UBC Social Ecological Economic Development Studies (SEEDS) Student Report

An Investigation Into Biodiesel Production on UBC Campus

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Formal Report:

An Investigation Into Biodiesel Production on UBC Campus

POWERED BY
BIODIESEL

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Abstract

Biodiesel has been produced on campus since 2002 and has contributed to reductions in discarded waste vegetable oil and Plant Operations vehicle emissions to varying degrees. Current biodiesel production has been limited to 500L a year due to lack of funding, and use of UBC-produced biodiesel by Plant Operations has not been as high as in previous years. This report addresses the subject of biodiesel production and consumption on campus; specifically, it details the social, economic, and environmental benefits of the use of biodiesel as part of a triple bottom line analysis.

The scope of this project and its recommendations are based on the University of British Columbia campus. The findings and recommendations proposed in this report are based on both primary and secondary research. Stakeholders such as UBC Plant Operations representative Adam McCluskey, Vancouver Biodiesel Co-op Vice President Lucas Closs, and Chemical and Biological Engineering professor Dr. Naoko Ellis were all consulted in the research process.

Economic indicators and projections were found to be promising. With an available WVO feedstock requiring minimal transportation, and the projections of a positive NPV, it can be concluded that the project is economically viable. Biodiesel was found to produce lower emissions in virtually all categories, notably those that affect human health. Biodiesel was also deemed compatible with Plant Operations vehicles, and can lubricate and reduce the noise level of the engines. The operation would allow the university to capitalize on the social benefits realized by the Vancouver Biodiesel Co-op, including opportunities for research and outreach programs. The recommendation is to proceed with the campus biodiesel operation.

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Glossary

Biodegradability:Chemical dissolubility of materials by bacteria or other biological means.

Catalyst: A substance that causes or accelerates a chemical reaction without being consumed in the process

Cetane Number: Cetane number or CN is a measurement of the combustion quality of diesel fuel during compression ignition

Energy Density: A term used for the amount of useful energy stored in a given system or region of space per unit volume.

Flash Point:The lowest temperature at which a substance can vaporize to form an ignitable mixture in air.

National Biodiesel Board: A commercial trade association representing the biodiesel industry as the unifying and coordinating body for research and development in the United States.

Net Present Value:The difference between the present value of cash inflows and the present value of cash outflows. NPV is used in capital budgeting to analyze the profitability of an investment or project.

Transesterification: a chemical process by which the organic group of an ester molecule is exchanged with the organic group of an alcohol molecule

List of Abbreviations

ASTM: American Society for Testing and Materials

CARB: California Air Resources Board

CHBE: Chemical and Biological Engineering

EPA: Environmental Protection Agency

ERB: Energy Ratio Balance

GHG: Green House Gas

NPAH: Nitrated Polycyclic Aromatic Hydrocarbons

NrCan: Natural Resources Canada

PAH: Polycyclic Aromatic Hydrocarbons

NPV: Net Present Value

UBCPO: University of British Columbia Plants Operations

VBC: Vancouver Biodiesel Co-op

WVO: Waste Vegetable Oil

1.0 Introduction

In this report, the technical considerations of biodiesel production are outlined. Succeeding this section, analyses of the environmental, economic, and social indicators of the operation are carried out. The report finishes with conclusions and recommendations for the campus operation.

2.0 Technical Considerations

Following subsections outline and briefly describe the process of converting waste vegetable oil to biodiesel.

2.1 Transesterification

Waste vegetable oil is converted to biodiesel through a process known as transesterification. WVO is rich in triglycerides, which are large molecules that do not combust easily. The transesterification process uses catalytic acids or bases to break down the triglycerides into biodiesel and glycerol. The process is demonstrated in Figure 1 and described in further detail below.

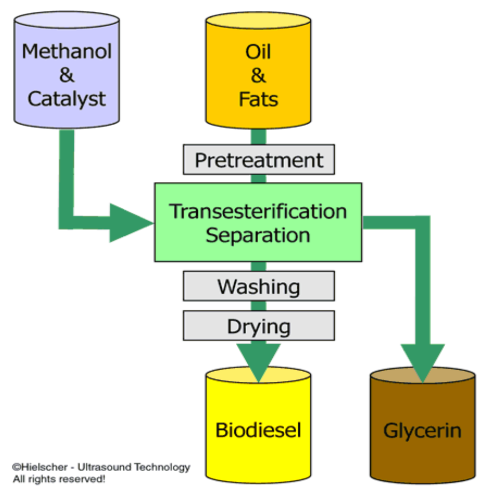

Figure 1: WVO to Biodiesel Conversion Process

(Source: Hielscher – Ultrasound Technology)

Base catalysts are commonly used over acid catalysts, as the reaction rate is much quicker with a base catalyst. Bases such as sodium hydroxide (NaOH) or potassium oxide (KOH) are commonly used. The reaction involves the use of a base catalyst, methanol, and triglycerides, as found in waste vegetable oil. The components are mixed together over heat; in a stepwise conversion, the triglyceride is reacted with the alcohol to produce glycerol and biodiesel. Once the reaction is complete, the mixture is allowed to separate into two layers. The top layer consists of the biodiesel, while the bottom layer consists of a mixture of glycerol, the recovered catalyst, and water.

Acid-catalyzed transesterification is not as widely used, despite the fact that it is more suitable for waste or unrefined oil such as WVO. Acid-catalyzed transesterification is less preferred due to its slower reaction kinetics, as well as the fact that it requires a much higher alcohol-to-oil molar ratio. Research has been conducted on using Lewis acids such as aluminum chloride and zinc chloride, and it has been shown that under optimum conditions, a yield of 98% is possible to obtain.

2.2 Biodiesel Production at UBC

Biodiesel production at UBC began in 2002 with the UBC Biodiesel Initiative. The project was started by students Geoff Hill and Peter Doig, under the guidance of Dr. Naoko Ellis, who was a PhD candidate at the time. The UBC Biodiesel Initiative soon became associated with community partners such as the Alma Mater Society, the Environmental Youth Alliance, and the UBC Sustainability Office. Mostly using spare equipment that could be found in the CHBE department building, as well as WVO provided by UBC Food Services and methanol donated by Methanex, the UBC Biodiesel Initiative had produced over 2000L of biodiesel by the end of April 2003.

The CHBE Sustainability Club took over the biodiesel production plant this academic year after several years of inactivity. Current funding only affords the club to produce 500L of biodiesel; while Dr. Ellis maintains that the amount that is currently being produced by the plant would be able to provide a significant source of B20 biodiesel (20% biodiesel blend) for Plant Operations vehicles, the current fleet managers have not been as willing to utilize UBC-produced biodiesel to its maximum potential. Dr. Ellis explained that resistance to adopting biodiesel produced by the CHBE Sustainability Club stems from the fact that it requires manual labor to blend the biodiesel with regular fuel. Currently, UBC Plant Operations obtains its biodiesel from an external source, and their fuel comes pre-blended. The CHBE Sustainability Club is currently in discussion with Plant Operations regarding the possibility of running Plant Operations vehicles with biodiesel produced on campus.

3.0 Economic Indicators

To fully examine the economic viability of biodiesel for UBC campus, the group attained data on the amounts of diesel thatUBC Plants Operations (UBCPO) consumes, the prices associated with fuel/biofuel purchases, as well as the amount of waste vegetable oil produced on-campus. In addition, establishment cost estimates, equipment cost estimates, and price and profit projections are considered, using data published by the UBC Biodiesel Initiative.

3.1 UBCPO's Fuel Consumption and WVO produced on Campus

According to data provided through an email (Appendix A) from Mr. Adam McCluskey, Fleet and Inventory Manager at UBC Plants Operations, almost 413,000 liters of fuel was used in 2011. Of this total amount, 302,000 liters corresponds to petroleum diesel, while the remainder consists of B5 biodiesel purchased from Chevron. This means that only about 5500 liters of current fuel purchases made by UBCPO consists of biofuel. This value corresponds to only a small portion of less than 1.5% of the overall fuel consumption.

According to data provided by Mr. Justin Ritchie from the AMS, UBC Food Services produces 15,505 liters of WVO per annum. In addition, two other major consumers of vegetable oil on UBC Village include McDonalds and Vera's Burger Shack, which cumulatively produce 46,660 liters of WVO per annum. Therefore, a total amount of over 61,000 liters of WVO is being produced on campus, which if fully collected, can yield up to 59,000 liters of biodiesel per year. This amount of biodiesel can provide UBCPO with a B14 biodiesel blend (14% biodiesel, 86% petroleum diesel). Consequently, all of the biodiesel produced can be used by UBCPO. Currently, however, the pilot project has a production capacity of 1000 liter per week, or 52,000 liter per annum, assuming that all necessary funding is provided.

It is also essential to mention that currently, neither of these restaurants gets charged for their oil to be discarded, nor do they charge the recycling companies. Therefore, it is safe to assume they will not charge a biodiesel plant on campus for using the WVO they produce. This will then give an advantage to the biodiesel plant, since it will receive its feedstock free of charge. Also, transportation costs of the WVO from restaurants to the plant's location are negligible due to short distances on campus.

3.2 Biodiesel Price Projections and other Economic Indicators

Based on statements provided by Mr. McCluskey, it was calculated that UBCPO purchased both B5 biofuel and petroleum diesel at the price of $1.17 per liter. Therefore, an estimate for market price UBC-Produced biofuel is required to then be compared to the price of petroleum. Due to our limited time and resources, all relative data regarding production costs and market price estimates of biodiesel has been adapted from the 2003 report *Helping Communities to Help Their Future* by the UBC Biodiesel Initiative (Appendix B), but the comparison ratios and trends can be extended to the current date, as the global price of oil, its derivatives, and other market prices are interdependent. All this data and corresponding conclusions are for a production rate of <u>1000 liter per week as of 2003</u>.

Based on data from this report, the following conclusions can be made:

- ✓ An initial investment fund of $12,599 is required to start-up the project
- ✓ The produced biodiesel will have a market price of $0.789 per liter, while the price of $0.68 per liter (Boyd et al, 2004).
- ✓ Given the importance of a start-up loan, future project value is an important indicator. For the UBC biodiesel plant, a NVP of $16,484.20 has been calculated. This positive net present value is a predicting indicator of economic success of this project over its estimated life span (20 years).

Based on these values, it can be concluded that since UBCPO has continually purchased both B5 biodiesel and petroleum at $1.17 as of 2011, and assuming the ratio of petroleum diesel to biodiesel remains roughly the same, the market price of biodiesel produced at UBC can be estimated to be around $1.30 per liter.

4.0 Environmental Indicators

With growing environmental concerns on use of fossil fuels over the last two decades, biodiesel has gained a lot of attention due to its biodegradable nature as an alternative for fossil-based diesel. Arguably, some of the most important merits of biodiesel arethat it lessens dependency on fossil fuels and lowers green house gas emissions. Other characteristics that distinguish biodiesel from traditional fuels are its better lubricity, lower toxicity and nearly zero percent sulfur emissions (Marchetti et al, 2008). Furthermore, production of biodiesel from waste vegetable oil (WVO) takes advantage of the waste oil which otherwise must be discarded. Therefore, biodiesel production seems to be a promising answer for small communities. To further investigate the environmental merits of biodiesel versus regular diesel, several indicators have been considered. These environmental indicators include: carbon lifecycle emissions, energy ratio balance, toxic emissions and hazardous material rating.

4.1 Carbon Lifecycle

Due to more oxygen content, B100 biodiesel has a higher combustion rate compared to regular diesel; consequently, it results in lower combustion tailpipe emissions. In 2002, Natural Resources Canada (NrCan) carried out a study to assess the emissions resulting from biodiesel versus regular diesel. This research compared the emissions from B100 and B20 blends of biodiesel with regular diesel. The findings of this research are shown in the following table(Levelton Engineering, 2002):

	Diesel Fuel (grams/mile)	**B20 (grams/mile)**	**B100 (grams/mile)**
GHGs			
CO_2	2180.2	1870.4	588.3
CH_4	4.906	4.418	2.408

N_2O	0.094	-0.202	-1.443
Total CO_2 Equiv.	2312.4	1900.5	191.4
Non-GHGs			
CFCs+HFCs	0.003	0.003	0.003
CO	20.448	17.738	5.232
NO_x	25.292	27.833	25.976
VOC ozone weighted	2.206	2.023	1.595
SO_x	1.305	1.240	0.746
PM	1.278	1.232	0.777

Table1:Lifecycle of GHG and non-GHG Emissions for regular diesel, B20 and B100 Blends

According to Table 1, it can be concluded that there is a consistent reduction trend, showing biodiesel blends to have significantly less emissions of GHG and non-GHG in their carbon lifecycle, with the exception of NO_xgases. Although not displayed in Table 1, it is important mention that waste vegetable oils generally show greater improvement in their emissions profile compared to virgin vegetable oils, as they have already been used and are now being used as a form of recycling(Boyd et al, 2004).

4.2 Energy Ratio Balance (ERB)

This indicator measure the units of energy yielded for each unit of energy required to produce the fuel. Therefore, a low energy ratio balance means that almost as much energy has been used to produce the fuel as was returned as fuel energy.

This number is significantly small for fossil fuels; in fact most fossil fuels have negative ERB values and petroleum diesel only yields 0.83 units of energy per unit of fossil fuel-based energy consumed.

For biodiesel blends, however, ERB values are significantly higher. The ERB for B100 blends is at least 3.2 units. This can be put into perspective by saying that for every unit of energy needed to produce fuel, B100 biodiesel returns almost 2.5 times more energy than petroleum. (13)

4.3 Toxic Emissions

Toxic emissions can act as carcinogens, which are the causes of diseases such as cancer and emphysema. Biodiesel, as compared to regular diesel, produces far less toxic emissions. Table-2, adapted from National Biodiesel Board (Boyd et al, 2004), gives a numerical comparison for reduction of toxic emissions of B100 and B20 biodiesel blends.

Smog-Forming Pollutant	B20	B100
Polycyclic Aromatic Hydrocarbons (PAH)	13% reduction	80% reduction
NPAH (Nitrated PAH)	50% reduction	90% reduction

Table 2: Toxic Emissions
(Source: National Biodiesel Board: http://www.biodiesel.org/pdf_files/emissions.PDF)

4.4 Hazardous Material Rating

Based on a research from Transport Canada, biodiesel has been identified as the only alternative fuel to be non-hazardous and non-flammable for transportation and storage. The following table outlines the hazards corresponding to biodiesel as compared to regular diesel.

Property	Biodiesel	Petroleum Diesel
Biodegradability	Readily biodegradable 3+ times faster than diesel	Poor
Flashpoint	150°C	51.7°C
Toxicity	Non-toxic	Highly toxic
Spill Hazard	Benign: safe to handle with no dangerous fumes. No Training required for handling	Dangerous and toxic, hazmat training required

Table3: Comparison of Hazardous Factors of Biodiesel and Petroleum (regular) Diesel by Transport Canada

As shown in Table 3, due to the nature of biodiesel, transportation and storage of biodiesel does not require new or additional infrastructure. Currently, petroleum has to be stored and handled in a twin-walled container, whereas biodiesel can be stored in single-walled containers. This not only reduces the cost of storage and handling units, but also in large scales, it reduces the potential hazards resulting from transportation of petroleum diesel, and consequently helps to reduce negative environmental impacts(Boyd et al, 2004).

4.5 Environmental Indicators in the Context of UBC Campus

As an environmentally conscious university, UBC has been allocating many resources towards the development of green technologies. Due to the size of UBC campus, there is a considerable amount of transportation and machinery used by UBC Plant Operations. Furthermore, Ray Hryciuk, Manager of Environmental Programs, has approved the production of biodiesel on campus;furthermore, the suggested process does not violate UBC's Environmental and Safety regulations(Chou et al, 2003). Therefore, as examined in this section of the report, by adapting blends of biodiesel derived from the waste grease produced on campus, UBC can significantly reduce its carbon footprint and hence move one step further towards its suitability goals.

5.0 Social Indicators

With regards to the social aspect of the analysis, possible indicators were drawn from the literature. In order to further investigate these indicators and their applicability to the UBC operation, the Vancouver Biodiesel Co-op was contacted for first-person research. This analysis will use the Co-op as a model for the prospective UBC operation, and act as a case study to extrapolate conclusions.

5.1 An Introduction to the Vancouver Biodiesel Co-op

The Vancouver Biodiesel Co-op is located near downtown Vancouver and is currently the lower mainland's only source of 100% recycled, locally sourced biodiesel. The Co-op currently has 263 members and has sold 57,463 liters of fuel, resulting in a CO_2 offset of 111,478 kg (Vancouver Biodiesel Co-op, 2012). The executive members of the VBC volunteer their time to maintain a supply of ASTM D 6751 certified biodiesel for members. ASTM D 6751 is an internationally recognized quality standard for biodiesel production set forth by the American Society for Testing and Materials (ASTM International, 2012).

The primary supplier is Cowichan Energy Alternatives which provides public and commercial WVO collection and drop-off services across British Columbia, sustainably produces biodiesel, and acts as a public education and research facility for local bio-fuels and alternative energies (Cowichan Energy Alternatives, 2012). Yearly membership to the VBC costs $25, and includes 24/7 card-lock access to the 4420 liter pump. The representative contacted for an interview was Lucas Closs, who has served as Vice President of the VBC for the past four years.

Figure 2: VBC Pump (Source: Vancouver Biodiesel Co-op)

5.2 The Human Health and Safety Factor

The first social indicator to be discussed is the human health and safety factor. Petrol diesel engines account for 79% of all particulate matter emitted by vehicles, 92% of which are less than 1.0 micron by mass and therefore inhalable by the human respiratory system. Over 40 of these components are listed by the US EPA as toxic air contaminants, and 21 are known carcinogens or reproductive. The use of biodiesel yields a significant reduction in harmful air-borne particulate matter as recognized by the U.S. Clean Air Act, and hence reduces the risk of cancer and respiratory illness(Boyd et al, 2004).Biodiesel is also less volatile and flammable than petro diesel, and is therefore safer to transport (Crabbe et. Al, 2001).

In an increasingly health-conscious city such as Vancouver, the reduction in health and safety risks associated with biodiesel use is an important social indicator. On a campus scale, the use of biodiesel in Plant Operations vehicles would allow the university to publicize these health benefits, and thus reinforce its image as a health-conscious and desirable campus.

5.3 Community Autonomy and Reduced Dependence

Small-scale biodiesel operations empower communities through self-sufficiency. Local production of biodiesel reduces dependency on foreign oil, increases energy availability, and has a positive effect on foreign exchange resources (Khanaet. Al, 2007). These points are generally of high concern in an academic community, and hence this factor becomes a social indicator.

A comparison can be drawn to the UBC farm project. The UBC farm supplies crops to UBC businesses while also acting as an interactive research site for the feasibility of small-scale, sustainable farming. The biodiesel operation would realize similar benefits; providing a valuable service to the campus (fuel sourcing and WVO rendering) while providing an avenue for feasibility studies and educational opportunities for students. The biodiesel operation capitalizes on a novel research opportunity in conjunction with working towards the university's carbon neutrality promises.

5.4 Effects on Traditional Diesel Engines

A third social indicator to consider is the effect biodiesel use has on traditional diesel engines. Any significant degradation to the performance or reliability of Plant Operations vehicles would reduce social support for the operation, both internally (Plant Operations executives) and externally (students and the community).

The following findings are based on the results of 40 million kilometers of field-testing by the National Biodiesel Board. In terms of efficiency and performance, the energy density of biodiesel is approximately 10% less than that of CARB certified low-sulfur diesel, 950 Btu/ft^3 versus 1,058 Btu/ft^3(Boyd et al, 2004). Horsepower and torque characteristics are found to be comparable. The cetane number of biodiesel is 10 to 15 points higher than petrol diesel, yielding smoother combustion and quieter engine operation. Biodiesel also has superior lubricity by up to 65% over CARB low-sulfur diesel, which is beneficial to engine systems (Boyd et al, 2004).

It should be noted that initial fuel filter clogging may occur due to the solvent effect dislodging particles in the fuel system, but will subside with continued use. Generally, vehicles built after 1993 do not require modification to run biodiesel, and those built prior require rubber fuel lines to be replaced before use (Vancouver Biodiesel Co-op, 2012). There are specific vehicles for which biodiesel is not recommended, but these are not found in the Plant Operations fleet. Lucas Closs provided the following response when asked about member complaints: "We very rarely hear of problems, and when we do they are usually because a member is running too rich of a blend of biodiesel in cold weather. Cold weather gelling doesn't cause any permanent damage."

5.5 Social Indicators and the Vancouver Biodiesel Co-op

According to Lucas, the reception of the operation has been outstanding: “The members love our fuel. They love voting with their dollars and supporting an alternative to the mega petro-fuels industry.” He explains that the primary challenge faced by a small-scale operation is achieving ASTM compliance in a cost-effective manner, as testing is expensive: “A small producer would not be able to afford the $1000 test cost on every batch. So a small supplier would likely only test once or twice per year. This is, for example, what the Cowichan group does.” Insufficient testing reduces confidence in the fuel, which lowers public interest and forms a vicious cycle.

The success of a small-scale operation is dependent on public interest and involvement, which explains the increasing emergence of biodiesel Co-ops across North America. Lucas included that the VBC has worked with community groups to enable fleets to become more sustainable in their operation, and has participated in outreach events to increase public awareness on alternative fuels. These social pursuits could be explored by the campus operation as well. Although the UBC operation is not financially dependent on community support, UBC is considered to be a pioneer in sustainability in the public eye. With adequate publicity, the biodiesel operation would help the university secure its reputation as a progressive institution.

Figure 2: VBC Volunteers pouring concrete for pump construction
(Source: Vancouver Biodiesel Co-op)

6.0 Conclusions and Recommendations

In this report, the transesterification process of biodiesel production was outlined, past campus initiatives were uncovered, and economic, environmental and social indicators were derived from the literature. These indicators in conjunction with first-person research has allowed the following conclusions to be drawn.

Economic indicators and projections for the UBC biodiesel project prove promising. Given that the feedstock is already available and transportation cost for the feedstock is minimal, and given the proportion of biodiesel that can be put into use in UBCOP and considering that projections show a positive NPV, it can be concluded that the project is economically viable. Regarding environmental indicators, it is clear that biodiesel is one of the best alternative fuels for petroleum diesel, as overall it has significantly less environmental impacts.

UBC has been considered as a pioneer in campus and community sustainability, and continuation with the biodiesel operation would respond to an increasing social interest while also providing novel opportunities for research. A positive effect on human health and community autonomy will also result. Biodiesel also integrates well with the Plant Ops fleet, and there are even notable benefits to its use in a diesel vehicle.

Based on the aforesaid findings, the recommendation is to move forward with the biodiesel operation on campus.

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Appendix A: Email Commnication with Adam McCluskey

Seyed,

As promised...

- Has UBC Plant Operations been involved in purchasing Biodiesel from any organization? - **Yes**

- If yes, is the organization a subset of UBC administration or is it through an independent contractor? – **Wepurchase from Chevron**

- what is the amount of biodiesel currently being purchased per week, per month or annually? – **See below (we buy as needed, certain periods are busier than others. The transactions=# of times we purchased, you could extrapolate the data.**

- What ratio of biodiesel to diesel is being used by UBC Plant Ops? (e.g B20 consists of %20 biodiesel and %80 conventional diesel) – **B5**

- How much is UBC Plant Ops being charged for this purchase of biodiesel? (per liter, per gallon, or per 1000 liter, etc) – **See table below**

Fuel Releases 2011

INVENTORY DESCRIPTION	PART	UOM	TOTAL COST ($)	QUANTITY	TRANSACTIONS
FUEL. REGULAR-UNLEADED CLEAR	000461	LI	355,149.24	302,410.31	2,037
FUEL. DIESEL-REGULAR CLEAR (BIO-DIESEL)	201112	LI	128,979.43	110,440.66	639

Cheers,

Adam McCluskey

Manager, Fleet and Inventory - OE

Appendix B: Data from UBC Biodiesel Initiative

Exhibit 7: SAMPLE TRANSFERABILITY PACKAGE, PAGE 1

Input Data (* Can Be Adjusted)

Section A: Input Schedule:

Input Costs (Revenues)	$/unit	Units	Adjustable Field
Waste Oil	($0.13)	Litres	*
Methanol	$1.11	Litres	*
KOH	$3.60	Kilograms	*
Phos.Acid	$4.65	Litres	*
Labour	$8.25	Hours	*
Electricity	$0.06	KiloWattHou	*

Section B: Variable Input Amounts (Per 1L Biodiesel Unless Noted)

Chemical	Amount	Units	
Waste Oil	1.000	Litres	
Methanol	0.170	Litres	
KOH	0.005	Kilograms	
Phosphoric Acid	0.010	Litres	
Electricity	0.446	KiloWattHour	
Labour A	1.265	Hours	*
Labour B	4.750	Hours	

Labour A: Per 100L - Labour Involved In Pickup

Labour B: Per Batch Size; to monitor lab reaction

Fixed Inputs/Month	Amount	Units	Rate
Lab Space	200	Square Feet	$ 326.00
Coordinator	52	Hours	$ 13.50
Director of Finance	52	Hours	$ 13.50

Section C: Other Variables

Variable	Amount	Units	
Batch Size	500	Litres	*
Batches Per Week	2	Batches	*
Avg. Weeks\Month	4.3	Weeks	
Avg. Output/month	4,333	Litres	
Mkt.Price Conv. Diesel	$0.7890	Litres	

Initial Equipment Investment Cost (500L Lab)

Description of parts	Unit Cost	Qnty.	S/H	Total
Welding Machine	$ 1,600.00	1	$ 200.00	$ 1,800.00
Reactor Tank	$ 1,300.00	1	$ 162.50	$ 1,462.50
Wash Tank	$ 800.00	1	$ 100.00	$ 900.00
Methanol NaOH Tank	$ 400.00	1	$ 50.00	$ 450.00
Pump Methanol	$ 580.00	1	$ 72.50	$ 652.50
Pump Biodiesel	$ 1,126.00	1	$ 140.75	$ 1,266.75
Pump Water	$ 1,085.00	1	$ 135.63	$ 1,220.63
Pump Circulation	$ 1,810.00	1	$ 226.25	$ 2,036.25
Condensor	$ 300.00	1	$ 37.50	$ 337.50
Spill Basin	$ 200.00	1	$ 25.00	$ 225.00
Misc. Other Parts	$ 500.00	1	$ 62.50	$ 562.50
Viscosity Test Kit	$ 201.00	1	$ 25.13	$ 226.13
Glycol Test Kit	$ 119.00	1	$ 14.88	$ 133.88
Filters (strainer)	$ 300.00	1	$ 37.50	$ 507.32
Misc. Safety Equip.	$ 300.00	1	$ 37.50	$ 337.50
Drum Heaters	$ 212.00	2	$ 26.50	$ 238.50
Thermometer	$ 52.75	2	$ 6.59	$ 59.34
Drums	$ 28.00	20	$ 3.50	$ 31.50
pH probe	$ 134.50	1	$ 16.81	$ 151.31
Total Equipment Cost				**$ 12,599.10**

Explanatory Note: The two spreadsheets shown on this page include the "Input the "Initial Lab Investment Costs." The data for both of these sheets has been ta the actual costs and rates associated with the UBC Biodisesl Project. Figures wi **star** next to them (*) may vary across time and space, and should be analysed b new projects in other communities. The figures **without** the red stars can be exp remain constant. **These adjustable charts, along with the "Profit-Loss" state the following page, comprise our "Transferability package that would be di to individuals interested in starting up a Biodiesel Project, so that they cou localised inputs in order to determine whether or not a Project would be w**

$\$2{,}517.12 * [1-(1.0591^{20})]/0.0591 = \$2{,}517.12 * 11.5542 =$ $29,083.30

Less equipment purchase costs: (12,599.10)

BioD Valuation Equals: $16,484.20

This evaluation shows that the UBC BioD site would have had a positive NPV even if it had not received grant funding.