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**Overview of:**

**The Feasibility of Biodiesel from  
Waste/Recycled Greases  
and Animal Fats**

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## **EXECUTIVE SUMMARY**

Data related to historical prices and supply and demand of waste/recycled greases and animal fats is less clear than that available for major commodity oils. This makes a thorough analysis difficult. USDA yellow grease production estimates for the U.S. from 1995 to 2000 average 2.6 billion pounds, equivalent to 350 million gallons of biodiesel. Minnesota yellow grease production estimates range from 16 million to 48 million pounds equivalent to 2 to 6 million gallons of biodiesel.

However, it is clear that yellow grease is about half the cost of soybean oil. Whereas soybean oil prices range from 14 to 28 cents per pound, yellow grease prices range from 7 to 16 cents per pound. Commercially manufactured biodiesel from yellow grease currently meets industry specifications and yellow grease biodiesel performed well in heavy duty snow plow vehicles in a Minnesota demonstration conducted in the winter of 2001-2002. These facts indicate that yellow grease is a serious candidate for significant biodiesel production in the future.

A combination of greases and animal fats represent one third of the U.S. total fats and oils production, but soybean oil alone represents more than half of U.S. production. Because of its size and technological development, the soybean processing industry is expected to dominate biodiesel production for the foreseeable future. However, the production of biodiesel from grease can be expected to benefit from a raw material cost advantage and eventually from improved technology. If significant development of grease to biodiesel occurs, it will help reduce overall biodiesel cost and add to the diversity of raw materials used for the production of biodiesel. Greater use of grease for biodiesel also has the potential to increase grease values and improve the likelihood that grease now discarded can be used to replace conventional diesel fuel.

Federal legislation pending in Washington would provide a tax credit similar to the credit now available to ethanol fuels. Such a credit would reduce the cost of biodiesel and dramatically increase the production and use of biodiesel in the U.S. As a renewable fuel, biodiesel is likely to benefit from global warming policy actions proposed by the Bush administration. Federal efforts to reduce diesel emissions are also likely to improve the market position of biodiesel. Finally, the prospect for cleaner diesel fuels and engines combined with the greater efficiency and mileage available from diesel engines could result in more diesel engines in cars and SUVs. If this were to occur, the use of diesel fuel and biodiesel could increase rapidly.

## INTRODUCTION

Biodiesel is a domestic renewable diesel fuel that can be used alone or in a blend with conventional diesel fuel. The fuel passed Tier II EPA certification and industry specifications have been established. Biodiesel, at a 20 percent concentration in diesel fuel, qualifies as an alternative fuel under the Department of Energy's EPACT program.

To address concerns that the use of biodiesel might not be advisable in cold climates like Minnesota, a demonstration project was conducted with snow plow units at the Hennepin County Department of Public Works (DPW). The project was successful and no problems were experienced. In an attempt to help reduce the cost of biodiesel and to reduce waste and pollution, the use of biodiesel made from waste greases was proposed. Since biodiesel from waste grease is expected to display cold flow properties less desirable than that for soy based biodiesel, a demonstration of that product at Hennepin County was funded and implemented. This report is a part of that study and is intended to consider aspects related to the feasibility of the production of biodiesel from waste/recycled greases and animal fats.

This report was written as a result of a project "To Evaluate Biodiesel Made From Waste Fats and Oils," made possible by Minnesota Laws for 1999, Ch 231, Sec. 16, Subd. 9 (c). Funding was provided through the Minnesota Legislative Commission for Minnesota Resources (LCMR), with matching funds provided by the Minnesota Soybean Research and Promotion Council. Project activities were implemented by the Agricultural Utilization Research Institute (AURI), the University of Minnesota, Center for Diesel Research (CDR) and the Marketing and Promotion Division of the Minnesota Department of Agriculture (MDA).

The first two steps in the project were to develop, analyze and evaluate a waste grease biodiesel product suited for blending and use with conventional diesel in Minnesota winters. This step in the process resulted in the selection of a combination of 10 percent biodiesel from yellow grease, 10 percent biodiesel from soybean oil and 80 percent conventional diesel fuel. These activities are described in reports from CDR and AURI. (19) (22)

The third step of the project was to conduct a vehicle demonstration with the use of this special B20 snow plow units, operated by Hennepin County in the winter of 2001-2002. The results of this portion of the project indicated that the B20 biodiesel blend performed comparably with conventional diesel fuel and are described in the CDR report. (19)

The fourth step of the project included:

1. An estimate of the yellow grease available in the Twin Cities metropolitan area, which is included in the CDR report. (19)
2. An estimate of the "Economic Impact of the Yellow Grease Industry in Minnesota" by the MDA, which is included in the Final Report. (16)
3. An evaluation of issues related to the feasibility of the production of biodiesel from waste/recycled greases and animal fats, which is included in this report.

## BACKGROUND AND TERMINOLOGY OF GREASES, FATS AND OILS.

In some industry discussions, the word *grease* may refer to yellow grease, choice white grease, or combinations of fat and oil products. A reference to grease by the general population may refer to yellow grease, choice white grease, edible or inedible tallow, lard, trap grease, poultry fat, hydrogenated vegetable oil or other items. In general terms, all greases and oils are classified as fats. Fats are described in Webster's Dictionary as "energy-rich esters that occur naturally in animal fats and in plants and are soluble in organic solvents (as ether) but not in water." Chemically, fats are classified as *triglycerides*.

Oils are generally considered to be liquids, while greases are solid. Many animal fats and hydrogenated vegetable oils (Crisco<sup>®</sup>-type products) tend to be solid at room temperature. Fresh vegetable oils are generally liquid at room temperature and are sometimes referred to as *virgin oils*. Many consider the consumption of non-hydrogenated vegetable oils more favorably than hydrogenated products. Hydrogenated vegetable oils are more stable at cooking temperatures and last longer in frying equipment. For these reasons, both hydrogenated and non-hydrogenated vegetable oils are used in commercial food cooking (frying) operations.

Recycled grease products are sometimes referred to as *waste grease*, *byproduct grease*, *recycled grease* or *animal fats*. These greases are generally low in cost, well adapted to certain industrial markets and widely used in livestock feed or pet food markets. Greases are generally placed into one of three categories:

- 1) Animal fats are primarily derived as byproducts from meat animal processing facilities. The primary animal fats include edible and inedible tallow from processing cattle, lard and choice white grease from swine processing and poultry fat from the processing of chicken, turkey or other birds. <sup>(3)</sup> Since the supply source is fairly concentrated and the markets are well established, animal fat may be collected and sold by rendering companies or by the animal processors themselves.

Another source of animal fats is the collection and processing of animal mortalities by rendering companies around the country. Collecting these "waste" byproducts not only provides valuable products for industrial uses, but also reduces the amount of material that might otherwise end up in landfills, posing pollution problems or a threat to the public health through the spread of disease. Livestock producers not served by a renderer may have to compost or bury animal mortalities. Increased demand for animal fats used in the production of biodiesel may help to increase the number of animal mortalities processed by renderers.

The infrastructure for animal fats collection and distribution is well established. Less expensive animal fat products including inedible tallow, choice white grease and poultry fat are promising candidates for biodiesel production.

- 2) Yellow grease is manufactured from *spent cooking oil* and other fats and oils collected from commercial or industrial cooking operations. Other fats may include grease rendered from hamburger, bacon or cooked meat entrees. For purposes of this discussion we will call this unprocessed mix of oils and grease products *restaurant grease*. Spent cooking oil may be vegetable oil or animal fat that has been heated and used for cooking a wide variety of meat, fish or vegetable products. After a period of time, the cooking oil is replaced with fresh product. At that time, the spent cooking oil may be collected by a rendering company or discarded.

Renderers filter out the solids and heat the spent cooking oil to drive out moisture until it meets industry specifications for yellow grease. Yellow grease, which may already contain some animal fat from cooked food, may be sold as is or blended with other grease products to meet the specific needs of various customers. Yellow grease is often sold to livestock feed and pet food manufacturers. As mentioned, the infrastructure for collection of yellow grease is well established and it is estimated that 70 to 95 percent of the available yellow grease is now being collected in metropolitan areas. <sup>(6)</sup> Most heavy users of cooking grease probably use the services of a renderer.

Less is known about the amount of yellow grease collected from low-level grease users or in rural areas where restaurants may be smaller or more remote. If the price of yellow grease were to increase, more small businesses might take advantage of the additional income available through renderers. Yellow grease is a relatively low value byproduct, often half the price of soybean oil. This low cost, well-developed collection system makes yellow grease a prime candidate for biodiesel production. Most of the biodiesel not made from soybean oil in the U.S. is produced from yellow grease.

- 3) Trap grease, sometimes referred to as *brown grease*, is collected from grease traps that are installed in commercial, industrial or municipal sewage facilities to separate grease and oil from waste water. Grease traps are sealed containers installed in sewer lines in a manner that allows the lighter grease and oil that is flushed down a drain to float to the top of the trap. These traps allow the water to flow under the grease and through to the main sewer or water treatment area. Grease traps are installed so that the top of the container can be opened, allowing the grease and oil to be removed. If traps are not periodically emptied, they become full, allowing grease and oil to flow directly into sewer systems.

Given the potential for contamination from soaps and other chemicals, trap grease is not likely to command a premium for use in animal feed products. The water content of trap grease is also very high, resulting in a low yield-per-pound collected. In many locations, including the Twin Cities, water treatment facilities are large enough to process trap grease. In some areas like California, however, policymakers have considered requiring that trap grease be processed in rendering plants. <sup>(4)</sup>

Uncertainty exists regarding the amount of treatment that would be required to make trap grease suitable for conversion into biodiesel. If it could be collected and processed, however, trap grease's relatively low market value could make it a strong candidate for biodiesel production. Moreover, the prospect of a new market could raise the price of trap grease, thereby providing an incentive for increased collection and use. It is estimated that in the U.S., 13 pounds of trap grease is produced per capita, but less than one-third of that amount is actually collected.

All of these waste or recycled grease products have potential for use in the growing biodiesel market. It is the purpose of this report to consider certain aspects of the feasibility of these grease products for use in biodiesel production. This report will also explore factors that may influence their cost and availability.

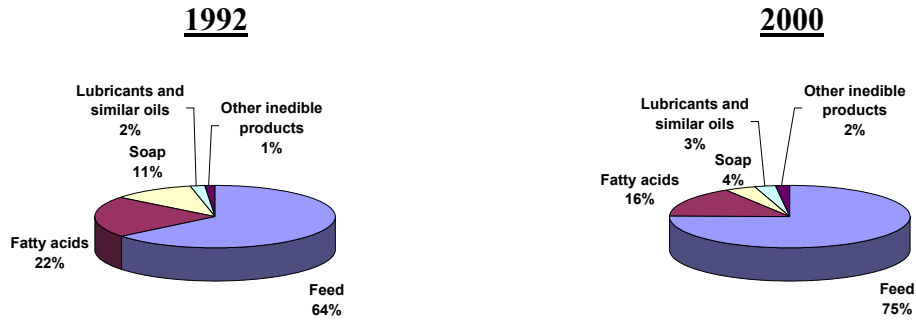
## **SUPPLY AND USE OF FATS, OILS AND GREASES FOR BIODIESEL**

Assuming that technology will allow the efficient processing of a wide variety of fat and oil products into biodiesel, one could assume that the lowest-cost fat would always be the most profitable and widely used input for biodiesel production. There are other factors, however, that must be considered.

For instance, the efficiency of a large multiple product-processing facility relies in part on uniform inputs, quality-controlled outputs and a carefully controlled process that operates around the clock. These factors, combined with quantity purchases and large labor, management and resource pools, may reduce the overall production costs suggested by a comparison of the spot prices of various process inputs. In other words, it may be more profitable for large industrial facilities to use more expensive commodity oils than the current low-cost options such as the various waste/recycled grease products.

Some recycled grease products may be well suited for livestock feed or specific industrial uses, but not for other food or industrial markets. Major commodity oils, however, may have application in a wide range of uses. Depending upon process efficiencies and market factors, one fat or oil product that has enjoyed a given industrial market for years may be replaced by another product. For example, 11 percent of the tallow in the U.S. was used to make soap in 1992, but by the year 2000, only 4 percent was being used in this fashion. *See Charts 1 and 2.* Industry experts suggest that the soap market was captured by a commodity oil product. The balance of the tallow supply was apparently absorbed by the lower-value feed market, which consumed 75 percent of the tallow and grease in 2000 compared with only 64 percent in 1992.

*Charts 1 and 2. U.S. Inedible Tallow and Grease Consumption in End Products*



Source: U.S. Census Bureau, *Fats and Oils: Production, Consumption, and Stocks, 1993 and 2001*

These market interactions suggest that the recycled grease market cannot be considered without a review of the fats and oils market as a whole. According to USDA figures, the U.S. produces more than 23 billion pounds of plant oils and 11 billion pounds of animal fats. Soybean oil (more than 18 billion pounds) comprises more than half of the total domestic supply of fat and oil products. (Table 1.)

**Table 1. U.S. Production of Fats and Oils, billion pounds**

Vegetable Oil Production		Animal Fat Production	
Soybean	18.340	Edible tallow	1.625
Corn	2.420	Inedible tallow	3.859
Peanuts	0.220	Lard and grease	1.306
Sunflower	1.000	Yellow grease	2.633
Cottonseed	1.010	Poultry fat	2.215
Others	0.669	<b>Total</b>	<b>11.638</b>
<b>Total</b>	<b>23.659</b>		

Source: National Renderers Association (USDA averages, 1995-2000)

In reviewing the overall fats and oils market, we found that information for commodity oils, such as corn and soybean, is fairly complete. A review of information from various sources, however, revealed the difficulty of developing a clear profile of certain other grease, fat and oil markets. In some cases, data reveal only general and sometimes conflicting results depending on the year the data were collected and how the various products were classified.

Perhaps, as a result of the many interactions in the fat market, data sources do not always lend themselves to tracking historical trends for the price and availability of certain fat and oil products. For example, the USDA specifies data on the supply and demand for edible and inedible tallow as separate categories, but the same agency indicates only one price category for “tallow.” Information from the U.S. Census Bureau indicates specific export quantities for “yellow grease,” yet their U.S. production and consumption tables



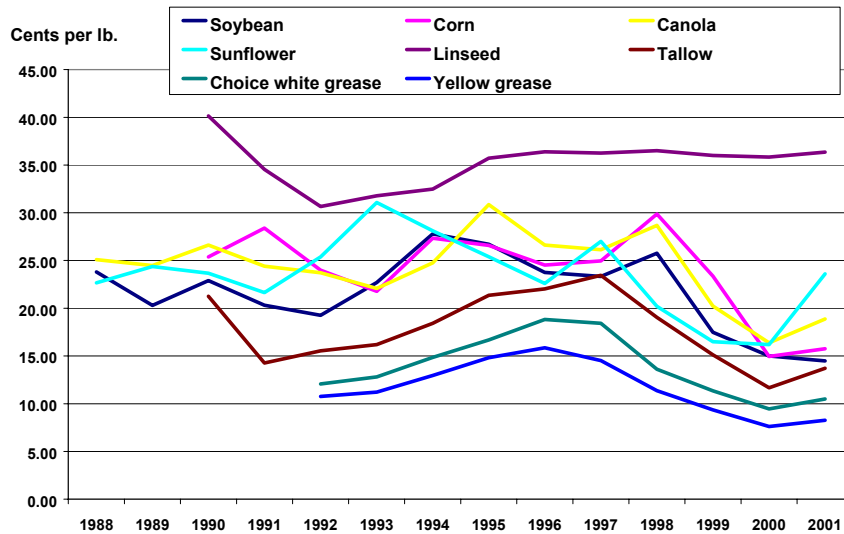
group yellow grease and choice white grease together into a category labeled “greases.” While the USDA indicates a separate listing for poultry fat, Census Bureau figures include only a heading labeled “All other inedible products,” which includes “poultry fat and by-product meal, blood meal, and raw products for pet food.” Thus, to develop a clear picture of grease markets is rather difficult, if not impossible.

According to PROMAR, <sup>(3)</sup> reference data may overlook a considerable amount of fat and oil products in the U.S. market. They suggest that information on fats used in livestock feed includes manufacturers use, but may altogether miss product acquired directly and blended by livestock producers on the farm. The document also asserts that in “further processing centers,” which process skinless and boneless meat and prepared consumer products, poultry fat may be recycled back into poultry feed without being included in data files.

### PRICES OF FATS, OILS AND GREASES

Despite a wide range of product origins and uses, the prices of many fat and oil products can follow quite similar patterns. This suggests a price relationship among a wide variety of fat and oil products. The major commodity oils are suited to many food uses, but also to a wide range of industrial applications. Certain grease products are not suitable for food or other special applications and therefore have limited markets and lower prices.

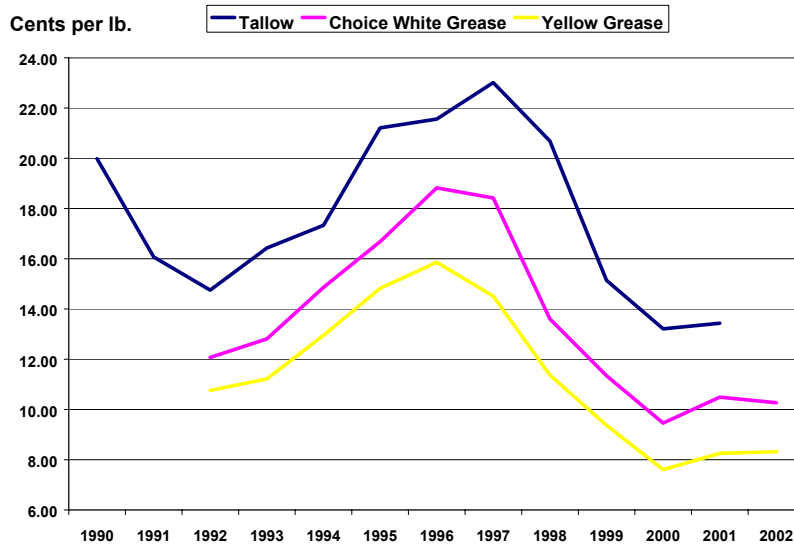
**Chart 3. U.S. Fats and Oils Price Trends**



Source: USDA, Economic Research Service

As illustrated clearly in *Chart 4*, tallow, choice white grease and yellow grease display a clear price hierarchy, but generally rise and fall in unison.

**Chart 4. Animal Fat Prices in the U.S.**



Source: USDA, Economic Research Service

## MEASURING THE ECONOMIC IMPACT OF THE YELLOW GREASE INDUSTRY

According to the Institute of Shortening and Oils and the National Renderers Association, previous attempts to establish the economic impact of yellow grease and other grease products have met with significant difficulty. The reason cited for this difficulty was the inability of analysts to collect sufficient data on industry income, expenses, employment, and product output to conduct such a study.

One possible reason for the lack of data is that the industry is so competitive that company representatives are reluctant to divulge information that might compromise their ability to compete. Another potential obstacle to a thorough economic assessment is the wide variety of the raw materials collected, the processes employed in manufacturing and the number of products and product blends sold by renderers. These include:

1. Raw materials collected for processing by the rendering industry, which may include spent cooking oils, raw byproducts from livestock processing facilities, animal mortalities from livestock production operations and trap grease from industrial and commercial sewer systems. Large animal processing facilities are becoming more involved in rendering materials from their own operations, yet industry experts indicate that up to 40 percent of certain livestock processing and food processing byproducts are handled by independent rendering companies. <sup>(1)</sup>

2. Rendering business operations may include the collection of raw materials, product processing, the blending of various products, the distribution and sale of processed materials and the sale of materials from other vendors.
3. End products sold by these renderers may include a wide range of protein and fat and other products. Fat and oil products sold may include yellow grease and edible or inedible fats from cattle, hogs, sheep, goats and poultry, or blends of these fat and oil products. In some cases, companies collecting spent cooking oil from locations where food is prepared may also supply fresh cooking oil or grease to their customers. Other products from the rendering industry may include blood meal, feather meal, hides and skins, offal, and meat and bone meal. <sup>(4)</sup>

To conduct an economic analysis of a single product would require the allocation of income and expenses that specifically apply to yellow grease. Not having access to these data, we applied IMPLAN database categories listed under “Rendering Industry” to the yellow grease production estimate developed by the CDR. <sup>(19)</sup> The national average price for yellow grease published by the USDA was then applied to the total production estimate. This analysis indicates the potential economic impact of the production of yellow grease in Minnesota, which undoubtedly is a benefit to the state’s economy.

#### A Discussion of National Production Estimates by Various Sources.

According to a 1993 study by Applewhite, the amount of yellow grease produced in the U.S. was approximately 1.5 billion pounds. <sup>(6)</sup> Applewhite computed his result by adding the amount of frying fat purchased to the amount of fat rendered from meat cooked, and then subtracting the amount of fat uptake from the foods that are fried. Considering the 260 million estimated U.S. population at that time translates to 5.78 pounds of yellow grease per capita. This figure multiplied by the 2000 Minnesota population of 4.91 million equals 28 million pounds of yellow grease.

According to a 1990 study conducted by the rendering industry, 2.5 billion pounds of “waste restaurant fats” were collected, and after processing yielded only 1.6 billion pounds of finished yellow grease. According to the report, the reduced yield was due to the high level of water and impurities in the grease. The survey result, however, is quite close to the 1.5 billion pound estimate from Applewhite and was used in his 1993 study to help validate his results. <sup>(6)</sup> Spent cooking oil is said to be a major component of restaurant grease. Since this oil is used at temperatures around 350° Fahrenheit, it is difficult to understand how it could contain as much as 35 percent water.

The April 2002 issue of the industry trade publication, *Render Magazine*, uses information from the U.S. Census Bureau and indicates that in 2001, the U.S. production of “grease” was 3.17 billion pounds. <sup>(18)</sup> (It is not clear how much of this amount is yellow grease.) This amount, divided by the 2000 U.S. Census population of 280 million, indicates that the national per-capita production of grease is 11.3 pounds. This figure, multiplied by Minnesota’s 2000 population of 4.91 million, indicates statewide grease production of up to 55 million pounds.

Finally, the USDA average yellow grease production for 1995-2000 is indicated as 2.633 billion pounds. *See Table 1.* This amount, divided by the 2000 U.S. Census population of 280 million, equals 9.4 pounds per capita. Applying Minnesota's 2000 population of 4.91 million indicates a yellow grease production for the state of 46 million pounds. Since the USDA estimate is an average of six years production and because the yellow grease production trend in the U.S. is increasing, this estimate is probably conservative.

#### How These Estimates Relate to Minnesota

There is no clear indication as to what percentage of the restaurant grease available from metro or rural food handling establishments is actually collected. There is further uncertainty as to the yellow grease yield of restaurant grease collected. According to the per-capita estimates indicated by USDA, and considering our inability to accurately determine amount of yellow grease that could be collected, the potential statewide yellow grease production may be considerably more or less than the high level of 48 million pounds posed in the MDA economic impact study. <sup>(16)</sup>

An industry source who asked not to be named indicated that a non-scientific industry estimate based on many years of experience concluded that only 12 to 15 million pounds of yellow grease are produced from restaurant grease collected from the Twin Cities metropolitan area. Only 16 to 18 million pounds are produced from grease collected statewide according to the source. The source did not offer any estimate on what percent of total grease disposed of is actually rendered, but did question the likelihood of a significant increase in collections.

This wide range of estimates on the generation of yellow grease from various sources highlights a lack of clarity and raises some interesting questions, such as:

1. How much of the restaurant grease that is produced is actually collected?
2. Does Minnesota produce less than one half of the yellow grease per capita compared to the national average?
3. Are renderers able to recover only 0.64 pounds of yellow grease from every pound of restaurant grease collected?

## **THE BIODIESEL PRODUCTION PROCESS**

Biodiesel can be made from a variety of animal or vegetable fat products. Biodiesel, described as a mono-alkyl ester, is produced from triglycerides (fat) through a chemical process known as transesterification. A triglyceride (fat) has a glycerine molecule as its base with three long chain fatty acids attached. The characteristics of the fat are determined by the nature of the fatty acids attached to the glycerine. The nature of the fatty acids can in turn affect the characteristics of the biodiesel. During the esterification process, the triglyceride (fat) is reacted with alcohol in the presence of a catalyst, usually a strong alkaline like sodium hydroxide. The alcohol reacts with the fatty acids to form the mono-alkyl ester, or biodiesel and crude glycerine. The crude glycerine, stripped of its fatty acids, can be isolated for sale or further processing into commercial grade glycerine. A part of the alcohol can be reused.

Basically, ten units of grease and one unit of alcohol will yield ten units of biodiesel and one unit of glycerine. The density of animal fats and grease and their resulting esters may be slightly greater than that of vegetable oils. However, for purposes of simplicity, this discussion will assume that they are all approximately 7.35 pounds per gallon. Before an ester product qualifies as biodiesel it must meet American Society of Testing and Materials (ASTM) specifications designated in ASTM D-6751 “Standard Specification for Biodiesel Fuel (B100) Blend Stock for Distillate Fuels.”<sup>(15)</sup>

With increasing production and larger shipments, the cost of biodiesel has declined considerably in the past few years. Currently, quantities can be purchased for less than \$1.50 per gallon or 20 cents per pound. In order to convert the crude glycerine into a higher value product, additional equipment and processing is required. Finished glycerin is a product with an established market price that varied from 50 cents to more than \$1.00 per pound from 1999 to 2002.<sup>(23)</sup> Glycerin from inedible greases may not be suitable for certain markets and therefore may experience a lower price than glycerin from edible products. It should also be considered that, if biodiesel becomes a significant factor in the diesel market, a large increase in the supply of this byproduct could flood the glycerine market and reduce its price significantly. These factors could impact the cash flow projections and the feasibility of biodiesel production.

Numerous recycled fat and oil products can be used in the production of biodiesel fuels. Most of the biodiesel in the U.S. today is made from soybean oil. In Europe, the predominant feedstock is rapeseed oil, the major oilseed crop raised there. Soybean oil prices may vary from less than 15 cents to 28 cents per pound, whereas yellow grease varies from 8 cents to 15 cents per pound. While making biodiesel from a wide variety of fat products is possible, the technology for processing soybean oil has received the most attention in the U.S. Animal or recycled fats cost considerably less than soybean oil and therefore represent an attractive option to increase the supply of biodiesel, especially for smaller, more specialized facilities or facilities that generate their own grease. Further research on converting these lower-priced fats could aid in the development of more efficient processes, greater demand for grease and perhaps more recycling of grease that is now wasted.

## **PROS AND CONS OF VARIOUS FATS AND OILS USE FOR BIODIESEL**

The fats and oils used for the production of biodiesel will depend upon a variety of factors, including:

1. Price and availability of fats and oils in the marketplace. Given the wide range of fats and oils that can be used in the production of biodiesel, the relative price and availability of individual products will have an impact on which raw material is most profitable at any given point in time. Bumper crops or crop failures in various parts of the world may increase or decrease the price and availability of certain fats and oils. As illustrated in *Chart 3*, the relative prices of vegetable oils such as soybean,

corn, canola and sunflower vary and one may be higher than the others one year and lower the next. However, grease product prices are consistently lower than oil prices.

Market forces may act on the fat or oil products themselves or on co-products or byproducts. For example, concerns about the impact of mad cow disease in Europe and bovine spongiform encephalopathy (BSE) in the U.S. resulted in the ban of feeding certain animal proteins to certain classes of livestock. <sup>(1)</sup> This and other factors increased the demand for soybean meal, triggered a larger soybean crush, put more soybean oil on the market and helped to drive vegetable oil prices down. Despite the decline in the price of vegetable oil, however, most grease prices remained consistently lower.

2. Legislation and regulation may also impact the price and availability of all fat and oil products for the production of biodiesel. For example, the Renewable Fuels Standard being considered in the U.S. Senate would require the use of 5 billion gallons of ethanol and biodiesel by the year 2012. If implemented, this legislation could easily have a significant impact on the national demand for fats and oils, increasing the value of virgin as well as rendered fat products. Another important feature of federal legislation under consideration includes a fuel tax credit that would apply to biodiesel. Once the legislation is passed, a careful review of the details of how the credit will apply to various raw materials would be advisable.
3. The physical and chemical characteristics of various fats and oils may affect certain properties of the resulting biodiesel product. All biodiesel is required to meet specifications designated in ASTM D-6751, <sup>(15)</sup> therefore any process design for grease products should guarantee that the product will meet those specifications. At the same time, the use of grease products may provide some improvement in oxidative stability and cetane value or a reduction in the cold flow properties of the fuel. It may be possible to mitigate some of the cold flow problems of biodiesel from grease by the use of isopropyl in place of methyl alcohol. <sup>(13)(14)</sup> However, at the low blend levels contemplated for Minnesota, little if any impact on cold flow properties would be expected from any biodiesel product.

If the process is effective and economical, it doesn't appear that any fat or oil product would be excluded as a candidate for use as a raw material for biodiesel. The potential for a wide variety and multiple origins of virgin and recycled fat products will allow the biodiesel industry to maintain a wide range of raw material options. These options can help stabilize biodiesel prices, which will help provide a market hedge against our continued dependence on crude oil imported from the Middle-East.

## **MINNESOTA'S BIODIESEL LAW**

Laws of Minnesota for 2002, Chapter 244 includes a requirement for the use of 2 percent biodiesel in the state's diesel fuel by 2005. <sup>(21)</sup> With certain considerations, the law requires that diesel fuel sold in the state must contain 2 percent biodiesel by June 30, 2005. It would take approximately 16 million gallons of biodiesel to replace 2 percent of

the petroleum-based diesel fuel used in the state. Before the 2 percent requirement is implemented, the law requires that Minnesota biodiesel production capacity is at least half of the amount required, or eight million gallons.

Biodiesel can be made from virtually any fat or oil product, but the most abundant oil product produced in the state is soybean oil. It would take oil from about 3 percent of the state's soybean crop to produce eight million gallons of biodiesel. <sup>(17)</sup> Almost all biodiesel in the U.S. is made from soybean oil. Technology and production facilities are well established to process soybean oil into biodiesel and many other products. But what about "waste" grease? How much is produced in Minnesota and how much diesel fuel could it replace?

## **QUANTIFYING THE AVAILABILITY OF GREASE FOR BIODIESEL**

### Yellow Grease

The CDR conducted a market survey concluding that the Minneapolis-St. Paul metropolitan area produces about 24 million pounds of yellow grease annually, the equivalent of 3 million gallons of biodiesel. <sup>(19)</sup>

According to Applewhite<sup>(6)</sup> in a 1993 study of the production of yellow grease in U.S. restaurants, the total amount of fat sold for frying purposes was 1.58 billion pounds. This fat was used in fryers to cook various food products in restaurants and other food processing establishments. Foods cooked in fat tend to absorb a certain amount of fat in the process. This "uptake" amount was estimated by Applewhite to be 0.687 billion pounds and reduced the expected amount available for collection to 0.894 billion pounds. Applewhite then estimated that 0.596 billion pounds of "invisible fat" is rendered from cooking meat and combined with the spent cooking oil, yielding a combined total of 1.49 billion pounds of yellow grease. This additional fat includes that rendered from fried chicken, which becomes part of the spent cooking oil, plus fat from baked or grilled meat that is combined with spent cooking oil and available for collection. The 1.49 billion pounds of yellow grease is the equivalent of more than 200 million gallons of biodiesel fuel each year.

According to USDA, the average U.S. production of yellow grease from 1995 through 2000 was 2.6 billion pounds, which would correlate to 350 million gallons of biodiesel. *See Table 1.*

The MDA's economic impact study estimates the impact of the processing and sale of spent cooking oil into yellow grease based on the survey result for the Twin Cities metropolitan area. The CDR report indicates that 24 million pounds represents a conservative estimate of the yellow grease produced in the metropolitan area, the equivalent of 3 million gallons of biodiesel. They suggest that actual production for the metro area could be as much as 31 million pounds. The population of the metro area is 2.579 million people, but the estimated statewide population for 2001 is 4.9 million, 89 percent more people. Though little work on yellow grease in rural populations has been

done, an 89 percent increase over the 31 million estimate would yield 58 million pounds of yellow grease.

Rendering industry representatives have not offered much information to support or refute such estimates. However, one representative suggested that these estimates of available spent cooking oil are excessive. The CDR estimates were based on a survey of “heavy” users (fast food outlets that sell a lot of deep fried products) as well as “medium” and “light” users who generate less grease per location. Applewhite indicates that in his study, only 12 percent of the restaurants with deep fat fryers were major fast food chains and they used up to 35 percent of the frying fat sold, indicating that at least 65 percent of the fat was sold to medium to low volume users. Of the 3100 establishments represented in the CDR survey estimates, only 257 (8 percent) were classified as heavy users.

The large number of low to medium cooking fat users in the metro area raises a question as to how much of the total spent cooking oil and other grease generated in Minnesota is actually collected by renderers. When yellow grease prices were higher, renderers paid users for the collection of their restaurant grease. With recent low grease prices, renderers are forced to charge food establishments for the service of collecting the grease. What percentage of small or remote restaurants is willing or able to pay to have a small amount of grease collected? How many small businesses are willing or able to store grease in their place of business long enough to make a pick-up worthwhile?

The MDA’s study contemplates the potential statewide impact of a 50 percent and a 100 percent increase in yellow grease production increments over and above the 24 million pound CDR estimate for the metro area. These percentage increases result in yellow grease production estimates of 36 million and 48 million pounds or 4.5 to 6.0 million gallons of biodiesel production, respectively. The increase would allow for consideration of statewide production, the uncertainty in data sources as well as the prospect for collecting grease that is now discarded.

#### Choice White Grease

We are not aware of any estimate of choice white grease production in Minnesota. However, USDA averages for 1995 through 2000 indicate the U.S. production of lard and grease totals 1.3 billion pounds. (Table 1.) An industry document estimates that less than 500 million pounds of this amount is lard which has a well established market. This leaves about 800 million pounds of choice white grease, equivalent to 100 million gallons of biodiesel. The author of this document also makes a note of the difficulty of accurately estimating the availability of grease products in the marketplace because of the confusing nature of the various reporting methods used by the data publishers. <sup>(7)</sup>

#### Trap Grease

It is estimated that 13 pounds of trap grease is generated per capita in the U.S., but only 4 pounds per capita is captured by renderers. <sup>(9)</sup> In 1998, the 4 pounds per capita was estimated to yield approximately 1 billion pounds of trap grease. <sup>(3)</sup> Assuming that all 13 pounds per capita of trap grease were collected, the U.S. could produce as much as 3.5 billion pounds. However, there is uncertainty about the water content of trap grease. It is



also unclear if mention of “trap grease” refers to the product before or after water and impurities have been removed. Assuming there is 60 percent water in trap grease, there could be the equivalent of 1.4 billion pounds or 190 million gallons of processed trap or *brown grease* in the U.S.

Using similar calculations, the CDR study indicates that 56 million pounds of trap grease is available in the metro area. Assuming a 40 percent yield of fat from trap grease would suggest that 22 million pounds of fat, or the equivalent of about 3 million gallons of biodiesel, is flushed into sewer systems in the Twin Cities each year.

#### Summary of Inexpensive Grease Resources

The Renewable Fuels Standard (RFS) now being considered in the U.S. Congress requires the use of 5 billion gallons of renewable fuels by the year 2012. It is estimated that this will create a market for 340 million gallons of additional biodiesel fuel and 2.49 billion additional gallons of ethanol. <sup>(8)</sup> It is estimated that most of the biodiesel will be made from soybean oil. However, if all the yellow grease produced in the U.S. were converted to biodiesel, it could produce 200 to 350 million gallons of biodiesel. Depending on the accuracy of reports, there is also the potential for 190 million gallons from trap grease and 100 million gallons from choice white grease. Given the assumptions made in the above analysis, Minnesota could generate 3 to 6 million gallons of biodiesel from yellow grease annually.

### **ECONOMIC CONSIDERATIONS OF BIODIESEL FROM YELLOW GREASE**

The cost of production for biodiesel is dependent on many variables, including those described below.

The cost of design, permitting, construction and start-up of a biodiesel facility is one of many factors to be considered when contemplating the cost of production. These costs will vary depending on site specific issues such as the local cost and availability of water, waste treatment, professional services, labor and transportation. The location of the proposed plant may or may not include adequate rail or road access, water and sewage treatment or a number of other factors that could increase or reduce the cost of construction.

This industry may be poised for significant growth and the construction of multiple new biodiesel plants in the next few years is possible. The rapid growth could result in intense competition among engineering and construction firms to establish their reputation for building plants that operate efficiently and are completed on time, according to budget. Interest and principal payments on buildings and equipment will also depend upon the credit market and individual project characteristics.

The cost of production inputs, such as fat and oil products, reagents, catalysts, labor, electrical power, process energy, and service and supplies must be considered. It is advisable to use historical prices for consideration of the potential cost of biodiesel

production at the location of a proposed facility. Yet in the changing market, there are no guarantees that the prices of any of these factors will follow a given pattern.

Although the efficiency of the U.S. transportation infrastructure generally tends to reduce the negative impact of proximity to input supply, these issues must also be taken into consideration and must be balanced with considerations of proximity to the market for biodiesel.

Many of these cost factors have fluctuated over time and are subject to continued changes pending market, political and regulatory developments. It is important for any developers and potential investors to carefully consider these factors before taking the action. Although no amount of research can remove all doubt or risk, it is important to conduct a thorough evaluation, including the development of a business plan that provides a foundation for the decision-making process.

The beginning of the ethanol industry in Minnesota in the early 1980s saw a similar need to evaluate the potential for successful development of ethanol production facilities. Many plants were built and much stock was sold despite considerable risk factors, including low ethanol prices, high corn prices and uncertain political and regulatory landscapes. In hindsight, the process was successful. Out of 15 major ethanol production facilities developed in Minnesota, 14 remain in business. Many investors gained sufficient return on their investments to provide the confidence to expand existing operations. It should be kept in mind that the state of Minnesota provided a significant production incentive and that the relative prices of corn and ethanol have, for the most part, been favorable.

Some aspects of the decision-making process are changed by the success of the ethanol experience. Prospects for successfully developing a renewable liquid fuel that will replace imported fossil fuels have improved. The concept of developing locally funded, economically viable units of production has gained credibility. Certain programs of assistance that can help stimulate local investment and development have been identified. As with ethanol, any investment in biodiesel will involve considerable risk and requires the careful examination of related markets and technology.

## **BUILDING ANOTHER RENEWABLE FUEL INDUSTRY**

In the 1990s, hundreds of millions of gallons of ethanol were produced and sold throughout the U.S. because a federal tax credit helped make the cost of ethanol competitive with the cost of gasoline. The production of ethanol was profitable for large, diversified corn processors. Local investors and policymakers struggled to evaluate the potential risks and benefits of developing small dry-mill ethanol production facilities. The goal was to design plants that would be large enough to benefit from state-of-the-art equipment, professional management and competent technical staff, yet small enough to be within reach of local investors. The Minnesota ethanol plants' ability to prosper was partly due to the fact that farmer owners produced corn, the basic raw material for ethanol

production. A similar advantage may be available to producers of vegetable oils and grease products.

Biodiesel does not presently enjoy a tax credit and therefore has not been competitive with the price of diesel fuel. Although biodiesel sales have increased in recent years, hard statistics are difficult to find. Most biodiesel has been used in demonstration projects, to qualify for federal Alternative Fuels requirements or in low concentration blends of 2 percent or less. The prospect for successful biodiesel production is heavily dependent upon the outcome of Congressional action. If the biodiesel tax credit provisions of the energy bill now being considered in Congress become reality, the production and use of biodiesel will most likely increase dramatically.

The feasibility of biodiesel production from yellow grease depends upon process efficiencies, product quality and input/output economics. Yellow grease is currently being used for the production of biodiesel, the product does in fact meet ASTM specifications and yellow grease is often half the price of soybean oil. (See Chart 3) These basic considerations would indicate that the economics of biodiesel production from "waste grease" should be competitive with production from soybean oil, but such production is currently limited. In the fall of 2001 when the MDA was looking for biodiesel suppliers, several soy-based biodiesel suppliers were identified, but only one yellow grease biodiesel vendor could be found. It is not clear that mono-alkyl esters from inedible fat products have access to key markets that esters from edible products now enjoy. If that is the case, this might explain the reason for the low number of producers.

It is very important to ensure that the engineering and construction will result in an efficient and dependable system. Also, the size of the facility may be limited by the availability of raw materials. It is important to ensure that the facility is large enough to support high quality equipment, skilled labor and competent management and marketing expertise. Quality in these areas will enhance the likelihood of efficient and profitable operation. If there is only enough yellow grease in Minnesota to produce 5 million gallons of biodiesel, then the prospect of building a plant dedicated solely to the production of biodiesel from yellow grease may deserve even more careful scrutiny. A plant that would operate on multiple raw materials might be more feasible from a supply standpoint, but design and operation of a plant that would efficiently switch from one feedstock to another might present a significant operational challenge.

## **MARKETING BIODIESEL**

Marketing biodiesel will be similar to the marketing of ethanol in that it will be sold through the petroleum infrastructure, where the product will be blended and sold along with conventional diesel fuel.

In terms of performance characteristics, such as energy density and distillation and combustion properties, biodiesel is more similar to diesel fuel than ethanol is to gasoline. Also, biodiesel is not saddled with the negative image that ethanol assumed because of

the problems associated with the radical changes taking place in gasoline refining at the time of ethanol's introduction. When Minnesota ethanol projects were initiated, hundreds of millions of gallons of ethanol were being marketed across the nation and marketing was already quite heavily consolidated. At first, ethanol marketing was done by each individual plant. Later, plants merged their marketing efforts or signed on with existing marketers. The marketing of fuel ethanol for small producers is still evolving and yet, by comparison, the market for biodiesel is relatively undeveloped.

Another significant factor is that, although biodiesel is a relatively new market, mono-alkyl esters (the chemical term for biodiesel) and similar chemicals have been used in the chemical and food market for many years. Current estimates of total U.S. methyl ester and fatty acid production is 1.968 billion pounds, the equivalent of 276 million gallons of biodiesel.<sup>(20)</sup> It is not clear that these manufacturers could or would change to the production of biodiesel, but some producers of esters and fatty acids may be potential producers of biodiesel. Currently, few producers are seriously engaged in the biodiesel market, but this condition could rapidly change in the event of federal tax credit legislation. As with ethanol, a tax credit could bring the cost of biodiesel more in line with the cost of conventional diesel fuel.

As biodiesel is established in the marketplace, its price will most likely be influenced more by the price of conventional diesel fuel than by the price of the fats and oils from which it is made. Therefore, profits for the biodiesel industry are likely to ebb and flow with the relationship between the price of diesel fuel and the cost of fats and oils. One of the most difficult factors to predict is the price and availability of conventional crude oil in the foreseeable future. A very destabilizing influence on petroleum prices is the fact that most of the world's crude oil reserves are concentrated in the politically volatile Middle East. Growing debate about the impact of the consumption of fossil fuels on global warming may also prompt regulatory actions that could increase the cost of petroleum products.

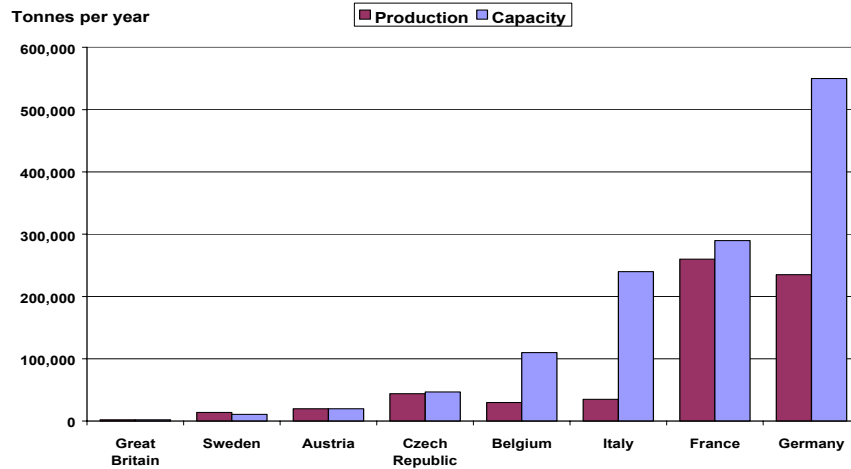
In addition, there is emerging scientific concern that the world supply of conventional crude oil could begin to decline in the next 10 to 30 years.<sup>(12)</sup> The U.S. production of conventional oil peaked in 1970, and has steadily declined since then. Geology experts suggest that when world oil production peaks, the supply of conventional crude oil will steadily decline. Combined with the potential for rapid growth in developing economies, and a related increase in their demand for petroleum products, these factors indicate that the future of crude oil prices is far from certain.

The greatest single barrier to increased biodiesel use in the U.S. market is its cost compared to conventional diesel fuel. Any increase in the cost and consumer price of diesel fuel will directly influence the marketing of biodiesel. Diesel prices in Europe are considerably higher than in the U.S., partially due to a higher fuel tax. This may help explain why biodiesel usage there is greater than it is in the U.S.

## WHAT ARE EUROPEAN COUNTRIES DOING WITH BIODIESEL?

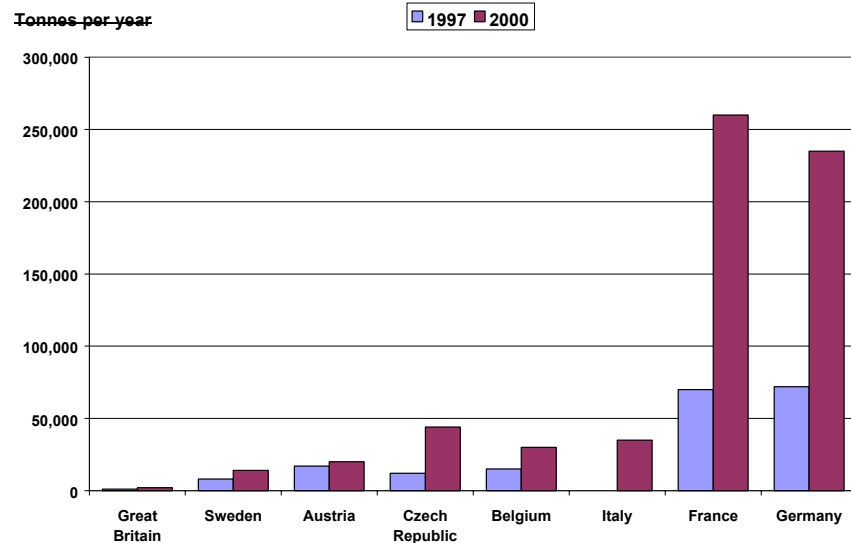
European countries are ahead of the U.S. as their use of biodiesel increased dramatically from 1997 to 2000. While using a fraction of the diesel fuel used in the U.S., France produced over 250,000 metric tons (62 million gallons) while Germany exceeded 230,000 metric tons, (62 million gallons) of biodiesel in the year 2000.<sup>(5)</sup> By comparison, industry experts estimate 25 million gallons of biodiesel production in the U.S. for 2002.

**Chart 15. Biodiesel Production and Production Capacity in the European Union, 2000**



Source: Oelmühle Leer Connemann GmbH & Co.<sup>(11)</sup>

**Chart 16. Biodiesel Production in the EU, 1997 and 2000**



Source: Oelmühle Leer Connemann GmbH & Co.<sup>(5)(11)</sup>

According to Energy Information Administration, average retail prices for diesel in the U.S. spiked at \$1.49 per gallon in the year 2000. At the same time (converting diesel prices obtained from EUROPA<sup>(23)</sup> to U.S dollars per gallon) prices in Germany averaged \$2.58, France \$2.75 while U.K. prices topped out at \$4.27 per gallon. These prices may help explain the difference in biodiesel market penetration between the US and Europe.

**Table 3. Diesel Fuel Prices in the EU and the US, 1990 to 2000**

*U.S. dollars per gallon, including tax*

Country	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Belgium	1.73	2.03	1.83	2.07	2.07	2.10	2.17	2.34	2.14	2.00	2.47
Denmark	2.00	2.14	1.90	2.17	2.03	2.10	2.17	2.37	2.20	2.10	2.78
Germany	1.76	1.80	1.73	1.86	2.00	2.00	2.17	2.27	2.00	1.86	2.58
Greece	0.68	1.05	1.29	1.76	1.63	1.59	1.73	1.90	1.76	1.63	2.10
Spain	1.53	1.90	1.86	1.90	1.80	1.73	1.86	1.97	1.83	1.76	2.10
France	1.76	1.86	1.69	1.76	2.03	2.00	2.17	2.37	2.27	2.14	2.75
Ireland	2.44	2.51	2.24	2.41	2.30	2.24	2.30	2.71	2.51	2.30	2.61
Italy	2.07	2.47	2.44	2.20	2.24	2.14	2.37	2.61	2.47	2.34	2.85
Luxembourg	1.22	1.29	1.25	1.56	1.66	1.73	1.80	1.97	1.83	1.66	2.14
Netherlands	1.59	1.73	1.63	1.97	2.10	2.07	2.24	2.41	2.27	2.17	2.64
Austria						2.10	2.27	2.37	2.30	2.03	2.47
Portugal	1.59	1.90	1.93	1.93	1.83	1.83	1.83	2.00	1.93	1.86	1.86
Finland							2.14	2.41	2.27	2.14	2.61
Sweden						2.64	2.58	2.64	2.47	2.27	2.75
UK	1.83	2.10	2.03	2.00	2.34	2.34	2.30	2.88	3.22	3.08	4.27
EU average	1.80	2.00	1.90	1.93	2.07	2.03	2.17	2.41	2.30	2.17	2.78
US						1.11	1.24	1.20	1.04	1.12	1.49

*Source: EUROPA<sup>(23)</sup> and Energy Information Administration<sup>(24)</sup>*

## POLICY IMPLICATIONS OF THE GREENHOUSE GAS DEBATE

Animal fats and vegetable oils are ultimately products of current solar energy. Solar energy is used by plants to convert carbon dioxide and water from the atmosphere into proteins, starches, cellulose, oil and other products. These *biomass* agricultural products are created and harvested each year and therefore are referred to as *renewable*. Animal agriculture uses plant material to provide other renewable biomass energy.

By contrast *fossil* fuels (coal, natural gas and oil), also originating from plant and animal matter, were created and buried underground over millions of years as fossilized plant and animal material. Humans have become so efficient in extracting fossil fuels that we have mined nearly half of the known reserves of conventional crude oil in the last 100 years. It took nature hundreds of millions of years to produce and store conventional crude oil and we have extracted and used half of that oil in just 100 years. Given that our demand for crude oil continues to increase, it is evident that nature will not replace conventional crude oil in time to meet the timetable established by world markets.

In addition, the use of fossil fuels involves the burning of most of the carbon they contain to produce energy, as well as large amounts of carbon dioxide gas (CO<sub>2</sub>). CO<sub>2</sub> is the

single largest and most important *greenhouse gas*, and a growing number of scientists believe this process is accelerating global warming. They believe this trend may be leading to an increase in severe weather, damage to the environment and increases in diseases and coastal flooding.

According to the recent EPA publication, U.S. Climate Action Report 2002, <sup>(2)</sup> President Bush “reiterated the seriousness of climate change and ordered a cabinet level review of U.S. climate change policy.” The report acknowledges the President’s climate change initiative announced in February 2002, articulating the need to “enhance the reliability of U.S. energy supplies and reduce U.S. reliance on energy imports.” It also proposes to “increase funding for research and development of renewable and alternative energy resources.”

The report includes an emissions inventory that quantifies U.S. greenhouse gas emissions in terms of the equivalent of one million metric tons of CO<sub>2</sub> (Tg CO<sub>2</sub>). The report indicates that U.S. total greenhouse gas emissions for 2000 were 7,037 Tg CO<sub>2</sub>. Of the total emissions, 83 percent were caused by the use of fossil fuels. Without action, the projection for the year 2020 indicated total greenhouse gas emissions of 9,502 Tg CO<sub>2</sub>, again with 82 percent originating from the use of fossil fuels. Of the fossil fuel contribution to greenhouse gasses, 3,266 Tg CO<sub>2</sub> (41 percent) was from the use of petroleum fuels alone. This would indicate that replacing gasoline, diesel fuel and other petroleum products will continue to be an important public policy issue.

Carbon sequestration is another issue in the Bush Administration’s climate change policy. The report calls for improved management practices on forest and agricultural lands, combating soil erosion and renewed support for renewable energy and energy efficiency tax credits. This also indicates the intention of the administration to use agricultural production to help replace imported fossil fuels.

## **IMPACT OF BIODIESEL ON THE LIVESTOCK FEED MARKETS.**

According to Promar, <sup>(3)</sup> the two main sources of fat in all livestock rations are corn (52 percent) and added fat products (32 percent), such as choice white grease and yellow grease, with the balance of fat (16 percent) coming from other products. The value of fat in livestock rations is primarily in its ability to deliver calories (energy) for livestock production. Pound for pound, animal or vegetable fats have twice the energy content of corn and most other common livestock feed ingredients.

As indicated in previous sections, the use of yellow grease and choice white grease could remove 2.9 billion pounds of fat currently used for the livestock and pet food industry. If competition from biodiesel producers removed a portion of these fat products from the livestock feed market, livestock rations could make up the energy by feeding additional corn, distillers grain, gluten feed, oilseed meal, and other feedstuffs.

It is interesting to note that the Renewable Fuels Standard (RFS) legislation is expected to help increase ethanol production by nearly 2.5 billion gallons by the year 2014. <sup>(8)</sup> It is estimated that more than 2.1 billion gallons of this new ethanol production will come from an expansion of the dry-mill corn processing industry. A byproduct of the corn dry-milling industry is a high-protein livestock feed known as dried distiller's grains with solubles (DDGs). As a result of expanded ethanol production, an additional 6.4 million metric tons of DDGs is expected to be produced in the U.S.

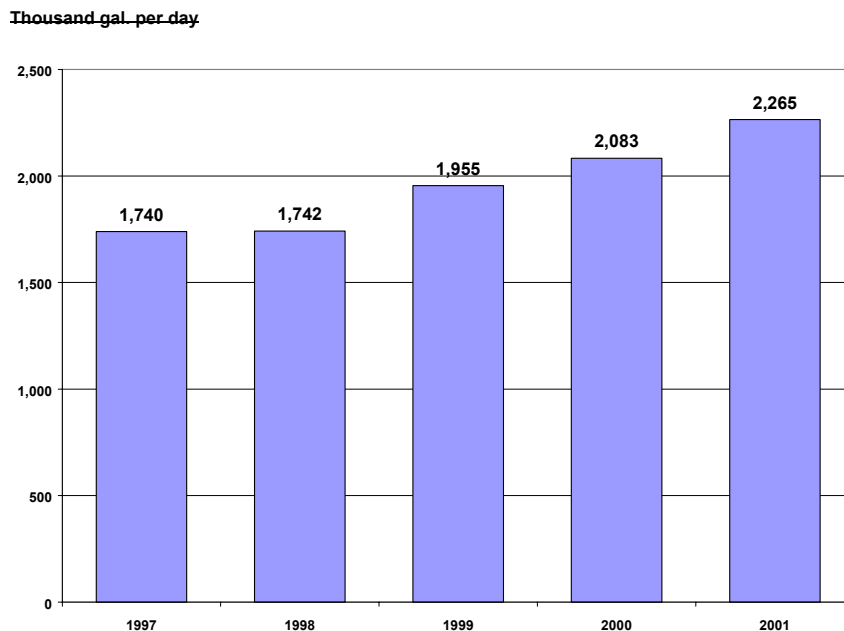
The balance of ethanol, 400 million gallons, is expected to come from wet mill plants. A combination of increased production and a reduction in exports is expected to add an additional 1.2 million metric tons of corn gluten feed. <sup>(8)</sup>

DDGs, as a result of its high oil and fiber content, is roughly equivalent in energy to a corn and soybean ration for swine and poultry production. Cattle, however, have the unique ability to convert fiber into energy. This means that the relatively high fat content of DDGs compared to corn and soybean meal provides a rich source of energy for cattle rations.

### **THE INCREASE IN DIESEL FUEL USE IN MINNESOTA AND THE U.S.**

The increase in the use of diesel fuel in Minnesota exceeds that of the U.S. as a whole. Diesel fuel use in Minnesota increased 30 percent between 1997 and 2001 compared to the U. S. increase of 17 percent.

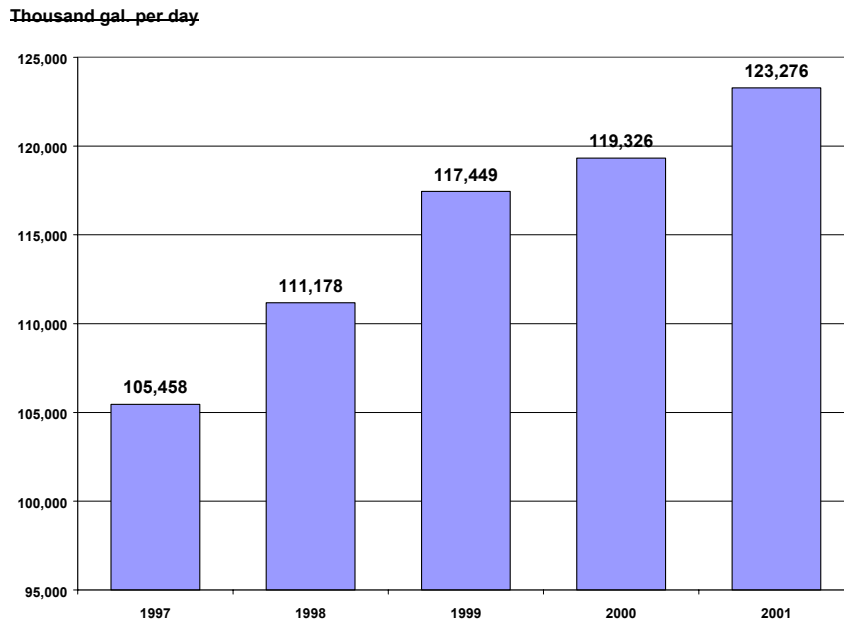
**Chart 15. MN Diesel Fuel Sales Trend**



Source: Energy Information Administration



**Chart 16. U.S. Diesel Fuel Sales Trend**



*Source: Energy Information Administration*

### **INCREASED USE OF DIESEL ENGINES FOR LIGHT DUTY VEHICLES.**

On September 3, 2002, the EPA released findings relevant to the impact of diesel exhaust on human health. The significance of this report is that it strengthens the EPA's attempts to require cleaner diesel engine technology and lower sulfur content of diesel fuel. Reduced sulfur is expected to reduce pollution from diesel engines and allow catalysis and particle traps to remove more pollutants from diesel exhaust. Unfortunately, removing sulfur from diesel fuels also reduces the lubrication properties of diesel fuel, creating increased wear in the fuel system components of many diesel engines. Biodiesel, even at low levels, has the capacity to replace the lubricant properties of diesel fuel and to protect diesel engines from component failure.

It is believed that, with cleaner diesel fuels and diesel engines now being pursued by the EPA and developed by industry, more diesel powered light trucks, SUVs and even passenger cars will be produced. The greater use of cleaner diesel engines and fuels can lead to increased mileage and fewer emissions. The increase in the use of diesel engines in light and medium duty vehicles would also substantially increase the demand for diesel fuel and biodiesel.

## CONCLUSION

The final outcome of federal energy legislation will play a defining role in the growth of the biodiesel industry and the involvement of the grease industry in that market. Given the sheer magnitude of the U.S. soybean oil market and the extensive development of its refining and processing industry, soybean oil is likely to dominate biodiesel production for the foreseeable future.

The processing of grease products for biodiesel is technically feasible and its relatively low raw material cost is definitely an advantage. Given the existing grease market and processing industry structure, biodiesel production from grease may develop as a profit center for existing renderers, or as an alternative for multi-feedstock or specialized processors. With increased development, grease processing technology is likely to improve and has the potential to add diversity and stability to the biodiesel market. Greater use for biodiesel production also has the potential to increase overall grease prices and possibly reduce the amount of grease disposed of in land fills or water treatment facilities.

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