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Government Mandates Mandate More Research

Earlier this year a bill was introduced into the Minnesota legislature calling for mandates surrounding the fuel "biodiesel". Backed strongly by in-state agricultural interests, the bill finally hit a snag this past week in the House, where the mandate was reduced in scope to just state vehicles (Brunswick). In the development of American gasoline and diesels, government regulators play the biggest role. The Environmental Protection Agency (EPA) has long regulated sulfur content in diesel fuels, and is considering regulating biodiesel content too. Biodiesel is a viable alternative to traditional diesel for many environmental and political reasons. However, it would be jumping the gun for Washington or any state legislature to tote it as an environmental cure-all simply because research has yet to fully explain its environmental and economic implications and chemical characteristics.

Biodiesels, or the class of fuels made from renewable biological sources such as animal fats and vegetable oils, are not a new thing: Rudolph Diesel's first diesel engine ran on pure peanut oil in the late 1800s. However, pure vegetable oils were soon deemed less effective fuels than the less viscous and more volatile petroleum-based diesel. In a short time, with seemingly plentiful supplies of fossil fuels and little knowledge of air pollution and health risks, petroleum diesel had replaced the more renewable biodiesels.

However, with new technologies currently available to improve biodiesel's properties and diminishing supplies of fossil fuels, biodiesel is being studied and publicized with renewed vigor. The Federal Government has cited biodiesel in its efforts to decrease petroleum dependency in its fleets by 20% by 2005 (Duffield 34). Some environmental groups promote biodiesel because of its lower emissions profile while farmers like the idea of fatter wallets from higher crop prices (Brasher). Activists see biodiesel as an alternative to drilling in the Arctic National Wildlife Refuge. But is America ready for biodiesel? Is biodiesel ready for America?

Much of America is more than ready for biodiesel, as it can be used in any diesel engine without modification. With oil prices on the rise, destructive methods of oil extraction practiced elsewhere in the world, the Organization of Petroleum Exporting Country's (OPEC) dominance looming and the Middle East's volatility unchecked, many politicians are interested in decreasing America's reliance on good ole' petrol, and especially OPEC oil. Transportation fleets across the country are ready, if not forced, to lower their greenhouse-gas emissions in order to get credits in the Federal Government's Energy Policy Act of 1992 (EPACT) system. Clean air advocates across the country are calling for better and less toxic and carcinogenic diesels. Also, California, more than any state, could benefit from a reduction in oil use: California power companies, pressed to the wall by demand and an unstable regulatory system, are pursuing modifications to make existing oil-based power plants burn biodiesel. The time has certainly come for biodiesel, if not all renewable fuels.

But can biodiesel deliver? This paper serves to show that biodiesel can, and probably *will* be all that America expects it to be. Until it is, however, biodiesel is not ready for America. The slow evolution of biodiesel has led to new discoveries and a better fuel. More focused research can only add to the benefits of the fuel. However, the brute force of a Government mandate is premature because proper research has not shown the extent of biodiesel's environmental and economic implications and its chemical limitations.

Certainly the main impetus behind the push for biodiesel is its environmental benefits. Perhaps the most cited benefit is the reduction of tailpipe emissions. However, these benefits are called into question when the entire life cycle of the fuel, from the raw source to the tank, is considered, as it was in a 1998 study performed jointly by the US Department of Agriculture and the US Department of Energy (Sheehan, J et. al). Tailpipe emissions are telling when viewing pollutants on an urban scale. However, when viewing overall environmental impacts from a fuel, life-cycle data is much more important. Figure 1 to the left shows the commonly agreed upon tailpipe emission statistics for biodiesel versus conventional diesel, and next to it is Figure 2, a chart of data from a 1998 study relating the life cycle emissions of these pollutants in biodiesel blends to those of petroleum diesel. As one expects, higher blends of biodiesel yield higher

Regulated	
Total Unburned Hydrocarbons	-93%
Carbon Monoxide	-50%
Particulate Matter	-30%
NOx	+13%
Non-Regulated	
Sulfates	-100%
PAH (Polycyclic Aromatic Hydrocarbons)	-80%
nPAH (nitrated PAH's)	-90%
Ozone potential of speciated HC	-50%

Figure 1 Tailpipe Emissions (Biodiesel: The Clear Choice).

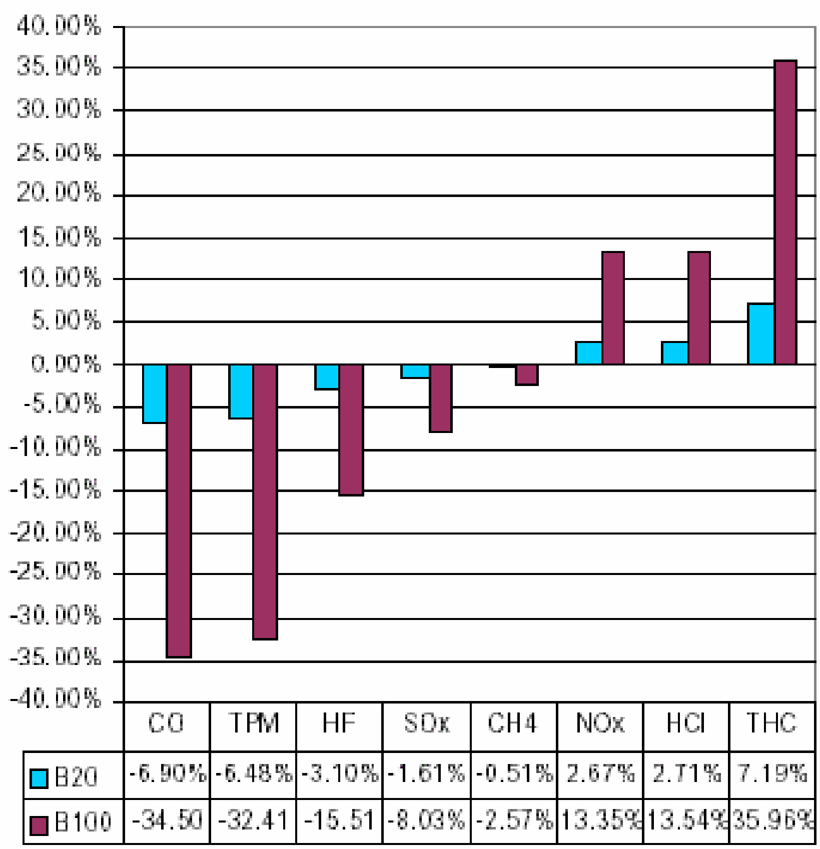

Figure 2 Life Cycle Emissions (Sheehan, J et. al. 5)

percentage changes.

So what does this data say about biodiesel versus conventional diesel? First of all, at the tailpipe, biodiesel is a very clean burner. Figure 1 highlights drastic reductions in almost all pollutants with the most noticeable being those that are obvious to the senses. Biodiesel exhaust is not the traditional sooty, smelly diesel we have long associated with trucks and buses.

However, the emissions associated with a fuel are not only found at the tailpipe. One obvious disparity exists between Figure 1 and Figure 2. Total Unburned Hydrocarbons (THCs) are well known greenhouse gases, and while decreased by 93% at the tailpipe, are hugely increased in the life cycle of soybean-based biodiesel. This disparity is due to large amounts of THCs produced during the soybean crushing process. In effect, use of biodiesel will drastically reduce THC concentrations in urban areas in exchange for very high concentrations near soy-bean processing plants. Research into the effects of this trade-off has yet to be done.

Unlike THCs, the other pollutants line up across figures. A 34.5% reduction in Carbon Monoxied (CO), an EPA monitored ozone- and smog- producing gas, and 32% reduction particulate matter (TPM), which has been linked to certain types of lung cancer and respiratory diseases, is shown in the life cycle data. The PM that does leave a biodiesel powered engine is much more water-soluble, and techniques already in place to reduce petroleum diesel particulate matter have even more success with biodiesel. Also, biodiesel particulate matter has been proven to be less mutagenic and toxic in lab animals than diesel PM (“Cytotoxicity” 490). With biodiesel, black soot is a thing of the past.

On the other hand, the life cycle emissions of Hydrochloric Acid (HCl), a key element in acid rain, and Nitrogen Oxide (NO_x), another smog-producing gas, are both increased by 13 percent. HCl is produced during the refinement of biodiesel, whereas NO_x is produced in the diesel engine. It is possible that engine modifications may reduce NO_x emissions, but many of those proposed also limit engine performance. The real question is whether benefits from reductions in CO, TPM, and sulfates outweigh the costs from increase in THC, HCl, and NO_x emissions. Future research into these tradeoffs and their effects on the environment of cities, lakes and the world as a whole should be performed before biodiesel is mandated in any percentage blend.

Adding to the confusion behind the environmental impacts of biodiesel is the basic unpredictability of emissions data. Older cars often show lesser reductions, and oils other than soybean show different results. For example, when Thomas Durbin tested four light-duty trucks with soy-based biodiesel and F-T (synthetic) and California diesels, he recorded data starkly different from that displayed in Figure 1. By following the Federal Testing Procedure (FTP) for diesel engines, Durbin's results, as seen in Figure

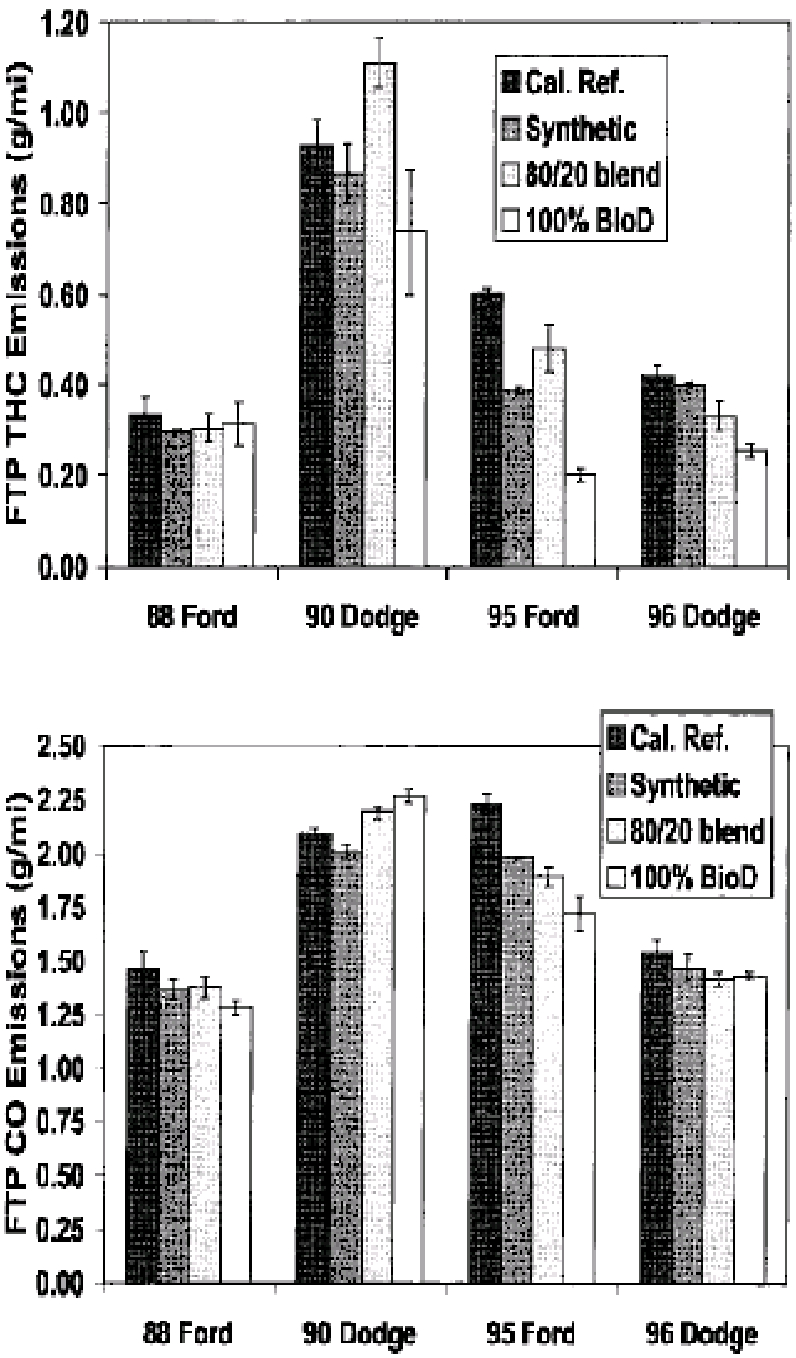

Figure 1 Varied Emissions Results (Durbin 352).

3, highlight the varied responses of different sizes, makes, and models on emission results. Also, when Wang studied the emissions from 9 heavy duty trucks he found equally conflicting results (935-7). Future studies should be done in an effort to better determine the factors in this variability, so the feasibility of necessary modifications to correct it can be established. This should be done before biodiesel is mandated, as the fuels benefits in newer engines may be outweighed by its shortcomings in ’90 Dodges, for example.

Aside from emissions data, there are a few other environmental impacts that require research before wide scale biodiesel use should be recommended. For instance, though biodiesel replaces oil at the pump, it still relies on fossil fuels for its production. Figure 4 charts the amount of fossil fuels and water used in the life cycle of biodiesel blends and petroleum diesel. Pure biodiesel production relies on fossil fuels for electricity during refining and agricultural pesticides and fertilizers applied to the feedstock seed-oil crop. This reliance ties coal and natural gas price fluctuation inevitably to the price of biodiesel, and is a major non-renewable aspect of biodiesel. Research into improving the efficiency of the soybean->biodiesel process or changing agricultural inputs could certainly cut down on this

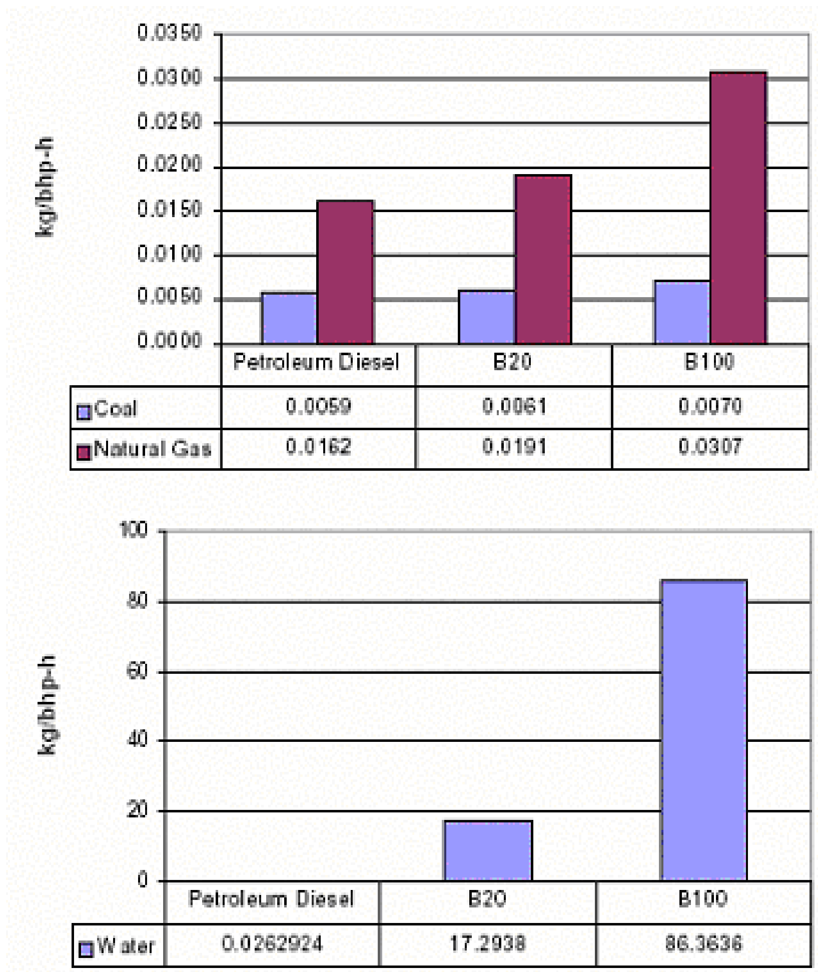

Figure 2 Fossil Fuel and Water Usage (Sheehan, J et. al. 16).

dependence. Otherwise, the ramp-up of soybean production will come hand in hand with electricity shortage and higher prices for not only electricity, but biodiesel as well. Similarly, figure 4 shows the exorbitant amount of water used for 100% biodiesel. Research into the effects of mass biodiesel production on our nation's water tables should be conducted.

While the production of biodiesel relies heavily on electricity and water now, the biodiesel refining process is a new one. Because of all the emissions benefits conceivable with biodiesel usage, the refining process should be streamlined in order to affect our already strained power grid and water tables as little as possible. Also, our nation's diesel fleet is a varied but primarily aging one. If Durbin's study suggests anything, it calls into question the applicability of emission reduction data to older vehicles. Finally, though the biodiesel emission statistics contain more positives than negatives, the tradeoffs inherent in the statistics need to be examined. Until the effects of these attributes of biodiesel mass production are known, the government should hold off placing it in American fuel tanks.

Certainly, the mass production and use of biodiesel will affect more than just the environment. Every government mandate always carries with it some sort of associated cost; whether it is the private sector reacting to a new environmental code or the public sector responding to federally mandated petroleum-use reductions. What are the economic implications associated with a biodiesel mandate?

The major limiting factor in biodiesel usage today is its cost—anywhere from 15 cents to a dollar more than traditional diesel. Recent federal subsidies for soybeans have brought the price down slightly. However, there are a number of reasons why biodiesel will continue to be a costly fuel.

The most pressing reason is the simple lack of supply of potential feedstocks. Figure 5 shows that if ten percent of potential feedstocks were used to produce fuel, biodiesel could only make up 7% of all diesel sold—a problem when you consider that many feedstocks are already used elsewhere in the agricultural world as food for farm animals. With biodiesel demands, the price of these feedstocks can only go up, sending ripples through the agricultural industry to the consumer in the form of a 50 cent surcharge for milk, even before increased transportation costs from biodiesel are taken into account. How much can production be ramped up before other barely profitable agricultural industries are adversely affected?

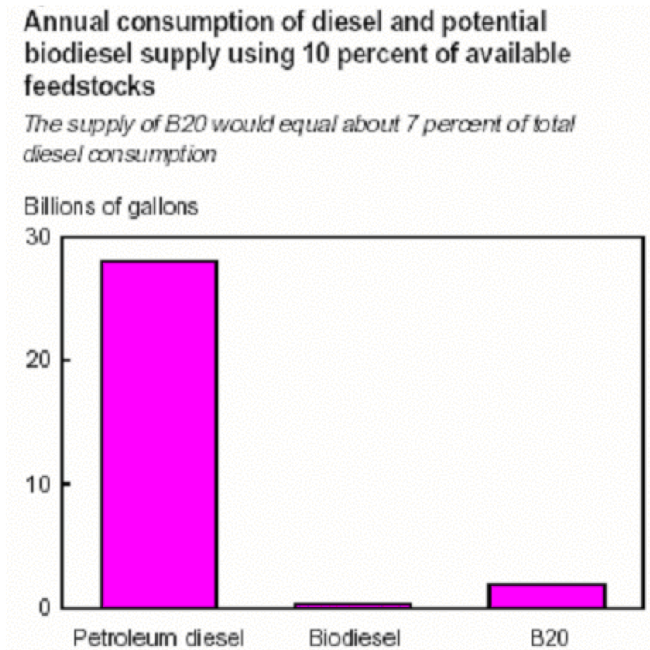

Figure 3 (Sheehan, J et. al. 7).

Adding to the problems of limited supply, the price of biodiesel feedstocks are very variable and consistently more expensive than standard petroleum. In high-yield years prices drop and during droughts they soar. Shall we be at the whim of the weather or of OPEC? Figure 6 shows just how variable feedstock prices can be. Furthermore, the soybean oil prices below do

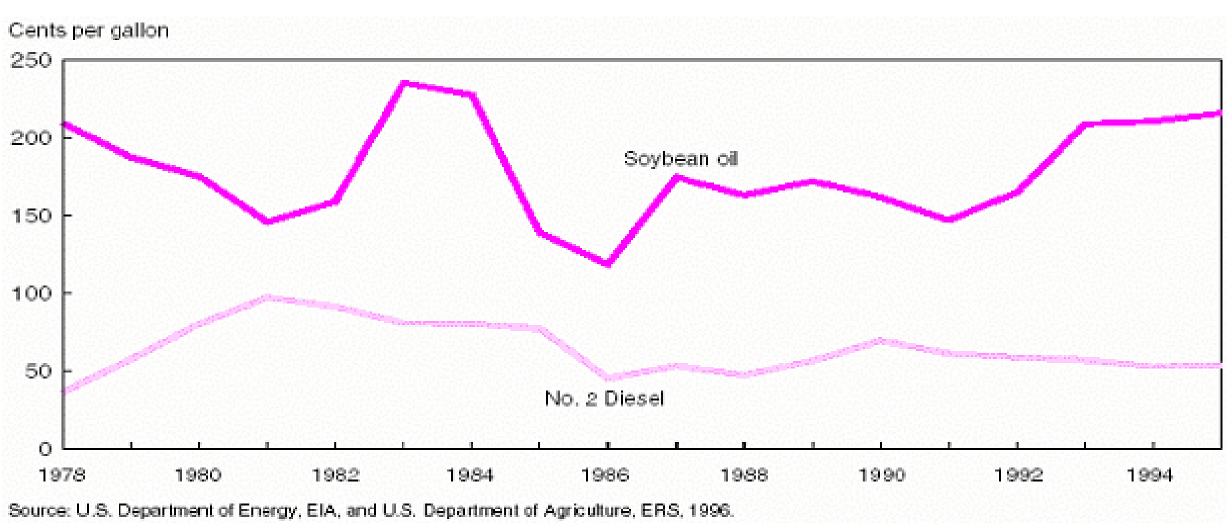

Figure 4 Price of Soybean Oil and No. 2 Diesel (Sheehan, J et. al. 11).

not even reflect refining costs which typically add 50 cents or so to biodiesel by the gallon. Of course, cheaper feedstocks such as yellow grease could be used—see Figure 7. Yellow grease, the cheapest feedstock option next to pure petroleum diesel, is a term for leftover restaurant grease and similar greases, and has given biodiesel infamy as the “French Fried Fuel”. However, biodiesel made from the cheapest feedstocks tends to perform much worse overall, freezing at

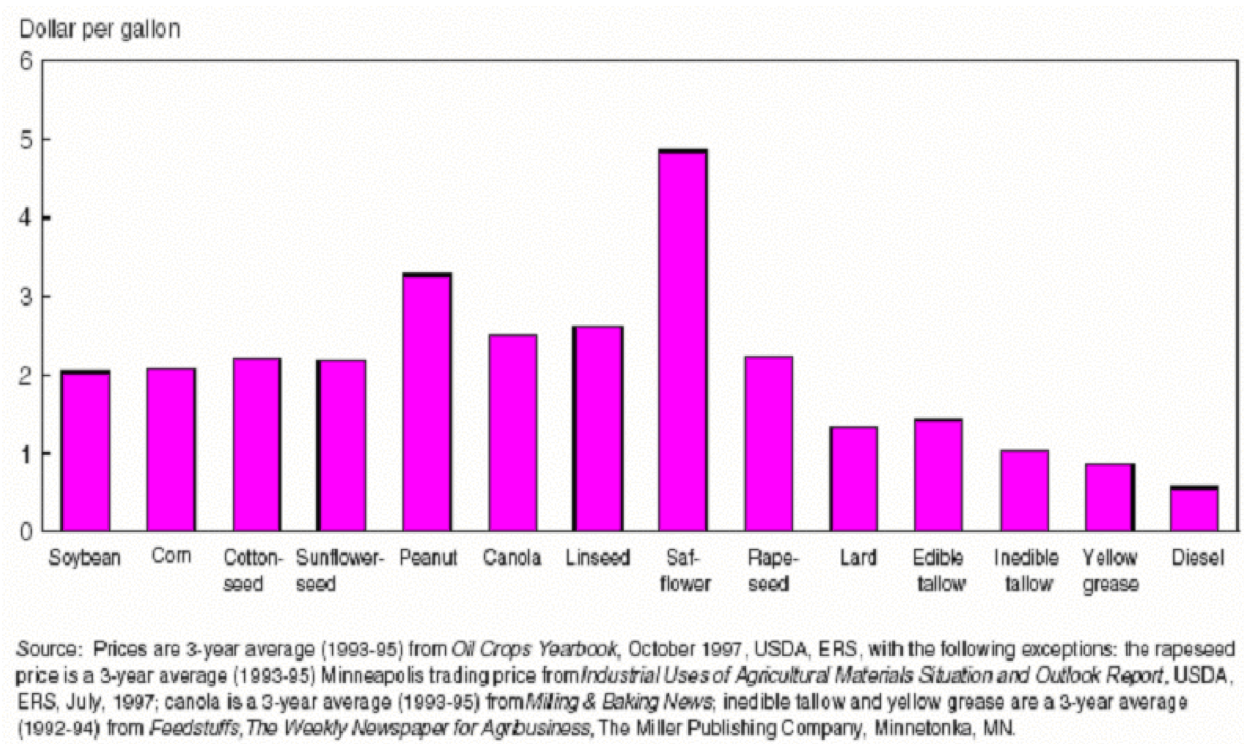

Figure 5 Biodiesel Feedstocks and Prices (Sheehan, J et. al. 10).

higher temperatures and reducing gas mileage noticeably.

The aforementioned supply-side issues are consumer-side nightmares. Everyone notices price increases on their milk carton due to oil price hikes. A single cent increase in the price of fuel cuts another cent, if not two out of the US economy. Such price fluctuations could be much more devastating with a trucking industry powered by vegetable oil, if acreage existed to provide enough feedstock for such demand. Before biodiesel can power our transportation fleets, a stable feedstock needs to be identified that can be produced in large quantities without disturbing the agricultural balance. Research into hydroponic farms, genetically engineered high-oil feedstock, and higher yielding crops is necessary. Curbing refinery costs is also an option that should be pursued. Many cite the possibility of selling the byproducts of biodiesel—glycerine, fertilizer, soapstock—as a way to lower costs.

Aside from supply-side concerns, another economic concern is the decreased power of bio-derived diesels. Figures range wildly—a commonly agreed upon stat cites a 10% decrease in fuel economy and engine power (Biodiesel—The Clean 1). This figure is larger for higher saturated oils and less for oils like soybean and rapeseed. Nonetheless, even if all of the costs incurred producing biodiesel are minimized, a biodiesel user will pay more refueling with veggie fuel and get less power for fewer miles.

The final area of scrutiny when considering a biodiesel mandate should be biodiesel's characteristics as a fuel and how closely it resembles actual diesel in the engine. Among biodiesel feedstocks, composition varies greatly. When used to make biodiesel or biodiesel blends, these feedstocks create fuels with different properties that offer distinct advantages and disadvantages over petroleum diesel. The effects to engines must be analyzed to fully compare the potential of biodiesel feedstocks. Several properties can be examined to determine significant fuel quality differences, including cold flow, ignition quality, flash point, heat of combustion, viscosity, oxidative stability, and lubricity. These properties affect engine performance, storage stability, and versatility of use.

Possibly the biggest chemical difference between diesel and biodiesel is oxygen and sulfur content. Biodiesel by nature contains no sulfur while diesel contains an amount regulated by the EPA because sulfur content translates directly into sulfur oxides in the exhaust, which are known carcinogens (Mutagenicity 395). Also, petroleum diesel contains no oxygen in contrast to biodiesel's 10-12% by weight. Oxygen lowers the fuel energy content and particulate emissions. Biodiesel is also benefited by a high flash point, or auto-ignition temperature, which translates into safer storage compared to traditional diesel.

However, biodiesel's chemical composition is not entirely beneficial. One of the major objections to biodiesel, especially in the recent Minnesota case, is the cold-flow properties of biodiesel. Cold-flow properties determine a fuel's ability to function in cold temperature. Depending on the feedstock, biodiesel will cloud with wax particulate anywhere from -5ºC to 10ºC (Sheehan, J et. al 36). This characteristic can be improved with fuel additives, but not enough research has been done to yield a determinate solution. Without improvements, biodiesel powered vehicles may need to be garaged or parked with engine heaters to avoid clogged fuel filters at low temperatures.

The chemical properties of biodiesel vary by feedstock. Research should be done to determine which, if any, feedstock produces the best, or most 'diesel-compatible', fuel. Perhaps genetic engineering can then improve the feedstock's fuel properties further. Before settling upon soy-bean oil as the feedstock for the future, an in-depth analysis of alternatives should be pursued.

Biodiesel has been around for a century. However, for nearly the entire century, scientific naivety, big oil, and under-funded research have limited our knowledge of biodiesel's benefits and interest in learning more. However, economic situations and environmental awareness have brought biodiesel to the forefront, and actions like those taken in St. Paul recently are echoing across the country. Slowly, private industries with spare change and a green thumb are taking interest in biofuels. However, there are still many unknowns in this renewable resource's equation. How will biodiesel stress our power grid and our water table? Can our farms produce enough oilseeds to put fuel in the tank for a reasonable price? Can a Minnesota driver come to his truck assured that it will start in -15 degrees Celsius weather? Before the federal government can mandate biodiesel for the private sector it needs to be able to answer these and the many other questions raised in this paper. There is no question that biodiesel is an attractive alternative to petroleum diesel. However, before abandoning good ole' petrol, America should be fully aware of the consequences.

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