Project Background and Purpose

The first phase of the SGEF project involved setting up a biodiesel production facility that utilizes the used cooking oil from restaurants and dining halls on the USF campus to convert these into renewable biodiesel fuel using supercritical transesterification. The process is fast, converting used oil to biodiesel within minutes, with glycerol as byproduct to be used in making soap. The continuous process minimizes chemical handling and provides a small footprint of a few cubic meters. Thus, there are no waste streams coming out of the process, making it novel as well as truly green.

This project involved constructing a pilot that can be scaled up to produce about 20,000 gallons of B100 grade biodiesel annually, which also meets the current fuel demands of the Bull-Runner bus fleet. Plans for testing of the fuel in powering these buses efficiently, development and validation of the waste alcohol recovery and deployment component, development and validation of oil recovery systems, development of infrastructure were within the scope of the project. The Standard Operating Procedures (SOPs) for recovering the used/waste components from locations on campus are already in place and are under constant review for improvement. This current infrastructure is depicted as Figure 1. What has been accomplished includes:

Technical/Infrastructure

- Necessary capital purchases have been made with the exception of a few minor items.
- Successful implementation of this technology on a pilot scale to demonstrate its promising potential to produce biodiesel.
- Initial fuel tests have been done as per ASTM standards with very good results.
- SOP created for processing and creating novel soap products to be sold at bookstore as well liquid soap for the dormitories.
- SOP created for waste cooking oil filtration, handling waste cooking oil.

Logistical/Promotional

- Letters of support from ARAMARK, USF Transportation to proceed with using fuel, and support from various on-campus organizations, as well as administration including President Genshaft was achieved.

- National Biodiesel Board made the technology as a show case.
- Preliminary research and inquiries with various State agencies indicate that our process will be exempt from most permit requirements.

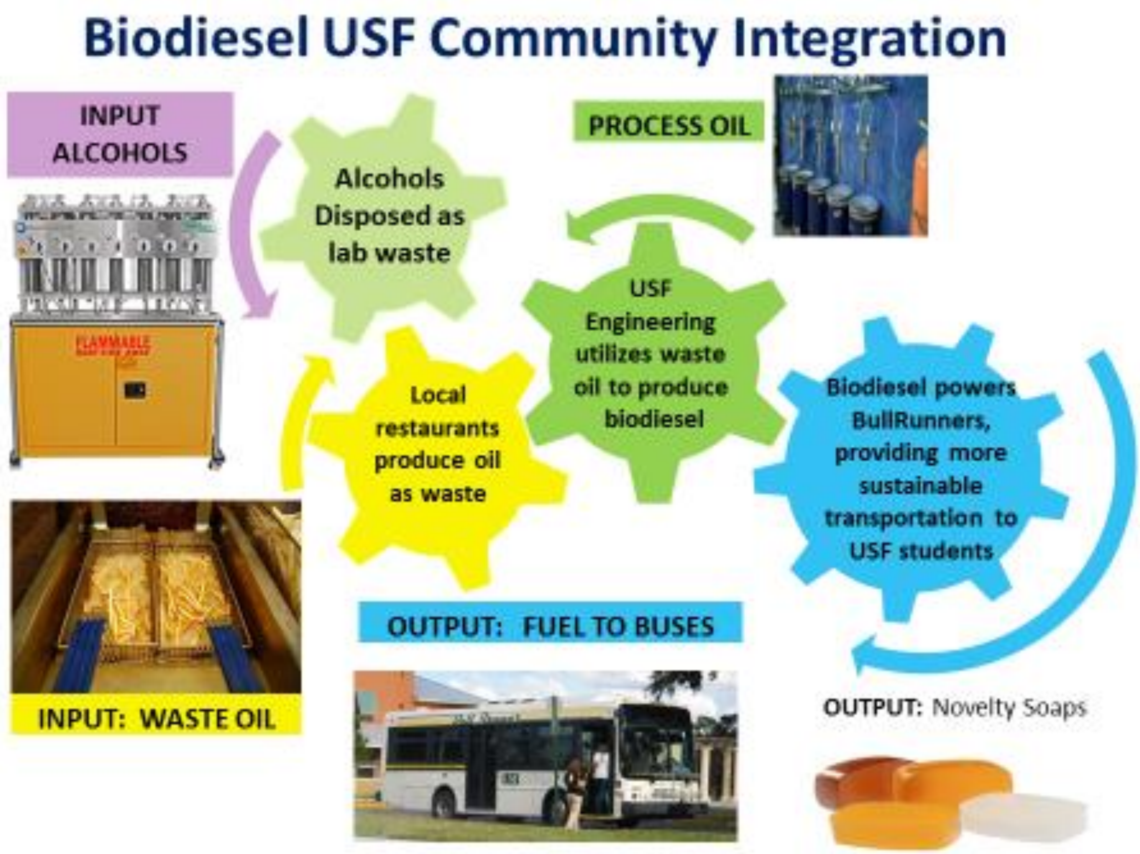

Figure 1. Current schematics for cooking oil and laboratory waste to biodiesel and soap

The facility location challenges and scale that will make it an economically sustainable initiative beyond university training activity resulted to further the study plans with a modified design. A minimum of 100,000-200,000 gallon/year mobile mini-plant is proposed. A five to 10 fold increase in capacity from the current 20,000 gallons per year will not change the unit footprint. The design involves still the same size trailer that houses the processing unit. The unit is functionally complete and self-sufficient—including the processing unit, the waste oil storage, the biodiesel storage as well as pumping capability—along with solar panels and energy storage batteries. The revenue potential of the project is over half a million dollars due to by product soap production capability.

Project Activities

The proposed project activities includes three parallel but integrated areas of development.

The first direction is the technology components. The design of the mobile mini-plant to include the components depicted in Figures 2, 3, and 4. These figures with the exception of 2 which is processing unit are off-the-shelf. Figure 2 shows a similar unit to what is being developed to be housed in a solar-powered integrated trailer, while Figure 4 shows the fuel delivery system. The dimension also product testing as well as soap manufacturing unit which is off-the shelf.

Figure 2. A mobile unit with similar footprint [Mowry, G. (2011)]

Figure 3. A solar power trailer that can house the mini plant [http://www.mobilesolarpower.net/]

Figure 4. A Mobile fueler [http://www.microfueler.com/products.html]

The second direction involves infrastructure development for oil collection and delivery with revised capacity. With the proposed mobilized processing unit, the project envisions exploiting surrounding off campus waste cooking oil resources including but not limited to Busch Gardens, Raymond James Stadium, Port Tampa Bay, other campuses and surrounding restaurants. This increased source of waste oil will improve visibility for USF's sustainable efforts in the Bay Area as well as increase biodiesel production.

The third direction involves integration of the oil collection and technology components within a framework that ensures an enterprise that has sustained financial and educational performance. This direction will allow community integration opportunities and resources to stake-holders.

Project Results

The project will facilitate in judicious waste utilization through a green novel technology operated through a community centered enterprise to reduce the emission locally and globally in an economic way. Glycerol is the by-product generated from this process, which is of high value. At the proposed scale of 2000 gallons per week of B100, enough glycerol is produced to make about 30000 lbs. of soap per month. This can be either translated into liquid soap for use on campus or can be made into bar soap that is sold as a novelty product in the bookstore. Further, our team plans to purchase the waste oil from the University at a competitive price and sell the biodiesel produced back to the university at a price lower than the market price. This benefits the university and maintains a win-win situation for both the parties. The ROI is expected to be close to 44 % after the expenses even when waste cooking oil is purchased at $1.00/gal. The ROI increases to 88% when the waste oil free. The $1.00/gallon of waste oil value will be additional benefit for the student organizations.

Table 1. Economic Analysis

Item	Description	Rate	Total Cost ($/year)
Waste Oil	Purchased from USF*	1 ($/gallon)	$ 94,855
Methanol	Purchased from vendor	0.75 ($/gallon)	$ 18,475
Biodiesel	Sold to USF	3 ($/gallon)	$ 300,000
Energy Costs	Purchased from TECO**	0.12 ($/kWh)	$ 3,200
Labor	4 Students	12 ($/hr, 20 hr/week)	$ 49,920
Overheads	Operation costs		$ 25,000
Profit of Biodiesel operation			$ 108,650 ($ 203, 505)*
ROI for Biodiesel Operation			44.3% (83%)
Variable Soap Manufacture capacity to make 250,000 bars of soap			
Soap Operation	Operating Cost per bar		$ 1.5 /bar
	Retail Price per bar	-	$5/bar

*This amount is an added revenue item for USF. The accounting is done with and without it.
**This cost diminishes with Battery Pack from Tesla option, one time purchase, no annual cost thereafter.

Although the sale of biodiesel does not generate huge revenue for the Renew-a-Bull project, the soap produced from the byproduct glycerol generates enough cash-flow to not only sustain the project but also contribute by about $500,000 annually as the net profit. These funds can then be diverted into purchasing waste oil from other sources beyond the confines of the USF campus (like

Busch Gardens, Port of Tampa, Raymond James Stadium, Local restaurants etc.) at competitive prices. The biodiesel and soap thus produced from this waste oil can be sold at competitive prices to generate additional revenue. The entire biodiesel production primarily utilizes solar energy drawn from the solar panels and the batteries on the trailer. For additional support, backup and operations like soap production, the process will utilize about 3 kW of electricity every cycle. This can be drawn from the grid, the annual cost of which is a meager $3200, or can be drawn from a solar charged-battery pack. We are looking into innovative battery pack designs, particularly the 'Powerwall' battery pack from Tesla Motors, which has a 6.4 kWh capacity (3.3 kW of power) and charges via solar panels. The cost of this system is about $3000, with a minimum life of 10 years (Warranty covered). It is important to note that this will be a one-time investment, and the product is net-zero energy rated.

In addition to the economic benefits, there are emission benefits. Included are two tables comparing key pollutant emissions from petroleum diesel versus biodiesel. Significant reductions are achieved for carbon dioxide and carbon monoxide, in addition to notable reductions in methane and sulfur oxides. The table below is derived from a Department of Transportation study on the BullRunner Shuttles at USF, in Tampa. This study notes the reduction in tailpipe emissions in all the pollutants listed, other than a slight increase in NOx emissions. The Figure 5 and 6 depict the full benefit of our approach. The 13 gr CO_2 per Mega Joule emissions from Waste Cooking Oil to Biodiesel is comparable to what one expects from solar power life cycle analysis. The mobile unit and technology cut the emissions to about 10gr CO_2 mega Joule.

Table 2: Annual Air Emissions from Consumption of 2,000 gallons per week (kg)

Greenhouse Gas	Petroleum Diesel	B20	B100
Carbon Dioxide	1,183,019	991,787 (-16%)	226,860 (-81%)
Carbon Monoxide	2,372	2,175 (-8%)	1,384 (-42%)
Methane	379	369 (-3%)	329 (-13%)
Particulate Matter	401	663 (+65%)	1,712 (+327%)
Sulfur Oxides	1,730	1,667 (-4%)	1,417 (-18%)
Nitrogen Oxides	9,359	9,376 (+0.2%)	9,447 (+1%)
Non-Methane Hydrocarbons	247	345 (+40%)	740 (+200%)
Other Hydrocarbons	465	423 (-9%)	253 (-46%)
Total	1,197,972	**1,006,805 (-16%)**	**242,142 (-80%)**

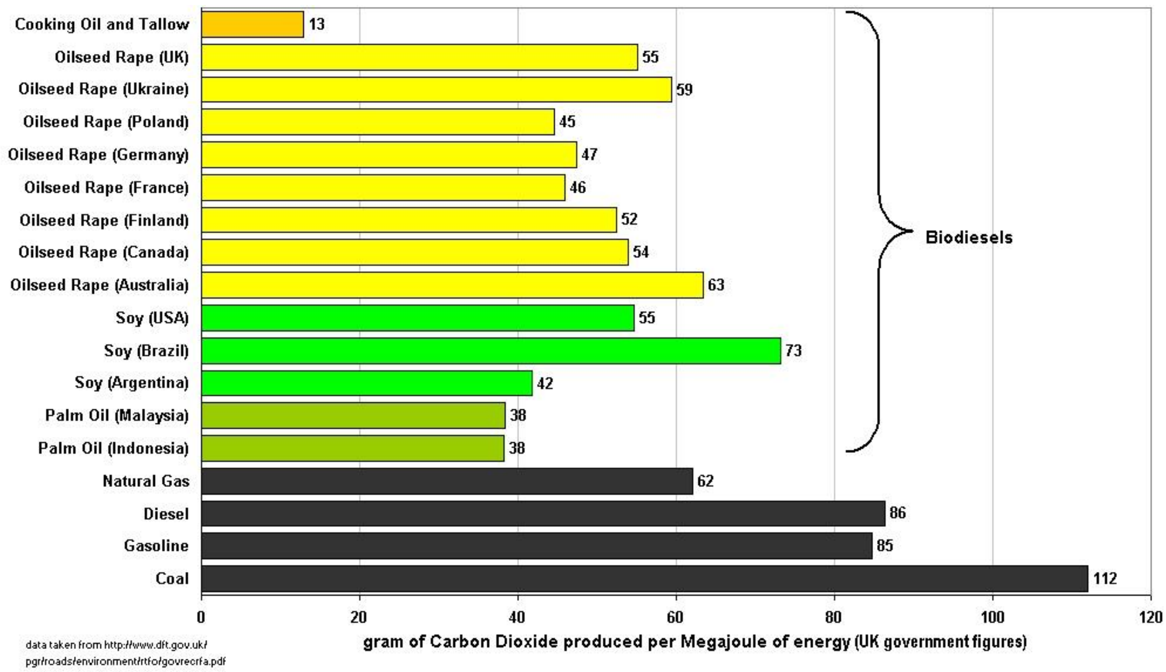

Figure 5. The Carbon Dioxide Emission per Mega Joule from different Fuels.

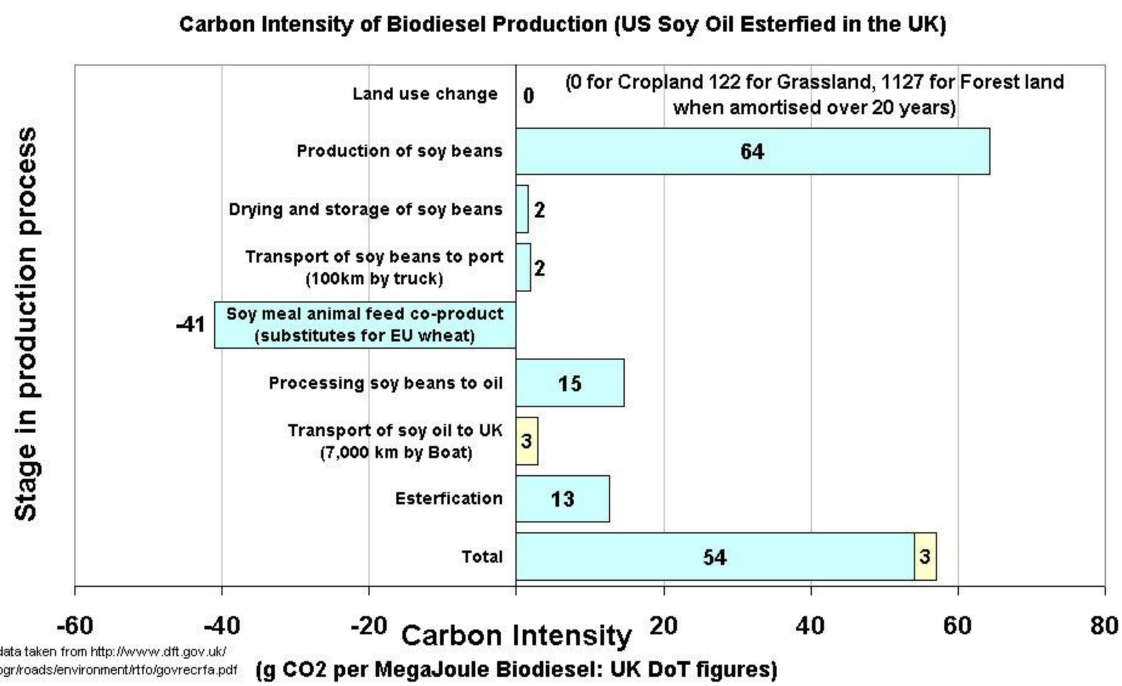

Figure 6. Carbon Intensity of Biodiesel Production Steps

Proposed Budget and Justification

Proposed Item	Requested From SGEF	Applicant Contribution	Total
Equipment (Truck, Solar Trailer, Processing parts, Soap facility)	$145,000	$200,000 (Pre-existing + Phase 1 Funding+ sponsors)	$345,000
Independent lab work, toll services and engineering	$30,000	$15,000	$15,000
Soap Making Materials	$5,000	$10,000	$12,500
Personnel	$45,000	$70,000	$110,000
Travel, Marketing and Promotion	$10,000	$5,000	$15,000
Contingency	$10,000		$10,000
Total Project Costs	**$245,000**	**$300,000**	**$545,000**

The proposed budget includes all equipment necessary to mobilize the biodiesel processing. In order to haul the mobile processing unit, a diesel truck large enough to haul the trailer, but small enough to not require a CDL is requested ($50,000). Additionally, a custom built trailer that will be fitted with 7kWh solar panels as well as 30kW of battery storage will be ordered in order to sustainably operate in remote locations ($35,000). The remaining processing equipment to be purchased will be items necessary to operate in a mobile environment (transportable storage tanks, mobile fueling and pump stations, etc.) ($60,000). Prior to having fuel used in the buses, our produced biodiesel must be ASTM certified. This certification process requires analysis from a certified lab ($10,000). Three graduate students will be working on the Phase Two development and deployment at 10hrs/wk ($45,000). In order to increase visibility of both the project and SGEF, our proposed budget includes marketing material (stickers, banners, handouts, etc.) that can be used at various University or community events. The team also proposes to have promotion artwork on the exterior of the trailer and truck to create a “mobile billboard” for USF’s sustainable efforts. A contingency fund is requested in the event that excess funds is needed. The matching fund is associated with faculty time of 10% per faculty during the project time, a sponsor who will be donating a soap production facility, engineering assistance services, machine shop services, and laboratory services.