A MODEL FOR POTENTIAL COOPERATIVE BIODIESEL PRODUCTION IN GAINESVILLE, ALACHUA COUNTY, FLORIDA

By

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This thesis is dedicated to my family.

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Refined petroleum diesel fuel is a ubiquitous source of energy used in the operations of heavy equipment, vehicles and machinery. Biodiesel is an alternative to refined petroleum diesel. It requires no engine or infrastructure modifications and the two are completely interchangeable, such that biodiesel can be mixed with diesel in any percentage.

Biodiesel is a superior fuel to refined petroleum diesel. However, it is widely believed to be an expensive alternative to refined petroleum diesel. This study seeks to dispel this myth and to provide credible evidence to the contrary. It investigates the potential for a community-based, cooperative biodiesel production facility in Gainesville, Alachua, Florida, wherein waste cooking oil is collected by the city, processed at a refinery constructed by the city, made into biodiesel and used as a diesel proxy for the city's diesel fleets.

CHAPTER 1
INTRODUCTION

Introduction to Biodiesel

Refined petroleum diesel fuel is a ubiquitous source of energy used in the operations of heavy equipment, vehicles and machinery. Biodiesel is an alternative to refined petroleum diesel. It requires no engine or infrastructure modifications and the two are completely interchangeable, such that biodiesel can be mixed with diesel in any percentage.

Biodiesel can be defined in many different ways because of the variety of potential feedstocks or sources of oil, including vegetable oils and animal fats. Of particular interest to this thesis is biodiesel made from waste cooking oil. The Independent Business Feasibility Group defines biodiesel as follows.

> Biodiesel is a domestic, renewable fuel for diesel engines derived from natural oils like soybean oil that can be used in any concentration with petroleum based diesel fuel. Chemically, biodiesel is defined as the mono alkyl esters of long chain fatty acids derived from renewable lipid (fat or oil) sources. In the United States, biodiesel has been registered with the United States Environmental Protection Agency as a pure fuel or a fuel additive under section 211 (b) of the Clean Air Act and is a legal fuel for commerce. (Independent Business Feasibility Group 2002, p. ii)

Biodiesel is produced through a chemical process known as transesterification. Tickell explains tranesterification in the following way:

> Transesterification is the transformation of an *ester* into another type of ester. An ester is a hydrocarbon that will bond with another molecule.
>
> A vegetable oil is made up of three esters attached to a molecule of glycerin. To imagine a vegetable oil molecule, picture an octopus with only three legs. The head of the octopus is the glycerin. The three legs are the

> esters. Vegetable oil is called a *triglyceride*. Tri refers to the three esters and glyceride refers to the glycerin. Vegetable oil is also called *glycerol esters*.
>
> About 20% of a vegetable oil molecule is glycerin. Glycerin is also called glycerine, glycerol, and glyceride. Glycerin makes vegetable oil thick and sticky. During transesterification, glycerin is removed from vegetable oil to make the oil thinner, or to reduce its viscosity. (Tickell 2000, p. 59)

In lay terms, transesterification is the chemical process that takes place when vegetable oil, including waste cooking oil, is mixed with an alcohol, methanol or ethanol and a catalyst, usually sodium hydroxide or potassium hydroxide. The mixture produces two products, crude glycerin and biodiesel (Tickell 2000, p. 59). In many ways, biodiesel is a superior fuel to conventional petroleum based diesel. It lowers emissions, enhances lubricity and reduces toxicity. The following paragraphs are explanatory.

Emissions

Biodiesel reduces the emissions of a number of Environmental Protection Agency targeted pollutants, depending on the percentage or proportion of biodiesel used. Although conclusive studies have yet to be produced, biodiesel is also thought to limit the emissions of a number of mobile source air toxics. (2002a, p. 85).

The percentage of biodiesel used in a fuel mixture depends on economics, fuel properties, and the fuel's benefits as they relate to the natural environment. In the United States there are typically three general types of biodiesel; B100 is neat or one hundred percent biodiesel, B20 is twenty percent biodiesel and B2 is two percent biodiesel and mainly used as a fuel additive. According to the

National Biodiesel Board (n.d.a), B100 and B20 compare with conventional diesel as follows:

Table 1 - Biodiesel Emissions Data

AVERAGE BIODIESEL EMISSIONS COMPARED TO CONVENTIONAL DIESEL		
Regulated Emissions	B100	B20
Total Unburned Hydrocarbons	-67%	-20%
Carbon Monoxide	-48%	-12%
Particulate Matter	-47%	-12%
NOx	10%	2%

Source: (National Biodiesel Board n.d.a)

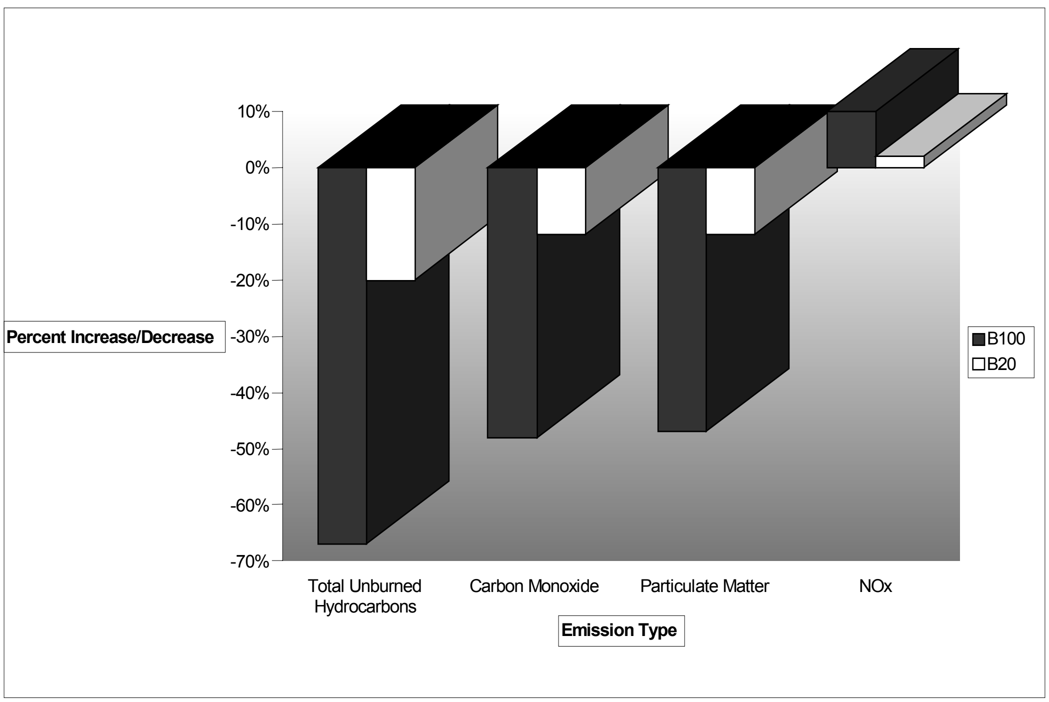

Figure 1 – Biodiesel emissions compared to diesel

One of the major benefits of biodiesel is that it is cleaner burning with reduced pollutants, meaning better air quality and less greenhouse gas emissions. Biodiesel does not significantly contribute to net carbon in the atmosphere because the crops needed to grow biodiesel absorb much of the carbon dioxide emitted during combustion. Tickell explains.

> A crop of oil producing plants will absorb exactly the same amount of carbon dioxide in order to produce a gallon of vegetable oil as a gallon of vegetable oil emits when it is burned in an engine. Because plants produce hydrocarbons and absorb carbon dioxide, renewable fuels do not contribute significantly to global warming. (Tickell 2000, p. 20)

In terms of carbon dioxide, therefore, biodiesel can be viewed a low emissions fuel, because it is a part of the carbon cycle (Figure 1).

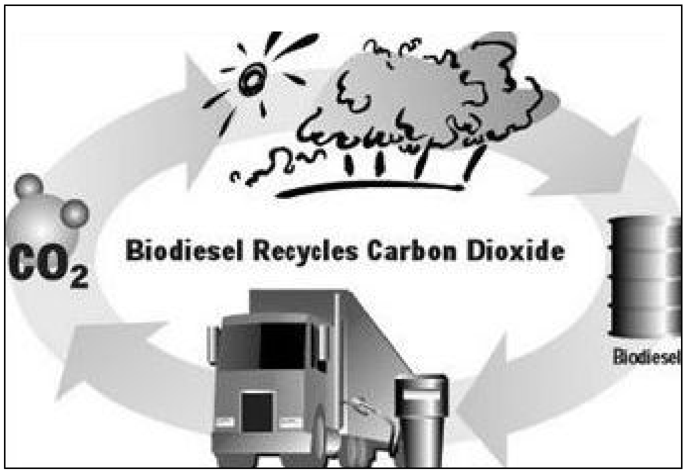

Figure 2-The carbon cycle. Souce: (Office of Transportation Technologies n.d.)

However, according to the emissions data provide by the National Biodiesel Board (Table 1), biodiesel is also known to increase nitrogen oxide emissions, up to ten percent with the use of one hundred percent or neat biodiesel and up to two percent with the use of twenty percent biodiesel (National Biodiesel Board n.d.a). Nitrogen oxide compounds are a significant component of ground level ozone and all cause the same types of problems, as the Environmental Protection Agency explains. “NOx is a prime ingredient in the formation of ground level ozone (smog), which can irritate the respiratory tract, impair breathing ability and cause various other respiratory problems” (Environmental

Protection Agency 2002b). While many researchers would argue that it is possible to reduce NOx emissions with the use of biodiesel, they are ultimately talking about adjusting the injection timing and engine operating temperature (Journey to Forever n.d.). While certain engine adjustments do lower emissions of nitorgen oxide, they also lower fuel efficiency, exacerbating an existing weakness in that biodiesel already has lower energy content than conventional diesel. Joshua Tickell explains:

> Biodiesel contains approximately 12% less energy than diesel fuel. Biodiesel contains 37 megajoules of energy per kilogram whereas diesel contains approximately 42 megajoules per kilogram. The reduction of energy in biodiesel is partially offset by a 7% average increase in the combustion efficiency of biodiesel. On average, biodiesel use results in a 5% decrease in torque, power, and fuel efficiency. (Tickell 2000, p. 37)

Overall, the difference in emissions between conventional petroleum diesel and biodiesel is best viewed as a trade-off. While biodiesel increases the emissions of Nitrogen Oxide, it decreases the emissions of Carbon Monoxide, Particulate Matter, Total Unburned Hydrocarbons and Sulfates. This is a favorable balance. It must be concluded therefore, that biodiesel is a cleaner, more environmentally friendly alternative.

Lubricity

The discussion of biodiesel's properties eventually leads one to consider the topic of *lubricity*. Biodiesel provides for a longer engine life because of its higher lubricity. In other words, biodiesel reduces engine ware by allowing the engine's moving parts, to move more easily. Again, Tickell explains lubricity.

> Between 0.4-5% biodiesel mixed with petroleum diesel fuel increases the fuel *lubricity*. Lubricity describes how a fuel lubricates the fuel system and engine. Diesel fuel was once lubricated primarily with sulfur. When fuel containing sulfur is burned, it produces sulfur dioxide (SO_2), the primary

> component of acid rain. When the legal limit of sulfur in diesel fuel was decreased in the United States, many Diesel engines experienced fuel system problems. Biodiesel can be used to restore the lubricity of diesel fuel. (Tickell 2000, p. 35)

Tickell goes on to say that, “lubricity should not be confused with viscosity” (Tickell 2000, p. 35). Viscosity refers to the thickness of a particular liquid, whereas lubricity refers to properties within said liquid to reduce friction and ware between moving parts, hence the market for B2 (2% biodiesel), which is used mainly as a fuel additive to increase the lubricity in diesel engines. This is another positive attribute of biodiesel fuel. The engine is kept clean from Unburned Hydrocarbons and Particulate Matter and the engine’s moving parts move more freely.

Toxicity

Another social benefit for biodiesel fuel is that it is completely non-toxic and biodegradable (Tickell 2000, p. 37). According to the text, From the Fat Fryer to the Fuel Tank,

> Biodiesel is biodegradeable and non-toxic. 100% biodiesel is as biodegradeable as sugar and less toxic than table salt. Studies have shown biodiesel to biodegrade up to four times faster than petroleum diesel fuel, with up to 98% biodegradation in 3 weeks. (Tickell 2000, p. 37)

For these reasons, biodiesel is a more sensible alternative for long distance transport. Chemically, it is less harmful to the natural environment and, as Tickell explains in the following paragraph, the higher flashpoint allows for safer transport.

> Biodiesel is also safer to transport because of its higher flash point. Biodiesel will not spontaneously explode or ignite under normal circumstances because of its high *flashpoint,* or ignition temperature. Biodiesel must be at least 300°F (150°C) before it will ignite. Comparatively, petroleum diesel has a flashpoint of 125°F (52°C). Since

> biodiesel is not explosive under normal circumstances, it can be transported with shipping services such as Yellow freight or UPS. (Tickell 2000, p. 37)

In sum, biodiesel is a superior fuel to conventional, refined petroleum diesel. However, the use of biodiesel is not widespread. Few people know about biodiesel and production is relatively low. More importantly, biodiesel is expensive.

Hypothesis

This thesis is a case study of the potential for biodiesel production from waste cooking oil in the City of Gainesville, Alachua County, Florida. It deals with the economics of biodiesel production in this geographic area and seeks to test the hypothesis that biodiesel is a cost-competitive alternative to conventional diesel fuel. Gainesville and Alachua government fleets using conventional diesel fuel paid anywhere from $0.72 per gallon up to $1.33 per gallon for the fiscal year 2001-2002. Henceforth, economically feasible biodiesel production shall be defined as the costs of production not exceeding the costs of conventional diesel.

Method

The logical first step in assessing the economic feasibility of biodiesel production is to consult the wisdom of one's predecessors and to review the literature. A thorough investigation of prior research will offer some explanation as to the broader market forces that dictate the cost of production for biodiesel fuel. Moreover, precedence may even contain the seminal ingredients necessary for the genesis of future research, namely one's own.

As a second step, this thesis will attempt to quantify the size of the Gainesville/Alachua biodiesel feedstock. While there are a number of ways of doing this, only one seems realistic. An existing inventory of waste cooking oil for the city and county areas needed to be found. Griffin Industries in Hampton, Florida, has such an inventory and office manager Jim Siragusa agreed to an interview.

Several other interviews were conducted. Bev Thessem of the National Biodiesel Board was interviewed to gain some general perspective as to the nature of government subsidy programs, the appropriate scale of production and the general market dynamics involved with biodiesel production.

A third survey asked questions of twenty-five Gainesville restaurants; the goal being to uncover the sordid, waste cooking oil-habits of restaurant owners. It is hoped that this survey provides some insight on “tipping fees,” the service charges associated with the disposal of waste cooking oil.

A final survey was conducted with Wendell Chastain, the Alachua County fleet manager, and user of biodiesel. This interview was designed to acquire accurate data for biodiesel demand in the county and to qualify the use of biodiesel in the local area.

A subsequent query quantifies demand through an investigation of conventional diesel use in the Gainesville/Alachua area. Potential clients for biodiesel are existing diesel vehicles in the city and county fleets, including the Regional Transit System bus service, and Alachua County School Board buses.

The final step in assessing the feasibility of production is to construct a working model. The Independent Biodiesel Feasibility Group has constructed such a model and this will serve as the basic format. However, since this study focuses on the potential for cooperative biodiesel production, other information, such as the price of collection vehicles, and biodiesel equipment shall be researched independently and adapted to the model as the author sees fit. Ultimately, a new model, specifically geared towards community-based, cooperative biodiesel production will emerge.

CHAPTER 2
LITERATURE REVIEW

A Preliminary Philosophy of Energy and Waste

> As the global crescendo of information and investments rushes toward the culmination of civilization, most of the six billion people on Earth are oblivious to the turndown ahead. It's time for people to recognize what is happening and how they will be forced by circumstances to adapt to the future. (Odum and Odum 2001, p. xiii)

The preceding, courtesy of the late Howard T. Odum of the University of Florida, leaves the reader with a strangely ambivalent feeling; while one does not wish to be alarmed or puzzled, neither does one wish to be oblivious. We feel compelled therefore to understand the "turndown" that Odum refers to; a "turndown" that is widely anticipated in environmental circles, a "turndown" that the experts say is inevitable, a "turndown" that some have predicted for years.

In 1949, Frederick Jackson Turner published The Turner Thesis; Concerning the Role of the American Frontier in American History. In much the same way, The Turner Thesis predicted the end of not just a frontier, but also a way of life and a way of thinking.

In effect, Turner foresaw the limitations of our natural resources. He stated that the end of the frontier was in fact an irredeemable limit placed upon an economy based on expansion. Furthermore, expansion was so institutionalized in American economics, politics and society that limitation would ultimately lead to these institutions undoing. In this way, a new ideology would necessarily take its place.

> To know that at any one time a nation may be called a democracy, an aristocracy, or a monarchy, is not so important as to know what are the social and economic tendencies of the state. These are the vital forces that work beneath the surface and dominate the external form. It is to changes in the economic and social life of a people that we must look for the forces that ultimately create and modify organs of political action. (Turner 1949, p. 19)

The foundation of this paradigm, of these expansion-based environmental principles came some years earlier, in John Locke's second treatise. Locke argued that nature had no inherent value, and that value could only be ascribed to it through the toil of man. By essentially putting a price tag on the natural functions of the planet, Locke deemed that nature alone was without value. His argument in the Second Treatise is as follows:

> 27. Though the earth and all inferior creatures be common to all men, yet every man has a property in his own person; this nobody has a right to but himself. The labor of his body and the work of his hands, we may say, are properly his. Whatsoever then he removes out of the state that nature has provided and left it in, he has mixed his labor with, and joined to it something that is his own, and thereby makes it his property. (Gruen and Jamieson 1994, p. 19)

Regrettably, while Locke's argument may have been compelling three hundred and thirteen years ago, the Second Treatise is antiquated and no more suited for today's world than a powdered wig, also a powerful fashion statement at the time. Yet, it is this ethic that drives today's institutions; an economy based on resource extraction and the false assumption of infinite resources. While this may satisfy our penchant for growth for the time being, it will ultimately yield to life's preset limits and cannot be sustained.

A more sensible alternative to the super consumption of natural systems is to maximize the potential of the resources that we must necessarily use. The mantra of this belief system says, reduce, reuse and recycle. Thus, this thesis is philosophically grounded in this belief system and in the reuse of materials, specifically waste cooking oil.

Commercialization of an Alternative

> Whether or not Biodiesel can penetrate into the existing fuel market depends on its cost as compared to conventional diesel. Biodiesel can be produced from waste oil or imported from other countries. The price depends on the market of the feedstock (Leung 2001, p. 2)

In light of the preceding philosophy, many researchers are trying to find a way around the current paradox, by allowing for economic growth, while at the same time accommodating the needs of the natural environment. Much of this research is related to the matter of energy, specifically alternative energies such as wind, geothermal, solar and biomass. These forms of energy are called renewable, because theoretically, there is no limitation to the amount of power they may produce. They are deemed alternatives, because they are not widely accepted or used, nor are they priced at competitive rates.

For example, there has been quite a bit of research done on the economic feasibility of biodiesel, both domestically and abroad. The body of research is remarkably consistent; older research on economic feasibility dating back to the late 1970s suggests that biodiesel production is far from economically viable. However, more recent research, and this refers to studies written within the last few years, suggest that not only is biodiesel becoming more economically feasible, but, in some markets it is preferable (Glaser, Price and Raneses 1996, p. 1). Niche markets, such as sensitive natural areas or wetland habitats benefit from the reduced emissions. Recent research also suggests that the biodiesel industry is growing.

Perhaps the most compelling evidence pertains to the operation of several viable biodiesel plants around the country. While data are not readily shared in the industry, the plants appear, at least from the outside, to be feasible operations. Prudence may eliminate concerns over competition, but it makes economic feasibility assessments all the more complicated. Groschen makes the following observation:

> One possible reason for the lack of data is that the industry is so competitive that company representatives are reluctant to divulge information that might compromise their ability to compete. Another potential obstacle to a thorough economic assessment is the wide variety of materials collected, the processes employed in manufacturing and the number of products and product blends sold by renderers. (Groschen 2002, p. 6)

Through the interviews conducted for this thesis, it became evident that much of the information about the rendering and biodiesel industries is jealously guarded, especially information about the cost of operations, tipping fees, i.e. collection fees and price. While credible data are difficult to come by, and the argument therefore a little more difficult to substantiate, many researchers predict that the biodiesel market will grow. For example, the U. S. Department of Energy has the following prediction:

> Within the decade, advance technology will make biofuels as affordable and easy to use as today's petroleum gasoline and diesel fuels. By the turn of the century, biofuels could furnish America with a cost-competitive alternative to imported oil that is domestically produced and environmentally compatible. (United States Department of Energy 1993)

Two years later, the Environmental Policy Act mandated that biodiesel, along with a host of other alternative energies, be incorporated into existing government fleets and in the production of electricity. While the Department of Energy has the authority to mandate quotas for Alternatively Fueled Vehicles under the Energy Policy Act of 1992 for private and local government fleets, they have yet to implement any rules. Legislation has only been established for fleets at the Federal and State levels and for companies acting as a public utility. (United States Department of Energy n.d.a)

The provisions of the Energy Policy Act also recognize forms of analysis like Life-Cycle Costing in assessing the economic feasibility of biodiesel production. An example of this type of analysis was done by the United States Department of Agriculture. They measured the collective costs of infrastructure, bus alteration, refueling and maintenance expenses over the course of a thirty year period. They concluded that in terms of Life Cycle Costing, biodiesel was the least expensive alternative fuel, ranking higher than both compressed natural gas and methanol. This is due to the fact that biodiesel requires no engine or infrastructure related modifications. Biodiesel increases the longevity of an engine, so less maintenance needs to be done and the engine will run for a longer period of time. These factors all diminish the Life Cycle Cost. (Ahouissoussi and Wetzstein 1995, p. 3)

A report written by Shapouri and Duffield looks at economic feasibility in yet another way. It considers the prospect of “negative externalities”; a phenomenon not often considered by conventional economic measurement.

> A review of studies and crop data show that the cost of growing and converting various feedstocks with current technology is greater than the cost of producing conventional fuels. Conventional motor fuels have a price advantage over biofuels, but market prices don’t always reflect the cost of negative externalities imposed on society. Government decisions to invest in alternative energy sources should be based on research that includes the environmental costs and benefits of energy production. (Shapouri and Duffield 2000, p. 9)

This same type of logic is incorporated into a study done by D.L. Van Dyne, J.A. Weber, and C.H. Braschler. They state the following:

> Current and previous efforts to evaluate biodiesel fuel have focused on direct price comparisons with petro-diesel fuel, demonstration of the fuel in various types of vehicles, engine performance, emissions testing, and identification of potential market niches. While each of these are important, another significant aspect of biodiesel has been ignored. That is, estimating the macroeconomic impacts that would result from a biodiesel plant or industry. (Van Dyne, Weber and Braschler 1996, P. 6)

There are several consistencies in the literature as they relate to the economic feasibility of production. First and foremost, the price of the feedstock is consistently ranked as the most critical factor in feasible production. This is primarily due to the fact that it requires some 7.5 pounds of yellow grease or more to make one gallon of biodiesel. Even though the price of yellow grease varies, the cost of acquiring enough feedstock to make one gallon of biodiesel can often exceed the retail selling price of petroleum diesel. When other costs are attributed to the production process, the price of biodiesel seems invariably more expensive than conventional diesel.

A second important factor in the production of biodiesel is the value of the by product, glycerol, which if purified to food-quality standards (glycerin), is a very valuable commodity and can be used in a variety of products ranging from soap to cosmetics. In the Independent Business Feasibility Group's Biodiesel Plant Development Handbook, crude Glycerine is valued at $0.077 per gallon of biodiesel produced and incorporated as part of the overall feasibility model (Independent Business Feasibility Group 2002, p. 43). However, this price is also subject to variation depending on the available market and level of purity. In other words, accurate values for glycerine are only transient

Another equally important factor to the feasibility of production is the scale of the operation, in that the cost of production goes down in proportion to volume. The scale of operations is especially important when biodiesel is compared to conventional diesel because conventional diesel has a much larger scale of production, an established infrastructure, and an omnibus of government subsidies.

Government subsidies also turn out to be an important factor, since they provide a major cost savings for the industry. Currently, there are several government subsidies that relate to biodiesel and all will be examined in further detail in the subsequent section.

Ultimately, the British Association for Biofuels and Oils synthesizes most of the essential ingredients for feasible biodiesel production in the article Rationale and Economics of a British Biodiesel Industry and the basic gist of the argument goes like this:

> The cost of biodiesel production is dependent on three factors:
>
> - The price of rapeseed. This is a significant cost and the net figure for biodiesel is highly sensitive to change in the raw material price.
> - The value of the by-products (rapemeal and glycerine). The sale of by-products are important to the final figure, but the net cost of Biodiesel is less sensitive to their price fluctuation.
> - There are significant economies of scale to be obtained in the processing. Other work on the cost of biodiesel production has used capital and working costs based on plants of less than optimal size. (Korbitz and Walker 1994, p. 11)

While this observation refers to a virgin feedstock, and do not take into account the cheaper cost of waste cooking oil, they do provide the necessary guidelines in formulating some basic guidelines for assessing feasibility, government subsidy notwithstanding.

The Importance of the Feedstock

As the Energy Information Administration said in 1994 “Biodiesel can be produced from a number of vegetable oil sources. The most economical choice will depend on the yield per acre, product quality, by product values, geography, and government policies. ” (Department of Energy 1994, p. 91). Indeed, the price of feedstock is situational and subject to change with location. It is also true that the economic feasibility of biodiesel is dependent on the quality of the feedstock. Since waste cooking oil tends to have a higher clouding point or “pour point”, contains a greater quantity of free fatty acids, impurities and water, it is both a blessing and a curse. These properties make waste cooking oil cheaper, but harder to transesterify.

The Biodiesel Plant Development Handbook goes into to more detail about the benefits and pitfalls of a cheaper feedstock.

> The choice of biodiesel feedstock is dependent upon many factors but the leading determinants are cost, quality, technology requirements, finished product impact and the reliability of supply. Cost is probably the single most important determinant of feedstock choice. However, quality of the fat or oil (as determined primarily by the level of free fatty acids (FFA), water and solids) and the ability of the chosen technology to effectively handle lower cost, lower quality raw materials may override the feedstock cost difference. Finally, as the industry grows, reliability of supply will become increasingly important even though this factor has been generally overlooked in today’s developing market. (Independent Business Feasibility Group 2002, p. 4)

A similar opinion on cheaper feedstocks is conveyed in an article released in Inform magazine in 1996**.** “The biggest stumbling block for Biodiesel is the cost, especially if it is made from virgin vegetable oils,’ said Chuck Peterson of the University of Idaho-Moscow. ‘With recycled waste oils, that cost can be reduced substantially, but such sources present some problems in production and usage” (Krawczyk 1996, p. 804).

Again, the problems in production and usage that Peterson refers to are the presence of impurities in the oil, such as food particles, water, or free fatty acids. These impurities make the process of transesterification generally more difficult, requiring more heat, chemical input and filtration to achieve an acceptable quality of fuel, i.e. to attain the American Society for Testing and Materials (ASTM) standard.

Groschen further supports these statements with the following explanation of feedstock characteristics.

> Assuming that technology will allow the efficient processing of a wide variety of fat and oil products into biodiesel, one could assume that the lowest-cost fat would always be the most profitable and widely used input for biodiesel production. There are other factors, however, that must be considered.
>
> For instance, the efficiency of a large multiple product-processing facility relies in part on uniform inputs, quality-controlled outputs and a carefully controlled process that operates around the clock. These factors, combined with the quantity of purchases and large labor, management and resource pools, may reduce the overall production costs suggested by a comparison of the spot prices of various inputs. In other words, it may be profitable for large industrial facilities to use more expensive commodity oils than the current low-cost options such as various waste/recycled products. (Groschen 2002, p. 3)

Although these comments would seem to indicate the uniformity and purity are preferable in the production of biodiesel, Groschen goes on to say that waste cooking oil and other similar grease products are consistently cheaper.

> Given the wide range of fats and oils that can be used in the production of biodiesel, the relative price and availability of individual products will have an impact on which raw material is most profitable at any given point in

> time. Bumper crops or crop failures in various parts of the world may increase or decrease the price and availability of certain fats and oils. [T]he relative price of vegetable oils such as soybean, corn, canola and sunflower vary and one may be higher than the others one year and lower the next. However, grease product prices are consistently lower than oil prices. (Groschen 2002, p. 10)

The cheapest feedstock may also depend on other factors, such as the location of production, the motivation of production, i.e. profit-based versus cooperative purposes and the economic model preferred. For example, in farming communities with an abundance of raw oil crops, and very little Yellow Grease, the cheapest feedstock will almost certainly be virgin.

The factors are significant because they comprise the price of the feedstock, which according to a 1994 study, was the single most important factor in feasible production.

> At the end of December 1993, biodiesel was being sold for $2.80 per gallon by Interchem Environmental. The price of the fuel varies significantly, depending on the cost of the soybean oil feedstock. In April 1993, biodiesel sold for $2.20 per gallon.
>
> Approximately 75 percent of final biodiesel product cost is due to the cost of soybean oil. The remaining 25 percent is attributable to processing, handling and capital plus a small profit margin. Because feedstock cost dominates the production economics, larger volume production will not have a large effect on biodiesel cost. Similarly, lowering processing costs will not greatly affect final product costs. (Booz Allen and Hamilton, Inc 1994, p. 6)

The Booz-Allen study focuses mostly on feedstock costs as they relate to the total operating costs, such that 75% of the costs involved with the production of biodiesel are attributable to the feedstock. This seems to echo what Independent Business Feasibility Group believe. They estimate that the feedstock comprises 78.4% of the total production costs based on a scale of production of 3,000,000 gallons a year (Independent Business Feasibility Group 2002). Coltrain concurs with the following paragraph.

> The major economic factor to consider for input costs of biodiesel production is the feedstock, which is about 80 percent of the total operating cost. It takes around 7.5 pounds of fat or oil to produce a gallon of biodiesel. If a feedstock is 20 cents per pound, the feedstock cost alone is nearly $1.50 per gallon. Other important costs including plant overhead, labor and methanol must be added to the feedstock cost to determine the total cost per gallon in biodiesel production. (Coltrain 2002, p. 6)

Regardless of the actual figure, the cost of the feedstock dominates and compromises the ability of biodiesel to be competitive with conventional diesel.

Booz Allen and Hamilton, Inc. elaborate with the following: “Because feedstock cost dominates the production economics, larger volume production will not have a large effect on biodiesel cost” (Booz Allen and Hamilton, Inc. 1994, p. 6). While this may be true at larger volumes, the Independent Business Feasibility Group states that there is a significant cost difference between higher and lower scales of production. Based on their model for costs, scale affects the cost of biodiesel production in the following way.

Table 2- Biodiesel Costs by Scale

Gallons Per Year	Price
21,000,000	$1. 748
15,000,000	$1. 759
9,000,000	$1. 784
3,000,000	$1. 908

(Independent Business Feasibility Group 2002, p. 43)

Although Booz-Allen and Hamilton Inc. stated that there is very little relationship between the scale of production and price, the Independent Business Feasibility Group states that the jump from nine million gallons a year to three million gallons a year causes costs to go up significantly, approximately 12 cents per gallon. It is worth noting here that three million gallons is an immense quantity of fuel, especially when compared to today's average biodiesel production capacity. The independent Business Feasibility Group might be asked the following questions; how much do costs increase below the three million gallon capacity? Are lower scale production facilities increasingly less feasible?

Supplemental information seems to confound this argument. This study received two separate quotes on biodiesel fuel and found that at a scale of two million gallons per year, biodiesel was being sold for $1.75 a gallon plus $0.16 per gallon in transportation fees from Butler, Kentucky, to Gainesville, Florida (personal communication with J. Hart Moore 2003).

A subsequent investigation revealed that these prices were not indicative of true costs. Rather, the lower costs were a result of the Bioenergy Program, which reimburses biodiesel producers for feedstock costs associated with increased production. Consequently, some producers are attributing these savings to their costs of production and ultimately, to their prices. (personal communication with J. Alan Weber 2003).

Feedstock price also depends on the availability of supply. In a 1994 report, Nelson, Howell and Weber report on the potential of certain feedstocks:

> Soybean oil is by far the most abundant feedstock for Biodiesel in the United States with almost 14 million pounds produced each year which represents a potential of over 1.8 billion gallons of biodiesel. At present, nearly all of the biodiesel produced in the United States is made from soybean oil. The use of beef tallows and waste frying oils have the potential of producing almost 900 million gallons. These fats and greases are less expensive than soybean oil, and could represent an effective option to reduce the cost of biodiesel as well as extending the supply of biodiesel. (Nelson et al. 1994, p. 66)

The results of this report are intriguing because the concentration of this thesis is waste cooking oil. According to a report by the National Renewable

Energy Laboratory entitled Urban Waste Grease Resource Assessment, G. Wiltsee concludes, based on an average of thirty distinct metropolitan areas around the country, North Americans produce on average nine pounds of Yellow Grease (waste cooking oil) per person per year (Wiltsee 1998,p. 3). This could potentially add up to a total of 2,616,697,233 pounds of yellow grease and consequently a total of 348,892,964 gallons of biodiesel per year. If both authors' conclusions are accurate, waste cooking oil represents approximately 39% of this potential feedstock.

Many studies have attempted to reduce costs wherever possible. A study published by the University of Missouri-Columbia attempted to reduce costs by striking transaction costs, and running the biodiesel refinery as a cooperative.

> The results of this study conclude that under specific conditions, biodiesel can be produced economically at the community level. The results of different simulations demonstrate that without farm program benefits to minor oilseeds, soybeans are the most economic feedstock to use in a community-based operation. Realistic price information suggests that biodiesel (from soybeans) could be produced for $1.26 a gallon. (Van Dyne and Weber 2003, p. 6)

This study puts forth the thought that "transaction costs" contribute significantly to price. Transaction costs exclude factors like marketing and include benefits like retained ownership. Eliminating these costs may prove crucial to the feasibility of biodiesel production

As a final observation on the cost of the feedstock, K. Shaine Tyson, of the National Renewable Energy Laboratory, states that the cost of producing biodiesel can range from approximately $0.90 per gallon to $1.35 per gallon, with a glycerin credit of approximately 7.5 cents per gallon (Tyson, K. Shaine 2003, p. 24). If these results are combined with the results of the Weber and Van Dyne study and ownership is retained, costs then become less than prices and biodiesel becomes economically feasible.

Ultimately, when one talks about the feasibility of biodiesel production, one is talking about the cost of the feedstock, ranging anywhere from 75 %-80 % of the total cost according to the literature. However, feasible biodiesel production is also dependent on other factors.

The Value of Glycerol

The authors of a paper presented at Bioenergy ’94 (Nelson et al.), the National Bioenergy Conference, state that the most important consideration in terms of economic feasibility was the price of the feedstock. However, as a secondary consideration, they mention the importance of the by product, glycerin.

> Biodiesel break-even price, which does not include profit, income and road taxes, or transport costs, ranged from $0.96 per gallon under the best conditions to $3.39 under the worst. By far, the most important factor was feedstock cost. Plant size and glycerin by-product values were of secondary concern, but are still significant factors. (Nelson et al. 1994, p. 63)

Groschen explains the value of glycerin in a little more detail. While price varies, one thing remains constant; glycerin produced from virgin feedstocks will always achieve a higher value than glycerin produced from waste cooking oils.

> Finished glycerin is a product with an established market price that varied from 50 cents to more than $1.00 per pound from 1999 to 2002. Glycerin from inedible greases may not be suitable for certain markets and therefore may experience a lower price than glycerin from edible products. It should also be considered that, if biodiesel becomes a significant factor in the diesel market, a large increase in the supply of this byproduct could flood the glycerine market and reduce its price significantly. These factors could impact the cash flow projections and the feasibility of biodiesel production. (Groschen 2002 p. 9)

In a report by Fletchner and Gushee, the dynamics of the glycerin market are expanded upon. They also feel that while the by product glycerol may temporarily lower costs; it may also decrease in value of the product because of increased supply.

> An important factor in biodiesel economics is the market value of the glycerol produced. Glycerol markets are limited; any major increase in biodiesel production would undoubtedly cause glycerol sales prices to decline, meaning that biodiesel price would have to cover an increasing share of total costs. (Flechtner, Gushee 1993, p. 4)

Coltrain observes the relative value of glycerol. Whether the price of glycerol is $0.39 or $0.03 per pound, the market dictates that the value of glycerol will consistently offset the cost of production. He states the following:

> While feedstock cost is the major component in producing biodiesel, other operating costs will occur. One study estimated that the transesterification costs are about 58 cents per gallon and overhead costs are 33 cents per gallon. If the co-product glycerol is credited at 39 cents per gallon, the total cost for processing biodiesel is 52 cents per gallon. Other studies have estimated total operating costs of 30-60 cents per gallon. The total operating cost for converting fats and oils to biodiesel ranges from $1.39 to $2.52 per gallon, depending on which feedstocks are used. (Coltrain 2003, p.12)

Krawczyk gives no prices for the value of glycerol. However he does differentiate between crude grade glycerol and refined glycerin, lending the following perspective.

> Some pricing relief comes from the fuel production process itself, which yields a glycerol by-product that can be sold. The glycerol from biodiesel is not refined by the biodiesel producers, and sells at crude grade prices. Top grade glycerin can fetch two to three times the market price of crude glycerol, however, and the ability to refine the glycerol from the transesterification process will become more valuable as production increases. (Krawczyk 1996, p. 805)

A British report finds the market for glycerin to be a promising cost reduction in both Britain and the United States.

> The current price for glycerine in Britain is exceptionally strong at 1,300 pounds/ton. The European market has seen price increases in refined glycerine of nearly 5% per week since late August. Rapidly improving consumption linked to poor supply has led to a very tight situation in Europe with customers being allocated supplies by their suppliers. Consequently, the price today represents an increase of 50% in just 3 months. Stocks of refined glycerine are astonishingly low in both Europe and the US. For example, in the US these stocks stand at 10 million lbs for a market which consumes more than 350 million lbs annually. Consumption of refined glycerine in the US for 1993 is 10% above 1992 levels and 25% above 1991 levels. (Walker and Korbitz 1994, p. 13)

These findings would seem to refute the belief that additional glycerin will adversely affect price. While increased supply will ultimately lower prices, according to this report, demand far exceeds supply. Thus, supply can be safely increased without adversely affecting price.

The Independent Business Feasibility Group values glycerin in perhaps the most pragmatic way; as part of a working feasibility model. They suggest that glycerin may reduce the production costs of biodiesel by as much as $0.077 per gallon. Of course, it is worth mentioning that this number is subject to the typical market variation.

J. Alan Weber notes that glycerin is not the only by product for biodiesel production. In the following excerpt, from his 1993 thesis, he describes a substance that is not mentioned in the majority of the literature.

> In addition to glycerin, the transestenfication process has one additional co-product. During the continuous flow process a portion of the mixture will not be “dean” enough to qualify as esters; but, it is also not glycerin. This fatty acid mixture can be marketed as a commodity and is worth approximately 2 cents per pound less than animal fats (personal communication with Steve Howell in May, 1993). (J. Alan Weber 1993, p. 33)

The general consensus on the value of glycerol or glycerin is that it will lower costs in the production of biodiesel, depending on the quality and purity of the end product and the mood of the glycerin market. There is also some consistency in the belief that if too much glycerin is produced via the biodiesel market, that its value will decrease.

Scale

Despite the findings of the Booz-Allen & Hamilton, Inc. study, scale is undoubtedly a factor in the cost of production. When the scale of production is compared for petroleum diesel and biodiesel, the difference is extreme. In 2001, petroleum diesel consumption for highway vehicles totaled 33,215,320,000 gallons (United States Department of Energy 2001), as compared with biodiesel, with 60-80 million gallons of the fuel produced for the same year. (National Biodiesel Board n.d.b). Might the scale be a factor in the difference in price between the two products?

Flechtner and Gushee agree that the scale of the plant is an important factor in the feasibility of biodiesel production.

> Developments in transesterification technology would also lower the costs of production. Currently, biodiesel is produced in “batches”, or small, fixed quantities. Transesterification done on a “continuous” basis would be more efficient and would contribute economies of scale to the production process. (Flechtner and Gushee 1993, p. 5)

Weber and Van Dyne feel that biodiesel plants of various sizes may be feasible. In Cost Implications of Feedstock Combinations for Community Sized Biodiesel Production, they cite an Austrian plant with a capability of 500,000 gallons per year. In their report they not only state that such a plant is feasible, but that a plant of this size may be optimal if run as a cooperative (Van Dyne and Weber 2003).

Krawczyk seems to agree. “Experts feel that, as expanding markets require more biodiesel fuel, the production facilities will get larger, and economics of scale will result in lower fuel prices” (Krawczyk 1996, p. 810).

Groschen describes the question of scale with a little more detail, suggesting that perhaps volume is not necessarily the final answer, rather ideal volume is.

> It is very important to ensure that the engineering and construction will result in an efficient and dependable system. Also, the size of the facility may be limited by the availability of raw materials. It is important to ensure that the facility is large enough to support high-quality equipment, skilled labor and competent management and marketing expertise. Quality in these areas will enhance the likelihood of efficient and profitable operation. If there is only enough yellow grease in Minnesota to produce 5 million gallons of biodiesel, then the prospect of building a plant dedicated solely to the production of biodiesel from yellow grease may deserve even more careful scrutiny. A plant that would operate on multiple raw materials might be more feasible from a supply standpoint, but design and operation of a plant that would efficiently switch from one feedstock to another might present a significant operational challenge. (Groschen 2002, p. 15)

Overall, not much information about the appropriate scale of production is available because biodiesel production is still in its infancy, at least at the industrial scale. However, there is a general feeling that the larger the operation becomes, the more costs will decrease. The Independent Business Feasibility Group concurs, that production costs decrease in relation to the scale of the operation. According to their model for biodiesel plant feasibility, production costs for biodiesel as related to scale are as seen in Table 2 (Independent Business Feasibility Group, Inc. 2002, p. 43).

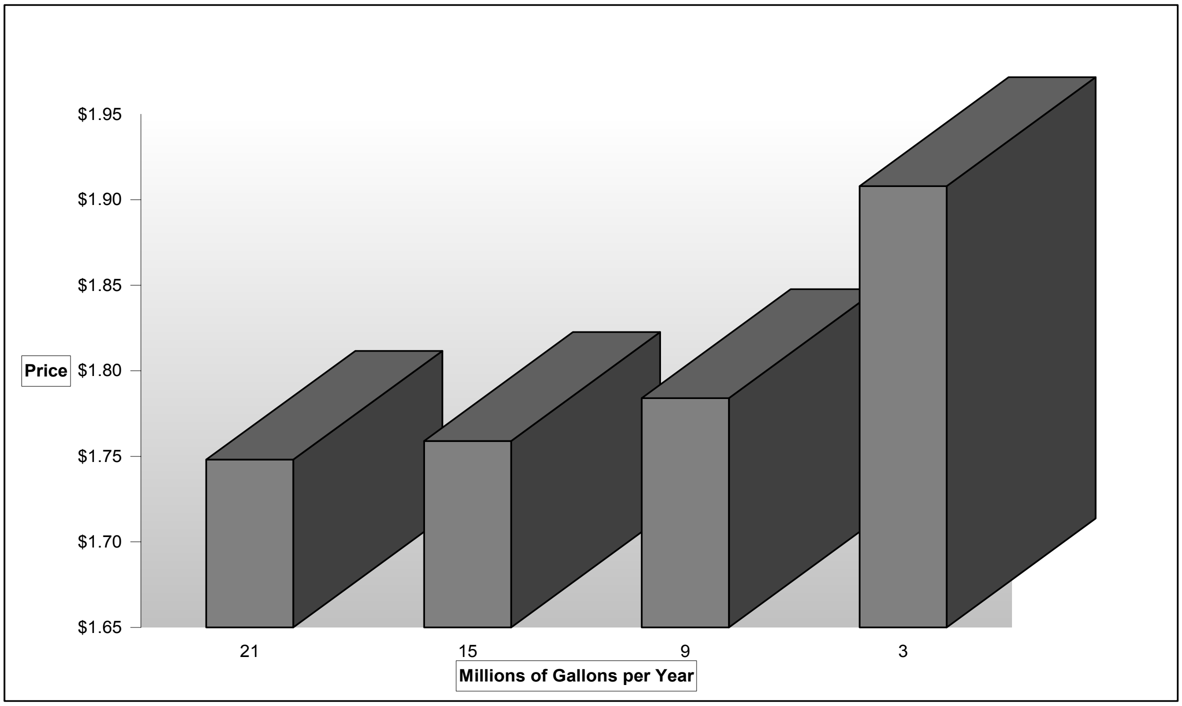

Figure 3- Production costs of biodiesel in relation to scale

Government Subsidy

The most significant form of subsidy for biodiesel was created in 1992, with the passage of the Energy Policy Act. EPAct, as it is commonly known, mandates the use of alternative fuels and alternatively fueled vehicles in federal and state government fleets and in the production of commercial electricity and power. Under EPAct, the Department of Energy has the authority to implement similar rules for local government and private fleets, but has yet to do so. The following is a compilation of government subsidies that benefit biodiesel.

> In 1992, the United States passed a law called the Energy Policy Act (EPACT). The goal of EPACT is to displace 10% of U.S. petroleum use by the year 2000 and to displace 30% of U.S. petroleum use by 2010. By passing EPACT, the United States has set very high goals for itself while setting an example for the rest of the world. EPACT sparked a new interest in alternative fueled and powered vehicles in the United States. EPACT resulted in government subsidies for research into electric vehicles, ethanol,

> methanol, and biodiesel as well as other alternative energy technologies. (Tickell 2000, P. 44)

According to the Department of Energy, the purpose of EPAct was to provide the United States with a degree of energy independence.

> The Energy Policy Act of 1992, or EPAct, was passed by Congress to reduce the nation's dependence on imported petroleum. Provisions of EPAct require certain fleets to purchase alternative fuel vehicles. [The Department of Energy] administers the regulations through State & Fuel Provider Program, Federal Fleet Program, Private Local Government Program, and Fuel Petition Program. (United States Department of Energy n.d.a)

The benefits of EPAct are already being seen in Florida and Alabama.

> Fleets get an EPAct credit for every 450 gallons of pure biodiesel used in a 20 percent blend level or higher. Since the incremental cost of pure biodiesel ranges from 25 cents to $1.25 a gallon. The cost of an EPAct credit using biodiesel averages about $450. This is significant since according to FPL (Florida Power and Light), EPAct credits trade for about $2,200 each. The incremental cost for B20 (20% biodiesel) is approximately 10 to 25 cents per gallon, similar to the difference between regular and premium gasoline. (National Biodiesel Board n.d.c, p. 14)

Another subsidy under EPAct is the Clean City Designation. The following describes the Clean Cities Designation and the conditions that must be met in order to attain said designation.

> From local businesses and municipal governments to regional air quality organizations and national alternative fuel companies, more than 4,400 stakeholders have found the Clean Cities Program to be an effective route to building a local alternative fuels market. Participants join Clean Cities because they are motivated by the spirit of voluntary partnerships not government mandates.
>
> There are five steps to complete to earn a Clean Cities Designation
>
> - Build a coalition of interested stakeholders
> - Assess local or regional alternative fuel markets (i.e. identify existing and potential AFV fleets and refueling stations).
> - Work to ensure a strong market foundation

- Create a program plan and submit to the DOE for review
- Celebrate designation (United States Department of Energy n.d.c)

As to the success of the Clean Cities program, a number of transportation fleets, heavy equipment fleets, and local governments have participated. While a Clean City designation does not translate directly into dollars and cents, it does provide some incentive to promote the use of Alternative Fuel Vehicles, especially with the prospect of a local government EPAct mandate seeming more and more likely.

Another subsidy geared towards the production of biodiesel takes the shape of the Bioenergy Program. The USDA explains Bioenergy.

> Under the program, the Secretary of Agriculture makes payments through the Commodity Credit Corporation to eligible producers to encourage increased purchases of eligible commodities (energy feedstocks) for the purpose of expanding production of bioenergy and supporting new production capacity. Payments to eligible producers are based on the increase in quantity of bioenergy they produce during a fiscal year over the quantity they produced during the preceding fiscal year. (United States Department of Agriculture 2003)

These subsidies come at a time when many researchers view government subsidy as the most critical aspect in making biodiesel price competitive with conventional diesel. Coltrain agues that biodiesel will never be able to be cost-competitive with petroleum diesel unless it is given further government subsidy.

> Ethanol can be thought of as an equal price substitute for gasoline and its market normally reflects this fact. Biodiesel does not have this relationship with diesel. With any type of federal subsidy, biodiesel is relatively higher priced than diesel. Now if diesel fuel prices increase and low cost animal fats and plant oils are used, biodiesel could become a price substitute for diesel…diesel prices are generally increasing. In fact, diesel was over $1. 00 per gallon for much of 2000. At this price and with proposed government subsidy, biodiesel could become quite competitive with diesel. (Coltrain 2002, p. 13)

Flechtner and Gushee presented a report to congress in 1993, concluding that Biodiesel was not at the time price competitive. They state that further reductions are necessary for biodiesel to compete.

> Biodiesel fuel costs over $2 per gallon, compared to 65 to 70 cents for the diesel fuel it would displace. However, it does have advantages over possible replacements such as alternative fuels. Some of this higher cost would be compensated for by engine modification costs, fuel storage costs, and infrastructure investments required by alternative fuels such as natural gas and methanol. But these advantages do not fill the gap. Further cost reductions are necessary for biodiesel to compete. (Fletchner and Gushee 1993)

Unfortunately, biodiesel feedstocks have competing interests. For example, waste cooking oil may be used for many kinds of machine lubricant, livestock feed, ink and various kinds of fertilizer. Thus, the economics and policy measures affecting biodiesel are slightly more complicated than assessing the feasibility of production. One must also factor in the added risk of competition, a factor that contributes to the market value of waste cooking oil and indicates that biodiesel may not be the most profitable use for the product.

In sum, contemporary models indicate that biodiesel is more expensive than petroleum diesel based on price. However, according to K. Shaine Tyson of the National Renewable Energy Laboratory and others, biodiesel can be produced at fairly competitive rates (Tyson 2003, p. 24).

Demand

Virtually all of the literature on the economic feasibility of biodiesel neglects one very important aspect of the economic feasibility of biodiesel production; demand. The Independent Business Feasibility Group however, recognizes this deficiency and has this to say about demand.

Investigating the potential viability of a biodiesel plant begins with assessing who the potential users may be, the size of the market and whether the potential users are willing to purchase and use biodiesel. (Independent Business Feasibility Group 2002, p. 1)

In the Gainesville, Alachua County area, the assessment of demand entails an assessment of diesel fleets in the area, namely the Regional Transit Systems bus fleet, Alachua County School Board school bus fleet, the City of Gainesville's diesel fleet and the Alachua County diesel fleet. Incidentally, Alachua County is already using biodiesel in its fleet (personal communication with Wendell Chastain).

CHAPTER 3
THE GAINESVILLE STUDY

The initial goal of this thesis was to attain a credible number for the size of the area's feedstock and to find an existing inventory of waste cooking oil for the Gainesville/Alachua area. After a number of visits to various public government agencies, including the Alachua County Department of Health, it was determined that no public agency had an inventory of waste cooking oil. Only a private company located in Hampton, Florida had such an inventory.

Griffin Industries is a business that deals with the recycling of all kinds of food wastes. The operation in Hampton, Florida is what is commonly known as a rendering plant. It is located in a sparsely populated area of North Central Florida and there is good reason why; anyone who has ever been to a rendering plant will know that it produces an ineffably pungent smell.

Griffin is responsible for the collection of approximately 98% of the waste cooking oil in the Gainesville and Alachua area. Hampton office manager Jim Siragusa was contacted. The interview took place on January 21st, 2003. The results are as follows.

Interview 1 – Jim Siragusa-Office Manager of Griffin Industries, Hampton, Florida

1. You make various products at Griffin industries. Will you please list those products?

-chicken guts and feet are rendered into a product called chicken meal which is used as a feed for livestock.

-similarly, meat clippings from supermarkets and slaughterhouses are rendered, and make two products: beef meal, which is used as a feed for livestock, and tallow, a greasy substance used in the making of soap and cosmetics. Apparently, the higher the content of beef tallow, the higher the quality of the soap.
-yellow grease is also filtered at this facility and sold. A typical product is machine lubricant.

2. Which products are made from waste cooking oil?

-both animal feed and yellow grease.

3. Are you the only company that collects waste cooking oil in the Gainesville area?

-No. Both Darling and Grease Pro (Cairo, Georgia) have accounts in the Gainesville area. However, Mr. Siragusa estimates that Griffin controls 98% of the accounts in Gainesville.

4. Are you the only company that collects waste cooking oil in Alachua County?

-No. Along with the two companies mentioned previously, RTI also collects waste cooking oil in Alachua. However, Mr. Siragusa estimates that Griffin controls 98% of the Alachua market.

5. You collect waste cooking oil from the Gainesville area, how much?

-Mr. Siragusa gave an amount, but due to the constraints of the informed consent form and the conditions governing the disclosure of information during the interview, that number is confidential

6. You collect waste cooking oil from Alachua county, how much?

-Mr. Siragusa did not know

7. Do you collect waste cooking oil from outside Alachua County? If so, how much?

-According to Mr. Siragusa, Griffin's Hampton office collects waste cooking oil from all over North Florida. The monthly average of waste cooking oil processed at the Hampton location was also given, but is confidential.

8. Do you charge people a "tipping fee" or any other type of fee for removing their waste cooking oil? If so, how much?

-Yes. High volume customers are not charged, but lower volume customers are charged but Mr. Siragusa would not reveal how much.

9. Do you pay people for their waste cooking oil? If so, how much?
-Yes. For high volume (confidential)
10. Do you have any contract with Gainesville or Alachua County? If so, what does it say?

-No. The contracts are with the restaurants.

11. Do you have authorization from a local government?

-Some countries require an operating permit. For example, Alachua and Marion County. Duval County requires an operating license.

12. Do you need a license to collect waste cooking oil?

-No. However, Griffin is regulated by the Florida Department of Environmental Protection.

13. Do you think it would be a good idea to have a contract between yourselves and a local government?

-No. Mr. Siragusa believes that such an agreement would never work. Legal issues would stagnate the entire process. He states that it would be nice, but doesn't see how it could work.

(personal communication with Jim Siragusa)

Mr. Siragusa's response for question number one indicates that Griffin does not produce anything out of the waste cooking oil that they collect. Instead, they refine it into a product that the industry knows as yellow grease. In some of the literature on the economic feasibility of biodiesel production, for example the Booz-Allen and Hamilton Inc. study, yellow grease is mentioned as a viable feedstock for the production of biodiesel. They go on to say that the feedstock is attributed to 80 % of the cost of production; "[I]t takes around 7.5 pounds of fat or oil to produce a gallon of biodiesel. If a feedstock is 20 cents per pound, the feedstock cost alone is nearly $1.50 per gallon" (Booz-Allen and Hamilton Inc.

1994, p. 6). Mr. Siragusa's response for question number two confirms this thought; yellow grease is in fact a commodity in and of itself.

The answers for questions numbered three and four indicate that there are other companies that collect waste cooking oil in the City of Gainesville and Alachua County. Even though these companies operate in the local area, Mr. Siragusa believes they control a mere two percent of the market.

The answer to question number five is confidential under the constraints of the informed consent form that was given to Mr. Siragusa, and legally, this number cannot be displayed in this thesis. However, the quantity of waste cooking oil feedstock available in this area falls within the parameters of the three models set out in the following section. Questions six had the same answer as number five, mainly because Mr. Siragusa did not know how much waste cooking oil he collected from other parts of Alachua County. He stated that the City of Gainesville represents most of the waste cooking oil market in Alachua County. Other satellite towns like Archer and Hawthorne contribute only a minimal amount of Alachua County's waste cooking oil feedstock. Again, Mr. Siragusa's claims that Griffin Industries has 98 % of the market in Alachua County. Under the agreement of the informed consent form and for similar reasons, the answer to question number seven is also confidential.

Question eight demonstrates that the nature of the cooking oil/waste cooking oil market is extremely competitive. Mr. Siragusa's answer prompts yet another series of questions: do "tipping fees" cover the expense of collecting the waste cooking oil? Is collecting waste cooking oil a profitable venture in and of itself? Is waste cooking oil collected for a loss; i.e. do the “tipping fees” associated with waste cooking oil cover only part of the costs? Are costs made up elsewhere?

Question number nine, while it does not answer the most pressing question in this study (i.e. is the collection of waste cooking oil economically feasible?), indicates that the collection of waste cooking oil is a service that restaurants, bakeries and supermarkets are willing to accept as part of their monthly expenses. Is this a form of subsidy? Are restaurants required to pay for a waste cooking oil disposal service? Technically, waste cooking oil is defined as a solid waste. There is no state prohibition on dumping waste cooking oil into a regular dumpster or trash can (personal communication with Ashwin Patel 2003). However, municipal and private waste disposal services often require waste cooking oil to be disposed of separately because it is messy.

Question ten affirms that the City of Gainesville and Alachua County are uninvolved with the flow of grease through their jurisdictions. This also supports the statement that there are no government offices with an existing inventory of yellow grease and reinforces the purpose of this study. Perhaps the City or the County, or other cities or counties will have to recognize that a significant source of energy and revenue sits right under their noses, and while it does not smell very good at first, it smells like French fries when combusted.

The response to question eleven indicates that permits are required for the collection of waste cooking oil. This seems to indicate that City and County government have the final say in terms of who may acquire a permit to collect waste cooking oil within their jurisdiction. If cities or counties govern and may lay claim to the waste products of their citizens, then a strong argument for a community-based plant can be made. This would allow city and county governments to use this potential energy source for purposes and as they see fit.

Question twelve indicates that the true governing body behind Griffin's operation is the Department of Environmental Protection. However, this does not mean that the Department of Environmental Protection is the governing body behind the collection of waste cooking oil. In regard to a personal contact with Ashwin Patel of the Florida Department of Protection, waste cooking oil is not considered hazardous waste unless it has some kind of toxic solution in it, like solvents or chlorides (personal communication with Ashwin Patel, 2003). Thus, the only permit required for waste oil collection is an operating permit from the local jurisdiction.

Mr. Siragusa thought that question thirteen was a good idea, but thought it would never work because of legal issues. In a way this relates to question eleven. If a city or county government were to withhold permits on the grounds that they wanted the grease for themselves, the matter would almost certainly become litigious. Mr. Siragusa firmly believes that contracts between local government and waste cooking oil collectors do not exist because of the legal risk involved.

While the most important information in the interview (i.e. the size of the feedstock) cannot legally be revealed, other answers from Mr. Siragusa's interview provide this study with a few more leads to pursue. In hopes of gaining further perspective on this matter, additional interviews were needed. These interviews would be focused on the operations of local restaurants.

A substantial list was found in the Yellow Pages. While other, perhaps more comprehensive lists of restaurants do exist for the City of Gainesville, financial constraints prohibited their use; a comprehensive list of local businesses at the City of Gainesville's Department of Commerce costs sixty-five dollars. So, in favor of minimizing this study's research budget, the Yellow Pages would serve as a complete listing of restaurants.

There are two-hundred and ninety-nine restaurants listed in the Gainesville area, twenty-five of which were chosen using random selection in PLSS software. A sample of the interview is as follows.

Interview 2 – Selected Restaurants in the City of Gainesville to Determine Supply Lines for Cooking Oil

1. How long has your company been in business at this location?
2. Does your restaurant have a grease fryer?
3. In your estimation, how much cooking oil does your restaurant dispose of each month?
4. Does your restaurant have a grease trap?
5. How much of your waste cooking oil is disposed of in your grease trap?
6. How much of your waste cooking oil is disposed by other means?
7. Where do you buy your cooking oil?
8. How much does it cost to dispose of you waste cooking oil? Is there a "tipping fee" associated with your waste cooking oil?
9. If cost remained the same, would you be willing to give your waste cooking oil to the city of Gainesville?

The results for these interviews can be viewed in subsequent pages.

Table 3- Results of Gainesville Restaurant Survey

Restaurant	Q #1	Q #2	Q #3
Miraku	1 year	yes	117lbs
Sandy's place	1 year, 2 months	yes	80 gallons
Las Margarita's	5 years	no	100 gallons
Moraghot	2 1/2 years	yes	160 lbs
Boston Market	8 years	no	100 gallons(chicken fat)
JP Gators	20 years	yes	50 lbs
Napolatano's	12 years	yes	300lbs
Calypso Bar & Grill	1 1/2 years	yes	72-80 gallons
El Toro	14 years	no	600 lbs
Mildred's Café	8 1/2 years	yes	30 gallons
Chik-fil-A	24 years	yes	1052 lbs
Kotobuki	14 years	yes	600 lbs
Ballyhoo Bar & Grill	3 years	yes	3400 lbs
Porter's	4 years	yes	20 gallons
Clara's	1 year	yes	420 lbs
Hot Wok	10 months	yes	100 gallons
Mr. Han's Restaurant & Nightclub	17 years	yes	140 gallons
Miya Sushi	8 years	yes	12 gallons
Timber Creek Steakhouse	12 years	yes	560lbs
August Moon	none participant	none participant	none participant
Maui Teriyaki	none participant	none participant	none participant
EA Yoder Subway Stores	incorrect address	incorrect address	incorrect address
Greater Gainesville Pizza	incorrect address	incorrect address	incorrect address
Marcia's Restaurant & Deli	closed for repairs	closed for repairs	closed for repairs
Larry's Giant Subs	incorrect address	incorrect address	incorrect address

Table 3 Continued

Restaurant	Q #4	Q #5	Q #6
Miraku	yes	none	all (Griffin)
Sandy's place	yes	none	all (Griffin)
Las Margarita's	yes	none	all (Griffin)
Moraghot	yes	none	all (Boone West Company)
Boston Market	yes	none	all (Griffin)
JP Gators	yes	none	all (Griffin)
Napolatano's	yes	none	all (Griffin)
Calypso Bar & Grill	yes	none	all (Griffin)
El Toro	yes	none	all (Griffin)
Mildred's Café	yes	none	all (Griffin)
Chik-fil-A	yes	none	all (Griffin)
Kotobuki	yes	none	all (Griffin)
Ballyhoo Bar & Grill	yes	maximum 5%	RTI system
Porter's	yes	none	all (SWS)
Clara's	yes	none	all
Hot Wok	yes	none	all (Griffin)
Mr. Han's Restaurant & Nightclub	yes	70%-Myers Bros.	30%
Miya Sushi	yes	<1 gallon per week	all (Griffin)
Timber Creek Steakhouse	yes	all-Myers Brothers	none
August Moon	none participant	none participant	none participant
Maui Teriyaki	none participant	none participant	none participant
EA Yoder Subway Stores	incorrect address	incorrect address	incorrect address
Greater Gainesville Pizza	incorrect address	incorrect address	incorrect address
Marcia's Restaurant & Deli	closed for repairs	closed for repairs	closed for repairs
Larry's Giant Subs	incorrect address	incorrect address	incorrect address

Table 3 Continued

Restaurant	Q #7	Q #8	Q #9
Miraku	Sysco	Free	Yes
Sandy's place	Florida Foods	?-a monthly fee?	Yes
Las Margarita's	El Maizal (Atlanta, GA)	$120/month	Yes
Moraghot	Sysco	?	No
Boston Market	none	$150/month	Yes
JP Gators	Sysco	Free	Yes
Napolatano's	Sysco	less than $10/month	Yes
Calypso Bar & Grill	Sysco	free	Yes
El Toro	Florida Food Service	$40/month	No
Mildred's Café	Sysco	?	Yes
Chik-fil-A	MBM-specific to Chik-fil-A	No Charge	Yes
Kotobuki	Sysco	?	Deferred to landlord
Ballyhoo Bar & Grill	RTI	$511-550/year	No, RTI is better
Porter's	US Foods	$80/month	Yes
Clara's	Sysco or Florida Foods	$150/year	Yes
Hot Wok	N & C Inc.	$230 year	Yes
Mr. Han's Restaurant & Nightclub	South Eastern Foods	$60/month for septic plus oil	Yes
Miya Sushi	Sysco	$100/year	Yes
Timber Creek Steakhouse	Sysco	$130/month	Yes
August Moon	none participant	none participant	none participant
Maui Teriyaki	none participant	none participant	none participant
EA Yoder Subway Stores	incorrect address	incorrect address	incorrect address
Greater Gainesville Pizza	incorrect address	incorrect address	incorrect address
Marcia's Restaurant & Deli	closed for repairs	closed for repairs	closed for repairs
Larry's Giant Subs	incorrect address	incorrect address	incorrect address

(personal communication with 25 Gainesville restaurants)

The first question in this interview was designed to demonstrate the relative permanence of restaurants in the City of Gainesville. While some restaurants come and go, or go out of business, most of the restaurants in the sample had been in the City of Gainesville for over a year. In fact the mean time spent in business for the study's nineteen participants was 8.23 years. In point of fact, Gainesville restaurants, and consequently, the size of the feedstock are fairly stable.

The second question in the survey asked if the restaurants have a grease fryer or not. Only three out of the nineteen restaurants (15.78%) participating did not have a grease fryer. Since a grease fryer uses a good deal of cooking oil, it was thought that restaurants using this type of cooking device would also use more cooking oil. While there was no noticeable trend in the use of grease fryers and the amount of waste cooking oil, the results of this question indicate that a large percentage, approximately 84. 3% of the study's participants use grease fryers.

Question three was perhaps the most important question of all. The waste cooking oil disposed of each month was averaged, and multiplied by the number of restaurants in the city limits according to the City of Gainesville Yellow Pages (299). If the feedstock was estimated by means of these interviews, it would underestimate the actual quantity. It may be suggested therefore, that the sample of nineteen restaurants for this study is not representative of the whole. Possible explanations may include the fact that very few of the restaurants interviewed were large, corporate fast-food outfits. These operations tend to produce the most waste cooking oil.

Unfortunately, question four was written under the impression that a grease trap contained a substantial amount of oil. While some restaurants do dispose of their waste cooking oil in the grease trap, typically they do not. For example, of the nineteen survey participants, only two restaurants disposed of the majority of their cooking oil in the grease trap. These restaurants had contracted for septic service and grease trap disposal as one combined service. By the same rationale, all of the other restaurants were linked to the municipal sewage system and had contracted with a waste cooking oil disposal company.

Since a grease trap only contains approximately 10% oil, the results of this question are not very valuable. A grease trap contains so many impurities that its contents, Food Service Sludge, are not very useful in the production of biodiesel.

Most of the restaurants interviewed stated that they disposed of either none or a very minimal percentage of their waste cooking oil via the grease trap. Again, only two restaurants disposed of a large quantity of their cooking oil in this way. Both of these restaurants disposed of a significant amount of waste cooking oil; 140 gallons and 74. 6 gallons each month respectively.

Question seven was designed to investigate the sources of cooking oil for the City of Gainesville and Alachua County. Ten out of the nineteen participants indicated that they bought their cooking oil from Sysco Corporation, a supplier of food service and restaurant goods. When this lead was pursued, Sysco declined to answer any questions about the cooking oil market, stating that it may compromise their ability to compete. Consequently, the input side of the feedstock investigation had reached a dead end. This seems to support Groschen's statements regarding the competitive nature of the industry.

Question eight is by far the most revealing question on the survey. In fact, tipping fees may be the most essential factor in making biodiesel production economically feasible at the community level. Given that the majority of the study's participants have to pay some kind of tipping fee, it may be suggested that the collection of waste cooking oil is a profitable venture in and of itself. For example, the price of yellow grease on May 7th, 2003, was \$0.13-\$0.1325 per pound delivered in the Carolinas, \$0.1175-\$0.12 per pound delivered in New Orleans and \$0.12 per pound delivered in Illinois (personal communication with Trade News Service, 5/7/03). From these data, one may impute that the price of yellow grease in Florida on May 7th, 2003, was somewhere between \$0.12 and \$0.1325 per pound. These data beg the questions: how much does it cost to collect and refine waste cooking oil into yellow grease? And, is \$0.12 or \$0.1325 enough to cover those costs?

In question nine, eighteen out of the study's nineteen participants stated that they would give their waste cooking oil to the City of Gainesville if price and service remained the same. If a community-based plant were constructed, citizen participation would be critical, and based on the survey results, we may contend that citizen participation would be strong.

Interview 3 – Bev Thessem of the National Biodiesel Board

Another interview was conducted on March 20th, 2003, with the National Biodiesel Board. Representative Bev Thessem answered the following questions.

1. Could you briefly describe your duties at the National Biodiesel Board?

-My name is Bev Thessem and I serve as the Information Coordinator for the National Biodiesel Board.

2. Is Biodiesel economically feasible in the United States? If so, what is the market for biodiesel, given that it costs more than regular diesel per gallon?

-In the US, biodiesel is used in three primary applications to address three different market segments: B100 (neat biodiesel); B20 (20%biodiesel/80% petroleum diesel); and B2 (2% biodiesel). It is also popular with environmentalists and others wanting to achieve the best emissions reductions. B20 is a very common blend because it offers the most emissions benefits versus incremental cost and because certain federal, state, and public utility fleets can use it to help with EPACT credits. B2 is a growing market especially among the farming community. Other markets include marine, mining, transit, electrical generation, and as a replacement for heating oil.

3. What are the main factors that make the production and sale of Biodiesel feasible or infeasible? As general guidelines, I have the cost of the feedstock, the value of the bi-product glycerol, the scale of production, and government subsidies; are there other factors that contribute to the profitability of biodiesel?

-Feedstock cost and biodiesel selling price are obviously the biggest ones. Biodiesel selling price is dependent upon what markets you are selling to and what their next best alternative is. The technology selected and capital costs will also be an important factor. Other factors as noted value of the by-product, scale of production, location of plant to customers, access to feedstock/methanol supply, ability to produce high quality fuel that meets ASTM D6751 specs, government subsidies, state incentives, and market size.

4. Is there a government subsidy for biodiesel? If so, how does it work? Who benefits and why?

-Biodiesel has gotten where it is largely on its own merits. Last year, the Senate Energy Bill included a partial federal diesel excise tax exemption for

biodiesel. It would have been in the amount of one penny per percentage of biodiesel, up to 20 percent. The biodiesel provision was expected to pass the conference committee, but Congress ran out of time and adjourned without taking action on the Energy Bill. Just weeks ago, several US members of Congress introduced important legislative measures designed to encourage increased use of biodiesel, including one that mirrors the partial tax exemption for biodiesel in last year's Senate Energy Bill. A companion bill was filed late last week. Other significant bills introduced in February include: EPACT Reform (S. 356, HR 316); CMAQ (H. R. 318); and the Renewable Fuel Standard (S. 3385). This office is currently tracking 180 bills, with 52 biodiesel specific. With increasing petroleum prices and a war in the Middle East looming, it is expected that energy will remain a priority for Congress. After all, the petroleum industry is subsidized in this country…so why shouldn't a fuel that is renewable, domestically produced and better for the environment be given a chance to be cost
competitive?
One program that contributes to the growth of the biodiesel industry is the Bioenergy Program, part of the Commodity Credit Corporation (CCC) administered under USDA. The Bioenergy Program has provided a temporary production incentive for biodiesel which, in some instances, has been used to lower the incremental cost of the fuel, and has done much to energize the growth of the industry. For more information, please visit the following website -www.fsa.usda.gov/daco/bio_daco.htm.

5. Are some states better locations for the production of Biodiesel than others in regard to government subsidy? If so, what are those states?

-I have asked our regulatory director for information on states that currently offer some type of incentive for plant development. I'm not aware of any at this time. As soon as I hear back from him, I'll let you know. For pending legislation, see the attached memo that in one sentence describes each of the 52 current bills in 24 states that relate specifically and directly to biodiesel. Overall, we are tracking 180 different pieces of legislation in 37 states.

6. Is there a necessary scale of production for a feasible Biodiesel plant?

-Specific answers can be expected to vary with numerous conditions and a company's desires, so we normally suggest that interested individuals consider employing a well-versed consulting firm to conduct a feasibility study for their particular situation.

7. In your view, what needs to be done in order to make Biodiesel a more feasible product?
-Biodiesel is a premium product and right now is being marketed in areas that recognize its attributes and performance justify the increased price. If we

want to see a substantial increase in on-road usage, then a federal incentive program would be the most significant event that needs to happen.

8. What is the average sale price for a gallon of biodiesel today?

-It has been reported to us that currently B2 (a blend of 2% biodiesel with 98% petroleum diesel) runs about 2 to 4 cents more per gallon than diesel; B20 about 20 cents more per gallon; and B100 averaging across the US at $1. 95-$2. 00 pre-taxes. Two sources for prices of alternative fuels include EMI's Alternative Fuels Index and the Department of Energy's Clean Cities Alternative Fuel Price Report.

9. What is the average price for a pound of crude glycerol?

-The price of crude glycerol has gone up lately. For the current price, we suggest you check with Chemical Marketer Report.

(personal communication with Bev Thessem)

Question number one of the National Biodiesel Board survey was solely a means of introducing the person interviewed and her work related duties. Question two, while an answer for economic feasibility was not directly given, described the three typical market segments that pervade the industry. Since biodiesel can be mixed with conventional diesel in any percentage, there are in fact more than three markets. However, these three blends are the most common

Ms. Thessem’s answer to question number three confirms that the single greatest obstacle in biodiesel production is the cost of the feedstock. However, she also mentions other factors as being significant, for example the location of the plant in relation to consumers, the size of the market and the producer’s access to methanol. The preference in feedstock differs in relation to location. For example, the ideal location for a biodiesel refinery employing a waste feedstock is near a dense concentration of waste cooking oil, i.e. a large urban area. For a refinery employing a virgin feedstock, the ideal location would almost certainly be rural.

The answer for question number four gives a summary of the governmental subsidy programs mentioned in the literature review section of this thesis. While most or the literature on biodiesel production mentions government subsidy at one stage or another, the synthesis of information is often left out. This answer provides a concise summary of subsidies for biodiesel.

The answer to question number five is crucial in determining a good location for biodiesel production. Many states offer additional incentives for the use of biodiesel. Florida is not one of those states, as can be evidenced by the following compendium of state biodiesel legislation.

ARKANSAS
HB 1467 Tax deduction up to $5,000 per year for renewable energy equipment (inc. equip. using biomass)
SB 363 Provides a 5% income tax credit for plant and equipment for "advanced biofuels" wholesale or retail distribution.

ARIZONA
HB 2463 Excise tax exemption until 9/1/2005 with partial exemption through 2008.

CONNECTICUT
HB 5427 Exempts B20 from one-half of the state sales tax for purchases of such fuel.
HB 5975 Exempts motor vehicles using biodiesel from random emissions road tests and imposes a fine of at least $5,000 for obtaining the exemption by fraud. HB 5984 Biodiesel Task Force to promote the use of biodiesel and explore commercial and industrial applications.

FLORIDA
SB 1176 Biodiesel manufacturers must be licensed by Revenue Department

HAWAII
HB 356 Exempts general excise and fuel taxes on alternative fuel, with biodiesel defined as an alternative fuel.
HB 1405 State procurement preference for biodiesel
HB 1539 Fuel tax reduction for alt. fuels. Tax on BD cut in half.
SB 1239 Biodiesel mandate for use in state fleets.

ILLINOIS
HB 46 Original was mirror of SB 46.
SB 46 Extends the partial excise exemption for biodiesel blends to 12/31/13, gradually reducing the exemption to zero for blends up to B10. Biodiesel blends above B10 are completely exempt during this period. If the excise on biodiesel blend is 1.25%, then the partial exemption does not apply. SB 134 B2 mandate upon 8 million gallon capacity and federal incentive of .02 or after 6/30/06.
HB 2837 Mirror of SB 46.

IOWA
HSB 276 Excise exemption of 2. 5 cents on B2.

INDIANA
SB 483 Creates production and retail sales incentives through a new Biodiesel Production Tax Credit and Biodiesel Retailer Tax Credit.

KANSAS
HB 2036 Restricts claims of “biodiesel” to B2 or above.
SCR 1604 Encourages federal legislation regarding biodiesel incentives.
SCR 1606 Encourages Kansas governor to promote biodiesel use.
SB 191 Biodiesel mandate for B2 if no more than 10 cents higher.

MAINE
HB 307 Exempts biodiesel from excise tax.
SB 160 Exempts biodiesel from excise tax.

MASSACHUSSETTS
SB 402 Mandates option of buying “renewable” electricity.

MICHIGAN
HB 4010 Tax abatement for biodiesel production plants.

MISSOURI
SB 494 Effectively deletes the Biodiesel Revolving Fund

MONTANA
HB 502 Implements a B2 mandate. Includes an effective trigger that 10 million gallons of biodiesel must be available in the state.

NEW HAMPSHIRE
HB 96 Includes biodiesel run electrical generators for net energy metering.

NEW JERSEY
SB 1731 Exempts B100 and all biodiesel blends from excise tax.
SB 3084 Mirror of SB 1731.
AB 3116 New vehicles purchased by the State must be (1) certified as a LEVs, ULEV, SULEV, or a zero emissions vehicle or (2) an alternative fuel vehicle. Biodiesel is included in definition of alternative fuel and alternative fuel vehicle. SB 771 Tax credit for alternative fuel vehicles for 15% of cost, alt fuel includes biodiesel

NEW MEXICO
SB 193 Includes fuel mixtures containing 20% or higher of vegetable oil in the definition of alternative fuel, making it eligible for tax incentives.
HB 587 Mirror of SB 193.

NORTH DAKOTA
HB 1309 B2 mandated beginning 7/1/2007. Triggers are: 5 million gallon production facility; federal action reducing B2 by 2 cents. Includes income tax credit for biodiesel producers or blenders for equipment.
HB 1483 Requires an energy conservation plan to reduce fuel consumption and increase alternative, clean-burning fuels, including biodiesel.

OKLAHOMA
HB 1705 Requires use of alternative fuels when station is within 5 miles and deletes the cost exemption.

PENNSYLVANIA
HB 120 Alternative fuel defined to include biodiesel. Existing incentives for retrofitting costs and related issues.
SB 225 Mirror of HB 120

SOUTH DAKOTA
SB 163 B2 mandate beginning 7/1/05. B5 mandate beginning 7/1/07.
HB 1279 Reduces excise tax on biodiesel by two cents.

TEXAS
HB 666 Biodiesel production incentives.
HB 777 Identical to HB 666.

VIRGINIA
HJR 205 Study on biodiesel in state fleets.
SB 1257 Raises excise taxes and adds a consumer price index.

WASHINGTON
HB 1240 Provides tax incentives for biodiesel and alcohol fuel production.
HB 1241 Provides a tax incentive for investments associated with distribution and retail sale of biodiesel.
HB 1242 Encourages state agencies to use B20; requires state agencies to use B2 as a lubricity agent starting 6/1/2006.
HB 1243 Creates a biodiesel-ultra low sulfur diesel pilot project for school transportation.
HB 1762 Creates funding source (vehicle reg. fees) and fund to be used to purchase biodiesel and biodiesel fueling infrastructure.
SB 5467 Defines B20 and higher as an alt. fuel. Provides tax exemptions for purchase of biodiesel fueling infrastructure.
SB 5469 Creates a tax credit for purchase of biodiesel fueling infrastructure.

(Thessem, Bev 2003)

Florida is not an ideal location for biodiesel production, in that no incentive is given to the consumer or to the producer. However, as Ms. Thessem mentions in question number four, the United States Senate finance committee has enacted legislation that would compensate consumers of biodiesel on April 2nd, 2003, regardless of their geographic location

> The Senate Finance Committee today approved a tax incentive for biodiesel during its markup of the comprehensive energy tax package. In a critical bipartisan step to Senate passage, the Committee approved the provisions in S. 355 that Finance Committee Chairman Charles Grassley (R-IA) and Senator Blanche Lincoln (D-AR) had introduced. The legislation would provide a one-cent reduction in the diesel fuel excise tax for each percentage of biodiesel blended with petroleum diesel up to 20 percent. (National Biodiesel Board n.d.d).

Under these provisions, biodiesel certainly becomes more cost-competitive with petroleum diesel.

Ms. Thessem’s answer to question number six indicates the importance of expert assessment. In this way, the conclusions of this thesis are largely based on the opinions and findings of others.

Ms. Thessem agrees with the proposition of further government subsidy as she indicates in question number seven. This supports the beliefs of Gushee, Fletchner and Coltrain in that they all feel further government subsidy is necessary.

The answer to question nine confirms that the price of biodiesel is on average higher than that of petroleum diesel. However, it is worth mentioning that this belief assumes a particular kind of economic model, and should be viewed as extraneous to the conclusions and recommendations of this thesis.

While Ms. Thessem suggested that the Chemical Marketer Report was a good place to investigate the price of glycerol, the Independent Business Feasibility Group's Biodiesel Plant Development Handbook gives another plausible number. They state that the Gycerol credit will reduce the cost of production by 7.7 cents to the gallon (Independent Business Feasibility Group, Inc. 2002, p.43).

A final interview took place on April 29th, 2003. Wendell Chastain is the fleet manager for Alachua County, Florida and already uses biodiesel in his vehicles. The purpose of the interview was, in part, to assess the demand for biodiesel and to calculate costs associated with its use. The results of this interview are as follows.

Interview 4 – Wendell Chastain, Manager of the Alachua County Government Fleet

1. Could you briefly describe your job as Alachua County fleet manager?

-Mr. Chastain is the fleet manager for Alachua County. His job involves budgeting, costs associated with management, the purchase and maintenance of vehicles.

2. What are the total operating costs for the Alachua County fleet for one year?

-We budget for $2,797,000 from October 1st, 2002 to September 31st, 2003.

3. How much of those costs are attributable to fuel?

-Mr. Chastain states that he does not have the staff to directly answer this question.

4. How much fuel do you use in gallons per year?

-Mr. Chastain states that he does not have the staff to directly answer this question.

5. What is the average fuel economy of your fleet? What is the average m.p.g.?

-Mr. Chastain states that he does not have the staff to directly answer this question.

6. You use biodiesel as part of your fleet's fuel. How much or what percentage do you typically use?

-The percentage of fuel varies depending on economics. The percentage of biodiesel used varies anywhere for B5 (5% biodiesel) to B20 (20% biodiesel). Largely, the difference between the percentages of biodiesel used depends on the price of petroleum diesel. The more expensive petroleum diesel becomes, the more economically feasible the use of biodiesel becomes, and vice versa.

7. How much do you typically pay for a gallon of fuel?

-There is no typical price. Nor is there an average for last year.

8. Where do you buy your biodiesel? Where do you buy your petroleum diesel? Do you buy them in the same place?

-Yes. Both products are bought from Lewis Oil Company

9. Are you satisfied with the biodiesel that you have used?

-Yes.

10. Have you noticed any difference in engine performance?

-None. Alachua County switched to biodiesel without telling any of their vehicle operators. There was no publicity, no complaints and no difference in performance.

11. Why did you choose to use biodiesel in your fleet?

-At the time, the Board of County Commissioners decided that they wanted to try it out. It was a unanimous decision.

12. Did you choose biodiesel to comply with any law at the federal, state, local level?

-No.

13. Do you think that local government fleets should be required to use AFVs?

-It is an environmental and costs issue. The two should be balanced. If fuel becomes so expensive so as to prohibit travel, then environmental concerns should be less of a concern. If fuel becomes too cheap, then perhaps consideration for the environment should be increased.

14. Does your use of biodiesel qualify Gainesville or Alachua County as a Clean City under the Department of Energy's EPAct incentive?

-No. Clean Cities is a coalition rather than a practicing fleet. There is a public and private partnership necessary.

15. Overall, what are the benefits of using biodiesel?

-Mr. Chastain stated that he had already answered this question

16. Do you think the City of Gainesville should produce its own biodiesel? Do you think a community-based plant would work?

-Mr. Chastain stated that this was not for him to decide.

(personal communication with Wendell Chastain)

Again, question one was merely a means of introducing the interviewee and their duties. Question two is a little more pertinent. Only, it is of little use to the rest of the study since Mr. Chastain declined to answer questions three through five.

Mr. Chastain's answer to question number six indicates that incorporating biodiesel into an existing fleet depends not only on the price of biodiesel, but also the price of conventional diesel as compared with biodiesel.

The answer to question number seven does not reveal much; only that the price of conventional diesel fuel and biodiesel are subject to variation. This supports Mr. Chastain's response to question number six. Given that both fuels are subject to variation in price, the percentage of biodiesel that can reasonably be incorporated into an existing fuel stock will also vary.

Similarly, question eight does not reveal much, although many oil companies are now becoming involved in the sale of biodiesel. The response for question nine also lacks in depth. However, for those who need to be reassured, there are no problems associated with the use of biodiesel. The answer for question ten strongly supports this assertion, indicating that there were so few differences with the performance of the engines, not even the vehicle operators knew that the fuel had been changed.

Question number eleven seems to indicate that there is sufficient political will in the local area to incorporate biodiesel into governmental fleets. For example, the decision to use biodiesel in Alachua County was the decision of the county commission, and while some of the members of the commission have been replaced in recent months, the program remains intact. Furthermore, the decision was made without any incentive or mandate from the Department of Energy, thereby providing an answer for question number twelve.

Mr. Chastain's answer for question number thirteen is understandably to the point. However, in regard to this study, the main concern should be how to make biodiesel cost-competitive with regular diesel, not to accept it as a fact of life. It is true that in this day and age, and with prices for petroleum diesel consistently lower than those of bidiesel, the issue inevitably becomes one of costs versus the good of the environment. For these reasons, the argument for subsidy becomes a more important. At present, biodiesel needs additional support in order to compete.

Mr. Chastain claims that Clean City designation is a coalition rather than a practicing fleet. Therefore, in order to attain this designation, a city must only organize and promote Alternative Fuel Vehicles and need not use them. While Alachua County uses biodiesel in its fleet, it does not qualify as a Clean City Coalition. As for the rest of the interview, not much information was given.

As a means of assessing demand, several governmental fleets were contacted including; the Alachua County School Board, Regional Transit System, the City of Gainesville's diesel fleet and the Alachua County diesel fleet. While no numbers were available for Alachua County's fleet, data for the rest of the areas fleets is as follows.

Table 4- Diesel Demand for the Gainesville/Alachua Area 2001-2002

	Annual Diesel Fuel Consumption (gallons)	**Total Annual Operating Costs**	**Percent Fuel of Total**	**Price per Gallon**	**Total Fuel Costs**	**Passengers**	**Price Per Passenger**
City of Gainesville*							
Diesel 1	222,000	$3,100,000	6.09%	$0.85	$188,700	N/A	N/A
B20 ($1.91/$0.85)	222,000	$3,100,000	7.09%	$0.99	$219,780	N/A	N/A
Diesel 2	222,000	$3,100,000	9.52%	$1.33	$295,260	N/A	N/A
B20 ($1.91/$1.33)	222,000	$3,100,000	9.81%	$1.37	$304,140	N/A	N/A
B100	222,000	$3,100,000	13.68%	$1.91	$424,020	N/A	N/A
RTS**							
Diesel 1	734,068	10,776,043	7.22%	$1.06	$778,112	7,100,000	$0.11
B20($1.91/$1.06)	734,068	10,776,043	7.83%	$1.15	$844,178	7,100,000	$0.12
B100	734,068	10,776,043	13.01%	$1.91	$1,402,070	7,100,000	$0.20
Alachua County School Board***							
Diesel 1	715,046	$7,505,608	6.84%	$0.72	$513,403	6,618,143	$0.08
B20 ($1.91/$0.72)	715,046	$7,505,608	8.38%	$0.88	$629,240	6,618,143	$0.10
B100 ($1.91)	715,046	$7,505,608	18.20%	$1.91	$1,365,738	6,618,143	$0.21

Sources:
*Personal contact with Kenneth Green
**Personal contact with Paul Starling
***Personal contact with Richard Trainer

There are several things worth noting in the preceding table. Perhaps the most important deals with the number of passengers for the Regional Transit System (RTS) bus service, 7,100,000. Needless to say, there are not that many people residing in the City of Gainesville, nor in the surrounding area for many miles. Most of these people are repeat riders. However, in order for the city to use B20 in the RTS fleet, all patrons would have to pay one penny extra for each ride, a small amount by any definition.

In regard to the Alachua County School Board, riders would have to pay an extra two cents every time they rode the bus. Is it worth the money? According to Environment and Human Health Inc., diesel fuel is believed by many to be a human carcinogen. They state; “Diesel Exhaust Contains 40 Hazardous Air Pollutants: In addition, diesel exhaust contains both carbon particulates and 40 chemicals that are classified as “hazardous air pollutants” under the Clean Air Act” (Environment and Human Health Inc. 2003).

Another excerpt from the same report give a more detailed account of diesel emissions.

> The vast majority of US school buses are powered by diesel fuel. Diesel exhaust is comprised of very fine particles of carbon and a mixture of toxic gases. Federal agencies have classified diesel exhaust as a probable human carcinogen. Benzene, an important component of the fuel and exhaust, is designated to be a known human carcinogen. Components of diesel exhaust are genotoxic, mutagenic, and can produce symptoms of allergy, including inflammation and irritation of airways. There is no known safe level of exposure to diesel exhaust for children, especially those with respiratory illness. (Environment and Human Health Inc. 2003)

While both RTS and the Alachua County School Board and their patrons could benefit immensely from the use of biodiesel, the question of additional funds for such an undertaking boils down to a matter of dollars and cents.

A Model for Community-Based Biodiesel Production in the City of Gainesville, Alachua County, Florida.

As a final measure of feasibility, a model for a community-based biodiesel plant has been constructed. In large part, this is to answer the initial question posed by this thesis. Is the production of biodiesel economically feasible in the City of Gainesville and Alachua County, Florida? The resultant models detail three different scales of operation, 250,000, 500,000 and 1,000,000 gallons per year respectively. Most of the numbers were extrapolated from the existing Independent business Feasibility Group model. Other figures, such as the price of sludge tankers and plant infrastructure were researched independently. The models assume the following:

- That a City, County government has legal rights to its citizens' private waste, e.g. the reclamation of water, garbage or in this case, waste cooking oil. Or, that a city government has the ability to compete with private enterprise in the collection of waste cooking oil
- That a facility will cost $1 for every gallon of production capacity (personal contact with Daryl Reece-5/13/03)
- That a fully-equipped sludge tanker will cost $50,000 (personal contact with Daryl Reece-5/13/03), and last for 20 years
- That a fully equipped fuel tanker will cost $50,000, and last twenty years
- That a fuel budget of $100,000 will suffice for plants at all three scales
- That all other ingredients in the production of biodiesel can use the IBFG model as a point of reference (Independent Business Feasibility Group Inc. 2002)
- That employee wages for a 250,000 gallon plant would cost 150,000 a year
- That employee wages for a 500,000 gallon plant would cost 185,000 a year
- That employee wages for a 1,000,000 gallon plant would cost 285,000 a year

- That no “tipping fees” were collected from local restaurants

The results for the three plants are as follows:

Table 5- Model for a 250,000 Gallon/Year Community-Based Plant

Model for 250,000 Gallon/Year Community-Based Plant	
Costs	
Permitting	0.0200
Facility Costs	
Sludge Tankers-3,000 gallons capacity (1)	0.0100
Fuel Tankers-5,000 gallon capacity (1)	0.0100
Processing Tanks + Equipment Storage Tanks	0.0500
Operating Costs	
Feedstock, FFA <0.10% (lb) x 10	0.4000
Methanol	0.1100
Catalyst-Sodium hydroxide (lb)	0.0020
Power (kWhr)	0.0070
Steam (lb)	0.0030
Cooling Water (ft3)	0.0010
Wash Water (ft3)	0.0000
Fuel Oil for Heat (gal)	0.0080
Number of Employees	
250,000 gallon plant (5 employees)	0.3000
Maintenance (% of Capital Cost/Gallon	0.0210
Insurance (% of Capital Cost/Gallon	0.0080
Cost per Gallon before Interest, Depreciation & Glycerine Credit	0.9210
Crude Glycerine	0.077
Cost per Gallon before Interest, Depreciation	0.8440

Table 6- Model for a 500,000 Gallon/Year Community-Based Plant

Model for 500,000 Gallon/Year Community-Based Plant	
Costs	
Permitting	0.0200
Facility Costs	
Sludge Tankers-3,000 gallons capacity (1)	0.0050
Fuel Tankers-5,000 gallon capacity (1)	0.0050
Processing Tanks + Equipment Storage Tanks	0.0500
Operating Costs	
Feedstock, FFA <0.10% (lb) x 10	0.2000
Methanol	0.1100
Catalyst-Sodium hydroxide (lb)	0.0020
Power (kWhr)	0.0070
Steam (lb)	0.0030
Cooling Water (ft3)	0.0010
Wash Water (ft3)	0.0000
Fuel Oil for Heat (gal)	0.0080

Table 6 Continued

Number of Employees	
500,000 gallon plant (7 employees)	0.3700
Maintenance (% of Capital Cost/Gallon	0.0210
Insurance (% of Capital Cost/Gallon	0.0080
Cost per Gallon before Interest, Depreciation & Glycerine Credit	0.7810
Crude Glycerine	0.077
Cost per Gallon before Interest, Depreciation	0.7040

Table 7- Model for a 1,000,000 Gallon/Year Community-Based Plant

Model for 1,000,000 Gallon/Year Community-Based Plant	
Costs	
Permitting	0.0200
Facility Costs	
Sludge Tankers-3,000 gallons capacity (2)	0.0160
Fuel Tankers-5,000 gallon capacity (1)	0.0100
Processing Tanks + Equipment Storage Tanks	0.0500
Operating Costs	
Feedstock, FFA <0.10% (lb) x 10	0.1000
Methanol	0.1100
Catalyst-Sodium hydroxide (lb)	0.0020
Power (kWhr)	0.0070
Steam (lb)	0.0030
Cooling Water (ft3)	0.0010
Wash Water (ft3)	0.0000
Fuel Oil for Heat (gal)	0.0080
Number of Employees	
1,000,000 gallon plant (10 employees)	0.5700
Maintenance (% of Capital Cost/Gallon	0.0210
Insurance (% of Capital Cost/Gallon	0.0080
Cost per Gallon before Interest, Depreciation & Glycerine Credit	0.8970
Crude Glycerine	0.077
Cost per Gallon before Interest, Depreciation	0.8200

CHAPTER 4
CONCLUSIONS

There are four things that are critical in the feasible production of biodiesel from waste cooking oil in the City of Gainesville. Without a doubt, the most important of these is the cost of the feedstock. Estimates from the literature suggest that the feedstock comprises anywhere from seventy-five to eighty percent of total production costs. The most logical explanation for the high cost is that oils and fats, including waste cooking oil, have many different uses and therefore many different competing interests.

The second factor in the feasibility of biodiesel production is the value of the by product glycerin. Food grade glycerin can fetch up to three times the price of crude glycerin (Krawczyk 1996,p. 805) and can only be produced from an edible feedstock, i.e. virgin oil. While waste cooking oil is also capable of producing glycerin, the product will not be edible and consequently sell for less. However, as mentioned in the independent Business Feasibility Group's model for biodiesel production (Independent Businiss feasibility group 2002, p. 43) and Tyson's research at the National Renewable Energy Laboratory (Tyson 2003, p. 24), an approximate value for glycerin can be established at 7.5 cents per gallon of biodiesel produced. While this may not make all the difference when biodiesel is compared to its petroleum counterpart, it consistently lowers costs and is therefore an essential element of biodiesel production.

Most of the researchers involved with the production of biodiesel argue that scale is also an important issue. In the Independent Business Feasibility Group's Biodiesel Plant Development Handbook, the price of biodiesel varied from just under $1.75 for a plant producing 21,000,000 gallons a year, to just over $1.90 for a plant producing 3,000,000 gallons a year. These scales show that biodiesel production becomes cheaper with increased volume. While this thesis suggests that biodiesel can be produced at a competitive price, the production of biodiesel from a virgin feedstock and the production of biodiesel from a waste cooking oil feedstock are too dissimilar to compare. Therefore, it should be concluded that scale is an essential factor in the production of biodiesel.

The fourth critical element in feasible biodiesel production is government subsidy. Currently, government subsidies are not enough to make biodiesel use as widespread as that of petroleum diesel. However, this is not to say that biodiesel cannot be made more cheaply. When the production of biodiesel is combined with the collection of waste cooking oil, the costs of production can be drastically reduced. In reference to the community-based models above, biodiesel can be made even more cheaply for both public and private markets.

Based on the original hypothesis put forward by this thesis, there are three resultant conclusions. The first is that biodiesel is a cost competitive substitute given the parameters of the definition of economic feasibility, in that it can be produced in the Gainesville area at seventy-nine cents per gallon, which falls within the parameters of $0.72 to $1.33. This conclusion is supported by the literature, by Tyson of the National Renewable Energy Laboratory (Tyson 2003,

p. 24) who states that biodiesel can be produced from waste cooking oil for approximately eighty-five cents per gallon, by Van Dyne and Weber (n.d., p. 6) who sate that biodiesel can be produced from a virgin feedstock for $1.26 per gallon, by Nelson, Howell and Weber (Bioenergy 1994, p. 64) who state that biodiesel can be produced from waste cooking oil for ninety-six cents under ideal conditions and by the results of this thesis.

The second conclusion is that in order for biodiesel to be economically feasible at a community-based plant, it must be combined with the collection of waste cooking oil as one operation. This avoids the most crucial obstacle in the feasible production of biodiesel which is the cost of the feedstock. By collecting waste cooking oil, one bears the cost of equipment depreciation, wages, fuel and time. However, once the oil is collected, the feedstock is valued as the user sees fit, not at national commodity prices. This process may entail minimal gains or minimal losses, yet the feedstock is no longer subject to the whims of the market and becomes, for all intents and purposes, free.

The third conclusion put forth is that the biodiesel market, the glycerin market and the waste cooking oil are all subject to variation. To complicate matters, this variation is not related to the fluctuations of the petroleum diesel market. In others words, the cost and price of biodiesel are somewhat unpredictable. Even though the petroleum diesel market and biodiesel market are not connected, the hypothesis put forward by this thesis is accepted. However, biodiesel can be a cost-competitive substitute for conventional diesel in a community-based, cooperative type configuration, only if its production is combined with the collection of waste cooking oil.

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BIOGRAPHICAL SKETCH

Aneurin Grant was born in Calgary, Alberta, Canada. At the age of three months, his family moved to London, England, and lived there for ten years. At the age of ten, his family moved to Calgary and lived there for another five years. At fifteen, the family moved again, this time to Laguna Beach California, where Aneurin lived for twelve years.

In the midst of this transient existence, Aneurin has developed a liking, albeit a survival skill, for travel, change and constant stimulation. He is interested in many things. Yet it is the simple pleasure of his day to day activities that give him the most pleasure.