A Study to Determine Biodiesel Usage by Puget Sound Fleet Operators

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Abstract

This case study research seeks to determine if biodiesel use by vehicle fleets in the Puget Sound area of both commercial and municipal fleets is a suitable fuel substitute or adjunct with respect to conventional petroleum based diesel. This paper examines the 'real-world' usage of biodiesel by municipal transit and utility vehicle fleets, as well as a heavy equipment operator, compared with available literature and expert testimony in the field of biodiesel renewable fuels. In terms of environmental health justifications, this paper finds that biodiesel has a positive environmental health impact, such as reduced carcinogenic exposure to diesel equipment users and the community's environment in which they serve. "Green House" gas emissions are significantly reduced, thus reducing contributions to global warning. Therefore, on the basis of environmental and related health reasons, and related economics, biodiesel usage is justifiable.

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Introduction and Statement of the Problem

Our Oil Consumption

One does not have to search the contemporary news media too far to find articles on the concern of rising fuel prices. One way in which individual consumers feel the effects of this nation's dependence upon foreign oil occurs when they pay more for higher gas prices, especially during times of crisis such as war and hurricanes. One does not have to look far to learn of the effects of this nation's collective consumption of oil. In fact, according to a report from environmental scholars and scientists of the Natural Resources Defense Council (Greene, et al., 2004) we Americans consume about 25% of the world's total oil production, and most of that oil is exported from what is arguably described as having originated from some of the most unstable regions of the world. According to Van Gerpen, Shanks, Pruszko, Clements, and Knothe, of the National Renewable Energy Laboratory (2004) suggests that an additional fuel source such as Biodiesel, though not able to completely replace foreign petroleum oil imports, may have a significant impact on stabilizing fuel market prices. Many proponents from both business and government tout the many possibilities and reasons that alternative fuels such as Biodiesel may be a suitable replacement for petroleum based diesel.

This case-study based research paper will begin by looking at several publicly available literature examples written by business and government authorities on the subject, as well as the expert testimonial from Robert L. McCormick, Ph.D. – Principal Engineer from the National Renewable Energy Laboratory (R. McCormick, Ph.D., personal communication, February 16, 2006) in which he provides information based on his laboratory's scientifically based research regarding performance results of Biodiesel quality and performance.

An Issue of Definition

Biodiesel seems to take on different meanings to different people. There are those who believe that Biodiesel is merely the use of vegetable oil poured directly into the fuel tank and used by the engine in its raw form. Others may mistakenly refer to a mixture of 80% petroleum based diesel with the remaining 20% as biodiesel, as entirely biodiesel. Such errant definitions serve nothing more than to add confusion and possibly worse, especially when someone attempts to use raw vegetable oil in their diesel engine with the assumption that it is 'biodiesel', they will soon discover degraded engine performance and eventual damage to their engine (BECON, 2004) but the credibility or public perception of Biodiesel as a whole may be at risk. The research paper will use the U.S. Department of Energy – National Renewable Energy Laboratory's definition of Biodiesel: "…as the mono-alkyl ester of fatty acids derived from vegetable oils or animal fats." Putting that in lay-person's terms it means that when vegetable oil or animal fat (even the waste oil from the grease traps at restaurants or the fatty float-grease sludge from the sewage treatment plant) is chemically reacted with an alcohol such as de-natured or ethyl-grain alcohol, the production results in "fatty-acid-alkyl-esters", known as "Biodiesel". The only major by-product noted is Glycerol, a handy product that can be used to make soaps or cosmetics with.

Frequently, consumers may opt to mix Biodiesel with petroleum based diesel. When this is the case, a ratio is involved. Biodiesel is commonly found in either "pure" or blended form, ranging from "B-2" a ratio of 2% biodiesel and 98% conventional petroleum diesel, to B-5 (5%), or a more commonly found ratio of 20% biodiesel and the remaining 80% petroleum based diesel, known as "B20", un-blended or "pure" biodiesel is commonly known as "B100" . This paper will later explain the significance and reasons why a blend is typically used by consumers such

as those who were interviewed for this research paper. When biodiesel is referenced throughout it will for the sake of efficiency be referred to as either "B20" or if it is un-blended, then it is "B100", unless stated otherwise.

Statement of the Problem: Real-World Reasons for using Biodiesel

Washington State Governor-Christine Gregoire's recently proposed legislation which was designed to stimulate economic growth in the field of biodiesel, was loaded with incentives such as low interest loans to assist production startups. With such incentives abound, it might be easy for an individual to be caught up in the excitement of going forth with using biodiesel in transportation fleets and equipment pools in order perhaps to keep pace with a 'green energy' fad. There are actually a number of reasons why perhaps a transportation fleet manager or construction equipment manager might opt to have their engines use Biodiesel or Biodiesel blends. Most commonly cited reasons for fleet managers and individual consumers alike for using Biodiesel are usually: Economic, Political, and Environmental reasons. Using biodiesel has a few challenges, and this paper will discuss them and what actual users are reporting. The purpose of this case study is to examine and compare five equipment fleet managers reported "real-world" use of Biodiesel and to determine the various reasons why they are using it, and what issues they have learned about biodiesel usage. This paper seeks to determine if use of biodiesel is a practical adjunct to, or outright substitute for petroleum-based diesel fuel, in terms of realistic benefits that have been experienced by the fleet consumers and the communities within which they operate.

Literature Review and Expert Testimonial

Literature Review Summary

Government scientists, educational institutions and private enterprise have produced a lot of information on the subject of biodiesel. The National Biodiesel Board (NBB), is a U.S. trade association representing the nation's biodiesel industry. They report that more than 600 commercial vehicle fleets use biodiesel commercially (National, 2006). According to numerous experts in the field, there appear to be several reasons as to why consumers use biodiesel for their equipment fleets or individual vehicles. This section will steer the reader into viewing samples of what the authorities on the subject of biodiesel say about it through contemporary published literature, industry and trade publications, government findings, and expert testimony from the Department of Energy: National Renewable Energy Laboratory, as to why biodiesel may be chosen by fleet managers as a fuel source or additive to petroleum based diesel within these areas of focus: Economic, Environmental, and Political justifications. In each case interviewed by the author of this research paper, frequently more than one of the above categories was cited by the fleet and equipment biodiesel consumers as a factor in their decision to utilize biodiesel in "pure" or blended form.

Economic

Economic reasons for switching to biodiesel appear to vary depending on how economic justification is perceived by the consumer in at least the following ways: Market related, Subsidy influenced, and/or Technological concerns. Pursuit of economic justification from a 'Market' related point of view is presently difficult, but ever improving. This is primarily due to a robust

production and distribution infrastructure for this fuel has not reached a level of maturity as that of the petroleum industry (Manella, 2006). In fact, according to a guest article in the U.S. Department of Energy: Biomass Research and Development Initiative website, most biofuels production such as soy-based biodiesel originates from the Mid-West, a significant distance away from urban refineries and petroleum infrastructure pipelines according to Manella (2006). However, in growing contrast to the DOE report, according to a recent estimate by the National Biodiesel Board (April 3, 2006), there are approximately 25 petroleum terminals in the United States that have invested in equipment in preparation for blending biodiesel with petroleum based diesel prior to tanker truck shipment. What makes this significant according to the NBB, the potential of saving the consumer money by avoiding the necessity of a shipment having to make additional stops for blending, or requiring the final distribution point to purchase additional blending equipment. As the infrastructure for biodiesel is built, adapted, or improved the possibility of lower prices appears to be hopeful (NBB, 2006).

Government subsidies and other incentives such as maintenance or technically related advantages are another potential factor to consider in the decision to switch to biodiesel. At the time of this study, government subsidies were cited by at least one case study participant as a factor in their decision to utilize biodiesel. According to the "Energy Policy Act of 2005", Agriculturally based biodiesel producers are also eligible for a tax credit of .10 cents per gallon produced, for up to 15-Million gallons (Department of Energy, 2006). In June of 2005, according to an article by the Union of Concerned Scientists (November, 2005), an amendment to the Energy Bill known as "The Diesel Emissions Act of 2005", passed by the Senate, provided additional funding to help cut emissions from "high-polluting" diesel engines. Specifically, this legislation will disburse $200-million per year over a five year period, beginning in 2007, to help

states and organizations in the effort to clean up diesel fleets. It essentially creates a national program to fund the cleanup of all types of diesel vehicles such as trucks, busses, ships, tractors, and trains according to the article (November, 2005). Incentives may serve to narrow the competitive gap between conventional diesel and biodiesel, and subsequently the decision to switch a fleet to biodiesel use.

As for the biodiesel related farming industry some of the strongest reasons cited by Van Gerpen, Shanks, Pruszko, Clements, and Knothe, of the National Renewable Energy Laboratory (2004) as to why we as a nation should encourage the development of a biodiesel industry: It provides a market for excess materials such as Soy oil and waste animal fats to be utilized to allow farmers and rendering plants to be more profitable than they are now. Both the Soy farming industry and the animal by-products industry have a problem with excess oil and waste fats that presently pose a profit challenge.

With the exception of government subsidy, there are a few areas of consideration according to several sources as to why it may be more economical to switch to biodiesel fuels: Engine Technology and Production Technology.

It is not difficult to make a basic comparison between the fuel consumption rate of a diesel engine with that of a comparable gasoline counterpart. For example, a comparison between diesel and gas versions of the 2006 Volkswagen Jetta, passenger vehicle on U.S. Volkswagen website (www.vw.com) reveals that by using the diesel powered version, the fuel economy is reported to be an average of 41 miles per gallon on the freeway, a gain of 9 miles per gallon over the gasoline version. The diesel Jetta's acceleration is reportedly slower (0 to 60 mph in 11.5 seconds versus 7.1 for the gas version) but to the average commuter, one might speculate this may not be a serious concern. If one compares one fuel system over another such as switching

a vehicle fleet from a gasoline power plant to one that uses diesel there are cases to consider. A Willamette Valley, Oregon winery switched from using gasoline-consuming delivery vans to biodiesel (Alley, 2006). At the time of the article, gasoline may have been less expensive that diesel itself ($2.79 per gallon based at the time of the article) yet being less fuel efficient than diesel engines, and despite the fact the price of biodiesel was up to $3.20 per gallon, the winery still reported fuel savings over its gasoline fleet. Agriculturally based biodiesel producers are also eligible for a tax credit of .10 cents per gallon produced, for up to 15-Million gallons (Department of Energy, 2006). Such a subsidy closes the gap of cost effectiveness in order to encourage development and use of alternative fuels such as biodiesel. Couple the subsidy incentives mentioned above with the fact that many other consumers and government authorities are reporting that biodiesel can be used in any diesel consuming engine (NBB, 2006) with varying claims that few to no modifications are necessary, and that innovations are opening the possibility of even more biodiesel sources, and the incentive for switching over to biodiesel may be greater.

In reviewing available literature, this author initially discovered concerns raised about the cost-effectiveness of some methods of biodiesel production from sources such as corn oil, animal fats or lard, and waste vegetable oil to name a few. There are recent innovations that have been developed that hold promise these potential sources of biodiesel will be rendered profitable. The issues surrounding corn, fats, and other "waste" oils should not overshadow the very promising results that have been revealed in careful research conducted by government agricultural and fuel energy experts in 'Life Cycle' analysis from currently common biodiesel sources such as soy beans. From a 'soil to final product', the U.S. Department of Energy and U.S. Department of Agriculture life cycle studies of soybean based biodiesel found that for every

unit of fossil energy used in the biodiesel production cycle, 3.2 units of energy are gained (NBB, 2005). This means the effort expended in producing biodiesel is most certainly not 'operating at a loss', and therefore has profitable potential, even without government subsidy. One interesting fact about soybean oil is that it is relatively high in energy content compared other fats and oils, which is the way nature stores energy. In the same report, Robert McCormick Ph.D., of the National Renewable Energy Laboratory, and with the support of additional authorities, challenged the validity of a controversial, and ultimately discredited, a report which suggested that "biodiesel production consumed more energy than it yields". Dr. McCormick noted at least eight peer reviewed studies that confirmed biodiesel definitely had a, "...highly positive energy balance" which supports such findings as the soybean 1 for 3.2 units positive balance (NBB, 2005, July).

History is replete with examples of how an industrial or market innovation can suddenly open or improve upon a market that may previously have been considered unprofitable. Once recent example that applies to biodiesel is that of corn oil production', where corn crop as a fuel source has received news media coverage about its use for ethanol "E-85" fuel for gasoline type engines. However, corn oil production for processing into biodiesel languished due to lack of a cost-effective method of extracting corn oil (De Guzman, 2005). Until recently, corn oil was not considered a suitable source of biodiesel because of the inability of conventional oil extraction technology to yield oil of acceptable quality. According to an article by "Oils, Fats, and Waxes – Markets" reporter: Doris De Guzman of the Chemical Market Reporter magazine, Ethanol Oil Recovery Systems, LLC of Clayton, Georgia, has introduced to the world a potential market innovation that will enable corn ethanol producers to additionally and efficiently extract large volumes of corn oil of sufficient grade to be adequate for biodiesel production. According to

Guzman's article, the EORS Company stands to produce a potential 200-million gallons of corn oil per year from the estimated two-thirds of corn-ethanol production by-product of recent measure.

"Brown Grease," the type of waste oil that is found in the drainage traps of restaurants and wastewater-sewer treatment plants up until recently had to be disposed of by paying a disposal service to pump out and haul the grease to a specialized waste treatment facility (Rovins, 2005). A cost effective solution for waste grease disposal was recently outlined in an article featured in BioCycle Energy magazine (Rovins, 2005), where an innovation by the North American Biofuels Corporation of New York, led to cost effective technology that can render waste grease, trap grease, rancid vegetable oil, yellow fat (animal scraps), fish oils, tallow, and even meat scraps (anything that has some form of grease or fat content) into biodiesel. This innovation may serve as a reminder that sometimes the solution of a given problem such as waste management may also provide solutions for other needs such as biodiesel resources.

Advances in biofuels production holds promise that it will become competitive with gasoline and diesel by 2010 and will increase demand for byproducts of farming that can be used for biodiesel production (Greene, Celik, Dale, Jackson, Jayawardhana, Jin, , et al., 2004, December). According to the Natural Resources Defense Council, biodiesel could become less expensive to purchase than gasoline and diesel by 2050, while by 2025, American farmers may reap profits of more than $5-billion in today's dollar per year.

According to Robert L. McCormick, Ph.D. – Principal Engineer of the National Renewable Energy Laboratory (R. McCormick, Ph.D., personal communication, February 16, 2006), when asked about economic benefits that a consumer might expect by switching to biodiesel, he notes:

There is a one dollar per gallon tax credit available to the biodiesel blender, which puts the cost of biodiesel close to conventional petroleum diesel. Biodiesel may cost a few cents more, but last fall, when conventional diesel was high, biodiesel was actually cheaper.

Many are also claiming increased power and fuel economy. However, Dr. McCormick notes there is "...no quantitative data to support these claims." In fact, he says laboratory results show a small decrease in peak power and small decrease in fuel economy in terms of 'miles-per-gallon'. This finding makes sense according to him because energy content of biodiesel compared to an equivalent unit of conventional diesel is less. But the reductions noted in his findings, "...are probably too small to be noticed in real-world applications for B-20 and lower blends."

As far as conversion costs associated with economic concerns in the decision to switch to biodiesel, Dr. McCormick commented that using biodiesel blends of B-20 or lower should involve little to no changes in engine hardware. He recommends that users should consider using a 'water separator' as a part of the engine's fuel filtration system that is specifically designed for biodiesel. He noted that few biodiesel users are actually doing this. Finally, Dr. McCormick speculated there may be costs associated with fuel tank cleaning and changing out fuel dispensing system materials that use plastics and elastomers that may need to be addressed prior to filling-up with biodiesel.

Environmental

Biodiesel is better for the environment not only because it is produced from renewable agricultural resources (NBB, 2006), but it is far safer than gasoline and petroleum based diesel. The biodiesel flash point is 150 C compared to 70 C for that of petroleum diesel, and does not

require any specialized equipment and can be fuelled directly in to the diesel tank as a direct substitute or blend (USDOE, 2005, August 4). In fact, biodiesel according to the National Biodiesel Board, is less toxic than table salt and is as biodegradable as sugar. According to Van Gerpen, Shanks, Pruszko, Clements, and Knothe, of the National Renewable Energy Laboratory (2004), since biodiesel is renewable from plant-based sources, it doesn't contribute to global warming. Biodiesel originates from plant products, which means that every growing season, this resource is renewable. Biodiesel is also referred to as a 'carbon-neutral' fuel, meaning there is no net gain or loss in carbon dioxide production since the fuel originated from plants, which originally obtained its carbon-dioxide from the air during its growth cycle. The NREL experts also noted that exhaust emissions from biodiesel use such as carbon monoxide and particulate emissions are substantially reduced with the exception of a slight increase in nitrogen oxides. The nitrogen oxide emissions reportedly can be held to a minimum by special adjustments made to the engine's injection timing while at the same time maintaining a particulate emission to a minimum.

Using biodiesel compared to conventional diesel in regard to health issues of exposure to known carcinogenic and respiratory provoking elements associated with conventional petroleum-based diesel, might serve to strengthen the current case for biodiesel use in terms of environmental justification. At least two of the case study participants noted the anticipated health benefits of using biodiesel or at least a blend. According to the American Lung Association of Washington in their "State of the Air 2005," report: Diesel exhaust is, "...an especially serious threat to public health" (2005). It might be difficult to quantify the healthcare savings accurately, but it would be reasonable to assume that reduced exposure to any amount of potentially hazardous

emission would be viewed as a positive, if not at least an indirect economic benefit toward switching to biodiesel.

In regard to environmental aspects of using biodiesel, Robert L. McCormick Ph.D. – Principal Engineer of the National Renewable Energy Laboratory (R. McCormick, Ph.D., personal communication, February 16, 2006), points out that biodiesel is well known for reduced exhaust emissions of 'Particulate Matter' (soot), toxic compounds, and carbon monoxide. In regard to the earlier mentioned issue of nitrogen oxide emissions, though laboratory results may show an increase in nitrogen oxides, 'real-world' driving results apparently show no change in those emissions, and the data suggests there may perhaps be a small decrease in nitrogen oxide emissions. Dr. McCormick also confirms that biodiesel use also reduces the life cycle emissions of carbon dioxide, a known contributor to global warming.

Political

The mainstream news media cites examples of how much society is dependent upon foreign oil production. According to the Natural Resources Defense Council (Greene, Celik, Dale, Jackson, Jayawardhana, Jin, , et al., 2004, December) the United States consumes about 25% percent of the world's total oil production, yet has only 3% percent of the world's known oil reserves. By relying on foreign sources of oil, this nation is exposed to the political whims and sensitivities of those sources. As an article written by Thomas Friedman, columnist for "The New York Times" (September 21, 2005), suggested this country is in need of liberation and energy independence away from the "worst regimes in the world for our oil…" (In Business, 2005, September-October). Former President Bill Clinton endorsed the use of biodiesel to the American public as a means of pursuing energy independence and pushed for energy policy

change that would include the production and use of such fuels as biodiesel (In Business, 2005, September-October).

Yet in contrast to such political persuasions as these, are the public statements made by Saudi Oil Minister Ali Naimi, who was speaking on the subject of globalization and pointed out how economic growth around the world would also require more energy (Naimi, 2005). What is especially striking about his speech is that nowhere in it, is there any mention of biodiesel. Naimi indicates, "...there are currently no viable substitutes for oil, particularly in the transportation sector where oil accounts for 95% of the energy consumed locally." He briefly mentions other alternative transportation technologies such as battery and fuel-cell powered vehicles, but points out that no alternative technology comes close in his opinion, to competing with gasoline or diesel engine technology. Though according to Naimi, "...the world is not running out of oil any time soon" he projects the world will need many more units of energy and there will be a role for all modes of fuel technologies (Naimi, 2005). Regardless of Naimi's failure to mention biodiesel as an alternative fuel, this nation's lawmakers are surely not ignorant of its existence. For example U.S. Senator Barack Obama of Illinois introduced legislation during the 109th Congress, calling for a biodiesel standard (S. 1920: Renewable Diesel Standard Act of 2005), for the intent of improving economic opportunities for America's farmers, and for economic security presumably lessening our dependence on foreign oil (Biocycle, 2005). As of April 10, 2006 this Senate bill remains in the hands of the Committee on Environment and Public Work in Washington D.C. (The Library of Congress-Thomas, 2006).

Justification for switching to biodiesel may be based upon any of the previous three general reasons discussed: Economic, environmental, and political.

Research Methodology

Case Study Format

This research paper is based on the results of a case study method. The number of surveyed individuals was small for controllability. To be specific, there were five participants: Two municipal vehicle fleet managers, two transit fleet managers, and one heavy equipment fleet company, all of whom utilized some form of biodiesel (B-20 to B-100 grades). Consent to use the identity of at least one biodiesel survey participant was not confirmed, so all identities were suppressed and alternate identities were substituted for the purpose of tracking the responses through this paper. The following identities serve in the place of the participants: "North-Sound Fleet Manager", "South-City Fleet Manager", "South-Sound Transit Operator", "King County Transit Operator", and an "East County Heavy Equipment Operator".

Each participant was provided with a questionnaire through e-mail, with the request for an in person interview or supplemental telephone interview if possible. The following eleven questions were asked:

- When did your organization switch to a biodiesel fuel system?
- Why did your organization choose biodiesel as your fuel source?
- What economic benefits did your organization perceive before switching over to biodiesel?
- What environmental benefits did your organization perceive before switching over to biodiesel?
- What economic benefits do you realize now since you've switched?
- What environmental benefits do you realize now since you've switched?
- What equipment/engine conversion costs were involved when you make the switch to biodiesel?

- Performance – What performance or efficiency differences do you see with your equipment now, compared to when it was using the older fuel system?
- What positive unanticipated results do you see as a result of using biodiesel?
- What negative unanticipated results do you see as a result of using biodiesel?
- Would YOU recommend the use of Bio-diesel as a fuel source? Why?

Responses to the e-mailed questionnaires were not answered in an identical manner. Some answered the e-mails, others answered the questions and provided telephone interviews, and one allowed an in-person interview. The "North-Sound" fleet manager not only answered the e-mailed questionnaire, but also allowed an in-person interview. To his credit he was able to link me to a fellow colleague in the fleet management field: The "South-County" Fleet Manager, for which the author is thankful. The "East County" heavy equipment operator was unavailable for both, telephonic or in-person interviews, but provided brief answers to the questions. The "King County" transit operator was in the process of changing the way they used biodiesel and did not answer the questions, but provided other public information that provided some answers as to their experience. The "South-City" Fleet Manager was able to grant me a telephone interview despite his busy schedule. The "South-Sound" transit operator provided a telephonic interview to answer the e-mailed survey. These variations may affect the consistency of answers, but not likely to the point the experiences conveyed would be thrown off-scope.

Case Study Questionnaire Results

"North-Sound Fleet Manager"

This fleet began using a B20 biodiesel blend as part of a pilot study in the beginning of 2006. They started with just one location as a result of the County Executive's agricultural initiative to foster the beginnings of a local "end-to-end" economic infrastructure that would include supporting local and regional farmers that would be able to produce crops such as canola seeds that might then go to processing at a local biodiesel 'refinery' to be transformed into fuel for local use with the hopes that a locally produced 'crop' would result in lower distribution costs. The "North-Sound Fleet Manager", did not realize any economic gains at present. In fact by switching to biodiesel for his fleet of trucks, it actually costs .15 cents more per gallon at the time the interview was conducted. The respondent does note that it is too early to tell what economic benefits may ultimately be realized. As far as any equipment conversion costs, there were none, except for the need for their biodiesel fuel provider to clean the fuel tanks on each truck prior to the new fuel provisioning.

As for environmental concerns this Fleet Manager noted they are benefiting from a 20% reduction in Hydrocarbon emissions: A 12% reduction in carbon monoxide emissions, a 12% reduction in particulate matter (PM) or 'Soot', out of the 20% (due to the B-20 use) less petroleum diesel used. As far as known carcinogens, he noted that a 13% reduction in "Polycyclic Aromatic Hydrocarbons" was possible. He also noted the potential for a 50% reduction in "Nitro-Polycyclic Aromatic Hydrocarbons", which are also known carcinogens and mutagens according to the National Institutes of Health on-line reference (PubMed, 2006). This brings him to a positive unanticipated result in terms of the health impacts over the long term as he puts it, regarding employee health. One problem noted was experienced variations in the fuel

quality. It is not maintained to standards established by the American Society for Testing and Materials, but overall he would still recommend other entities consider using biodiesel because it does benefit the environment as well as reduce our dependency on foreign oil.

"East County Heavy Equipment Operator".

This heavy equipment operator converted to 100% biodiesel (B-100) for use in their construction equipment. The primary reason for the switch was over the issue of "Carbon Neutrality". Biodiesel originates from plant products, which in turn, get their carbon from the atmosphere (Carbon Dioxide), there is no addition in fuel product cycle for producing more or less CO2, a known greenhouse gas to contribute to global warming, hence it is neutral in its carbon count. In their opinion, it is "much nicer to work around", where fuel spills is a minor environmental issue to clean up. The primary reasons why the respondent heavy equipment operator would recommend biodiesel use to others is that farmers are potentially supported, fuel source independence for this country, and what they believe to be a positive contribution to the health of future generations.

"King County Transit Operator"

A King County transit bus and utility fleet management representative provided answers regarding the direction they were taking with the use of biodiesel. For 2006 all of their vehicles will switch to consuming biodiesel in some form. Blends to be used will phase in gradually from B-2 to B-20. The minimum of B-2 (2% biodiesel), was a statewide mandate that was scheduled to take effect on March 1st, 2006. They have been using B-5 (5%) biodiesel in their transit bus fleets since 2004, making them the largest consumer of biodiesel in the state of Washington at the time. However, they were experienced some technical issues which led to a temporary

suspension of its use until recently. They suspect the issue may have been related to fuel quality control issues, which is the primary reason why they will gradually phase in the biodiesel blend increase over time until they can isolate the cause of their technical issues regarding the fuel. The respondent noted the benefits of biodiesel include health benefits as a result of cleaner air and the reduction of "Green House Gasses". Fortunately, the respondent noted that it has become more financially feasible for them to purchase biodiesel since the advent of the Federal $1 dollar per gallon tax rebate for biodiesel.

"South-City Fleet Manager"

This major city utility fleet has been using B-20 biodiesel in its garbage trucks since 2001. Though the respondent was not at the time required by their superiors to use this fuel, the Fleet Manager hoped to 'get ahead of the curve' by using biodiesel in their vehicles, especially during at time they were better able to justify it financially. To them, biodiesel was competitively priced with no initial conversion costs. The Fleet Manager stated that biodiesel was .20 cents higher per gallon than petroleum based diesel, but they were able to justify the cost by a contractual agreement with the biodiesel supplier that required them to fuel their city's trucks nightly. The cost savings from this arrangement were realized when the individual truck drivers were no longer required to take the extra time (and pay) to drive their individual trucks to the fuel station. He noted several health benefits they believe have been realized since the shift to biodiesel usage: Environmentally 'friendlier', reduced carbon dioxide output, lower particulate matter, and a 20% reduction in carcinogenic emissions. As far as problems were concerned, the Respondent mentioned that cold weather caused the fuel to gel. In subsequent investigation, they found the fuel wasn't always manufactured in conformity to established

standards for biodiesel such as ASTM D 6751. They sometimes found the fuel contained too much glycerin, which caused them to suspend use for a while. Their solution involved an arrangement where a quality testing lab has been established by their local fuel supplier, who gets the soy-bean oil based fuel by railroad from the Mid-West, to test the fuel quality, and injects fuel additives if needed. He would recommend the use of biodiesel to others, especially in light of the fact that a "Federal Mixing Credit" offsets the cost to the point where they are paying a recent average of less than .05 cents a gallon difference for biodiesel B-20, compared to full petroleum diesel. Though it is unclear as to exactly what the Fleet Manager meant or in what context, he added, "Biodiesel is cheaper in the long run."

"South-Sound Transit Operator"

A bus transit fleet was switched to biodiesel in December of 2002, due to a directive to adopt a new fuel strategy policy. Biodiesel was an option considered among other fuel options ranging from liquefied natural gas (LNG), liquefied to compresses natural gas (LCNG), hydrogen, and propane. Conversion to an LCNG fuel system for example, would have required the construction of a nearby natural gas compression station, an up-front cost of millions of dollars. Ultimately, the transit organization determined that using biodiesel for the fleet made the best sense because it was more cost effective, safe to handle, and reliable as a fuel. Additionally, the fleet operator acknowledged that studies indicated that particulate matter (PM) and other harmful emissions were significantly reduced by using this fuel. Though it appears they have not realized an economic benefit to using biodiesel, even noting the slight increase in fuel filter replacement frequency, the Respondent clearly emphasized the environmental health

benefits of biodiesel usage and the additional political benefit that it implicates, in terms of reducing some degree of dependence on foreign oil production.

Findings & Conclusion

Findings

All participants surveyed acknowledge environmental health benefits associated with biodiesel use, as one of the contributing reasons for having switched. Three of the five participants specifically referenced the reduction in harmful or carcinogenic emissions by using a blend of biodiesel such as B-20, which would result at least in a 20% reduction in harmful emissions. All participants noted the environmental benefits of having switched to biodiesel in terms of reduced, "Green House" gas emissions such as CO2. Though consuming biodiesel may be "Carbon Neutral" in and of itself, blending it with petroleum diesel will result in a fuel blend that will result in a reduced CO2 emission. Findings also revealed an implied direct health benefits not only for the equipment operators that drive or use these vehicles, but for the community within which these vehicles serve. Nearly all of the participants anticipate positive long-term impacts by the use of this fuel either for the environment, future generations, or both. It appears the use of biodiesel is justifiable from the aspect of positive environmental health concerns, not only for the people that drive or use the equipment, but for the communities within which they operate.

Conclusion

This research has uncovered what appears to be a collective sense of stewardship among fleet manager/owners as they collectively lead a trend for a better fuel that contributes to a cleaner and safer atmosphere. This author recommends that in addition to national standards, a worldwide standard for production and quality assurance of biodiesel fuel should be established and enforced by an appropriate global authority. As with any market, if there is a lack of enforcement of established quality standards it would be difficult to have fair competition and to

realize equitable profits on the part of the producers and suppliers, especially if one supplier for example, were able to sell a substandard fuel at a greater profit than one who might have the integrity to assure a consistent quality of fuel. This would eventually have the effect of ruining the credibility of the entire market, thus eroding trust, and perhaps crippling the ability to make a reasonable profit within the entire market for all participant in it at some point.

There is another question that might be worthy of further research:

Why is there an apparent lack of a global biodiesel standard?

This author would hypothesize that if a global standard could be established and enforced by ISO and the United Nations, it might have the strong potential for opening up even greater opportunities for farmers and producers involved with biodiesel production and distribution. As nations develop their infrastructures to participate in the global market, their need for energy also increases, so does the potential market opportunity for a producer (Czinkota, Ronkainen, & Donath, 2004). It may also be of interest to highly dependent oil nations, if further research could be done to examine to potential impact a globally established market would have on fuel price stability.

It is apparent that use of biodiesel would likely have a positive environmental impact on the planet's atmosphere. This may not be a concern, since it might be difficult to perceive even an incremental impact of one diesel engine to the planet's atmosphere, so another approach might be in order: Health care costs of employees and their employers may potentially be reduced by the use of biodiesel. Potential death or costly health-care claims alleged from exposure to known carcinogens released by conventional diesel might become an issue in the future, especially now that the world is attuned to settlements regarding "Second-Hand-Smoke" lawsuits. It might be reasonable to extrapolate that using petroleum based diesel exposes equipment operators to

carcinogens, but by making the effort to switch to biodiesel, if at least a blend, may very well attest to a good-faith effort by the fleet owners to make the working environment that much safer for the employee and the community they serve. Though not legislatively prompted to do so, fleet owners have demonstrated socially responsible stewardship by taking the proactive approach of using a safer fuel source. Their efforts should be appreciated and recognized as a role model for other organizations to strongly consider following.

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