

# UR BIODIESEL

*A Proposal to the University of Rochester to Implement a Waste Vegetable Oil  
to Biodiesel Program*



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## Executive Summary

One of the most pressing issues of the 21st century is global climate change. In their role of educating the world's next generation, universities have a responsibility to stress the importance of sustainability and environmental responsibility. Here at the University of Rochester, the environmental movement has picked up in recent years, with the increased activity of environmental student groups, the Cogeneration Utility Plant, various programs and events that promote environmental sustainability, and more recently, the University's creation of the Sustainability Task Force.

Waste vegetable oil (WVO) from dining centers can be used to efficiently produce biodiesel to use in diesel engines. The use of biodiesel as a fuel has been proven all over the country as an effective way to power diesel vehicles. Though it can be purchased from a supplier, biodiesel can also be produced through a well-understood process that can easily be completed by a University student. During this process, the WVO is filtered and mixed with different chemicals, eventually yielding biodiesel. This process has been well analyzed and various commercial products are available for aiding in the production of this fuel. A blend of biodiesel and petrodiesel will prolong engine life because of its lubricating qualities. In addition, combustion of biodiesel results in significantly lowered emissions of carcinogenic and polluting chemicals, some of which contribute to global warming. The performance of biodiesel is comparable to conventional petrodiesel.

The University of Rochester produces a significant amount of WVO at our own dining centers, which we currently pay a private contractor to dispose of. Our proposal is for the University to internally use this WVO to convert into biodiesel. This biodiesel can then be blended and used throughout the University bus system. This project will not only strongly support the University's environmental responsibility programs, but, in the long run, will save the University money. Furthermore, we believe that the expansion of the sustainability movement in the Rochester area will bring strong positive publicity to the University. The implementation of the UR Biodiesel plan would greatly improve the environmental reputation of the University while making the University a pioneer in the environmental movement. UR Biodiesel will also offer new research and internship opportunities to supplement classes and allow students to better understand the production of biodiesel.

In brief summary of the plan, we are proposing that the University implement a fry oil to biodiesel plan in which WVO from River Campus dining centers be removed by a University employee and brought to a campus-owned biodiesel processor, ideally located at 612 Wilson Boulevard. There, the WVO would be filtered, processed and blended with conventional petrodiesel into an B20 blend. This blend can then be pumped into one of the First Transit busses that the University currently contracts. Our understanding is that a stipula-

tion requiring First Transit to work with the University to use biodiesel in their busses was in their initial contract. Ideally, the biodiesel will always be used in the same bus, allowing us to publicize the program on the bus itself. This program will cost in the range of \$15,000 in its first year, and around \$11,000 in each year following. However, the long run plans for the program include expansion to the Eastman and Strong Memorial Hospital campuses, as well as the eventual partnership with the local business. Doing so will allow us an increased supply of WVO, and in turn more biodiesel to work with, without a major increase in the cost. As the price of petrodiesel continues to rise over the next decade, we believe that this plan will allow the University to save money in the long run by reducing our dependence on conventional petrodiesel and the high cost associated with it. Overall, we believe that both the financial cost and the necessary investment of time to start up this program will be justified by the enormous benefits that will come from it.

Our team has been working on various forms of this proposal since January of 2007. Our April version of this proposal was the second prize winner of the annual Forbes Entrepreneurial Competition. We occasionally reference that proposal throughout this one, as it includes far more detail about certain aspects of this plan; if you are interested in a copy, please let us know and we would be more than happy to provide one. We have attempted to cover every angle possible and consider every potential problem. We have met with representatives from dining, transportation, facilities, the Fire Marshall, the Hazardous Waste Coordinator, the Engineering Department, and Student Activities. We have further sought advice from other Universities, private companies, and national organizations. By no means do we claim to be nationally recognized experts in the topics we discuss. However, we do strongly believe that this project is one that would be of great value to the University, and we are confident that, with the support of all involved parties at the University, we can make this plan a reality. We hope that you share our excitement, and we are eager for others in the University to take ownership of this project, as we have, to help put this plan into action.

## Benefits

There are a number of benefits from this project that are of significant value to the University. The most significant of these benefits is the “green” image of the University that would be visibly displayed should this plan go forward. The prospect of a bus having a sign reading “This bus powered by the waste vegetable oil from University Dining Centers” is a very powerful statement. This concept significantly furthers the sustainability and green causes that are sweeping across colleges around the country and would make the University a pioneer in the field. This project would also tie in nicely with the University’s Report of the

Sustainability Task Force. Initiative 20 of that report calls for a “fry oil to bio-diesel fuel program,” which is exactly what we propose.

There are a variety of other benefits to the University community. For example, the processor can be run by a student employee, providing new educational student employment options. It could also be an internship course that students can take for University credit. The processor can be further used as an educational tool in teaching University students and local elementary and secondary school students the importance of environmentally friendly activities. Similarly, students in engineering and the sciences can use the processor (and the WVO, the biodiesel, and its byproducts) for experiments. After the program becomes established, we hope to organize informative seminars and workshops that are open to students, faculty, and staff, as well as people in the community to learn about the process of making biodiesel and the vast environmental benefits that our program provides. Furthermore, our long term plan calls for our pick up and use of the Waste Vegetable Oil of local businesses. This will save them money and improve their reputation as a contributor to the University’s green campus initiative.

## Processing Waste Vegetable Oil (WVO)

In order to process the waste vegetable oil, it is first necessary that we filter and dewater the oil. This can be done with a filtration system and heating coils. The filtration system can be developed by university students or purchased through a company as it consists of funneling the oil through multiple filters bags of about 25 microns and downwards to 10 microns. As the WVO is filtered, it can be heated by heating coils to approximately 100 degrees in insulated 55 gallon drums to separate the water.

The ideal location to house the processor and filtration system is 612 Wilson Blvd. due to its proximity to the University diesel tanks. It is also the headquarters of facilities and therefore can be closely monitored by personnel. Additional considerations that must be taken into account when choosing housing for the processor and filtration system include ventilation systems, fire code, and extension of the SPCC plan.

While we are very open to alternatives, we propose using the Home Biodiesel Processor, which can load up to 80 gallons of WVO per batch and has a 24-hour operating time period, which includes wash time. Throughout this process, operating time by trained personnel is only necessary for 30 minutes. It offers a separate storage unit of multiple carboys for the reuse and storage of methanol for safety purposes (details on the processor selection can be found in our April 23rd proposal).

Sodium hydroxide (lye) must be added to the waste vegetable oil in an amount proportional to its viscosity. Methanol also must be added, though it can be reused through each process. In order to find the amount of lye used per batch we will perform titrations for each shipment of WVO received. The processing system accounts for the introduction of these various materials into the mixture and outlines the times at which these additions are necessary throughout the process.

In addition to these necessary reactants, the process will also produce glycerin. We will need to dispose of the glycerin properly, as it is considered to be a hazardous waste. One option for disposing of the glycerin would be to attempt to rework the current contract with Baker Commodities, having them dispose of the glycerin and unusable food residues that were filtered out of the WVO. The second option is to use the University's hazardous waste disposal plan and store the glycerin temporarily in large drums (this is the option estimated and described in slightly more detail in the cost analysis below).

### *TESTING AND BLENDING*

After we produce the biodiesel, it is necessary to test the quality before using it. This can be done to varying levels of quality assurance. One option is to purchase ASTM standards from ASTM International and perform all the necessary tests to know that the fuel meets the rigorous standards of commercial biodiesel. Another option is to purchase a testing kit from a company specializing in testing biodiesel quality. These tests are generally less rigorous than the ASTM tests, but they would also save a significant amount of time while still ensuring good quality.

There are several ways to accomplish the blending of petrodiesel with biodiesel to get B20. The easiest method for blending is called splash blending. This requires simply filling a vehicle's fuel tank separately with biodiesel and petrodiesel fuel in the appropriate amounts. Because of the similar chemical properties of the two fuels, driving down the road is regarded as enough agitation to sufficiently mix the two fuels. There are also other options for blending, but splash blending appears to be ideal in that it avoids the handling of either type of fuel directly in order to blend them.<sup>1</sup>

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<sup>1</sup> See <http://www.nrel.gov/vehiclesandfuels/npbf/pdfs/40555.pdf> for more information on blending methods

## Comparisons: Biodiesel vs. Petrodiesel

### *EMISSIONS*

One major advantage of using biodiesel is the vastly lower emissions. The resulting emissions from biodiesel of carbon monoxide (CO), particulate matter (PM), hydrocarbons (HC), sulfur oxides, and sulfates, which are all health hazards and harm the environment, are significantly less than for petrodiesel. The amount of decrease varies by the composition of the blend. However, NOx emissions increase slightly from burning biodiesel. The use of a biodiesel blend of B20 reduces carbon dioxide (CO<sub>2</sub>) emissions by 15% when compared to petrodiesel.<sup>2</sup>

### *PERFORMANCE*

Range, power, payload, and performance are on par with petrodiesel. Biodiesel has a greater lubricity, resulting in longer engine life over the course of the vehicle's operating life. Biodiesel is about 5-8% less energy dense than petroleum diesel, but its greater lubricity and more complete combustion offset that somewhat, leading to an overall fuel efficiency about 2% less than petroleum diesel. For B20, the EPA reports a 0.9-2.1% reduction in miles per gallon efficiency than when using petrodiesel. For B100, the reduction is larger at a reduction of 4.6-10.6% miles per gallon.<sup>3</sup> Biodiesel is also often attributed with engines running much quieter, with less vibration, and starting up easier than when running on petrodiesel.

The use of pure biodiesel (B100) has a solvent effect that may release buildups accumulated on tank walls from previous diesel usage. Therefore, high blends of biodiesel tend to initially result in the release of deposits that may clog the filter until the petroleum deposits are eliminated. However, this is much less prevalent in lower blends such as B20.<sup>4</sup>

### *COLD TEMPERATURE USE*

Operation in cold weather can cause both petrodiesel and biodiesel to gel. This is considered in the production of regular petrodiesel and is the reason for the use of certain additives and for taking other precautions. The use of B20 requires no additional precautions beyond what must normally be considered for petrodiesel. The additives in petrodiesel which prevent its congealing in colder temperatures will act similarly in a B20 mixture in

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<sup>2</sup> [http://www.eere.energy.gov/afdc/fuels/biodiesel\\_benefits.htm](http://www.eere.energy.gov/afdc/fuels/biodiesel_benefits.htm)

<sup>3</sup> "A Comprehensive Analysis of Biodiesel Impacts on Exhaust Emissions"  
<http://www.epa.gov/otaq/models/analysis/biodsl/po2001.pdf>

<sup>4</sup> <http://www.biodiesel.org>

this temperature range. However, B100 will gel faster than petrodiesel when operating in cold weather. Solutions to this are the same as solutions for using low-sulfur #2 petrodiesel in similar conditions. For example, it can be blended with #1 petrodiesel, fuel heaters can be used, and vehicles can be stored indoors.<sup>5</sup> It will be necessary to heat the biodiesel in order to be able to pump it into the gas tank since it will congeal otherwise.

## *T O X I C I T Y*

Biodiesel is a much safer substance than petrodiesel. It is non-toxic and is four times more biodegradable than conventional diesel. Biodiesel also has a significantly higher flash point, the temperature at which it will ignite when exposed to a flame. This means that spills are much less of a safety and environmental concern, because the biodiesel will decompose in the ground like any other plant and will be far less flammable. This is in sharp contrast to conventional petrodiesel.

## Anticipated Costs

### *W A S T E V E G E T A B L E O I L*

University dining centers produce WVO as part of their daily meal preparation. This WVO is disposed of in large storage containers in various locations on each campus. The University pays a fee to a private contractor, Baker Commodities, to remove the WVO from the campuses (currently, Baker Commodities primarily uses the WVO for animal feed). The cost for removal from the River Campus is \$220 per month, based on two pickups per month from both Douglass and Danforth Dining Centers. This cost over the course of 12 months totals \$2,640. Dining Services also pays about \$100 per month to have WVO removed from the Eastman campus. Finally, Baker charges \$54 monthly to remove WVO from the Strong Hospital Campus. This brings the total cost of WVO removal to \$4,488. In the short term, our proposal suggests only using WVO from the River Campus. If our proposal is implemented, this \$2,640 yearly cost would be eliminated. The long-term affect of our proposal would eliminate the entire \$4,488 cost of WVO removal spread across all campuses.

While the amount of WVO produced by the dining centers is variable, the amounts can be estimated based on data from Dining Services and Baker Commodities. Unfortunately, neither Baker Commodities nor Dining Services keeps a monthly record as to the number of gallons of WVO disposed. Instead, Baker keeps track of the number of pounds removed,

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<sup>5</sup> [http://www.utahbiodiesel.org/biodiesel\\_using.html](http://www.utahbiodiesel.org/biodiesel_using.html)

and Dining Services keeps track of the number of pounds of oil purchased. In the table below, we have estimated the monthly supply of WVO based on this information.

SOURCE OF WVO	POUNDS OF WVO	GALLONS OF WVO	COST OF DISPOSAL
RIVER CAMPUS (DOUGLASS AND DANFORTH DOCKS)	8,500 pounds per year	1,260 gallons per year (105 gallons per month)	\$220 per month
EASTMAN CAMPUS DOCK	1,500 pounds per year	240 gallons per year (20 gallons per month)	\$100 per month
STRONG MEMORIAL HOSPITAL DOCK	10,000 pounds per year	1,500 gallons per year (125 gallons per month)	\$54 per month
<b>TOTAL</b>	<b>20,000 pounds per year</b>	<b>3,000 gallons per year</b>	<b>\$374 per month</b> <b>\$4,488 per year</b>

### *PROCESSOR AND PROCESSING OF WVO*

The most significant cost of the project is the initial cost of the processor. The processor will cost between \$4,000 and \$5,000. There are a number of other costs associated with the processor. For example, someone would have to operate it for several hours per week. While a student would ideally fill this position, we are very flexible as to the details of this position. Drums need to be purchased to store the WVO, the waste products from the processor (such as glycerin), and for mixing and pumping the new biodiesel fuel. These drums can be purchased through University Facilities at somewhat discounted prices.

Another cost associated with the processor is the chemical additives that must be added to the WVO. These additives include lye and methanol. Costs for these chemicals are about \$0.33 for lye and \$0.40 for methanol per gallon of WVO processed. The methanol, however, can be recycled, as it is a byproduct of the reaction. An estimate of the actual cost per gallon of WVO processed is about \$0.25 for methanol. Maintenance of the filtration system, specifically the purchase of new filters, is another ongoing cost that has been taken into consideration.

## *PICK UP AND TRANSPORTATION OF WVO*

The physical process of transporting the WVO from its various disposal locations is currently handled by Baker Commodities. This would be a new cost and procedure that the University would have to incur. There are two primary ways to handle this, including pumping the WVO into containers on a truck or performing a container exchange. The easiest method is to load containers from a disposal location into an existing University vehicle. In the winter months, it is common for the WVO to gel up, making it very difficult to pump. Currently, Baker Commodities actually warms the WVO at the dock in order to pump it. We believe that a container exchange makes the transportation process easier, especially in the winter. The University Courier Services department owns a truck with a lift-gate and contracts its services to University departments. We propose renting this truck and service once a week and simply perform a container exchange at each pickup location. The cost for this truck and service is \$50 per hour. Ideally, we would prefer to use a lift-gate truck owned by Facilities in an effort to streamline the process.

## *REGULATION AND OTHER COSTS*

There are a number of costs associated with regulation that we are aware of. For example, as a byproduct of biodiesel, glycerin needs to be properly disposed of. This will cost about \$100 per 55-gallon drum. Since it is necessary to filter the waste vegetable oil, there is a cost associated with the filters. A rough estimate for the cost of filters is about \$450 per year based on the price of filters and an estimate of how many will be necessary.

Another important regulatory issue is the SPCC plan. For our proposal to go into effect, this plan would have to be updated to include the new procedure. While it is possible for plan changes to be combined to reduce the cost, a base price of \$1,250 is charged for any plan changes. Finally, it is necessary to assure that the quality of the biodiesel is up to ASTM standards. We have estimated a cost of \$1,400 in the first year for this quality assurance, and about \$600 per year after that. These estimates are based on the approximate costs of biodiesel testing kits and necessary materials. The costs for purchasing ASTM standards and testing the biodiesel accordingly are commensurate.

## *OVERALL COSTS*

Based on the above, we have compiled some rough estimates of the overall costs of the UR Biodiesel proposal in the tables below. These numbers are estimated based on data we have compiled and estimates we have made best on the best available information.

While these costs are not insignificant in the short run, we believe the long-run effect will be quite different. If all costs of Baker Commodities are eventually displaced (totaling

\$4,488) and savings on fuel are considered (as the costs of fuel are always rising), in the long run this proposal will allow the University as a whole to save money.

#### ESTIMATED UP-FRONT COSTS

PURCHASE OF PROCESSOR	PURCHASE OF STORAGE DRUMS	ASTM QUALITY ASSURANCE	TOTAL UP-FRONT COSTS
\$3,000	\$500	\$1,400	<b>\$4,900</b>

Source/Notes: Purchase of storage drums based on estimated cost of \$50 per 55-gallon drum with 10 drums, from prices listed at [Bascousa.com](http://Bascousa.com).

#### ESTIMATED LONG RUN COSTS

Operation Cost (Employee Salary)	Cost Of Fuel Additives	Transportation of WVO	Removal of Glycerin	ASTM Quality Assurance	Filters	Total Long-Run Costs
\$2,880 per year	\$1,740 per year	\$2,400 per year	\$550 per year	\$600 per year (after first year)	\$450 per year	\$11,070 per year

Source/Notes:

- Cost of Operation determined by estimating an 8-hour per week time commitment at \$7.50 per hour for operating the processor and for transporting the WVO.
- Cost of Fuel Additives determined based on (\$0.25 per gallon of WVO for methanol and \$0.33 per gallon of WVO for lye) \$0.58 per gallon of WVO for additives. The approximate costs for the additives determined based on wholesale chemical information from Sigma Aldrich, Inc. and laboratory tests by UR Biodiesel. Bulk purchasing discounts may be available.
- Transportation of WVO based on \$50 per hour lift-gate truck rental, one hour per week in WVO pickups (Bill Orel, UR Courier Services)
- Removal of Glycerin cost estimate provided by Marvin Stillman, Manager of Environmental Compliance, University Hazardous Waste Dept. Based on production of 10% glycerin per gallon of WVO used, and estimated by Marvin Stillman to be \$100 / 55-gallon container of waste.

## Summary

To conclude, we believe that our proposal would be beneficial for the University community as a whole. While it is both expensive and labor intensive to start up this program, the benefits far outweigh these initial costs. This program would bring the University local and regional media attention, focusing on the University's commitment to sustainability. Undergraduate students would have the opportunity to learn first-hand how a biodiesel program works, and would have endless research opportunities related to biofuels. The local community would benefit from educational seminars about sustainability and climate change. Hopefully, local businesses, governments and non-profits would take similar steps as the University toward creating a more sustainable environment. Ideally, smaller local restaurants would be directly involved with this program as we would purchase their WVO for use in our busses. Not only does this expand the University's ability to use biodiesel, but it also supports local businesses. We sincerely look forward to the day when we can ride on a University of Rochester bus decorated with the tag-line: "This bus fueled by the grease from your lunch." We are excited to work with you to achieve this end.

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For a comprehensive overview of biodiesel please see:  
<http://www.nrel.gov/vehiclesandfuels/npbf/pdfs/40555.pdf>