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Biodiesel: A Policy Choice for Minnesota

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Introduction

Since the 2001 Legislative Session began, Minnesotans have had numerous opportunities to read and hear about biodiesel in print and electronic media. They are likely to hear more. On this topic people generally ask two questions, "1) Just what is biodiesel? 2) Why is it being so hotly debated at the Minnesota Legislature and in some other farm states?" This paper has been written to give you more information about this debate. The first question can be quickly answered. Biodiesel is defined as a variety of ester-based oxygenated fuels made from vegetable oils (such as soybean oil, rapeseed oil, sunflower oil, etc) or animal fats. Its manufacture and production economics will be discussed in more detail in later sections of this paper.

Two bills before the Minnesota Legislative bodies in 2001, H.F. 362 and its companion, S.F. 326, propose that biodiesel **derived from vegetable sources** be blended into diesel fuel supplies of the state at a 2% rate. In their original state, the bills identified an implementation date of July 1, 2002 for this measure. In addition, the bills would mandate the blending of biodiesel at the 5% rate after July 1, 2006. Diesel fuel for all diesel engines, whether used on-road or off-road would be affected; however, jet fuel and aviation fuel would be excused from this requirement.

Current estimates identify approximately 800 million gallons of diesel fuel used per year in Minnesota with approximately 550 million gallons used on roads and 250 million used off-road.[1] To achieve the 2% blend would require the blending of 16 million gallons of neat (100%) biodiesel in 2002 for use in all diesel-powered engines. Starting in 2006, 40 million gallons of neat biodiesel would be needed annually to achieve the 5% blend level. Current national production of biodiesel is estimated at 30 million gallons per year.[2] A lively debate has occurred over these bills and their effects, if enacted. Truckers, airlines, railroads, pipelines, and oil refineries have criticized the bills, citing a variety of reasons such as concerns about cold weather performance and costs, while farmers growing oilseeds, oilseed processors, both private and farmer-owned have supported the bills, noting the increasingly competitive price to produce biodiesel and its attributes of reduced emissions, reduced greenhouse gases, reduced engine wear, reduced dependence on foreign oil, enhanced local processing of Minnesota-grown crops, and benefits to the overall U.S. economy. Whatever fate befalls the proposals that started the 2001 Legislative Session mandating the inclusion of biodiesel in Minnesota fuel supplies, this issue is likely to return to the public eye in the course of farm and energy policy discussions in this state and others. Discussions of biodiesel touch on the science of fuels and combustion, energy balances, production economics of farm commodities and petroleum products, energy policy, and farm policy. In the pages that follow, I will share some of my research and analysis.

I shall discuss this proposal and its economic dimensions for Minnesota along the following lines:

1) the use of mandates as a policy implementation tool
2) the nature of technological change in engines and fuel attributes
3) the ultra-low sulfur mandate and the role biodiesel may play
4) national incentives encouraging biodiesel production
5) the stability of biodiesel supplies and prices
6) a recent history of Minnesota diesel and gasoline price levels
7) the potential net price effects of biodiesel blends
8) the adequacy of fat and oil supplies for biodiesel and current users
9) the likely economic impacts of this proposal on Minnesota
10) the sustainability of biodiesel production in Minnesota
11) the appropriateness of Minnesota as a site for this proposal
12) conclusions

1) Use of Mandates as a Policy Implementation Tool

Mandates and industry standards that reduce choice confront consumers constantly throughout our economy, and these measures are not always appreciated. As a rule, consumers like to have as many choices in the products and services they buy. However, they also demand adequate testing for product safety, quality, and compatibility when used in conjunction with other associated products. In the area of food, most consumers readily accept the science behind milk enriched with vitamins A and D and bread enriched with iron or folic acid. Some of these inclusions have resulted from government mandates, some have resulted from the development of industry standards, and some inclusions and alterations to products reflect the strategies of sellers to influence consumer choice by offering certain attributes deemed favorable.

With respect to fuel, most people older than thirty remember when all gasoline contained tetra-ethyl lead as an anti-knock agent. The oil and automotive industries recommended the use of lead in our fuel because tests of engine performance and wear convinced them that consumers would appreciate the inclusion of this additive. Adding tetra-ethyl lead to gasoline proved to be a cheap means of raising octane and reducing these engine-performance issues when considering only the costs to the buyer of the fuel. Later, federal mandates, backed by scientific research, called for the removal of lead to prevent toxic effects from that element being released into the environment and also to prevent lead from ruining the catalytic converters being mandated so that engines could more completely burn fuels and reduce other harmful emissions. After concern by the petroleum and automotive industries, this measure was implemented and additives developed by the petroleum industry obviated the former need for lead even in older gasoline engines. Advances in engine design, prompted by federal and state mandates, resulted in the formulation of cleaner-burning gasoline. Later, federal mandates applied in local markets required the inclusion of oxygenates such as ethanol in order to facilitate even cleaner burning of gasoline in automobiles.

Mandates to include oxygenates required some readjustment in the petroleum distribution industry and undoubtedly raised consumer's fuel costs. However, elected officials and government regulators established the standards of the mandate and imposed the cost on all drivers as a means to improve air quality. Society had determined that the increased costs borne by consumers in the costs of their cars and the fuel to be used in their cars were necessary to reduce the human health and environmental consequences of emissions. This is a reasonable policy because consumers of gasoline have difficulty recognizing the contribution of the emissions of their individual vehicles to overall air quality in "the commons." It is possible for consumers to be motivated to buy a certain gasoline based on perceived attributes offering better vehicle performance such as acceleration and reduced engine maintenance costs. Although the benefits of cleaner air are generally accepted by the public, the automobile and petroleum industries did not offer catalytic converters or the fuel to operate them in response to consumer demand. It required the use of government mandates to make these changes to reduce harmful emissions.

Like gasoline, the decisions for diesel fuel attributes are often determined at the refiner or terminal level with buyers not knowing the components or attributes of the fuel they are buying, but merely accepting the products supplied to them in a convenient manner. Refiners and suppliers often perform significant modifications to gasoline and diesel fuel to suit local operating conditions throughout the seasons of the year. End users of the fuel are not consulted about these modifications, but merely accept them.

While there may be higher direct monetary costs associated with mandates, the will of the people as expressed in government mandates is sufficient to serve as a countervailing influence to the market power of large, vertically integrated industries. Because recent business trends in many industries favor vertical integration, market share protection, and as much control over production inputs as possible, it is unlikely, that market forces in the petroleum industry will allow the widespread use of non-petroleum products like ethanol or biodiesel in the absence of a mandate, especially in the case of products whose benefits are society-wide, like improved air quality. Current examples of this situation are the mandates by the U.S. EPA for ultra-low sulfur diesel fuel beginning in 2006 and for diesel engine design and after-treatment devices required in 2007.

2) The Nature of Technological Change in Engines and Fuel Attributes

History records the existence of a continuing dance between engine design and fuel attributes. One could say that co-evolution of both fuels and engine designs has been going on since internal combustion engines have been in use. Notable advances occurred at the time of World War I when pilots sought greater performance from the early fighter planes, which were unable to maintain their performance at varying altitudes and temperature conditions. This deficiency prompted the development and introduction of the additive tetra-ethyl lead into gasoline in order to provide higher performance. After World War I efforts to improve performance occurred with improvements in engine design and manipulation of fuel characteristics, but lead remained an important additive in gasoline for fifty years. It was a path that was cheap for the individual buyer of fuel to improve his engine performance, but it proved costly for society as a whole, with resulting harm to human health and the environment from this toxic substance.

Some of the first practical diesel engines were quite large and were first used primarily in ships because of their simple design, durability, and ability to utilize cheap fuels around the world. Breakthroughs spurred by Charles Kettering and his research team at General Motors allowed diesels to be manufactured in smaller sizes, such as railroad locomotives, generators, bulldozers, industrial equipment, trucks and tractors. [3]

Diesel engines have been popular because of their simplicity, durability, and ability to provide large amounts of usable power. U.S. petroleum-base diesel fuel has generally been slightly cheaper than gasoline, largely due to the desire of U.S. refiners to maximize gasoline output for the domestic market.[4] In the U.S., diesel fuel is considered a less-desired by-product of making higher profit gasoline, since U.S. consumers utilize roughly twice the amount of gasoline (8.38MM barrels per day) as diesel (3.55MM barrels per day).[5] Diesel fuel is composed of hydrocarbon molecules that are arranged in longer chains and that contain more energy than those of gasoline. That is the reason diesel fuel appears thicker and oilier than gasoline. Diesel fuel contains more energy; and diesel engine designs permit higher efficiency in burning and capturing the available energy in the fuel than gasoline and gasoline engines.[6]

The Clean Air Act of 1990 has had an enormous impact on the fuels industry. The US EPA has clamped down on gasoline emissions, requiring cleaner burning gasoline, catalytic converters, stricter emissions regulations on new vehicles, and other preventative maintenance requirements to reduce car emissions. Significant progress has been made with gasoline applications, and now EPA is focusing on diesel applications. For the most part, many of the emissions strategies that are currently employed to reduce emissions from gasoline engines are not currently used with diesel engines. EPA found that in order to use the after-treatment technologies (largely NOx catalysts, particulate traps with catalysts, and exhaust gas re-circulation) that would significantly reduce diesel emissions, the sulfur level in the fuel would need to be significantly reduced.

In 2000 the EPA released its new diesel regulations, which require over 90% reductions in both NOx and particulate matter from diesel engines beginning in the year 2007. These regulations will make conventional diesel engines cleaner burning than current natural gas engines, which are considered ultra-clean. In order to accomplish these dramatic diesel engine emission reductions, EPA, mandated that the sulfur level in on-road diesel fuel be reduced from the current 500 ppm maximum to 15 ppm maximum beginning in 2006. These low sulfur levels are needed because sulfur incapacitates the catalysts used in the after-treatment systems that will be employed to provide most of the 90% reduction in diesel emissions mandated by EPA.[7]

As suggested before, there are **aspects of public gain** from the ultra-low sulfur mandate for diesel fuel, but they are delivered society-wide, are difficult to recognize and appreciate by consumers of diesel. EPA took this action for two reasons: 1) the diesel engine is viewed as an attractive technology option for reducing emissions of gases that contribute to global warming and 2) diesel engines have greater operating efficiency than a gasoline engines. In their ruling, EPA also encouraged retrofits to diesel engines because of "the slow turnover of the diesel fleet to the new low-emitting engines makes it difficult to achieve near-term air quality goals through the new engine program alone."[8] **The benefits of these air quality gains are improved respiratory health of residents and reductions in premature deaths due to lowered emissions from vehicles, in addition to reductions in greenhouse gases.**

There are **three aspects of higher costs** that truckers, farmers, mining companies, railroads, utilities, and others will feel as a consequence of recent EPA regulations on diesel engines and diesel fuel:

1) Diesel fuel will be more expensive due to increased refinery investments and processing expenses in order to remove additional sulfur. The Environmental Protection Agency estimates that the additional cost of producing and distributing diesel fuel meeting the lower sulfur standard of 2006 to be **$.045 to $.05 per gallon** of finished product.[9] The American Petroleum Institute referenced an Energy Department study that identified costs to refiners ranging from $.078 to $.106 per gallon.[10]

2) The diesel engines that will be produced in 2007 with after-treatment technology will cost $1200 to $1900 more than their predecessors, according to EPA, although some industry experts say the costs will be much higher. Whatever the resulting level of costs, they will have to be passed on to their customers.

3) The increased removal of sulfur from diesel fuel also has the unintended consequence of removing other components that provide the lubricating ability of the fuel. This lack of fuel lubricity will result in increased engine wear, repair expense, and downtime. **Lubricity additives will have to be added to this new ultra-low sulfur diesel fuel to provide satisfactory protection for engines and high-pressure fuel injection equipment.** To remedy issues of lowered lubricity in ultra-low sulfur diesel fuel, charges for research and development as well as discrete costs for fuel additives, and efforts to properly blend them will occur. The additives needed to compensate for reduced lubricity in ultra-low sulfur diesel fuel will come at a cost to all diesel operators.

3) The Ultra-Low Sulfur Mandate and the Role Biodiesel May Play

Biodiesel fuel has already demonstrated that it contains virtually no sulfur. Pure biodiesel, or B100, already meets the new sulfur requirements mandated by the U.S. EPA. If the mandated after-treatment technologies for diesel engines were available, B100 could be used in them today in order to reduce harmful emissions. Blending biodiesel with diesel fuel reduces the sulfur content of the blend based on the proportion of biodiesel that is added. As a blending stock, biodiesel may play a role in helping refiners meet future sulfur specifications for particular batches of ultra-low sulfur diesel they may produce.

Biodiesel fuel has also demonstrated excellent lubricity characteristics and the ability to improve lubricity even when blended as low as 2% in conventional diesel fuel.[11]

I conclude that the additional expense of inclusion of biodiesel in Minnesota diesel supplies will help reduce the costs associated with increased engine wear that will result from the federal ultra-low sulfur standards when imposed by the federal government. **In this case, biodiesel becomes a homegrown remedy for the lubricity problems arising from the federal mandate to reduce sulfur in all diesel fuels.** The petroleum industry has conducted research on petroleum-derived lubricity enhancing additives, which could be used to remedy diesel fuel lubricity issues at some additional cost. However, biodiesel blended at the levels identified in these bills may be a superior technical remedy to lowered lubricity in ultra-low sulfur diesel fuel because there would be no risk of under-dosing or overdosing a batch of fuel with biodiesel, a common problem with petroleum-based lubricity additives. Over-dosing diesel fuel supplies with certain petroleum-origin lubricity agents will harm engines.[12] Incidence of this problem may increase in the future with heightened awareness of lubricity concerns.

4) Existing and Proposed Incentives for Biodiesel Production

The Bioenergy Program administered by the USDA's Commodity Credit Corporation encourages the production of ethanol and biodiesel in order to increase utilization of domestically produced crops. The CCC makes payments to bioenergy companies expanding production utilizing U.S. grains and oilseeds and reducing CCC purchases of surplus commodities. For each fiscal year, bioenergy companies have the opportunity to bid for the level of CCC payments necessary to encourage their expansion of bioenergy production. A maximum budget for biofuels has been set for each of the annual rounds of bidding. For the period December 2000 through September 2001 agreements were reached with 42 ethanol and 12 biodiesel producers projected to produce 246.2 million gallons of ethanol and 36.5 million gallons of biodiesel. The biodiesel payments range from $.85 to $1.17 per gallon of proven production and are made on a quarterly basis. For the current bid cycle, which will end in September 2001, the following agreements have been accepted in the following states: [13]

	Plants	Increased Capacity Eligible for Payment
Minnesota	1	10,000,000 gallons
Iowa	2	8,400,000 gallons
Illinois	2	4,053,000 gallons
Indiana	1	4,000,000 gallons
Florida	1	5,200,000 gallons
Kentucky	1	1,400,000 gallons
Nebraska	1	200,000 gallons
Nevada	1	1,400,000 gallons
North Carolina	1	1,400,000 gallons
Tennessee	1	400,000 gallons
Total	12	36,453,000 gallons

In some cases the plants may never be built, so the increased production of biodiesel may not occur. It is common for organizers of biodiesel and ethanol production facilities to seek the bioenergy payments and sign agreements while in the process of raising money for their businesses.

National energy policy, including renewable fuels, has also become a recent focal point. Current initiatives include a proposed National Renewable Standard.[14] If enacted, this measure would require low levels of renewable fuels (ethanol and/or biodiesel) in motor fuels. Nationally, the American Soybean Association (ASA) has also recommended a partial exemption to the diesel fuel excise tax similar to the partial tax exemption for ethanol. The amount of the exemption would be 3 cents for diesel fuel that contains 2 percent biodiesel. The proposal would save taxpayer dollars because ASA is proposing to reimburse the Federal Highway Trust Fund through the U.S. Department of Agriculture's Commodity Credit Corporation (CCC). The cost to the CCC would be offset initially by the savings due to increased biodiesel sales, which would reduce government expenditures under the soybean marketing loan program. If the partial excise tax exemption is enacted, Minnesota on-road users of biodiesel could receive a net price reduction for every gallon of biodiesel blend purchased. (Net price impacts will be discussed in Section 7 with and without the enactment of the proposal to reduce federal diesel excise taxes.)

5) The Stability of Biodiesel Supplies and Prices

Table 1 shows prices of neat (100%) biodiesel derived from feedstock fats and oils over a range of prices and for alternative net processing charges. This table helps identify the likely costs of biodiesel that would be produced by various processes, the most common of which is base catalyzed transesterification with alcohol. In this reaction, liquid fats or oils are treated with a solution of an alcohol in the form of either methanol or ethanol together with a catalyst such as potassium hydroxide (KOH) or sodium hydroxide (NaOH). Biodiesel, glycerine, some alcohol, and water are the products of the reaction, which may occur under conditions such as 150 degrees F. and 20 pounds of pressure per square inch.[15]

Depending upon the structure of costs of facilities, the costs of alcohol and the price available to sell the glycerine by-product, net processing charges can be derived. Review of published literature of net processing costs range from a high at $.52 per gallon of biodiesel at an Austrian rapeseed processing cooperative[16] to a low of $.19 per gallon estimated for a plant designed for canola crushing and transesterification in Washington State.[17] Shaine Tyson, Project Manager, at the National Renewable Energy Laboratory also cites net processing charges ranging from $.15 per gallon to $.50 per gallon, which are highly dependent on investment per unit of capacity and annual operating intensity. Tyson reports investments in facilities as high as $2.00-$3.00 per gallon of capacity for small plants with capacities less than 3 million gallons to $1.00 per gallon for plants in the 5-10 million gallons range, and as low as $.50 per gallon of capacity for very large plants of 30 million gallons of annual capacity.[18]

Table 1: Derived Price Per Gallon of Neat Biodiesel

Feedstock Oil Price Per Pound									
$0.32	2.66	2.70	2.74	2.78	2.82	2.86	2.90	2.94	2.98
$0.30	2.51	2.55	2.59	2.63	2.67	2.71	2.75	2.79	2.83
$0.28	2.36	2.40	2.44	2.48	2.52	2.56	2.60	2.64	2.68
$0.26	2.20	2.24	2.28	2.32	2.36	2.40	2.44	2.48	2.52
$0.24	2.05	2.09	2.13	2.17	2.21	2.25	2.29	2.33	2.37
$0.22	1.89	1.93	1.97	2.01	2.05	2.09	2.13	2.17	2.21
$0.20	1.74	1.78	1.82	1.86	1.90	1.94	1.98	2.02	2.06
$0.18	1.59	1.63	1.67	1.71	1.75	1.79	1.83	1.87	1.91
$0.16	1.43	1.47	1.51	1.55	1.59	1.63	1.67	1.71	1.75
$0.14	1.28	1.32	1.36	1.40	1.44	1.48	1.52	1.56	1.60
$0.12	1.12	1.16	1.20	1.24	1.28	1.32	1.36	1.40	1.44
$0.10	0.97	1.01	1.05	1.09	1.13	1.17	1.21	1.25	1.29
	$0.20	$0.24	$0.28	$0.32	$0.36	$0.40	$0.44	$0.48	$0.52
		Net Processing Charge Per Gallon							

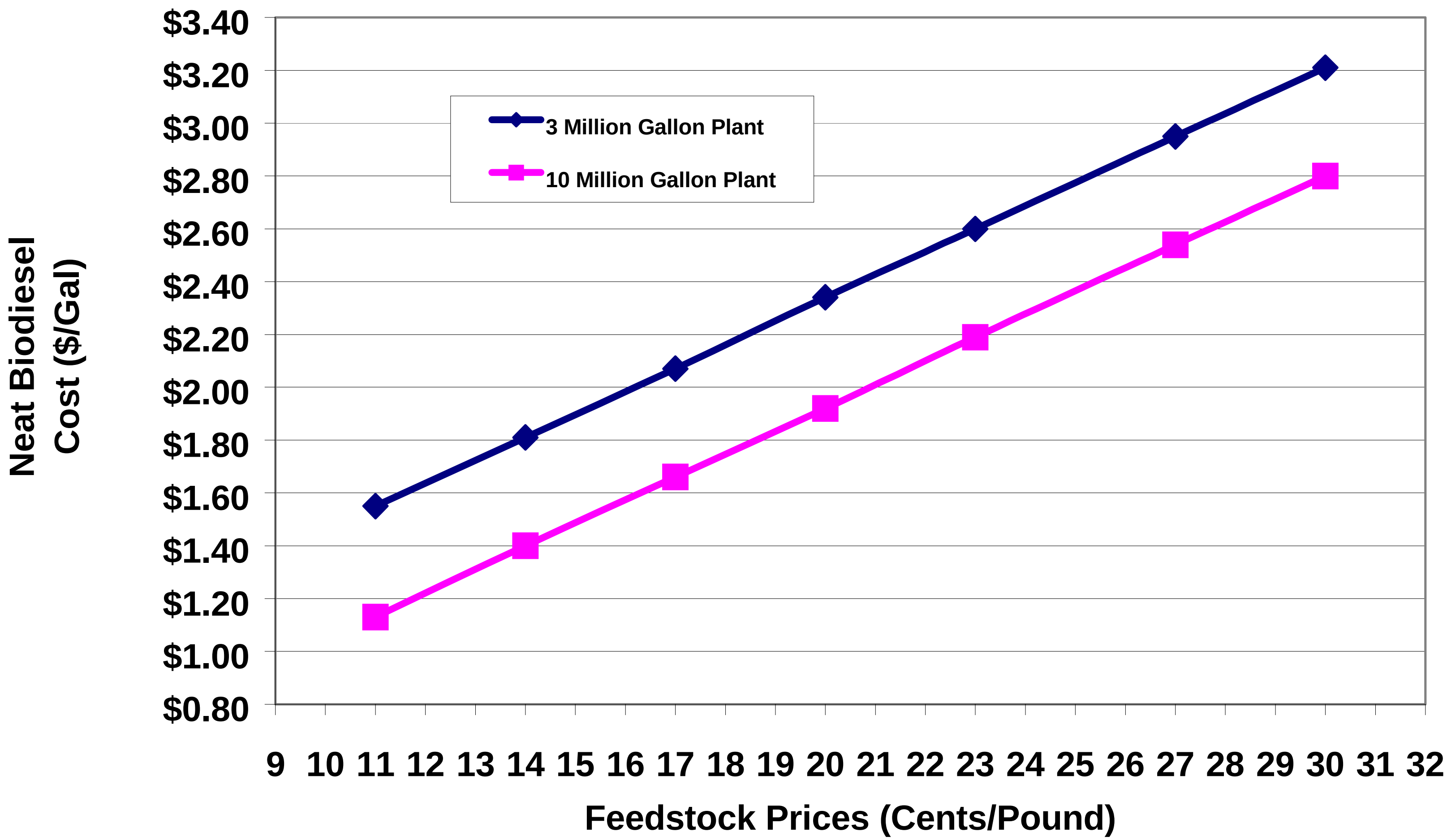
Considering the monthly average prices of soybean oil that have existed for the past two year period (March 99-March 01) of $.17 per pound) and net processing costs of $.35 per gallon (middle of range) of biodiesel produced, one can derive a cost of neat biodiesel of $1.66 per gallon. With lower cost feedstocks at $.12 per pound such as yellow grease and tallow, one might find biodiesel produced as low as $1.27 per gallon. It is significant that feedstock oil prices would have to rise above $.22 per pound in order to result in neat biodiesel prices above $2.00 per gallon.

Graph 1 portrays the costs to produce biodiesel with various feedstock prices for plants of two sizes and assuming a 15% return on costs, as calculated by a model developed by Shaine Tyson of the National Renewable Energy Lab. The patterns that emerge demonstrate the importance of attaining sufficient economies of scale in production for producers of biodiesel. Van Dyne and Blasé in their paper discussing the influence of transaction costs on biodiesel prices suggest the potential for smaller plants to be competitive if American coops are able to reduce transactions costs in the fashion of an Austrian rapeseed cooperative, with farmer-members providing feedstock and taking back protein meal to feed their livestock.

Graph 2 portrays a retrospective cost series for biodiesel prices that would have occurred over the past twelve years if biodiesel had been made from soybean oil or lard assuming the requirement of 7.7 pounds of feedstock oil and a net conversion cost of $.35 per gallon. On the same graph a time series of reported diesel fuel prices for Minnesota before taxes is found. The generally lower cost of diesel is immediately apparent as well as the impact of feedstock costs on derived costs of biodiesel. The patterns of the two graphs reveal that they do not always move in harmony with one another. The pattern of movements over the time shows that these two substitutes may dampen the price movements of the other when used as a blended product. **Note how prices of biodiesel from fats and oils have converged with petro-diesel prices over the last year and a half.**

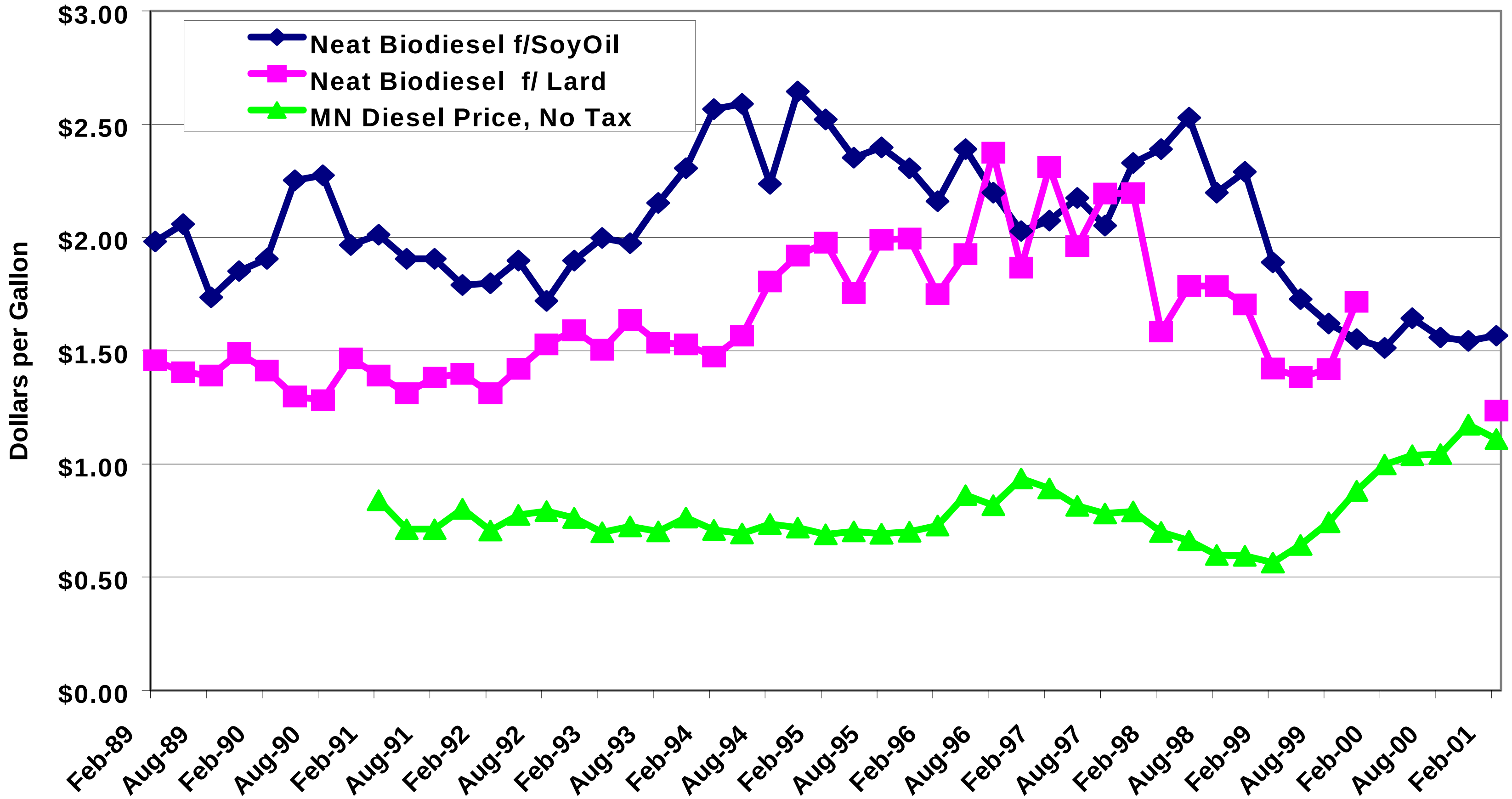
Looking to the future of soybean oil prices, outlook material just published, by FAPRI, a public agricultural trade and policy-modeling center, contains soybean oil prices based in Decatur, Illinois. The prices range from $.143 per pound for the current marketing season to $.21 per pound in ten years. The average of the yearly oil prices predicted for the next ten years is $.173, which matches the price levels experienced by sellers of soybean oil over the last two years.[19] Prices for soy oil quoted by ADM and Cenex in Mankato, Minnesota were below $.13 per pound on May 9, 2001, a price level often recorded for the by-product animal fats.

Graph 1. Biodiesel Costs for Alternative Plant Sizes, Feedstock Prices & 15% ROR



(Source: Data Points from Model by Shaine Tyson, National Renewable Energy Laboratory, DOE.)

Graph 2: Retrospective Prices of Minnesota #2 Diesel and Modelled Neat Biodiesel from Soyoil and Lard

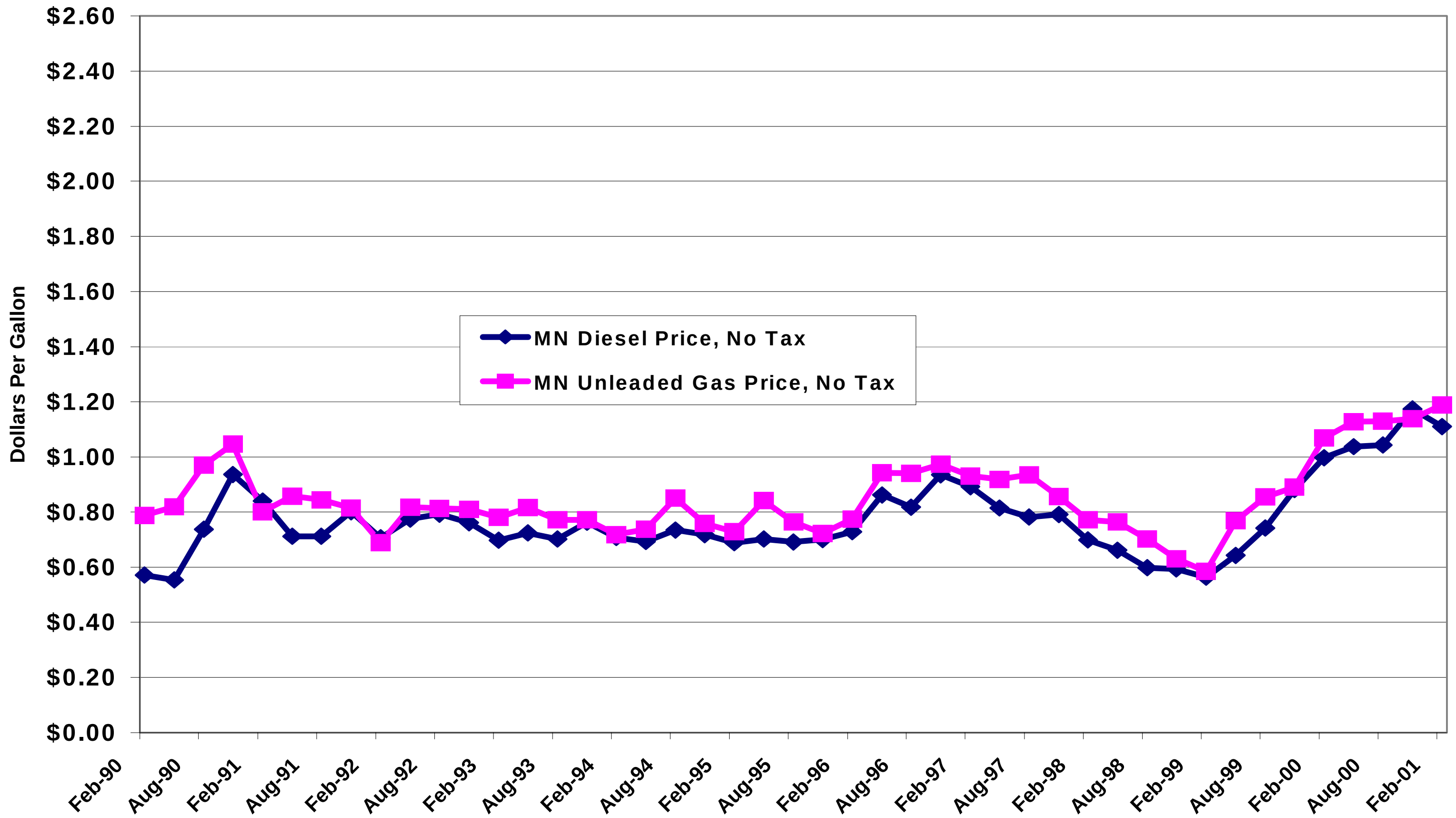


6) A Recent History of Minnesota Diesel and Gasoline Price Levels

Graph 3 contains an eleven-year review of the pattern of prices of lead-free regular gasoline and diesel fuel sold in Minnesota at retail before taxes. Note the consistency of the patterns with diesel close in magnitude and highly correlated in direction of price movements. Diesel usually runs slightly below the price of gasoline, with Minnesota diesel prices generally $.15 higher than the national average for this type of fuel. Diesel prices betray a typical seasonal price rise that occurs when refiners produce more heating fuel in the fall and winter. Heating oil is distilled from a similar fraction of crude oil, so the efforts of some consumers to fill the tanks in their homes removes a significant portion of the supply of distillate fuels, causing diesel prices to rise. Diesel prices typically fall in spring and summer, when demand for heating oil is low.

When we are confronted by predictions of much higher prices for gasoline in the $2.00 - $3.00 range, as we have been in recent months, we should realize that those predictions are based on pump prices. Per gallon pump prices for gasoline in Minnesota typically include $.186 for federal gasoline excise tax, $.20 for state petroleum tax, $.00085 for petroleum inspection fees, and occasionally $.02 for spill cleanup fees (to fund a cleanup account). Per gallon pump prices of diesel fuel in Minnesota include $.244 for federal diesel excise taxes, $.20 for state petroleum tax, $.00085 for petroleum inspection fees, and occasionally a similar $.02 for spill cleanup fees. Minnesota gasoline taxes and fees range from $.38685 to $.40685, while diesel taxes and fees range from $.44485 to $.46485. Therefore, $3.00 gasoline price predictions would correspond to levels of $2.60 prices before tax on Graph 3**.** Diesel fuel prices are often $.10 lower in price, but pay approximately $.05 more in taxes per gallon. Therefore, one could expect pre-tax retail diesel prices of $2.55 on Graph 3 if gasoline pump prices should reach $3.00 per gallon. Recent reporting suggests that the incidence of pipeline and refinery mishaps could play a large role in the level of prices attained with current tight supplies. With diesel prices often slightly less than gasoline prices, we can consider the impacts on biodiesel blends in the event of price hikes in petro-diesel prices by reviewing the relationship between gasoline and petro-diesel prices on Graph 3.

Graph 3. MN Pre-Tax Price Comparison: Lead-free Gas and Diesel



7) The Potential Net Price Effects of Biodiesel Blends

Conservatively assuming the cost of biodiesel at $2.00 per gallon and petro-based diesel at $1.00 per gallon identifies the additional cost to Minnesota diesel fuel consumers as $.02 per gallon in a 2% blended product assumed to occur over a long period of time. **The current differential between the two fuels is probably closer to $.32 than to $1.00**, **with current soybean oil prices at $.13 per pound, resulting in biodiesel at $1.35 per gallon and petro-diesel at $1.03 per gallon. Blending neat biodiesel with petro-diesel at these prices would result in a minor increase of only six-tenths of a cent increase in the retail price of diesel.**

The following page contains **Tables 2 and 3, which** identify the additional costs for purchased diesel with biodiesel included at 2% and 5% levels, respectively. Biodiesel producers eligible for the CCC Bioenergy Subsidy may be able to profitably offer substantial price cuts in neat biodiesel for sale as their time of eligibility in that program comes to a close, although this lowered price would be available for a limited volume of fuel. Each table has series of blend prices with borders around the cells in a pattern that runs diagonally from left to right. The cells in the boxes conform to a situation of biodiesel blends resulting in no net increase in prices over petro-diesel prices. The region of each table above and to the left of this series of cells represents fuel price combinations that result in **net increases** (before figuring any credits or subsidies for biodiesel). The region of each table below and to the right of the bordered cells running diagonally left to right on each graph represent the combinations of diesel and neat biodiesel prices that result in **net decreases** in the blend price.

Examination of Table 2 reveals three bold-bordered boxes in the column of $1.00 “Diesel Prices”. The lowest box, containing the figure 1.008, referring to $1.008 approximates **current prices** of biodiesel likely produced from soybean oil priced at $.136 per pound (really $.13 per pound) or $1.40 per gallon and diesel fuel at $1.00 per gallon (really $1.03 per gallon). The additional cost of a 2% biodiesel blend, according to the table is 8/10 of a cent per blended gallon of fuel. The box above contains the figure “1.012”, which means that a 2% blend of biodiesel would cost 1.2 cents more per gallon than petro-diesel at feedstock **prices approximately equal to the average of soybean oil prices over the last two years**, which was $.17 per pound, nationally. The bold-bordered box above containing “1.020” means a 2 cent per gallon increase results from blending at **the conservative baseline conditions** of $1.00 petro-diesel fuel and neat biodiesel priced at $2.00 per gallon, which is the cost derived from soybean oil or another feedstock costing $.214 per pound. Examination of these examples can help one appreciate the influence of feedstock costs on biodiesel prices. The same dynamics of blended prices occur in the Table 2 for the 5% Biodiesel Blends.

Table 2: 2% Biodiesel Blend Prices

Feedstock Prices Per lb.	Neat Biodiesel Prices	$0.60	$0.80	$1.00	$1.20	$1.40	$1.60	$1.80	$2.00	$2.20	$2.40	$2.60
$0.318	**$2.80**	0.644	0.840	1.036	1.232	1.428	1.624	1.820	2.016	2.212	2.408	2.604
$0.292	**$2.60**	0.640	0.836	1.032	1.228	1.424	1.620	1.816	2.012	2.208	2.404	**2.600**
$0.266	**$2.40**	0.636	0.832	1.028	1.224	1.420	1.616	1.812	2.008	2.204	**2.400**	2.596
$0.240	**$2.20**	0.632	0.828	1.024	1.220	1.416	1.612	1.808	2.004	**2.200**	2.396	2.592
$0.214	**$2.00**	0.628	0.824	1.020	1.216	1.412	1.608	1.804	**2.000**	2.196	2.392	2.588
$0.188	**$1.80**	0.624	0.820	1.016	1.212	1.408	1.604	**1.800**	1.996	2.192	2.388	2.584
$0.162	**$1.60**	0.620	0.816	1.012	1.208	1.404	**1.600**	1.796	1.992	2.188	2.384	2.580
$0.136	**$1.40**	0.616	0.812	1.008	1.204	**1.400**	1.596	1.792	1.988	2.184	2.380	2.576
$0.110	**$1.20**	0.612	0.808	1.004	**1.200**	1.396	1.592	1.788	1.984	2.180	2.376	2.572
$0.084	**$1.00**	0.608	0.804	**1.000**	1.196	1.392	1.588	1.784	1.980	2.176	2.372	2.568

Diesel Prices

Table 3: 5% Biodiesel Blend Prices

Feedstock Prices Per lb.	Neat Biodiesel Prices	$0.60	$0.80	$1.00	$1.20	$1.40	$1.60	$1.80	$2.00	$2.20	$2.40	$2.60
$0.318	**$2.80**	0.710	0.900	1.090	1.280	1.470	1.660	1.850	2.040	2.230	2.420	2.610
$0.292	**$2.60**	0.700	0.890	1.080	1.270	1.460	1.650	1.840	2.030	2.220	2.410	**2.600**
$0.266	**$2.40**	0.690	0.880	1.070	1.260	1.450	1.640	1.830	2.020	2.210	**2.400**	2.590
$0.240	**$2.20**	0.680	0.870	1.060	1.250	1.440	1.630	1.820	2.010	**2.200**	2.390	2.580
$0.214	**$2.00**	0.670	0.860	1.050	1.240	1.430	1.620	1.810	**2.000**	2.190	2.380	2.570
$0.188	**$1.80**	0.660	0.850	1.040	1.230	1.420	1.610	**1.800**	1.990	2.180	2.370	2.560
$0.162	**$1.60**	0.650	0.840	1.030	1.220	1.410	**1.600**	1.790	1.980	2.170	2.360	2.550
$0.136	**$1.40**	0.640	0.830	1.020	1.210	**1.400**	1.590	1.780	1.970	2.160	2.350	2.540
$0.110	**$1.20**	0.630	0.820	1.010	**1.200**	1.390	1.580	1.770	1.960	2.150	2.340	2.530
$0.084	**$1.00**	0.620	0.810	**1.000**	1.190	1.380	1.570	1.760	1.950	2.140	2.330	2.520

Diesel Prices

If Congress enacts the National Renewable Standard as mentioned in Part 4 of this paper, 2% blends of biodiesel will be reduced in price by $.03 per blended gallon. If Congress does not pass this bill, purchasers of biodiesel blends will not receive this favorable impact on price**. The following figures refer to net price effects under the conservative assumptions of $1.00 per gallon price of petro-diesel and the $2.00 per gallon price of neat biodiesel.**

Per gallon costs for on-road inclusion of biodiesel at the 2% level follow for both scenarios:

	With Reduced Fed. Excise	W/O Reduced Fed. Excise
Cost of Inclusion of Biodiesel @ $2.00 per gallon	$.020	$.020
Direct Lubricity Agent Credit [20]	(.003)	(.003)
Proposed Federal Reduction of Diesel Fuel Excise Tax	($.030)	-0-
Net Cost to Consumers in Biodiesel Blend	($.013)	$.017

Per gallon costs for on-road inclusion of biodiesel at the 5% level follow:

	With Reduced Fed. Excise	W/O Reduced Fed. Excise
Cost of Inclusion of Biodiesel @ $2.00 per gallon	$.050	$.050
Direct Lubricity Agent Credit	(.003)	(.003)
Proposed Federal Reduction of Diesel Fuel Excise Tax	($.030)	-0-
Net Cost to Consumers in Biodiesel Blend	$.017	$.047

In the event the National Renewable Standard is enacted, Minnesota highway diesel consumers will receive a net price reduction of $.013 per gallon, which includes the value of biodiesel as a lubricity agent for 2% biodiesel blends. In the event no federal exemption is granted from the Diesel Fuel Excise Tax, all consumers will experience a net price increase of $.017 also including the substitution of biodiesel for petroleum-based lubricity agents. In this analysis, it is not assumed the National Renewal Standard would be extended to fuel used in farm or off-road vehicles. Similarly, 5% biodiesel blends would require highway diesel users to pay $.017 more with the NRS enacted and $.047 more in its absence for all diesel consumers.

8) The Adequacy of Fat and Oil Supply for Biodiesel and Existing Uses

Minnesota has substantial firms crushing oilseeds and extracting oil within its borders, and there is substantial crushing capacity in neighboring states. Two large plants operate in Mankato, and another large one operates at Dawson. A large plant is planned for Brewster, MN. The proposed plant in Brewster, Minnesota will be allied with a plant in Volga, South Dakota, which is a cooperative with numerous Minnesota farmers as members.[21] There is substantial soybean crushing capacity in Iowa and even more in Illinois, the center of the U.S. soybean processing industry.

The average U.S. citizen is responsible for the disappearance of approximately 91.4 pounds of vegetable oils in the current year among amounts consumed, used as cooking oil, or included in non-food products. For the last ten years over 95% of all vegetable oil removed by the U.S. domestic market was used in food. [22] If one assumes that Minnesotans consume the same amount of vegetable as the rest of the country, it is possible to determine the additional vegetable oils required by Minnesotans at present and in the event this proposal should be enacted. First, we need to recognize a few features of the soybean crushing industry in Minnesota. Soybeans are crushed in the state in order to meet the demand for livestock feed. For the 1999 crop, 34% of the Minnesota soybean crop was crushed in the state or approximately 95,400,000 bushels of the crop totaling 278,400,000 bushels. [23] Minnesota soybean crushing activity results in the release of approximately 11 pounds of oil per bushel of soybeans, or 1,049,400,000 pounds. The figures displayed below show the impacts of this proposal on soybean oil utilization by the Minnesota population:

Soybean Oil Released from 1999 MN Crop	1,049,400,000 lb.
Current Edible Fats & Oils Used in MN (91.4 #/cap.)	449,640,381 lb
Percent of MN Soy Oil Production Used by MN	42.8%
MN Use of Fats & Oils w/ 2% Biodiesel (116.4#/cap.)	572,840,381 lb.
Percent of MN Soy Oil Production Used by MN	54.6%
MN Use of Fats & Oils w/ 5% Biodiesel (154.0#/cap.)	757,640,381 lb.
Percent of MN Soy Oil Production Used by MN	72.2%

If these bills are enacted Minnesota consumers will find adequate vegetable dressings at the salad bar and in stores, while local food industry buyers of soybean oil will find plentiful supplies to purchase. If additional soy oil is utilized in Minnesota as a consequence of adoption of this proposed legislation, less soybean oil will need to be shipped out of the state to be marketed.

9) Likely Economic Impacts of Proposal in Minnesota

There are four major aspects of economic impacts to be discussed in these two bills which include the following:

1) Effects on State Government Budget
2) Effects on All Consumers of Diesel Fuel in Minnesota
3) Effects on Farmers
4) Effects on State Economy

The discussion that follows tries to break out the economic impacts of the current biodiesel bills.

Minnesota State Government

Although the proposal contained in H.F. 362/ S.F 326 identifies a mandate to include biodiesel in the supply of fuel, it does not result in fiscal obligations for state government to subsidize the production of this fuel. In contrast, ethanol production requires state subsidies for ethanol produced in the state.

Minnesota Consumers

A mandate to include 2% and later 5% biodiesel in diesel fuel sold in Minnesota may increase the operating costs for all consumers of diesel fuel, depending upon the fate of the federal diesel excise tax reduction. Today biodiesel costs more than diesel derived from petroleum, and this situation is likely to persist. Blends including biodiesel will generally cost more than straight diesel derived from petroleum at both the 2% and 5% rates of inclusion. As mentioned in **Part 7**, off-road consumers will effectively pay $.017 per gallon regardless of federal excise tax reductions. On-road consumers may effectively pay less than $.017 extra per gallon for a 2% blend or may receive a credit of $.013 per gallon if the federal excise tax is reduced for biodiesel and biodiesel lubricity qualities are considered. These figures are based on conservative long-range planning figures of biodiesel priced at $2.00 per gallon and diesel fuel priced at $1.00 per gallon. With mid-May prices of diesel fuel (before tax) exceeding $1.00 per gallon and current soybean oil prices below $.13 per pound, the net price effect is an increase of .64 cents per gallon ($1.0364 versus $1.03). At the 5% blend rate, off-road users would pay $.047 cents more per gallon (at conservative baseline figures), as would on-road consumers with the reduced federal excise taxes. If the federal excise tax reduction remains at $.03 per blended gallon, then on-road consumers will end up paying an additional $.017 per gallon under the 5% inclusion rate.

Minnesota Farmers

In the case of farmers producing oil crops such as soybeans, corn, canola, sunflowers, and flax various economic studies identify that farmers would have net gains from the biodiesel mandate delivered to them in terms of higher prices that can be paid for their crops for the oil extracted from those crops. A study conducted in 1994 modeled the price impact of exogenous demand increases in soybean oil on the prices paid to farmers for soybeans. This FAPRI study offers some guidance for the scenario offered by this bill. The initial, 2% inclusion rate slated for Minnesota in 2002 is in keeping with the study's assumption for a 32 million gallon expansion of biodiesel **in the country as a whole**. In this scenario a one-year price hike in soybeans of $.09 per bushel is predicted, with soybean prices to be $.05 per bushel higher after the first year. The 5% inclusion rate, which would require the production of 40,000,000 gallons of biodiesel for use in Minnesota in 2006, is similar in scale to the modeled exogenous increase in biodiesel of 65 million gallons in biodiesel for the country. This increase in soy oil usage caused the model to predict an initial year price increase of $.18 per bushel, with $.10- $.12 increase persisting after the first year.[24] **What should be emphasized is that apart from the impacts that the FAPRI model suggests on soybean prices nationally, a narrowing of the basis for Minnesota soybeans should result, causing even greater increases in Minnesota farm prices.** This should occur because Minnesota crushers will be able to bid more aggressively for Minnesota soybeans because the crushers will know that they have a nearby market for the surplus oil that is crushed in Minnesota.

Minnesota's Economy

An economic study designed to measure regional and sector impacts (IMPLAN) was run by the Minnesota Department of Agriculture. However, the assumptions established for the model were quite different from the conditions eventually set forth in this bill. That model assumed that additional soybeans would be grown and that additional crushing capacity equal to the amount of neat biodiesel needed to blend for the on-road use of diesel consumption in the state would be built. Although there is a cooperative seeking members that intends to crush soybeans, it is difficult to attribute additional crushing capacity in the state to a biodiesel mandate, alone. I conclude that adequate soybean oil supplies exist within the state from current production levels of soybeans, and current crushing capacity of soybeans can provide adequate feedstock material to produce biodiesel to satisfy both the 2% and 5% blend levels for total diesel consumption in the state. It is logical that transesterification facilities will be associated with existing soybean crushing facilities, so it may not be necessary to hire a management team for such an enterprise. The model correctly shows the positive direction of economic activity in terms of the construction, some of the employment in soybean processing, and a component of the value-added impacts identified by the study. Revised IMPLAN studies may be very instructive in identifying the sectors of the Minnesota economy that will benefit from this kind of development. Although these types of studies have a mixed track record for telling us precise magnitudes of the economic impact, they are very useful in understanding the stability of the levels and proportions of economic impacts that are direct, indirect, and induced.

Minnesota experiences with other agricultural processing enterprises such as ethanol development, suggest the manner in which development of transesterification capacity will impact the economy of Minnesota. Current national production of biodiesel is estimated at 30 million gallons per year. [25] According to Shaine Tyson of the National Renewal Energy Laboratory there are currently seven companies producing biodiesel and four to seven more that are actively pursuing development of biodiesel capacity. Based on current capacity and long-term production agreements, over 200 million gallons of potential biodiesel capacity currently exists. In addition, biodiesel processing facilities are capable of doubling production within eighteen months.[26]

Minnesota has plentiful supplies of vegetable oil available for biodiesel production as a consequence of the substantial crushing activities needed to supply Minnesota's growing livestock populations as well as fats available from slaughter facilities. Under current situations, much of the vegetable oil is shipped out of the state. This occurs because crushers have built and maintained crushing capacity in the state roughly in step with the requirements to feed livestock in the state. Because the protein meal derived from soybeans represents 80% of the weight of the raw beans, it has been reasonable and economic to locate crushing facilities in close proximity to livestock consuming units. The oil in excess of local needs has been shipped out of the state. Whole soybeans prove to be a very convenient and stable package for storage until the time the two co-products are needed from a freshness standpoint. Whole soybeans are also a very convenient package for transport around the world, for Minnesota soybeans frequently take the longest journeys to their ultimate destinations of any of soybeans produced in the nation.

Summary Table of Economic Benefits and (Costs)

	2% Mandate	5% Mandate
State Government	0	0
Consumers On-Road (550M gal.)	$7.15 M -($ 9.35M*)	($9.35M) – ($25.85M*)
Consumers Off-Road (250M gal.)	($4.25M)	($11.75M)
Farmers (Oilseed Crops)	$15.00M	$36.0M
Minnesota Economy	Positive	Positive

* Figures reflect absence of proposal to reduce federal diesel excise tax by $.03 per gal.

10) The Sustainability of Biodiesel Production in Minnesota

It is an exciting moment when Minnesota farmers, in the course of producing their crops using diesel engines, may be utilizing a component of their soybeans, canola, sunflowers, and flax crops. A portion of the energy in sunlight falling on their fields one year will be making its way back to the farmers as they produce their next crop. A portion of the sunlight that fell on last year's crop will help power the trucks, barges, and trains transporting the current crop to its ultimate destinations. Use of a small portion of the total fuel supply of Minnesota would represent a closed loop of carbon dioxide in our environment. Carbon dioxide emitted in burning biodiesel would be sequestered in the growing oilseeds of the state and eventually converted to fuel. Biodiesel has an energy balance of 3.24, meaning that for every unit of energy applied in the production of biodiesel from growing the feedstocks through the crushing/extraction and finally transesterification, 3.24 units of energy are available from every unit of energy expended.[27] This is much better than the energy balance figures frequently mentioned for ethanol at 1.25.[28] The attributes of biodiesel are well known. The product has been standardized and the specifications and use of this fuel have been thoroughly researched and documented. Users of this fuel included with petro-origin diesel at 2%, 5%, 20% rates of inclusion have documented the performance of this fuel doing various jobs with various sizes of diesel engines. Pollution control officials and environmental regulators understand the potential for environmental benefits from the use of this fuel in terms of gaseous and particulate emissions.

11) The Appropriateness of Minnesota as a Setting for this Proposal

Adequate supplies of feedstock oils from soybeans, corn, sunflowers, canola, and flax as well as animal fats are found in the state. The current proposal does not include the use of animal fats and oils as feedstock materials. Minnesota and neighboring states have substantial livestock slaughter capacity, which yield animal fats as a by-product. Efforts to reduce or eliminate feeding of animal fats to livestock may offer greater supplies of feedstock materials such as tallow, lard, and yellow grease. These low-cost materials can certainly be converted to biodiesel. At present, problems in cold-flow characteristics of biodiesel derived from animal-origin feedstocks have been observed under winter conditions. Further research may correct these issues and offer a greater supply of low-cost feedstocks for biodiesel production.

In addition to plentiful supplies of vegetable oils in the state, Minnesota farmers receive lower prices for their soybeans than farmers in other parts of the country. Part of this problem is location that requires a high proportion of Minnesota soybeans to travel further to destinations for processing. The crushing capacity of the state has been built to a size to serve the soybean meal required by the livestock fed in the state. Soybean oil released in the crushing process is largely shipped out of the state to numerous users of vegetable oils.

Minnesota consumers pay higher prices for diesel fuel than the rest of the country. Again, location may explain part of this effect, due to our distance from oil production areas or crude oil import docks. Because Minnesota diesel prices are higher than U.S. average prices by $.10 to $.15 per gallon, blends of diesel including biodiesel will have less impact on Minnesota consumers than they would in other parts of the country. [29]

The process of tranesterifying vegetable oils to biodiesel requires the use of alcohol. Either ethanol or methanol can be used, although methanol is cheaper and perhaps more efficient in processing. Methanol is manufactured from natural gas, so increases in natural gas prices raise the price of methanol and may make ethanol more competitive as a reagent in the process. Minnesota has an established ethanol industry, which could supply the requirements of the plants that would transesterify vegetable oils into biodiesel.

Minnesota has a head start in local research efforts on biodiesel substantial work being done at the Diesel Research Center at the University of Minnesota and the Agricultural Utilization Research Institute's lab at Marshall.

12) Conclusions

Consideration of proposals to introduce biodiesel into fuel supplies by a state mandate at the 2% level and later at the 5% level have numerous economic and social implications. I have concentrated on the economic issues and documented my understanding of this proposal and its economic effects. Diesel engines have been society's reliable workhorses for over a century and have the capability of utilizing a range of fuels. The co-evolution of engine design and fuel characteristics makes biodiesel an economic choice as a blended fuel with excellent lubricity. Effects of fuel costs to consumers can be variable, depending upon the enactment of the National Renewal Standard with the reduction in diesel excise taxes for on-road use and due to the CCC Bioenergy subsidy available for fuel derived from biomass. A mandate to include 2% and later 5% blends of biodiesel will result in raising farm level prices of soybeans by raising demand for the soybean oil component of soybeans being crushed in Minnesota and neighboring states if the proposal is enacted. It is likely that substantial capacity of transesterification facilities will be built and operated in Minnesota. The requirements for biodiesel fuels needed at 2% and 5% rates of inclusion range from 16 million gallons to 40 million gallons. Minnesota experience with the economic development effects of the state ethanol industry should be instructive for understanding the impact that biodiesel processing will have on the state economy. Minnesota enjoys advantages for the establishment of transesterification facilities in the state including plentiful feedstock materials that are cheaper than in the country as a whole, as well as having a history of diesel prices higher than the national average. Establishment of biodiesel production in the state would be equivalent to adding refinery capacity for 2% and eventually 5% of Minnesota's diesel usage of 800 million gallons.

The current petroleum product supply chain in this country generally provides low-cost distribution of products. However, this system is not immune to potential problems that may disrupt the price and supply of diesel fuel available for Minnesota consumers such as future political instability in the Persian Gulf, increased OPEC solidarity, national and regional refinery capacity issues, pipeline disruptions, and reduced domestic opportunities to drill for oil due to expense or regulation. The state mandate to sell blends of biodiesel fuel will reduce the energy dependence of the state, improve air quality, provide fuels that reduce engine wear, and strengthen the local economy in a sustainable fashion with no budget exposure to the state of Minnesota.

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