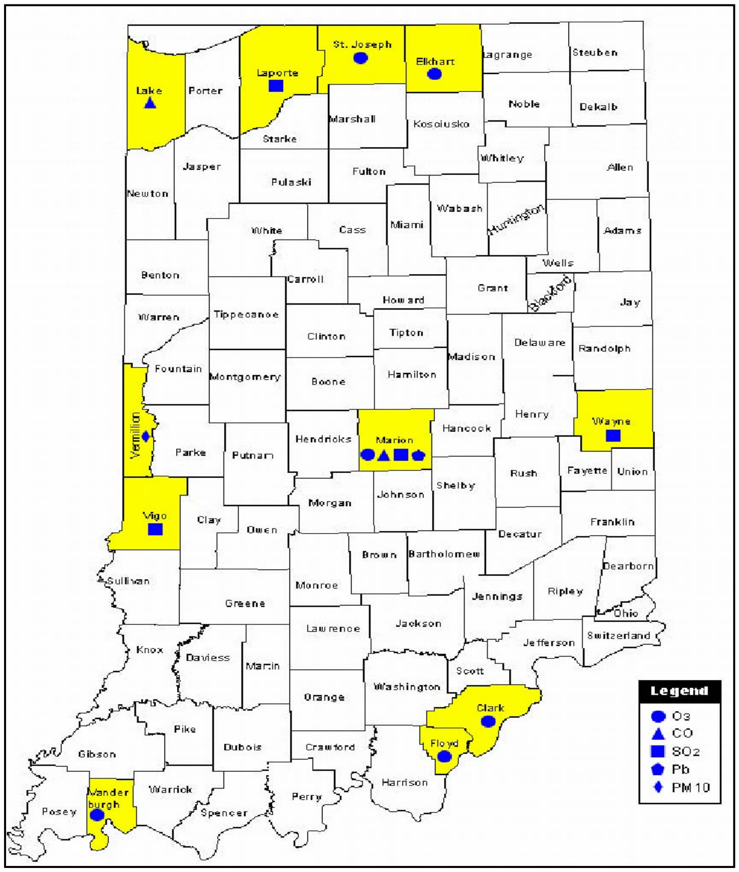
Within the ozone classification is a graduated scale from marginal non-attainment to moderate and serious, and up to severe non-attainment. An area may also be classified as either moderate or serious non-attainment for PM10 or CO. An area can be in non-attainment for more than one pollutant. A non-attainment area can be redesignated to attainment once ambient air quality standards are met.

Indiana has a small portion of non-attainment areas in the extreme north western corner of the state. Both Lake and Porter counties are non-attainment areas with a number of pollutants (both counties have severe O_3, while Lake County also has moderate SO_2 and particulate matter).

Figure 3.1 indicates which counties have had past problems with attainment, but have successfully undertaken EPA approved measures to control emissions. These counties were in nonattainment in the past. Currently they are in attainment with federal air standards, and have been for at least 3 years.

[82] "Permit Guide" Indiana Department of Environmental Management.

Figure 3.1 Indiana maintenance areas[83]



Energy Policy Act of 1992 (EPACT)

Congress passed the Energy Policy Act (EPACT) in October, 1992, to accelerate the use of alternative fuels in the transportation sector. It is administered by the Department of Energy (DOE) and primarily focuses on decreasing the nation's dependence on foreign oil and increasing energy security through the use of domestically produced alternative fuels. DOE's overall mission is to replace 10 percent of petroleum-based motor fuels by the year 2000 and 30 percent by the year 2010.

The primary strategy for increasing the use of alternative fuel has been a mandate to require federal, state and alternative fuel provider fleets to have a certain percentage of alternatively-fueled vehicles. Starting in 2002, some municipal and private fleets were provided with purchasing guidelines. Effective in January 2001, the Biodiesel Fuel Use Credit Final Rule allowed covered fleets to earn credits through the purchase of biodiesel fuel. Covered fleet operators can meet up to half of their AFV acquisition requirements using blends of B20 biodiesel. One AFV credit is earned through every 450 gallons of

[83] "Permit Guide" Indiana Department of Environmental Management.

B100 (2,250 gallons of B20) purchased. B20 can be used in off-road and on-road vehicles to qualify.[84]

Farm Bill – USDA

Further Congressional action on bioenergy emerged in the form of the 2002 Farm Bill, signed into law in May 2002. The Farm Security and Rural Investment Act of 2002 is the first Farm Bill to contain an energy title. Title IX of the Farm Bill reauthorizes and establishes several programs that promote bioenergy. In total Title IX authorizes $405 million in mandatory funding over the six year life of the bill. Table 3.1 summarizes the programs and funding.

Table 3.1 Farm Bill, Title IX – Energy[85].

Program	Notes	Cost
CCC Bioenergy Program (Section 9010)	Provides mandatory funding for the CCC Bioenergy Program, which will enable the Secretary to continue making payments to bioenergy producers who purchase agricultural commodities for the purpose of expanding production of biodiesel and fuel grade ethanol.	$204 million
Biobased Product Purchasing Preference (Section 9002)	Establishes a new program for the purchase of biobased products by Federal agencies.	$6 million
Biodiesel Fuel Education (Section 9004)	Creates a grant program to educate government and private fuel consumers about the benefits of biodiesel fuel use.	$5 million
Renewable Energy System & Energy Efficiency Improvements (Section 9006)	Establishes a loan, loan guarantee & grant program to assist farmers in purchasing renewable energy systems and making energy efficiency improvements.	$115 million
Biomass Research and Development Act of 2000 (Section 9008)	Reauthorizes and funds the Biomass Research and Development Act through FY 2007.	$75 million
Total		**$405 million**

[84] "Alternative Fuel Transportation Program; Biodiesel Fuel Use Credit."
[85] "Farm Bill Conference Summary" US Senate Agriculture Committee.

Key to biodiesel is the Commodity Credit Corporation's bioenergy program (Section 9010). This program pays ethanol and biodiesel producers that increase use of stocks of agricultural commodities (and thus reduce CCC purchases of surplus commodities). Recent revision of the program expands production to a larger base, as well as to more bioenergy feedstocks.[86] The program started in 2001 and has been extended through 2006. Subsidies are provided based on the increase in use from the previous year using conversion factors for different commodities of feedstocks.[87] Table 3.2 shows that in fiscal year 2002 over 12 million dollars were provided to seven companies that had increased production by 8,861,232 gallons. The subsidy equates to about $1.43 per gallon on average but this varied depending upon the feedstock used.[88] These federal subsidies and other proposed state initiatives can encourage the development and expansion of production facilities for biodiesel.

Table 3.2 FY2002 Bioenergy Payments for Biodiesel[89]

Commodity	Gallons Paid	Payment ($)	$/gallon	$/lb
Soybeans	8,768,555	12,612,044	1.438	0.195
Animal Fats and Oils	91,636	26,782	0.292	0.039
Mustardseed	1,041	1,386	1.331	0.181
Total	**8,861,232**	**$12,640,212**	**$1.426**	**$0.194**

Using 7.35 pounds per gallon conversion factor

The USDA has continued the bioenergy subsidies for increased production, and as of May 2003, the USDA will subsidize all current biodiesel production from 2003 through 2005. Payments for current production will be calculated as a proportion of the rate subsidizing the increase in production. Benefits for current production will be gradually phased down from 50 percent of the rate for increase production in 2003, to 30 percent in 2004, 15 percent in 2005 and eliminated in 2006. Payment levels on production of biodiesel from animal fats and oils will be increased, while payment levels for soybean based biodiesel production will be unchanged.

To provide an estimate on the potential subsidy that producers could receive, the USDA example of soybean feedstocks with a November 1, 2002 price of $5.59 per bushel and a yield of 1.41 gallons of oil per bushel has been evaluated.[90] Any biodiesel plant that is in operation will be able to receive around $0.80 per gallon of biodiesel at the 50 percent rate for all production in FY2003. This would drop to about $0.48 per gallon for FY2004 for 30 percent and about $0.16 per gallon for FY2005. However, this would be only on their current production during these periods. Increased production would receive around $1.59 per gallon using soybeans but total payments would be limited to $7,500,000 (5 percent of the $150 million available for funding)

Before revision in May 2003, the subsidy took the form of a quarterly cash reimbursement of an increase in stocks used over the previous year, with higher subsidies

86 "Veneman Announces Bioenergy Program Changes and Sign-up."
87 "Bioenergy Program." Federal Register.
88 FY 2002 – Bioenergy Program Participant Payments. US Department of Agriculture.
89 "Bioenergy Payments FY 2002." US Department of Agriculture.
90 "Bioenergy Program; Final Rule: 7 CFR Part 1424." Federal Register.

for smaller producers. The average subsidy per gallon across all facilities for using soybeans was $1.17 (in the first quarter of 2002).

Section 9002, directs the USDA to develop a list of bio-based products for federal purchase, in partnership with the EPA, the General Services Administration and the Department of Commerce. Items on the list are to be given preference when similar and comparatively priced. Such a preference may stimulate production of these goods as well as bring them into common use by using the government's power as a consumer to promote biobased products, much like what has been done with recycled paper.

Section 9004, the biodiesel education program, sets up a competitive grant with $1 million in mandatory funding for fiscal years 2003 to 2007. The purpose is to educate governmental and private entities with vehicle fleets, and the public, about the benefits of biodiesel use. It is likely that from one to three awards will be made.

Section 9006, the Renewable Energy and Energy Efficiency Program, is to provide monies to purchase renewable energy systems and make efficiency improvements. It provides mandatory funding of $23 million per year. To participate, applications must be made to state rural development offices.

As of May 2003, funds for these programs have been approved and appropriated. In addition, several programs were outlined with discretionary funding subject to annual appropriations, including the following:

1. Section 9003 Biorefinery Development Grants
2. Section 9005 Energy Audit and Renewable Energy Development Program
3. Section 9009 Cooperative Research and Extension Projects

No funds were requested by USDA for these programs for FY2004, so unless Congress allocates funds these projects will not be carried out.[91]

B. State Regulation

Recent Legislative Efforts

There a number of proposals at the state level that could regulate and promote biodiesel use. The National Biodiesel Board, in tracking this activity, categorizes them into four general types of legislation, as follows:

- Mandates (state wide and for government fleets)
- Excise tax incentives
- Producer credits
- User/Distributor

[91] "Administration's Proposed FY04 Budget Cuts Funding for Renewable Energy in Department of Energy and Agriculture."

This section of the report will summarize efforts in each of the four categories, paying particular attention to the most aggressive legislation, mandates.

Minnesota Mandate

While individuals may approve of higher quality air, the majority of fuel consumers continue to purchase the products based on price. Even if a consumer wanted to purchase a technology a vertically integrated and large fuel industry may not necessarily offer it, unless motivated by mandate. This was the case with catalytic converters, as Tiffany has pointed out.[92] The Minnesota mandate is, in many cases, the model for legislation found in other state proposed biodiesel legislation. Thus, some background into it would be instructive.

In March 2002, Minnesota enacted the nation's first statewide biodiesel mandate (SF 1495).[93] It requires nearly all diesel fuel sold in the state contain at least 2 percent biodiesel by 2005 (earlier if certain conditions are met). The law specifically states that the biodiesel should be derived from vegetable sources.

The law does not go into effect until two out of three trigger actions take place. The trigger actions under the legislation require that the state must have 8 million gallons of vegetable oil based biodiesel production capacity in place. Once that is met, then either one of two actions can trigger the mandate: 1) the federal government must have enacted tax credits, which were in place for 18 months, or 2) the date June 30, 2005 is reached. Once the state attains two of those performance levels, all diesel sold commercially in the state will be required to contain at least 2 percent biodiesel.[94]

This mandate requires 16 million gallons of biodiesel per year (2 percent of the 800 million gallons of diesel consumed in Minnesota). The feedstock required to satisfy this potential demand for biodiesel would be more than 100 million pounds of soybean oil.

Provisions within the bill were designed to increase the acceptability of the mandate. In particular the bill would provide distributors with a partial reimbursement of unique compliance expenses if the law is repealed within eight years. To take advantage of this provision a distributor must prove that the expenditure was made solely for compliance with the bill. Primarily this has to do with building facilities or buying equipment that is used to keep B100 from gelling in cold weather. Distributors were concerned that they would be forced to buy insulated tankers and build heated storage facilities to keep biodiesel from gelling. Opponents to the mandate argued that market forces should be allowed to integrate fuel into retail outlets based on the evolving demand for biodiesel. Concerns were expressed that if the proper infrastructure and production facilities were not in place, bottlenecks and price-exploitation could occur as the mandate was enforced.[95]

---

[92] Tiffany. Douglas. "Biodiesel: A Policy Choice for Minnesota."
[93] "Landmark Biodiesel Legislation Passes in Minnesota." National Biodiesel Board.
[94] S.F No. 1495, 3rd Engrossment: 82nd Legislative Session (2001-2002).
[95] Runge, C. Ford. "Minnesota's Biodiesel Mandate: Taking from Many, Giving to Few."

A similar bill was submitted and failed in the 2001 session. It proposed a more significant 5 percent biodiesel use and a nearly immediate implementation. The 2002 legislation reduced the percentage, delayed the implementation date, and provided for a federal financial incentive (a credit). The legislation was opposed by the trucking industry, which saw it essentially as a tax that would put trucking companies, particularly smaller ones, out of business. The trucking industry also thought the mandate would cause truckers to avoid Minnesota service stations to buy fuel in other states. The House voted 78-53 for the 2002 bill, a few hours after the Senate approved it by a wider margin of 53-11. [96] It became law without the signature of the governor, who was an outspoken critic of all mandates.

The biodiesel mandate could result in more soybean processing inside the state. The effects from such will be an accompanying increase in jobs and income, as well as an increase in the price of soybeans. Minnesota has relatively little soybean processing compared to other top soybean producing states, like Iowa. This mandate creates at least one biodiesel processing plant in the state but has the potential to raise the price of the feedstock (soybeans) by several cents per bushel.

Summary of State Legislation, 2003

For 2003 no Minnesota style mandates were passed. Several state agency mandates passed, as well as a number of incentives for producers, distributors and retailers. Other legislation which was approved involved policies that defined the term biodiesel. The list below summarizes the legislation. For 2003 summaries are used courtesy of the National Biodiesel Board, which tracks biodiesel related legislation throughout the US. Legislation that is noted as PASSED has become law (these are listed first). All other legislation is dead for this term.

Mandate Proposals

There were currently two general types of mandates proposed, three Minnesota style mandates, and three state agency mandates. A state agency mandate would require vehicles operated by the state to use biodiesel.

General State Mandate

South Dakota SB 163: Defeated in Senate. Beginning on July 1, 2005, any diesel fuel end seller would have been B2.

Montana HB502: Implements a B2 mandate. It included an effective trigger that 10 million gallons of biodiesel must be available in the state.

Illinois: SB134 referred to Rules Committee. Requires all diesel fuel to be B2 within (a) 30 days of certification of 8 million gallon capacity and; (b) 18 months have passed since published notice of a federal action lowering B2 by at least 2 cents. The mandate also will go into effect regardless of conditions after June 30, 2006. If repealed, distributors may be reimbursed pro-rata for capital expenditures necessary to blend the B2.

State Agency Mandates. (mandated biodiesel use in government fleets)

[96] McCallum, Laura. “Biodiesel survives rocky road at Legislature.” Minnesota Public Radio.

Washington (PASSED) HB 1242 It's two primary provisions were encourage state agencies to use B20, and to mandate state agency use of B2 as a lubricity agent starting June 1, 2006.

Kansas (PASSED) HB 2036 Restricts claims of "biodiesel" to B2 or above. Diesel powered state vehicles and equipment mandate for B2 as long as the price is no greater than 10 cents more per gallon than the price of diesel fuel.

Hawaii (SB 1239) Mandated biodiesel use in government fleets.

Excise tax incentives

Connecticut HB 5427 Exempts B20 from one-half of the state sales tax for purchases of such fuel.

Hawaii HB 356 Exempts general excise and fuel taxes on alternative fuel, with biodiesel defined as an alternative fuel.

Hawaii HB 1539 Fuel tax reduction for alternative fuels. Tax on biodiesel cut in half.

Illinois (PASSED) SB 46 Extends the partial excise exemption of 20 percent for biodiesel blends to the end of 2013, gradually reducing the exemption to zero for blends up to B10. Biodiesel blends above B10 are completely exempt during this period from state sales tax, which is 6.25 percent. If the excise on biodiesel blend is 1.25%, then the partial exemption does not apply.

Iowa HSB 276 Excise exemption of 2.5 cents on B2.

Maine HB 307 Exempts biodiesel from excise tax. SB 160 Exempts biodiesel from excise tax.

New Jersey SB 1731 Exempts B100 and all biodiesel blends from excise tax.

New Mexico SB 193 Includes fuel mixtures containing 20% or higher of vegetable oil in the definition of alternative fuel, making it eligible for tax incentives.

South Dakota HB 1279 Reduces excise tax on biodiesel by two cents.

Arizona HB 2463 Excise tax exemption until 9/1/2005 with partial exemption through 2008.

New Jersey SB 771 Tax credit for alternative fuel vehicles for 15% of cost, alternative fuel includes biodiesel .

Virginia SB 1257 Raises excise taxes and adds a consumer price index. Starting July 2004, the state excise tax on diesel fuel and diesel fuel blends (which includes biodiesel), alternative fuel, gasoline and other fuels would be indexed annually to the CPI.

Washington HB 1240 Provides tax incentives for biodiesel and alcohol fuel production.

HB 1241 Provides a tax incentive for investments associated with distribution and retail sale of biodiesel.

Washington HB 1243 Creates a biodiesel-ultra low sulfur diesel pilot project for school transportation.

Washington SB 5469 Creates a tax credit for purchase of biodiesel fuel distribution facilities.

Producer Incentive

Arkansas (PASSED) SB 363 Provides a 5 percent income tax credit for plant and equipment used in wholesale or retail distribution of biodiesel. Provides a 10 cent per gallon grant to qualified producers. Grants are limited to the first 5 million gallons of biodiesel produced annually, not to exceed 5 years. Biodiesel is defined by the ASTM specification.

Illinois. (PASSED) HB 46. Establishes the Illinois Renewable Fuels Development Program to offer grants of up to $15 million annually for constructing, modifying, altering or retrofitting a renewable fuels plant with a minimum production capacity of 30 million gallons.

Indiana (PASSED) HB 1001 – Tax credits for producers, blenders and retailers. The producer credit is equal to $1 per gallon of biodiesel produced in Indiana, and used to make blended biodiesel. The blender credit (above B2) is 2 cents per gallon, if using Indiana biodiesel. The retailer credit is 1 cent per gallon (no restriction on state production). It is capped at $1 million per incentive. Effective 2004-2005.

Washington (PASSED) HB 1240 Provides tax incentives for biodiesel and alcohol fuel production - sales/use/property tax "deferral" (wiped clean after seven years).

Florida (PASSED) SB 1176 Biodiesel manufacturers must be licensed by Revenue Department.

Texas HB 666 Biodiesel production incentives.

User/Distributor

North Dakota (PASSED) HB 1309 10% tax credit per year for five years for blenders/producers to add biodiesel equipment. Also includes a 1.05 cent excise reduction on B2 after 8 million gallon capacity. This language was already law, but would have expired June 2003. Biodiesel is defined by ASTM specification.

Washington (PASSED) HB 1241 Provides a tax incentive for investments associated with distribution and retail sale of biodiesel. No taxes on equipment and ingredients until 2009 (if equipment is used for at least 75 percent biodiesel distribution).

Connecticut HB 5975 Exempts motor vehicles using biodiesel from random emissions road tests and imposes a fine of at least $5,000 for obtaining the exemption by fraud.

Hawaii HB 1405 State procurement preference for biodiesel.

New Hampshire HB 96 Includes biodiesel run electrical generators for net energy metering.

New Jersey AB 3116 New vehicles purchased by the State must be (1) certified as a LEV, ULEV, SULEV, or a zero emissions vehicle or (2) an alternative fuel vehicle. Biodiesel is included in definition of alternative fuel and alternative fuel vehicle.

North Dakota HB 1483 Requires an energy conservation plan to reduce fuel consumption and increase alternative, clean-burning fuels, including biodiesel.

Oklahoma HB 1705 Requires use of alternative fuels for government and school vehicles modified to use them given price equivalency and 'reasonable availability'. This act requires use when available within a 5 mile radius, and deletes pricing language.

Virginia HJR 205 Study on biodiesel in state fleets.

Other

South Dakota (PASSED) HB 1279 Puts biodiesel definition (ASTM) into law.

Washington (PASSED) HB 1243 Creates a biodiesel-ultra low sulfur diesel pilot project for school transportation. Pilot project for one year, in two school districts requiring B20.

Connecticut HB 5984 Biodiesel Task Force to promote the use of biodiesel and explore commercial and industrial applications.

Pennsylvania HB 120 Alternative fuel defined to include biodiesel. Existing incentives for retrofitting costs and related issues. SB 225 Mirror of HB 120.

Washington HB 1762 Creates funding source (vehicle registration fees) and fund to be used to purchase biodiesel and biodiesel fueling infrastructure.

Table 3.3 is a summary of the five types of legislative activity tracked this year. In total there were six mandates, 11 tax incentives, five producer incentives, eight user/distributor incentives and four other state legislative actions, in 21 states. Illinois is the only state neighboring Indiana that currently has legislation regarding biodiesel.

Table 3.3. Summary of 2003 Proposed Biodiesel Legislation.

	Mandate	Excise Tax Incentives	Producer Incentive	User / Distributor Incentive	Other
Arizona		X			
Arkansas			X		
Connecticut		X		X	X
Florida			X		
Hawaii	X*	X		X	
Illinois	X	X			
Indiana			X		
Iowa		X			
Kansas	X*				
Maine		X			
Montana	X				
New Hampshire				X	
New Jersey		X		X	
New Mexico		X			
North Dakota				X	
Oklahoma				X	
Pennsylvania					X
South Dakota	X	X			X
Texas			X		
Virginia		X		X	
Washington	X*	X	X	X	X

* State Agency Mandates

Chapter 4. US Demand and Supply of Biodiesel

Primary Author: Kyle Althoff

This chapter examines the factors that influence the demand and supply for biodiesel. The first section of the chapter, consumption and pricing, reviews the economic factors that create the demand for biodiesel, apart from the functional properties discussed in Chapter 2. The consumption and pricing section will highlight the current utilization of petroleum diesel compared to biodiesel while also revealing the segments of engine users that are propelling the demand. It concludes with a discussion of the resulting pump price for the two fuels. The second section of this chapter will focus on the production and supply of biodiesel. The three main areas that are addressed include the biodiesel production process, a macro-level industry analysis, and external supply factors. This chapter concludes with a review of several biodiesel-related economic impact studies that have been conducted. Throughout this chapter, an emphasis is placed on addressing the economical factors that have shaped the biodiesel market within the US.

A. Consumption and Pricing of Biodiesel

The first part of this chapter describes the current utilization of biodiesel in the US domestic market including a categorization of the US market based on the different end-user segments for diesel and biodiesel. This section also will explore prices for diesel, biodiesel, and blends of the two fuels within the US market.

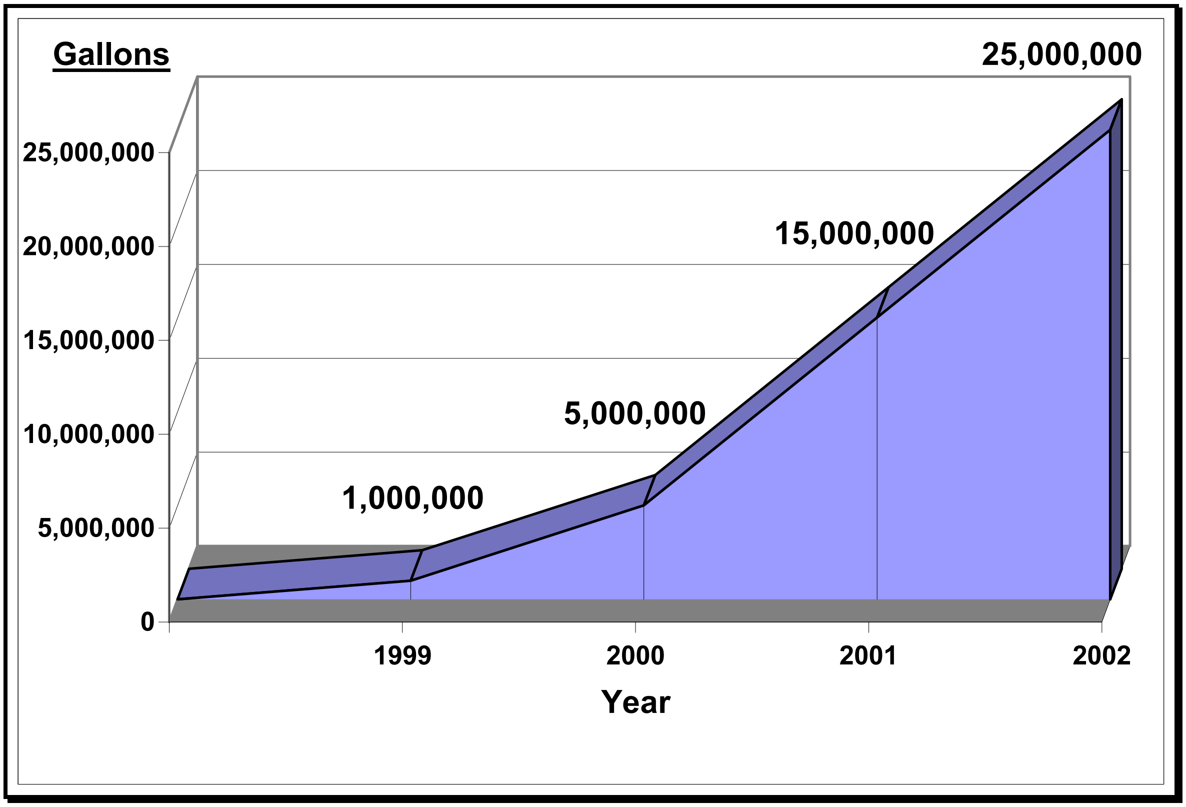
Analysis of Diesel and Biodiesel Demand

Although the growth of biodiesel production within the US has primarily occurred in the past five years, production of the renewable fuel has increased quite extensively over the past decade in other countries, especially within several European nations. Appendix B provides a brief overview of the international market for biodiesel.

In the US, biodiesel production has expanded from 1 million gallons of industrial production in 1999 up to an estimated 25 million gallons by 2002.[97] The following figure illustrates the historical growth in biodiesel production (and demand) over that time period.

[97] Coltrain, David. “Biodiesel: Is It Worth Considering?”

Figure 4.1 US Biodiesel Production.



Source: "Biodiesel: Is It Worth Considering?"

In comparison to other transportation-related fuels, biodiesel has experienced the largest percentage growth over the past four years.[98] Such rapid growth has been dependent upon a number of factors including expanded interest in renewable fuels, government subsidies, and the development and diffusion of production technology. One of the most significant factors was the amendment of the Energy Policy Act in 1998 to allow for the use of biodiesel in federal and state fleets to meet requirements for alternative fuel use.[99] The addition of biodiesel as an option for government fleets to meet the specific renewable fuel restrictions has led to an increase in the overall consumption of the fuel.

There are several estimates of future demand for biodiesel within the US. The National Biodiesel Board has predicted that biodiesel production would grow to 30 to 40 million gallons in 2003.[100] Prior to 1994, the American Biofuels Association had stated that, "with Government incentives comparable to those provided for ethanol, biodiesel production from seed oils could reach about 2 billion gallons per year, or about 8% of highway diesel consumption early in the next century."[101] Another study presented at the

[98] Coltrain, David. "Biodiesel: Is It Worth Considering?" 4.
[99] "What is Biodiesel?" Alternative Fuels Data Center.
[100] "US Interest in Biodiesel Growing." New York Times.
[101] "Biodiesel Fuel: What is It – Can It Compete?" National Biodiesel Board.

Ohio/Michigan Biofuels Conference predicted that by 2010 the annual consumption of the fuel could exceed 400 million gallons per year.[102]

Typically influenced by its higher relative cost from diesel, future increases in biodiesel demand will also likely be dependent upon state and federal government incentives to promote biodiesel production, distribution and consumption. For example, Minnesota's recently passed mandate, which requires all on-road diesel vehicles and some of the off-road engines within the state to use a 2 percent biodiesel blend by 2005, is expected to require 16 million gallons of biodiesel production.[103] As economies of scale are captured by the construction of larger production plants and government incentives are maximized, biodiesel could become more cost competitive with diesel fuel. Most estimates concur that such a scenario would positively alter the demand for biodiesel.

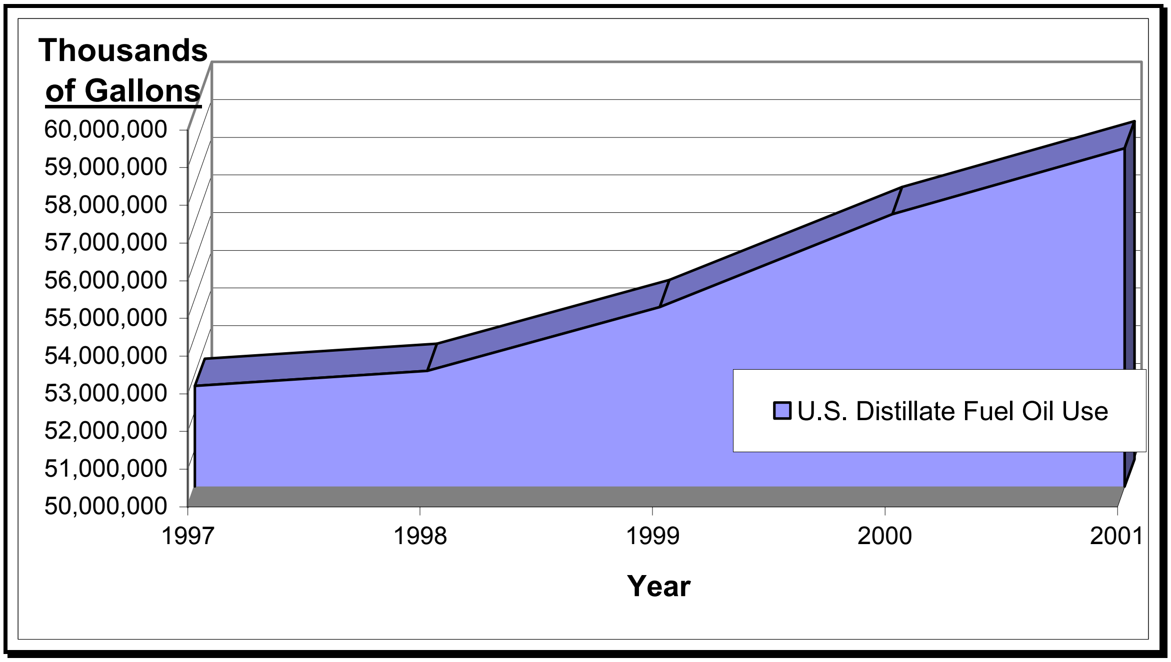
Segments of US Demand

As the industry has evolved, biodiesel has been used in diesel engines that operate cars, buses, trucks, farm tractors, marine engines, home heating units, and other motors. There is a wide variety of prescribed and trial uses across America using pure biodiesel (B100) and biodiesel blends. From park vehicles in Yellowstone National Park to the county government vehicles in Arlington County, Virginia, thousands of engine users have experimented and adopted biodiesel for a substitute diesel fuel. This next section will examine the segments of US diesel and biodiesel demand.

Diesel demand within the US is categorized by the Department of Energy based on end user segments for distillate fuel. In 2001 total sales of distillate fuel oil in the US amounted to almost 59 billion gallons.[104] Breaking that figure down into the separate user segments derives ten separate divisions of utilization that include: Residential, Commercial, Industrial, Oil Company, Farm, Electric Power, Railroad, Vessel Bunkering, On-Highway Diesel, Military, and Off-Highway Diesel. A historical representation of yearly consumption for diesel fuel and the demand from the different user segments is presented for fuel oil sales from 1997 to 2001 in the following figures.

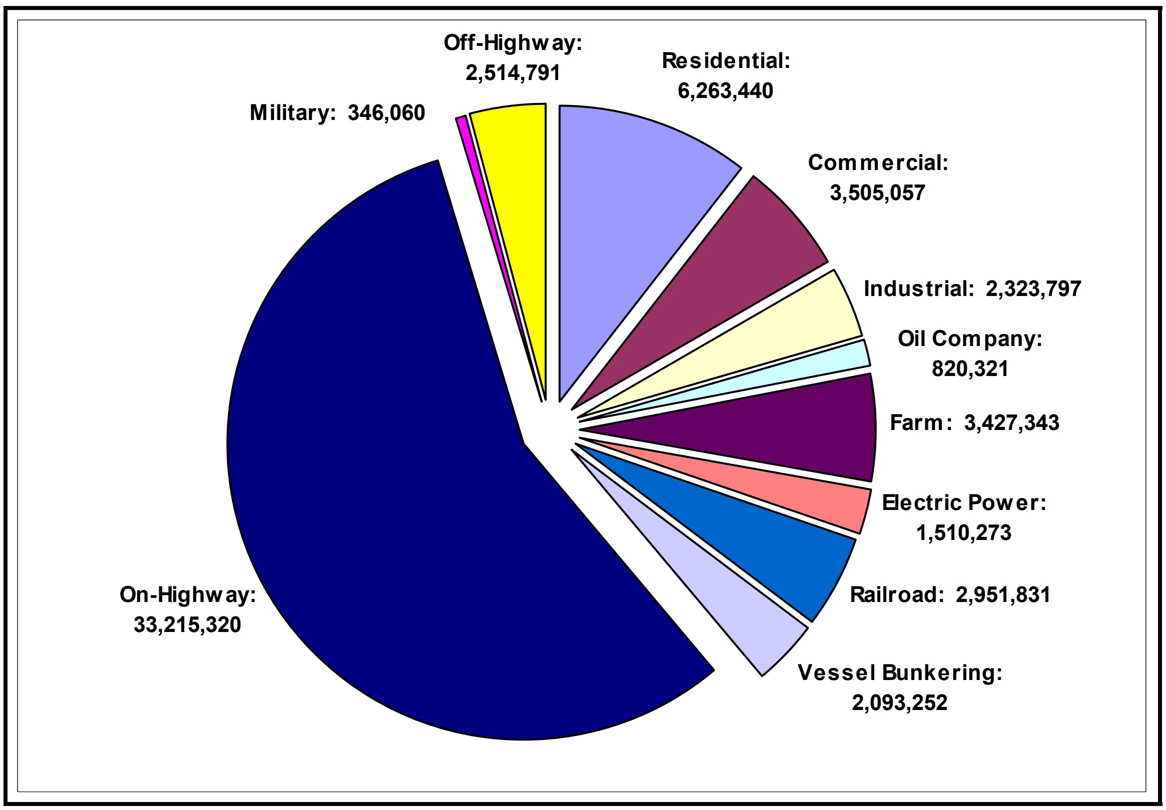
[102] Frazier, Rod. "Biodiesel Production Potential in Michigan and Ohio."
[103] Groschen, Ralph. "Minnesota's Renewable Fuels Program." Presentation.
[104] The Energy Information Administration defines Distillate Fuel Oil as, "a general classification for one of the petroleum fractions produced in conventional distillation operations." This includes several grades of diesel fuel and fuel oil for transportation, heating, and other uses: Fuel Oil and Kerosene Sales 2001. US Department of Energy. Energy Information Administration.

Figure 4.2 US Distillate Fuel Oil Sales.



Source: US Department of Energy, Energy Information Administration

Figure 4.3 Sales of Distillate Fuel Oil by Energy Use in 2001 (Thousands of Gallons).

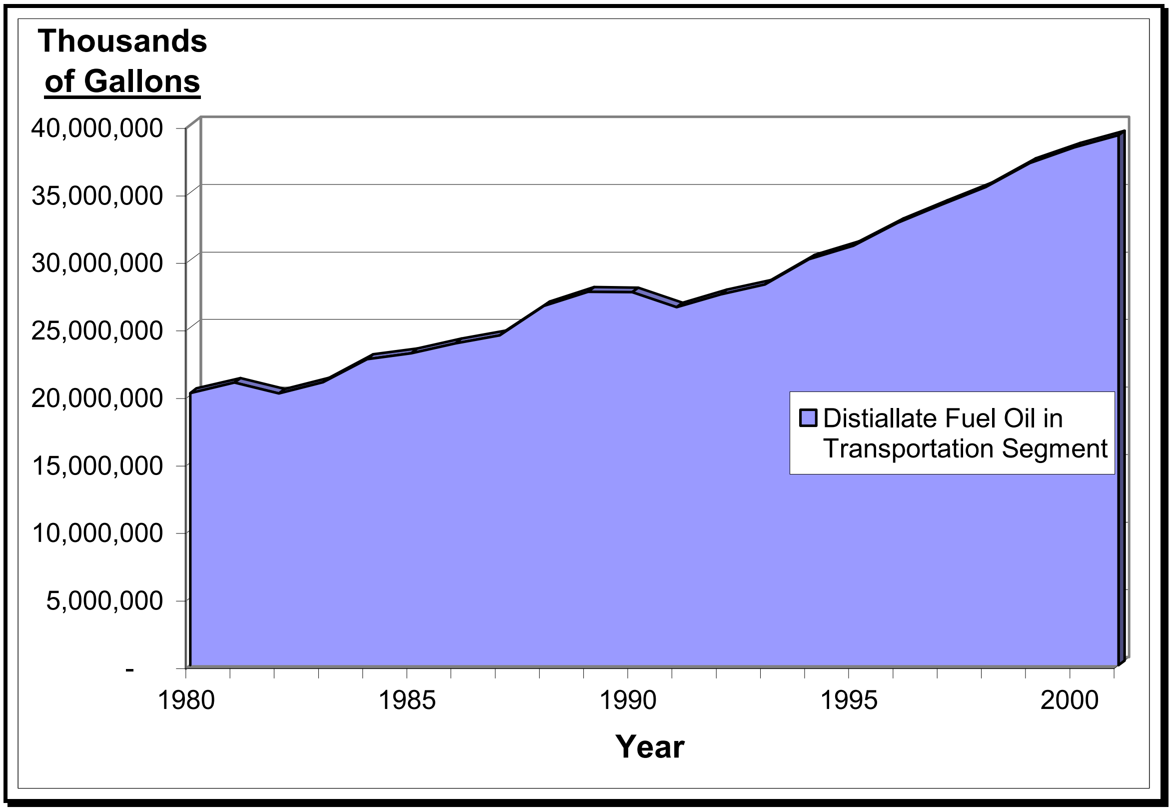


Source: US Department of Energy, Energy Information Administration

As illustrated by Figure 4.3, on-highway diesel fuel generates the majority of the distillate sales within the US. In 2001 alone, on-highway diesel sales amounted to over 33 billion gallons, or more than 55 percent of total distillate sales.

Another way of evaluating the distillate fuel sales is based upon the annual growth of consumption within the transportation sector (includes on-highway diesel). Figure 4.4 illustrates that demand within this category has almost doubled over the past two decades as domestic consumption of transportation fuels has increased.

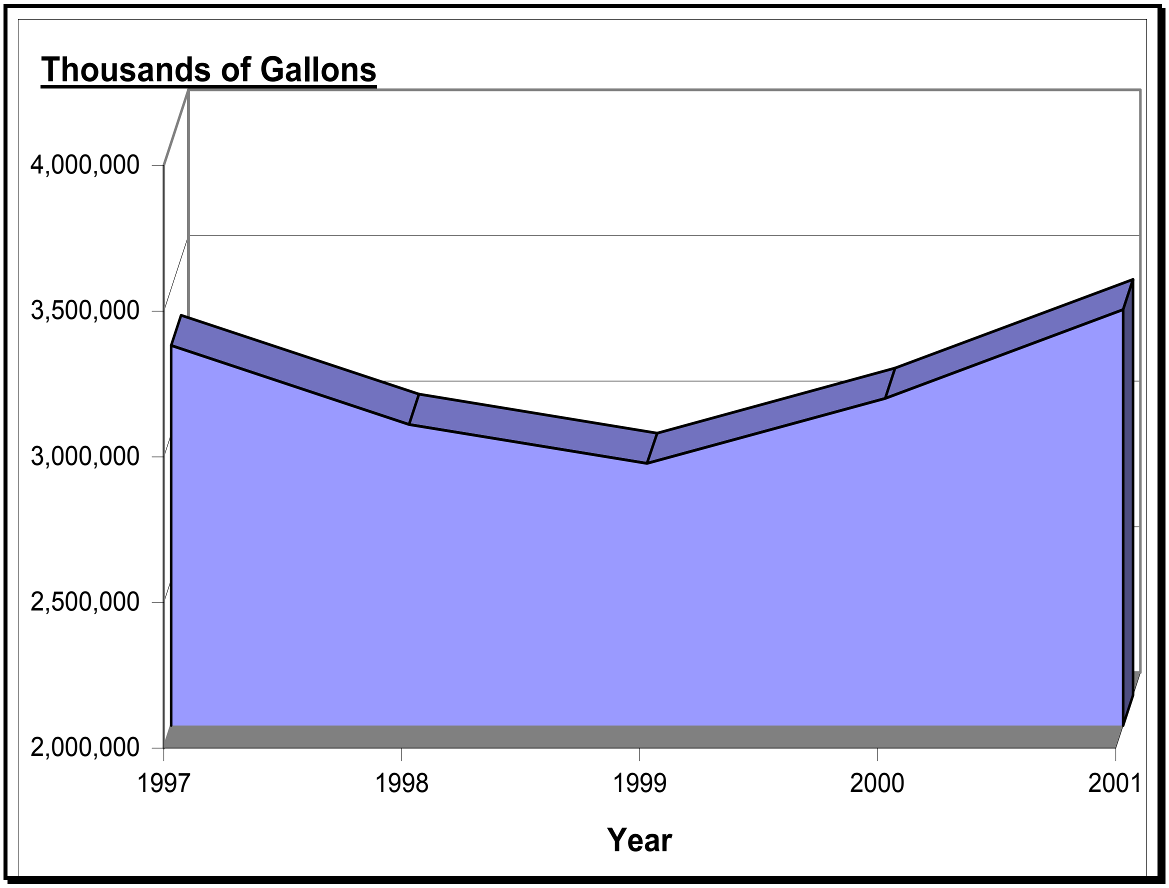
Figure 4.4 Distillate Fuel Oil Use in US Transportation Segment.



Source: US Department of Energy, Energy Information Administration

On-farm demand for distillate fuels has also been a notable market for biodiesel because the fuel can be derived from agricultural feedstocks. The National Biodiesel Board, several agricultural organizations, and academic researchers have emphasized the potential for biodiesel to be used within the farm segment. Figure 4.5 depicts the past five years of US distillate fuel demand for farm use.

Figure 4.5 US Sales of Distillate Fuel Oil for Farm Segment.



Source: US Department of Energy, Energy Information Administration

A number of sectors rely on distillate fuels for energy. While transportation, especially on-highway vehicles, comprises the majority of distillate sales, the graphs on sales by segment indicate consistent growth in demand for distillate fuels. As demand for such fuels increases, there may be more opportunities for biodiesel to become a potential substitute for the assorted user segments.

Biodiesel in its pure and blended form is used by consumers to fill a variety of energy needs. One of the challenges to estimating the demand within different user segments for biodiesel results from the variety of the blends available. After classifying some of the most prevalent forms of biodiesel consumed and the attributes associated with them, the following paragraphs on the segments of demand for the fuel with reveal some of the current and potential future target markets.

The most common compositions for biodiesel fuel can be divided into three main categories: Neat biodiesel (B100), Blends (B20-B50), and Additives (B1-B2).[105] Neat biodiesel can provide the most environmental and performance benefits to the consumer while also posing some potential drawbacks, most notably in its cost. The highest

[105] How is Biodiesel Used? Mechanical Engineering Department. Iowa State University.

demand for this type of fuel could occur in ecologically sensitive areas and among environmentally conscious consumers. Blends from B20 to B50 could be utilized when the additional cost associated with pure biodiesel becomes a major concern for consumers. Finally, additives of biodiesel such as B1-B2 can provide users with enhanced lubricity while minimizing the costs associated with using the alternative fuel. While each of these compositions appeals to unique and diverse markets, consumers' valuations and requirements will dictate their actual selection of fuel type.

Biodiesel consumption can be analyzed through four main user segments: public sector demand, individual consumers, private fleet operators, and specialized markets. Recent estimates from Joe Jobe of NBB reveal that over 200 fleets alone rely upon biodiesel for a portion of their fuel demands.[106] Each segment has special valuations for the renewable fuel and their resulting consumption of different fuel types reflects their preferences.

Public sector demand includes government users at the local, state, and national levels. The amendment of the Energy Policy Act in 1998 had a direct impact on the use of biodiesel within the government sector. On the federal level, the US Department of Defense, the National Forest Service, the US Postal Service, and all branches of the US military use biodiesel in some of their diesel engines.[107] The US Postal Service alone consumed 671,000 gallons of biodiesel in 2001.[108] Within the Washington D.C area, Arlington County, Virginia, has instituted the use of biodiesel in 500 of its vehicles.[109] Further growth in demand has been realized as "school districts, transit authorities, national parks, public utility companies and garbage and recycling centers also use the fuel." [110]

Individual consumer use of diesel-powered engines does not comprise a large portion of the total automobiles within the US. In 2000 sales of light-duty diesel vehicles amounted to only 0.26 percent of all new cars sold within the US. In comparison to Western Europe where biodiesel demand has grown extensively in the past decade, light-duty vehicles there account for about 33 percent of new car sales.[111] Two of the primary factors that may also limit demand from this market segment in the US include the limited supply of retailers with biodiesel products available at the pump and the general lack of understanding about the alternative fuel. In May 2001 the New York Times estimated that there were only 21 retail pumps with biodiesel or blends of the product within the US.[112] Additionally, although some consumers may be willing to pay the higher costs associated with the fuel, the majority of individuals have been willing to wait until the cost of biodiesel decreases or governmental policy mandates its use.

[106] Caparella, Tina. "Biodiesel and CWD are Hot Topics at NRA's Central Region Convention."
[107] Caparella, Tina. Render. "Biodiesel and CWD are Hot Topics at NRA's Central Region Convention."
[108] "US Interest in Biodiesel Growing." New York Times.
[109] "Nation's Capitol Turns to Biodiesel." Iowa Farm Bureau. 9 April 2003.
[110] "Biodiesel Fuel Market." Alternative Fuels Data Center.
[111] Demand for Diesels: The European Experience. Diesel Technology Forum.
[112] "US Interest in Biodiesel Growing." New York Times.

Composing a large portion of the private diesel market segment, most trucking firms do not appear to have adopted biodiesel as aggressively as other market segments. The primary reason for this is most likely cost, but there may also be concerns about the performance issues associated with the fuel. For example, Grant Goodman, a Phoenix concrete producer, began using biodiesel in all 130 of his businesses vehicles in 2001. He noted that the additional cost for biodiesel was up to 70 cents higher than diesel and has consequently forced him to lower his blends to below 40 percent biodiesel.[113] However, the upcoming enactment of the sulfur mandate combined with recent increases in diesel fuel prices may drive more users within the private industry segment towards biodiesel.

Consumers and authorities valuing the environmental and/or performance attributes of biodiesel may insist upon using the fuel in specialized markets. Biodiesel has been identified as a prospective fuel for a number of such markets including marine engines, underground mining operations, and other areas with environmental or safety concerns. The additional benefits of a higher flashpoint, faster biodegradability, and lower emissions levels for some pollutants have been cited as incentives for further expansion within specialty markets. [114]

In review, the factors that created the segments of demand for diesel and biodiesel are typically defined by the end-user's intentions for the fuel. In terms of biodiesel, there should be recognition given to the specific segments of markets, including public sector entities and specialty users, where the environmental and performance attributes of the fuel have proven to be more valuable in meeting certain objectives. However, as biodiesel consumption grows, the price of the renewable fuel will likely influence which user segments experience the greatest growth in demand.

Pricing

This section will relate the role of diesel and biodiesel fuel prices in determining the demand for biodiesel. Acting as a direct substitute for diesel fuel in many applications, biodiesel typically has a higher price which has limited the adoption of the fuel among some users. Not surprisingly though, the lower price of diesel has been noted as being "the greatest single barrier to increased biodiesel use in the US market."[115] By illustrating the relevant diesel fuel price and providing recent estimates of biodiesel prices, this section will analyze the potential price and demand for biodiesel in its pure and blended forms.

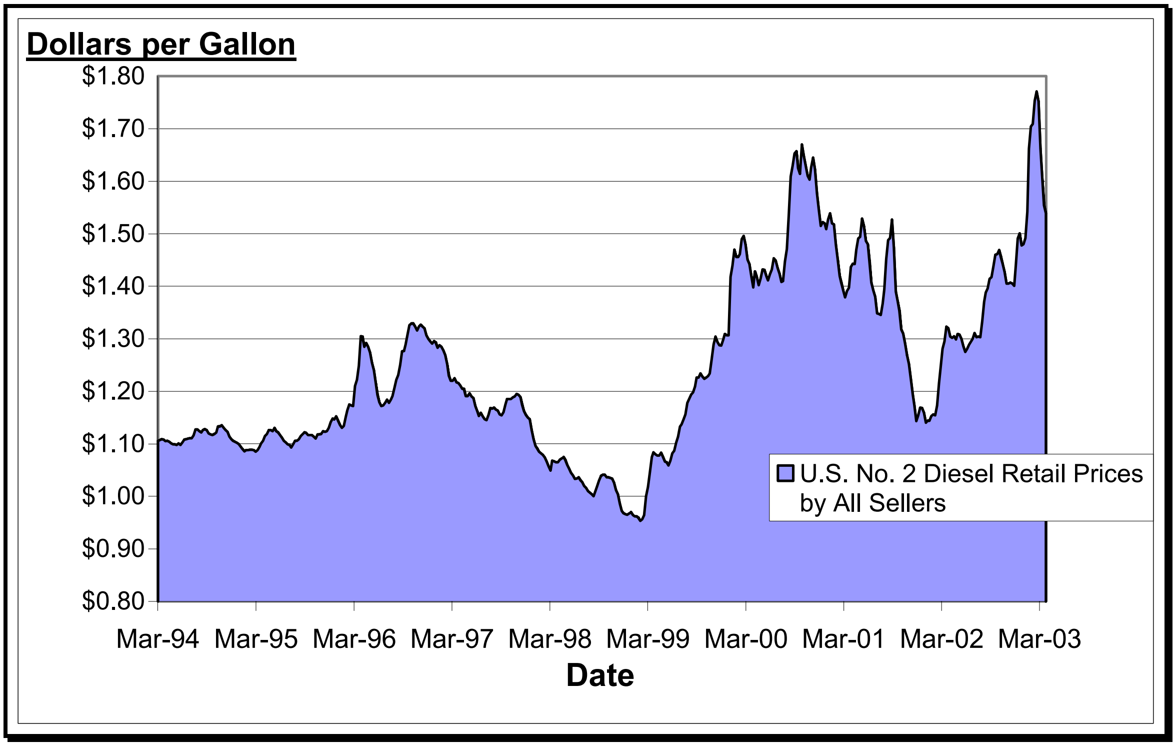
The following chart, Figure 4.6, depicts the average national No. 2 diesel fuel price over the past nine years. Ranging from a low of $0.95 per gallon to its peak of around $1.70 per gallon, No. 2 diesel fuel prices have a direct influence on the demand for biodiesel. No. 2 diesel is typically used in high-speed diesel engines such as trucks and automobiles for on-highway consumption as well as railroad locomotives.[116] As the

---

[113] Lavelle, Marianne. "Biodiesel; Ethanol; Hydrogen; Natural Gas."
[114] Howell, Steven, and J. Alan Weber. US Biodiesel Overview.
[115] Groschen, Ralph. Overview of: The Feasibility of Biodiesel from Waste/Recycled Greases and Animal Fats.
[116] Fuel Oil and Kerosene Sales 2001. US Department of Energy. Energy Information Administration.

price of diesel fuel has increased over the past year, it has become more comparable with the price of biodiesel.

Figure 4.6 US No. 2 Diesel Retail Sales by All Sellers (Includes All Taxes).



Source: US Department of Energy, Energy Information Administration

Within the US, Diesel fuel sold for on-highway use is taxed at both a state and a federal level. The federal tax has been at $0.244 per gallon since October 1997. The revenue from the national tax is collected and placed within the Federal Highway Trust fund.[117] State tax levels vary both in their rates and collection methods. Indiana, for example, has a state tax of $0.16 per gallon, a quarterly reported surcharge tax of $0.11 for motor carriers, and a sales tax of 6 percent on the pretax price of the diesel fuel.[118]

While it is generally recognized within the US that current biodiesel prices exceed diesel prices, finding a definitive price for the renewable fuel is complicated by several factors including feedstock costs, different markets for the fuel, blending potential, federal subsidies and fuel taxes. Feedstock costs may vary considerably because of the range of feedstocks available to make biodiesel and the market price for those inputs. Markets for the fuel may cause the price of biodiesel to differ due to geographical regions or separate user segments for demand. The blending of biodiesel also complicates estimates because several reports do not specifically address whether the quoted price is for blended or pure forms of the fuel. Federal subsidies for biodiesel production may also not be incorporated into the price estimates.

---

[117] "Highway Taxes and Fees." United States Department of Transportation - Federal Highway Administration. Office of Highway Policy Information.

[118] "Indiana Tax Descriptions and Receipts." Indiana Department of Revenue Annual Report - October 1, 2001.

The US Department of Energy made a rough prediction that biodiesel prices fall somewhere between $1.00 and $2.00 per gallon.[119] A University of Minnesota study relied upon a Missouri report to determine that soybean-derived biodiesel could cost about $1.66 per gallon.[120] A recently released Minnesota Department of Agriculture analysis referenced biodiesel prices being at or below $1.50 per gallon.[121] However, the most precise estimate originated from Iowa State University with an estimate between $1.30 and $1.50 per gallon when fuel taxes are ignored. Capturing the complex pricing involved with biodiesel, the Iowa State description also explained, "the selling price of biodiesel must exceed the feedstock cost to cover processing, packaging, transportation, distribution, and profit."[122]

The price of biodiesel/diesel blends typically reflect the costs of the two fuels proportional to the respective amounts of each included within the mixture. One estimate for blends predicted that B2 would cost $.02 more per gallon than regular diesel.[123] Another from a researcher at the University of Arkansas pegged the prices of B5-B20 blends from $.05 to $.10 more expensive than petroleum diesel.[124] Although the estimates for blend prices vary, a standard prediction within the industry appears to be that for each 1 percent increase in biodiesel added, consumers should expect to see a 1 to 2 percent price increase for the blend.

The availability of historical biodiesel prices for public use is currently limited to only a few databases. The Alternative Fuels Data Center, a division within the US Department of Energy, publishes a quarterly report, Clean Cities Alternative Fuel Price Report, which collects data from individuals associated with the Clean Cities program[125]. Prices are reported for a one week time frame during each quarter and also compared with the previous period's estimates. The report brakes down the data based on several geographic regions and also reports the median price across the US. The prices for B20 were first published for the quarter that included October 2001 but that lack of consistent responses has historically left several regions with unreported prices. Table 4.1 provides the reported prices for the various regions.

---

[119] "Bringing Greener Machines to National Parks – Part 2: Cleaner, Quieter Park Fleets." US Department of Energy.
[120] Tiffany, Douglas. Biodiesel: A Policy Choice for Consumers. Presentation.
[121] Groschen, Ralph. Overview of: The Feasibility of Biodiesel from Waste/Recycled Greases and Animal Fats.
[122] Mechanical Engineering Department. Iowa State University. Economic Considerations.
[123] Tiffany, Douglas. "Points of Disagreement and Agreement on Minnesota's Biodiesel Mandate: A Review of C. Ford Runge's, 'Taking From Many, Giving to Few.' "
[124] Manning, P., Popp, and Cochran. Biodiesel: Potential and Possibilities for the Arkansas Economy.
[125] The Alternative Fuel Price Report. US Department of Energy.

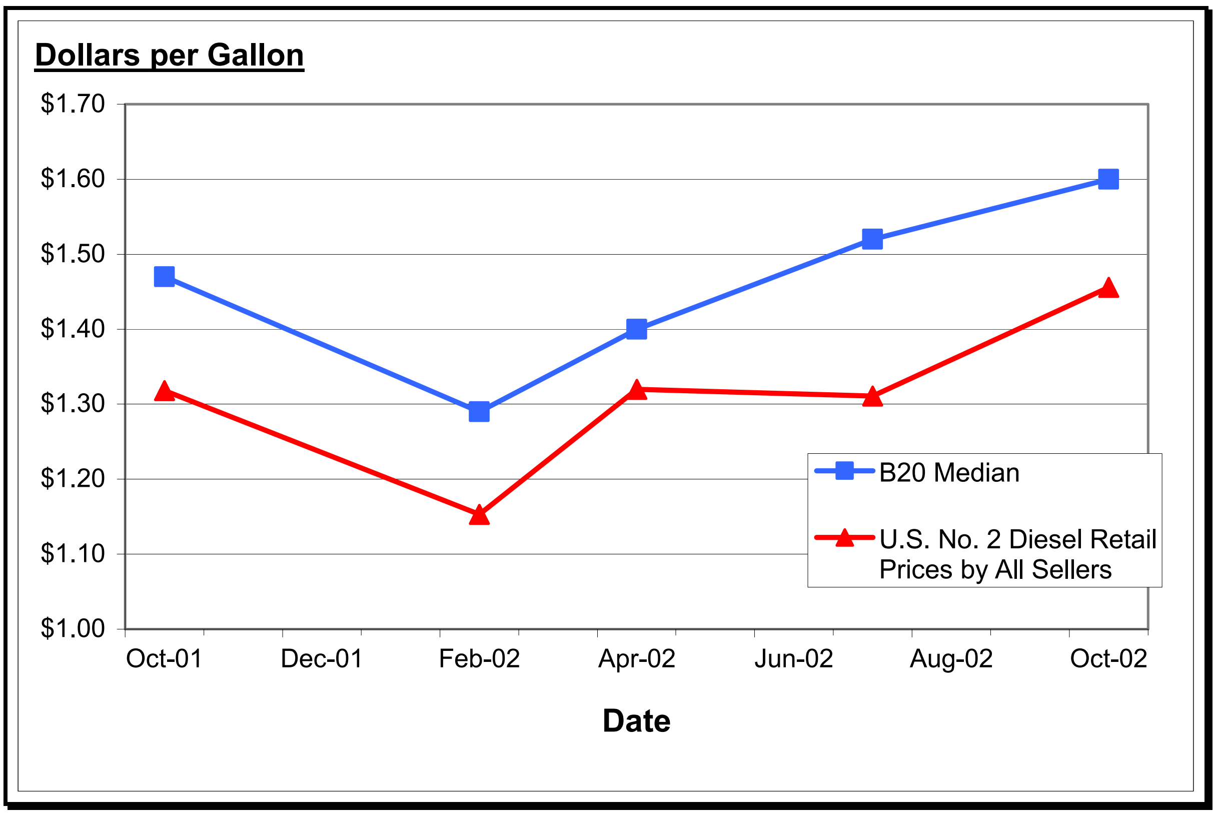
Table 4.1 B20 Prices for US Regions from Quarterly Surveys.

			Date		
Region	**10/22/01**	**2/11/02**	**4/15/02**	**7/22/02**	**10/28/02**
New England	-	$1.77	-	$1.58	-
Central Atlantic	$1.80	-	-	$1.39	$1.60
Lower Atlantic	$1.45	$1.06	$1.06	$1.22	$1.46
Midwest	$1.47	$1.27	1.25	$1.23	$1.60
Gulf Coast	-	$1.40	-	-	-
Rocky Mountain	-	$1.29	$1.40	$1.52	$1.61
West Coast	$1.80	$1.40	$1.66	$1.79	$1.73

Source: US Department of Energy – Alternative Fuel Data Center: The Alternative Fuel Price Report

To provide a comparison with the diesel prices in Figure 4.6, Figure 4.7 depicts the diesel and biodiesel prices recorded during each of the five quarters of data from the Alternative Fuels Data Center. The median value for B20 was provided within the quarterly reports.

Figure 4.7 B20 and Diesel Price Estimates within the US (Includes Taxes).



Source: Alternative Fuel Data Center: The Alternative Fuel Price Report, US Department of Energy, Energy Information Administration

Several private biodiesel producers, fuel distributors, and consultants maintain records of prices for both neat biodiesel (B100) blends of the fuel. Most of those prices are not distributed publicly, but one example can be found on the Energy Management Institute's web site. The site's sample Alternative Fuel Index report indicates biodiesel and diesel prices that are consistent with other estimates relating to the proportional increase expected based on the amount of biodiesel in the blend.[126]

While price levels vary from report to report, some generalities can be made about biodiesel prices. In general, biodiesel prices improve from around $.80/gallon to $1 more per gallon that diesel prices depending on the current cost of feedstocks. Fuel blends are about $.01 to $.02 per gallon for B2 up to $.10 per gallon for B20.

B. Production and Supply of Biodiesel

The supply of biodiesel can be examined within three general parameters: (1) production process, (2) macro-level industry analysis), and (3) external supply factors. This section begins with an assessment of the production processes involved to convert feedstocks and other inputs into biodiesel and the glycerol byproduct. The second portion is a macro-level industry analysis of the current production locations and capacities within the US. The analysis will also examine the various feedstocks available to use in the production of biodiesel. The third portion of the supply section, external supply factors, will discuss governmental policies such as subsidies and mandates, the role of the National Biodiesel Board, and the development of industry quality standards will be examined.

Production Process

The production process for biodiesel is relatively simple. Although there are several web sites and a book titled From the Fryer to the Fuel Tank that describe how individuals can create biodiesel in small quantities, the focus of this section will be to describe the larger-scale production processes used within the industry. The next sections break down the necessary inputs, the phases of processing, and the outputs created from the entire process. The current main production process used within the industry is base catalyzed transesterification. This method is preferred economically due to the high conversion rate, direct conversion process, low investment costs and the reduced temperature and pressure levels required.[127] The intent of this section is to provide a brief summary of the steps involved in the production process.

Inputs

The main inputs to produce biodiesel include the feedstocks, methanol, a catalyst, and neutralizing acids. However, there are also several other operating inputs, including the plant and equipment, labor, and energy resources, necessary for production. This segment on inputs will discuss the four main inputs and then provide a review of estimates for the other operating inputs involved.

As described later, feedstock costs contribute the majority of the total costs for producing biodiesel. Although the prices for those feedstocks may change in the future, previous historical averages place trap greases at the lowest cost, followed by yellow greases, mustard oil, tallow and lard, soybean oil, and finally canola oil. Costs for these feedstocks range from below five cents for trap greases to more than 25 cents for canola

---

[126] Alternative Fuels Index. Energy Management Institute.
[127] Biodiesel Production. National Biodiesel Board.

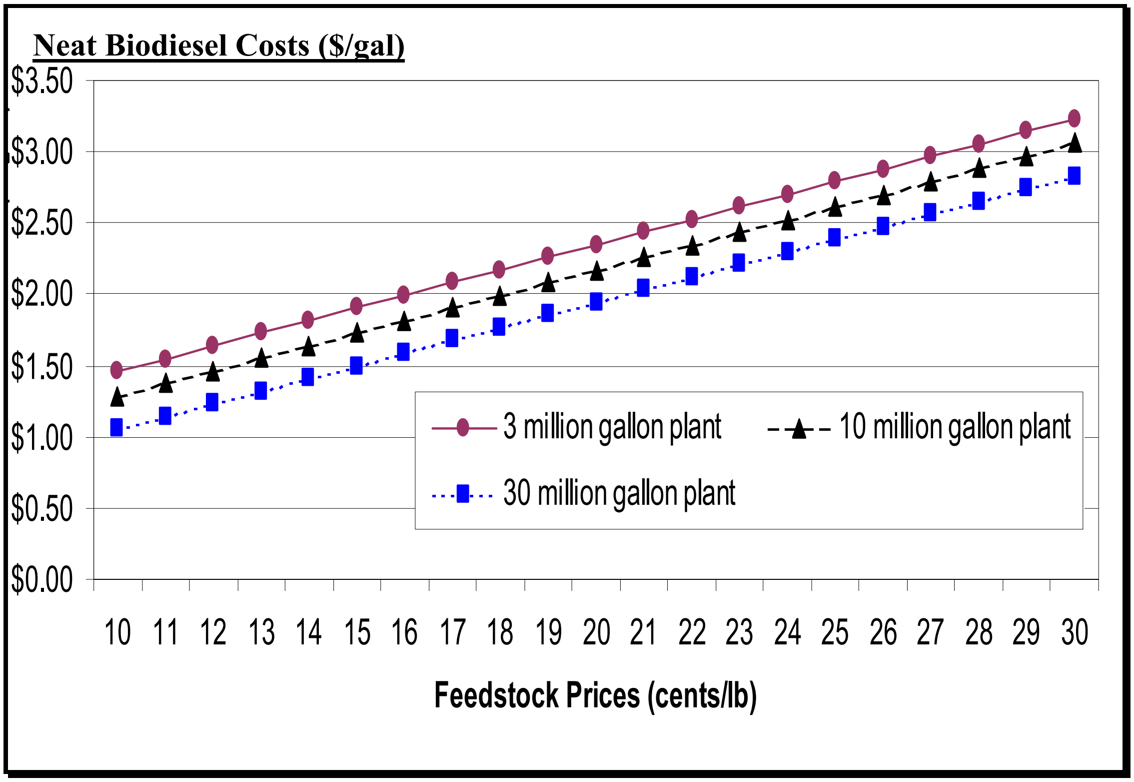
oil. In addition to feedstock cost Transportation, refining of the oil and the presence of an infrastructure to acquire the oils should also be considered in total costs.

Methanol and catalysts are added to the feedstocks to initiate the transesterification process to make biodiesel. Methanol, or another alcohol, is used at roughly a 1:10 ratio with the feedstocks. However, many producers will increase the amount of methanol within the solution to ensure that the conversion process is completed.[128] Some of the methanol is recovered at the end of the production process and reused in future production. A catalyst such as sodium or potassium hydroxide is premixed with the methanol and aids in the conversion process. Neutralizing acids are also used later in the production process to neutralize the unused catalysts and soaps within the reaction.[129]

Apart from the necessary inputs, other operating expenses incurred during production include plant and equipment investments, labor requirements, and energy resources. Estimates for the capital costs vary significantly depending upon the size of the plant, the efficiency of the production process (continuous flow or batch production), and the level of technology incorporated. In 1998 the NREL estimated that the facility investment costs would vary based on the size of the production plant. A small-scale plant under 3 million gallons would cost as much as two to three dollars per gallon of capacity, while a 5 to 10 million gallon plant would be about one dollar per gallon, and a 30 million gallon plant would be about 50 cents per gallon.[130] Labor costs will vary depending upon the number of employees required for the production process as well as the regional wage rate. The level of technology within the plant may have a bearing on the total number of employees required for production. Energy and other resource requirements such as heat, electricity, and water, must also be considered in the costs of production. A study conducted by Popp and Cochran of the effects of biodiesel on the Arkansas economy illustrates costs of production for three different plant sites at various feedstock cost levels in Figure 4.8.

[128] Mechanical Engineering Department. Iowa State University.
[129] Biodiesel Production and Quality. National Biodiesel Board.
[130] Manning, P., Popp, and Cochran. Biodiesel: Potential and Possibilities for the Arkansas Economy.

Figure 4.8 Costs of Production for Various Plant Sizes and Feedstock Costs.



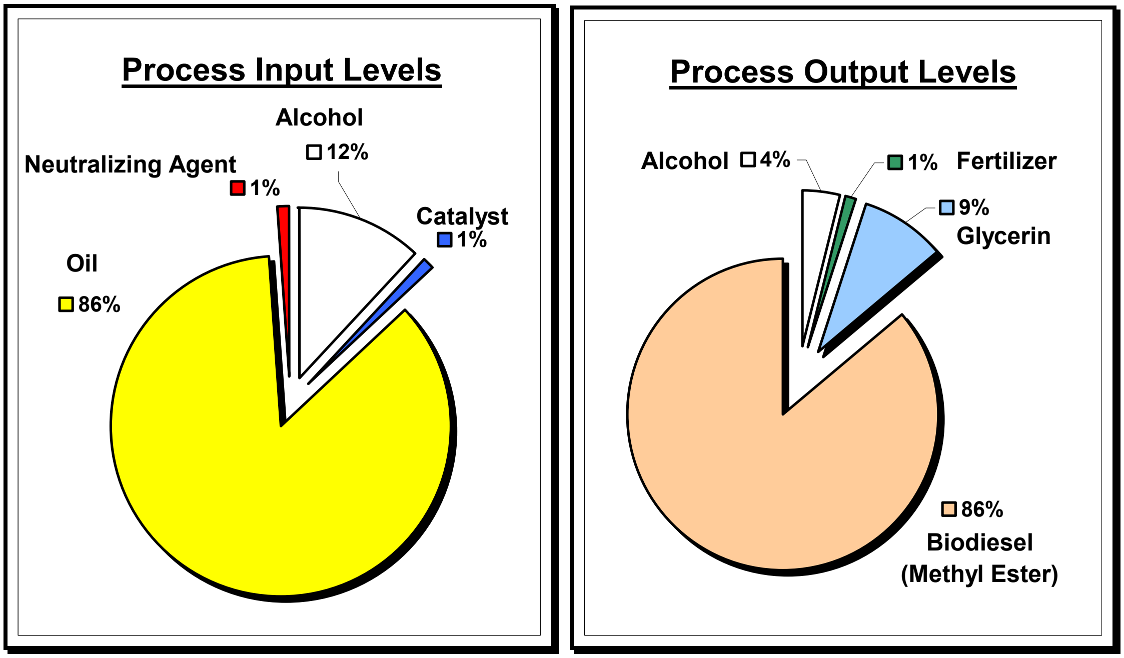
Includes 15% rate of return
Source: Biodiesel: Potential and Possibilities for the Arkansas Economy

Production Phases

This section describes the phases of production for making biodiesel. The production phases are explained using the descriptions provided by the National Biodiesel Board unless otherwise noted. The chemical composition of biodiesel is created through the process called transesterification. The process involves the separation of the glycerin molecules from three long chain fatty acids within the oil or fat (triglyceride). Approximately 7.35 pounds of oil are used to create one gallon of biodiesel, but this figure may vary depending upon the feedstock source.[131] Also, a common conversion ratio used within research is that 10 units of feedstock plus one unit of alcohol will yield 10 units of biodiesel and one unit of glycerin[132] Figure 4.9 gives a more accurate description of the levels of inputs and outputs involved within the phases of production for biodiesel. Figure 4.10 provides an illustration of the entire biodiesel production process which will be described next.

[131] "Biodiesel Production Technology Overview." National Biodiesel Board.
[132] Groschen, Ralph. "Overview of: The Feasibility of Biodiesel from Waste/Recycled Greases and Animal Fats."

Figure 4.9 Input and Output Levels in Biodiesel Production.



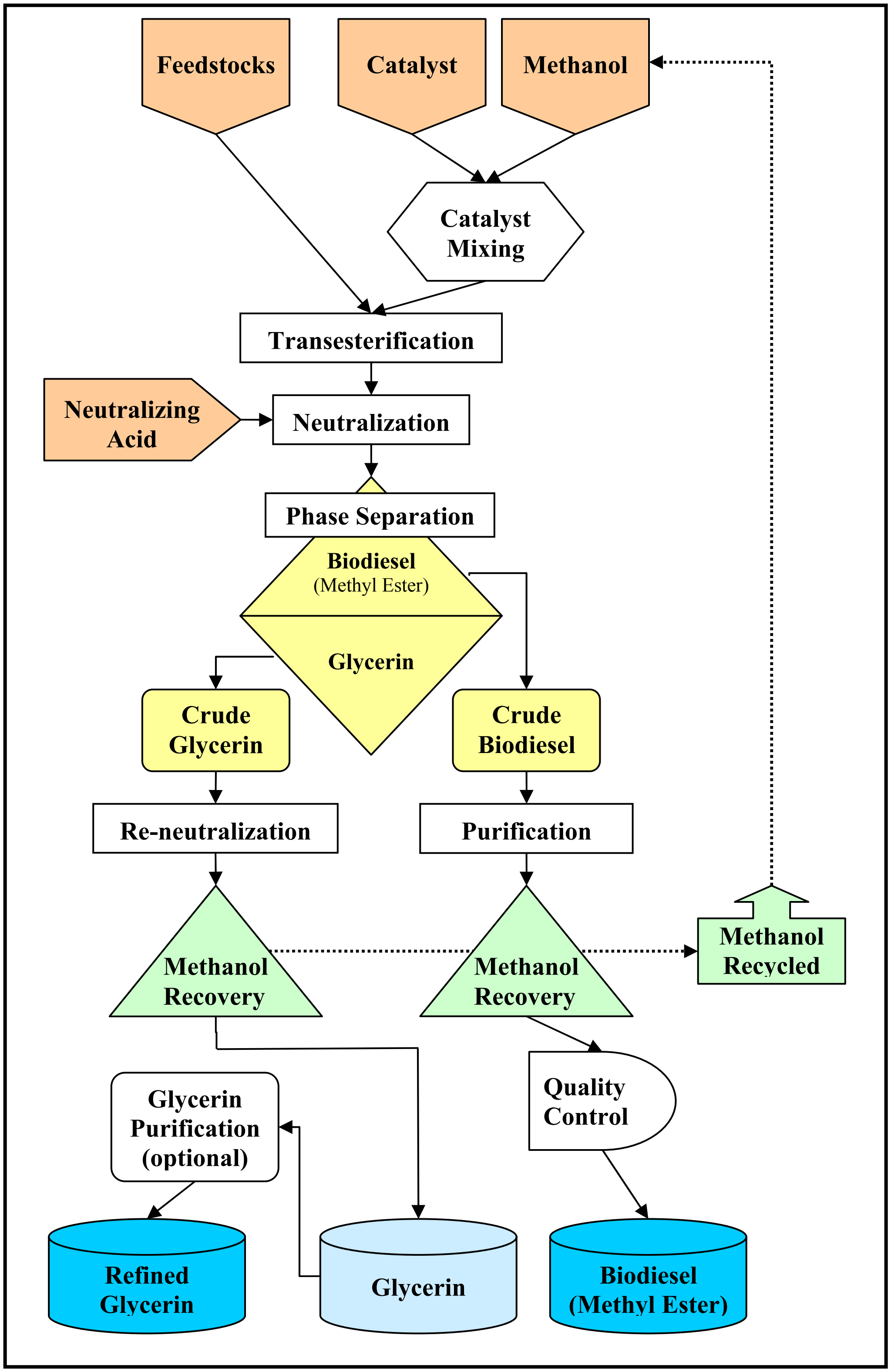
Source: National Biodiesel Board

To initiate the production process, the catalyst is mixed with methanol and then added to the vegetable oil for the transesterification phase. Because of the unique qualities of different feedstocks, special attention must be given to mixing the appropriate inputs.[133] During this phase the main reaction occurs over a time period of one to eight hours. The reaction is a closed process that typically involves temperatures near 160° F. As the oil molecules are separated, glycerin and biodiesel (methyl esters) are created from transesterification and the two outputs are then neutralized to offset the excess methanol that may be present.[134]

---

[133] Faye, Zenneth. CanolaInfo. "Canola Biodiesel."
[134] Biodiesel Production and Quality. National Biodiesel Board.

Figure 4.10 Biodiesel Production Process.



Source: National Biodiesel Board reconciled with Dr. Shaine Tyson, "Brown Grease Feedstocks for Biodiesel".

The two converted products, biodiesel and glycerin, have different densities and are then divided into separate solutions. The crude biodiesel is purified and excess methanol is removed. At the same time, excess methanol is removed from the glycerin. Both processes rely upon flash evaporation or distillation to remove the methanol. The excess methanol is often recycled. The biodiesel then goes through a wash phase in some plants and is analyzed to ensure proper quality. The glycerin may be marketed in its crude form or refined to more than 99 percent purity to be sold at a higher price.[135]

The National Biodiesel Board maintains a detailed description of the entire production process. The Board emphasizes five key aspects to ensure that the biodiesel meets industry and performance standards including: complete reaction, removal of glycerin, removal of catalyst, removal of alcohol, and absence of free fatty acids.[136] The Mechanical Engineering Department at Iowa State University hosts a video from the Biomass Energy Conversion Center (BECON) for the Iowa Energy Center. The video provides a more detailed description of the biodiesel production process and is available at: www.bioproducts-bioenergy.gov/0801.html.

Outputs

The two main outputs from the production process are biodiesel and glycerin. Methanol is recycled within the production phases and a small amount of fertilizer can also be created. Pure biodiesel should adhere to specific ASTM (American Society for Testing and Materials) standards in order to protect against engine problems.[137] Those standards, included in Table 4.2, mandate the limits of certain chemicals such as glycerin, and carbon, while also placing restrictions on the performance standards such as the cloud point and flash point temperatures. Once it is checked for quality, the biodiesel is then packaged according to consumer demands and shipped out for distribution.

[135] Biodiesel Production and Quality. National Biodiesel Board.
[136] Biodiesel Production and Quality. National Biodiesel Board.
[137] “Requirements for B100.” Alternative Fuels Data Center. US Department of Energy.

Table 4.2 ASTM D-6751 Standards for Biodiesel.

Property	ASTM Test Method	Limits	Units
Flash Point	D 93	130.0 min	°C
Water and sediment	D 2709	0.050 max	% volume
Kinematic viscosity, 40°C	D 445	1.9-6.0[C]	mm^2/s
Sulfated ash	D 874	0.020 max	% mass
Sulfur[D]	D 5453	0.05 max	% mass
Copper strip corrosion	D 130	No.3 max	
Cetane number	D 613	47 min	
Cloud point	D 2500	Report	°C
Carbon residue (100% sample)	D 4530	0.050 max	% mass
Acid number	D 664	0.80 max	mg KOH/g
Free glycerin	D 6584	0.020	% mass
Total glycerin	D 6584	0.240	% mass

Source: US Department of Energy – AFDC: Biodiesel Standards, Codes, and Legislation

Glycerin is used in a wide variety of products including as an additive within food and beverages, pharmaceutical drugs, cosmetics and toiletries, tobacco, paper and printing, and textiles.[138] In 2001 glycerin demand in the US was estimated to be increasing at a rate of about 3 to 4 percent from around 530 million pounds per year.[139] With 15 production facilities Proctor and Gamble is one of the largest natural glycerin manufactures in the US. Although industrial operations using triglycerides and biodiesel production create natural glycerin as a byproduct, it can also be made synthetically. Dow Chemical has one synthetic production plant and is the leading US manufacturer of the product.[140] Prices for its 99.7 percent glycerin product, which typically command a 10 percent premium over animal derived glycerin, were at $0.86 per pound as of March 2003.[141,142]

To reach this level of purity, the glycerin from biodiesel production must be refined, which adds to the costs for equipment and processing at a facility. Additionally, biodiesel produced from inedible greases may not produce a glycerin byproduct that meets the desired quality levels for customers. From 1992 to 2002, glycerin prices have been volatile and have ranged from around $0.50 to $1.00 per pound. If biodiesel production expands within the US, the supply of natural glycerin from the industry would be expected to increase.[143] Because of the potential revenues from glycerin prices, the total market supply of glycerin and the resulting prices will have an impact on the future feasibility and profits for biodiesel production.

---

[138] "Uses for Methyl Esters, Glycerol." National Biodiesel Board.
[139] Reilly, Christopher. "Glycerin Market begins Upward Turn
[140] "Crambe, Industrial Rapeseed, and Tung Provide Valuable Oils."
[141] Economic Feasibility of Producing Biodiesel in Tennessee. Agri-Industry Modeling & Analysis Group et. al.
[142] "OPTIM Glycerine 99.7% USP/EP Prices." E-Epoxy.
[143] Groschen, Ralph. Overview of: The Feasibility of Biodiesel from Waste/Recycled Greases and Animal Fats.

The inputs, outputs and production phases involved in the manufacturing of biodiesel influence the overall price and performance of the fuel. In a 1998 USDA report, the total cost for producing biodiesel ranged from $1.39 to $2.52 per gallon depending upon expected costs of various feedstocks.[144,145] There are a multitude of estimates for the cost of biodiesel production depending upon input and operating costs.

Macro-level Industry Analysis

The industry analysis will be separated into two components, current production and alternative feedstocks. The current production component will describe the past and present state of biodiesel production within the US. The second component of this section, will explore the different inputs that are available for chemical conversion to create biodiesel. Feedstocks are estimated to contribute between 65 to 75 percent of the total cost to produce biodiesel.[146] The industry analysis component of alternative feedstocks will focus on the availability, prices, and potential consequences resulting from the demand of different feedstocks for biodiesel production.

Current US Production

US production of biodiesel has increased significantly in the past five years. As demand for the fuel has expanded, several new production plants have emerged within the US. In February 2000, Joe Jobe, Executive Director of the National Biodiesel Board testified that there were thirteen biodiesel producers at that time, up from only four just two years earlier.[147] The growth has continued, with registration in August 2002 revealing that there were 17 biodiesel producers within the US.[148] A new 12 million gallon plant was added in December 2002, bringing current dedicated production level to 18 plants.[149] Table 4.3 lists the names, and locations for most of the biodiesel production facilities within the US. Figure 4.11 from the NBB illustrates most of the locations of those biodiesel production plants throughout the US.

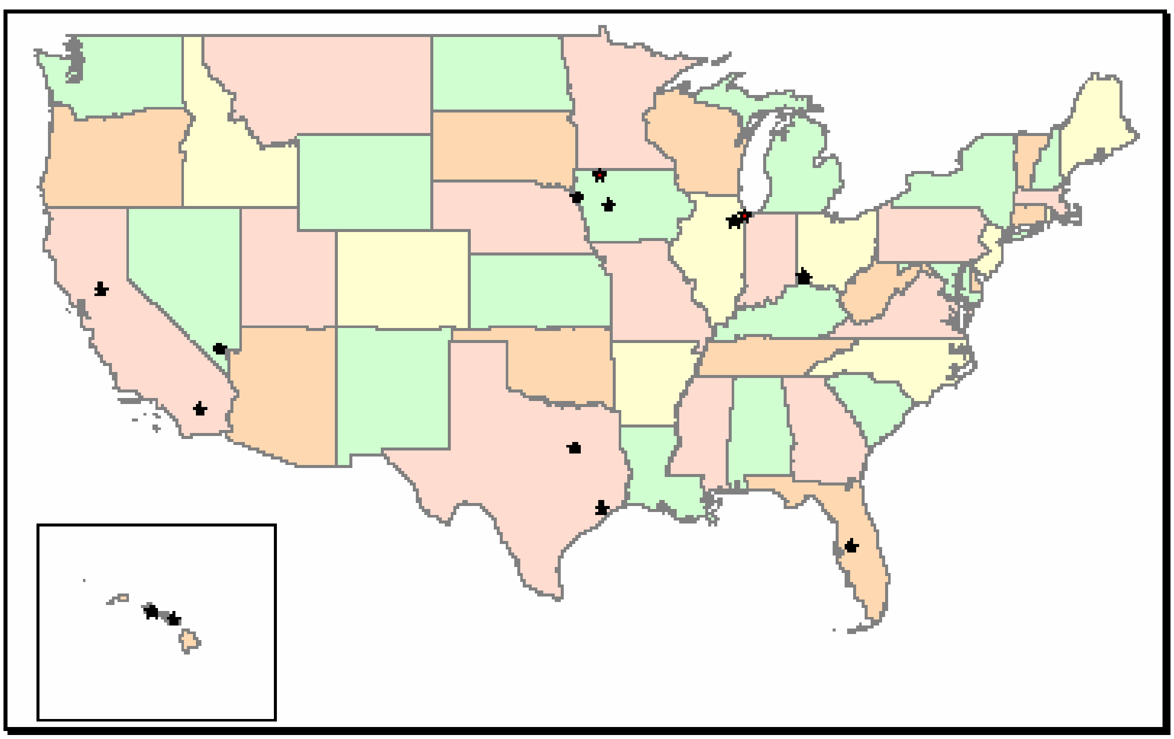
[144] Coltrain, David. Biodiesel: Is It Worth Considering
[145] Duffield, James, et al. "US Biodiesel Development: New Markets for Conventional and Genetically Modified Agricultural Products."
[146] Pearl, Gary. "Biodiesel Production in the US."
[147] H.B. 2643 "Clean Burning Fuel: Biodiesel." Arizona House of Representatives Forty-Fourth Legislature – Second Regular Session.
[148] Coltrain, David. Biodiesel: Is It Worth Considering
[149] "Biodiesel Facility Begins Production in Ralston, Iowa." National Biodiesel Board.

Table 4.3 Current US Biodiesel Production.

Production Facility	City	State
Ag Environmental Products	Sergeant Bluff	IA
Biodiesel Industries	Las Vegas	NV
Columbus Foods	Chicago	IL
Corsicana Technologies, Inc	Corsicana	TX
Griffin Industries	Cold Spring	KY
Huish Detergents	Pasadena	TX
Imperial Western Products	Coachella	CA
Iowa Lakes Processing	Milford	IA
Ocean Air Environmental	Lakeland	FL
Pacific Biodiesel	Honolulu	HI
Pacific Biodiesel	Kahului	HI
Peter Cremer NA	Cincinnati	OH
Proctor and Gamble	Sacramento	CA
Stepan Company	Millsdale	IL
West Central Soy	Ralston	IA

Source: National Biodiesel Board

Figure 4.11 Locations of US Biodiesel Production.



Source: National Biodiesel Board, used by permission.

Recent national and company news releases also provide indications concerning the biodiesel industry's growth and operations. In May 2002, the New York Times reported that World Energy Alternatives of Chelsea, MA had 75 percent of the biodiesel market. While the company was using soybeans for feedstocks at the time, it is also able to substitute for the soybeans and continue biodiesel production using other oils from rapeseed, waste oils, and recycled grease. The company has plant locations in Ohio, Texas, Florida, California, and Hawaii. American Bio-fuels LLC, a joint-venture company, announced in February 2003 that a 35 million gallon capacity facility for biodiesel production was being constructed. The facility is expected to start by mid-2003.[150] It should be noted that biodiesel production can be increased substantially, in a very short time periods due to the modular nature of the operations.

As depicted in Figure 4.1 production of biodiesel in 2002 reached an estimated 25 million gallons within the US. However, estimates of the total industry capacity vary widely depending upon the source and assumptions. The USDA reported in 1998 that that the annual capacity was 60 million gallons.[151] In 2001, Dr. Gary Pearl of the Fats and Proteins Research Foundation indicated recent predictions put the actual capacity at about 230 million gallons.[152] Additionally, the National Renewable Energy Laboratory has published estimates that the near term supply capacity for the fuel may be 1 billion gallons with a potential 2 billion gallons “expected to be available by 2010.”[153] One of the complications in determining the actual capacity is in separating out dedicated and potential production. Dedicated production has been estimated at between 60-80 million gallons in 2002 while the potential capacity within the oleochemical industry may be upwards of 200 million gallons.[154] The oleochemical industry uses similar processes to create industrial chemicals such as solvents, surfactants and adjuvant applications, and it can also be used for biodiesel production. Future projections on the potential industry supply will likely be dependent upon technological innovation within the production processes, changes in feedstock costs, and governmental support of the fuel.

In comparison with the ethanol industry, some researchers suggest that the biodiesel industry could be progressing down a similar path. In the mid 1970s, ethanol production was only at a few million gallons. Since then, the industry has experienced almost continuous growth with production in 2000 equaling about 1.63 billion gallons of ethanol.[155] While both are renewable fuels that can be derived from agricultural inputs, industry consultants have speculated that the growth in the “US biodiesel industry will not become as large as the ethanol industry.”[156]

To summarize the current production section, the US industry may only be in its initial stages of growth. Considerable growth has and is continuing to occur throughout the US to meet the increased consumer demand. Both the US ethanol and European biodiesel industry developments (Appendix B) may provide insight on some of the factors necessary for further US biodiesel growth. With increased consumer demand and governmental support both being strong drivers for the two industries, these components could pave the way for future growth in the US biodiesel industry.

[150] “Largest Biodiesel Plant in the US Now Being Assembled In Bakersfield, California.”
[151] Duffield, James, et al. “US Biodiesel Development: New Markets for Conventional and Genetically Modified Agricultural Products.”
[152] Pearl, Gary. “Biodiesel Production in the US.”
[153] “Biodiesel Fuel.” National Renewable Energy Laboratory (NREL).
[154] Coltrain, David. Biodiesel: Is It Worth Considering
[155] Coltrain, David. Biodiesel: Is It Worth Considering
[156] Frazier, Rod. “Biodiesel Production Potential in Michigan and Ohio.”

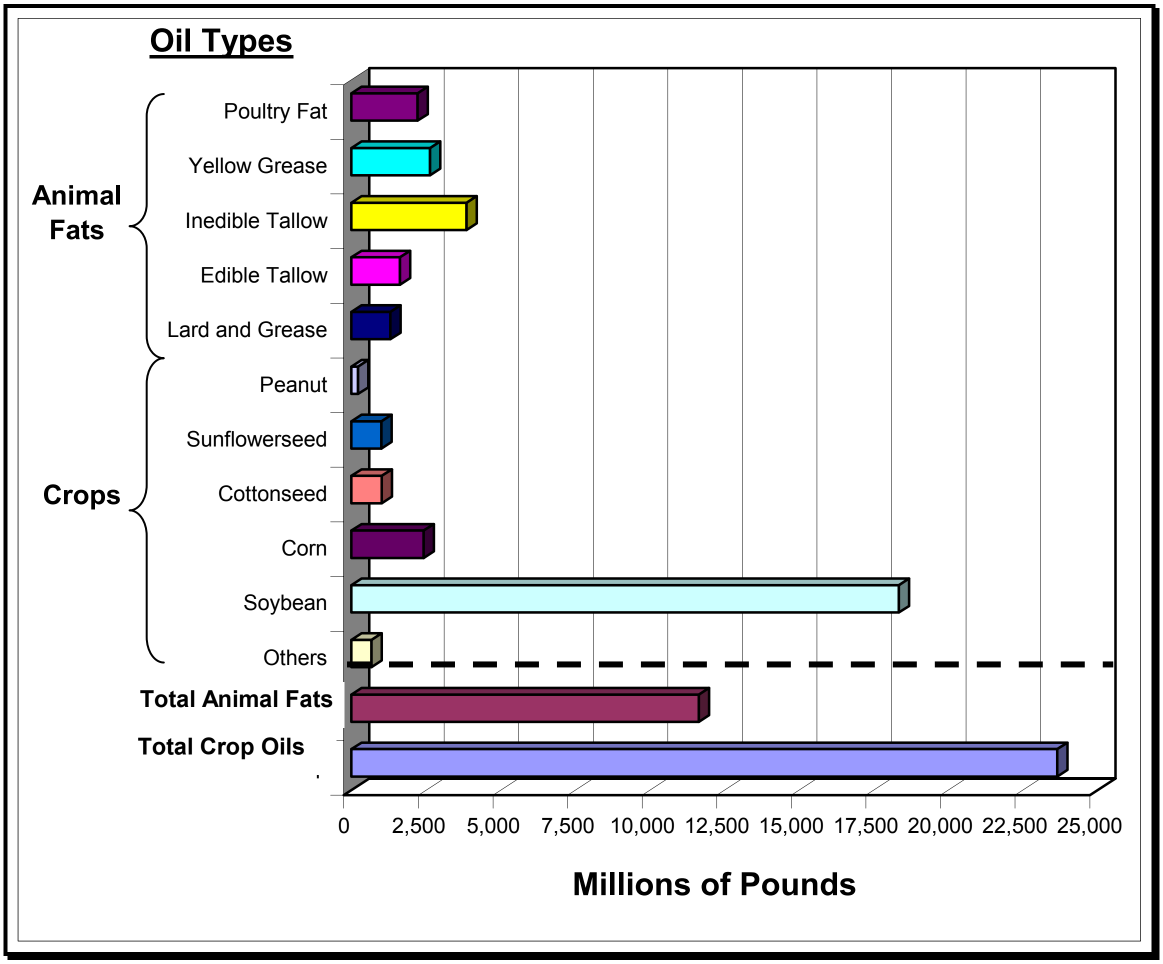
Alternative Feedstocks

Biodiesel can be derived from both plant and animal oils. It can also be created from new or previously used forms of those two types of oil. With a majority of the production expenses for biodiesel dependent upon the feedstock costs, three factors, namely supply, prices, and the chemical nature, become important when considering the different options for making the fuel. This section discusses how these factors affect the industry in terms of inputs utilized and potential growth. If future expansion within the biodiesel industry increases the demand for the various feedstocks, prices for the oils and the respective products which they are derived from could increase. This would ultimately affect the producers responsible for creating those oil products, as well as other industries that rely upon the different types of oil as inputs within their operations.

Industry standards allow biodiesel to be produced from any biomass feedstock as long as the fuel product meets specific performance standards.[157] Biodiesel can be produced using vegetable oils derived from soybeans, corn, canola, cottonseed, rapeseed, mustard, and several other plants. It can also be created using animal fats including beef tallow and pork lard, as well as waste oils and used grease from restaurants and other sources.[158] Figure 4.12 shows that, of the total supply of 35.297 billion pounds of fats and oils within the US, soybean oil amounts to 18.34 billion pounds, or almost 52 percent of the total stock. Behind soybean oil, inedible tallow from cattle slaughter facilities was second in available supply with 3.859 billion pounds.[159]

[157] "Biodiesel from Multiple Feedstocks: Challenges and Opportunities in the Market Place." US Department of Energy (DOE).
[158] Mechanical Engineering Department. Iowa State University. What is Biodiesel
[159] Duffield, James, et al. "US Biodiesel Development: New Markets for Conventional and Genetically Modified Agricultural Products."

Figure 4.12 US Supply of Potential Biodiesel Feedstocks.



Source: "The Feasibility of Biodiesel from Waste/Recycled Greases and Animal Fats" (average 1995-2000)

It's estimated that about 55 percent of the biodiesel production within the US can utilize any fat or oil feedstock. The rest of the industry is limited to only vegetable oil feedstocks.[160] As biodiesel production has evolved, the majority of U.S production plants have relied upon soybean oil feedstocks. Soybean oil accounted for 90 percent of the feedstocks used to produce biodiesel within the U.S in 2001.[161] This contrasts with the European industry where rapeseed is the most common feedstock for biodiesel.[162] The Alternative Fuels Data Center notes:

> "The soy industry has been the driving force behind biodiesel commercialization because of excess production capacity, product surpluses and declining prices. Similar issues apply to the recycled grease and animal fats industry, even though these feedstocks are less expensive compared to soy oils."[163]

---

[160] "What is Biodiesel?" Alternative Fuels Data Center. US Department of Energy.
[161] "US Interest in Biodiesel Growing." New York Times.
[162] "What is Biodiesel?" Mechanical Engineering Department. Iowa State University.
[163] "What is Biodiesel?" Alternative Fuels Data Center. US Department of Energy.

If previous US feedstock usage patterns continue, future expansion in the biodiesel industry would be expected to rely mainly on soybean oil feedstocks. Although this trend may continue, other raw material market developments including technological advances in processing or growing of certain feedstocks may shift the demand for feedstock types as the industry grows. The next three segments will examine the various feedstocks including plant oils, animal oils, and reusable oils that can be utilized for biodiesel production.

Plant Oils

Plant oils can be produced from a variety of oil crops including soybeans, rapeseed, palm, peanut, cottonseed, palm kernel and coconuts. Total production of vegetable oils worldwide amounted to 60 million tonnes (or about 18 billion gallons at 7.35 pounds per gallon) in 2000-2001. The oils must be extracted from the source and then refined to produce the specific qualities desired for the oil. The most common uses for vegetable oils are edible and industrial products.[164] Oil yields per acre can vary significantly depending upon the plant type and growing conditions. The next two paragraphs focus on two potential feedstocks, soybeans and mustard, as inputs for biodiesel production within the US.

Soybean oil is currently the most widely used feedstock for biodiesel production within the US. The oil is derived from the processing of soybeans either mechanically or chemically to produce soybean oil and soybean meal. It's estimated that an average bushel of soybeans will yield about 11.8 pounds of oil and 47.5 pounds of meal, but the exact quantities will depend upon the processing method employed.[165] Considered the more valuable product, soybean meal is used as a protein source within animal feeds.[166] In 1995 soybean oil production amounted to about 15 billion pounds each year. While about 2 billion pounds of the oil was exported, over 97 percent of the remaining quantity was used for edible purposes such as salad and cooking oils, baking and frying fats, and margarine. The remaining 3 percent (300 millions pounds) was utilized for industrial purposes within the oleochemical industry which includes lubricants, plastics, soap, cosmetics and surfactants.[167] Recent estimates from the US Census Bureau recorded 93 establishments producing soybean oil throughout the country. Two of the leading producers included Ag Processing Inc. of Omaha, NE, and the Archer Daniels Midland Company (ADM) of Decatur, IL.[168] In 2002 the total soybean production amounted to 2.73 billion bushels within the US with an average yield of 37.8 bushels per acre.[169] Over the past several years, soybean oil prices have fluctuated between $0.15 and $0.25 per pound. The season average for soybean oil in 2001/02 was $0.165 per pound.[170]

---

[164] Hernandez, Ernesto. "Fats and Oils Processing."
[165] Nelson, Richard, Steve Howell, and J. Alan Weber. "Potential Feedstock Supply and Costs for Biodiesel Production."
[166] Duffield, James, et al. "US Biodiesel Development: New Markets for Conventional and Genetically Modified Agricultural Products."
[167] Duffield, James, et al. "US Biodiesel Development: New Markets for Conventional and Genetically Modified Agricultural Products."
[168] "Soybean Oil Mills." Encyclopedia of American Industries.
[169] Crop Production 2002 Summary. US Department of Agriculture.
[170] Ash, Mark, and Erik Dohlman. Oil Crops Outlook. US Department of Agriculture.

Although soybean oil remains the primary feedstock for biodiesel, the potential benefits of mustard oil have also recently been noted by some industry experts. The Department of Energy is currently exploring the possibility of producing biodiesel from mustard seed. The meal created from processing mustard could be used as a high-value organic pesticide.[171] While proponents of this feedstock may face challenges in registering the pesticide product, the potential returns from the meal may result in lower prices for the inedible oil byproduct. The Alternative Fuels Data Center reports that mustard oil can be produced for about $0.10 per pound.[172]

Several other US crops have been recognized as potential feedstocks for biodiesel production including cottonseed, sunflower, corn, flax, canola, safflower, rapeseed, and peanuts. However, many of these crops are used in other products and their relatively higher prices in comparison to soybean and mustard oils have resulted in little attention to their use in biodiesel production.[173]

Animal Fats

Animal fats, otherwise known as tallow, are acquired during meat processing. Tallow can be derived from cattle, swine, poultry, turkeys and other birds in edible and inedible forms.[174] Roughly 5 billion pounds of tallow is collected from cattle and about 1 billion pounds from swine each year. [175] Poultry fat has also averaged around 2.2 billion pounds from 1993-1998 in the US.[176] The highest concentration of these sources is throughout the Midwest. With an infrastructure already in place to handle animal fats in the US, 75 percent of the tallow produced in 2000 was used in feed markets. The remainder was utilized to make soap, lubricants, and other inedible products.[177] From 1990 to 2001, prices for tallow ranged from about $0.23 to below $0.14 per pound. As concerns over using animal waste within animal feed mixes increase, tallow markets may become saturated and new uses such as biodiesel production may become more important markets.

Reusable Oils

Biodiesel can also be created using recycled grease products including yellow grease and trap grease. Yellow grease is produced from "spent cooking oil and other fats and oils collected from commercial or industrial cooking operations." On the other hand, trap greases are "collected from grease traps that are installed in commercial, industrial or

---

[171] "What is Biodiesel?" US Department of Energy.
[172] "What is Biodiesel?" US Department of Energy.
[173] Duffield, James, et al. "US Biodiesel Development: New Markets for Conventional and Genetically Modified Agricultural Products."
[174] Groschen, Ralph. Overview of: The Feasibility of Biodiesel from Waste/Recycled Greases and Animal Fats.
[175] Duffield, James, et al. "US Biodiesel Development: New Markets for Conventional and Genetically Modified Agricultural Products."
[176] Pearl, Gary. "Biodiesel Production in the US."
[177] Groschen, Ralph. Overview of: The Feasibility of Biodiesel from Waste/Recycled Greases and Animal Fats.

municipal sewage facilities to separate grease and oil from waste water." [178] Renderers will collect and filter yellow grease products before selling them as a supplement to feed for livestock and pets. Trap grease is usually serviced by tank trucks or can flow into wastewater treatment plants, but the exact collection methods vary depending on local regulations. In 1998 the NREL conducted an assessment, the Urban Grease Resource Assessment, and predicted that the total yearly supply for waste grease averaged about 22 pounds per person. Broken down, that amounted to about nine pounds per person of yellow grease and thirteen pounds per person of trap grease.[179] The largest expected supplies for the reusable greases would be within major urban and suburban areas. In terms of prices, yellow grease has been about $0.02 to $0.04 less than animal fats over the past decade. The prices of the two products typically rise and fall together but the higher quality and expanded market for animal fats has allowed that oil product to obtain a premium over reusable greases.[180]

Impacts of Alternative Feedstocks

The capability to produce biodiesel from different feedstocks influences not only the costs of production for making biodiesel; it also affects the supply and demand for the fats and oil feedstocks utilized. This section will discuss the impacts of using alternative feedstocks and review other studies that have focused on predicting the feedstock price implications that could result with increased biodiesel demand.

While price and supply are the major components considered when producers select feedstocks, it's evident that other considerations such as potential subsidies, relationship with suppliers, and the feedstock properties affect the final decision. Subsidies will be discussed towards the end of the supply section in this chapter. Many of the current biodiesel suppliers rely upon soybeans for their major feedstock. Depending upon whether the biodiesel producer is organized as a cooperative or has other soybean milling operations, the direct and indirect relationships with soybean oil suppliers and soybean farmers could also influence the choice of feedstock. Furthermore, the different feedstocks each have separate chemical properties that have consequences for manufactured biodiesel during production, distribution, and consumption of the fuel. For example, the recent EPA analysis on emissions found that animal-based biodiesel decreased carbon monoxide and nitrogen oxides considerably more than soybean-based biodiesel.[181] Research at Iowa State University has revealed however that biodiesel derived from animal fats or greases may incur cold flow problems at higher temperature than soybean-based biodiesel.[182] In summary, although price and final costs may dictate the majority of feedstock preferences, there are other factors that may influence the final production decision.

---

[178] Groschen, Ralph. Overview of: The Feasibility of Biodiesel from Waste/Recycled Greases and Animal Fats.
[179] Wiltsee, G. Urban Waste Grease Resource Assessment.
[180] Groschen, Ralph. Overview of: The Feasibility of Biodiesel from Waste/Recycled Greases and Animal Fats.
[181] Korotney, David. "EPA analysis of the Exhaust Emission Impacts of Biodiesel."
[182] Data on Cold Flow Properties. Mechanical Engineering Department. Iowa State University.

Many of the estimates for future biodiesel production recognize the historical trend for soybean oils to be used as the primary feedstock, but several other researchers have noted that current grease prices make the input an enticing alternative. Groschen from the Minnesota Department of Agriculture remarked, "because of the size and technological development, the soybean processing industry is expected to dominate biodiesel production for the foreseeable future." Additionally, he concluded that if the biodiesel industry relied on multiple feedstocks, there may be greater stability in the pricing of the fuel.[183] In regards to the current primary US feedstock, soybean prices fluctuate depending upon the market demands and potential supplies which are affected annually by global growing conditions and production. If soybean oil prices rise drastically, biodiesel producers may find it advantageous to use other lower-priced feedstocks to create the fuel. In an effort to convey the potential feedstock price implications, the next paragraph will review some studies focused on forecasting input prices and the expected impacts biodiesel production may have on the feedstock markets.

Most analyses of feedstock prices have concentrated on the impact to soybean prices if biodiesel production expands. The USDA released a report in July 2001 that forecasted a $0.17 increase for a bushel of soybeans with the assumption that 200 million gallons of biodiesel would be created from the feedstock by 2010.[184] FAPRI (Food and Agricultural Policy Research Institute) researchers have conducted a study to project the impacts of increased demand for both ethanol and biodiesel in the current decade. Using an assumption that soy oil use for biodiesel would increase by two billion gallons from 2000 to 2011, the analysis concluded that soybean oil prices would increase by 14 percent and soybean prices would also rise by about 3 percent or around $0.17 per bushel. Another report prepared by AUS Consultants examined the potential impacts from legislation that would require specific quantities of consumption for renewable fuels. The report estimated that if legislation increased demand for alternative fuel feedstocks such as soybeans, the expected increase in prices could lead to a decrease in the costs of governmental crop support programs by $7.8 billion from 2002 to 2016. Over the same period, the report forecasted an increase in soybean prices of about 11.8 percent on a national level.[185] Each of these studies recognized that if biodiesel production using soybeans increases the demand and prices for the feedstocks will also rise, and other industries that rely upon soybeans as inputs would face higher costs as a result.

This macro-level industry analysis has explored the current status of biodiesel production and has also evaluated the potential for various feedstocks to be used within that production. Although the majority of the US industry relies upon soybean oil for its primary feedstock, future price fluctuations and industry developments may encourage the increased utilization of substitute feedstocks.

---

[183] Groschen, Ralph. Overview of: The Feasibility of Biodiesel from Waste/Recycled Greases and Animal Fats.
[184] Biomass Research and Development Initiative. "Newsletter Archive".
[185] Food and Agricultural Policy Research Institute (FAPRI). Impacts of Increased Ethanol and Biodiesel Demand.

The production and supply of biodiesel is dependent upon several factors. This section has reviewed three parameters including the production process, a macro-level industry analysis, and external supply factors that have effected the biodiesel market. The next section will discuss how expectations and predictions for the future demand and supply of biodiesel have translated into various economic analyses.

C. Economic Impact Studies

Although there is some variation in the expectations for the future demand and supply of biodiesel, several researchers have attempted to estimate the local, state, and national economic impacts from future growth within the biodiesel industry. These reports, which will be described next, have projected that increased usage of biodiesel would encourage less dependence upon foreign oil supplies, increase the demand and expected prices for feedstocks, and could potentially stimulate rural and urban development. Although definitive estimates vary across each study, it is important to recognize the relative significance that increased biodiesel demand could have on each of these economic sectors.

National Energy Needs Biodiesel consumption could promote domestic production of renewable fuels and may reduce the US reliance upon foreign oil. For decades several interests have debated the level of dependence the United States places upon foreign oil suppliers. Of the 19.7 million barrels of petroleum consumed by the US in a single day, roughly 52 percent of that oil is imported. In June 2002, the US Secretary of Energy testified to Congress that the most recent estimates predict that this figure could rise to 62 percent by 2020 as the US demand for oil increases.[186] Taking into account the costs of providing security and military forces to support oil producing nations, one rather extraordinary estimate predicts that it costs about "$100 a barrel or $5 a gallon," to support US petroleum demands.[187] If oil supplies begin to decrease, it is expected that costs to obtain those resources would escalate.

While biodiesel production could mitigate the long-term effects of oil fluctuations, the availability of feedstocks for biodiesel will limit the amount of petroleum the renewable fuel could displace. In 1998 the USDA estimated that the annual total production of biodiesel-related feedstocks was 29 billion pounds. Converting all of the potential feedstocks into pure biodiesel (B100) would yield about 3.7 billion gallons of the fuel. In comparison, the US consumes an estimated 55 billion gallons of total diesel fuel each year.[188] Even while relying upon all available feedstocks, this supply would only equal "about 13 percent of the total 28 billion gallons of transportation diesel fuel consumed in the United States in 1996."[189] Because of other markets for the oil and fat feedstocks, the USDA analysis took a more realistic approach and assumed that not all of the available feedstocks would be committed to biodiesel production. The report

---

[186] "Oil Dependency a Major Concern, Energy's Abraham Says." US Department of State.
[187] "Biodiesel Fuel and Its Integration into the Agricultural Economy of this State – Background Memorandum." North Dakota Legislative Council.
[188] New York Times. "US Interest in Biodiesel Growing."
[189] Duffield, James, et al. "US Biodiesel Development: New Markets for Conventional and Genetically Modified Agricultural Products." pg. 6.

illustrated that if 10 percent of the available feedstocks were dedicated to biodiesel production, the resulting neat biodiesel production would be about 1.3 percent of the total petroleum diesel supply. Mixed with diesel to form B20 or B2 blend however, and the fuel could be blended with about 7 or 70 percent of diesel fuel, respectively.

Economic Development Several other analyses have been conducted relating to the economic impacts on local, state and national levels from increased biodiesel production. Some of those include the Economic Impact of Soy Diesel in Minnesota, and the University of Missouri reports titled Impacts of Increased Ethanol and Biodiesel Demand and Soy Diesel Processing in Buchanan County, Missouri: Potential Impacts. Each suggests that there are several prospective national and regional economic benefits that could evolve as biodiesel production is increased.

The study "Economic Impact of Soy Diesel in Minnesota" examined the potential direct, indirect, and induced effects from state-wide consumption of either 2 percent or 5 percent biodiesel blends. The study concentrated on the economic impacts of soybean-derived biodiesel. Using a 2 percent blend, the results predicted that demand for Minnesota's soybean crop would increase by 3 percent and the in-state soybean processing capacity would grow by 9 percent assuming all production of soybeans and soyoil would occur within Minnesota. The study concluded that with a 2 percent blend mandate, the total potential economic impact in the state would be $212 million including the expectation that it would create 1,128 jobs. The study also emphasized that several other sectors of the economy outside of agriculture would benefit from growth in the biodiesel industry.[190]

The University of Missouri's analysis of "Impacts of Increased Ethanol and Biodiesel Demand" evaluated how growth in the two renewable fuels could affect future agricultural prices. The results stipulated that increased demand for feedstocks, primarily soybeans, would drive regional and national prices of the two commodities higher.[191] In terms of the soybean feedstocks, the price increases could produce multiple benefits for different factions. Soybean farmers and possibly other oil crop producers could receive higher prices for their crops. Depending on the actual soybean price levels, government subsidies for crops may also decrease as the soybean prices rise above loan deficiency payment (LDP) and counter-cyclical payment levels. This savings could conceptually be transferred to taxpayers, used to support the biodiesel industry, or fund other government programs.

The other University of Missouri study, "Soy Diesel Processing in Buchanan County, Missouri: Potential Impacts", found that a vertically integrated soybean crushing-biodiesel production plant with annual production at about 4.5 million gallons in Missouri could create 81 direct jobs, 162 indirect and induced jobs, increase retail sales

[190] Economic Impact of Soy Diesel in Minnesota. Minnesota Department of Agriculture.
[191] Impacts of Increased Ethanol and Biodiesel Demand. Food and Agricultural Policy Research Institute (FAPRI).

by $9 million and raise county government revenues and expenditures by $12 million.[192] Using the same capacity, similar research estimated that a Virginia plant would create 81 direct jobs, 54 indirect and induced jobs, and increase industrial and commercial sales by $35 million.[193]

While most of the biodiesel economic development reports analyze the potential benefits for the rural sector while utilizing soybean feedstocks, there is also some recognition given to the economic development possible for plants located near large cities.[194, 195] These plants could rely upon used restaurant grease and other available oils, that are typically discarded for feedstocks, and convert them into biodiesel which could become cost competitive in the local market. Thus, the potential for both rural and urban development could occur from increased biodiesel production.

D. Summary

Summarizing the section on economic impact studies, the US demand for biodiesel has been expanding in the past decade. Increased biodiesel production could create new markets for the feedstocks used which include soybean oil, animal fats, or used vegetable grease. While it has the potential to decrease the US reliance on foreign oil, the constraints on available feedstocks will limit the extent of total displacement possible. Depending on the location of biodiesel production plants, local and regional economies with such sites would prosper from increased demand for the fuel. As biodiesel production expands, it is expected that increased feedstock prices and industry development would have a multiplying affect outwards by providing benefits to a wide range of economic interests.[196]

- With most development occurring in the past five years, biodiesel production is a relatively new industry within the US.

- Demand for biodiesel has been encouraged by the fuel's environmental and performance characteristics as well as governmental support for its use.

- The primary obstacle to widespread adoption has been biodiesel's higher cost in comparison to diesel and other distillate fuels.

- While the majority of biodiesel production relies on soybeans as the primary feedstock, the process can be achieved using an assortment of feedstocks. The quality of feedstocks and production methods can vary depending on several factors.

---

[192] Ma, Jian, James Scott, and Thomas Johnson. Soy Diesel Processing in Buchanan County, Missouri: Potential Impacts.
[193] Manning, P., Popp, and Cochran. Biodiesel: Potential and Possibilities for the Arkansas Economy.
[194] "Biodiesel Poised to be a Significant Contributor to the US Alternative Fuels Market." National Biodiesel Board.
[195] Life Cycle Inventory of Biodiesel and Petroleum Diesel for Use in an Urban Bus: 139. NREL.
[196] Ma, Jian, James Scott, and Thomas Johnson. Soy Diesel Processing in Buchanan County, Missouri: Potential Impacts.

- Increased demand and production of biodiesel will have an significant impact on markets for other inputs and outputs including feedstocks and glycerin products

- Current production costs are substantially higher than diesel fuel. The availability of government production subsidies to encourage growth within the industry may allow the fuel to be more costs competitive with diesel fuel.

- A number of studies have been conducted on the economic impacts of increased biodiesel production. Generally these studies have found that adding biodiesel production would benefit regional economies. However, the total availability will likely limit the total amount of biodiesel that can be produced.

- The biodiesel industry is in a dynamic phase of growth. Many states are contemplating their government's role in supporting the industry in their state. Based on the information collected in this report, the next chapter will explore the potential impacts to the Indiana economy that would result alternative legislation to support biodiesel consumption in the state.

Blank for duplication.

Chapter 5. Economic Analysis of Alternative Biodiesel Legislation in Indiana

Primary Author: Kyle Althoff and Allan Gray

A. Introduction

Depending upon the nature and direction of potential legislation, initiatives to support biodiesel may have a range of direct and indirect impacts on the economy. The objective of the economic analysis for this report is to estimate selected impacts on consumers, industries and the state government from Indiana state legislation supporting biodiesel.

First, three potential legislative scenarios will be introduced, followed by a graphical depiction of the theoretical economic impacts of legislation on distillate fuel consumers and producers. Then a brief discussion of the methodology used to estimate the impact of the legislation is presented. The various inputs for modeling the economic impacts, including consumption quantities, prices, elasticity responses, and projected biodiesel demand, will be described. IMPLAN and partial equilibrium analysis were the two methods used to model the economic impacts of biodiesel. The inputs, results, and limitations for each of the models will be depicted in the latter sections of this chapter. It is important to recognize that while both of the modeling techniques are capable of forecasting several impacts from potential legislation, there are also many more effects that are beyond the scope of this analysis.

B. Potential Legislative Scenarios

The economic analysis of legislative proposals focuses on three potential Indiana-specific policy scenarios:

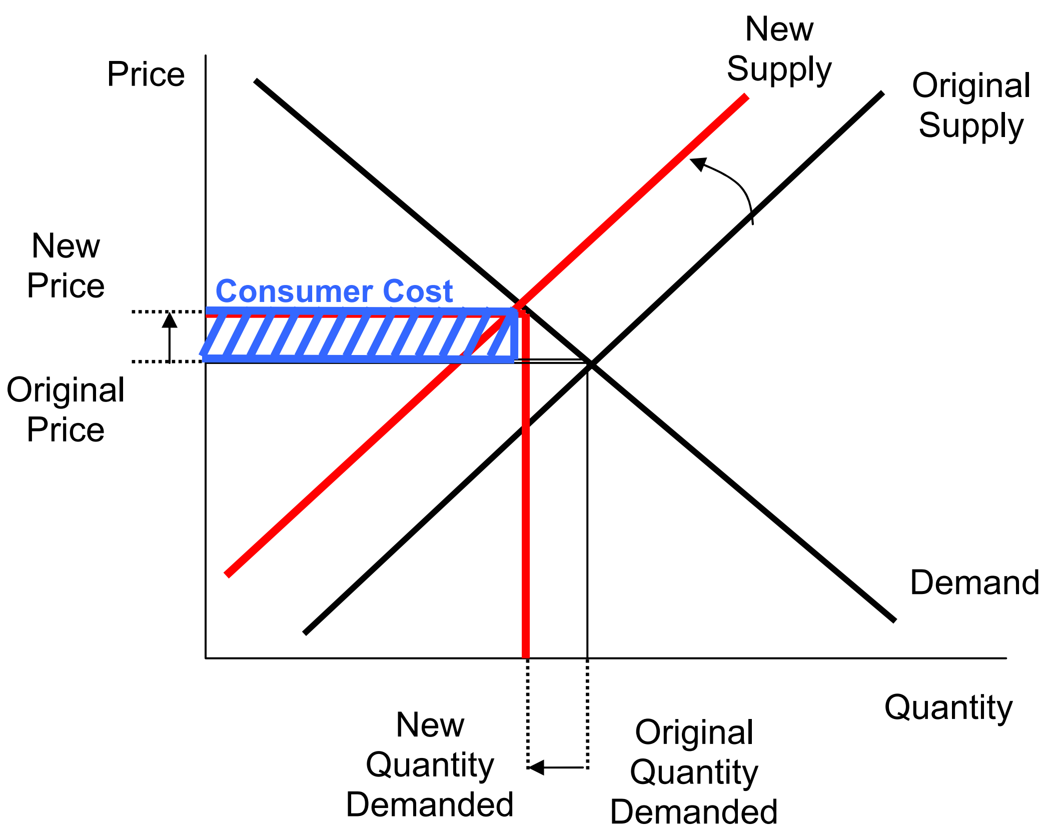
1) Mandating the blending of 2 percent biodiesel with distillate fuels,
2) Subsidizing the cost of blending 2 percent biodiesel to equal the price of distillate fuels, and
3) Mandating the blending of 2 percent biodiesel with distillate fuels while also including the tax credits from the recently passed Indiana HB 1001.

Each of the scenarios assumes that biodiesel production would be located within the state. Although biodiesel can be created from a variety of fats, oils, and reusable greases, this analysis also assumes that all biodiesel produced will be derived from soybean oil feedstocks. The results and analysis focus primarily on the localized impacts to Indiana's economy. Although there would realistically be market activities that defied the state's geographical borders, the analysis assumes that the demand for distillate fuel, biodiesel inputs, and other impacts would be confined to Indiana. These limiting assumptions likely result in "best case" scenarios for the measured impacts. Because of differences in the capabilities of the two models, the IMPLAN analysis was run only for Scenario 1 while the partial equilibrium spreadsheet analysis incorporates all three scenarios.

C. Economic Theory of Potential Legislative Proposals

Mandating, subsidizing, and other legislative initiatives to support biodiesel can affect the demand and supply curves within the distillate fuel market. A mandate could require a minimum amount of biodiesel blended into diesel fuel, which would introduce additional costs for each gallon of fuel supplied to consumers. The resulting impact to the distillate fuel market, assuming all other things equal, would be an upward shift in the supply curve from its origin due to the incremental cost added to each gallon of fuel (Figure 5.1).[197] The rationale for the rotation in the supply curve is derived from the higher price associated with supplying biodiesel at the pump in comparison to diesel fuel. The supply curve shift will realign the market to a new equilibrium price. The move causes less fuel to be demanded at the new price. This response by consumers, the price elasticity response, is expected over the long run when a shift in the price motivates consumers to demand less fuel and search out substitute energy sources. The shaded rectangle represents the additional cost to consumers for the mandate.

Figure 5.1 Economic Theory of Mandating Biodiesel at the Consumer Level.



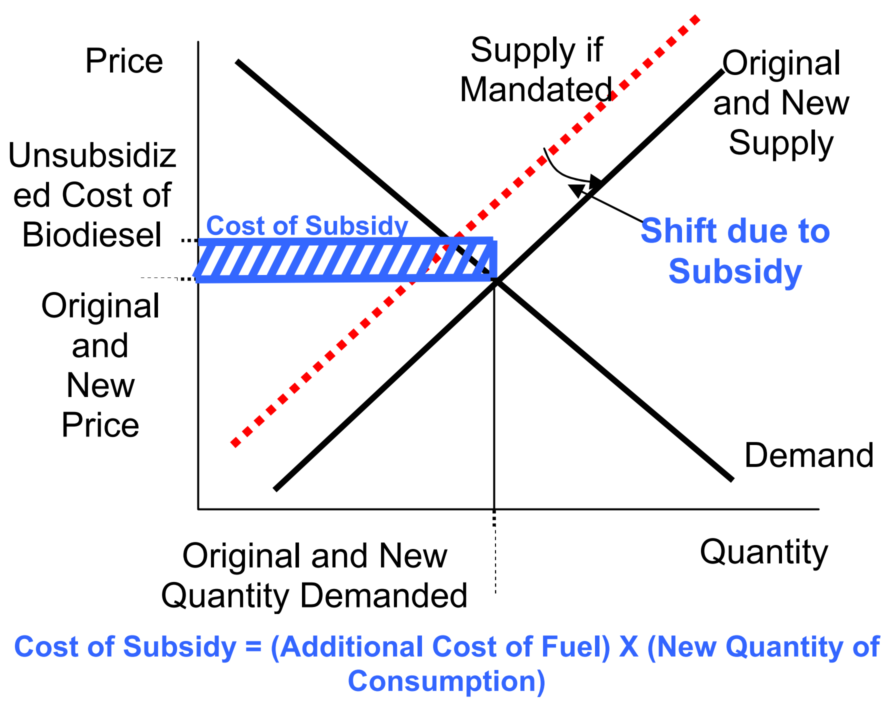
In 2002 Minnesota passed a mandate for B2 which is pending commencement until the "trigger" mechanisms within the law are realized. Some opponents to the measure argued that a single-state mandate would amplify the price elasticity response by

[197] Assumes all other variables held constant, including costs of distribution and taxes per gallon.

consumers. C. Ford Runge contended that if a biodiesel mandate was enacted, the vehicles and trucks passing through the state would choose to fill up with less expensive diesel in border states and avoid buying blended biodiesel within MN.[198] If such a response occurred, it would amplify the change in quantity noted in the earlier illustration and total demand for distillate fuels would decrease further.

The effects that other legislative proposals, such as subsidies, have on the distillate fuel market depends upon the magnitude of funding, existence of complementary legislation (i.e. mandates), and the assumptions of pass through effects to consumers. For example, if a subsidy was enacted along with a mandate for the blending of biodiesel, the level of the subsidy and method of administration would directly impact the earlier changes noted in the supply curve (Figure 5.2). Assuming complete pass through of all subsidies to consumers, the supply curve would theoretically shift back to its original position. In the scenario illustrated, the level of subsidy brings the price of blended biodiesel down to a competitive price with diesel. The cost of the subsidy would be the difference between the cost of biodiesel blends before and after the subsidy multiplied by the total quantity of diesel consumed. While a subsidized mandate would decrease the price elasticity response in comparison to an unsubsidized mandate, the cost of the subsidy would also decrease the finances for the state government. This in turn would affect the total economic impact of the legislation.

Figure 5.2 Economic Theory of Subsidizing Biodiesel to Equal the Price of Distillate fuels.



[198] Runge, C. Ford. "Minnesota's Biodiesel Mandate: Taking from Many, Giving to Few."

Although the complete pass through of subsidies and tax credits may be assumed in theoretical perfect competition, the premise remains contested in research and actual practice. Michael Martin, a Senior Economist for the American Road and Transportation Builders Association, analyzed the economic impacts of the gas tax cuts within Indiana and Illinois in the summer and fall of 2000.[199] He argued that the tax relief provided during that time period removed $0.07 per gallon in state revenues while consumers only experienced about a $0.04 per gallon price decrease. Because of the short run influence of the 2000 tax relief, further research would be encouraged to examine the assumptions for full pass through of biodiesel subsidies and tax credits over the long run.[200]

D. Structure of Analysis

The theoretical analysis gives an idea of the consumer impacts of legislation. However, the framework for analyzing the economic impacts depends on a complex set of inputs and interactions that are expected to occur if governmental policy were enacted to support biodiesel. To follow the path of this analysis and the expected impacts from such legislation, the subsequent two flow charts depict the progression of the selected effects within the economy. The first chart, Figure 5.3, shows how the demand and price inputs for diesel and biodiesel translate into projected price elasticity responses and the total demand for biodiesel. The fourth section of this chapter discusses the required inputs as well as the feedstock requirements and revenues expected from a new biodiesel plant.

An increased demand for biodiesel is expected to translate into the five impacts within the agricultural industry shown in Figure 5.3 in addition to the biodiesel industry itself. These industries include soybean oil volumes and prices, soybean meal volumes and prices, soybean production and revenues, corn production and revenues, and revenues in the agricultural input sector. Due to limitations with the model, the IMPLAN analysis will be utilized primarily to forecast the economic impacts of adding production in the agricultural sector without price or volume changes.

With assistance from a United Soybean Board (USB) model, the partial equilibrium analysis will project the potential impacts for the previously mentioned impacts as well as four additional impacts depicted in Figure 5.4. Substituting biodiesel for diesel fuel causes price elasticity responses depending upon the price differences between the two fuels. The elasticity response would impact the refining and fuel distribution sectors as well as state fuel tax revenues. There would also be a consumer loss if the price of fuel increased. The partial equilibrium analysis estimates the impacts for the three legislative scenarios on all nine identified sectors including both anticipated price and volume changes in each sector.

[199] Martin, Michael F. "Who Benefits From Gas Tax Cuts?"
[200] Further information on the pass through effects in fuel price changes can be accessed at the US Department of Energy's "Diesel Fuel Price Pass-through" page: http://www.eia.doe.gov/pub/oil_gas/petroleum/feature_articles/2002/diesel/diesel.html

Figure 5.3 Economic Analysis Flowchart.

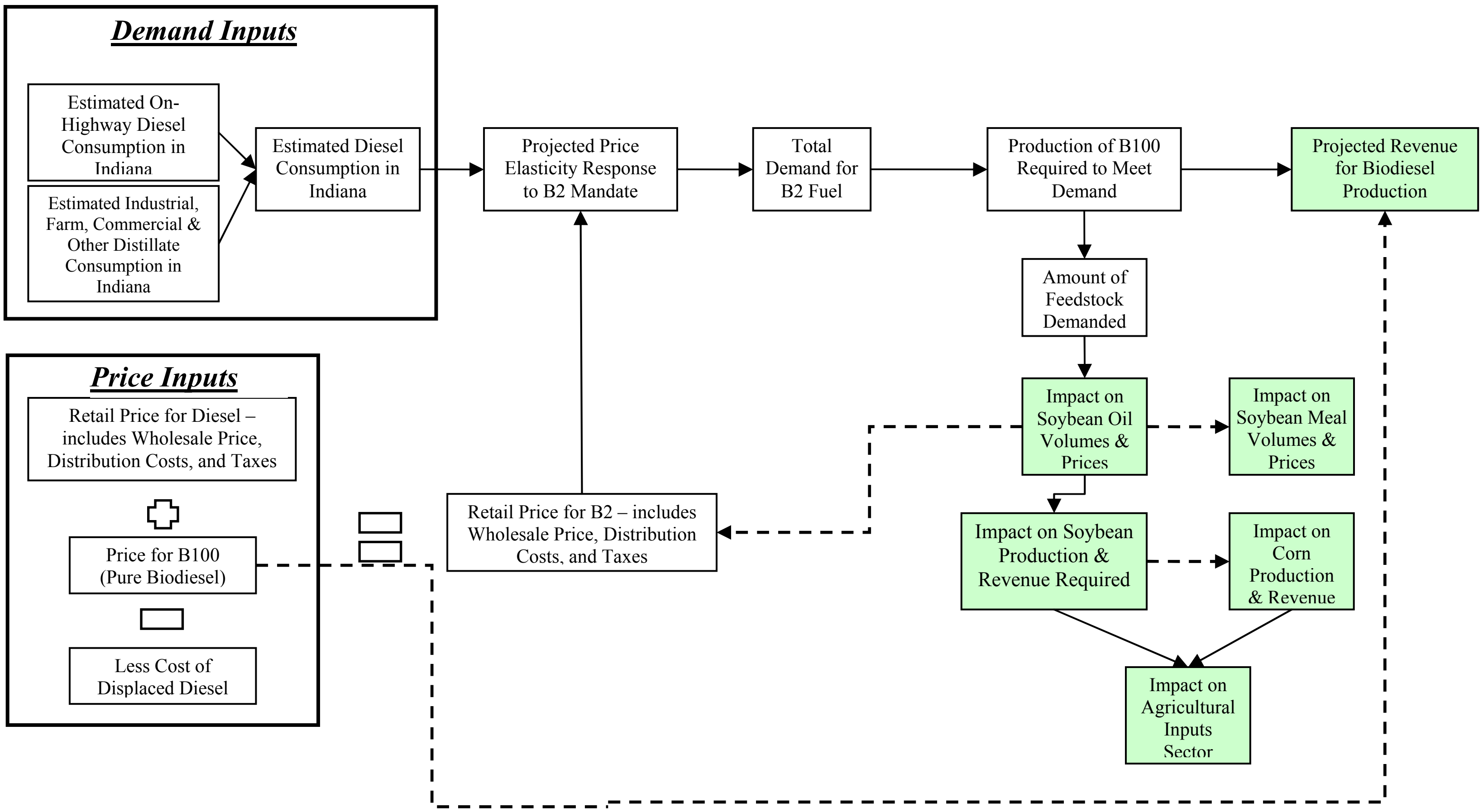
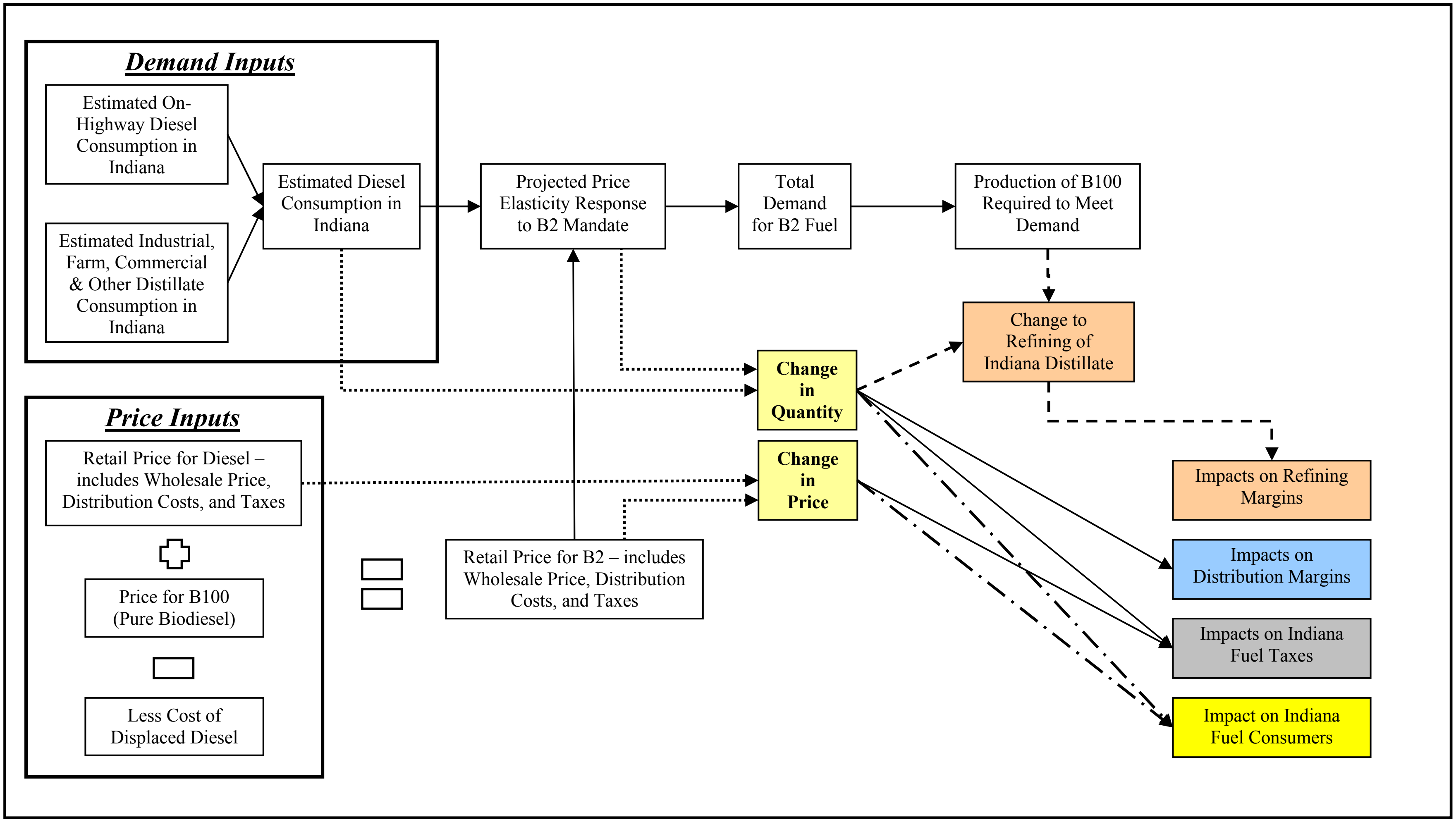


Figure 5.4 Refining, Fuel Distribution, Tax & Consumer Sectors' Economic Impacts Flowchart.

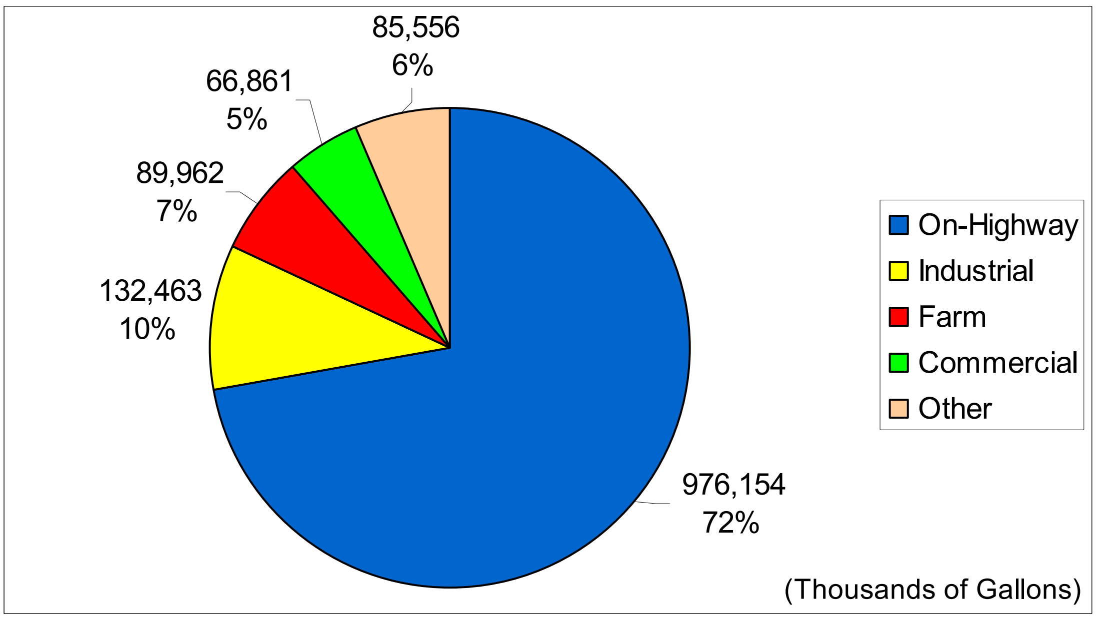


E. Inputs for Analysis

Indiana Distillate Fuel Use

The United States Department of Energy (DOE) classifies distillate fuel oil as any "petroleum fraction produced in conventional distillation operations."[201] Several different types of fuel such as diesel, fuel oil, and kerosene can be found under this classification. In 2001 Indiana total distillate consumption was 1,420,008,000 gallons.[202] While the DOE maintains eleven user categories, this analysis separated the distillate fuel use into seven primary groups and further divided the On-highway segment into three subdivisions (Figure 5.5 and 5.6). Those segments that were not primary users of diesel fuel were eliminated from the analysis. Eliminating non-diesel using segments created a base Indiana reference point for diesel fuel of 1,350,996,000 gallons.

Figure 5.5 Estimated Distillate Consumption in Indiana.



Source. US Department of Energy, Energy Information Administration

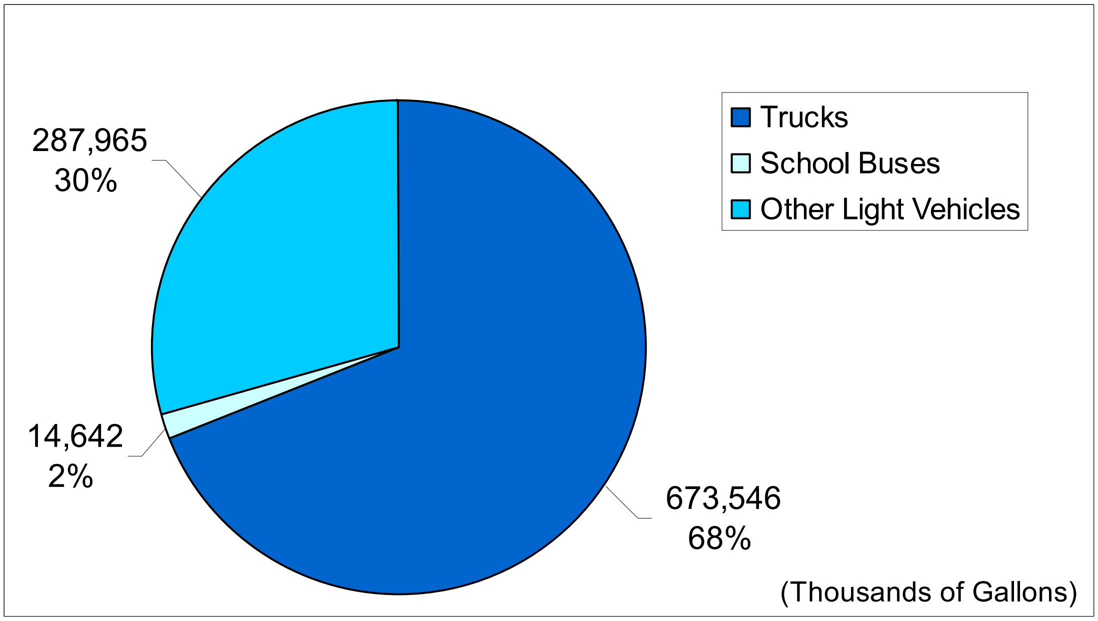
Due to the large share of Indiana diesel fuel consumption in the On-Highway segment and the different elasticity responses within the group, the segment was further broken down into three subgroups. The subgroups contain user segments ranging from: 1) semi tractors/over-the-road trucks, 2) school buses, and 3) other light vehicles including transit buses and personal consumer automobiles (Figure 5.6). The separation for over-the-road trucks was based on tax receipts from the Indiana motor carrier surcharge tax.[203] School buses were calculated using estimates for the average mileage, fuel economy, and percent of diesel buses within the state.[204, 205, 206] Finally, the light

---

[201] Fuel Oil and Kerosene Sales 2001. US Department of Energy.
[202] Fuel Oil and Kerosene Sales 2001. US Department of Energy.
[203] Indiana Department of Revenue 2002 Annual Report. State of Indiana.
[204] Alspach, Brent. Indiana State Police.
[205] "Whitman Announces New Partnership to Reduce Children's Exposure to Emissions from Diesel School Buses." US Environmental Protection Agency.

vehicles category combined all other segments not previously estimated within the On-Highway segment including transit buses and consumer automobiles.

Figure 5.6. Estimated On-Highway Diesel Consumption in Indiana



Sources. Various References –Refer to Footnotes

Prices

The relevant prices for diesel, biodiesel, and blends of biodiesel were computed using data from the US Department of Energy (DOE) as well as Federal and Indiana tax rates. While this analysis assumes one standard retail price, it is necessary to note that different user segments face varying prices for distillate fuels depending on the type of fuel demanded and tax requirements for the respective fuel and users (i.e. agricultural exemptions, motor carrier surcharge tax, etc.).

The DOE weekly average retail on-highway price for diesel fuel within the Midwest as of May 5, 2003 was $1.46 (including taxes).[207] The DOE also maintains monthly averages for the cost of refining, distribution, taxes, and crude oil per gallon of diesel. For the previous year, the average cost for distribution was 10 percent while refining was around 10.15 percent. Taxes and crude oil composed the majority of the cost of diesel with their average costs at 34 percent and 46 percent respectively per gallon of diesel. Using the preceding twelve month average DOE estimates for the cost of distribution and taxes, a wholesale price of $0.815 for diesel was established for the analysis.[208]

Taxes comprise a considerable portion of the retail price for distillate and biodiesel fuels within Indiana. Those taxes include a 6 percent state sales tax, a $0.16 per

[206] "Clean School Bus USA." US Environmental Protection Agency.
[207] "Weekly Retail On-Highway Diesel Prices." US Department of Energy.
[208] "Gasoline and Diesel Fuel Update." US Department of Energy.

gallon state special fuels tax, and a $0.244 per gallon Federal special fuels tax.[209, 210] Indiana also charges a $0.11 per gallon Motor Carrier Services Surcharge Tax which is collected on a quarterly basis for all motor carrier miles traveled within the state.[211] The total cost of the tax was converted to a per gallon basis using state surcharge tax receipts divided by the total gallons of on-highway truck consumption for Indiana. By taking the ratio of on-highway truck consumption in terms of the total state distillate consumption, the tax was then spread across the price for all users. This results in a retail price to Indiana consumers of $1.41 per gallon for diesel.

The Department of Energy does not maintain weekly or monthly averages for alternative fuel prices.[212] To obtain a comparable price for biodiesel, the most recent price of B20 was balanced with the price of diesel during the same week and then reconciled with the May 5, 2003 diesel price.[213] The average projected price of B100 as of May 5, 2003 was estimated to be $2.23 per gallon retail and $1.59 wholesale (before taxes and distribution costs). The distribution costs and taxes per gallon were assumed to be the same for pure biodiesel in comparison to diesel.[214]

Pure biodiesel is typically blended with diesel at rates that depend, among other characteristics, on consumer expectations for price, lubricity, cold flow properties and the percent of renewable fuel required within the blend. The primary focus for this analysis was the economic impact of legislative proposals that encouraged blends of 2 percent biodiesel and 98 percent diesel (B2). The prices of diesel and biodiesel from the earlier estimates were adjusted appropriately based on the respective volumes of each fuel to determine the effective price for a B2 blend. The resulting retail price of B2 diesel is $1.428 per gallon under Scenario 1.

The expected demand for biodiesel created a demand for soybean oil feedstocks within the analysis. A primary concern was the potential soy oil price increase that could occur due to a substantial increase in biodiesel production. Incorporating the United Soybean Model into the analysis, the feedstock demand translated into an increase of about $0.06 per gallon to the estimated wholesale price of B100 for each scenario.

The total adjusted price of B100 and B2 for each of the three scenarios is displayed in Table 5.1. The slight difference in the biodiesel prices prior to the tax

---

209 Special Taxation of Special Fuels. Highway Statistics 2001.
210 Federal Highway User Fees. Highway Statistics 2001.
211 Indiana Department of Revenue 2002 Annual Report.
212 Alternative Fuels – Frequently Asked Questions. US Department of Energy.
213 The Alternative Fuel Data Center within the US Department of Energy maintains an "Alternative Fuel Price Report" with prices reported on a quarterly basis. The relevant Midwest prices for biodiesel and diesel on average were $1.329 and 1.47 per gallon in October 2002. Using those prices, an estimate for the price of B100 at that time was generated. The ratio between the estimated B100 price and the diesel price was then used to project an estimated retail price for biodiesel corresponding with the May 5, 2003 diesel price. The average of the preceding twelve month DOE estimates for the cost of distribution and taxes per gallon of diesel were then deducted to create a projected wholesale price of biodiesel of $1.59 per gallon.
214 Assuming the cost of biodiesel adds an additional cost per gallon that is constant for all quantities demanded. The distribution costs for biodiesel were assumed to be equal to that of distillate fuels. However, it has been acknowledged that many distributors and blenders experience increased fixed costs for equipment to store and handle biodiesel.

credits/subsidies represents the price impacts from the soy oil feedstocks that vary depending on the total biodiesel demanded and price elasticity responses for each proposal.

Table 5.1 Estimated Diesel, B100, and B2 Price Effects from Legislative Scenarios.

Price Estimates for Diesel, Biodiesel, and B2 (per gallon)	Scenario #1 B2 Mandate	Scenario #2 Tax Credit (B2 = Diesel)	Scenario #3 Mandate & HB1001
Estimated Indiana On-Highway Retail Diesel Price to End Users (Including Taxes)	$1.412	$1.412	$1.412
Estimated Wholesale Diesel Price	$0.815	$0.815	$0.815
Estimated Wholesale Biodiesel Price	$1.649	$1.649	$1.649
Incremental Cost for Blending B2	$0.015	$0.015	$0.015
B2 Fuel Tax Credit (*Assumes full pass through)	$0.000	$0.016	$0.002
Projected Retail Price of B2	**$1.428**	**$1.412**	**$1.426**
Change in Retail Price after Tax Credit/Subsidies	**$0.016**	**$0.000**	**$0.014**
Percent Change from Retail Price of Diesel Fuel	**1.13%**	**0.00%**	**0.97%**

Projected Price Elasticity Response

As established in the economic theory section, a shift in the supply curve from its origin would cause a price elasticity response in total fuel demand. Only Scenario 2, the tax credit (subsidized) proposal, would leave the retail consumer price for the blended fuel unchanged. The retail price for Scenario 3 was slightly lower than for Scenario 1, reflecting the $3 million subsidy contained in HB1001[215]. Long run price elasticities for each user segment in the analysis were utilized to predict the consumer response in reduced diesel demand resulting from the price increase.[216] The total response of each user segment due to the policy initiatives is depicted in Table 5.2. Scenario 1 would show a 1.13 percent increase in prices due to the mandate resulting in a 0.57 percent reduction in demand for B2.

[215] It takes one million gallons to exhaust the $1 per gallon producer tax credit resulting in a $0.0007 per gallon reduction for 1.35 billion gallons of diesel fuel. Fifty million gallons is needed to exhaust the blenders $0.02/gallon tax credit lowering the consumer price of B2 by $0.0007 per gallon. One hundred million gallons is needed to exhaust the retailers $0.01 per gallon tax credit lowering the price another $0.0007 per gallon. The total reduction in price is $0.0022 per gallon.

[216] Dahl, Carol. A Survey of Energy Demand Elasticities in Support of the Development of the NEMS.

Table 5.2 Projected Price Elasticity Responses (in gallons).

Price Elasticities and Impacts on Indiana Demand for Diesel - Long Run (Gallons)		Scenario #1 B2 Mandate	Scenario #2 Tax Credit (B2 = Diesel)	Scenario #3 Mandate & HB1001
	Elasticity			
Commercial	-0.76	(572,112)	-	(491,839)
Industrial	-0.76	(1,133,452)	-	(974,417)
Farm	-0.54	(546,950)	-	(470,208)
Railroad	-0.37	(102,145)	-	(87,813)
Marine	-0.27	(57,819)	-	(49,706)
Off-Highway	-0.54	(255,449)	-	(219,607)
On-Highway				
Truck	-0.54	(4,095,021)	-	(3,520,448)
Bus	-0.48	(79,131)	-	(68,028)
Car and Light Truck	-0.27	(875,385)	-	(752,560)
Total Reduction in Fuel Demand		**(7,717,463)**	-	**(6,634,626)**
New Demand for Blended Fuel		1,343,278,537	1,350,996,000	1,344,361,374
Percent Reduction in Fuel Demand		**-0.57%**	**0.00%**	**-0.49%**

Projected Demand for Biodiesel

After adjusting the Indiana demand for distillate fuels by the price elasticity response, the total expected demand for B2 was determined. With the amount of biodiesel in the blend at 2 percent, the total demand for pure biodiesel was also established. Converting the feedstocks into actual biodiesel requires about 7.35 pounds of oil for every gallon of biodiesel.[217] The total demand for feedstocks to produce biodiesel was thus calculated. Concentrating on soybean-based biodiesel, the feedstock requirement was then translated into a potential demand for that agricultural commodity. The conversion ratio for the analysis was 11 pounds of soybean oil/bushel although different soybean varieties and crushing methods may yield slightly lower or higher amounts of oil.[218] The resulting demand for blended and pure biodiesel, oil feedstocks, and soybeans for each scenario is shown below in Table 5.3. Depending on the scenario, Indiana would need 26.8 to 27 million gallons of Biodiesel to meet the 2 percent mandate requirement. The biodiesel demand translates to 197.4 to 198.5 million pounds of soyoil or 17.9 to 18.0 million bushels of soybeans.

Table 5.3 Projected New Demand for Biodiesel and Feedstocks.

New Demand for Pure Biodiesel, B2 and Biodiesel Feedstocks	Scenario #1 B2 Mandate	Scenario #2 Tax Credit (B2 = Diesel)	Scenario #3 Mandate & HB1001
Total Demand of Biodiesel for B2 (Gallons)	1,343,278,537	1,350,996,000	1,344,361,374
Total Demand for Pure Biodiesel (Gallons)	26,865,571	27,019,920	26,887,227
Oil Feedstock Required (Pounds)	197,461,945	198,596,412	197,621,122
Converting Oil Demand to Soybeans (Bushels)	17,951,086	18,054,219	17,965,557

217 Biodiesel Production Technology Overview. National Biodiesel Board.
218 Hatcher, Charles. "RE: VENEMAN ANNOUNCES BIOENERGY PROGRAM CHANGES AND SIGN-UP."

Projected Revenue from Biodiesel Production

The total demand for pure biodiesel in each scenario was then translated into expected revenues for a production facility from the fuel sales. The soybean-adjusted wholesale price for biodiesel from the earlier price analysis was multiplied by the demand for biodiesel within each respective scenario to create the projected revenues in Table 5.4.

Table 5.4 Projected Revenue for Biodiesel Production.

Revenue for Biodiesel Production Facility	Scenario #1 B2 Mandate	Scenario #2 Tax Credit (B2 = Diesel)	Scenario #3 Mandate & HB1001
Total Demand for Pure Biodiesel (Gallons)	26,865,571	27,019,920	26,887,227
Estimated Wholesale Biodiesel Price	$1.649	$1.649	$1.649
Total Revenue	$44,302,605	$44,566,264	$44,339,593

This estimated revenue serves as the basis for the analysis of economic impacts on the other eight sectors identified earlier.

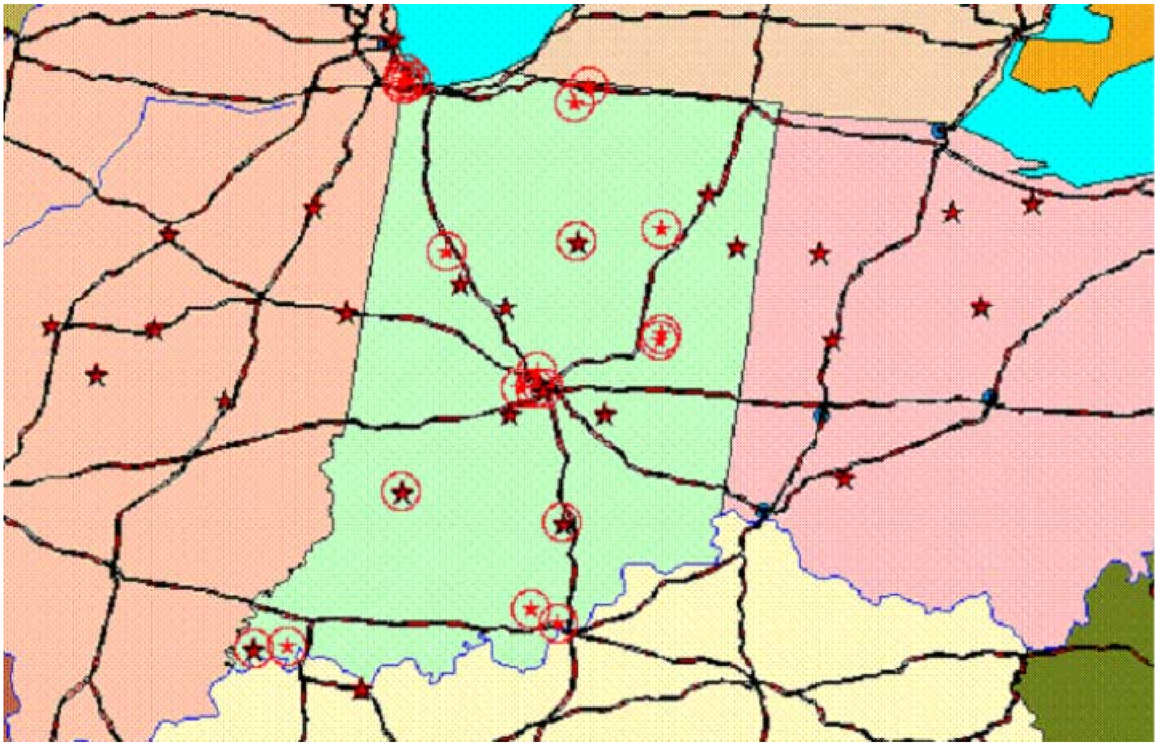
F. Distribution Capabilities within Indiana

Adding almost 27 million gallons of biodiesel production would require a coordinated distribution system to supply the necessary soybean oil feedstocks and also to allow for the blending of biodiesel with distillate fuels. With the total US production of biodiesel around 25 million gallons in 2002, the demand for the fuel from any one of the Indiana scenarios would likely involve additional development of biodiesel production facilities in or around the state. The location selection for a biodiesel plant would depend upon a number of criteria including proximity to feedstocks, fuel terminals, and other inputs required to produce the fuel.

An illustration of the potential distribution capabilities for biodiesel within Indiana was made by mapping the location of soybean processors and fuel terminals. While it is evident that the final selection for a biodiesel plant would be dependent on a wide variety of standards, the map in Figure 5.7 provides a basic description for the possibilities to integrate biodiesel production within the state. The red stars with circles identify the locations of fuel terminals throughout the state. These locations were identified using the Indiana Fuel Tax Book.[219] Positioned in and around the state of Indiana, the darkened red stars without circles distinguish soybean processing facilities that were found using the Soya and Oilseed Blue Book.[220] Areas of the state that have the two sets of locators either close by or right on top of one another could be favorable site considerations for biodiesel production.

[219] Fuel Tax Handbook. Indiana Department of Revenue.
[220] Soya and Oilseed Blue Book. 2003. Soyatech, Inc. Bar Harbor, ME.

Figure 5.7 Soybean Processing and Fuel Terminal Locations within Indiana.



G. IMPLAN Analysis

IMPLAN software can be utilized as "an economic impact assessment modeling system" to project the effects of potential industries added to a geographic area. [221] IMPLAN incorporates multipliers to project the impacts from a change to the equilibrium Input/Output model. Databases for state, regional, or national economies can be inserted into the model for an analysis. Although originally developed for the US Forest Service in the early 1980s, IMPLAN has been continued for almost two decades now by the Minnesota IMPLAN Group in Stillwater, MN.

The software uses the production functions of several hundred categories which include aggregated Standard Industrial Classification (SIC) codes and governmental entities to project the revenue, value-added (revenue less cost of goods sold), and employment from selected changes to an economy. The effects are separated into direct, indirect and induced categories. Established by the new expected total revenues for an industry, the direct effects are inserted into the analysis by the user. The indirect effects are tracked through the modeled economy based on the trickle-down impacts within other industries which result from the direct changes. The induced effects are generated from the adjustments to consumers' income and purchasing power that results from the direct and indirect effects.

[221] "What is IMPLAN?" Minnesota IMPLAN Group.

Methodology

The IMPLAN analysis relied on a 1999 Indiana database to analyze the impacts to the state's economy from biodiesel production under Scenario 1, mandating the blending of B2. Several changes were necessary to update the IMPLAN data and enable it to reflect the inputs, outputs, and value added from biodiesel production and interrelated industries (See Appendix C). This analysis does not include the economic effects that would occur during the construction of biodiesel production facilities. Using the projected biodiesel revenues of $44,302,605 from Scenario 1 (B2 mandate), the impact of adding a production facility within the state of Indiana was then analyzed.

Results

Adding biodiesel production to Indiana shows an increase in the overall revenue, value added, and employment in the state. However, due to the inherent limitations of the software, the potential negative impacts on the trucking, refining, fuel distribution, and other industries have not been accounted for.

The first table of IMPLAN results, Table 5.5, reveals that $44,302,605 worth of biodiesel production would raise the total revenues within the state's economy by $130,667,550. The total impact combines the direct effects from the biodiesel production, the indirect effects from all interrelated industries, and the induced effects from a change in income within the state. The indirect effects include higher revenues within the soybean oil processing industry ($28,501,020) and the soybean production sectors ($24,550,140). The majority of the total effects from biodiesel production are derived from the indirect effects generated in other industries.

Table 5.5 IMPLAN Output Results from Adding Biodiesel Production within Indiana.

Impacts	Sector	Direct	Indirect	Induced	Total
Selected Industries	**Biodiesel Industry**	$ 44,302,605	$ 465,628	$ 3,892	**$ 44,772,125**
	Soybean Oil Mill	$ -	$ 28,501,020	$ 9,105	**$ 28,510,125**
	Oil Bearing Crops	$ -	$ 24,550,140	$ 8,962	**$ 24,559,102**
	All Other Industries	$ -	$ 22,860,921	$ 9,965,277	**$ 32,826,198**
Total Statewide Effects		$ 44,302,605	$ 76,377,709	$ 9,987,236	**$ 130,667,550**

While the total revenue effects may appear impressive, most of the weight for the figure is double counting the pull through effects from biodiesel production. The total revenues includes the cost of goods sold throughout the economy. A more relevant figure for the significance of new biodiesel production would be the "Value Added" statistics from IMPLAN. The value-added component removes the costs of goods sold from the total revenues to project the "Value Added" from the proposed changes. For the biodiesel analysis, the total value added amounted to $30,447,185 (Table 5.6). Combining the biodiesel, soybean processing, and soybean production sectors shows that about 38 percent of the value added from a new biodiesel facility could be attributed to these three industries.

Table 5.6 IMPLAN Value Added Results from Adding Biodiesel Production within Indiana.

Impacts	Sector	Direct	Indirect	Induced	Total
Selected Industries	Biodiesel Industry	$ 4,430,305	$ 46,563	$ 389	**$ 4,477,257**
	Soybean Oil Mill	$ -	$ 2,117,382	$ 676	**$ 2,118,058**
	Oil Bearing Crops	$ -	$ 4,943,917	$ 1,805	**$ 4,945,722**
	All Other Industries	$ -	$ 12,729,596	$ 6,176,552	**$ 18,906,148**
Total Statewide Effects		$ 4,430,305	$ 19,837,458	$ 6,179,422	**$ 30,447,185**

The employment effects from adding a new biodiesel plant are also important when evaluating legislation for the alternative fuel. IMPLAN creates an estimate for the potential jobs that would arise from a change to the economy based on the revenue per worker within each industry. Table 5.7 shows the projected employment effects from adding biodiesel production. The biodiesel plant alone would be expected to utilize 21 employees, while the total impact throughout the Indiana economy is projected to be about 467 jobs.

Table 5.7 IMPLAN Employment Results from Adding Biodiesel Production within Indiana.

Impacts	Sector	Direct	Indirect	Induced	Total
Selected Industries	Biodiesel Industry	20.8	0.2	0.0	**21.0**
	Soybean Oil Mill	0.0	13.4	0.0	**13.4**
	Oil Bearing Crops	0.0	98.2	0.0	**98.2**
	All Other Industries	0.0	197.7	137.0	**334.7**
Total Statewide Effects		20.8	309.5	137.0	**467.3**

One problem that arises during the use of IMPLAN stems from the configuration of the model. Organized as a multiplier analysis, it makes projections assuming that all of the necessary resources are available, prices are constant, and demand for inputs as well as outputs will not change. For this analysis the dramatic increase in soybean production revenues (Oil Bearing Crops) within Indiana would have to come from higher yields, converting non-farmland into soybean acres, or shifting corn acreage into soybean production. While data on the costs of the first two changes was not readily available for this project, the revenue effects from a switch in corn production to soybeans were an occurrence that could be calculated.

Using the increase in soybean revenues found in the IMPLAN analysis, the current government loan rate of $5.00 per bushel and an Indiana soybean trend yield estimate of 45 bushels per acre, it was estimated that 109,152 acres would be shifted from corn to soybean production. This amounts to about a 1.8 percent increase in the soybean acreage within the state.[222] To highlight the impacts from the losses in corn production, the acreage shift was multiplied by the Indiana corn trend yield estimate of 141 bushels per acre and the current $1.98 per bushel loan rate to determine the abandoned corn

[222] National Agricultural Statistics Service. US Department of Agriculture.

revenues.[223] The decreased revenue effects in corn production of $(30,472,944), were then added into IMPLAN as an impact and analyzed.[224]

Reducing Indiana corn production had a considerable impact on total revenues, value added, and employment effects of adding biodiesel production to the state. The total revenue decreased from $130,667,550 down to $78,966,150. Removing $30,472,944 of corn revenue from the economy forced other reactions in industries that were connected with corn which resulted in the $51,701,400 reduction in revenue from the previous analysis (Table 5.8).

Table 5.8 IMPLAN Output Results from Adding Biodiesel Production with Corn Adjustments.

Impacts	Sector	Direct	Indirect	Induced	Total
Selected Industries	**Biodiesel Industry**	$ 44,302,605	$ 424,184	$ 2,268	**$ 44,729,057**
	Soybean Oil Mill	$ -	$ 28,470,900	$ 5,305	**$ 28,476,205**
	Oil Bearing Crops	$ -	$ 24,425,260	$ 5,221	**$ 24,430,481**
	Feed Grains	$ -	$ (30,576,126)	$ 1,424	**$ (30,574,702)**
	All Other Industries	$ -	$ 6,101,047	$ 5,804,062	**$ 11,905,109**
Total Statewide Effects		$ 44,302,605	$ 28,845,265	$ 5,818,280	**$ 78,966,150**

In similar fashion, the value added by the new biodiesel production also decreased, going from $30,447,185 to $13,630,721 when the impacts on the corn industry are included (Table 5.9). While the value added to the biodiesel, soybean processing and soybean production sectors remained nearly constant, the substantial decline in corn revenues and its impact on all other industries forced the total value added to drop from the initial projections.

Table 5.9 IMPLAN Value Added Results from Adding Biodiesel Production with Corn Adjustments.

Impacts	Sector	Direct	Indirect	Induced	Total
Selected Industries	**Biodiesel Industry**	$ 4,430,305	$ 42,419	$ 227	**$ 4,472,951**
	Soybean Oil Mill	$ -	$ 2,115,144	$ 394	**$ 2,115,538**
	Oil Bearing Crops	$ -	$ 4,918,767	$ 1,051	**$ 4,919,818**
	Feed Grains	$ -	$ (4,855,875)	$ 226	**$ (4,855,649)**
	All Other Industries	$ -	$ 3,380,005	$ 3,598,058	**$ 6,978,063**
Total Statewide Effects		$ 4,430,305	$ 5,600,460	$ 3,599,956	**$ 13,630,721**

Since the employment results are dependent on the total revenues generated, the number of jobs created also decreased from the earlier projections when the corn revenue adjustments were entered. The total employment went from 467.3 workers down to 133.1 (Table 5.10). The reduction in corn revenues forced a decline in jobs associated with that sector but also caused an even larger drop to the industries related to corn production.

[223] National Agricultural Statistics Service. US Department of Agriculture.
[224] Although the loss of corn revenues had to be added into IMPLAN as a direct impact, the results for the charts are structured to combine the direct and indirect impacts for Feed Grains within the Indirect column.

The high amount of labor inputs associated with corn production and its related industries caused a substantial decline to the overall employment impacts of adding biodiesel production. The important negative impact of the Biodiesel mandate on other sectors of the economy has been ignored in many other studies. However, as this analysis shows, ignoring other impacts would substantially overestimate the benefits of biodiesel.

Table 5.10 IMPLAN Employment Results from Adding Biodiesel Production with Corn Adjustments.

Impacts	Sector	Direct	Indirect	Induced	Total
Selected Industries	Biodiesel Industry	20.8	0.2	0.0	**21.0**
	Soybean Oil Mill	0.0	13.4	0.0	**13.4**
	Oil Bearing Crops	0.0	97.7	0.0	**97.7**
	Feed Grains	0.0	-122.3	0.0	**-122.3**
	All Other Industries	0.0	43.5	79.8	**123.3**
Total Statewide Effects		20.8	32.5	79.8	**133.1**

Limitations of the Analysis

While IMPLAN allows adjustments within its database to make specific input changes, analyze new industries, and update statistics for the modeled economy, the assumption of available excess resources ultimately restricts the model's usefulness for analyzing biodiesel production. The program was able to project the potential jobs and revenues that would be created through indirect and induced effects from the addition of a biodiesel production plant. However, it is apparent that mandating the use of 2 percent biodiesel and adding such a facility would impact the economy in a more extensive fashion than the IMPLAN analysis is capable of managing.

IMPLAN is not able to account for the potential price changes or elasticity responses that would occur to the distillate fuels and soybean sector. Although the model used the multiplier effect to pull through $28,501,020 worth of soybean oil from the processing industry, it was not capable of directly addressing the co-product effects that would arise from the additional soybean meal which would also be created.[225] Furthermore, the program does not consider the negative impacts on the distillate refining, fuel distribution, and trucking industries as well as the cost to consumers and loss of tax revenues.

H. Partial Equilibrium Analysis

In an effort to calculate some of the potential impacts that IMPLAN was incapable of addressing, a partial equilibrium analysis was created specifically for this project. This next section of the chapter will reveal the input factors that contributed to the model and results that were generated from the analysis. The main goal for the partial equilibrium analysis was to capture the potential effects that three types of biodiesel

[225] The Economic Impact of Soy Diesel in Minnesota attempted to capture the co-product effect by adding both the soybean oil and soybean meal production as direct impacts within its IMPLAN analysis. However, such inputs may not properly account for the available stocks (inventory) of oil and meal that are presently available.

legislation could have on the agricultural, refining and fuel distribution industries and the impacts such policies would have on consumers and government finances. This analysis will not provide impacts on other industries or employment.

Methodology

The foundation for the partial equilibrium spreadsheet analysis includes the price and volume inputs reported earlier in this chapter accompanied by a soybean market model from the United Soybean Board (USB). Using the expected increase in demand for soybean oil, the USB model was used to estimate expected price and volume changes in soybean production and processing (oil and meal products). Other impacts, including refining, fuel distribution, government finances, and consumer losses were derived within the spreadsheet model.

To examine the impact of increased demand for soybean oil resulting from new biodiesel production, the level of feedstocks from the calculations in Table 5.3 were inserted into the USB model for each scenario. The demand shock created changes to the prices and volumes for the soybean production, soybean meal processing, and soybean oil processing sectors. Those outputs were then transferred into the spreadsheet analysis and compared to their original figures to find the additional revenue resulting from the new soybean oil demand.

For the purposes of this study, the additional volume was considered to originate exclusively from within Indiana. However, the price impacts for the current volumes of soybean production, soybean meal processing, and soybean oil processing sectors were factored into the analysis using Indiana's share of production in relation to the entire US. In 2001, Indiana's soybean production amounted to about 9 percent of the total US cash receipts for the crop while the state's soy processing industry produced about 7.2 percent of the total output value for US soy processing.[226, 227] The price changes were thus appropriated across the additional volumes of production while also being considered as new revenue to the current Indiana production.

The loss in corn production revenues was calculated in the same method used for the IMPLAN analysis by finding the potential increase in soybean acres and then backing out corn revenues from that figure. The costs of production impacts to the corn and soybean production input sectors was determined using the change in volume for each commodity multiplied by the 2001 Indiana operating cost estimates (Corn: $152.00 per acre, Soybeans $78.34 per acre).[228] The net revenues from soybean production reflect the revenues to an agricultural producer less the cost of production for the crop.

Impacts on the refining and fuel distribution sectors relied upon the Department of Energy estimates noted earlier to determine the potential in-state loss to these sectors. With a total distillation output of 433,000 barrels per day, it is estimated that about 25 percent of the total Indiana capacity is used to produce distillate fuels (1.66 billion

[226] Indiana's Rank in US Agriculture. National Agricultural Statistics Service.
[227] 1997 Economic Census Data. US Census Bureau.
[228] Crop Production Costs. National Agricultural Statistics Service.

gallons per year).[229, 230, 231] The local refining sector would consequently be negatively impacted by the substitution of biodiesel for diesel and also by the magnitude of elasticity responses by consumers. The impact to the distribution sector was calculated based primarily on the price elasticity response.

Along with the lower tax effects from the price elasticity responses, the effects of legislation on the state finances is also adjusted based on the size of subsidies provided under each legislative initiative. The potential loss to consumers relies on the increased price per gallon that consumers would pay for biodiesel as well as the price elasticity responses to determine the total impact that legislative measures would have on consumers.

Results

The results of the partial equilibrium spreadsheet analysis indicate that there would be both positive and negative impacts for each legislative scenario. The description for those impacts will be separated into positive and negative industry impacts with an additional section for consumers and the state government. The net revenue impact will be revealed after these three sections.

Positive Impacts on Revenue

The revenue from the biodiesel production under each legislative scenario varies depending on the consumer price and demand for the fuel. Table 5.11 summarizes the revenue impacts for each scenario. The tax credit initiative, Scenario 2, resulted in the highest demand for biodiesel, $44,566,264 in revenue, because the policy resulted in no elasticity response by consumers. With the total demand for distillate fuels unchanged, the tax credit legislation would result in the greatest amount of B2 consumption.

Table 5.11 Positive Impacts from Potential Biodiesel Legislation.

Positive Impacts on Revenue	Scenario #1	Scenario #2	Scenario #3
	B2 Mandate	Tax Credit (B2 = Diesel)	Mandate & HB1001
Biodiesel Sector New Revenue	$44,302,605	$44,566,264	$44,339,593
Soybean Processing (Crushing) New Revenue	46,942,038	47,219,738	46,981,006
Soybean Production Sector New Revenue*	33,922,462	34,118,626	33,949,992
Soybean Production Input Sector New Revenue	12,725,504	12,798,552	12,735,756

* Excludes Government Payments

The soybean industry, including processing, production and the input sectors, becomes a direct beneficiary from the increased demand for biodiesel feedstocks. Using the USB model which accounted for expected demand, supply, and inventory, estimates for each of the components to the soybean industry were calculated. The increase in soybean processing revenues reflects both the additional revenues from the new demand

229 "Petroleum Profile: Indiana." US Department of Energy. Energy Information Administration.
230 Lantz, Jon. "Re: Distillate fuels." Countrymark Energy Products.
231 BP Amoco – Whiting Refinery, IN. Personal Communication with Company Representative.

for biodiesel feedstocks within Indiana as well as the expected price effects for the current oil and meal production in the state (Table 5.12).

Table 5.12 Soybean Processing Industry Revenue Impacts.

Soybean Processing Industry Impacts	Scenario #1	Scenario #2	Scenario #3
	B2 Mandate	Tax Credit (B2 = Diesel)	Mandate & HB1001
Oil Feedstock Required (Pounds)	197,461,945	198,596,412	197,621,122
Soybean Oil Sector Impacts			
New Revenue from Soy Diesel Purchases	29,876,817	30,057,597	29,902,182
New Revenue from Price Increase	9,970,043	10,027,099	9,978,051
Total Soybean Oil Sector New Revenue	39,846,860	40,084,696	39,880,233
Soybean Meal Sector			
New Revenue from Soy Diesel Purchases	11,947,061	12,014,695	11,956,554
New Revenue from Price Increase	(4,851,883)	(4,879,652)	(4,855,781)
Total Soybean Meal Sector New Revenue	7,095,178	7,135,043	7,100,773
Total Soybean Processing Revenue	**46,942,038**	**47,219,738**	**46,981,006**

For instance, under the mandate initiative, Scenario 1, the new volume of oil that was created to satisfy the demand for biodiesel feedstocks produced $29,876,817 of new revenue. While the new revenue reflects the price increase for soybean oil, the current Indiana production of soybean oil would also benefit from the price change. Thus, Scenario 1 also translated the higher prices into new Indiana revenue of $9,970,043 for existing oil within that sector. The total impact from that scenario in the soybean oil sector was $39,846,860 (Table 5.12).

In the soybean meal sector, the additional demand for soybean oil resulted in a decrease in the price of soybean meal due to an increase in production of soybean meal. Consequently, while the new volume of soybean meal increases revenue by $11,947,061, the value for current Indiana soybean meal production actually decreases by $4,851,883 because of the drop in soybean meal prices. This results in a net increase of $7,095,178 for the soy meal sector. Similar effects can be seen for scenarios 2 and 3.

Indiana soybean production revenues also increased due to both the volume and price impacts of each legislative scenario. Table 5.13 shows the new revenues derived from the additional Indiana volume to supply the biodiesel feedstock demands as well as the new revenues expected from the national price increase while the total amount of soybeans needed was calculated earlier at 17.9 million bushels, available stocks of soyoil reduce the need for new soybean production down to only 7.3 million bushels, depending on the scenario.

Table 5.13 Soybean Production Impacts.

Soybean Production Impacts	Scenario #1	Scenario #2	Scenario #3
	B2 Mandate	Tax Credit (B2 = Diesel)	Mandate & HB1001
Additional Bushels of Soybeans Required	**7,309,774**	**7,351,734**	**7,315,663**
Soybean Production Revenue			
New Revenue from Soy Diesel Pruchases	$33,646,762	$33,841,495	$33,674,091
New Revenue from Price Increase	$10,149,339	$10,207,407	$10,157,489
Change in Revenue of LDP Payments	(9,873,639)	(9,930,275)	(9,881,588)
Soybean Production Sector New Revenue	**33,922,462**	**34,118,626**	**33,949,992**
Less Costs of Production	(12,725,504)	(12,798,552)	(12,735,756)
Net Revenue to Soybean Production	**21,196,958**	**21,320,075**	**21,214,236**

The price of soybeans increased from $4.57 to $4.60 due to the increase in soybean oil demand. While the additional revenues would benefit agricultural producers, the revenue gain would be offset partially by a change to the federal loan deficiency payments (LDP). A net loss in government payments to farmers of over $9 million would result from the price change as income support shifted from the government to the market. Combining the revenue impacts from the expected price and volume changes with the decrease in total government payments gave a total change in revenues for soybean farmers in each scenario of about $34 million. Removing the estimated operating costs for the additional soybean production needed to meet the increased demand for soy oil, the net revenue impacts provided over $21 million to soybean growers for each legislative scenario. The operating costs were considered to be additional revenue for the agricultural input sector.

Negative Impacts on Revenue

As noted in the IMPLAN analysis, the increase in soybean production would come at the expense of either higher production costs or else a shift in corn acreage. Using the same methodology from the IMPLAN analysis, a loss of 162,439 acres in corn production was predicted. This translated into a loss of revenue of more than $45 million for corn production (Table 5.14). Utilizing the expected operating costs for corn, the change in revenues for the agricultural input sector of corn production was calculated, resulting in a net decline to the input sector of $24.7 to $24.8 million and a net decline in corn revenue of $20.6 to $20.8 million.

Table 5.14 Negative Impacts from Potential Biodiesel Legislation.

Negative Impacts on Revenue	Scenario #1	Scenario #2	Scenario #3
	B2 Mandate	Tax Credit (B2 = Diesel)	Mandate & HB1001
Corn Production Sector Lost Revenue*	($45,349,837)	($45,610,156)	($45,386,372)
Corn Production Input Sector Lost Revenue	(24,690,792)	(24,832,523)	(24,710,683)
Distillate Refining Industry In-state Revenue	(2,859,788)	(2,234,369)	(2,772,036)
Fuel Distribution Industry In-state Revenue	(649,048)	-	(557,980)

* Excludes Government Payments

The impact to the distillate refining sector revenues accounted for the decrease in volume due to the substitution of 2 percent biodiesel within fuel blends and also the change in volume that would result from the price elasticity response. Since there is zero elasticity response in Scenario 2, the change in revenues comes exclusively from the substitution of biodiesel for diesel and this initiative has the smallest impact to the refining sector.

The fuel distribution impact was derived from the change in revenues due to the price elasticity response. The unchanged consumer demand from Scenario 2 caused the total impact to be zero while the other two scenarios exhibited a loss in revenue for this sector. This is because Scenario 2 has the same total gallons of fuel being distributed as without the mandate. However, any additional costs the distribution channel may face for equipment and other handling issues have been ignored in this analysis.

Other Impacts

The impact to the government is highly dependent on the type of legislation evaluated. For the mandate initiative, Scenario 1, the government impact is derived only from the change in tax revenues that would result from the elasticity response. Under the partially-subsidized mandate, Scenario 3, the tax credit decreased the elasticity response slightly but also added a $3,000,000 cost to the government (Table 5.15). In Scenario 2, the subsidy for biodiesel made the price of the fuel equal to diesel and there was zero elasticity response. However, subsidizing the incremental costs of B2 blends at $0.0159 per gallon transformed into a total cost to the state government of $(21,486,738).

Table 5.15 Other Impacts from Potential Biodiesel Legislation.

Other Impacts	Scenario #1	Scenario #2	Scenario #3
	B2 Mandate	Tax Credit (B2 = Diesel)	Mandate & HB1001
Impact on Indiana Government Finances	($865,653)	($21,486,738)	($3,753,544)
Impact on Consumers	($21,354,374)	$0	($18,372,940)

The impact to consumers varies under each legislative scenario. In Scenario 2 the subsidy on biodiesel keeps the consumer price of B2 the same as the initial distillate price. Thus, consumers do not change their purchasing behavior and there is zero consumer loss expected. In the other two scenarios, the increased price of biodiesel causes an additional burden to consumers associated with the higher price of fuel.

Net Revenue Impact

For this analysis, the term “Net Revenue” is used to define the total revenues less costs of the inputs that could be accounted for in the analysis. The reason for using “Net Revenues” was to avoid the double counting problems which were first identified in the IMPLAN model. The total net revenue impacts for biodiesel production, soybean processing, corn and soybean production, and the agricultural input sector reflect the total revenue impacts less the revenues for sectors further down the supply chain. For example, the net revenue for biodiesel is the revenue less the cost associated with purchasing soyoil. The purchase costs are included in the total revenue for soy processing. Soy processing’s net revenue is computed less the cost of purchasing the additional soybeans. This process continues through each sector. The net revenue impact for each scenario varies depending upon the volume change due to the price elasticity response and also because of the state government's financial support. In each of the scenarios, the shift in agricultural production from corn to soybeans contributes substantially to the negative value of the total impact for the legislation.

Table 5.16 summarizes the net revenue impacts of the various scenarios. In Scenario 1, the unsubsidized mandate, consumers bear the full weight from the increased fuel price and the net impact for the legislation is $(17.2 million).Under Scenario 2, the price of B2 equals the original distillate price and the government bears the full cost of subsidizing the fuel. The net impact for Scenario 2 is $(15.2 million). This increased cost is due to the government subsidizing a more expensive fuel at higher quality than consumers would be willing to buy without the subsidy. For Scenario 3, a mandate is added to the current Indiana legislation limiting the cost of the tax credit to $3 million and the net impact at $(16.9 million) is only a slight improvement over Scenario 1.

Table 5.16 Net Revenue Impact Summary from Potential Biodiesel Legislation.

Net Revenue Impact Summary	Scenario #1	Scenario #2	Scenario #3
	B2 Mandate	Tax Credit (B2 = Diesel)	Mandate & HB1001
Sector Impacts:			
Biodiesel	$14,425,788	$14,508,668	$14,437,411
Soybean Processing	5,506,994	5,545,402	5,512,379
Soybean Production	21,196,958	21,320,075	21,214,236
Corn Production	(20,659,045)	(20,777,633)	(20,675,689)
Agricultural Inputs	(11,965,288)	(12,033,971)	(11,974,927)
Refining	(2,859,788)	(2,234,369)	(2,772,036)
Distribution	(649,048)	-	(557,980)
Consumers	(21,354,374)	-	(18,372,940)
Taxpayers	(865,653)	(21,486,738)	(3,753,544)
Total Indiana Impact	(17,223,457)	(15,158,568)	(16,943,090)

Limitations to the Analysis

The partial equilibrium analysis is able to capture the price and volume changes that would occur from increased demand for biodiesel feedstocks. It also highlights the impacts that could arise for the refining industry, the fuel distribution sector, consumers and the state government. Unlike the IMPLAN analysis though, the partial equilibrium analysis does not project all of the potential indirect and induced impacts from adding biodiesel production. Because the margins for each industry vary, the partial equilibrium analysis is not able to account for the actual "value added" to each sector as defined by IMPLAN. However, the analysis does attempt to avoid the problems of double counting benefits and drawbacks by calculating the net revenue impacts. The partial equilibrium analysis also does not attempt to forecast the effects on employment although the revenue per worker for each industry could be used from the IMPLAN model to estimate the impacts on employment.

Excluded Impacts

While both the partial equilibrium analysis and IMPLAN analysis address some of the key impacts from biodiesel legislation, there are several exceptions to the two models that would also be relevant when considering the approval of such policy. The final section of this chapter will discuss a few of the excluded impacts as factors that also should be considered but would be difficult to ensure impacts for.

One of the main exclusions to this analysis is the indirect effect that an increase in the price of fuel could have on the entire economy. Comprising at least 49 percent of the total demand for distillate fuels, the trucking industry would be expected to suffer considerably from any increase in the price of fuel. The US Department of Transportation maintains statistics on the total ton-miles of truck shipments for each state. Indiana ranks second among the 50 states in the total "through" miles with 22,083 million (shipments not originating or concluding within the state) and sixth in total miles with 37,514 million ton-miles.

Such a high capacity of trucks moving through the state would likely translate into an adjustment in purchasing behavior if the price of fuel increased. The Indiana Motor Truck Association has noted that in 1999 the trucking industry, which has an average annual wage of $33,338 per worker, employed 238,243 people in Indiana.[232] The American Trucking Association has claimed that for "every 10 cent increase in the price of diesel fuel, on average, 1,000 motor carriers with five trucks or more in their fleet will file for bankruptcy."[233] The complete economic impact of biodiesel legislation will have to weigh each of these factors appropriately.

Industries that are directly or indirectly related may feel the strain of a marginal increase in fuel prices. Companies that maintain fuel depots within the state may choose to move their locations into bordering states to take advantage of less expensive fuels. It would also be expected that if the price of fuel for on-highway trucking increases, the prices of goods that utilize that form of transportation would also increase due to the higher shipping costs.

This analysis has also not been able to capture the potential for cross price elasticity in the surrounding states. Operating in a similar manner to the price elasticity identified earlier, the cross price elasticity for distillate fuels in states that border Indiana could have a greater impact than the change in demand noted in the analysis. Opponents of mandates have argued that the trucking segment of demand would respond more aggressively than captured within the analysis by purchasing fuel in Border States before traveling into Indiana.

The analysis restricted the impacts for soybean production and processing as well as consumer, refining and fuel distribution effects to the state of Indiana. Given the unrestricted trade flows between states, it is likely that each of these categories could

[232] "Strength for the State's Economy." Indiana Motor Truck Association.
[233] "ATA Calls Attention to Rising Diesel Prices." American Trucking Association.

have impacts outside the state. The supply of soybeans and its products may come from neighboring states reducing the positive impacts of legislation

While the analysis did not depict an additional cost for the blending or distribution of B2 in the pricing section, the difference between the B20 and diesel prices from the DOE conceivably includes the increased costs for handling the fuel. Thus, the conversion into a wholesale price of biodiesel actually would include an estimate for added distribution and storage costs.

There are potential logistical and supply chain issues that could arise from a mandate or subsidy which incorporates 2 percent biodiesel into all distillate fuels. Runge noted that the biodiesel mandate in Minnesota could "create serious bottlenecks in soybean oil processing, and in the handling and storage of processed soydiesel."[234] Introducing biodiesel into the entire fuel distribution system will require additional storage and handling equipment and education on the unique chemical properties of the fuel.

While the United Soybean Board model was valuable to estimating the effects of additional soybean oil demand, the analysis did not consider whether the extra soybean meal created would actually have a market within the region. An absence of potential buyers for the soybean meal could push the local price for the soybean meal down even further which would have negative effects on each scenario.

Taxes would also be affected by the change in government receipts, industry revenues and consumers' income. This analysis measured only the state tax receipts that changed directly due to the demand for distillate fuel. The change in Federal taxes was not considered in the impact on the state government. However, the Federal taxes account for a significant portion of the national funds distributed to each state to support highway and road development.[235]

The partial equilibrium analysis takes a static look at the potential economic impacts from biodiesel legislation. It is obvious that the prices and demand for distillate fuels, soybeans, soybean oil, soybean meal, and corn are constantly changing during the year due to market forces. Changes that made the price of biodiesel cost more or less than measured within this analysis would affect the total demand for the fuel and the value of every impact.

Finally, Chapter 2 identifies a number of environmental benefits associated with biodiesel. This analysis does not quantify the economic value associated with these environmental characteristics. However, the net impact on the economy of negative \$15 to \$17 million would be an estimate of the needed benefits from environmental improvements to make the mandate of 2% biodiesel result in a net benefit to Indiana society. It is left to legislators and constituents of the state of Indiana to determine the value of the environmental benefits.

---

[234] Runge, C. Ford. Uncertain Costs and Unanswered Questions: Minnesota's Biodiesel Fuel Mandate.
[235] Your State's Share: Attributing Federal Highway Revenues to Each State. US Department of Transportation. Federal Highway Administration.

I. Conclusions

Figure 5.8 visually captures the net revenue effects of biodiesel legislation in the state of Indiana. The data represented on the next page corresponds with the results from the partial equilibrium analysis in Table 5.16.

The conclusions that can be derived from empirical analysis are:

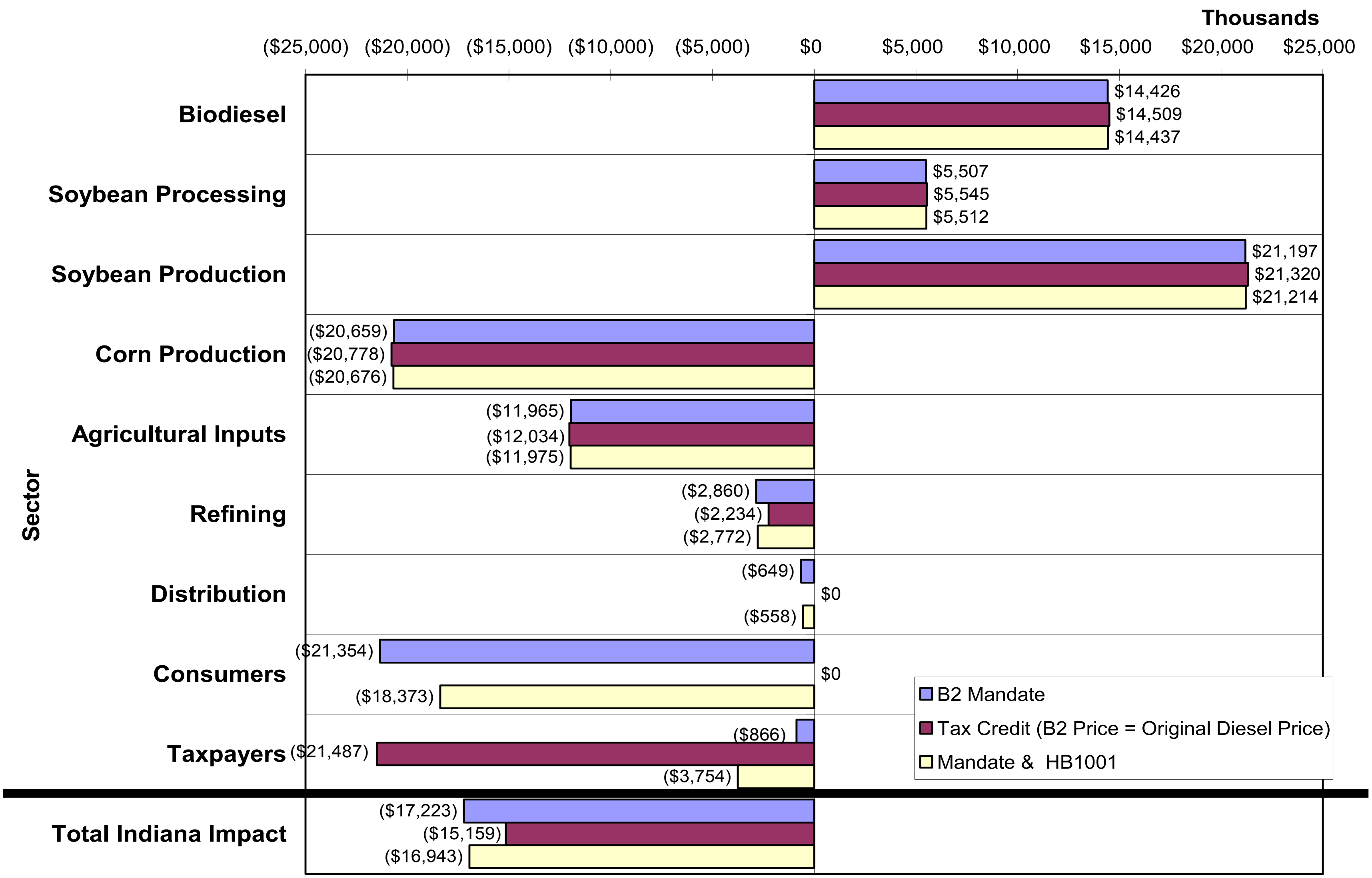
- Indiana uses approximately 1.3 billion gallons of diesel annual
- A 2 percent biodiesel blend would raise pump prices about $0.015 per gallon
- There would be a demand for 27 million gallons of biodiesel to meet a 2 percent mandate resulting in the use of:
    - 197 million pounds of soyoil
    - 18 million bushels of soybeans
- Some of the economic benefits include
    - Net value-added activity of about $13 million annually to the biodiesel and related industries,
    - As many as 133 new jobs created across the impacted sectors of the economy
    - A 3 cent per bushel increase in soybean prices, and
    - Approximately $5.5 million in new net revenue to the soy processing industry in Indiana.
- The subsidy proposal, which has the least negative total net revenue impact, would benefit B2 consumers and the soy industry the most, but the state government, and therefore taxpayers, would end up paying directly for the additional cost of biodiesel.
- The corn production and agricultural input sectors would face decreased total net revenues from each of the proposals as acres of corn were shifted to soybean production.
- The refining sector would be negatively impacted under each policy because of the substitution of biodiesel for distillate fuel and the resulting reduction in consumer demand for diesel fuels.
- The fuel distribution sector would face negative net revenues because of the reduced consumer demand unless the cost of biodiesel was subsidized.
- While taxpayers will face additional burdens under all of the proposals, the impacts from mandating B2, which were derived from the decreased tax revenues due to reduced consumer demand, are significantly less than the costs of subsidizing the additional cost of biodiesel.
- The total net revenue effects from each of the three legislative proposals, including costs to consumers and taxpayers, is a negative value ranging from a loss of $17.2 million without tax breaks to $15.2 million with tax breaks.

While the IMPLAN analysis portrayed that adding biodiesel production could have a range of direct, indirect, and induced effects, the total “value added” may be offset by other industries that are burdened by the increase in fuel prices and shifts to soybean production. Even without these other industry effects, the $13million in value added would not be enough to offset the $21 million in costs to consumers and/or taxpayers.

This analysis does not try to capture the value of the environmental and performance characteristics of biodiesel as well as the fuel's renewable nature. Despite the fact that the economic analysis of the three biodiesel initiatives predicts that the total impact on net revenues within Indiana would be negative, $17 million dollars annually is only about 0.01 percent of Indiana's gross state product of approximately $192 billion based on government figures from 1999.[236] To the extent that environmental benefits are worth more than 0.01 percent of gross state product the biodiesel mandate would be a positive for the state of Indiana. There may also be alternative motivations for encouraging the production and use of biodiesel. It may be that short-term industry subsidization is justified to entice in-state production of biodiesel necessary to meet the increased demand for biodiesel when the new federal sulfur emissions standards are implemented in 2006.

[236] Panek, Sharon and George K. Downey. "Gross State Product by Industry, 1998–2000."

Figure 5.8 Net Revenue Impacts of Alternative Biodiesel Legislation for Indiana.



References

1997 Economic Census Data. US Census Bureau. Accessed May 4, 2003. www.census.gov/epcd/www/econ97.html

"A Comprehensive Analysis of Biodiesel Impacts on Exhaust Emissions – Draft Technical Report." US Environmental Protection Agency (EPA). October 2002. Accessed February 13, 2003. www.epa.gov/otaq/models/analysis/biodsl/p02001.pdf

"Administration's Proposed FY04 Budget Cuts Funding for Renewable Energy in Department of Energy and Agriculture." Accessed February 4, 2003. www.eesi.org

Ahouissoussi, Nicolas and Michael Wetzstein. "A Comparative Cost Analysis of Biodiesel, Compressed Natural Gas, Methanol, and Diesel for Transit Bus Systems." National Biodiesel Board. Accessed March 14, 2003. www.biodiesel.org/resources/reportsdatabase/reports/tra/tra-030.pdf

Alspach, Brent. Indiana State Police. Commercial Vehicle Enforcement Division. Accessed May 1, 2003. www.in.gov/isp/divisions/cved/schoolbus/

"Alternative Fuel Transportation Program; Biodiesel Fuel Use Credit." As appeared in the Federal Register: January 11, 2001 (Volume 66, Number 8)]. Accessed May 8, 2003. www.epa.gov/fedrgstr/EPA-IMPACT/2001/January/Day-11/i744.htm

Alternative Fuel Price Report, The. US Department of Energy. Alternative Fuel Data Center. Various reports. Accessed April 14, 2003. www.afdc.doe.gov/documents/pricereport/pricereports.html

Alternative Fuels Data Center. Biodiesel General Information. US Department of Energy. Accessed February 2003. www.afdc.doe.gov/altfuel/bio_general.html

Alternative Fuels – Frequently Asked Questions. US Department of Energy. Energy Information Administration. Accessed May 4, 2003. www.eia.doe.gov/cneaf/alternate/page/faq.html#9

Alternative Fuels Index. Energy Management Institute. Accessed April 8, 2003. www.energyinstitution.org/alt%20Fuels%20index%20free%20request.htm

Ames, Jeremy. "New and Proposed Federal Incentives for Bioenergy Production." Bioenergy 2002 Conference. September 23, 2002.

Ames, Jeremy. "New Federal Incentives Promote Biopower and Biobased Products." BioCycle. November 2002.

Ash, Mark, and Erik Dohlman. Oil Crops Outlook. US Department of Agriculture. December 11, 2002. Accessed March 13, 2003. www.ers.usda.gov

"ASTM Issues Biodiesel Fuel Standard" National Biodiesel Board. May 3, 2002. Accessed February 10, 2003. www.biodiesel.org/pdf_files/ASTM_Spec_02.pdf

"ATA Calls Attention to Rising Diesel Prices." American Trucking Association. Accessed May 18, 2003. www.truckline.com/insideata/press/011403_diesel_letter.html

Blank for duplication.

"Benefits of Biodiesel." National Biodiesel Board. Accessed March 4, 2003. www.biodiesel.org/pdf_files/Benefits%20of%20Biodiesel.PDF

"Biodiesel Beats the Cold." National Biodiesel Board. January 27, 2003. Accessed March 8, 2003. www.nbb.org/resources/pressreleases/gen/20030203_coldweather.pdf

"Biodiesel Emissions." National Biodiesel Board. Accessed February 2003. www.biodiesel.org/pdf_files/emissions.PDF

"Biodiesel Facility Begins Production in Ralston, Iowa." Biodiesel Bulletin. National Biodiesel Board. January 2, 2003 Accessed April 4, 2003. www.biodiesel.org/news/bulletin/2003/010203.pdf

"Biodiesel Fuel and Its Integration into the Agricultural Economy of this State – Background Memorandum." North Dakota Legislative Council. August 2001. Accessed April 1, 2003. www.state.nd.us/lr//assembly/57-2001/docs/pdf/39011.pdf

"Biodiesel Fuel." National Renewable Energy Laboratory (NREL). Accessed April 5, 2003. www.ctts.nrel.gov/heavy_vehicle/refuel_lab/biodiesel.html

"Biodiesel Fuel: What Is It – Can It Compete?" National Biodiesel Board. December 10, 1993. Accessed February 24, 2003. www.biodiesel.org/resources/reportsdatabase/reports/gen/gen-003.pdf

"Biodiesel Fuel Market." Alternative Fuels Data Center. US Department of Energy. Accessed February 24, 2003. www.afdc.doe.gov/altfuel/bio_market.html

"Biodiesel from Multiple Feedstocks: Challenges and Opportunities in the Market Place." US Department of Energy (DOE). Clean Cities Program. Accessed April 5, 2003. www.ccities.doe.gov/conference/pdfs/peeples.pdf

"Biodiesel Handling and Use Guidelines." National Renewable Energy Laboratory. September 2001. Accessed February 3, 2003. www.afdc.doe.gov/pdfs/5845.pdf

"Biodiesel Non-Attainment Market Pre-evaluation: Final Report to the National Biodiesel Board." October 30, 1995. Arthur D. Little, Inc. Reference 48455. Acorn Park, Cambridge, Massachusetts. Accessed March 18, 2003. www.nbb.org/resources/reportsdatabase/reports/gen/19951030_gen-145.pdf

Biodiesel: On the Road to Fueling the Future. Ed. Karl Lang, Higgins and Nazzaro. National Biodiesel Board. 2001. Accessed March 13, 2003. www.biodiesel.org/pdf_files/bdreport.pdf

"Biodiesel Performance." National Biodiesel Board. Accessed February 10, 2003. www.nbb.org/pdf_files/Performance.PDF.

"Biodiesel Poised to Be a Significant Contributor to the US Alternative Fuels Market." National Biodiesel Board. January 2000. Accessed February 15, 2003. www.biodiesel.org/resources/reportsdatabase/reports/gen/gen-212.pdf

"Biodiesel Production and Quality." National Biodiesel Board. March 11, 2002. Accessed March 14, 2003. www.nbb.org/pdf_files/prod_quality.pdf

"Biodiesel Production Technology Overview." National Biodiesel Board. Accessed May 4, 2003. www.nbb.org/resources/reportsdatabase/reports/gen/gen-004.pdf

"Biodiesel Producers in Europe 2000." Oelmühle Leer Connemann GmbH & Co. Accessed February 25, 2003. www.biodiesel.de/img99/fig11.htm

"Biodiesel Production." National Biodiesel Board. Accessed March 1, 2003. www.nbb.org/pdf_files/Production.PDF

"Biodiesel Production Technology Overview." National Biodiesel Board. Accessed May 4, 2003. nbb.org/resources/reportsdatabase/reports/gen/gen-004.pdf

"Bioenergy Payments FY2002." US Department of Agriculture. November 26, 2002. Accessed March 12, 2003. www.fsa.usda.gov/daco/bioenergy/2002_4thqtrpmnts.pdf

"Bioenergy Program; Final Rule: 7 CFR Part 1424." Federal Register. November 13, 2000. Accessed March 12, 2003. www.fsa.usda.gov/daco/bioenergy/CompleteFederalRegisterFinalRule.pdf

"Bringing Greener Machines to National Parks – Part 2: Cleaner, Quieter Park Fleets." US Department of Energy. Regional Biomass Energy Program. Accessed April 16, 2003. www.ott.doe.gov/rbep/pdfs/trucks_parks.pdf

Bockey, D. and W. Korbitz. "Situation and Development Potential for the Production of Biodiesel – an International Study." Union for the Promotion of Oil and Protein Plants. Accessed April 3, 2003. www.ufop.de/Biointernational.pdf

Boehlje, Michael. "Agricultural Finance." Purdue University. West Lafayette, IN. April 29, 2003.

BP Amoco – Whiting Refinery, IN. Personal Communication with Company Representative. May 12, 2003.

"Bush Administration Proposes Dramatic Reductions of Pollution from Nonroad Diesel Engines." Environmental News. US Environmental Protection Agency (EPA). April 15, 2003. Accessed April 16, 2003. www.epa.gov/newsroom/headline2_041503.htm

Caparella, Tina. "Biodiesel and CWD are Hot Topics at NRA's Central Region Convention." Render. August 2002. Accessed February 26, 2003. www.rendermagazine.com

Caparella, Tina. "Distributors Not Choosy About Biodiesel." Render. October 2002. Accessed February 27, 2003. www.rendermagazine.com/October2002/BiodieselBulletin.html

"Clean School Bus USA." US Environmental Protection Agency. Accessed May 1, 2003. www.epa.gov/otaq/schoolbus/basicinfo.htm

Coltrain, David. "Biodiesel: Is It Worth Considering?" Department of Agricultural Economics. Kansas State University. Manhattan, KS. August 15, 2002. Accessed January 30 2003. www.agecon.ksu.edu/renewableenergy/pdfs/Biodiesel%20Is%20it%20Worth%20Considering.pdf

"Crop Production 2002 Summary." US Department of Agriculture. January 10 2003. Accessed March 13, 2003. usda.mannlib.cornell.edu/reports/nassr/field/pcp-bban/cropan03.pdf

Crop Production Costs. National Agricultural Statistics Service. Indiana Agricultural Statistics Service. Accessed May 5, 2003. www.nass.usda.gov/in/annbul/0203/pg46.pdf

"Crambe, Industrial Rapeseed, and Tung Provide Valuable Oils." Industrial Uses. US Department of Agricultural. Economic Research Service. September 1996: 21. Accessed April 12, 2003. www.ers.usda.gov/publications/ius6/ius6c.pdf

Dahl, Carol. A Survey of Energy Demand Elasticities in Support of the Development of the NEMS. Colorado School of Mines. Department of Mineral Economics. Golden, Colorado. October 19, 1993.

"Data on Cold Flow Properties." Mechanical Engineering Department. Iowa State University. Accessed March 12, 2003. www.me.iastate.edu/biodiesel/Pages/bio26.html

"Diesel Fuel Cold Flow Properties." Mechanical Engineering Department. Iowa State University. Accessed March 12, 2003. www.me.iastate.edu/biodiesel/Pages/bio18.html

"Diesel Fuel Price Pass-through". US Department of Energy. Energy Information Administration. Accessed March 18, 2003. http://www.eia.doe.gov/pub/oil_gas/petroleum/feature_articles/2002/diesel/diesel.html

"Demand for Diesels: The European Experience." Diesel Technology Forum. July 2001. Accessed April 1, 2003. www.dieselforum.org/whitepaper/downloads/EuropeanExperience.pdf

Duffield, James and Hosein Shapouri. "US Biodiesel Development: New Markets for Conventional and Genetically Modified Agricultural Products." Report No. 770. US Department of Agriculture. Economic Research Service September 1998: 18. Washington, DC. Accessed March 9, 2003. www.ers.usda.gov/publications/aer770/aer770.pdf

"Economic Feasibility of Producing Biodiesel in Tennessee." Agri-Industry Modeling & Analysis Group et. al. Accessed April 4, 2003. web.utk.edu/~aimag/pubs/biodiesel.pdf or alternatively at: economics.ag.utk.edu/pubs/business/biodiesel.pdf

"Economic Impact of Soy Diesel in Minnesota." Minnesota Department of Agriculture. Agricultural Marketing Services Division. Accessed February 3, 2003. www.mda.state.mn.us/ams/biodiesel/ecoimpsoydiesel.pdf

"Environmental & Safety Information." National Biodiesel Board. Accessed February 21, 2003. www.biodiesel.org/pdf_files/Envi&Safetyinfo.PDF

"EPA Gives the Green Light on Diesel-Sulfur Rule." Environmental News. US Environmental Protection Agency (EPA). Communications, Education and Media Relations. Washington, DC. February 28, 2001. Accessed February 12, 2003. www.epa.gov/otaq/regs/hd2007/frm/final-pr.pdf

"EPA Registration." Mechanical Engineering Department. Iowa State University. Accessed March 12, 2003. www.me.iastate.edu/biodiesel/Pages/bio27.html

"EPA Releases Comprehensive Study on Biodiesel Emissions." National Biodiesel Board. November 14, 2002. Accessed January 31, 2003. www.nbb.org/resources/pressreleases/gen/20021114_epaemissionsstudy%20nr.pdf

"Fact Sheet." Clean Cities Alternative Fuel Information Series. US Department of Energy. Office of Energy Efficiency and Renewable Energy. May 2001. Accessed February 14, 2003. www.afdc.doe.gov/pdfs/Biodiesel_fs.

"Farm Bill Conference Summary" US Senate Agriculture Committee. April 30, 2002. Accessed 20 March 2003. agriculture.senate.gov/Briefs/2001FarmBill/conframe.htm.

<u>Federal Highway User Fees</u>. Highway Statistics 2001. Department of Transportation. Federal Highway Administration. Accessed May 4, 2003. www.fhwa.dot.gov/ohim/hs01/fe21b.htm

<u>Fuel Oil and Kerosene Sales 2001</u>. Table 16. Accessed May 1, 2003. www.eia.doe.gov/pub/oil_gas/petroleum/data_publications/fuel_oil_and_kerosene_sales/ current/pdf/table16.pdf

<u>Fuel Oil and Kerosene Sales 2001</u>. US Department of Energy. Energy Information Administration. November 2002: 54. Accessed May 1, 2003. www.eia.doe.gov/oil_gas/petroleum/data_publications/fuel_oil_and_kerosene_sales/foks.html

<u>Fuel Tax Handbook</u>. Indiana Department of Revenue. March 2002. Accessed March 12 2003. http://www.in.gov/dor/publications/fuel/pdf/fuelhndbk.pdf

"Bioenergy Program" Farm Service Agency. Accessed March 17, 2003. www.fsa.usda.gov/daco/bio_daco.htm.

Faye, Zenneth. "Canola Biodiesel." CanolaInfo. Accessed February 23, 2003. www.canolainfo.org/html/bibliography/biodieselframe.html

Frazier, Rod. "Biodiesel Production Potential in Michigan and Ohio." Ohio/Michigan Biofuels Conference. 2002. Accessed March 16, 2003. www.bbiethanol.com/oh-mi-biofuels/Frazier-OHMI.pdf

"Fuel Oil and Kerosene Sales 2001." US Department of Energy. Energy Information Administration. November 2002: 54. Accessed May 1, 2003. www.eia.doe.gov/oil_gas/petroleum/data_publications/fuel_oil_and_kerosene_sales/foks.html

"Fuel Stability." Mechanical Engineering Department. Iowa State University. Accessed March 12, 2003. www.me.iastate.edu/biodiesel/Pages/bio22.html

<u>Fuel Tax Handbook</u>. Indiana Department of Revenue. March 2002. Accessed March 2003. www.in.gov/dor/publications/fuel/pdf/fuelhndbk.pdf

"FY 2002 – Bioenergy Program Participant Payments." US Department of Agriculture. November 26, 2002. Accessed March 12 2003. www.fsa.usda.gov/daco/bioenergy/bioparticipantpayment2002.pdf

Gasoline and Diesel Fuel Update. US Department of Energy. Energy Information Administration. Accessed May 4, 2003. tonto.eia.doe.gov/oog/info/gdu/gasdiesel.asp

"Global Warming - Climate." US Environmental Protection Agency (EPA). April 15, 2003. Accessed April 16, 2003. yosemite.epa.gov/oar/globalwarming.nsf/content/climate.html

Groschen, Ralph. "Minnesota's Renewable Fuels Program." Presentation. Minnesota Department of Agriculture. Accessed March 1, 2003. www.aedc.state.ar.us/Energy/Biodiesel/

Groschen, Ralph. "Overview of: The Feasibility of Biodiesel from Waste/Recycled Greases and Animal Fats." Minnesota Department of Agriculture. Accessed March 17, 2003. www.mda.state.mn.us/ams/wastefatsfeasability.pdf

Hatcher, Charles. "RE: VENEMAN ANNOUNCES BIOENERGY PROGRAM CHANGES AND SIGN-UP." National Biodiesel Board. E-mail to the author. May 8, 2003.

H.B. 2643 – "Clean Burning Fuel: Biodiesel." Arizona House of Representatives Forty-fourth Legislature – Second Regular Session. Committee on Environment. February 1, 2000. Accessed April 2, 2003. www.azleg.state.az.us/legtext/44leg/2r/comm_min/ house/0201env.doc.htm

"Health Effects Testing." National Biodiesel Board. Accessed February 2003. www.biodiesel.org/pdf_files/HealthEffectsTesting.PDF

Henderson, Paul. "OEM's – Building OEM Support: Biodiesel Quality." Presentation. Biodiesel Research & Brainstorming Workshop. New Orleans, LA. January 29-30, 2003.

Hernandez, Ernesto. "Fats and Oils Processing." World Markets Research Center. Business Briefing: Foodtech. Accessed April 5, 2003. www.wmrc.com/businessbriefing/pdf/foodtech2002/ publication/hernandez.pdf

"Highway Taxes and Fees." United States Department of Transportation - Federal Highway Administration. Office of Highway Policy Information. Accessed February 21, 2003. www.fhwa.dot.gov/ohim/hwytaxes/2001/index.htm

"History." Mechanical Engineering Department. Iowa State University. Accessed March 12 2003. www.me.iastate.edu/biodiesel/Pages/bio6.html

"How is Agricultural Data Being Created?" Minnesota IMPLAN Group. 2 Mar 1998. Accessed May 13, 2003. www.implan.com/KnowledgeBase/DisplayArticle.asp?KBID=20035

"How is Biodiesel Used?" Mechanical Engineering Department. Iowa State University. Accessed March 12 2003. www.me.iastate.edu/biodiesel/Pages/bio4.html

Howell, Steve. "Rigorous Standards Ensure Biodiesel Performance." Biodiesel: On the Road to Fueling the Future. Ed. Karl Lang, Higgins and Nazzaro. National Biodiesel Board. 2001: 7. Accessed March 13, 2003. www.biodiesel.org/pdf_files/bdreport.pdf

Howell, Steven, and J. Alan Weber. US Biodiesel Overview. National Biodiesel Board. Accessed March 3, 2003. www.nbb.org/resources/reportsdatabase/reports/gen/gen-263.pdf

Indiana Department of Revenue 2002 Annual Report. State of Indiana. October 1, 2002: 31. Accessed May 4, 2003. www.in.gov/dor/publications/report/02pdf/fullreport02.pdf

"Indiana Tax Descriptions and Receipts." Indiana Department of Revenue Annual Report - October 1, 2001. www.in.gov/dor/publications/report/01pdf/descriptions01.pdf

Indiana's Rank in US Agriculture. National Agricultural Statistics Service. Indiana Agricultural Statistics Service. Accessed May 4, 2003. www.nass.usda.gov/in/ranking/rank01.txt

"Impacts of Increased Ethanol and Biodiesel Demand." Food and Agricultural Policy Research Institute (FAPRI). UMC Report #13-01. University of Missouri – Columbia, Iowa State University. October 2001. Accessed February 14, 2003. www.fapri.missouri.edu/Publications/2001Publications/EthanolBiodiesel/Ethanol_Biodiesel.pdf

"Just the Basics: Biodiesel." Transportation for the 21st Century. US Department of Energy. Office of Transportation Technologies. Energy Efficiency and Renewable Energy. January 2002. Accessed February 13, 2003. www.ott.doe.gov/pdfs/jtb_biodiesel.pdf

Kaufman, Joe. "Ultra Low Sulfur Diesel Delivery Challenges." Presentation. Clean Heavy Duty Vehicles Conference. February 2003. Accessed March 20, 2003. www.calstart.org/hdv/2003CHDVPresentations/ConocoPhillipsPresentation.pdf

Korotney, David. "EPA analysis of the Exhaust in Emission Impacts of Biodiesel." Presentation. Biodiesel Research & Brainstorming Workshop. New Orleans, LA. January 29-30, 2003.

"Landmark Biodiesel Legislation Passes in Minnesota." National Biodiesel Board. March 15, 2002. Accessed March 8, 2003. www.nbb.org/resources/pressreleases/gen/20020315_mn_leg.pdf

Lantz, Jon. "Re: Distillate fuels." Countrymark Energy Products. E-mail to the author. May 15, 2003.

"Largest Biodiesel Plant in the US Now Being Assembled in Bakersfield, California." Green Star Products, Inc. Bakersfield, C.A. 24 Feb 2003. Accessed April 7, 2003. www.baat.com/pr03-02-24.htm

Lavelle, Marianne. "Biodiesel; Ethanol; Hydrogen; Natural Gas." US News and World Report. February 17, 2003. 34-38. Accessed February 25, 2003. www.usnews.com/usnews/

"Life Cycle Inventory of Biodiesel and Petroleum Diesel for Use in an Urban Bus." National Renewable Energy Laboratory (NREL). May 25, 1998. Accessed February 10, 2003. www.nrel.gov/docs/legosti/fy98/24089.pdf

Ma, Jian, James Scott, and Thomas Johnson. "Soy Diesel Processing in Buchanan County, Missouri: Potential Impacts." University of Missouri – Columbia. Accessed February 13, 2003. www.ssu.missouri.edu/faculty/jscott/soydsl.htm

Manning, P., Popp, and Cochran. “Biodiesel: Potential and Possibilities for the Arkansas Economy.” Presentation. Department of Agricultural Economics and Agribusiness. University of Arkansas. Accessed March 1, 2003. www.aedc.state.ar.us/Energy/Biodiesel/ MARK%20COCHRAN.ppt

Martin, Michael F. “Who Benefits From Gas Tax Cuts?” American Road & Transportation Builders Association. Accessed May 2, 2003. www.artba.org/economics_research/current_issues/ indiana-illinois_gas_tax_2001_.pdf

McCallum, Laura. “Biodiesel survives rocky road at Legislature.” Minnesota Public Radio March 12, 2002. Accessed March 18, 2003. news.mpr.org/features/200203/12_mccalluml_biodiesel/index.shtml.

McCormick, Robert. “Re: Biodiesel emissions.” E-mail to the authors. February 21, 2003.

“Memo: Biodiesel Legislation.” National Biodiesel Board: March 13, 2003.

“Nation’s Capitol Turns to Biodiesel.” Iowa Farm Bureau. April, 9 2003. Accessed February 18, 2003. www.ifbf.org/media/print/textArticle.asp?number=607&type= Notes%20for%20Busy%20Editors

National Agricultural Statistics Service. US Department of Agriculture. Accessed May 8, 2003. www.nass.osda.gov

Nazzaro, Paul. “Biodiesel is Lubricity.” In <u>BIODIESEL On The Road To Fueling The Future</u>. National Biodiesel Board. Accessed May 27, 2003. www.biodiesel.org/pdf_files/bdreport.pdf

Nelson, Richard, Steve Howell, and J. Alan Weber. “Potential Feedstock Supply and Costs for Biodiesel Production.” Bioenergy ’94. Presented at the Sixth National Bioenergy Conference. Reno/Sparks Nevada. October 2-6, 1994. National Biodiesel Board. Accessed March 5, 2003. www.biodiesel.org/resources/reportsdatabase/reports/gen/gen-290.pdf

“New Diesel Fuels: They Are in Your Future for Nonroad Equipment.” November 2001. Association of Equipment Manufacturers. Accessed February 12, 2003. www.aem.org/Technical/PDF/diesel-fuels-rpt.pdf

“Newsletter Archive”. Biomass Research and Development Initiative. August 2001. Accessed March 19, 2003. www.bioproducts-bioenergy.gov/0801.html

“Oil Dependency a Major Concern, Energy’s Abraham Says.” US Department of State. Office of International Information Programs. June 20, 2002. Accessed March 3, 2003. usinfo.state.gov/regional/nea/text/0620oil.htm

“OPTIM Glycerine 99.7% USP/EP Prices.” E-Epoxy. Accessed April 12, 2003. www.e-epoxy.com

Panek, Sharon and George K. Downey. “Gross State Product by Industry, 1998–2000.” June 2002. Accessed May 18, 2003. <u>www.bea.gov/bea/ARTICLES/2002/06june/0602gsp.pdf</u>

Pearl, Gary. “Biodiesel Production in the US” Render. August 2001. Accessed February 26, 2003. www.rendermagazine.com

“Permit Guide” Indiana Department of Environmental Management. Accessed May 5, 2003. www.in.gov/idem/guides/permit/air/nonattainment.html

Petroleum Profile: Indiana. US Department of Energy. Energy Information Administration. Accessed May 4, 2003. tonto.eia.doe.gov/oog/info/state/in.html

“Registration of Fuels and Fuel Additives.” US Environmental Protection Agency. Accessed April 15, 2003. www.epa.gov/fedrgstr/EPA-AIR/1997/March/Day-17/a6022.htm

Reilly, Christopher. “Glycerin Market Begins Upward Turn.” Purchasing. December 13, 2001. Accessed April 17, 2003. www.manufacturing.net/pur/index.asp?layout=articleWebzine&articleid=CA186951

“Requirements for B100.” Alternative Fuels Data Center. US Department of Energy. Accessed March 18, 2003. www.devafdc.nrel.gov/altfuel/bio_resources_table.html

Runge, C. Ford. “Minnesota’s Biodiesel Mandate: Taking from Many, Giving to Few.” February 15, 2002.

Runge, C. Ford. Uncertain Costs and Unanswered Questions: Minnesota’s Biodiesel Fuel Mandate. Email from Rick Wajda. Indiana Petroleum Council. Re: Biodiesel. April 8, 2003.

S.F No. 1495, 3rd Engrossment: 82nd Legislative Session (2001-2002). Minnesota Legislature. Posted on Mar 12, 2002. Access March 8, 2003. www.revisor.leg.state.mn.us/cgibin/getbill.pl?number=SF1495& session=ls82&version=latest

Shumaker, George A., et al. A Study on the Feasibility of Biodiesel Production in Georgia. February 2003. Accessed May 21, 2003. www.agecon.uga.edu/~caed/biodieselrpt.pdf

Soya and Oilseed Blue Book. 2003. Soyatech, Inc. Bar Harbor, ME.

"Soybean Oil Mills." Encyclopedia of American Industries, 3rd ed. 2 vols. Gale Group, 2001. Reproduced in Business and Company Resource Center. Farmington Hills, Mich.: Gale Group. 2003. Accessed March 13, 2003. www.galenet.com/servlet/BCRC

Soybean Processing. 1997 Economic Census. Manufacturing. US Census Bureau. Oct 1999: 7. Accessed May 13, 2003. www.census.gov/prod/ec97/97m3112e.pdf

Special Taxation of Special Fuels. US Department of Transportation. Federal Highway Administration. Accessed May 4, 2003. www.fhwa.dot.gov/ohim/hwytaxes/2001/pt2.htm

Standard Industrial Classification (SIC) System Search. US Department of Labor. Occupational Safety & Health Administration. Accessed May 10, 2003. www.osha.gov/oshstats/sicser.html

“Strength for the State’s Economy.” Indiana Motor Truck Association. Accessed May 21, 2003. www.imtaonline.net/docs/Indiana%20Stats%20IMTA.pdf

"Summary Results from NBB/USEPA Tier I Health and Environmental Effects Testing for Biodiesel: Final report." March 1998. Accessed march 8, 2003. www.worldenergy.net/articles/supportRes/ documents/Tier%20I%20Results.doc

Tickell, Joshua and Kaia. From the Fryer to the Fuel Tank. 2nd Edition. GreenTeach Publishing. Sarasota, FL. 1999.

"Tier 2 Testing of Biodiesel Exhaust Emissions: Final Report." Report for National Biodiesel Board. Lovelace Respiratory Research Institute (LRRI). May 22, 2000. Accessed April 3, 2003. www.biodiesel.org/resources/reportsdatabase/

Tiffany, Douglas G. "Biodiesel: A Policy Choice for Minnesota." Staff Paper P01-4. Department of Applied Economics. University of Minnesota. May 2001. Accessed February 7, 2003. www.biodiesel.org/resources/reportsdatabase/reports/gen/gen-324.pdf

Tiffany, Douglas G. "Points of Disagreement and Agreement on Minnesota's Biodiesel Mandate: A Review of C. Ford Runge's 'Taking From Many, Giving to Few.' " March 11, 2002.

Tiffany, Douglas G. "Biodiesel: A Policy Choice for Consumers." Presentation. University of Minnesota. November 30, 2001. www.misa.umn.edu/programs/BiodieSOY1130.ppt

Tyson, K. Shaine. National Renewable Energy Laboratory (NREL). Personal interview. March 10, 2002.

Tyson, K. Shaine. "Brown Grease Feedstocks for Biodiesel". Presentation. National Renewable Energy Laboratory (NREL). June 19, 2002. Accessed March 11, 2003. www.nrbp.org/pdfs/pub32.pdf

Tyson, K. Shaine. "RE: Tonnes/gallon." E-mail to the author. April 8, 2003.

"US Interest in Biodiesel Growing." New York Times. May 16, 2002. Accessed February 4, 2003. www.evworld.com/databases/shownews.cfm?pageid=news160502-01

"Uses for Methyl Esters, Glycerol." Memo to All Interested Parties. National Biodiesel Board. Accessed April 5, 2003. www.biodiesel.org/resources/reportsdatabase/reports/gen/gen-051.pdf

Van Gerpen, Jon H. "Biodiesel Blend Sensing." Biodiesel Research & Brainstorming Workshop. New Orleans, LA. January 29-30, 2003. Presentation.

VanWechel, Tamara, Cole R. Gustafson, and F. Larry Leistritz. Economic Feasibility of Biodiesel Production in North Dakota. November 2002. Accessed May 13, 2003. agecon.lib.umn.edu/cgi-bin/pdf_view.pl?paperid=8777&ftype=.pdf

"Veneman Announces Bioenergy Program Changes and Sign-up." US Department of Agriculture. Office of Communications News Room 460-A. Washington, DC. Release No. 0146.03 May 7, 2003.

"Weekly Retail On-Highway Diesel Prices." US Department of Energy. Energy Information Administration. Midwest (PADD II). Accessed May 4, 2003. tonto.eia.doe.gov/oog/info/wohdp/diesel.asp

"What are Biodiesel's Advantages?" Mechanical Engineering Department. Iowa State University. Accessed March 12, 2003. www.me.iastate.edu/biodiesel/pages/bio10.html

"What Do You Need to Know?" Mechanical Engineering Department. Iowa State University. Accessed March 12 2003. www.me.iastate.edu/biodiesel/Pages/bio11.html

"What is Biodiesel?" Alternative Fuels Data Center. US Department of Energy. Accessed February 14, 2003. www.afdc.doe.gov/altfuel/bio_general.html

"What is Biodiesel?" Mechanical Engineering Department. Iowa State University. Accessed March 12, 2003. www.me.iastate.edu/biodiesel/Pages/bio1.html

"What is IMPLAN?" Minnesota IMPLAN Group. Accessed May 13, 2003. www.implan.com/about_us/what_is_implan.htm

"Whitman Announces New Partnership to Reduce Children's Exposure to Emissions from Diesel School Buses." US Environmental Protection Agency. 7 Apr 2003. Accessed May 1, 2003. www.epa.gov/newsroom/headline2_040703.htm

"Who Are We?" National Biodiesel Board. Accessed April 24, 2003. www.biodiesel.org/aboutnbb/whoarewe/

Williamson, Dave. "Biodiesel in Berkeley." Earth Island Journal. 10410406. Summer 2002. Vol. 17, Issue 2. Accessed February 15, 2003. www.ebsco.com

Wiltsee, G. "Urban Waste Grease Resource Assessment." National Renewable Energy Laboratory. Accessed March 11, 2003. www.ott.doe.gov/biofuels/pdfs/urban_waste.pdf

Ye, Su. "Supply and Demand of Soybeans as A Feedstock for Soy Diesel." Minnesota Department of Agriculture. Agricultural Marketing and Development Division. June 2000.

"Your State's Share: Attributing Federal Highway Revenues to Each State." US Department of Transportation. Federal Highway Administration. Accessed May 24, 2003. www.fhwa.dot.gov/ohim/attrib.htm

Blank for duplication.

Appendix A. Definitions for Biodiesel

The following section includes references that are either directly quoted or indirectly paraphrased from various references within the report.

Aftertreatment device. Engine pollutant emissions are generally reduced by engine modifications, fuel specifications or exhaust gas aftertreatment. An aftertreatment device is a component used to reduce engine pollutant emissions downstream of the combustion chamber. Catalytic converters and particulate traps are examples of aftertreatment devices.

Alternative fuel. As defined in the EPAct, methanol, denatured ethanol and other alcohols, separately or in mixtures of 85 percent by volume of more (but not less than 70 percent as determined by DOE rule) with gasoline or other fuels, CNG, LNG, LPG, hydrogen, "coal-derived liquid fuels," fuels "other than alcohols" derived from "biological materials," electricity or any other fuel determined to be "substantially not petroleum" and yielding "substantial energy security benefits and substantial environmental benefits."

Aromatic. A chemical that has a benzene ring in its molecular structure (benzene, toluene, xylene). Aromatic compounds have strong, characteristic odors.

Attainment area. A geographic area in which levels of a criteria air pollutant meet the health-based primary standard (national ambient air quality standard, or NAAQS) for the pollutant. An area may have on acceptable level for one criteria air pollutant, but may have unacceptable levels for others. Thus, an area could be both attainment and nonattainment at the same time. Attainment areas are defined using federal pollutant limits set by EPA.

Biodiesel. A biodegradable transportation fuel for use in diesel engines that is produced through transesterification of organically derived oils or fats. Technically it is a mono alkyl ester of long chain fatty acids derived from renewable lipid feed stocks, such as vegetable oils or animal fats, for use in compression ignition (diesel) engines. Biodiesel is the generic term for the fuel regardless of the feedstock from which it is produced. It may be used either as a replacement for or as a component of diesel fuel and meets American Society For Testing and Materials Specification D6751-02 for Biodiesel Fuel (B100) Blend Stock for Distillate Fuels. Also known as soydiesel, methyl soyate, or soy methyl esters.

B20. A mixture of 20 percent biodiesel and 80 percent petroleum diesel based on volume.

Biomass. An energy resource derived from organic matter. These include wood, agricultural waste and other living-cell material that can be burned to produce heat energy. They also include algae, sewage and other organic substances that may be used to make energy through chemical processes.

Catalytic converter. A catalytic converter consists of a metal housing filled with a hard material which is covered with a catalytic compound. The presence of the catalytic converter in the engine exhaust system breaks down the chemicals in the exhaust and reduces harmful pollutant emissions.

Catalyst. A substance that increases the rate of a chemical reaction, without being consumed or produced by the reaction. Enzymes are catalysts for many biochemical reactions.

Cetane number. an indication of a fuels readiness to autoignite after it has been injected into the diesel engine.

Clean Air Act. The original Clean Air Act was passed in 1963, but the national air pollution control program is actually based on the 1970 version of the law. The 1990 Clean Air Act Amendments are the most far-reaching revisions of the 1970 law.

Cloud Point. A temperature, determined by ASTM test D2500, at which the fuel's visual appearance becomes cloudy. It denotes that temperature when wax crystals come out of liquid solution and behaves as a solid material – potentially clogging filters.

Criteria air pollutants. a group of common air pollutants regulated by EPA on the basis of criteria (information on health and/or environmental effects of pollution). (source: EPA www.epa.gov/oar/oaqps/peg_caa/pegcaain.html)

Ozone (ground-level ozone is the principal component of smog)

- Ozone (O3) is a photochemical oxidant and the major component of smog. While O3 in the upper atmosphere shields the earth from harmful ultraviolet radiation that comes from the sun, high concentrations of O3 at ground level are a major health and environmental concern. O3 is not emitted directly into the air but is formed through complex chemical reactions between emissions of volatile organic compounds (VOC) and oxides of nitrogen (NOx) in the presence of sunlight. These reactions are stimulated by sunlight and temperature so that peak O3 levels occur typically during the warmer times of the year. Both VOCs and NOx are emitted by transportation and industrial sources such as autos, chemical manufacturing, dry cleaners and paint shops.
- Source - chemical reaction of pollutants; VOCs and NOx
- Health Effects - breathing problems, reduced lung function, asthma, irritates eyes, stuffy nose, reduced resistance to colds and other infections, may speed up aging of lung tissue
- Environmental Effects - ozone can damage plants and trees; smog can cause reduced visibility
- Property Damage - Damages rubber, fabrics, etc.

Nitrogen Dioxide (One of the NOx); smog-forming chemical

- Oxides of nitrogen (NOx) are a family of reactive gaseous compounds that contribute to air pollution in both urban and rural environments. NOx emissions are produced during the combustion of fuels at high temperatures. The primary sources of atmospheric NOx include highway sources (such as light-duty and heavy-duty vehicles), nonroad sources (such as construction and agricultural equipment, and locomotives) and stationary sources (such as power plants and industrial boilers).

- Source - burning of gasoline, natural gas, coal, oil etc. Cars are an important source of NO2.
- Health Effects - lung damage, illnesses of breathing passages and lungs (respiratory system)
- Environmental Effects - nitrogen dioxide is an ingredient of acid rain (acid aerosols), which can damage trees and lakes. Acid aerosols can reduce visibility. Nitrogen oxides in general are an important precursor both to ozone and acid rain, and may affect both terrestrial and aquatic ecosystems.
- Property Damage - acid aerosols can eat away stone used on buildings, statues, monuments, etc.

Carbon Monoxide (CO)

- CO is a colorless, odorless and poisonous gas produced by the burning of fuels. Automobiles are the primary source of CO pollution.
- Source - burning of gasoline, natural gas, coal, oil etc.
- Health Effects - reduces ability of blood to bring oxygen to body cells and tissues; cells and tissues need oxygen to work. Carbon monoxide may be particularly hazardous to people who have heart or circulatory (blood vessel) problems and people who have damaged lungs or breathing passages

Particulate Matter (PM-10);

- Particulate matter includes dust, dirt, soot, smoke and liquid droplets directly emitted into the air by sources such as factories, power plants, cars, engines, construction activity, fires and natural windblown dust. Particles formed in the atmosphere by condensation or the transformation of emitted gases are also considered particulate matter.
- Source - burning of wood, diesel and other fuels; industrial plants; agriculture (plowing, burning off fields); unpaved roads
- Health Effects - nose and throat irritation, lung damage, bronchitis, early death
- Environmental Effects - particulates are the main source of haze that reduces visibility
- Property Damage - ashes, soots, smokes and dusts can dirty and discolor structures and other property, including clothes and furniture

Sulfur Dioxide

- Source - burning of coal and oil, especially high-sulfur coal from the Eastern United States; industrial processes (paper, metals)
- Health Effects - breathing problems, may cause permanent damage to lungs
- Environmental Effects - SO2 is an ingredient in acid rain (acid aerosols), which can damage trees and lakes. Acid aerosols can also reduce visibility.
- Property Damage - acid aerosols can eat away stone used in buildings, statues, monuments, etc.

Diesel engine. An engine that operates on diesel fuel and principally relies on compression-ignition for engine operation. The non-use of a throttle during normal operation is indicative of a diesel engine.

EPAct. Congress passed the Energy Policy Act of 1992, or EPAct, to reduce the nation's dependence on imported petroleum. EPAct requires certain federally regulated fleets to purchase alternatively fueled vehicles. The Department of Energy administers the program.

Flashpoint. The flash point is the lowest temperature at which a combustible mixture can be formed in the vapors above the liquid fuel.

Fuel Segments. Consumers of distillate fuel, as defined by the US Department of Energy are:

> **Residential.** An energy-consuming sector that consists of living quarters for private households. Common uses of energy associated with this sector include space heating, water heating, air conditioning, lighting, refrigeration, cooking, and running a variety of other appliances. Sales to farmhouses are reported under "Farm" and sales to apartment buildings are reported under " Commercial."
>
> **Commercial.** An energy-consuming sector that consists of service-providing facilities and equipment of nonmanufacturing businesses; Federal, State, and local governments; and other private and public organizations, such as religious, social, or fraternal groups. The commercial sector includes institutional living quarters. Common uses of energy associated with this sector include space heating, water heating, air conditioning, lighting, refrigeration, cooking and running a wide variety of other equipment.
>
> **Industrial.** An energy-consuming sector that consists of all facilities and equipment used for producing, processing, or assembling goods. The industrial sector encompasses the following types of activity: manufacturing and mining. Overall energy use in this sector is largely for process heat and cooling and powering machinery, with lesser amounts used for facility heating, air conditioning, and lighting. Fossil fuels are also used as raw material inputs to manufactured products.
>
> **OilCompany.** An energy-consuming sector that consists of drilling companies, pipelines or other related oil companies not engaged in the selling of petroleum products. Includes fuel oil that was purchased or produced and used by company facilities for operation of drilling equipment, other field or refinery operations, and space heating at petroleum refineries, pipeline companies, and oil-drilling companies. Sales to other oil companies for field use are included, but sales for use as refinery charging stocks are excluded.
>
> **Farm.** An energy-consuming sector that consists of establishments where the primary activity is growing crops and/or raising animals. Energy use by all facilities and equipment at these establishments is included, whether or not it is directly associated with growing crops and/or raising animals. Common types of energy-using equipment include tractors, irrigation pumps, crop dryers, smudge pots, and milking

machines. Facility energy use encompasses all structures at the establishment, including the farm house.

Electric Power. An energy-consuming sector that consists of electricity only and combined heat and power(CHP) plants whose primary business is to sell electricity, or electricity and heat, to the public--i.e., NAICS 22 plants. Volumes directly imported and used by the electric power companies are included.

Railroad. An energy-consuming sector that consists of all railroads for any use, including that used for heating buildings operated by railroads.

Vessel Bunkering. An energy-consuming sector that consists of commercial or private boats such as pleasure craft, fishing boats, tugboats, an ocean-going vessels, including vessels operated by oil companies. Excluded are volumes sold to the US Armed Forces.

On-Highway Diesel. An energy-consuming sector that consists of motor vehicles: automobiles, trucks, and buses. Vehicles used in the marketing an distribution of petroleum products is also included.

Military. An energy-consuming sector that consists of the US Armed Forces, Defense Energy Support Center (DESC), and all branches of the Department of Defense(DOD).

Off-Highway. An energy-consuming sector that consists of:

1. **Construction.** An energy-consuming sub sector that consist of all facilities and equipment including earthmoving equipment, cranes, generators, air compressors, etc.

2. **Other.** An energy-consuming sub sector that consists of all off-highway uses other that construction.

Includes logging, scrape and junk yards, and refrigeration units on trucks.

All Other Uses. Sales for all other energy-consuming sectors not included elsewhere.

Glycerin. ($C_3H_8O_3$) A liquid by-product of biodiesel production. Glycerin is used in the manufacture of dynamite, cosmetics, liquid soaps, inks, and lubricants.

Lipid sources. Generic chemical term for naturally occurring oils or fats like soybean oil or beef tallow.

Low sulfur fuel. Current EPA regulations specify that diesel test fuel contain 300 - 500 ppm sulfur for highway engines and 300 - 4000 ppm sulfur for nonroad engines. Significant reductions from these current sulfur levels are necessary in order for many retrofit technologies to provide meaningful, lasting emissions reductions. The manufacturers of these retrofit technologies will specify the maximum allowable sulfur level for effective operation of its products. In addition to enabling a wide array of emissions control technologies, the use of low sulfur alone reduces emissions of particulate matter. Sulfate, a major constituent of particulate matter, is produced as a byproduct of burning diesel fuel containing sulfur. Reducing the sulfur content of fuel in turn reduces sulfate byproducts of combustion and therefore particulate matter emissions. The retrofit program will verify particulate matter reductions from the use of low sulfur alone. For the purposes of the diesel retrofit program diesel fuel must contain less than 50 ppm sulfur to be considered a low sulfur fuel.

Lubricity. The property of a lubricant that causes a difference in friction under conditions of boundary lubrication when all the known factors except the lubricant itself are the same. The lower the friction the higher the lubricity.

Methyl Esters. Chemical term for Biodiesel made from menthol and vegetable oils for animal fats.

National Ambient Air Quality Standards (NAAQS). The Clean Air Act, which was last amended in 1990, requires EPA to set National Ambient Air Quality Standards for pollutants considered harmful to public health and the environment. The Clean Air Act established two types of national air quality standards. Primary standards set limits to protect public health, including the health of "sensitive" populations such as asthmatics, children, and the elderly. Secondary standards set limits to protect public welfare, including protection against decreased visibility, damage to animals, crops, vegetation, and buildings.

Nonattainment area. a geographic area in which the level of a pollutant is higher than the level allowed by the federal standards. A single geographic area may have acceptable levels of one criteria air pollutant but unacceptable levels of one or more other criteria air pollutants; thus, an area can be both attainment and nonattainment at the same time. It has been estimated that 60% of Americans live in nonattainment areas.

Non-renewable resource. A non-renewable energy resource is one that cannot be replaced as it is used. Although fossil fuels, like coal and oil, are in fact fossilized biomass resources, they form at such a slow rate that, in practice, they are non-renewable.

Oxygenate. An oxygenate is a compound which contains oxygen in its molecular structure. Ethanol and biodiesel act as oxygenates when they are blended with conventional fuels. Oxygenated fuel improves combustion efficiency and reduces tailpipe emissions of CO.

Renewable energy resource. An energy resource that can be replaced as it is used. Renewable energy resources include solar, wind, geothermal, hydro and biomass.

Stability. A fuel is considered unstable when it undergoes chemical changes that produce undesirable consequences such as deposits, acidity, or a bad smell. There are three different types of stability commonly described in the technical literature: thermal stability, oxidative stability, and storage stability.

Transesterification. A chemical process which reacts an alcohol with the triglycerides contained in vegetable oils and animal fats to produce biodiesel and glycerin.

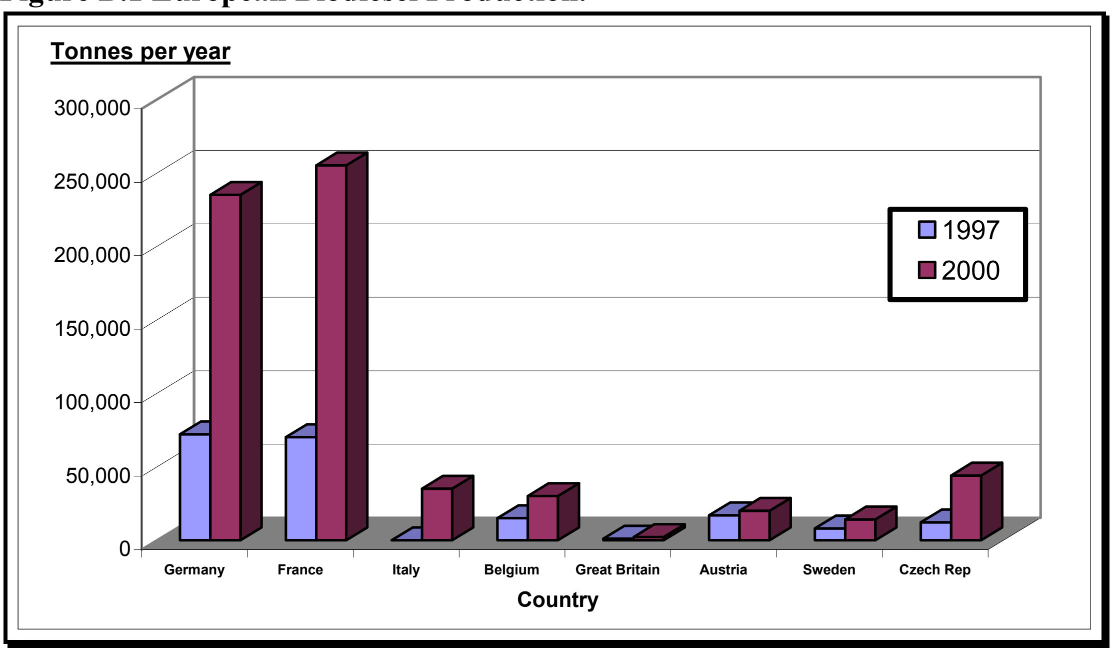
Yellow grease. Trade name commonly used for oils and fats processed from waste cooking grease, primarily comprised of used restaurant frying oils. It is primarily used as an added fat source in animal feeds, as a feedstock for industrial fatty acids or as a dilution for higher grade inedible products.

Blank for duplication.

Appendix B. Review of International Supply and Demand of Biodiesel

The biodiesel industry has grown throughout the world partially as a result of the range of feedstocks available for production and the desire many countries have for a substitute to petroleum diesel. Outside of the United States, several other countries have been relying on biodiesel for a larger portion of their transportation energy needs. A geographic breakdown by 1999 revealed that Europe maintained 74 production plants, the US had seven biodiesel plants, Japan had two operating plants, and both Nicaragua and Malaysia sustained one biodiesel plant each.[1] At the same time biodiesel related research had been conducted in no less than 28 countries. Biodiesel production was occurring in a total of 21 nations, with the greatest concentration of plants on the European continent. Because the industry developed earlier than its US counterpart, total production of biodiesel within Europe greatly exceeds current US production. Ralph Groschen estimated that France's output alone of 250,000 metric tons in 2000 would equate to about 62 million gallons of biodiesel production.[2] In comparison, the US production in 2002 was only at about 25 million gallons of biodiesel. Figure B1 illustrates the growth in production that occurred in several European countries using output data from 1997 and 2000.[3, 4]

Figure B.1 European Biodiesel Production.



Source: "The Feasibility of Biodiesel from Waste/Recycled Greases and Animal Fats."

[1] Tickell, Joshua and Kaia. From the Fryer to the Fuel Tank.
[2] Groschen, Ralph. "Overview of: The Feasibility of Biodiesel from Waste/Recycled Greases and Animal Fats."
[3] "Biodiesel Producers in Europe 2000." Oelmühle Leer Connemann GmbH & Co.
[4] Oelmühle Leer Connemann GmbH & Co. "Biodiesel Producers in Europe 2000."

With several European countries adding biodiesel production, the capacity within the European Union (EU) has "increased by a factor of four to a total of 2 million tonnes" (about 600 million gallons) in the past five years. Germany, for example, had 19 biodiesel production plants in operation in 2003 with an additional five under construction. Out of the country's 13 largest capacity plants, only one began production prior to mid-1999. The industry throughout Germany is evolving towards production in larger capacity plants as new construction at more sites continues. Demand has outpaced supply in several European countries as the industry continues to add production plants.[5] The primary feedstock for European biodiesel production has been rapeseed oil.[6]

Although several European countries have realized considerable growth in biodiesel production over the past decade, individual countries have adopted different strategies to market and promote the fuel. In Germany and Austria, biodiesel is typically marketed in its pure form (B100) while other countries tend to supply the fuel as an additive to diesel. With regards to tax policies for the industry, in France and Italy the "produced quantity in the state countries is tied to quantitative contingents which are determined annually by the respective parliaments." [4] In comparison, Germany has no such limitations which may promote more production capacity growth within the country. The EU has also set minimum target quantities for the growth of biofuels to increase the share of the renewable fuels within the market to 2 percent by 2005 and 5.75 percent by 2010. It has also been recognized by some writers however that the availability of raw materials and production facilities may limit the amount of diesel fuel that can be replaced by biodiesel.[7]

One rationale for the dramatic increase in European production is that the total consumer cost of substituting biodiesel for diesel within European countries is much lower than in the US. In 2000 diesel prices including taxes ranged from $1.86 per gallon in Portugal to $4.27 per gallon in the United Kingdom. Taxes contribute to a more significant portion of the pump price for fuel in many European nations than in the US.[8]

Taxes for biodiesel have been reduced over the past decade in several of the European nations that have witnessed increased production. The result is that the cost of the fuel decreases to a level where more consumers are willing to purchase it. In the United Kingdom for example, the duty for biodiesel has been lowered from the diesel fuel tax level by a US equivalent of about 30 cents per liter, or roughly $1.14 per gallon.[9] [10] Due to the higher fuel tax levels and subsidies in some of the European countries, biodiesel pump prices for consumers have become comparable to regular diesel fuel. Also, with a strong emphasis on the environment in Europe, the demand for biodiesel has been supported by many of the region's governments, consumers, and retailers.

[5] Bockey, D. and W. Korbitz. "Situation and Development Potential for the Production of Biodiesel."
[6] Faye, Zenneth. "Canola Biodiesel."
[7] Bockey, D. and W. Korbitz. "Situation and Development Potential for the Production of Biodiesel."
[8] Groschen, Ralph. "Overview of: The Feasibility of Biodiesel from Waste/Recycled Greases and Animal Fats."
[9] Conversion used: 3.785 liters = 1 gallon.
[10] Caparella, Tina. "Distributors Not Choosy About Biodiesel."

Appendix C. IMPLAN Methodology

Because of concerns with the reliability of inputs for the agricultural sector in IMPLAN, the output for "Oil Bearing Crops" and "Feed Grains" was adjusted to $250,000 per worker in order to reflect benchmarks for production operations.[11 ,12] The output per worker within the Soybean Oil Mills sector was also adjusted to reflect $2,130,775 of revenue per worker.[13] Within the Soybean Oil Mill sector, the original demand for soybeans (Oil Bearing Crops) was set at 47 percent of the input costs for production. In order to adjust the function to correspond with soybean processing results in the spreadsheet analysis, the demand for "Miscellaneous Oil Crops" was transferred into the "Oil Bearing Crop" category and the production function for that category was set at 83 percent of total inputs.

The industry data for the Organic Chemical sector, under which ethanol production has been classified, was also altered to reflect biodiesel production.[14] The value of feedstocks from the Soybean Oil Mill sector was adjusted to compose 63.9 percent of the production costs. This value compared with the results of the spreadsheet analysis and also was in the range for the costs of feedstock as a percentage of total operating costs from the University of Tennessee's biodiesel feasibility study.[15] The input costs for organic chemicals were also increased to 5 percent of the production costs to reflect the costs of methanol for producing biodiesel. The remaining industry costs were balanced across the selected IMPLAN inputs. The value added component within IMPLAN was adjusted to 10 percent for biodiesel production which is slightly higher than the 7.43 percent within the Soybean Oil Mill sector. The output per worker and wages were also changed to be comparable to the soybean processing industry inputs.[16] With the projected plant creating 21 direct jobs under Scenario 1, the output per worker emulated the economies of scale ratio noted for biodiesel production between the respective 5 million and 15 million gallon plants in the North Dakota State University and University of Georgia feasibility studies.[17, 18] Finally, the outputs for the biodiesel production were adjusted and balanced to reflect that 98 percent of the outputs from the plant would be in the Organic Chemical sector, which includs biodiesel and glycerin.

For the purposes of this project, the Regional Purchase Coefficient (RPC) for the Soybean Oil Mill sector was adjusted to force the industry to acquire all of its "Oil Bearing Crop" inputs within Indiana. The RPC for the biodiesel industry was similarly altered in order to compel the industry to demand all of its oil feedstocks from in-state.

---

[11] Boehlje, Michael. "Agricultural Finance."
[12] "How is Agricultural Data Being Created?" Minnesota IMPLAN Group.
[13] Soybean Processing. 1997 Economic Census.
[14] Standard Industrial Classification (SIC) System Search. US Department of Labor.
[15] Economic Feasibility of Producing Biodiesel in Tennessee. Agri-Industry Modeling & Analysis Group et. al.
[16] The labor costs also were similar to the ranges in terms of percent of total operating costs when compared with the ND, TN, and GA feasibility studies.
[17] VanWechel, Tamara, Cole R. Gustafson, and F. Larry Leistritz. Economic Feasibility of Biodiesel Production in North Dakota.
[18] Shumaker, George A., et al. A Study on the Feasibility of Biodiesel Production in Georgia.

Due to supply restrictions within the model, the state's "Oil Bearing Crop" exports also had to be adjusted downward by about $154 million to allow the RPC within the Soybean Oil Mill sector to be adjusted to 100 percent.

Appendix D. Partial Equilibrium Analysis

Biodiesel Partial Equilibrium Analysis

5/30/2003

	Input Parameter	Scenario #1 B2 Mandate	Scenario #2 Tax Credit (B2 = Diesel)	Scenario #3 Mandate & HB1001
Sales of Distillate Fuel Oil by Energy Use				
2001 Indiana (Gallons)				
Commercial	5%	66,861,000	66,861,000	66,861,000
Industrial	10%	132,463,000	132,463,000	132,463,000
Farm	7%	89,962,000	89,962,000	89,962,000
Railroad	2%	24,520,000	24,520,000	24,520,000
Marine	1%	19,020,000	19,020,000	19,020,000
Off-Highway	3%	42,016,000	42,016,000	42,016,000
On-Highway	72%	976,154,000	976,154,000	976,154,000
Truck (Percent of On-Highway)	69%	673,546,260	673,546,260	673,546,260
Bus (Percent of On-Highway)	2%	14,642,310	14,642,310	14,642,310
Car and Light Truck (Percent of On-Highway)	30%	287,965,430	287,965,430	287,965,430
Total Gallons	**100%**	**1,350,996,000**	**1,350,996,000**	**1,350,996,000**
Decision: Applies to all of the above		1,350,996,000	1,350,996,000	1,350,996,000
Wholesale Diesel Price Estimated Using Department of Energy May 5, 2003 U.S. Average Retail Price		$0.82	$0.82	$0.82
Distribution	10%	$0.0841	$0.0841	$0.08
Average Price/Gallon for Sales to End Users Excluding Taxes		$0.90	$0.90	$0.90
Indiana Sales Tax (2003 version)		6%	6%	6%
Federal Taxes		$0.24	$0.24	$0.24
Indiana State Tax		$0.16	$0.16	$0.16
Indiana Surcharge Tax (*Assumed for Trucks only but spread across all)	0.11	$0.05	$0.05	$0.05
Estimated Average Indiana Retail Price per Gallon of Diesel to End Users Including Taxes		**$1.4120**	**$1.4120**	**$1.4120**
Estimated Wholesale Cost of Biodiesel using Biodiesel/Diesel Price Rat	1.59	$1.65	$1.65	$1.65
Blend		2%	2%	2%
Incremental Cost for Blending Biodiesel		$0.0149974	$0.0150041	$0.0149983
New Wholesale Price		$0.83	$0.83	$0.83
Distribution		$0.08	$0.08	$0.08
Average Price		$0.91	$0.91	$0.91
Plus: Sales Taxes		$0.05	$0.05	$0.05
Plus: Indiana State Tax		$0.16	$0.16	$0.16
Plus: Indiana Surcharge Tax		$0.05	$0.05	$0.05
Plus: Federal Tax		$0.24	$0.24	$0.24
Biodiesel Fuel Tax Credit (*Assumes full pass through to consumers)	per gallon of B2	$0.00	**$0.01590**	**$0.00223**
Total Price for B2 Fuel		$1.4279	$1.4120	$1.4256
Actual Change in Retail Fuel Price after Tax Credit/Subsidies		$0.0159	$0.00	$0.0137
Percent Change from Retail Price of Diesel Fuel (Including Tax)		1.13%	0.00%	0.97%
Price Elasticities for Diesel (Long-Run)				
Commercial	-0.76	(572,112)	-	(491,839)
Industrial	-0.76	(1,133,452)	-	(974,417)
Farm	-0.54	(546,950)	-	(470,208)
Railroad	-0.37	(102,145)	-	(87,813)
Marine	-0.27	(57,819)	-	(49,706)
Off-Highway	-0.54	(255,449)	-	(219,607)
On-Highway				
Truck	-0.54	(4,095,021)	-	(3,520,448)
Bus	-0.48	(79,131)	-	(68,028)
Car and Light Truck	-0.27	(875,385)	-	(752,560)
Total Reduction in Fuel Demand		(7,717,463)	-	(6,634,626)
Percent Reduction in Fuel Demand		-0.57%	0.00%	-0.49%
New Demand				
Total Demand of Biodiesel for B2 blend		1,343,278,537	1,350,996,000	1,344,361,374
Total Demand for Pure Biodiesel		26,865,571	27,019,920	26,887,227
Pounds of feedstock required	7.35	197,461,945	198,596,412	197,621,122
Bushels of Soybeans Required to Meet Feedstock Demands	11	17,951,086	18,054,219	17,965,557

Impact Summary

Biodiesel Sector				
Old Price		0	0	0
Price Change		$1.65	$1.65	$1.65
Original Volume		0	0	0
New additional Volume		26,865,571	27,019,920	26,887,227
Total New Revenue		$44,302,605	$44,566,264	$44,339,593
Soy Oil Sector (Soybean Model from USB)				
Old Price (Cents per lb.)		14.33	14.33	14.33
New Price (Cents per lb.)		15.13	15.14	15.13
Price Change		0.803369	0.807966	0.804014
Original Volume (1,000,000 lbs)		17,024	17,024	17,024
New Volume (1,000,000 lbs)		17,221	17,222	17,221
New additional Volume		197.461905	198.596369	197.621122
Total Old Revenue		2,438,998,116	2,438,998,116	2,438,998,116
Total New Revenue		2,605,638,212	2,606,601,652	2,605,773,422
Additional New Revenue		166,640,096	167,603,536	166,775,307
Indiana New Revenue from Soy Diesel Purchases	1.0000	29,876,817	30,057,597	29,902,182
Indiana New Revenue from Price Increase	**0.0729**	9,970,043	10,027,099	9,978,051
Indiana Total New Revenue		39,846,860	40,084,696	39,880,233
% Increase in Total Soyoil Demand		0.011599218	0.011665858	0.01160857
Increased Expenses for Soyoil		1,586,347	1,604,592	1,588,901
Extra $/gallon added to Soy Diesel cost		0.059047596	0.05938551	0.059095021
Soy Meal Sector (Soybean Model from USB)				
Old Price ($/ton)		162.4265574	162.4265574	162.4265574
New Price ($/ton)		160.372796	160.3610417	160.3711463
Price Change (Soybean Model from USB and AEC)		-2.05	-2.07	-2.06
Original Volume (1,000 tons)		32,407	32,407	32,407
New Volume (1,000 tons)		32,481	32,481	32,481
New additional Volume		74	75	75
Total Old Revenue		5,263,684,748	5,263,684,748	5,263,684,748
Total New Revenue		5,209,076,481	5,208,763,199	5,209,032,513
Additional New Revenue		(54,608,267)	(54,921,549)	(54,652,235)
Indiana New Revenue from Soy Diesel Purchases	1.00	11,947,061	12,014,695	11,956,554
Indiana New Revenue from Price Increase	**0.0729**	(4,851,883)	(4,879,652)	(4,855,781)
Indiana Total New Revenue		7,095,178	7,135,043	7,100,773
Total Soybean Processing (Crushing) Revenue				
Indiana New Crush Revenue from Soy Diesel (Direct)		41,823,878	42,072,292	41,858,736
Indiana New Crush Revenue from Price Increase (Indirect)		5,118,160	5,147,447	5,122,270
Indiana Total New Crush Revenue		46,942,038	47,219,738	46,981,006
Soybean Sector (Prices and Production from SoyVCA)				
Old Price		4.57	4.57	4.57
New Price		4.60	4.60	4.60
Price Change (Soybean Model from USB and AEC)		0.04	0.04	0.04
Original Acres Planted		73.18	73.18	73.18
New Acres Planted		73.37	73.37	73.37
Additional Acres Planted		0.19	0.19	0.19
Assumed Yield per Acre		38.6	38.6	38.6
Original Volume (Soybean Model from USB and AEC)		2,822,810,129	2,822,810,129	2,822,810,129
New Volume		2,830,119,903	2,830,161,863	2,830,125,792
New additional Volume		7,309,774	7,351,734	7,315,663
Total Old Revenue		12,886,510,777	12,886,510,777	12,886,510,777
Total New Revenue		$13,026,992,687	$13,027,798,662	$13,027,105,803
Additional New Revenue		$140,481,909	$141,287,885	$140,595,025
Indiana Volume Needed (*Assuming all New Volume obtained within state)	**1**	7,309,774	7,351,734	7,315,663
Indiana Trend Estimate Yield (USDA - NASS)		45	45	45
Indiana Acres Required		162,439	163,372	162,570
Indiana New Revenue from Soy Diesel Pruchases		$33,646,762	$33,841,495	$33,674,091
Indiana New Revenue from Price Increase	**0.095**	$10,149,339	$10,207,407	$10,157,489
Indiana Total New Revenue		$43,796,101	$44,048,902	$43,831,580
New Additional Soybean Processing (Crushing) Margin		$5,506,994	$5,545,402	$5,512,379

Soybean Net Revenue				
Change in Revenue from Market		$43,796,101	$44,048,902	$43,831,580
Change in Revenue from Government		(9,873,639)	(9,930,275)	(9,881,588)
Net Change in Revenue for Farmer		33,922,462	34,118,626	33,949,992
Costs of Production	**78**	12,725,504	12,798,552	12,735,756
Net Revenue to Soybeans		21,196,958	21,320,075	21,214,236
Corn Net Revenue				
Acres		(162,439.42)	(163,371.86)	(162,570.28)
Yield		141.00	141.00	141.00
Price		1.98	1.98	1.98
Revenue Loss		(45,349,836.99)	(45,610,156.45)	(45,386,371.79)
Costs of Production	**152**	(24,690,791.68)	(24,832,523.04)	(24,710,683.11)
Net Loss		(20,659,045.30)	(20,777,633.42)	(20,675,688.67)
Gain or Loss to Ag Production Sector		$537,913	$542,441	$538,547
Gain or Loss to Soydiesel Sector		$14,425,788	$14,508,668	$14,437,411
Profit or Loss to Soybean Processing (Crushing) Sector		$5,506,994	$5,545,402	$5,512,379
Gain or Loss to Ag Inputs Sector		($11,965,288)	($12,033,971)	($11,974,927)
Net Gain or Loss to the entire Sector		$8,505,407	$8,562,539	$8,513,410
Impact on Petroleum Diesel Industry				
Old Amount of Diesel Revenue		$1,101,167,363	$1,101,167,363	$1,101,167,363
New Amount of Diesel Revenue		$1,072,979,487	$1,079,144,016	$1,073,844,432
Net Gain or Loss		($28,187,876)	($22,023,347)	($27,322,931)
Indiana Share of the Loss (Assumes Refining Portion Only)	10.15%	($2,859,788)	($2,234,369)	($2,772,036)
Impact on Distribution Industry				
Old Amount Spent on Diesel Distribution		$113,620,450.67	$113,620,450.67	$113,620,450.67
New Amount Spent on Diesel Distribution		$112,971,402.38	$113,620,450.67	$113,062,470.37
Net Gain or Loss		($649,048)	$0	($557,980)
Impact on Consumers				
Old Amount Spent on Diesel Fuel		$1,896,670,719	$1,907,567,555	$1,898,199,654
New Amount Spent on Diesel Fuel		$1,918,025,093	$1,907,567,555	$1,916,572,595
Net Gain or Loss		($21,354,374)	$0	($18,372,940)
Impact on Indiana Government				
Old Tax Revenue		$363,136,717	$363,136,717	$363,136,717
New Tax Revenue		$362,271,064	$363,136,717	$362,383,173
Biodiesel Fuel Tax Credit		$0	($21,486,738)	($3,000,000)
Total Change in Tax Revenue		($865,653)	($21,486,738)	($3,753,544)
Total Taxpayer and Consumer Losses		($22,220,027)	($21,486,738)	($22,126,484)
Net Benefit or Loss from Biodiesel Mandate		($17,223,457)	($15,158,568)	($16,943,090)