Biodiesel Trailer Initial Plan

Illinois Biodiesel Initiative

**Introduction**:

Illinois Biodiesel Initiative is a dynamic student-driven enterprise that sells clean-burning and efficient biodiesel products produced from cafeterias’ waste vegetable oil. Founded in 2006 within Engineers Without Borders at the University of Illinois at Urbana-Champaign, Illinois Biodiesel is focused on supplying biodiesel without impacting food supply chains. Originally housed at Illinois Sustainable Technology Center (ISTC) in a pilot lab, Illinois Biodiesel is looking for a new space to produce biodiesel from. In addition to producing biodiesel, IBI converts the byproduct of the biodiesel process into soap. By producing from waste oil, Illinois Biodiesel provides environmentally friendly and sustainable products to companies and consumers that value reducing their environmental impact.

Biodiesel offers reduced emissions compared to petroleum diesel and is sustainably produced from waste vegetable oil. Biodiesel is essentially carbon neutral because the carbon released when burned was initially used by the plant used to produce the cooking oil. The biodiesel can be used without modification in diesel vehicles or can also be blended with petroleum diesel. The biodiesel IBI produces is sold to Facilities and Services, which blends the biodiesel with biodiesel into a 7% blend (B7). At a cost competitive with petroleum diesel, IBI's biodiesel reduces both waste and emissions. The glycerin byproduct from the biodiesel process is used to produce industrial and premium consumer grade soap. IBI's soap products provide a safe and sustainable soap alternative to environmentally conscious companies and consumers.

Illinois Biodiesel is looking for a new space to produce biodiesel. The primary reason ISTC requested that IBI find a new space was that a new project was going to be implemented in the previous space and was run at high temperatures, so was not safe with IBI’s process. Another reason was that the previous method of storing WVO and was not done in a safe manner. Previously, the totes used were precariously stacked on top of each other without any secondary containment in the event of leaks. This concern will be addressed later in this paper. A campus wide search for suitable spaces was performed but no potential space was usable without significant renovation. This is not an option for IBI because the high expense of retrofitting a building could not be justified given that none of the spaces were guaranteed for the long term. Therefore, the most feasible solution to continuing production is through a trailer housed production process. This option would only require a physical space to house the trailer and would be relatively low impact on the surrounding facilities.

**Reaction Overview:**

Biodiesel production is a relatively straightforward process. IBI collects up to 200 gallons of waste vegetable oil per week. When about 400 gallons is acquired, it is reacted with methanol and potassium hydroxide (KOH) using ultrasonication. The methanol and KOH are mixed in a small vessel prior to reaction. In the main reaction vessel, ultrasonication mixes the reagents by ultrasonic waves through the mixture, creating and collapsing very small vacuum bubbles. After reaction, there is a significant quantity of unreacted methanol still present in the reactor. Through various methods, the methanol can be recovered and reused in later reactions. The two products, glycerin and biodiesel, form two layers based on density; the heavier glycerin is drained into a separate container. The crude biodiesel is passed through a resin-based filter to remove contaminants and the final product is stored. The glycerin is reacted in a separate process and is transformed into soap. To create soap, it is simply mechanically mixed under heat (130-150 F).

**Trailer Plan Overview:**

Currently, the most feasible option for the new reaction process involves engineering a trailer design which contains all the essential machinery required for production of biodiesel. The trailer will contain the methanol mixing vessel, the reactor vessel, ultrasonication system, methanol recovery system, filtration system, and the pumps, piping, and other elements required for reaction. The trailer will be stainless steel and is estimate to be sized 8’x20’ feet. In the following sections, detailed information regarding concerns and specifications of the trailer are presented.

**Reactor Details and Timeframe:**

The biodiesel reaction process requires a large 500 gallon HDPE vessel, a small methanol/KOH mixing vessel, a flow through ultrasonication element, a flash distillation element, a biodiesel filtration system, and various pumps and piping. The soap reaction process requires a heated and mechanically mixed 100 gallon reactor vessel. The process is designed to be as compact as possible without compromising on output or safety.

The WVO is pumped from a truck that contains roughly 250 gallons of WVO. In order to react 500 gallons total WVO per batch, the truck tank will be filled in the middle of the reaction. A small 50 gallon HDPE tank contains mixed methanol and KOH and pumped to join the WVO flow. This combined flow is reacted in the ultrasonicator and flows through the flash distillation where methanol is removed from the biodiesel and glycerin. The methanol is collected in a small HDPE container that is vented by hose to the outdoors. The products are pumped into the 500 gallon HDPE tank and allowed to settle. After the product has settled, glycerin is simply drained out into a separate tank while the biodiesel is pumped through a resin based filter that removes trace contaminants. The biodiesel is collected and stored. After a certain number of batches the non-hazardous resin is replaced and disposed of. The full conversion for the biodiesel process is estimated to take about 5-6 hours. The time allowed for the biodiesel to settle will be about a day. Filtration of biodiesel should take about a day. Students will work in shifts in order to oversee the reaction to completion.

Soap production requires a smaller footprint than the biodiesel process. Glycerin is added to a heated 250 gallon HDPE and mixed with KOH. The reactor IBI plans on using will be mounted on a frame with locking wheels so that it can be permanently stored and reacted in the trailer but temporarily stored outside during the biodiesel reaction. This set up will increase safety by adding increased operating space to the trailer during the biodiesel reaction. The soap subunit is currently researching the length of time and number of reactions per month needed to efficiently scale up the soap production process.

The only waste product of both reactions is the resin that is used to filter the biodiesel. The resins that are being considered can be safely disposed of in the trash and can be replaced. The usage of the resin can be monitored after each reaction, ensuring safe filtration of product.

**Trailer Details:**

The trailer will be parked long term at the location and ideally will not be moved again unless the space is no longer suitable or another space is acquired. The trailer could be fenced off in order to mitigate risk of car accidents damaging the trailer. When not in use, the trailer will be locked.

Since the storage of glycerin and biodiesel will be separate from the reaction trailer, cart mounted totes can be used to transfer biodiesel from the trailer to the storage area. The carts can be pushed up into the trailer and transferred into the reactor. Depending on whether the entry to the trailer is a ramp or a power lift, the tote will be sized to allow for safe operating conditions.

The trailer needed will be 8’x20’. This size will allow ample room for the reactor process, movement space, and miscellaneous equipment and methanol storage. A stainless steel trailer will be used in order to maximize the strength of the trailer. In the event of a reactor vessel breach, the trailer will ensure the escaped material will only leave the trailer through the back exit. To catch any material that escapes, an inflatable berm would be set up in order to prevent environmental contamination.

Ventilation is a key concern for the trailer. Methanol is a volatile liquid that is flammable and poisonous when inhaled. Methanol will be handled to minimize exposure to air and leakage events. The trailer will have ventilation fans cut into the sides in order to expel potentially contaminated air and bring in fresh air. Furthermore, the door to the trailer will remain open during reaction at all times in order to maximize air circulation.

**Input Requirements:**

IBI would collect 150-200 gallons of waste vegetable oil per week from Ikenberry Dining Hall. This yields 600-800 gallons of waste vegetable oil per month. Each reaction of 500 gallons of waste vegetable oil would yield approximately 420 gallons of biodiesel and 80 gallons of glycerin. For 2 reactions per month, 1000 gallons WVO will yield 840 gallons of biodiesel and 160 gallons of glycerin. Currently, Illinois Biodiesel is planning on starting with one reaction per month, but as the production process becomes more familiar, 2 reactions per month will be done.

The average power consumption rate for industry is 0.19 KWh/gal of biodiesel produced, which equates to approximately $9 of electricity per reaction for IBI. This cost is just an estimate and the actual process would cost slightly more or less. The additional costs would come from running the pumps, the ultrasonicator and methanol distillation. The power source needed will most likely be 230V or more but will not be known until specific machinery is determined. If suitable power sources are not available, another option would be to use portable generators to meet the voltage requirements.

**Storage Details:**

There exist two options for the storage of biodiesel. Either it will be stored outside next to the trailer or inside, if a suitable location is found.

For the outside storage option, primary storage for the containment of the finished biodiesel product would be stored in dual lined metal storage tanks. The final sizing requirement is still being considered, but should be around 1200 gallons biodiesel total. The appropriate tanks would be double lined in order to contain a breach and would need to be built to endure the elements. If temperatures drop below freezing these containers would need to be heated to keep the biodiesel liquid at above the freezing point of 0ºC in order to keep the biodiesel a liquid. IBI is currently looking into additives that can decrease the freezing point of biodiesel, allowing unheated outdoor storage.

` Outside containment would be located adjacent to the trailer. The containers that store biodiesel could be fenced off if needed as they could pose a risk for drivers in the area.

The inside option for the storage of biodiesel would involve large totes with secondary storage and a location to store them. This location would need to be accessible and relatively close by. Regardless of the method of storing the biodiesel, WVO and glycerin would be stored indoors since they are more temperature dependent. Ideally, it would be kept at room temperature so that materials such as WVO and glycerin, which have freezing points of -10 ºC and 17.8 ºC respectively. From this location IBI would need to load and unload the WVO into the truck tank and transport glycerin and biodiesel back. The building used to store should be easily accessible for loading and unloading.

Some of the necessary reagents would be stored inside the trailer. This would include containers that store methanol, KOH, and excess resin for filtration. Methanol would be stored in a plastic, screw-capped bottle in a second plastic container that could contain and spills and leaks. Potassium hydroxide would be store in a glass, screw-capped bottle with a plastic bin underneath that could prevent spills that may happen when transferring the chemical. The resin is non hazardous and will be stored in it’s original container without any further containment.

**Regulations and Safety:**

Various safety regulations must be considered for a complete consideration of the trailer’s safety. In order to mitigate fire risk, the methanol will be stored in the trailer and will be isolated from possible sources of ignition. The trailer must be wired in a way that is spark proof and adherent to campus fire codes. IBI is planning on working with an already identified member of Facilities and Services specializing in fire codes for campus, in order to create a safe design. In order to satisfy EPA regulations, IBI will work with another Facilities and Services faculty that has extensive knowledge of EPA regulations.

Once the trailer is set up, proper training is required in order to mitigate risk of accidents. IBI will create a systematic method of training new students to operate the equipment so that future members can safely produce biodiesel.

**Summary:**

IBI will need a space that is able to contain, at the minimum, an 8’x20’ trailer and movement space for a pickup truck. Additional space could be used to house outdoor storage. Furthermore, indoor space would be used to store WVO and glycerin. Indoor space does not necessarily need to be directly next to the trailer so other buildings on campus could also satisfy this requirement. Power inputs must be will be minimum 230V and likely 3 phase, but a generator might be supplant this requirement. This is a preliminary plan documenting the plan of action IBI has taken and is open for criticism and further development. IBI would use this space for long-term storage, moving the trailer only if a new space is required. Students would operate the reaction process 1-2 weekends per month for the biodiesel process. Soap production may also take 1-2 weekends per month, but is not final at this point.