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UR Biodiesel – December 2008 Update

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Introduction

The months between June and December 2008 brought about some of the most exciting moments of the UR Biodiesel project. On July 17th, 2008, in a conference call with Dean Parker (then the Dean of the School for Engineering and Applied Sciences) and Ovide Corriveau (the University's Senior Operations Officer), UR Biodiesel was officially given the go-ahead. On that day, Dean Parker and Ovide expressed excitement about the program and agreed to a financial commitment as well as other support from the College. After two years of work on UR Biodiesel, it was a moment that was met with great excitement, but also with recognition of the extensive work ahead.

Progress During Fall 2008 Semester

Construction Finally Begins

The long process of construction began in early September. Originally, the plan had been for construction to be completed by Meliora Weekend, which would have allowed full tours of the facility at that time. As we will discuss later, a number of challenges prevented this. Regardless, though, the most important first step was completed as we had broken ground in the construction of the UR Biodiesel facility. It is located at 612 Wilson Boulevard, the former Facilities Headquarters. The facility is housed in an old garage that was not being used. The location is ideal given its proximity to the University's diesel fuel pump (located in the same complex), which is where University vehicles fill up. It is also in the same area as the offices for a number of Facilities mechanics. This is essential as these individuals are extremely helpful in organizing the construction teams and building the facility. More importantly, as we begin construction on the processor itself, it will be helpful to have the assistance of trained mechanics nearby. Eris Oleksyn, Facilities Trades Supervisor and Area Manager, has coordinated the entire construction project. He has been UR Biodiesel's primary contact in Facilities, and has been an essential part

of the project's success. Eris manages construction on a daily basis, works through challenges, orders parts and plans for the processor and meets with the UR Biodiesel team frequently to review progress.

Above are some pictures of the very beginning of the construction.

Finalized Plans with Dining Services

UR Biodiesel has built up a good relationship with UR's Dining Services, particularly Cam Schauf (Director of Dining and Auxiliary Operations) and Mary Locke (Director of Operations). During the spring of 2008 we learned that Dining Services had been approached by an outside company to purchase all of our waste vegetable oil (WVO). The arrangement seemed likely to occur, but Dining agreed to keep the WVO in-house to accommodate UR Biodiesel. This semester, we finalized the details of how we will receive the WVO.

WVO is stored in two River Campus locations: Danforth Dock and Douglass Dock. The Douglass Dock location is filled with the waste from Douglass Dining Center's smokehouse, making it more difficult to use for conversion, as a more complex filtration process would be necessary. In the short term, we will not use this WVO because of this issue. However, the Danforth Dock's WVO is much more pure. UR Biodiesel will be able to pick up WVO from this location on an as-needed basis. A day or two prior to pick-up, we will contact Mary Locke and Bob Fox, the

Director of Danforth Dining, to confirm the time of pickup. Once that confirmation occurs, we are able to make the pickup on our own for transport back to our facility.

Another detail that was finalized this semester was the way by which we will transport the waste vegetable oil to UR Biodiesel's facility. Eris Oleksyn was able to secure a sprayer tank that is no longer used. Currently, one of the Facilities mechanics who has been assisting us with UR Biodiesel is building a pump-valve system to connect to the sprayer tank, and a wand to place in the WVO container at the dock. The benefit of the wand is that it will ensure that the highest quality WVO is being extracted from the tank by pumping from the *middle* of the container. This WVO is less affected by water and food waste. The process is as follows: A tractor will pull the sprayer tank to the Danforth Dock; a member of the UR Biodiesel team will place the wand in the container; the pump will suck the appropriate amount of WVO into the sprayer tank; the valves will be closed and the tank driven to the UR Biodiesel facility; the pump will then pump the WVO into a tank at the UR Biodiesel facility. The photo below is the sprayer tank before modification as described above (modifications are currently being performed).

Another change that occurred during the past semester is the way that Dining Services conducts business with the company that currently removes WVO from campus. Prior to this year, Dining Services would pay Baker Commodities a nominal monthly fee to remove WVO from various campus locations. However, beginning in early August, Baker Commodities began *paying* a small fee to Dining

Services for continued access to our WVO. While we expected that this shift would occur eventually, we were surprised that it happened so soon. Admittedly, this hurts our case that UR Biodiesel helps the University financially. However, it reinforces our view that WVO is quite valuable, and that it can be most sustainably used as fuel on our campus.

Working with Art Department for Bus Design

When we first learned that University Transportation would be providing our project with a bus, we knew it had to look good. We also made a decision early on in the project to include as many campus individuals and groups as possible, so that UR Biodiesel would be a truly collaborative effort that the whole campus community could take ownership of. At the beginning of September, the UR Bioidiesel team met with the leadership of the Creative Arts Club, an undergraduate club dedicated to art on campus. We began brainstorming some ideas of how to include their talent in the design of the UR Bio-Bus. This semester, I had the pleasure of working with Annalise Kjolhede, a student in the Chemical Engineering 278 course. One of her tasks was to continue to work with the Creative Arts Club to come up with a plan. The Creative Arts Club felt strongly that to best accomplish our goal of campus involvement, coupled with the goal of good art, they want to have a campus-wide design competition to design the bus. Their executive board will then review the top submissions with our team and we will select a winner. The winning artist will be required to work with the UR Office of Communications to ensure a professional-looking design on the bus.

Marketing and Website Design

We made a lot of headway this semester in terms of our marketing. It is important to the project that the entire University of Rochester community is aware of UR Biodiesel, including what it is, how it works, and how to get involved. We want to raise awareness as much as possible to help contribute to the community spirit and make future growth possible.

Earlier in the semester, we met with Melissa Greco-Lopes, the University's Student Life Publicist. We provided her with a wide range of information about UR Biodiesel and about biodiesel generally. Her office is extremely enthusiastic about UR Biodiesel, and they see it as one of the most exciting publicity stories this year. They are sitting on the story currently as it has not had much action lately. However, once we are in the facility and building, they plan to contact local media to bring them in to learn about UR Biodiesel. Additionally, they want to write a story for Rochester Review, the parent and alumni magazine. Finally, on the day that we officially launch UR Biodiesel in the spring, the Office of Communications hopes to conduct a whole media event. We envision a "maiden voyage" of the UR Bio-Bus, to include the College administration and local media as passengers. To our surprise, the Office of Communications believes there may also be national media interest in this story. Additionally, the *Campus Times*, UR's student newspaper, wrote a Features article about UR Biodiesel in its November 20th, 2008 issue. This was the first important step in raising awareness among students. Finally, as part of her work for UR Biodiesel, Annalise Kjolhede wrote some marketing materials for easy distribution, which can be found in Appendix 1.

Additionally, some students in *Engineers for a Sustainable World* have been building a website for UR Biodiesel. We hope to launch the site next semester, and it will be publicized to the campus community in a variety of ways. We expect that it will be tied in to the University's sustainability webpage as well. There is a lot of potential in the future for UR Biodiesel's homepage, including live data feeds from the bus directly on emissions, mileage and GPS location, though this year we will be more focused on getting a basic webpage up with information about the UR Biodiesel project.

Relationships with Other Groups

In the weeks before Meliora Weekend, we were contacted by the group Alumni for Social Responsibility (ASR), an organization comprised of alumni from the U of R who have a particular focus on sustainability. We discussed UR Biodiesel

with their members at a panel discussion over Meliora Weekend. Additionally, one of the members of their steering committee, Aadika Singh, was interested in a tour of the facility over Meliora Weekend. We had extensive discussions with her about how alumni can get involved in the project. Among other things, we decided to invite ASR's members to the kick-off of UR Biodiesel in the spring.

In early November, I met with two medical students from the University's Medical School. They are part of a student organization on the medical center campus that looks at environmental sustainability and ways of getting involved. We discussed potential partnerships between the two campuses in terms of UR Biodiesel. Specifically, we will look at instituting a biodiesel presentation at the UR Biodiesel facility each semester specifically for Medical Center students. We also discussed receiving assistance from interested students at the Medical Center to actually run the UR Biodiesel processor. They could be worked into the rotation just as River Campus students will be. Both of these relationships go back to the fundamental importance of involving the community and increasing awareness of UR Biodiesel.

Challenges During Fall 2008 Semester

We learned the difficult lesson early on that these types of projects always encounter problems along the way. UR Biodiesel has certainly had its fair share of problems. This semester alone, there have been a few main issues that we have had to deal with and that have slowed down the progress of the project overall.

Construction of the UR Biodiesel facility faced two separate environmental shutdowns that halted all construction. The first was fuel oil that was found in the groundwater. During construction, workers digging to run the electrical and water lines to the facility encountered fuel oil in the ground. As is required by law, the University notified the New York State Department of Environmental Conservation (DEC). They visited the site and instructed our Facilities department to dig up a large area of the parking lot, dig out and replace the soil to eliminate all fuel oil in

the ground. Additionally, three testing wells were installed in the parking lot to allow the DEC to periodically check for the quality of the soil. This shutdown took several weeks and halted all other construction. Because of the extensive digging that was necessary, the parking lot in the Facilities complex needed to be repaved (repaving can be seen in the below pictures).

Another major hurdle that we faced was the necessary replacement of the sewer. Part of the construction included the extension of the sewer line to the UR Biodiesel facility. In that process, the construction group ran a camera into the existing sewer lines to look at the piping and connections so that they could be duplicated in the extension. What they found, though, was that the sewer was completely rotted out and was filling with sand. Had they not discovered this problem, it is likely that there would have been a sewage emergency within a year or two. Unfortunately, though, this required a complete replacement of the sewer line, which took another several weeks and further delayed construction. Below are some pictures of the rotted sewer and digging it up.

Another challenge we encountered was funding. University Facilities generously agreed to cover the cost of all construction of the facility, including shelving, insulation, heating, sewage, electrical, etc. However, the College and the School of Engineering agreed to cover the costs for construction of the processor. We were not able to purchase items such as plans, containers, tubing, etc. until that funding had been provided, which did not occur until early December. Unfortunately, projects such as this must go through quite a bit of bureaucratic red tape, and delays in funding are included in that. However, now that funding has been received, we have begun to purchase many of the necessary items to begin building the processor.

One of the goals of UR Biodiesel is to promote general environmental sustainability in any way we can. When we learned that we could use Cogen to heat our facility, we jumped at the opportunity. One neat way to do this is through the use of radiant flooring. Radiant flooring allows Cogen's hot water to coil under the floor, thereby heating the floor and the whole room only with the Cogen hot water byproduct. While we are particularly excited about this, it unfortunately caused further delays in construction. The construction team encountered difficulties laying the floor, and it has taken months to dry (it is only supposed to take a few days). While the floor is drying, it cannot have anything placed on it, meaning we have not been able to order many of the items to begin building the processor. This caused a further delay, as we have been unable to spend time in the facility beginning to plan layouts and schematics of the processor. Below are some pictures of the radiant flooring being placed:

Current Status and Timeline for Spring 2009

Currently, just about all construction has been completed. The water still needs to be hooked up to the sink, and Cogen needs to be connected to the radiant flooring. We are still waiting for the flooring to dry, though we expect this to be complete by the middle of January. In early December we purchased access to a website from a company called Utah Biodiesel Kits. This website will guide us as we design the particulars of our biodiesel processor and as we make it work in our facility. We recently acquired six 55-gallon drums that can be used for storage, as well as a 200-gallon hot water heater that will be converted into the processor. During the final weeks of December and early January we will be purchasing additional supplies necessary to build the processor, such as tubing and tools.

We have finally reached a point in the UR Biodiesel project that roughly all that is left to be done is build the processor. We will spend January and early February ordering the last of the necessary parts and mapping out the facility so we know exactly where everything is supposed to go. Most of the month of February will be spent building the processor. We also hope to make our first biodiesel pickup at the end of February or early March. In March and early April we plan to test the WVO, run the processor, research efficient biodiesel-diesel blends, and attempt to run the UR Bio-Bus on WVO. In March we also plan to have completed the bus design competition and paint the Bio-Bus. Additionally, we will spend late March and early April finalizing the details of the "official" launch of UR Biodiesel, slated for April 22nd, 2009: Earth Day.

Appendix List

UR BIODIESEL

(PREPARED BY ANNALISE KJOLHEDE)

It was in the fall of 2006 at the when the heads of four bright undergraduate students came together and UR Biodiesel was born at the University of Rochester. This student driven plan is to use the waste vegetable oil that is generated at one of the dining centers on campus to

create biodiesel to be used in one of the campus buses. Realizing the advantage of a liaison to the administration and faculty, these students, Chris Babcock (2007), Dan Fink (2009), Dave Borrelli (2009), and Eric Weissman (2010) contacted and won the support of former Dean of Engineering, Kevin Parker. The present Dean of Engineering, Robert Clark has also shown his support for UR Biodiesel.

A goal of this project is to have an interdisciplinary approach to sustainability and thus include participation from many different departments. It includes an academic component utilizing Ben Ebenhack, Senior lecturer in the Department of Chemical Engineering, and his class, Energy Alternatives Laboratory, to integrate involvement of other students with similar interests. This is an important aspect of the project because it ensures its student driven propagation. This semester three students from this class have joined in the efforts of UR Biodiesel: Hannah Baker (2010), Katie Maloney (2010) and Annalise Kjolhede (2010). The Department of Transportation and its Director, Glen Sicard, have been helpful in providing the bus that will use the biodiesel and the project has incorporated the talents of the Art Department to create a design and paint the bus that will serve as a traveling billboard for UR's commitment to sustainability. This project has received immense support from UR facilities including Eris Oleksyn, Trades Supervisor and Area Manager; Jeff Foster, Director of River Campus Facilities & University Properties; and Richard Pifer, Associate Vice President of University Facilities and services. UR Facilities and Operations has been instrumental in providing space, materials, information and guidance for the waste vegetable oil processor and laboratory. Even campus dining officials have joined in the efforts of UR Biodiesel. Mary Locke, Campus Executive Chef, and Cam Schauf, director of Campus Dining Services and Auxiliary Operations, have contributed to UR biodiesel by providing ample data regarding the waste vegetable oil. The involvement of many diverse university members has broken strides for student projects and developed a better sense of community.

Another goal of this project is to integrate sustainable principles in every manner possible. This includes adaptive reuse of materials and spaces. For example, the previously unused facilities garage that will house the processor will be heated by the University's Cogeneration facility and many of the materials such as the sink and heat exchanger are used from other locations around campus. Also, the combustion of biodiesel has overall lower emissions than that of petrodiesel. The very nature of the project is environmentally sustainable because the feedstock is a waste stream, which thereby reduces waste output. UR Biodiesel saves money by diverting fuel costs and Waste Vegetable Oil disposal costs alike. The adaptive reuse of materials and spaces has proved to be economically beneficial as well. These side effects of the project have illustrated that being green can be synonymous with being economical.

The collaboration of many diverse parts of the university and the resulting biodiesel bus will promote sustainable objectives in the university's social climate. As UR Biodiesel expands there are hopes that these sustainable principles will be assimilated into the mainstream, not only for the University of Rochester, but peer institutions and the Rochester community as well.

UR BIODIESEL

UR Biodiesel is an undergraduate student driven project that began in the fall of 2006 at the University of Rochester. The plan is to use the waste vegetable oil from campus dining centers to produce biodiesel as fuel for one of the campus buses. This bottom-up operation has gained the support and participation of many campus administrators, faculty and employees setting up a network for success and bettering the university's sense of community. A goal of this project is to promote sustainability in every manner possible. There are foreseen environmental benefits including lowering emissions by using biodiesel and reducing waste outputs. Illustrating the economic benefits of sustainability, this project will save money with adaptive reuse of spaces and materials and will also divert costs of fuel and waste vegetable oil disposal. The collaboration of many diverse parts of the university and the resulting biodiesel bus will promote sustainable objectives in the university's social climate. As UR Biodiesel expands there are hopes that these sustainable principles will be assimilated into the mainstream, not only for the University of Rochester, but peer institutions and the Rochester community as well.

STEP BY STEP PROTOCOL. (FOR DEMONSTRATION ONLY)

`1. Load the reactor with WVO

1. If Sight Tube is full of oil, open Sight Tube Valves. Place a waste bucket under the Drain Valve and open the drain to let old WVO out of Sight Tube. Leave Sight Tube Valves open.
2. Close Drain Valve ( ).
3. Open Solar Preheat Tank Valve ( ) and WVO inlet valve ( )
4. Close Tank Isolator Valve ( )
5. Open Recirc. Valve ( ) and Vent Valves ( ) and ( )
6. Connect Vent Tube to the vent outlet.
7. Turn on reactor pump.
8. Watch the oil level as it appears in the sight tube. When the oil level reaches 54 the 54 gallon mark, turn off the pump.
9. Close the Solar Preheat Tank Valve ( ) and WVO inlet valve ( ). Close the Vent Valves ( ).

2. Heat the oil to reaction temperature: Before beginning this process, make sure you or another staff member will have time to complete fuel processing steps 3-5.

1. Make sure there is oil in the reactor before turning on heat.
2. Turn on the heat using the heat control switch
3. Note the heat start time and ambient temperature on the batch record sheet
4. Monitor the tank temperature. When the guage reads 100 F turn on reactor pump. Set the valves as follows:
    a. Open Tank Isolator Valve ( )
    b. Open Recirc. Valve ( )
    c. Open Vent Valves ( ) and ( )
    d. All other valves should be closed
5. Continue to watch tank temperature. When tank temperature reaches 130 F turn off the heat using the heat control switch.
6. Note the heat stop time on the batch record sheet
7. You are now ready to process the oil into biodiesel.

3. Mixing the methanol and catalyst

1. Determine the proper catalyst amount using the titration test.
2. Materials needed: Catalyst, scale, container for weighing, powder funnel, two five gallon jugs of methanol and one jug with two gallons of methanol (for a total of 12 gallons).
3. If using recovered methanol, note the purity on the batch record sheet
4. If you need to pour methanol to make up the 2 gallon jug, use a funnel and pour carefully. Do this far away from the storm drain in case of a spill.
5. Put on gloves, dust mask, goggles, and rubber apron. You must also be wearing closed-toed shoes and long pants to perform the following steps. Perform the remaining steps outside the shop:
6. Place the empty weighing container on the scale and zero out the scale.
7. Open the catalyst container. Weigh out the proper amount of catalyst for one five gallon jug. Close and seal the catalyst container.
8. Open the first five gallon methanol jug. Using the powder funnel, carefully add the catalyst to the jug. Close the lid on the methanol jug.
9. Make sure the vent lid on the jug is closed. Lift the jug and gently agitate it back and forth with a twisting motion. Set the jug down and open the vent lid to release pressure.
10. If you notice any methanol leaks, stop immediately and fix the leak.
11. Repeat steps 6 – 9 for the other five gallon jug and the jug with two gallons.
12. Continue to agitate the methanol jugs until all of the catalyst has dissolved.
13. NOTE: Be sure that the vent lids are closed when agitating the jug, but open them as soon as you return the jug to the ground to prevent a pressure buildup.
14. Typically KOH will dissolve into methanol in roughly 5 minutes, while NaOH may take 15 minutes or more. The time will increase if methanol is cold, or if using large amounts of catalyst for high titration number oils.
15. When the catalyst has dissolved, you are ready to add the methoxide mixture to the reactor.

4. Adding the methoxide to the reactor and mixing the batch.

1. Wear gloves and goggles for the following steps.

2. Be sure the reactor is full of oil, and that the tank temperature is above 125 but below 140 F. Note the mixing temperature in the record sheet.
3. BE SURE THAT THE HEAT IS TURNED OFF.
4. Valves should be set in the recirculation position.
5. Check to be sure that the first Vent Valve is open. Connect a collecting jug to the methanol condenser outlet tube, then open the Condenser Vent Valve. Connect the vent hole on the methanol collection jug to the ventilation system.
6. Turn on the pump.
7. Connect a methoxide jug to the methoxide inlet port on the reactor. Lay the jug on its side, with a block of wood under the front side to prevent methanol from leaking out of the vent hole. Open the vent lid slightly to allow air to enter. Check for any leaks.
8. With the pump running, open the methoxide inlet valve fully. Throttle back on the tank isolator valve until methanol is drawn through the injection tube into the reactor. Watch the sight glass on the recirculation line for a color change in the oil stream. Adjust the tank isolator valve so that the methanol feeds into the reactor slowly, approximately one-half gallon per minute.
9. When the jug is nearly drained, move the wood block to the back of the jug to tip it forward for complete drainage. Lift the jug if necessary, but be careful not to spill methanol out of the vent hole. Clean up any spills promptly.
10. When the jug is empty, close the methoxide inlet valve and open the tank recirculation valve fully.
11. Repeat steps 6 – 9 for the remaining jugs of methoxide.
12. When finished, close the Condensor Vent Valve. Remove the collection jug from the condenser outlet. If any significant amount of methanol was collected, note it in the batch record sheet. Return the jug to the methanol storage cabinet.
13. Note in the record sheet the time that the last of the methanol was added to the reactor.
14. Run the reactor pump with the valves set for recirculation for 90 to 120 minutes or more.
15. Shut down the pump. Note the total mixing time on the batch record sheet.
16. Turn off the main power switch to the reactor and close all valves.