

Illinois Biodiesel Initiative

FINAL REPORT – December 30th, 2010

I. Summary:

The Illinois Biodiesel Initiative is a project focused primarily on lowering the emissions of the university and promoting education of renewable fuel sources. Our team is striving to ensure that the Illinois Biodiesel Initiative becomes a model for university and community biodiesel production. After performing vast amounts of research, we designed a 400 gallon batch biodiesel processor. This system will allow us to process all of the available used cooking oil on campus, approximately 300 gallons per week, and provide a steady supply of quality biodiesel fuel to the University. To advance our goals, we have secured \$32,354 funding from the Student Sustainability Committee, the Cozad design competition, the Clinton Global Initiative, and Engineering Design Council to build this large scale reactor on campus.

II. Project Execution

A. Oil Collection

Weekly used vegetable oil collections are performed by the students involved in IBI using a pickup provided by the Garage & Carpool. The pickup truck is equipped with a 110 gallon fuel tank and a 200 gallon tote for oil transportation. The students driving the truck are required to have driver training and at least one student on the oil pick up is required to have spill training, both training sessions are administered by the Garage & Carpool. The pickup truck also carries spill prevention and spill clean up supplies.

In the previous years IBI provided 35 gallon drums on the loading docks of all university dining halls. All of the dining halls also have Darling bins which they can use to dispose of the used vegetable oil. With the beginning of operation of the Ikenberry Commons this past semester, Fall 2010, IBI has become the sole used vegetable oil collector from the Ikenberry dining hall. An indoor tank has been installed at the loading dock of Ikenberry Commons which holds approximately 400 gallons of oil. This system was a new development this semester and took a couple weeks to adjust to. From our experience, Ikenberry dining hall on average produces 100 gallons of used vegetable oil every week.

Due to the time delay associated with the reactor piping upgrade, few reactions were performed this semester and the collected oil was stored at ISTC. Because of this fall behind, IBI students were unable to process used vegetable oil from the university dining halls other than Ikenberry Commons. Ikenberry dining hall produces the most oil and, since IBI is the only oil collector, was viewed as a priority. Our contact at ISTC, Joe Pickowitz, took over the oil collection from the remaining dining halls.

B. Production

Production started off the year like many of the sub-groups looking for individuals at the beginning of semester on Quad Day. Production inherited the successful undertakings that preceded it from the prior school year. This included a large scale reactor, catalyst/methanol mixer, mezzanine and its many short-term connections that were used to complete three large reactions between the fall '09 and spring '10 semesters. Along with the parts was a 'to do' list of issues that needed addressed and corrected before long term viability of the reactor and its systems would reliably produce fuel. This list was also compiled from the various groups that

participated in the engineering class 'LINC' Living and Learning in Community of which IBI was a participant. This is what the production team set out to do. This upgrade, from soft to hard piping, will ensure that the large reactor has a much longer life before things need to be replaced again.

The first completed event of production was the delivery of 385 gallons of biodiesel to the Garage and Carpool (G&CP) facility which was completed the second week of classes, Sept. 9. This was completed using older members who were spill trained from the G&CP. This led into the training of new members to be G&CP spill trained the following week on Sept. 16 and 17.

The next item to tackle was the interconnections of our reactor, methanol tank, and various inputs and outputs from the process. Hard piping was requested by ISTC in the previous school year to provide for safety and reliability. A design session meeting was completed and parts were ordered. The first round of parts came in the week of October 4. A build day was completed that Thursday in which the design was slightly altered to accommodate tolerances and restrictions in the scheme. Many parts of the process required fitting a pipe and having it custom made by the Mechanical Engineering Lab. This resulted in a long build time because it required essentially a week between each alteration. Once our second round of parts had been acquired in the first weeks of November the reactor was successfully pressure tested for leaks. A few loose joints were found and tightened. The reactor was essentially completed by the third week of November. Since thanksgiving was fast approaching the first reaction with the redesigned large scale reactor was postponed until the first week back after the fall break. The reaction was successful and also throughout the process a wash-ring was built off a modified design by one of the LINC groups. The reaction was also successfully decanted and washed the following week thus proving the reactor is ready to meet a long term production schedule reliably. Throughout the process, the duty of picking up oil was still accomplished and thus an inventory of oil has been collected and ready to put into the production schedule.

C. Soap Production

Sustainability is one of the main goals of the Illinois Biodiesel initiative. The biodiesel production process produces glycerin as a byproduct which has potential for reuse. Glycerin is a very good degreaser and cleaner. Each 400 gallon batch of biodiesel will produce about 80 gallons of glycerin. This is too large an amount of glycerin to simply dispose of but too little of an amount to justify purifying it and selling it for commercial use. The Illinois Biodiesel initiative found that glycerin can be reused. Instead of disposing of this byproduct, the Illinois Biodiesel Initiative will recycle it into a liquid, marketable soap which will then be sold to consumers, with proceeds going back to the Initiative. Potential consumers of the soap are dining halls, which can use the soap as a prewash for their dishes, or the Garage and Carpool, which can use the soap to wash their vehicles or tools which can build up large amounts of grease. Soap production is a relatively new part of the Initiative, with hopes of gaining ground on the startup of the procedure in the spring 2011 semester. This means buying equipment to produce soap, finding markets for the soap, and developing a reliable soap recipe will be the most important parts of this process. Another aspect of soap production is methanol recovery. Excess methanol often ends up in the glycerin byproduct and must be removed before the glycerin is used for soap production. Illinois Biodiesel Initiative is looking into obtaining a methanol recovery system which will safely evaporate the methanol for the glycerin and condense it back down so that it is separate from the glycerin. This methanol can then be reused for further biodiesel reactions. This process also lends itself to the sustainability of the process.

D. Outreach

The Illinois Biodiesel Outreach Program began to establish a solid footing this past semester. After taking over in late October, I discovered what tasks needed to be done to put the Outreach Program on the same level as the rest of the Biodiesel Initiative. This semester the Outreach Program took control of securing both a bid and funding for EOH this upcoming February. The Outreach Program will continue to control and distribute information about EOH until the event day next semester. Also, there were several attempts to communicate with Loyola University's Outreach Program and prospects look good as both sides are eager to work together in the future, hopefully culminating in visits to both campuses within a semester or two. Loyola's Outreach program is the model that the Illinois Outreach hopes to grow into within the next few years and hopefully the initial steps taken this past semester can lead to joint projects that can help both sides grow. The Outreach program is still in its infancy right now; however, the sky is the limit considering how respected and effective the rest of the organization is.

E. Special Projects

The special projects team is a new division of IBI. The purpose of this group is to recruit members who strive to work on more specialized projects that require more of a time commitment than some of the other projects in the group. This semester the group worked on developing a mini reactor which can be used for precise biodiesel production. This reactor, funded by a grant from Engineering Council, will allow the testing and soap production groups to accurately test different production techniques and mixtures in order to produce a higher quality fuel and glycerin by-product.

During the fall 2010 semester the group came up with the design of the reactor as well as finding sources for all the parts of the reactor. At the moment the group is working to find a professor in the School of Chemical Sciences who is willing to help submit the reactor design to the glass blowers in Noyes. With the assistance of a professor in that school, the special projects team will be able to get a reduced price for the reactor allowing for a more advanced system to be produced.

F. Funding

We are cooperating with the Illinois Sustainable Technology Center to produce 80 gallons of fuel per week. These 80 gallon batches allow us to test and perfect our production techniques as well as educate new members about producing biodiesel.

- We have been performing our quality tests on every batch we produce and the results are promising. At the moment the testing procedures are one of the more expensive parts of every batch. The testing generally costs around \$500.
- The fuel we produce from these weekly reactions will eventually be integrated into the campus diesel supply, located at the Garage and Car Pool facility. We are starting the first stage of this integration process by testing custom blends of biodiesel fuel in individual vehicles.
- If these blends produce no ill side effects, we will begin dumping our fuel into the 10,000 gallon underground dispensing tank to augment the overall blend of biodiesel available on

campus. We plan on eventually providing a 15 – 20% blend of biodiesel after we begin large scale production.

III. Account Data Summary Table

Voucher Date	Description	Revenue	Materials & Supplies	Travel	Equipment	Services	Total Expenses	Available Balance
7/1/2009	Beginning Balance						\$ -	25,353.88
9/1/2009	McMaster Carr - polyester filter bags		\$ 58.45				\$ 58.45	\$ 25,295.43
9/11/2009	Boyer - sodium hydroxide beads		\$ 110.00				\$ 110.00	\$ 25,185.43
9/22/2009	Boyer - potassium hydroxide beads		\$ 163.80				\$ 163.80	\$ 25,021.63
9/25/2009	United Fuel - methanol		\$ 385.06				\$ 385.06	\$ 24,636.57
10/15/2009	US Plastics - translucent bottles & pump		\$ 15.74				\$ 15.74	\$ 24,620.83
10/30/2009	ethyl acetate reagent		\$ 102.36				\$ 102.36	\$ 24,518.47
10/30/2009	potassium chloride		\$ 39.25				\$ 39.25	\$ 24,479.22
10/28/2009	United Fuel - methanol		\$ 652.50				\$ 652.50	\$ 23,826.72
11/6/2009	McMaster Carr - stainless tees, valves, etc.		\$ 1,859.93				\$ 1,859.93	\$ 21,966.79
11/6/2009	US Plastics - polyethylene bulk tote		\$ 1,993.95				\$ 1,993.95	\$ 19,972.84
11/6/2009	Pump Biz - electric drum pump		\$ 581.80				\$ 581.80	\$ 19,391.04
1/18/2010	US Plastics - CPVC fittings, cement, primer, etc.		\$ 157.14				\$ 157.14	\$ 19,233.90
1/13/2010	United Fuel - methanol		\$ 422.50				\$ 422.50	\$ 18,811.40
1/26/2010	Alumitank, Inc. - stainless biodiesel reaction tank				\$ 2,323.11		\$ 2,323.11	\$ 16,488.29
3/1/2010	Refund for overcharge on shipping for Alumitank				\$ (47.95)		\$ (47.95)	\$ 16,536.24
3/8/2010	United Fuels - methanol - 1 55 gal drum		\$ 129.25				\$ 129.25	\$ 16,406.99
3/9/2010	McMaster Carr - air powered mixer				\$ 1,117.87		\$ 1,117.87	\$ 15,289.12
4/1/2010	Motion Ind. - flow meter		\$ 76.06				\$ 76.06	\$ 15,213.06
4/1/2010	Boyer Corporation - sodium hydroxide		\$ 273.80				\$ 273.80	\$ 14,939.26
4/14/2010	United Fuels - methanol 2 - 55 gal drums		\$ 409.50				\$ 409.50	\$ 14,529.76
4/26/2010	United Fuels - methanol 2 - 55 gal drums		\$ 379.50				\$ 379.50	\$ 14,150.26
4/22/2010	Black & Co - mezzanine walkway				\$ 6,609.21		\$ 6,609.21	\$ 7,541.05
4/2/2010	Mezzanine Installation					\$ 6,448.00	\$ 6,448.00	\$ 1,093.05
5/11/2010	Bio Blend Fuels - 110 gal		110				\$ 110.00	\$ 983.05
5/24/2010	Analytical Services					449.75	\$ 449.75	\$ 533.30
	Ending Account Balance	\$ -	\$ 7,920.59	\$ -	\$ 10,002.24	\$ 6,897.75	\$ 24,820.58	\$ 533.30

IV. Energy, Environmental, Social and Economic Impact

- Energy and cost savings:

The production of diesel with IBI will help the university avoid the costs of alternative oil collection companies. Also, once some of the fuel transportation and production costs are set in stone we will likely be able to produce the fuel at a price below market diesel price (the current selling price).

- Environmental Impact:

Compared to diesel, biodiesel is much more environmentally friendly. According to the most recent EPA estimates (2002) a 100% biodiesel blend will lead to more than a 45% reduction to CO₂ compared to regular diesel. Emissions of particulate matter and hydrocarbon emissions are reduced compared to regular diesel.

- Social Impact:

We are constructing an “Appleseed” biodiesel reactor, a small 60 gallon processor, to use as a demonstration tool. This Appleseed reactor is small enough that it can be transported to local schools or farms to show people what a typical batch processor looks like. We have also built a small, diesel powered go-cart to demonstrate the emissions benefits gained from using biodiesel.

The Biodiesel Initiative is a multi-disciplined, environmentally friendly project that aims to engage the bright minds at our university to make our campus more sustainable and environmentally friendly. This project does not have an end date, it is constantly evolving to better serve the University of Illinois and the surrounding community and promote the use of biodiesel fuel created from unconventional sources.

V. Outreach and Education

- In addition to producing fuel for the University, the Biodiesel Initiative strives to educate the community about the benefits of producing biodiesel fuel from unconventional sources, like used cooking oil
- The LINC (Learning IN Community) course available during the spring 2010 semester taught students about the various benefits of using biodiesel as well as how it can be manufactured from cooking oil. Students were also able to gain valuable practical experience while working with the team.

VI. Lessons Learned and Future Outlook

G&CP blend/timeline limitations:

The G&CP currently only accepts the biodiesel on what their administration feels comfortable with in terms of when they accept fuel, seasonally, and how much, blend ratio. These dates and numbers will need to be set more concretely in stone before IBI can take on more oil and produce more fuel. The maximum capacity of the system at ISTC is not currently being reached; 100 gallons a week is currently being brought in, almost solely from Ikeneberry Commons. The increase to capacity will be made by incorporating more oil from the other dining halls. This increase can only be made in the coming semester if both a storage option is pursued for surplus fuel in the seasonal decrease in blend ratio and if the actual ratio is known and made maximum to accept this increase in fuel.

ISTC and truck storage limitations:

During the winter months IBI develops a used oil and fuel storage problem. The dilemma is that University housing continues to produce oil while G&CP isn't accepting any biodiesel. During this time IBI still has the ability to produce the fuel so as to create a surplus during the warm months of the year but the group has nowhere to store the fuel. This limitation prevents the group running at capacity so IBI chooses to limit its winter collection to Ikenberry dining halls. In the future the Initiative hopes to obtain funding

for some sort of permanent biodiesel storage tank. This will allow the group to continue reacting and collecting oil during low distribution periods.

Another issue that arises with storage is the transportation of the fuel and oil with the biodiesel truck. With the current infrastructure we are able to transport 200 gallons of oil and 110 gallons of fuel in the truck. This corresponds to about 2 dining halls of oil and $\frac{1}{4}$ the total amount of fuel produced in one reaction. This means that every week there the IBI must take 4 trips to and from the ISTC facility and at least 4 trips per reaction to G&CP. The time it takes to travel these distances every week is not sustainable for IBI. Not only does it mean unnecessary trips must be taken but it also makes the group unappealing for new members. In the future, other considerations must be made in order to make liquid transportations simpler for the group. One proposed suggestion was to remove the fuel container from the truck that we currently own and install a larger tank. The fuel that would be produced at ISTC would then be stored in a tank on location and it would be the G&CP's responsibility to transport the fuel from ISTC. This set up would not only reduce the turnaround time of the fuel but would also keep volunteers active in the production process itself and allow the G&CP to have more control on how much fuel it wants from the IBI. This system would also solve some of the winter surplus issues.

IBI thanks the SSC and the students of the Urbana-Champaign campus for their enthusiasm and support of this project. It has been a pleasure working with you.