Economic and Health Benefits of Biodiesel Production: A Case Study at CSU Stanislaus

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On September 18, 2008, Lehman Brother filed for bankruptcy, signaling the beginning of a global-scale economic decline. This decline hit California very hard, because of high levels of development in the Californian housing market. The housing decline began a long series of cuts to the state budget to make ends meet. The California State University system, along with the University of California and K-12 systems, all suffered massive cuts in response to the state budget deficit. In fact, the CSU system is underfunded by the $283 million it needs to fulfill its operational needs. It is thus important to find ways to save money in the university budget to avoid firing more faculty and staff, limiting student services and lowering the quality of education. However, budget cuts should be made discerningly, in order to provide long-term solutions with the least loss of function.

In response to these new budgeting constraints, it would be ideal to implement a biodiesel program on the CSU Stanislaus campus. Although there would be an initial investment of equipment, materials, and training time, this investment would have a return in less than three years, and save the campus many thousands of dollars thereafter. A biodiesel program is a ripe opportunity for the college's foundation or other group to invest in. This program would not only help save the college money in the long term, it would also reduce the health impact on anyone on or near the campus, provide a learning opportunity for students, and showcase CSU Stanislaus as a community leader and innovator.

This analysis aims to establish a case for implementing a biodiesel program on the CSU Stanislaus campus. I begin with a brief *overview* of the diesel engine. The diesel engine was originally built to run off of vegetable oils. In 1911 Dr. Rudolf Diesel wrote, “The diesel engine can be fed with vegetable oils and would help considerably in the development of the agriculture of the countries which will use it.” However, the price of petroleum-based diesel, or *petrodiesel*, was so much cheaper than vegetable oil that engines were modified to run on processed fuel instead of straight vegetable oil (SVO). Although modern diesel engines can run on vegetable oil after some modifications to the engine, biodiesel can be used in standard diesel engines without any engine changes after the process of transesterification. With the price of *petrodiesel* increasingly rising and erratic, biodiesel is an economically viable option.

In addition, biodiesel has a smaller environmental impact than petroleum-based diesel (*petrodiesel*), as well as a high-energy balance, and is itself biodegradable and non-toxic. If a two year old were to fall into a bucket of biodiesel and swallowed some, the worst that would happen would be a messy clean up for the parents. Apparently the fuel tastes like salad dressing and causes no internal damage. On the other hand, *petrodiesel* contains many chemicals that could injure people including 17 different chemicals that are considered carcinogens by the California Air Resources Board (CARB). Biodiesel emissions are safer to breathe and present a significantly lower health risk than *petrodiesel* emissions. Implementation of a biodiesel program on any college campus would reduce the health risk to students, faculty, administration, and staff, especially those staff who operate the diesel machinery. Biodiesel is registered as a fuel and fuel

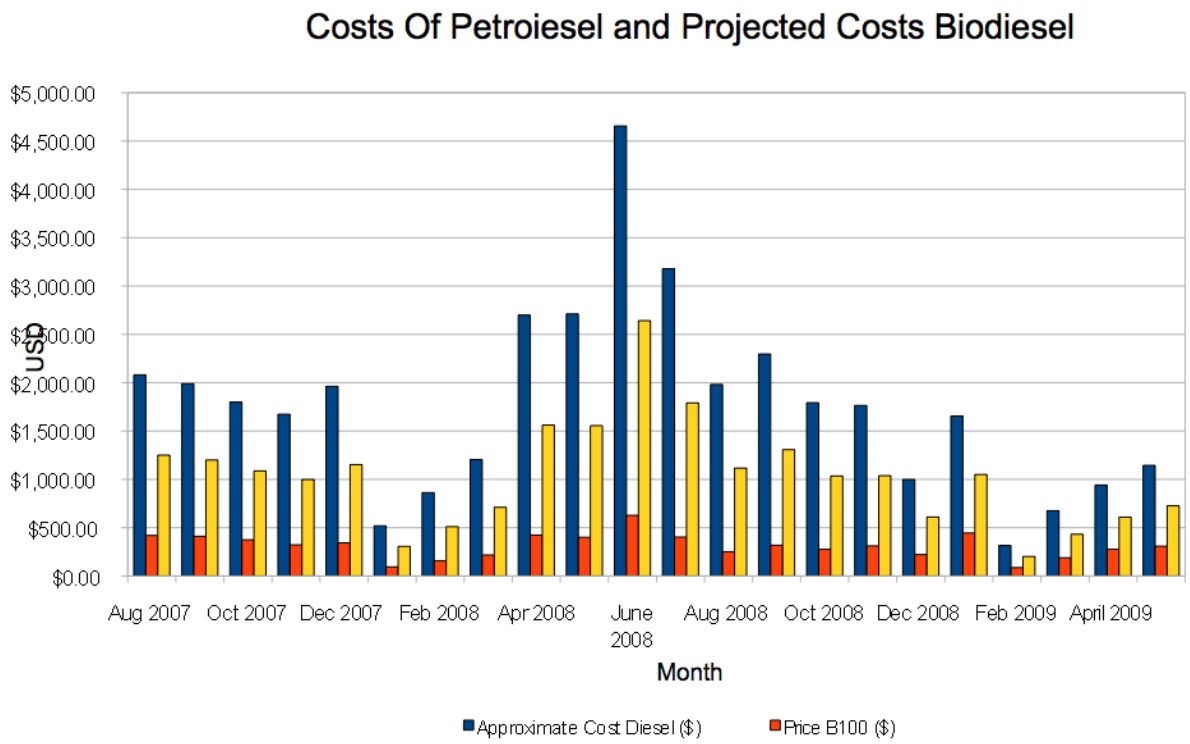
additive with the Environmental Protection Agency (EPA) and meets clean diesel standards established by CARB. This policy means that in addition to being economically viable and safe, biodiesel is also approved for commercial usage, and its users would not encounter legislative red tape.

Before we can recommend a biodiesel program for the CSU Stanislaus campus, we need to demonstrate how it is economically viable. A cost/benefit analysis over time will show how much money could be saved monthly, as well as how long it will take for the initial investment to be paid off. It is difficult to put a price on the health of the students and maintenance workers, but it is certainly an added benefit and could result in reduced sick time for employees.

Methods

Diesel usage information was provided by Cliff Bailey, Director of Landscape, Transportation & Custodial Services. Where the number of gallons was not specified, the average price of diesel in California per month was taken from the U.S. Energy Information Administration, and the number of gallons used was calculated based on how much was spent on diesel. Correspondence with Robin Bower, Director of Dining Services, disclosed that the cafeteria produces between 48-64 gallons of cooking oil per week, an average of 224 gallons per month, which would enable there to be a B50 or 50% blend of biodiesel and *petrodiesel*.

Figure 1



With this information and estimating the operating costs of biodiesel (as provided by Arizona based non-profit Alternative Energy) at $0.63 per gallon, the estimated savings was calculated, for back-projected implementation of the program from July 2007 though April

2009. Results were significant. (fig. 2 below).

An investment is not typically considered significant until a return is seen within three years. Projecting a $1500 initial investment on equipment, and a $0.63/gallon cost for reagents, we can calculate how long it would take to see a return on investment. The cost of equipment was gained by researching complete units online. However, after correspondence with Central Valley Biodiesel, a company based in Fresno which provides the equipment needed, I was able to determine that the start-up might be much less that the initial $1,500 estimate. We used the actual diesel information as provided by Cliff Bailey, and assumed CSU Stanislaus had made the investment July 2007. However, in order to not underestimate the amount of start-up funds, we can compare the $1,500 estimated costs with an $11,000 start-up costs for an industrial biodiesel set-up. A factor to consider is that we will want the biodiesel to stand up to ASTM standards, ensuring the fuel will not damage the diesel engines, which means some money will have to be spent for quality assurance. However, this source should cost no more than $300/year, which would still allow us to make money on the process. It is possible that other operating costs should be considered, such as electricity and maintenance, which could be potentially offset by the sale of the valuable byproduct glycerol. Glycerol production was not considered because of drastic market fluctuations, but remains a potential source of income.

Results

It was calculated that using the B50 blend, the initial investment would take less than three months to pay off. Thereafter B50 biodiesel production would save the university over $14,000 in the 22 months we had data for. To counter the possible argument that the original estimate of $1,500 was inadequate for starting up the operation, the $11,000 needed to start up a commercial biodiesel operation was also calculated. On these figures, this investment would be paid off in a year, and would save the university $5,000 in the remaining 10 months. The actual costs of starting up a biodiesel program will most likely be on the low end between these extremes, but will save money regardless.

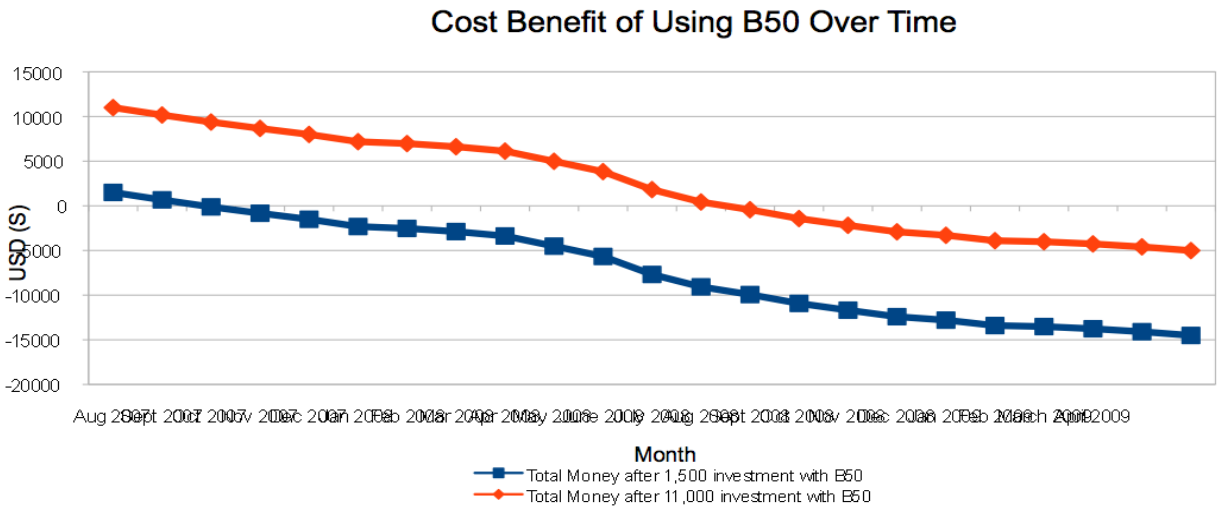


Figure 2

Discussion

In creating this biodiesel, the assumptions made were that the oil would be provided for free, and that there would be no labor costs involved. Currently Chartwell, the provider of cafeteria services, gives its waste oil to a local farmer in exchange for the farmer cleaning the container, which is something that could be accomplished on campus. If a biodiesel program were implemented, it could be set up as a service learning opportunity in Biology, Chemistry, or Environmental Sciences, which would add a practical dimension to student learning. The value of this opportunity was not included in the benefits listed, but should provide additional incentive for program implementation. While using 100% biodiesel (B100 or neat biodiesel) is the cheapest and most environmentally friendly option, the volume of waste oil produced by the cafeteria is not enough to produce the amount of diesel needed by the campus staff. This could be remedied by collecting waste oil from fast food outlets and other restaurants near campus. However, this would incur the extra costs of transportation, and it is unknown if this oil would be provided free of charge or even if we would be able to find enough. Fortunately, biodiesel can be blended at any concentration, and using a 50% blend (B50) would also provide significant financial and health benefits. It is recommended that this blend should be initially considered.

There is substantial evidence that because biodiesel is a solvent it will actually extend the life of diesel engines, because it prevents clogging according to Biofuel Oasis based in Berkeley, Ca. However, they also that it will also dissolve rubber gaskets, common on vehicles built before 1994 and Mercedes Benz. Lastly, it will take a few trial runs to make sure the process runs smoothly, and some initial training in equipment from an external source for those who would continue the project.

Over time, *petrodiesel* fuel prices will continue to rise as a basic principle of supply and demand. China and India are rapidly industrializing, meaning they will want a larger share of the dwindling fossil fuel supply, thereby increasing the price of diesel. California Air Resources Board (CARB), has quality standards that must be met for the Clean Diesel Act, and biodiesel is compliant with these requirements, meaning expensive engine retrofitting will be unnecessary. Biodiesel is the solution not only in today's financial difficulties, but is also a solution tomorrow when fuel becomes more and more expensive and scarce.

In October 2002, the EPA did a study measuring the effects of biodiesel on exhaust emissions from diesel-powered vehicles. The main findings were that the higher the percentage of biodiesel in the fuel, the lower the amount of hydrocarbons and particulate matter. Hydrocarbons, or more specifically polycyclic aromatic hydrocarbons (PAH) and nitrited PAH compounds are known carcinogens, and can cause damage to the skin and lungs upon contact. Using B20 reduces the amount of hydrocarbons in diesel emissions by 20%, while using B100 reduces hydrocarbons by over 65%. Particulate matter in the air is an extreme health risk. Exposure has been linked with acute short-term symptoms such as headache, dizziness, light-headedness, nausea, coughing, difficult or labored breathing, tightness of chest, and irritation of the eyes, nose and throat. Long-term exposure can lead to more serious health problems such as cardiovascular disease, cardiopulmonary disease, and lung cancer. Were the state to adopt stricter standards for particulate matter emissions, it could reduce costs to the healthcare system and increase productivity in workers, another indirect fiscal benefit. B20 reduces particulate matter by around 12% and B100 reduces it by over 45%. Also, the particulate matter filters in the typical diesel fleet are very expensive to replace, so if there is less particulate matter in

the emissions, these would have to be replaced less often. When looking at only these two chemicals, it is hard to find a reason not to use biodiesel, yet there is a third type of chemical.

The third main types of chemicals tracked by the EPA were nitrogen oxides, or NOx. These chemicals are dangerous because they are extremely reactive and can combine with other chemicals to form nitric acid, which when inhaled can cause severe lung damage and even death. They have been shown to aggravate existing respiratory problems and even worsen the condition of people with heart diseases. Ozone is beneficial when it is high up in the atmosphere, because there it blocks UV radiation, but when it is formed closer to the earth's surface, it can damage the lungs, and this low lying ozone is formed by the reaction of NOx with various volatile organic compounds. There are several state agencies that have considered banning biodiesel because the 2002 study by the EPA showed a steady increase in the amount of NOx in emissions up to 10% in B100. However, in 2006, the National Renewable Energy Laboratory has shown that this data was taken from too small a subset, and by widening the types of vehicles tested, overall NOx levels do not change with the percentage of biodiesel used, although for individual vehicles they may go up or down. The health benefit of using biodiesel is substantial because of the reduction of dangerous chemicals in emissions as well as the safety and non-toxicity of the fuel itself.

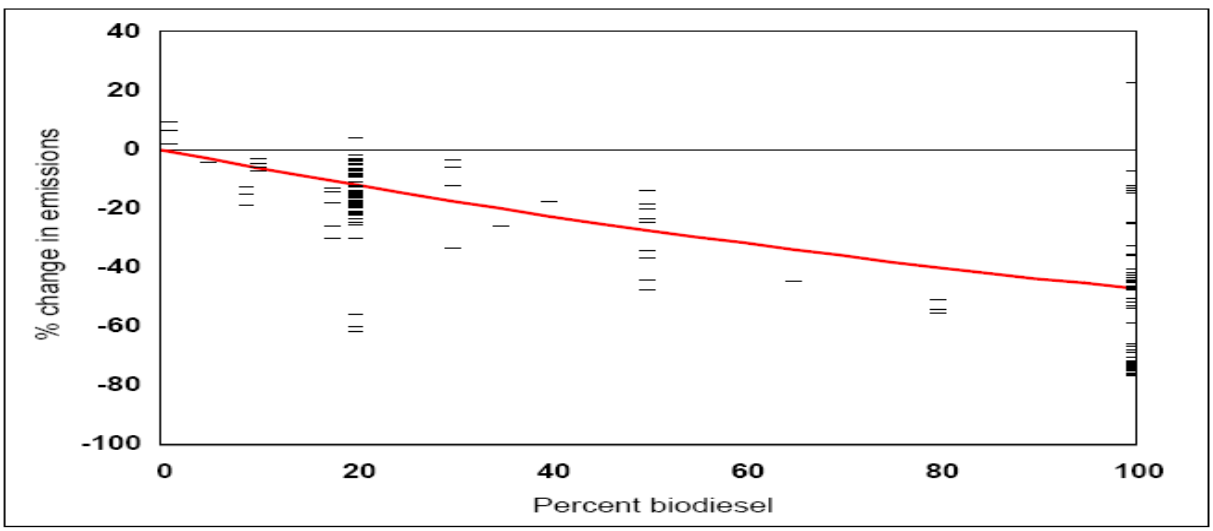


Figure 3, $NO_{(X)}$ emissions

Biodiesel is the wave of the future. Biodiesel fuels are cost effective; they are better for the environment and better for people's health; and they can be run in an unmodified diesel engine. This study has shown that biodiesel can be made on campus from used cooking oil for an initial investment that can be paid off in less than two years. It would have a significant impact on emissions that would not only be proactive in combating global climate change, but would also be beneficial to the health of the workers who operate the diesel machinery, as well as all the students, faculty, staff and administrators on campus. Finally, and importantly, implementing biodiesel would show that CSU Stanislaus is a leader and role model in the green movement.

References

B-60 Bio Diesel Processor With Wet Wash System. (2009). Retrieved May 16, 2009, from http://alternativeenergy.ecrater.com/product.php?Pid=3557051

Biofuel Basics. (n.d.). Retrieved December 15, 2009 from

http://www.biofueloasis.com/html/basics.html

Environmental Benefits (n.d.). retrieved May 1, 2009, from http://www.biodiesel.org/pdf_files/fuelfactsheets/Enviro_Benefits.PDF

Haas, M., McAloon, A., Yee, W., Foglia, T. (2004). A process model to estimate biodiesel production costs. *Bioresource Technology*, 97 (2006) 671–678. Retrieved December 9, 2009 from http://www.che.uah.edu/courseware/che460-Fall2007/papers4review/biodiesel-superpro-model-bioprocessing.pdf

Hammond, R. (1976). Decision Making for Energy Choices. Karam, R. & Morgan, K. (Ed.*) Energy and the Environment Cost Benefit Analysis* (pp. 80-89). Elmsford, NY: Maxwell House.

How Biodiesel is Made. (n.d.). Retrieved May 20, 2009, from htttp://www.utahbiodieselsupply.com/makingbiodiesel.php

Lehman Bros Files for Bankruptcy. (2008). Retrieved December 1, 2009, from http://news.bbc.co.uk/2/hi/business/7615931.stm

McCormick et al. (2006). Effects of Biodiesel Blends on Emissions [electronic version] *Milestone Report NREL/MP-540-40554.* Retrieved May 14, 2009, from http://www.nrel.gov/vehiclesandfuels/npbf/pdfs/40554.pdf

The California State University. (2008). S*tate Budget Cuts to California State University Continues to Impact System's Ability to Serve Students.* Retrieved December 1, 2009 from http://www.calstate.edu/PA/News/2009/budget_feb.shtml

Peiro, L., Mendez, G., & Durany, X. (2008). Exergy Analysis of Integrated Waste Management in the Recovery and Recycling of Used Cooking Oils. *Environmental Science & Technology*, *42*(13), 4977-81. Retrieved May 21, 2009, from General Science Full Text database.

Sassone, R & Schaffer, W. (1978) *Cost-Benefit Analysis.* New York, NY: Academic Press, Inc.